

Environmental Impact Statement for TVA's Integrated Resource Plan

TVA's Environmental & Energy Future

March 2011 | Volume 1

TVA

Document Type: EIS-Administrative Record
Index Field: Final Environmental Impact Statement
Project Name: Integrated Resource Plan
Project Number: 2009-19

Environmental Impact Statement **March 2011**

Proposed action: Integrated Resource Plan

Lead agency: Tennessee Valley Authority

For further information on the EIS, contact:

Charles P. Nicholson
National Environmental Policy Act Manager
Tennessee Valley Authority
400 W. Summit Hill Drive, WT 11D
Knoxville, Tennessee 37902

Phone: 865-632-3582

Fax: 865-632-3451

E-mail: IRP@tva.gov

For further information on the project, contact:

Randall E. Johnson
Integrated Resource Plan Project Manager
Tennessee Valley Authority
1101 Market St., EB 8D
Chattanooga, TN 47402

Phone: 423 751-3520

E-mail: rejohnson1@tva.gov

Abstract: The Tennessee Valley Authority (TVA) proposes to adopt a new Integrated Resource Plan (IRP) to determine how it will meet the electrical needs of its customers over the next 20 years and fulfill its mission of low-cost, reliable power, environment, and economic development. Planning process steps include: 1) determining the future need for power; 2) identifying potential supply-side options for generating power and demand-side options for reducing the need for power; 3) developing a range of planning strategies encompassing various approaches TVA can take on issues such as the amount of renewable generation, amount of demand-side reductions, and constraints on future coal-fired and nuclear generation; and 4) identifying a range of future conditions (scenarios) used in evaluating the strategies. Capacity expansion plans (portfolios) are then developed for each combination of strategies and scenarios, and these are evaluated for financial, risk, environmental, and economic criteria. A final suite of four alternative strategies, the Baseline Plan (No Action alternative), the Diversity-Focused, the Energy Efficiency-Demand Response and Renewables Focused, and the Recommended Planning Direction, is then evaluated in detail. Under all of these strategies, coal-fired generation decreases and reliance on renewable and demand-side resources increase. All strategies add varying amounts of new nuclear and natural gas-fueled generation. Emissions of air pollutants and the intensity of greenhouse gas emissions decrease under all strategies. Other environmental impacts vary across strategies and scenarios and for most resource areas are lowest for the Energy Efficiency-Demand Response and Renewables Focused Strategy. TVA's preferred strategy is the Recommended Planning Direction.

SUMMARY

INTRODUCTION

The Tennessee Valley Authority (TVA) has developed the Integrated Resource Plan (IRP) and associated programmatic environmental impact statement (EIS) to address the demand for power in the TVA service area, the resource options available for meeting that demand, and the potential environmental, economic, and operating impacts of these options. The IRP will serve as a roadmap for meeting the energy needs of TVA's customers over the next 20 years

The Tennessee Valley Authority (TVA) is the largest producer of public power in the United States. With a generating capacity of 37,000 megawatts, TVA provides wholesale power to 155 distributors and directly sells power to 56 large industrial and federal customers. TVA's power system serves nine million people in a seven-state, 80,000 square mile region (Figure 1).

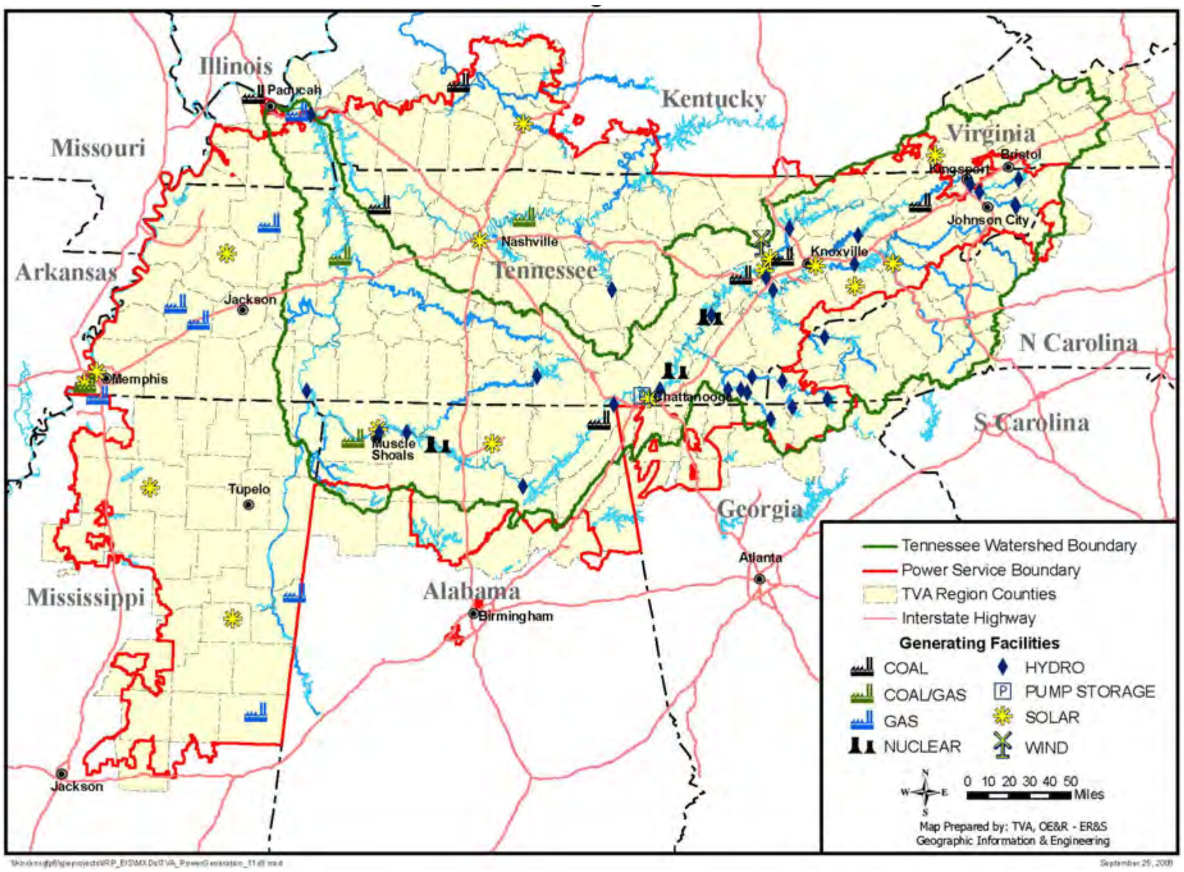


Figure 1. The TVA service area and generating facilities.

Purpose and Need

Like other utilities, TVA develops power supply plans. This planning process includes forecasting the demand for power and developing capacity resource plans. In the mid-1990s, TVA developed a comprehensive integrated resource plan with extensive public involvement. This process was completed with issuance of the Energy Vision 2020 IRP/Final EIS (EV2020) in 1995 (TVA 1995) and the associated Record of Decision in 1996. Based on the extensive evaluation, TVA adopted a flexible portfolio of supply- and demand-side energy resource options to meet the growing demand for electricity in the region, prepare for industry deregulation, and achieve the goals of the TVA Act and other congressional directives. The adopted portfolio has subsequently been amended by Records of Decision for various implementing actions. When completed, the new IRP and EIS will replace EV2020.

The purpose of this study is to evaluate TVA's current portfolio and alternative future portfolios of energy resource options to meet the future electrical energy needs of the TVA region and achieve a sustainable future. Energy resource options include the means by which TVA generates or purchases electricity, transmits that electricity to customers, and influences the end use of that electricity through energy efficiency and demand response programs. As part of the integrated resource planning process, TVA has evaluated the future demand for electricity by its customers, characterized potential supply- and demand-side options for meeting future demand, and assembled these options into planning strategies and portfolios. TVA then evaluated the strategies for several criteria including capital and fuel costs, risk, reliability, compliance with existing and anticipated future regulations, environmental impacts, and flexibility in adapting to changing future conditions. Following the public review of the Draft IRP and EIS, TVA conducted further evaluations, including the development of a new strategy, addressed the public comments, and has issued this Final EIS and the Final IRP These reports identify TVA's preferred alternative strategy, which will be submitted to the TVA Board of Directors for approval.

Public Participation

TVA conducted public scoping for the IRP and associated EIS in June 2009 with the publication of the Notice of Intent in the Federal Register. TVA simultaneously issued news releases, posted notice on the project website, and sent letters about the project to numerous state and federal agency offices and Indian tribal representatives. During the 60-day scoping period, TVA held public scoping meetings at seven locations across the TVA region. About 200 people attended these meetings.

TVA received over 1,000 individual comments during the scoping period. These included oral and written comments submitted at the scoping meetings, comments submitted through the TVA website, letters, and comments submitted by email. About 845 people completed at least part of a scoping questionnaire. Comments were also received from nine offices of four federal agencies and from 20 state agencies representing six of the seven TVA region states.

Scoping comments addressed a wide range of issues, including the integrated resource planning process, preferences for various types of power generation, support for increased energy efficiency and demand response efforts, and the environmental impacts of TVA's power generation, fuel acquisition, and power transmission operations. Comments on these issues are briefly summarized below; a more detailed discussion of the scoping comments is available in the IRP EIS Scoping Report issued in October, 2009.

To gain additional input, TVA established a Stakeholder Review Group that has regularly met throughout the development of the IRP. The Stakeholder Review Group is composed of 16 members representing state agencies, the Department of Energy, distributors of TVA power, industrial groups, academia, and non-governmental organizations. TVA has also held quarterly public briefings to educate the general public on the IRP planning process and to present results of major planning steps. Participants could attend these meeting in person or by web conference.

The Draft IRP and EIS were issued to the public on September 15, 2010 and the notice of their availability was published in the *Federal Register* on September 24, 2010. This initiated a 45-day public comment period. The comment period was later extended to 52 days and closed on November 15, 2010. During the comment period, TVA held five public meetings to describe the project and to accept comments on the Draft IRP and EIS. TVA staff presented an overview of the planning process and draft results. Attendees then had the opportunity to make oral comments and ask questions about the project. A panel of TVA staff responded to the questions. Stakeholders could also participate in the meetings via webinar and TVA responded to comments and questions submitted by webinar participants in the same manner as those from in-person attendees.

TVA received 501 comment submissions, which included letters, form letters, emails, oral statements, and submissions through the project website. These were carefully reviewed and synthesized into about 370 individual comments. These comments and TVA's responses to them are provided in Volume 2 of the Final EIS. As a result of the comments, TVA made several changes to the Final IRP and EIS. TVA also considered the comments during the development of Recommended Planning Direction alternative that has been added to the Final IRP and EIS.

TVA'S RESOURCE PLANNING PROCESS

TVA chose to employ a scenario planning approach in the IRP. The major steps in this approach include identifying the future need for power, developing scenarios and strategies, determining potential supply-side and demand-side resource options, developing portfolios associated with the strategies, and ranking the strategies and portfolios.

Need for Power

The need for additional power is based on forecasts of the demand for power over the next 20 years and the ability of TVA's existing facilities to meet the forecast demand. Demand forecasts are based on mathematical models that link electricity sales to the price of electricity, the price of natural gas, growth in economic activity, and other factors for the residential, commercial, and industrial sectors. The results are forecasts of peak load (the maximum amount of power used at a given point in time) and net system energy (the amount of power used over a specified time period). Forecasts are developed for baseline conditions (Reference Case: Spring 2010 scenario) and high- and low-demand scenarios (Figure 2).

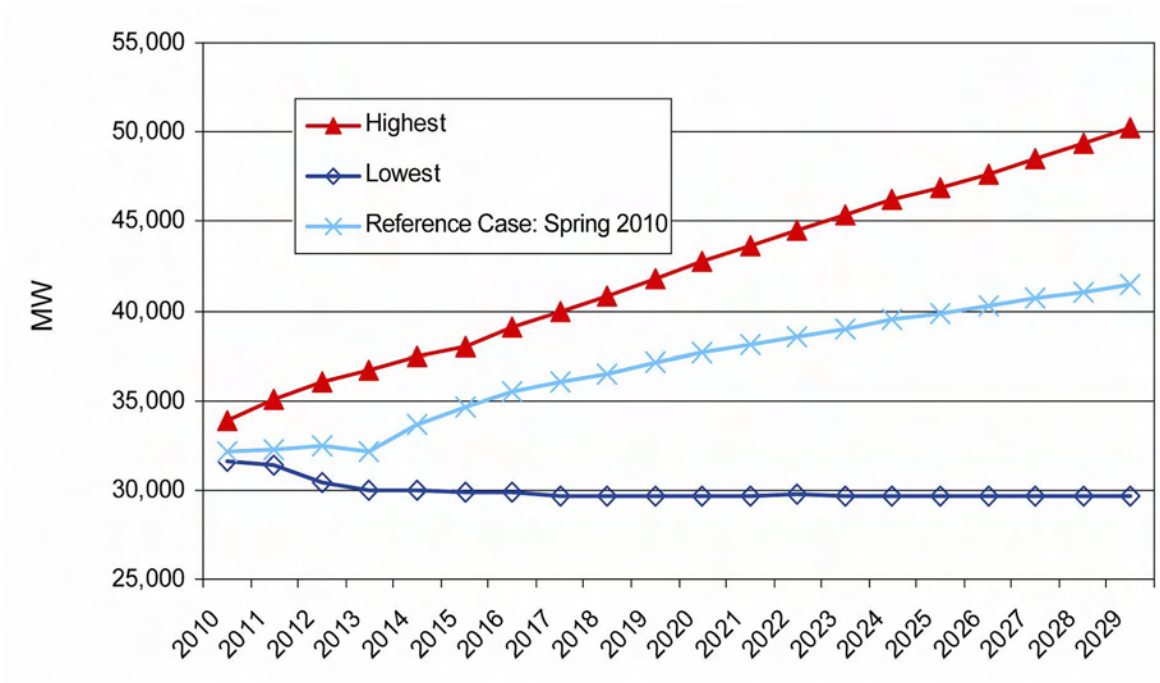


Figure 2. Peak load forecast through 2029 in megawatts (MW) for the IRP Baseline, high- and low-growth scenarios.

The next step in determining the need for power is to assess TVA's current generating mix and how the existing resources will change over the next 20 years. The largest components of TVA's 2010 energy resources, which total about 37,200 megawatts in capacity, are coal-fired and nuclear facilities (Figure 3). The major changes to this over the next few years are the addition of the 880-megawatt John Sevier combined cycle plant in 2012 and 1,180-megawatt Watts Bar Nuclear Plant Unit 2 in 2013, and the expiration of several power purchase agreements for combined-cycle generation.

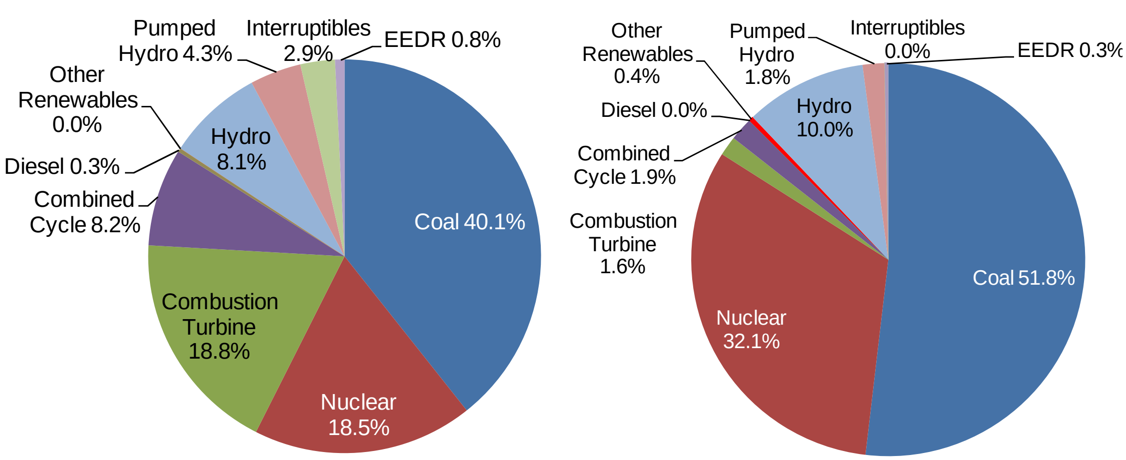


Figure 3. 2010 baseline portfolio firm capacity (left) and generation (right).

The last step in determining the need for additional power is to compare the existing energy resource portfolio with the forecasted need for power. The differences define the capacity gap (Figure 4) and the energy gap. The capacity gap includes a 15 percent reserve margin necessary to meet reliability standards.

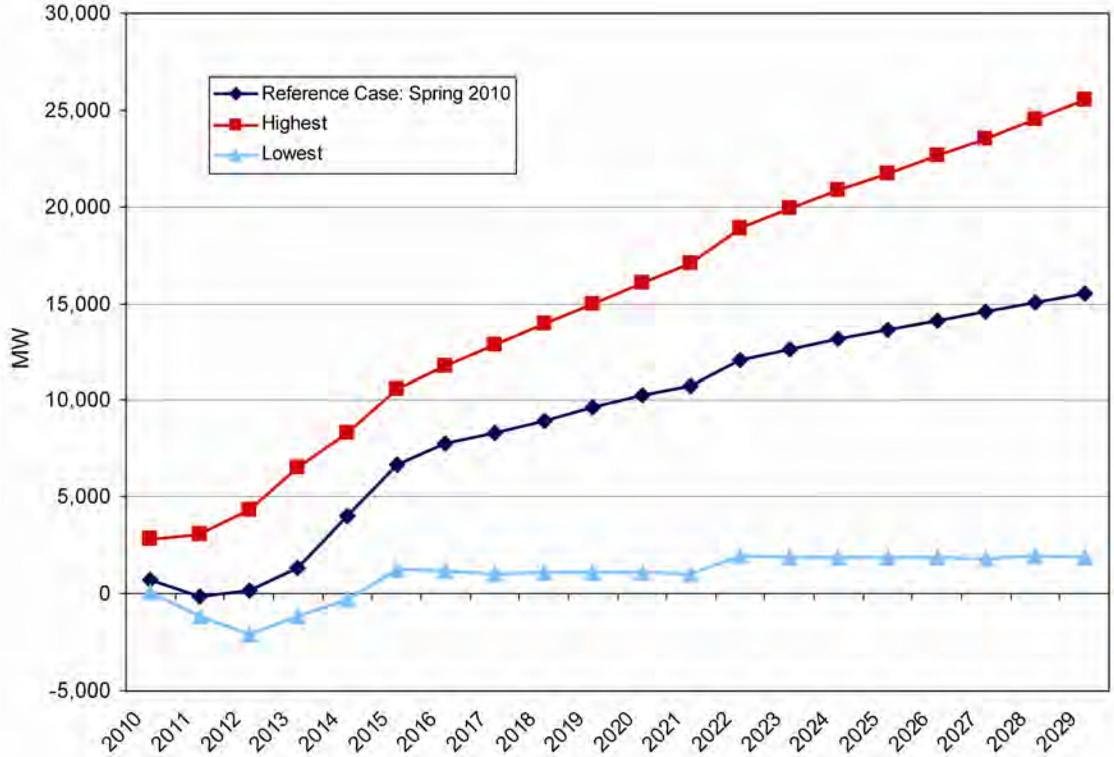


Figure 4. Capacity gap (in megawatts) for the IRP Baseline and high- and low-growth scenarios.

Scenario Development

TVA developed a set of scenarios used in evaluating the performance of the resource strategies against potential future conditions. These conditions (uncertainties) address a range of economic, financial, regulatory, and legislative conditions, as well as social trends and adoption of technological innovations. Six unique scenarios were developed and are summarized in the following table. Two additional scenarios reflect TVA's Spring 2010 and Fall 2010 planning approaches.

Strategy Development

Five distinct planning strategies were developed and analyzed in the draft IRP and EIS, and a sixth strategy was added during the development of the final IRP and EIS. These strategies describe a broad range of business options that TVA could adopt. Their attributes are assumed to be within TVA's control, and include the amounts of energy efficiency and demand response (EEDR); renewable energy, energy storage, nuclear capacity, and natural gas-fired capacity additions; coal plant shutdowns; limitations on the technology and timing of coal-fired capacity additions; reliance on purchased power; and the required transmission infrastructure. The attributes of the six planning strategies are described in a table below.

Key Characteristics of the Scenarios

Scenario	Key Characteristics
1 - Economy Recovers Dramatically	• Economy recovers stronger than expected and creates high demand for electricity • Carbon legislation and renewable electricity standards are passed • Demand for commodity and construction resources increases • Electricity prices are moderated by increased gas supply
2 - Environmental Focus is a National Priority	• Mitigation of climate change effects becomes a national priority • The cost of CO_2 allowances, gas and electricity increase significantly • Industry focus turns to nuclear, renewables, conservation and gas to meet demand
3 - Prolonged Economic Malaise	• Prolonged, stagnant economy results in low to negative load growth and delayed expansion of new generation • Federal climate change legislation is delayed due to concerns of adding further pressure to the economy
4 - Game-changing Technology	• Strong economy with high demand for electricity and commodities • High price levels and concerns about the environment incentivize conservation • Game-changing technology results in an abrupt decrease in load served after strong growth
5 - Reduce Dependence on Foreign Energy Sources	• The U.S. focuses on reducing its dependence on non-North American fuel sources • Supply of natural gas is constrained and prices for gas and electricity rise • Energy efficiency and renewable energy move to the forefronts as an objective of achieving energy independence
6 - Carbon Regulation Creates Economic Downturn	• Federal climate change legislation is passed and implemented quickly • High prices for gas and CO_2 allowances increase electricity prices significantly • U.S. based energy-intensive industry is non-competitive in global markets and leads to an economic downturn

Attributes of the Six Planning Strategies

Attributes	Planning Strategies: A - Limited Change in Current Resource Portfolio	B - Baseline Plan Resource Portfolio	C - Diversity Focused Resource Portfolio	D - Nuclear Focused Resource Portfolio	E - EEDR and Renewables Focused Resource Portfolio	R - Recommended Planning Direction
EEDR	1,940 MW & 4,725 annual GWh reductions by 2020	2,100 MW & 5,900 annual GWh reductions by 2020	3,500 MW & 11,400 annual GWh reductions by 2020	4,000 MW & 8,900 annual GWh reductions by 2020	5,900 MW & 14,400 GWh annual reductions by 2020	2,100-3,500 MW & 4,700-14,400 GWh annual reductions by 2020[1]
Renewable Additions	1,300 & 4,500 GWh competitive renewable resources or PPAs by 2020	Same as Strategy A	2,500 MW & 8,500 GWh competitive renewable resources or PPAs by 2020	Same as Strategy C	3,500 MW & 12,000 GWh competitive renewable resources or PPAs by 2020	1,500-3,500 MW competitive renewable resources or PPAs by 2020[2]
Coal Capacity Idled	No reductions	2,000 MW total reductions by 2017	3,000 MW total reductions by 2017	7,000 MW total reductions by 2017	5,000 MW total reductions by 2017	2,400-4,700 MW total reductions by 2017[3]
Energy Storage	No new additions	Same as Strategy A	Add one pumped storage unit	Same as Strategy C	Same as Strategy A	Same as Strategy C
Nuclear	No new additions after WBN2	First unit online no earlier than 2018 Units at least 2 years apart	Same as Strategy B	Same as Strategy B	First unit online no earlier than 2020 Units at least 2 years apart Limited to 3 units	Same as Strategy B
Coal	No new additions	New coal units are outfitted with CCS First unit online no earlier than 2025	Same as Strategy B	Same as Strategy B	No new additions	Same as Strategy B
Gas-Fired Supply (Self-Build)	No new additions	Meet remaining supply needs with gas-fired units	Same as Strategy B	Same as Strategy B	Same as Strategy B	Same as Strategy B

Attributes of the Six Planning Strategies (Continued)

Attributes	Planning Strategies: A - Limited Change in Current Resource Portfolio	B - Baseline Plan Resource Portfolio	C - Diversity Focused Resource Portfolio	D - Nuclear Focused Resource Portfolio	E - EEDR and Renewables Focused Resource Portfolio	R - Recommended Planning Direction
Market Purchases	No limit on market purchases beyond current contracts and contract extensions	Purchases beyond current contracts and contract extensions limited to 900 MW	Same as Strategy B	Same as Strategy B	Same as Strategy B	Same as Strategy B
Transmission	Potentially higher level of transmission investment to support market purchases Transmission expansion (if needed) may have impact on resource timing and availability	Complete upgrades to support new supply resources	Increase transmission investment to support new supply resources and ensure system reliability Pursue inter-regional projects to transmit renewable energy	Same as Strategy C	Potentially higher level of transmission investment to support renewable purchases Transmission expansion (if needed) may have impact on resource timing and availability	Same as Strategy C

[1]Assumed 3,627 MW reduction by 2020 in portfolios
[2]Assumed 1,854 MW by 2020 in portfolios
[3]Assumed 4,000 MW reductions by 2017 in portfolios

Portfolio Development

Potential 20-year resource plans or portfolios were developed for each combination of a planning strategy and scenario. A major input to the portfolio development is the definition of the supply-side and demand-side energy resource options that can become components of the portfolios. These options include existing and potential future TVA generating facilities and existing and potential future power purchase agreements. They were evaluated according to their technological maturity, commercial availability, availability to TVA either within the TVA region or importable through market purchases, economics, and ability to contribute to TVA objectives of reducing emissions of air pollutants, including greenhouse gases. In addition to TVA's existing generating facilities, resource options evaluated include advanced coal plants with carbon capture and sequestration, natural gas-fueled combustion turbine and combined cycle plants, completion of the two Bellefonte Nuclear Plant units, construction of new nuclear units at Bellefonte or on an undetermined site, pumped hydro and compressed air energy storage plants, wind, solar photo-voltaic, and biomass generation, and combinations of demand-response programs.

The portfolios are developed with a capacity planning model that finds the "optimum" combination of resource options to meet projected demand/energy requirements over the 20-year planning period. An optimized portfolio has the lowest net Present Value of

Revenue Requirements while meeting energy balance, reserve, operational, environmental, and other requirements. The portfolios are then evaluated using an hourly production costing program to determine detailed revenue requirements and short-term rates. Additional metrics developed to rank the portfolios include financial risk, CO_2 emissions, water impact (thermal cooling requirements), waste handling costs, and changes in total employment and personal income. These metrics were used to compare the planning strategies and their associated portfolios and eliminate those that performed poorly or duplicated other portfolios.

ALTERNATIVE STRATEGIES

The two strategies ranked highest for the cost and risk factors are Strategy C - Diversity Focused Resource Portfolio, and Strategy E - EEDR and Renewables Focused Resource Portfolio. Strategy B - Baseline Plan Resource Portfolio ranked in the middle of the range and Strategy D - Nuclear Focused Resource Portfolio and Strategy A - Limited Change Resource Portfolio rank lowest. Strategies D and E had the best (i.e., lowest) scores for the environmental metrics and strategies A and B had the worst scores. Strategy C was in the middle of the range. Strategy A performed poorly due to the continued operation of all TVA coal plants and the likely reliance on natural gas for most future capacity additions through power purchase agreements. The other four strategies all had reductions in coal capacity and, under most scenarios, nuclear capacity additions; these factors resulted in their lower CO_2 emissions. The ranking of the strategies by the two economic development metrics was similar. Strategies B and D performed similarly and had greatest increases in total employment and personal income under the high-growth scenario. Strategies C and E also performed similarly and were in the middle of the range. Strategy A consistently ranked lowest.

Based on these rankings, TVA eliminated strategies A and D from further consideration. The retained Strategy B (Baseline Plan) is a continuation of TVA's current planning strategy and this represents the No Action Alternative. In order to better evaluate the retained strategies B, C, and E, the individual scenario-specific portfolios that comprise each strategy were examined more closely.

Within strategies B, C, and E, the portfolios and resulting capacity expansion plans tended to be similar for the paired scenarios 1 (Economy Recovers Dramatically) and 4 (Game-Changing Technology), for scenarios 2 (Environmental Focus is a National Priority) and 5 (Energy Independence), and for scenarios 3 (Prolonged Economic Malaise) and 6 (Carbon Legislation Creates Economic Downturn). The Scenario 7 (IRP Baseline Case) portfolios tended to be relatively unique. Based on the results of this examination, the portfolios associated with scenarios 1, 2, 3, and 7 were retained for further consideration. Portfolios were also developed for the fall 2010 baseline Scenario 8 (Great Recession Impact Recovery) and for Strategy R. Characteristics of the resulting No Action Alternative (Strategy B) and the three Action Alternatives (strategies C, E, and R) are listed in the following tables.

The No Action Alternative - Strategy B - Baseline Plan Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	229	35	-	PPAs & Acquisitions				
2011	385	48	(226)					
2012	384	137	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	610	155	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,363	155	(935)	CT - 621 CT - 828 GL CT - 170				
2015	1,496	160	(2,415)	CT - 828 CC - 910	GL CT - 170[4]		CT - 621, GL CT - 170	GL CT - 170
2016	1,622	160	(2,415)	CT - 828			CT - 621	MKT
2017	1,751	160	(2,415)	CT - 828			CT - 828	MKT
2018	1,881	160	(2,415)	BLN1 - 1,250			BLN1 - 1,250	BLN1 - 1,250
2019	2,012	160	(2,415)	CT - 828	BLN1 - 1,250			MKT
2020	2,124	160	(2,415)	BLN2 - 1,250			BLN2 - 1,250	BLN2 - 1,250
2021	2,216	160	(2,415)	CC - 910	BLN2 - 1,250			
2022	2,294	160	(2,415)	CT - 828, CC - 910			CC - 910	CC - 910
2023	2,362	160	(2,415)	CT - 828			CT - 828	CT - 621
2024	2,429	160	(2,415)	BLN3 - 1,117				CT - 828
2025	2,470	160	(2,415)	IGCC - 490	BLN3 - 1,117		CT - 828	
2026	2,495	160	(2,415)	BLN4 - 1,117				CT - 828
2027	2,509	160	(2,415)	CT - 828	BLN4 - 1,117		CT - 828	
2028	2,516	160	(2,415)	CC - 910		CT - 828		CT - 828
2029	2,520	160	(2,415)	IGCC - 490, CT - 621	CT - 621		CC - 910	CT - 621 MW

[1]Peak load impact in MW
[2]Firm capacity at the summer peak
[3]Cumulative capacity of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Action Alternative - Strategy C - Diversity Focused Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	298	35	-	PPAs & Acquisitions				
2011	389	48	(226)					
2012	770	146	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,334	286	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,596	442	(935)	CT - 621				
2015	2,069	515	(3,252)	CT - 828, GL CT 170[4], CC - 910			CT - 621, GL CT - 170	GL CT - 170
2016	2,537	528	(3,252)	CT - 828				
2017	2,828	715	(3,252)					
2018	3,116	768	(3,252)	BLN 1 - 1,250			BLN1 - 1,250	
2019	3,395	822	(3,252)					
2020	3,627	883	(3,252)	BLN2 - 1,250, PSH - 850	PSH - 850	PSH - 850	BLN2 - 1,250, PSH - 850	PSH - 850
2021	3,817	896	(3,252)	CT - 828				
2022	3,985	911	(3,252)	CC - 910	BLN1 - 1,250			BLN1 - 1,250
2023	4,143	922	(3,252)	CC - 910				
2024	4,295	935	(3,252)	BLN3 - 1,117	BLN2 - 1,250			BLN2 - 1,250
2025	4,412	942	(3,252)	IGCC - 490			CT - 828	
2026	4,502	947	(3,252)	BLN4 - 1,117				
2027	4,561	948	(3,252)	CT - 828			CC - 910	
2028	4,602	953	(3,252)	CT - 828				CT - 621 MW
2029	4,638	954	(3,252)	IGCC - 490, CT - 621	BLN3 - 1,117		CT - 621	CT - 828

[1]Peak load impact in MW
[2]Firm capacity at the summer peak
[3]Cumulative capacity of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Action Alternative - Strategy E - EEDR and Renewables Focused Resource Portfolio

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	34	35	-	PPAs & Acquisitions				
2011	181	48	(226)					
2012	1,136	178	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,664	314	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	2,431	493	(935)					
2015	3,479	580	(4,730)	GL CT - 170[4], CT - 621, CC (2) - 910			CT - 621, GL CT - 170	GL CT - 170
2016	3,843	616	(4,730)	CT - 828				
2017	4,183	846	(4,730)					
2018	4,504	921	(4,730)	CT - 828			CC - 910	
2019	4,811	994	(4,730)	CC - 910				
2020	5,074	1,060	(4,730)	CC - 910				
2021	5,353	1,074	(4,730)	CT - 621				
2022	5,460	1,094	(4,730)	BLN1 - 1,250	BLN1 - 1,250		BLN1 - 1,250	BLN1 - 1,250
2023	5,599	1,107	(4,730)	CT - 828				
2024	5,739	1,124	(4,730)	BLN2 - 1,250	BLN2 - 1,250		BLN2 - 1,250	BLN2 - 1,250
2025	5,815	1,133	(4,730)	CT - 828				
2026	5,893	1,142	(4,730)	CT - 828			CT - 828	CT - 621
2027	5,961	1,145	(4,730)	CT - 828				
2028	6,009	1,154	(4,730)	BLN3 - 1,117			CT - 621	CT - 621
2029	6,043	1,157	(4,730)	CT - 828			CT - 621	CT - 621

[1]Peak load impact (MW)
[2]Firm capacity at the summer peak (MW)
[3]Cumulative capacity (MW) of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Action Alternative - Strategy R - Recommended Planning Direction

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	298	39	-	PPAs & Acquisitions				
2011	389	53	(226)					
2012	770	168	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,334	309	(935)	WBN2 - 1,180, PPAs	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,596	465	(935)	CT - 828				
2015	2,069	538	(4,002)	GL CT - 170[4], CT - 621, CC - 910, PPAs			GL CT - 170, PPAs	GL CT- 170, PPAs
2016	2,537	551	(4,002)	CT - 828			MKT	
2017	2,828	738	(4,002)	MKT			MKT	
2018	3,116	791	(4,002)	BLN1 - 1,250	BLN1 - 1,250		BLN1 - 1,250	
2019	3,395	845	(4,002)	MKT			MKT	MKT
2020	3,627	906	(4,002)	BLN2 - 1,250, PSH - 850	BLN2 - 1,250, PSH - 850	PSH - 850	BLN2 - 1,250, PSH - 850	BLN1 - 1,250, PSH - 850
2021	3,817	919	(4,002)	CC - 910				
2022	3,985	934	(4,002)	CC - 910, MKT				BLN2 - 1,250
2023	4,123	945	(4,002)	CT - 828, MKT			CT - 828	
2024	4,295	958	(4,002)	BLN3 - 1,117				
2025	4,412	965	(4,002)	IGCC - 490, MKT			CT - 621	
2026	4,412	970	(4,002)	BLN4 - 1,117			MKT	CT - 828
2027	4,561	970	(4,002)	CT - 828			CT - 828	MKT
2028	4,602	971	(4,002)	CT - 828			MKT	CT - 828
2029	4,638	977	(4,002)	CT - 828, IGCC - 490	CT - 828		CT - 828	CT - 621

[1]Peak load impact (MW)

[2]Firm capacity at the summer peak (MW)

[3]Cumulative capacity (MW) of coal units to be idled

[4]Upgrade of Gleason CT plant from 360 to 530 MW

Key to the preceding tables:

EEDR - Energy Efficiency and Demand Response, expressed as peak load impact in MW
Renewables - firm capacity at the summer peak in MW
Coal Idled - cumulative value of coal capacity idled in MW.
PPA - power purchase agreement
CC - natural gas-fired combined cycle plant
WBN2 - Watts Bar Nuclear Plant Unit 2
CT - natural gas-fired combustion turbine plant
GL CT - upgrade of the TVA Gleason CT plant from 360 to 530 MW
BLN - Bellefonte Nuclear Plant. BLN1 and BLN2 are partially constructed units, and BLN3 and BLN4 are new units.
PSH - pumped storage hydro plant
IGCC - coal-fueled integrated gasification combined cycle plant with carbon capture and sequestration

The preferred alternative strategy is Strategy R - Recommended Planning Direction. This strategy has the highest total ranking metric score of the four alternative strategies, indicating that it performs well across the range of range of scenarios. It performs best in six of the eight tested scenarios for total plan cost (PVRR) and best in five of the eight scenarios for the risk/benefit ratio metric. Based on the strategic metrics, it is the second best performing strategy, behind Strategy E. This is primarily due to the differences in the environmental stewardship metrics; the differences in the economic impact metrics among the four strategies are negligible. Across the full range of environmental resources, Strategy E would result in the lowest level of potential environmental impacts, followed by Strategies R, C, and B.

AFFECTED ENVIRONMENT

The primary study area, hereinafter called the TVA region, is the combined TVA power service area and the Tennessee River watershed. This area comprises 202 counties and approximately 59 million acres. In addition to the Tennessee River watershed, it covers parts of the Cumberland, Mississippi, Green, and Ohio Rivers where TVA power plants are located. For some resources such as air quality and climate change, the assessment area extends beyond the TVA region. For some socioeconomic resources, the study area consists of the 170 counties where TVA is a major provider of electric power and Muhlenberg County, Kentucky, where the TVA Paradise Fossil Plant is located.

<u>Climate and Greenhouse Gas Emissions</u> - The TVA region has a generally mild climate. Both annual average temperature and precipitation vary from year to year and neither shows significant long-term increasing or decreasing trends. Wind speeds are generally light with higher speeds in winter and spring and lower speeds in summer and fall. Across the TVA region, the potential for wind generation is likely to be no more than about 1,300 MW of capacity and 3,400 gigawatt-hours (GWh) of annual generation. The potential for solar photovoltaic generation is moderate relative to the rest of the U.S.

In 2008, direct CO_2 emissions from the generation of power marketed by TVA (from both TVA-owned facilities and facilities owned by others) totaled approximately 99.9 million metric tons. The CO_2 emission rate (expressed in terms of tons emitted per GWh) in recent years has been around 690 tons/GWh, somewhat below the average for large electrical utilities in the central and eastern United States.

Air Quality - Air quality in the TVA region is generally good and has steadily improved over the last 30 years. There are currently no areas in the TVA region (non-attainment areas) that do not meet air quality standards for carbon monoxide, lead, nitrogen dioxide, sulfur dioxide (SO_2), ozone, and larger particulate matter (PM_{10}). A few counties in the eastern half of the region are designated as non-attainment for fine particulate matter ($PM_{2.5}$). Portions of the TVA region are expected to be designated as non-attainment for a recent, more stringent SO_2 standard and for ozone after an anticipated more stringent ozone standard is implemented.

The burning of coal is a major source of SO_2 emissions, a contributor to acid deposition, regional haze, and fine particulate concentrations. TVA has equipped about half of its coal-fired generating capacity with scrubbers to control SO_2 emissions and burns low-sulfur coal at its other coal units. These measures have resulted in an 85 percent decrease in TVA's SO2 emissions since 1974 and further reductions are anticipated. These measures have been a major factor in the 63 percent reduction in SO_2 concentrations in the TVA region since 1979. Nitrogen oxides (NOx) are a highly reactive group of gases that include nitrogen dioxide and contribute to ozone, fine particulates, regional haze, acid deposition, and nitrogen saturation. TVA has reduced its NOx emissions by 68 percent since 1993 and currently emits 11 percent of man-made regional NOx emissions. Regional nitrogen dioxide concentrations have declined by 41 percent since 1979 and by 54 percent since peaking in 1988. Regional ozone concentrations vary greatly from year to year due to meteorological conditions and have decreased by 11 percent since 1978. The reductions in air pollutants from TVA facilities have contributed to regional improvements in visibility.

Water Resources - Power generation affects water resources by discharging treated liquid wastes, by using water directly to generate electricity in hydroelectric plants, and by using water to produce steam and cool plants. Water quality across the TVA region is generally good. TVA's coal-fired and most nuclear plants predominantly operate with open-cycle cooling, where large volumes of water are withdrawn from a river or reservoir, circulated through the plant, and discharged back to the river or reservoir. The combined-cycle plants and Watts Bar Nuclear Plants use closed-cycle cooling, where a smaller quantity of cooling water is withdrawn and evaporated in cooling towers. Water sources for the combined-cycle plants include groundwater, surface waters, and reclaimed wastewater.

Land Resources - The TVA region encompasses nine ecoregions and its land resources are diverse. They include large numbers of plant communities, diverse wildlife populations, and a variety of endangered and threatened species. The TVA power system affects land resources through site selection for power plants, transmission lines, fuel procurement, air emissions, radioactive waste management and solid waste management. TVA's existing power plant reservations, excluding the hydroelectric plants associated with multi-purpose reservoirs, occupy about 24,000 acres. The actual area disturbed by facility construction and operation totals about 17,400 acres.

Wastes - In recent years the TVA coal plants have produced about 3.9 million tons of ash and slag and about 2.4 million tons of scrubber waste per year. About 40 percent of these coal combustion wastes are marketed for beneficial use. The remainder is stored at or near the plant sites. TVA uses both dry and wet storage for these wastes and is in the process of converting to only dry storage. The TVA nuclear plants produce a total of about 650 tons of high-level radioactive waste and about 614 tons of low-level radioactive waste per year. The high-level waste, almost all spent fuel, is stored on the plant sites. The low-level waste is either shipped to an off-site processor or stored at the Sequoyah site, depending on the type of waste.

ANTICIPATED ENVIRONMENTAL IMPACTS

The environmental impacts of the resource option vary depending on the type of option. EEDR measures may result in the production of some solid waste but reduce the air emissions and other impacts associated with generating electricity. Among the various types of generating facilities, coal-fired plants have the greatest environmental impacts. A major cause of these impacts is the emission of air pollutants; TVA has substantially reduced these impacts over the years and will continue to further reduce them.

Air Quality - All four alternative strategies will result in significant long-term reductions in total emissions of SO_2, NOx, and mercury. The trends in emissions of these air pollutants are similar with decreases of about 60 percent between 2010 and 2015. Factors contributing to these decreases include the continued installation of emission controls necessary to comply with the Clean Air Act, including the anticipated requirements for use of maximum achievable control technology to reduce emissions of hazardous air pollutants, and reduced coal-fired generation due to the coal capacity idled and the increase in nuclear and natural gas generation. The decreases in emissions are greatest under Strategy E and least under Strategy B. Under all of these alternative strategies, there will likely be a substantial beneficial cumulative impact on regional air quality.

Greenhouse Gas Emissions and Climate Change - Total direct CO_2 emissions under the alternative strategies are highest under Strategy B and lowest under Strategy E. Compared to TVA's recent annual average direct CO_2 emissions of around 100 million tons, all of the strategies result in a decrease in CO_2 emissions. For most scenarios other than Scenario 1, and especially under strategies C, E, and R, the decrease is marked and significant. The CO_2 intensity of TVA's power generation, around 700 tons/GWh in recent years, significantly decreases under all of the alternative strategies. For both total direct CO_2 emissions and CO_2 intensity, the reductions are greatest under Strategy E and least under Strategy B.

The long-term increase in temperature forecast for the TVA region by many climate researchers would likely increase the overall demand for electricity. It would also increase the temperature of surface waters used for cooling fossil and nuclear plants. This can reduce the efficiency of the generating plants and may require reductions in power generation or increased use of cooling towers (if available) to remain in compliance with permit requirements. The installation of increased cooling capacity at coal and nuclear plants may be necessary in the future.

Water Resources - Potential impacts to water quality, with the exception of thermal discharges, are generally greater from coal-fired generation than from other types of generation due to the various liquid waste streams from coal-fired plants and the potentially adverse water quality impacts from coal mining and processing. The overall potential for water quality impacts would decrease under all alternative scenarios, with the greatest decrease under Strategy E. Under all alternative strategies, TVA would continue to meet water quality standards through compliance with National Pollutant Discharge Elimination System permit requirements.

All of the alternative scenarios would increase both the volume of water used and the volume of water consumed (evaporated) for cooling generating plants. The increases in water use are relatively small. In contrast, the increases in water consumption are large (up to 560 percent) because all future plants requiring cooling water are anticipated to use closed-cycle cooling. TVA would carefully assess the potential impacts of water use and water consumption during the planning process for any new generating facility.

Fuel Consumption - The major fuels used for generating electricity would continue to be coal, enriched uranium, and natural gas in all of the alternative strategies. The proportion of generation from coal, as well as the quantity of coal consumed, declines in the future as coal units are idled and, except for an advanced coal plant proposed under the highest growth scenarios in Strategies B, C, and R, no additional coal plants would be built. The consumption of nuclear fuel increases with the startup of Watts Bar Nuclear Plant Unit 2 in 2013 under all of the alternative strategies and continues to increase with up to four additional nuclear units are added under Scenarios 1, 2, 7, and 8. Natural gas consumption increases under all of the alternative strategies. Under all strategies, it remains fairly constant for Scenario 3, and increases by about 50 percent for Scenarios 2 and 7. The increase in gas consumption for Scenario 1, which has the highest electrical demand, ranges from about 270 percent under Strategy B to 350 percent under Strategy E. Overall natural gas consumption is greatest under Strategy E and least under Strategy C. Much of the increase is anticipated to provide intermediate generation and will likely displace some coal-fired generation. The consumption of biomass fuels increases under all alternative strategies and is greatest under Strategy E, which has the most biomass-fueled generation. Accurately forecasting this increase in the quantity of biomass fuels is difficult without knowing the types of biomass fuels and the types of new dedicated biomass generating facilities deployed during the planning period. All of the fuel life-cycles have associated environmental impacts that are probably greatest for coal-fired plants.

Solid Waste - The largest amounts of solid waste produced by the alternative strategies are coal ash and scrubber waste. The production of ash decreases under the alternative strategies by about 19 to 42 percent as a result of the coal capacity idled. The production of scrubber sludge increases from an average of about 30 percent for the Strategy E scenarios to about 58 percent for the Strategy B scenarios. The increases are due to the continued operation of coal plants that are presently equipped with scrubbers and the anticipated installation of scrubbers on unscrubbed plants that continue operating. The trends in production of high- and low-level radioactive waste are similar to the trends in the use of nuclear fuel described above. TVA would continue to store high-level waste (predominantly spent fuel) at the nuclear plants until a long-term disposal facility is operating.

Land Resources - The potential for a facility to impact vegetation, wildlife, endangered and threatened species, historic properties, and other land resources increases as the facility's land requirements increase. The alternative strategies require between about 4,530 and 8,130 acres for new generating facilities. These land requirements only include those for the generating facility footprints and associated access roads. Wind and ground-mounted solar photovoltaic generation plants have large facility land requirements relative to the amount of energy generated. With its large amount of renewable generation, Strategy E has the largest facility land requirements and Strategy B, with the least amount of renewable generation, has the lowest land requirements. Life-cycle land requirements, which include the fuel cycle as well as lands affected by a facility - but not necessarily physically altered, such as the area surrounding wind turbines - are also greatest for

Strategy E and least for Strategy B. Because of the present uncertainty over long-term disposition of spent nuclear fuel, it was not included in the comparison of life-cycle land requirements. Had it been included, nuclear life-cycle land requirements would have increased.

<u>Socioeconomics</u> - Socioeconomic impacts were analyzed by comparing the changes in forecast total employment and personal income of the alternative strategies to those of the baseline plan. The changes are all small and mostly beneficial. Strategies C, E, and R had somewhat greater beneficial impacts than Strategy B.

TABLE OF CONTENTS

VOLUME 1

LIST OF TABLES

LIST OF FIGURES

VOLUME 2

CHAPTER 1

1.0 INTRODUCTION

1.1 Introduction

The Tennessee Valley Authority (TVA) is conducting a comprehensive study of alternatives for meeting the future electrical energy needs of the Tennessee Valley. The purpose of this study, the Integrated Resource Plan (IRP), *TVA's Environmental and Energy Future*, is to develop a plan that TVA can enact to achieve a sustainable future and meet the electricity needs of its customers over the next 20 years. TVA has undertaken this study in response to recent and anticipated changes in the utility industry and recommendations from individuals and stakeholder groups.

TVA has prepared this Final Programmatic Environmental Impact Statement (DEIS) in accordance with the National Environmental Policy Act (NEPA) 42 USC §§ 4321 et seq., Council on Environmental Quality (CEQ) regulations for implementing NEPA 40 C.F.R Parts 1500-1508, and TVA's procedures for implementing NEPA.

1.2 The Tennessee Valley Authority

The Tennessee Valley Authority was established by an act of Congress in 1933. As stated in the TVA Act, TVA is to "improve the navigability and to provide for the flood control of the Tennessee River; to provide for reforestation and the proper use of marginal lands in the Tennessee Valley; to provide for agricultural and industrial development of said valley; [and] to provide for the national defense…." Fundamental to this mission was the construction of a series of hydroelectric dams, other generating resources, and electrical transmission system which brought abundant and inexpensive electricity to the TVA region. This electrical system has grown to serve 9 million people in a seven-state, 80,000 square mile region that includes most of Tennessee and parts of Alabama, Georgia, Kentucky, Mississippi, North Carolina, and Virginia (Figure 1-1).

TVA is the largest public power producer in the United States. Dependable generating capacity on the TVA power system is about 37,200 megawatts. TVA generates most of this with 3 nuclear plants, 11 coal-fired plants, 9 combustion-turbine plants, 3 combined cycle plants, 29 hydroelectric dams, two diesel generator plants, a pumped-storage plant, a windfarm, a methane-gas cofiring facility, and several small photovoltaic facilities. A portion of delivered power is provided through long-term power purchase agreements. Electricity is transmitted to 155 local distributors and 56 large industrial and federal installations through a network consisting of approximately 16,000 miles of transmission line; 498 substations, switchyards and switching stations; and 1,240 individual customer connection points. Chapter 3 presents a more detailed description of the TVA power system. The TVA Act requires the TVA power system to be self-supporting and operated on a nonprofit basis and directs TVA to sell power at rates as low as are feasible. TVA receives no funding from taxpayers. Amendments to the TVA Act in 2004 changed the structure of the TVA Board of Directors from three full-time members to nine part-time members with the responsibility to "affirm support for the objectives and missions of [TVA], including being a national leader in

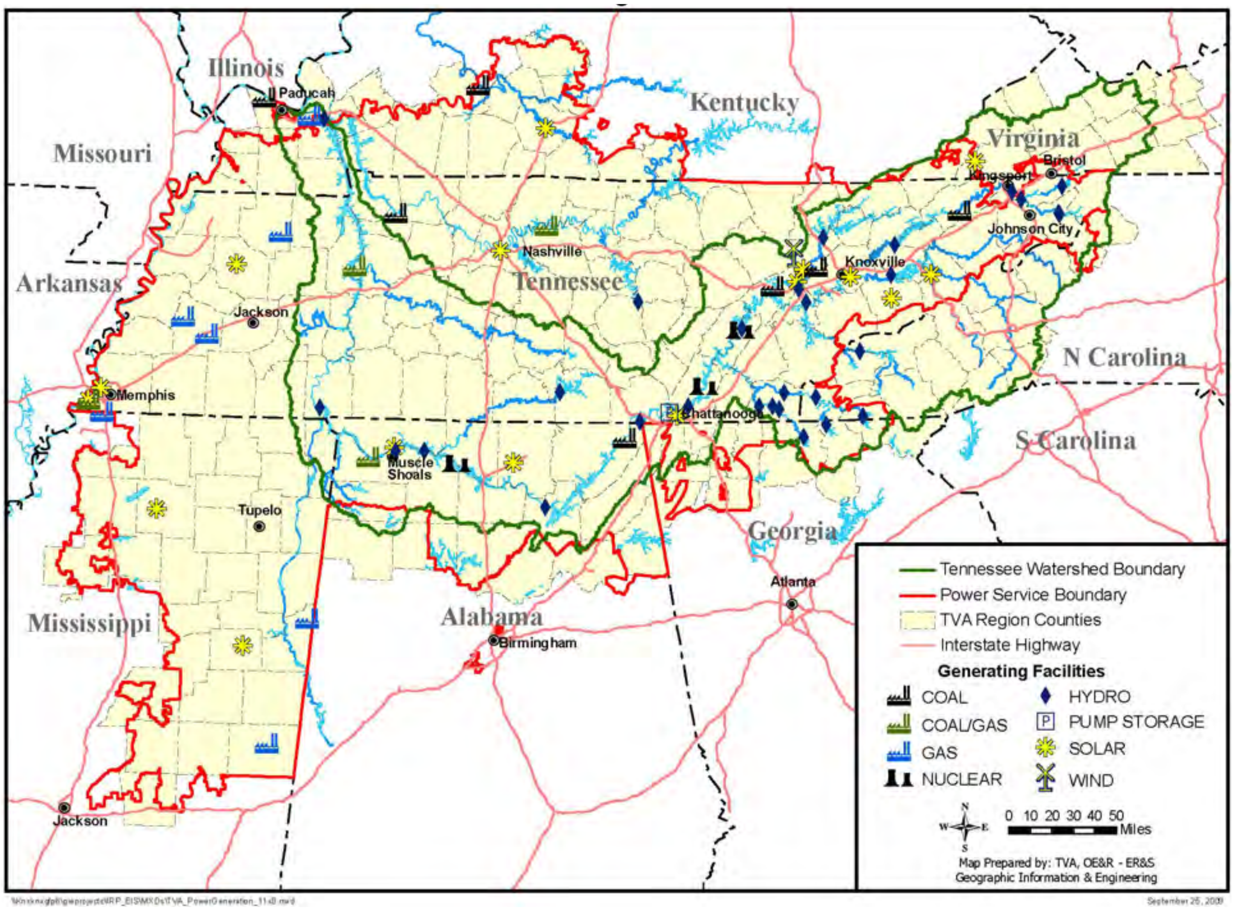


Figure 1-1. The TVA region.

technological innovation, low-cost power, and environmental stewardship." The amendments also created a full-time Chief Executive Officer. Directors are nominated by the President and confirmed by the U.S. Senate to serve five-year terms.

1.3 History of the TVA Power System

At the time of TVA's establishment in 1933, the Tennessee Valley region was suffering from the Great Depression, flooding along the Tennessee River, and erosion of the region's natural resources. From its beginning, TVA was charged with the integrated development of the region with emphasis on flood control, navigation, and power production. Consistent with these purposes, TVA was also to provide a range of other public benefits including the proper use of reservoir lands, the conservation and development of the natural resources of the region, and the enhancement of the economic and social well-being of residents. As described by President Franklin Roosevelt, TVA was created as "a corporation clothed with the power of government but possessed of the flexibility of a private enterprise" (Roosevelt 1933).

To meet its objectives of flood control, navigation, and power production, the newly formed TVA took over the operation of Wilson Dam and began constructing a series of hydroelectric dams on the Tennessee River and its tributaries. The first new TVA dam to be completed was Norris Dam in 1936; by that time four other dams were under construction. Simultaneous with this was the construction of a network of transmission lines to make electricity available across the region. Early transmission system developments included the construction of TVA's first long-distance high-voltage line, the Wilson-Wheeler-Norris line, the construction of lines connecting to the newly completed hydroelectric plants, and the integration of numerous existing transmission lines purchased by TVA. By 1939, this transmission system included about 4,200 miles of transmission lines; a large proportion of these lines were 44-kV. These lines connected to a network of local electrical distributors, who constructed and operated low-voltage lines serving end users. TVA also directly supplied a few large industrial end users. This early generation, transmission, and distribution system provided abundant and inexpensive electricity, a major tool for improving the quality of life in the region. Electric lights and modern appliances made life easier and farms more productive. Electricity also drew industries into the region, providing desperately needed jobs.

The construction of hydroelectric dams greatly accelerated during World War II in order to provide power for critical war industries. At its peak in 1942, 12 hydroelectric projects and the coal-fired Watts Bar Steam Plant were under construction and design and construction employment reached a total of 28,000. Over 1,800 miles of new transmission line were constructed during this period, and a large proportion of them were 154- and 161-kV lines.

By the late 1940s, the rapid growth in the demand for electricity was about to exceed the capacity of TVA's dams, Watts Bar Steam Plant, and a few small steam plants acquired by TVA. TVA began planning several large coal-fired steam plants and started constructing the first of these in 1949. The newest of these 11 large steam plants, Cumberland, was completed in 1973. The steam plants incorporated several technology advancements, including the largest, first-of-a-kind, coal-fired units in the world. Early in this period, TVA faced increasing difficulty in securing federal appropriations to build these single-purpose plants. In 1959, Congress passed legislation to make the TVA power system self-financing, a situation which continues to this day. This legislation also established a statutory "fence" which prohibited TVA from selling power beyond its service area with the exception of those neighboring electric companies with which TVA already had power exchange agreements. This fence was modified by the Energy Policy Act of 1992 by prohibiting the Federal Energy Regulatory Commission from requiring TVA to transmit electricity from suppliers outside the fence to customers inside the fence; this modification limits the ability of other utilities to serve TVA customers.

TVA became the largest power producer in the US during the 1950s. The TVA transmission system also greatly expanded during this period, due in large part to the need to transmit electricity from the new steam plants. Over 4,300 miles of new transmission line were constructed, mostly 154- and 161-kV lines. The 154-kV lines were soon routinely operated at 161-kV. During the 1950s, TVA installed its first microwave communication systems and began using electronic data processing equipment to manage system operations.

The 1960s were years of unprecedented economic growth in the Tennessee Valley and TVA power rates were among the lowest in the country. To meet the need for more power, TVA expanded its generating resources through an ambitious program of nuclear plant construction. This program originally called for a total of 17 nuclear units at 7 plant sites. Construction of the first TVA nuclear plant, Browns Ferry, began in 1967 and its three units began commercial operation between 1974 and 1977. The two-unit Sequoyah Nuclear Plant was completed in 1982.

The great increase in generating capacity led to the construction of a network of extra-high voltage 500-kV lines to economically and reliably transmit large amounts of power within the TVA service area and to exchange power with neighboring utilities. TVA built an experimental 6-mile 460-kV line in 1959 in order to gain experience with construction methods and costs. TVA then completed the world's first 500-kV line, a 155-mile line from Johnsonville Fossil Plant to an interconnection with Arkansas Power and Light near Memphis, in 1965. In the spring of 1966, a new 500-161-kV substation was energized at Cordova, just east of Memphis, and the 500-kV line was looped into Cordova, thus creating two lines. Over the next 2 decades TVA built several other high voltage transmission lines to better serve the region.

The 1970s brought significant changes in the economy and the demand for electricity. These started with the international oil embargo in 1973 and continued with rapidly rising fuel costs later in the decade. The average cost of electricity in the Tennessee Valley increased fivefold from the early 1970s to the early 1980s. With energy demand dropping and construction costs rising, TVA canceled the four-unit Hartsville Nuclear Plant and the two-unit Phipps Bend and Yellow Creek Nuclear Plant. Completion of the two-unit Watts Bar and Bellefonte Nuclear Plants was deferred. The passage of several major environmental laws during this period also affected TVA and the rest of the utility industry.

During 1970s and 1980s, TVA constructed or participated in several innovative and/or experimental plants. The Raccoon Mountain Pumped-Storage Plant near Chattanooga was completed in 1978. This facility works like a large storage battery by pumping water from Nickajack Reservoir to a mountaintop reservoir during periods of low demand and reversing the water flow to generate electricity during periods of high demand. After operating an experimental 20-MW atmospheric fluidized bed combustion (AFBC) pilot unit at Shawnee Fossil Plant in the early 1980s, TVA completed a 160-MW AFBC unit at Shawnee in 1989, the first commercial scale unit of its kind. TVA was a partner with the Department of Energy and Commonwealth Edison in the development and construction of the Clinch River Breeder Reactor near Oak Ridge, Tennessee; this project was canceled in 1983. In 1981 TVA began work on the Murphy Hill Coal Gasification Plant in northeast Alabama with funding from the Synthetic Fuels Corporation. This plant, designed to convert coal into liquid fuels, was canceled after Congress stopped funding the Synthetic Fuels Corporation.

As energy costs across the nation continued to climb in the 1970s and early 1980s, TVA introduced programs to encourage customers to reduce their electricity use. These programs focused on energy conservation and peak load reduction, and helped TVA's existing generating resources meet energy demands for several years. To become more competitive, TVA began aggressively improving the efficiency and productivity of its operations while cutting costs. In the late 1980s, TVA began a period of rate stability that would last for the next decade. It also halted several of its energy conservation programs. During this time period, TVA's seasonal electrical load peak changed from winter to summer.

In 1985, the Browns Ferry and Sequoyah Nuclear Plants were shut down due to safety concerns. The two Sequoyah units were restarted in 1988. After extensive modifications, Browns Ferry Units 2 and 3 were restarted in 1991 and 1995, respectively, and Unit 1 was restarted in 2007. Following a long period of deferred construction, Watts Bar Nuclear Plant Unit 1 was completed and began generating electricity in 1996. TVA resumed work on Watts Bar Unit 2 in 2007 and plans to begin operating it in 2013.

As the electric-utility industry moved toward restructuring in the 1990s, TVA began preparing for competition. It further cut operating costs, reduced its workforce, and increased the generating capacity of some its plants. TVA began a program to modernize its hydroelectric plants by automating their operation and replacing aging equipment, resulting in an increase in their generating capacity. In the mid-1990s, TVA completed the Energy Vision 2020 Integrated Resource Plan and adopted short- and long-term action plans to serve the energy needs of the Tennessee Valley region and be competitive in a deregulated market. Since then, TVA has increased its natural gas-fueled generating capacity and implemented a clean-air strategy to greatly reduce emissions from it coal-fired plants. It has also continued to build an annual average of about 150 miles of new transmission lines and many new customer delivery points. In 2008, TVA completed its first major 500-kV transmission line since the 1980s.

1.4 Purpose and Need for Integrated Resource Planning

Like other utilities, TVA develops power supply plans. This planning process includes forecasting the demand for power and developing capacity resource plans. In the mid-1990s, TVA developed a comprehensive integrated resource plan with extensive public involvement. This process was completed with issuance of the Energy Vision 2020 IRP/Final EIS (EV2020) in 1995 (TVA 1995) and the associated Record of Decision in 1996. Based on the extensive evaluation, TVA decided to adopt a flexible portfolio of supply- and demand-side energy resource options to meet the growing demand for electricity in the region, prepare for industry deregulation, and achieve the goals of the TVA Act and other congressional directives. The adopted portfolio has subsequently been amended by Records of Decision for various implementing actions. When completed, the new IRP and EIS will replace EV2020.

The purpose of this study is to evaluate TVA's current portfolio and alternative future portfolios of energy resource options in order to meet the future electrical energy needs of the TVA region and achieve a sustainable future. Energy resource options include the means by which TVA generates or purchases electricity, transmits that electricity to customers, and influences the end use of that electricity through energy efficiency and demand response programs. As part of the integrated resource planning process, TVA has evaluated the future demand for electricity by its customers, characterized potential supply- and demand-side options for meeting future demand, and assembled these options into planning strategies and portfolios. TVA then evaluated the strategies for several criteria including capital and fuel costs, risk, reliability, compliance with existing and anticipated future regulations, environmental impacts, and flexibility in adapting to changing future conditions. Following the public review of the Draft IRP and EIS, TVA conducted further evaluations, including the development of a new strategy, addressed the public comments, and has issued this Final EIS and the Final IRP. These reports identify TVA's preferred alternative strategy, which will be submitted to the TVA Board of Directors for approval.

1.5 The Integrated Resource Planning Process

The basic integrated resource planning process consists of the six steps summarized below.

1. Scoping - Through interaction with the public and expert TVA staff, identify important issues to be considered in the planning process. The results of the public scoping are described in more detail below in Section 1.8.
2. Develop Modeling Inputs and Framework - Much of the IRP analysis involves sophisticated computer modeling. In this step, model inputs for topics mostly out of

TVA's control, such as the forecasted need for power, fuel prices, environmental and other legislation, and construction and materials costs, are determined. These inputs are organized into various scenarios which portray possible future "worlds" that TVA may find itself in. Another phase of this step is the development of various strategies in which TVA varies attributes under its control, such as the size of energy conservation and demand reduction programs, the amount of renewable energy to be used, how much nuclear generation will be added, whether and when to idle existing plants, and how much energy will be bought from other producers. These scenarios and strategies are described in more detail in Chapter 2.

3. Analyze and Evaluate - Once the model inputs and framework are developed, a two-phase modeling process produces least cost energy resource plans and associated plan costs. A unique resource plans is produced for each combination of a scenario and a strategy. The results of this modeling are described in Chapter 6.
4. Issue Draft Plan - The Draft IRP incorporating the results of the modeling and the associated Draft EIS are issued for review by the public.
5. Incorporate Public Comment and Conduct Modeling - After the close of the public comment period, TVA reviews all comments. TVA also conducts any necessary additional modeling in response to public and internal feedback as well as updated modeling inputs.
6. Identify Preferred Strategy and Issue Final Plan - Based on the public comments and results of any additional analyses, TVA identifies a preferred strategy. This is documented in the Final IRP and associated Final EIS. The Final EIS also contain responses to the public comments. The TVA Board will subsequently select the strategy to be implemented.

1.6 The TVA Strategic Plan and Vision

The TVA Strategic Plan (TVA 2007a) reiterates the TVA mission of improving the quality of life in the TVA region through its work in the three key areas of energy, the environment, and economic development as follows:

1. Energy: TVA supplies reliable, affordable electricity to the Tennessee Valley region. It strives to meet the changing needs of power distributor customers and directly served industrial customers for electricity and related products and services in a dynamic marketplace.
2. Environment: To fulfill its environmental stewardship mission, TVA manages the natural resources of the Valley for the benefit of the region and the nation. It manages the Tennessee River system and associated public lands to reduce flood damage, maintain navigation, support power production and recreational uses, improve water quality and supply, and protect shoreline resources.
3. Economic Development: TVA works with its power distributor customers; state, regional, and local economic development organizations; and other federal agencies to build partnerships that help bring jobs to the Tennessee Valley and make the economy stronger to benefit the people of the region.

Key components of the TVA business structure, in addition to the continued focus on the three-part mission of energy, environment, and economic development, include the following:

- All aspects of the business area will continue to be funded from power revenues and financings.

- Generation and transmission services will continue to be provided as part of a “bundled” package.
- Demand for power will be met through a careful balance of self-reliance and partnership with others, limiting dependence on the market to keep costs competitive and reduce risk associated with short-term market volatility.
- Financing obligations will be appropriate to the value of the assets.

The plan identifies the following five broad strategic objectives and corresponding critical success factors:

1. Customer: Maintain power reliability, provide competitive rates, and build trust with TVA’s customers
    - Strengthen relationships and trust by being responsive to stakeholder needs
    - Develop a portfolio of product and pricing structures that more accurately reflect the costs of serving load at different times and levels of use.
    - Partner with distributors and directly served customers to encourage conservation, promote energy efficiency, and reduce peak demand
    - Partner with customers to limit volatility in rates and participate in power supply through shared generation ownership
    - Assist states, communities, and distributors in sustaining economic development programs
2. People: Build pride in TVA’s performance and reputation
    - Safeguard the health and safety of employees and the public
    - Strengthen workforce knowledge and skills and management processes to motivate performance and successfully implement the strategic objectives
    - Treat employees, customers, and other stakeholders with integrity and respect
    - Communicate clearly and consistently
3. Financial: Adhere to a set of sound guiding financial principles to improve TVA’s fiscal performance
    - Apply sound economic and financing practices to new investments
    - Pay financing obligations before assets are fully depreciated
    - Strengthen TVA’s balance sheet by improving the ratio of financing obligations to total assets
    - Improve TVA’s cash return on total assets in order to service debt, preserve existing assets, reinvest in new assets, and improve environmental performance
    - Achieve top-quartile performance in non-fuel operation and maintenance expenses and then hold increases to be less than unit sales growth (kilowatt-hours)
4. Assets: Use TVA’s assets to meet market demand and deliver public value
    - Balance TVA’s production capabilities and load by adding assets (buy, build or through long-term contracts) and encouraging the use of energy in ways that reduce the need for new generation

- Preserve, maintain, repower or retire existing assets where appropriate and cost-effective
- Manage land and water resources to provide multiple benefits to the Valley
- Reduce fuel supply risk with a diverse portfolio of generation assets

5. Operations: Improve performance to be recognized as an industry leader
    - Deliver reliable electric power generation and transmissions products and services
    - Benchmark the industry's best performers to develop metrics for top-quartile performance
    - Make nuclear safety the overriding priority for each nuclear facility and for each individual associated with it
    - Continue to reduce the impacts of TVA's operations on the environment
    - Serve as a responsible steward of the Tennessee River system
    - Apply science and technological innovation to improve operational performance

In August 2010, TVA announced a renewed vision (TVA 2010d) to become one of the nation's leading providers of low-cost and cleaner energy by 2020. This will be done by:

- Leading the nation in improving air quality
- Leading the nation in increased nuclear production
- Leading the Southeast in increased energy efficiency.

1.7 The TVA Environmental Policy

The TVA Environmental Policy (TVA 2008) was issued to align with TVA's mission of energy, environment, and economic development and to accent and integrate environmental leadership into all aspects of this mission. The policy is organized into six environmental areas and establishes an objective and critical success factors for each. The six areas and their objectives are listed below. The climate change mitigation, air quality improvement, and waste minimization areas are most relevant to the IRP.

1. Climate Change Mitigation: TVA will stop the growth in volume of emissions and reduce the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower-carbon-dioxide (CO_2) energy-supply opportunities and energy efficiency.
2. Air Quality Improvement: TVA will continue efforts to reduce sulfur-dioxide, nitrogen-oxide, mercury, and particulate emissions and engage regional and national stakeholders to develop better ways to understand, monitor, and improve regional air quality, including all regulated air emissions.
3. Water Resource Protection and Improvement: TVA will improve reservoir and stream-water quality, reduce the impact of its operations, and leverage alliances with local and regional stakeholders to promote water conservation.
4. Waste Minimization: TVA will drive increased sustainability in existing compliance programs and waste management practices by focusing on waste avoidance, minimizing waste generation, and increasing recycling to reduce environmental impacts.

5. Sustainable Land Use: TVA will strive to maintain the lands under its management in good environmental health, balancing their multiple uses, and will improve its land transaction processes to support sustainable development.
6. Natural Resource Management: TVA will be a leader in natural resource management through the implementation of sustainable practices in dispersed recreation while balancing the protection of cultural, heritage, and ecological resources.

1.8 Scoping and Public Involvement

NEPA regulations require an early and open process for deciding what should be discussed in an EIS. This scoping process involves requesting and using comments from the public and interested agencies to help identify the issues and alternatives that should be addressed in the EIS, as well as the temporal and geographic coverage of the analyses.

1.8.1 Scoping

TVA initiated the public scoping process for the IRP and associated EIS with the publication of the Notice of Intent in the *Federal Register* on June 15, 2009. TVA simultaneously issued news releases, posted notice on the project website http://www.tva.com/environment/reports/irp/index.htm, and sent letters about the project to numerous state and federal agency offices and Indian tribal representatives. This began a 60-day scoping period.

TVA solicited scoping comments by mail, e-mail, a comment form and questionnaire on the project website, and at public meetings. TVA held seven public meetings between July 20 and August 6 (Table 1-1). About 180 people attended these meetings; attendees included members of the general public, representatives from state agencies and local governments, distributors of TVA power, non-governmental organizations, and other special interest groups. Exhibits, fact sheets, and other materials were available at each public meeting to provide information about the study and the EIS. TVA personnel introduced the project and answered questions about the planning process, the EIS, the TVA power system, supply- and demand-side options, and environmental issues.

Table 1-1. IRP 2009 Public Scoping Meetings.

Date	Location
July 20	Nashville, TN
July 21	Chattanooga, TN
July 23	Knoxville, TN
July 28	Huntsville, AL
July 30	Hopkinsville, KY
August 4	Starkville, MS
August 6	Memphis, TN

TVA received over 1,000 individual comments during the public scoping. About 40 attendees submitted oral or written comments during the public meetings. Sixty-five email comments were received from individuals and organizations and an additional 50 comments were submitted through the TVA website. Eight hundred forty-five people completed at least part of the scoping questionnaire, and almost 640 of these respondents answered the write-in questions as well as the multiple-choice questions. Responses were received from nine offices of four federal agencies and from 20 state agencies representing six of the seven TVA region states. Some of these agency responses included specific comments; others stated they had no comments at this time but would like to review the draft IRP/EIS. Scoping comments were received from six of the seven TVA region states and about four percent of the comments were from outside the TVA region. Three-fourths of the comments were from Tennessee residents. The geographic origin of three percent of the comments was not identified.

Some comments from agencies, organizations, and individuals were specific to TVA's natural and cultural resource stewardship activities and are not included in this summary of scoping results. At the time scoping was initiated, TVA anticipated that the IRP would also address many of these stewardship activities. TVA subsequently established a separate planning process for these stewardship activities, the Natural Resource Plan. Information on this planning process is available at http://www.tva.com/environment/reports/nrp/index.htm. The comments on stewardship activities received during the IRP scoping are being addressed in the Natural Resource Plan and associated EIS.

Scoping comments addressed a wide range of issues, including the integrated resource planning process, preferences for various types of power generation, support for increased energy efficiency and demand response efforts, and the environmental impacts of TVA's power generation, fuel acquisition, and power transmission operations. Comments on these issues are briefly summarized below; a more detailed discussion of the scoping comments is available in the IRP EIS Scoping Report issued in October, 2009 (TVA 2009).

The most frequently mentioned issue in the scoping comments was the cost of electricity. While a large number of commenters were opposed to any future price increases, a majority of those completing the questionnaire expressed willingness to pay more for electricity generated from non-greenhouse gas emitting sources. Reliability and the ability to meet future demand were also among the most frequently mentioned issues. A large number of commenters also expressed concern about and/or dissatisfaction with TVA leadership, TVA facility maintenance, and TVA's ability to adapt to future conditions. A majority of those completing the questionnaire also expressed willingness to take various measures to reduce their energy use; the willingness to undertake some measures increased with the availability of financial incentives.

The Integrated Resource Planning Process

Several commenters addressed the integrated resource planning process. Their comments recommended that TVA: follow industry standard practices; enter the process without preconceptions about the adequacy of various resource options; be open and transparent throughout the planning process; treat energy efficiency and renewable energy as priority resources, and address the total societal costs and benefits, including externalities.

Recommended Energy Resource Options

Many scoping comments included general recommendations about TVA's future supply-side and demand-side resource options. Common themes throughout a large number of the comments were that TVA's future resource portfolio avoid or minimize rate increases, minimize or reduce pollution and other environmental impacts, and be reliable. The most frequently mentioned generalized resources included increased renewable generation (including wind, solar, locally sourced biomass and low-impact hydro), decreased coal-fueled generation, and increased nuclear generation. Somewhat less frequently mentioned were decreased nuclear generation, increased energy efficiency and demand response programs, reliance on a diversity of fuel sources, avoidance of uneconomical renewable generation, and the need for a modernized or “smart” transmission system. A few commenters recommended specific goals such as 15 to 20 percent renewable generation capacity by 2020, 60 to 70 percent nuclear generation capacity by 2029, and a 1 percent annual increase in energy efficiency savings through 2020. Many commenters recommended that TVA take a leadership role (or reestablish its former leadership role) in researching and developing a wide range of supply-side and demand-side options.

Environmental Impacts of Power System Operations

A majority of the commenters expressed concerns about the environmental impacts of the TVA power system. General concerns about pollution were the second most frequently mentioned issue, and over half of questionnaire respondents ranked the issues of air pollutants, greenhouse gas emissions/climate change, spent nuclear fuel, and coal combustion byproducts as of high importance. The Kingston Fossil Plant coal ash spill in December 2008 was also frequently mentioned. Many written comments encouraged TVA to decrease its emissions of greenhouse gases while others questioned the human influence on climate change. Several commenters also raised the issue of the impacts of buying coal from surface mines, particularly mountaintop removal mines, and recommended that TVA stop this practice.

Options to Be Evaluated

Scoping participants recommended a large number of traditional and non-traditional demand- and supply-side resource options. TVA has evaluated an extensive list of options, including the options currently used by TVA, options mentioned during public scoping, and options identified by TVA staff. Each option has been characterized by a suite of factors and initially screened by various feasibility criteria. The feasible resource options were then grouped into portfolios consisting of specific combinations of demand- and supply-side options.

Issues to Be Addressed

The various resource options are screened and then combined into possible 20-year planning strategies. The strategies are evaluated against a long list of criteria or issues. This list has been developed from standard industry practices, public scoping comments, and TVA staff input. In both the options screening and strategy evaluations, TVA considers numerous criteria including technological maturity and availability; operational criteria such as duty cycle, capacity, reliability, and fuel requirements; transmission requirements; environmental criteria such as air pollutants, greenhouse gas emissions, water requirements and thermal discharges, solid waste generation, and land requirements; financial criteria such as construction/implementation costs, operating costs, and decommissioning costs; risk; and workforce requirements. Some of these criteria are quantitatively evaluated in industry-standard models; others are evaluated qualitatively. These criteria address many of the environmental objectives and critical success factors listed in TVA’s Environmental Policy.

The strategies are evaluated against a set of scenarios that address uncertainties in predicting economic conditions, power demand and load shape, environmental regulations including reductions in greenhouse gas emissions, renewable energy standards, commodity prices, cost of financing, cost of purchased power, construction cost escalation, and risks associated with licensing, permitting, and the schedule for new generating and transmission facilities. The ranges of forecasts associated with these key uncertainties have been aggregated into the scenarios described in Section 2.3. The results of the evaluation of each of the planning strategies against the criteria in this range of scenarios will be a key factor in selecting the preferred strategy and associated short- and long-term action plans.

Because this is a programmatic EIS, site specific issues associated with constructing and operating power facilities are not addressed. Before implementing a specific resource option, a resource-specific environmental review will be conducted as appropriate.

Alternatives to Be Evaluated
TVA's current power supply planning strategy represents the No Action Alternative. The Action Alternatives consist of the final short list of strategies and associated portfolios which are evaluated against the range of scenarios.

1.8.2 Public Briefings

In addition to the public scoping meetings described above, TVA held quarterly public briefings on November 16, 2009, February 17, 2010, and May 13, 2010. Participants could attend in person or by web conference. Videos of the briefings and presentation materials were posted on the project website. Topics discussed at the public briefings included an introduction to the resource planning process, load forecasts, resource options, development of scenarios and strategies, and evaluation metrics.

1.8.3 Stakeholder Review Group

Following the public scoping efforts, TVA established a Stakeholder Review Group to more actively engage stakeholders throughout the IRP development process. The 16-member review group is composed of representatives of state agencies, the Department of Energy, distributors of TVA power, industrial groups, academia, and non-governmental organizations. These members are expected to represent their constituency and report to them on the IRP process, as well as give input to TVA on the process. Review group meetings have been held throughout the study. Additional information about the review group, including a list of members and meeting materials, is available at http://www.tva.gov/environment/reports/irp/stakeholder.htm.

1.8.4 Public Review of the Draft IRP and EIS

The Draft IRP and EIS were issued to the public on September 15, 2010 and the notice of their availability was published in the *Federal Register* on September 24, 2010. This initiated a 45-day public comment period. The comment period was later extended to 52 days and closed on November 15, 2010.

The Draft IRP and EIS were posted on the project website. Printed copies and/or CDs containing electronic files of the documents were mailed to state and federal agencies and to others upon request. Others on the project contact list were mailed or e-mailed notifications of the availability of the documents and instructions on how to submit comments.

TVA accepted comments submitted through an electronic comment form on the project website, and by mail and email. During the comment period, TVA held five public meetings (Table 1-2) to describe the project and to accept comments on the Draft IRP and EIS. TVA staff presented an overview of the planning process and draft results. Attendees then had the opportunity to make oral comments and ask questions about the project. A panel of

TVA staff responded to the questions. Stakeholders could also participate in the meetings via webinar and TVA responded to comments and questions submitted by webinar participants in the same manner as those from in-person attendees. About 125 people attended these public meetings in person and 43 attended by webinar.

Table 1-2. Public Meetings Held in 2010 Following Release of Draft IRP and EIS.

Date	Location
October 5	Bowling Green, KY
October 6	Nashville, TN
October 7	Olive Branch, MS
October 13	Knoxville, TN
October 14	Huntsville, AL

TVA received 501 comment submissions, which included letters, form letters, emails, oral statements, and submissions through the project website. These were carefully reviewed and synthesized into about 370 individual comments. These comments and TVA's responses to them are provided in Volume 2 of this Final EIS. As a result of the comments, TVA made several changes to the Final IRP and EIS. TVA also considered the comments during the development of Recommended Planning Direction alternative that has been added to the Final IRP and EIS.

1.9 Statutory Overview

Several federal laws and executive orders are relevant to TVA's integrated resource planning. Those that are specific to the natural, cultural, and socioeconomic resources potentially affected by the TVA power system are described below. This section begins with a detailed description of the National Environmental Policy Act and then lists other potentially applicable laws and executive orders. Compliance with these laws and orders may affect the environmental consequences of an alternative or measures needed during its implementation. Chapter 4, Existing Environment, describes the regulatory setting for each resource in more detail. Chapter 7, Environmental Consequences, discusses applicable laws and their relevance to this analysis.

National Environmental Policy Act

This EIS has been prepared by TVA, in compliance with the National Environmental Policy Act (NEPA) of 1969 (42 United States Code [U.S.C] §§ 4321 et seq.), regulations implementing NEPA promulgated by the Council on Environmental Quality (40 Code of Federal Regulations [C.F.R] Parts 1500 to 1508), and TVA NEPA procedures. TVA will use this EIS, as well as the analyses in the IRP, to select the resource plan to be implemented.

NEPA requires federal agencies to consider the impact of their proposed actions on the environment before making any decisions. Actions, in this context, include new and continuing activities conducted, financed, assisted, regulated or approved by federal agencies, as well as new or revised agencies rules, regulations, plans, policies, or procedures. For major federal actions, NEPA requires that an EIS be prepared. This process must include public involvement and analysis of a reasonable range of alternatives.

According to CEQ regulations, a programmatic EIS is appropriate when a decision involves a policy or program, or a series of related actions by an agency over a broad geographic area. Due to the nature of the IRP, this EIS is programmatic. The environmental impacts of the alternative actions are therefore addressed at a regional level with some extending to a national or global level. The more site-specific effects of specific actions proposed to implement the IRP will be addressed in later tiered environmental reviews.

The Draft EIS was distributed to interested individuals, groups, and federal, state, and local agencies for their review and comment. Following the close of this public comment period, TVA has compiled and responded to the substantive comments received on the DEIS and incorporate any required changes into the Final EIS. The completed Final EIS will be sent to those who received the DEIS or submitted comments on the Draft EIS. It will also be transmitted to the Environmental Protection Agency which will publish a notice of its availability in the *Federal Register*. The TVA Board will be asked to approve an energy resource strategy no sooner than 30 days after the publication of this notice of availability. TVA will then issue a Record of Decision which will include (1) what the decision was; (2) the rationale for the decision; (3) what alternatives were considered; (4) which alternative was considered environmentally preferable; and (5) any associated mitigation measures and monitoring, and enforcement requirements.

Other Laws and Executive Orders

Several other laws and executive orders are relevant to the effects of power system planning, construction, and operation on natural, cultural, and socioeconomic resources (Table 1-3). Compliance with these laws and orders may affect the environmental consequences of an alternative or measures needed during its implementation. Most of these laws also have associated implementing regulations. Chapter 3, Affected Environment, describes the regulatory setting for each resource in more detail. Chapter 7, Environmental Consequences, discusses applicable laws and their relevance to this analysis.

1.10 Relationship with Other NEPA Reviews

Energy Vision 2020 - Integrated Resource Plan and Environmental Impact Statement

TVA completed this comprehensive IRP and Final EIS (TVA 1995) in December 1995. Based on the extensive evaluation, TVA adopted a flexible portfolio of supply- and demand-side energy resource options to meet the growing demand for electricity in the region, prepare for industry deregulation, and achieve the goals of the TVA Act and other congressional directives. The adopted portfolio has subsequently been amended by Records of Decision for various implementing actions. The new IRP and EIS update EV2020 and when completed will replace it.

Table 1-3. Laws and executive orders relevant to the environmental effects of power system planning, construction, and operation.

Environmental Resource Area	Law / Executive Order
Water Quality	Clean Water Act
Groundwater	Safe Drinking Water Act
Air Quality	Clean Air Act
Wetlands	Clean Water Act Executive Order 11990 – Protection of Wetlands
Floodplains	Executive Order 11988 – Floodplain Management
Endangered and Threatened Species	Endangered Species Act
Cultural Resources	National Historic Preservation Act Archaeological Resource Protection Act Native American Graves Protection and Repatriation Act
Environmental Justice	Executive Order 12898 – Federal Actions to Address Environmental Justice in Minority and Low-Income Populations
Land Use	Farmland Protection Policy Act
Coal Mining	Surface Mining Control and Reclamation Act
Waste Management	Resource Conservation and Recovery Act Comprehensive Environmental Response, Compensation, and Liability Act Toxic Substances Control Act

River Operations Study Final Environmental Impact Statement
Published in 2004, this EIS (TVA 2004) evaluated potential changes in TVA's policy for operating its reservoir system. The new operating policy adopted by TVA established a balance of reservoir system operating objectives to produce a mix of benefits that is more responsive to the values expressed by the public. The changes include enhancing recreational opportunities while avoiding unacceptable effects on flood risk, water quality, and TVA electric power system costs. This EIS contains a detailed description of TVA's hydroelectric generating facilities and is incorporated by reference.

Adoption of PURPA Standards for Energy Conservation and Efficiency Environmental Assessment
This 2007 environmental assessment (TVA 2007b) evaluates TVA's proposed adoption of standards established by the Public Utilities Regulatory Policies Act of 1978, as modified by the Energy Policy Act of 2005, for Smart Metering, Net Metering, Fuel Diversity, Fossil Fuel Generation Efficiency, and Interconnection. TVA determined that it would adopt the first three standards without changing its operations and it would adopt modified versions of the last two standards. These standards are relevant to the integrated resource planning process.

Environmental Impact Statements and Environmental Assessments for Generating Facilities and Transmission Lines
Since the early 1970s, TVA has issued numerous EISs and environmental assessments describing the anticipated impacts of the construction and operation of new generating

facilities, major upgrades to generating facilities, and new transmission lines and substations. Most of these issued since 2002 are available at http://www.tva.com/environment/reports/index.htm. Several of these were used as sources of information for the impact analyses in Chapter 6. The following are examples of these reports:

- The 2000 EIS for the Lagoon Creek combustion turbine generating plant in Haywood County, Tennessee (TVA 2000)
- The 2001 EIS for a combined cycle generating plant in Franklin County, Tennessee (TVA 2001)
- The 2005 environmental assessment of the modernization of turbines at Wilson Hydro Plant (TVA 2005a)
- The 2005 EIS for a 500-kV transmission line and substation in middle Tennessee (TVA 2005b)
- The 2006 environmental assessment of the flue gas desulfurization system at Kingston Fossil Plant (TVA 2006)
- The 2007 EIS on the completion of Watts Bar Nuclear Plant unit 2 (TVA 2007c)

1.11 EIS Overview

This Final EIS consists of two volumes. The contents of each volume are outlined below.

Volume 1
Chapter 1: Introduction—describes the purpose and need for the IRP EIS, the decision to be made, history of the TVA power system, an overview of integrated resource planning, and the scoping process and public involvement.

Chapter 2: TVA's Resource Planning Process—describes the integrated resource planning process, evaluation metrics, the power needs assessment, and scenario and strategy development.

Chapter 3: Existing Power System—describes TVA customers, sales, and power exchanges; TVA-owned generating facilities; purchased power; energy efficiency and demand response programs, and the transmission system.

Chapter 4: Existing Environment—describes aspects of the natural, cultural, and socioeconomic environment potentially affected by the alternative actions.

Chapter 5: Energy Resource Options—describes supply-side (e.g., generating facilities) and demand-side (e.g., energy efficiency and demand response programs) options potentially comprising the power portfolios.

Chapter 6: Alternatives/Strategies—describes the alternative/strategy development process, the alternatives/strategies assessed in this EIS, and a comparison of the alternatives/strategies.

Chapter 7: Environmental Consequences—describes the anticipated environmental impacts of each of the options used in the final alternatives/strategies, as well as the environmental impacts of each alternative/strategy over the 20-year planning period.

Chapters 8-10—contain lists of the literature cited, preparers, and EIS recipients. It is followed by the glossary and index.

Volume 2
Chapter 1: Introduction and Overview

Chapter 2: Responses to Public Comments

Chapter 3: Listing of Commenters and Affiliations

Chapter 4: Agency Comment Letters

CHAPTER 2

2.0 TVA'S RESOURCE PLANNING PROCESS

2.1. Introduction

TVA chose to employ a scenario planning approach in the IRP. The major steps in this approach are identifying the future need for power, developing scenarios and strategies, determining potential supply-side and demand-side resource options; developing portfolios associated with the strategies, and ranking the strategies and portfolios. With the exception of determining the potential options, which is described in Chapter 4, these steps are described in this chapter.

2.2. Need for Power Analysis

In the analysis of the need for power, TVA forecasts the demand for power, identifies the current power supply resources available to meet this demand during the 2010-2029 planning period, and uses the difference in these to identify the capacity and energy gaps. The long-term energy and peak demand forecasts are developed from individual forecasts of residential, commercial, and industrial sales. These forecasts serve as the basis for the power system and financial planning activities.

Capacity is the instantaneous maximum amount of energy that can be supplied by a generator. For long-term planning purposes, capacity can be specified in several ways such as nameplate (the maximum design generation), dependable (the maximum expected during normal operation), seasonal (the maximum expected during a particular season), and firm (dependable less all known adjustments). Capacity is measured in watts; common units are kilowatts (kW, one thousand watts) and megawatts (MW, one million watts).

The term energy is used in power planning to describe the amount of power generated or used in a specified time period. Common measurement units are kilowatt-hour (kWh, one thousand watts for one hour, megawatt-hour (MWh, one million watts for one hour), and gigawatt-hour (GWh, one billion watts for one hour).

Peak demand is the maximum rate of electricity use, typically measured in MW. A related concept is peak load, the maximum amount of electric power drawn from the electric system at a given point in time.

2.2.1. Load Forecasting Methodology

TVA's load forecasting uses the best available data and both econometric and end-use models. Econometric models link electricity sales to several key factors in the market, such as the price of electricity, the price of natural gas, and growth in economic activity. These models are used to forecast sales growth in the residential and commercial sectors and in each industrial sector. Underlying trends within each sector, such as the use of various types of equipment or processes, play a major role in forecasting sales. To capture these trends, TVA uses a variety of end-use forecasting models. For example, in the residential sector, sales are forecast for space heating, air conditioning, water heating, and several other uses. In the commercial sector, categories including lighting, cooling, refrigeration, and space heating are examined. For both sectors, other factors such as changes in energy efficiency over time and appliance and equipment replacement rates are also considered.

Forecasting is inherently uncertain, so TVA supplements its modeling with industry analyses and studies of specific major issues. This is part of an effort to improve TVA's understanding of the Valley load and economy and produce accurate forecasts. TVA also produces alternative regional forecasts such as the high and low forecasts that define a range of possible loads with a 90 percent confidence that the true forecast will fall within this range.

Of the many key inputs to the load forecasts for the residential, commercial, and industrial sectors, the most important are economic activity; price of electricity; customer retention; and prices of substitute sources of energy, including natural gas.

<u>Economic Activity</u> - TVA produces forecasts of regional economic activity for budgeting, long range planning, and economic development purposes. These forecasts are based on national forecasts of the national economy developed by the forecasting service Moody’s Economy.Com.

The economy of the TVA service territory has historically been more dependent on manufacturing than the U.S. as a whole, with industries such as pulp and paper, aluminum, and chemicals drawn to the region because of the availability of natural resources and reliable, inexpensive electricity. Regional growth has historically outpaced national growth because manufacturing products grew at a faster pace than non-manufacturing products and services. Regional growth contracts faster and more sharply during an economic downturn due to its relative dependence on manufacturing; however, the regional economy also recovers more quickly and reaches a higher growth rate during an economic recovery.

As markets for manufacturing industries have become global in reach, production capacity has moved overseas from the TVA region for many of the same reasons that the industries first moved to the TVA region. The contraction of these industries, and the load growth associated with them, has been offset to some degree by the growth of the automobile industry in the Southeast in the last 25 years. Although the TVA region is expected to retain its comparative advantage in the automotive industry, as exemplified by the new Volkswagen auto plant under construction in Chattanooga, reduced long-term prospects for the U.S. automotive industry will also have an impact on the regional industry.

As job growth in the manufacturing sector is declining, job opportunities are growing within the services industry. While some of this growth stems from jobs in businesses (such as retail) serving the region’s population, a growing part is services exported to areas outside the region. Healthy population growth is expected to continue as people migrate to the Valley for job opportunities. In addition, the TVA region has become attractive to retirees looking for a moderate climate in an affordable area. Thus, the rising population will result in additional growth to the services industries and demand will rise for people needed to work in them.

<u>Price of Electricity</u> - Forecasts of the price of electricity are based on long-term estimates of TVA’s total costs to operate and maintain the power system and the markups charged by distributors. Forecasts of these total revenue requirements are based on estimates of key costs such as fuel, operations and maintenance, capital investment, and interest. The high and low electricity price forecasts are derived from variations in these same factors.

Customer Retention - In the last 20 years, the electric utility industry has undergone a fundamental change in most parts of the country. In many states, an environment of regulated monopoly has been replaced with varying degrees of competition. Wholesale open access (the rights of wholesale customers to buy power from generating utilities other than the utility who owns the transmission and distribution lines that serve them) is largely mandated, except for TVA, by the Federal Energy Regulatory Commission (FERC).

While TVA has long-term contracts with its 155 distributors of TVA power, it is not immune to competitive pressures. These contracts allow distributors to give TVA five years' notice of contract cancellation, after which they may procure power from other sources. Many of TVA's large, directly served customers have the option to shift production from plants served by TVA to plants in service territories of other utilities if TVA's rates are not competitive with those of the utilities serving those territories.

In the spring 2010 forecast (used in Scenario 7 - Reference Case: Spring 2010, see Section 2.3), TVA's average price of electricity was expected to remain competitive with the rates of other utilities. As a result, the net impact of competition in the medium forecast is that TVA will retain its current customer base.

Price of Substitute Fuels - Electricity is a source of energy, and some of the utility derived from it can be obtained from other sources of energy. The potential for substitution between the use of electricity and fossil fuels, primarily oil and natural gas, depends on relative prices and the physical capability to change fuels. Changes in the TVA price of electricity relative to the price of natural gas and other fuels influence consumers' choices of fuels for appliances, space heating, and commercial and industrial processes. While other substitutions are possible, natural gas prices serve as the benchmark for determining substitution impacts in the load forecasts.

2.2.2. Forecast Accuracy

The accuracy of the forecasts is measured in part by error in the forecasts, whether day ahead, year ahead, or multiple years ahead. The mean annual percent error of TVA's forecast of net system energy requirements and peak load for the 2000-2009 period was 1.9 percent and 2.8 percent, respectively. These include large errors in 2009 as the 2008 financial crisis and the resulting depression continued to adversely affect the economy. The 2000-2008 error was 1.1 percent for net system energy requirements and 2.2 for peak load, which is more representative of the accuracy of TVA year-in and year-out load forecasts. Forecast accuracy is described in more detail in IRP Section 4.1.2.

2.2.3. Peak Load and Net System Energy Forecasts

To deal with the uncertainty inherent in forecasting, TVA has developed a range of forecasts, each corresponding to a different scenario (see Section 2.3).

Forecasts of peak load and net system energy for the baseline Scenario 7 - Reference Case: Spring 2020 and the scenarios with the highest and lowest demands are shown in Figure 2-1.

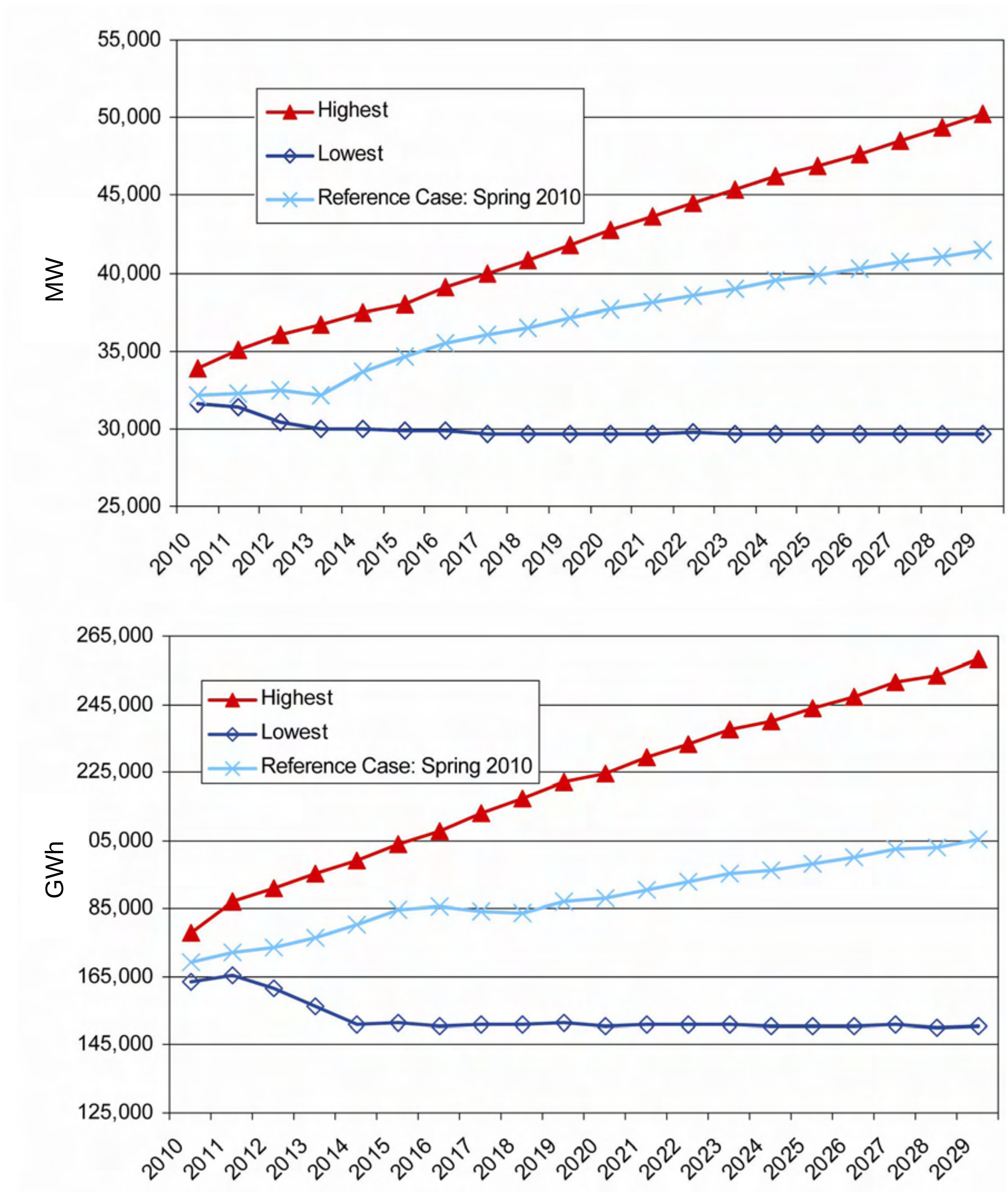


Figure 2-1. Peak load (top) and net system energy (bottom) forecasts for the baseline Scenario 7 - Reference Case: Spring 2010 and high- and low-growth scenarios**.**

Peak load grows at an average annual rate of 1.3 percent in the IRP Baseline scenario, decreases slightly and then stays flat in the lowest scenario, and grows by 2.0 percent in the highest scenario. Net system energy requirements grow at an average annual rate of 1.0 percent in the IRP Baseline scenario, decrease significantly and then stay flat in the lowest scenario, and grow by 1.9 percent per year in the highest scenario.

2.2.4. Power Supply Resources

TVA's generation supply consists of a combination of TVA-owned resources, budgeted and approved projects (such as new plant additions and uprates of existing plants), and power purchase agreements (PPAs). PPAs are contractual rights to the capacity and/or output (energy) of generating facilities not owned by TVA. The generation supply includes a diverse portfolio of coal, nuclear, hydroelectric, natural gas, oil, and renewable resources, as well as market purchases, designed to provide reliable, low-cost power and minimize the risk of disproportionate reliance on any one type of resource. Each type of generation can be categorized, based on its degree of utilization, as supplying base load, intermediate, peaking, or storage generation. Generation can also be categorized by capacity and energy.

Base Load Resources - Base load generators are primarily used to meet continuous energy needs by operating continuously at full capacity for long time periods. They have low operating costs but high capital costs, and are typically larger coal plants and nuclear plants. Some energy providers consider combined-cycle plants for incremental base load generation needs. However, historically, natural gas prices, when compared to coal and nuclear fuel prices, make combined cycle a more expensive option for large continuous generation needs.

Intermediate Resources - Intermediate resources are primarily used to fill the gap in generation between base load and peaking needs. They are required to change their output as the energy demand increases and decreases over time (usually during the course of a day). Intermediate units are more costly to operate than base load units but less costly than peaking units. This type of generation typically comes from natural gas-fired combined cycle plants and smaller coal plants. TVA's hydroelectric plants can also be operated as intermediate resources during periods of adequate precipitation. Corresponding back-up balancing supply needed for intermittent renewable generation (such as wind or solar) typically comes from intermediate resources. It is possible to use the energy generated from solar and wind as an intermediate resource with the use of energy storage.

Peaking Resources - Peaking units are only expected to operate during shorter duration high demand periods. They are essential for maintaining system reliability requirements, as they can ramp up quickly to meet sudden capacity changes. Typical peaking resources include natural gas-fired combustion turbines (CTs), conventional hydroelectric generation and pumped hydro storage, and, under some conditions, renewable resources. Storage Resources - Storage units usually serve the same power supply function as peaking units, but use low-cost off-peak electricity to store energy for later generation at peak times. TVA's Raccoon Mountain pumped storage plant is an example of a storage unit that pumps water to a reservoir during periods of low demand and releases it to generate electricity during periods of peak demand. Consequently, a storage unit is both a power supply source and an electricity user.

Figure 2-2 illustrates the uses of peaking, intermediate and base load generation. Although these categories are useful, the differences between them are not always distinct. For example, a peaking unit may be called on to run continuously for some time period like an intermediate or base load unit, although it is less economical to do so. Similarly, many base load units are capable of operating at different power levels, giving them some of the characteristics of an intermediate or peaking unit. This IRP considers strategies that take advantage of this range of operations.

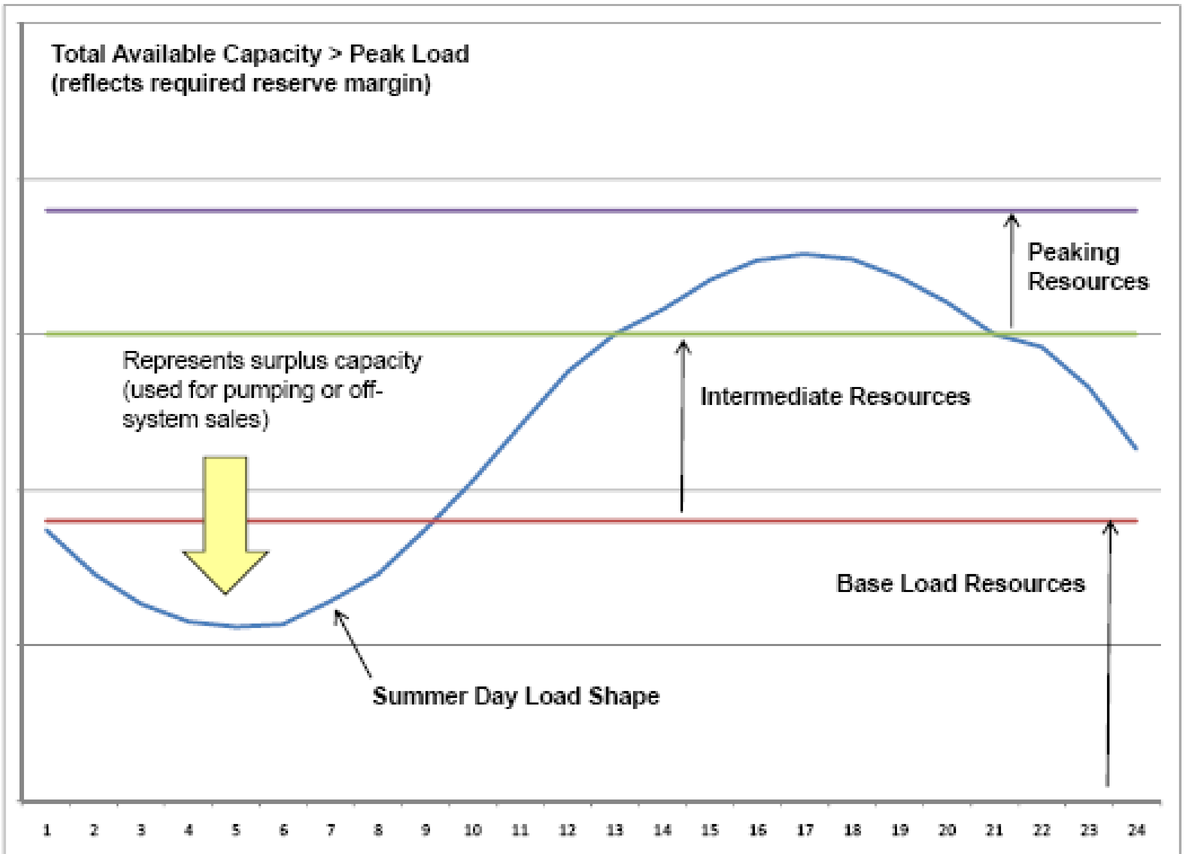


Figure 2-2. Representative summer day load shape and use of peaking, intermediate, and base load generation**.**

2.2.5. Capacity and Energy

Power system peaks are measured in terms of capacity (typically in MWs) and overall power system usage is measured in terms of energy (typically in GWhs). Capacity factor is a measure of the actual amount of energy delivered by a generator compared to the maximum amount it could have produced. Base load plants such as nuclear and large coal plants have high capacity factors and generate large amounts of energy. Plants that are used infrequently such as CTs have low capacity factors and provide relatively little energy. Because the energy they generate is often delivered at times of peak demand, CTs and other peaking resources are highly valued.

Demand-side resources (also known as energy efficiency and demand-response (EEDR) resources, see Section 3.5) can also be measured in terms of capacity and energy. Even though these resources do not generate power, their effect on the system is similar as they represent power that is not required or whose use can be shifted from high demand periods to low demand periods.

2.2.6. 2010 Resource Mix

TVA's 2010 resource mix consists of a wide range of supply-side technologies and demand-side resources to meet the needs of TVA's customers (Figure 2-3). Approximately 55 percent of TVA's electricity was expected to be produced from coal and natural gas-fired plants (51.8 percent coal; 3.5 percent gas). Nuclear plants would produce about 32 percent and hydroelectric plants approximately 12 percent. Most of the remainder is generation from renewables other than hydroelectric and avoided generation from demand-side programs. See Chapter 3 for a more detailed description of TVA's generating facilities, power purchase agreements, and demand-side programs. Interruptibles are of power sales agreements under which TVA has the right to suspend power delivery to the purchaser.

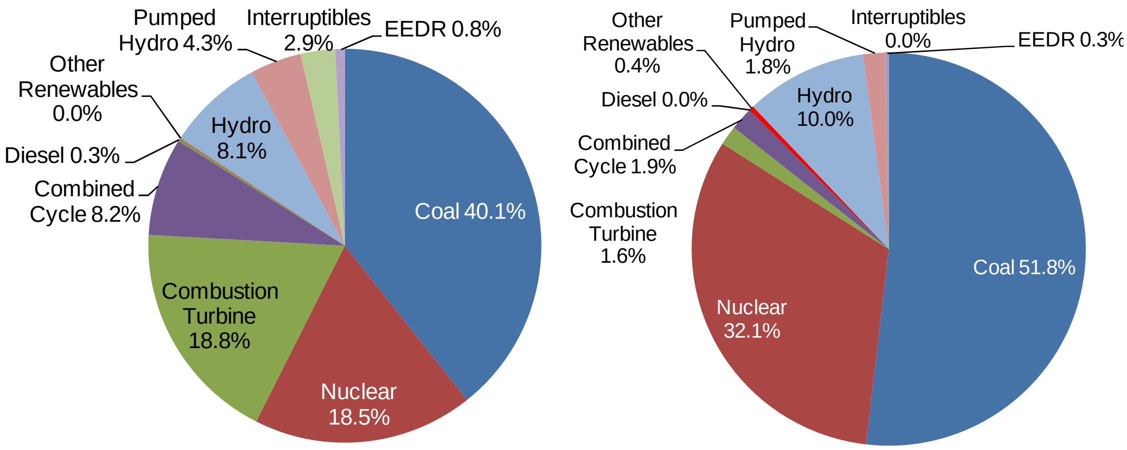


Figure 2-3. 2010 baseline portfolio firm capacity (left) and generation (right).

Figure 2-4 shows the changing composition of existing resources that currently are planned to be operated through 2029. It shows only those resources that currently exist or are under contract (such as PPAs and EEDR programs), as well as changes to existing resources and additions of new resources that are planned and approved. The total capacity of existing resources decreases through 2029 primarily because of the anticipated idling of coal-fired generating units. Total capacity also decreases when PPAs, mostly for combined-cycle generation, expire. The renewable energy component of the existing portfolio is primarily composed of wind PPAs (see Section 3.4). The current EEDR programs comprise 0.8 percent of the capacity.

2.2.7. Assessment of Need for Power

The TVA system is dual-peaking with high demand occurring in both the summer and winter months. For example, the annual peak demand in 2007 occurred in August, while in 2009, the annual peak occurred in January. Winter peaks are expected to continue for the next couple of years; thereafter, the forecasted peak load is during the summer months.

To ensure that enough capacity is available to meet peak demand, including unforeseen contingencies (e.g., forced outage of large generating units), additional generating capacity beyond that needed to meet peak demand is necessary. This additional generating capacity, known as "reserve capacity" or "operating reserves," must be large enough to cover the loss of the largest single operating unit (contingency reserves), be able to respond to moment by moment changes in system load (regulating reserves), and replace contingency resources should they fail (replacement reserves). Total reserves must also be sufficient to cover uncertainties such as unplanned unit outages, load forecasting error including the difference between actual weather and the forecast weather, and undelivered purchased capacity.

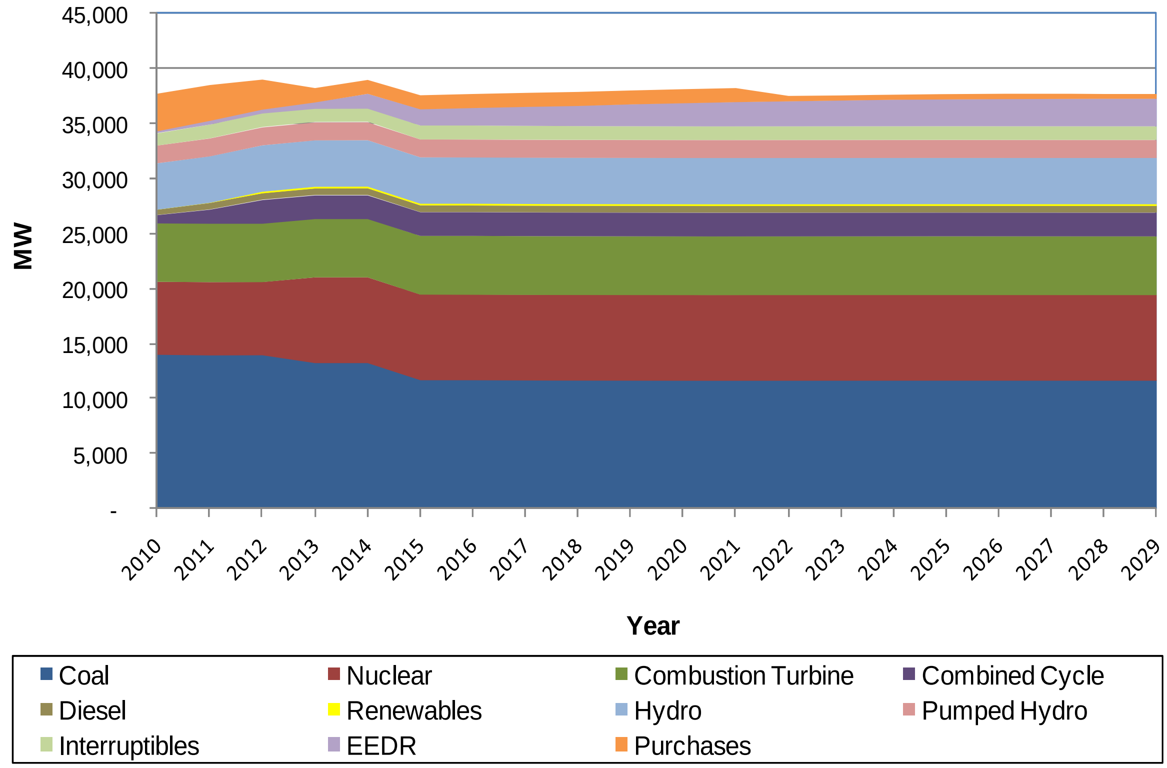


Figure 2-4. 2010 - 2029 firm capacity under the 2010 baseline portfolio.

As typical for the utility industry, TVA plans for total reserves of between 12 and 20 percent of total system load, depending on the age of current resources, as required by North American Electric Reliability Corporation (NERC) reliability standards. TVA optimizes its mix of generating assets and purchases to meet these standards. For the IRP, required total reserves were set at 15 percent.

The capacity gap is defined as the difference between the existing firm capacity (Figure 2-4) and the load forecasts (Figure 2-1) plus reserve requirements. Figure 2-5 shows the resulting capacity and generation (energy) gaps for the baseline Scenario 7 - Reference Case: Spring 2010 peak load forecast and the range corresponding to the highest and lowest planning scenarios (see Section 2.4). Under most scenarios and in most years, additional capacity and generation or EEDR is required to meet or offset forecasted capacity and energy needs. The Spring 2010 baseline need for additional generating capacity or EEDR programs is 9,617 MWs and 29,086 GWhs of additional generation in 2019, growing to 15,513 MWs and 44,988 GWhs in 2029.

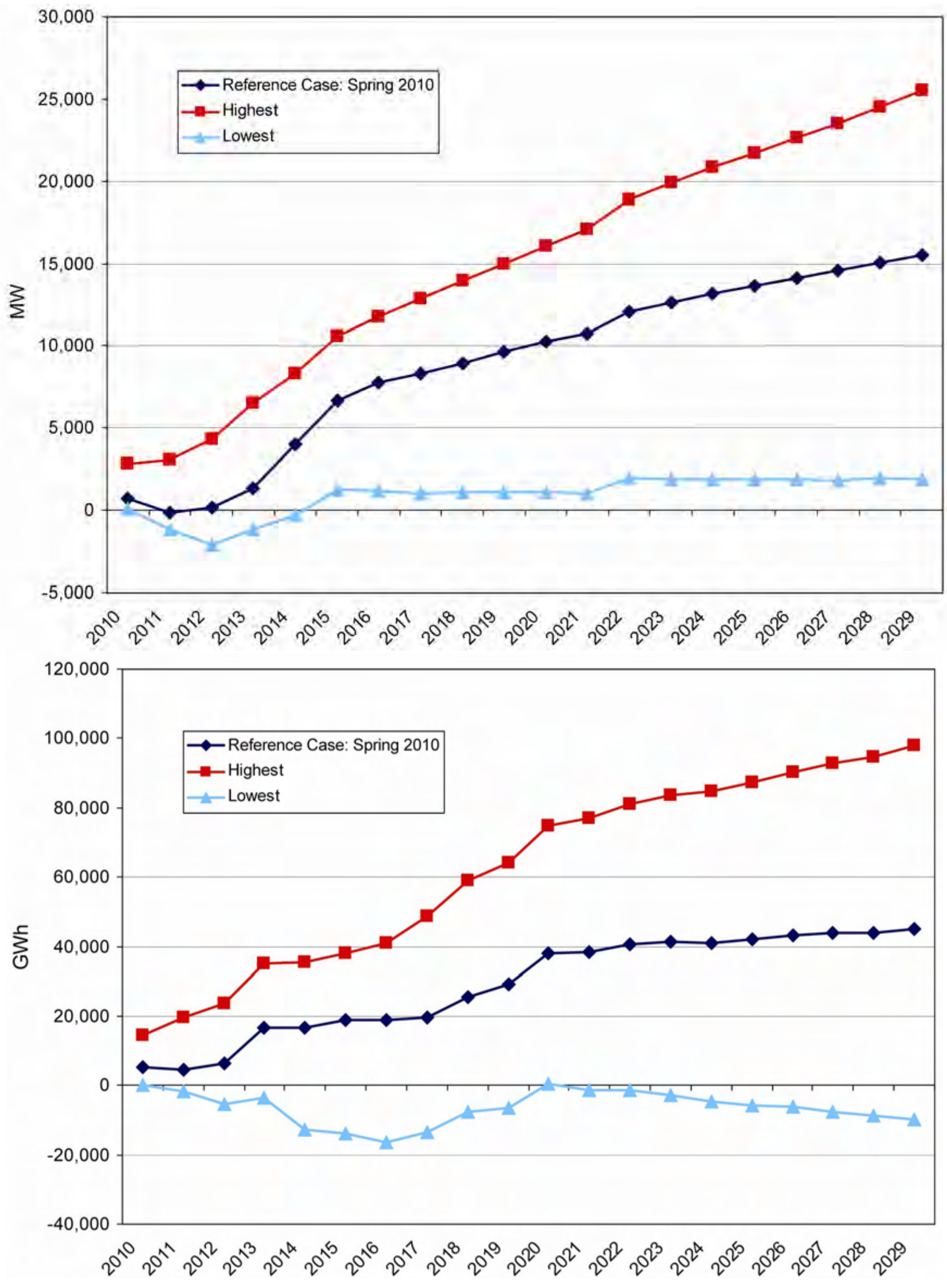


Figure 2-5. Capacity (top) and generation (bottom) gaps for the baseline Scenario 7 - Reference Case: Spring 2010 and lowest and highest scenarios.

2.3. Scenario Development

TVA chose to employ a scenario planning approach in the IRP. Scenario planning provides an understanding of how near-term and future decisions would change under different conditions ("plausible futures"). Near-term decisions that are common across different scenarios may imply that these decisions are less "risky," while major differences in near-term decisions across scenarios may imply the possibility of future problems. Scenarios provide a foundation to consider various supply and demand options in selecting a low risk, adaptable 20-year resource plan.

Scenarios are sets of potential future conditions, typically organized around different themes or narratives. As applied in the IRP, the scenarios:

- Bound key uncertainties to create a wide range of possible outcomes.
- Present sets of conditions that are plausible, but not intended to predict the future.

Major steps in scenario development are:

- Identify the uncertainties to be evaluated. These include regulations and legislation, economic and financial conditions, social trends, technological innovations, and other factors.
- For the identified key uncertainties, determine the range of variation and relative impacts to long-term plan.
- Develop the scenarios around themes and related combinations of specific conditions or values of the key uncertainties.

Uncertainties are the essential attributes that define the scenarios considered in the resource planning process. The key uncertainties used to define the scenarios are described below.

- Greenhouse gas (GHG) requirements—The levels of CO_2 and other GHG emission reductions mandated by federal legislation plus the cost of carbon emission allowances
- Environmental outlook—Changes in regulations addressing air emissions (exclusive of GHGs), water, land, and waste
- Energy efficiency and renewable energy standards (also known as renewable portfolio standards)—Consideration of mandates for minimum amounts of generation from renewable sources, the viability of renewable sources, and the percentage of renewable standards that can be met with energy efficiency
- Total load—The variance between the actual load and the forecast load, after accounting for the results of energy efficiency and demand response efforts
- Capital expansion viability and costs—For nuclear, fossil, and other generation, as well as transmission system projects, the risks associated with licensing, permitting, and the project schedule
- Financing—The cost (interest rate) of securing capital
- Commodity prices—Prices of natural gas, coal, oil, uranium, and the spot (i.e., immediate) price of electricity
- Contract purchase power cost—The demand cost, availability, and transmission constraints on purchased power

- Construction cost escalation—For generation and transmission construction, the escalation in costs of commodities, labor, and equipment
- Change in load shape—The effects of factors such as energy storage, time-of-use rates, plug-in electric vehicle charging, energy efficiency, smart grid development, distributed generation and economic effects on the customer base.

The final set of scenarios selected for use in the IRP was refined to ensure the following characteristics:

- Each scenario is distinct and reflects plausible, meaningful risks (e.g., uncertainties related to cost, regulation, environment) to TVA
- Stresses (tests) resource selection to provide a foundation for analyzing the combination of various supply and demand options (capacity plans)
- Reflects key stakeholder interests, to the extent possible.

In developing specific numerical values for each of the uncertainties within each scenario, the following design assumptions were used:

- Climate change uncertainty is based upon stringency of requirements, timeline required for compliance, and cost of CO_2 allowances
- An aggressive air quality regulatory schedule is expected to lead to additional compliance requirements (e.g., Hazardous Air Pollutants Maximum Achievable Control Technology (HAPs MACT), revised ambient air standards)
- Command and control requirements for HAPs MACT will likely drive plant-by-plant compliance instead of system-wide compliance
- Renewable energy standards (RES) will be a component of GHG reduction requirements at the federal level
- The spot price of electricity will track the price of natural gas and coal
- Total load is primarily driven by economic conditions but will also be affected by energy efficiency, demand response, and other factors
- Schedule risk is related to demand and uncertainty of permitting and licensing of generation and transmission projects
- Economic conditions and associated inflationary pressures are the primary drivers for financing costs
- Construction costs are driven by demand and availability of labor, equipment, design, and raw materials. Economic conditions are the primary driver, but the legislative / regulatory environment can apply additional pressure by introducing uncertainty related to potential schedule impacts
- Cost and availability of contract power purchases are primarily driven by economic conditions (i.e., load growth).

Six scenarios were subsequently developed (Table 2-1). A seventh baseline scenario that represented TVA's then-current longterm planning outlook was also used in the analyses. This scenario was named the IRP Baseline Case in the Draft IRP and EIS, and is here named the Reference Case: Spring 2010. Following the release of the draft plan and EIS, an eighth scenario representing summer and fall, 2010 conditions was developed; this scenario is Scenario 8 - Reference Case: "Great Recession" Impacts Recovery. Scenario 8 differs from Scenario 7 in having somewhat lower load growth.

Table 2-1. Attributes of the eight scenarios.

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-Changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	Scenario 7 Reference Case: Spring 2010*	Scenario 8 Reference Case: Great Recession Impacts Recovery
Greenhouse gas requirements	CO_2 price $27/ton ($30/metric ton) in 2014 and $82 ($90/metric ton) by 2030. 77% allowance allocation, 41% by 2030	CO_2 price $17/ton ($19/metric ton) in 2012 and $94 ($104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	No federal requirement (CO_2 price = $0/ton)	CO_2 price $18/ton ($20/metric ton) in 2013 and $45 ($50/metric ton) by 2030. 77% allowance allocation, 39% by 2030	CO_2 price $18/ton ($20/metric ton) in 2013 and $45 ($50/metric ton) by 2030. 77% allowance allocation, 39% by 2030	CO_2 price $17/ton ($19/metric ton) in 2012 and $94 ($104/metric ton) by 2030. 77% allowance allocation, 28% by 2030	CO_2 price $15/ton ($17/metric ton) in 2013 and $56 ($62/metric ton) by 2030. 77% allowance allocation, 39% by 2030	Same as Spring 2010 Reference Case
Environmental outlook	Same as Spring 2010 Reference Case	SO_2 controls 2017 NOX controls Dec 2016 Hg MACT 2014 HAP MACT 2015	No additional requirements (CAIR requirements, with no MACT requirements)	Same as Spring 2010 Reference Case	Same as Spring 2010 Reference Case	Same as Spring 2010 Reference Case	SCR all units by 2017 FGD all units by 2018 HAPs MACT by 2015	Same as Spring 2010 Reference Case
Energy Efficiency (EE) & Renewable Electricity Standards (RES)	RES - 3% by 2012, 20% by 2020 (adjusted total retail sales) EE can meet up to 25% of requirement	RES - 5% by 2012, 30% by 2020 (adjusted total retail sales) EE can meet up to 25% of requirement	No federal requirement	RES - 5% by 2012, 20% by 2020 (adjusted total retail sales) EE can meet up to 40% of requirement	RES - 5% by 2012, 20% by 2020 (adjusted total retail sales) EE can meet up to 40% of requirement	RES - 5% by 2012, 30% by 2020 (adjusted total retail sales) EE can meet up to 25% of requirement	RES - 3% by 2012, 15% by 2021 (adjusted total retail sales) EE can meet up to 25% or requirement	Same as Spring 2010 Reference Case

Table 2-1. Continued.

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-Changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	Scenario 7 Reference Case: Spring 2010*	Scenario 8 Reference Case: Great Recession Impacts Recovery
Total load	Med grow to High by 2015; High Dist; Alcoa Returns in 2010+; USEC stays forever; Dept Dist same as 2010 Ref Case	Medium case, then 2012 40% rate increase; Low Dist; DS customer reductions (steel/paper plants); USEC stays forever; Dept Dist same as 2010 Ref Case	Low Load Case; Low Dist; Alcoa not returning, No HSC & Wacker; USEC leaves June 2013; Dept Dist same as 2010 Ref Case	Med-High load growth through 2020, then 20% decrease 2021-2022 including USEC departure, reduced dist sales & extended time of use	Medium case, then 20% rate increase in 2014; unrestricted PHEV included; time of use	Medium load case 2010-2011; 2012 low case then flat w/no growth; USEC leaves 2013; Alcoa not returning, HSC & Wacker not in; time of use	Moderate Growth	Moderate to low growth
Capital expansion viability & costs	Moderate Schedule Risk	High Schedule Risk	Low Schedule Risk	Moderate Schedule Risk	Moderate Schedule Risk	Low Schedule Risk	Moderate Schedule Risk	Moderate Schedule Risk
Financing	Higher Than 2010 Ref Case--Higher inflation due to higher economic growth	Higher Than 2010 Ref Case--Higher inflation due to looser monetary policy supporting economic growth	Lower Than 2010 Ref Case--Lower inflation due to lower economic growth	Same as 2010 Ref Case--Increased productivity due to technology leads to stronger economic, wealth, and non-inflationary money supply growth	Higher Than 2010 Ref Case--Higher inflation due to looser monetary policy supporting economic growth	Lower Than 2010 Ref Case--Lower inflation due to lower economic growth	Based on Current Borrowing Rate	Based on Current Borrowing Rate

Table 2-1. Continued.

Uncertainty	Scenario 1 Economy Recovers Dramatically	Scenario 2 Environmental Focus is a National Priority	Scenario 3 Prolonged Economic Malaise	Scenario 4 Game-Changing Technology	Scenario 5 Energy Independence	Scenario 6 Carbon Legislation Creates Economic Downturn	Scenario 7 Reference Case: Spring 2010*	Scenario 8 Reference Case: Great Recession Impacts Recovery
Commodity prices	Gas & Coal Higher than 2010 Ref Case	Gas Higher; Coal Lower than 2010 Ref Case	Gas Much Lower & Coal Much Higher than 2010 Ref Case	Gas Lower & Coal Slightly Higher than 2010 Ref Case	Gas & Coal Higher than 2010 Ref Case	Gas & Coal Much Lower than 2010 Ref Case	Gas - $6-8 / MMBTU Coal $40 / ton	Gas - $6-8 / MMBTU Coal $40 / ton
Contract Purchase Power Cost	Much Higher Cost & Lower Availability	Higher Cost & Lower Availability	Same as Base, then Much Lower Cost with High Availability	Higher Cost & Lower Availability, then Much Lower Cost with High Availability after Load Decrease	Higher Cost & Lower Availability	Lower Cost with High Availability	Moderate Cost & Availability	Moderate Cost & Availability
Construction cost escalation	Much Higher than 2010 Ref Case--High economic growth causes high demand for new plants and high escalation rate	Somewhat higher than 2010 Ref Case--due to construction costs escalating at high rate due to large volume of nuclear, renewables, and env controls projects. High regulatory scrutiny adds to project costs	Lower than 2010 Ref Case--Low load growth leads to low escalation	This scenario has two stages of escalation: 1) higher than 2010 Ref Case due to high load growth early, then 2) lower escalation when game-changing technology hits	Somewhat Higher than 2010 Ref Case--Moderately strong economy and load growth lead to somewhat higher than base escalation	Lower than 2010 Ref Case--Negative load growth, very weak economy and high renewables lead to low escalation	Moderate Escalation	Moderate Escalation

Notes on table entries: Hg MACT - Maximum Achievable Control Technology for mercury; HAP MACT - Maximum Achievable Control Technology for hazardous air pollutants; CAIR - Clean Air Interstate Rule; SCR - selective catalytic reduction (for NOx control); FGD - flue gas desulfurization; High Dist. - high sales by distributors; Low Dist. - low sales by distributors; USEC - U.S. Enrichment Corporation; HSC - Hemlock Semiconductor; Dept Dist - departure of distributors

*Named the IRP Baseline Case in the Draft IRP and EIS

2.4. Planning Strategies

Planning strategies are designed to test various business options TVA might consider in order to determine how each strategy performs in the scenarios developed. The attributes of these strategies are assumed to be within TVA's control. This is an important difference between strategies and scenarios; the attributes of scenarios are largely outside of TVA's control.

The planning strategies considered in the IRP frame alternative business plans that are tested across multiple scenarios. Each alternative business plan is described by a unique combination of strategic objectives and/or constraints. The objective in the IRP is to identify one or more strategies that provide stability and flexibility over a broad range of conditions during the next 20 years.

In developing the planning strategies, TVA identified nine categories of attributes. The choice of attributes was influenced by comments received during the public scoping and focused on those assumptions that would have the greatest impact on the options that might be included in the long-term resource plan. These attributes (Table 2-2) fall into one of two groups which vary in how they are treated in the capacity optimization model (described in more detail in Section 2.5) used to develop the resource portfolios:

- Defined model inputs—attributes that are "locked in" and assumed by the model to already exist
- Constraints—attributes that form boundary conditions within which the model will identify a resource portfolio.

Table 2-2. Attributes of planning strategies.

Attribute	Description	Type
EEDR Portfolio	The level of energy efficiency (EE) and demand response (DR) included in each strategy	Defined Model Input
Renewable Additions	The amount of renewable resources added in each strategy	Defined Model Input
Coal Capacity Idled*	A proposed schedule of coal units idled tested in each strategy	Defined Model Input
Energy Storage	Inclusion of a pumped storage hydro unit in selected strategies	Defined Model Input
Nuclear Generation	Limitations on the addition of new nuclear capacity	Constraint
Coal-Fired Generation	Limitations on technology and timing for new coal-fired plants	Constraint
Gas-Fired Generation (Self Build)	Limitations on the addition of gas-fired units	Constraint
Market Purchases	Level of reliance on purchased power allowed in each strategy	Constraint
Transmission Investment	Type and level of transmission infrastructure required to support resource options in each strategy	Constraint

*Defined in Section 5.4.1.

These nine attributes were combined to create five distinct planning strategies (Table 2-3).

Table 2-3. Attributes of the five planning strategies.

Attributes	Planning Strategy				
	A - Limited Change in Current Resource Portfolio	B - Baseline Plan Resource Portfolio	C - Diversity Focused Resource Portfolio	D - Nuclear Focused Resource Portfolio	E - EEDR and Renewables Focused Resource Portfolio
EEDR	1,940 MW & 4,725 annual GWh reductions by 2020	2,100 MW & 5,900 annual GWh reductions by 2020	3,500 MW & 11,400 annual GWh reductions by 2020	4,000 MW & 8,900 annual GWh reductions by 2020	5,900 MW & 14,400 annual reductions by 2020
Renewable Additions	1,300 & 4,500 GWh competitive renewable resources or PPAs by 2020	Same as Strategy A	2,500 MW & 8,500 GWh competitive renewable resources or PPAs by 2020	Same as Strategy C	3,500 MW & 12,000 GWh competitive renewable resources or PPAs by 2020
Coal Capacity Idled	No reductions	2,000 MW total reductions by 2017	3,000 MW total reductions by 2017	7,000 MW total reductions by 2017	5,000 MW total reductions by 2017
Energy Storage	No new additions	Same as Strategy A	Add one pumped storage unit	Same as Strategy C	Same as Strategy A
Nuclear	No new additions after WBN2	First unit online no earlier than 2018 Units at least 2 years apart	Same as Strategy B	Same as Strategy B	First unit online no earlier than 2020 Units at least 2 years apart Limited to 3 units
Coal	No new additions	New coal units are outfitted with CCS First unit online no earlier than 2025	Same as Strategy B	Same as Strategy B	No new additions
Gas-Fired Supply (Self-Build)	No new additions	Meet remaining supply needs with gas-fired units	Same as Strategy B	Same as Strategy B	Same as Strategy B
Market Purchases	No limit on market purchases beyond current contracts and contract extensions	Purchases beyond current contracts and contract extensions limited to 900 MW	Same as Strategy B	Same as Strategy B	Same as Strategy B

Table 2-3. Continued.

Attributes	Planning Strategy				
	A - Limited Change in Current Resource Portfolio	B - Baseline Plan Resource Portfolio	C - Diversity Focused Resource Portfolio	D - Nuclear Focused Resource Portfolio	E - EEDR and Renewables Focused Resource Portfolio
Transmission	Potentially higher level of transmission investment to support market purchases Transmission expansion (if needed) may have impact on resource timing and availability	Complete upgrades to support new supply resources	Increase transmission investment to support new supply resources and ensure system reliability Pursue inter-regional projects to transmit renewable energy	Same as Strategy C	Potentially higher level of transmission investment to support renewable purchases Transmission expansion (if needed) may have impact on resource timing and availability

An additional strategy, Strategy R - Recommended Planning Direction, was developed following the release of the Draft IRP and EIS. This strategy is described below in Section 6.2.

2.5. Portfolio Development

The next step in the resource planning process is the development of the potential 20-year resource plans or portfolios. A major input to the portfolio development is the definition of the supply-side and demand-side energy resource options that can become components of the portfolios. These options include existing and potential future TVA generating facilities and existing and potential future PPAs. These are described in Chapter 5. Costs, construction schedules, fuel requirements, operational characteristics, and other attributes are defined for each of these options. This resource option information and the forecast power demands are then used by the capacity planning model to develop a portfolio for each combination of a planning strategy and scenario, for a total of 35 portfolios.

The capacity planning model (System Optimizer produced by Ventyx, Inc.) found the "optimum" combination of resource options to meet projected demand/energy requirements over the 20-year planning period. An optimized portfolio has the lowest net Present Value of Revenue Requirements (PVRR) subject to the constraints of energy balance, reserve margin, generation and transmission operating limits, fuel purchase and utilization limits, and environmental compliance requirements. PVRR is the current value of the total expected future revenue requirements associated with a particular resource portfolio. The capacity planning modeling process is described in more detail in IRP Section 6.2.

Each of the 35 portfolios was then evaluated using an hourly production costing program with stochastics (the consideration of uncertainty using probability distributions). This second step computed detailed plan costs and financial indicators. This analysis was accomplished using the Strategic Planning (MIDAS) software produced by Ventyx; its operation is described in more detail in IRP Section 6.2. The results of the MIDAS analyses are the expected values of PVRR and short-term rates for each portfolio. Short-term rate is the levelized cost in dollars/MWh to serve load from 2011-2018. Portfolios were similarly developed and evaluated for the Recommended Planning Direction alternative strategy.

2.6. Portfolio and Strategy Evaluation Metrics

The portfolios and strategies are evaluated with a trade-off analysis that focuses on cost, financial risk, other risks, environmental impacts, and other aspects of TVA's overall mission. A strategy scorecard consisting of ranking metrics and strategic metrics is used to facilitate this trade-off analysis. The ranking metrics include the cost (combination of PVRR and short term rates) and financial risk metrics (combination of the risk ratio and the risk/benefit ratio). The two risk ratios are based on the potential of exceeding the expected PVRR and are explained in more detail in IRP Section 6.3.1.1.2. Each of these ranking metrics is based on a weighted formula:

Cost metric = 0.65 * PVRR + 0.35 * short-term rates

Risk metric = 0.65 * risk ratio + 0.35 * risk/benefit ratio

Ranking Metrics Score = 0.65 * cost + 0.35 * risk

The strategic indicators include environmental metrics and economic development metrics. The environmental metrics are:

Carbon footprint metric = average annual tons of direct CO_2 emissions

Water impact metric = Generation by fuel type (GWh) x heat input (mmBTU) x design factor

Waste impact metric = Fuel consumed (mmBTU) x waste factor x handling costs

The water impact metric is a measure of the amount of "leftover" heat that is released into the environment by thermal generating plants. It does not account for the type of cooling at a plant and thus is not a direct measure of potential water impacts. The design factor used in its calculation is related to the thermal efficiency of the plant, i.e., the proportion of the energy in the fuel that is converted to electricity. Among widespread generation sources, combined cycle plants have the lowest design factor (e.g., the highest proportion of heat converted to electricity) and nuclear plants have the highest design factor (see IRP Appendix A). The waste impact metric estimates the costs of managing wastes produced from coal and nuclear generation only.

The economic metrics are included to provide a general indication of the impact of each portfolio and strategy on the general economic conditions in the TVA service area. They compare the changes in total employment and personal income indicators of Strategies A, C, D, E, and R, to those of the baseline Strategy B. They are calculated with a regional economic model, developed by Regional Economic Models, Inc., of the economies of the TVA region and the surrounding area. The model maps the region's economic structure, its inter-industry linkages, and responses to TVA rate and customer cost changes, including those from energy efficiency. Inputs specific to the alternative strategies that include direct TVA expenditures on labor, equipment, fuels, and materials and the costs of electricity to customers are used to estimate the effects of the strategies on total employment and personal income. This analysis is described in more detail in Final IRP Appendix B. The economic metrics were calculated for Scenarios 1 and 6 for each strategy; these scenarios are assumed to define the upper and lower range of the economic impacts.

The ranking metrics in the scorecard are expressed on a 100-point scale for each strategy with the highest ranking ("best") value receiving 100 points and the lower ranking values receiving scores based on their relative position to the highest value.

The strategic metrics are assigned ordinal scores based on their ranking within a given scenario. These scoring methods are described in more detail in Final IRP Section 6.3.1.3.

CHAPTER 3

3.0 THE TVA POWER SYSTEM

3.1. Introduction

This chapter describes TVA's existing power system, including power sales and purchases, generating facilities, energy efficiency and demand response programs, and the transmission system.

As of September 30, 2010, TVA's power system had a dependable summer generating capacity of 37,177 MW. Approximately 34,000 MW of the total capacity was provided by TVA facilities and the remainder was purchased from non-TVA facilities under long-term power purchase agreements (PPAs). In fiscal year 2010, TVA sold 176 billion kilowatt-hours of electricity; 88 percent was sold to distributors and 12 percent was sold to directly-served large industries and federal installations. The total revenue from these sales was $10.7 billion. TVA operates a network of approximately 16,000 miles of transmission lines and 498 substations, switching stations, and switchyards. This system transmits power from 51 generating facilities to 1,020 customer connections points. TVA's power system is described in more detail in the remainder of this chapter.

3.2. TVA Customers, Sales, and Power Exchanges

TVA is primarily a wholesaler of power (Table 3-1). Wholesale power is delivered to 155 local power distributors that, in turn, distribute electricity to residential, commercial, and industrial customers within their service areas. These non-profit, publicly owned distributors are diverse and include municipal systems and rural electric cooperatives. The largest, Memphis Light, Gas and Water Division, serves approximately 412,000 electric customers with annual electric sales of almost 15 billion kilowatt-hours. Some of the smallest distributors serve less than 1,500 customers. Many only provide electrical service while others provide water, wastewater, and/or natural gas service. TVA sells power directly to 57 large industries and federal installations (Table 3-1). The directly served industries include chemical, metal, paper, textile, and automotive manufacturers.

The TVA service area (Figure 1-1) is defined by the TVA Act. The TVA Act restricts TVA from entering into contracts that would make TVA or its distributors a source of power outside the area for which TVA or its distributors were the primary source of power on July 1, 1957. The Federal Power Act prevents the Federal Energy Regulatory Commission (FERC) from ordering TVA to provide access to its transmission lines to others for the purpose of using TVA's transmission lines to deliver power to customers within the TVA service area.

The TVA Act authorizes TVA to exchange, buy, or sell power, with 13 neighboring electric utilities. This arrangement gives TVA the ability to purchase power when its generating capacity cannot meet demand or when it is more economical for TVA to purchase power from a neighboring utility than to generate it. It also allows TVA to sell power to neighboring utilities when its generation exceeds its demand.

Table 3-1. TVA customers and power sales for fiscal years 2006-2010.

Type	Customers	Energy (Millions of kWh)		Sales Revenue (in millions)	
	FY 2009	FY 2006-2008 Average	FY 2009	FY 2006-2009 Average	FY 2010
Distributor-Served		140,227	133,078	$8,477	$9,275
Residential	3,840,013		59,426		
Commercial (< 1,000 kW)	705,148		39,290		
Industrial (> 1,000 kW)	2,728		33,570		
Outdoor Lighting	19,422		1,688		
Directly Served Industries and Federal Installations	57	34,268	30,726	1,390	1,436
Other Sales and Losses			5,828	12	2
Totals	4,567,389	174,495	176,304	$9,854	$10,713

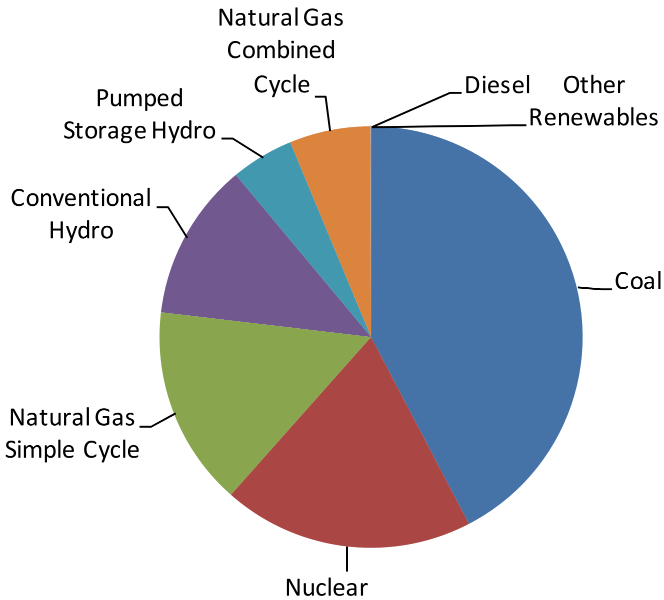
TVA conducts these exchanges through 64 transmission system interconnections. To the extent allowed by federal law, TVA offers transmission services to others to transmit or “wheel” power through the TVA service area.

In recent years TVA has purchased more power in the interchange market than it has sold. For fiscal year 2009, power exchanges with other utilities were as follows:

Sales to other utilities	0.1 billion kilowatt-hours
Purchases from other utilities	1.3 billion kilowatt-hours
Wheeling transactions	11.2 billion kilowatt-hours

3.3. TVA-Owned Generating Facilities

TVA owns approximately 34,000 MW of generating capacity (Figure 3-1). These facilities generated about 147,400 million kWh in FY 2010, a decrease from the average of the preceding four years (Table 3-2).



Type of Generation	Capacity (MW)	Percent
Coal	14,573	42
Nuclear	6,632	19
Natural Gas – Combustion Turbine	5,270	15
Conventional Hydro	4,157	12
Pumped-Storage Hydro	1,653	5
Natural Gas - Combined Cycle	2,143	6
Diesel	13	<1
Other Renewables	2	<1
TOTAL	34,443	100

Figure 3-1. Fiscal Year 2010 TVA-Owned Summer Generating Capacity by Type of Generation.

Table 3-2. Fiscal Year 2006-2010 TVA-Owned Generation by Type.

Type of generation	Kilowatt Hours (millions)		Percent	
	FY 2006-2009 Average	FY 2010	FY 2006-2009 Average	FY 2010
Coal	93,828	74,590	54	42
Nuclear	49,043	53,339	28	30
Hydroelectric/Pumped Storage	9,278	14,013	5	8
Natural Gas	2,318	5,475	1	3
Other Renewables	33	4	<1	<1
Diesel Turbines			<1	<1
SUBTOTAL	154,500	147,421		
Purchased Power	21,034	28,782	12	16
TOTAL	175,534	176,203	100	100

Coal-Fired Generation

TVA has 59 coal-fired generating units at 11 plant sites (Figure 1-1, Table 3-3). The coal-fired units range in size from 107 MW (Johnsonville Units 1-6) to 1,239 MW (Cumberland Unit 1). The oldest unit was placed in service in 1951 at Johnsonville, and the newest is Cumberland Unit 2, which began operation in 1973.

TVA's coal-fired units have a total net summer capacity of 14,711 MW. This capacity is expected to decrease by a small amount in the next few years as TVA installs additional pollution control equipment that consumes energy when operated. All TVA coal-fired units are equipped with mechanical precipitators, electrostatic precipitators, scrubbers, or baghouses to control emissions of particulate matter. Other controls for reducing emissions of sulfur dioxide and nitrogen oxides are listed in Table 3-3. Some units also use boiler optimization to limit nitrogen oxide emissions.

Table 3-3. Characteristics of TVA coal-fired generating facilities.

Facility	Units	2009 Summer Net Capacity (MW)	Commercial Operation Date (First and Last Unit)	Boiler Type*	Emissions Controls**
Allen	3	741	1959	CF	LSC, SCR
Bull Run	1	870	1967	SCPC	FGD, SCR
Colbert	5	1,184	1955, 1965	PC	LSC, SCR (1 unit), LNB
Cumberland	2	2,470	1973	SCPC	FGD, LNB, SCR
Gallatin	4	976	1956, 1959	PC	LSC, LNB
John Sevier	4	704	1955, 1957	PC	LSC, LNB
Johnsonville	10	1,206***	1951, 1959	PC	LSC, LNB (4 units), SNCR
Kingston	9	1,425	1954, 1955	PC	LNB (4 units), SCR, FGD
Paradise	3	2,201	1963, 1970	SCPC	FGD, SCR
Shawnee	10	1,330	1953, 1956 1988 (AFBC)	PC (9 units, AFBC (1 unit)	LSC (9 units), LNB (9 units), SNCR
Widows Creek	8	1,604	1952, 1965	PC	LSC (6 units), FGD (2 units), SCR (2 units), LNB (2 units)

*AFBC – Atmospheric circulating fluidized bed; CF – cyclone furnace; PC – pulverized coal; SCPC – supercritical pulverized coal
**FGD – Flue gas desulfurization (“scrubber”); LNB – low-NOx burner; LSC – low sulfur coal, may be blended with high sulfur coal; SCR – selective catalytic reduction; SNCR – selective non-catalytic reduction
***The output of Johnsonville Units 1-4 is reduced by about 19 MW each by the sale of steam to the adjacent DuPont facility.

In August 2010, TVA announced that nine coal-fired units totaling about 1,000 MW of capacity at three plants will be idled or indefinitely removed from service by 2015. At Widows Creek, two of the older, smaller units were idled in fall 2010 and the other four older, smaller units will be idled by 2015. Unit 10 at Shawnee was idled in fall 2010 and will be evaluated for possible conversion to biomass fuel. John Sevier Units 1 and 2 will be idled by 2015.

Fuel Procurement - TVA is one of the largest consumers of coal in the United States and consumed a total of 36 million tons of coal in FY 2010. During the previous four years, TVA's coal consumption ranged from 37.0 to 46.5 million tons (Figure 3-2). In 2009, TVA consumed 3.8 percent of eastern U.S. coal production and 2.9 percent of western U.S. coal production. In recent years, TVA has procured coal from the Northern Appalachian, Central Appalachian, and Illinois Basin regions in the eastern U.S. and from the Powder River Basin and Uinta Basin regions in the western U.S. In FY 2010, TVA purchased 43 percent of its coal from the Illinois Basin, 28 percent from the Powder River Basin, 20 percent from the Uinta Basin, and 9 percent from the Central Appalachian regions.

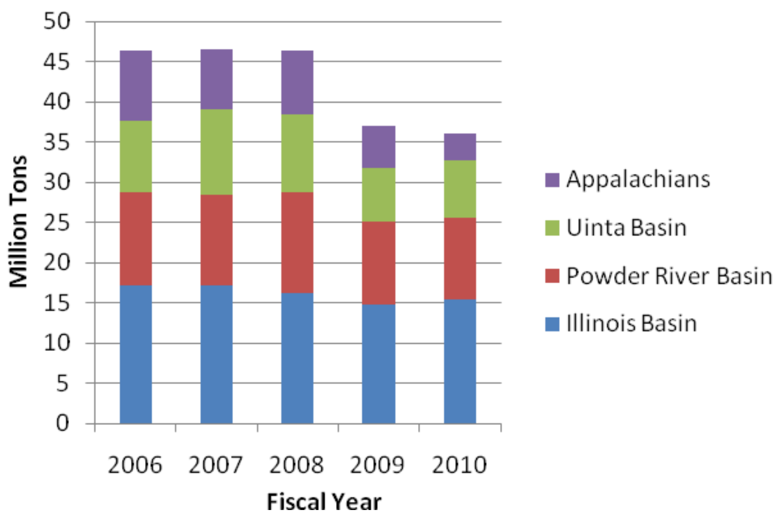


Figure 3-2. Fiscal year 2006-2010 coal purchases by mining region.

In 2011, TVA contracted to purchase 38.7 million tons of coal; 44 percent is projected to be from the Illinois Basin, 9 percent from the Central Appalachians, 21 percent from the Powder River Basin, and 26 percent from the Uinta Basin (Table 3-4). About two-thirds of this coal will be from underground mines.

TVA purchases coal under both short-term (one year or less) and long-term (more than one year) contracts; 92 percent of 2009 purchases were with long-term contracts. During 2010, 34 percent of TVA's coal supply was delivered by rail, 26 percent was delivered by barge, and 33 percent was delivered by a combination of barge and rail. The remainder was delivered by truck.

TVA uses large quantities of limestone to operate the scrubbers at five of its coal plants. This limestone is acquired from quarries in the vicinity of the plants and transported to the plants primarily by truck.

Table 3-4. TVA coal purchase contracts for 2011, in millions of tons, by mining region and mining method.

Region	Million Tons/Year by Mining Method				Totals
	Underground	Surface - Open Pit/Area	Surface - Contour/ Highwall	Surface - Mountaintop Removal	
Illinois Basin	16.1	0.9	--	--	17.0 (44%)
Powder River Basin	--	8.0	--	--	8.0 (21%)
Uinta Basin	10.0	--	--	--	10.0 (26%)
Central Appalachians	2.0	0.2	0.8	0.6	3.6 (10%)
Totals	28.1 (73%)	9.2 (24%)	0.8 (2%)	0.6 (1.5%)	38.7

Nuclear Generation

TVA operates six nuclear units at three sites (Figure 1-1). These three nuclear plants have a total net summer capacity of 6,671 MW (Table 3-5). In 2007, TVA resumed construction of Watts Bar Unit 2, which had been halted in the mid-1980s. Once complete in 2013, this unit will provide an additional 1,180 MW of net summer capacity. TVA is currently undertaking an Extended Power Uprate project at Browns Ferry to add 375 MW of capacity. TVA has submitted a license amendment request for this uprate to the Nuclear Regulatory Commission (NRC) and does not presently have a firm completion date. This uprate in incorporated into the forecast of the capacity of existing generating resources used in determining the future need for power.

Table 3-5. Characteristics of TVA nuclear generating units.

Facility	Units	2009 Net Summer Capacity (MW)	Type	Commercial Operation Date (First and Last Unit)	Operating License Expiration
Browns Ferry	3	3,242	Boiling Water	1974, 1977	2033, 2034, 2036
Sequoyah	2	2,282	Pressurized Water	1981, 1982	2020, 2021
Watts Bar	1	1,100	Pressurized Water	1996	2034
Total	6	6,624			

In 2007, TVA, as a member of the NuStart Energy Development consortium, submitted a Combined Licensing Application to the NRC for the construction and operation of two Westinghouse AP1000 advanced passive pressurized light water nuclear units at its Bellefonte Nuclear Plant site. The two AP1000 units would have a total capacity of about 2,200 MW. TVA had previously begun construction of two Babcock and Wilcox 1,260 MW pressurized light water units at Bellefonte in the 1970s; their construction was halted in 1988. TVA has not proposed constructing the two AP100 units. In August 2009, TVA issued a Notice of Intent and in May 2010 issued a Final Supplemental EIS for the completion or construction and operation of a single nuclear unit at Bellefonte, either one of the partially completed pressurized light water units or an AP1000 unit. TVA's preferred alternative is to complete the construction of a partially completed pressurized light water unit.

In August 2010, the TVA Board authorized staff to continue engineering activities and the procurement of long-lead time components of Bellefonte Unit 1, one of the partially completed units. A decision to complete construction of this unit has been deferred until the spring of 2011, after completion of this IRP.

Fuel Procurement - TVA's six nuclear units use a total of about 4 million pounds of enriched uranium (U_{238}) per year. This uranium comes from uranium producing areas around the world. TVA currently has sufficient enriched uranium under contract to provide all of its requirements through 2014. TVA has agreements with the U.S. Department of Energy (DOE) and nuclear fuel contractors to mix surplus DOE highly enriched uranium with other uranium to fabricate fuel suitable for use in nuclear power plants. TVA began using this blended nuclear fuel at Browns Ferry in 2005 and at Sequoyah in 2008, and expects to continue using it through at least 2011 at Sequoyah and 2016 at Browns Ferry.

Natural Gas-Fired Generation

TVA has 92 natural gas-fueled combustion turbine units at 10 sites (Figure 1-1, Table 3-6). The oldest turbines were completed in 1971 and the newest in 2010. Fifty-six simple cycle combustion turbine (CT) units are located at five coal-fired plant sites and 31 simple cycle units are located at five stand-alone plant sites. Five combined cycle units are located at three stand-alone plant sites; five units are owned by TVA and three units are leased by TVA. Most of the simple cycle units are capable of using fuel oil and 76 are capable of quick start-up by reaching full generation capability in about 10 minutes. The combined capacity of the combustion turbine units is approximately 5,326 MW and the capacity of all of the combined cycle units is approximately 1,377 MW.

In August 2009, TVA announced a proposal to construct and operate an 880-MW combined cycle combustion turbine plant at John Sevier Fossil Plant. Construction began in April 2010 and the plant is scheduled to begin generating at full capacity in 2012.

Fuel Procurement - In 2009, TVA used 84 trillion cubic feet of natural gas to fuel its combustion turbine and combined cycle plants and to fuel generating facilities some non-TVA plants that sell power to TVA under terms of a PPA. TVA purchases natural gas from a variety of suppliers under contracts with terms of one year or less. Most of the natural gas is from the Gulf of Mexico. TVA also contracts with its suppliers to store natural gas at a facility in southwest Virginia. This storage capacity doubled in 2008 and was scheduled to further increase in 2010.

Most of the fuel oil is purchased on the spot market for immediate delivery to the plants. TVA maintains an inventory of fuel oil at its plants with oil fueling capability to provide a short-term backup supply in the event the gas supply is disrupted.

Table 3-6. Characteristics of TVA natural gas-fueled plants.

Facility	Units	2009 Summer Net Capacity (MW)	Type	Commercial Operation Date (First and Last Unit)	Oil Fueling Capability
Allen	20	452	Simple Cycle	1971, 1972	Yes
Brownsville	4	460	Simple Cycle	1999	No
Colbert	8	384	Simple Cycle	1972	Yes
Gallatin	8	588	Simple Cycle	1975, 2000	Yes
Gleason	3	494	Simple Cycle	2007	No
Johnsonville	20	1,104	Simple Cycle	1965, 2000	Yes
Kemper	4	304	Simple Cycle	2001	Yes
Lagoon Creek	12	932	Simple Cycle	2002	Yes
Lagoon Creek	2	600*	Combined Cycle	2010	No
Marshall County	8	608	Simple Cycle	2007	Yes
Southaven	3	777	Combined Cycle	2003	No
Total	92	6,703			

*Began commercial operation in September, 2010.

Hydroelectric Generation

The TVA hydroelectric generating system consists of 109 conventional hydroelectric generating units at twenty-eight sites along the Tennessee River and its tributaries and at a single site (Great Falls) on a Cumberland River tributary (Figure 1-1). TVA also operates the four-unit Raccoon Mountain pumped storage hydroelectric facility near Chattanooga.

The total net summer capacity of the TVA hydroelectric system is 5,153 MW; this includes 3,538 MW of conventional hydroelectric generation and 1,615 MW from Raccoon Mountain. Conventional hydroelectric plants range in size from the 4-unit, 11-MW Wilbur plant to the 21-unit, 675-MW Wilson plant. The oldest of the conventional plants was completed in 1911 and the newest was completed in 1970. Since 1994, TVA has been replacing outdated turbines and other equipment in the hydroelectric plants; at the end of FY 2009, these modernization efforts had been completed for 57 hydroelectric units. These efforts resulted in a 564-MW increase in generating capacity and an average efficiency gain of 5 percent. TVA plans to update an additional 38 units by 2030. Details about the hydroelectric plants and the operation of the hydroelectric system are available in the Reservoir Operations Study (TVA 2004).

Renewable Generation

TVA owns about 2.4 MW of non-hydro renewable capacity consisting of one small windfarm with three 660-kW turbines on Buffalo Mountain near Oliver Springs, TN, and 15 photovoltaic (PV) installations throughout the TVA region (Figure 1-1). All of these were constructed since 2000. The capacity of the PV facilities ranges from 7 to 85 kW. TVA also co-fires methane from a nearby sewage treatment plant in a boiler at Allen Fossil Plant and co-fires wood waste in a boiler at Colbert Fossil Plant. The combined output of these two co-firing projects during FY 2009 was about 29,000 MWH. Electricity generated by the windfarm, the PV facilities, and the methane co-firing is marketed through TVA's Green Power Switch program (see Section 3-5).

Diesel-Fired Generation

TVA owns two diesel generating facilities with a total net summer capacity of 13 MW. One of these facilities is located at Meridian, Mississippi and consists of 5 units completed in 1998. The other facility, at Albertville, Alabama, consists of 4 units completed in 2000.

Diesel fuel is purchased on the spot market.

3.4. Purchased Power

TVA has power purchase agreements (PPAs) for 4,495 MW of generating capacity; the major PPA contracts/facilities are listed in Table 3-7. The hydroelectric generation is from eight U.S. Army Corps of Engineers plants on the Cumberland River and its tributaries and from four Alcoa Power Generating, Inc., plants on the Little Tennessee River system. The power generated by the Corps plants is purchased through a long-term contract with the Southeastern Power Administration (SEPA), a federal power marketing agency. The power generated by the Alcoa plants is used to partially supply the energy needs of Alcoa, a directly served TVA customer. The power generated by the Invenergy windfarm is marketed through the Green Power Switch program (see Section 3-5).

Seven of the facilities listed in Table 3-7 are qualifying facilities as defined by the Public Utility Regulatory Policies Act (PURPA). Qualifying facilities are cogeneration or small power production facilities that meet certain ownership, operating, and efficiency criteria. Cogeneration (also known as combined heat and power) facilities produce electricity and another form of useful thermal energy (heat or steam) for industrial or other uses. Small power production facilities typically have a capacity of 80 MW or less whose primary energy source is renewable (hydro, wind or solar), biomass, waste, or geothermal resources. Utilities are required to purchase energy from qualifying facilities at their avoided cost of self-generating or purchasing the energy from another source.

In December 2008, TVA issued a request for proposals (RFP) for up to 2,000 MW of electricity from renewable and/or clean sources to be delivered by 2011. Qualifying sources include solar, wind, hydropower, ocean, tidal, geothermal, biomass and other biologically derived fuels, combined heat and power, waste heat recovery and other low-carbon emitting resources. TVA has subsequently signed contracts for purchasing power from seven windfarms with a combined capacity of 1,625 MW.

Two of these windfarms, the Iberdrola Streator Cayuga Ridge windfarm in Illinois and the Horizon Wind Energy Pioneer Prairie windfarm in Iowa, began delivering power in 2010 (Table 3-7). The execution of the other seven contracts (Table 3-8) is dependent on meeting applicable environmental review requirements and securing firm transmission paths for the delivery of the power to the TVA system. TVA is continuing to evaluate other responses to the RFP.

In October 2010, TVA issued the Renewable Standard Offer, which offers set prices to developers of small to mid-size renewable projects under long-term contracts of up to 20 years. The generating facilities must be between 200 KW and 20 MW in size and located

Table 3-7. Major power purchase agreement contracts/facilities.

Type of Generation	Owner/Marketer	Location	Capacity (MW)[1]
Natural Gas - Combined Cycle	Cogentrix Energy	Caledonia, MS	768
Natural Gas - Combined Cycle	Calpine - Morgan Energy Center	Decatur, AL	800[2]
Natural Gas - Combined Cycle	Calpine - Decatur Energy Center	Decatur, Al	500
Natural Gas - Combined Cycle	Suez Energy Marketing	Ackerman, MS	690
Lignite[3] (Coal) - CFBC	Choctaw Generation	Chester, MS	432
Diesel	various	various	total of 119
Wind	Invenergy TN	Oliver Springs, TN	27
Wind	Iberdrola Renewables	Livingston County, IL	300
Wind	Horizon Wind Energy	Howard, Mitchell Counties, IA	115
Industrial Gases, Chemicals	Air Products	Calvert City, KY	30[2]
Biomass - Landfill Gas		Rutherford County, TN	5.4
Biomass - Landfill Gas	WM Renewable Energy	Heiskel, TN	3.2[2]
Biomass - Landfill Gas	Cogeneration Technologies	Chattanooga, TN	2[2]
Biomass - Corn Milling Residue[4]	Cargill	Memphis, TN	11[2]
Biomass - Wood Waste	Weyerhaeuser	Columbus, MS	70[2]
Biomass - Wood Waste	Armstrong Hardwood Flooring	Jackson, TN	3.2[2]
Hydroelectric	Alcoa Power Generating	TN, NC	347
Hydroelectric	US Army Corps of Engineers/SEPA	TN, KY	360

[1]Capacity available to TVA and used in capacity planning; total facility capacity may be greater.
[2]Qualifying facility as defined by PURPA.
[3]The lignite is supplied by an adjacent surface mine.
[4]Cargill has not recently generated power from this source and is not expected to in the near future.

within the TVA region. The initiative is limited to a total of 100 MW and no single type of renewable generation can exceed half of the total 100 MW limit. Eligible types of renewable generation include wind, solar, methane recovery, biomass direct combustion and/or co-firing with greater than 50 percent biomass, and biomass gasification. Additional

Table 3-8. Pending power purchase agreements resulting from the 2008 RFP for the delivery of renewable energy.

Facility Name	Owner/Marketer	Location	Capacity (MW)	Power Delivery Date
Pioneer Prairie I Wind Farm	Horizon Wind Energy	Howard, Mitchell Counties, IA	44	1/2012
White Oak Energy Center	Invenergy Wind	McClean County, IL	150	1/2012
Bishop Hill Wind Energy Center	Invenergy Wind	Henry County, IL	200	1/2012
Cimarron	CPV Renewable Energy	Gray County, KS	165	early 2012
Hurricane Lake Energy Center I	Invenergy Wind	Roberts County, SD	250	early 2012
Caney River Wind Project	Tradewind Energy	Elk County, KS	201	2012
Ashley	CPV Renewable Energy	McIntosh County, ND	200	2012

information on the Renewable Standard Offer is available at http://www.tva.gov/renewablestandardoffer/index.htm. The first contract resulting from the standard offer was signed in January 2011 for the delivery of 4.8 MW of power generated from landfill gas at Camden, Benton County, TN.

TVA also purchases renewable power through its Generation Partners Program; this power is resold through the Green Power Switch program (see Section 3-5). In early 2011, 310 facilities with a total generating capacity of about 4.8 MW were enrolled in the program and generating about 34,000 kWh per month.

3.5. Demand-Side Management Programs

TVA has had a portfolio of demand-side management programs focusing on energy efficiency and demand response for many years. Energy efficiency programs are designed to reduce the use of energy while providing the same level of energy service. Demand response programs are designed to temporarily reduce a customer's use of electricity, typically during peak periods when demand is highest. Because the energy use is typically shifted to off-peak times, demand response typically has little effect on total energy use.

The TVA energy efficiency and demand response (EEDR) portfolio is a combination of fully deployed mature programs, recently initiated programs, and programs under development.

Some of these programs have been in place for several years. Between FY 1995 and FY 2008, they resulted in an estimated cumulative demand reduction of 547 MW (Figure 3-3). The 2007 Strategic Plan (see Section 1-5) recognized the need for increased EEDR efforts and in 2008 a total of reducing the growth in peak demand by up to 1,400 MW by the end of 2012 was established. Along with the establishment of the new goal and redesign of many EEDR programs, TVA also changed the way it measured demand reduction. Progress towards achieving the 1,400 MW demand reduction goal is shown in Figure 3-4. Anticipated FY 2010 incremental demand reductions were approximately 40 MW from residential programs, 33 MW from commercial and industrial programs, 26 MW from demand response, and 2 MW from end-use generation.

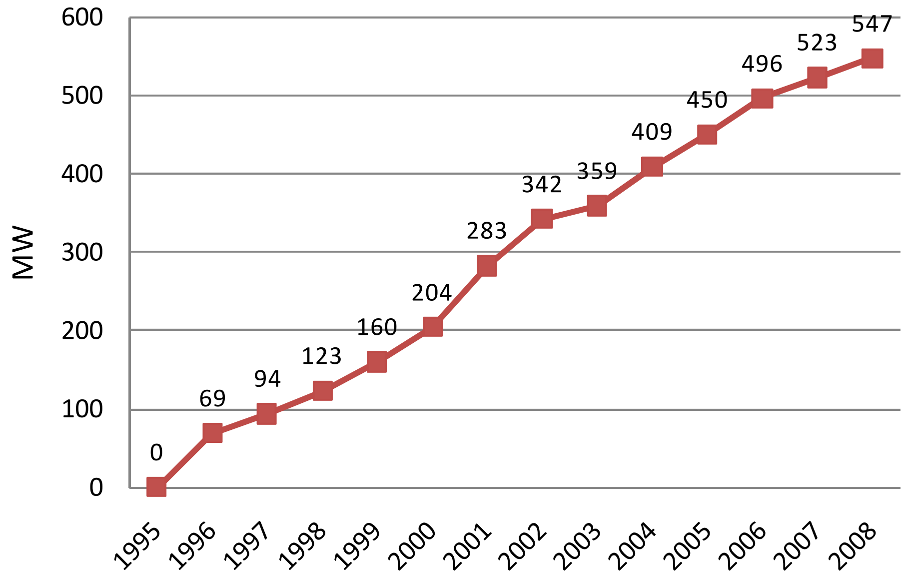


Figure 3-3. Cumulative demand reduction of TVA EEDR programs, fiscal years 1995-2008.

TVA EEDR programs are targeted at residential, commercial and industrial customers, and include a variety of energy-saving tools and incentives that help save energy and reduce power costs while providing peak reduction benefits for the power system. They are delivered through partnerships with the 155 local power distributors, however not all distributors participate in all programs. The TVA EEDR portfolio is described in more detail below; information about many programs is also available at http://www.tva.com/ee/.

Residential Energy Efficiency Programs

New Homes Program - This program provides incentives for builders to construct new homes with increased energy efficiency. Incentives range from $300 to $800 depending on the efficiency of the home. There are three levels of efficiency:

- Homes built *energy right*® must exceed minimum overall energy efficiency requirements by 7 percent
- Homes built at least 15 percent better than minimum requirements qualify as *energy right* Platinum
- *energy right* Platinum Certified (ENERGY STAR®) qualification requires additional testing at the expense of the builder or homeowner as well as being built at least 15 percent better than the minimum requirements and receives the highest incentive.

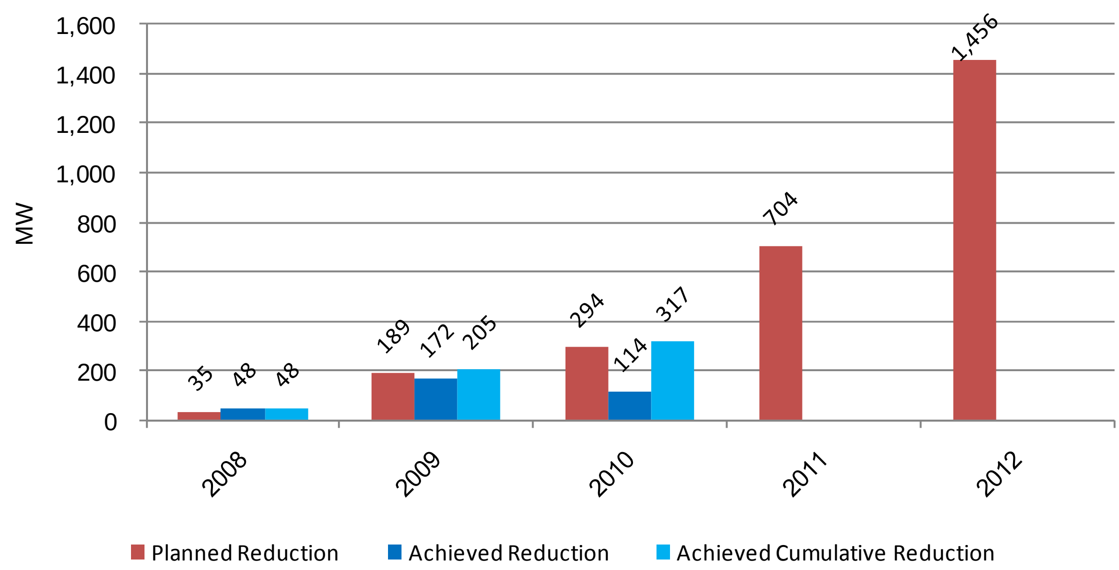


Figure 3-4. Fiscal year 2008-2012 demand reduction goals and achieved demand reduction.

Do-It-Yourself Home Energy Evaluation - Homeowners complete a home energy survey, either online or on a paper form submitted to TVA. The homeowners then receive a personalized report that breaks down their annual and monthly energy usage by category and makes recommendations for increasing energy efficiency. Participants also receive a free energy efficiency kit that may include items such as compact fluorescent light bulbs and gaskets for wall outlet and light switches.

In-Home Energy Evaluation (IHEE) - Under this program, a trained evaluator conducts a comprehensive in-home energy assessment of a participant's home. The homeowner receives a detailed listing of potential energy-efficiency improvements and available cash incentives and financing options. The homeowner pays for the evaluation, but TVA rebates the evaluation cost to homeowners who make at least $150 in improvements and have post-installation inspections. This program was introduced in 2009 and by August 2010 was offered through 121 distributors.

New Manufactured Homes Program - This program provides incentives for manufacturers and dealers that install high-efficiency heat pumps in new manufactured homes. Qualifying heat pumps must have a seasonal energy efficiency ratio (SEER) of at least 13 to qualify for a $300/home incentive. TVA is also piloting an ENERGY STAR Manufactured Homes effort with the Manufactured Housing Research Alliance.

Heat Pump Program - Under this program, TVA promotes the installation of high-efficiency heat pumps in homes and small businesses by providing low-interest, fixed-rate financing for up to ten years through a third-party lender, with repayment through the consumer's electric bill. Installation, performance, and weatherization standards ensure the comfort of the customer and the proper operation of the system. TVA has established a Quality Contractor Network of installers to maintain high installation standards. TVA reimburses local distributors for inspection and loan processing/collection.

Commercial and Industrial Energy Efficiency Programs

Major Industrial Program - This program is designed to encourage reductions in electric energy intensity in large industrial facilities that have a contract demand of 5 MW or greater. TVA provides customized technical assistance to participants taking a plant-wide, holistic assessment to finding and developing energy efficiency opportunities. Participants who implement qualified projects may be eligible for financial incentives of $100 per kW of load reduced during TVA's critical peak period. Approximately 250 large industrial customers throughout the TVA area are eligible to participate.

Commercial Efficiency Advice and Incentives - Through this program, TVA offers various levels of technical assistance to commercial and general industrial (up to 5 MW demand) businesses to help them identify energy-saving opportunities in their facilities. Depending on the customer's size, technical assistance may include initial energy assessments, onsite energy reviews and detailed energy studies, as well as a portfolio of online business energy efficiency tools and resources. Online assistance includes an Energy Efficiency Library, a Commercial Energy Calculator, and a Preferred Partners Network list of installers and energy service companies. Eligible commercial businesses that install lighting or HVAC improvements which reduce demand during TVA's critical peak period may receive an incentive of $200 per kW reduced. After being piloted by over 35 distributors, this program was offered throughout the TVA area in mid-2010. In 2010, TVA also began offering small business customers (up to 50 KW demand) the "Fast Cash Incentive" designed to speed their installation of efficient lighting and HVAC systems selected from a list of qualifying equipment.

Education and Outreach

National Theatre for Children - TVA and local distributors have partnered with the National Theatre for Children to conduct live theater performances in K-12 schools that promote energy efficiency. During FY 2009, performances were presented to over 250,000 students in over 700 schools and a similar number is planned for FY 2010.

Alliance to Save Energy Green Schools Program - TVA and power distributors began piloting the Alliance to Save Energy's Green Schools Program (ASE 2010) in 21 Tennessee K-12 schools in fall semester 2009. In Green Schools, teams of teachers, other staff, and students identify and implement energy-saving measures, typically resulting in school electric cost savings of 5 to 15 percent.

Trade Ally Network - This program provides local distributors with master lists, maintained by TVA, of trade allies that meet a set of criteria demonstrating commitment to the design, installation, servicing, and promotion of high quality energy efficiency and demand response technologies and equipment.

TVA Facilities

Internal Energy Management Program - This TVA program, created in 1978, is responsible for the planning, coordination of regulatory reviews, performance analysis and reporting, oversight of energy related audits, and sustainable design for TVA facilities. It has coordinated TVA compliance with energy efficiency goals and objectives for federal agencies established by the National Energy Conservation Policy Act, the subsequent Energy Policy Acts of 1992 and 2005, and several Executive Orders including the 2009 EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance. This program has resulted in significant reductions in energy use; for example, between 2003 and 2009, energy intensity in facilities was reduced by 12.6 percent. See http://www.tva.gov/abouttva/energy_management/ for more information and annual reports of accomplishments.

Demand Response Programs

Commercial and Industrial Demand Response - Under this initiative, TVA provides incentives to businesses shifting energy-intensive operations from periods of high power demand to periods of lower demand. Participants must be able to achieve a demand response reduction of at least 100 kW and be available for dispatch up to 80 hours per year. Demand reduction events are dispatched and monitored with near-real-time software. Participating customers receive capacity payments monthly and energy payments based on their performance during demand reduction events. The program was initiated in 2009 with a 160-MW peak reduction goal and had 99 distributors and 230 facilities participating. In June 2010, the TVA Board approved an expanded program with a 560-MW peak demand reduction goal by 2012.

Conservation Voltage Regulation Program - This program uses conservation voltage regulation (CVR) by power distributors to achieve capacity and energy savings through operation of distribution feeders in the lower portion of the American National Standards Institute (ANSI) service voltage requirement range, either continuously or on a dispatch-basis. The objective of CVR is to lower the voltage delivered to a customer while maintaining the proper operation of equipment within the name plate ratings and levels set by regulatory agencies. ANSI standards set the ranges for voltages at the distribution transformer secondary terminals at 120 volts +/- 5 percent or between 114 and 126 volts. Most electrical equipment, including air conditioning, refrigeration, appliances, and lighting is designed to operate most efficiently at 114 volts. If power is delivered at a voltage higher than 114 volts, energy is wasted.

5 Minute Response and 60 Minute Response Rate Products - Under these products, qualifying customers with contract demands greater than 1 MW receive credits on their power bills in exchange for TVA's right to suspend power availability during critical times. Two notification options are available to customers: 5 minute and 60 minute notice. Upon receiving notice from TVA, the customer must reduce their load to a previously determined level for the duration of the demand reduction event. Failure to reduce load can result in non-compliance charges. The credits are periodically evaluated to align with changes in valuation bases, and may not be changed more than once in a 12-month period.

Generation Partners

Under this end-use generation program, begun in 2003, TVA purchases renewable energy generated by facilities installed by residential, commercial, and industrial customers. TVA purchases this power by paying the retail rate, any fuel cost adjustment, and a premium of $0.12/kWh for solar and $0.03/kWh for other renewable generation. New participants also receive a $1,000 incentive from TVA to help defray their start-up costs. Payment is in the form of a credit on the participant's monthly bill from their local distributor that shows the energy they used, which is billed at the standard rate, and the energy they generated, for which they receive credit. Power bills are reconciled either monthly or annually at the discretion of the participating distributor. The participant is guaranteed payments for 10 years from the time they signed the participation agreement.

The Generation Partners Pilot Program was expanded in 2009 and in early 2011 had 310 generating participants with a total combined capacity of 4.8 MW. Potentially qualifying generation sources include biomass, landfill gas, solar, micro hydro, wastewater treatment biogas, and wind generating facilities up to 200 KW nameplate generating capacity. Additional information on the program is available at http://www.tva.com/greenpowerswitch/partners/index.htm. TVA resells the power generated by Generation Partners through the Green Power Switch program, which offers customers the opportunity to purchase blocks of renewable energy at premium prices. Other sources of energy marketed through the Green Power Switch program are described above in Sections 3.3 and 3.4.

Generation Partners continues to operate as a pilot program and is limited to a total of 200 MW of qualifying generation and a total power purchase expenditure of $50 million. TVA is working with local power distributors and others to make Generation Partners an established program.

3.6. Transmission System

TVA operates one of the largest transmission systems in the U.S. It serves an area of 80,000 square miles through a network of approximately 16,000 miles of transmission line; 498 substations, switchyards and switching stations; and 1,240 individual customer connection points. The system connects to 52 generating facilities, where power is produced at relatively low voltages. Transformers in the generating facility switchyards boost voltage to either 161 kV or 500 kV for transmission to distributors and directly served customers. Substations at delivery points reduce the voltage for delivery through distribution lines serving end users.

The TVA transmission system operates at a range of voltages:

- 2,464 miles of 500-kV lines
- 157 miles of 345- and 230-kV lines
- 11,222 miles of 161-kV lines
- 202 miles of 138- and 115-kV lines
- 1,161 miles of 69-kV lines
- 718 miles of 46-kV lines
- 15 miles of 26- and 13-kV lines.

The TVA transmission system connects to 13 neighboring utilities with interconnection voltages ranging from 69- to 500-kV. These interconnections allow TVA and its neighboring utilities to buy and sell power from each other and to wheel power through their systems to other utilities. To the extent that federal law requires access to the TVA transmission system, the TVA transmission organization offers transmission services to others to transmit power at wholesale in a manner that is comparable to TVA's own use of the transmission system. TVA has also adopted and operates in accordance with the Standards of Conduct for Transmission Providers (FERC 2008) and appropriately separates its transmission functions from its marketing functions.

In recent years, TVA has built an average of about 150 miles of new transmission lines and several new substations and switching stations to serve new customer connection points and/or to increase the capacity and reliability of the transmission system. The majority of these new lines are 161-kV. In 2008, TVA completed a 39-mile 500-kV transmission line in Tennessee which was the first major TVA 500-kV line built since the 1980s. TVA also completed a 27-mile 500-kV transmission line in Tennessee in 2010. TVA has also upgraded many existing transmission lines in recent years to increase their capacity and reliability by re-tensioning or replacing conductors, installing lightning arrestors, and other measures. In FY 2009, TVA spent about $230 million on transmission system construction and over the past decade the system has operated with 99.999 percent reliability.

CHAPTER 4

4.0 AFFECTED ENVIRONMENT

4.1. Introduction

This chapter describes the natural and socioeconomic resources that could be affected by the alternative strategies and portfolios developed in the integrated resource planning process. These resources are described at a regional scale rather than a site-specific scale.

The primary study area, hereinafter called the TVA region, is the combined TVA power service area and the Tennessee River watershed (Figure 1-1). This area comprises 202 counties and approximately 59 million acres. In addition to the Tennessee River watershed, it covers parts of the Cumberland, Mississippi, Green, and Ohio Rivers where TVA power plants are located. For some resources such as air quality and climate change, the assessment area extends beyond the TVA region. For some socioeconomic resources, the study area consists of the 170 counties where TVA is a major provider of electric power and Muhlenberg County, Kentucky, where the TVA Paradise Fossil Plant is located. The economic model used to compare the effects of the alternative strategies on general economic conditions in the TVA region includes surrounding areas to address some of TVA's major fuel sourcing areas and inter-regional trade patterns

4.2. Climate

The TVA region spans the transition between a humid continental climate to the north and a humid subtropical climate to the south. This provides the region with generally mild temperatures (i.e., a limited number of days with temperature extremes), ample rainfall for agriculture and water resources, vegetation-killing freezes from mid-autumn through early spring, occasional severe thunderstorms, infrequent snow, and infrequent impacts—primarily in the form of heavy rainfall—from tropical storms. The seasonal climate variation induces a dual-peak in annual power demand, one for winter heating and a second for summer cooling. Rainfall does not fall evenly throughout the year, but tends to peak in late winter/early spring and again in mid-summer. Winds over the region are generally strongest during winter and early spring and lightest in late summer and early autumn. Solar radiation (insolation) varies seasonally with the maximum sun elevation above the horizon and longest day length in summer. However, insolation is moderated by frequent periods of cloud cover typical of a humid climate.

The remainder of this section describes the current climate and recent climate trends of the TVA region in more detail. Identifying recent trends in regional climate parameters such as temperature and precipitation is a complex problem because year to year variation may be larger than the multi-decadal change in a climate variable. Climate is frequently described in terms of the climate "normal," the 30-year average for a climate parameter (NCDC 2008). The climate normals described in the following sections are for the 1971-2000 period. Earlier and more recent data are also presented, where available. The primary sources of these data are National Weather Service (NWS) records and records from the rain gauge network maintained by TVA in support of its reservoir operations. NWS records, unless stated otherwise, are for Memphis, Nashville, Chattanooga, Knoxville, and Tri-Cities, Tennessee, and Huntsville, Alabama.

Temperature

1971-2000 Climate Normals - Average monthly temperatures for the TVA region during 1971-2000 ranged from 38.4 ºF in January to 79.1 ºF in July (Table 4-1).

Table 4-1. Monthly, seasonal, and annual temperature averages for six NWS stations in the TVA region for 1971-2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ºF	38.4	42.6	50.9	59.2	67.5	75.3	79.1	78.0	71.7	60.3	50.1	41.7
ºC	3.5	5.9	10.5	15.1	19.7	24.1	26.2	25.6	22.1	15.7	10.0	53.9

	Winter	Spring	Summer	Fall	Annual
ºF	40.9	59.2	77.5	60.7	59.6
ºC	5.0	15.1	25.3	16.0	15.3

Recent Trends - There is significant year-to-year variability in temperature. As suggested by the plot in Figure 4-1, annual temperature in the TVA region appears to have increased approximately 1 ºF (0.56ºC) over the 30-year period between 1970 and 2000 (this is equivalent to a change of about 0.19ºC/decade). This increase is most prominent in the winter and summer seasons. Spring and fall experienced little change in temperature. However, the overall annual change in temperature for the longer 1958-2008 period was not statistically significant (runs test (Bendat and Piersol 1986),$r^2 = 0.0994$, $p>0.05$). This implies that average temperature during the 50-year period was within the expected range of variability and the long-term trend could not be distinguished from random variation.

There is an appearance of inconsistency with these observations when different time periods are considered. For example, the number of days during the year with temperatures at or above 90 ºF increased by about 12 days during 1971-2000. However, the number of days experiencing 90+ ºF decreased during both 1958-2004 (by 6 days) and 1979-2004 (by 10 days). For 1958-2009, the number of days essentially remained unchanged.

The US Climate Change Science Program (Lanzante et al. 2006) reports that global surface temperature through 2004 has increased at a rate of about 0.12ºC per decade since 1958, and about 0.16ºC per decade since 1979. Regional differences from the global trends are expected. In the tropics, for example, the observed surface temperature trends have increased about 0.11ºC per decade since 1958 and about 0.13ºC per decade since 1979. These rates represent an acceleration of temperature changes that, during the entire 20th century, were estimated by the Intergovernmental Panel on Climate Change (IPCC) as being in the range of 0.06 to 0.09ºC per decade (Trenberth et al. 2007).

For the southeastern U.S., Trenberth et al. (2007) found that temperature change during the 20th century (through 2005) was slightly negative with a mean cooling rate of about 0.2 to 0.3ºC per decade in the vicinity of the TVA region.

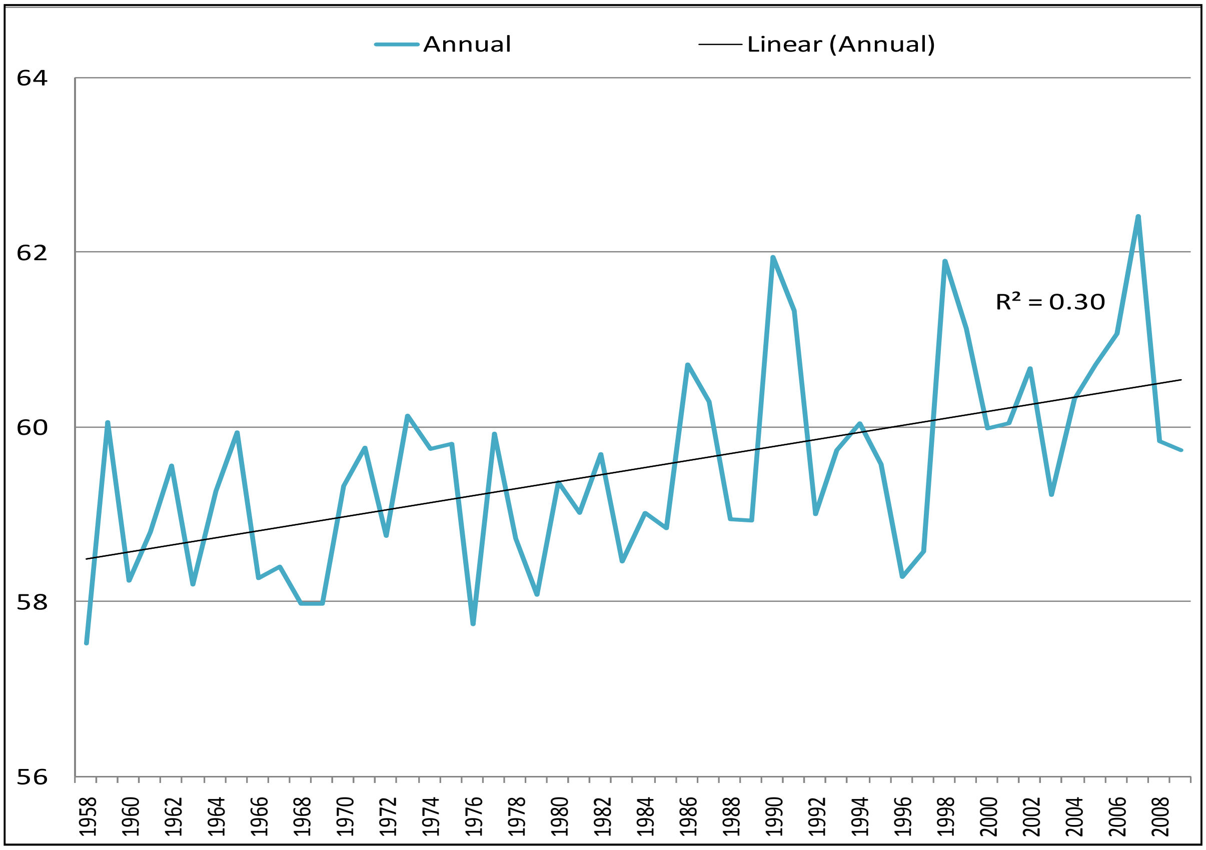


Figure 4-1. 1971-2000 TVA region annual average temperature (°F) based on data from six NWS stations.

Their data indicates a warming rate of 0.3-0.4ºC per decade for 1979-2005 for the TVA region, which is greater than the global average trend. The lack of significant temperature change (i.e., +0.19 ºC/decade) during 1958-2008 for the TVA region is consistent with these published findings.

Precipitation
<u>1971-2000 Climate Normals</u> - The average annual precipitation in the Tennessee River watershed during 1971-2000 was 49.92 inches; monthly averages ranged from 3.04 inches in October to 5.42 inches in March (Table 4-2).

<u>Recent Trends</u> - Although there is significant year-to-year variability, there appears to be a decrease in precipitation during the 30-year period (Figure 4-2). The overall annual change in precipitation over the period of 1958-2008 was not statistically significant (with 95 percent confidence) based on results from a standard statistical test (Bendat and Piersol 1986). This implies that average precipitation during the 50-year period was within the expected range of variability and the long-term change could not be assumed to be anything other than random variation in the data.

Table 4-2. Monthly, season, and annual precipitation averages in the Tennessee River watershed for 1971-2000. Source: TVA rain gage network data.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inches	4.87	4.31	5.42	3.97	4.52	3.84	3.97	3.24	3.59	3.04	4.32	4.85
Centimeters	12.4	10.9	13.8	10.1	11.5	9.8	10.1	8.2	9.1	7.7	11.0	12.3

	Winter	Spring	Summer	Fall	Annual
Inches	14.03	13.91	11.04	10.95	49.92
Centimeters	35.6	35.3	28.0	27.8	126.8

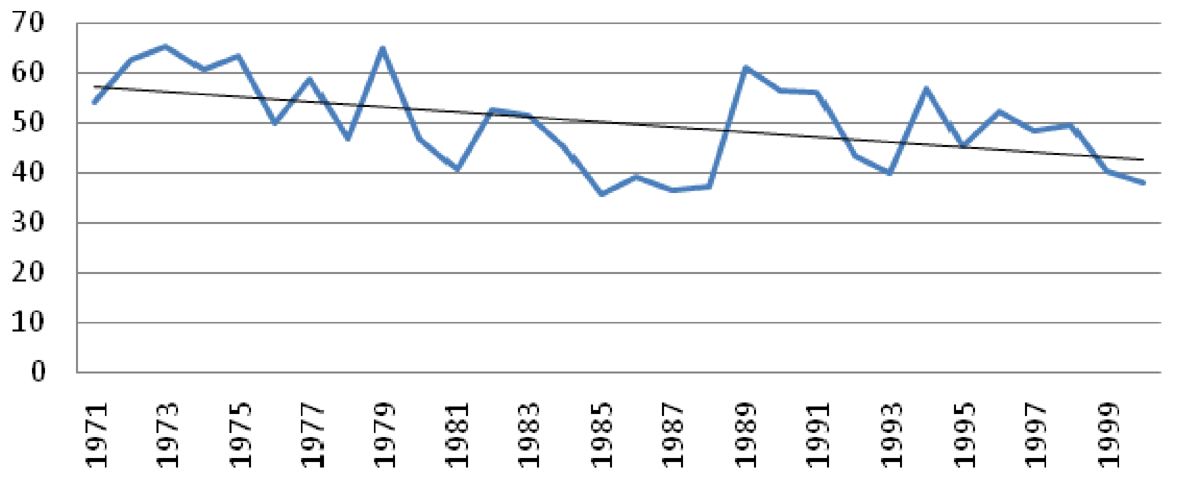


Figure 4-2. Annual average precipitation (inches) for the Tennessee River basin. The straight line represents the mean change in annual precipitation for the period. Source: TVA rain gauge network data.

Note that precipitation information is highly variable and can appear contradictory when different time periods are considered. Data for 1958-2004 indicate that annual precipitation is decreasing while data for 1979-2004 indicate that precipitation is increasing.

Recent changes in precipitation around the world are more variable than changes in temperature. Such behavior is expected as changes in atmospheric circulation (wind patterns) and temperature combine differently in different regions to influence the basic physical processes that control precipitation. The IPCC 2007 climate assessment reported that a few regions in North America, southern South America, Eurasia and Australia experienced precipitation increases during the 1901-2005 period (Trenberth et al. 2007). However, changes since 1979 have been less pronounced except in Australia. Over the southeastern U.S., precipitation since 1901 has shown a small increase of generally <10 percent overall, and since 1979, the changes have been near zero. These results are consistent with a US Global Change Research Program (USGCRP) summary of recent and projected climate change in the Southeast (Karl et al. 2009) which shows small precipitation increases across Tennessee during the 20th century offset by decreases over Alabama, Georgia, and North Carolina. Hoerling et al. (2008:47), in describing the 1951-2006 interval, state that "The spatial variations and seasonal differences in precipitation change are *unlikely* [sic] to be the result of anthropogenic greenhouse forcings alone." On a related issue they further state that (p. 48) "It is *unlikely* [sic] that a systematic change has occurred in either the frequency or area coverage of severe drought over the contiguous United States from the mid-twentieth century to the present." This does not mean that anthropogenic warming of the climate has not exacerbated the effects of drought. To the contrary, Hoerling et al. (2008) concluded that an anthropogenic link to worsening drought effects (through the enhanced drying effects of warming) is likely.

Wind

<u>1971-2000 Climate Normals</u> - Wind speed and direction are important indicators of weather patterns and dispersion of air pollutants. Wind speed is also a factor in determining the potential of an area for wind energy development.

Average surface wind speeds (measured 33 feet (10 m) above the ground) for nine NWS stations in the TVA region for 1973-2000[1] are relatively light with higher speeds in winter and spring and lower speeds in summer and fall (Table 4-3). In general, wind speeds at higher elevations are greater than those shown in the table. Average wind speeds in winter, spring, and fall were slightly less than the 1961-1990 seasonal norms. A similar decrease is also shown in the maximum, minimum, and annual average wind speeds. The months of occurrence for the maximum and minimum wind speed remain unchanged, with highest wind recorded in March and lowest wind in August.

Table 4-3. Monthly, seasonal, and annual wind speed averages for nine sites[2] in the TVA region for 1973-2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Miles/Hour	8.3	8.4	8.9	8.4	7.1	6.3	5.8	5.4	5.8	6.2	7.3	7.9
Meters/second	3.7	3.7	3.9	3.7	3.1	2.8	2.6	2.4	2.6	2.8	3.2	3.5

	Winter	Spring	Summer	Fall	Annual
Miles/Hour	8.2	8.1	5.8	6.4	7.1
Meters/Second	3.6	3.6	2.6	2.7	3.2

Surface wind directions in the TVA region for the same period are shown in the wind rose diagram (Figure 4-3). A wind rose is a diagram with spokes representing directions (e.g., N, NNE, NE). The frequency with which the measured wind blows from a given direction is illustrated by the distance between the point where a heavy line crosses a spoke and the center of the diagram. The most frequent wind directions are from the south and north sectors. This occurs at Memphis, Tupelo, Paducah, Nashville, Chattanooga, and Asheville. Prevailing wind directions at Knoxville and Tri-Cities are from northeast and/or southwest sectors, which reflect the down-valley and up-valley flow pattern seen in the area. Wind directions at Huntsville are more variable than at other sites.

[1] Data for 1971 and 1972 are not available from NCDC.
[2] The nine sites are Asheville, NC; Tri-Cities, Knoxville, Chattanooga, Nashville, and Memphis, TN; Huntsville, AL; Tupelo, MS; Paducah, KY.

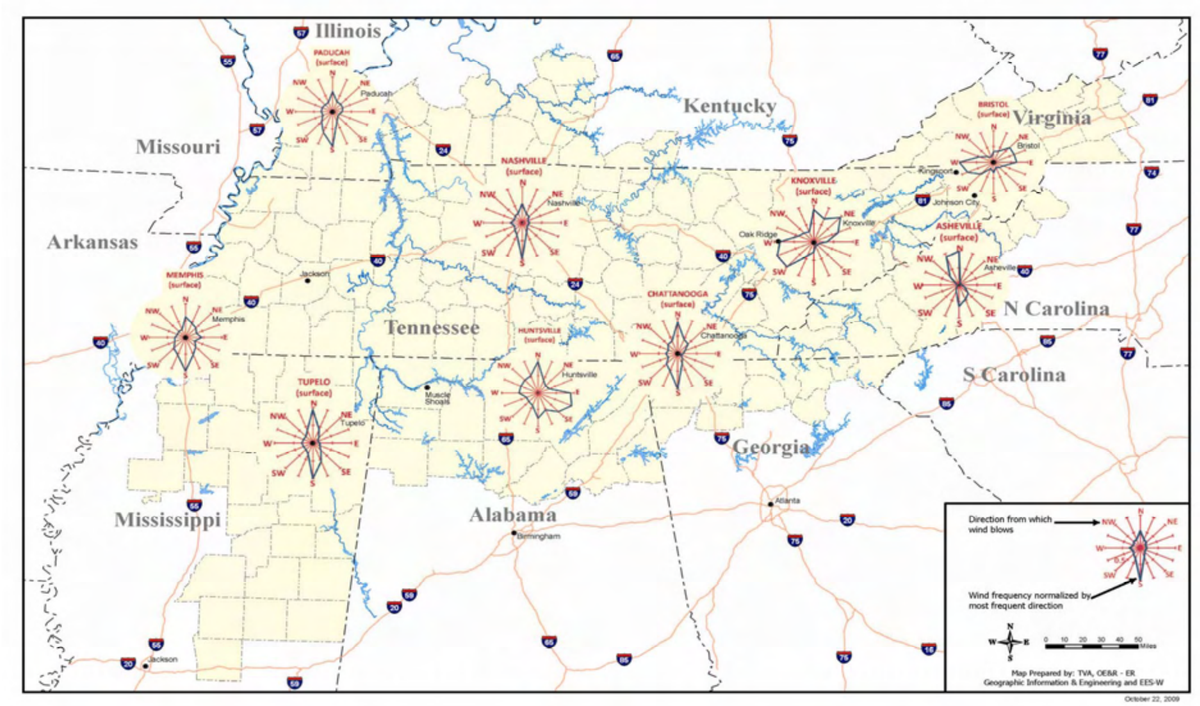


Figure 4-3. Prevailing wind direction for surface winds at nine regional airports, 1973-2000.

Overall, the prevailing wind directions in the TVA region during 1973-2000 are nearly identical to those during 1961-1990.

Recent Trends - Trends in wind direction and speed are important because of their potential to affect air quality and wind power generation. Recent trends in wind speed and direction over land have not been examined in recent climate reports (e.g., Trenberth et al. 2007, Karl et al. 2009)). Pryor et al. (2009), however, recently analyzed surface wind speed trends over the continental U.S. for the periods 1973-2000 and 1973-2005. They found that the median and 90th percentile[3] wind speeds significantly decreased at over 75 percent of the sample sites and increased at about 5 percent of the sample sites. Sites in the TVA region had either small decreases or no change in both the median and 90th percentile wind speeds. The decrease in wind speed is most prevalent at eastern U.S. sites and shows no seasonality (i.e., variation across seasons).
Data from the nine sites used to describe the wind speed normals were analyzed to quantify trends in wind speed in the TVA region (Figure 4-4). Wind speeds decreased from 1973 to 1978, slightly increased from 1979 to 1988, and decreased after 1989. The overall trend has been a significant decrease ($p < 0.05$). This trend in the TVA region is consistent with the trend identified for the continental U.S. by Pryor et al. (2009).

[3] 90th percentile is the point below which 90 percent of all observations fall. It excludes the highest 10 percent of observations.

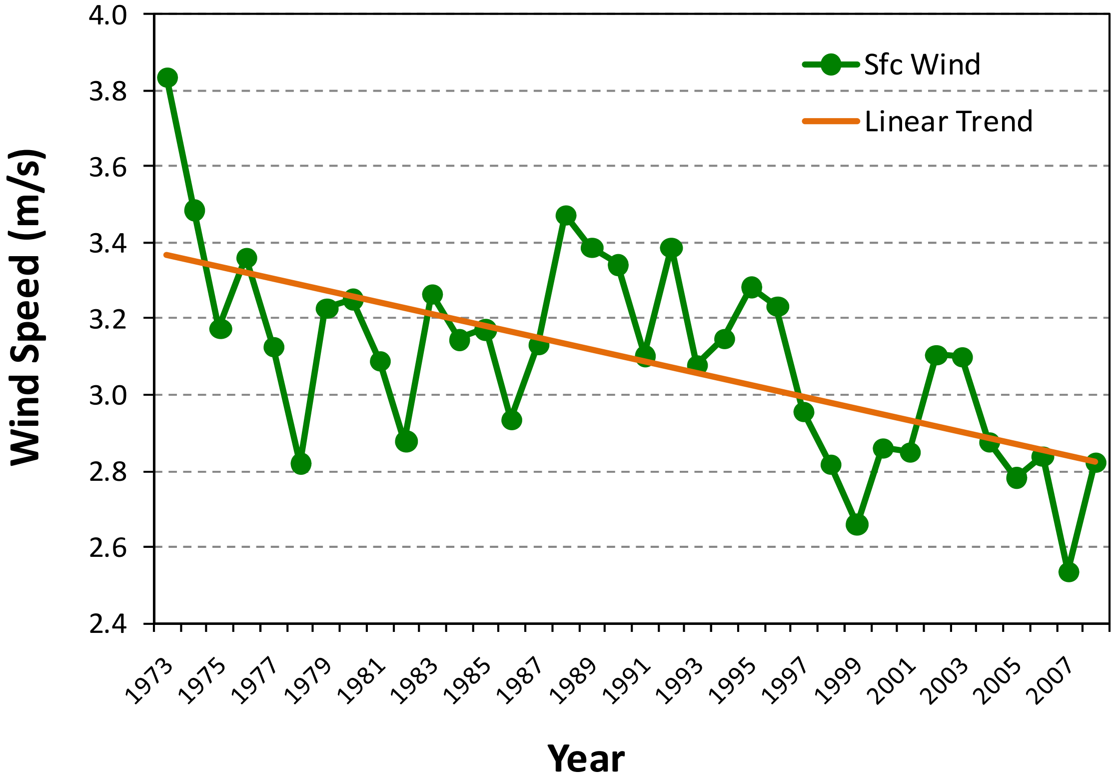


Figure 4-4. Annual median wind surface wind speeds for the TVA region, 1973-2008.

Solar Radiation

1971-2000 Climate Normals - Solar radiation (insolation) received at the earth's surface is a function of two factors, cloud cover and atmospheric particles (aerosols). Clouds generally decrease insolation by scattering and reflecting incoming solar radiation back into space. Aerosols scatter and absorb solar radiation. Absorbed radiation tends to be re-radiated by aerosols in longer wavelengths with some of the energy reaching the earth surface, some warming the atmosphere, and some going back into space.

Solar radiation is measured at few NWS weather stations and most of the data in the National Solar Radiation Database produced by the National Renewable Energy Laboratory is based on modeling rather than original measurements. Cloud cover, however, is measured at all NWS weather stations and ranges from zero (totally clear sky) to 100 percent (completely covered by clouds). Table 4-4 shows mean cloud cover for nine sites in the TVA region during 1973-2000. TVA has monitored solar radiation at Sequoyah Nuclear Plant (SQN) and Browns Ferry Nuclear Plant (BFN) since the 1970s. Figure 4-5 shows these monitoring results as well as cloud cover measurements at the Chattanooga airport (about 15 miles from SQN) and at the Huntsville airport (about 21 miles from BFN).

Cloud cover at the Chattanooga airport was negatively correlated (correlation coefficient of -0.35) with solar radiation at SQN and cloud cover at Huntsville airport was negatively correlated (correlation coefficient of -0.38) with solar radiation at BFN.

Table 4-4. Monthly, seasonal, and annual cloud cover averages for nine sites[4] in the TVA region for 1973-2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Percent (%)	66	64	63	57	59	56	53	51	53	49	59	63

	Winter	Spring	Summer	Fall	Annual
Percent (%)	65	60	53	53	58

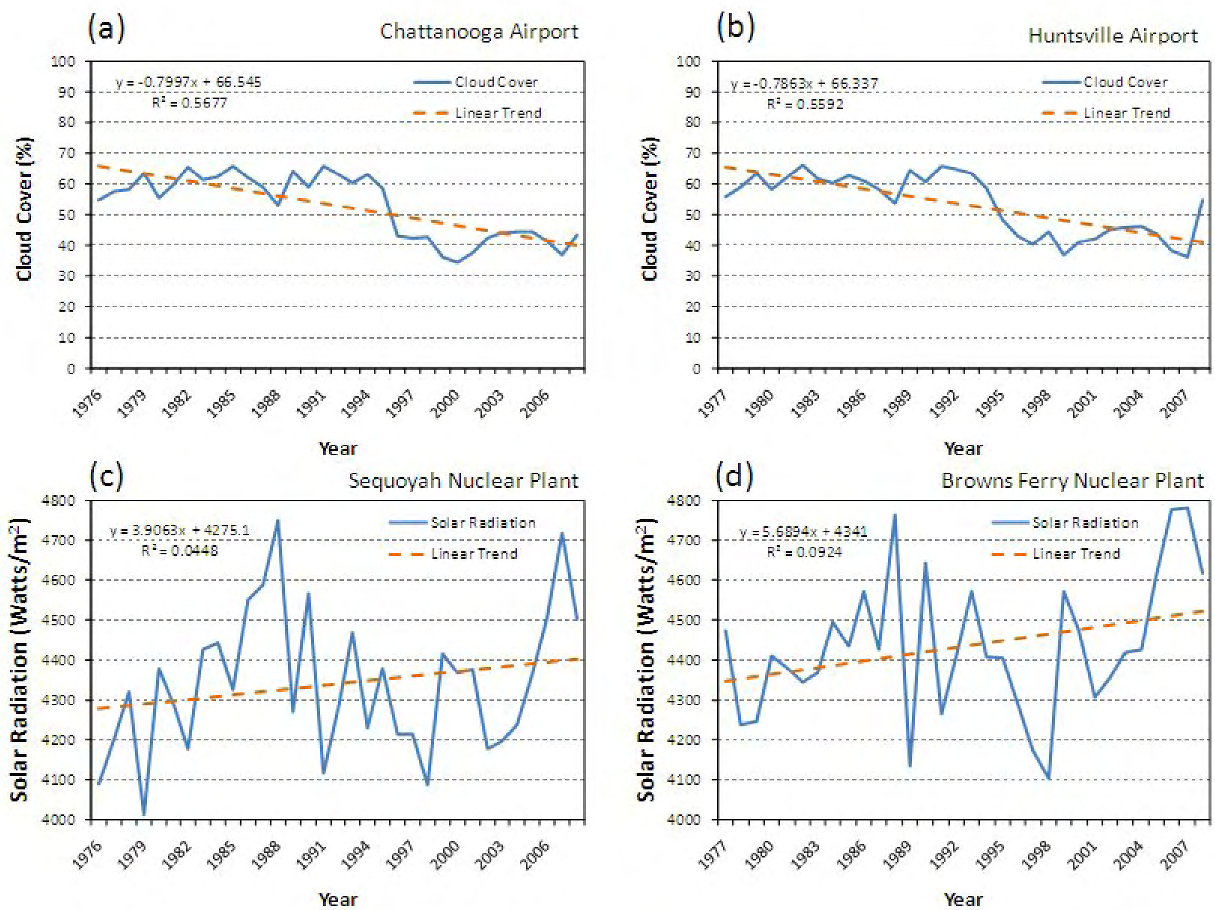


Figure 4-5. Observed annual observations and fitted trend lines for (a) cloud cover at the Chattanooga airport, (b) cloud cover at the Huntsville airport, (c) solar radiation at Sequoyah Nuclear Plant, and (d) solar radiation at the Browns Ferry Nuclear Plant for 1976/1977-2008.

[4] The nine sites are Asheville, NC; Tri-Cities, Knoxville, Chattanooga, Nashville, and Memphis, TN; Huntsville, AL; Tupelo, MS; Paducah, KY.

Recent Trends - Liepert and Tegen (2002) analyzed insolation data collected since the 1960s at 21 sites across the U.S. They focused on measurements during clear sky conditions so they could identify trends associated with aerosol scattering. They found that insolation decreased from the 1960s to the 1980s by a daily average of 7 watts/m^2 at eastern U.S. sites (including Nashville), resulting in a long-term decrease in average daily insolation of 3 percent. Although atmospheric aerosols increased during this period, Liepert and Tegen were unsuccessful in identifying the cause of the change in insolation.

The decreasing trends in cloud cover at both Chattanooga and Huntsville are significantly different ($p \leq 0.05$) from random variability. However, no trend is detected in solar radiation at SQN and BFN at the same level of significance. Due to this weak relationship between measured solar radiation and cloud cover, cloud cover is, at best, a weak proxy for solar radiation at specific sites in the TVA region.

Stanhill and Cohen (2005) examined sunshine duration (a proxy for insolation) at 106 U.S. stations with data records of at least 70 years during the period of 1891-1987. A small majority of sites in several regions, including the Southeast, had decreases in sunshine duration (with an implied decrease in insolation) since 1950. However, across all U.S. sites Stanhill and Cohen found no evidence suggesting a significant decreasing trend in insolation over the period 1891-1987.

The IPCC 2007 climate report cites three other studies that concluded finding significant increases in cloud cover, based on surface cloud observations, over the U.S. in the latter half of the 20th century (Trenberth et al. 2007). One of these, based on independent human observations at military stations, suggests an increasing trend (~1.4 percent of sky per decade) in total cloud cover. A complicating factor in identifying cloud cover trends is the change in observation methods from reliance on human observers for most of the 20th century to automated instrumentation with a concomitant increase in data uncertainty. This is the reason that human-derived military observations may carry more weight. Trenberth et al. (2007) found a lack of consensus in cloud cover changes based on satellite observations. The data are equally equivocal for surface-based solar radiation trends.

Figure 4-6 shows trends in cloud cover in the TVA region since 1973, as measured at nine sites. Between 1973 and 2008, cloud cover shows a significant ($p<0.05$) decreasing trend (Figure 4-6a). This trend, however, should be interpreted with caution. Prior to 1995, cloud cover at NWS stations was estimated by human observers, and from 1973 through 1995 there was no significant trend ($p>0.05$) in cloud cover (Figure 4-6b).

Since 1995 cloud cover has been measured with automated equipment and, because this equipment only detects clouds up to 12,000 feet above the surface, automated measurements since 1995 are noticeably lower than earlier human observations. Although the cloud cover in the TVA region appears to show a downward trend after 1995 (Figure 4-6c), this trend is not significant ($p>0.05$).

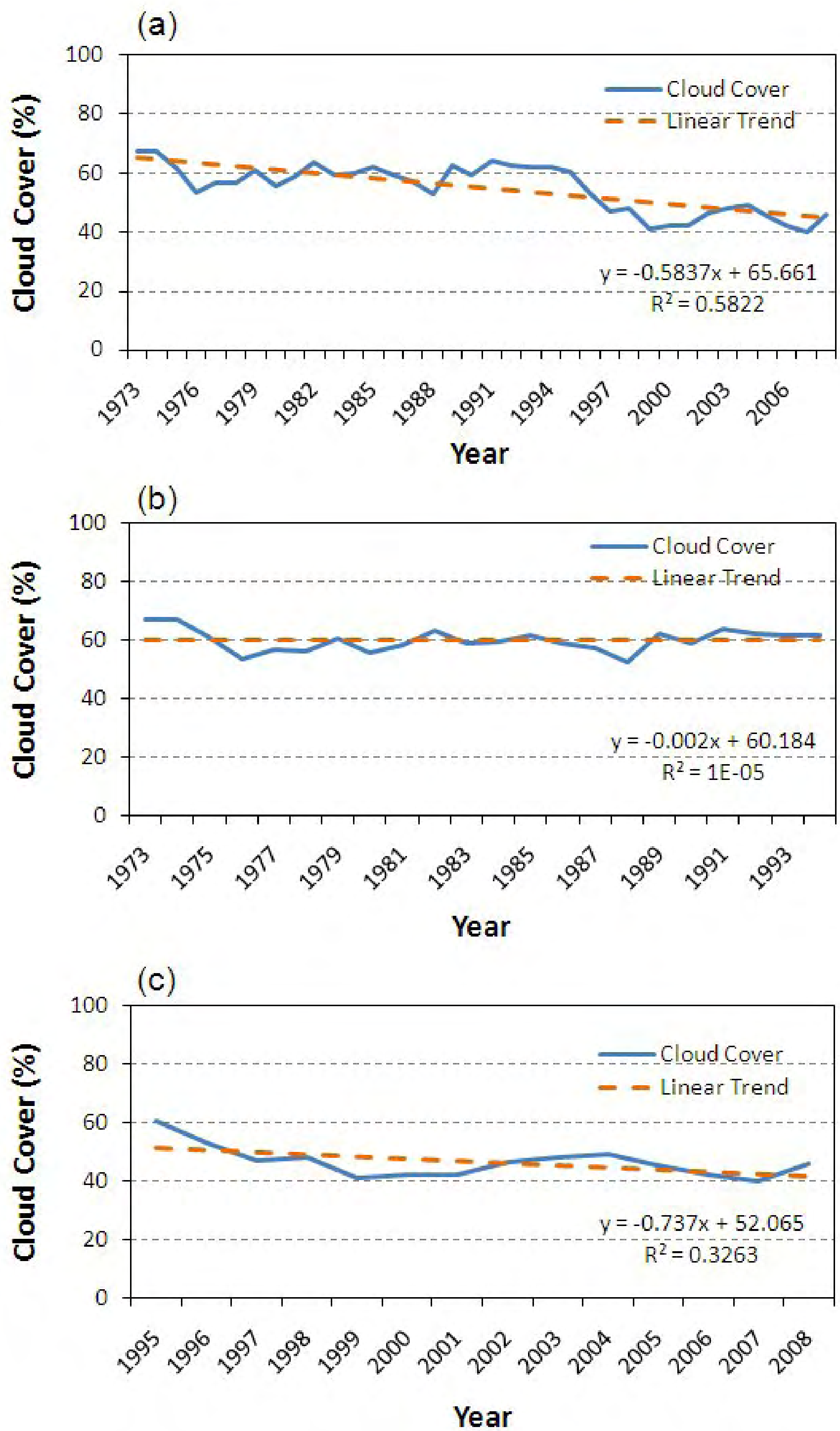


Figure 4-6. Trends in cloud cover at nine sites[5] in the TVA region for (a) 1973-2008, (b) 1973-1995, and (c) 1995-2008.

[5] The nine sites are Asheville, NC; Tri-Cities, Knoxville, Chattanooga, Nashville, and Memphis, TN; Huntsville, AL; Tupelo, MS; Paducah, KY.

Greenhouse Gas Emissions
Energy from the sun that reaches the earth is absorbed by oceans and land masses. Some of this energy is radiated back into the atmosphere in the form of infrared radiation (heat). A portion of infrared energy is absorbed and re-radiated back to the earth by water vapor, greenhouse gases (GHGs), and other substances. Greenhouse gas is a term used to describe natural and man-made heat-trapping gases that absorb heat radiated from the earth's surface (Thomas et al. 2009). As concentrations of GHGs increase, there are direct and indirect effects on the earth's energy balance. The direct effect is often referred to as a radiative forcing, a change in the difference between incoming and outgoing radiation energy (USCCSP 2007); an increase in incoming energy relative to outgoing energy tends to warm the system.

Water vapor is the most abundant GHG and comprises 90+ percent of the total amount of GHGs. The six most commonly discussed man-made GHGs which have recently been determined by EPA to endanger public health and welfare (EPA 2009a) are listed along with their global warming potentials (GWPs) in Table 4-5. GWP is a measure of the potential for a given amount of a greenhouse gas to contribute to global warming; it varies with the amount of infrared radiation absorbed, the wavelength of absorption, and the atmospheric lifetime of the gas (Forster et al. 2007). GWP is typically expressed in relation to CO_2, which has a GWP of 1, and for a 100-year period. A standard measure of GHGs is units of CO_2 equivalents, where the amounts of GHGs other than CO_2 are translated into equivalent amounts of CO_2 based on their GWPs (Forster et al. 2007). CO_2 equivalents are frequently abbreviated as CO_2-eq.

Table 4-5. The major man-made greenhouse gases and their global warming potentials. Source: Forster et al. (2007).

Gas	Global warming potential
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydroflourocarbons (HFCs)	140 - 11,700
Perfluorocarbons (PFCs)	6,500 - 9,200
Sulfur hexaflouride (SF_6)	23,900

The most abundant man-made GHG is CO_2; its major U.S. emission sources include combustion of fossil fuels, non-combustion uses of fossil fuels in producing chemical feedstocks, solvents, lubricants, waxes, asphalt and other materials, iron and steel production, cement production, and natural gas systems. The major U.S. emission sources of CH_4 are ruminant animals (cows and sheep), landfills, natural gas systems, and coal mining. HFCs, PFCs,and SF_6 are all industrial chemicals with no natural sources and emitted by various industrial activities (USCCSP 2007).

The major GHGs directly emitted by electric utility operations are CO_2, from burning fossil fuels and other substances containing carbon compounds, and SF_6, a flourine compound used in electrical transmission and distribution equipment. Electric utilities are also a major source of indirect emissions of methane from coal mining and natural gas extraction and transportation.

In addition to the six GHGs described above, several other naturally occurring substances whose levels have also been enhanced by human activities cause radiative forcing. These substances remain in the atmosphere for days to months, and thus, are not well mixed in the atmosphere. Their effects have both regional patterns and global consequences. These substances include water vapor, radiation-absorbing aerosols such as black carbon and other particulate matter; sulfur dioxide, the main precursor of the reflecting aerosols; and other gases such as volatile organic compounds, nitrogen dioxide, other oxides of nitrogen, and carbon monoxide (USCCSP 2007). Some of these compounds are considered criteria air pollutants and described in more detail below in Section 4.3.

Global concentrations of man-made GHGs have increased since the pre-industrial era (~1750). Increases in individual GHGs through 2008 include: CO_2 - from 278 ppmv (parts per million by volume) to 385 ppmv, a 38 percent increase; CH_4 - from 700 ppbv (parts per billion by volume) to 1745 ppbv, a 150 percent increase; and N_2O - 270 ppbv to 314 ppbv, a 16 percent increase (Thomas et al. 2009).

In 2008, global CO_2 emissions were estimated to be 30,493 million metric tons (MMT) (USEIA 2009). This is approximately 41 percent higher than 1990 levels. In 2008, CO_2 emissions for the United States were 5,833 MMT or 19.1 percent of the estimated global CO_2 emissions (Table 4-6). U.S. sources of CO_2 emissions include: industrial, commercial, and residential energy-use; transportation, and a small percentage from direct industrial emissions such as cement production, waste combustion, and natural gas flaring (USEIA 2009). In comparison, CO_2 emissions from the seven TVA region states and direct emissions from TVA power generation comprised 15.9 and 1.6 percent of U.S. CO_2 emissions (Table 4-6).

Table 4-6. 2008 global, United States, and TVA region CO_2 emissions. Source: USEIA (2009, 2010).

Area / Source	Amount (million metric tons)	Percent of Global CO_2 Emissions	Percent of U.S. CO_2 Emissions
Global	30,493	--	--
United States	5,833	19.1	--
TVA region states	928	3.0	15.8
TVA power generation	99	0.3	1.7

In 2009, direct CO_2 emissions from the generation of power marketed by TVA (from both TVA-owned facilities and facilities owned by others) totaled approximately 66.2 MMT. This is a decrease of about a third from the average of about 100 MMT/year for the previous five years, due in part to reduced demand for power in 2009 (Figure 4-7). The CO_2 emissions totals do not include the relatively small amount of CO_2 emissions from auxiliary equipment, vehicles, and infrastructure such as cooling and heating buildings. They also do not include indirect emissions from the fuel cycle (e.g., extraction, transportation, processing, spent fuel/waste management) and associated activities. TVA's emissions from power generation have increased approximately 35 percent since 1982. TVA's CO_2 emission rate (expressed in terms of tons/gigawatt-hours (GWh, 1 GWh = one million KWh) of generation) of 652 tons/GWh in 2004 was somewhat above the median but below the average of the emission rates for 28 major electrical utilities in the central and eastern United States. TVA's 2009 CO2 emission rate was approximately 485 tons/GWh.

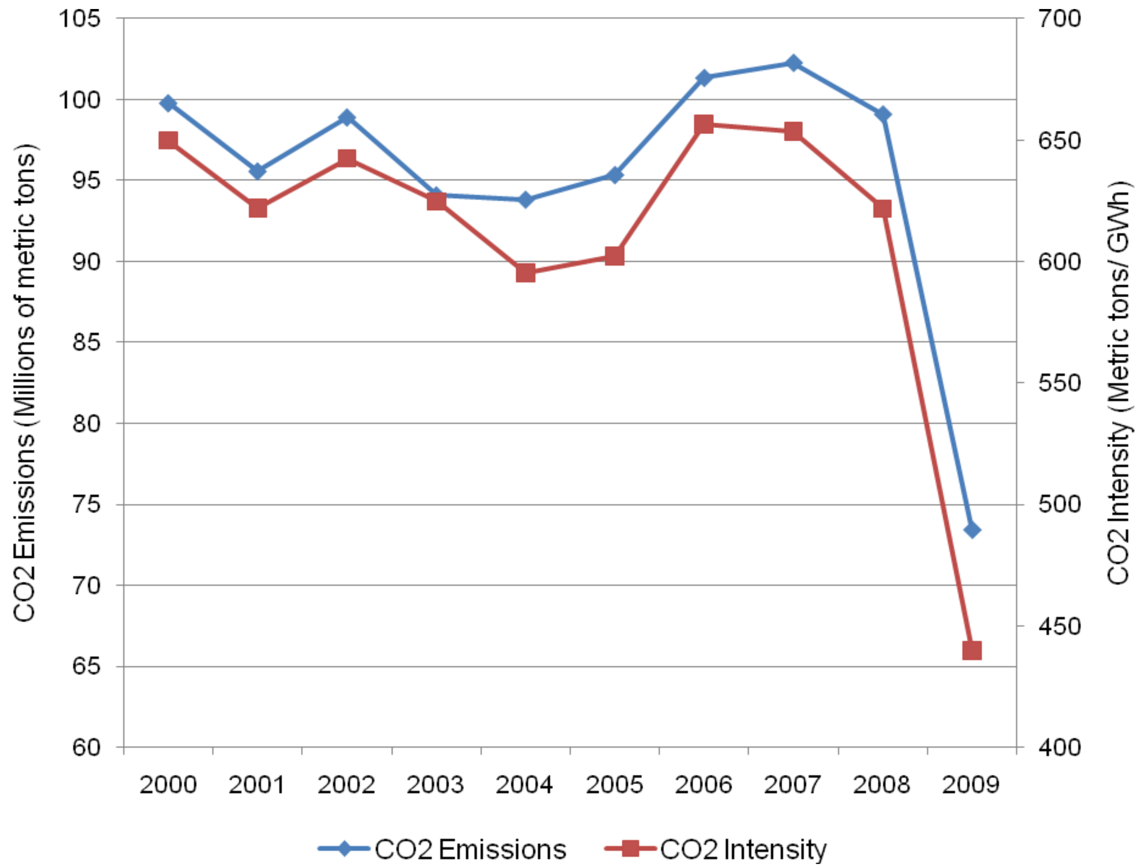


Figure 4-7. CO_2 emissions from TVA power plants and other plants with long-term TVA power purchase agreements, 2000 - 2009.

About 77 percent of SF_6 emissions are from electrical applications, and most of the remainder is from magnesium smelting and semiconductors. SF_6 is used for high voltage electrical insulation, current interruption, and arc quenching in the transmission and distribution of electricity because of its inertness and insulating properties (EPA 2008a). It is considered a long-lived GHG because it can remain in the earth's atmosphere up to 3,200 years, compared to CO_2 which has a radiative effect of about 100 years (USCCSP 2007). While global SF_6 concentrations are a small fraction of CO_2 emissions, they are 23,900 times more efficient in trapping heat and radiation (EPA 2008a). U.S. emissions of SF_6 have decreased by half since 1990 (USEIA 2000).

4.3. Air Quality

Air quality is a vital resource that impacts us in many ways. Poor air quality can affect our health, ecosystem health, forest and crop productivity, economic development, as well as our enjoyment of scenic views. This section summarizes current conditions and trends over the past 30 years for key air quality issues, including criteria pollutants, hazardous air pollutants, mercury, acid deposition, and visibility impairment. Air quality within the TVA region has steadily improved over the last 30 years.

Criteria Air Pollutants

EPA has established National Ambient Air Quality Standards (NAAQS) for six "criteria" air pollutants: carbon monoxide, lead, nitrogen dioxide, ozone, particulate matter, and sulfur dioxide (Table 4-7). There are two different standards for particulate matter, one for particles less than 10 microns in size (PM_{10}) and one for particles less than 2.5 microns in size ($PM_{2.5}$). Primary standards protect public health, while secondary standards protect public welfare, (e.g., visibility, crops, forests, soils and materials). Ambient air monitors measure concentrations of these pollutants to determine attainment with these standards. Areas where these measurements exceed the standards are designated as non-attainment areas. Non-attainment areas for fine particulate matter ($PM_{2.5}$) are shown in (Figure 4-8).

Table 4-7. National Ambient Air Quality Standards.

	Primary Standards		Secondary Standards	
Pollutant	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm	8-hour	None	
	35 ppm	1-hour		
Lead	0.15 µg/m^3	Rolling 3-month average	Same as Primary	
	0.15 µg/m^3	Quarterly average	Same as Primary	
Nitrogen Dioxide	0.053 ppm	Annual (arithmetic mean)	Same as Primary	
	0.100 ppm	1-hour	None	
Particulate Matter (PM_{10})	150 µg/m^3	24-hour	Same as Primary	
Particulate Matter ($PM_{2.5}$)	35 µg/m^3	Annual (arithmetic mean)	Same as Primary	
Ozone	0.075 ppm (2008 std.)	8-hour (4th highest)	Same as Primary	
	0.08 ppm (1997 std.)	8-hour (4th highest)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (arithmetic mean	0.5 ppm (1300 µg/m$^{3)}$	3-hour
	0.14 ppm	24-hour	None	
	0.075 ppm	1-hour	None	

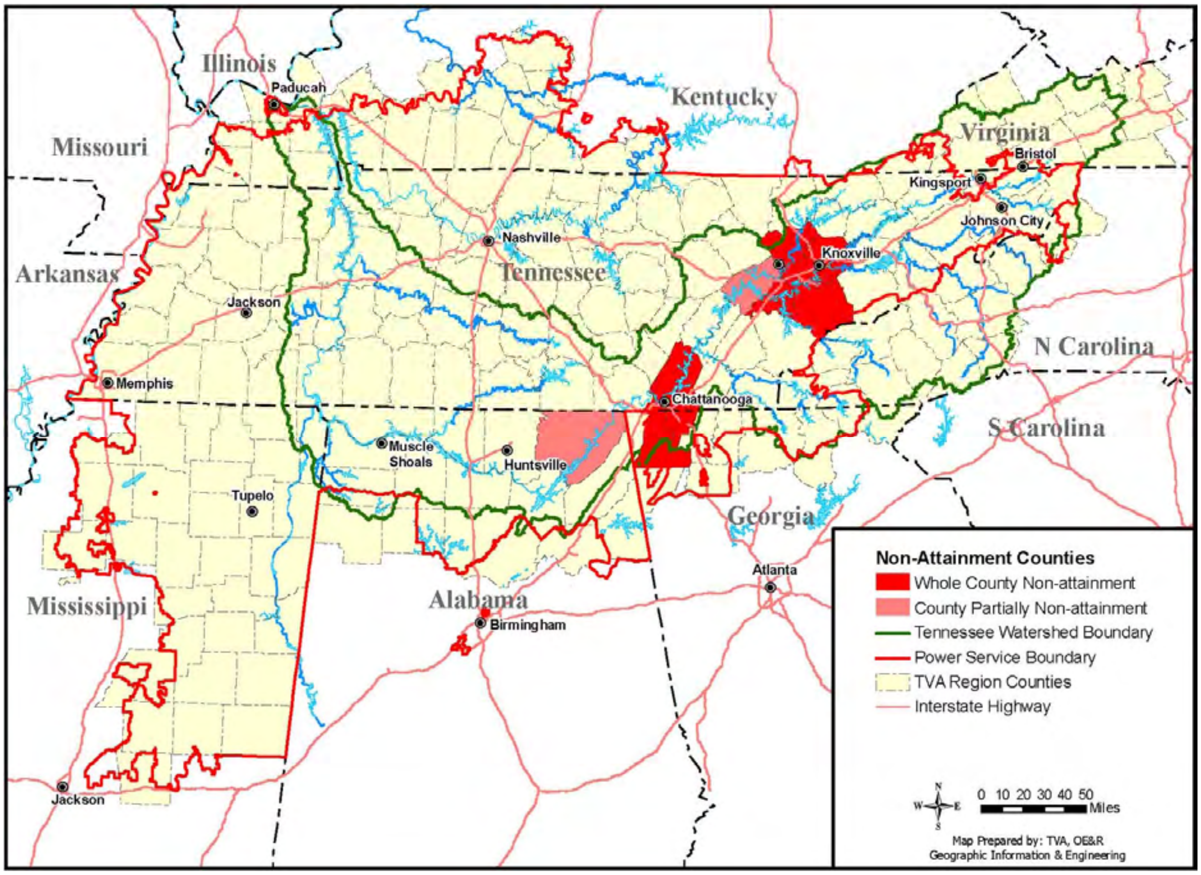


Figure 4-8. Non-attainment areas for fine particles ($PM_{2.5}$).

There are currently no non-attainment areas for carbon monoxide, nitrogen dioxide, sulfur dioxide and PM_{10} in the TVA region. However, EPA recently adopted more stringent standards for lead, nitrogen dioxide and sulfur dioxide, and one area in the region was recently designated non-attainment for lead. Additional non-attainment areas have not yet been designated for the other new standards. All or parts of seven counties in the vicinity of Knoxville have been designated non-attainment for the 1997 ozone standard. Recent monitoring data shows these counties in compliance with the ozone standard, although as of late February 2011, EPA had not finalized the redesignation of the areas attainment status . In 2008, EPA revised the ozone standard to 0.075 ppm, but this standard is under review and a more stringent ozone standard is expected to be announced very soon. Once this new standard is implemented, numerous counties in the TVA region are expected to be designated non-attainment areas for ozone.

Sulfur Dioxide

Sulfur dioxide (SO_2) is a colorless gas with a sharp odor that can cause respiratory problems at high concentrations. SO_2 also combines with other elements to form sulfate, a secondary pollutant that contributes to acid deposition, regional haze, and fine particle concentrations.

Most SO_2 is produced from the burning of fossil fuels (coal and oil), as well as petroleum refining, cement manufacturing and metals processing. In addition, geothermic activity, such as volcanoes and hot springs, can be a significant natural source of SO_2 emissions.

TVA currently emits 59 percent of the human-produced SO_2 emissions in the Tennessee Valley (Figure 4-9). While this is still a large amount of emissions, it has been substantially reduced over the past 30 years. TVA's SO_2 emissions have decreased by 85 percent since 1974 (Figure 4-10). Currently about half of TVA's coal-fired capacity is equipped with flue gas desulfurization systems ("scrubbers") to control SO_2 emissions; this percentage will likely increase in the future. The coal units without scrubbers burn low-sulfur coal.

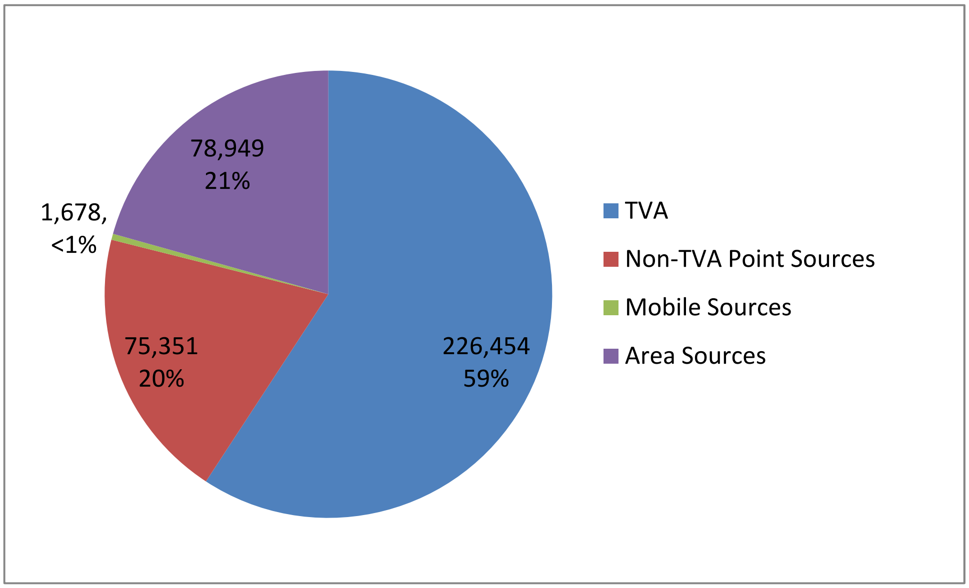


Figure 4-9. Sulfur dioxide (SO_2) emissions in the TVA region in tons and percent by source. Source: VISTAS (2009).

There are three air quality standards for SO_2: an annual standard, a daily standard and a new one-hour standard. Annual and 24-hour concentrations of SO_2 in the TVA region have been reduced by 63 percent since 1979 (Figure 4-11). Regional average concentrations are well below the annual and daily NAAQS. In 2008, annual SO_2 concentrations were 12 percent of the NAAQS and 24-hour concentrations were 18 percent of the NAAQS and there were no exceedances of the annual or daily SO_2 NAAQS in the TVA region. On June 2, 2010, EPA finalized a new one-hour SO_2 NAAQS. Non-attainment areas for this new standard have not yet been designated and some areas in the TVA region are expected to exceed this standard. Further air quality improvements are anticipated as legislative and regulatory changes will likely require additional emissions reductions.

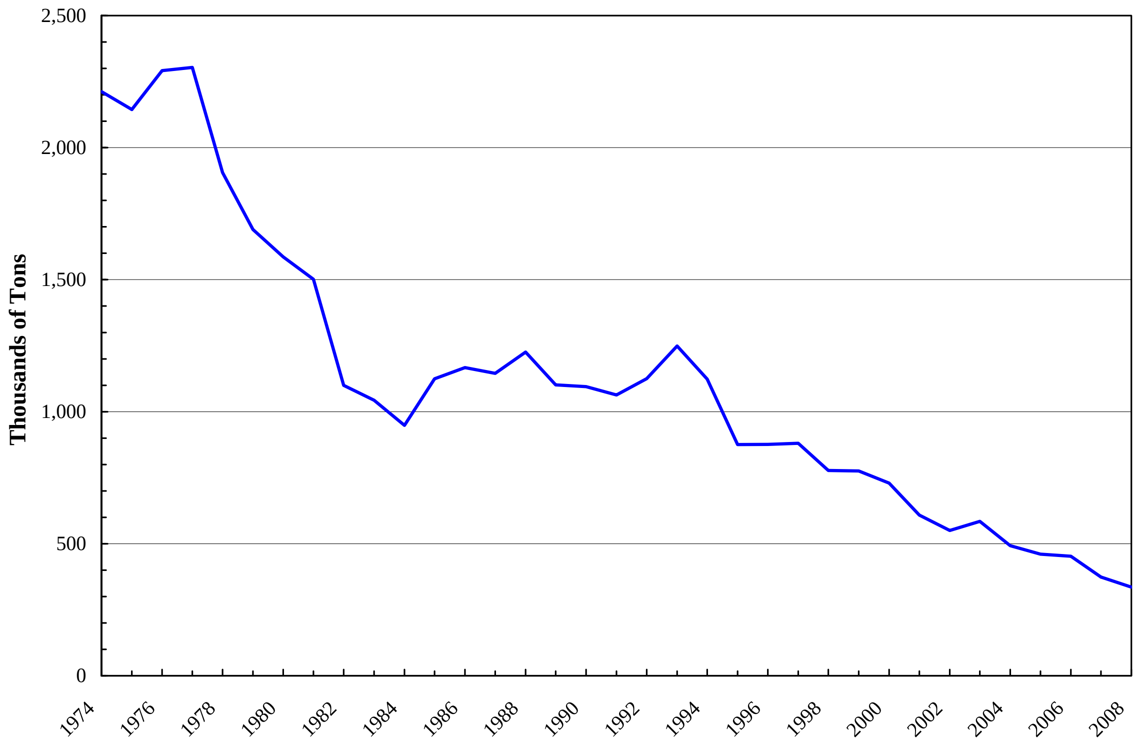


Figure 4-10. TVA sulfur dioxide (SO_2) emissions, 1974 - 2008. Source: TVA data.

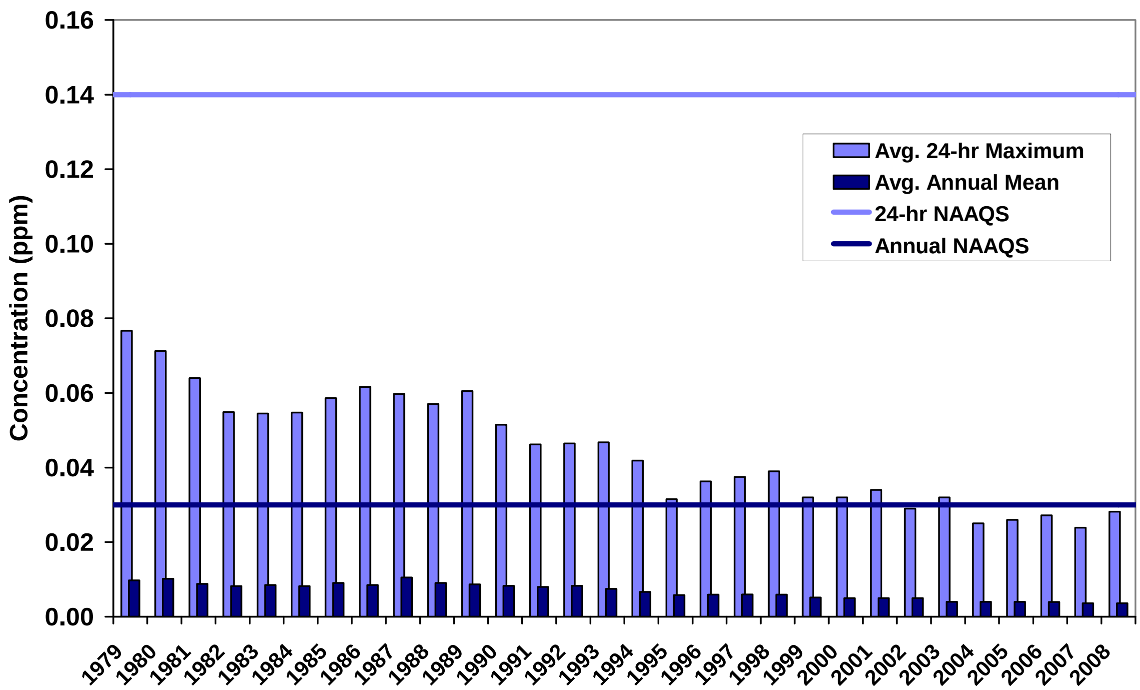


Figure 4-11. Regional average annual sulfur dioxide (SO_2) concentrations, 1979-2008. Source: EPA AQS Database.

Nitrogen Oxides

Nitrogen oxides (NOx) is a generic term for a group of highly reactive gases that contain varying amounts of nitrogen and oxygen. Nitrogen dioxide (NO_2) is one member of this group of gases. NOx emissions contribute to a variety of environmental impacts, including ground-level ozone, fine particulate matter, regional haze, acid deposition, and nitrogen saturation. Natural sources of NOx include lightning, forest fires and microbial activity; major sources of human-produced NOx emissions include motor vehicles, electric utilities, industrial boilers, nitrogen fertilizers and agricultural burning. Within the TVA region, most of the human-produced NOx emissions come from mobile sources (43 percent) and area sources (33 percent) which include off-road vehicles, agricultural activities and forest fires (Figure 4-12). Between 1993 and 2008 (Figure 4-13), TVA reduced its NOx emissions by 68 percent (and by more than 80 percent during the summer ozone season) and currently emits 11 percent of the anthropogenic NOx emissions in the TVA region. These emissions reductions have been the result of an aggressive emissions control program consisting of the installation of selective catalytic reduction (SCR) systems on 21 coal units, representing 60 percent of TVA's coal-fired capacity. The remaining coal units are equipped with selective non-catalytic reduction (SNCR) systems or utilize low NOx burners. In the fall of 2008, TVA changed the operation of SCRs and SNCRs from a seasonal to a year-round basis. This change will further reduce annual NOx emissions and will result in lower ambient NO_2 concentrations, ground-level ozone, fine particulate matter, regional haze, and acid deposition.

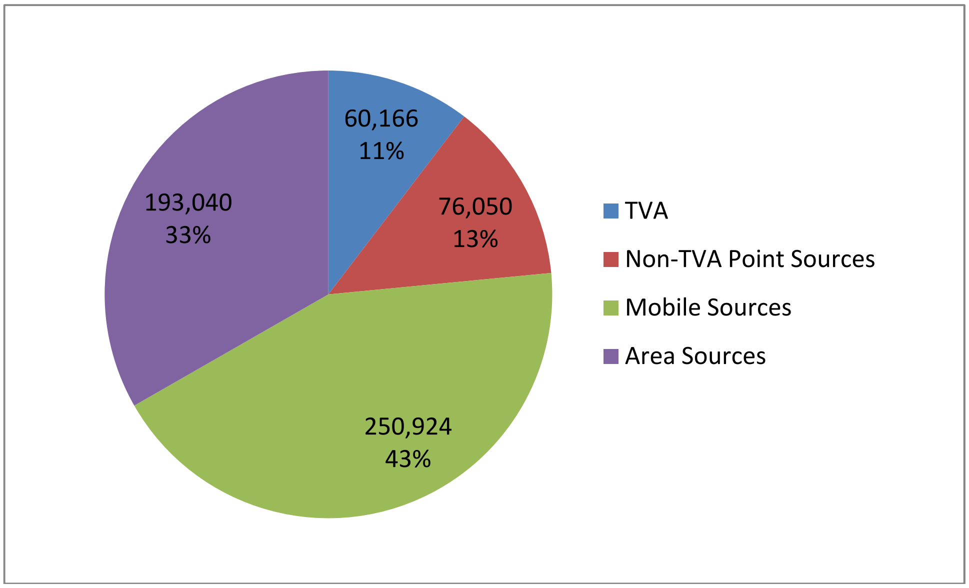


Figure 4-12. Nitrogen oxides (NOx) emissions in the TVA region in tons and percent by source. Source: VISTAS (2009).

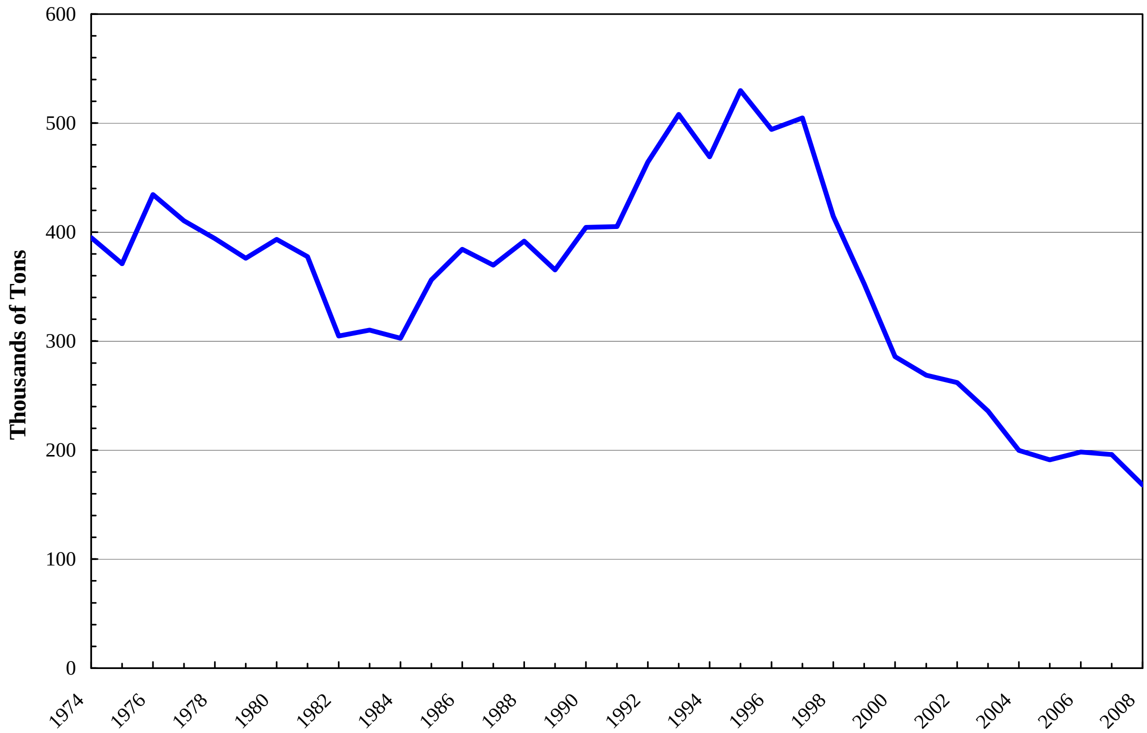


Figure 4-13. Trends in TVA nitrogen oxides (NOx) emissions, 1974 – 2008. Source: TVA data.

Regional NO_2 concentrations declined by 41 percent between 1979 and 2008 and by 54 percent since the peak concentration in 1988 (Figure 4-14). Average regional concentrations are well below the NO_2 annual NAAQS standard; the 2008 average concentration was 17 percent of the NAAQS. EPA has set a new one-hour NO_2 standard that became effective in January 2010. Non-attainment areas for this new standard have not yet been designated and some areas in the TVA region may exceed this standard.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are compounds that have a high vapor pressure (i.e., readily evaporates at ambient temperatures) and low solubility in water. The most common sources of man-made VOCs are petrochemical storage and transport, chemical processing, motor vehicles, paints and solvents. Natural sources of volatile organic compounds include vegetation, biological decay, and forest fires. In many areas of the Southeast, natural sources contribute up to 90 percent of total volatile organic compounds. TVA VOC emissions are less than 1 percent of the regional total (Figure 4-15). While VOCs are not a criteria pollutant, they are important because they are a precursor to ground-level ozone.

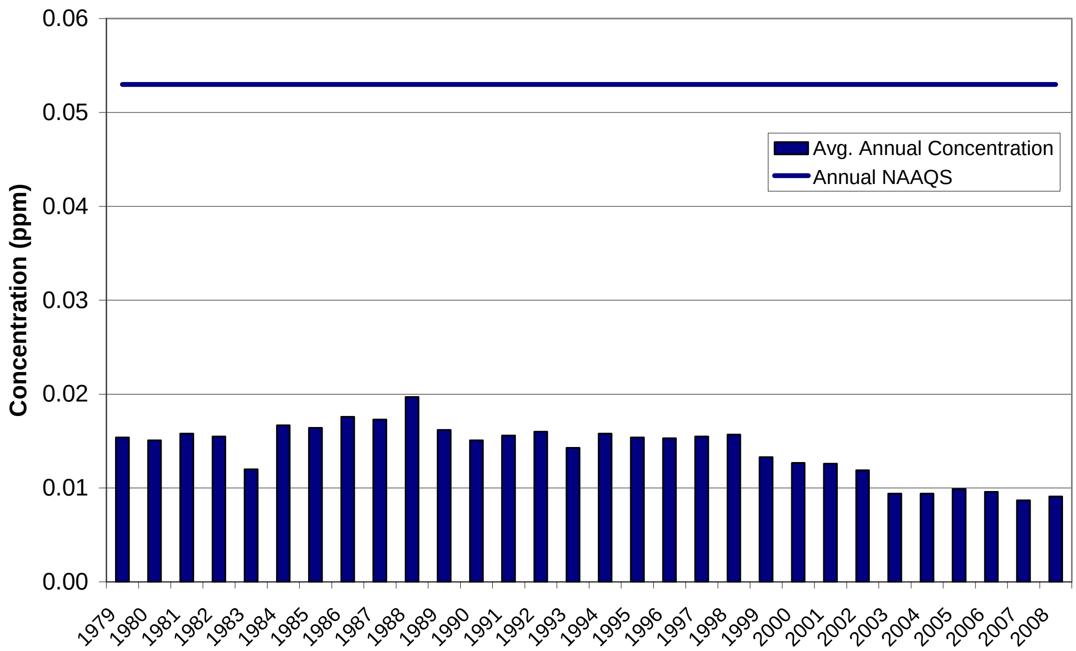


Figure 4-14. Regional average annual nitrogen dioxide (NO_2) concentrations, 1979-2008. Source: EPA AQS Database.

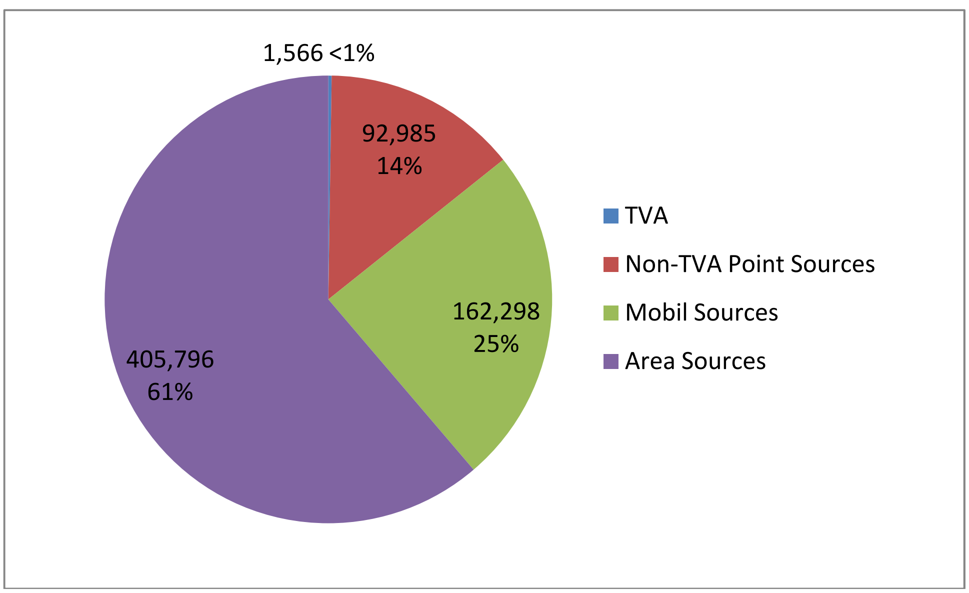


Figure 4-15. Volatile organic compounds emissions in the TVA region in tons and percent by source. Source: VISTAS (2009).

Ozone

Ozone is a gas that occurs both in the stratosphere (10 to 30 miles above the earth's surface) and at ground level where it is the main ingredient of smog. While stratospheric ozone is beneficial due to its role in absorbing ultraviolet radiation, ground-level ozone is an air pollutant that can damage lung tissue and harms vegetation. Ozone is a secondary pollutant which is not directly emitted by any source; it is formed by a chemical reaction between NOx and VOCs in the presence of sunlight. Because ozone formation is dependent on sunlight, ozone concentrations are highest during the summer and greater in areas with hot summers, such as the southeastern U.S.

On October 12, 2010, EPA published a final rule determining that that the former Knoxville non-attainment area had sufficient data to show compliance with the 1997 ozone standard, although as of late February 2011, EPA had not finalized the redesignation of the areas attainment status. In 2008 EPA lowered the ozone standard to 0.075 ppm, but it has not yet been implemented and EPA is currently reconsidering this standard. EPA is expected to promulgate a revised ozone standard between 0.060 and 0.070 ppm in the immediate future. Once the new ozone standard is implemented, many areas in the TVA region are expected to be designated as non-attainment areas for ozone.

Ozone concentrations are strongly impacted by meteorological conditions with higher ozone concentrations during hot, stagnant years and lower concentrations in wet, milder years. This causes a great deal of variability in ozone trends; despite this variability, average ozone concentrations have decreased about 11 percent over the past 30 years (Figure 4-16). However, additional reductions will be necessary in many areas to attain a NAAQS set below 0.075 ppm.

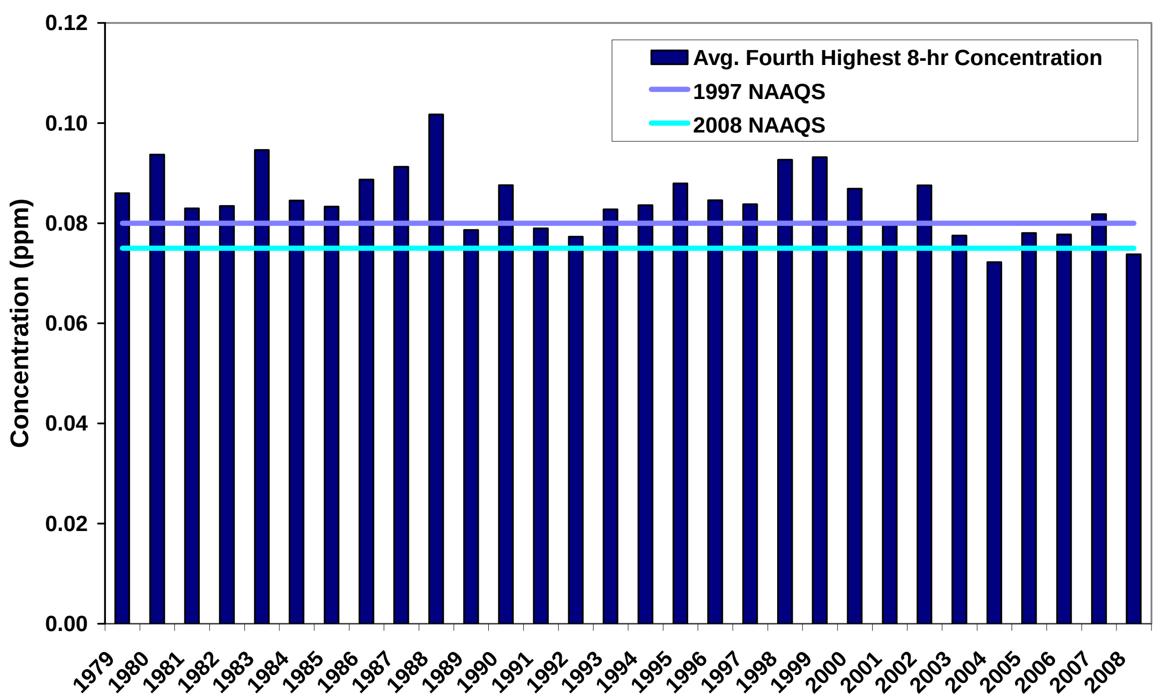


Figure 4-16. Regional average annual ozone concentrations, 1979 – 2008. Source: EPA AQS Database.

Particulate Matter

Particulate matter consists of small solid "dust" particles or liquid droplets–some just large enough to be seen with the naked eye, while others are too small to be seen without the aid of a microscope. The composition and shape of these particles varies greatly, as do their many sources. Particles emitted directly from a pollution source are called primary particles, whereas those formed after emission – by the chemical and physical conversion of gaseous pollutants – are called secondary particles. Generally speaking, primary particles tend to be larger, heavier and are deposited close to their source, while smaller, lighter, secondary particles may remain in the air for several days and can be transported long distances. Primary particle emissions are generally considered a local air quality issue, while secondary particles are a regional concern.

Fine particles have more adverse health impacts, since large particles are filtered by the nose and throat, but fine particles can be drawn deeper into the lungs (EPA 2009b). Exposure to high levels of fine particles can impact the respiratory and cardiovascular systems, particularly in elderly people and those with respiratory or cardiovascular disease. In addition to potential health effects, fine particles also contribute to acid deposition, visibility impairment, and hazardous air pollutants.

Particulate matter has many natural and human-made sources. Natural sources include wind-blown dust, forest fires, volcanoes, and ocean spray. Man-made sources include motor vehicles, fossil-fuel combustion, industrial processes, mining, agricultural activities, waste incineration, and construction. Area (non-point) sources, such as mining, agricultural and construction activities, contribute 55 percent of the primary fine particle ($PM_{2.5}$) emissions in the TVA region and non-TVA point sources, such as factories, waste incinerators, and power plants operated by other utilities, contribute 29 percent (Figure 4-17). TVA contributes 12 percent of the primary fine particles in the region, although TVA's SO_2 and NOx emissions also contribute to the formation of secondary particles.

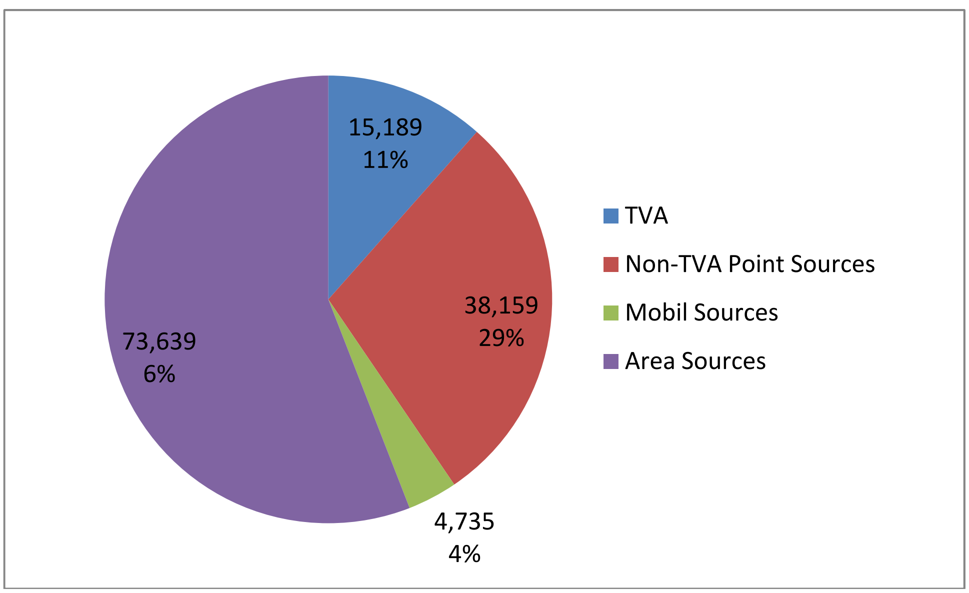
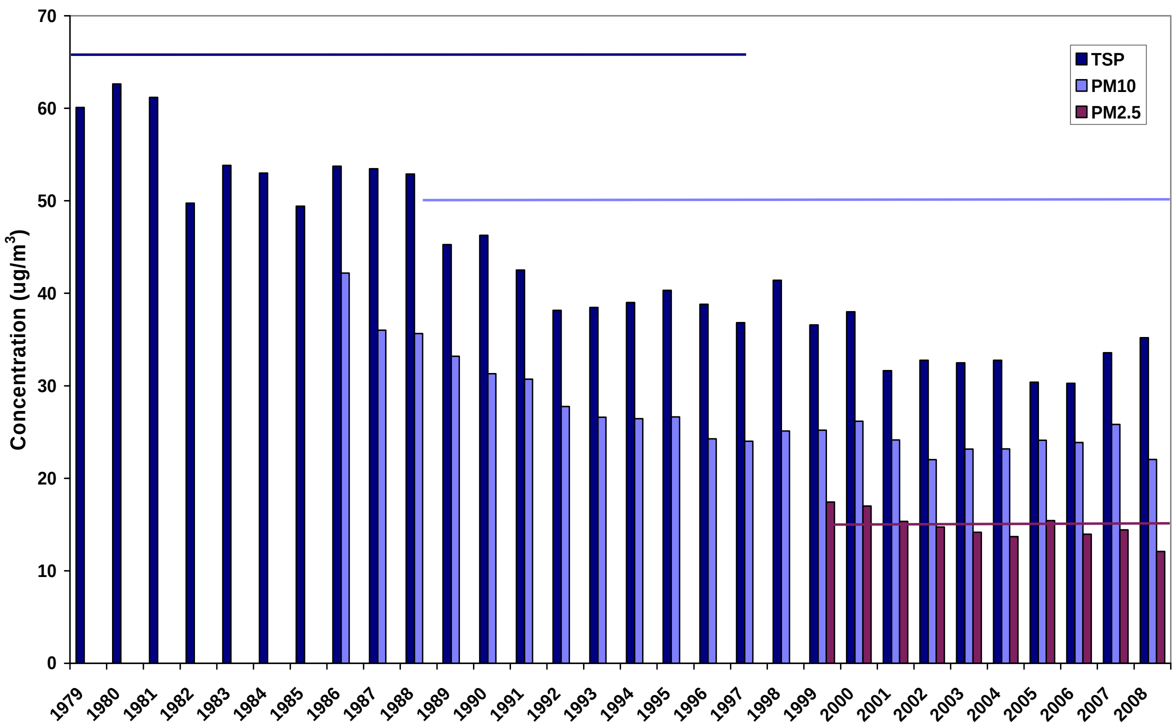


Figure 4-17. Fine particle ($PM_{2.5}$) primary emissions in the TVA region in tons and percent by source. Source: VISTAS (2009).

Particulate matter is regulated by size classes: total suspended particulates (TSP), particulate matter less than 10 micrometers in diameter (PM_{10}), and particulate matter less than 2.5 micrometers in diameter ($PM_{2.5}$). These regulations have evolved over the past 40 years to become more stringent and to place more importance on fine particles. The first NAAQS for particulate matter established in 1971 was based on total suspended particulates (TSP). In 1987 the PM_{10} NAAQS was added; in 1997 the $PM_{2.5}$, NAAQS was added and the TSP NAAQS was dropped.

Particulate levels have steadily decreased over the past 30 years. Annual average TSP concentrations decreased by more than 44 percent between 1979 and 2007 and annual average PM_{10} levels decreased by 48 percent between 1986 and 2008 (Figure 4-18).



TSP=Total suspended particles
PM_{10}=Particulates less than 10 micrometers in size
$PM_{2.5}$=Particulates less than 2.5 micrometers in size

Figure 4-18. Regional average annual particle concentrations, 1979 – 2008. Source: EPA AQS Database.

In the past decade, as the monitoring network for $PM_{2.5}$ has greatly expanded, the number of TSP and PM_{10} monitors has declined and these monitors are now primarily located near large industrial sources and are less representative of regional air quality than they once were. This accounts for the fact that TSP and PM_{10} concentrations appear not to have declined, but in some cases, have increased slightly in the past several years. Recently, the focus of regional particulate monitoring has shifted to fine particles ($PM_{2.5}$). There are two NAAQS for $PM_{2.5}$: an annual standard and a 24-hr standard. From 1999 to 2008, annual average fine particle concentrations decreased 31 percent and 24-hr average concentrations decreased 33 percent (Figure 4-19). Particulate levels are strongly influenced by weather patterns, so there is considerable fluctuation from year to year, but the trend of declining particulate levels is still apparent.

All or parts of several counties in the vicinity of Chattanooga and Knoxville are designated as non-attainment for $PM_{2.5}$ (Figure 4-8).

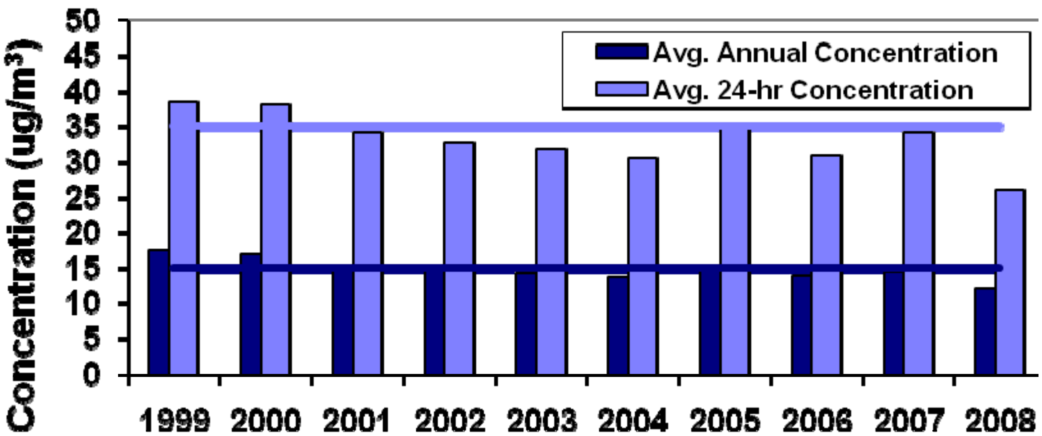


Figure 4-19. Regional average annual fine particle ($PM_{2.5}$) concentrations, 1999 – 2008. Source: EPA AQS Database.

Carbon Monoxide

Carbon monoxide (CO) is a colorless and odorless gas formed when carbon in fuel is not burned completely. At high concentrations, CO can aggravate heart disease and even cause death. Major CO sources include motor vehicles, off-road sources (i.e., construction equipment, airplanes and trains), metals processing and chemical manufacturing. The primary natural source of CO is wildfires. Electric utilities are not a major source of CO emissions and account for 1 percent of the total CO emissions in the United States.

There are two CO air quality standards: one-hour and eight-hour. From 1979 to 2008, regional average one-hour concentrations decreased by 69 percent, and eight-hour concentrations decreased by 73 percent (Figure 4-20). Regional average concentrations are well below both standards and there are no CO non-attainment areas in the TVA region, though a monitoring station in Birmingham, Alabama exceeded the level of the 8-hour standard in 2006.

Lead

Lead is a naturally occurring metal and exposure to lead can adversely affect the nervous system, kidneys and the cardiovascular system. There has been particular concern over neurological effects on children from exposure to lead-based paint in older homes. For many years, lead was added to gasoline to increase engine performance and the primary source of human-made lead emissions was motor vehicles.

Lead in gasoline was phased out during the 1980s and early 1990s, and currently, the largest sources of lead emissions are metals processors, battery manufacturers and waste incinerators. Coal contains small amounts of lead, and TVA emits about 5,000 pounds of lead per year, which is about 2 percent of lead emissions in the southeastern U.S.

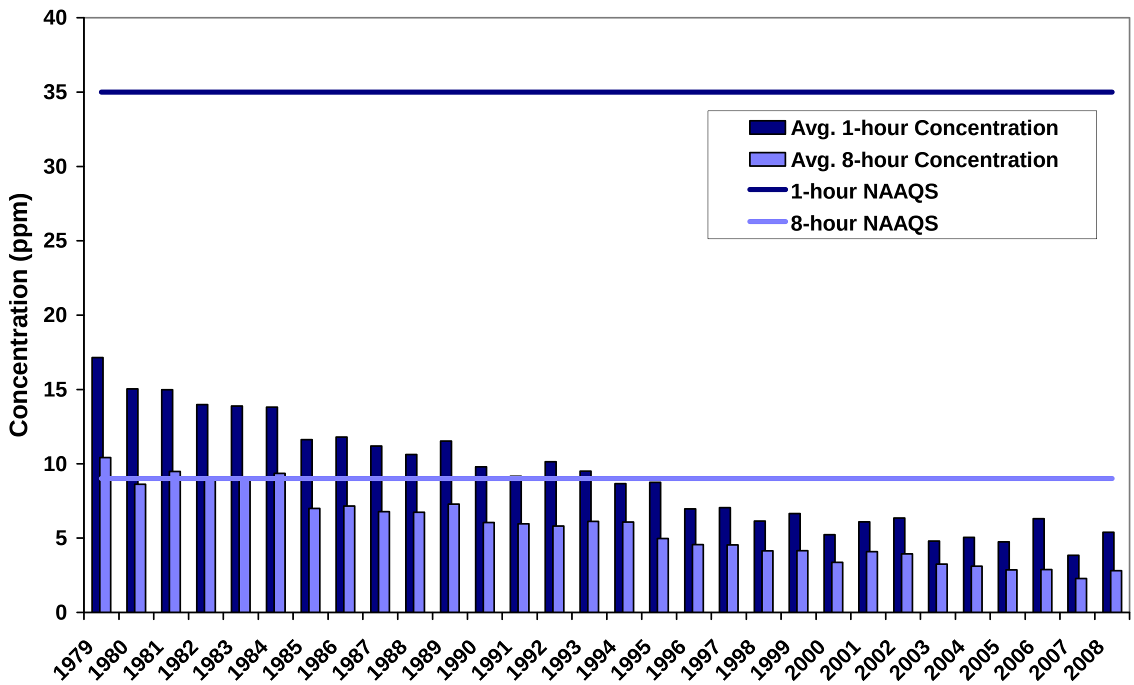


Figure 4-20. Regional average annual carbon monoxide concentrations, 1979 – 2008. Source: EPA AQS Database.

Regional lead concentrations increased through the early 1990s, primarily due to increases in the number of motor vehicles and miles driven. Following the phase-out of leaded gasoline, concentrations decreased 64 percent from the peak in 1993 to 2008 (Figure 4-21).

There are currently two non-attainment areas for lead in the vicinity of the TVA region. One, designated under an early lead standard, is associated with a lead smelting operation in Herculaneum, Missouri. Part of Sullivan County, Tennessee was designated non-attainment in November, 2010 under the more stringent lead standard based on the 3-month rolling average lead concentration established in October 2008. An EPA analysis indicated that nationwide, approximately 40 percent of the counties with a lead monitor are likely to exceed the new lead NAAQS (EPA 2008c). There are very few lead monitors currently operating in the U.S. and the new NAAQS will require additional monitors in the vicinity of large lead sources and large urban areas. Therefore, additional non-attainment areas will likely be designated after data are available from the expanded monitoring network.

Hazardous Air Pollutants (HAPs)

Hazardous air pollutants (HAPs) are toxic air pollutants, which are known or suspected to cause cancer or other serious health effects or adverse environmental effects. The Clean Air Act regulates 187 pollutants as HAPs. Most HAPs are emitted by human-activity, including motor vehicles, factories, refineries, and power plants.

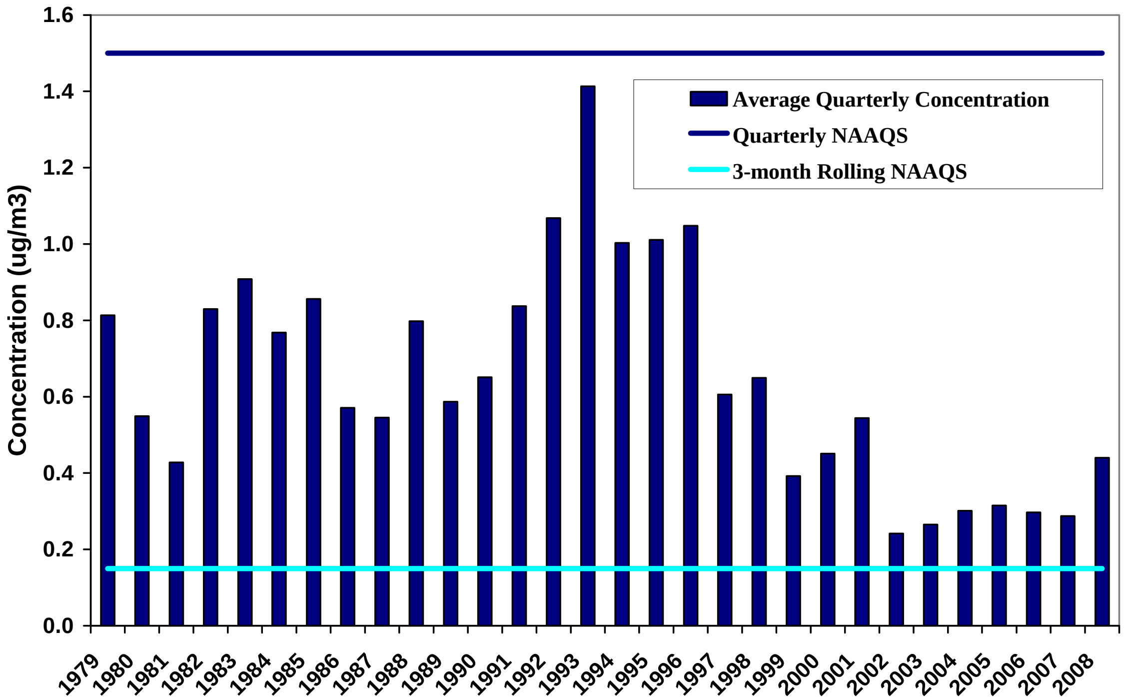


Figure 4-21. Regional average annual lead concentrations, 1979 – 2008. Source EPA AQS Database.

There are also indoor sources of HAPs which include building materials and cleaning solvents. Some HAPs are emitted by natural sources, such as volcanic eruptions and forest fires. Exposure to HAPs can result from breathing air toxics, drinking water in which HAPs have deposited, or eating food that has been exposed to HAPs deposition on soil or water. Exposure to high levels of HAPs can cause various harmful health effects including cancer, chronic and acute health effects. The level of exposure which may result in adverse health impacts varies for each pollutant.

EPA established the Toxic Release Inventory (TRI) under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA) and expanded it under the Pollution Prevention Act of 1990. TRI is a database containing information on toxic chemical releases and waste management activities for nearly 650 chemicals. TRI air emissions decreased 20 percent from 2001 to 2007, when they accounted for 32 percent of all TRI emissions (EPA 2009c). In 2008, TVA emitted just over 28 million pounds of TRI pollutants to the air (Figure 4-22). Acid gases (sulfuric acid, hydrochloric acid and hydrofluoric acid) accounted for 99 percent of these emissions. The remaining one percent was made up of heavy metals, such as arsenic, barium, chromium, copper, lead, manganese, mercury, nickel, vanadium and zinc, as well as very small amounts of organic compounds, such as benzoperylene, dioxin, naphthalene and polycyclic aromatic hydrocarbons. TVA reduced its TRI air emissions by 46 percent from 1999 to 2008 (Figure 4-22).

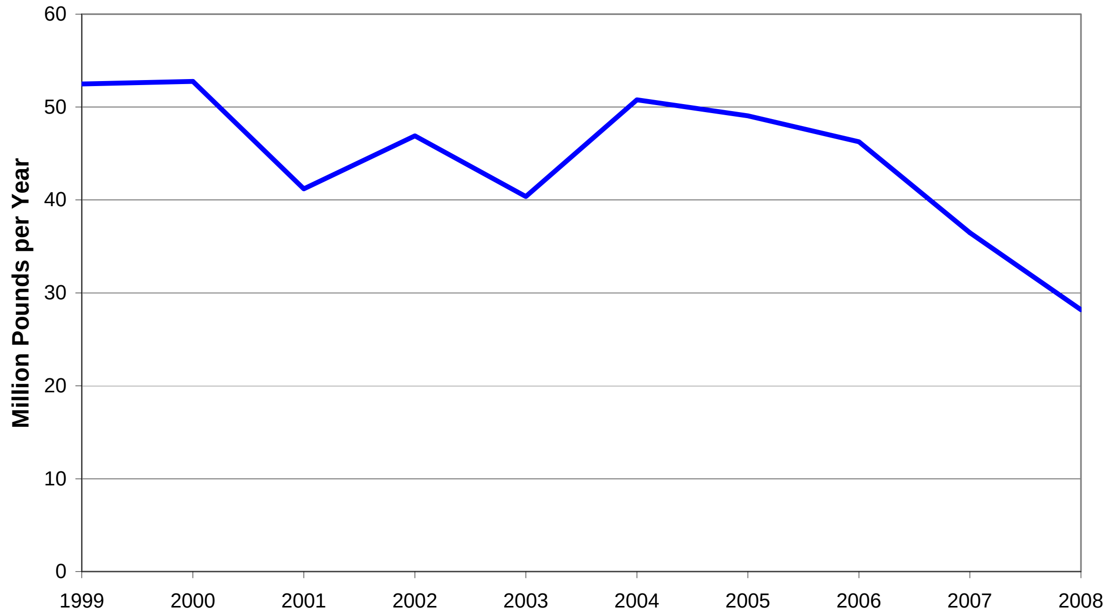


Figure 4-22. TVA Toxic Release Inventory (TRI) air emissions, 1999 – 2008. Source: TVA Form R Submittal to EPA TRI Database.

Mercury

Mercury is a naturally occurring element found in many rocks and minerals, including coal; when coal is burned, naturally occurring inorganic mercury is released into the air. Mercury emissions in the air can travel very long distances before being deposited in lakes, streams, and oceans. Once deposited, micro-organisms convert inorganic mercury to organic mercury, primarily methyl-mercury, which is a more toxic form of mercury. As fish consume these micro-organisms, they also consume increasing amounts of methyl-mercury, which is then cycled through the food chain. Large fish, birds, and mammals, including humans, can accumulate significant amounts of methyl-mercury in their bodies if they eat fish often (especially large ocean species, such as shark and swordfish). At high levels, methyl-mercury can cause neurological effects and harm the heart, lungs, liver, kidneys, and stomach. Risks to young children and developing fetuses are particularly of concern and EPA and the Food and Drug Administration have issued a joint advisory recommending that people limit their consumption of certain fish and shellfish (EPA 2004). Advisories on fish consumption due to mercury have been issued for some TVA region rivers and reservoirs (see Section 4-6).

Mercury is transported globally and about 8 percent of global mercury emissions are emitted from North America (UNEP Chemicals Branch 2008). Mercury is emitted by coal-fired power plants, municipal and medical waste incinerators, chlorine manufacturers, and mining of metals. Natural sources of atmospheric mercury include volcanoes, as well as evaporation from naturally enriched soils and water bodies. Re-emissions of previously deposited mercury can also be a significant source. TVA's mercury emissions decreased by 32 percent from nearly 4,400 pounds in 2000 to just under 3,000 pounds in 2008 (Figure 4-23).

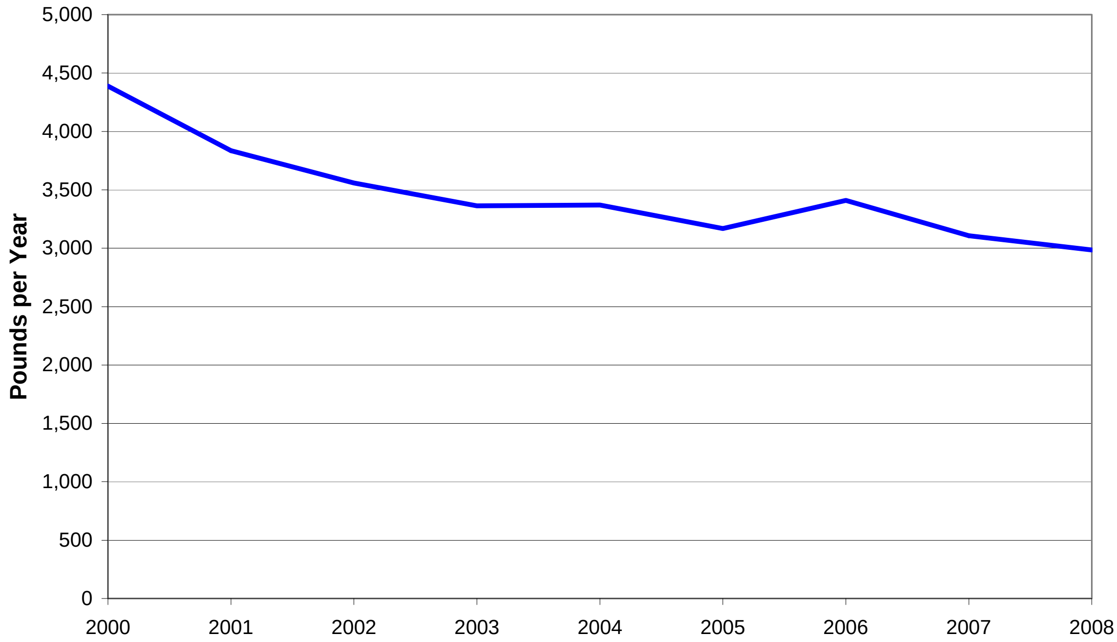


Figure 4-23. TVA mercury air emissions, 2000 – 2008. Source: TVA Form R Submittal to EPA TRI Database.

Deposition occurs in two forms: wet (dissolved in rain, snow or fog) and dry (solid and gaseous particles deposited on surfaces during periods without precipitation). Wet mercury deposition is measured at Mercury Deposition Network monitors operated by National Atmospheric Deposition Program. Dry deposition is not directly measured. The highest wet deposition of mercury in the U.S. occurs in south-central and southeastern states (Figure 4-24). Mercury deposition in the TVA region ranges from 8 to 12 micrograms per square meter, which is in the middle range for eastern North America.

The Mercury Deposition Network has operated monitors since 2001. The monitoring results for sites in the vicinity of the TVA region do not show a clear trend (Figure 4-25) and there is a large amount of variation due to the influence of seasonal variation and meteorological conditions on mercury deposition.

Acid Deposition

Acid deposition, also called acid rain, is primarily caused by SO_2 and NOx emissions which are transformed into sulfate (SO_4) and nitrate (NO_3) aerosols. Acid deposition causes acidification of lakes and streams in sensitive ecosystems which can have an adverse impact on aquatic life. Acid deposition can also reduce agricultural and forest productivity. Some ecosystems, such as high elevation spruce-fir forests in the southern Appalachians, are quite sensitive to acidification, while other ecosystems have more buffering capacity and are less sensitive to the effects of acid deposition. The acidity of precipitation (rain, snow, or fog) is typically expressed on a logarithm scale called pH which ranges from 0 to 14 with 7 being neutral. pH values less than 7 are considered acidic and values greater than 7 are considered basic or alkaline. It is thought that the average pH of pre-industrial rainfall in the eastern United States was approximately 5.0 (Charlson and Rodhe 1982).

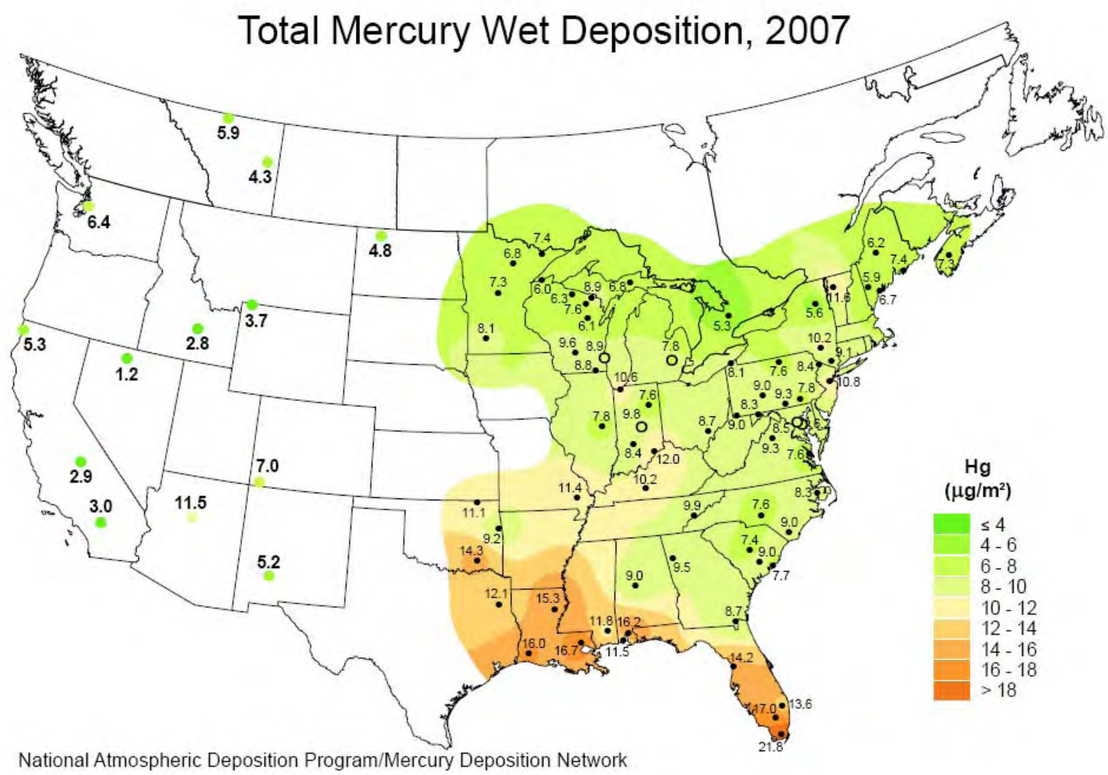


Figure 4-24. Total mercury wet deposition, 2007. Source: National Atmospheric Deposition Program / Mercury Deposition Network.

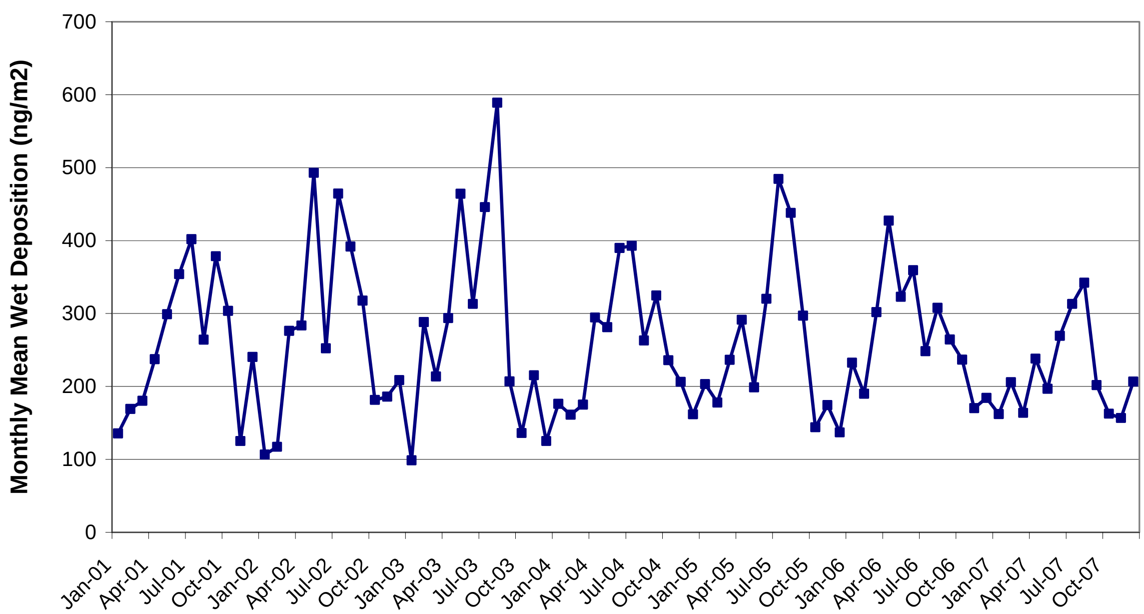


Figure 4-25. Average mercury wet deposition in the TVA region, 2001 – 2007. Source: National Atmospheric Deposition Program / Mercury Deposition Network.

A historic average pH of 5.0 is considerably lower than the pH of rainfall in the TVA region in recent years (Figure 4-26). Because pH is a logarithm, it must be converted to the hydrogen ion concentration in order to calculate percent changes. Across the region, there has been a 42 percent improvement in hydrogen ion concentration from 1979 to 2008 and a 55 percent improvement since 1985.

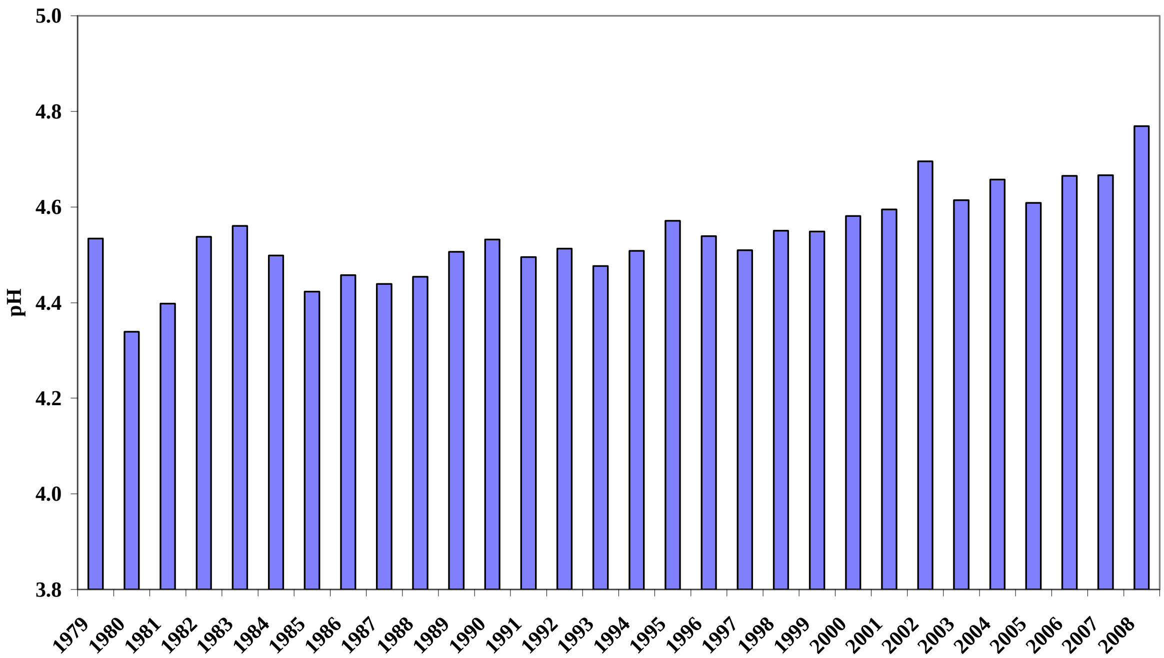
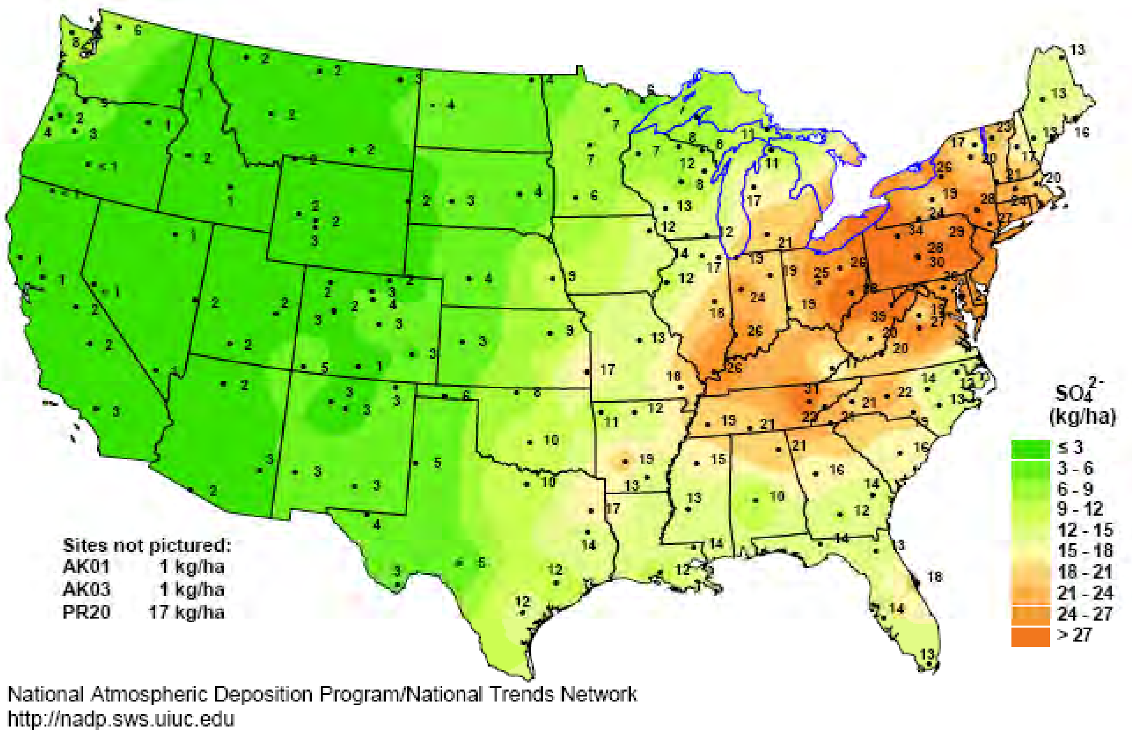


Figure 4-26. Acid deposition trends in the TVA region, 1979 – 2008. Source: National Atmospheric Deposition Program.

As previously shown in Figures 4-9, 4-10, 4-12 and 4-13, TVA currently emits 59 percent of the SO_2 emissions and 10 percent of the NOx emissions in the region and has reduced its SO_2 emissions by 85 percent since 1974 and reduced its NOx emissions by 68 percent since 1995.

The 1990 Clean Air Act Amendments established the Acid Rain Program to reduce SO_2 and NOx emissions and the resulting acid deposition. Since this program was implemented in 1995, reductions in SO_2 and NOx emissions have contributed to significant reductions in acid deposition, concentrations of $PM_{2.5}$ and ground-level ozone, and regional haze. Figure 4-27 illustrates the decrease in sulfate deposition between 1994, prior to the implementation of the Acid Rain Program, and 2007. These figures show a reduction in both the magnitude of sulfate deposition and the size of the impacted area.



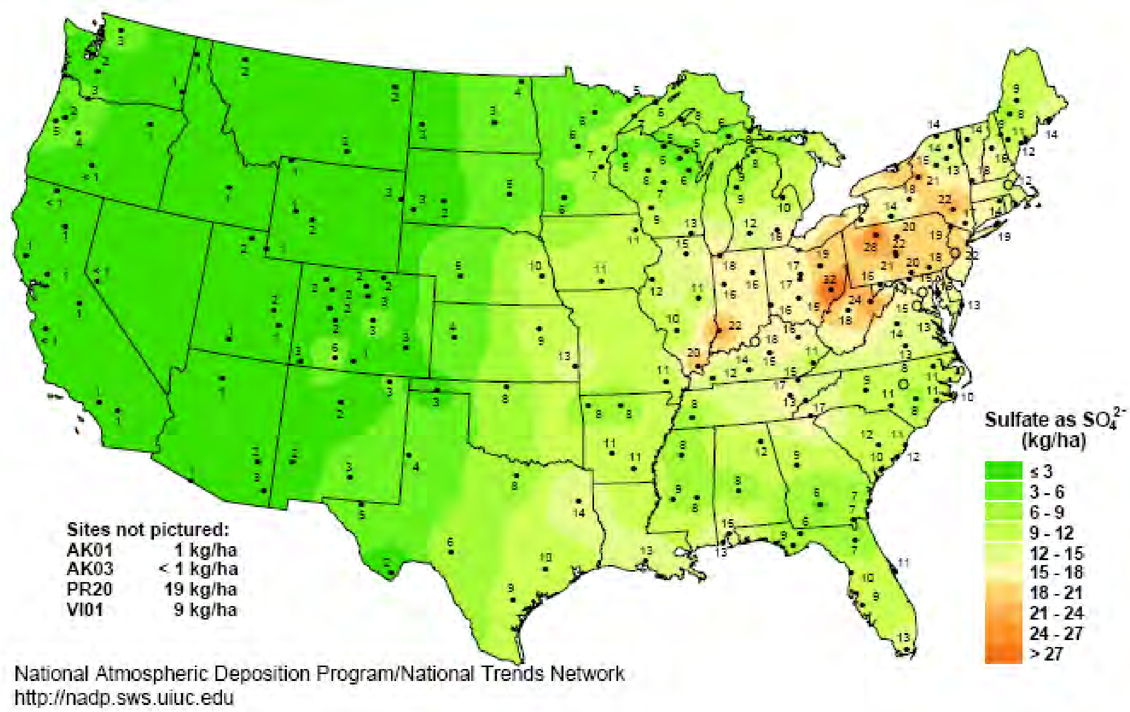


Figure 4-27. United States sulfate (SO_4) deposition in 1994 (top) and 2007 (bottom). Source: National Atmospheric Deposition Program / National Trends Network.

Visibility

Air pollution can impact visibility, which is a particularly important issue in national parks and wilderness areas where millions of visitors expect to be able to enjoy scenic views. Historically, “visibility” has been defined as the greatest distance at which an observer can see a black object viewed against the horizon sky. However, visibility is more than just a measurement of how far an object can be seen; it is a measurement of the conditions that allow appreciation of the inherent beauty of landscape features.

Visibility in the eastern United States is estimated to have declined by as much as 60 percent in the second half of the 20th century (EPA 2001). Visibility impairment is caused when sunlight is scattered or absorbed by fine particles of air pollution obscuring the view. Some haze-causing particles are emitted directly to the air, while others are formed when gases are transformed into particles. In the TVA region, the largest contributor to visibility impairment is ammonium sulfate particles which are formed from SO_2 emissions (primarily from coal-fired power plants). Other particles impacting visibility include nitrates (from motor vehicles, utilities, and industry), organic carbon (predominantly from motor vehicles), elemental carbon (from diesel exhaust and wood burning), and dust (from roads, construction and agricultural activities). Visibility extinction is a measure of the ability of particles to scatter and absorb light and is expressed in units of inverse mega-meters (Mm^{-1}). The chemical composition of visibility extinction varies by season as well as degree of visibility impairment. Figure 4-28 shows the chemical composition of visibility extinction in the Great Smoky Mountains National Park on the 20 percent best days and the 20 percent worst days in 2007 (IMPROVE 2007). On the best days (Figure 4-28, top), 56 percent of the visibility extinction was due to ammonium sulfate, 17 percent due to ammonium nitrate and 14 percent due to organic carbon. On the 20 percent worst days (Figure 4-28, bottom), ammonium sulfate contributed nearly 80 percent of the visibility extinction and organic carbon was still about 14 percent, while ammonium nitrate dropped to 1.3 percent.

The Clean Air Act designated national parks greater than 6,000 acres and wilderness areas greater than 5,000 acres as Class I areas in order to protect their air quality under more stringent regulations. There are eight Class I areas in the vicinity of the TVA region: Great Smoky Mountains National Park, Mammoth Cave National Park and Joyce Kilmer, Shining Rock, Linville Gorge, Cohutta, Sipsey, and Upper Buffalo Wilderness Areas (Figure 4-29). In 1999, EPA promulgated the Regional Haze Rule to improve visibility in Class I areas. This regulation requires states to develop long-term strategies to improve visibility with the ultimate goal of restoring natural background visibility conditions by 2064. Visibility trends are evaluated using the average of the 20 percent worst days and the 20 percent best days with the goal of improving conditions on the 20 percent worst days, while preserving visibility on the 20 percent best days. From 1990 to 2007, there has been a 30 percent improvement in the visibility on the worst days and a 12 percent improvement on the best days at Class I areas in and near the TVA region (Figure 4-30).

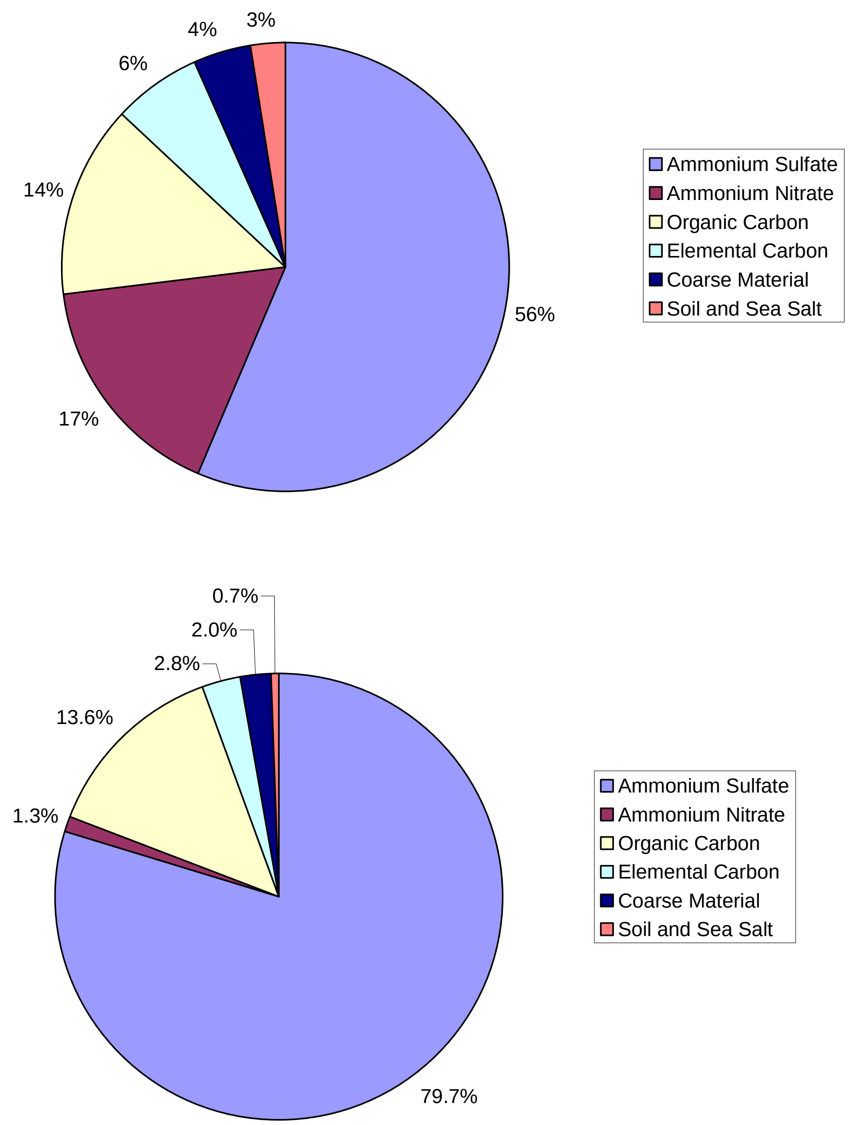


Figure 4-28. Composition of visibility extinction at Great Smoky Mountains National Park on the best 20% days (top) and the worst 20% days (bottom). Source: IMPROVE 2007.

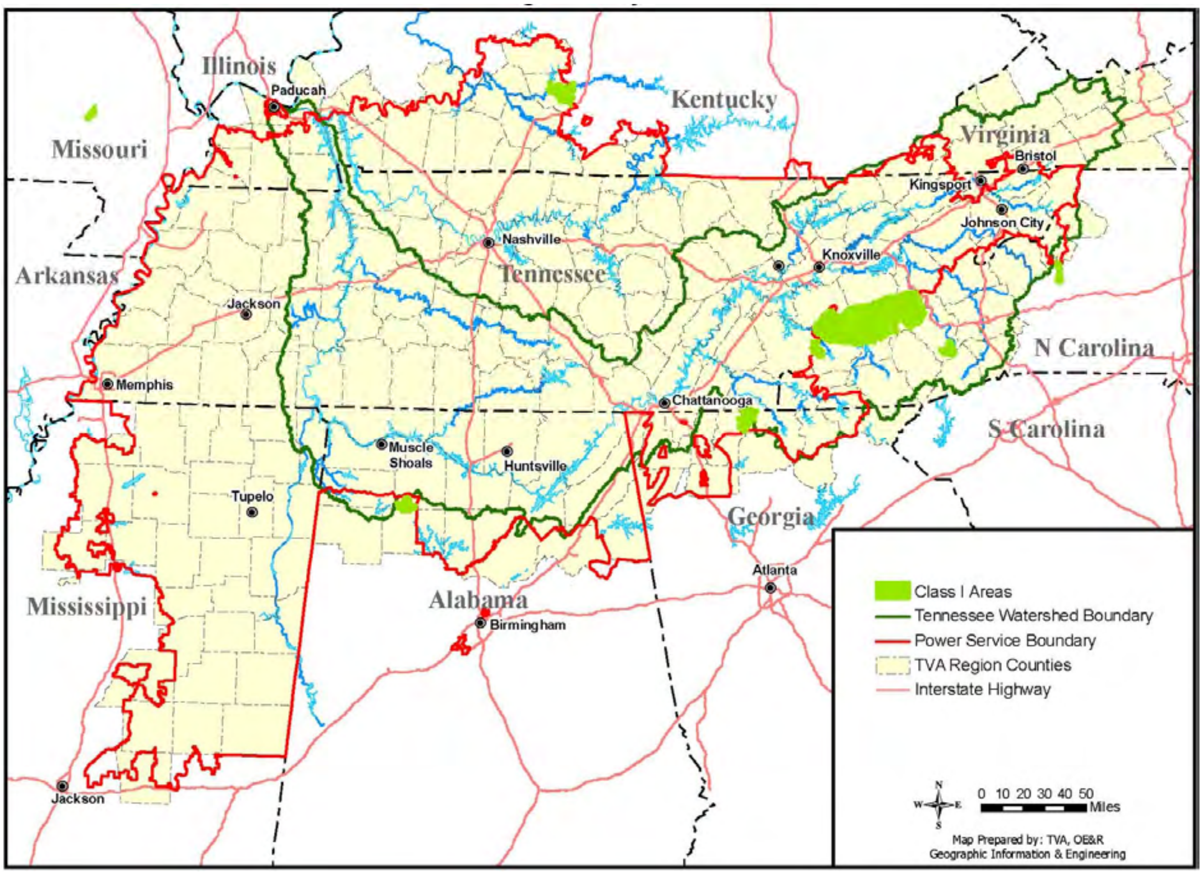


Figure 4-29. Class I areas in and near the TVA region.

4.4. Regional Geology

The TVA region encompasses portions of five major physiographic provinces and six smaller physiographic sections (Figure 4-31) (Fenneman 1938, Miller 1974). Physiographic provinces and sections are areas of similar land surfaces resulting from similar geologic history.

The easternmost part of the region is in the Blue Ridge physiographic province, an area composed of the remnants of an ancient mountain chain. This province has greater variation in terrain in the TVA region. Terrain ranges from nearly level along floodplains at elevations of about 1,000 feet to rugged mountains that reach elevations of more than 6,000 feet. The rocks of the Blue Ridge have been subjected to much folding and faulting and are mostly shales, sandstones, conglomerates, and slate (sedimentary and metamorphic rocks of Precambrian and Cambrian age – from over a billion to about 500 million years ago).

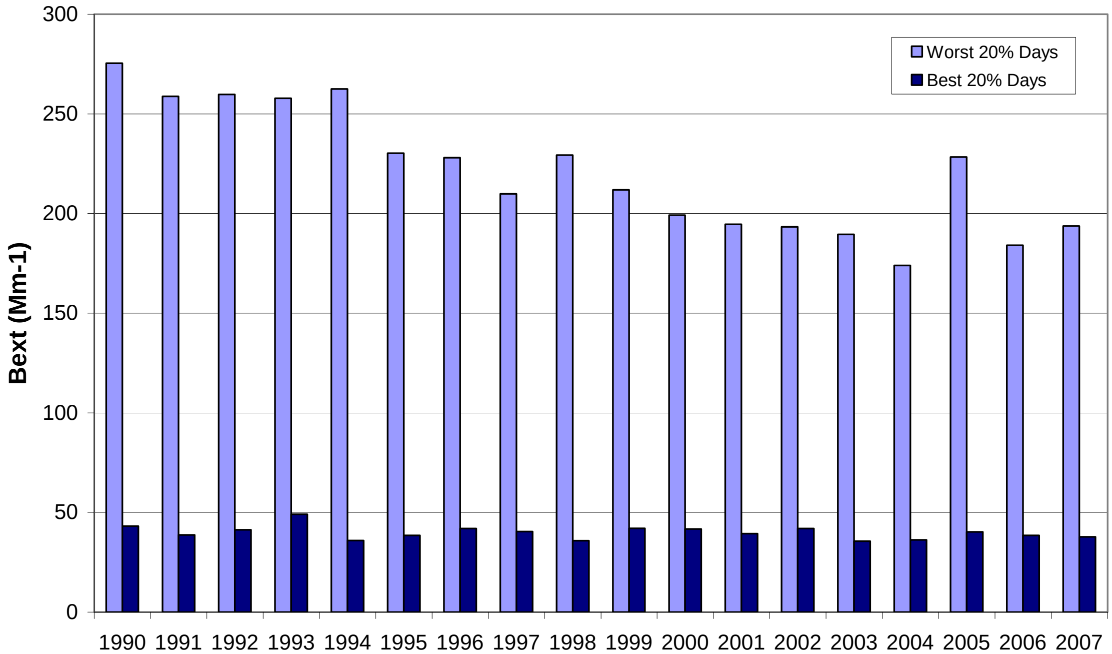


Figure 4-30. Average annual visibility extinction in and near the TVA region on the worst 20% days and the best 20% days, 1990-2007. Source: IMPROVE Program.

Located east of the Appalachian Plateaus and west of the Blue Ridge, the Valley and Ridge Province has complex folds and faults with alternating valleys and ridges trending northeast to southwest. Ridges have elevations of up to 3,000 feet and are generally capped by dolomites and resistant sandstones, while valleys have developed in more soluble limestones and dolomites. The dominant soils in this province are residual clays and silts derived from in-situ weathering. Karst features such as sinkholes and springs are numerous in the Valley and Ridge. “Karst” refers to a type of topography that is formed when rocks with a high carbonate (CO_3) content, such as limestone and dolomite, are dissolved by groundwater to form sink holes, caves, springs, and underground drainage systems.

The Appalachian Plateaus Province is an elevated area between the Valley and Ridge and Interior Low Plateaus provinces. It is comprised of two sections in the TVA region, the extensive Cumberland Plateau section and the smaller Cumberland Mountain section. The Cumberland Plateau rises about 1,000 to 1,500 feet above the adjacent provinces and is formed by layers of near horizontal Pennsylvanian sandstones, shales, conglomerates, and coals, underlain by Mississippian and older shale and limestones. The sandstones are resistant to erosion and have produced a relatively flat landscape broken by stream valleys. Towards the northeast, the Cumberland Mountain section is more rugged due to extensive faulting and several peaks exceed 3,000 feet elevation. The province has a long history of coal mining and encompasses the Appalachian coal region (USGS 1996). Coal mining has historically occurred in much of the province. The most recent Appalachian coal mining within the TVA region has been from the southern end of the province in Alabama, the northern portion of the Cumberland Plateau section in Tennessee, and the Cumberland Mountain section. Two sections of the Interior Low Plateaus Province occur in the TVA region. The Highland Rim section is a plateau that occupies much of central Tennessee

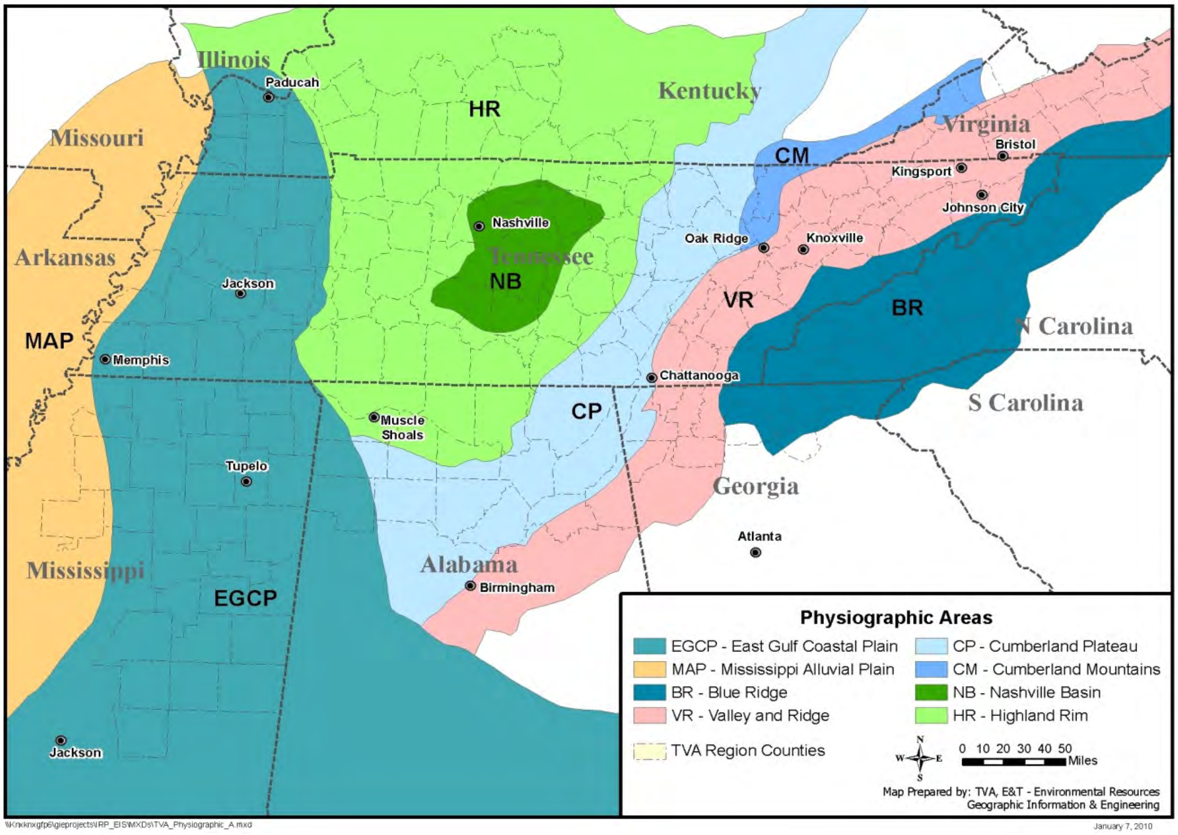


Figure 4-31. Physiographic areas of the TVA region. Adapted from Fenneman (1938).

and parts of Kentucky and northern Alabama. The bedrock of the Highland Rim is Mississippian limestones, chert, shale and sandstone. The terrain varies from hilly to rolling to extensive relatively flat areas in the northwest and southeast. The southern end of the Illinois Basin coal region (USGS 1996) overlaps the Highland Rim in northwest Kentucky and includes part of the TVA region. The Nashville Basin (also known as the Central Basin) section is an oval area in middle Tennessee lying about 200 feet below the surrounding Highland Rim. The bedrock is limestones that are generally flat-lying.

Soil cover is usually thin and surface streams cut into bedrock. Karst is well-developed in parts of both the Highland Rim and the Nashville Basin.

The Coastal Plain Province encompasses much of the western and southwestern TVA region (Figure 4-31). Most of the Coastal Plain portion of the TVA region is in the extensive East Gulf Coastal Plain section. The underlying geology is a mix of poorly consolidated gravels, sands, silts, and clays. Soils are primarily of windblown and alluvial (deposited by water) origin, low to moderate fertility, and easily eroded. The terrain varies from hilly to flat in broad river bottoms. The Mississippi Alluvial Plain section occupies the western edge of the TVA region and much of the historic floodplain of the Mississippi River. Soils are deep and often poorly drained. The New Madrid Seismic Zone, an area of large prehistoric and historic earthquakes, is in the northern portion of the section.

Geologic Carbon Dioxide Sequestration Potential

The sequestration (i.e., capture and permanent storage) of CO_2 from large stationary point sources, such as coal-fired power plants, is potentially an important component of efforts to significantly reduce anthropogenic CO_2 emissions. Successful large-scale, economical, CO_2 sequestration (also referred to as carbon capture and storage (CCS)) would enable coal to continue to be used as an energy source if the decision is made to reduce CO_2 emissions. There are, however, significant technical and legal issues associated with establishing CCS as a viable CO_2 reduction technique.

Geologic CO_2 storage involves capturing and separating the CO_2 from the power plant exhaust, drying, purifying, and compressing the CO_2, and transporting it by pipeline to the storage site where it is pumped through wells into deep geological formations. When the CO_2 capacity of the formation has been reached, or when the pressure of the formation or injection well has reached a pre-determined level, CO_2 injection is stopped and the wells are permanently sealed. The storage site would then be monitored for a period of time.

The suitability of a particular deep underground formation for CO_2 storage depends on its and the surrounding geology. In the continental and southeastern U.S., deep saline formations, unmineable coal seams, and oil and gas fields are considered to have the best potential to store CO_2 from large point sources (NETL 2008). A brief description of each of these formations is given below.

<u>Saline Formations</u>. Saline formations are layers of porous rock that are saturated with brine. They are more extensive than unmineable coal seams and oil and gas fields and have a high CO_2 storage potential. However, because they are less studied than the other two formations, less is known about their suitability and storage capacity. Potentially suitable saline formations are capped by one of more layers of non-porous rock, which would prevent the upward migration of injected CO_2. Saline formations also contain minerals that could react with injected CO_2 to form solid carbonates, further sequestering the CO_2.

<u>Unmineable Coal Seams</u>. Unmineable coal seams are typically too deep or too thin to be economically mined. When CO_2 is injected into them, it is adsorbed onto the surface of the coal. Although their storage potential is much lower than saline formations, they are attractive because the injected CO_2 can be used to displace coalbed methane, which can be recovered in adjacent wells and used as a natural gas substitute.

<u>Oil and Gas Fields</u>. Mature oil and gas fields/reservoirs are considered good storage formations because they held crude oil and natural gas for millions of years. Their storage characteristics are also well known. Like saline formations, they consist of layers of permeable rock with one or more layers of cap rock. Injected CO_2 can also enhance the recovery of oil or gas from mature fields.

Geologic Storage Potential in the TVA Region

In 2002, the Department of Energy's National Energy Technology Laboratory launched the Regional Carbon Sequestration Program to identify and evaluate carbon sequestration in different regions of the country. TVA, along with other agencies and utilities, is a participant in the program's Southeast Regional Carbon Sequestration Partnership (SECARB). This group used screening criteria for identifying potentially suitable deep, underground geologic formations for CO_2 storage (Smyth et al. 2007, NETL 2008). Using publicly available information, SECARB characterized the geologic sequestration potential in the TVA region and adjacent areas in Phase I of this program. The Midwest Geological Sequestration Consortium is conducting similar studies in the Illinois Basin area of Illinois, Indiana, and Kentucky. Following is a brief description the results of these studies. Suitable or potentially suitable geologic formations occur at or near TVA's Gallatin, Paradise, and Johnsonville Fossil Plants.

<u>Saline Formations</u>. Middle Tennessee is underlain by the Mt. Simon formation (Figure 4--32), a saline formation with a depth of 3,940 to 7,880 feet (1,200 to 2,400 meters) and average thickness of 100 feet (30 meters). The estimated storage capacity of the Mt. Simon is 2.5 gigatons (2.5 billion tons) of CO_2 (NETL 2008). To put this in perspective, a 1,000 MW coal-fired power plant emits about 7 million tons of CO_2 per year. The Mt. Simon formation may extend into northern Alabama and Kentucky, but its CO_2 storage potential has not been assessed in these areas. The Gallatin plant is located above the Mt. Simon formation and the potential to store CO_2 directly below or near the plant is considered good. If the Mt. Simon extends into northwest Alabama and it is still at a sufficient depth for CO_2 storage (below 800 meters), then it may be suitable for storing CO_2 from Colbert Fossil Plant. Although Cumberland Fossil Plant is underlain by the Mt. Simon, its potential to store CO_2 under or near the plant is low because of the structural complexity of the surrounding Wells Creek meteor impact crater.

The Knox formation below the Paradise plant and the Knox and Mt. Simon formations below the Johnsonville plant are considered to have good potential for CO_2 storage due to their geological characteristics (NETL 2008). Although saline formations occur in the vicinity of Allen and Shawnee Fossil Plants, their sequestration potential is considered low due to their proximity to the New Madrid Seismic Zone.

Other saline formations in or near the TVA region with the potential to store CO_2 include the Knox Group in eastern Kentucky and the extensive Tuscaloosa Group in southwest Alabama, southern Mississippi, and western Florida (NETL 2008). These formations are not close to any TVA fossil plants and pipelines would have to be built to transport the CO_2 from TVA plants to these formations.

<u>Unmineable Coal Seams</u>. The only TVA coal plant in the immediate vicinity of assessed coal seams is Paradise (Figure 4-33). Due to the nature of these seams, their potential to store CO_2 is considered low (NETL 2008). Potentially suitable coal seams occur elsewhere in the Illinois Basin, as well as in southeast Kentucky/southwest Virginia, west-central Alabama, and southwest Mississippi. The use of these formations to store CO_2 from TVA plants would require the construction of pipelines.

<u>Oil and Gas Fields</u>. No suitable or potentially suitable oil and gas fields occur in the immediate vicinity of TVA's fossil plants (Figure 4-34). The use of oil and gas fields to store CO_2 from TVA plants would require the construction of pipelines.

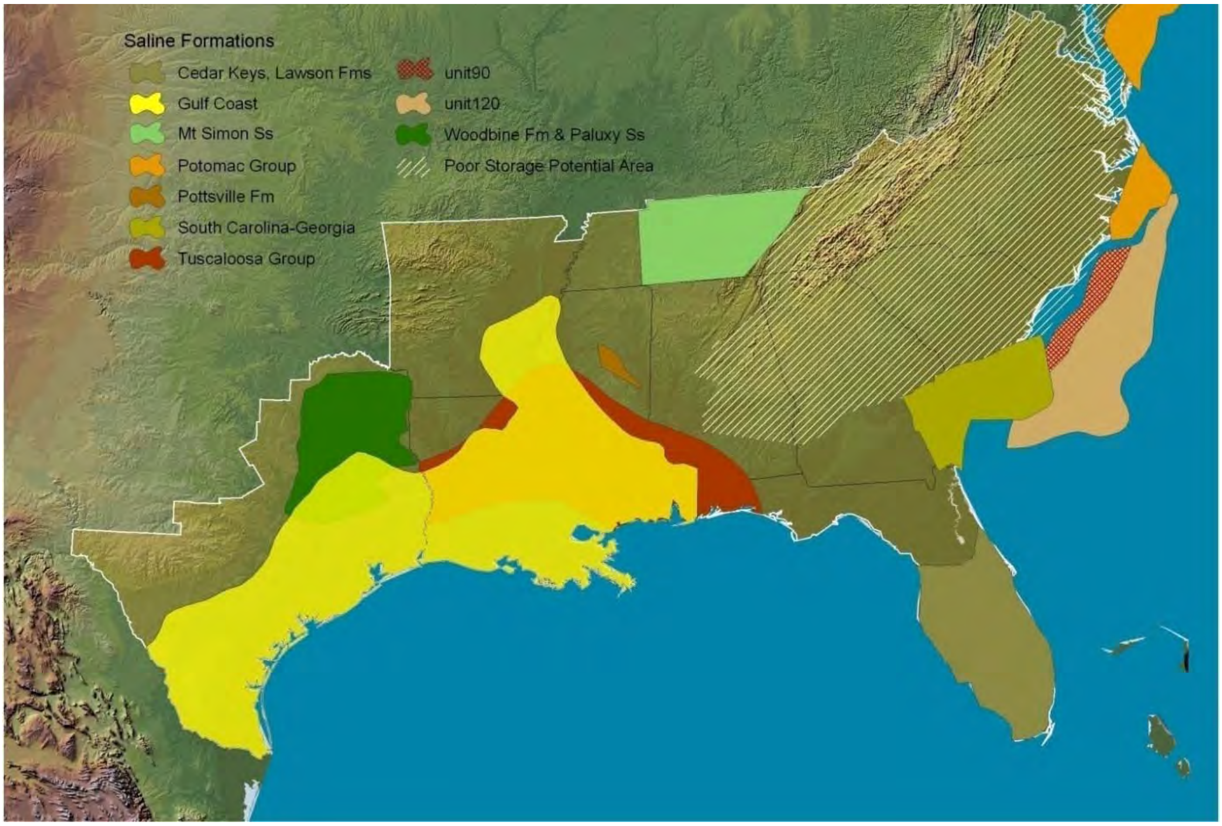


Figure 4-32. Saline formations in the southeastern United States potentially suitable for CO_2 storage. Source: NETL (2008).

The screening results described above are based on the results of Phase I characterization studies conducted through the southeast and midwest regional programs. Both of these programs are conducting Phase II (Validation) and Phase III (Deployment) tests which will better refine the potential and costs of storing regional CO_2 emissions.

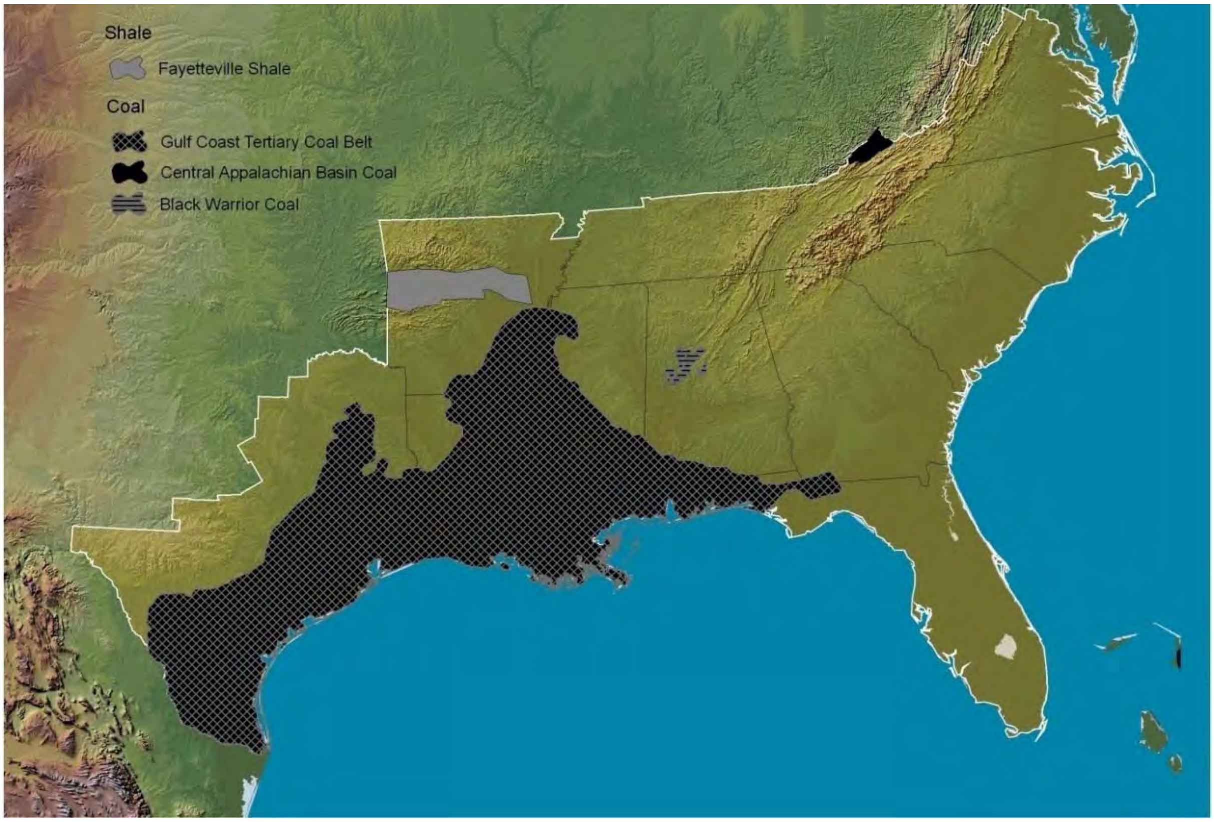


Figure 4-33. Unmineable coal seams in the southeastern United States potentially suitable for CO_2 storage. Source: NETL (2008).

4.5. Groundwater

Three basic types of aquifers (water-bearing geologic formations) occur in the TVA region: unconsolidated sedimentary sand, carbonate rocks, and fractured noncarbonate rocks. Unconsolidated sedimentary sand formations, composed primarily of sand with lesser amounts of gravel, clay and silt, constitute some of the most productive aquifers. Groundwater movement in sand aquifers occurs through the pore spaces between sediment particles. Carbonate rocks are another important class of aquifers. Carbonate rocks, such as limestone and dolomite, contain a high percentage of carbonate minerals (e.g., calcite) in the rock matrix. Carbonate rocks in some parts of the region readily transmit groundwater through enlarged fractures and cavities created by dissolution of carbonate minerals by acidic groundwater. Fractured noncarbonate rocks represent the third type of aquifer found in the region. These aquifers include sedimentary and metamorphic rocks, e.g., sandstone, conglomerate, and granite gneiss, which transmit groundwater through fractures, joints, and beddings planes. Eight major aquifers occur in the TVA (Table 4-8). These aquifers generally align with the major physiographic divisions of the region (Figure 4-31).

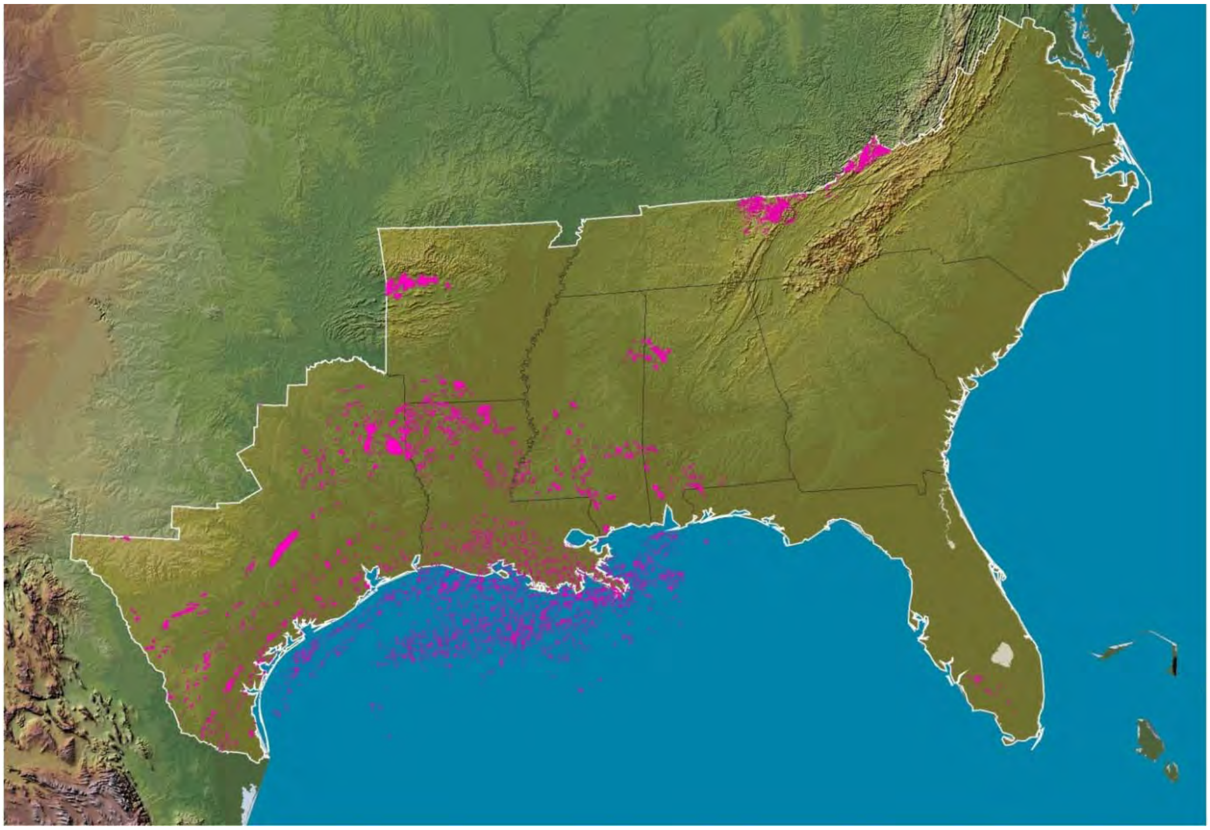


Figure 4-34. Oil and gas fields in the southeastern United States potentially suitable for CO_2 storage. Source: NETL (2008).

The aquifers include (in order of increasing geologic age): Quaternary age alluvium occupying the floodplains of major rivers, notably the Mississippi River; Tertiary and Cretaceous age sand aquifers of the Coastal Plain Province; Pennsylvanian sandstone units found mainly in the Cumberland Plateau section; carbonate rocks of Mississippian, Silurian and Devonian age of the Highland Rim section; Ordovician age carbonate rocks of the Nashville Basin section; Cambrian-Ordovician age carbonate rocks within the Valley and Ridge Province; and Cambrian-Precambrian metamorphic and igneous crystalline rocks of the Blue Ridge Province.

The largest withdrawals of groundwater for public water supply are from the Tertiary and Cretaceous sand aquifers in the Mississippi Alluvial Plain and Coastal Plain physiographic areas. These withdrawals account for about two-thirds of all groundwater withdrawals for public water supply in the TVA region. The Pennsylvanian sandstone and Orodovician carbonate aquifers have the lowest groundwater use (less than 1 percent of withdrawals) and lowest potential for groundwater use. Groundwater use is described in more detail in Section 4-7. The quality of groundwater in the TVA region is largely dependent on the chemical composition of the aquifer in which the water occurs (Table 4-8). Precipitation entering the aquifer is generally low in dissolved solids and slightly acidic. As it seeps through the aquifer it reacts with the aquifer matrix and the concentration of dissolved solids increases.

Table 4-8. Aquifer, well, and water quality characteristics in the TVA region. Source: Webbers (2003).

Aquifer Description	Well Characteristics (common range, maximum)		Water Quality Characteristics
	Depth (feet)	Yield (gpm*)	
Quaternary alluvium: Sand, gravel, and clay. Unconfined.	10 - 75, 100	20 - 50, 1,500	High iron concentrations in some areas.
Tertiary sand: Multi-aquifer unit of sand, clay, silt, and some gravel and lignite. Confined; unconfined in the outcrop area.	100 - 1,300, 1,500	200 - 1,000, 2,000	Problems with high iron concentrations in some places
Cretaceous sand: Multi-aquifer unit of interbedded sand, marl, and gravel. Confined; unconfined in the outcrop area.	100 - 1,500, 2,500	50 - 500, 1,000	High iron concentrations in some areas.
Pennsylvanian sandstone: Multi-aquifer unit, primarily sandstone and conglomerate, interbedded shale and some coal. Unconfined near land surface; confined at depth.	100 - 200, 250	5 - 50, 200	High iron concentrations are a problem; high dissolved solids, sulfide or sulfate are problems in some areas.
Mississippian carbonate rock: Multi-aquifer unit of limestone, dolomite, and some shale. Water occurs in solution and bedding-plane openings. Unconfined or partly confined near land surface; may be confined at depth.	50 - 200, 250	5 - 50, 400	Generally hard; high iron, sulfide, or sulfate concentrations are a problem in some areas
Ordovician carbonate rock: Multi-aquifer unit of limestone, dolomite, and shale. Partly confined to unconfined near land surface; confined at depth.	50 - 150, 200	5 - 20, 300	Generally hard; some high sulfide or sulfate concentrations in places.
Cambrian-Ordovician carbonate rock: Highly faulted multi-aquifer unit of limestone, dolomite, sandstone, and shale; structurally complex. Unconfined; confined at depth.	100 - 300, 400	5 - 200, 2,000	Generally hard, brine below 3,000 feet
Cambrian-Precambrian crystalline rock: Multi-aquifer unit of dolomite, granite gneiss, phyllite, and metasedimentary rocks overlain by thick regolith. High yields occur in dolomite or deep colluvium and alluvium. Generally unconfined.	50 - 150, 200	5 - 50, 1,000	Low pH and high iron concentrations may be problems in some areas.

*gpm = gallons per minute

Acidic precipitation percolating through carbonate aquifers tends to dissolve carbonate minerals present in limestone and dolomite, resulting in reduced groundwater acidity and elevated concentrations of calcium, magnesium, and bicarbonate. Consequently, groundwater derived from carbonate rocks of the Valley and Ridge, Highland Rim, and Nashville Basin is generally slightly alkaline and high in dissolved solids and hardness. Groundwater from mainly noncarbonated rocks of the Blue Ridge, Appalachian Plateaus, and Coastal Plain typically exhibits lower concentrations of dissolved solids compared to carbonate rocks. However, sandstones interbedded with pyritic shales often produce acidic groundwater high in dissolved solids, iron, and hydrogen sulfide. These conditions are commonly found on the Appalachian Plateaus and in some parts of the Highland Rim and Valley and Ridge (Zurawski 1978).

The chemical quality of most groundwater in the region is within health-based limits established by the EPA for drinking water. Pathogenic microorganisms are generally absent, except in areas underlain by shallow carbonate aquifers susceptible to contamination by direct recharge through open sinkholes (Zurawski 1978).

4.6. Water Quality

The quality of the region's water is critical to protection of human health and aquatic life. Water resources provide habitat for aquatic life, recreation opportunities, domestic and industrial water supplies, and other benefits. Major watersheds in the TVA region include the entire Tennessee River basin, most of the Cumberland River basin, and portions of the lower Ohio, lower Mississippi, Green, Pearl, Tombigbee, and Coosa River basins. Fresh water abounds in much of this area and generally supports most beneficial uses, including fish and aquatic life, public and industrial water supply, waste assimilation, agriculture, and water-contact recreation, such as swimming. Water quality in the TVA region is generally good.

Causes of degraded water quality include:

- Wastewater discharges – Sewage treatment systems, industries, and other sources discharge waste into streams and reservoirs. These discharges are controlled through state-issued National Pollutant Discharge Elimination System (NPDES) permits issued under the authority of the federal Clean Water Act. NPDES permits regulate the concentrations of various pollutants in the discharges and establish monitoring and reporting requirements.
- Non-point source discharges – Runoff from agriculture, urban uses, and mined land can transport sediment and other pollutants into streams and reservoirs. Non-point runoff from some commercial and industrial facilities and some construction sites is regulated through state NPDES storm water permitting systems.
- Heated water discharges – Electrical generating plants and other industrial facilities may withdraw water from streams or reservoirs, use it to cool facility operations, and discharge heated water into streams or reservoirs. State regulations, under the authority of the Clean Water Act, limit the water temperature increases in the receiving waters and the resulting effects on the aquatic community.
- Air pollution – Airborne pollutants can affect surface waters through rainout and deposition.

Following is an overview of how power generation can affect water quality.

Fossil Plant Wastewater. Fossil plant sites have systems to control storm water runoff. These typically consist of retention ponds to capture sediment, and may include oil/water separators. Coal-fired power plants have several liquid waste streams that are treated and released to surface waters. These releases are permitted by each state under the NPDES program. Many of these waste streams receive extensive treatment before they are released and periodic toxicity testing ensures that there are no acute or chronic toxic effects to aquatic life. Coal mining and processing operations, as well as coal combustion waste processing operations, also discharge wastewater which can impact the receiving water body. Combined-cycle combustion turbine plants typically require an NPDES permit for the discharge of treated water from the cooling system ("cooling tower blowdown") and other plant processes. These discharges are typically to surface waters.

Nuclear Plant Wastewater. Nuclear plant sites have systems to control storm water runoff. These typically consist of retention ponds to capture sediment, and may include oil/water separators. Nuclear plants have noncomplex wastewaters from plant processes that are subjected to various levels of treatment and are usually discharged to surface waters. Periodic toxicity testing is performed on this discharge as part of the NPDES permit to ensure that plant wastes do not contain chemicals at deleterious levels that could affect aquatic life.

Fossil and Nuclear Plant Heat Releases**.** TVA's coal-fired and nuclear plants withdraw water from reservoirs or rivers for cooling and discharge the heated water back into the water body (see Section 4.7). TVA conducts extensive monitoring programs to help ensure compliance and to provide information about potential adverse effects. Recent programs have focused primarily on spawning and development of cool-water fish species such as sauger, the attraction of fish to heated discharges from power plants, and changes in undesirable aquatic micro-organisms such as blue-green algae. In general, these monitoring programs have not detected significant negative effects resulting from release of heated water from TVA facilities in the Tennessee River drainage.

Runoff and Air Pollution. Many non-point sources of pollution are not subject to government regulations or control. Principal causes of non-point source pollution are agriculture, including runoff from fertilizer, pesticide and herbicide applications, erosion, and animal wastes; mining, including erosion and acid drainage; and urban runoff. Pollutants reach the ground from the atmosphere as dust fall or are carried to the ground by precipitation.

Low Dissolved Oxygen Levels and Low Flow Downstream of Dams. A major water quality concern in the Tennessee River is low dissolved oxygen levels in reservoirs and in the tailwaters downstream of dams. Long stretches of river can be affected, especially in areas where pollution further depletes dissolved oxygen. In addition, flow in these tailwaters is heavily influenced by the amount of water released from the upstream dams; in the past, some of the tailwaters were subject to periods of little or no flow. Since the early 1990s, TVA has addressed these issues by installing equipment and making operational changes to increase dissolved oxygen concentrations below 16 dams and to maintain minimum flows in tailwaters (TVA 2004: 4.4-3).

The Tennessee River System

The Tennessee River basin contains all except one of TVA's dams and covers a large part of the TVA region (Figure 3-12). A series of nine locks and dams built mostly in the 1930s and 1940s regulates the entire length of the Tennessee River and allows navigation to Knoxville (TVA 2004). Virtually all the major tributaries have at least one dam, creating 14 multi-purpose storage reservoirs and seven single-purpose power reservoirs. The construction of the TVA dam and reservoir system fundamentally altered both the water quality and physical environment of the Tennessee River and its tributaries. While dams promote navigation, flood control, power generation, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river. This system of dams and their operation is the most significant factor affecting water quality and aquatic habitats in the Tennessee River and its major tributaries.

Major water quality concerns within the Tennessee River drainage basin include point and non-point sources of pollution that degrade water quality at several locations on mainstream reservoirs and tributary rivers and reservoirs. TVA regularly evaluates several water quality indicators as well as the overall ecological health of reservoirs through its Vital Signs monitoring program. This program evaluates five metrics: chlorophyll concentration, fish community health, bottom life, sediment contamination, and dissolved oxygen (DO) (TVA 2004: 4.4-3, -4). Scores for each metric from monitoring sites in the deep area near the dam (forebay), mid-reservoir, and at the upstream end of the reservoir (inflow) are combined for a summary score and rating. Vital Signs ratings, major areas of concern, and fish consumption advisories are listed in Table 4-9.

Six of TVA's nine coal-fired power plants and all of TVA's nuclear plants are in the Tennessee River watershed. All of these facilities are dependent on the river system for cooling water. Three of TVA's gas-fired generating plants are along or close to the Tennessee River; they are not dependent on it for cooling water.

Other Major River Systems

The Ohio, Green, and Mississippi Rivers each host a TVA coal-fired plant. TVA operates two coal-fired plants on the main stem of the Cumberland River and a small hydroelectric plant on a Cumberland River tributary. Combustion turbine plants are located in the Hatchie and Obion (both tributaries to the Mississippi River) drainages and the Tombigbee River drainage. Because of recent low summer flows in the Cumberland River due to repairs on Wolf Creek Dam by the U.S. Army Corps of Engineers and drought conditions, thermal discharges from the Cumberland Fossil Plant have led to the state of Tennessee placing a portion of the Cumberland River on the Clean Water Act Section 303(d) list of impaired waters (TDEC 2008). Fish consumption advisories are in effect for waters in the vicinity of Shawnee and Allen fossil plants, Otherwise, water resources conditions and characteristics in these river systems are generally similar to those in the Tennessee system.

4.7. Water Supply

In 2005, estimated average daily water withdrawals in the TVA region totaled 20,176 million gallons per day (mgd) (Kenny et al. 2009). About five percent of these water withdrawals were groundwater and the remainder was surface water. The largest water use (79 percent of all withdrawals) was for thermoelectric generation; this water use is described in more detail below.

Table 4-9. TVA reservoir ecological health ratings, major water quality concerns, and fish consumption advisories. Source: TVA Data at http://www.tva.com/environment/ecohealth/index.htm and state water quality reports.

Reservoir	Ecological Health Rating - Score	Latest Survey Date	Concerns	Fish Consumption Advisories
Apalachia	Good - 84	2008	--	Mercury (NC statewide)
Bear Creek	Fair - 64	2007	DO	Mercury
Beech	Poor - 51	2008	DO, chlorophyll	None
Blue Ridge	Good - 83	2007	DO	Mercury
Boone	Poor - 50	2007	DO, chlorophyll, bottom life	PCBs, chlordane
Cedar Creek	Fair - 69	2007	DO	Mercury
Chatuge	Fair - 59	2008	DO, bottom life, sediment quality	Mercury
Cherokee	Fair - 63	2008	DO, chlorophyll, bottom life	Mercury (upstream of Poor Valley Creek)
Chickamauga	Fair - 69	2007	Chlorophyll, bottom life	Mercury (Hiwssee River embayment)
Douglas	Poor - 55	2007	DO, chlorophyll	None
Fontana	Fair - 69	2008	Bottom life	Mercury (NC statewide)
Fort Loudoun	Poor - 50	2007	DO, chlorophyll, bottom life	PCBs, mercury (above US 129)
Fort Patrick Henry	Fair - 60	2007	Chlorophyll, bottom life	None
Guntersville	Fair - 68	2008	Chlorophyll	Mercury (Long Island to AL/TN state line)
Hiwassee	Fair - 67	2008	DO, chlorophyll	None
Kentucky	Good - 76	2007	DO, chlorophyll	Mercury (KY statewide)
Little Bear Creek	Fair - 60	2007	DO, bottom life	Mercury
Melton Hill	Fair - 65	2008	Bottom life	PCBs, mercury (Poplar Creek

Table 4-9. Continued.

Reservoir	Ecological Health Rating - Score	Latest Survey Date	Concerns	Fish Consumption Advisories
				embayment)
Nickajack	Good - 75	2007	Chlorophyll	PCBs
Normandy	Poor - 52	2008	DO, chlorophyll	None
Norris	Fair - 60	2007	DO, chlorophyll, bottom life	Mercury (Clinch River portion)
Nottely	Poor - 46	2007	DO, chlorophyll, bottom life	Mercury
Parksville	Fair - 71	2007	Sediment quality	None
Pickwick	Good - 78	2006	Chlorophyll	None
South Holston	Fair - 60	2006	DO, bottom life	Mercury (Tennessee portion)
Tellico	Fair - 59	2007	DO, chlorophyll, bottom life	PCBs, mercury
Tims Ford	Poor - 52	2008	DO, bottom life	None
Upper Bear Creek				Mercury
Watauga	Good - 75	2008	DO	Mercury
Watts Bar	Fair - 59	2008	DO, chlorophyll, bottom life	PCBs
Wheeler	Poor - 57	2007	DO, chlorophyll, bottom life	DDT, mercury (Limestone Creek embayment)
Wilson	Poor - 54	2008	DO, chlorophyll, bottom life	Mercury (Big Nance Creek embayment)

Groundwater Use

Groundwater use data is compiled by the U.S. Geological Survey (USGS) and cooperating state agencies in connection with the national public water use inventory conducted every five years (Bohac and McCall 2008, Bradley and Robinson 2009, Burt 2009, Fannin 2009, Kenny et al. 2009, Littlepage 2009, Pope 2009, Yeary 2009). The largest use of groundwater is for public water supply (Figure 4-35). About 60 percent of water used for irrigation and almost all water used for domestic supply in the TVA region is groundwater. Groundwater is also widely used for industrial and mining purposes. The extent of monitoring and reporting for these two uses, as well as for irrigation, is somewhat inconsistent among states. Public water supply is typically the largest category of groundwater use and is therefore a useful indicator of overall trends.

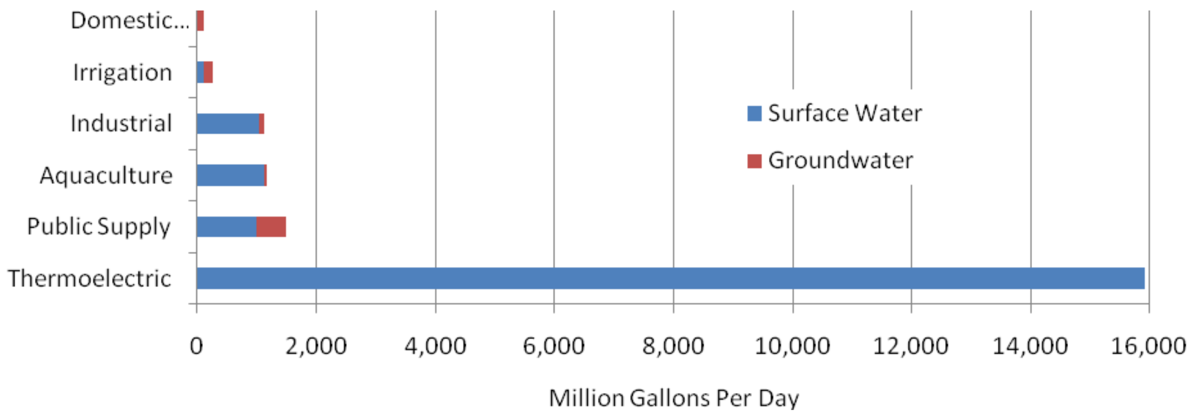


Figure 4-35. 2005 water withdrawals in the TVA region by source and type of use. Source: Kenny (2009).

The use of groundwater to meet public water supply needs varies across the TVA region and is greatest in West Tennessee and northern Mississippi. This variation is the result of several factors including (1) groundwater availability, (2) surface water availability, (3) where both surface and groundwater are present in adequate quantity and quality, which water source can be developed most economically, and (4) public water demand which is largely a function of population. For example, there are numerous sparsely-populated rural counties in the region with no public water systems. Residents in these areas are self-served, most often by individual wells or springs.

Total groundwater use for public water supply in 2005 averaged 492 mgd in the TVA region. Approximately 56 percent of all groundwater withdrawals were supplied by Tertiary sand aquifers in West Tennessee and North Mississippi. Shelby County, Tennessee alone pumped 187 MGD from Tertiary aquifers, accounting for 38 percent of total 2005 regional pumpage. The dominance of groundwater use over surface water use in the western portion of the TVA region is due to the availability of prolific aquifers and the absence of adequate surface water resources in some areas.

Since 1950, groundwater and surface water withdrawals by public supply systems in Tennessee have greatly increased (Figure 4-36). Since 1950, the magnitude and rate of growth of withdrawals of surface water has exceeded groundwater. The annual increase in groundwater withdrawals for public supply in Tennessee averaged about 2.5 percent and the increase in surface water withdrawals averaged about 3.8 percent. Although these data are for Tennessee public water supplies, they are representative of the overall growth in groundwater use for the TVA region.

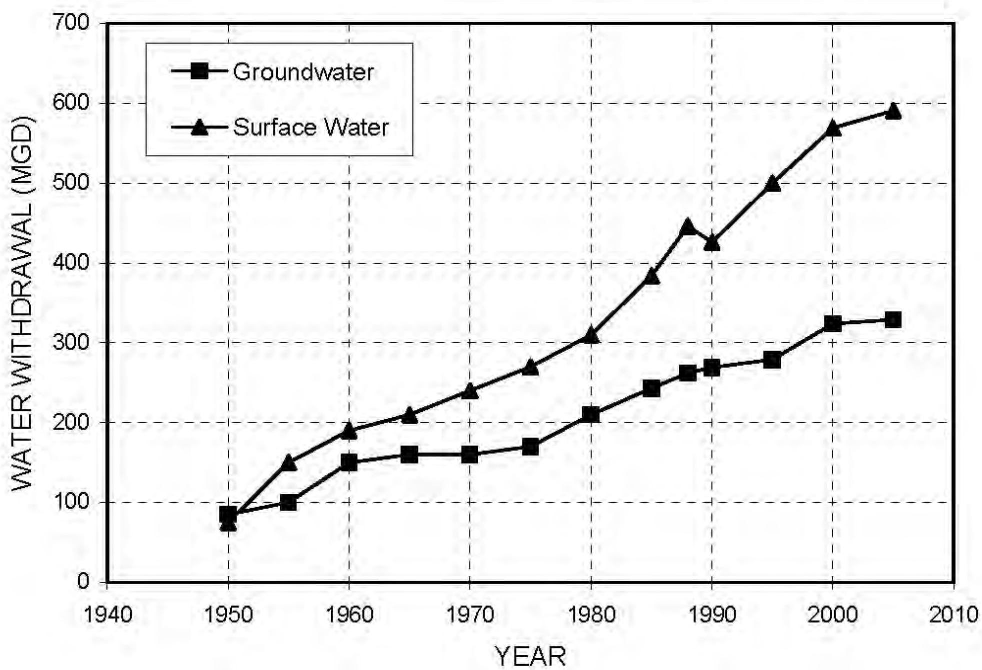


Figure 4-36. Groundwater and surface water withdrawals by public supply systems in Tennessee, 1950 to 2005. Source: Adapted from Webbers (2003).

Surface Water Use

The majority of water used for thermoelectric, public supply, aquaculture, and industrial uses is surface water (Figure 4-35). Most of this water is returned to streams or reservoirs; in the Tennessee River drainage, 96.5 percent of the withdrawn surface water was returned to the watershed (Bohac and McCall 2008). The water use categories with the greatest consumptive use (i.e., not returned to the watershed) were irrigation (~100 percent consumed), public supply (40 percent consumed), and industrial (7 percent consumed).

The trend in surface water use by public water supply systems is described above. Trends in some other use categories are more variable and irrigation and aquaculture are very sensitive to weather and market conditions.

Water Use for Thermoelectric Power Generation

Thermoelectric power generation uses steam produced from the combustion of fossil fuels or from a nuclear reaction. A significant volume of cooling water is required to condense steam into water. All TVA coal-fired plants and nuclear plants are cooled by water withdrawn from adjacent rivers or reservoirs. The amount of water required is highly dependent on the type of cooling system employed. While the volume of water used to cool the plants is large, most of this water is returned to the adjacent rivers or reservoirs.

In 2005, TVA coal-fired plants and nuclear plants withdrew an average of 15,539 mgd (Table 4-10). The amount of water used to generate electricity is often described as the water use factor, the total plant water withdrawal divided by the net generation. All TVA coal-fired plants except Paradise employ open-cycle (once-through) cooling all the time. In open cycle (once-through) systems, water is withdrawn from a water body, circulated through the plant cooling condensers, discharged back to the water body. Plant water use factors for the coal plants, except for Paradise, range from about 29,000 to 61,000 gal/MWh

Table 4-10. 2005 water use for TVA coal-fired and nuclear generating plants. Source: Bohac and McCall (2008).

Facility	Units	Withdrawal (mgd)	Return (mgd)	Consumption (Withdrawal - Return, mgd)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
			Fossil Plants			
Allen	1-3	405.7	405.5	0.2	5,160,139	28,697
Bull Run	1	563.2	563.2	0.0	6,587,608	31,205
Colbert	1-5	1294.1	1292.8	1.3	7,776,803	60,740
Cumberland	1-2	2291.6	2285.0	6.6	16,371,958	51,089
Gallatin	1-4	943.0	943.0	0.0	7,494,267	45,928
John Sevier	1-4	693.7	692.4	1.3	4,960,616	51,042
Johnsonville	1-10	1226.9	1226.8	0.1	7,639,746	58,617
Kingston	1-9	1280.0	1279.2	0.8	9,479,726	49,284
Paradise	1-3	354.7	305.7	49.0	13,974,044	9,265
Shawnee	1-10	1292.0	1292.0	0.0	9,293,226	50,744
Widows Creek	1-8	1476.3	1476.3	0.0	9,851,670	54,696
			Nuclear Plants			
Browns Ferry	2-3	1990.2	1987.5	2.7	17,931,672	40,511
Sequoyah	1-2	1539.3	1539.2	0.1	18,999,153	29,572
Watts Bar	1	188.2	173.9	14.3	8,803,955	7,803

of net generation. Differences in river temperature, plant design, atmospheric conditions, and plant operation account for the variability in water use factors. Year-to-year variation in water use factors is typically less than 10 percent.

Paradise employs substantial use of cooling towers (closed-cycle cooling) resulting in a relatively low plant water use factor and less water returned to the river (Table 4-10). In closed-cycle systems, water from the steam turbine condensers is circulated through cooling tower where the condenser water is cooled by transfer of heat to the air by evaporation, conduction, and convection. The proportion of cooling water discharged to the river or reservoir is lower than for open-cycle systems, as are the overall volume of water required and the plant water use factor. Browns Ferry and Sequoyah nuclear plants operate primarily in the open-cycle mode, with infrequent use of cooling towers except during the warmer summer months. Watts Bar uses a combination of open-cycle and closed-cycle cooling.

Power plant water use factors averaged about 50,000 gal/MWh nationally in 1960 and declined to about 38,000 gal/MWH in 1995 (EPRI 2002). The reduction was due to increasing use of closed-cycle cooling, particularly in the western United States where water is relatively scarce. For 2000, the national average water use factor was 21,450 gal/MWh (King and Webber 2008), which is lower than the TVA average of 39,300 gal/MWh. This is also due to a higher percentage of closed-cycle cooling systems in the national average compared to the TVA system, which was designed and located to specifically take advantage of open-cycle cooling. Although the individual plant water use factors vary, the TVA average water use factor appears to be fairly constant as the TVA average for 2005 was also 39,300 gal/MWh.

Browns Ferry Unit 1 returned to service in 2007 and Watts Bar Unit 2 is expected to begin commercial operation in 2013; the projected water use by all units at these plants is shown in Table 4-11. The addition of Browns Ferry Unit 1 is expected to slightly decrease the water returned to the river due to increased cooling tower operation. However, the plant water use factor for three unit operation is expected to be about the same as with two units operating. Because Watts Bar Unit 2 will primarily operate in closed-cycle, the plant water use factor is low but water consumption (withdrawal - return) will increase from that of Unit 1 operation.

Natural gas-fueled combined cycle generating plants require water to generate the steam used in powering the steam generator and to cool (condense) the steam. Water use requirements for TVA's Southaven plant is shown in Table 4-12. The Caledonia plant has contracted to use reclaimed wastewater, and Southaven uses groundwater. The Lagoon Creek combined-cycle plant, which began operations in September, 2010, uses groundwater and the John Sevier plant will use surface water and closed-cycle cooling. All of these facilities return or will return their process water to surface waters.

Table 4-11. Projected Browns Ferry and Watts Bar Nuclear Plant water use. Source: TVA data.

Facility	Units	Withdrawal (mgd)	Return (mgd)	Withdrawal - Return (mgd)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Browns Ferry*	1-3	3099.0	3094.3	4.7	27,921,676	40,511
Watts Bar**	1-2	274.0	234.0	40.0	20,297,000	4,927

*Browns Ferry Notes:

1. Withdrawal based on flow test data.

2. Withdrawal less Return based on a 2.6 percent increase in cooling tower operation with three units compared to two units (TVA 2002).

3. Net Generation is shown as an example assuming that the water use factor for two unit operation is the same for three unit operation.

**Watts Bar Notes:

1. Withdrawal and Return are based on total two-unit generation of 2317 MW (Hopping 2010).

2. Net Generation is shown as an example based on 2317 MW with capacity factor = 1.0 applied.

Table 4-12. TVA combined-cycle generating plant water use.

Facility	Units	Withdrawal (mgd)	Return (mgd)	Withdrawal - Return (mgd)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh)
Southaven, MS*	3	3.3	0.3	3	1,646,268	732

*2005 data, prior to TVA's acquisition of the facility

Although TVA generates the preponderance of electrical energy in the region, there are non-TVA power plants that used significant volumes of water in 2005 (Table 4-13). Four of these plants, Red Hills, Caledonia, Decatur, and Morgan, sell all or a large amount of their electricity to TVA.

Table 4-13. Regional non-TVA power generation and thermoelectric water use.

Facility	Units	Withdrawal (mgd)	Return (mgd)	Withdrawal - Return (mgd)	Net Generation (MWh/year)	Water Use Factor (gallons/MWh
			Coal			
Asheville, NC*	4	262.6	262.5	0.1	2,333,900	41,068
Clinch River, VA*	3	15.16	3.2	11.96	3,931,000	1,408
Red Hills, MS**	3	5.9	0	5.9	3,239,873	664
			Combined-Cycle			
Batesville, MS*	3	2.13	0.5	1.63	1,785,447	435
Caledonia, MS*	2	4	0.8	3.2	1,076,577	1,356
Decatur Energy Center, AL*	3	1.2	0.4	0.8	1,214,000	361
Morgan Energy Center, AL	3					
Magnolia, MS	3		0.04		1,525,750	NA

*2005 data, reported in Bohac and McCall (2008)
**TVA (1998)

The Asheville, Clinch River, Batesville, and Decatur plants use surface water and return their process water to surface waters. The Red Hills plant uses groundwater and does not discharge process water. The Magnolia plant uses groundwater and discharges to surface waters. The Caledonia plant uses reclaimed wastewater.

Current environmental regulations make it very difficult for new thermoelectric plants to use open-cycle cooling. A 2004 U.S. Second Circuit Court of Appeals decision effectively requires all new power plants to install closed-cycle cooling technology.

4.8. Aquatic Life

The TVA region encompasses portions of several major river systems including all of the Tennessee River drainage and portions of the Cumberland River drainage, Mobile River drainage (primarily the Coosa and Tombigbee Rivers), and larger eastern tributaries to the Mississippi River in Tennessee and Mississippi. These river systems support a large variety of freshwater fishes and invertebrates (including freshwater mussels, snails, crayfish, and insects). Due to the presence of several major river systems, the region's high geologic diversity (see Section 4.4), and the lack of glaciation, the region is recognized as a globally important area for freshwater biodiversity (Stein et al. 2000).

The Tennessee River Basin

The Tennessee River drainage is the dominant aquatic system within the TVA region and the most TVA generating facilities are within the watershed. The construction of the TVA dam and reservoir system fundamentally altered both the water quality and physical environment of the Tennessee River and its tributaries. While dams promote navigation, flood control, power benefits, and river-based recreation by moderating the flow effects of floods and droughts throughout the year, they also disrupt the daily, seasonal, and annual flow patterns that are characteristic of a river. Damming of the most of the rivers was done at a time when there was little regard for aquatic resources (Voigtlander and Poppe 1989). Beyond changes in water quality, flood control activities and hydropower generation have purposefully altered the flow regime (the main variable in aquatic systems) to suit human demands (Cushman 1985).

TVA has undertaken several major efforts (e.g., TVA's Lake Improvement Plan, Reservoir Release Improvements Plan, and Reservoir Operations Study (ROS; (TVA 2004)) to mitigate some of these impacts on aquatic habitats and organisms. While these actions have resulted in improvements to water quality and habitat conditions in the Tennessee River drainage, the Tennessee River and its tributaries remain substantially altered by human activity.

Mainstem Reservoirs - The nine mainstem reservoirs on the Tennessee River differ from tributary reservoirs primarily in that they are shallower, have greater flows, and thus, retain the water in the reservoir for a shorter period of time. Although dissolved oxygen in the lower lake levels is often reduced, it is seldom depleted. Winter drawdowns on mainstem reservoirs are much less severe than tributaries, so bottom habitats generally remain wetted all year. This benefits benthic organisms, but promotes the growth of aquatic plants in the extensive shallow overbank areas of some reservoirs. Tennessee River mainstem reservoirs generally support healthy fish communities, ranging from about 50 to 90 species per reservoir. Good to excellent sport fisheries exist, primarily for black bass, crappie, sauger, white and striped bass, sunfish, and catfish. The primary commercial species are channel and blue catfish and buffalo.

Tributary Reservoirs and Tailwaters - Tributary reservoirs are typically deep and retain water for long periods of time. This results in thermal stratification, the formation of an upper layer that is warmer and well oxygenated, an intermediate layer of variable thickness, and a lower layer that is colder and poorly oxygenated. These aquatic habitats are simplified compared to undammed streams, and fewer species are found. Aquatic habitats in the tailwater can also be impaired due to a lack of minimum flows and low dissolved oxygen levels. This may restrict the movement, migration, reproduction, and available food supply of fish and other organisms. Dams on tributary rivers affect the habitat of benthic invertebrates (benthos), which are a vital part of the food chain of aquatic ecosystems. Benthic life includes worms, snails and crayfish, which spend all of their lives in or on the stream beds, and aquatic insects, mussels and clams, which live there during all or part of their life-cycles. Many benthic organisms have narrow habitat requirements that are not always met in reservoirs or tailwaters below dams. Further downstream from dams, the number of benthic species increases as natural reaeration occurs and dissolved oxygen and temperatures rise.

Other Drainages in the TVA Region

The other major drainages within the TVA region (the Cumberland, Mobile, and Mississippi River drainages) share a diversity of aquatic life equal to or greater than that found in the Tennessee River drainage. As with the Tennessee River, these river systems have seen extensive human alteration including construction of reservoirs, navigation channels and locks. Despite these changes (as with the Tennessee River drainage), remarkably diverse aquatic communities are present in each of these river systems.

Major TVA generating facilities located in these watersheds include Allen Fossil Plant (Mississippi River), Cumberland and Gallatin Fossil Plants (Cumberland River), Paradise Fossil Plant (Green River/Ohio River), and Shawnee Fossil Plant (Ohio River). With the exception of the Marshall County facility, TVA's free-standing natural gas-fueled generating facilities are located in the Mississippi and Mobile River drainages.

4.9. Vegetation and Wildlife

The TVA region encompasses nine ecoregions (Omernik 1987) which generally correspond with physiographic provinces and sections (see Section 4.4 and Figure 4-31). The terrain, plant communities, and associated wildlife habitats in these ecoregions vary from bottomland hardwood and cypress swamps in the floodplains of the Mississippi Alluvial Plain to high elevation balds and spruce-fir and northern hardwood forests in the Blue Ridge. About 3,500 species of herbs, shrubs and trees, 55 species of reptiles, 72 species of amphibians, 182 species of breeding birds, and 76 species of mammals occur in the TVA region (Ricketts et al. 1999, Stein 2002, TWRA 2005, TOS 2007). Although many plants and animals are widespread across the region, others are restricted to one or a few ecoregions. For example, high elevation communities in the Blue Ridge support several plants and animals found nowhere else in the world (Ricketts et al. 1999), as well as isolated populations of species typically found in more northern latitudes.

Regional Vegetation

The southern Blue Ridge Ecoregion, which corresponds to the Blue Ridge physiographic province, is one of the richest centers of biodiversity in the eastern United States and one of the most floristically diverse (Griffith et al. 1998). The most prevalent land cover (80 percent) is forest, which is dominated by the diverse, hardwood-rich mesophytic forest and its Appalachian oak sub-type (Dyer 2006; USGS 2008). About 14 percent of the land cover is agricultural and most of the remaining area is developed. Relative to the other eight ecoregions, the Blue Ridge Ecoregion has shown the least change in land cover since the 1970s (USGS 2008).

Over half (56 percent) of the Ridge and Valley Ecoregion, which corresponds to the Valley and Ridge physiographic province, is forested. Dominant forest types are the mesophytic forest and Appalachian oak sub-type, and, in the southern portion of the region, the southern mixed forest and oak-pine sub-type (Dyer 2006, USGS 2008). About 30 percent of the area is agricultural and 9 percent is developed (USGS 2008).

The Cumberland Mountains physiographic section comprises the southern portion of the Central Appalachian Ecoregion. This ecoregion is heavily forested (83 percent), primarily with mesophytic forests including large areas of Appalachian oak (Dyer 2006, USGS 2008). The remaining land cover is mostly agriculture (7 percent), developed areas (3 percent), and mined areas (3 percent). The dominant source of land cover change since the 1970s has been mining (USGS 2008), and this ecoregion, together with the Southwestern Appalachian Ecoregion, comprises much of the Appalachian coalfield.

The Southwestern Appalachian Ecoregion corresponds to the Cumberland Plateau physiographic section. About 75 percent of the land cover is forest, predominantly mesophytic forest; about 16 percent is agricultural and 3 percent is developed (USGS 2008). The rate of land cover change since the 1970s is relatively high, mostly due to forest management activities.

The Interior Plateau Ecoregion consists of the Highland Rim and Nashville Basin physiographic sections. The limestone cedar glades and barrens communities associated with thin soils and limestone outcrops in the Nashville Basin support rare, diverse plant communities with a high proportion of endemic species (Baskin and Baskin 2003). About 38 percent of the ecoregion is forested, 50 percent in agriculture, and 9 percent developed (USGS 2008). Forests are predominantly mesophytic, with a higher proportion of American beech, American basswood, and sugar maple than in the Appalachian oak subtype (Dyer 2006). Eastern red cedar is also common.

A small area in the northwest of the TVA region is in the Interior River Valley and Hills Ecoregion, which overlaps part of the Highland Rim physiographic section. This ecoregion is relatively flat lowland dominated by agriculture and forested hills. It contains much of the Illinois Basin coalfield. Drainage conditions and terrain strongly affect land use. Bottomland deciduous forests and swamp forests were common on wet lowland sites, with mixed oak and oak-hickory forests on uplands. A large portion of the lowlands have been cleared for agriculture. About 20 percent of the ecoregion is forested and almost two-thirds is agricultural (USGS 2008). About 7 percent is developed and 5 percent is wetlands. The rate of land cover change since the 1970s is moderate and primarily from forest to agricultural and from agriculture and forest to developed.

The Southeastern Plains and Mississippi Valley Loess Plain Ecoregions correspond to, respectively, eastern and western portions of the East Gulf Coastal Plain physiographic section. They are characterized by a mosaic of forests (52 percent of the land area), agriculture (22 percent), wetlands (10 percent) and developed areas (10 percent). Forest cover decreases and agricultural land increases from east to west. Natural forests of pine, hickory, and oak once covered most of the ecoregions, but much of the natural forest cover has been replaced by heavily managed timberlands, particularly in the Southeastern Plains (USGS 2008). The Southeastern Plains in Alabama and Mississippi include the Black Belt, an area of rich dark soils and prairies. Much of this area has been cleared for agricultural purposes and only remnant prairies remain. Of the nine ecoregions in the TVA region, the rate of land cover change in the Southeastern Plains Ecoregion is the highest, with intensive forest management practices the leading cause. The rate of land cover change in the Mississippi Valley Loess Plain Ecoregion is moderate relative to the other ecoregions.

The Mississippi Alluvial Plain is a flat floodplain area originally covered by bottomland deciduous forests. A large portion has been cleared for agriculture and subjected to drainage activities including stream channelization and extensive levee construction. Most of the land cover is agricultural and the remaining forests are southern floodplain forest dominated by oak, tupelo, and bald cypress. The rate of land cover change since the 1970s has been moderate (USGS 2008).

The major forest regions in the TVA region include mesophytic forest, southern-mixed forest, and Mississippi alluvial plain (Dyer 2006). The mesophytic forest is the most diverse with 162 tree species. While canopy dominance is shared by several species, red maple and white oak have the highest average importance values. A distinct section of the mesophytic forest, the Appalachian oak section, is dominated by several species of oak including black, chestnut, northern red, scarlet, and white oak. The Nashville Basin mesophytic forest has close affinities with the beech-maple-basswood forest that dominates much of the Midwest. The oak-pine section of the southern mixed forest region is found in portions of Alabama, Georgia, and Mississippi, where the dominant species are loblolly pine, sweetgum, red maple and southern red oak (Dyer 2006). The Mississippi Alluvial Plain forest region is restricted to its namesake physiographic region. The bottomland forests in this region are dominated by American elm, bald cypress, green ash, sugarberry, and sweetgum.

Numerous plant communities (recognizable assemblages of plant species) occur in the TVA region. Several of these are rare, restricted to very small geographic areas, and/or threatened by human activities. A disproportionate number of these imperiled communities occur in the Blue Ridge region; smaller numbers are found in the other ecoregions (NatureServe 2009). Many of these imperiled communities occur in the Southern Appalachian spruce-fir forest; cedar glades; grasslands, prairies and barrens; Appalachian bogs, fens and seeps; and bottomland hardwood forest ecosystems. Major threats to the Southern Appalachian spruce-fir forest ecosystem include invasive species such as the balsam wooly adelgid, acid deposition, ozone exposure, and climate change (TWRA 2009). The greatest concentration of cedar glades is in the Nashville Basin; a few also occur in the Highland Rim and the Valley and Ridge. Cedar glades contain many endemic plant species, including a few listed as endangered (Baskin and Baskin 2003); threats include urban development, highway construction, agricultural activities, reservoir impoundment, and incompatible recreational use. The category of grasslands, prairies and barrens includes remnant native prairies; they are scattered across the TVA region but most common on the Highland Rim. This category also includes the high elevation grassy balds in the Blue Ridge and the Black Belt prairie in the East Gulf Coastal Plain. Threats to these areas include agricultural and other development, invasive plants, and altered fire regimes. Appalachian bogs, fens and seeps are often small, isolated, and support several rare plants and animals. Threats include drainage for development and altered fire regimes. Bottomland hardwood forests are most common in the Mississippi Alluvial Plain and East Gulf Coastal Plain; they also occur in the physiographic regions. About 60 percent of their original area is estimated to have been lost, largely by conversion to croplands (EPA 2008b).

Wildlife Population Trends

Many animals are wide-ranging throughout the TVA region; most species that are tolerant of humans have stable or increasing populations. The populations of many animals have been greatly altered by changes in habitats from agriculture, mining, forestry, urban and suburban development, and the construction of reservoirs. While some species flourish under these changes, others have shown marked declines. For example, populations of some birds dependent on grassland and woodland dependent birds have shown dramatic decreases in their numbers (SAMAB 1996). Across North America, 48 percent of grassland-breeding birds are of conservation concern because of declining populations, as are 22 percent of forest-breeding birds (NABCI 2009). A large number of the declining birds are Neotropical migrants, species that nest in the United States and Canada and winter south of the United States. Over 30 species of birds breeding in the TVA region are considered to be of conservation concern (USFWS 2008). The primary causes for their declines are the loss and fragmentation of habitats from urban and suburban development and agricultural and forest management practices.

In general gulls, wading birds, waterfowl, raptors, upland game birds (with the exception of the northern bobwhite), and game mammals are stable or increasing in the TVA region. Population trends of much non-game wildlife other than birds (e.g., reptiles, amphibians, and small mammals) are poorly known. The construction of the TVA and Corps of Engineers reservoir systems created large areas of habitat for waterfowl, herons and egrets, ospreys, gulls, and shorebirds, especially in the central and eastern portions of the TVA region where this habitat was limited. Ash and gypsum settling and storage ponds at TVA fossil plants also provide regionally important habitat for these birds and other wetland species. These increases in habitat, as well as the ban on the use of the pesticide DDT, have resulted in large increases in the local populations of several birds. Both long-term and short-term changes in the operation of the reservoir system affect the quality of habitat for these species (TVA 2004) as do pond management practices at fossil plants.

Invasive Species

Invasive species are species that are not native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (NISC 2008). Invasive species include terrestrial and aquatic plants and animals as well as other organisms such as microbes. Human actions, both intentional and unintentional, are the primary means of their introductions.

Four plants designated by the U.S. Department of Agriculture as noxious weeds under the Plant Protection Act occur in the TVA region: hydrilla, giant salvinia, cogongrass, and tropical soda apple. Hydrilla is a submersed aquatic plants present in several TVA reservoirs. Giant salvinia, also an aquatic plant, occurs in ponds, reservoirs, and slow-moving streams. It primarily occurs south of the TVA region and has not yet been reported from the Tennessee River drainage. Cogongrass is an upland plant present in several TVA region counties in Alabama and Mississippi. It occurs on and in the vicinity of several TVA transmission line right-of-ways and can be spread by line construction and maintenance activities. Tropical soda apple has been reported from a few counties in the TVA region and primarily occurs in agricultural areas.

Several additional invasive plants that are considered to be of severe threat or significant threat (TEPPC 2001) occur on or in the immediate vicinity of TVA generating facilities and transmission line right-of-ways. These include tree-of-heaven, Asian bittersweet, autumn olive, Chinese privet, kudzu, phragmites, Eurasian water-milfoil, multiflora rose, and tall fescue. Phragmites occurs in ash ponds at several TVA coal-fired plants and is otherwise uncommon in the TVA region.

Invasive aquatic animals in the TVA region that harm or potentially harm aquatic communities include the common, grass, bighead and silver carp, alewife, blueback herring, rusty crayfish, Asiatic clam, and zebra mussel. Because of their potential to affect water intake systems, TVA uses chemical and warm-water treatments to control Asiatic clams and zebra mussels at its generating facilities.

Invasive terrestrial animals at TVA generating facilities which occasionally require management include the rock pigeon, European starling, house sparrow, and fire ant. These species have little effect on the operation of TVA's power system.

4.10. Endangered and Threatened Species

In recognition of the declining populations of fish, wildlife and plant species, the Endangered Species Act of 1973 (ESA; 16 U.S.C. §§ 1531-1543) was passed to conserve the ecosystems upon which endangered and threatened species depend. Endangered species are defined by the ESA as any species in danger of extinction throughout all or a significant portion of its range. A threatened species is likely to become endangered within the foreseeable future throughout all or a significant part of its range. The ESA establishes programs to conserve and recover these species and makes their conservation a priority for federal agencies.

Thirty-seven species of plants, one lichen, and 109 species of animals in the TVA region area are listed under the ESA as endangered or threatened species or formally proposed for such listing by the U.S. Fish and Wildlife Service. An additional 31 species in the TVA region have been identified by the U.S. Fish and Wildlife Service as candidates for listing under the ESA. Several areas across the TVA region are also designated under the ESA as critical habitat essential to the conservation of listed species.

All of the seven states in the TVA region have passed laws protecting endangered and threatened species. The number of species on these state lists and the degree of protection they receive varies among the states. In addition to the species listed under the ESA, about 750 plant species and 1,500 animal species are formally listed by one or more of the states or considered as sensitive species.

The highest concentrations of terrestrial species listed under the ESA occur in the Blue Ridge, Appalachian Plateaus, and Interior Low Plateau regions. The highest concentrations of listed aquatic species occur in these same regions. Relatively few listed species occur in the Coastal Plain and Mississippi Alluvial Plain regions. The taxonomic groups with the highest proportion of species listed under the ESA are fish and mollusks. Factors contributing to the high proportions of vulnerable species in these groups include the high number of endemic species in the TVA region and the alteration of their habitats by reservoir construction and water pollution. River systems with the highest numbers of listed aquatic species include the Tennessee, Cumberland, Coosa, and Mobile rivers.

Populations of a few listed species have increased to the point where they are no longer listed under the ESA (e.g., bald eagle, peregrine falcon, Eggert's sunflower) or their listing status has been downgraded from endangered to threatened (e.g., snail darter, large flowered skullcap, small whorled pogonia). Other listed species with increasing populations include the gray bat. Among the listed species with populations that continue to decline are the Indiana bat and the American hart's tongue fern. Population trends of many listed species in the TVA region are poorly known.

Thirty-seven species listed under the ESA occur in the immediate vicinity of the TVA reservoir system and are potentially affected by its operation (TVA 2004, USFWS 2006). The major reservoir system habitats supporting listed species are flowing (unimpounded) mainstem reaches and warm tributary tailwaters. Other habitats in the TVA region less associated with the TVA reservoir system and supporting high concentrations of listed species include free-flowing rivers, caves, and limestone cedar glades. TVA has recently taken several actions to minimize the adverse effects of its operation of the reservoir system on endangered and threatened species (TVA 2004, USFWS 2006).

At least 11 species listed or candidates for listing under the ESA occur on or in the immediate vicinity of TVA generating facility reservations. These include the following:

- Large-flowered skullcap, *Scutellaria montana* - Threatened
- Gray bat, *Myotis grisescens* - Endangered
- Dromedary pearlymussel, *Dromus dromas* - Endangered
- Fanshell, *Cyprogenia stegaria* - Endangered
- Pink mucket, Lampsilis abrupta - Endangered
- Ring pink, *Obovaria retusa* - Endangered
- Rough pigtoe, *Pleurobema plenum* - Endangered
- White wartyback, *Plethobasis cicatricosus* - Endangered
- Slabside pearlymussel, *Lexingtonia dolabelloides* - Candidate for listing
- Spectaclecase, *Cumberlandia monodonta* - Candidate for listing
- Anthony’s river snail, *Athernia anthonyi* - Endangered

Species listed or candidates for listing under the ESA that occur on or in the immediate vicinity of TVA transmission line right-of-ways include the following:

- Braun's rock-cress, *Arabis perstellata* - Endangered
- Cumberland sandwort, *Minuartia cumberlandensis* - Endangered
- Fleshy-fruit gladecress, *Leavenworthia crassa* - Candidate for listing
- Green pitcher plant, *Sarracenia oreophila* - Endangered
- Large-flowered skullcap, *Scutellaria montana* - Threatened
- Leafy prairie-clover, *Dalea foliosa* - Endangered
- Monkey-face orchid, *Platanthera integrilabia* - Candidate for listing
- Price's potato-bean, *Apios priceana* - Threatened
- Pyne's ground plum, *Astragalus bibullatus* - Endangered
- Shorts bladderpod, *Lesquerella globosa* - Candidate for listing
- Spring Creek bladderpod, *Lesquerella perforata* - Endangered
- Tennessee coneflower, *Echinacea tennesseensis* - Endangered
- Gray bat, *Myotis grisescens* - Endangered

TVA transmission lines also cross many streams supporting listed aquatic species.

4.11. Wetlands

Wetlands are areas that are inundated or saturated by water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (EPA regulations at 40 C.F.R § 230.3(t)). Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands are highly productive and biologically diverse ecosystems that provide multiple public benefits such as flood control, reservoir shoreline stabilization, improved water quality, and habitat for fish and wildlife resources.

Wetlands occur across the TVA region and are most extensive in the south and west where they comprise 5 percent or more of the landscape (USGS 2008). Wetlands in the TVA region consist of two main systems: palustrine wetlands such as marshes, swamps and bottomland forests dominated by trees, shrubs, and persistent emergent vegetation, and lacustrine wetlands associated with lakes such as aquatic bed wetlands (Cowardin et al. 1979). Riverine wetlands associated with moving water within a stream channel are also present but relatively uncommon. Almost 200,000 acres of wetlands are associated with the TVA reservoir system, where they are more prevalent on mainstem reservoirs and tailwaters than tributary reservoirs and tailwaters (TVA 2004). Almost half of this area is forested wetlands; other types include aquatic beds and flats, ponds, scrub/shrub wetlands, and emergent wetlands. Emergent wetlands occur on many TVA generating facility sites, often in association with ash disposal ponds and water treatment ponds. Scrub-shrub and emergent wetlands occur within the right-of-ways of many TVA transmission lines. A large proportion of these wetlands were forested before the transmission lines were constructed.

National and regional trends studies have shown a large, long-term decline in wetland area both nationally and in the southeast (Dahl 2000, Dahl 2006, Hefner et al. 1994). Wetland losses have been greatest for forested and emergent wetlands, and have resulted from drainage for agriculture, forest management activities, urban and suburban development, and other factors. The rate of loss has significantly slowed over the past 10 years due to regulatory mechanisms for wetland protection. These include the Clean Water Act and state water quality legislation. Executive Order 11990—Protection of Wetlands requires federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance their natural and beneficial values.

4.12. Parks, Managed Areas, and Ecologically Significant Sites

Numerous areas across the TVA region are recognized and, in many cases, managed for their recreational, biological, historic, and scenic resources. These areas are owned by federal and state agencies, local governments, and private corporations and individuals. They are typically managed for one or more of the following objectives:

- Recreation—areas managed for outdoor recreation or open space. Examples include national, state, and local parks and recreation areas; reservoirs (TVA and other); picnic and camping areas; trails and greenways; and TVA small wild areas.
- Species/Habitat Protection—places with endangered or threatened plants or animals, unique natural habitats, or habitats for valued fish or wildlife populations. Examples include national and state wildlife refuges, mussel sanctuaries, TVA habitat protection areas, and nature preserves.
- Resource Production/Harvest—lands managed for production of forest products, hunting, and fishing. Examples include national and state forests, state game lands and wildlife management areas, and national and state fish hatcheries.
- Scientific/Educational Resources—lands protected for scientific research and education. Examples include biosphere reserves, research natural areas, environmental education areas, TVA ecological study areas, and federal research parks.
- Historic Resources—lands with significant historic resources. Examples include national battlefields and military parks, state historic sites, and state archeological areas.
- Scenic Resources—areas with exceptional scenic qualities or views. Examples include national and state scenic trails, scenic areas, wild and scenic rivers, and wilderness areas.

Numerous parks, managed areas, and ecologically significant sites occur in the TVA region. These areas occur throughout the TVA region in all physiographic areas; they are most concentrated in the Blue Ridge and Mississippi Alluvial Plain physiographic areas. Individual areas vary in size from a few acres to thousands of acres. Many cross state boundaries or are managed cooperatively by several agencies.

Parks, managed areas, and ecologically significant sites occur on or immediately adjacent to many TVA generating facility reservations, including Allen, Colbert, Gallatin, Kingston, Paradise and Shawnee fossil plants, Watts Bar Nuclear Plant, and the Bellefonte site. This is especially the case at hydroelectric plants, where portions of the original reservation lands have been developed into state and local parks. TVA transmission line right-of-ways cross six National Park Service units, eight National Forests, five National Wildlife Refuges, and numerous state wildlife management areas, state parks, and local parks.

4.13. Land Use

Major land uses in the TVA region include forestry, agriculture, and urban/ suburban/industrial (USDA 2009). About three percent of the area of the TVA region is water, primarily lakes and rivers. This proportion has increased slightly since 1982, primarily due to the construction of small lakes and ponds. About 5.5 percent of the land area is Federal land; this proportion has also increased slightly since 1982. Of the remaining non-Federal land area, about 12 percent is classified as developed and 88 percent as rural. Rural undeveloped lands include farmlands (28 percent of the land area) and forestland (about 60 percent of the land area). The greatest change since 1982 has been in developed land, which almost doubled in area due to high rates of urban and suburban growth in much of the TVA region. Forestland increased in area through much of the 20th century; this rate of increase has slowed and/or reversed in parts of the TVA region in recent years (Conner and Hartsell 2002, USDA 2009). Both cropland and pastureland have decreased in area since 1982 (USDA 2009).

Agriculture - Agriculture is a major land use and industry in the TVA region. In 2007, 27.8 percent of the land area in the TVA region was farmland and part of 147,349 individual farms (USDA 2007). Average farm size was 158 acres. Almost half (48.5 percent) of the farmland was classified as cropland in 2007; this classification includes hay and short rotation woody crops. A quarter (26.3 percent) of the farmland was pasture and the remainder was woodland or devoted to other uses such as buildings and other farm infrastructure. Farm size in the TVA region varies considerably with numerous small farms and a smaller number of large farms. The median farm size in most counties is generally less than 100 acres, and increases from east to west (USDA 2007).

Farms in the TVA region produce a large variety of products that varies across the region. While the proportion of land in farms is greatest in southern Kentucky and central and western Tennessee, the highest farm income occurs in northern Alabama and Georgia (EPRI and TVA 2009). Compared to farms in the southern and western portions of the TVA region, farms in the eastern and northern portions tend to be smaller and receive a higher proportion of their income from livestock sales than from crop sales. Region-wide, the major crop items by land area are forage crops (hay and crops grown for silage), soy, corn, and cotton. The major farm commodities by sales are cattle and calves, poultry and eggs, grains and beans, cotton, and nursery products (USDA 2007).

Although the area of irrigated farmland is small (1.2 percent of farmland), it increased by 143 percent between 1987 and 2007 to 281,741 acres (Bureau of Census 1989, USDA 2007). The area of irrigated farmland is likely to increase in the future as temperature and precipitation patterns become less predictable or drought conditions become more prevalent (EPRI and TVA 2009).

Crops grown specifically to produce biomass for use as fuels (dedicated energy crops) are a potentially important commodity in the TVA region. In 2002, the Census of Agriculture began recording information on short rotation woody crops, which grow from seed to a mature tree in 10 years or less. These have traditionally been used by the forest products industry for producing paper or engineered wood products. They are also a potential source of biomass for power generation. In 2007, there were 286 farms in the TVA region growing at least 12,433 acres of short rotation woody crops and 109 farms harvested over 1,326 acres of short rotation woody crops (USDA 2007).

Prime Farmland - The Farmland Protection Policy Act recognized the importance of prime farmland and the role that federal agencies can have in converting it to nonagricultural uses. The act requires federal agencies to consider the potential effects of their proposed actions on prime farmland and consider alternatives to actions that would adversely affect prime farmland.

Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops, and that is available for these uses (NRCS 2009a). It has the combination of soil properties, growing season, and moisture supply needed to produce sustained high yields of crops in an economic manner if it is treated and managed according to acceptable farming methods. Prime farmland is designated independently of current land use, but it cannot be areas of water, urban, or built-up land.

Approximately 22 percent[6] of the TVA region is classified as prime farmland (NRCS 2009b). An additional 4 percent of the TVA region would be classified as prime farmland if drained or protected from flooding.

Forestry - About 97 percent of the forestland in the TVA region is classified as timberland (USFS 2010), forestland that is producing or capable of producing more than 20 cubic feet of merchantable wood per acre per year and is not withdrawn from timber harvesting by law. About 14 percent of timberland is in public ownership, primarily national forests. About 20 percent is owned by corporations and the remainder in non-corporate private ownership. While the majority of corporate timberlands have historically been owned by forest industries, this proportion has decreased in recent years as many forest industries have sold timberlands due to changing market conditions.

4.14. Cultural Resources

Cultural resources include archaeological sites, historic sites, and historic structures. Because of their importance to the Nation's heritage, they are protected by several laws and Federal agencies, including TVA, are to facilitate their preservation. The primary law governing the role of federal agencies in their management and preservation is the National Historic Preservation Act (NHPA; 16 U.S.C. §§ 470 et seq.). Other relevant laws include the Archaeological and Historic Preservation Act (16 U.S.C. §§ 469-469c), Archaeological Resources Protection Act (16 U.S.C. §§ 470aa-470mm), and the Native American Graves Protection and Repatriation Act (25 U.S.C. §§ 3001-3013).

Section 106 of the NHPA requires Federal agencies to consider the effect of their actions on historic properties and to allow the Advisory Council on Historic Preservation an opportunity to comment on the action. Section 106 involves four steps: 1) initiate the process; 2) identify historic properties; 3) assess adverse effects; and 4) resolve adverse

[6] This estimate does not include about 20 counties for which soil survey information is incomplete or not available.

effects. This process is carried out in consultation with the State Historic Preservation Officer of the state in which the undertaking takes place and with any other interested consulting parties, including federally recognized Indian tribes.

Historic properties are defined as buildings, structures, sites, objects, and districts that meet the Criteria for Eligibility for the National Register of Historic Places (NRHP). Sites can be considered eligible for the NRHP if they meet one or more criteria related to significant historical events, important historical persons, distinctive construction or artistic value, and potential to yield important information. In addition to these criteria, the property must possess integrity of location, design, setting, materials, workmanship, feeling, and association.

Section 110 of the NHPA sets out the broad historic preservation responsibilities of Federal agencies and is intended to ensure that historic preservation is fully integrated into their ongoing programs. Federal agencies are responsible for identifying and protecting historic properties and avoiding unnecessary damage to them. Section 110 also charges each Federal agency with the affirmative responsibility for considering projects and programs that further the purposes of the NHPA, and it declares that the costs of preservation activities are eligible project costs in all undertakings conducted or assisted by a Federal agency.

Archaeological Resources

The TVA region has been occupied by humans for over 15,000 years. The earliest documentation of archaeological research in the region dates back to the 19th Century when entities such as the Smithsonian Institute and individuals such as Cyrus Thomas undertook some of the first archaeological excavations in America to document the history of Native Americans (Guthe 1952).

Archaeological survey coverage and documentation in the region varies by state. Each state keeps records of archaeological resources in different formats. While digitization of this data is underway, no consistent database is available for determining the number of archaeological sites within the TVA region. Survey coverage on private land has been inconsistent and is largely project-based rather than focusing on high-probability areas so data is likely skewed. Based on the knowledge of the seven states located in the TVA region, TVA estimates that over 67,000 archaeological sites have been recorded. Significant archaeological excavations have occurred as a result of TVA and other Federal projects and have yielded impressive information regarding the prehistoric and historic occupation of the Southeastern United States. Notable recent excavations and related projects in the region include those associated with the Townsend, Tennessee highway expansion, Shiloh Mound mitigation on the Tennessee River in Hardin County, Tennessee, the Ravensford in Swain County, North Carolina, and documentation of prehistoric cave art in Alabama and Tennessee.

TVA was a pioneer in carrying out archaeological investigations during the construction of its dams and reservoirs in the 1930s and early 1940s (Olinger and Howard 2009). Since then, TVA has conducted numerous archaeological surveys associated with permitting and power generation and transmission system activities. These surveys, as well as other off-reservoir projects, have identified more than 2000 sites, including over 250 associated with transmission system activities, within the TVA region. A large proportion of these sites have not been evaluated for NRHP eligibility and the number eligible or potentially eligible for listing on the NRHP is unknown.

Historic Structures
Numerous historic structures, buildings, sites and districts occur across the TVA region. Over 5,000 historic structures have been recorded in the vicinity of TVA reservoirs and power system facilities. Of those evaluated for NRHP eligibility, at least 85 are listed in the NRHP and about 250 are considered eligible or potentially eligible for listing. TVA power system facilities listed in the NRHP include the Ocoee 1, Ocoee 2, Great Falls, and Wilson Dams, and hydroelectric plants. Wilson Dam is also listed as a National Historic Landmark. Power system facilities determined to be eligible or potentially eligible for the NRHP are associated with Blue Ridge, Chatuge, Hiwassee, Nottely, Ocoee 3, Apalachia, Fontana, Norris, Watts Bar, Pickwick, and Guntersville Dams and the decommissioned Watts Bar Steam Plant. The switch houses at several TVA substations are also likely eligible for listing, and some of the oldest transmission lines are potentially eligible for listing. Given their age and historical significance, some of TVA's operating coal-fired fossil plants are potentially eligible for listing.

4.15. Socioeconomics

This section describes socioeconomic conditions in the TVA region with the focus on the power service area consisting of the 170 counties where TVA is a major provider of electric power (Figure 1-1). In addition to population, economy, employment, and income, it describes the relative size and location of minority and low income populations.

Population
The population of the TVA power service area was about 8.4 million in 2000 (Bureau of Census 2000a). By 2009, it had increased to about 9.2 million (Bureau of Census 2010). If trends over recent decades continue, the total population will be about 10.9 million by 2030 (TVA data).

Population varies greatly among the counties in the region (Figure 4-37). The larger population concentrations tend to be located along river corridors: the Tennessee River and its tributaries from northeast Tennessee through Knoxville and Chattanooga into north Alabama; the Nashville area around the Cumberland River; and the Memphis area on the Mississippi River. Low population counties are scattered around the region, but most are in Mississippi, the Cumberland Plateau of Tennessee, and the Highland Rim of Tennessee and Kentucky.

About 65 percent of the region's total population lives in metropolitan areas[7] (Table 4-14). Two of these have populations greater than one million: Nashville, almost 1.6 million, and Memphis, almost 1.1 million in the region. The Knoxville and Chattanooga metropolitan areas have populations greater than 500,000. These four metropolitan areas account for about 42 percent of the region's population.

Although the proportion of the region's population living in metropolitan areas is lower than the national average of 84 percent, it is has been increasing and this trend is likely to continue in the future (TVA data). A substantial part of this increase is likely to follow the pattern of increases in the geographic size of metropolitan areas as growth spreads out from the central core of these areas. Increases in the cost of energy and transportation may dampen this trend, however, resulting in more concentrated growth patterns.

---

[7] The Chattanooga MSA has one county outside the TVA region, Dade County, GA; the Memphis MSA has three counties outside the TVA region, Crittenden County in Arkansas and DeSoto and Tunica counties in Mississippi.

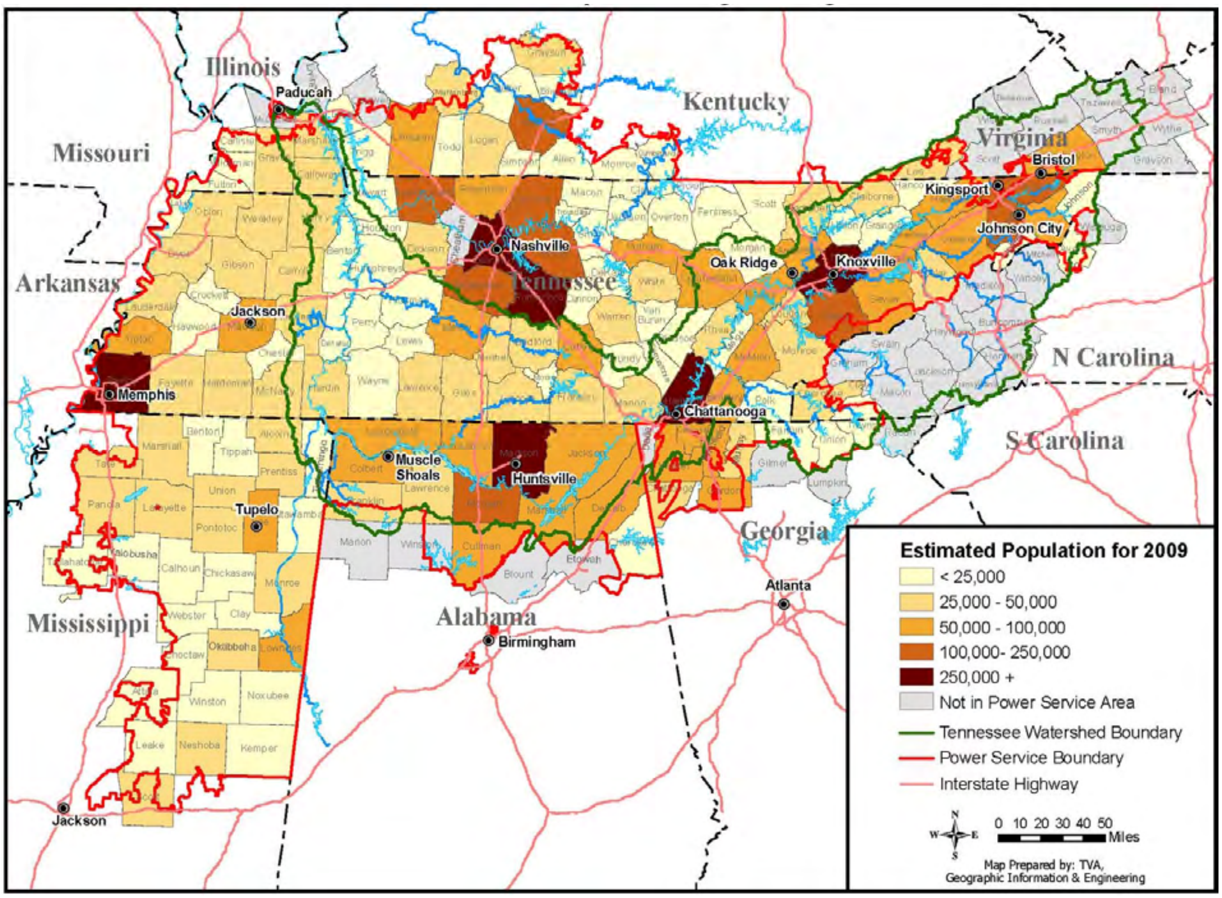


Figure 4-37. TVA region estimated 2009 population by county. Source: Bureau of Census (2010).

Economy and Employment

In 2008, the TVA region had an economy of about $361 billion in gross product and total personal income of about $286 billion, about 2.5 percent of the national total (USBEA 2010). Total nonfarm employment was slightly more than 4 million. While income levels in the region have increased relative to the nation over the past several decades, average income is still below the national level. 2008 per capita personal income averaged about $33,250, about 83 percent of the national average (USBEA 2010). The area is more rural and the economy depends more on manufacturing than does the nation as a whole. The area also has a larger proportion of agricultural workers than the nation as a whole.

Manufacturing — The manufacturing sector is relatively more important in the region than in the nation overall, providing about 12 percent of regional employment and 17 percent of regional earnings (Figure 4-38), compared to the national rates of 8 percent and 11 percent respectively. The relative importance of manufacturing has been declining for a number of years, both nationally and regionally. The estimated manufacturing employment in the TVA region is about 631,000 at the present time, a sharp decrease from its level of almost 852,000 ten years ago. Manufacturing in the TVA region accounts for about 2.5 percent of all manufacturing earnings in the nation, and is expected to maintain this share. Factors contributing to the high proportion of manufacturing include location with good access to
852,000 ten years ago. Manufacturing in the TVA region accounts for about 2.5 percent of all manufacturing earnings in the nation, and is expected to maintain this share. Factors

Table 4-14. TVA region metropolitan areas (Source: Bureau of Census 2000a, 2010).

Metropolitan Area	2000 (Census of Population)	2009 (Census Estimate)	2030 (Projection based on trend, 1970 to 2009)	2030 (Projection based on trend, 1980 to 2009)
Bowling Green, KY	104,166	120,595	143,901	144,821
Chattanooga, TN-GA	461,377	508,176	569,980	563,540
Clarksville, TN-KY	232,000	268,546	329,982	333,762
Cleveland, TN	104,015	113,358	140,995	137,536
Dalton, GA	120,031	134,319	171,322	172,717
Decatur, AL	145,867	151,399	179,790	176,345
Florence-Muscle Shoals, AL	142,950	144,238	159,582	152,547
Huntsville, AL	342,376	406,316	482,141	509,431
Jackson, TN	107,377	113,629	134,366	134,614
Johnson City, TN	181,607	197,381	229,429	226,895
Kingsport-Bristol-Bristol, TN-VA	275,081	273,044	320,109	306,493
Knoxville, TN	616,079	699,247	818,292	826,277
Memphis, TN-AR	1,037,912	1,082,749	1,227,188	1,228,318
Morristown, TN	123,081	137,612	166,680	166,139
Nashville- Davidson-Murfreesboro, TN	1,311,789	1,582,264	1,952,115	2,023,164
Total	5,305,708	5,942,873	7,025,872	7,102,600

contributing to the high proportion of manufacturing include location with good access to markets in the Northeast, Midwest, and Southwest, as well as the rest of the Southeast, good transportation, relatively low wages and cost of living, right-to-work laws, and abundant, relatively low-cost resources including land and electricity.

While the mix of manufacturing industries varies considerably across the region, there has been a continuing shift from non-durable goods, such as apparel, to durable goods, such as automobiles. In 1990, about 48 percent of manufacturing jobs were in durables. That share has increased to about 53 percent, and this increase is expected to continue (TVA data). Nondurable goods manufacturing peaked about 1993; the most notable decline has been in apparel and other textile products, which declined from about 13 percent of regional manufacturing in 1990 to about 2 percent in 2009 (TVA data). Nationally, there has been a slight increase in the share of non-durables, from about 40 percent in the year 2000 to a little more than 41 percent currently.

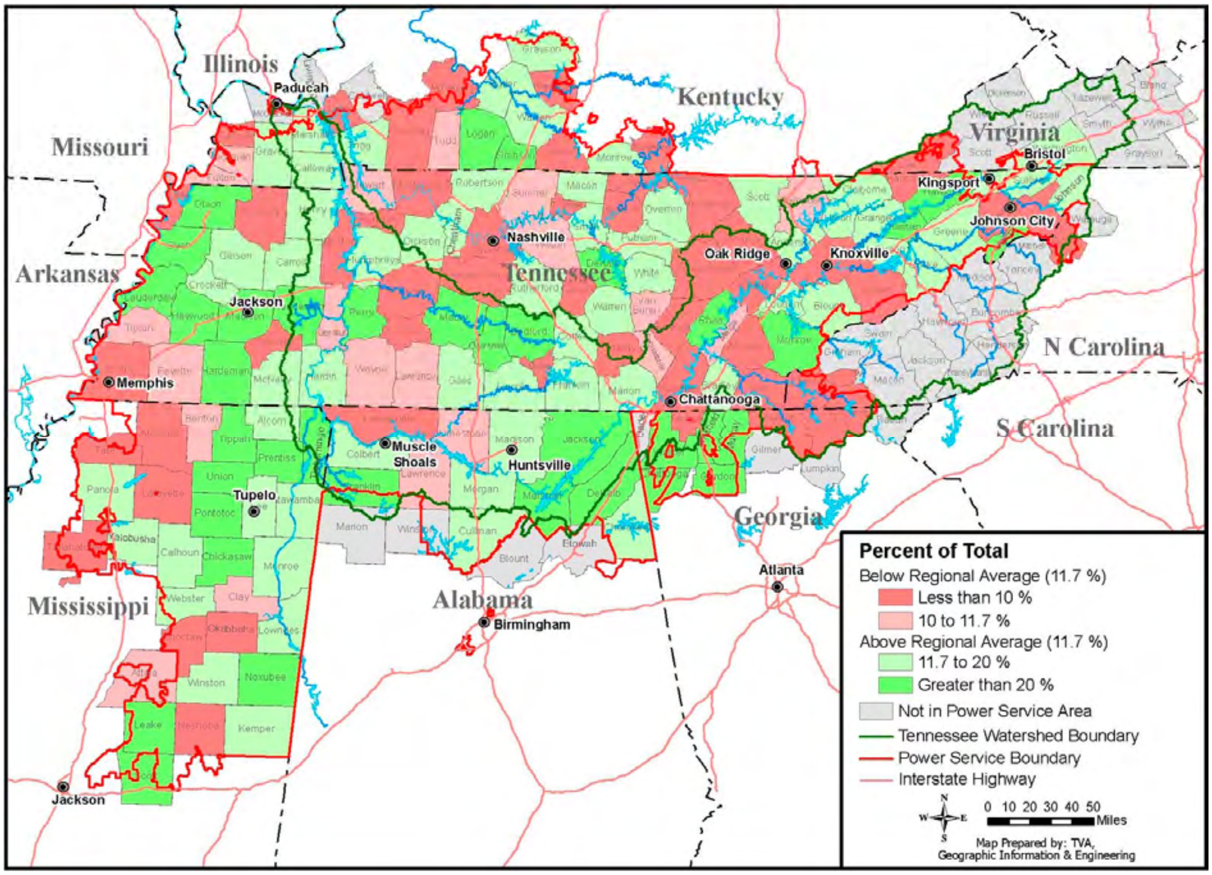


Figure 4-38. Manufacturing employment as proportion of total employment in 2008. Source: USBEA (2010).

Agriculture — The total market value of farm products produced in the TVA region in 2007 was $8.6 billion; 63 percent of this total ($6.2 billion) was from the sale of livestock, poultry, and their products and 27 percent ($2.3 billion) was from the sale of crops (USDA 2007). The regional farm sector provides approximately 141,000 jobs, about 2.6 percent of all jobs in the region (Figure 4-39). This is greater than the national average of 1.5 percent of workers employed in farming, and, like the national average, has decreased in recent decades. Part of this decrease is due to efficiency increases.

Much of the farming in the region is done on a part-time basis, and only 38.9 percent of principal farm operators in Tennessee reported farming as their primary occupation. Net cash farm income averaged $3,075 per farm, much less than the nationwide average of $33,827 (USDA 2007).

There is a large amount of diversity among farms in the region. For example, cotton is an important crop in parts of Mississippi and the western part of Tennessee. Soybeans are common through much of the region, and fruit and vegetable farming is widespread but generally in small operations. Pork and beef production are also widespread. Wholesale production of trees and shrubs for the commercial nursery industry is important in the southeastern Highland Rim of Tennessee.

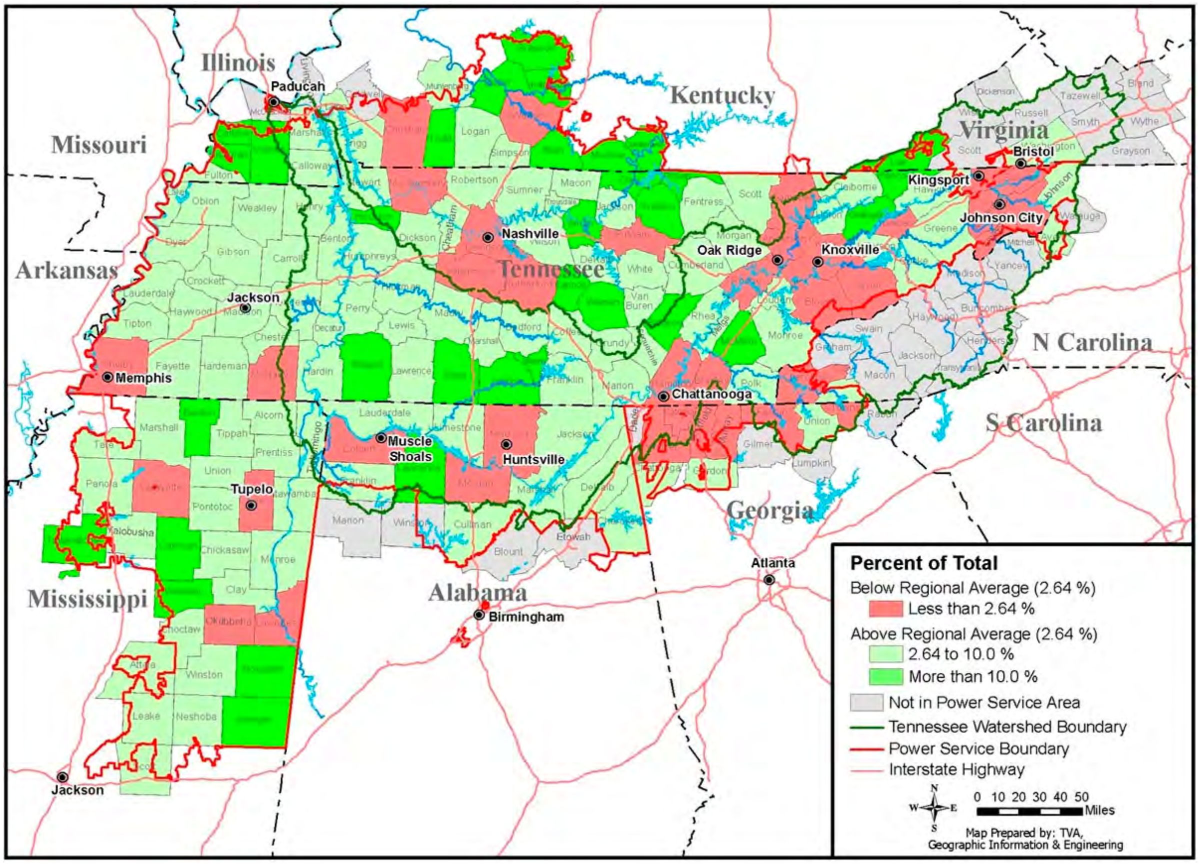


Figure 4-39. Agricultural employment as proportion of total employment in 2008. Source: USBEA (2010).

Services and Other — The service sector is a significant share of the regional economy, accounting for about 31 percent of nonfarm workers, slightly lower than the national proportion of 35 percent. The service sector and other non-farming, non-manufacturing sectors of the regional economy have continued to grow, increasing by about 21 percent and 9 percent, respectively, in the region since 2000. This growth was due to increases in services employment and, to a lesser extent, in civilian government. Employment in the region has declined or remained essentially level in other sectors. Nationally, services grew somewhat more slowly than in the region, about 13 percent, while civilian government grew only slightly faster, at almost 9.5 percent.

Income

Per capita personal income in the region in 2008 was $33,251, about 83 percent of the national average of $40,166. However, there was wide variation within the region (Figure 4-40). Most counties above the regional level are located in metropolitan areas. Williamson County, Tennessee, located in the Nashville metropolitan area, had the highest average, $55,717, almost 139 percent of the national average. Two other counties exceeded the national average, Davidson, TN, where Nashville is located, with $44,228, about 110 percent of the national average, and Shelby, TN, where Memphis is located, with $41,598, about 104 percent of the national average. At the other extreme only one county had per capita income less than half the national average, Hancock County, Tennessee, with about 46 percent of the national average.

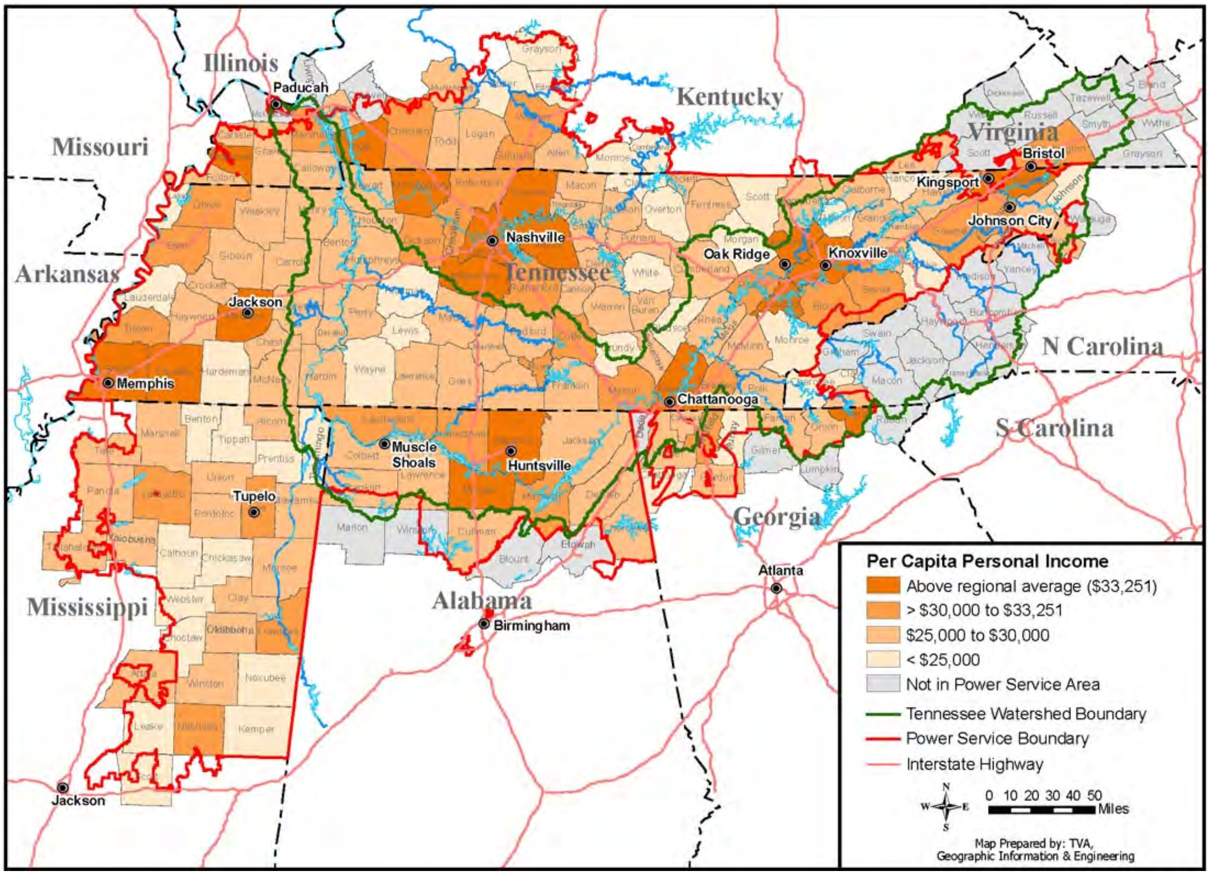


Figure 4-40. Per capita personal income in 2008. Source: USBEA (2010).

The Future of the Economy

The regional and national economies have recently shown signs of slowly recovering from the 2008-2010 recession. Total employment in the region is expected to increase from its current level of slightly less than 5.1 million, reaching about 5.5 million by 2014 and 6.3 million over the next 20 years (TVA data). Some small increase in manufacturing employment is expected in the nearer term as the economy recovers from the current recession. In the longer term, however, manufacturing employment will continue to decline, reflecting, at least in part, greater efficiencies in production. Employment, both regionally and nationally, will continue to grow in service sectors as they become an even larger component of the economy. Overall, it is likely that the region will surpass national growth rates once the effects of the current recession are over. The region has an advantage in manufacturing, especially in automobiles, distribution services, and tourism. It also has excellent opportunities for manufacturing and services related to energy, including alternative energy. It is expected, however, that growth, nationally as well as regionally, will be somewhat subdued by historical standards, given the severity of the current recession. Investment decisions will be likely to undergo greater scrutiny than in recent years, not only as a reaction to the recession, but also because greater financial market regulation and tighter credit conditions, along with large federal budget deficits due in part to the recession, will dampen growth expectations.

Minority and Low Income Populations
The minority population of the region, as of 2008, is estimated to be a little less than 2.1 million, about 22.6 percent of the region's total population of about 9.1 million (Bureau of 2009). This is well below the national average minority population share of 34.4 percent. About 12 percent of minorities in the region are white Hispanic and the rest are nonwhite. Minority populations are largely concentrated in the metropolitan areas in the western half of the region and in rural counties in Mississippi and western Tennessee (Figure 4-41).

The estimated poverty level in the region, as of 2008, is 15.8 percent, somewhat higher than the national poverty level of 13.2 percent (Bureau of Census 2009). Counties with the higher poverty levels are generally outside the metropolitan areas and most concentrated in Mississippi (Figure 4-42).

4.16. Solid and Hazardous Waste

This section focuses on the solid and hazardous wastes produced by the construction and operation of generating plants and transmission facilities. Wastes typically produced by construction activities include trees cleared from the facility site, demolition debris, packing materials, scrap lumber and metals, and domestic wastes (garbage). Non-hazardous wastes typically produced by common facility operations include sludge from water treatment plant filters and demineralizers, used oil and lubricants, spent resin, desiccants, batteries, and domestic wastes. Between 2006 and 2009, TVA power facilities produced an annual average of about 18,500 tons of solid waste. The amount of waste produced at a facility can vary from year to year due to maintenance and asset improvement activities.

Hazardous, non-radiological wastes typically produced by common facility operations include paint, paint thinners, paint solids, discarded laboratory chemicals, parts washer liquid, hydrazine, chemical waste from demineralizer beds and makeup water treatment, and broken fluorescent bulbs (TVA 2010c). The amount of these wastes generated varies with the size and type of facility. Standard TVA procedures for handling non-hazardous wastes include minimizing their production, reuse and recycling, and, where these are not feasible, offsite disposal in a permitted landfill.

Hazardous wastes and wastes requiring special handling (Table 4-15) are shipped to TVA's hazardous waste storage facility in Muscle Shoals, Alabama, for interim storage prior to disposal in permitted hazardous waste disposal facilities.

Hazardous wastes are defined by the Resource Conservation and Recovery Act to include those that meet criteria of ignitability, corrosivity, reactivity, or toxicity, or are listed in regulations or by the Toxic Substances Control Act. They can include paints, solvents, corrosive liquids, and discarded chemicals. TSCA wastes are regulated under the Toxic Substances Control Act, primarily chemicals (both hazardous and non-hazardous) and polychlorinated biphenyl compounds (PCBs), which have historically been used as insulating fluids in transformers. Universal wastes are a class of hazardous wastes that generally pose a relatively low threat, but contain materials that cannot be freely released into the environment. This classification includes batteries, pesticides, and equipment containing mercury.

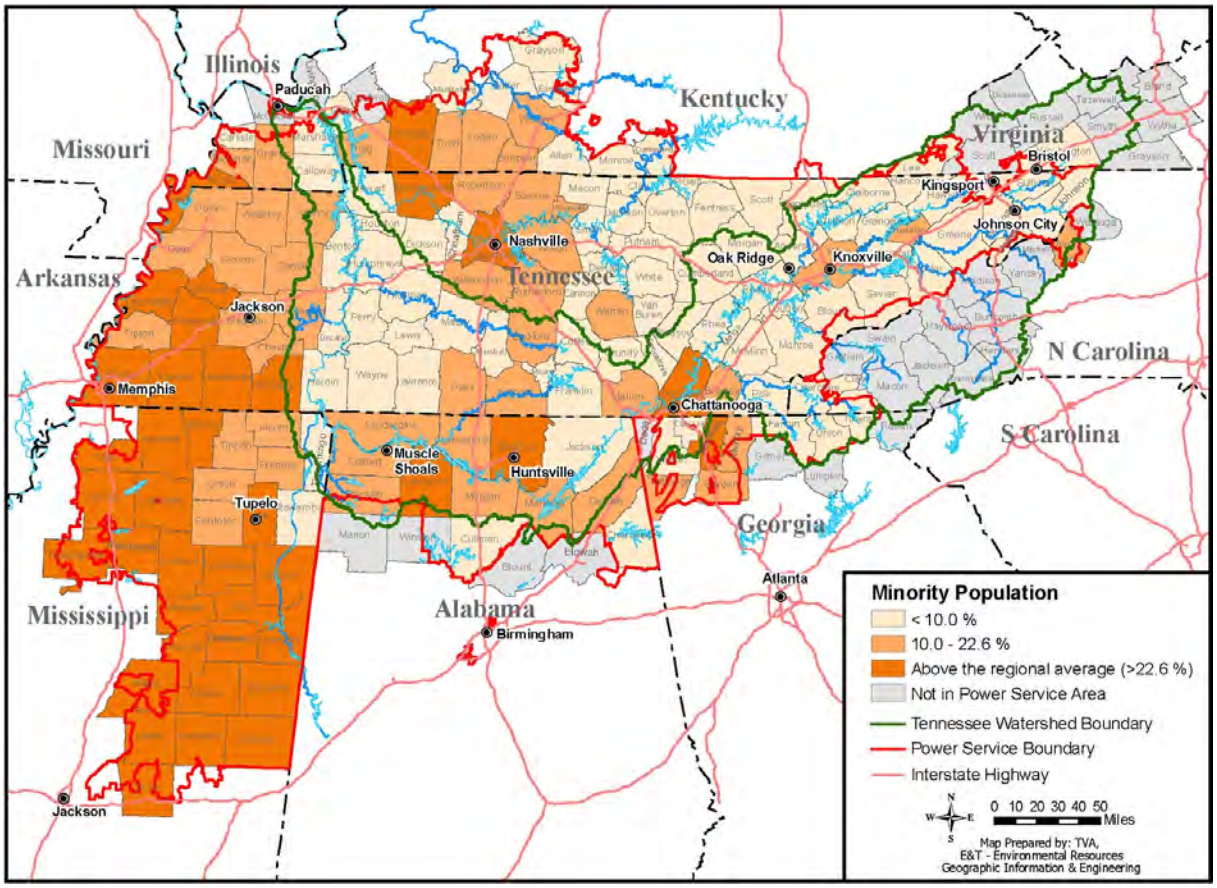


Figure 4-41. Percent minority population of TVA region counties in 2008. Source: Bureau of Census (2009).

Table 4-15. Quantities (in kilograms) of hazardous wastes and other wastes requiring special handling produced by TVA generating facilities, 2006-2009. See text for descriptions of the waste classifications.

Waste Classification	Type of Generating Facility							
	Coal		Nuclear		Hydro		Natural Gas	
	2006-08 average	2009	2006-08 average	2009	2006-08 average	2009	2006-08 average	2009
Hazardous	21,723	10,988	4,834	8,511	7,037	2,503	80	38
Universal	348	204	134	22	78	9	0	0
TSCA	19,807*	22,435	1,554	2,654	8,063	5,536	0	0
Used Oil	6,137	11,324	8,501	5,907	11,324	11,980	747	6,343

*All quantities in kilograms.

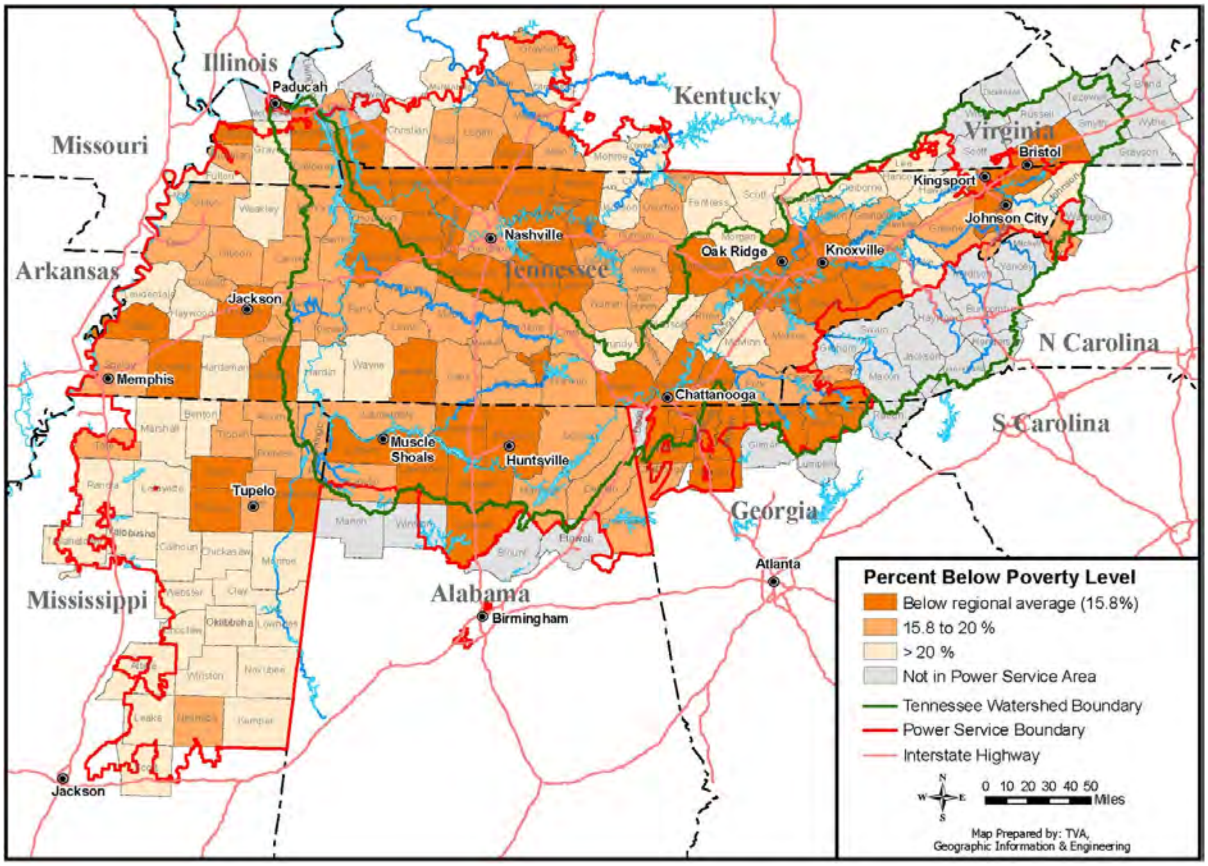


Figure 4-42. Percent of population below the poverty level in 2008. Source: Bureau of Census (2009).

Coal-fueled generating plants produce large quantities of ash and other coal combustion solid wastes, and nuclear plants produce radiological wastes. These wastes are described in more detail below.

Coal Combustion Solid Wastes

The primary solid wastes produced by coal combustion are fly ash, bottom ash, boiler slag, char, spent bed material, and synthetic gypsum. The properties of these wastes (also known as coal combustion products or CCPs) vary with the type of coal plant, the chemical composition of the coal, and other factors. Ash and slag are formed from the non-combustible matter in coal and small amounts of unburned carbon. Fly ash is composed of small, silt- and clay-sized, mostly spherical particles that are carried out of the boiler by the exhaust gas. Bottom ash is heavier and coarser with a grain size of fine sand to fine gravel. It falls to the bottom of the boiler where it is typically collected by a water-filled hopper. Boiler slag, a coarse, black, granular material, is produced in cyclone furnaces when molten ash is cooled in water. Ash and slag are primarily composed of silica (SiO_2), aluminum oxide (Al_2O_3), and iron oxide (Fe_2O_3). Spent bed material is produced in fluidized bed combustion boilers (e.g., Shawnee Fossil Plant Unit 10). Synthetic gypsum is formed in flue gas desulfurization systems (scrubbers) by the interaction of sulfur in the flue gas with finely ground limestone. It is primarily hydrated calcium sulfate ($CaSO_4 2H_2O$).

During 2009, TVA produced approximately 5.3 million tons of CCPs, with almost half being gypsum and 35 percent being fly ash (Table 4-16). Of the 5.3 million tons, 1.5 million tons, or 29 percent, were utilized or marketed. Coal combustion solid wastes are sold for reuse in the manufacture of wallboard, roofing, cement, concrete, and other products.

Table 4-16. 2006 - 2009 coal combustion solid waste production and utilization.

	Production (tons)		Utilization (percent)	
Type	2006-2008 Average	2009	2006-2008 Average	2009
Fly Ash	2,947,925	1,849,911	41.7	25.2
Bottom Ash	581,970	357,116	51.4	1.3
Boiler Slag	543,179	525,320	89.4	110.3*
Char	109,269	55,641	0	0
Spent Bed	34,429	17,261	0	0
Gypsum	2,308,609	2,487,950	34.3	19.9
Total	6,525,381	5,293,199	43.0	29.2

*More sold than produced during the year.

The 1.5 million tons sold during 2009 decreased from the 2.8 million ton annual average for 2006-2008; much of this decrease is due to reduced demand resulting from the recent recession. The CCPs that are not sold for reuse are stored in landfills and impoundments at or near coal plant sites. Five TVA plants use dry ash collection/storage systems, and six plants use wet ash collection/storage system. In response to the December 2008 collapse of a wet ash storage pond dike at Kingston Fossil Plant, TVA has committed to converting all wet ash and gypsum storage facilities, present at six of its plants, to dry storage and disposal facilities. These projects are expected to be completed in eight to ten years.

Nuclear Waste

The nuclear fuel used for power generation produces liquid, gaseous, and solid radioactive wastes (radwaste) that require storage and disposal. These wastes are categorized as high-level waste and low-level waste. These categories are based on the type of radioactive material, the intensity of its radiation, and the time required for decay of the radiation intensity to natural levels.

<u>High-Level Waste</u> **-** About 99 percent of high-level waste generated by nuclear plants is spent fuel, including the fuel rod assemblies. Nuclear fuel is made up of small uranium pellets placed inside long tubular metal fuel rods. These fuel rods are grouped into fuel assemblies, which are placed in the reactor core. In the fission process, uranium atoms split in a chain reaction which yields heat. Radioactive fission products - the nuclei left over after the atom has split, are trapped and gradually reduce the efficiency of the chain reaction. Consequently, the oldest fuel assemblies are removed and replaced with fresh fuel at about 18-month intervals. Because nuclear plants normally operate continuously at full load, spent fuel production varies little from year to year. The six operating nuclear units produce about 650 tons of high-level waste per year.

After it is removed from the reactor, spent fuel is stored at the nuclear plants in pools (steel-lined, concrete vaults filled with water). The spent fuel pools were originally intended to store spent fuel onsite until a monitored retrievable storage facility and a permanent repository were built by the Department of Energy as directed by the Nuclear Waste Policy Act of 1982. Because these facilities have not yet been built, the storage capacity of the spent fuel pools at Sequoyah and Browns Ferry nuclear plants has been exceeded, TVA, like other utilities, has begun storing spent fuel in above-ground dry storage casks constructed of concrete and metal storage casks. The Watts Bar plant is forecasted to start using dry storage casks in 2015 (TVA 2007c).

Low-Level Waste **-** Low-level waste consists of items that have come into contact with radioactive materials. At nuclear plants, these wastes consist of solids such as filters, spent resins (primarily from water filtration systems), sludge from tanks and sumps, cloth and paper wipes, plastic shoe covers, tools and materials, and liquids such as tritiated waste (i.e., containing radioactive tritium), chemical waste, and detergent waste, and gases such as radioactive isotopes created as fission products and released to the reactor coolant. Nuclear plants have systems for collecting these radioactive wastes, reducing their volume, and packaging them for interim onsite storage and eventual shipment to approved processing and storage facilities. Dry active waste, which typically have low radioactivity, are presently shipped to a processor in Oak Ridge, Tennessee for compaction and then to a processor in Clive, Utah for disposal. Wet active wastes with low radioactivity are shipped to the Clive processor. Other radioactive wastes are currently shipped to and stored at the Sequoyah plant. Table 4-17 lists the amounts of low level waste produced at TVA nuclear plants in recent years.

Table 4-17. Quantity (in lbs.) and rate (in lbs/GWh) of low level waste generated at TVA nuclear plants, 2006-2009. Source: TVA data.

	2006		2007		2008		2009	
Plant	Amount	Rate	Amount	Rate	Amount	Rate	Amount	Rate
Browns Ferry	517,576	29.0	1,182,591	55.8	1.386,551	55.5	702.830	27.3
Sequoyah	216,911	12.0	174,869	9.4	136,297	7.2	173,461	9.8
Watts Bar	63,516	9.5	91,465	9.1	101,413	12.5	126.922	13.8
Total	798,003	18.8	1,488,925	29.0	1,624,261	31.2	1,003,213	19.0

4.17. Availability of Renewable Resources

Most of the alternative strategies being evaluated include the increased reliance on renewable generating resources. TVA includes all renewable resources in its definition, including hydro generation. This assessment of potential renewable resources does not include TVA's existing hydro facilities and considers renewable resources in this context of recently proposed federal climate and renewable portfolio standard legislation and in many state renewable portfolio standards to include solar, wind, small hydro (see Section 5.4.3) and upgrades to existing large hydro plants, biomass, landfill gas, and geothermal energy.

Following is an assessment of the availability of potential renewable resources for generating electricity in and near the TVA region. Geothermal generation is not considered because of the lack of a developable resource in the TVA region (Augustine and Young 2010).

4.17.1. Wind Energy Potential

The suitability of the wind resource in an area for generating electricity is typically described in terms of wind power classes ranging from Class 1, the lowest, to Class 7, the highest (Elliott et al. 1986). The seven classes are defined by their average wind power density (in units of watts/m^2) or equivalent average wind speed for a specified height above ground. Areas designated Class 3 or greater at a height of 50 m above ground usually have adequate wind for most commercial wind energy developments. Based on wind resource assessments at the 50-m height, relatively little of the TVA region is suitable for commercial wind energy development (Figure 4-43).

Raichle and Carson (2009) presented the results of a detailed wind resource assessment in the southern Appalachian Mountains. Measured annual wind speeds at nine representative privately owned sites ranged from 4.4 m/s on the Cumberland Plateau in northwest Georgia to 7.3-7.4 m/s on sites in the Blue Ridge Mountains near the Tennessee/North Carolina/Virginia border. Two sites in the Cumberland Mountains and one site in the Blue Ridge Mountains were categorized as Class 3 and two sites in the Blue Ridge Mountains were categorized as Class 4. The Class 3 and Class 4 sites had capacity factors of 28 to 36 percent and an estimated energy output of 2.8-3.5 GWh per MW of installed capacity. Capacity factor is the ratio (in percent) of energy a facility actually produced over a given period of time (typically a year) to the amount of the energy that would have been produced if the facility had run at full capacity during the same time period. All sites had significantly less wind during the summer than during the winter and significantly less wind during the day than at night during all seasons. Due to the configuration of ridge tops within this area in relation to prevailing wind directions, potential wind projects would likely be linear in extent and relatively small.

More recent wind assessments have shifted from a power class rating to a capacity factor value and to higher elevations of 80 m and 100 m above ground, a tower height more representative of current wind turbines (NREL 2010). This re-evaluation showed an increased potential for wind generation in the western portion of the TVA region, especially at a height of 100 m. Due to the spatial resolution of this data, the ridgetop potential in the TVA region appears to have been devalued from previous National Renewable Energy Laboratory (NREL) estimates. Therefore, the total maximum wind resource potential for the TVA region may not be fully represented in this assessment.

Based on a 30 percent gross capacity factor (not adjusted for losses) and excluding undevelopable areas such as national and state parks, wilderness areas, wildlife refuges, and recreation areas, the potential installed wind capacity in the TVA region is 450 to 1,300 MW depending on elevation. The corresponding generation values are 1,200 and 3,400 GWh, respectively. The NREL Eastern Wind Integration and Transmission Study (NREL 2010b) further supplements this data by estimating a wind potential of 1,247 MW in the TVA region, with an expected annual energy generation value between 3,500-4,000 GWh. Additional wind speed data collection from high elevation towers (minimum of 50 m) is necessary to develop a more precise wind resource estimate for the TVA region.

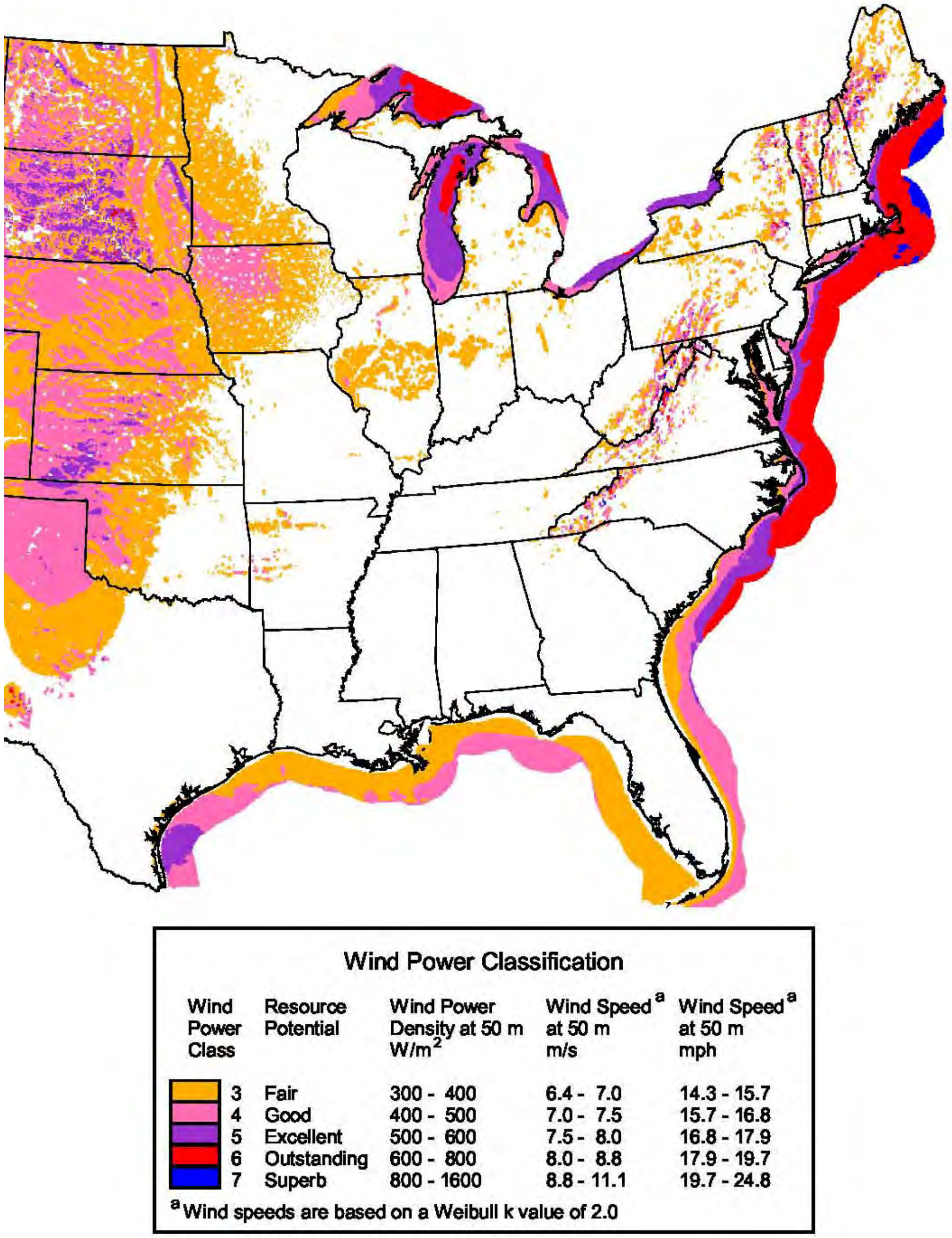


Figure 4-43. Wind resource potential of the eastern and central U.S. at 50 m above ground. Areas unlikely to be available for wind power development due to land use or environmental issues are not mapped. Source: Adapted from NREL (2009b).

4.17.2. Solar Energy Potential

Solar energy resource potential is a function of average daily solar insolation (see Section 4-2) and is expressed kWh/m^2/day (available energy (kWh) per unit area (square meters) per day). Solar resource measurements are reported as either direct normal radiation (no diffuse light) or total radiation (a combination of direct and diffuse light). Diffuse or scattered light is caused by cloud cover, humidity, or particulates in the air. These measurements do not incorporate losses from converting photovoltaic (PV)-generated energy (direct current) to alternating current or the reduced efficiency of some PV panels at high temperatures. PV panels are capable of generating with both direct and diffuse light sources while concentrating solar generators require direct normal radiation. Figure 4-44 shows the solar generation potential for both flat plate PV panels and concentrated solar technologies in the TVA region. The PV potential assumes flat-plate panels are oriented to the south and installed at an angle from horizontal equal to the latitude of the location.

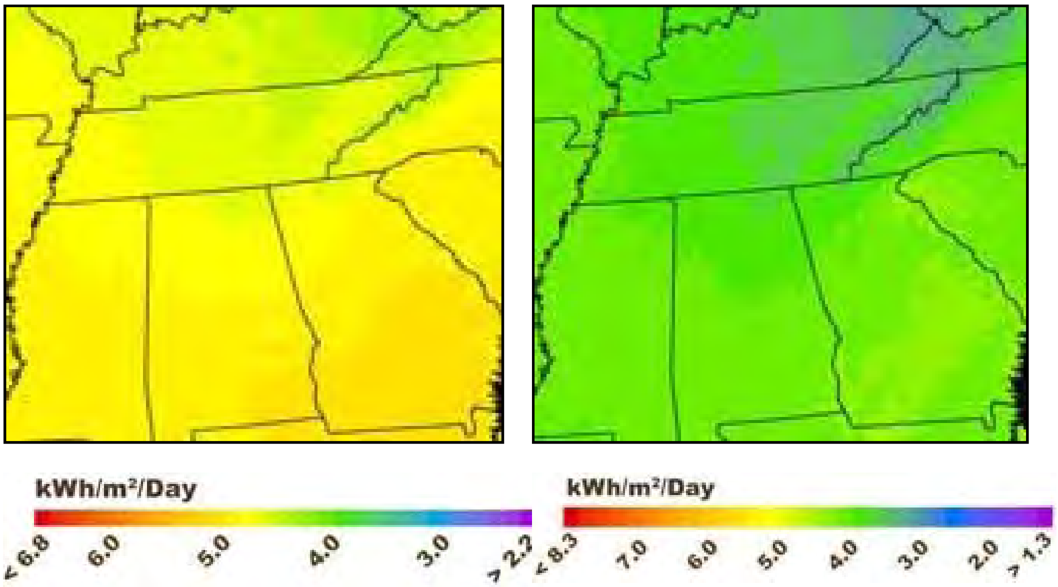


Figure 4-44. Solar photovoltaic generation potential (left) and concentrating solar generating potential (right) in the TVA region. Source: Adapted from NREL (2009a).

Most of the TVA region has between 4-5 kWh/m^2/day of available solar insolation for flat-plate PV collectors and 3.5-4.5 kWh/m^2/day for concentrated solar collectors. Because of the high proportion of diffuse sunlight, performance of concentrating solar generation is reduced in the TVA region and there has, to date, been no commercial development of this generation in or near the TVA region.

Because PV is the most abundant and easily deployable renewable resource, it is difficult to accurately assess a feasible potential value for the TVA region. Following are two distinct evaluation cases developed by the NREL. The first case examines the land area required to meet all of the 2005 TVA electrical load for each state in the TVA region. The second case explores the rooftop PV potential for states in the TVA region.

Land Area Relative to Electrical Load - Denholm and Margolis (2007) studied the land area of each state necessary to meet the state's entire electrical load by PV generation. To determine the annual PV generation per unit of module power, hourly insolation values were used for 2003-2005 from 216 sites in the lower 48 U.S. states. Net PV energy density (the annual energy produced per unit of land area) for each state was calculated using the weighted average of three distinctive PV technologies (polycrystalline silicon, monocrystalline silicon, and thin film) which vary in their generating efficiency. Various panel orientations including fixed positions and 1- and 2-axis tracking were included. Tracking panels (i.e., on mounts that pivot to follow the sun) produce more energy per unit area than fixed panels although their initial installation costs are higher.

The resulting state-level solar electric footprint shows that achieving all of the electricity is theoretically possible (Figure 4-45). Because PV generation is not a base load resource (only generates during the day), a scaling factor of 1.23 was applied to compensate for losses associated with back-up battery storage. Generating all of the region's electricity by PV it is not a practical goal unless very inexpensive and very high capacity energy storage devices become available. Therefore, the conclusion of this analysis is not to assign a specific theoretical solar potential but to point out that the solar resource in the TVA region is plentiful. Relative to other states, the seven TVA region states ranked between 14th (Alabama) and 29th (Kentucky) in PV energy density (Denholm and Margolis 2007).

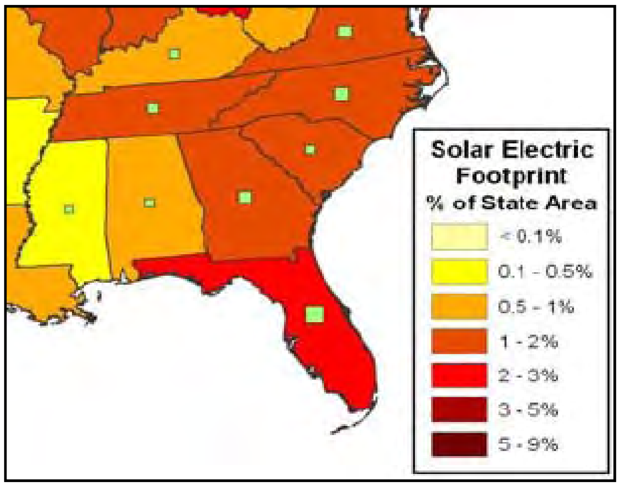


Figure 4-45. Solar electric footprint of southeastern states (2003-2005) Source: Adapted from Denholm and Margolis (2007).

<u>Available Rooftop Area</u> - Paidipati et al. (2008) examined the technical potential of rooftop area available for solar by considering both the PV system power density and available roof space. PV power density is defined as the deployable peak power per unit of land area (expressed in MW peak direct current per million square feet). The power density is based on a weighted-average module efficiency using the market share values for the three most prevalent solar technologies. An additional packing factor of 1.25 was applied to account for space needed for the PV array (e.g., access between modules, wiring, and inverters). The analysis assumed both rooftop areas and solar panel system efficiencies grow over time. The TVA power service area PV rooftop potential in 2010 is roughly 23,000 MW of solar capacity and 27,000 GWh of annual generation. The expected potential in 2015 is roughly 30,000 MW of capacity and 35,500 GWh of annual generation (Figure 4-46).

4.17.3. Hydroelectric Energy Potential

Hydroelectric generation (excluding the Raccoon Mountain pumped storage facility) presently accounts for about 10 percent of TVA's generating capacity (see Section 3-3). TVA has been gradually increasing this capacity by upgrading the hydro turbines and associated equipment. To date, this program has increased TVA's hydro generating capacity by about 15 percent. TVA anticipates upgrading about 34 turbines during the IRP planning period, resulting in a capacity increase of about 88 MW. This capacity increase would qualify as renewable energy under most recently proposed renewable portfolio standard legislation.

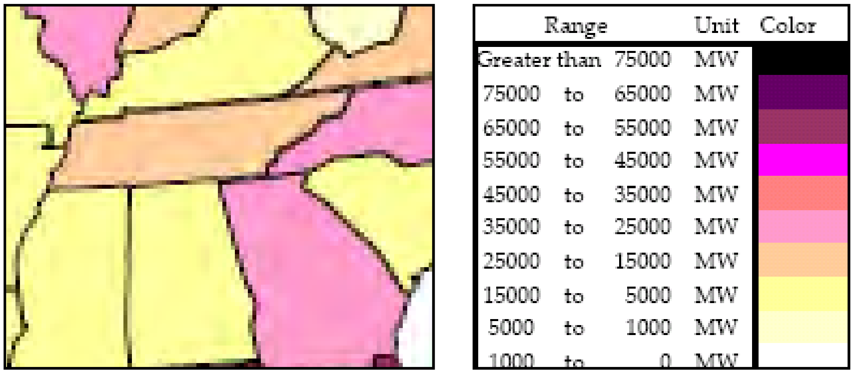


Figure 4-46. 2015 region rooftop PV technical potential for states in the TVA region. Source: Adapted from Paidipati et al. (2008).

A 1998 Department of Energy study identified approximately 547 MW of potentially developable conventional (dam and turbine) hydroelectric capacity at 54 sites in the TVA power service area and outside the power service area but in the Tennessee River drainage (Connor et al. 1998). The sites included previously identified undeveloped sites as well as existing dams without operating turbines, including 4 TVA dams and several Corps of Engineers dams. Most of the sites were potentially developable by adding turbines to existing dams or constructing new run-of-river dams and turbines. Twenty-nine of the sites were in the Tennessee River watershed. After considering environmental, legal, and institutional constraints, the adjusted potential for new capacity was 287 MW.

A more recent Department of Energy study (Hall et al. 2006) focused on the hydropower potential of sites developed as low power (<2 MW) and small hydro (between 2 and 60 MW) projects. Feasibility criteria, in addition to the water energy resource, included site accessibility, load or transmission proximity, and land use or environmental constraints that would inhibit development. Potential sites were assumed to be developed in ways that would not require the stream to be obstructed by a dam such as partial stream diversion through a penstock to a conventional turbine, as well as unconventional ultra-low head and kinetic energy (in-stream, see Section 5-4.2) turbines. The study identified numerous small hydro and low power sites with an estimated total feasible capacity of 1,770 MW. The study did not evaluate the hydrokinetic potential of sites with little or no elevation difference and thus likely underestimates this potential resource.

4.17.4. Biomass Fuels Potential

Milbrandt (2005; see also NREL 2009c) analyzed geographic patterns in the availability of biomass suitable for power generation. Her analysis included crop residues; forest residues; primary and secondary mill residues; urban wood waste; dedicated energy crops; and methane emissions from landfills, livestock and poultry manure management, and domestic wastewater treatment. Many TVA region counties had a total biomass resource potential of over 100,000 tons/year; these counties are concentrated in Kentucky, western Tennessee, Mississippi, and Alabama (Figure 4-47). The total potential biomass resource for the TVA region is approximately 36 million tons/year. This equates to a potential of up to 47,000 GWh[8] of annual biomass energy generation. The TVA region biomass resource potential for each resource type is shown in Figure 4-48.

Dedicated energy crops are crops grown specifically for use as fuels, either by burning them or converting them to a liquid fuel, such as ethanol, or a solid fuel, such as wood pellets or charcoal. They can include traditional agricultural crops, non-traditional perennial grasses, and short rotation woody crops. Traditional agricultural crops grown for fuels include corn, whose kernels are fermented to produce ethanol, and soybeans, whose extracted oil can be converted to biodiesel. Sorghum is also a potential fuel feedstock. Non-traditional perennial grasses suitable for use as fuel feedstocks include switchgrass (*Panicum virgatum*) and miscanthus, also known as E-grass (*Miscanthus x giganteum*, a sterile hybrid of *M. sinensis* and *M. sacchariflorus*) (Dale et al. 2010). Short rotation woody crops are woody crops that are harvested at an age of 10 years or less. Trees grown or potentially grown for short rotation woody crops in the TVA region include eastern cottonwood, hybrid poplars, willows, American sycamore, sweetgum, and loblolly pine (UT 2008; Dale et al. 2010). Plantations of these trees are typically established from stem cuttings or seedlings. With the exception of loblolly pine, these trees readily resprout from the stump after harvesting. As described in Section 4.13, the area of short rotation woody crops in the TVA region is small. Milbrandt (2005) analyzed the potential production of dedicated energy crops on Conservation Reserve Program lands, a voluntary program that encourages farmers to address natural resource concerns by removing land from traditional crop production. Growing dedicated energy crops on conservation reserve lands reduces their impact on food production.

Forest residues consist of logging residues and other removable material left after forest management operations and site conversions, including unused portions of trees cut or killed by logging and left in the woods. Mill residues consist of the coarse and fine wood materials produced by mills processing round wood into primary wood products (primary mill residues) and residues produced by woodworking shops, furniture factories, wood container and pallet mills, and wholesale lumberyards (secondary mill residues) (Milbrandt 2005). Crop residues are plant parts that remain after harvest of traditional agricultural crops; the amount available was adjusted to account for the amount left in fields for erosion control and other purposes. Methane sources include landfills, domestic wastewater treatment plants, and emissions from farm animal manure management systems.

This estimate of 36 million potential tons/year does not consider several important factors and may be optimistic. The analysis assumes that all of the biomass is available for use without regard to current ownership and competing markets. Growth in use of biomass will likely result in increased competition for biomass feedstock and reduce the feasibility of some biomass. Some biomass may also not meet environmental and operational standards for electrical generation. The distance between sourcing areas and the generating facility is also important; feasible sourcing areas for solid biomass fuels are typically considered to be within a 50- or 75-mile radius of the generating facility. Finally, there is currently no established infrastructure in the TVA region to transport, process, and utilize biomass for generating electricity. As biomass fuel markets develop in and near the TVA region, better resource estimates should become available.

---

[8] Based on assumed heating values for agricultural crops and wood residues of 7,200 to 8,570 Btu/lb and for methane of 6,400 to 11,000 Btu.lb, depending on feedstock type. Assumed generating unit heat rates are 13,500 Btu/kWh for crop and wood residues and 12,500 Btu/kWh for methane.

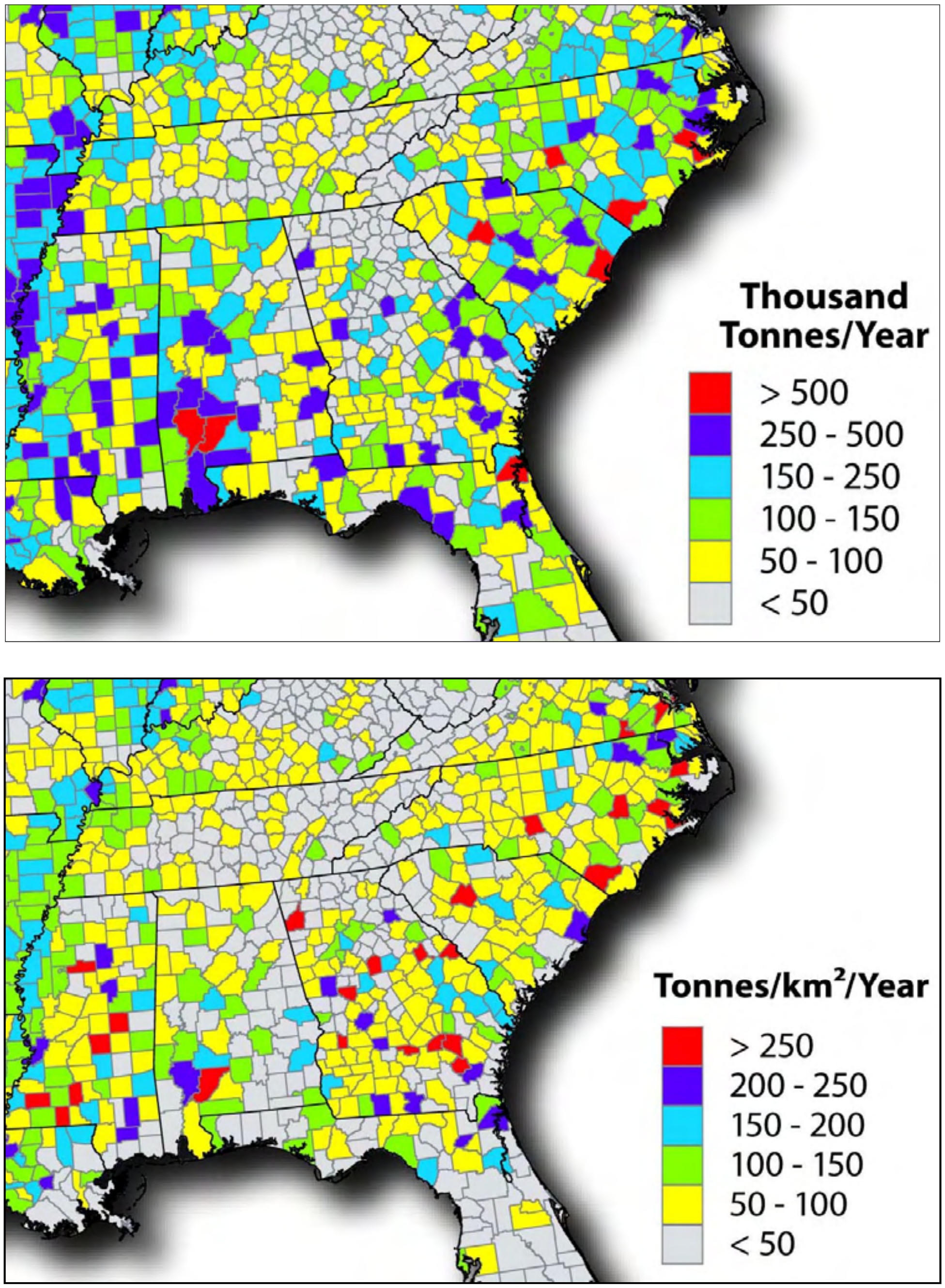


Figure 4-47. Total biomass resources potentially available in the TVA region by county (top) and per square kilometer by county (bottom). Source: Adapted from Milbrandt (2005).

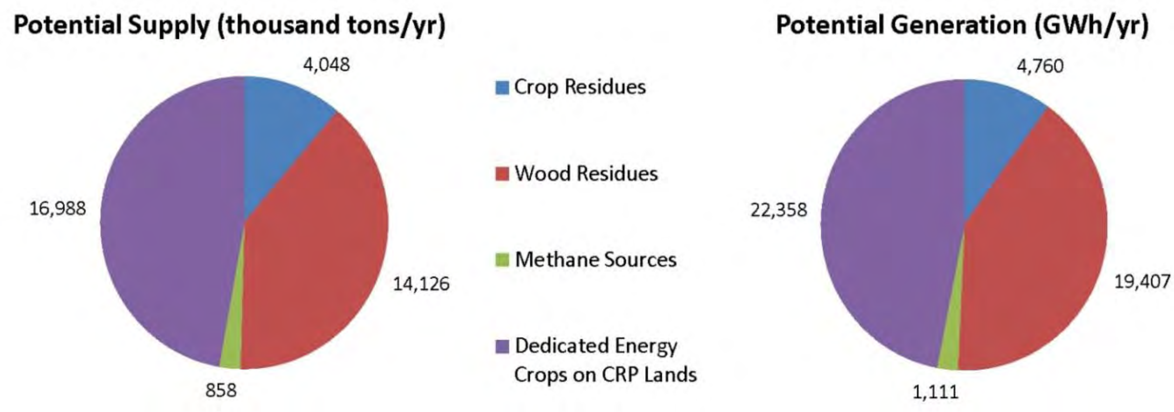


Figure 4-48. TVA region potential biomass resource supply (left) and generation (right). Source: Adapted from Milbrandt (2005 and NREL (2009c).

TVA has commissioned studies of the biomass potentially available for fueling its coal-fired generating plants. A 1996 study (ORNL 1996) addressed the potential supply of short-rotation woody crop and switchgrass biomass grown on crop and pasture lands. The potential supply is greatly influenced by the price paid for biomass, which influences its profitability relative to the profitability of conventional crops. With higher prices, larger amounts of more productive farmland would likely be converted from food production to biomass production, and the western portion of the TVA region has the greatest potential for producing large energy crop supplies.

In a more recent study, Tillman (2004) surveyed the availability of woody biomass for cofiring at eight TVA coal-fired plants (all except Bull Run, Cumberland, and Gallatin). Potential sources included producers of primary and secondary mill residues as described above. These sources produced about 433,000 dry tons/year (approximately 7,153,000 MBtu/yr) of potential biomass fuels within economical haul distances of TVA coal-fired plants. The most abundant material type was sawdust (about 57 percent of the total) and only about two percent of the biomass was not already marketed. At a 2004 price of $1.25-1.50/MBtu, sufficient biomass would be available to support 75-80 MWe of generating capacity and the annual generation of 300,000-450,000 MWh of electricity.

CHAPTER 5

5.0 ENERGY RESOURCE OPTIONS

5.1. Introduction

This chapter describes the various supply-side and demand-side options evaluated during the development of the IRP. It both describes the general characteristics of the options and the configurations considered in the various IRP strategies. In EV2020 (TVA 1995), TVA evaluated 100 supply-side and 60 demand-side resource options. The evaluation conducted for this IRP tiers from and incorporates these earlier evaluations.

5.2. Options Evaluation Criteria

TVA developed a long list of potential options to include in the various IRP strategies. This list was based on TVA staff expertise, public input during the IRP public scoping, and suggestions from the Stakeholder Review Group. To determine the options included in the various strategies, TVA evaluated potential options with the following criteria:

- The option must utilize a developed and proven technology, or one that has reasonable prospects of becoming commercially available before 2029.
- The option must be available to TVA either within the TVA region or importable through market purchases.
- The option must be reasonably economical and contribute to the reduction of emissions of air pollutants, including greenhouse gases, from the TVA power supply portfolio, in alignment with overall TVA objectives.

5.3. Options Excluded from Further Evaluation

Following is a list of options identified during the IRP scoping but, following screening, excluded from further evaluation (Table 5-1). Depending on future events, some of these resource options may be considered in more detail when TVA periodically updates the IRP.

Although not included in the IRP strategies, TVA is exploring the construction and operation of one or more small modular reactor nuclear plants and the deployment of electric vehicles. At least seven different corporations are developing these small modular reactors which have an electrical output of 10-335 MW (NRC 2010). These reactors would be manufactured in a factory and shipped by rail, truck or barge to the plant site. In most designs, the reactor containment vessel is underground and refueling cycles are longer than those of current reactors. Several of the developers intend to submit design certification applications to the Nuclear Regulatory Commission by 2013.

In 2009, TVA signed a letter of intent with Babcock & Wilcox to evaluate a site for an mPower reactor. The mPower reactor is a 125-MW modular reactor being designed by Babcock & Wilcox. TVA has identified its Clinch River Breeder Reactor site in Oak Ridge, Tennessee as a potential site for an mPower plant and in late 2010 began studies of its suitability, including environmental issues.

Table 5-1. Energy resource options identified during IRP scoping but excluded from further evaluation.

Energy Resource Option	Reason for Exclusion
Nuclear	
Small modular nuclear reactor	See text discussion of small modular reactors
Nuclear fuel reprocessing	This is a national issue and, as such, TVA will follow federal policies
Fast breeder reactor	In research phase and likely not ready during IRP planning period
Fusion reactor research	In research phase and likely not ready during IRP planning period
Gas turbine modular helium reactor	In research phase and likely not ready during IRP planning period
Complete Yellow Creek Nuclear Plant	Site is not available for a nuclear plant
Coal	
Plasma arc coal gasification	In research phase and likely not ready during IRP planning period
Replace old turbines in coal plants with new high efficiency turbines	Already considered this and found uneconomical
Utilization of lowest sulfur coals	This is already part of the compliance strategy for coal plants and is not a resource option
Stop use of coal from mountaintop removal mines	This is a fuel acquisition and environmental issue and not a resource option
Promote electric vehicles and their integration as energy storage systems	See text discussion of electric vehicles
Solar	
Space-based solar power	In research phase and likely not ready during IRP planning period
TVA self-build solar	The IRP considers solar resources; because of the tax incentives available to private developers, TVA will likely purchase solar power rather than build its own solar resources
Installation of PV panels on conveyors of fossil plants	The IRP considers solar resources; because of the tax incentives available to private developers, TVA will likely purchase solar power rather than build its own solar resources
Purchase PV panels in bulk, resell at cost, contract for installation	The IRP considers solar resources; because of the tax incentives available to private developers, TVA will likely purchase solar power rather than build its own solar resources
Solar cogeneration	While feasible with solar thermal plants, solar radiation in the TVA region is too low for cost-effective solar thermal plant development
Wind	
Installation of wind turbines on Shawnee Fossil Plant elevated dry ash stacks	It is unlikely that the ash stacks can provide a strong enough foundation for wind turbines

Table 5-1. Continued.

Energy Resource Option	Reason for Exclusion
Biomass	
Algal-based biofuel production at fossil plants utilizing captured CO_2 and waste heat	Waste heat applications were not considered because the opportunities for significant amounts of new generation from waste heat sources are limited
Cofiring biomass in natural gas facilities	Cofiring landfill gas is within the scope of potential power purchase agreements. To cofire solid biomass, the biomass must first be gasified; this technology is within the scope of potential renewable power purchases
Combustion of forest biomass	This is incorporated in the biomass options
Promote forest biomass resources for electric generation	While promotion of biomass is outside the scope of the IRP, the use of forest biomass is incorporated in the biomass options
High temperature combustion of municipal solid waste	TVA does not intend to construct or operate facilities using municipal solid waste as fuel but would consider purchasing power from such a facility
Renewable Energy (general)	
Expand Generation Partners program	The IRP includes the purchase of renewable energy
Support community owned wind and solar resources	The IRP includes the purchase of renewable energy
Direct payments for installation of renewable systems	The IRP includes the purchase of renewable energy
Loans for installation of renewable systems	The IRP includes the purchase of renewable energy
Natural Gas	
Replacement of coal plants with combined cycle plants	This option is considered in the IRP
Acquire and develop natural gas supplies	This is a fuel acquisition issue and not a resource option
Hydrogen / Fuel Cells	
Co-location of hydrogen production facilities at fossil or nuclear plants	The demand for hydrogen for use in fuel cells is not projected to be high enough to justify the additional required infrastructure
Combined Heat and Power (CHP)	
Promote CHP alternatives such as small gas turbines, microturbines, reciprocating engines, and fuel cells	Some of these options were considered in the IRP. They are also potential sources for power acquired through power purchase agreements
Waste heat recovery at natural gas generator stations	The potential for significant amounts of new generation from waste heat sources is limited. It is, however, a potential source of power acquired through power purchase agreements

Table 5-1. Continued.

Energy Resource Option	Reason for Exclusion
Heat pumps for commercial heat recovery	The potential for significant amounts of new generation from waste heat sources is limited. It is, however, a potential source of power acquired through power purchase agreements
<u>Waste to Energy</u>	
Promote waste to energy generation	Wood and other clean biomass wastes are a likely fuel source for the renewable generation included in the IRP. TVA does not intend to construct or operate facilities using municipal solid waste as fuel but would consider purchasing power from such a facility
<u>Transmission</u>	
Improve transmission line designs	This is an infrastructure issue and not an energy resource option, and therefore outside the scope of the IRP
Protect transmission grid against severe space weather events	This is an infrastructure issue and not an energy resource option, and therefore outside the scope of the IRP
Cooperate with other utilities in developing an 800-kV transmission system	The development of transmission needed to assure delivery of power is included in the IRP analyses.

Electric vehicles, like small modular reactors, are a focus area for TVA's research efforts. A major component of TVA's work with electric vehicles involves the construction and operation of prototype charging stations in partnership with ECOtotality North America and EPRI. TVA is also studying the integration of vehicle charging systems into the power grid and their potential effects of power demand. Electric vehicles are not expected to have a significant effect on the power system during the first few years of the IRP planning period.

5.4. Options Included in IRP Evaluation

Following is a description of the options included in the various IRP strategies. All of these options meet the criteria listed above. Environmental characteristics of these options, such as land requirements, air emission rates, water use, fuel consumption, and waste production are described in Chapter 7.

5.4.1. Fossil-Fueled Generation

Coal - Existing Facilities

TVA currently operates 59 coal-fired generating units at 11 generating plants with a total capacity of 14,500 MW (Table 3-3). While some strategies assume the continued operation of all of these plants, others assume placing different amounts of coal generating capacity (see Section 6.2) into long-term idled status (also known as mothball status in the power industry) for the foreseeable future. The goal of long-term idling is to preserve the asset so that it could be restarted in the future if power system conditions warrant. This preservation would require protection of plant equipment and materials from ambient conditions, particularly corrosion. This would likely require some modifications to the equipment. A variety of continuing equipment maintenance would also be required, such as periodic rotating of large equipment and lubrication. TVA would continue to maintain buildings and provide on-site security, and would likely employ a small on-site maintenance staff.

The determination of which coal units to idle and the timing of their idling is based on several factors including operating cost, forced outage rate, anticipated expenditures for environmental compliance, operation and maintenance cost, future ash handling costs, flexibility in handling different grades of coal, and the CO_2 emissions rate. Each unit was assigned scores for these factors. The units with the lowest rankings, and therefore candidates for layup, generally have high operating costs and high anticipated environmental compliance costs. Those units with the highest rankings generally have lower operating costs, fuel flexibility, low outage rates, and lower anticipated environmental compliance costs. In August 2010, TVA announced that the following nine coal units with a total capacity of about 1,000 MW would be idled:

- Two units at Widows Creek in 2011
- Shawnee Unit 10 in 2011, which will be evaluated for conversion to a dedicated biomass-fueled unit
- The remaining four older units at Widows Creek by 2015
- Units 1 and 2 at John Sevier by 2015.

TVA purchases the power generated by the 432-MW Red Hills coal-fired generating plant under a PPA extending through 2032. Unlike TVA's coal plants, the Red Hills plant burns low-Btu lignite mined from an adjacent surface mine in circulating fluidized bed boilers.

Coal - New Facilities
Because of the TVA objective of reducing greenhouse gas emissions and in anticipation of regulations restricting greenhouse gas emissions, options for new coal generating facilities were required to have carbon capture and storage (CCS) technology. Two types of coal plants, a supercritical pulverized coal (SCPC) plant with CCS and an integrated gasification combined cycle (IGCC) plant with CCS, were considered in the IRP evaluation. Both of these plant types are suitable for base load generation. Because of uncertainty over the viability of CCS, a CCS-equipped plant would not be built before 2025.

CCS is a process of reducing greenhouse gas emissions by capturing CO_2 produced in a power plant, compressing it, and transporting it to storage (see Section 4-4). The major components of a CCS system include CO_2 capture equipment, a pipeline to transport CO_2 from the plant to the sequestration site, and a compressor for injecting CO_2 into the storage medium. CCS systems add to the cost of a power plant and, because of the energy required to operate them, reduce the efficiency of the plant.

<u>Supercritical Pulverized Coal with CCS</u> - In a pulverized coal plant, finely ground coal is injected into the boiler (furnace) with sufficient air for combustion. The resulting heat boils water circulating in tubes within the boiler to produce steam which turns one or more turbines to generate electricity. An SCPC plant is a more recent version of the traditional pulverized coal plant that operates at higher temperatures and steam pressures between 3,200 and 4,400 pounds/square inch. SCPC plants operate at higher efficiencies (around 40 percent) and have lower emissions of air pollutants than "subcritical" pulverized coal plants. Major plant components include the coal receiving and storage area, boiler, steam turbine generator, air emissions control systems, stack, ash and gypsum handling and storage facilities, condenser cooling system and associated water supply, wastewater treatment system, office/maintenance buildings, transformer yard, and switchyard connected to the area electrical grid.

SCPC plants produce SO_2, NOx, mercury, CO_2, and ash as a result of burning coal. SO_2 is typically controlled in new SCPC plants by flue gas desulfurization systems (FGD or “scrubbers”). After fly ash is removed, the exhaust gases are mixed with finely ground limestone; the acidic SO_2 reacts with the basic calcium carbonate to form calcium sulfate and CO_2. If the calcium carbonate is in an aqueous solution, water is also produced by the reaction. The calcium carbonate (gypsum) is removed from the waste stream and sold for commercial use or deposited in a landfill. NOx is typically controlled in new SCPC plants by selective catalytic reduction (SCR) systems. In SCR systems, ammonia is mixed with the exhaust gases as they pass though a catalyst chamber. The resulting chemical reactions produce nitrogen and water. The combination of SCR and FGD systems also removes much of the mercury. SCPC plants require large volumes of water for operation of cooling towers. As previously stated in Chapter 4, new fossil and nuclear plants are assumed to have closed-cycle cooling systems which, relative to open-cycle cooling, decrease the volume of water used and heat discharged to the river but increases the amount of water consumed.

Two configurations of new SCPC plants are considered in the IRP evaluation:

- Single-unit 800-MW SCPC plant with CCS
- Two-unit 1600-MW SCPC plant with CCS.

<u>Integrated Gasification Combined Cycle with CCS</u> - An integrated gasification combined cycle (IGCC) plant converts coal into a gas composed primarily of hydrogen and carbon monoxide and then burns this gas in a combined cycle plant. The gasification process involves crushing the coal and then heating it in the presence of oxygen and steam. The resulting synthesis gas is cleaned by removing water vapor, CO_2, and sulfur compounds, which can be marketed. The synthesis gas, consisting primarily of hydrogen and carbon monoxide, can then be burned with very low SO_2 and NOx emissions. Heat is typically rejected to the atmosphere in a mechanical draft cooling tower. IGCC plants can burn a wide range of coals and be designed to use other carbon-based fuels, such as biomass. The gasification process can also be modified to produce liquid fuels and various chemicals.

Major plant components include the coal receiving and storage area, air separation unit, gasifier, synthesis gas treatment system (including CO_2 removal), combustion turbines, heat recovery steam generator, gasification ash and chemical byproduct handling systems, condenser cooling system and associated water supply, discharge water treatment system, office/maintenance building, transformer yard and switchyard connected to the area electrical grid, pipeline to CO_2 sequestration site, and CO_2 injection wells. The gasification components of an IGCC plant are complex and, at least at present, relatively expensive. The operating efficiency of an IGCC plant, however, is higher than a CT or conventional coal plant. Although there are few commercial-scale IGCC generating plants operating in the United States, several are currently proposed or under construction. The addition of CCS increases the plant construction and operating costs. TVA does not presently operate any IGCC plants, although it has considered them in the past (TVA 1997).

A new 490-MW IGCC plant with CCS designed to capture 90 percent of CO_2 emissions is considered in the IRP evaluation.

Natural Gas - Existing Facilities
TVA operates 11 natural gas-fueled generating facilities, 9 combustion turbine plants with a total capacity of 5,326 MW and 2 combined cycle plants with a total capacity of 1,327 MW (see Table 3-6). TVA is also constructing the 880-MW John Sevier combined cycle plant, scheduled for completion in 2012. Combustion turbine and combined cycle generating plants are described in more detail below. TVA also purchases power from three natural gas-fueled generating facilities (see Table 3-7).

Combustion Turbine - A simple cycle combustion turbine (CT) generator consists of an air compressor, combustor, and expansion turbine. Fuel is burned in the combustor, and the heated, high pressure combustion products drive the turbine, which drives the compressor and electric generator. The main fuel is natural gas, with fuel oil as the back-up fuel for most TVA CTs. CTs have low capital cost, short construction times, and rapid start-up, and are used for generating peaking power. Emissions are relatively low, as is their efficiency. Major plant components include the combustion turbines, generators, pipeline connection to the natural gas supply, fuel oil storage tanks, office/maintenance building, and transformer yard and switchyard connected to the area electric grid.

Combined Cycle - A combined cycle plant combines one or more CT generators with a heat recovery steam generator (HRSG). The hot exhaust gases from the CTs pass through the HRSG, where the steam powers a turbine-generator. Steam turbine exhaust is condensed and returned to the HRSG as feedwater and heat is rejected to the atmosphere in a mechanical draft cooling tower. The primary fuel is natural gas. Combined cycle plants are among the most efficient of conventional generators and are typically used for intermediate capacity additions. Additional peaking power can be generated by duct-firing, where natural gas is combusted in the CT exhaust gas stream to produce additional steam. Duct-firing, however, reduces the overall plant efficiency. The main combined cycle plant emissions are NOx, which is usually controlled by selective catalytic reduction, and CO_2. CO_2 emissions rates are the lowest of conventional fossil-fueled generators. Major plant components include the combustion turbines, heat recovery steam generator, air emissions control system, condenser cooling system and associated water supply, pipeline connection to the natural gas supply, office/maintenance building, and transformer yard and switchyard connected to the area electric grid.

Natural Gas - New Facilities
The following configurations of new natural gas generating facilities are considered in the IRP:

Combustion Turbine - The following CT plant configurations were considered:

- Upgrade of TVA's existing Gleason plant from 360 to 530 MW
- New 621 MW plant with three CTs
- New 828 MW plant with four CTs.

Combined Cycle - Three combined cycle plant configurations were considered:

- 513 MW plant consisting of 2 CTs and 1 HRSG
- 910 MW plant consisting of 3 CTs and 1 HRSG
- An existing 750 MW plant.

Petroleum
As noted above, TVA uses fuel oil as a backup fuel for many of its CT plants. TVA owns two diesel-fueled generating plants with a combined capacity of 13 MW. In these plants,

large diesel-fueled internal combustion engines drive electric generators. TVA also has several PPAs for a total of 120 MW of electricity generated by small (most < 1 MW) diesel units; these PPAs are expected to be phased out during the planning period. Diesel-fueled plants provide peaking generation. No additional diesel- or other petroleum-fueled plants are considered in the IRP evaluations, in part due to their high emissions of air pollutants.

5.4.2. Nuclear Generation

Nuclear - Existing Facilities

TVA operates three pressurized water units at two sites and three boiling water units at one site; these units have a total capacity of 6,900 MW (Table 3-5). The 1,150-MW pressurized water Watts Bar Unit 2 is scheduled to begin generating power in 2013. The total capacity includes anticipated capacity increases at Browns Ferry through the Extended Power Uprate project.

Nuclear generating plants use nuclear fission reactions to heat water to produce steam, which is then used to generate electricity. Nuclear plants in the United States are cooled and moderated by ordinary water; the two types of these “light water” reactors are pressurized water reactors and boiling water reactors. In the more common pressurized water reactors, coolant water is pumped under high pressure to the reactor core, and then the heated water transfers thermal energy to a steam generator. High pressure in the primary coolant loop prevents the water from boiling within the reactor. In boiling water reactors, coolant water pumped through the core boils and the steam then directly drives the turbine. In both designs, steam exiting the turbines is cooled in a condenser and recirculated. A separate water system cools the condenser, either with water circulated directly from a nearby reservoir or other water source, or circulated through a cooling tower. Nuclear plants provide base load generation. Major nuclear plant components include the reactor containment building housing the reactor vessel, the steam generators and reactor coolant pumps; turbine generators; spent fuel storage facility; condenser cooling system and associated water supply; office, control, and service buildings; wastewater treatment facility; transformer yard; and switchyard connected to the area electric grid. Nuclear plants produce very few air emissions, no direct CO_2 emissions, and discharge few water pollutants. They require large volumes of cooling water and, if operated in close-cycle cooling mode, consume large volumes of water (see Section 4.7).

Nuclear - New Facilities

In addition to the continued operation of the existing nuclear units, the completion of Watts Bar Unit 2, and the power uprates, new nuclear generating facilities considered in the IRP evaluation include the following:

- Completion of the 1,260-MW Bellefonte Nuclear Plant Units 1 and 2 pressurized water reactors
- Two new 1,117-MW Advanced Passive 1000 (AP1000) pressurized water reactors at Bellefonte (Bellefonte Units 3 and 4)
- A new 1,117-MW AP1000 reactor at an undetermined site.

TVA has recently taken several steps towards completing one or more nuclear units at Bellefonte. These, described in more detail in IRP Section 4.3.2, include submission of a Combined Construction and Operating License Application to the Nuclear Regulatory Commission for Units 3 and 4, reinstatement of the construction licenses for Units 1 and 2, and completion of detailed cost and engineering studies and a Final EIS for construction and operation of a single nuclear unit (TVA 2010c). On August 20, 2010, the TVA Board approved funding for additional engineering, design, and other activities at Unit 1 to maintain its feasibility for completion in 2018-2019. It is anticipated that the Board will be asked to approve the completion of Unit 1, depending on the outcome of the IRP in spring 2011.

5.4.3. Renewable Generation

TVA presently provides renewable energy from TVA facilities and acquired by PPAs. The renewable energy sources are hydroelectric, solar, wind and biomass-fueled facilities. As described below, renewable energy from these sources is considered in the IRP. Geothermal generation is not considered because it is not available in or near the TVA region.

Hydroelectric - Existing Facilities

TVA presently operates 110 conventional hydroelectric generating units at 29 dams with a combined capacity of 3,538 MW (Section 3.3). As also described in Section 3-3, TVA anticipates continuing its program of modernizing hydroelectric turbines, and the anticipated capacity increase of about 90 MW is included in most IRP strategies. TVA also has long-term power purchase agreements for 360 MW and 330 MW of hydroelectric capacity from SEPA and Alcoa, respectively (see Section 3-3). TVA hydroelectric plants are primarily operated to provide peaking power; during periods of abundant precipitation, they may also be operated to provide intermediate power. Their operation is described in more detail in the Reservoir Operations Study (TVA 2004). The continued operation of these facilities is evaluated in the IRP.

Hydroelectric generation uses the gravitational force of falling or flowing water to generate electricity. It is a form of renewable energy, as the water is not consumed while generating electricity. Operating costs are very low and no air pollutants are emitted. The reservoirs necessary for most conventional hydroelectric projects require large areas of land, but typically provide benefits in addition to electricity, such as flood control, water supply, and recreation. Typical components of conventional hydroelectric generating facilities include a dam, penstock (a pipe or sluice that transmits water from the dam to the turbine), gates to control the flow of water through the penstock, turbines, generators, and electrical transformers and switchyard connected to the area electrical grid. The turbines and generators are typically enclosed in a powerhouse, which may be located on the downstream face of the dam or of some distance downstream of the dam. The generating potential is proportional to the head, the difference in elevation between the water upstream of the dam and the turbines..

Hydroelectric - New Facilities

<u>Conventional Hydroelectric Facilities</u> - In addition to the continued operation of the existing hydroelectric plants, the IRP evaluates the following conventional hydropower options:

- Modernization of 38 generating units by 2029 with a resulting capacity increase of about 90 MW
- Addition of a 40-MW generator to an existing TVA hydroelectric plant
- Addition of a 5-MW generator to an existing TVA non-hydroelectric dam.

<u>Small and Low Power Hydroelectric Facilities</u> - As described in Section 4.17.3, the potential exists to develop small (between 2 and 60 MW) and low power (<2 MW) hydroelectric facilities on streams in the TVA region. These facilities include generators not requiring a dam and the addition of small turbines to existing dams. Hydroelectric generators not

requiring a dam, often called kinetic energy turbines or hydrokinetic generators, are currently under development by several companies in the U.S. and elsewhere and largely experimental at this time. The most common hydrokinetic generator under development uses turbines mounted on a pedestal on the river bottom or suspended from a barge or other structure (EPRI 2010). The turbines have an axis of rotation parallel to the current or an axis of rotation perpendicular to the current. The capacities of individual turbines under development are small, 25-40 KW, and developers anticipate deploying them in modular arrays of many turbines. Free Flow Power Corporation is in the early stages of developing hydrokinetic generation in the Mississippi River basin, including sites in the Mississippi River adjacent to the TVA region. The IRP evaluates up to 144 MW of small and low power hydro, likely acquired through PPAs.

Wind - Existing Facilities
TVA currently owns a 3-turbine, 2-MW windfarm and has PPAs with a 27-MW windfarm in the TVA region, a 300-MW windfarm in Illinois, and a 115-MW windfarm in Iowa (Section 3.4, Table 3-8). As noted in Section 3.4, TVA has pending PPAs with an additional 1080 MW of wind-generated power from six windfarms outside the TVA region. The continued operation of the existing facilities and completion of the pending PPAs is evaluated in the IRP.

Wind turbines generate electricity by capturing the wind's energy with blades that operate as airfoils. Land-based commercial-scale wind turbines are a mature technology and currently one of the most rapidly growing sources of electricity. Most commercial-scale wind turbines presently being deployed have generating capacities of 1.5-2.5 MW, towers 65-100 m tall, and blade diameters of 75-100 m. Turbines have been increasing in size for several years and the average capacity of turbines installed in 2008 was 1.7 MW (EPRI 2010). Because of transportation and other constraints, land-based turbines will likely be limited to 3-3.5 MW capacity and 100-110 m blade diameters in the future (EPRI 2010). Commercial wind turbines are usually deployed in arrays commonly called windfarms. The average size of windfarms has also increased and in 2007 was approximately 120 MW (EPRI 2010). The layout of turbines within a wind farm depends on the local terrain and land use conditions. On Appalachian ridges, such as TVA's Buffalo Mountain wind farm, turbines are typically in a single or multiple strings along ridgetops. On Midwestern farmland and Great Plains grasslands and shrublands, turbines are frequently arranged in clusters or parallel strings (Denholm et al. 2009) In addition to the wind turbines, the other major windfarm components are an electrical substation connected to the area electrical grid, access roads, and electrical lines (typically underground) connecting the turbines to the substation.

Wind - New Facilities
Because the potential and economics for wind energy development in the TVA region are not as great as in other parts of the U.S., TVA anticipates a large portion of wind energy it obtains in the future will be generated outside the TVA region. In addition, because TVA is not eligible for investment and production tax credits available to private developers, TVA assumes future additions of wind generating capacity will be through PPAs where these financial incentives can be used. The IRP evaluates the acquisition by PPAs of up to 2,380 MW of wind from outside the TVA region and 360 MW from within the TVA region. A small portion of this capacity may be from small wind turbines and purchased through the Generation Partners program (see Section 3-5). Small wind turbines typically have capacities of less than 100 KW. The most common designs use a 2- or 3-bladed horizontal

axis rotor with a diameter of 8-30 feet on a mono-pole tower 80-100 feet tall. Small wind turbines are typically owned by homeowners, farmers, and small businesses.

Solar - Existing Facilities
TVA owns 15 photovoltaic installations with a combined capacity of about 400 kW. TVA also purchases power from numerous photovoltaic installations through the Generation Partners program (see Section 3-5).

The two main types of solar electrical generation are photovoltaic (PV) and concentrating solar power (CSP). In PV cells, sunlight strikes semiconducting material, causing electrons to move between bands within the material and produce electricity. PV cells are usually packaged in flat modular panels and contain no moving parts. Panels may be mounted on buildings or on free-standing frames and are aligned to face south. The use of mounting systems which track the sun along one or two axes results in increased power generation but also increases installation costs. A more recent and still evolving approach is to integrate PV cells into building materials such as roofing and siding. CSP uses mirrors of various shapes to reflect sunlight onto a central receiver where fluid is heated to drive a turbine generator. The potential for CSP in the TVA region is relatively low because of atmospheric conditions (see Section 4.17.2).

Solar - New Facilities
As with wind generation, TVA is not eligible for investment and production tax credits to private developers. TVA therefore assumes that the great majority of future additions of solar generating capacity will be from PV systems and obtained through PPAs and purchases through the Generation Partners program. Most PV facilities in the TVA region have been in the 3-30 kW capacity range and installed by homeowners and small businesses. While installations of these small facilities will likely continue, there is a recent increase in installations of larger facilities of a few hundred kW to over 1 MW capacity. This trend will likely continue. The IRP evaluates the acquisition of up to 365 MW of solar capacity through PPAs.

Biomass - Existing Facilities
Biomass power plants can provide base load power and are one of few renewable power plants with generation that can be scheduled. TVA generates electricity by cofiring methane from a nearby sewage treatment plant at Allen Fossil Plant and by cofiring wood waste at Colbert Fossil Plant. This cofiring generated about 29,000 MWh in 2009. TVA presently purchases about 80 MW of biomass-fueled generation (Table 3-7). These purchases include 9.6 MW of landfill gas generation and 70 MW of wood waste generation. Biomass generating facilities can be classified by whether they use gaseous, liquid, or solid biomass fuels. Following is a description of generating facilities using gaseous and solid fuels, the most readily available biomass fuels in the TVA region (see Section 4.17.4).

Gaseous Biomass-Fueled Facilities - Landfill gas, a mixture of methane and CO_2, is produced by the decomposition of organic material in landfills. Air quality regulations require many landfills to prevent the release of this methane to the atmosphere, and thus have installed landfill gas collection systems. When used for generating electricity, the gas is cleaned to remove sulfur and other compounds and then used to fuel internal combustion engine-generators (modified diesel generator sets) with typical outputs of about 1 MW. System components include gas collection wells, pipes to transport the gas to a central point, the gas cleanup facility, a flare to burn excess gas, engine-generators, and a connection to the area electrical grid. The engine-generators are usually housed in a small building. Typical system components for generating electricity from methane produced by composition of other types of organic material, particularly from sewage treatment plants and livestock manure management systems, are, except for the gas collection system, similar to those used for landfill gas systems.

Solid Biomass-Fueled Facilities - The most readily available types of solid biomass are forest residues, mill residues, and crop residues (Section 4.17.4). Municipal solid waste is a potential fuel in urban areas. While TVA does not intend to construct or operate facilities using it as fuel, TVA would consider purchasing power from such a facility. Dedicated biomass crops are also a potential fuel although their supply in the TVA region is presently very limited. The two principal types of solid-fueled biomass generation are cofiring at coal plants and dedicated biomass facilities. TVA periodically cofires wood waste at the Colbert plant and has experimentally cofired wood waste at the Allen and Kingston plants. Fuel availability and cost are major factors for both cofiring and dedicated biomass facilities. Because of transportation expenses, fuel sourcing areas are typically no farther than about 50 miles from the biomass plant (EPRI 2010). This constraint can limit the amount of cofiring or the size of a dedicated facility.

An alternative to delivering raw solid biomass to generating facilities is pretreatment at or near the harvest site. Potential pretreatment methods include sizing, drying, compacting, pelletizing and torrefaction. While these increase fuel costs, they can reduce transportation, storage, boiler operation, and ash disposal costs (EPRI 2009).

Cofiring currently is a relatively low cost approach to renewable generation and can be deployed relatively quickly. At cofiring facilities, biomass is fed into the boilers along with coal. The primary additions to an existing plant are the biomass receiving system, where trucks typically dump the fuel, a storage stockpile, and equipment for either blending the biomass with the coal as it is fed into the boilers or directly injecting biomass into the boilers (EPRI 2010). Depending on the type and quality of biomass fuel, a fuel screening and grinding system may also be used. In cyclone plants, such as Allen, the biomass can be blended with coal on the coal pile or on the conveyor feeding the coal bunkers. While cyclone plants can readily burn woody fuels, they are not suitable for switchgrass or other herbaceous fuels. In pulverized coal plants, such as Kingston and Colbert, woody biomass can be blended with coal on the conveyor feeding the coal bunkers or injected directly into the furnace. Switchgrass must be injected directly into the furnace, and direct injection of both woody biomass and switchgrass requires changes to the boiler. Biomass cofiring at both cyclone and pulverized coal plants reduces the plant efficiency by a small amount due to the lower energy content of biomass.

Dedicated Biomass Facilities - The most common types of dedicated facilities using solid biomass fuels are stoker boilers, cyclone boilers, and circulating fluidized bed boilers (EPRI 2010). Because of fuel availability constraints, the typical capacity of these facilities is about 50 MW. Typical components of these facilities include the fuel receiving and unloading system, fuel screening and grinding system, fuel stockpile area, fuel conveyor and feed bunker, boiler, turbine generator, cooling water supply and mechanical draft cooling tower, air heater, air emissions control systems, stack, transformers and electrical switchyard, connection to the area electrical grid, and office and service buildings. Emissions control systems typically consist of fabric filters or electrostatic precipitators to control particulates and selective catalytic reduction or selective non-catalytic reduction systems to control NOx. Biomass gasification also has potential for power generation, although most facilities built to date have been relatively small and used in combined heat and power applications (EPRI 2010).

An alternative to the construction of new dedicated biomass facilities is the conversion of existing coal-fired boilers to burn biomass only. The required plant changes depend on the type of fuel and its pretreatment, and can require construction of a new fuel handling system and boiler modifications. Dedicated biomass facilities are suitable for base load generation.

The IRP evaluates the following options for biomass-fueled generation at existing TVA coal plants:

- Biomass cofiring, for a total biomass-fueled capacity of up to 169 MW. Individual cyclone and pulverized coal boilers would have up to 20 MW of their capacity fueled by biomass.
- Conversion of existing boilers to dedicated biomass fueling, for a total capacity of up to 170 MW. Shawnee Fossil Plant Unit 10, the fluidized bed boiler, is being evaluated for conversion.

BIOMASS - NEW FACILITIES

The IRP evaluates acquiring up to 117 MW of biomass-fueled generating capacity through PPAs. Likely plant types include:

- Stoker boiler plant with a capacity of about 50 MW
- Dedicated biomass circulating fluidized bed plant with a capacity of about 50 MW.

After considering the costs, capacity factors, renewable resource potential, and other factors, TVA developed two renewable energy capacity expansion portfolios. Their development is described in more detail in IRP Appendix D. One portfolio (Table 5-2) associated with Strategies C, D and R is designed to achieve 2,500 MW of new renewable generating capacity by 2020. The other portfolio (Table 5-3) associated with Strategy E is designed to achieve 3,500 MW of new capacity by 2020. The 2,500 MW and 3,500 MW portfolios would generate about 8,600 and 12,000 GWh of energy in 2020, respectively. Strategies A and B contain no renewable additions beyond the renewable power purchase agreements described in Section 3.4. The out-of-region wind component of the two portfolios includes the pending power purchase agreements listed in Table 3-8.

5.4.4. Energy Storage

Energy storage facilities are used to store energy generated at times of low demand and then return it to the grid at times of high demand. The energy stored in the facility is typically generated by low-cost facilities such as nuclear and large coal units which operate most efficiently at a constant full load. Stored energy can also be generated by intermittent facilities operating at off-peak times such as windfarms. Using the stored energy during high peak demand periods can offset the need for more expensive, less efficient generation such as combustion turbines. Storage facilities can provide both peak and intermediate power.

Table 5-2. Renewable generation capacity (in cumulative MW) expansion portfolio associated with Strategies C, D, and R.

	Fiscal Year																	
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
HMOD						10	20	32	43	54	65	75	83	89	89	89	89	89
Landfill Gas	2	4	12	16	18	21	25	28	30	30	30	30	30	30	30	30	30	30
Addl Hydro		24	24	49	49	76	76	108	144	144	144	144	144	144	144	144	144	144
Cofiring		60	118	118	118	118	146	146	146	146	146	146	146	146	146	146	146	146
Wind																		
- Out-of-region	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380	1380
- In region			50	100	150	200	250	300	360	360	360	360	360	360	360	360	360	360
Dedicated Biomass																		
- PPA		35	35	67	67	117	117	117	117	117	117	117	117	117	117	117	117	117
- Conversion			80	80	80	170	170	170	170	170	170	170	170	170	170	170	170	170
Solar	20	25	40	45	60	65	80	85	100	105	120	125	140	145	160	165	180	185
Total Capacity	1402	1528	1739	1854	1922	2157	2264	2365	2490	2506	2531	2547	2570	2581	2596	2601	2616	2621

Notes on table entries: HMOD - capacity gains from modernization of existing TVA hydroelectric turbines; Addl Hydro - small and low power hydro facilities; Cofiring - combustion of biomass in existing TVA coal-fired units; PPA - acquisition through power purchase agreement; Conversion - conversion of existing TVA coal-fired units to burn biomass only.

Table 5-3. Renewable generation capacity expansion portfolio associated with Strategy E.

	Fiscal Year																	
	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
HMOD						10	20	32	43	54	65	75	83	89	89	89	89	89
Landfill Gas	2	4	12	16	18	21	25	28	30	30	30	30	30	30	30	30	30	30
Addl Hydro		24	24	49	49	76	76	108	144	144	144	144	144	144	144	144	144	144
Cofiring		60	118	118	118	141	169	169	169	169	169	169	169	169	169	169	169	169
Wind																		
- Out-of-region	1380	1480	1630	1780	1930	2080	2230	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380	2380
- In region			50	100	150	200	250	300	360	360	360	360	360	360	360	360	360	360
Dedicated Biomass																		
- PPA		35	35	67	67	117	117	117	117	117	117	117	117	117	117	117	117	117
- Conversion			80	80	80	170	170	170	170	170	170	170	170	170	170	170	170	170
Solar	35	45	75	85	115	125	155	165	195	205	235	245	275	285	315	325	355	365
Total	1417	1648	2024	2294	2527	2940	3212	3468	3608	3629	3669	3690	3728	3744	3774	3784	3814	3824

Notes on table entries: HMOD - capacity gains from modernization of existing TVA hydroelectric turbines; Addl Hydro - small and low power hydro facilities; Cofiring - combustion of biomass in existing TVA coal-fired units; PPA - acquisition through power purchase agreement; Conversion - conversion of existing TVA coal-fired units to burn biomass only.

Energy Storage - Existing Facilities
TVA operates one large energy storage facility, the Raccoon Mountain Pumped Storage Plant. This plant has a capacity of 1,615 MW and can generate 1532 MW for 20 hours when fully charged. Its continued operation is considered in the IRP.

Pumped storage facilities operate by pumping water from a lower reservoir through pipes to a higher reservoir. The pumps can then be reversed to operate as turbine-generators when water flows from the higher reservoir to the lower reservoir. The amount of electricity generated is a function of the size of the storage reservoirs and the elevation difference (head) between the higher and lower reservoirs. Typical components of pumped storage facilities include the lower reservoir (which, in the case of Raccoon Mountain, may be an existing reservoir), upper reservoir, pipes connecting the reservoirs, reversible pump/turbine generators, electrical transformers and switchyard, connection to the area electrical grid, and office and service buildings. Depending on whether the pipes connecting the reservoirs are on the surface or underground, the pump/generators are located in an above-ground powerhouse or in an underground chamber. Large pumped storage facilities such as Raccoon Mountain have an efficiency of about 80 percent, meaning that for every 5 units of electricity used to pump water into the upper reservoir, 4 units are recovered during the generating cycle. Although they are net consumers of energy, they can be economically desirable because they consume energy during low-value periods and produce energy during high-value periods.

Energy Storage - New Facilities
The following new energy storage facilities are considered in the IRP:

- Pumped storage facility with a capacity of 850 MW
- Pumped storage facility with a capacity of 960 MW
- Compressed air energy storage facility with a capacity of 330 MW.

Compressed air energy storage (CAES) combines features of combustion turbines and pumped-hydro storage to provide peaking or intermediate power. It uses off-peak energy to compress air by a motor/generator compressor train, inject it into wells, and store it in an underground reservoir. During periods of high demand, the stored, pressurized air is released, heated, and passed through natural gas-fired high- and low-pressure turbines which drive the motor/generator. Turbine exhaust gas is used to heat the released air. A variation of this basic design, CAES with humidification, adds water vapor to the air entering the high-pressure turbine. A CAES facility would be used primarily for peaking power generation.

Surface facilities include the power block with the motor/generator compressor train, electrical transformers and switchyard, and office and service buildings, as well as the well field, compressed air pipelines, and a natural gas supply pipeline. TVA has investigated potential sites in northeast Mississippi that would use depleted natural gas fields in the Black Warrior geologic formation for the reservoir.

5.4.5. Energy Efficiency and Demand Response Options

TVA’s current EEDR portfolio is described in Section 3.5. New TVA EEDR programs considered in the IRP evaluation are listed below. Additional energy efficiency and demand reduction beyond that implemented by TVA may occur during the IRP planning period due to regulations, local and state statutes such as building code changes, state and federal incentive programs, and consumer behavior changes from education. These energy efficiency impacts are reflected in the need for power analysis in Chapter 2, and would be in addition to the results achieved from TVA programs. See Final IRP Appendix C for a description of the development of the EEDR portfolio associated with the Recommended Planning Direction strategy.

Residential Programs

- HVAC Maintenance - This program is focused on maintaining proper refrigerant charge and airflow across the coils in residential heat pumps and air-conditioning units. TVA will work with a third-party vender to offer a turnkey program.
- Weatherization Assistance - TVA has entered into an agreement with the Tennessee Department of Human Services under which TVA will provide curriculum development and training services for auditors and installers participating in the state Weatherization Assistance Program. In return, the Department is providing TVA with results of energy audits conducted before and after weatherization.

Commercial and Industrial Programs

- The present Commercial Efficiency Advice and Incentives Program would be split into the Industrial Efficiency Advice and Incentives Program, targeting industrial customers with less than 5 MW demand, and the Commercial Efficiency Advice and Incentives Program, targeting commercial businesses with billing demands greater than 50 kW. The incentives remain unchanged.
- Direct Installation (Small Commercial) - This program targets small commercial companies with less than 50 kW demand, such as small retail and office space tenants, with customized audits. Following the installation of identified energy efficiency improvements, customers could receive an incentive of up to $2,500.
- Retro/Re-Commissioning - This program is designed to optimize building performance by focusing on the interaction of building equipment and systems. Following screening to identify candidate buildings, the program would provide assistance for an audit of potential improvements to mechanical equipment, lighting, refrigeration, and related controls, training for building operators, and building monitoring. Incentive awards equivalent to $200/kW would be provided.
- White Tag - White Tags are energy trading certificates similar to Renewable Energy Certificates and equivalent to 1 MWh. They would be purchased from a third party for specific time periods relating to TVA's peak demand reduction needs. The third party would aggregate the tags and certify the demand and energy reductions.
- New Construction - This program is designed to provide incentives for businesses to invest in energy-efficient new commercial buildings and major renovation projects. The incentive options are based on HVAC and lighting systems and controls.
- Major Commercial - This program encourages reductions in electric energy intensity in large commercial facilities with a contract demand greater than 5 MW; about 65 large commercial customers are eligible. It offers customized technical assistance in taking a plant-wide, holistic approach to developing energy efficiency opportunities.
- Commercial Prescriptive - This program would offer incentives of $200/kW for reductions in electric energy intensity by commercial facilities with a demand less than 5 kW.
- Industrial Prescriptive - This program is similar to the Commercial Prescriptive program but aimed at industrial facilities with a demand less than 5 MW.

Education and Outreach

- National Energy Education Development Project - TVA, in partnership with state energy offices, would conduct energy management and education workshops for teachers, administrators, and facility staff at K-12 schools.
- District Projects - This program provides custom projects within TVA customer service districts.
- Valleywide Commercial Accounts - This program establishes single TVA points-of-contact for energy managers of corporations with multiple locations in the TVA region.
- Enhanced Security Deposit - This program provides a retail-based, credit insurance program as an alternative to collecting a two-month deposit for commercial and industrial customers with an electrical demand over 50 kW.
- Demand Response (SureGrid) - This program recruits customers to provide a demand response capacity under the SureGrid energy management system for up to 200 hours per year. Customers receive $35 per kW reduction.
- Direct Load Control - Under this program, two-way communication systems would be installed in homes of residential customers and TVA would remotely control water heaters and central air conditioners during peak load periods.
- Dynamic Voltage Regulation - This program is similar to the existing Conservation Voltage Regulation Program except that it uses the lower voltage on a dispatch basis instead of continuously.
- Biodiesel Generation - TVA would purchase electricity generated with biodiesel by end users in a manner similar to the existing Generation Partners program.
- Non-Renewable Clean Generation - TVA would purchase electricity generated by end users from clean but non-renewable sources. Eligible generation includes waste heat recovery, combined heat and power, and large industrial cogeneration. TVA would pay a 3-cent premium above the retail electric rate in a manner similar to the existing Generation Partners program.

CHAPTER 6

6.0 ALTERNATIVES

6.1. Introduction

As described in Chapter 2, TVA originally developed five resource planning strategies and a set of portfolios, corresponding to the seven scenarios, associated with each strategy. An additional strategy and scenario were developed following the release of the Draft IRP and EIS. These strategies are the basis for the alternatives in this EIS. This chapter describes the portfolios (resource plans) associated with each strategy, the results of the strategy screening process, and the strategies retained as alternatives for further consideration. This chapter also summarizes the environmental impacts of the alternatives.

6.2. Strategies and Associated Resource Plans

Following is a summary of the resource portfolio developed for each of the strategies. In the resource portfolio descriptions below, capacity additions and reductions are quantified in MW and energy additions and reductions are quantified in GWh.

All of the resource portfolios include the John Sevier Combined Cycle Plant, scheduled for completion in 2012, and Watts Bar Nuclear Plant, scheduled for completion in 2013. These two plants are not included in the discussions of nuclear and gas-fired supply additions in the following strategy descriptions.

The Recommended Planning Direction (Strategy R) was developed in a different manner than Strategies A-E. Its development involved the use of a bounded optimization analysis, in which the capacity planning model was allowed to select from the levels of EEDR, renewable additions, and coal capacity idled shown in Table 6-1. The other attributes of this strategy were the same as those of Strategy C. See Final IRP Sections 6.6, 8.1-3 for a more detailed description of the development of the Strategy R.

Table 6-1. Levels of EEDR, renewable additions, and coal capacity idled tested in the development of Strategy R.

Component	Range Tested				
EEDR Reductions by 2020	2,100 MW & 5,900 annual GWh		3,600 MW & 11,400 annual GWh		5,100 MW & 14,400 annual GWh
Renewable Additions in MW	1,500 by 2020	2,500 by 2020	2,500 by 2029	3,500 by 2020	3,500 by 2029
Coal Capacity Idled by 2017 in MW	2,400	3,200	4,000	4,700	

6.2.1. Strategy B – Baseline Plan Resource Portfolio

The Baseline Plan Resource Portfolio is essentially a continuation of TVA's current power planning approach with the defined inputs of EEDR reductions of 2,100 MW and 5,900 GWh by 2020, renewables additions of 1,300 MW and 4,600 GWh by 2020, coal plant reductions of 2,000 MW by 2017, and no energy storage additions. The primary sources of new generation are nuclear and gas-fired capacity. Transmission upgrades are necessary to support new gas, nuclear, and coal-fired capacity and to maintain system reliability. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—316 MW of capacity providing 550 GWh of energy reductions in 2010, growing to 2,900 MW providing 7,290 GWh in 2029
- Renewable Resources—1,330 MW of wind PPAs by 2015 providing 4570 GWh annually; PPAs continue through 2029
- Energy Storage—No additions
- Purchased Power—Purchased power decreases as existing PPAs expire; new PPAs limited to 900 MW
- Coal—Idling of 2,415 MW of capacity by 2017; coal units added in only one scenario, consisting of two IGCC coal units with CCS technology in 2025 and 2029
- Nuclear—Bellefonte Units 1&2 added in six scenarios; Bellefonte Units 3&4 added in two scenarios for total of four nuclear units in two scenarios
- Gas-Fired Supply (self-build)—Gas capacity added in most scenarios to meet remaining supply needs, ranging from 11,600 MW by 2029 for highest load scenario to no additional capacity in the lowest load scenario.

6.2.2. Strategy A - Limited Change in Current Resource Portfolio

Under the Limited Change in Current Resource Portfolio, TVA would continue to operate its existing generating facilities as long as possible, continue with the committed EEDR programs and additions of renewable capacity, and rely on power purchases to meet the remainder of its capacity needs. Defined model inputs include annual EEDR reductions of 1,940 MW and 4,725 GWh by 2020, renewables additions of 1,300 MW and 4,600 GWh by 2020, and no coal plant reductions or energy storage additions. The primary source of the purchased power under most scenarios is natural gas. This strategy would require transmission line upgrades to connect to the sources of the purchased power to the TVA grid. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—316 MW of capacity providing 550 GWh of energy reductions in 2010, growing to 2,200 MW providing 5,600 GWh in 2029
- Renewable Resources—1,330 MW of wind PPAs by 2015 providing 4,570 GWh annually; PPAs continue through 2029
- Energy Storage—No additions
- Purchased Power—Purchased power increases through new market purchases as contracts expire and to close future capacity and demand gaps
- Coal—No capacity idled and no new additions
- Nuclear—No new additions after Watts Bar Unit 2
- Gas-Fired Supply (self-build)—No new additions beyond those currently approved.

6.2.3. Strategy C - Diversity Focused Resource Portfolio

The Diversity Focused Resource Portfolio includes an increase in EEDR programs and renewable energy additions over Strategy B. Defined model inputs include annual EEDR reductions of 3,600 MW and 11,400 GWh by 2020, renewables additions of 2,500 MW and 9,600 GWh by 2020, 3,000 MW of coal capacity idled by 2017, and a pumped storage unit. Nuclear, coal, and gas-fired plants are options to meet demand. The Strategy C portfolio contains coal capacity of almost 3,400 MW idled under all scenarios and new nuclear units under all but the two scenarios with the lowest load growth. The primary source of new generation to meet future electricity needs is nuclear and gas-fired capacity. Transmission upgrades would be necessary to support new renewable, gas, nuclear and coal-fired capacity, and TVA could also participate in interregional project to transmit renewable energy. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—377 MW of capacity providing 705 GWh of energy reductions in 2010, growing to 5,300 MW providing 7,300 GWh in 2029
- Renewable Resources—1,760 MW of capacity providing 6,700 GWh by 2015 and increasing to 2,340 MW providing 8,600 GWh by 2029
- Energy Storage—850 MW of new pumped hydro storage
- Purchased Power—Purchased power decreases as existing PPAs expire; new PPAs for up to 900 MW in three scenarios
- Coal—Idling of 3,252 MW of capacity by 2017; additions of two IGCC plants with CCS under one scenario
- Nuclear—Bellefonte Units 1&2 added in six scenarios; Bellefonte Units 3&4 added in one scenario for total of four nuclear units in this scenario
- Gas-Fired Supply (self-build)—Gas capacity added in most scenarios, ranging from 8,200 MW by 2029 for highest load scenario to no additional capacity in the two lowest load scenarios.

6.2.4. Strategy D - Nuclear Focused Resource Portfolio

The Nuclear Focused Resource Portfolio includes an increase in EEDR programs and the same renewable energy additions as Strategy C. Defined model inputs include annual EEDR reductions of 4,000 MW and 8,900 GWh by 2020, the largest (7,000 MW) amount of coal capacity idled by 2017, and a pumped storage unit. In the resulting portfolio, new generation is predominantly by renewables, nuclear and gas-fired plants. Transmission upgrades would be necessary to support new renewables, gas, nuclear and coal-fired capacity, and TVA could also participate in interregional project to transmit renewable energy. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—1,529 MW of capacity providing 1,490 GWh of energy reductions in 2010, growing to 7,320 MW providing 16,500 GWh in 2029
- Renewable Resources—1,760 MW of capacity providing 6,700 GWh by 2015 and increasing to 2,340 MW providing 8,600 GWh by 2029
- Energy Storage—850 MW of new pumped hydro storage
- Purchased Power—Purchased power decreases as existing PPAs expire; new PPAs for up to 900 MW in four scenarios
- Coal—Idling of 6,972 MW of capacity by 2017; additions of two IGCC plants with CCS and one supercritical PC plant with CCS between 2025 and 2029 under one scenario
- Nuclear—Bellefonte Units 1&2 added in six scenarios; Bellefonte Units 3&4 added in two scenario for total of four nuclear units in these two scenarios
- Gas-Fired Supply (self-build)—Gas capacity added in most scenarios, ranging from 8,100 MW by 2029 for highest load scenario to no additional capacity in the lowest load scenario.

6.2.5. Strategy E - EEDR and Renewables Focused Resource Portfolio

The EEDR and Renewables Focused Resource Portfolio includes the largest amounts of both EEDR programs and renewable energy. The amount of coal plant layups is less than Strategy

D but more than A, B, and C. Defined model inputs include annual EEDR reductions of 5,900 MW and 14,400 GWh by 2020, 3,500 MW and 12,000 GWh of renewable resources by 2020, 5,000 MW of coal capacity idled by 2017, and no new energy storage. In the resulting portfolio, new generation is predominantly by renewables, nuclear and gas-fired plants. A high level of transmission upgrades would be necessary to support new renewable, gas, nuclear and coal-fired capacity, and TVA could also participate in interregional project to transmit renewable energy. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—318 MW of capacity providing 798 GWh of energy reductions in 2010, growing to 6,950 MW providing 16,300 GWh in 2029
- Renewable Resources—2,250 MW of renewable resources capacity providing 8,300 GWh by 2015; 3,590 MW providing 12,580 GWh by 2029
- Energy Storage—no additions
- Purchased Power—Purchases beyond current contracts and contract extensions limited to 900 MW; small additions under three scenarios
- Coal—Idling of 4,730 MW of capacity by 2017; no additions
- Nuclear—Four scenarios with Bellefonte Units 1&2 starting in 2022 and one scenario with Bellefonte Units 1, 2 and 3 starting in 2022; no nuclear additions in three scenarios
- Gas-Fired Supply (self-build)—Gas capacity added in five scenarios, ranging up to 10,800 MW in highest load scenario to no additional capacity in three scenarios.

6.2.6. Strategy R - Recommended Planning Direction

Strategy R includes an increase in EEDR programs and renewable energy additions over Strategy B. Based on the results of the bounded optimization analysis, EEDR reductions were set at 3,600 MW and 11,400 GWh by 2020, renewables additions at 2,500 MW by 2020, and coal capacity idled at 4,000 MW by 2017. The Strategy R portfolio contains new nuclear units under all but the two scenarios with the lowest load growth. The primary source of new generation to meet future electricity needs is nuclear and gas-fired capacity. Transmission upgrades would be necessary to support new renewable, gas, nuclear and coal-fired capacity, and TVA could also participate in interregional project to transmit renewable energy. Following is a summary of the portfolio attributes.

- Energy Efficiency / Demand Response—range of 2,100-5,100 MW and 4,700-14,400 GWh by 2020, with 3,600 of capacity by 2020 growing to 4,638 MW in 2029 assumed in portfolios
- Renewable Resources—range of 1,500-3,500 MW by 2020, with 1,854 MW of capacity providing 2,294 GWh by 2015 and 2,500 MW providing 3,600 GWh by 2029 assumed in portfolios
- Energy Storage—850 MW of new pumped hydro storage
- Purchased Power—Purchased power decreases as existing PPAs expire; new PPAs in five scenarios
- Coal—range of capacity idled of 2,400-4,700 MW by 2017, with idling of 4,000 MW of current units by 2017 assumed in portfolios; additions of two IGCC plants with CCS under one scenario
- Nuclear—Bellefonte Units 1&2 added in six scenarios; Bellefonte Units 3&4 added in one scenario for total of four nuclear units in this scenario

- Gas-Fired Supply (self-build)—Gas capacity added in most scenarios, ranging from 2,900 MW by 2029 for highest load scenario to no additional capacity in the two lowest load scenarios.

6.3. Strategy and Portfolio Evaluation

The metrics used to evaluate the cost and financial risk attributes, economic development attributes, and a set of environmental attributes are described in Section 2.6 and IRP Chapter 6. Following are the raw values for these metrics for each of the 35 portfolios developed for the original Strategies A-E and Scenarios 1-7 (Tables 6-2 and 6-3).

Table 6-2. Cost and financial metrics for the 35 resource portfolios and averages for each Strategies A-E.

		Scenario							
	Strategy	1	2	3	4	5	6	7	Average
PVRR (2010 billion $)	A	180	137	116	139	135	109	134	136
	B	173	134	114	136	133	107	133	133
	C	170	133	115	136	133	106	131	132
	D	180	141	121	145	141	110	139	140
	E	173	135	118	139	135	108	134	134
Short-term Rates ($/MWh, level 2011-2018)	A	76.82	75.92	78.42	74.47	75.75	77.31	74.97	76.24
	B	78.67	76.22	76.22	75.88	77.04	74.91	75.72	76.38
	C	79.95	76.73	78.93	77.25	76.99	77.11	77.35	77.76
	D	84.51	88.31	82.78	82.19	83.50	80.44	81.80	82.66
	E	80.41	79.29	82.05	77.91	79.40	79.82	78.52	79.64
Risk/Benefit Ratio	A	1.45	1.36	0.91	1.27	1.26	0.99	1.25	1.21
	B	1.41	1.24	0.97	1.16	1.18	1.00	1.18	1.16
	C	1.38	1.28	0.89	1.13	1.16	0.91	1.14	1.13
	D	1.40	1.22	1.00	1.21	1.17	0.96	1.18	1.16
	E	1.40	1.23	0.91	1.17	1.16	0.89	1.14	1.13
Risk Ratio	A	0.25	0.22	0.09	0.19	0.18	0.13	0.17	0.18
	B	0.24	0.20	0.10	0.16	0.16	0.14	0.16	0.16
	C	0.23	0.20	0.08	0.15	0.16	0.12	0.15	0.16
	D	0.23	0.19	0.10	0.17	0.16	0.11	0.15	0.16
	E	0.24	0.19	0.08	0.17	0.16	0.11	0.15	0.16

Table 6-3. Environmental and economic development metrics for the 35 resource portfolios and averages for Strategies A-E.

		Scenario							
	Strategy	1	2	3	4	5	6	7	Average
Air Impact (Total 2010-2028 CO_2 emissions in million tons)	A	2,054	1,719	1,402	1,775	1,723	1,190	1,767	1,661
	B	1,774	1,461	1,317	1,518	1,480	1,138	1,533	1,460
	C	1,673	1,418	1,210	1,408	1,422	1,035	1,427	1,370
	D	1,468	1,170	1,058	1,256	1,204	962	1,249	1,195
	E	1,613	1,299	1,106	1,410	1,303	959	1,352	1,292
Water Impact (ordinal ranking of scenarios based on need for cooling of steam generating plants)									Final Strategy Rank
	A	3	4	5	4	4	5	4	4
	B	5	5	4	5	5	4	5	5
	C	4	3	3	3	3	3	3	3
	D	2	2	1	2	1	1	1	1
	E	1	1	2	1	2	2	2	2
Waste (ordinal ranking of scenarios based on total handling costs)									Final Strategy Rank
	A	3	4	5	3	4	4	3	4
	B	5	5	4	5	5	5	5	5
	C	4	3	3	4	3	3	4	3
	D	1	1	1	1	1	1	1	1
	E	2	2	2	2	2	2	2	2
Total Employment (percent change from Strategy B, Scenario 7)	A	+0.1					-0.4		
	B	+1.0					-0.3		
	C	+0.9					+0.2		
	D	+1.2					-0.1		
	E	+0.8					+0.3		
Growth in Personal Income (percent change from Strategy B, Scenario 7)	A	+0.1					-0.4		
	B	+0.8					-0.3		
	C	+0.6					+0.1		
	D	+1.0					-0.2		
	E	+0.6					+0.2		

The raw values for these metrics were then converted into ranking scores as described in Final IRP Section 6,3 for ease in their interpretation. Final IRP Section 7.2 displays the scorecards containing the ranking scores for each original strategy. The cost and risk ranking metrics were combined into a single ranking metric score (see EIS Section 2.6) for each of the seven portfolios associated with each planning strategy. The seven ranking metric scores for each original planning strategy were then summed and used to rank the strategies (Table 6-4). The maximum possible score for a strategy is 700.

Table 6-4. Original planning strategies ranked by their total ranking metric scores for cost and financial risk factors.

Rank	Planning Strategy	Ranking Metric Score
1	C - Diversity Focused Resource Portfolio	693
2	E - EEDR and Renewables Focused Resource Portfolio	690
3	B - Baseline Plan Resource Portfolio	675
4	D - Nuclear Focused Resource Portfolio	668
5	A - Limited Change in Current Resource Portfolio	657

The two highest ranked strategies (C and E) have very similar scores for the cost and risk ranking factors. Strategy B ranks in the middle of the range, separated by 15 points from Strategy E. Strategies D and A rank lowest. The 3-point difference between the highest ranked strategies C and E is not statistically significant. Strategy C has the highest scores for PVRR and both risk metrics of all portfolios, and strategies A and B are essentially tied for the highest score for short-term rate impacts.

Planning strategies D has the best (i.e., lowest) score for the environmental metrics and A and B have the worst scores. Strategy C is in the middle of the range. Strategy A performed poorly due to the continued operation of all of the coal plants, the likely reliance on natural gas for most future capacity additions through PPAs, and small amount of EEDR. Strategy B performed poorly due to the large future reliance on coal, nuclear, and gas-fueled generation and relatively small amount of EEDR. The other four strategies all have coal units idled, larger amounts of EEDR, and, under most scenarios, nuclear capacity additions; these factors result in their lower CO_2 emissions and non-nuclear waste generation. The rank order of all six strategies, from best to worst, is D, E, R, C, A, and B.

The ranking of the strategies by the two economic development metrics was similar. Strategies B and D performed similarly and had greatest increases in total employment and personal income under the high-growth scenario. Strategies C, E, and R also performed similarly. Strategy A was consistently the lowest ranked.

Strategy R was ranked in the same manner as Strategies A-E, using the scores for the original seven scenarios as well as the Scenario 8 - Reference Case: Great Recession Impacts Recovery. Ranking metric scores were also developed for Strategies B, C, and E under Scenario 8. When ranked for all eight scenarios, each strategy has a maximum possible score of 800; these scores are listed in Table 6-5.

Table 6-5. Planning Strategies B, C, E, and R ranked by their total ranking metric scores for cost and financial risk factors.

Rank	Planning Strategy	Ranking Metric Score
1	R - Recommended Planning Direction	785
2	C - Diversity Focused Resource Portfolio	783
3	E - EEDR and Renewables Focused Resource Portfolio	782
4	B - Baseline Plan Resource Portfolio	762

6.4. Strategies and Alternatives

Based on the evaluations described in the preceding section, TVA eliminated strategies A and D from further consideration. The retained Strategy B (Baseline Plan Resource Portfolio) is a continuation of TVA's current planning strategy and this represents the No Action Alternative. The three retained alternative strategies representing the Action Alternatives are Strategy C - Diversity Focused Resource Portfolio, Strategy E - EEDR and Renewables Focused Resource Portfolio, and Strategy R - Recommended Planning Direction.

In order to better evaluate the retained strategies B, C, E, and R, the individual scenario-specific portfolios that comprise each strategy were examined more closely. Within each of the four strategies, the portfolios and resulting capacity expansion plans tended to be similar for the paired scenarios 1 (Economy Recovers Dramatically) and 4 (Game-Changing Technology), for scenarios 2 (Environmental Focus is a National Priority) and 5 (Energy Independence), and for scenarios 3 (Prolonged Economic Malaise) and 6 (Carbon Legislation Creates Economic Downturn). The Scenario 7 (Reference Case: Spring 2010) and Scenario 8 (Reference Case: Great Recession Impacts Recovery) portfolios also tended to be similar. Based on the results of this examination, the portfolios associated with scenarios 1, 2, 3, 7, and 8 have been retained for further consideration. The following Tables 6-6, 6-7, 6-8, and 6-9 list the defined amounts of EEDR, new renewable generation, and coal capacity idled and the generating capacity additions for each alternative strategy. The alternative strategies would also require varying amounts of new transmission system construction and upgrades to existing transmission facilities.

6.5. Preferred Alternative

The preferred alternative strategy is Strategy R - Recommended Planning Direction. This strategy has the highest total ranking metric score of the four alternative strategy (Table 6-5), indicating that it performs well across the range of range of scenarios. It performs best in six of the eight tested scenarios for total plan cost (PVRR) and best in five of the eight scenarios for the risk/benefit ratio metric. Based on the strategic metrics, it is the second best performing strategy, behind Strategy C. This is primarily due to the differences in the environmental stewardship metrics; the differences in the economic impact metrics among the four strategies are negligible. See Final IRP Section 8.3.3 for additional comparisons among the alternative strategies.

Table 6-6. The No Action Alternative - Strategy B - Baseline Plan Resource Portfolio. All listed capacities are in MW.

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew -ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	229	35	-	PPAs & Acquisitions				
2011	385	48	(226)					
2012	384	137	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	610	155	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,363	155	(935)	CT - 621 CT - 828 GL CT - 170				
2015	1,496	160	(2,415)	CT - 828 CC - 910	GL CT - 170[4]		CT - 621, GL CT - 170	GL CT - 170
2016	1,622	160	(2,415)	CT - 828			CT - 621	MKT
2017	1,751	160	(2,415)	CT - 828			CT - 828	MKT
2018	1,881	160	(2,415)	BLN1 - 1,250			BLN1 - 1,250	BLN1 - 1,250
2019	2,012	160	(2,415)	CT - 828	BLN1 - 1,250			MKT
2020	2,124	160	(2,415)	BLN2 - 1,250			BLN2 - 1,250	BLN2 - 1,250
2021	2,216	160	(2,415)	CC - 910	BLN2 - 1,250			
2022	2,294	160	(2,415)	CT - 828, CC - 910			CC - 910	CC - 910
2023	2,362	160	(2,415)	CT - 828			CT - 828	CT - 621
2024	2,429	160	(2,415)	BLN3 - 1,117				CT - 828
2025	2,470	160	(2,415)	IGCC - 490	BLN3 - 1,117		CT - 828	
2026	2,495	160	(2,415)	BLN4 - 1,117				CT - 828
2027	2,509	160	(2,415)	CT - 828	BLN4 - 1,117		CT - 828	
2028	2,516	160	(2,415)	CC - 910		CT - 828		CT - 828
2029	2,520	160	(2,415)	IGCC - 490, CT - 621	CT - 621		CC - 910	CT - 621 MW

[1]Peak load impact in MW
[2]Firm capacity at the summer peak
[3]Cumulative capacity of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Table 6-7. Action Alternative - Strategy C - Diversity Focused Resource Portfolio. All listed capacities are in MW.

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	298	35	-	PPAs & Acquisitions				
2011	389	48	(226)					
2012	770	146	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,334	286	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,596	442	(935)	CT - 621				
2015	2,069	515	(3,252)	CT - 828, GL CT 170[4], CC - 910			CT - 621, GL CT - 170	GL CT - 170
2016	2,537	528	(3,252)	CT - 828				
2017	2,828	715	(3,252)					
2018	3,116	768	(3,252)	BLN 1 - 1,250			BLN1 - 1,250	
2019	3,395	822	(3,252)					
2020	3,627	883	(3,252)	BLN2 - 1,250, PSH - 850	PSH - 850	PSH - 850	BLN2 - 1,250, PSH - 850	PSH - 850
2021	3,817	896	(3,252)	CT - 828				
2022	3,985	911	(3,252)	CC - 910	BLN1 - 1,250			BLN1 - 1,250
2023	4,143	922	(3,252)	CC - 910				
2024	4,295	935	(3,252)	BLN3 - 1,117	BLN2 - 1,250			BLN2 - 1,250
2025	4,412	942	(3,252)	IGCC - 490			CT - 828	
2026	4,502	947	(3,252)	BLN4 - 1,117				
2027	4,561	948	(3,252)	CT - 828			CC - 910	
2028	4,602	953	(3,252)	CT - 828				CT - 621 MW
2029	4,638	954	(3,252)	IGCC - 490, CT - 621	BLN3 - 1,117		CT - 621	CT - 828

[1]Peak load impact in MW
[2]Firm capacity at the summer peak
[3]Cumulative capacity of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Table 6-8. Action Alternative - Strategy E - EEDR and Renewables Focused Resource Portfolio. All listed capacities are in MW.

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	34	35	-	PPAs & Acquisitions				
2011	181	48	(226)					
2012	1,136	178	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,664	314	(935)	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	2,431	493	(935)					
2015	3,479	580	(4,730)	GL CT - 170[4], CT - 621, CC (2) - 910			CT - 621, GL CT - 170	GL CT - 170
2016	3,843	616	(4,730)	CT - 828				
2017	4,183	846	(4,730)					
2018	4,504	921	(4,730)	CT - 828			CC - 910	
2019	4,811	994	(4,730)	CC - 910				
2020	5,074	1,060	(4,730)	CC - 910				
2021	5,353	1,074	(4,730)	CT - 621				
2022	5,460	1,094	(4,730)	BLN1 - 1,250	BLN1 - 1,250		BLN1 - 1,250	BLN1 - 1,250
2023	5,599	1,107	(4,730)	CT - 828				
2024	5,739	1,124	(4,730)	BLN2 - 1,250	BLN2 - 1,250		BLN2 - 1,250	BLN2 - 1,250
2025	5,815	1,133	(4,730)	CT - 828				
2026	5,893	1,142	(4,730)	CT - 828			CT - 828	CT - 621
2027	5,961	1,145	(4,730)	CT - 828				
2028	6,009	1,154	(4,730)	BLN3 - 1,117			CT - 621	CT - 621
2029	6,043	1,157	(4,730)	CT - 828			CT - 621	CT - 621

[1]Peak load impact (MW)
[2]Firm capacity at the summer peak (MW)
[3]Cumulative capacity (MW) of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

Table 6-9. Action Alternative Strategy R - Recommended Planning Direction. All listed capacities are in MW.

Year	Defined Model Inputs			Capacity Additions by Scenario				
	EEDR[1]	Renew-ables[2]	Coal Idling[3]	SC1	SC2	SC3	SC7	SC8
2010	298	39	-	PPAs & Acquisitions				
2011	389	53	(226)					
2012	770	168	(226)	CC - 880	CC - 880	CC - 880	CC - 880	CC - 880
2013	1,334	309	(935)	WBN2 - 1,180, PPAs	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180	WBN2 - 1,180
2014	1,596	465	(935)	CT - 828				
2015	2,069	538	(4,002)	GL CT - 170[4], CT - 621, CC - 910, PPAs			GL CT - 170, PPAs	GL CT-170, PPAs
2016	2,537	551	(4,002)	CT - 828			MKT	
2017	2,828	738	(4,002)	MKT			MKT	
2018	3,116	791	(4,002)	BLN1 - 1,250	BLN1 - 1,250		BLN1 - 1,250	
2019	3,395	845	(4,002)	MKT			MKT	MKT
2020	3,627	906	(4,002)	BLN2 - 1,250, PSH - 850	BLN2 - 1,250, PSH - 850	PSH - 850	BLN2 - 1,250, PSH - 850	BLN1 - 1,250, PSH - 850
2021	3,817	919	(4,002)	CC - 910				
2022	3,985	934	(4,002)	CC - 910, MKT				BLN2 - 1,250
2023	4,123	945	(4,002)	CT - 828, MKT			CT - 828	
2024	4,295	958	(4,002)	BLN3 - 1,117				
2025	4,412	965	(4,002)	IGCC - 490, MKT			CT - 621	
2026	4,412	970	(4,002)	BLN4 - 1,117			MKT	CT - 828
2027	4,561	970	(4,002)	CT - 828			CT - 828	MKT
2028	4,602	971	(4,002)	CT - 828			MKT	CT - 828
2029	4,638	977	(4,002)	CT - 828, IGCC - 490	CT - 828		CT - 828	CT - 621

[1]Peak load impact (MW)
[2]Firm capacity at the summer peak (MW)
[3]Cumulative capacity (MW) of coal units to be idled
[4]Upgrade of Gleason CT plant from 360 to 530 MW

6.6. Comparison of Environmental Impacts of the Alternatives

All of the alternative strategies have several common features that affect their anticipated environmental impacts. All strategies result in decreases in coal-fired generation and increases in the reliance on renewable and EEDR resources. All strategies also add varying amounts of new nuclear and natural gas-fueled generation. Emissions of air pollutants and the intensity of greenhouse gas emissions decrease under all strategies.

The four alternative strategies result in significant long-term reductions in emissions of SO_2, NOx, and mercury. Strategy E has the greatest reduction and Strategy B has the least reduction, although the differences among the strategies are small. The total direct emissions of CO_2 during the planning period are greatest for Strategy E and least for Strategy B. For all alternative strategies, both annual direct CO_2 emissions and the CO_2 intensity decrease; as with total emissions, this decrease is greatest for Strategy E and least for Strategy B.

The volume of water used and water consumed by thermal generating facilities increase for the four alternative strategies. The increases in the volume of water used are mostly less than 5 percent and greatest for Strategy B and least for Strategy E. The percent increases in the volume of water consumed are considerably larger as new thermal facilities are anticipated to use closed-cycle cooling. Water consumption under strategies B and C is similar and greater than under Strategy E.

Coal consumption, and consequently its related fuel cycle impacts resulting from mining, processing, and transportation, decreases under all of the alternative strategies. These decreases, and the resulting decreases in fuel cycle impacts, are greatest for Strategy E and least for Strategy B. Nuclear fuel cycle impacts are similar for strategies B, C, and R, which are all greater than those of Strategy E. Natural gas fuel cycle impacts are somewhat greater for Strategy E than for strategies B, C, and R.

The production of coal ash decreases under all strategies, and the decrease is proportional to the amount of coal capacity idled. Consequently, ash production impacts would be greatest under Strategy B and least under Strategy E. The production of scrubber waste, and the impacts associated with its disposal, increases the most under Strategy B and the least under Strategy E. The amount of radioactive waste produced increases under all alternative strategies in proportion to the nuclear generating capacity added. The amounts are somewhat greater for strategies B, C, and R than for Strategy E.

Land requirements for implementing the alternative strategies, and thus the potential for affecting land resources, vary with the capacity and types of new generating facilities. Excluding renewable generation, the land area required for generating facility construction is greatest for Strategy C (average of 1,674 acres for the four scenarios), followed by Strategy R (1,525 acres), Strategy B (1,059 acres), and Strategy E (755 acres). The 750 acres required for a pumped storage facility. included in Strategies C and R, is the largest component of the facility land requirements. When renewable generation is included, the land requirements are greatest for Strategy E and least for Strategy B. Life-cycle land requirements, which include land required for fuel production and processing, as well as buffer areas around facilities, are greatest for Strategy E and least for Strategy B.

CHAPTER 7

7.0 ANTICIPATED ENVIRONMENTAL IMPACTS

7.1. Introduction

This chapter describes the anticipated environmental impacts of the alternative strategies and their associated portfolios. It first describes the general process TVA uses to site new power facilities. It next describes the impacts of the continued operation of TVA's generating facilities, the impacts of facilities from which TVA is purchasing power through a PPA, and the impacts of generating facilities that TVA is likely to own or purchase power from in the future. It then describes the impacts of energy efficiency and demand response (EEDR) programs and the impacts of the construction and upgrading of the transmission system necessary to support the future generating facilities.

7.2. Facility Siting and Review Processes

When planning new generating facilities, TVA uses several criteria to screen potential sites. Generating facilities are often needed in specific parts of the TVA power service area in order to support the efficient operation and reliability of the transmission system. Once a general area is defined, sites are screened by numerous engineering, environmental, and financial criteria. Specific screening criteria include regional geology and local terrain; proximity to major highways, railroads, and barge access; proximity to major natural gas pipelines; proximity to high-voltage transmission lines; land use and land ownership; regional air quality; sources of process water; the presence of floodplains, proximity to parks and recreation areas; potential impacts to endangered and threatened species, wetlands, and historic properties; and potential impacts to minority and low-income populations. Through this systematic process, TVA attempts to minimize the potential environmental impacts of the construction and operation of new generating facilities.

New transmission facilities are typically required to transmit power between two defined points or to improve transmission capacity and/or reliability in a defined area. As with generating facilities, potential transmission line routes, substation locations, and switching station locations are screened by numerous engineering, environmental, and financial criteria. Specific screening criteria include slope, the presence of highways, railroads, and airports, land use and land ownership patterns, proximity to occupied buildings, parks, and recreation areas, and potential impacts to endangered and threatened species, wetlands, and historic properties. TVA also encourages participation by potentially affected landowners in this screening process.

TVA has to date not been directly involved in the siting and operation of natural gas pipelines that may have to be built to serve new natural gas plants. It purchases natural gas service from contractors who are responsible for constructing and operating the pipeline. Construction and operation of a natural gas pipeline would be subject to various state and federal environmental requirements depending on how and where it would be constructed. If a pipeline is built specifically to serve TVA, TVA would evaluate its potential environmental impacts and take steps to ensure that any associated impacts are acceptable.

The results of the site screening process, as well as the potential impacts of the construction and operation of the generating and transmission facilities at the screened alternative locations, are described in comprehensive environmental review documents. TVA consults with the appropriate State Historic Preservation Officer on the potential impacts to historic properties and, as necessary, with the U.S. Fish and Wildlife Service on the potential impacts to endangered and threatened species during this environmental review process.

7.3. Environmental Impacts of Supply-Side Resource Options

Because the locations of most of the future generating facilities are not known, this impact assessment focuses on impact areas that are generally not location-specific. These impact areas are described below.

Air Quality - The potential impacts to air quality are described by the direct emissions of the sulfur dioxide (SO_2), nitrogen oxide (NOx), and mercury (Hg) and are quantified by the amount emitted per unit of electricity generated and the total amount emitted under each of the alternative strategies and portfolios.

Greenhouse Gases (GHG) - As recommended by CEQ (2010), GHG emissions are assessed for both the direct emissions of CO_2, from the combustion of non-renewable carbon-based fuels, and for the life-cycle GHG emissions, which include direct and indirect emissions of CO_2, methane, nitrous oxide (N_20), and other greenhouse gases. Life-cycle GHG emissions include emissions from the construction, operation, and decommissioning of generating facilities; the extraction or production, processing, and transportation of fuels; and the management of spent fuels and other wastes. Because life-cycle GHG emissions have not been determined for TVA's generating facilities, the estimates used in this assessment are based on published life-cycle assessments (e.g., Spath and Mann 2000, Odeh and Cockerill 2008). Both direct CO_2 emissions and life-cycle GHG emissions are quantified by the amount emitted per unit of electricity generated and the total amount emitted under each of the alternative strategies and portfolios.

Water Resources - The impacts of water pollutants discharged from a generating facility are highly dependent on facility-specific design features, including measures to control or eliminate the discharge of water pollutants, and are not addressed here. The impacts of the process water used and consumed by a thermal generating facility (primarily for cooling) are dependent on the characteristics of the source area of water withdrawals and of the water bodies to which process water is discharged. The quantities of process water used and consumed are indicators of the magnitude of these impacts. Facilities with open-cycle cooling systems withdraw and discharge large quantities of water. Facilities with closed-cycle cooling systems use less water but consume (typically by evaporation) a large proportion of it. Water use and consumption are quantified by the volumes used and consumed per unit of electricity generated and the total volumes used and consumed under each of the alternative strategies and portfolios.

Solid Waste - The potential for impacts from the generation and disposal of solid wastes are assessed by the quantities of coal ash, scrubber sludge (i.e., synthetic gypsum and related materials produced by flue gas desulfurization systems), low-level radioactive waste, and high-level radioactive waste (spent nuclear fuel). These are quantified by the amounts produced per unit of electricity generated and the total amounts under each of the alternative strategies and portfolios.

Fuel Consumption - The amount of fuel consumed is related to the potential impacts of the extraction or production, processing, and transportation of fuels. Fuel consumption is quantified by the amount consumed per unit of electricity generated and the amount consumed under each of the alternative strategies and portfolios. In addition to coal, coal plants equipped with scrubbers or circulating fluidized bed boilers use limestone as a reagent to reduce SO_2

emissions. The quantity of limestone consumed is a function of the quantity of coal consumed. The quarrying, processing, and transportation of limestone affect air, water, and land resources.

Land Requirements - Land requirements for the alternative strategies and portfolios are quantified by both the facility land requirements and life-cycle land requirements. These land requirements are indicators of the potential for impacts to land-based resources such as vegetation, wildlife, many endangered and threatened species, cultural resources such as archaeological sites and historic structures, land use, prime farmland, visual/aesthetic resources, and recreation. They are also related to the potential for impacts to aquatic resources resulting from runoff and sedimentation.

The facility land requirement is the land area permanently disturbed by the construction of the generating facility. It does not include adjacent lands that are part of the facility site and maintained in a natural or semi-natural state as buffers or exclusion zones. It is quantified by the total acreage permanently disturbed by the construction of new generating facilities under each of the alternative strategies and portfolios.

The life-cycle land requirement is a measure of the land area transformed during the life-cycle of a generating facility expressed in terms of units of area per amount of electricity generated. This land includes the facility site; adjacent buffer areas; lands used for fuel extraction or production, processing and transportation; and land used for managing spent fuels and other wastes. Some of the land areas, such as the facility site, are transformed for decades while others, such as some minelands, are transformed for shorter time periods. These differing time periods are considered in the assessment. The estimates used in this assessment are based on published life-cycle assessments (e.g., Fthenakis and Kim 2009).

Life-cycle land requirements can also be expressed with a land-use metric that accounts for the total surface area occupied by the materials and products used by a facility, the time the land is occupied, and the total energy generated over the life of the facility (Spitzley and Keoleian 2005, AEFPERR 2009). The rank order by energy technology reported for a sample of U.S. facilities, from the smallest to the largest land requirements, is natural gas, coal, nuclear, solar PV, wind, conventional hydroelectric, and biomass. The large land requirements for hydroelectric are due to the inclusion of the reservoirs, which typically have other uses. The biomass land requirements are based on the use of dedicated woody crops; the use of forest residues would also result in a large land requirement.

Following is a discussion of the environmental attributes of the generation options. Environmental characteristics of TVA's existing and potential new supply-side resources are listed in Tables 7-1 and 7-2, respectively. The various types of generating facilities are described in Sections 3.3 and 5.4. It is important to note that there now are comprehensive environmental laws and regulations that address almost all activities associated with the construction and operation of new industrial facilities, particularly energy generation facilities. This regulatory umbrella ensures that the environmental impacts associated with energy resources are acceptable and that in general public health and the environment are protected.

Table 7-1. Environmental characteristics of current and committed supply-side options included in alternative strategies.

	Net Capacity - MW	Capacity factor - %	Heat rate - Btu/kWh	Fuel consumption	Limestone consumption - tons/MWh	SO_2 emissions - lbs/MWh	NOx emissions - lbs/MWh
Coal-Fueled							
TVA fleet total	13,149	var.[2]	10,331	0.524 tons/MWh		6.5204	1.9232
PPA lignite	432	84	10,500	0.963 tons/MWh	0.076	1.5259	1.2288
Natural Gas-Fueled							
Combustion turbine - fleet total	5,716	5	11,486	11,184 ft^3/MWh	0	0	0.1402
Combined cycle - fleet total - TVA and PPA	4,935	40	7,150	6,998 ft^3/MWh	0	0	0.0863
Diesel-Fueled							
Fleet total - TVA and PPA	132	5	7,500	67.6 gal/MWh	0	0.5339	31.474
Nuclear							
Fleet total	7,895	95	10,136	2.2 kgU/GWh	0	0	0
Hydro							
Fleet total	4,144	var.	--	--	0	0	0
Storage[1]							
Raccoon Mountain pumped hydro	1,615	20	--	--	0	0	0
Renewable							
Wind - out of region	300	30	--	--	0	0	0
Wind - in region	29	25	--	--	0	0	0
Landfill gas - fleet total	9.6	83	13,500	27,551 ft^3/MWh	0	0.024	3.0
Solar			n/a	n/a	0	0	0

[1]Fuel requirements and emission rates exclude those of the generation used during pumping mode
[2]Varies by facility
[3]Combined with ash due to use of circulating fluidized bed boiler
[4]Facility average
[5]Estimate from life-cycle literature, see text

Table 7-1. Continued.

Hg emissions - lbs/MWh	CO_2 emissions - tons/GWh	GHG life-cycle emissions - tons CO_2-eq/GWh	Process water use gallons/MWh	Process water consumption -gallons/MWh	Solid waste - coal ash - tons/MWh	Solid waste - coal SO_2 removal byproducts toms/MWh	Low-level waste	High-level waste	Facility Land Requirement - permanently disturbed acres
Coal-Fueled									
0.0428	1059.0	1,030[5]	43,765	219.5	0.044	.0059	0	0	1,105[4]
0.0348	1141.9	unk	610.5	610.5	0.219	--[3]	0	0	320
Natural Gas-Fueled									
0	678.97	unk	0	0	0	0	0	0	68[4]
0	420.77	509[5]	978.7	831.1	0	0	0	0	80[4]
Diesel-Fueled									
0	1501.3		0	0	0	0	0	0	1
Nuclear									
0	0	22.2[5]	26,674	806	0	0			890[4]
Hydro									
0	0	--	n/a	0	0	0	0	0	--
Storage[1]									
0	see text	see text	386,470	0	0	0	0	0	1,050
Renewable									
0	0	7.10	0	0	0	0	0	0	0.59/MW
0	0	7.25	0	0	0	0	0	0	0.86/MW
0	(2,814)	--	0	0	0	0	0	0	1
0	0	72.8	0	0	0	0	0	0	var.

Table 7-2. Environmental characteristics of new supply-side options included in alternative strategies.

	Net Capacity - MW	Capacity factor - %	Heat rate - Btu/kWh	Fuel requirement	SO_2 emissions - lbs/MWh	NOx emissions - lbs/MWh	Hg emissions - lbs/MWh
Coal Fueled							
IGCC with CCS	490	82	10,533	0.534 tons/MWh	0.0898	0.5263	0.0036
Natural Gas Fueled							
Combustion turbine	686	5	9,857	9.60 ft^3/kWh	0	0.2588	0
Combustion turbine	828	5	9,857	9.60 ft^3/kWh	0	0.2588	0
Combined cycle	1,045	40	6,706	6.53 ft^3/kWh	0	0.0827	0
Nuclear							
Bellefonte Unit 1 or Unit 2	1,250	92	10,100	2.2 kgU/GWh	0	0	0
Bellefonte Unit 3 or Unit 4 (AP1000)	1,117	92	10,100	2.2 kgU/GWh	0	0	0
Storage[1]							
Pumped storage hydro	850	20	n/a	n/a	0	0	0
Renewable							
Hydro modernization	88.8[2]	--	n/a	n/a	0	0	0
Hydro - small and micro-	var.[3]	50	n/a	n/a	0	0	0
Wind - out of region	var.	var.	n/a	n/a	0	0	0
Wind - in region	var.	var.	n/a	n/a	0	0	0
Landfill gas	var.	83	13,500	27.6 ft^3/kWh			0
Biomass - cofiring	up to 169[2]	var.	12,500	see text	see text	see text	see text
Biomass - dedicated facility	50	81	12,500	1.588 tons/MWh[4]			
Biomass - coal boiler conversion	var.	var.	12,500	see text			
Solar PV	var.		n/a	n/a	0	0	0

[1]Fuel requirements and emission rates exclude those of the generation used during pumping mode
[2]System-side total
[3]Varies by facility
[4]Stoker boiler; gasification plant has lower fuel requirement

Table 7-2. Continued.

CO_2 emissions - tons/GWh	GHG life-cycle emissions - tons CO_2-eq/GWh	Process water use gallons/MWh	Process water consumption -gallons/MWh	Solid waste - ash/slag - tons/GWh	Solid waste - coal SO2 removal byproducts	Low-level waste ft^3/GWh	High level waste	Facility Land Requirement - permanently disturbed acres
Coal-Fueled								
108.0		655	655	47.31	0	0	0	200
Natural Gas-Fueled								
588.2		0	0	0	0	0	0	68
588.2		0	0	0	0	0	0	68
404.7	509	978.7	831.1	0	0	0	0	80
Nuclear								
0	39	1680	576	0	0	0.807	2.59E-06 tons uranium/MWh	400
0	39	1289	859	0	0	0.213	2.64E-06 tons uranium/MWh	450
Storage[1]								
0						0	0	750
Renewable								
0		0	0	0	0	0	0	0
0		var.	0	0	0	0	0	0.5/MW
0		0	0	0	0	0	0	0.59/MW
0		0	0	0	0	0	0	0.86/MW
		0	0		0	0		0
see text	see text	0	0			0	0	0
0	var.			31.78	0	0	0	50
0	var.			var.	0	0	0	var.
0	27.6 - 72.8	0	0	0	0	0	0	var.

7.3.1. Fossil-Fueled Generation

Coal - Existing Facilities

TVA operates 59 coal-fired generating units at 11 plant sites. Flue gas desulfurization systems (scrubbers) have been installed at 17 of these units and selective catalytic reduction (SCR) systems for NOx emissions control have been installed at 21 of these units. The plants with these scrubber and SCR systems include TVA's largest coal units and total about 8,000 MW of generating capacity. The remaining coal-fired units use other methods to reduce SO_2 and NOx emissions, and additional emission controls will likely be required for these units to comply with anticipated air quality regulations. Many of the older coal units that lack scrubbers and SCR systems are candidates or already identified for long-term idling under the alternative scenarios.

While the life-cycle GHG emissions for TVA coal plants have not been calculated, several studies have calculated these emissions for comparable coal plants. Spitzley and Keoleian (2004) found an emission rate of 1060 tons CO_2-eq/GWh for pulverized coal boilers without advanced emissions control systems. Odeh and Cockerill (2008) calculated a life-cycle GHG emission rate of 1085 tons CO_2-eq/GWh for a pulverized coal plant equipped with an electrostatic precipitator, SCR, and scrubber, comparable to Widows Creek units 7 and 8. They also calculated an emission rate of 969 tons CO_2-eq/GWh for a supercritical pulverized coal plant equipped with an electrostatic precipitator, SCR, and scrubber, comparable to Bull Run, Cumberland, and Paradise plants.

The largest source of life-cycle GHG emissions at coal plants similar to TVA's is CO_2 from the coal combustion, which typically accounts for between 80 and 90 percent of GHG emissions (Spath et al. 1999, Kim and Dale 2005, Odeh and Cockerill 2008). The next highest source is methane emissions from coal mining; these emissions are higher for underground than surface mines. Other notable GHG sources include coal preparation, coal transport, and limestone mining. GHG emissions from plant construction, decommissioning, and other process are relatively small.

All TVA coal plants, except Paradise, use open-cycle cooling and thus, have high water use rates but low water consumption rates (see Section 4.7). Paradise uses closed-cycle cooling much of the year and has lower water use and higher water consumption rates. As a result, the amount of heat discharged to the river at Paradise is relatively low.

The Red Hills plant in Mississippi burns coal from an adjacent surface mine. Relative to the average for TVA's coal plants, its SO_2, NOx, and mercury emissions rates are low and its CO_2 emission rate is high due to the lower fuel energy content. Like the TVA coal plants with scrubbers, Red Hills uses limestone to reduce SO_2 emissions. The plant occupies about 320 acres and fuel cycle disturbs about 275 acres/year, equivalent to 0.09 acre/GWh of energy generated. It uses groundwater in a closed-cycle cooling system with no discharges to receiving water bodies.

Coal - New Facilities

The only new coal plant included in the alternative strategies is an integrated gasification combined cycle (IGCC) plant with carbon capture and sequestration (CCS). The environmental impacts of constructing and operating IGCC plants with CCS have been described for the proposed FutureGen plant in USDOE (2007) and for the Kemper County,Mississippi IGCC Project in USDOE (2010). Relative to conventional coal plants, emissions of air pollutants and CO_2 are very low (Tables 7-1, 7-2). Projected life-cycle emissions for IGCC plants with CCS operating at 90 percent CO_2 capture rate have been estimated to be 0.1841 tons CO_2-eq/GWh (Odeh and Cockerill 2008) and 0.2381 tons CO_2-eq/GWh (Spath and Mann 2004).

Recently proposed commercial scale IGCC plants with CCS have closed-cycle cooling systems with zero liquid discharge. The water use and consumption rate for the Kemper County IGCC plant is 469 gallons/MWh (USDOE 2010) and for the FutureGen IGCC plant is 655 gallons/MWh (USDOE 2007). Instead of fly ash, bottom ash, and scrubber sludge, IGCC plants produce a glassy, inert slag during the gasification process. The slag production rate for the FutureGen plant, using Illinois Basin coal, is 47.3 tons/GWh (USDOE 2007).

Facility surface land requirements for IGCC plants with CCS are approximately 200 acres (DOE 2007). Life-cycle land requirements are not available and would vary with the distance from the generating facility to the carbon sequestration site.

Natural Gas - Existing Facilities

The construction and operational impacts of TVA's existing and committed (i.e., John Sevier CC plant) combustion turbine and combined cycle plants are described in several EISs and environmental assessments (e.g., TVA 2000, TVA 2008a, TVA 2010a). Natural gas-fired plants do not emit SO_2 or mercury, and direct emissions of NOx (usually controlled by steam injection and/or SCR systems) and CO_2 are low relative to other fossil plants. Life-cycle GHG emissions have not been calculated for TVA's gas-fired plants; published rates for such plants average about 509 tons CO_2-eq/GWh (Meier and Kulcinski 2000, Spath and Mann 2000, Jaramillo et al. 2007). Direct CO_2 emissions account for 85 - 90 percent of total GHGs; most of the remaining GHG emissions are from methane and CO_2 emitted during natural gas extraction, processing, and transport. Life-cycle GHG emissions from combustion turbine plants are higher due to the plant's lower efficiency. These life-cycle GHG emissions are based on the use of natural gas extracted in North America and transported by pipelines. Life-cycle GHG emissions would be greater for the use of liquefied natural gas due to the energy requirements and leakage during the additional compression, transportation, and decompression steps. Jaramillo et al. (2007) estimated life-cycle GHG emissions from generating facilities using liquefied natural gas to be about 28 percent greater than those from facilities using domestic natural gas.

Published studies of life-cycle GHG emissions from natural gas production and use are largely based on conventional non-shale onshore and offshore wells. Armendariz (2009) estimated GHG emissions from 2007 natural gas production in the Barnett Shale formation in Texas to be 22,375 tons CO_2-eq/day. Based on actual 2007 production data from RRC (RRC 2011), this equates to 1,317 tons CO_2-eq per billion cubic feet of natural gas. Wood et al. (2011) estimated GHG emissions from shale gas production ranging from 0.14 to 1.63 metric tons CO2-eq/TJ of natural gas. The Marcellus and Barnett shale gas areas were in the lower half of this range.

Combustion turbine plants require no process water. TVA's combined cycle plants use closed-cycle cooling, as do most other combined cycle plants. Facility land requirements for TVA combustion turbine plants that are not co-located with coal plants average 135 acres, about half of which are developed. Combined cycle plant sites average 119 acres, about two-thirds of which are developed.

Natural Gas - New Facilities
The alternative scenarios include two configurations of combustion turbine plants and one combined cycle plant. The environmental characteristics of these plants are similar to the existing natural gas-fueled facilities, except that the emission rates are somewhat lower due to the use of more modern components.

7.3.2. Nuclear Generation

Nuclear - Existing Facilities
The impacts of operating TVA's existing and committed (i.e., Watts Bar Unit 2) nuclear plants are described in previous EISs and other reports (e.g., TVA 2002, 2007c).

Nuclear power generation does not directly emit regulated air pollutants of GHGs. The largest variables in life-cycle GHG emissions of a nuclear plant, aside from the operating lifetime, electrical output, and capacity factor, are the uranium concentration in the ore, the type of uranium enrichment process, and the source of power for enrichment facilities. Current enrichment facilities in the U.S. use the energy-intensive gaseous diffusion process largely powered by fossil fuels. New enrichment facilities currently under construction will use much less energy-intensive processes resulting in reduced nuclear plant life-cycle emissions. The use of nuclear fuel from dismantled nuclear weapons also reduces GHG emissions. The life-cycle GHG emissions of TVA's nuclear plants have not been determined. In a recent survey of nuclear life-cycle studies, Sovacool (2008) reported a range of 1.5 to 317 tons CO_2-eq/GWh, with a mean of 73 tons CO_2-eq/GWh for plants throughout the world. Reported emissions for U.S. plants range from 17 to 61 tons CO_2-eq/GWH, with a mid-point of 39 tons CO_2-eq/GWh (White and Kulcinski 2002, Meier 2002, Fthenakis and Kim 2007, Sovacool 2008). Water use and consumption rates and radioactive waste and spent fuel production rates are listed in Table 7-2.

TVA's nuclear plants occupy an average of 1,114 acres each and about 80 percent of this area is developed. Life-cycle land metrics have not been determined for TVA's nuclear plants. Fthenakis and Kim (2009) estimated a life-cycle land transformation of 0.023 acres/GWh for nuclear power. About half of this transformed land is the power plant site. Due to the current uncertainty over the long-term disposal of spent fuel, the land required for offsite spent fuel disposal is excluded from this estimate.

Nuclear - New Generation
The impacts of constructing and operating a one- or two-unit nuclear plant at the Bellefonte site are described in previous EISs (e.g., TVA 1974, 2008c, 2010c). Because this site contains a partially built, two-unit nuclear plant, the impacts of construction of one or two nuclear units would likely not be significant. Most operational impacts are comparable to those of TVA's existing nuclear plants with the exception of water use and water consumption. Bellefonte would primarily operate with closed cycle cooling and water use is relatively low and water consumption is relatively high compared to TVA's other thermoelectric plants.

7.3.3. Renewable Generation

With the exception of upgrades to TVA's existing hydroelectric facilities, cofiring biomass at existing coal plants, and conversion of existing coal units to dedicated biomass units, increases in renewable generation are expected to be through power purchase agreements with non-TVA generators. Following is an overview of the environmental impacts of renewable generation.

Hydroelectric - Existing Facilities
Impacts of the operation of TVA's hydroelectric facilities are described in the Reservoir Operations Study (TVA 2004). Hydropower generation does not directly emit CO_2 and its life-cycle GHG emissions are among the lowest of the various types of generation. Although not studied for TVA facilities, reported life-cycle GHG emissions from other hydroelectric facilities vary greatly, primarily due to uncertainties over methane emissions from the decomposition of flooded biomass (AEFPERR 2009). These methane emissions are site-specific, and are poorly known for reservoirs in areas with temperate climates such as the TVA region. Excluding these emissions, reported life-cycle emissions include 12.1 tons CO_2/GWh for a temperate zone 10MW run-of-river plant (Hondo 2005), and 28.8 tons CO_2/GWh for the much larger Glen Canyon plant (Spitzley and Keolieian 2004). Emissions from hydro reservoirs are also offset by the multi-purpose use of the reservoirs.

Hydroelectric - New Facilities
Under all the alternatives, TVA would continue to modernize its hydroelectric units, with an eventual capacity increase of up to 89 MW from 38 units. The impacts of these upgrades have been described in environmental assessments for many facilities (e.g., TVA 2005a). While the upgrades generally do not change the volume of water used on a daily cycle, they can increase the rate of water passing through the turbines and result in small, periodic increases in downstream velocities. A potential consequence of this is increased downstream bank erosion, which TVA mitigates as necessary by protecting streambanks with riprap or other techniques. Other environmental impacts of hydro modernization are minimal and there is typically no additional long-term conversion of land.

Potential future hydroelectric generation also includes small and micro-hydro facilities. One type of small hydro generation would be the addition of turbines to existing run-of-river dams, such as old mill dams. If these continue to operate in a run-of-river mode, environmental impacts would be small. Other new small and micro-hydro projects would be run-of-river with little or no reservoirs. One class of these would divert part of the streamflow into a raceway to a downstream generator without totally blocking the stream channel. Potential environmental impacts include alterations of the streambed and streambanks, removal of riparian vegetation, and, for at least a short stretch of the stream, reduction of streamflow (EPRI 2010). Another type of project is in-stream generators mounted on the streambed or suspended from a barge or other structure. These could potentially interfere with boating and other recreational uses of the stream. At this time, their potential impacts on fish and other aquatic life is poorly known, although a few studies have suggested they are not significant. Land requirements vary with the type of facility and for this analysis are assumed to be 0.5 acres/MW.

Wind - Existing Facilities
A relatively small portion of TVA's generation portfolio is wind generation from the Cumberland Mountains of Tennessee and the upper Midwest. TVA is also in the process of acquiring more wind generation from the upper Midwest and Great Plains.

Impacts of windfarm construction include the clearing and grading of access roads and turbine sites and excavation for turbine foundations and electrical connections. Denholm et al. (2009) reported an average direct permanent impact area of 0.74 acres/MW, and a direct average temporary impact area of 1.73 acres/MW. These impact areas average somewhat smaller in mid-western croplands and somewhat larger in Great Plains grasslands/herbaceous areas and forested Appalachian ridges.

The total windfarm area tends to be much larger than the direct impact areas and nationwide averages 84 acres/MW or a capacity density of 1 MW/82 acres (Denholm et al. 2009). This density, while low relative to most other types of electrical generation, varies greatly due to different leasing practices by developers. A very small proportion of this area is directly disturbed and most land use practices can continue on the remainder of the windfarm area.

Other operational impacts include turbine noise, which can be audible for distances of a quarter mile or more, the visual impacts of the turbines which can dominate the skyline, displacement of some wildlife that avoid tall structures, and mortality of birds and bats from collision with turbines or trauma induced by air pressure changes caused by the rotating turbines (BLM 2005, Baerwald et al. 2008). The impacts of bird mortality are probably not significant in most areas, while the impacts of bat mortality are potentially significant at Appalachian windfarms (Arnett et al. 2007). Measures to mitigate bat mortality include locking the turbines in a fixed position during the late summer/early fall period of highest mortality.

Wind turbines produce no direct emissions of air pollutants or GHGs. Martinez et al. (2009) calculated a life-cycle GHG emission rate of 7.25 tons CO_2-eq/GWh for a modern 2-MW turbine operating at a 23 percent capacity factor.

Wind - New Facilities

Most of the wind energy marketed by TVA in the future under the alternative strategies will likely be purchased from windfarms outside the TVA region in the upper Midwest and Great Plains. A portion of new wind capacity, up to 360 MW (about 180 - 240 turbines), may be purchased from windfarms in the TVA region. The impacts of constructing and operating these facilities are the same as those described above. A very small portion of purchased windpower may be from small wind turbines (<100 KW). Aside from the potential visual impact of a 60-100 foot tower, these small turbines have minimal environmental impacts.

Solar - Existing Facilities

TVA operates 15 small PV installations. The environmental impacts of constructing and operating these have been negligible (TVA 2001). TVA also purchases energy generated from numerous PV facilities ranging from 2 KW to 1 MW in size.

PV facilities have the potential to cause visual impacts; this potential is both dependent on the local context and the type of installation. PV facilities produce no direct emissions of air pollutants or GHGs. Life-cycle GHG emissions from PV generation vary from about 28 - 73 tons CO_2-eq/GWh (Fthenakis and Kim 2007, Fthenakis et al. 2008). The major source of this variation is the type of PV technology; thin-film cadmium telluride panels have lower life-cycle emissions than the more common silicon-based panels which require much more energy to manufacture.

Land requirements for PV facilities vary greatly and are dependent on the type of installation. Building-mounted systems require no additional land. Ground-mounted systems may be on canopies that provide shelter and thus, do not negatively impact land use. Land requirements for stand-alone ground-mounted systems vary with the type of mounting system. Fixed systems (with panels that do not move to track the movement of the sum) require less land than those with 1- or 2-axis tracking (Denholm and Margolis 2007). The generation by tracking systems, however, is greater than from fixed systems.

Solar - New Generation

The alternative strategies include the purchase of up to 365 MW of solar capacity through PPAs. The potential impacts of the facilities generating this power vary with the facility size and type of installation.

Biomass - Existing Facilities

TVA generates electricity from biomass by cofiring methane from a sewage treatment plant at Allen Fossil Plant and by cofiring wood waste at Colbert Fossil Plant. The relative amounts of this generation are small and adverse environmental impacts are minimal. A beneficial impact is the avoidance of methane emissions and the small reduction of emissions from the displaced coal generation.

TVA also purchases electricity generated from landfill gas and wood waste. The environmental impacts of this generation are, overall, beneficial due to the avoidance of methane emissions and utilization of residues at wood and grain processing plants.

Biomass - New Generation

The alternative strategies include the purchase of energy from biomass facilities through PPAs cofiring biomass at existing TVA coal units, and converting existing TVA coal units to dedicated biomass operation. The potential environmental impacts vary with the type of facility; all of the facilities have potential beneficial impacts from the avoidance of methane emissions.

Most published studies of life-cycle GHG emissions from electrical generation with biomass fuels, including those cited below, assume that combustion of biomass does not result in the direct emission of CO_2. The combustion of biomass, however, does result in the release of the carbon stored in the biomass. For fast growing, short-rotation biomass fuels such as grasses, the released carbon is soon sequestered by regrowth. For trees, sequestering the released carbon may require many years. The effects of this on life-cycle GHG emissions varies with the characteristics of the generating plant, whether the biomass generation is replacing fossil generation, the type of fossil generation replaced, characteristics of the forest, the post-harvest management of the forest, and other factors (Walker et al. 2010).

The harvesting and transportation of woody biomass (trees) for use a fuel can result in adverse environmental impacts. These impacts are similar to those that can result from harvesting trees for other purposes, such as for wood chips for the manufacture of pulp or other forest products (TVA 1993). Potential impacts include the modification or loss of wildlife habitat, sedimentation, reduction in soil fertility, loss of old growth forest, change in forest type and understory vegetation, altered scenery, and competition with other wood-using industries. The severity of these impacts varies with the use of appropriate best management practices, the proportion or quantity of trees harvested from a stand, whether the harvested stand is a plantation, post-harvest site treatment, and other factors.

<u>Landfill Gas</u> - A small portion of future biomass generation is likely to be from landfill gas. Land requirements for landfill gas facilities are minimal as they are typically constructed on previously disturbed areas at landfills. Although the direct CO_2 emission rate from landfill gas generation is high, the net impact is an overall reduction in life-cycle GHG emissions due to the avoidance of methane emissions and the conversion of heat energy, which otherwise would have been produced by the open flaring of the methane, to electrical energy.

Biomass Cofiring - The alternative strategies include up to 169 MW of capacity and 1,155 GWh/year of generation from cofiring biomass at TVA coal plants. A large portion of this biomass would likely be wood waste. Cofiring requires the construction of a biomass fuel handling system and, depending on the type of plant, boiler modifications (EPRI 2010). The additional facility land requirements are small, typically one to five acres. Whether this requires new site clearing and grading depends on the configuration of the coal plant; for purposes of this impact analysis, TVA has assumed that no additional land will be disturbed. Life-cycle land requirements may increase somewhat over those of the coal plant; this is dependent on the type of biomass and its sourcing areas. Plant process water requirements remain the same or may slightly decrease due to the lower heat value of biomass fuels.

Biomass cofiring reduces emission rates of many air pollutants and may result in a reduction of GHG emissions; the percent reduction increases with the percent of coal replaced by biomass. Mann and Spath (2001) analyzed wood waste cofiring in a pulverized coal plant. At 5 percent cofiring (i.e., 5 percent of the heat input from biomass), emissions of SO_2, NOx, and CO_2 were reduced by 3, 2, and 2 percent, respectively. At 15 percent cofiring, emissions of SO_2, NOx, and CO_2 were reduced by 12, 8, and 6 percent, respectively. Although not described by Mann and Spath (2001), mercury emissions would also decrease due to the very low mercury content of wood waste. Other studies have shown small increases in NOx emissions due to the presence of nitrogen in the biomass (AEFPERR 2009). Life-cycle GHG emissions were reduced from 1,145 tons CO_2-eq/GWh to 1,106 tons CO_2-eq/GWh at 5 percent cofiring and 936 tons CO_2-eq/GWh at 15 percent cofiring (Mann and Spath 2001). These GHG emission rates are based on the assumption that the wood waste would not have otherwise been used in durable products such as building materials. Consequently, the disproportionately large reductions in GHG emissions relative to the percent cofiring are due, in part, to avoided CO_2 and methane emissions from decomposition of the wood waste.

Dedicated Biomass Boiler Conversion - The alternative strategies include 170 MW of capacity and 1,042 GWh/year of generation from coal boilers converted to dedicated biomass boilers. A large portion of this biomass would likely be wood waste. The conversions would require changes to the boilers, changes to or replacement of the boiler coal feed system, and construction of a biomass fuel receiving and processing facility. The land requirements for these vary and are plant-specific. Life-cycle land requirements would increase over those of a coal facility if there are multiple, dispersed fuel sourcing areas. Emission rates would likely be similar to those of a new dedicated biomass facility described below. Water use and consumption rates would be somewhat less than those of the coal unit.

Dedicated Biomass Facility - The alternative strategies include 117 MW of capacity and 912 GWh/year of generation from dedicated biomass facilities acquired through PPAs. The fuels for these facilities could include wood waste, forest residues, and dedicated biomass crops such as switchgrass, hybrid poplar, eastern cottonwood or sweetgum (see Section 4.17.4). Plant capacity is frequently limited due to fuel delivery constraints, and plants larger than 50 MW are uncommon (AEFPERR 2009). The amount of fuel consumed per unit of generation varies with the type of biomass and its moisture content; fuel consumption rates reported at several dedicated facilities range from 4.4 to 5.1 tons/MWh (Wiltsee 2000). Facility land requirements vary; reported values include 17 acres for a 36-MW plant, 31 acres for a 40-MW plant, 39 acres for a 50-MW plant, and 200 acres for a

100-MW plant (Wiltsee 2000, EPRI 2010). This impact analysis assumes 50 acres are required for a 50-MW plant.

While there are no net direct CO^2 emissions, GHGs are emitted during several process steps. For waste woods, as with biomass cofiring described above, the life-cycle GHG emissions may be negative; Spath and Mann (2004) calculated a rate of -452 tons CO_2-eq/GWh for a 60 MW direct-fired boiler using wood waste. For dedicated biomass crops, life-cycle GHG emissions are low but positive. Spitzley and Keoleian (2005) reported rates of 58 tons CO_2-eq/GWh for a 50-MW direct-fired boiler and 44 tons CO_2-eq/GWh for a 75-MW IGCC plant; both of these facilities were fueled with willow energy crops. Dedicated biomass facilities do not emit SO^2 or mercury; NOx emissions vary with the type of facility and NOx emission reduction systems are typically required.

7.3.4. Energy Storage

Existing Facilities

Operational impacts of the Raccoon Mountain facility are summarized in Table 7-1. Denholm and Kulcinski (2004) analyzed life-cycle GHG emissions of pumped storage facilities. The construction, operation (excluding pumping), and decommissioning of the facility produce life-cycle GHG emissions of approximately 5.5 tons of CO_2-eq/GWh of storage capacity, a small proportion of the total life-cycle GHG emissions. GHG emissions from generation are a function of the GHG intensity of the electricity used in the pumping mode. Assuming 78 percent efficiency of energy conversion (slightly lower than the 80 percent efficiency of Raccoon Mountain) and 5 percent transmission loss factor (a function of distance from the energy source and load center), GHG emissions are approximately 1.35 times the energy source emissions. At TVA's 2008 CO_2 intensity of 672 tons/GWh, the operation of Raccoon Mountain and a future pumped storage facility would be 907 tons/GWh. This emission rate will decrease with the decrease in CO_2 intensity occurring under the action alternatives. Although Raccoon Mountain uses a large volume of water, none of this water is consumed.

New Facilities

The operational impacts of the 850-MW combined cycle plant included in Alternative C are expected to be similar to those of the Raccoon Mountain plant. Construction impacts would include the construction of the upper reservoir, excavation of the tunnel connecting the upper and lower reservoirs and of the powerhouse, and construction of the discharge structure in the lower reservoir. If the lower reservoir is an existing reservoir, dredging of the discharge area and construction of an enclosure around the discharge structure would likely be required. If a new lower reservoir is required, additional impacts would result from the construction of the dam and reservoir and diversion of existing streams around or into the reservoirs. These impacts could be substantial.

7.4. Environmental Impacts of Energy Efficiency and Demand Response Programs

The sources of environmental impacts from the proposed expansion of TVA's EEDR programs under the alternative strategies include the following:

- The reduction in or avoidance of generation (collectively "reduction") resulting from energy efficiency measures. This reduction is incorporated into the alternative strategies and portfolios assessed in Section 7.6.
- The change in the type of generation due to changes from on-peak to off-peak energy use resulting from demand-response programs. This change in load shape,

and the resulting change in peak demand, is incorporated into the alternative strategies and portfolios assessed in Section 7.6. Historically, most demand response has been in emergency situations and shifted the time of electrical use with little net change in use and little environmental impact. More widespread employment of demand response is likely to result in a small net reduction in electrical use and the associated impacts from generation (Huber et al. 2011)

- The impacts of the generation of renewable electricity by end users participating in the Generation Partners, biodiesel generation, and non-renewable clean generation programs. The impacts of this generation are included in the discussion Section 7.6.
- The generation of solid waste resulting from building retrofits and the replacement of appliances, heating and air conditioning (HVAC) equipment, and other equipment to reduce energy use.

Building retrofits to reduce energy use, such as replacing windows and doors produce solid wastes which are often disposed of in landfills. The disposition of old appliances, HVAC equipment, water heaters, and other equipment varies across the region with the local availability of recycling facilities. Old refrigerators and HVAC equipment may also contain hydro chloroflourocarbon refrigerants (“freon”) whose use and disposal is regulated due to their harmful effects on stratospheric ozone (“the ozone layer”) and/or because of their high global warming potential. To reduce these harmful effects, HVAC contractors are required to reclaim and recycle these refrigerants from HVAC being replaced.

7.5. Environmental Impacts of Transmission Facility Construction and Operation

As described in Chapter 6, all of the alternatives would require the construction of new or upgraded transmission facilities. Following is a listing of generic impacts of these construction activities (Table 7-3). This listing was compiled by reviewing the EISs (e.g., TVA 2005b), environmental assessments (e.g., TVA 2010b), and other project planning documents for TVA transmission construction activities completed since 2005.

The construction activities include construction of new transmission lines, substations and switching stations; upgrades to existing transmission lines; and expansions of existing substations and switching stations.

The anticipated amount of construction of new or upgraded transmission facilities varies among the alternative strategies. All new generating facilities would require connections to the transmission system; the length of connecting transmission lines and the need for new substations and switching stations depend on the location of the facilities. Strategies C and E, with their higher amounts of coal capacity idled, would require more transmission system work to ensure system reliability is not affected by the loss of generation in parts of the TVA region. This need could be somewhat offset if new generating facilities are sited at or close to the locations of plants being laid up. Strategies C and E could also likely require more transmission system work to transmit renewable energy generated outside the TVA region. Under these scenarios TVA could participate in inter-regional project to transmit renewable energy.

Table 7-3. Generic impacts of transmission system construction activities.

	Transmission Lines	Substations and Switching Stations
Land Use Impacts		
Land requirements	Average of 12.1 acres/line mile, range 5.2 - 22.7	Average of 14.3 acres, range 1.8 - 53
Floodplain fill	0	Average of 0.02 acres, range 0 - 0.29
Prime farmland converted	0	Average of 5.1 acres, range 0 - 29.1
Land Cover Impacts		
Forest cleared	Average of 6.0 acres/line mile for new lines, range 0.4 - 11.9	Average of 0.68 acres, range 0 - 2.7
Wetland Impacts		
Area affected	Average of 0.76 acres/line mile, range 0 - 1.6	-
Forested area cleared	Average of 0.24 acres/line mile of new line, range 0 - 1.1	-
Stream Impacts		
Stream crossings	Average of 2.1 per mile of new line, range 0 - 7.1 Average of 2.3 per mile of existing line, range 0 - 17.9	n/a
Forested stream crossings	Average of 1.0 per mile of new line, range 0 - 1.8	n/a
Endangered and Threatened Species	11 of 57 projects affected federally listed endangered or threatened species, or species proposed or candidates for listing 23 of 57 projects affected state-listed endangered, threatened, or special concern species	
Historic Properties	11 of 57 projects affected historic properties	

.

7.6. Environmental Impacts of Alternative Resource Strategies and Portfolios

While the total amount of energy generated during the 2010-2029 planning period is, by design, similar across strategies for each scenario, the manner in which this energy is generated varies greatly across strategies (Figure 7-1). This is a result of the varying amounts of coal capacity idled, EEDR reductions, renewable additions, constraints on adding nuclear plants, and other factors described in Sections 2.4 and 6.2. The Strategy E portfolios consequently have smaller amounts of coal-fueled generation, larger amounts of wind and solid biomass-fueled generation, and larger amounts of energy demand met by EEDR programs. Renewable generation from sources other than solid biomass (hydroelectric modernization, new hydrogeneration, landfill gas, and solar) is not shown in Figure 7-1 due to their relatively small quantities ranging from 7,228 GWh in Strategy B to 15,704 GWh in Strategy E.

Alternative Strategies:
- B - Baseline Plan (No Action)
- C - Diversity Focused
- E - EEDR and Renewables Focused
- R - Recommended Planning Strategic Direction

Scenarios:
- 1 - Economy Recovers Dramatically
- 2 - Environmental Focus is a National Priority
- 3 - Prolonged Economic Malaise
- 7 - Reference Case: Spring 2010
- 8 - Reference Case: Great Recession Impacts Recovery

Following is a discussion of the impacts of each alternative strategy on air quality, greenhouse gas emissions and climate change, water withdrawals and water use, and land requirements.

7.6.1. Air Quality

All three alternative strategies will result in significant long-term reductions in total emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), and mercury. The trends in emissions of these three air pollutants (Figures 7-2, 7-3, and 7-4) are similar with decreases of about 60 percent between 2010 and 2015. Factors contributing to these decreases include the continued installation of emission controls necessary to comply with the Clean Air Act, including the anticipated requirements for use of maximum achievable control technology to reduce emissions of hazardous air pollutants, and reduced coal-fired generation due to the coal capacity idled and the increase in nuclear and natural gas generation. The decreases in emissions are greatest under Strategy E and least under Strategy B. Under all of these alternative strategies, there will likely be a substantial beneficial cumulative impact on regional air quality.

The reductions in SO_2, NOx, and mercury emissions will continue recent trends in emissions of these air pollutants. By 2020, TVA emissions of SO_2 will have decreased about 97 percent. This is expected to result in further decreases in regional concentrations of SO_2 and sulfate (a component of acid deposition), regional haze, and fine particulates. TVA emissions of NOx will have decreased about 95 percent since 1996. Although this continued reduction will likely result in reductions in regional NOx and ozone concentrations, the effect may be small as TVA emissions make up a relatively small proportion (11 percent) of regional NOx emissions (Figure 4-12).

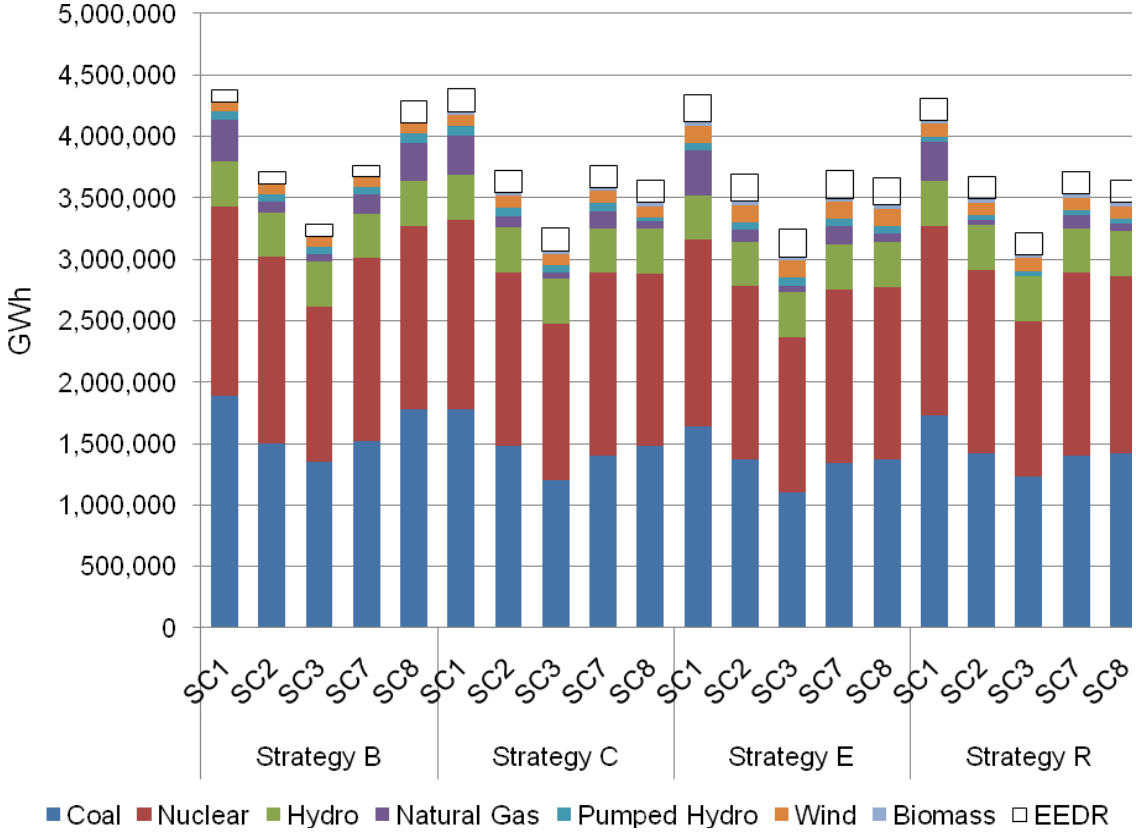


Figure 7-1. Generation (and avoided generation) by source, strategy, and scenario for the 20-year planning period. Generation by other renewable sources (hydroelectric modernization, new hydrogeneration, landfill gas, solar) is not shown because of the small quantities.

7.6.2. Greenhouse Gas Emissions and Climate Change

Total direct CO_2 emissions under the alternative strategies are highest under Strategy B and lowest under Strategy E. Compared to TVA's recent annual average direct CO_2 emissions of around 100 million tons, all of the strategies result in a decrease in CO_2 emissions (Figure 7-5). For most scenarios other than Scenario 1, and especially under strategies C, E, and R, the decrease is marked and significant. The lowest average reductions for the alternative strategies are 15.6 percent from both 2010-2020 and 2010-2028 for Strategy B (Table 7-4). The greatest reductions are 25.1 percent from 2010-2020 for Strategy R and 27.8 percent from 2010 - 2028 for Strategy E. Some strategy/scenario combinations show an increase in CO_2 emissions late in the planning period due to increased natural gas-fueled generation. The strategy/scenario combinations with the largest reductions in CO_2 emissions would approach proposed long-term GHG emissions reduction targets such as the 40 percent reduction from 2005 levels by 2030 in the recent American Clean Energy and Security Act (H.R. 2454).

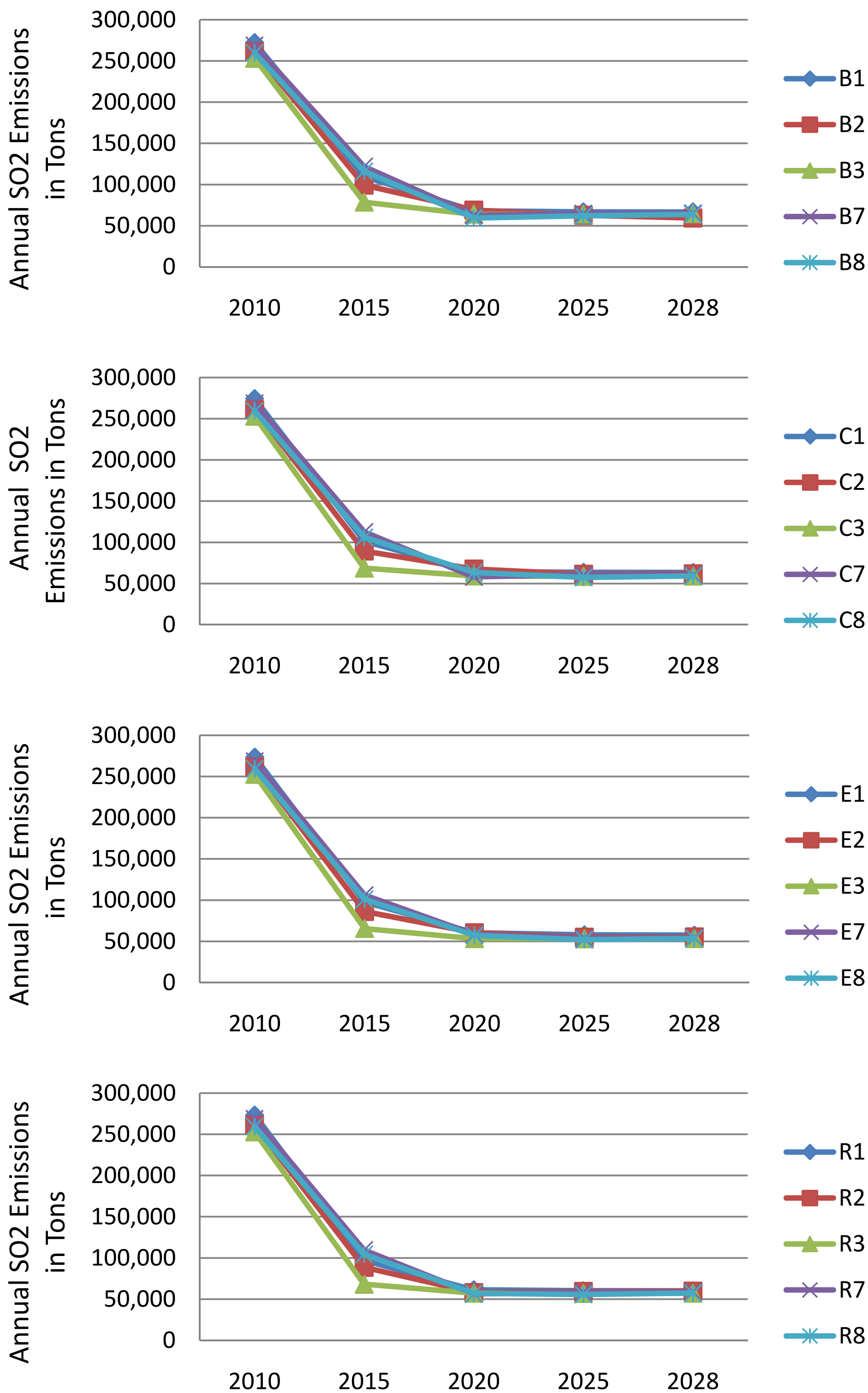


Figure 7-2. Trends in SO_2 emissions by scenario for (top to bottom) Strategies B, C, E, and R.

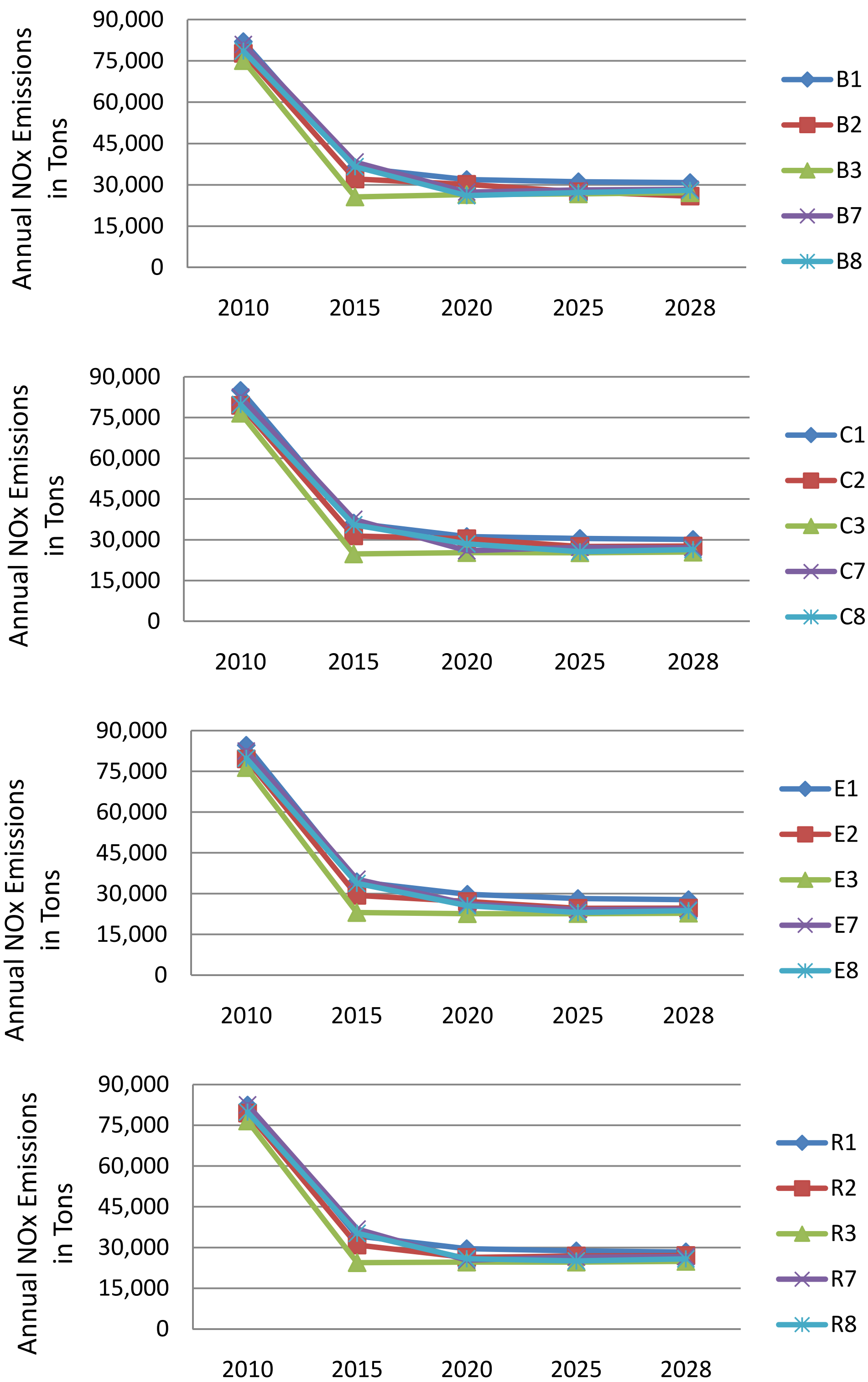


Figure 7-3. Trends in NOx emissions by scenario for (top to bottom) Strategies B, C, E, and R.

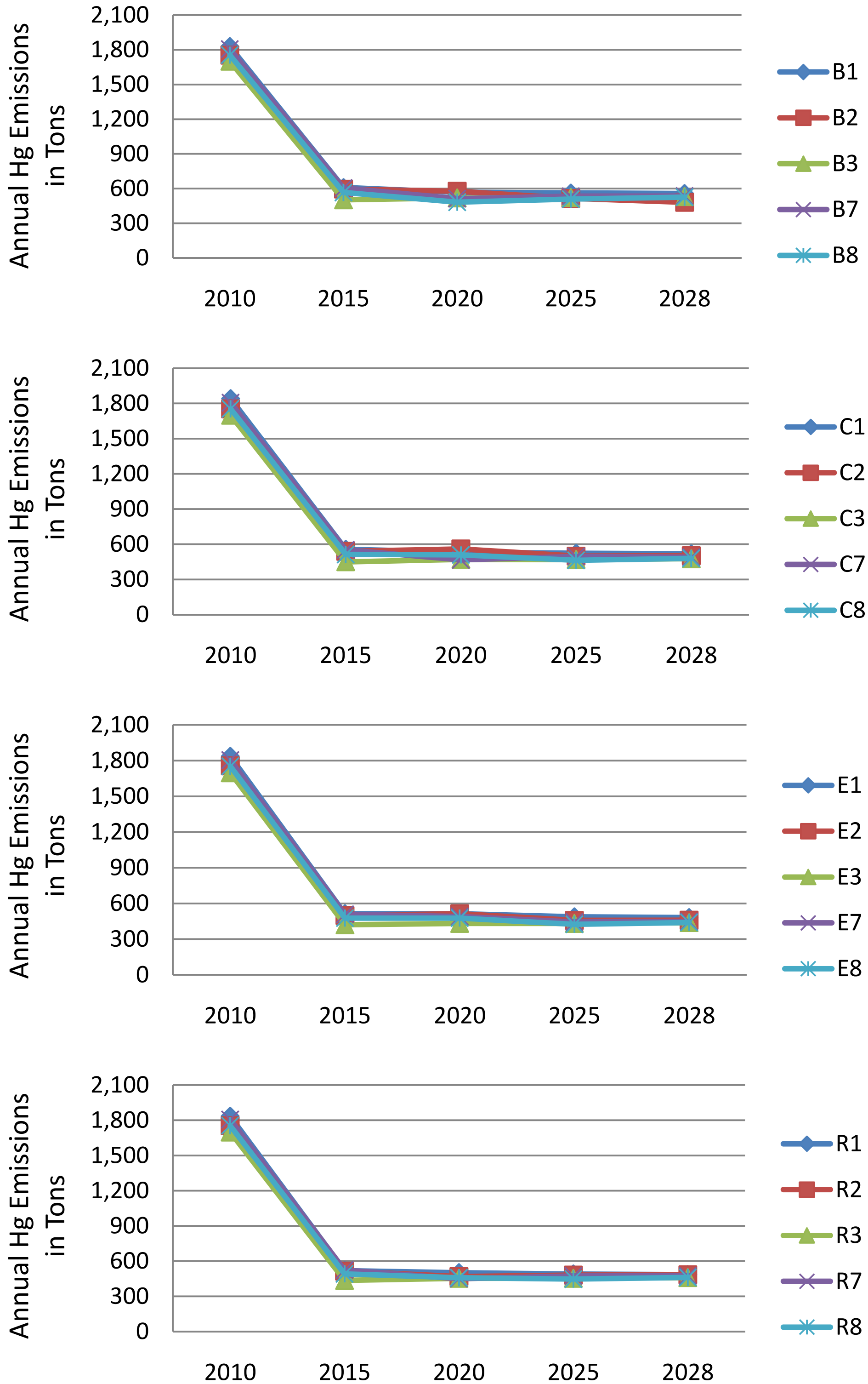


Figure 7-4. Trends in mercury (Hg) emissions by scenario for (top to bottom) Strategies B, C, E, and R.

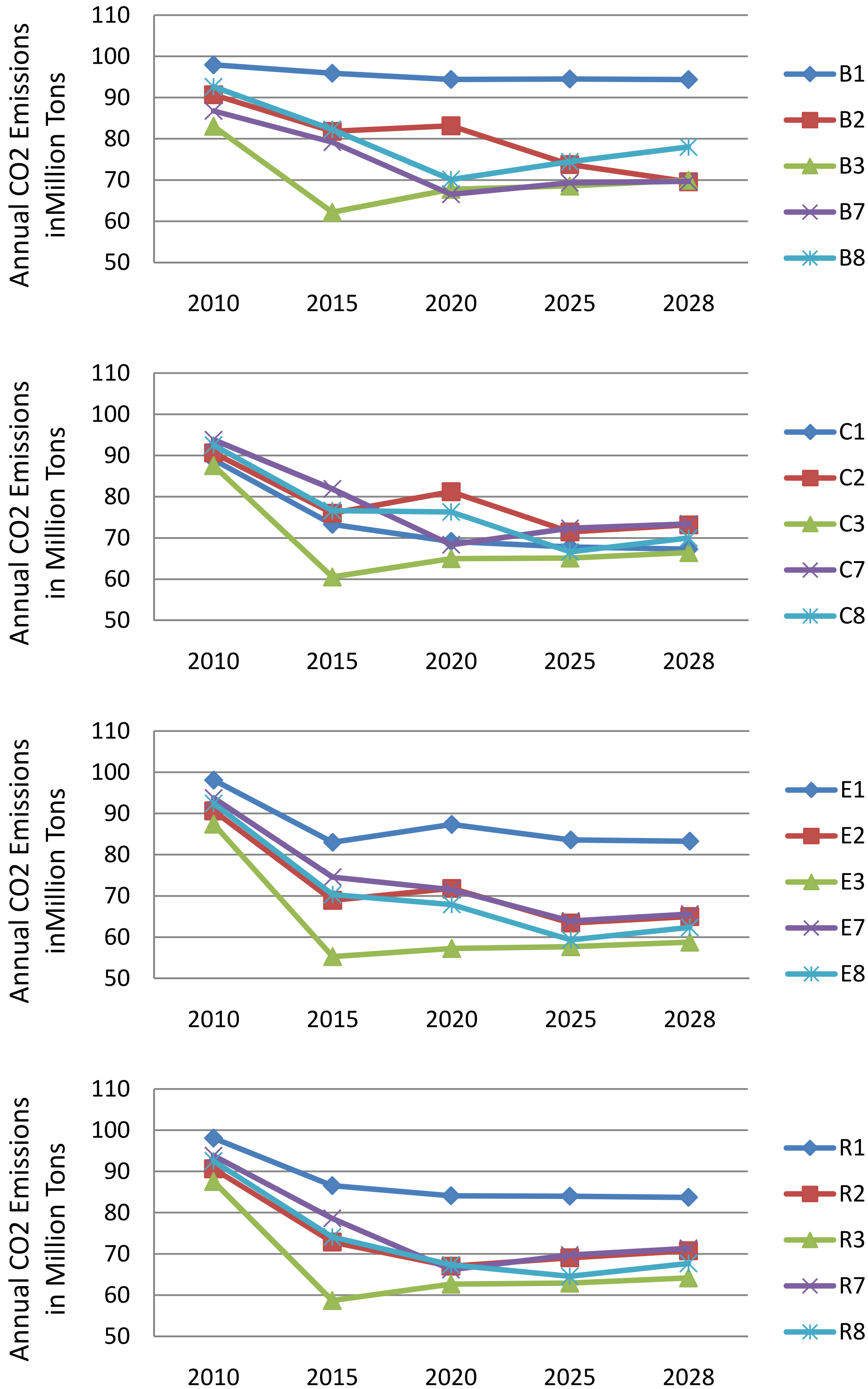


Figure 7-5. 2010-2028 trends in direct CO_2 emissions for (top to bottom) Strategies B, C, E, and R.

Table 7-4. Average percent reductions in CO_2 emissions by strategy.

	Strategy			
Years	B	C	E	R
2010 - 2020	15.6	20.6	23.3	25.1
2010 - 2028	15.6	22.8	27.8	22.8

TVA's 2005 CO_2 emissions were about 105 million tons. The CO_2 emissions rate of TVA's power generation, also known as the CO_2 intensity and expressed in terms of tons/GWh, averaged around 700 tons/GWh in recent years (Figure 4-7). It significantly decreases under the all of the alternative strategies (Figure 7-6, Table 7-5). This reduction is largely attributable to the fact that most new base-load generation will be from nuclear power, which does not have direct CO_2 emissions.

Table 7-5. Average percent reductions in CO_2 intensity by strategy.

	Strategy			
Years	B	C	E	R
2010 - 2020	25.2	28.0	27.5	31.3
2010 - 2028	29.0	33.7	36.4	30.9

For both total direct CO_2 emissions and CO_2 intensity, the reductions are greatest under Strategy E and least under Strategy B. over the planning period (Figure 7-6) are proportionately somewhat larger than the declines in direct CO_2 emissions.

The EPRI and TVA (2009) report summarizes temperature and precipitation forecasts for the TVA region based on General Circulation Model results presented in the 2007 IPCC report (Christensen et al. 2007). These forecasts are based on the A1B scenario; GHG projections associated with this scenario are in the middle of the range of the scenarios analyzed by the IPCC. The TVA region spans two model regions, the Central and Eastern North America region. Temperature forecasts for the TVA region are similar for the two model regions and predict an increase in annual mean temperatures in the TVA region of about 0.8°C (1.4°F) from 1990 to 2020 and up to 4.0°C (7.2°F) by 2100. Precipitation forecasts for the two model regions are more variable. In the central region, winter precipitation is forecast to increase by 2.6 percent from 1990 to 2020 and by 3.6 percent by 2100. Central region summer precipitation is forecast to decrease by 6.1 percent from 1990 to 2020 and by 3 percent by 2100. In the eastern region, winter precipitation is forecast to increase by 11.3 percent from 1990 to 2020 and by 13 percent by 2100. No change in eastern region summer precipitation is forecast from 1990 to 2020 or by 2100. It is important to note that these forecasts are based on coarse-scale model results; more localized downscaled analyses are required to refine the forecasts (USCCSP 2008).

The effects of the forecast climate change in the TVA region are likely to be relatively modest over the next decade and increase in magnitude by mid-century (EPRI and TVA 2009). Potential effects on water resources include increased water temperatures, increased stratification of reservoirs, reduced dissolved oxygen levels, and increased water demand for crop irrigation. Potential effects on agriculture include increased plant evapotranspiration, altered pest and pathogen regimes, changes in the types of crops grown, and increased demand for electricity by confined livestock and poultry operations.

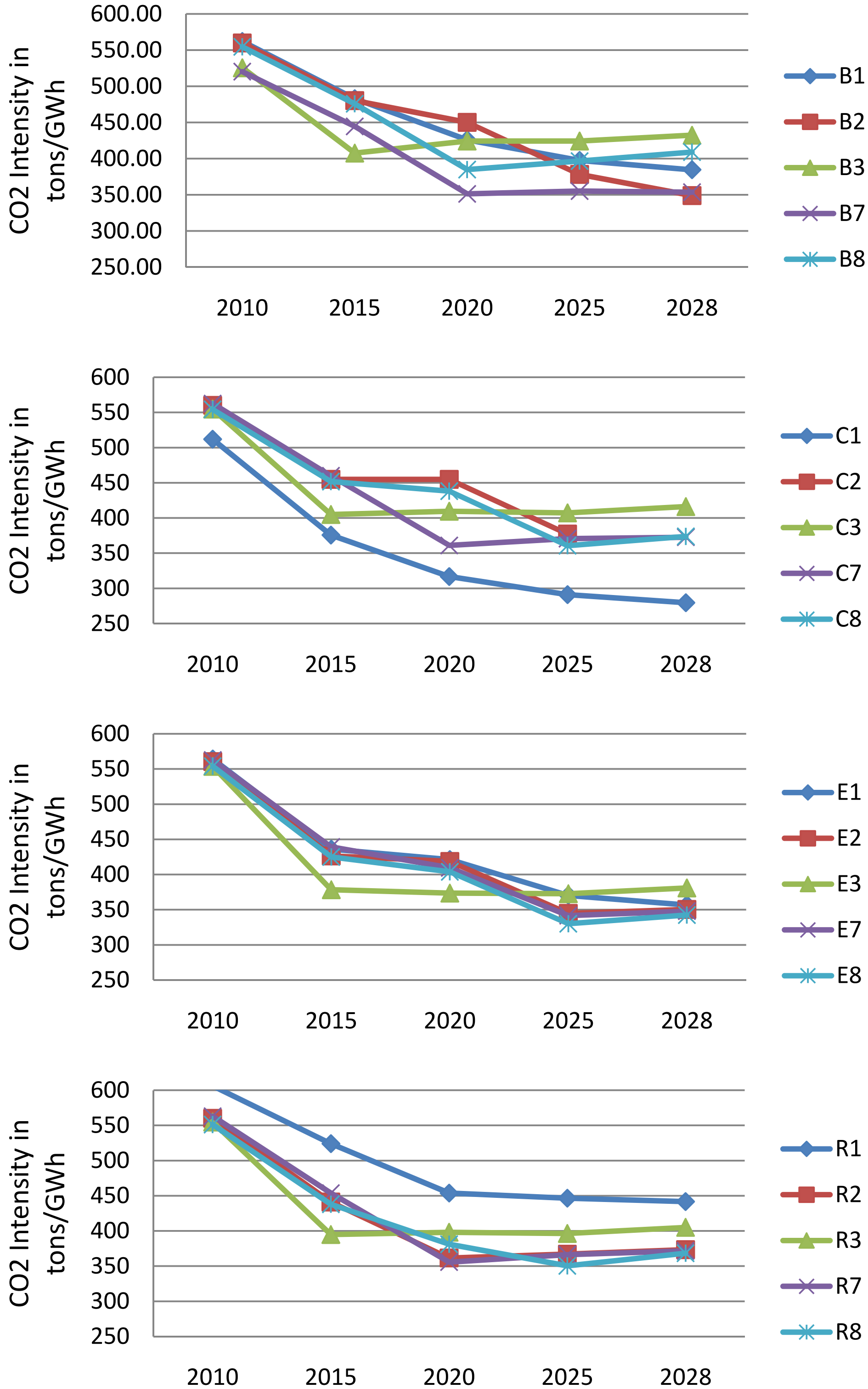


Figure 7-6. 2010-2028 trends in direct CO_2 emissions for (top to bottom) Strategies B, C, E, and R.

Potential effects on forest resources include increased tree growth, altered disturbance regimes, changes in forest community composition with declines in species currently at the southern limit of their ranges, and expansion of the oak-hickory and oak-pine forest types. Potential effects on fish and wildlife include range retractions and expansions, altered community composition, loss of cool to cold aquatic habitats and associated species such as brook trout, and increased threats to many endangered and threatened species.

The modeled higher air temperatures, the associated higher water temperatures, and the altered precipitation patterns that could result from climate change likely would affect the operation of TVA generating facilities. One likely effect is an increase in the demand for electricity. Warmer summer temperatures would result in more electricity used for air conditioning; this increase would likely be greater than the reduction in electricity used for space heating resulting from warmer winter temperatures. Most of TVA's thermal (fossil and nuclear) plants use open-cycle cooling and discharge heated water to the river system. NPDES permits, required for the discharge of cooling water into rivers and reservoirs, prescribe the maximum temperature of discharged water. The NRC also sets safety limits at nuclear plants on the maximum temperature of intake water used in essential auxiliary and emergency cooling systems. When cooling water intake temperatures are high, power plants must reduce power production (derate) or use cooling towers (if available) to reduce the temperature of the discharged water and avoid non-compliance with thermal limits. If nuclear safety intake temperatures reach their limits, NRC requires the plants to shut down. Consequently, elevated water temperatures can reduce thermal generation by causing forced deratings, additional use of cooling towers (which reduces net generation), and/or nuclear plant shutdown.

Increased air and water temperatures also influence the operation of thermal power plants with cooling towers. Increased condenser cooling water temperatures reduce the efficiency of power generation. Hotter, more humid air also reduces evaporation potential and the performance of cooling towers. A 1993 TVA study (Miller et al. 1993) analyzed the relationships between extreme air and water temperatures and power plant operations based on historical meteorological and operational data.

In the upper Tennessee River drainage, for each 1°F increase in air temperature (April through October), water temperatures increased by 0.25°F to almost 0.5°F, depending upon year and location in the TVA reservoir system. In general, air temperature effects cascaded down the reservoir system. In the Tennessee River system, for both closed- and open-cycle plants in Tennessee (on or above Chickamauga Reservoir) and in Alabama (on Wheeler Reservoir below both Chickamauga and Guntersville reservoirs), this study found that the incremental impact to operations from increased temperature were greatest during hot-dry years. Operation of most thermal power plants in the TVA power system was resilient to temperature increases during cold-wet and average meteorological years. The dominant meteorological variables affecting thermal plant performance were water temperature, and, for plants using cooling towers, humidity.

Changes in the operation of the Tennessee River system implemented in the ROS (TVA 2004) provide TVA flexibility to adapt to some climate change impacts while minimizing the effects on thermal generation. The analyses in the ROS were based on historical conditions and assume that unusually high air temperatures last a relatively short time.

Further adaptation, such as the installation of increased cooling capacity at thermal plants, may be necessary in the future given the forecast long-term increases in temperature.

7.6.3. Water Resources

Coal-fired generation would decrease and most new generating capacity would be nuclear and natural gas-fired under all of the alternative strategies. Potential impacts to water quality, with the exception of thermal discharges, are generally greater from coal-fired generation than from other types of generation due to the various liquid waste streams from coal-fired plants and the potentially adverse water quality impacts from coal mining and processing. The overall potential for water quality impacts would decrease under all alternative scenarios and this decrease would be greatest under Strategy E. Under all alternative strategies, TVA would continue to meet water quality standards through compliance with NPDES permit requirements.

All of the alternative strategies result in an increase in the volume of water used and consumed for cooling coal, natural gas, and nuclear generating facilities. As described in Section 4.7, TVA's coal and nuclear generating facilities primarily use open-cycle cooling systems. These systems withdraw large volumes of water from an adjacent reservoir or river, circulate it through condensers, and return the warmer water to the water body. Very little of the water is evaporated in the process and consequently these facilities use large volumes of water and consume a very small proportion of the water used. With closed-cycle cooling systems, water is circulated through a cooling tower where much of it evaporates; closed-cycle systems use much less water than open-cycle systems and consume a much greater proportion of the water. All of TVA's coal and nuclear plants, with the exception of Watts Bar, operate exclusively or primarily in open-cycle mode. Watts Bar Nuclear Plant Unit 1 uses a combination of open-cycle and closed-cycle cooling and thus has lower water use and higher water consumption rates than TVA's other large generating plants. TVA's combined-cycle natural gas plants, as well as the coal and combined-cycle plants from which TVA purchases power, use closed-cycle cooling. With the exception of Watts Bar Nuclear Plant Unit 2, which will operate similarly to Unit 1, all of TVA's future thermal generating plants are anticipated to use closed-cycle cooling.

Figure 7-7 shows projected trends in water use for the alternative strategies and scenarios. The major differences among the strategies and scenarios are due to the number of new nuclear units constructed during the planning period. Water use increases for all strategies between 2010 and 2015 due primarily to the completion and operation of Watts Bar Unit 2. Beyond 2015, most Strategy B and C portfolios use more water use than do most Strategy E portfolios. The overall differences, however, are relatively small and the largest increases during the planning period are 5.3 percent.

The trends in water consumption for the alternative strategies and scenarios (Figure 7-8) are similar to those for water use. The proportional increase in consumption, however, is much greater (up to a maximum of 560 percent) due to the increased proportion of energy that will be generated by thermal plants with closed-cycle cooling.

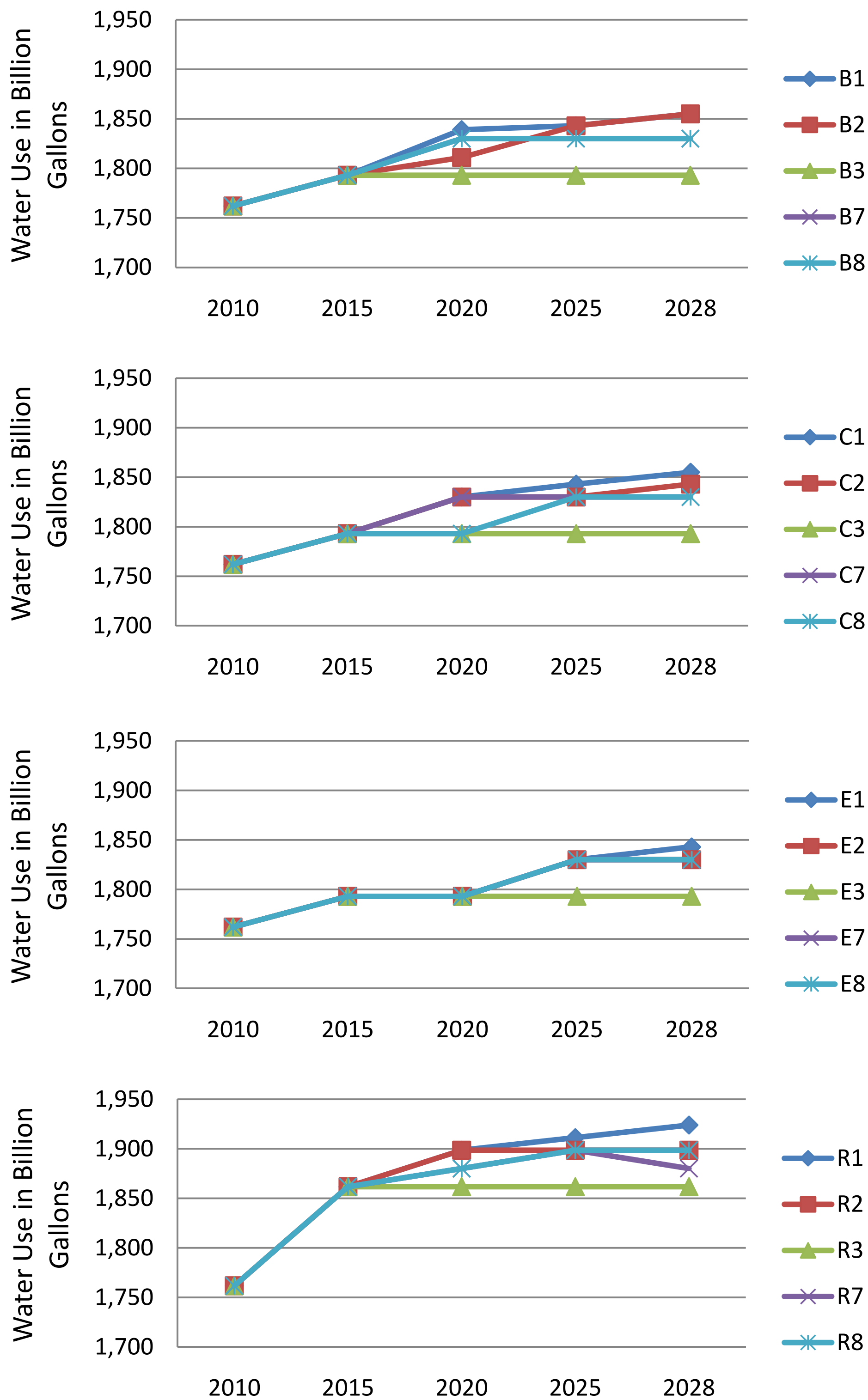


Figure 7-7. Trends in water use by coal, nuclear, and natural gas generating facilities by scenario for (top to bottom) Strategies B, C, E, and R.

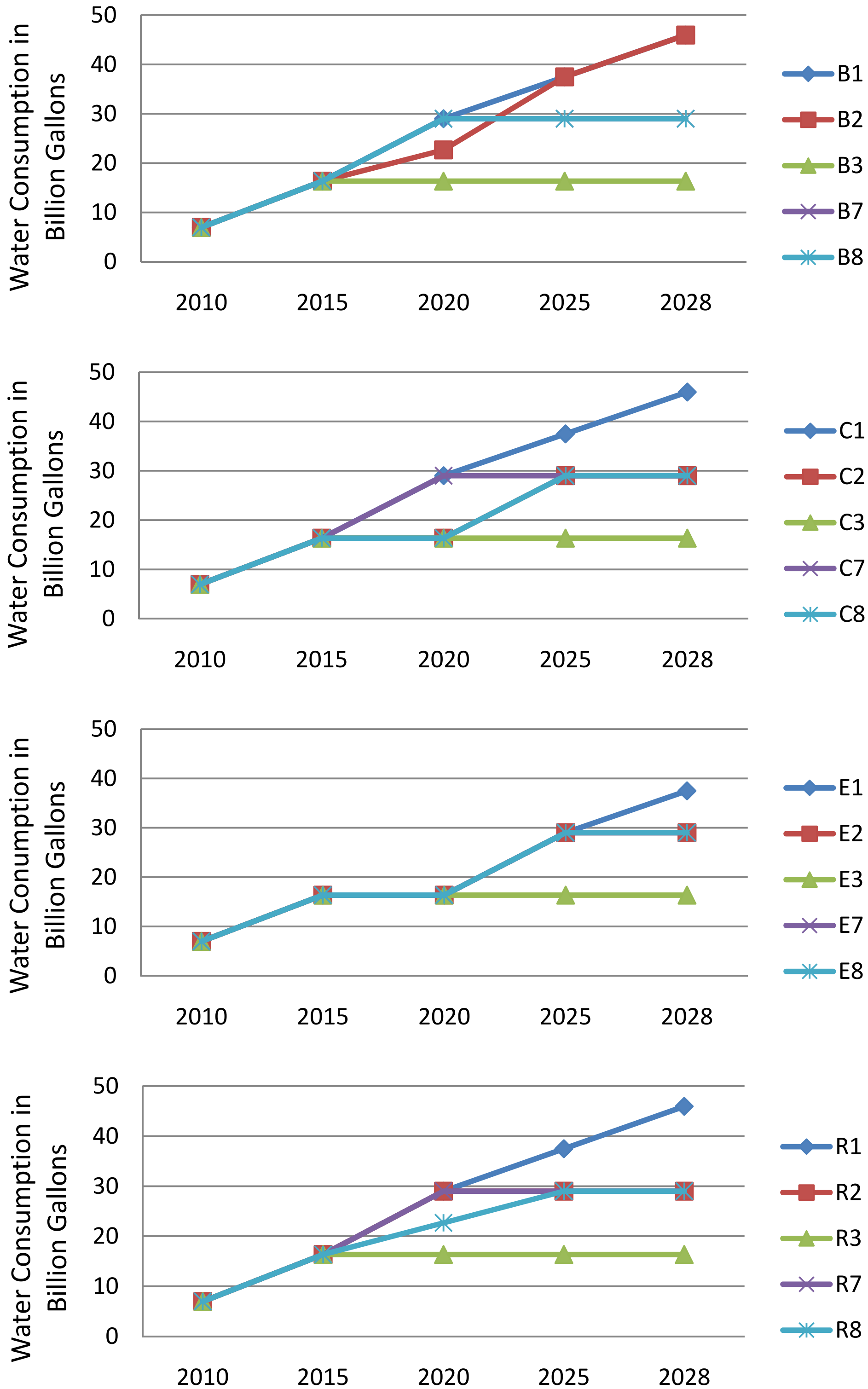


Figure 7-8. Trends in water consumption by coal, nuclear, and natural gas generating facilities by scenario for (top to bottom) Strategies B, C, E, and R.

The new nuclear units proposed in several of the strategies would consume water withdrawn from the TVA reservoir system, but would represent a very small proportion of the total water flow. The other potential combined-cycle and IGCC would likely be sited at locations across the TVA region and could consume groundwater, water withdrawn from a reservoir or river, or other source such as reclaimed wastewater. TVA would carefully assess the potential impacts of water use and water consumption during the planning process for any new generating facility.

7.6.4. Fuel Consumption

The major fuels used for generating electricity would continue to be coal, enriched uranium, and natural gas in all of the alternative strategies. The proportion of generation from coal, as well as the quantity of coal consumed (Figure 7-9), declines in the future as coal units are laid up and, except for an IGCC plant proposed under one Strategy B and one Strategy C scenario, no additional coal plants are built. The decreases in coal consumption are about 23 percent under Strategy B, 22 percent under Strategy C, and 31 percent under Strategy E. Although the future sources of coal purchased by TVA cannot be accurately predicted, the anticipated decrease in coal consumption could reduce the adverse impacts associated with coal mining, particularly with surface mining in Appalachia (EPA 2005, Palmer et al. 2010). These impacts include the loss of forests and wildlife habitat and the alteration of streams on and downstream of the mine area.

The consumption of enriched uranium increases with the startup of Watts Bar Nuclear Plant Unit 2 in 2013 under all of the alternative strategies and continues to increase as up to four additional nuclear units are added under scenarios 1, 2, and 7 (Figure 7-10). Potential impacts from producing the nuclear fuel include land disturbance, air emissions (including the release of radioactive materials), and discharge of water pollutants from uranium mining, processing, tailings disposal, and fuel fabrication. The magnitude of these impacts is difficult to predict with certainty due to the great variability in potential sources for nuclear fuel. The environmental impacts of uranium enrichment are expected to greatly decrease in the future as more energy-efficient enrichments are used in the U.S. The future use of surplus DOE highly enriched uranium would also reduce overall uranium fuel cycle impacts as this reduces the need for uranium mining and enrichment.

Natural gas consumption increases under all of the alternative strategies (Figure 7-11). Under all strategies, it remains fairly constant for Scenario 3 and increases by about 50 percent for Scenarios 2 and 3. The increase in gas consumption ranges for Scenario 1, which has the highest electrical demand, ranges from about 270 percent under Strategy B to 350 percent under Strategy E. When averaged across the five strategies, the percent increase in overall natural gas consumption is greatest under Strategy B at 87 percent and least under Strategy C at 55 percent. The increase under Strategy R is 72 percent. Much of the increase is due to increased intermediate generation and will likely displace some coal-fired generation. Overall impacts of the natural gas fuel cycle are less than those of the coal fuel cycle.

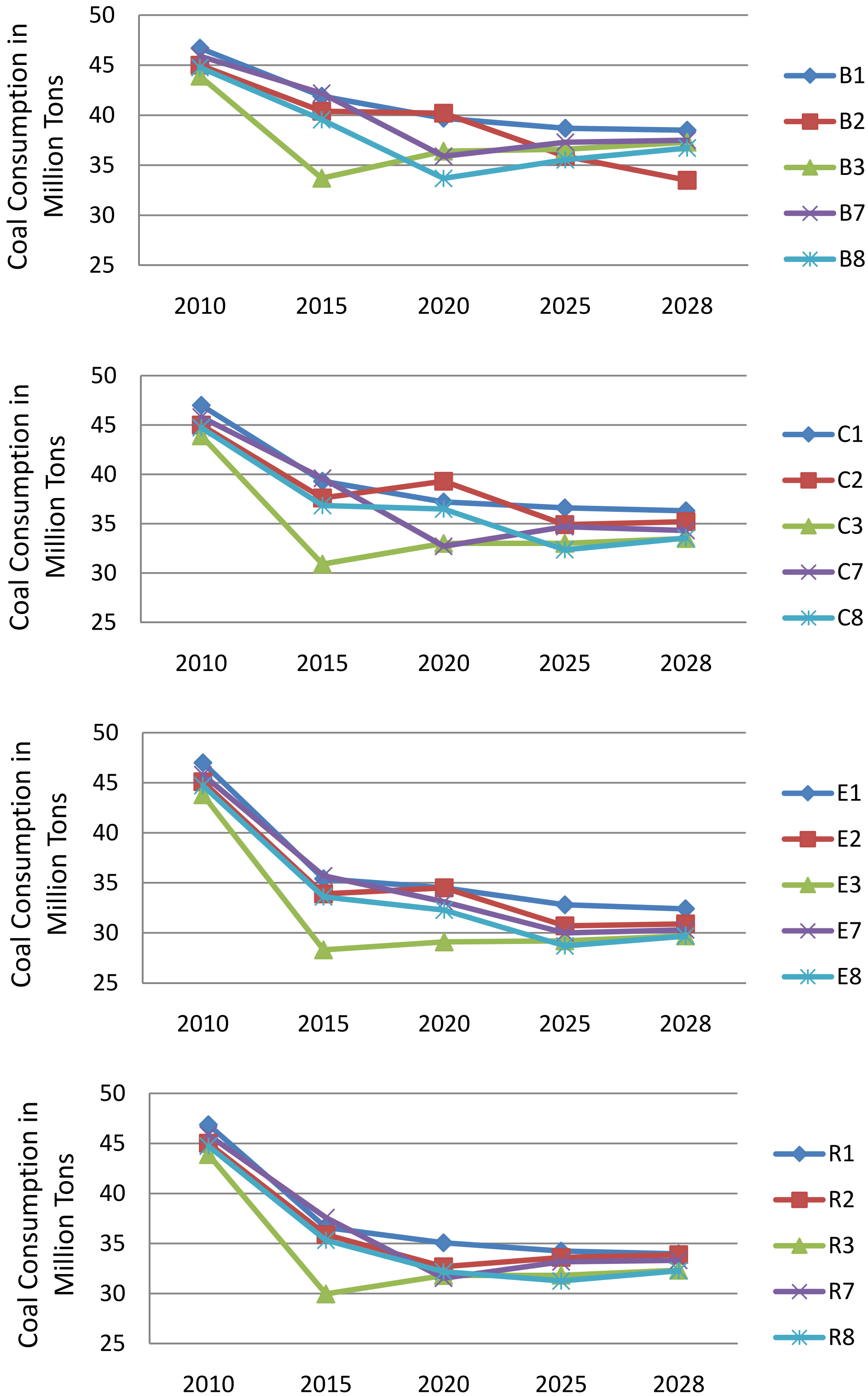


Figure 7-9. Trends in coal consumption by scenario for (top to bottom) Strategies B, C, E, and R.

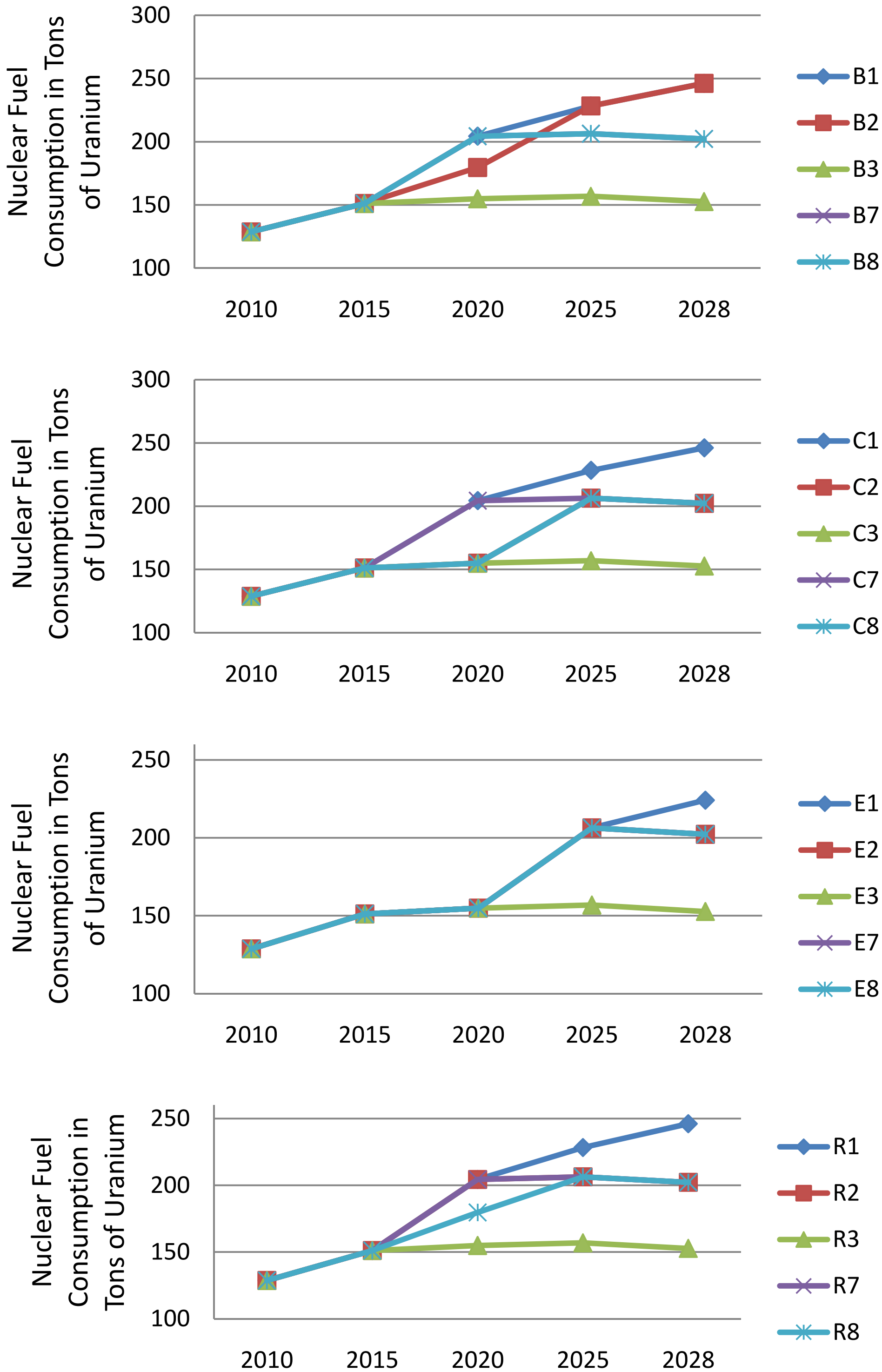


Figure 7-10. Trends in nuclear fuel consumption by scenario for (top to bottom) Strategies B, C, E, and R.

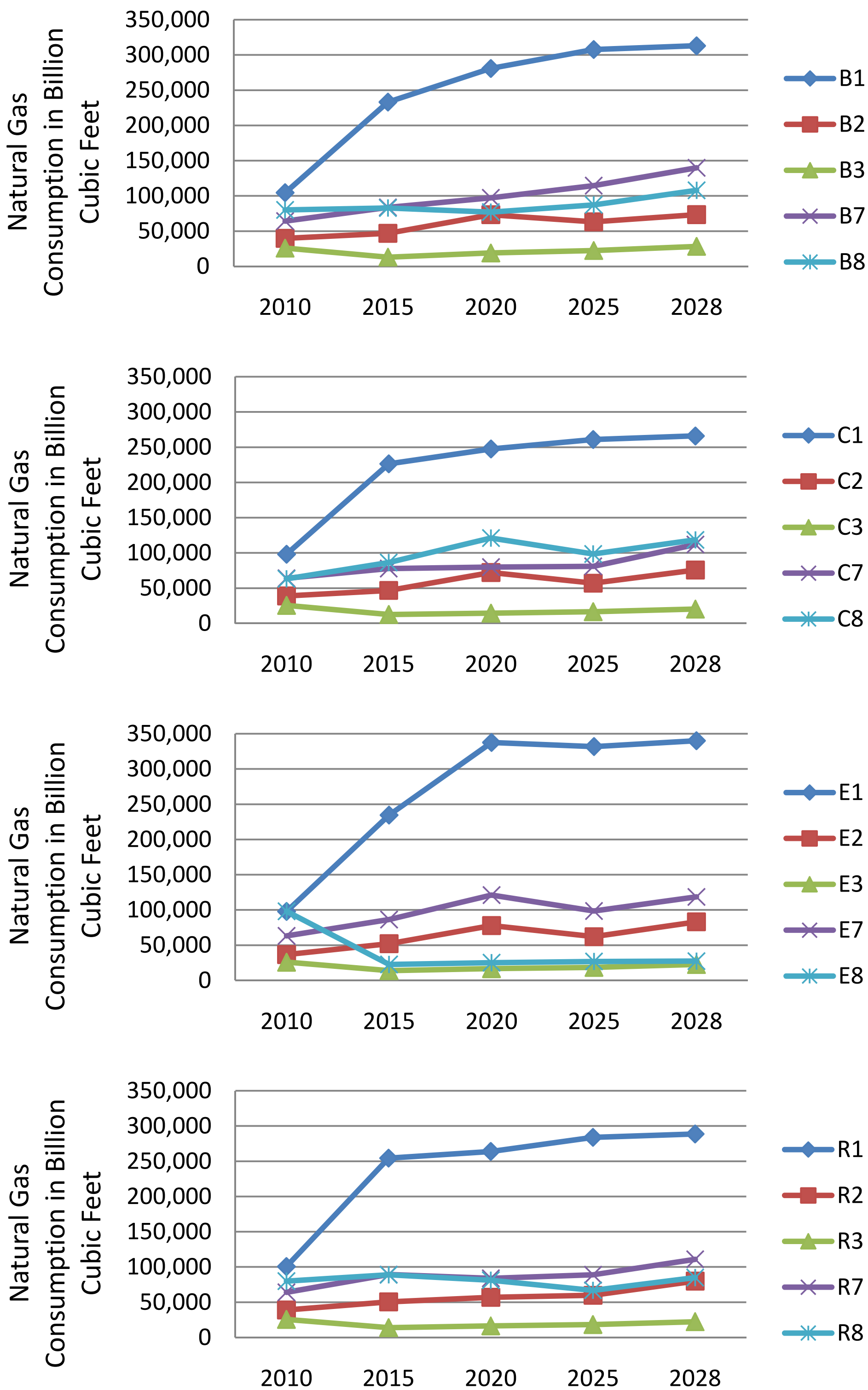


Figure 7-11. Trends in natural gas consumption by scenario for (top to bottom) Strategies B, C, E, and R. The volume is based on the heat content of 1,025 Btu/cubic foot of natural gas used by the electric power sector in 2009 (USEIA 2010b).

Based on recent trends in natural gas production, an increasing amount of natural gas is expected to be extracted from shale formations, including the Barnett Shale in Texas, the Antrim Shale in Michigan, and the Marcellus Shale in central and northern Appalachia. Producing this gas requires hydraulic fracturing, the process of injecting pressurized fluids (predominantly water with gels and chemical additives) and sand into the well borehole to fracture the gas-bearing rock formation and increase its permeability. Concerns have been expressed about the potential impacts of this "fracking" on water supplies and other environmental resources (Soeder and Kappel 2009, Kargbo et al. 2010, Zoback et al. 2010). These impacts include gas migration, groundwater, surface water, and soil contamination, the large volume of water required, seismic risks, and drillpad, road, and pipeline construction. Concerns have also been expressed over the emission of greenhouse gases from shale gas production. The magnitude of these several of these impacts, however, is poorly known and presently being investigated by EPA and others.

The consumption of biomass fuels increases under all alternative strategies and is greatest under Strategy E, which has the most biomass-fueled generation (Figure 7-1). Accurately forecasting this increase in the quantity of biomass fuels is difficult without knowing the types of biomass fuels and the types of new dedicated biomass generating facilities. For example, a dedicated stoker boiler biomass plant consumes more fuel per MWh of generation than does a biomass IGCC plant (EPRI 2010). The quantity of fuel consumed also varies with the type and the moisture content of the biomass fuel.

7.6.5. Solid Waste

Coal Combustion Solid Wastes

All three alternative strategies will result in long-term reductions in the production of ash (including related materials such as slag) from coal combustion (Figure 7-12). These reductions range from an average of about 19 percent for the Strategy B scenarios to about 42 percent for the Strategy E scenarios. These reductions are a result of the idling of coal units. The small increases in ash generation late in the planning period under some Strategies B, C, and R scenarios are due to the addition of IGCC plants . When ranked by strategy, the amount of coal ash produced would be greatest under Strategy B, followed by Strategies, C, R, and E.

In recent years, TVA has marketed between 40 and 50 percent of the annual production of ash for beneficial reuse. The remaining ash is stored in landfills and impoundments at or near coal plants. TVA is in the process of converting the wet ash collection/storage systems at six coal plants to dry storage and disposal facilities in order to reduce the potential environmental risk. TVA is also committed to increase the beneficial reuse of ash. Even with an increase in beneficial reuse, TVA will likely need additional storage areas for ash produced at many of its plants.

Unlike ash, the production of scrubber waste (synthetic gypsum) increases under all alternative strategies (Figure 7-13). Under all of the alternative strategies, the TVA coal plants with scrubbers are anticipated to continue to operate throughout the planning period, and scrubbers are anticipated to be installed on the unscrubbed coal plants that continue to operate after about 2015. Thus the increase is greatest for Strategy B which, with the fewest coal units idled, continues to rely more on coal-fired generation than do the other strategies. When ranked by strategy, the amount of scrubber waste would be greatest under Strategy B, followed by Strategies C, R, and E.

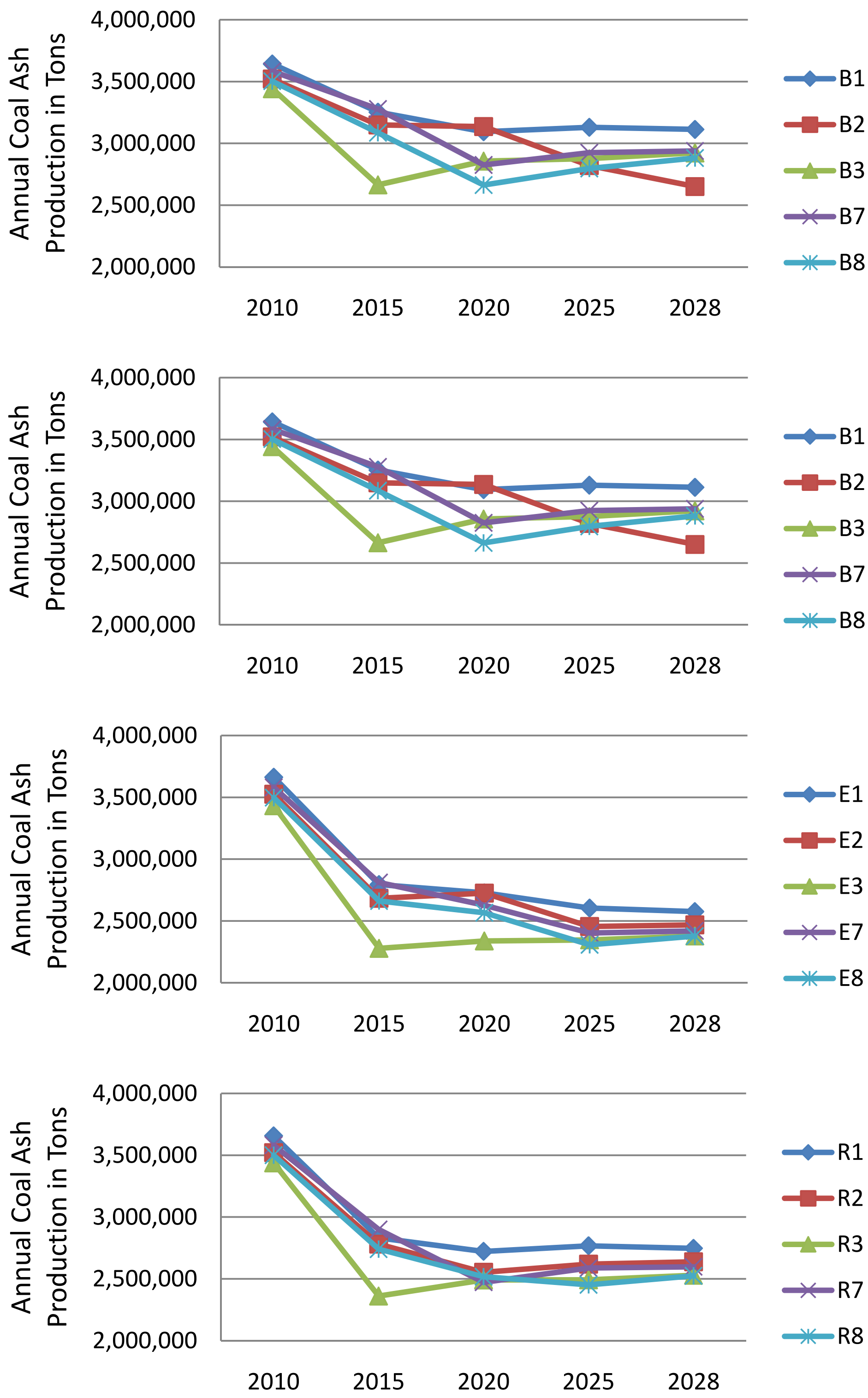


Figure 7-12. Trends in coal ash production by scenario for (top to bottom) Strategies B, C. E, and R.

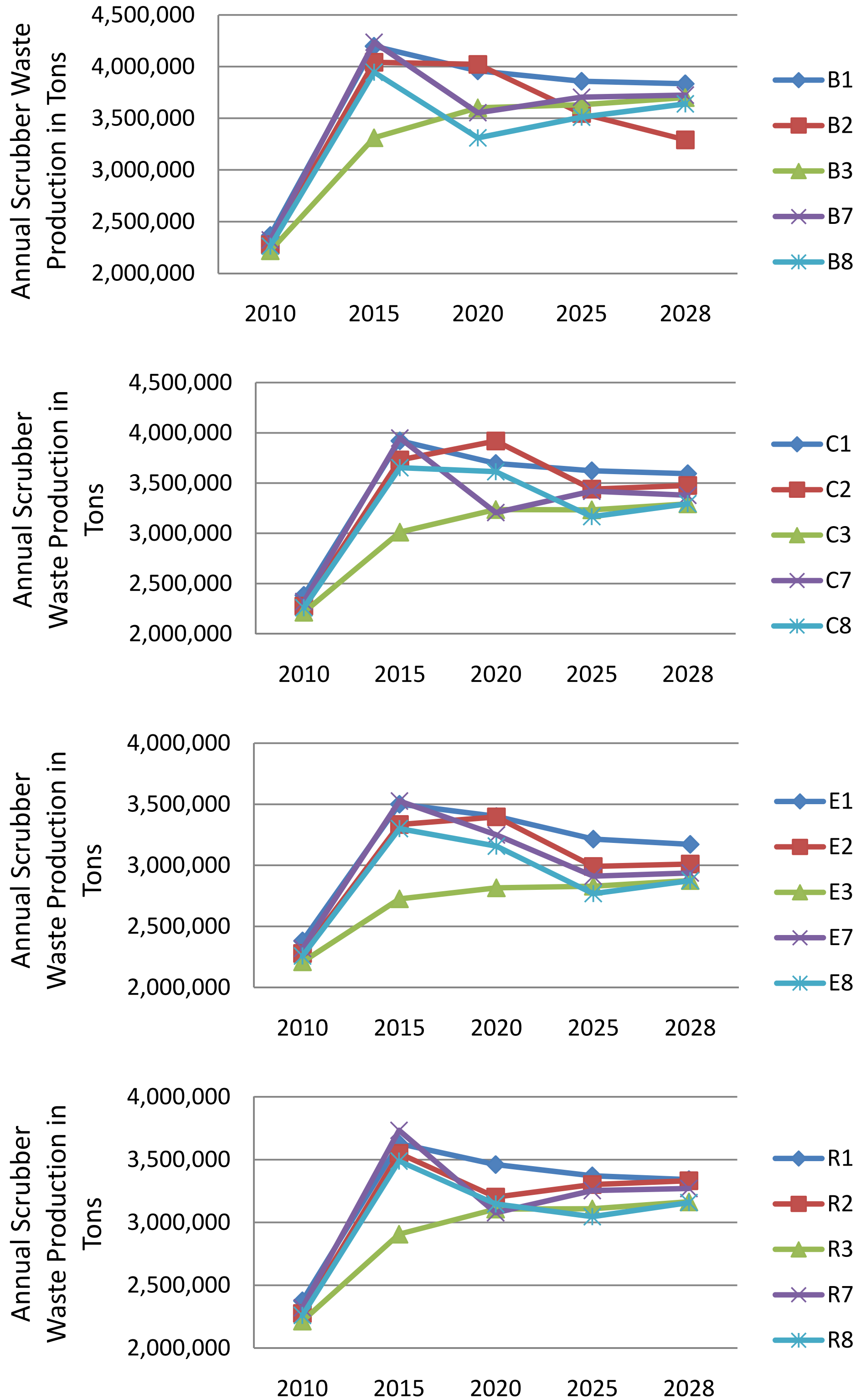


Figure 7-13. Trends in scrubber waste production by scenario for (top to bottom) Strategies B, C. E, and R.

About 30 percent of the scrubber waste produced in recent years has been marketed for beneficial use. The remaining scrubber waste is stored in landfills and impoundments at or near coal plants. As with ash, TVA has committed to converting the wet scrubber waste storage impoundments to dry storage facilities. This conversion, as well as the increased scrubber waste production, will likely require additional storage areas for scrubber waste at many plants. TVA is also committed to increase the beneficial reuse of scrubber waste.

Nuclear Wastes
The trends in the production of high-level waste (Figure 7-14), which is primarily spent nuclear fuel and other fuel assembly components, are the same as the trends in the use of nuclear fuel (Figure 7-10). The major differences among the alternative scenarios results from the number of nuclear units added under the high-growth Scenario 1 and the moderate-growth Scenario 2. When ranked by strategy, the amount of high-level waste would be greatest under Strategy B, followed by Strategies, R, C, and E. TVA anticipates continuing to store spent fuel on the nuclear plant sites until a centralized facility for long-term disposal and/or reprocessing are operating. This continued on-site storage will require the future construction of additional dry cask storage facilities.

All of the alternative strategies show a long-term increase in the production of low-level waste. The proportional increase is somewhat less than the increase in nuclear generation due to the anticipated continued development and implementation of techniques to reduce the production of low-level waste and better consolidate the low-level waste that is produced. The ranking of the strategies by amount of low-level waste is the same as their ranking by amount of high-level waste.

7.6.6. Land Requirements
TVA's existing power plant reservations have a total area of approximately 23,937 acres. This total does not include conventional hydroelectric plants, most of which are closely associated with multi-purpose dams and reservoirs, or the 1,761-acre Bellefonte site. Many of the power plant reservations have large, relatively undisturbed areas and the actual area disturbed by facility construction and operation (the "facility footprint") totals about 17,360 acres. The existing generating facilities from which TVA purchases power under long-term PPAs (> 5 years, and excluding hydroelectric plants) have facility footprints of about 600 acres.

The alternative strategies require between about 4,530 and 8,130 acres for new generating facilities (Figure 7-15). These land requirements only include those for the generating facility footprints and associated access roads. They do not include undisturbed portions of the power plant reservations or the land area needed for extraction (e.g., mining), production (e.g., biomass plantations), processing and transportation of fuels or long-term disposal of ash and other wastes. The high solar land requirements are based on the PV energy density for the TVA region described by Denholm and Margolis (2008), and adjusted to assume 40 percent of the PV is deployed on rooftops and thus has no land requirements. The remaining PV is deployed using a combination of fixed and tilting ground-based arrays. The biomass land requirements illustrated in Figure 7-16 are for dedicated biomass facilities. Biomass cofiring, conversion of coal units to dedicated biomass operation, and landfill gas are assumed not to require any land beyond that of the existing coal plant or landfill.

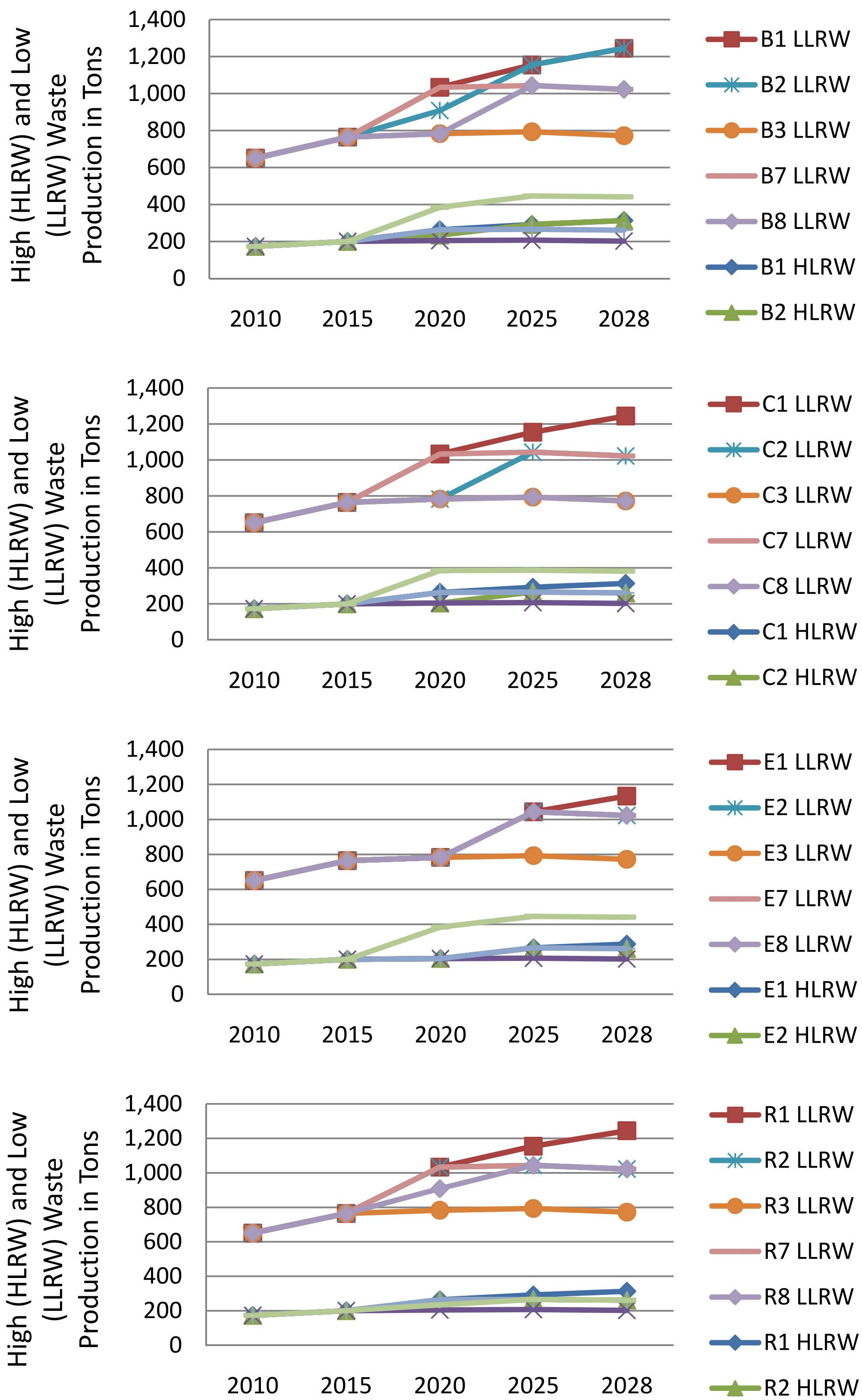


Figure 7-14. Trends in production of high and low level waste by scenario for (top to bottom) Strategies B, C. E, and R.

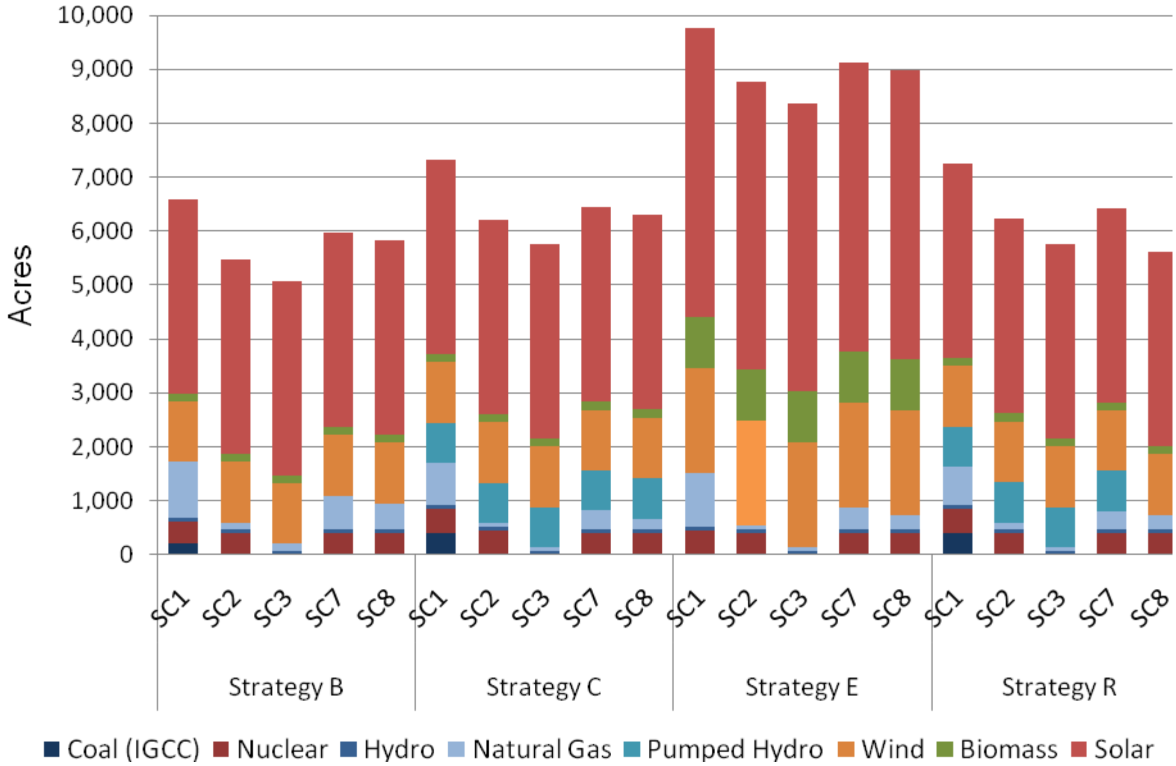


Figure 7-15. Land requirements for new generating facilities by type of generation, strategy, and scenario.

If wind and PV generation (both of which produce relatively low amounts of power per unit of area) are excluded, Strategy C has considerably larger facility land requirements for each scenario than do Strategy B and Strategy E. Strategy E has the lowest land requirements for large, central station generating facilities (average of 755 acres) and, because of its large wind and PV capacity, the largest overall land requirements (average of 9,002 acres). Average central station generating facility and overall land requirements for the other strategies are, respectively: Strategy B - 1,059 and 5,788 acres; Strategy C - 1,675 and 6,403 acres; and Strategy R - 1,525 and 6,404 acres.

Figure 7-16 shows the life-cycle land requirements for the coal, nuclear, natural gas, wind, and biomass generation components of the various alternative strategies. These land requirements are expressed in acre-years/GWh to show the land requirements over time (Spitzley and Tolle 2004, Spitzley and Keoleian 2005). It considers the amount of land occupied by a particular component of a facility life-cycle process, such as metal fabrication, coal mining, and waste disposal. For most types of generation shown in Figure 7-16 life-cycle land requirements are dominated by those associated with fuel acquisition. The biomass land requirements are based on the use of short-rotation woody crops, a biomass with large land needs and thus, present a worst-case scenario. The use of wood waste would greatly reduce life-cycle land requirements, although this is difficult to quantify without more definitive information. Life-cycle land requirements were not calculated for the other types of generation shown in Figure 7-16 because they do not greatly differ from the facility land requirements or, in the case of conventional hydroelectric generation, because of the multipurpose nature of the dams and reservoirs.

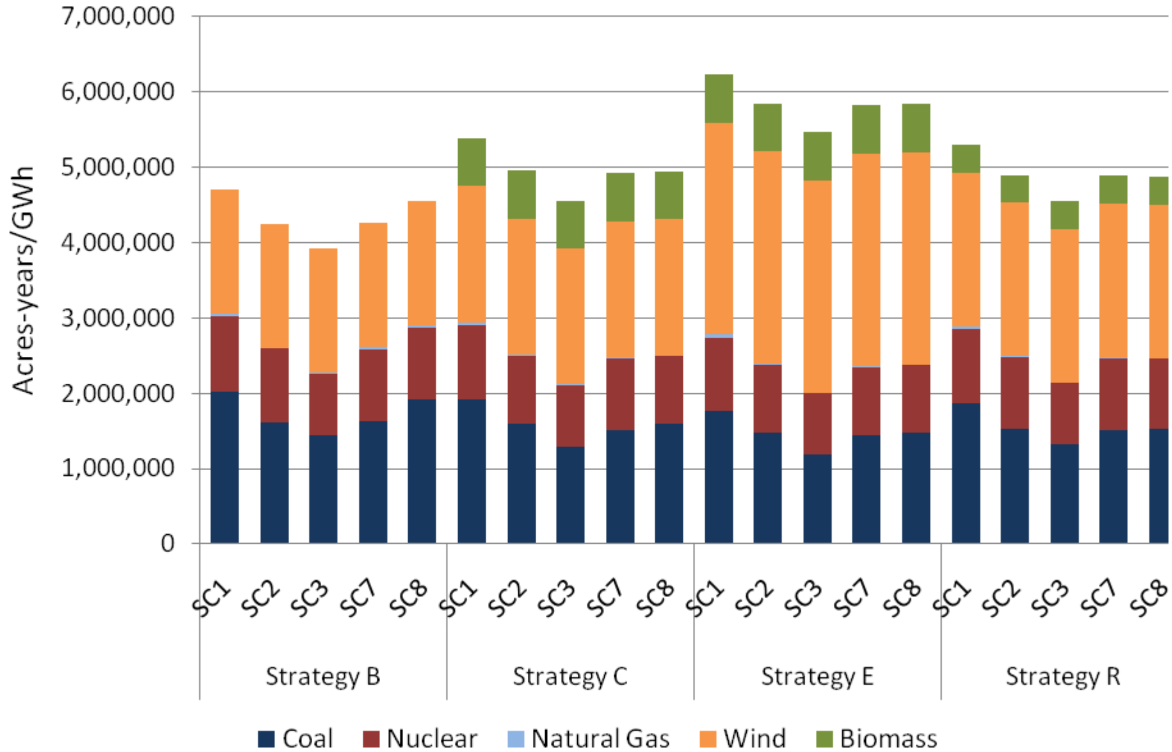


Figure 7-16. Life-cycle land requirements for generating facilities by type of generation, strategy, and scenario.

Nuclear power, because of the high power density of the fuel, has low life-cycle land requirements relative to other types of generation. Its land requirements, however, do not include those associated with the long-term disposal of spent nuclear fuel. Inclusion of spent fuel disposal would increase the land requirements because of the long life-span of a disposal area. The life-cycle land requirements for wind energy are relatively large because of the large area surrounding wind turbines on which some land uses may be restricted.

Average life-cycle land requirements are lowest for Strategy B (4,334,721 acre-years/GWh) which has the smallest renewable portfolio and highest for Strategy E (5,840,919 acre-years/GWh) which has the largest renewable portfolio. The average life-cycle land requirements for Strategies R (4,896,751 acre-years/GWh) and C (4,948,742 acre-years/GWh).

7.6.7. Socioeconomics

Potential socioeconomic impacts of the alternative strategies were assessed by comparing the economic metrics described in Sections 2.6. For each strategy, these metrics were calculated for the high-growth Scenario 1 and the low-growth Scenario 6 (Table 7-6. Although Scenario 6 is not otherwise analyzed in the retained alternative strategies, its results are very similar to the low-growth Scenario 3. Therefore, the use of scenarios 1 and 6 to define the economic development metrics encompasses the upper and lower range of impacts.

Strategy B would result in the greatest increase in total employment and in personal income growth under the high-growth Scenario 1, but would also result in the greatest decrease in both employment and income under the low-growth scenario. Strategies C and E have similar impacts, with moderate increases in both employment and income under the high-growth scenario. Under the low-growth scenario, both would have small but positive increases in employment and income. Overall, the beneficial socioeconomic impacts of strategies C, E, and R are somewhat greater than those of Strategy B across the range of scenarios.

Table 7-6. Comparison of socioeconomic impacts of alternative strategies based on the percent difference from the no-action Strategy B/Scenario 7.

		Percent Difference in			
		Total Employment		Total Personal Income	
Strategy	Scenario	Average 2011-2028	Average 2011-2015	Average 2011-2028	Average 2011-2015
B	1	1.0%	0.3%	0.8%	0.3%
	6	-0.3%	-0.4%	-0.3%	-0.3%
C	1	0.9%	0.2%	0.6%	0.2%
	6	0.2%	-0.2%	0.1%	-0.1%
E	1	0.8%	0.0%	0.6%	0.0%
	6	0.3%	-0.1%	0.2%	-0.1%
R	1	0.9%	0.2%	0.7%	0.2%
	6	0.2%	-0.2%	0.1%	-0.1%

Before implementing a specific resource option, TVA will conduct a review of its potential socioeconomic impacts. This review will, as appropriate, focus on resource- and/or site-specific socioeconomic issues such as impacts on employment rates, housing, schools, emergency services, water supply and wastewater treatment capacity, and local government revenues, as well as the potential for disproportionate impacts on minority and low-income populations.

7.7. Potential Mitigation Measures

As previously described, TVA's siting processes for generation and transmission facilities, as well as practices for processes for modifying these facilities, are designed to avoid and/or minimize potential adverse environmental impacts. Potential impacts are also reduced through pollution prevention measures and environmental controls such as air pollution control systems, wastewater treatment systems, and thermal generating plant cooling systems. Other potentially adverse impacts can be mitigated by measures such as compensatory wetlands mitigation, payments to in-lieu stream mitigation programs and related conservation initiatives, enhanced management of other properties, documentation and recovery of cultural resources, and infrastructure improvement assistance to local communities.

7.8. Unavoidable Adverse Environmental Impacts

The adoption of an alternative strategy for meeting the long-term electrical needs of the TVA region has no direct environmental impacts. The implementation of the strategy, however, would have adverse environmental impacts. The nature and potential significance of the impacts will depend on the energy resource options eventually implemented under the strategy. Resource options in each strategy have associated adverse impacts that cannot be realistically avoided.

Under every strategy, TVA would continue to operate most of its existing generating units for the duration of the 20-year planning period. The exceptions are predominantly the coal plants that would be laid up. The operation of the generating units would continue to result in the release of various air and/or water pollutants, depending on the kind of unit. As previously described, the installation of additional air emission control systems on coal units is expected to reduce the release of air pollutants.

The construction and operation of new generating facilities would unavoidably result in changes in land use unless new facilities are located at existing plant sites.

The conversion of land from a non-industrial use to an industrial use will unavoidably affect land resources such as farmland, wildlife habitat, and scenery.

7.9. Relationship Between Short-Term Uses and Long-Term Productivity of the Human Environment

The adoption and implementation of a long-term energy resource strategy would have various short- and long-term consequences. These depend, in part, on the actual energy resource options that are implemented. Option-specific and/or site-specific environmental reviews will be conducted before final implementation decisions are made to use certain energy resources and will examine potential environmental consequences in more detail.

In both the short and long term, TVA would continue to generate electrical energy to serve its customers and the public. As described in Chapter 2, the demand for electricity is forecast to grow in the future. The availability of adequate, reliable, low-priced electricity will continue to sustain the economic well-being of the TVA region and allow it to grow.

The generation of electricity has both short- and long-term environmental impacts. Short-term impacts include those associated with facility construction and operational impacts, such as the consequences of exposure to the emission of air pollutants and consequences of thermal discharges. Potential long-term impacts include land alterations for facility construction and fuel extraction, and the generation of nuclear waste that requires safe storage for an indefinite period.

7.10. Irreversible and Irretrievable Commitments of Resources

The continued generation of electricity by TVA will irreversibly consume various amounts of non-renewable fuels (coal, natural gas, diesel, fuel oil, and uranium). The continued maintenance of TVA's existing generating facilities and the construction of new generating facilities will irreversibly consume energy and materials. The siting of most new energy facilities, except for wind and PV facilities, will irretrievably commit the sites to industrial use because of the substantial alterations of the sites and the relative permanence of the structures. The continued generation of nuclear power will produce nuclear wastes; therefore, some site or sites will have to be devoted to the safe storage of these wastes. Any such site would essentially be irretrievably committed to long-term storage of nuclear waste.

The alternative strategies contain varying amounts of EEDR and renewable generation. Reliance on these resources would lessen the irreversible commitment of non-renewable fuel resources, but would still involve the irreversible commitment of materials and, depending on the type of renewable generation, the irreversible commitment of generating sites.

CHAPTER 8

8.0 LITERATURE CITED

Alliance to Save Energy. 2010. About Green Schools. http://ase.org/section/program/greenschl/aboutgs. Accessed June 1, 2010.

America's Energy Future Panel on Electricity from Renewable Resources (AEFPERR). 2009. Electricity from Renewable Resources: Status, Prospects, and Impediments. National Academies Press, Washington, D.C.

Armendariz, A. 2009. Emissions from Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements, Version 1.1. Available at http://edf.org/documents/9235_Barnett_Shale_Report.pdf.

Arnett, E. B., D. B. Inkley, D. H. Johnson, R. P. Larkin, S. Manes, A. M. Manville, J. R. Mason, M. L. Morrison, M. D. Strickland, and R. Thresher. 2007. Impacts of Wind Energy Facilities on Wildlife and Wildlife Habitat. Technical Review 07-2. The Wildlife Society, Bethesda, MD.

Augustine, C., and K. R. Young. 2010. Updated U.S. Geothermal Supply Curve. Conference Paper NREL/CP-6A2-47458, National Renewable Energy Laboratory, Golden, CO.

Baerwald, E. F., G. H. D'Amours, G. J. Klug, and R. M. R. Barclay. 2008. Barotrauma Is a Significant Cause of Bat Fatalities at Wind Turbines. Current Biology 18:R695-R696, doi:10.1016/j.cub.2008.06.029.

Baskin, J. M. and C. C. Baskin. 2003. The Vascular Flora of Cedar Glades of the Southeastern United States and Its Phytogeographical Relationships. Journal of the Torrey Botanical Society 130: 100-117.

Bendat, J. S., and A. G. Piersol. 1986. Random Data –Analysis and Measurement Procedures, 2nd Edition, John Wiley & Sons, Inc., New York, NY, pp. 95-97.

Bohac, C. E., and M. J. McCall. 2008. Water Use in the Tennessee Valley for 2005 and Projected Use in 2030. Tennessee Valley Authority, Chattanooga, TN.

Bradley, M., and J. Robinson. 2009. Personal communication of 2005 groundwater withdrawal data for public-water supply in Tennessee, July 2.

Bureau of Census. 1989. 1987 Census of Agriculture, Vol. 1, Geographic Area Series. U.S. Dept. Commerce, Bureau of Census, Washington, D.C.

_____. 2000a. Census 2000 Summary File 1 (SF 1) 100-Percent Data, Detailed Tables. Retrieved from http://factfinder.census.gov/servlet/DTGeoSearchByListServlet?ds_name=DEC_2000_SF1_U&_lang=en&_ts=285869678994. Accessed May 5, 2010).

_____. 2009. 2008 County Characteristics - Age, Sex, Race, and Hispanic Origin. Retrieved from http://www.census.gov/popest/counties/asrh/. Accessed April 21, 2010.

———. 2010. 2009 County Total Population Estimates. Retrieved from http://www.census.gov/popest/estimates.html. Accessed May 5, 2010.

Bureau of Land Management. 2005. Final Programmatic Environmental Impact Statement on Wind Energy Development on Bureau of Land Management-Administered Lands in the Western United States. FES 05-11, U.S. Department of the Interior, Bureau of Land Management. Available online: http://windeis.anl.gov/documents/fpeis/index.cfm.

Burt, D. 2009. Personal communication of 2004 groundwater withdrawal data for public-water supply in Mississippi, June 23.

Center for Resource Solutions. 2010. Green-e Energy. http://www.green-e.org/getcert_re.shtml. Accessed June 1, 2010.

Charlson, R. J., and H. Rodhe. 1982. Factors Controlling the Acidity of Natural Rainwater. Nature 295:683-685.

Christensen, J. H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R. K. Kolli, W. T. Kwon, R. Laprise, V. Magana Rueda, L. Mearns, C. G. Menendez, J. Raisanen, A. Rinke, A. Sarr, and P. Whetton. 2007. Regional Climate Projections. Pp.847-940 In Climate Change 2007: The Physical Science Basis; Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S.; D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, Eds. Cambridge University Press, Cambridge, United Kingdom and New York.

Conner, A. M., J. E. Francfort, and B. N. Rinehart. 1998. U.S. Hydropower Resource Assessment Final Report. DOE/ID-10430.2, Idaho National Engineering and Environmental Laboratory, U.S. Department of Energy, Idaho Falls, ID. Available at http://hydropower.id.doe.gov/resourceassessment/index.shtml. Accessed July 13, 2010.

Conner, R.C., and A. J. Hartsell. 2002. Forest Area and Conditions. Pp. 357-402 *In* Wear, D.N., and J.G. Greis (eds.). Southern Forest Resource Assessment. Gen. Tech. Rep. SRS-53, U.S. Forest Service, Southern Research Station, Asheville, NC.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of Wetland and Deepwater Habitats of the United States. Washington, D.C.: U.S. Fish and Wildlife Publication FWS/OBS-79/31.

Council of Environmental Quality (CEQ). 2010. Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions. http://ceq.hss.doe.gov/nepa/regs/Consideration_of_Effects_of_GHG_Draft_NEPA_Guidance_FINAL_02182010.pdf

Cushman, R. M. 1985. Review of Ecological Effects of Rapidly Varying Flows Downstream from Hydroelectric Facilities. N. Amer. J. Fisheries Management 5:330–339.

Dahl, T. E. 2000. Status and Trends of Wetlands in the Conterminous United States 1986 to 1997. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

_____. 2006. Status and Trends of Wetlands in the Conterminous United States 1998 to 2004. U.S. Department of the Interior; Fish and Wildlife Service, Washington, D.C.

Dale, V. H., K. L. Kline, J. Wiens, and J. Fargione. 2010. Biofuels: Implications for Land Use and Biodiversity. Biofuels and Sustainability Reports, Ecological Society of America. Available at http://www.esa.org/biofuelsreports.

Denholm, P., and G. L. Kulcinski. 2004. Life-cycle Energy Requirements and Greenhouse Gas Emissions from Large Scale Energy Storage Systems. Energy Conversion and Management 45:2153-2172.

_____ and R. Margolis. 2007. The Regional Per-Capita Solar Electric Footprint for the United States. Technical Report NREL/TP-670-42463. National Renewable Energy Laboratory, U.S. Department of Energy, Golden, Colorado.

_____ and R. Margolis. 2008. Land-use Requirements and the Per-capita Solar Footprint for Photovoltaic Generation in the United States. Energy Policy 36:3531-3543.

_____, M. Hand, M. Jackson, and S. Ong. 2009. Land-use Requirements of Modern Wind Power Plants in the United States. National Renewable Energy laboratory Tech. Rep. NRWL/TP-6A2-45834.

Dyer, J. M. 2006. Revisiting the Deciduous Forests of Eastern North America. Bioscience 56: 341-352.

Elliott, D. L., C.G. Holladay, W.R. Barchet, H.P. Foote, and W.F. Sandusky. 1986. Wind Energy Resource Atlas of the United States. Pacific Northwest Laboratory, Richland, Washington. Available at http://rredc.nrel.gov/wind/pubs/atlas/atlas_index.html.

Electric Power Research Institute (EPRI). 2002. Water and Sustainability (Volume 2): An Assessment of Water Demand, Supply, and Quality in the U. S. – The Next Half Century, 1006785. Topical Report, Palo Alto, California.

_____. 2009. Program on Technology Innovation: Utility Scale Use of Biomass. Report 1018661, EPRI, Palo Alto, California.

_____. 2010. Renewable Energy Technology Guide-RETG: 2009. Report 1021379, EPRI, Palo Alto, California.

_____ and Tennessee Valley Authority. 2009. Potential Impact of Climate Change on Natural Resources in the Tennessee Valley Authority Region. Report 1020420, EPRI, Palo Alto, California, and TVA, Knoxville, Tennessee.

Environmental Protection Agency (EPA). 1995. AP-42 Compilation of Air Pollutant Emission Factors, Vol. I, fifth ed. Available at http://www.epa.gov/ttnchie1/ap42/.

_____. 2001. Visibility in Mandatory Federal Class I Areas (1994-1998), A Report to Congress. EPA-452/R-01-008, Research Triangle Park, North Carolina.

_____. 2004. What You Need to Know about Mercury in Fish and Shellfish. Available at http://water.epa.gov/scitech/swguidance/fishshellfish/outreach/advice_index.cfm.

_____. 2005, Mountaintop Mining/Valley Fills in Appalachia Final Programmatic Environmental Impact Statement. EPA 9-03-R-05002, Philadelphia. Available at http://www.epa.gov/region3/mtntop/eis2005.htm.

_____. 2008a. SF6 Emission Reduction Partnership for Electric Power Systems: 2007 Annual Report. Available at http://www.epa.gov/electricpower-sf6/resources/index.html. Accessed October 31, 2009.

_____. 2008b. Wetland types: Bottomland Hardwoods. Available at http://www.epa.gov/owow/wetlands/types/bottomland.html. Accessed June 8, 2009.

_____. 2008c. Memorandum dated October 6, 2008 from Mark Schmidt to Lead NAAQS Review Docket. Available at http://www.epa.gov/ttn/naaqs/standards/pb/data/20081006comparison.pdf.

_____. 2009a. Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act - Final Rule. Federal Register 74:66496-66546.

_____. 2009b. Integrated Science Assessment for Particulate Matter (Second External Review Draft). EPA/600/R-08/139B Research Triangle Park, NC.

_____. 2009c. 2007 Toxics Release Inventory (TRI) Public Data Release Report. EPA 260-R-09-001 http://www.epa.gov/TRI/tridata/tri07/brochure/EPA_TRI_Brochure_2007_mar.pdf

Fannin, J. 2009. Personal communication of 2005 groundwater withdrawal data for public-water supply in Georgia, July 7.

Federal Energy Regulatory Commission. 2008. Standards of Conduct for Transmission Providers. 18 CFR Part 358, Docket No. RM07-1-000; Order No. 717. Available at http://www.ferc.gov/whats-new/comm-meet/2008/101608/M-1.pdf.

Fenneman, N. M. 1938. Physiography of the Eastern United States. McGraw-Hill, New York.

Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D. W. Fahey, J. Haywood, J. Lean, D. C. Lowe, G.r Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz, and R. Van Dorland. 2007. Changes in Atmospheric Constituents and in Radiative Forcing. Pp. 129-234 In Climate Change 2007: The Physical Science Basis; Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S.; D. Qin, M. Manning, Z. Chen, M. Marquis, K.B.

Averyt, M. Tignor, and H.L. Miller, Eds. Cambridge University Press, Cambridge, United Kingdom and New York.

Fthenakis, V., and H. C. Kim. 2007. Greenhouse-Gas Emissions from Solar Electric- and Nuclear Power: A Life-Cycle Study. Energy Policy 35:2549-2557.

_____, H. C. Kim, and E. Alsema. 2008. Emissions from Photovoltaic Life-cycles. Environ. Sci. Technol. 42:2168-2174.

_____ and H. C. Kim. 2009. Land Use and Electricity Generation: A Life-Cycle Analysis. Renewable & Sustainable Energy Reviews 13:1465-1474.

Griffith, G.E., J. M. Omernik and S. Azevedo. 1998. Ecoregions of Tennessee (color poster with map, descriptive text, summary tables, and photographs). Reston, Virginia. US Geological Survey (map scale 1:250,000). Available at http://www.epa.gov/wed/pages/ecoregions/tn_eco.htm. Accessed May 15, 2009.

Guthe, C. E. 1952. Twenty Five Years of Archeology in the Eastern United States. Pp. 1-2 *In* J. B. Griffin, ed., Archeology of Eastern United States. University of Chicago Press.

Hall, D. G., K. S. Reeves, J. Brizzee, R. D. Lee, G. R. Carroll, and G. L. Sommers. 2006. Feasibility Assessment of the Water Energy Resources of the United States for New Low Power and Small Hydro Classes of Hydroelectric Plants. DOE-ID-11263, Office of Energy Efficienty and Renewable Energy, U.S. Department of Energy. Available at http://hydropower.id.doe.gov/resourceassessment/index.shtml. Accessed July 13, 2010.

Hefner, J. M., B. O. Wilen, T. E. Dahl, and W. E. Frayer. 1994. Southeast Wetlands, Status and Trends. Cooperative Publication by United States Department of the Interior, Fish and Wildlife Service, and the U.S. Environmental Protection Agency.

Hoerling, M., G. Hegerl, D. Karoly, A. Kumar, and D. Rind. 2008. Attribution of the Causes of Climate Variations and Trends over North America during the Modern Reanalysis Period. Pp. 47-92 In Reanalysis of Historical Climate Data for Key Atmospheric Features: Implications for Attribution of Causes of Observed Change; Dole, R.; Hoerling, M.; Schubert, S., Eds. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC.

Hondo. H. 2005. Life-cycle GHG Emission Analysis of Power Generation Systems: Japanese Case. Energy 30:2042-2056.

Hopping, P. N. 2010. Watts Bar Nuclear Plant, Unit 2 Response to RAI. H-14, Letter from Joel S. Wiebe, U.S. NRC Office of Nuclear Reactor Regulation, to Ashok S. Bhatnagar, U.S. TVA Office of Nuclear Generation Development and Construction; Subject—Watts Bar Nuclear Plant, Unit 2, Request for Additional Information Regarding Environmental Review (TAC No. MD8203); Docket No. 50-391. Tennessee Valley Authority, Knoxville, Tennessee.

Huber, D., Z. Taylor, and S. Knudson. 2011. Environmental Impacts of Smart Grid. DOE/NETL-201-/1428,National Energy Technology Laboratory, U.S. Department of Energy. Available at http://www.netl.doe.gov/energy-analyses/pubs/EnvImpact_SmartGrid.pdf. Accessed January 20, 2011.

Interagency Monitoring of Protected Visual Environments (IMPROVE). 2007 Monitoring Results. Available at http://vista.cira.colostate.edu/improve/.

James, R.J., T. J. Skone, L. C. Dauker, and R. Bromiley. 2010. Life Cycle Analysis: Natural Gas Combined Cycle (NGCC) Power Plant. DOE/NETL-403-110509. U.S. Department of Energy, National Energy Technology Laboratory. http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=353. Accessed January 21, 2011.

Jaramillo, P., W. M. Griffin, and H. S. Matthews. 2007. Comparative Life-Cycle Air Emissions of Coal, Domestic Natural Gas, LNG, and SNG for Electricity Generation. Environ. Sci. Technol. 41:6290-6296.

Kargbo, D. M., R. G. Wilhelm, and D. J. Campbell. 2010. Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities. Environ. Sci. Technol. 44:5679-5684.

Karl, T. R., J. M. Melillo, and T C. Peterson, eds. 2009. Global Climate Change Impacts in the United States. Cambridge University Press, New York. Available at http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts. Accessed April 2, 2010.

Kenny, J. F., N. L. Barber, S. S. Hutson, K. S. Linsey, J. K. Lovelace, and M. A. Maupin. 2009. Estimated Use of Water in the United States in 2005. U.S. Geological Survey Circular 1344. Available at http://pubs.usgs.gov/circ/1344/.

Kim, S., and B. E. Dale. 2005. Life-cycle Inventory Information of the United States Electricity System. Int. J. Life-cycle Assessment 10:294-304.

King, C. W. and Webber, M. E., 2008. The Water Intensity of the Plugged-In Automotive Economy, Environmental Science and Technology 42(12):4305–4311.

Lanzante, J.R., T.C. Peterson, F.J. Wentz, and K.Y. Vinnikov. 2006. What Do Observations Indicate about the Change of Temperatures in the Atmosphere and at the Surface since the Advent of Measuring Temperatures Vertically? In Temperature Trends in the Lower Atmosphere: Steps for Understanding and Reconciling Differences; Karl, T.R.; Hassol, S.J.; Miller, C.D.; Murray, W.L., Eds. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research, Washington, DC.

Liepert, B. and I. Tegen. 2002. Multidecadal Solar Radiation Trends in the United States and Germany and Direct Tropospheric Aerosol Forcing. J. Geophys. Res. 107, D12,4153, doi:10.1029/2001JD000760.

Littlepage, T. .2009. Personal communication of 2005 groundwater use data for Alabama, July 6.

Mann, M. K., and P. L. Spath. 2001. A Life-cycle Assessment of Biomass Cofiring in a Coal-Fired Power Plant. Clean Prod. Processes 3:81-91.

Martinez, E., F. Sanz, S. Pellegrini, E. Jimenez, and J. Blanco. 2009. Life-cycle Assessment of a 2-MW Rated Power Wind Turbine: CML Method. Int. J. Life-cycle Assess. 14:52-63.

McDonald, R. I., J. Fargione, J. Kiesecker, W. M. Miller, and J. Powell. 2009. Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural habitat for the United States of America. PLoS ONE 4:(8): e6802. Doi:10.1371/jourmal.pone.0006802.

Meier, P. J. 2002. Life-Cycle Assessment of Electricity Generation Systems and Applications for Climate Change Policy Analysis. Fusion Technology Institute of University of Wisconsin, Madison.

_____, and G. I. Kulcinski. 2000. Life-Cycle Energy Cost and Greenhouse Gas Emissions for Gas Turbine Power. Research Report 202-1, Energy Center of Wisconsin, Madison.

Milbrandt, A. 2005. A Geographic Perspective on the Current Biomass Resource Availability in the United States. Tech. Report NREL/TP-550-39181, National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

Miller, B. A., V. Alavian, M. D. Bender, D. J. Benton, L. L. Cole, L. K. Ewing, P. Ostrowski, et al. 1993. Sensitivity of the TVA Reservoir and Power Supply Systems to Extreme Meteorology. Tennessee Valley Authority, Engineering Laboratory, Report No. WR28-1-680-111.

Miller, R. A. 1974. The Geologic History of Tennessee. Tennessee Div. Geology Bull. 74, Nashville.

National Climatic Data Center (NCDC). 2008. U.S. Climate Normals, 1971-2000. U.S. Department of Commerce, National Climatic Data Center. http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormals.html. Accessed November 18, 2009.

National Energy Technology Laboratory (NETL). 2008. 2008 Carbon Sequestration Atlas of the United States and Canada, 2nd Edition. U.S. Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory. http://www.netl.doe.gov/technologies/carbon_seq/refshelf/atlasII/. Accessed July 8, 2009.

_____. 2010. Life Cycle Analysis: Power Studies Compilation Report. DOE/NETL-2010/1419, U.S. Department of Energy, National Energy Technology Laboratory. http://www.netl.doe.gov/energy-analyses/pubs/PowerLCA_Comp_Rep.pdf. Accessed January 21, 2011.

National Renewable Energy Laboratory (NREL). 2009a. Dynamic Maps, GIS Data, and Analysis Tools - U.S. Solar Resource Maps. http://www.nrel.gov/gis/solar.html. Accessed December 22, 2009.

_____. 2009b. Dynamic Maps, GIS Data, and Analysis Tools - Wind Maps. http://www.nrel.gov/gis/wind.html. Accessed January 20, 2010.

_____. 2009c. Dynamic Maps, GIS Data, and Analysis Tools - Biomass Maps. http://www.nrel.gov/gis/biomass.html. Accessed January 20, 2010.

_____. 2010a. New Wind Energy Resource Potential Estimates for the United States. http://www.windpoweringamerica.gov/wind_maps.asp. Accessed February 19, 2010.

_____. 2010b. Eastern Wind Integration and Transmission Study. NREL, Golden, CO. Available at http://www.nrel.gov/wind/systemsintegration/ewits.html. Accessed July 29, 2010.

National Invasive Species Council (NISC). 2008. 2008-2012 National Invasive Species Management Plan. U.S. Department of Interior, Washington, D.C. http://www.invasivespecies.gov/main_nav/mn_NISC_ManagementPlan.html. Accessed September 28, 2009.

Natural Resources Conservation Service (NRCS). 2009a. National Soil Survey Handbook, Title 430-VI. U.S. Department of Agriculture, Natural Resources Conservation Service. Available at: http://soils.usda.gov/technical/handbook/. Accessed October 26, 2009.

_____ 2009b. Web Soil Survey. Available at http://soils.usda.gov/survey/. Accessed October 26, 2009.

NatureServe. 2009. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available at http://www.natureserve.org/explorer. Accessed 4 June 2009.

North American Bird Conservation Initiative, U.S. Committee (NABCI). 2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior: Washington, DC. 36pp. Available at http://www.stateofthebirds.org/pdf_files/State_of_the_Birds_2009.pdf. Accessed July 14, 2009.

Nuclear Regulatory Commission. 2010. Advanced Reactors. http://www.nrc.gov/reactors/advanced.html. Accessed August 7, 2010.

Oak Ridge National Laboratory. 1996. Potential Supply and Cost of Biomass from Energy Crops in the TVA Region. Publication No. 4306, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN.

Odeh, N. A., and T. T. Cockerill. 2008. Life-cycle GHG Assessment of Fossil Fuel Power Plants with Carbon Capture and Storage. Energy Policy 36:367-380.

Olinger, D. E. and A. E. Howard. 2009. In the Beginning… Pp. 17-37 *In* E.E. Pritchard, ed., TVA Archaeology: 75 Years of Prehistoric Site Research. University of Tennessee Press, Knoxville.

Omernik, J.M. 1987. Ecoregions of the Conterminous United States. Map (scale 1:7,500,000). Annals of the Association of American Geographers 77(1):118-125. Available at http://www.epa.gov/wed/pages/ecoregions/level_iii.htm#Ecoregions. Accessed: May 15, 2009.

Paidipati, J., Frantzis, L., Sawyer H., Kurrasch, A., and Navigant Consulting, Inc. 2008. Rooftop Photovoltaics Market Penetration Scenarios. Subcontract Report NREL/SR-581-42306. National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

Palmer, M. A., E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, E. Foufoula-Georgiou, M. S. Hendryx, A. D. Lemly, G. E. Likens, O. L. Loucks, M. E. Power, P. S. White, and P. R. Wilcock. 2010. Mountaintop Mining Consequences. Science 327:148-149.

Peel, M. C., B. L. Finlayson, B. L. and T. A. McMahon. 2007. Updated World Map of the Koppen-Geiger Climate Classification. Hydrol. Earth Syst. Sci. 11: 1633–1644.

Pope, J. 2009. Personal communication of 2005 groundwater use data for Virginia, July 10.

Pryor, S.C., R.J. Barthelmie, D.T. Young, E.S. Takle, R.W. Arritt, D. Flory, W.J. Gutowski Jr., A. Nunes, and J. Roads. 2009. Wind Speed Trends over the Contiguous United States. J. Geophys. Res., 114, D14105, doi:10.1029/2008JD011416.

Raichle, B. W., and W. R. Carson. 2008. Wind Resource Assessment of the Southern Appalachian Ridges in the Southeastern United States. Renewable & Sustainable Energy Reviews 13:1104-1110.

Railroad Commission of Texas (RRC). 2010. Newark East (Barnett Shale) Statistics. http://www.rrc.state.tx.us/data/fielddata/barnettshale.pdf, Accessed February 18, 2011.

Ricketts, T. H., E. Dinerstein, D. M. Olson, C. J. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P. T. Hurley, K. M. Carney, R. Abell, and S. Walters. 1999. Terrestrial Ecoregions of North America: A Conservation Assessment. Island Press, Washington, D.C.

Roosevelt, F. D. 1933. Message to Congress Suggesting the Tennessee Valley Authority, April 10, 1933. Available at http://docs.fdrlibrary.marist.edu/odtvacon.html. Accessed October 6, 2009.

Smyth, R. C., S. D. Hovorka, T. Meckel, C. Breton, J. G. Paine, and G. R. Hill. 2007. Potential Sinks for Geologic Storage of Carbon Dioxide Generated in the Carolinas. Gulf Coast Carbon Center, University of Texas at Austin.

Soeder, D. J., and W. M. Kappel. 2009. Water Resources and Natural Gas Production from the Marcellus Shale. USGS Fact Sheet 2009-3032, U.S. Geological Survey.

Southern Appalachian Man and the Biosphere (SAMAB). 1996. The Southern Appalachian Assessment Terrestrial Technical Report. Report 5 of 5. Atlanta: U. S. Department of Agriculture, Forest Service, Southern Region 286pp.

Sovacool, B. K. 2008. Valuing the greenhouse gas emissions from nuclear power: A critical survey. Energy Policy 36:2950-2963.

Spath, P. L., M. K. Mann, and D. R. Kerr. 1999. Life-cycle Assessment of Coal-fired Power Production. Tech. Report NREL/TP-570-25119, National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

_____, and M. K. Mann. 2000. Life-cycle Assessment of a Natural Gas Combined-Cycle Power Generation System. Tech. Report NREL/TP-570-27715, National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

_____ and M. K. Mann. 2004. Biomass Power and Conventional Fossil Systems with and without CO_2 Sequestration - Comparing the Energy Balance, Greenhouse Gas Emissions and Economics. Tech. Report NREL/TP-510-32575, National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

Spitzley, D. V., and D.A.Tolle. 2004. Evaluating Land-Use Impacts: Selection of Surface Area Metrics for Life-Cycle Assessment of Mining. J. Industrial Ecology 8:11-21.

_____ and G. A. Keoleian. 2005. Life-cycle Environmental and Economic Assessment of Willow Biomass Electricity: A Comparison with Other Renewable and Non-Renewable Sources. Report No. CSS04-05R, Center for Sustainable Systems, Univ. Michigan, Ann Arbor, MI.

Stanhill, G. and S. Cohen. 2005. Solar radiation changes in the United States during the twentieth century: evidence from sunshine duration measurements. J. Climate 18:1503-1512.

Stein, B. A. 2002. Status of the Union: Ranking America's Biodiversity. Natureserve, Arlington, Virginia.

_____, L. S. Kutner, G. A. Hammerson, L. L. Master, and L. E. Morse. 2000. State of the States: Geographic Patterns of Diversity, Rarity, and Endemism. In B. A. Stein, L. S. Kutner, and J. S. Adams, eds. Precious Heritage: The Status of Biodiversity in the United States. Oxford University Press, New York, New York.

Tennessee Department of Environment and Conservation (TDEC). 2008. Final Year 2008 303(d) List. Division of Water Pollution Control, Tennessee Department of Environment and Conservation, Nashville.

Tennessee Exotic Pest Plant Council (TEPPC). 2001. Invasive Exotic Pest Plants in Tennessee. Tennessee Exotic Pest Plant Council, Nashville. Available at http://www.tneppc.org/Invasive_Exotic_Plant_List/Invasive%20List%20Introduction.htm. Accessed December 18, 2009.

Tennessee Ornithological Society (TOS). 2007. The Official List of the Birds of Tennessee. Availabe at http://www.tnbirds.org/TBRC/TBRC_checklist.html. Accessed 14 July, 2009.

Tennessee Valley Authority. 1974. Final Environmental Statement, Bellefonte Nuclear Plant Units 1 and 2. Chattanooga, Tennessee.

_____. 1995. Energy Vision 2020 Integrated Resource Plan Environmental Impact Statement. Chattanooga, Tennessee.

_____. 1997. Final Environmental Impact Statement for the Bellefonte Conversion Project. Knoxville, Tennessee.

_____. 1998. Red Hills Power Project - Final Environmental Impact Statement. Knoxville, Tennessee.

_____. 2000. Addition of Electric Generation Peaking and Baseload Capacity at Greenfield Sites, Haywood County, Tennessee - Final Environmental Impact Statement. Knoxville, Tennessee.

_____. 2001. Construction and Operation of Photovoltaic Facilities within the Tennessee Valley Power Service Territory - Final Generic Environmental Assessment. Knoxville, Tennessee.

_____. 2001. Addition of Electric Generation Baseload Capacity in Franklin County, Tennessee - Final Environmental Impact Statement. Knoxville, Tennessee.

_____. 2002. Final Supplemental Environmental Impact Statement for Operating License Renewal for the Brown Ferry nuclear Plant in Athens, Alabama. Knoxville, Tennessee.

_____. 2003. Chip Mill Terminals on the Tennessee River - Final Environmental Impact Statement. Knoxville, Tennessee.

_____. 2004. Reservoir Operations Study Final Programmatic Environmental Impact Statement. Knoxville, Tennessee.

_____. 2005a. Wilson Hydro Plant Modernization of Hydroturbines - Final Environmental Assessment. Knoxville, Tennessee.

_____. 2005b. 500-kV Transmission Line in Middle Tennessee - Final Environmental Impact Statement. Knoxville, Tennessee.

_____. 2006. Installation of Flue Gas Desulfurization System at Kingston Fossil Plant - Final Environmental Assessment. Knoxville, Tennessee.

_____. 2007a. Strategic Plan. Knoxville, Tennessee. Available at http://www.tva.gov/stratplan/.

_____. 2007b. Adoption of PURPA Standards for Energy Conservation and Efficiency – Environmental Assessment. Knoxville, Tennessee.

_____. 2007c. Completion and Operation of Watts Bar Nuclear Plant Unit 2, Rhea County, Tennessee - Final Supplemental Environmental Impact Statement. Knoxville, Tennessee.

_____. 2008. Environmental Policy. Knoxville, Tennessee. Available at http://www.tva.com/environment/policy.htm.

_____. 2008a. Supplemental Environmental Assessment For The Potential Upgrade Of The Tenaska Site For Establishing A Simple-cycle Or Combined-Cycle Electric Generation Facility. Knoxville, Tennessee.

_____. 2009. Integrated Resource Plan Environmental Impact Statement Scoping Report. Knoxville, Tennessee. Available at http://www.tva.com/environment/reports/irp/index.htm.

_____. 2008c. Bellefonte Nuclear Plant, Units 3&4, COL Application, Part 3, Environmental Report, Revision 1. Chattanooga, Tennessee.

_____. 2010a. John Sevier Fossil Plant Addition of Gas-Fired Combustion Turbine/Combined-Cycle Generating Capacity and Associated Gas Pipeline - Environmental Assessment. Knoxville, Tennessee. Available at http://www.tva.com/environment/reports/johnsevier_ct/index.htm.

_____. 2010b. Biggersville, Mississippi 161-Kilovolt Transmission Line - Provide Delivery Point - Environmental Assessment. Chattanooga, Tennessee. Available at http://www.tva.gov/environment/reports/biggersville/index.htm.

_____. 2010c. Single Nuclear Unit at the Bellefonte Plant Site - Final Supplemental Environmental Impact Statement. Knoxville, Tennessee. Available at http://www.tva.com/environment/reports/blnp/index.htm.

_____. 2010d. TVA's Mission and Values. Knoxville, Tennessee. Available at http://www.tva.gov/abouttva/vision.htm.

Tennessee Wildlife Resources Agency (TWRA). 2005. Tennessee's Comprehensive Wildlife Conservation Strategy. TWRA, Nashville, Tennessee.

_____. 2009. Climate Change and Potential Impacts to Wildlife in Tennessee: An update to Tennessee's State Wildlife Action Plan. Tennessee Wildlife Resources Agency, Nashville. Available at http://www.state.tn.us/twra/cwcs/cwcsindex.html.

Thomas, R. K.; J.M. Melillo, and T.C. Peterson (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press, New York.

Tillman, T. A. 2004. Draft Report: Biomass Resource Availability Characteristics in the Tennessee Valley Authority Area. D. A. Tillman and Associates, Easton, PA.

Trenberth, K.E.; P.D. Jones, P. Ambenje, R. Bojariu, D. Easterling, A.K. Tank, D. Parker, F. Rahimzadeh, J.A. Renwick, M. Rusticucci, B. Soden, and P. Zhai. 2007. Observations: Surface and Atmospheric Climate Change. In *Climate Change 2007: The Physical Science Basis*; Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon, S.; D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller, Eds. Cambridge University Press, Cambridge, United Kingdom and New York.

United Nations Environment Programme (UNEP) Chemicals Branch. 2008. The Global Atmospheric Mercury Assessment: Sources, Emissions and Transport. UNEP Chemicals, Geneva, Switzerland. Available at http://www.chem.unep.ch/mercury/Atmospheric_Emissions/Atmospheric_emissions_mercury.htm.

U.S. Bureau of Economic Analysis (USBEA). 2010. Regional Economic Accounts. Retrieved from http://www.bea.gov/regional/index.htm. Accessed May 28, 2010.

U.S. Climate Change Science Program (USCCSP). 2007. Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations (Part A) and Review of Integrated Scenario Development and Application (Part B). A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research [Clarke, L., J. Edmonds, J. Jacoby, H. Pitcher, J. Reilly, R. Richels, E. Parson, V. Burkett, K. Fisher-Vanden, D. Keith, L. Mearns, C. Rosenzweig, M. Webster (Authors)]. U.S. Department of Energy, Office of Biological & Environmental Research, Washington, DC.

_____. 2008. Climate Models: An Assessment of Strengths and Limitations. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. [Bader D. C., C. Covey, W. J. Gutowski Jr., I. M. Held, K. E. Kunkel, R. L. Miller, R. T. Tokmakian and M. H. Zhang (Authors)].. U.S. Department of Energy, Office of Biological & Environmental Research, Washington, DC.

U.S. Department of Agriculture (USDA). 2004. AgCensus – The U.S. Census of Agriculture 1987, 1992, 1997. Available at http://agcensus.mannlib.cornell.edu/. Accessed June 24, 2009 and October 6, 2009.

_____. 2007. 2007 Census of Agriculture, Vol. 1, U.S. Summary and State Reports. http://www.agcensus.usda.gov/Publications/2007/Full_Report/index.asp. Accessed June 24, 2009 and October 6, 2009.

_____. 2009. Summary Report: 2007 National Resources Inventory. Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames, Iowa. Available at http://www.nrcs.usda.gov/technical/NRI/2007/2007_NRI_Summary.pdf.

U.S. Department of Energy (USDOE). 2007. FutureGen Project - Final Environmental impact Statement. DOE/EIS-0394. Morgantown, W.V. Available at http://www.netl.doe.gov/technologies/coalpower/futuregen/EIS/.

_____. 2009. Mesaba Energy Project - Final Environmental Impact Statement. DOE/EIS-0382. Pittsburgh, PA. Available at http://nepa.energy.gov/1167.htm.

_____. 2010. Kemper County Integrated Gasification Combined-Cycle Project - Final Environmental Impact Statement. DOE/EIS-0409. Pittsburg, PA. Available at http://www.netl.doe.gov/technologies/coalpower/cctc/EIS/eis_kemper.html.

U.S. Energy Information Administration. 2009. Emissions of Greenhouse Gases Report. U.S. Department of Energy. DOE/EIA- 0573(2008), available at http://www.eia.doe.gov/oiaf/1605/ggrpt/.

_____. 2010. State CO_2 Emissions. http://www.eia.doe.gov/oiaf/1605/state/state_emissions.html. Accessed February 1, 2011.

_____. 2010b. Heat Content of Natural Gas Consumed. http://www.eia.gov/dnav/ng/ng_cons_heat_dcu_nus_a.htm. Accessed January 25, 2011.

U.S. Fish and Wildlife Service (USFWS). 2006. Routine Operations and Maintenance of TVA's Water Control Structures in the Tennessee River Basin - Biological Opinion. Log No. 42430-2006-F-0146, Cookeville, TN.

_____. 2008. Birds of Conservation Concern 2008. United States Department of Interior, Fish and Wildlife Service, Division of Migratory Bird Management, Arlington, Virginia. Available at http://www.fws.gov/migratorybirds/.

U.S. Geological Survey (USGS). 1996. Coal Fields of the Conterminous United States. USGS Open-File Report OF 96-92. Available at http://pubs.usgs.gov/of/1996/of96-092/doc.htm. Accessed December 16, 2009.

_____. 2008. Land Cover Trends Project. Available at http://landcovertrends.usgs.gov/main/resultsOverview.html. Accessed May 28, 2009.

U.S. Forest Service (USFS). 2010. Forest Inventory Data Online. Available at http://fiatools.fs.fed.us/fido/index.html. Accessed March 23, 2010.

University of Tennessee (UT). 2008. Short Rotation Woody Crops for Biofuel. UT Agricultural Extension Station Publication SP702-C, Knoxville.

Visibility Improvement State and Tribal Association of the Southeast (VISTAS). 2009. G4 Emissions Inventory. Available at http://www.metro4-sesarm.org/vistas/SesarmBF_Area.htm.

Voigtlander, C. W., and W. L. Poppe. 1989. The Tennessee River. Pages 372-384 *in* D. P. Dodge, ed. Proc. International Large River Symposium, Canadian Journal of Fisheries and Aquatic Sciences Special Publication 106.

Walker, T., P. Cardellichio, A. Colnes, J. Gunn, B. Kittler, R. Perschel, C. Recchia, and D. Saah. 2010. Biomass Sustainability and Carbon Policy Study. Manomet Center for Conservation Sciences, NCI-201--03. Available at http://www.manomet.org/node/322.

Wiltsee, G. 2000. Lessons Learned from Existing Biomass Power Plants. NREL/SR--570-26946, National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO.

White, S. W., and G. L. Kulcinski. 2000. Birth to death analysis of the energy payback ration and CO_2 gas emission rates from coal, fission, wind, and DT-fusion electrical power plants. Fusion Engineering and Design 48:473-481.

Wood, R., P. Gilbert, M. Sharmina, K. Anderson, A. Footitt, S. Glynn, and F. Nicholls. 2011. Shale Gas: A Provisional Assessment of Climate Change and Environmental Impacts. Tech. Report, Tyndall Centre for Climate Change. Available at http://www.tyndall.ac.uk/publications/technical-report/2011/shale-gas-provisional-assessment-climate-change-and-environmental.

Yeary, C. 2009. Personal communication of 2005 groundwater use data for Kentucky, July 10.

Zoback, M., S. Kitasei, and B. Copithorne. 2010. Addressing the Environmental Risks from Shale Gas Development. Natural Gas and Sustainable Energy Initiative Briefing Paper 1, Worldwatch Institute. Available at http://www.worldwatch.org/node/6421.

Zurawski, A. 1978. Ground-Water Resources of the United States, Tennessee Region. USGS Professional Paper 813-F.

CHAPTER 9

9.0 LIST OF PREPARERS

John T. Baxter
Education: M.S. and B.S., Zoology
Experience: 21 years in protected aquatic species monitoring, habitat assessment, and recovery; 13 years in environmental review
Role: Aquatic Ecology, Threatened and Endangered Species

J. Markus Boggs
Education: M.S., Hydrology; B.S., Geophysics
Experience: 37 years in hydrologic investigation and analysis for environmental and engineering applications
Role: Groundwater

Charles E. Bohac, P.E.
Education: Ph.D., M.S., and B.S., Civil Engineering
Experience: 36 years in water resource investigations, water quality analysis, waste treatment and disposal system design, groundwater supply and contamination analysis, and hydro and fossil power plant engineering
Role: Water Supply

Gary S. Brinkworth, P.E.
Education: M.S. and B.S., Electrical Engineering
Experience: 28 years of electric utility experience in system planning, DSM analysis, forecasting, and rate analysis
Role: Need for power, capacity expansion, production cost and financial modeling; stochastic and risk analysis

Lawrence A. Cole
Education: B.S., Electrical Engineering
Experience: 3 years experience as field engineer, 24 years in TVA power control center including 4 years in day ahead generation planning. 1 year experience long term power supply planning. NERC Certified System Operator.
Role: IRP preparation

Edward L. Colston
Education: B.S., Mechanical Engineering
Experience: 30 years in demonstration, design, implementation, and measurement of energy efficiency and demand response programs
Role: Input on energy efficiency and demand response (EEDR) program accomplishments, current programs, and program plans.

Patricia B. Cox
Education: Ph.D., Botany (Plant Taxonomy and Anatomy); M.S. and B.S., Biology
Experience: 31 years in plant taxonomy at the academic level; 7 years in environmental assessment and NEPA compliance
Role: Threatened and Endangered Species, Terrestrial Ecology

Russell E. Dotson, CPA
Education: M.B.A.; B.S., Accounting and Finance
Experience: 9 years in accounting, compliance, and financial reporting and analysis
Role: IRP preparation, metric development, portfolio scoring

L. Suzanne Fisher
Education: M.S., Environmental Health; B.S., Ecology and Evolutionary Biology
Experience: 11 years in Assessments of Environmental Health and Ecological Trends
Role: Greenhouse Gas Emissions, Climate Change

Nicholas D. Galle (Sargent & Lundy)
Education: Masters of Energy Engineering; B.S., Chemical Engineering
Experience: 10 years in energy industry and business management consulting
Role: Need for Power analysis

B. J. Gatten
Education: B. S. in Communications, MBA in Marketing
Experience: 25 years in communications, including issues management, advertising, crisis communications, and public participation
Role: IRP and EIS review, project media relations

Steven M. Gilbert (ScottMadden)
Education: B.S., Mechanical Engineering; M.S., Management and Engineering
Experience: 3 years consulting experience in utility system planning
Role: Scenario planning development; summarizing and communicating results to internal/external stakeholders

Jill Glenn
Education: B.B.A., Marketing; M.B.A., Marketing
Experience: 2 years of experience in project management, including TVA integrated resource planning, distributed generation and green power pricing programs. 5 years experience working in TVA Supply Chain.
Role: Project manager of IRP communications

Jaun E. Gonzalez
Education: B.A., Economics, Political Science, and Mathematics M.A., Economics
Experience: 32 years of experience in TVA economic forecasting and economic development. Previous experience includes research in economic forecasting and utility economics at the University of Florida.
Role: Economic impact analysis

James R. Hagerman, P.E.
Education: M.S. and B.S., Agricultural Engineering
Experience: 21 years in nonpoint source pollution and water quality
Role: Water Quality

David A. Hankins
Education: B.S., Fish and Wildlife Management
Experience: 30 years in geographic information and engineering
Role: Map Preparation

Heather M. Hart
Education: M.S., Environmental Science and Soils; B.S., Plant and Soil Science
Experience: 8 years in surface water quality and soil and groundwater Investigations; 6 years in environmental reviews
Role: Parks, managed areas, and ecologically significant sites

Travis Hill Henry
Education: M.S., Zoology; B.S., Wildlife Biology
Experience: 22 years in zoology and endangered species; 15 years in NEPA compliance
Role: Terrestrial Ecology, Threatened and Endangered Species

Randall E. Johnson, PE
Education: MS, Engineering Management; BS, Civil Engineering; Registered Professional Engineer
Experience: 34 years engineering and project management experience in the areas of fuel handling, combustion and quality control; environmental control systems and balance of plant systems
Role: Integrated Resource Plan project manager

Scott C. Jones, PE
Education: BS, Electrical Engineering, Professional Engineer in Tennessee
Experience: 20 years TVA experience in nuclear systems engineering, resource planning, price forecasting, and financial analysis
Role: Integrated expansion, production cost, and financial modeling. Application of stochastic and risk analysis.

P. Alan Mays
Education: B.S., Plant and Soil Science
Experience: 33 years in soil-plant-atmospheric studies
Role: Prime Farmland

Randy McAdams (ScottMadden)
Education: B.S., Management Science; M.B.A.
Experience: 28 years as a management consultant; the last 23 in the electric utility industry with consulting to over 50 utilities
Role: IRP team member and subject matter expert on integrated resource planning, strategy development, and scenario planning.

Alisha Spears Mulkey
Education: B.S., Environmental and Soil Sciences
Experience: 4 years in land and resource management, 2 years in environmental policy
Role: IRP and EIS preparation, development of strategic environmental metrics

Charles P. Nicholson
Education: PhD, Ecology and Evolutionary Biology; MS, Wildlife Management; BS, Wildlife and Fisheries Science
Experience: 1 5 years in NEPA compliance, 17 years in wildlife and endangered species management
Role: NEPA compliance and EIS preparation

W. Chett Peebles, RLA; ASLA
Education: Bachelor of Landscape Architecture
Experience: 22 years in site planning, design, and scenic resource management; 5 years in architectural history and historic preservation
Role: Historic Architectural Resources

Kim Pilarski
Education: M.S., Geography, Minor Ecology
Experience: 15 years in wetlands assessment and delineation
Role: Wetlands

Erin E. Pritchard
Education: M.A., Anthropology
Experience: 13 years in archaeology and cultural resource management
Role: Cultural Resources

Edward A. Stephens, Jr.
Education: MS, Engineering Science and Mechanics; BS, Engineering Science
Experience: 35 years in the electric power industry; 30 years in research and development on generation, environmental control, and renewable energy technologies
Role: Carbon sequestration potential, electric power generation technical support

Ryan M. Swanson (Sargent & Lundy)
Education: BS and MS in Mechanical Engineering
Experience: 2 years in energy research and development
Role: Energy Alternatives analysis

Tommy R. Thompson
Education: B.S., M.S., Mechanical Engineering
Experience: 35 years in power plant systems design
Role: IRP preparation

Christopher D. Ungate (Sargent & Lundy)
Education: M.B.A; B.S., M.S., Civil Engineering
Experience: 35 years in engineering, planning, management and consulting in the electric utility industry
Role: Preparation of IRP chapters on Need for Power, Energy Alternatives, and IRP Results

Cassandra L. Wylie
Education: M.S., Forestry and Statistics; B.S., Forestry
Experience: 22 years in air quality analyses and studying the effects of air pollution on forests
Role: Air Quality

Courtne E. Yetter
Education: B.S., Environmental and Soil Science
Experience: Recent graduate
Role: IRP preparation and editing, project coordination

Michael J. Young, Jr.
Education: B.S., M.S., Business Administration
Experience: 3 years in TVA system planning, 3 years in TVA risk management and economic analysis
Role: Capacity expansion modeling and data analysis

CHAPTER 10

10.0 LIST OF AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM COPIES ARE SENT

Federal Agencies

USDA Forest Service, Region 8, Atlanta, GA
U.S. Environmental Protection Agency, Washington, DC
U.S. Environmental Protection Agency, Region 4, Atlanta, GA
Department of Interior, Atlanta, GA
U.S. Fish and Wildlife Service, Southeast Region Office, Atlanta, GA
U.S. Fish and Wildlife Service, Frankfort, KY
U.S. Fish and Wildlife Service, Asheville, NC
U.S. Fish and Wildlife Service, Abingdon, VA
U.S. Fish and Wildlife Service, Cookeville, TN
U.S. Fish and Wildlife Service, Gloucester, VA
U.S. Fish and Wildlife Service, Daphne, AL
U.S. Fish and Wildlife Service, Athens, GA
U.S. Army Corps of Engineers, Savannah District
U.S. Army Corps of Engineers, Nashville District
U.S. Army Corps of Engineers, Memphis District
U.S. Army Corps of Engineers, Wilmington District
U.S. Army Corps of Engineers, Vicksburg District
U.S. Army Corps of Engineers, Mobile District
Economic Development Administration, Atlanta, GA
Advisory Council on Historic Preservation

State Agencies

<u>Alabama</u>
Department of Agriculture and Industries
Department of Conservation and Natural Resources
Department of Economic and Community Affairs
Department of Environmental Management
Department of Transportation
Alabama Historic Commission
Top of Alabama Regional Council of Governments
North-Central Alabama Regional Council of Governments
Northwest Alabama Council of Local Governments

<u>Georgia</u>
Georgia State Clearinghouse
Historic Preservation Division

<u>Kentucky</u>
Department for Local Government
Department for Environmental Protection
Energy and Environment Cabinet
Department for Energy Development and Independence
Department for Natural Resources
Kentucky Heritage Council

Mississippi
Northeast Mississippi Planning and Development District
Department of Finance and Administration
Department of Environmental Quality
Department of Wildlife, Fisheries, and Parks
Historic Preservation Division

North Carolina
North Carolina State Clearinghouse
Office of Archives and History

Tennessee
Department of Environment and Conservation
Division of Water Pollution Control
Division of Air Pollution Control
Division of Natural Heritage
Division of Ground Water Protection
Division of Water Supply
Division of Solid Waste Management
Department of Economic and Community Development
Tennessee Historical Commission
Tennessee Wildlife Resources Agency
First Tennessee Development District
East Tennessee Development District
Southeast Tennessee Development District
Upper Cumberland Development District
South Central Tennessee Development District
Greater Nashville Regional Council
Southwest Tennessee Development District
Memphis Area Association of Governments
Northwest Tennessee Development District

Virginia
Office of Environmental Review
Department of Historic Resources

Federally Recognized Tribes

Cherokee Nation
Eastern Band of Cherokee Indians
United Keetoowah Band of Cherokee Indians in Oklahoma
The Chickasaw Nation
Muscogee (Creek) Nation of Oklahoma
Poarch Band of Creek Indians
Alabama-Coushatta Tribe of Texas
Alabama-Quassarte Tribal Town
Kialegee Tribal Town
Thlopthlocco Tribal Town
Choctaw Nation of Oklahoma
Jena Band of Choctaw
Mississippi Band of Choctaw

Seminole Tribe of Florida
Seminole Nation of Oklahoma
Absentee Shawnee Tribe of Oklahoma
Eastern Shawnee Tribe of Oklahoma
Shawnee Tribe

Individuals

Cal Abel, Chattanooga, TN
Harvey Abouelata, Farragut, TN
Melissa Adams, Knoxville, TN
David Agee, Oak Ridge, TN
Bob Alexander, Nashville, TN
Steven Alexander, Tillson, NY
Suzanne Allin, Knoxville, TN
Jeffrey Anthony, Washington, DC
Brian D. Armitage, Marietta, GA
Charlie Ary, Houston, TX
Kenneth H. Ashby, Hopkinsville, KY
David Axley
Karen Bean
Gordie Bennett, Knoxville, TN
Douglas Benton
David Berry, Houston, TX
Wayne M. Berry
Barney Bishop, Crofton, KY
Douglas Bishop, Nashville, TN
Glen Blazier
Don Bollenbacher, Huntsville, AL
Charles H. Bradford
Dixie Bray, Huntsville, AL
John Brown, Chattanooga, TN
Lance Brown, Montgomery, Alabama
Philip D. Brown
John and Linda Bulla, Nashville, TN
Josh Carlon
John Carter, Knoxville, TN
Tina Carter, Manchester, TN
Carroll Chambliss
Mike Chapman, Columbia, MD
Dana Christensen, Oak Ridge, TN
William Chittenden, St. Ann, MO
Donald B. Clark, Pleasant Hill, TN
Alisa Coe
Kevin Colburn, Missoula, MT
Dargan Cole
William Coleman, Hopkinsville, KY
Scott Collins, Franklin, TN
Creighton Combs, Atlanta, GA
Larry Cooty, Scottsboro, AL
Warren and Louise Cornell, Hopkinsville, KY
Ruth Cox, Fairview, TN
Robert L. Crawford, Knoxville, TN
Cindy Cummings, Hopkinsville, KY
Calvin Daniels, Adairsville, GA
J. T. Davenport
Elizabeth Day, Walton, KY
Don Denney, Cleveland, TN
Jim Dodson, Signal Mountain, TN
Gary Dreadin, Cypress, TX
Victor P. Dura, Rogersville, AL
Brenda K. Eberhart, Chattanooga, TN
Geoff Edelman, Blue Ridge, GA
Chris Estes, Flora, MS
Jim Fehr, Columbus, NE
Amy Fitzgerald, Oak Ridge, TN
Penny Fitzgerald, Gray, TN
Dave Flessner, Chattanooga, TN
Karl Floyd, Kingsport, TN
F. E. Forster
Ronald L. Forster
S. Veronica Fox, Athens, TN
Tami Freedman, Rossville, GA
Gary Garrett, Decatur, GA
Lisa and Kim Gels, Toney, AL
Rebekah Gillespie, Nashville, TN
John Glass, Signal Mountain, TN
Roy A. Glisson
Jerry Golden
Louise Gorenflo
Sandra K. Goss, Knoxville, TN
Wilbert and Gloria Griffith, Mountain City, TN
David Guest
Susan H. Hall
Kim Hammond, Huntsville, AL
Jean Hanson
David Hempfling, Cullman, AL
Sharon L. Hendon, Jasper, TN
Mark Hoepker, Murfreesboro, TN
Stefanie Hoglund, Knoxville, TN
Richard Holland, Nashville, TN

Stephen E. Holland
Arthur Holmgren, Huntsville, AL
George Hopley
Joel Horton, Maryville, TN
Melissa Howell, Henagar, AL
Carl Hudson, Nashville, TN
Jerry L. Huff, Memphis, TN
Douglas B. Hunt, Knoxville, TN
Patrick Hurt
Phil Huss, Smyrna, TN
Joseph A. Imhof, Harvest, AL
Lance Irwin, Maryville, TN
Todd Jackson, Nashville, TN
Don Jarman, Huntsville, AL
Curt Jawdy, Oak Ridge, TN
David S. Johnson, Athens, AL
Elizabeth Johnston
Fred Kaempf
Doug Kallesen, Columbus, NE
Cindy Kendrick, Knoxville, TN
Robert Kieffer, Hopkinsville, KY
Tom Kimmerer, Lexington, KY
George Kitchens, Trinity, AL
Ken Klintworth, Hixson, TN
Sandra L. Kurtz, Chattanooga, TN
Russ Land, Franklin, TN
Marcy Larkin
Michael Lastovic, Huntsville, AL
Rich Lauman, San Francisco, CA
Debbie Leavell, Trenton, KY
John Leka, Huntsville, AL
Kevin Lillard
Jim Lindsey, Nashville, TN
Henry Lorenzo
Audrey Lyke, Kennett Square, PA
Jasmin Lynar, Sydney, Australia
David Maker, Huntsville, AL
Vincent Marascuilo, Cordova, TN
Rob Martin
Tiger Martin
Dana May, TN
Mark McCreedy, Knoxville, TN
Keith McMillion, Soddy Daisy, TN
Loretta McNamee, Powell, TN
Mark Meckel, Nashville, TN
Michael Miles
Annette Molitor, Knoxville, TN
Hank Moseley, Starkville, MS
Glen Moultrie, Chattanooga, TN
Steve Mulroy, Memphis, TN
Steve Noe, Knoxville, TN
Jeff North, Huntsville, AL
J. Gregg O'Brien, Cranberry Township, PA
David O'Keefe
Rebecca Ochalek, Wingo, KY
Yvonne Ortega, Brownsboro, AL
T. Owens, Columbus, NE
Jena Paine, Medina, TN
Dave Park
Cynthia Patton, Memphis, TN
Jerry Paul, Knoxville, TN
Charles Perry, Paris, TN
Robert Pletz, Knoxville, TN
Tim Porter, Cumming, GA
Steve Poteet, Soddy Daisy, TN
Barry Rager, Elkton, KY
Frank Rambo, Charlottesville, VA
David Rapp, Tampa, FL
William J. Ray, Glasgow, KY
Nancy Ream, Cordova, TN
Dan Reese, Johnson City, TN
Ronnie Reeves, Mount Juliet, TN
David Reister, Knoxville, TN
William Reynolds, Chattanooga, TN
Paul F. Rice, Jackson, TN
Jim Riley, Russellville, KY
Nona Riley, Huntsville, AL
Tom Roe, Alexandria, TN
Nancy Rogers
Daniel Ruiz, Sacramento, CA
Donnie Safer, Nashville, TN
Manuel Santo, Houston, TX
Ken Scalf
Stuart Schare, Boulder, CO
Maria Scheller, Fairfax, VA
Kim Scullion
Mark Sharp, Nashville, TN
Donnell A. Shehane, Soddy Daisy, TN
Tamica Shipman, Charlotte, NC
Chris Shugart, Houston, TX
Megan Siems
Jack Simmons, Chattanooga, TN
Michael Skelly, Houston, TX
John B. Smith, Pikeville, TN
Libby Hill Smith, Knoxville, TN
Mollie Smith
Stephen Smith, Knoxville, TN
James W. Snuggs, Chattanooga, TN
Ken Soalf
Katie Southworth
Michael Sparks, Houston, TX

Mary Shaffer Speight, Knoxville, TN
Nancy D. Stafford, Memphis, TN
Jake Standifird
Samuel M. Steffey
Susan Stovall
Derek Sunderman, Lenaxa, KS
Lana Sutton
Wesley Symank, Houston, TX
Judy Takats, Nashville, TN
Charles Thomas, Starkville, MS
Rhonda Truitt
Mike Vernon, Cordova, TN
Alan W. Voss, Signal Mountain, TN
Bill Watkins, Loudon, TN
Lloyd Webb, Cleveland, TN
Howard Weinberg, New York, NY
Kenneth Wilson
Martha and Glen Wilson, Brentwood, TN
L. B. Windley
Tom Winters, Columbia, TN
Evelyn Winther, Knoxville, TN
Wally Witmer, Memphis, TN
Shane Womack, Chattanooga, TN
Jeff Wood, Franklin, TN
Linda Woodcock, Huntsville, AL
Deborah Woolley, Nashville, TN
Louise Zeller, Glendale Springs, NC

11.0 GLOSSARY, ACRONYMS, AND ABBREVIATIONS

Acid Deposition - The deposition of wet or dry acidic chemical compounds from the atmosphere on land or water. Sometimes known as acid rain.

Base Load - The minimum electrical load over a given period of time. It is typically met by large generating plants, often coal-fueled or nuclear, that run continuously at full capacity.

BFN - Browns Ferry Nuclear Plant.

BLN - Bellefonte Nuclear Plant.

BTU - British Thermal Unit, a commonly used unit of energy, especially for fuels or heat. A kilowatt-hour (kWh) is equal to 3412 BTU. MMBTU (or mmBTU) is frequently used to represent one million BTUs.

Capacity - The amount of electric power that can be delivered by a generating unit or electric system, as determined by the manufacturer's nameplate rating or by testing. It is typically expressed in MW.

Capacity Factor - A standard for measuring power plant performance, expressed as the ratio in percent, of a plant's actual output to its maximum potential output.

CCP - Coal Combustion Product, a term for the ash, slag, scrubber waste, and other solids produced by burning coal.

CH_4 - Methane

CO - Carbon monoxide.

CO_2 - Carbon dioxide.

CO_2-eq - Carbon Dioxide Equivalent, the amount of a carbon dioxide that would have the same global warming potential as a given amount of another greenhouse gas.

CCS - Carbon Sequestration and Storage, the capture and permanent storage of CO_2 from large stationary sources.

CEQ - Council on Environmental Quality.

C.F.R. - Code of Federal Regulations.

Cogeneration - The production of electricity and useful thermal energy from a single fuel source. Also known as combined heat and power.

CAES - Compressed Air Energy Storage, an energy storage system that compresses air and stores it underground during periods of low electrical loads. During periods of high electrical loads, the compressed air is released to drive natural gas-fired combustion turbine generators to produce electricity.

CC - Combined Cycle, a generating plant that combines a simple cycle combustion turbine and a heat recovery steam generator, which uses the exhaust heat from the combustion turbine to generate steam which in turn drives a steam turbine-generator. The combustion turbine also drives a generator.

CT - Combustion Turbine, a turbine, typically fueled by natural gas or fuel oil, that drives a turbine and generator to produce electricity.

DEIS - Draft environmental impact statement.

Demand - The amount of electric energy used at a specific point in time.

Demand Response - See Energy Efficiency and Demand Response.

Demand-Side Management - Activities and programs designed to reduce the use of electricity; a synonym for Energy Efficiency and Demand Response.

Demand-Side Resource - An activity that can be used to reduce customer energy demand.

Derate - Lowering the capacity of a generating unit due to factors such as age, loss of reliability, of lack of adequate cooling capacity.

Distributor - A company that usually buys wholesale electricity from a provider and delivers it to individual industrial, commercial, and residential customers.

DO - Dissolved oxygen.

DOE - U.S. Department of Energy.

Ecoregion - A geographic area with characteristic, distinct assemblages of natural communities and species.

EIS - Environmental impact statement.

Energy - The amount of power consumed over a period of time, measured in watt hours.

EEDR - Energy Efficiency and Demand Response, measures to reduce overall electricity consumption without degrading the services provided (energy efficiency) or to shift the use of electricity from high demand to low demand times (demand response).

EPA - Environmental Protection Agency.

EPRI - Electric Power Research Institute.

ESA - Endangered Species Act.

EV2020 - The 1995 TVA *Energy Vision 2020* Integrated Resource Plan and Environmental Impact Statement.

FERC - Federal Energy Regulatory Commission.

FGD - Flue Gas Desulfurization, a technique for removing sulfur dioxide from the flue gas of a coal-fired power plant by using limestone or related compounds. Also known as a scrubber.

Gasification - The process of converting a typically solid fuel such as coal or biomass to a fuel gas.

GHG - Greenhouse Gases, gases whose presence in the upper atmosphere contribute to the greenhouse effect by allowing visible light to pass through the atmosphere while preventing heat radiating back from Earth to escape.

GW - Gigawatt, an amount of energy equal to 1,000 megawatts or 1 billion watt-hours.

GWh - Gigawatt Hour, an amount of energy equal to 1,000 megawatt-hours or 1 billion watt-hours.

GWP - Global Warming Potential, a measure of the potential for a given amount of a greenhouse gas to contribute to global warming.

HAP, Hazardous Air Pollutant, air pollutants that are not covered by ambient air quality standards but that are known or suspected to cause adverse or environmental effects

Hazardous Waste - A waste that poses substantial or potential threats to public health or the environment due to its ignitability, corrosivity, toxicity, or reactivity, or are listed as hazardous by regulation.

High-Level Waste - Highly radioactive waste consisting primarily of spent (used) nuclear fuel.

Highly Enriched Uranium - Uranium containing 20 percent of more of the uranium-235 isotope and typically used in nuclear weapons, in fast neutron reactors, or to produce medical isotopes. It can be blended with low-enriched uranium for use in commercial nuclear power plants.

HRSG - Heat Recovery Steam Generator, a component of a combined cycle plant that produces steam from the heat in combustion turbine exhaust.

HVAC - Heating, ventilation, and air conditioning.

Insolation - Solar radiation (sunshine).

IGCC - Integrated Gasification Combined Cycle, a generating facility combining a coal gasification plant, which converts coal into a synthetic fuel gas, and a combined cycle generating plant. IGCC plants may also be fueled with biomass.

Integrated Resource Planning - A utility planning process that evaluates a full range of supply-side and demand-side resources to reliably and cost-effectively meet the future energy needs of customers.

Intermediate Resource - A generating plant that is used to fill the gap in generation between base load and peaking needs and can change its output as energy demand increases and decreases over time. Typical intermediate resources include combined cycled plants and smaller coal plants.

Interruptible Power - A type of demand-side management in which TVA has contractual rights with a customer to turn off the power when overall demand is high in return for a lower electricity price to the customer.

IPCC - International Panel on Climate Change.

IRP - Integrated Resource Plan.

JSF - John Sevier Fossil Plant.

kV - Kilovolt, one thousand volts

KWh - Kilowatt Hours, an amount of energy equal to 1 thousand watt-hours.

Load - The amount of electricity that is drawn from the TVA system at a given point in time.

Load Shape - The time-of-use of electricity consumption, typically for a 24-hour daily or 8,760-hour annual period.

Low-Level Waste - Trash and other materials that are slightly to moderately contaminated with radioactive material or have become radioactive through exposure to neutron radiation.

MACT - Maximum Achievable Control Technology, an emission standard for air pollutants not covered by the National Ambient Air Quality Standards that requires the maximum degree of emission reduction that the Environmental Protection Agency determines to be achievable.

MBtu - One million BTUs

MW - Megawatt, the amount of power equal to 1,000 kilowatts or 1,000,000 watts.

MWh - Megawatt Hour, an amount of energy equal to 1 thousand KWh or 1 million watt-hours.

MGD - Million gallons per day

NAAQS - National Ambient Air Quality Standards, uniform national air quality standards established by the Environmental Protection Agency that restrict ambient levels of certain pollutants to protect public health or public welfare.

NEPA - National Environmental Policy Act.

NERC - North American Electric Reliability Corporation.

Non-attainment Area - A geographic area that does not meet one or more of the National Ambient Air Quality Standards for criteria air pollutants.

NOx - Nitrogen oxide or nitrous oxide.

NPDES - National Pollutant Discharge Elimination System

NRC - Nuclear Regulatory Commission

NREL - National Renewable Energy Laboratory

NRHP - National Register of Historic Places.

NWS - National Weather Service

PC - Pulverized Coal, a type of coal-fired generating plant in which finely ground pulverized coal is injected into the boiler.

PM - Particulate Matter, typically expressed as PM_{10}, airborne particulate matter less than 10 micrometers in diameter, and $PM_{2.5}$, particulate matter less than 2.5 micrometers in diameter.

Peak Load - The maximum load experienced during a given period of time (often a day). It is often met by generating plants that can rapidly change the amount of electricity they generate, such as combustion turbines, conventional hydroelectric generation, and energy storage facilities.

PPA - Power Purchase Agreement, a contractual right to the capacity and output of generating facilities not owned by TVA.

PVRR - Present Value of Revenue Requirements, the current value of the total expected future revenue requirements associated with a particular resource portfolio.

PSH - Pumped Storage Hydro, a hydroelectric plant consisting of two reservoirs at different elevation connected by an underground tunnel or pipes, and a reversible pump/generator unit. When demand for electricity is low, water from the lower reservoir is pumped to the upper reservoir. When demand is high, water is released from the upper reservoir to generate electricity.

PURPA - Public Utility Regulatory Policies Act.

PV - Photovoltaic, a method of generating electricity by converting solar energy into direct current electricity using semiconductors, typically embedded in flat panels.

SCPC - Supercritical Pulverized Coal, a more modern and efficient version of a pulverized coal plant in which the boiler operates at supercritical pressures of more than 3,200 pounds per square inch.

Scrubber - See Flue Gas Desulfurization.

Scrubber Sludge - The effluent from a scrubber (flue gas desulfurization system) composed mostly of calcium sulfate. It is typically stored in a landfill or, as synthetic gypsum, used in making wallboard.

SCR - Selective Catalytic Reduction, a method of reducing emissions of nitrogen oxides by using a catalyst to promote the reaction between nitrogen oxides and ammonia or urea to produce molecular nitrogen and water.

SNCR - Selective Non-catalytic Reduction, a method of reducing emissions of nitrogen oxides by injecting ammonia or urea into the hot flue gas to reduce the nitrogen oxides to molecular nitrogen and water.

SF_8 - Sulfur hexafluoride.

SO_2 - Sulfur dioxide.

SQN - Sequoyah Nuclear Plant.

Supply-Side Resource - An energy resource that meets customer needs by generating electricity.

TSP - Total Suspended Particulates.

TVA - Tennessee Valley Authority.

U.S.C. - United States Code.

USCCSP - U.S. Climate Change Science Program.

USDA - U.S. Department of Agriculture.

VOCs - Volatile organic compounds.

Volt - The unit of electromotive force of electric pressure analogous to water pressure in pounds per square inch.

Watt - A unit of power, defined by the International System of Units as one joule per second.

WBN - Watts Bar Nuclear Plan

INDEX

Environmental Impact Statement for TVA's Integrated Resource Plan

TVA's Environmental & Energy Future Comments

March 2011 | Volume 2

TVA

Document Type: EIS-Administrative Record
Index Field: Final Environmental Impact Statement
Project Name: Integrated Resource Plan
Project Number: 2009-19

Final Environmental Impact Statement for TVA's Integrated Resource Plan

TVA's Environmental & Energy Future

March 2011 | Volume 2

Responses to Comments on the DEIS

Tennessee Valley Authority
1101 Market Street Chattanooga, TN 37402-2881

TABLE OF CONTENTS

VOLUME 2

RESPONSES TO COMMENTS ON THE DEIS

CHAPTER 1

1.0 INTRODUCTION

The Draft Integrated Resource Plan (IRP) and Environmental Impact Statement (EIS) were issued to the public on September 15, 2010 and the notice of their availability was published in the *Federal Register* on September 24, 2010. This initiated a 45-day public comment period. At the request of several people interested in commenting of the drafts, the comment period was extended to 52 days and closed on November 15, 2010.

The Draft IRP and EIS were posted on the project website. Printed copies and/or CDs containing electronic files of the documents were mailed to state and federal agencies and to others upon request. Others on the project contact list were mailed or e-mailed notifications of the availability of the documents and instructions on how to submit comments. At their request, many people receiving these notices were mailed either printed copies or CDs of the draft documents.

TVA accepted comments submitted through an electronic comment form on the project website, and by mail and email. During the comment period, TVA held five public meetings (see table below) to describe the project and to accept comments on the Draft IRP and EIS. TVA staff presented an overview of the planning process and draft results. Attendees then had the opportunity to make oral comments and ask questions about the project. A panel of TVA staff responded to the questions. Stakeholders could also participate in the meetings via webinar and TVA responded to comments and questions submitted by webinar participants in the same manner as those from in-person attendees. About 125 people attended these public meetings in person and 43 attended by webinar.

Public Meetings Held in 2010 Following Release of Draft IRP and EIS.

Date	Location
October 5	Bowling Green, KY
October 6	Nashville, TN
October 7	Olive Branch, MS
October 13	Knoxville, TN
October 14	Huntsville, AL

TVA received 501 comment submissions, which included letters, form letters, emails, oral statements, and submissions through the project website. Almost 300 of these comment submissions were one of five different pre-printed postcards distributed by a stakeholder organization. TVA carefully reviewed all comment submissions and identified the specific comments about the IRP and EIS contained in each of them. Specific comments received in different comment submissions that addressed the same issues and concerns were synthesized into comment statements. The result of this analysis and synthesis process is a list of 372 individual comments to which TVA has provided responses in Chapter 2 of this volume. The comments and responses are categorized into 27 different topics. Many of these topics are further categorized into different issues.

The most frequent comment statement commended TVA for undertaking the integrated resource planning process and urged TVA to repeat it at regular, more frequent intervals. The topical areas with the most comments statements were Energy Efficiency and Demand Response, Renewable Energy, and Nuclear Energy.

CHAPTER 2

2.0 RESPONSES TO COMMENTS

2.1. Air Quality

2.1.1. Air Quality Impact Assessment

1. DEIS Summary page S-15 and Section 7.6.1 page 179 note that under all alternative strategies, there will likely be a substantial beneficial cumulative impact on regional air quality. Hazardous air pollutants (HAPS) generally have local rather than regional impacts and while regional air quality benefits are important, they should not be used to justify or offset increases in local concentrations of HAPs. (*Commenter: Heinz J. Mueller - EPA*)

Response: While some hazardous air pollutants may have localized impacts rather than regional impacts, reduced generation from coal plants will result in reduced emissions of hazardous air pollutants with beneficial impacts both in the vicinity of those plants and regionally.

2. The air quality analysis in DEIS Chapter 7 focuses on criteria air pollutants and greenhouse gases, with minimal mention of hazardous air pollutants. Given the large emissions of HAPs from TVA facilities, they should be addressed in more detail. (*Commenter: Heinz J. Mueller - EPA*)

Response: Unit-specific information would be necessary to evaluate possible hazardous air pollutant impacts in great detail. In addition, as the preceding comment states, some HAPS could have more localized effects that would require consideration of local terrain and conditions, including site-specific ambient air quality modeling. Analyses at this level are typically done for project- or site-specific actions. While such analyses could provide additional information about HAPs issues, this would not necessarily be very useful at the programmatic level of review and decision making here. As stated in the description of the scenarios, TVA anticipates that EPA will require the installation of Maximum Achievable Control Technology for HAPs at coal-fired power plants. The installation of these controls, as well as the reduction in generation from coal plants, will result in significant reduction in HAPs emissions under all of the alternative strategies evaluated in the IRP. These reductions vary most depending on the number of coal units idled. From a strategic or programmatic perspective, this is what is important for decision-making purposes.

3. While the DEIS describes TVA's emissions of air pollutants, it does not adequately address the effects of the continued emissions of air pollutants that would occur under the alternative strategies. The continued operation of over 10,000 MW of coal-fired generating capacity would result in the continued emissions of large amounts of SO_2, NOx, PM2.5, and hazardous air pollutants for two more decades. (*Commenter: Abigail Dillen - Earthjustice*)

Response: The Environmental Strategic Indicators developed for each of the strategies considered include the total emissions, both from new generation sources and from existing generation sources that remain in operation. The EIS evaluates the environmental impacts of all of the resources included in the Recommended Planning Strategy.

2.1.2. Clean Option (not fossil)

4. Adopt a plan that aggressively develops the Valley's cleaner alternative energy sources, particularly solar, wind and bioenergy resources. Developing these resources will create jobs, strengthen local economies and create a clean, healthier environment for all Valley residents. (*Commenter: Erin Ouzts*)

Response: Comment noted.

2.1.3. NAAQS

5. DEIS pages 70-73 do not discuss the non-attainment status of the Chattanooga and Knoxville areas for PM2.5. (*Commenter: Heinz J. Mueller - EPA*)

Response: The Chattanooga and Knoxville non-attainment areas for PM2.5 are shown in Figure 4-8 of the Draft and Final EISs. The text in the Final EIS has been revised to mention these non-attainment areas.

6. DEIS Summary page S-15 and Section 4.3 page 70 incorrectly state that the only non-attainment area in the TVA region for PM 2.5 is a few counties in the eastern part (Chattanooga and Knoxville). Knoxville is also currently non-attainment for the 1997 8-hr ozone standard, but has clean data and EPA has proposed redesignation to attainment. (*Commenter: Heinz J. Mueller - EPA*)

Response: Comment noted. The text of the Final EIS has been revised to mention the PM2.5 non-attainment area. EPA has proposed the Knoxville ozone non-attainment area be re-designated as attainment, though the action has not yet been finalized.

7. The DEIS page 75 discussion of lead does not mention that Bristol, TN has a violating monitor for the 2008 lead standard. This area will soon be designated non-attainment for lead. (*Commenter: Heinz J. Mueller - EPA*)

Response: The text of the Final EIS has been revised to state that part of Sullivan County, Tennessee, was designated as non-attainment for the 2008 lead standard on November, 16, 2010.

2.2. Alternative Energy / Advanced Generation

2.2.1. Fuel Cells

8. TVA should incorporate the use of fuel cells into its plan. They are efficient, very clean, and provide the benefits of distributed generation and combined heat and power. (*Commenter: Regina Jay*)

Response: TVA recognizes the potential benefits of distributed generation and combined heat and power using sources such as fuel cells. Fuel Cells were evaluated during the IRP options screening process and eliminated from further consideration due to their small scale, current lack of proven, commercial availability, and high cost. TVA will continue to monitor the development of fuel cells and assess them for consideration in future IRPs.

2.2.2. Heat Differential Generators

9. TVA should install secondary heat differential-operated turbines using refrigerants on waste heat streams from existing thermal plants. These systems can operate with about a 10º C temperature differential and are in use with solar ponds and sea water temperature differentials around the world. (*Commenter: Paul Noel - NEC*)

Response: Secondary heat differential-operated turbines refer to technologies such as Ocean Thermal Energy Conversion, or OTEC. The low OTEC temperatures result in low efficiencies and low operating pressures; as a result, plant sizes are much larger than conventional plants of the same generating capacity and capital costs are correspondingly higher. TVA continues to follow waste heat utilization technology, has developed and patented a technology to use low temperature waste heat, and is currently investigating cost effective applications within TVA's system. As these systems become commercially viable they will be considered in future IRP studies.

10. Waste heat recovery is dismissed as a potential energy resource or energy efficiency measure (see DEIS Table 5-1). Recent developments in this area, including organic Rankine cycle methods, are highly efficient and show great potential. We urge TVA to reconsider the inclusion of this resource. (*Commenter: Lawrence Carroll*)

Response: The potential for significant amounts of new generation from waste heat sources is limited. While it was not included as an option that TVA would consider constructing and operating, it is, as stated in DEIS Table 5-1, a potential source of power acquired through power purchase agreements. TVA continues to follow waste heat utilization technology (such as the organic Rankine cycle), has developed and patented a technology to use low temperature waste heat, and is currently investigating cost effective applications within TVA's system. As options become commercially viable they will be considered in future IRP studies.

2.3. Coal

2.3.1. Coal Plant Air Pollutants

11. Although TVA has reduced its emissions of air pollutants by installing improved controls on coal-fired plants, TVA remains a major primary source of sulfur dioxide, nitrous oxides, and small particles. (*Commenter: Michael J. Crosby - TEC/BCAAT*)

Response: Comment noted. All of the strategies under consideration will result in significant reductions of these air pollutants.

12. TVA should commit to reducing the air pollutant emissions at all fossil fuel power plants that are not idled. This would require installing scrubbers and other pollution control systems at all plants by 2015. (*Commenters: Jeff Deal, Sheila Green - NCDA, Chris Pamplin, James Randolph*)

Response: All of the strategies considered in the Final IRP and EIS result in significant long-term reductions of SO_2, NOx, and mercury of about 60% between 2010 and 2015. The primary factors contributing to these emissions declines are the reduced coal-fired generation from idling of coal units and the installation of additional emission control systems on coal units that continue to operate. About half of TVA coal units are presently equipped with FGD and SCR systems. These are the largest units on the TVA system and are typically operated in base load mode. This proportion will increase in the future as the coal units expected to continue operating are individually evaluated for the need and feasibility of additional emission controls.

2.3.2. Coal Plant Layups/Retirement

13. Reduce reliance on coal-fueled generation as quickly as possible. The use of coal results in adverse economic, environmental, and human health effects. TVA's use of coal also ships billions of dollars out of the Valley to pay for coal. Alternative sources can be developed quickly and cost-effectively. (*Commenters: Lisa Archer, Lain Arubin [sic], Moonis Roger Axley [sic], Lauren B. [sic], M. B. [sic], Paul Bevney [sic], Melissa A. Burt, Margie Buxbaum, Jason Campbell, Mike Chapman - ME/KE, Brenda Chinck [sic], Chris Christie, Mary H. Clarke - TCV, Arqunsia Cornwall, Gary D. [sic], Lacy Damiles [sic], Jeff Deal, April Dixon, Laura Elis, Kathleen Ferris - BEST/CENDIT, Charles Foster, Shanequa Fountain, Robin L. Gerahann [sic], Nancy Givens - WKU/KSES/BGGP, P.N. H. [sic], John Hamilton, Rita Harris - SC, Whitaker M. Haskins, Redel Hesh [sic], Christine Johnson - LSE, Glenda Jordan, Ivan Juny [sic], Sam K. [sic], Sandra Kurtz - BEST, Gloria Lathem-Griffith - MEC, Michael Lussier, Burton Mandrell [sic], Nancy McFadden, J. Michael Meece, Austin Milt, Erin Ouzts, Linda Park, Barbara Peach, Erwin Peritt [sic], W. J. Pruit, Cody R. [sic], James Randolph, Gordon Robinson, Kevin Routan - CGSC, Don Safer - TEC, Grace Safer, Don Scharf, Jack Slede [sic], Michelle Smith, Kathy Stone [sic], Danville and Beverly Sweeton, Gary Verst - SC, B.S. Vick [sic], Chuck Walker, Sue A. & Steven M. Williams, Bruce Wood - BURNT, J. Y. [sic], Louise A. Zeller – BREDL*)

Response: Comment noted. The alternative strategy in the final IRP and EIS that staff is recommending to the TVA Board includes the idling of 2,400 to 4,700 MWs (net dependable capacity) of coal capacity.

14. The draft IRP and EIS do not adequately describe the criteria used to determine which coal plants would be idled. The EIS states that candidate plants generally had “high operating costs and high anticipated environmental compliance costs.“ The environmental compliance issues and their associated costs, however, are not described. Without this information, it is not possible to determine whether the costs were estimated fully and reasonably. (*Commenters: Michelle Bloodworth - ANGA, Frank Rambo - SELC*)

Response: The evaluation of coal units for idling considers nine key elements: operating cost, equivalent forced outage rate (EFOR), transmission impacts, remaining clear air capital, fixed O&M and yearly plant capital, future ash handling costs, fuel flexibility, required capital improvements, and CO_2 intensity. These are described in ‘An Overview and Evaluation of the Fossil Fleet’ presented to the Stakeholder Review Group on June 29, 2010. The presentation is posted on the IRP website. The financial impact on TVA for each of the nine factors was determined for each unit to develop a relative merit ranking. Other qualitative considerations will also be factored into final decisions. These considerations may influence a decision to retire more or fewer units than indicated by the quantitative ranking process. These other considerations include power system reliability, overall portfolio design and diversity, local area considerations, local employment and economic impacts, and age of the units. Additional detailed studies related to fossil unit idling will be performed during the implementation of the selected strategy.

15. TVA has announced that it will idle up to two units at Widows Creek by 2011. Given the age of the other Widows Creek units, how many of them does TVA plan to idle during the IRP planning period? (*Commenter: Thad Huguley - HCG*)

Response: On August 24, 2010 TVA formally announced plans to idle the six small units at Widows Creek. Two units will be idled in FY 2011, and four other units there will be idled between 2011 and 2015. The two largest and newer units, Units 7 and 8, are proposed to continue operating throughout the IRP planning period. Both of these units have selective catalytic reduction (SCR) systems for NOx control and flue gas desulfurization (FGD) scrubbers for SO_2 control.

16. Which coal plants are considered “must run” due to transmission constraints/load pockets? If there are “must run” plants, has TVA performed studies to compare the cost of upgrading the plants with the cost of upgrades to remove the transmission constraints? If so, what are the results of the studies? (*Commenter: W.R. Kendrick*)

Response: TVA has no coal plants that are classified as “must run” due to transmission constraints or load pockets. The effects on the transmission system are an important consideration in TVA’s ongoing studies to determine which coal plants are candidates for idling.

2.3.3. Coal Price and Supply Forecasts

17. Reports have recently been published about a potential 'Peak Coal,' the point at which the maximum extraction of coal is reached and production declines. How will TVA respond if this Peak Coal occurs during the lifespan of the coal facilities considered in the IRP? (*Commenter: Don Richardson - SC*)

Response: TVA monitors developments in coal mining and transportation on an ongoing basis. At this time, available data indicate there are enough economically recoverable coal reserves for all U.S. coal facilities to be operated beyond their current economically useful lives. If this starts to change, TVA’s monitoring should detect this in time to mitigate possible adverse effects. The fact that TVA has a diverse portfolio of generating assets would help TVA make adjustments.

18. While TVA assumes that the future price of natural gas will be volatile, TVA seems to be assuming that the future price of coal will remain relatively stable. This point was reiterated by a TVA staff person at one of the public meetings on the draft IRP. An examination of coal price history shows that while coal prices can remain stable for long periods, they can dramatically increase with the price of oil and natural gas. In 2008, a 128% increase in TVA's coal prices resulted in a rate increase. Since 1972, the ratio of natural gas prices to coal prices has averaged about 2.1. Therefore TVA should consider natural gas and coal to have approximately equal future price volatility. (*Commenter: Mike Chapman - ME/KE*)

Response: TVA updates coal and gas forecasts during each business planning cycle on an annual basis. Forecasts for each fuel are produced with ranges and reflect both current and expected market conditions at the time of each fuel forecast. The next IRP is scheduled to incorporate the latest available information near the 2015 timeframe.

2.3.4. Coal Waste

19. The DEIS does not assess and disclose the risks associated with the disposal of coal waste, including coal ash and scrubber sludge. It also acknowledges the need for additional coal waste storage areas, but does not describe the impacts of these storage areas. (*Commenters: Dana Beasley Brown, Abigail Dillen - Earthjustice, Annette Gomberg*)

Response: Potential environmental impacts from the disposal of coal ash and scrubber sludge include the change in land use and habitat resulting from the construction of the storage areas, particulate emissions during transportation and disposal, impacts to surface waters from suspended solids, metals, and other compounds in runoff, and impacts to groundwater from leaching and infiltration. TVA is taking steps to mitigate these impacts at current and planned coal ash and scrubber sludge disposal areas, as well as working to increase the beneficial reuse of these materials to reduce the volume landfilled. TVA's preferred strategy involves idling a large amount of coal capacity. If this is done, the amount of coal waste that would have to be managed would be substantially reduced.

Cost of Environmental Compliance Upgrades

20. The draft IRP gives little information on the cost of emission controls and other plant upgrades necessary to meet current and anticipated environmental regulations. We are concerned that TVA has not sufficiently analyzed these costs. Several studies suggest that in many cases adding controls to many uncontrolled coal plants is not cost effective. TVA's recent projection of upgrade costs of $4.2 billion over the next decade (in 2009 TVA Form 10-K) is likely an underestimate as it does not include anticipated CO_2 requirements or the proposed Clean Air Transport Rule. (*Commenters: W.R. Kendrick, Lanny Night, Peter Robertson - ANGA*)

Response: All IRP scenarios were designed to conform to likely regulatory requirements, including additional NOx and SO_2 reductions, via requirements like the Clean Air Transport Rule. Similarly, carbon emission reduction requirements and the costs of meeting these requirements were included in all but one IRP scenario. The costs of these emissions reductions (i.e., control equipment) are significant and were a major factor in removing Strategy A from further consideration. Under Strategy A, all of TVA's coal-fired units would have been controlled and would have continued to be operated.

2.3.5. Mountaintop Removal Mining

21. Stop the use of coal mined by mountaintop removal methods. Mountaintop removal mining results in significant adverse environmental impacts. (*Commenters: Lisa Archer, Margie Buxbaum, Jason Campbell, Lawrence Carroll, Jeff Deal, Nancy Givens - WKU/KSES/BGGP, John Hamilton, Nancy McFadden, J. Michael Meece, Linda Park, James Randolph, Don Safer - TEC, Grace Safer, Don Scharf, Fred Stanback, Danville and Beverly Sweeton, Bruce Wood - BURNT, Edward Zuger - CCSC III*)

Response: Comment noted. TVA uses relatively little coal that is produced using mountaintop removal techniques. As shown in Section 3.3 of the FEIS, approximately 1.5% of the coal TVA is purchasing in 2011 is produced in the Central Appalachian mining region by mountaintop removal methods. In 2010, 4% of the coal was mined by mountaintop removal methods. Because of the high BTU and low sulfur content characteristics of the Central Appalachian region coal, it is predominantly burned in TVA's older unscrubbed units. As many of these coal units are idled, the quantity of Central Appalachian region coal, including that produced by mountaintop removal, will decrease.

22. The DEIS does not adequately describe the impacts of coal mining, including mountaintop removal mining. Under all alternative strategies, TVA will use nearly a billion tons of coal over the next 20 years and the mining of this coal will cause widespread impacts. (*Commenter: Abigail Dillen - Earthjustice*)

Response: A detailed description of the impacts of coal mining is beyond the scope of this EIS. The impacts of mountaintop removal mining are described in detail in the citations in Section 7.6.4 of the Final EIS.

2.4. Cost of Power

2.4.1. Cost by Type of Generation

23. What is the current average costs of power to TVA for each type of generation (coal, natural gas, nuclear, hydro, wind, solar, biomass, diesel)? (*Commenter: Russ Land*)

Response: The average cost of power varies depending on unit operating characteristics, utilization, and changes in assumptions regarding fuel prices and availability, among other factors. Often comparisons among generation types are done using a levelized cost of electricity (LCOE) value to provide a more consistent basis for understanding cost differences between technologies. Following are LCOE values in $/MWh for technologies considered in the IRP study: Coal - $125, Nuclear - $71, Gas CC - $120, Gas CT - $250, Wind - $70, Solar - $295, and Biomass - $73.

Purchases from Outside the TVA Region

24. How much did TVA spend for purchases of fuel and power from outside the TVA region last year? (*Commenter: Stephen Levy - TSEA*)

Response: TVA spent $2.7 billion during FY 2010 on fuel and purchased power from sources outside of the TVA service region. About two-thirds of this expense is attributable to coal; these coal purchases were made from 8 different coal-producing states to meet environmental requirements and supply the lowest fuel cost for TVA customers.

25. How much did TVA spend for the disposal of wastes outside the TVA region last year? (*Commenter: Stephen Levy - TSEA*)

Response: During FY 2010, $126,755,000 million was spent for the transport and disposal of coal wastes from Kingston to outside the TVA region.

2.4.2. Rate Equity

26. TVA's recently adopted peak pricing rate structure favors large users and discriminates against heads of households who have relatively little ability to reduce power use during peak periods. These heads of households have also born the brunt of seven rate hikes in the last decade, including one resulting from short-sighted decisions at Browns Ferry Nuclear Plant. These rate policies violate the TVA Act which is supposed to protect households from price gouging. (*Commenter: Laurence T. Britt*)

Response: Both residential and industrial customers were moved off of flat, non-temporal rates and onto rates that were differentiated by time of day and season of the year in order to bring about better alignment between TVA's production costs and customers' consumption decisions. Residential customers were provided two rates—one which included time of day and season of the year differentials; another that provided only seasonal differentials (i.e., prices remained flat within the day). In both cases, however, the differentials in rates (daily or seasonally) were very small. While both rates (daily and seasonal) are available at the onset, the seasonal-only rate will go away at some future date leaving all residential customers with a time of day varying rate only. Residential customers should see very little change in rate structure as a result of these actions. In contrast, industrial customers received the same structural changes with two notable exceptions: (1) time of day and season of year differentials are more substantial and (2) their option to elect a seasonally-differentiated-only rate option will remain available for the foreseeable future.

2.5. Distributed Generation

2.5.1. Distributed Natural Gas Generation

27. Promote smaller, local distributed natural gas generation instead of large, centralized natural gas plants. Inexpensive distributed plants can be built with high public acceptance, scaled to commercial and neighborhood needs, and be unobtrusive. They can provide electricity and the waste heat can be used for HVAC and hot water needs. (*Commenter: Paul Noel - NEC*)

Response: TVA did consider several resource options in varying detail that would lend themselves to a distributed generation use such as small gas turbines, microturbines, reciprocating engines and fuels cells. Such energy options could be used by TVA in the future in a dispersed generation mode. TVA anticipates that the next IRP will explore in more detail the merits of those dispersed generation energy options.

2.5.2. End User Generation

28. Are there TVA customers that generate more electricity than they consume and do not have contracts to sell their excess power to TVA? If so, how much excess power do these customers generate? (*Commenter: Russ Land*)

Response: All power generated by a facility enrolled in the Generation Partners program is transmitted to the power grid. TVA does not track the amount of generation customers generate with other facilities and consume for their own use.

2.5.3. Effect of Plan on Economic Development in TVA Region

29. Adopt a plan that maximizes the economic development of the TVA region through creation of clean energy jobs/green jobs. Developing the Valley's energy efficiency and renewable energy resources creates local jobs, supports the clean energy efficiency industries located in the Valley, reduces our monthly power bills and strengthens local economies. (*Commenters: Debra K. Agner, Lisa Archer, Grace Ashford, Brent Bailey - 25X25, Cameron Z. Bennett, Kelvin Butler, Jason Campbell, Torri Dunn, Robyn Galochee [sic], Donald Gilligan - NAESC, Joshua Guthrey, Daniel Joranko - TAP, R.R. Karpsal [sic], Eric Lewis, Selma Marks [sic], Nancy McFadden, John M. Nald [sic], Aesthor Nievons [sic], Paul Noel - NEC, Ann Olsen, Don Safer - TEC, Grace Safer, Don Scharf, Jane L. Shelton, Jack W. Simmons - TVPPA, Jennifer Sneed, Lynn Strickland - PS, Paulrann P. Stocks [sic], Danville and Beverly Sweeton, G.R. W., Chad Watters [sic]*)

Response: Comment noted. In recent years, TVA has experienced great success in the continued growth and development of the clean energy industry. TVA has been an active partner in recruiting major clean energy manufacturing operations to the TVA region, including Wacker-Chemie, Hemlock, and Confluence Solar, all of which are instrumental to the further growth of the Valley's clean energy economy. Additionally, TVA has seen recent exponential growth in the generation of renewable energy in the TVA region through the Generation Partners program and anticipates additional growth through the new Renewable Standard Offer program. The recent increase in EEDR efforts has also resulted in increased local green jobs. These increases are anticipated to continue under most of the planning strategies. At the scale of the total regional economy, however, the differences in total employment and income among the alternative strategies are relatively small, as described in Section 7.6.7 of the Final EIS.

30. Adopt a plan with the least expensive sources of power supply that will result in the least expensive power rates. This will promote a more robust economy and raise the standard of living in the TVA region. (*Commenter: Gray Cassity - BES*)

Response: The goal of the IRP is to produce the least cost plan that finds the best balance of providing competitive rates, delivering reliable power, and meeting our commitment to environmental stewardship. While not resulting in the least expensive possible rates, the recommended strategy finds that best balance and is consistent with TVA continuing to provide low-cost power.

31. Continue the region's leadership in the clean energy jobs sector by helping to create a synergy between local clean energy manufacturing and the production of clean energy through funding or incentivizing the creation of clean energy facilities and the installation of clean energy technologies. (*Commenter: Daniel Joranko - TAP*)

Response: Comment noted. Please see the response to Comment 29.

32. Solar energy is rapidly increasing its role as a major economic driver in the TVA region, particularly in Tennessee. Because of the small amount of solar generation included in the IRP strategies, TVA does not appear to be taking full advantage of the regional solar potential. (*Commenters: Donald L. Audley [sic], Annette Gomberg, Andrew Johnson - TSEIA, Scott Wills - TTCGC*)

Response: IRP planning strategies were developed to test a broad range of business options that TVA could adopt, including renewable additions. New renewables incorporated into the IRP were based on two given portfolios amounts: 2,500 and 3,500 MWs, respectively. These amounts do not represent resource potentials; rather, reasonable deployment schedules for various resource capacities were developed based on cost, technological maturity, regional resource availability, diversified resource portfolio, and anticipated federal legislation/regulation and tax policy factors. TVA recognizes that solar energy potential in the region (and around the world) is largely untapped, not because of limited solar resources, but due to the cost of deployment of solar technology compared to other power generation technologies. Currently, the largest driver of solar energy development in the United States are: (1) state renewable portfolio standards; (2) federal tax grants/credits to subsidize the nation's development of solar energy; and (3) state tax incentives (grants, loans, rebates) to subsidize in-state development of solar energy. With the exception of North Carolina, there are no mandatory state renewable portfolio standards in effect in TVA service territory. There are some state-level incentive programs for solar energy in the region. More information on these incentives can be found at: http://www.dsireusa.org/. Notably, TVA currently offers significant incentives for deployment of distributed small-scale (less than 200 kW) solar installations and generation through the Generation Partners program. In late 2010, TVA also issued a renewable energy standard offer to purchase renewable energy, including solar, for larger-scale projects from 200 kW to 20 MW. According to data from a Photon International survey of 170 manufacturing companies, the United States manufactured 4.4% of worldwide photovoltaic (PV) cell production in 2009, compared to 5.5% in 2008. Nevertheless, the solar PV market is growing rapidly and there is an opportunity for both new and existing businesses based in the Tennessee Valley to capture an increasing share of the growing worldwide market. Manufacturers of solar components with the lowest costs of production will be in the best position to grow their market share. TVA's vision to produce low-cost and cleaner energy will help to provide a market for regional manufacturers of solar components while also providing the same manufacturers with a competitive edge needed to export their products to other parts of the country and throughout the world.

33. Studies by the University of Tennessee's Bio-based Energy Analysis Group and others have found that increased development of renewable energy in the TVA region would result in significant benefits to the agricultural and forestry sectors and economic development in rural areas. We encourage TVA to develop and utilize local biomass resources. (*Commenters: Brent Bailey - 25X25, Courtney Piper - TBLCEE*)

Response: Comment noted. As described in Section 4.17.4 of the Final EIS, the potential biomass fuel resource in the TVA region is large and TVA agrees that its development in a cost-effective and sustainable manner would benefit the agricultural and forestry sectors and promote economic development in rural areas. Existing and future renewable energy resources will play a role in achieving TVA's vision to become one of the nation's leading providers of low-cost and cleaner energy by 2020. In support of this vision, TVA is continuing to evaluate the best overall opportunities for increasing the use of renewable energy on the TVA system and anticipates revising its analyses of renewables in future IRP updates. TVA currently purchases power generated from local biomass by several regional industries (see Final EIS Section 3.4), and the renewable standard offer issued by TVA in 2010 (see Final EIS Section 3.4) could result in TVA purchasing more energy generated from biomass. The alternative strategies evaluated in the IRP and EIS, including the preferred strategy, include an increase in biomass-fueled generation. TVA recognizes, however, that there are a number of logistical, technical, environmental, and economic issues that must be addressed in order to greatly increase biomass-fueled generation. These issue include: the disseminated nature of biomass and the need for dependable fuel delivery infrastructure; low energy density (energy content per volume of material) and high moisture content when compared to fossil fuels; potential need for specialized fuel processing, fuel handling and boiler feed mechanisms and equipment; high delivered fuel cost (cost per unit of energy) that affects total cost of power delivered with adverse impacts on TVA rates; uncertainty over how biomass will be considered in potential federal policies on renewable energy and carbon emissions; required emission control equipment; and the environmental impacts of acquiring and transporting biomass fuels.

34. The TVA states rank near the bottom on many health and social measures such as infant mortality, obesity, education, literacy and health insurance. TVA's economic development programs do not appear to help those most in need. We question whether this new plan will make a difference. (*Commenter: Bruce Wood - BURNT*)

Response: A number of different factors contribute to the ranking of Tennessee Valley states in the categories identified by the commenter. While TVA is not responsible for any of these categories, it has been charged by Congress with improving the quality of life in the region. It has done this primarily through energizing the Valley, bringing electricity to the Valley's institutions, businesses and homes, and doing so reliabily and at affordable prices. This has vastly improved the quality of life in the Valley compared to what it was before TVA did this, especially for those who were and are economically disadvantaged. By continuing to maintain low electricity prices, Valley residents have more income to spend on other things, including the categories identified in this comment. In addition to the benefits resulting from TVA's energy activities, TVA has an active and successful Economic Development program. The goal of this program is to contribute to improving the quality of life in the Valley by helping create and retain quality, high paying jobs and increase capital investment in the business community. By leveraging partnerships with other groups across the Valley including public power distributors, TVA's directly served customers, heads of Economic Development groups at state, regional, and local levels, local communities, state leaders, and elected officials at all levels, we work to help create an environment of sustainable economic growth.

2.6. Economic Impact Analysis

35. The economic impact analysis of the IRP should be broader than the performance metrics based on the cost of electricity. For example, the EIS describes a likely increase in temperature in coming years. As shown in 2007 and 2010, hotter summer weather reduced base load capacity due to derates. Ratepayers were billed more for this as well as their increased air conditioning load. The cost of reducing carbon emissions is incorporated into some scenarios. The long-term economic benefits of the necessary carbon reductions by TVA, as well as the nation, resulting from reduced power consumption and avoidance of necessary mitigation and adaptation do not appear to included in the economic impact analysis. Please consider a more comprehensive long-term economic impact analysis that considers issues such as this. (*Commenter: Arthur Ruggles*)

Response: The economic impact analysis covers the interactions within the regional economy. The potential effect of climate change is indirectly included in the economic analyses. Taking the air conditioning example mentioned, if air conditioning use increases, TVA's load and cost would increase which would result in these costs being reflected in the charges to ratepayers. Households would then have less money to spend on other items and businesses would have greater costs to cover in their operations, resulting in additional effects in the economy. These interactions, also known as the multiplier effect, are reflected within the economic model used to calculate the net economic impact.

The IRP study covers a range of assumptions about carbon emissions and loads, including air conditioning loads. The issue of carbon emissions and its possible climatic, economic, and environmental effects involve substantial uncertainty and are largely driven by national and international considerations.

36. While we support the use of the REMI Policy Insight tool for conducting the economic impact analysis, we are concerned about the assumptions and input data that were used. The explanation of its use in the draft IRP lacks detail. Our concerns include the treatment of energy efficiency, compliance costs, in-Valley renewable generation projects. We are also concerned that its use was limited to the most extreme cases which may have biased

TVA's calculation of the economic impact indicator. We recommend that TVA fully describe the inputs and assumptions used in the REMI evaluation and assess the economic impacts of all strategy/scenario combinations. (*Commenter: Sam Gomberg - SACE*)

Response: TVA has provided additional information about the REMI model in the final EIS. The comment supports the use of the REMI model as a "sophisticated tool" for this type of analysis. TVA agrees that customized detail inputs would help when making decisions about competing specific resource options, programs, and projects. This type of detailed analysis has been conducted and presented in the EIS at the project level. In Energy Vision 2020, TVA's 1995 IRP, even though such level of detail was used, the conclusion of the economic impact analysis was that none of the strategies exhibited a significant impact on the TVA region economy. Thus, for the current IRP EIS, the process was to first conduct the analysis at a more aggregate level of detail to determine if any of the strategies exhibited a significant impact on the TVA region economy and/or results different from those of Energy Vision 2020. If significant impacts or results at variance with Energy Vision 2020 were found for any of the strategies, then a more detailed analysis would have been conducted. However, the economic impact analysis for the current IRP exhibited impacts that were not significant to the TVA region economy, consistent with the findings in Energy Vision 2020.

2.7. Editorial Comments

2.7.1. Errors in Draft EIS

37. DEIS Page 172 describes life-cycle GHG emissions of U.S. nuclear plants as "12 to 61 tons CO_2e/GWh with an average of 22.2 tons CO_2e/GWh." The cited Sovacool (2008) reference reports a range of 1.4 grams of CO_2e per kWh (g CO_2e/kWh) to 288 g CO_2e/kWh, with an average value of 66 m CO_2e/kWh. This correlates to a range of 1.5 to 317 tons CO_2e/GWh, with an average of 73 tons CO_2e/GWh (assuming one ton = 907.185 g). We recommend TVA re-evaluate the literature to ensure the accuracy of the stated range of values. (*Commenter: Heinz J. Mueller - EPA*)

Response: The values from Sovacool (2008) used in describing life-cycle GHG emissions were those listed in Table 4 for plants in the United States. This has been clarified in the text of the Final EIS, which now lists the range and mean for nuclear plants worldwide, as well as the range of 17 to 61 tons CO_2e/GWh and mid-point of 39 tons CO_2e/GWh for U.S. nuclear plants.

38. DEIS Page 176 states that Spath and Mann (2004) calculated an emission rate of -452 CO_2-eq/GWh for a 60 MW direct-fired boiler using wood waste. The mass units for the emissions are not stated. The Spath and Mann report gives a value of -410 g CO_2e/kWh for a 600 MW biomass direct-fired reference case. Please review and confirm the various values, particularly those used for conversions. (*Commenter: Heinz J. Mueller - EPA*)

Response: The omitted mass units should have been tons CO_2-eq/GWh. This omission has been corrected in the Final EIS.

39. DEIS page 203, Section 7.7, the first sentence appears to be a mistake (the adoption of an alternative strategy has no environmental impacts). All realistic alternative strategies will have some environmental impacts. (*Commenter: Heinz J. Mueller - EPA*)

Response: The Final EIS has been revised to note that the action of adopting an alternative strategy does not result in direct environmental impacts. As stated in the EIS, the subsequent actions taken in implementing the alternative strategies do have environmental impacts, some of which may be adverse.

40. DEIS Table 4-9, page 96, omits some fish consumption advisories. These include the Clinch River portion of Norris Reservoir, Hiwassee River embayment of Chickamauga Reservoir, South Holston Lake, Watauga Lake, Cherokee Lake and Douglas Lake. (*Commenter: Bob Alexander*)

Response: The fish consumption advisory table in the Final EIS has been updated to include the listings from advisories issued in 2010 by Alabama, Georgia, and Tennessee.

41. On DEIS page 186, second paragraph, last sentence, last phrase (after the semicolon) seems to be an incomplete statement. (*Commenter: Heinz J. Mueller - EPA*)

Response: This error has been corrected in the Final EIS.

42. On DEIS page 59, the last part of the last sentence of the first paragraph is separated from the remainder of the sentence by an intervening paragraph. (*Commenter: Heinz J. Mueller - EPA*)

Response: This error has been corrected in the Final EIS.

43. On DEIS page S-13, the table key for this summary table could have defined 'EEDR' as 'Energy Efficiency and Demand Response', as defined in the DEIS Glossary, Acronyms and Abbreviations section. (*Commenter: Heinz J. Mueller - EPA*)

Response: EEDR was previously defined as Energy Efficiency and Demand Response in the EIS summary, and the intent of this table key entry is to describe the model input units. This description has been revised in the Final EIS to include 'Energy Efficiency and Demand Response.'

44. On DEIS pages 158-160, the Table 6-5 and 6-6 headings use 'Fossil Layups' while Table 6-4 uses 'Coal Layups'. Is there an intended difference, such as the layup of natural gas plants in addition to coal plants for Strategies C and E? (*Commenter: Heinz J. Mueller - EPA*)

Response: These headings should all have used 'Coal Layups' in order to better describe the types of plants considered for layups. To better align with industry-standard terminology, the term 'layup' has been replaced with 'idle' in the Final IRP and EIS. TVA has no plans to idle any natural gas units.

45. The DEIS Table of Contents (List of Tables) does not include Tables 6-4 to 6-6. (*Commenter: Heinz J. Mueller - EPA*)

Response: This omission has been corrected in the Final EIS.

46. The scientific name for the pink mucket mussel is given as *Obovaria retusa* — the correct name is *Lampsilis abrupta*. (*Commenter: Gregory Hogue - USDI*)

Response: The text of the Final EIS has been revised to correct this error.

2.7.2. Errors in Draft IRP

47. According to the IRP Executive Summary, page 7, TVA held seven public meetings on the IRP. This is an error as TVA is holding these meetings as I submit these comments on the draft IRP. (*Commenter: Laurence T. Britt*)

Response: The seven public meetings mentioned on Draft IRP Executive Summary page 7 were public scoping meetings held during the summer of 2009. TVA held five public meetings in October 2010 to explain and accept comments on the Draft IRP and EIS.

48. Some figures in the IRP contain errors:

Figure 5-8 - Conversion from raw ranking metric (with units) into a unit-less score. Units are still present in the description of the converted (now unit-less) metric.

Figure 6-9 - Inconsistent X-axis labeling with following figures 6-10, 11, and 12. The values on top of the bars do not match the values on the y-axis, and neither the histogram values nor the values displayed on top add up to the 19 portfolios mentioned in the inset. (*Commenter: William K. Rutemeyer*)

Response: For figure 5-8, the values are unit-less and the reference to units should not have been included. In figures 6-9, 10, 11 and 12, the inset boxes contained the correct summary information, but the histogram graphs were not published correctly. The tables and graphs will be revised and included in Appendix A - Draft IRP Process and Results.

49. Under Alternative Strategy E, the added capacity for biomass-fueled generation is stated as 456 MW in the draft EIS and 410 MW in the draft IRP. Please explain this discrepancy. (*Commenter: Sam Gomberg - SACE*)

Response: The 456 MW stated in the EIS for the 3,500 MW Portfolio for Strategy E is correct. It includes 144 MW of co-firing, 117 MW of dedicated biomass PPA's, 170 MW of dedicated biomass conversions, and 30 MW of landfill gas capacity.

2.7.3. Suggestions for Improvement of EIS and/or IRP

50. Both the IRP and EIS would be improved by adding tables describing model outputs in terms of energy generated or saved by resource type. Both draft documents give model outputs in terms of capacity. Adding the generation data information would help in understanding the environmental impacts and the various evaluation metrics. (*Commenter: Sam Gomberg - SACE*)

Response: Energy generated or saved by resource type is shown graphically in Figure 7.1 of the Draft EIS and Final EIS.

51. Consider adding a table to EIS chapter 6 comparing Strategies B, C, and E (*Commenter: Kim Franklin - USCOE*)

Response: A table comparing Strategies B, C, E, and the newly developed R has been added to Final EIS Section 6.4.

52. DEIS Section 7.3.1, Coal-New Facilities, should include a description of additional air pollutants besides CO_2. (*Commenter: Heinz J. Mueller - EPA*)

Response: Anticipated emission rates of air pollutants other than CO_2 from new coal facilities are listed in Table 7-2.

53. Does the CO_2 emissions value given for IGCC with CCS in DEIS Table 7-2, page 169, represent emissions after CCS or prior to CCS? (*Commenter: Heinz J. Mueller - EPA*)

Response: All of the emissions values presented in the EIS for IGCC are for IGCC with CCS. TVA is not considering constructing IGCC plants without CCS.

54. Draft IRP Section 4.2 lists one of the reasons for excluding resource options from consideration as “The resource option is considered part of what private developers or individuals could elect to do as part of their participation in EEDR programs or their development of renewable resource purchase options for TVA consideration, but is not a resource option TVA would implement on its own.” This appears to exclude consideration of the Generation Partners program. Please explain how the Generation Partners program is considered in the IRP. (*Commenter: A. Morton Archibald - ASA*)

Response: The renewable generation that is part of Generation Partners is included in the Renewable Generation portfolios considered in the IRP. See, for example, the discussion of new wind and solar facilities in Section 5.4.3 of the EIS.

55. Draft IRP Section 4.3.3.3 makes no mention of the existing TVA Generation Partners program or the potential for rooftop solar PV generation. The potential for rooftop solar in the TVA region is very large and it would benefit the TVA system by increasing distributed generation and offsetting peak demand. (*Commenter: A. Morton Archibald - ASA*)

Response: Draft IRP Section 4.3.3.3 (Final IRP Section 5.2.3.4) does mention the existing Generation Partners program. Additional solar capacity is an important part of the renewable portfolios considered in the IRP. The 2500 MW portfolio includes 100 MW of solar capacity and the 3500 MW portfolio includes 195 MW of solar capacity. Rooftop solar is anticipated to be a large part of these solar capacities.

56. Draft IRP Section 4.3.5 describes the current EEDR programs. Unlike the other types of options, there is no description of the new EEDR programs that we presume TVA will need to meet the EEDR resource goals. Please describe these new programs. (*Commenter: Tami Freedman - CGSC*)

Response: Multiple individual portfolios of EEDR programs were developed for the five strategies evaluated in the IRP process. These portfolios contained programs under development as well as those only in the design stage. Based on the results of the IRP, TVA will now develop definitive designs and implementation plans to accomplish the goals recommended in the IRP. TVA is contracting with a consultant to develop a comprehensive five-year plan to achieve the energy and demand reduction goals identified in the IRP. When those plans are completed, they will be shared.

57. Draft IRP Section 4.3.5 mentions the importance of proper pricing signals, automatic metering and direct load control. There is, however, no explanation of how these will be implemented. Please provide this explanation. (*Commenter: Andy Gershwiler*)

Response: Changes to pricing structures, deployment of advanced metering, and implementation of direct load control programs that must be closely coordinated with power distributors are currently either under development or in process. After necessary further study and design, TVA and distributors would begin implementation of a new wholesale pricing structure in April 2011, with full implementation in 2012. Automated metering options are currently under study by TVA and power distributors, and TVA is funding demonstrations of several advanced metering technologies and load control methodologies, including direct load control, with a variety of power distributors which will inform the development of consistent metering interface protocols and load control policy in the future.

58. Draft IRP Section 5.5.2.1 and Appendix A do not explicitly display the scenarios, as is done in DEIS Section 7.6. This can cause some confusion, particularly when comparing the CO_2 graphs between the IRP (i.e., Figure A-1) and the DEIS (i.e., 7-6). (*Commenter: Heinz J. Mueller - EPA*)

Response: Although similar, the data presented serves two different purposes. The draft IRP Appendix A graphs contain the average values for all 7 scenarios and represent the values used in the scorecard evaluations of each Strategy. The DEIS broke the emissions down into individual scenarios for the purposes of completing environmental reviews of the impacts produced by each portfolio.

59. In the final EIS, please state the percentage of TVA's generating capacity that would be generated by renewables for each strategy. (*Commenter: Heinz J. Mueller - EPA*)

Response: The Final EIS lists the percentage of generating capacity generated by renewable resources in Section 6.4.

60. On DEIS page 61, the first paragraph under Table 4-5 references 'non-combustion uses of fossil fuels in industrial processes.' It would be useful to provide a parenthetical example of such as use. (*Commenter: Heinz J. Mueller - EPA*)

Response: The text of the Final EIS has been revised to include examples of non-combustion uses of fossil fuels.

61. Please clarify whether the air pollutant emissions forecasts are only direct emissions from sources producing electricity or full life-cycle emissions associated with the production of electricity. We encourage TVA to include significant associated indirect emissions in the emissions forecasts. (*Commenter: Heinz J. Mueller - EPA*)

Response: Emission forecasts for air pollutants other than greenhouse gases are for direct emissions from sources producing electricity.

62. Please provide a better explanation for Draft IRP Figure 3-7, Baseline Capacity Portfolio. Is it one of the portfolios under consideration or the continuation of the present business plan? (*Commenter: Russ Land*)

Response: Draft IRP Figure 3-7 represented the continuation of the business plan in place at the time the draft was written. It is quite similar to the resources described in Strategy B.

63. Please provide more detail on the rationale for eliminating Scenarios 4-6. Scenario 5, and possibly Scenario 4, appear highly likely to occur. (*Commenter: Heinz J. Mueller - EPA*)

Response: The portfolios contained in Scenarios 4, 5 and 6 were either identical to or very similar to the portfolios contained in Scenarios 1, 2, 3 and 7. The eliminated scenarios thus provided little to no additional information useful in the evaluation of the planning strategies. TVA has not made any assumptions about the probabilities of any particular scenario occurring.

64. The discussion of EEDR programs in the Draft IRP briefly mentions TVA's long involvement with DSM programs and summarizes some EEDR program development criteria. It does not provide any data on the effectiveness of the past EEDR programs that would help readers in evaluating which of the current and proposed programs will be most effective in participation and load reduction. Please provide this data. (*Commenter: Tami Freedman - CGSC*)

Response: Over the past thirty-five years, TVA's DSM programs have gone through numerous evolutions to match the changing needs of the TVA system, power distributors, and the consumer market. Analysis of the effectiveness of the programs is not as straightforward as a comparison of past performance. Program objectives, standards, and marketing methods have changed radically over the years to match needs enumerated above. Pertinent information from these past efforts was combined with current market assessments by TVA design teams led by experienced staff familiar with the development and execution of past programs. The focus of the EEDR portfolios in the IRP, however, was what works in the current market to meet future system needs. Past program performance will continue to be assessed as TVA develops a plan to proceed based on the overall results of the IRP process.

65. The draft IRP and EIS do not rely on the same assumptions for environmental compliance requirements. The EIS, for example, makes the assumption that scrubbers will be installed by 2015 and that future thermal plants will use closed-cycle cooling. Neither of these assumptions is stated in the IRP. Given this discrepancy, it is not possible to determine whether the IRP strategies and scenarios include the same assumptions as those described in the EIS. (*Commenter: Frank Rambo - SELC*)

Response: Assumptions for environmental compliance requirements for existing and future resource options are described in greater detail in Chapter 7 of the EIS (Environmental Impacts of Supply-Side Resource Options) than in the IRP. The analyses described in both the IRP and EIS rely on the same assumptions.

66. The final EIS should include tables that list the endangered and threatened species and critical habitats identified as occurring in the TVA region (147 listed species and 31 candidates), the 37 listed species identified as occurring in the immediate vicinity of the reservoir system, and the listed species in streams crossed by transmission lines. (*Commenter: Gregory Hogue - USDI*)

Response: Section 4.10 of the Final EIS includes a list of the 24 listed species occurring on or in the immediate vicinity of TVA generating facilities and transmission lines, and includes citations to the list of the other species occurring in the immediate vicinity of the reservoir system.

67. The Final IRP (and FEIS) should describe why the particular suite of air pollutants (SO_2, NOx, Hg, and CO_2) was selected to represent air pollution issues associated with power generation, while others, such as particulates and methane, were excluded. (*Commenter: Heinz J. Mueller - EPA*)

Response: The suite of pollutants selected as surrogates for air impacts of the IRP strategies represent the pollutants primarily associated with fossil-fueled power generation and air quality concerns, either directly or as precursors. Criteria pollutants are those where EPA has set National Ambient Air Quality Standards (NAAQS), and by focusing on SO_2 and NOx, the IRP is focusing on achieving those standards. In the Valley, fine particulate (PM2.5) and ozone pollution pose the most serious air quality challenges. These both primarily result from other emissions. Emissions of NOx have a major role in ozone formation and SO_2 and NOx emissions can impact fine particulate levels. By evaluating the effect of IRP strategies on these precursor emissions, conclusions can be reached about the potential effect on ozone and PM2.5 levels. Mercury is an air toxic and has become a major focus of air quality concerns. Emerging regulations are expected to require mercury emission reductions at coal-fired facilities. CO_2 is the most abundant man-made GHG, and the one most publicly associated with climate change concerns, though methane has a higher global warming potential. Direct methane emissions from TVA operations, however, are small and they have lesser overall impact. The data on SO_2, NOx, Hg, and CO_2 emissions allowed TVA to address a number of different potential air quality and climate change effects, and provided a reasonable method for evaluation of the IRP strategies.

68. The IRP Executive Summary states the goal "“to become one of the nation's leading providers of low-cost and cleaner energy by 2020.” It then fails to define both low-cost energy and clean energy. Without these definitions, it is impossible to determine whether this goal is met. Please define low-cost energy and clean energy. (*Commenter: Laurence T. Britt*)

Response: While TVA thinks the language of this goal reasonably conveys what it means, TVA has further specified that this goal includes being the nation’s leader in improving air quality, the nation’s leader in increased nuclear generation and the Southeast’s leader in increased energy efficiency.

69. The IRP presents nuclear power as a clean energy source with no greenhouse gas emissions. This is incorrect, as nuclear energy can have significant life cycle GHG emissions. (*Commenter: Garry Morgan*)

Response: Comment noted. Direct and life-cycle GHG emissions from all resource options including nuclear, fossil, and renewable generation sources are described in Final EIS Section 7.3.

70. We recommend that Figure 5-2 in the Final IRP include the impact of a changing climate on TVA's ability to provide low-cost reliable energy into the future. This topic is discussed in the EIS but it is not clear if it is considered in the scenario planning. How, for example, will increasing surface temperature affect summer peak demand? (*Commenter: Heinz J. Mueller - EPA*)

Response: Drawing conclusions on climate impacts on a regional scale is very difficult, owing to uncertainties in forecasting climate as well as forecasting the human and natural resource context in which impacts will be experienced. During the preparation of the IRP, TVA contracted with Electric Power Research Institute (EPRI) to prepare a report 'Potential Impact of Climate Change on Natural Resources in the Tennessee Valley Authority Region'. The study concluded that the near-term impacts of changes in climate that might be realized by 2020 are likely to be modest and within the range of existing adaptive capacity, but the impacts will likely become greater by 2050.

2.8. Electric Vehicles

71. According to the press, TVA is constructing and supporting the construction of charging stations for electric vehicles in East Tennessee. No such support for EVs has been announced in the Memphis area. Please explain why Memphis is apparently not part of this initiative. (*Commenter: Mary Ben Heflin*)

Response: Chattanooga, Knoxville, and Nashville are sites included in The EV Project, a DOE sponsored electric vehicle infrastructure project funded under the American Reinvestment and Recovery Act and managed by ECOtality North America. ECOtality received funding to install electric vehicle (EV) charging infrastructure in five markets across the United States to support the launch of the all-electric Nissan LEAF, and the three Tennessee cities constitute one of these markets. TVA is a partner in this ECOtotality project. Although Memphis is not included in this ECOtotality project, Memphis Light, Gas, and Water is participating with TVA and EPRI on research related to EVs and TVA has held several workshops on EVs with MLGW. Additional meetings and workshops in Memphis are planned in the winter and spring of 2011.

72. Promote the adoption of electric vehicles by investing in EV charging stations. (*Commenters: Nancy Givens - WKU/KSES/BGGP, Daniel Joranko - TAP*)

Response: TVA and the Electric Power Research Institute (EPRI) have designed and constructed a solar-assisted electric vehicle charging station, called the SMART Station (Smart Modal Area Recharge Terminal) and plan on building more as part of a research, demonstration and education effort. TVA recognizes electric vehicle infrastructure as a key focus area and a long-term beneficial technology for the Tennessee Valley.

2.9. Endangered and Threatened Species

73. The alternatives have the potential to affect endangered and threatened species and critical habitats. The DEIS, however, does not specifically describe these effects or contain a Biological Assessment of these effects. TVA should consider a programmatic consultation with the Fish and Wildlife Service or describe in greater detail when and how future programmatic and project-specific consultations will occur. (*Commenter: Gregory Hogue - USDI*)

Response: As noted in Final EIS Section 7.2 and elsewhere, TVA will conduct comprehensive assessments of the environmental impacts of proposed action to implement the IRP. These assessments will include evaluation of the potential effects to endangered and threatened species and critical habitats. TVA will, as necessary, consult with the U.S. Fish and Wildlife Service on these potential effects.

2.10. Energy Efficiency and Demand Response

2.10.1. Amount of EEDR Reductions

74. Adopt a plan that makes the Valley a national leader in energy efficiency by committing to a goal of at least 1% annual reductions in energy demand by 2015. Developing EEDR resources will create jobs, strengthen local economies and create a clean, healthier environment for all Valley residents. (*Commenters: Julia Aepping [sic], Lisa Archer, Donald L. Audley [sic], Kris B. [sic], M. Balangen [sic], April Bart, Margie Buxbaum, Dave Bordenkircher, Paul Boring, Deanna Bowden, Jenny Bowers, M. Boyd, Nancy Brannon, Harry E. Bryant, Jessica Buchanan, Paula Bunanek [sic], Melissa A. Burt, Kelvin Butler, Laura C. [sic], Lisa C. [sic], Jason Campbell, Teresa Campbell, Bruce Chicre [sic], James S. Collins, A. M. Conisin [sic], Cliff Corker, Josh M. Cox [sic], Thomas V. Cullen, Lori Curt [sic], H. Dwayne Cutshoul, Lacy Damiles [sic], Erika Davidson, Marge Davis, Roeyn Davis [sic], Courtney Day, I. Drelsecn [sic], Whodong Ebechnop [sic], Patricia Eleand [sic], R. Wray Estes, Peggy Evans, Douglas Felker, Melanie Felker, Heather Finolti, Sarah E. Flower, Vita French, Katherine Gamt [sic], Heather Gapsby [sic], Elizabeth C. Garber, Elizabeth Gazaway [sic], Joel Gearhardt, Danielle Gerhard, Kathy S. Gleeland [sic], Tony Gorton, Karen Gulk [sic], Ava Gunter, Mary Alan Guy [sic], Steven H. [sic], Meredith Hayes, Larry Hendrix, Kristen Hickey, R.M. Hill, Jessica Hill, Chloe Hirst, Steven R. Horton, Katherine Huddleton [sic], Jaun K. Hudson [sic], Lauren Hulson [sic], Cee J. [sic], Rofail H. Jenu, [sic], C. Johnson, Ivan Juny [sic], Barbara Kelly, Chrys Kemp [sic], Sara Keubbing [sic], J. Kewisn [sic], P. Kneuman [sic], Scott Kramer, David Brent Kulovich, Sandra Kurtz, William Kurtz, S. Kurtz, R.C. Last, Gloria Lathem-Griffith - MEC, John M. [sic], Julia Mangrin, Annie Mattson [sic], Nancy McFadden, Ralph McKenzie, Laura K. McKenzie, Paula McLen [sic], Rebecca Meade, Michael Miller [sic], Barbara Mott, Catherine Munay, Lauren N., J. N., Marissa N. [sic], Margaret F. Olson [sic], Janet Osborn, Linda Park, Jon Parker [sic], Erwin Peritt [sic], Kotel Perry, Zaria Person [sic], Norm Plate, Sara F. Plemons, Jennifer Porter, John F. Post, Patricia Post, Keith Rainy [sic], William Reynolds , Arnold C. Ringe [sic], Madeline Rogers, Mercedes Rodriguez, Phillip Roll [sic], Ruth F. Rothe, Kathy S., Tanya S. [sic], Grace Safer, Melinda Sanede [sic], Don Scharf, Feris J. Schlery, Cody Semabayl [sic], Judy Sheffield, Madeline Shelly, V.C. Shriever [sic], Roxanna Shohadaee [sic], Michelle Smith, Jamie K. Stand [sic], Karl Stirs [sic], Carolyn N. Stokes, Henry Stokes, A. Suny [sic], Lauren Szoech, Karen T. [sic], Bill Terry [sic], Andy Todd, Nancy G. Van Vallanburgh, Dorthy W., Jan H. Watson [sic], Mona Whitehead, Dean Whitworth, Paul Wieland, Debbie Williams, R.T. Williams, Sue A. & Steven M. Williams, Adelle Wood, Linda W. Woodcock, Kevin Woods, J. Y. [sic], Edward Zuger III – CCSC)*

Response: Based on estimates of realistic achievable potential using various market participation rates and program delivery mechanisms, TVA examined a range of energy efficiency and demand response portfolios in the IRP process. The EEDR portfolio included in the Recommended Planning Direction is designed to achieve a minimum savings of 3.5 percent by 2015.

75. Adopt a plan that makes the Valley a national leader in energy efficiency by committing to a goal of at least 1.5% annual reductions in energy demand by 2020. Developing EEDR resources will create jobs, strengthen local economies and create a clean, healthier environment for all Valley residents. (*Commenters: Margie Buxbaum, Gloria Lathem-Griffith - MEC, Linda Park, William Reynolds , Don Scharf, Sue A. & Steven M. Williams, Edward Zuger - CCSC III*)

Response: The EEDR portfolio included in the Recommended Planning Direction is designed to achieve a minimum savings of 3.5 percent by 2015. TVA will continue to refine this portfolio and additional savings between 2015 and 2020, when the peak load impact from EEDR is anticipated to be approximately 3,600 MW (see Final IRP Figure 8-14 and Final EIS Table 6.9).

76. Although not stated in the draft IRP or EIS, we are aware from discussions with the Stakeholder Review Group that TVA relied on a March 2010 Electric Power Research Institute (EPRI) report on energy efficiency potential to determine the maximum 7% cumulative energy reduction incorporated in the strategies. The conclusions of this report are overly conservative and contradicted by other studies of the energy efficiency potential in the Southeast. Based on the results of the other studies, we recommend that TVA include annual energy efficiency contributions of at least 1%/year throughout the planning period. (*Commenter: Sam Gomberg - SACE*)

Response: Comment noted. TVA considered the EPRI 'potential' study, but it was not solely used to set the bounds of the EEDR plans included in the IRP study. The EPRI study was an informational checkpoint and formed the basis for the EEDR plan included in Strategy D of the IRP study. It did not, however, limit the EEDR impact levels of the other Strategies. EEDR plans were based on estimates of overall impacts, costs, and participation levels in utility-sponsored programs. TVA did consider other EEDR studies, including specific studies called to its attention in comments. TVA contacted authors of some of the studies, but was unable to segregate the effects of policies, codes, and standards in their estimates. TVA is undertaking another potential study to supplement the work done by EPRI, and it is anticipated that this study will expressly address other relevant studies. This study is expected to be completed by early summer 2011. In future IRP updates, the results of this and other studies will be considered, and TVA anticipates revising EEDR goals in response to these studies and as it gains experience with the success of EEDR programs on its system.

77. By super-insulating our 1970s era homes and installing solar hot water systems, ground source heat pumps, and other super-efficient appliances, we have been able to drastically reduce our power bills. Our actions show that reductions in energy use by more than half are readily achievable by homeowners at modest cost with current technology. We urge TVA to maximize its energy efficiency efforts. The ongoing collaborative work by TVA and Oak Ridge National Laboratory also illustrates the large reductions in energy use achievable in new houses at modest costs. (*Commenters: Jeff Christian - ORNL, Richard & Marian Taschler, Kenneth Wilson*)

Response: TVA acknowledges that significant energy savings can be achieved by implementing multiple energy efficiency measures and TVA has programs promoting this. The EEDR component of the various strategies is designed to implement cost-effective energy efficiency and demand response across the TVA service territory. The EEDR programs include providing information and support to a broad range of potential participants from those who need basic information on how to make elementary improvements to the efficiency of their homes to those who wish to implement multiple advanced improvements to achieve large reductions in their use of electricity.

78. Shelby County, the City of Memphis, and the City of Nashville have all passed resolutions requesting TVA to increase its energy efficiency load reductions by 1% annually

for the next five years. We urge you to achieve at least this level of load reductions. (*Commenters: Kevin Routan - CGSC, Steven Sandheim - SC/TSVC*)

Response: TVA appreciates the support shown by these government bodies and looks forward to their continued support of our energy efficiency and demand response efforts. The EEDR component of the recommended strategy is designed to achieve 3.5% savings over projected sales by FY 2015.

79. The draft IRP and EIS do not describe the results of any study of the energy efficiency potential in the TVA region. Instead, they provide a cursory listing of current and future programs and their environmental impacts. In the absence of such studies, it appears that TVA is underestimating the achievable energy efficiency. TVA must conduct a study of energy efficiency potential and report its results. (*Commenters: Lanny Night, Frank Rambo - SELC*)

Response: TVA developed a range of EEDR portfolios for evaluation in the IRP process. In addition, a study of EEDR potential was done, not to serve as the basis for the portfolios, but as a check of the upper bounds of the estimated energy and demand reductions. The study validated the range of portfolios developed. The intent of the range of portfolios was to identify the performance of various levels of impacts across the range of potential future scenarios. A key consideration of the portfolios developed was their ability to deliver cost-effective efficiency impacts while providing a least cost resource for the power system under a variety of assumed future parameters. TVA plans to conduct new EEDR potential studies to support the development of future EEDR portfolios and implementation plans.

80. The energy efficiency programs in most strategies do not include any increases in energy efficiency beyond 2020. This artificial constraint limits their potential and results in an artificially large capacity gap and a premature commitment to completing Bellefonte Unit One. Other utilities have forecast and achieved longer term EEDR growth. (*Commenters: Sam Gomberg - SACE, Louise Gorenflo - TCSC*)

Response: The leveling off of the growth in EEDR impacts is the result of a focus on existing efficiency technologies and the constraints of finite markets assumed in the IRP strategies. This effect has been noted and will be addressed in future IRP updates. TVA does not anticipate limiting itself to the EEDR programs currently available and expects to revise and add EEDR programs throughout the 20-year planning period. In sensitivity analyses conducted after release of the Draft IRP and EIS, TVA evaluated higher levels of EEDR in order to test the need for future baseload capacity, which could be provided by various resources, including Bellefonte Unit 1. While the timing of additional baseload capacity varied based on the EEDR assumptions, it was not eliminated.

81. The IRP analyses show that TVA can meet most of the increase in energy demand with EEDR. By greatly increasing energy efficiency efforts, TVA would reduce the future environmental impacts resulting from burning coal and from nuclear energy. These energy sources create long-lasting coal ash, nuclear waste, and other pollutants. The biota of the region's rivers suffer from their heat discharges. The protection of our natural resources is affordable and necessary and TVA needs to be a national leader in this protection effort. (*Commenters: Louise Gorenflo - TCSC, Sandra Kurtz - BEST, Nancy McFadden, Gary Verst - SC, Jon Wolfe*)

Response: The amount of new resources identified in the IRP study depends on the particular scenario being considered and any assumptions about resources already available to TVA in each of the planning strategies being evaluated. In low or no growth scenarios, the study indicates that no major additional resources beyond the EEDR and renewable resource portfolios included in certain strategies and resources already under construction would be required. Results for other scenarios indicate that resources in addition to EEDR are required to make up the least cost plan and maintain the appropriate level of system reliability. The Recommended Planning Strategy includes a commitment to a substantial portfolio of EEDR in addition to other clean energy resources, and TVA has committed to continuing to evaluate the performance of EEDR and refine its planning assumptions in keeping with the results of actual experience with program delivery.

82. The projected 7 percent cumulative energy reduction through 2029 under the most aggressive Strategy E, with almost no energy savings between 2020 and 2030, does not address the full potential for the development of EEDR resources. The TVA region is presently among the least energy efficient areas in the nation. Studies by Georgia Tech and Synapse Energy Economics show a much greater potential than TVA seems willing to consider. Similarly, the experience of other utilities and the EEDR industry show that measures by the government, institutional, and commercial sectors can deliver much larger energy savings. (*Commenters: Chris Christie, Abigail Dillen - Earthjustice, Donald Gilligan - NAESC*)

Response: Comment noted. The leveling off of the growth in EEDR reductions is the result of a focus on existing efficiency technologies and the constraints of finite markets assumed in the IRP strategies. This effect has been noted and will be addressed in future IRPs. The end result will likely reflect more consistent continued growth in EEDR reductions through time. As for comparison of the EEDR portfolios with other potential studies, it should be noted that other studies address the effects of changes in policies, codes, and standards not included in the EEDR portfolios in the various IRP Strategies. TVA is continuing to examine new program opportunities and the mix of energy and demand reduction potentials to achieve increases in cost-effective results from program designs.

83. The strategies in the draft IRP contain from 1,400 to 6,000 MW of capacity avoidance through energy efficiency and demand response. These levels appear to have been chosen without adequate input from the local power distributors. Unlike many other utilities, TVA is not fully integrated and is dependent on the distributors for the interface with most customers. Without the involvement of the distributors, TVA's potential for EEDR savings is very limited. (*Commenter: George B. Kitchens - JWEMC*)

Response: Comment noted. TVA agrees that because TVA is primarily a wholesaler of electricity, the success of EEDR programs will require the cooperation of local distributors. TVA's approach to the development of the EEDR portfolios included in the IRP strategies involved construction of multiple detailed program designs. This 'ground up' approach enabled the analyses of individual components as well as the overall portfolios. TVA worked with the Tennessee Valley Public Power Association (TVPPA) Energy Services Committee and individual distributors in the design of these programs as well as the test marketing of some designs. The results of the market tests and the input of distributors and others were incorporated into the EEDR projections assessed in the IRP. TVA staff also relied on the historical performance of existing and past programs to estimate distributor participation levels and end-use consumer potential. All program estimates were constructed with the assumption that actual program design and implementation would be done in cooperation with local distributors and directly served customers.

84. TVA can quickly achieve much greater energy efficiency by drawing on the experience and expertise of other utilities and commercial energy efficiency program managers. In this manner, TVA can address the challenges of program design and implementation. (*Commenter: Gilligan - NAESC*)

Response: TVA agrees. TVA plans to use consultants to identify best-in-class performance of energy efficiency and demand response efforts throughout the utility industry. Those ideas and lessons learned will be adapted to the unique climate, demographics, and delivery structure of the TVA region and incorporated into the design considerations of the EEDR portfolio going forward.

85. TVA should adopt a comprehensive energy conservation and efficiency program. (*Commenter: Louise A. Zeller - BREDL*)

Response: Comment noted.

86. TVA should commit to achieving a level of energy efficiency equivalent to that of California, the Northeastern U.S., and Western Europe by 2015. As an example, the average residential home would consume no more than 500 kWh per month and would be 33% better insulated. (*Commenters: Jeff Deal, James Randolph*)

Response: The market in the TVA region does not mirror those of California, the Northeastern U.S., or Western Europe nor do those markets reflect the bifurcation of energy delivery that exists in the TVA region with TVA and its distributors. TVA has developed the various EEDR portfolios to implement a broad range of cost-effective energy efficiency and demand response efforts. In the more detailed design process necessary for implementation, TVA is working with a consultant to perform additional assessments of the potential for energy efficiency and demand response in the Valley.

87. TVA should take full advantage of all cost-effective energy efficiency by setting annual energy (GWh and MMTherm) and demand (MW) savings targets based on rigorous analyses of the achievable cost-effective potential and committing to aggressively ramp up programs well beyond the August 2010 commitment. (*Commenter: Luis Martinez - NRDC*)

Response: Comment noted. As described in the IRP, TVA is committing to increased reliance on cost-effective EEDR to meet future energy demands. As experience with the success of specific EEDR programs is gained, TVA anticipates changing its EEDR goals and will address proposed changes in its annual planning cycles and future IRPs. TVA anticipates that changes in goals and programs themselves will not necessarily be limited by the portfolios developed for the IRP analyses and will include designs beyond those contained in the IRP strategies.

88. TVA's modeling efforts artificially limit the amount of energy efficiency included in the portfolios. TVA should model energy efficiency as a resource equal to other potential resources it may deploy to meet demand. The constraints on energy efficiency deployment prevent all of the cost-effective energy efficiency to be utilized in the portfolios. (*Commenters: Sam Gomberg - SACE, Luis Martinez - NRDC, Frank Rambo - SELC*)

Response: As described in the IRP and EIS, the initial modeling used defined amounts of energy and peak demand reductions which spanned an approximate three-fold range across the various strategies. In the modeling conducted following the release of the Draft IRP and EIS (see IRP Section 6.6), the model was allowed to choose various levels of energy and peak demand reductions that spanned most of the previously used three-fold range. As expected from the financial analyses, the higher levels of EEDR implementation provided the lowest cost options. When all of the metrics were considered, modeling results showed little difference between the mid-level and larger EEDR portfolios (see IRP Section 8.2.3). Because of the uncertainties in customer participation and TVA's ability to implement the larger portfolio, the Recommended Planning Direction includes the mid-level EEDR portfolio.

89. We support the plan's emphasis on energy efficiency and demand response and encourage you to aggressively pursue energy efficiency for the residential, commercial, and industrial classes of customers. Industrial efficiency improvements are an important factor in maintaining the region's manufacturing base as energy prices increase. (*Commenter: Leonard K. Peters - KEEC*)

Response: Comment noted. As described in the plan and EIS, TVA has developed, and will continue to develop, programs to increase the energy efficiency of all classes of customers.

90. We support the TVA Board's August 2010 decision to be the Southeastern leader in energy efficiency. To do this will require energy efficiency saving exceeding 1%/year through 2016. Under the most aggressive portfolio, Strategy E, the annual energy efficiency target is 0.7%. The energy efficiency portfolios in the IRP need to be increased beyond the 0.7%/year to meet TVA's new goal, and should continue to increase throughout the planning period. (*Commenters: Louise Gorenflo - TCSC, Sandra Kurtz - BEST*)

Response: The EEDR evaluation in the IRP includes portfolios with cumulative reductions amounting to 3.5% of projected sales in 2015, which matches TVA's renewed vision to demonstrate leadership in increased energy efficiency in the Southeast. This requires TVA to increase its EEDR efforts significantly between now and 2015. TVA will continue to analyze the needs of the TVA system to determine appropriate levels of EEDR beyond achievement of this near-term 2015 goal.

91. What were the energy efficiency and demand response goals (in MW/MWh reductions) that TVA committed to in Energy Vision 2020 and what EEDR reductions were actually achieved prior to TVA's recent reemphasis of EEDR? (*Commenter: Lanny Night*)

Response: The programs outlined in Energy Vision 2020 were projected to have the potential to achieve approximately 2,000 MW of demand reduction by 2010. By 2008, when TVA greatly increased its emphasis on energy efficiency and demand reduction, an estimated 550 MW of demand reduction had been achieved.

92. While we are strong supporters of EEDR, we are concerned that Strategies C and E may be unrealistically aggressive in demand and energy reduction. Each of these strategies reflect demand reductions greater than the total load of the City of Memphis. The draft IRP did not sufficiently address why TVA believes this level of EEDR is realistic, especially since many distributors do not have smart metering in place now nor are they projected to have it in the foreseeable future. Given this situation, we believe the EEDR level in Strategy B is more realistic. (*Commenter: Dana Jeanes - MLGW*)

Response: This comment highlights the substantial uncertainties associated with the actual results of EEDR programs. Largely because of these uncertainties, TVA anticipates revising its EEDR program goals incrementally as experience is gained through the actual implementation of programs. If programs prove more successful or less successful than expected, changes can be considered in future IRP updates. Respecting the specific concerns identified in this comment, while an advanced metering infrastructure is anticipated to be a significant enabler of both the demand reduction and energy efficiency programs embedded in the IRP strategies, it is not essential to the achievement of the majority of the EEDR savings. For example, most of the demand reduction projected in Strategy C results from energy efficiency initiatives in the residential, commercial, and industrial sectors. Much of the anticipated demand reduction from programs categorized as demand response, such as commercial and industrial demand response managed by a third party and voltage regulation (see EIS Section 3.5), is not dependent on advanced metering. Other demand response efforts, such as direct load control, are designed to be closely tied to advance metering, but can be deployed using other methods. Planning for EEDR program implementation will continue to be tied to the actual deployment of advance metering infrastructure within the TVA region. While the speed of advanced metering infrastructure deployment could impact the achievement of some projected EEDR savings, it should not significantly affect the achievement of overall potential energy and demand savings from EEDR efforts.

2.10.2. Behavior-based Programs

93. Encourage participation by distributors in behavior-based EEDR programs by establishing performance incentives that reward distributors for meeting or exceeding energy efficiency targets. Performance incentives are used by state utility commissions to encourage investor-owned utilities to promote customer energy efficiency and provide models for TVA to encourage its distributors to promote energy efficiency. (*Commenter: Jim Kapsis - OPower*)

Response: TVA is examining the most effective methods of addressing power distributor needs and considerations in implementing EEDR programs. This includes behavior-based programs.

94. The TVA EEDR portfolio should include behavior-based programs that motivate consumers to reduce their energy use by comparing their energy use with the energy use of similar neighbors. Experience elsewhere shows these programs deliver measureable and verifiable energy savings at relatively low-cost, have high participation rates, maximize the value of other EEDR programs, and reduce the rebound effect common with some other EEDR programs. (*Commenter: Jim Kapsis - OPower*)

Response: Comment noted. As described in the response to Comment 93, TVA will consider the use of behavior-based programs at the implementation stage.

2.10.3. Building Codes

95. TVA should aggressively promote the establishment of building standards and codes that require new construction and retrofits to meet LEED or passive home standards. (*Commenter: Nancy Givens - WKU/KSES/BGGP*)

Response: TVA acknowledges the effectiveness of enhanced building codes and standards as well as elevated equipment performance standards. The consideration of enhanced building codes, including how TVA can support their creation and enforcement, is an important component in TVA's development of the comprehensive portfolios of EEDR programs to achieve the goals in the IRP strategies. While not a provider or enforcer of codes, TVA will seek opportunities to play a role through measures such as provision of data, education outreach, and incentives.

2.10.4. Cost of EEDR Programs

96. The experience of other states and utilities has shown that investments in energy efficiency and demand response often result in a very high rate of return. TVA's funding for EEDR has been insufficient and should be greatly increased. (*Commenter: Stewart Horn*)

Response: The strategic direction recommended in the IRP supports a significant increase in TVA's EEDR efforts. Specific design of the programs to implement the EEDR portfolio will focus on delivering energy efficiency at the needed levels while managing costs to maintain a positive cost/benefit relationship.

97. While I support energy efficiency programs, I am opposed to compulsory payments by ratepayers to fund them. TVA should provide industrial customers with the ability to opt out of paying for them. (*Commenter: William Cummings - KCC*)

Response: Part of the outcome of the IRP process was that the inclusion of significant levels of EEDR in strategies produced the least cost alternatives over a variety of future scenarios. Recognition of the relationship between costs and benefits for all customer classes is a consideration in the design of plans to implement the EEDR portfolio contained in the Recommended Planning Direction strategy.

2.10.5. Education

98. Education should be a major component of TVA's energy conservation efforts. Target audiences include homeowners, businesses, and government agencies. Many organizations have materials that could help TVA's education efforts. (*Commenters: A. Morton Archibald - ASA, Ann Ercelawn, Kevin Routan - CGSC, Danville and Beverly Sweeton, Scott Wills*)

Response: TVA agrees with the major role education plays in the effective deployment of EEDR. TVA currently has a range of efforts underway to develop and deliver information to all segments of the consumer population (see EIS Section 3.5). In addition, TVA will continue to broaden and enhance its EEDR education efforts through a variety of avenues such as printed materials, online resources, and advertising.

2.10.6. EEDR Leadership

99. Tennessee and other TVA states rank among the lowest states in the United States in energy conservation efforts. Energy awareness is low and examples of energy waste are abundant. TVA should lead efforts to increase energy conservation through aggressive education and marketing. (*Commenters: Mary H. Clarke - TCV, Donald Gilligan - NAESC, Bruce Wood - BURNT*)

Response: Comment noted. TVA recognizes that the potential for increased energy conservation in the TVA region is high and consumer education and marketing are very important components of its EEDR programs.

100. TVA should take the lead in making Tennessee one of the most productive states in the United States. The United States uses twice as much energy to produce a dollar of goods as Europe and Japan, which puts the United States at a competitive disadvantage. Increasing productivity through energy efficiency would make the region more globally competitive and reduce total electricity demand by as much as 34%. (*Commenter: Courtney Piper - TBLCEE*)

Response: TVA currently offers information, advice, and incentives through its EEDR programs for commercial and industrial consumers and will further refine these efforts and develop additional designs as it implements the recommended IRPstrategy. In addition, TVA supports improvements in energy efficiency and productivity through its economic development efforts such as the Valley Investment Initiative. While we have no data to quantify the suggested 34% reduction, program designs for the commercial and industrial sectors strive to maximize cost-effective energy efficiency improvements and support growth of existing Valley industries and development of new ones to maintain a healthy economic environment.

101. We applaud TVA's August 2010 commitment to become the leader in energy efficiency in the Southeast. TVA should lead the region in implementing energy efficiency. Meeting this goal will require a significant increase in energy efficiency programs and infrastructure. Numerous studies have shown that energy efficiency is the cheapest energy resource, both in terms of direct costs and avoided health and environmental costs of other alternatives. Energy efficiency is the cheapest and fastest way to cut pollution while reducing price volatility, hedging against financial risks, increasing customer satisfaction, improving economic productivity, keeping energy dollars local, and creating jobs. (*Commenter: Luis Martinez - NRDC*)

Response: Comment noted.

2.10.7. Financial Incentives

102. TVA should establish loan programs to encourage homeowners and businesses to make energy efficiency upgrades. Loans could be from TVA or through third-party lenders to assure easily accessible sources of low-cost financing. Repayment options would be based on energy savings and could be extended to allow for direct reimbursements to third party lenders by TVA. (*Commenters: A. Morton Archibald - ASA, Courtney Piper - TBLCEE, Danville and Beverly Sweeton*)

Response: Over the last 35 years, TVA has at various times provided loans for energy efficiency upgrades by both residential and commercial consumers. Initially, TVA was the provider of the loan funds, but several years ago realized the advantages of relying on loan professionals to fund and manage the process. Since that time, TVA has engaged third-party banking partners for these functions. In partnership with local power distributors, TVA continues to offer a financing option for participants in the residential heat pump program. The commercial loan program was discontinued several years ago and recent research with commercial and industrial consumers indicated that providing loans was a low priority for that customer segment. Loans will continue to be a tool considered in the design of future EEDR programs and may be added or expanded based on the identification of need by the particular market sector.

103. TVA should expand its partnerships with state and municipal governments to provide grants for energy efficiency improvements and retrofitting of homes, businesses, and public buildings. (*Commenter: Daniel Joranko - TAP*)

Response: TVA continues to seek willing partners in the government sector to leverage their unique resources and skills. In the last few months, TVA has partnered with state agencies to leverage funding provided by the American Reinvestment and Recovery Act and assist in the delivery of weatherization assistance and rebates for high-efficiency appliances. In addition, TVA has partnered with the state of Tennessee to establish a revolving loan fund through a third-party administrator and is seeking opportunities to expand this effort to other states. These opportunities to leverage resources and skill sets will continue to be important considerations as TVA implements the EEDR portfolio identified in the IRP Recommended Planning Strategy.

104. TVA's support for energy efficiency and demand response has varied greatly over the last 30 years. I am pleased to see that TVA is again promoting EEDR, and TVA should make a long-term commitment to it. The $1,500 Federal tax credit for homeowner energy conservation efforts is scheduled to expire at the end of 2010. If it does expire, TVA should commit to providing the same level of incentives for its customers. (*Commenter: Chris Pamplin*)

Response: The anticipated end of the Federal tax credit created a surge in program participation at the end of 2010, and TVA is working to carry that momentum forward with the recent last-minute extension of the credit. In designing EEDR programs, TVA seeks to create a positive cost/benefit relationship for participants when all aspects of the financial decision are taken into account, including tax credits and subsidies. The overall financial design, however, must also provide the EEDR system impacts on cost-effective basis. Program incentive levels are developed on a program-by-program basis by taking all financial parameters into consideration.

2.10.8. Homeowner Incentives

105. Expand the In-Home Energy Evaluation Program and extend it beyond October, 2010. (*Commenter: Courtney Piper - TBLCEE*)

Response: Part of implementing the recommended IRP strategy includes a thorough assessment of existing programs like the In-Home Energy Evaluation (IHEE) with the intent of identifying opportunities for improvement and expansion. The IHEE program has been well received and almost 17,000 evaluations have been conducted to date. TVA has extended the IHEE program in its current form pending completion of this assessment.

106. Increase support for improving the energy efficiency of the homes of middle-income customers and not just the economically disadvantaged. (*Commenter: Nelson Lingle - RSI, Joanne Logan*)

Response: TVA strives to design all EEDR efforts to provide participation opportunities on a non-discriminatory basis to all Valley consumers. Program portfolios are developed to offer program benefits to all market sectors such as residential, commercial, and industrial without regard to income levels or size. Consideration is given to ensure that participation does not present significant hardship to any given socioeconomic segment or demographic.

107. The EEDR portfolio described in the draft IRP and EIS does not include support for solar water heating and solar space heating. Both of these technologies can be more economical for homeowners, and in some cases businesses, than solar PV. (*Commenters: Nancy Givens - WKU/KSES/BGGP*)

Response: TVA's development of the EEDR program portfolio to implement the recommended IRP strategy will include an assessment of a wide variety of technologies. If solar water heating and space heating are shown to be cost-effective program options, they may be included in the portfolio. TVA's Generation Partners program already encourages use of solar and other renewables.

108. TVA incentives to improve homeowner's energy efficiency should include the following: (1) incentives for energy efficient appliances; (2) incentives for energy efficient light bulbs, including LED bulbs; and (3) incentives for water heater blankets. TVA should consider including coupons for these incentives that are put into monthly bills. (*Commenter: Margie Buxbaum*)

Response: TVA current energy efficiency programs include these technologies through the weatherization assistance program and energy efficient appliance programs in Tennessee and the distribution of free CFLs in its In-Home Energy Evaluation and Self-Audit programs. TVA anticipates that these technologies will continue to be components of its future EEDR program portfolio.

109. TVA used to provide energy efficient home designs and other information on building super-efficient homes. Please restore this service. (*Commenters: Melanie Felker, Sue A. & Steven M. Williams*)

Response: TVA is working with a variety of partners, such as the Department of Energy, to identify and provide information resources for energy consumers such as designs for near zero energy and other high efficiency homes. TVA recognizes that education efforts that include providing this information on home design and state-of-the-art building techniques and materials is an important potential component of its EEDR portfolio.

2.10.9. Innovation

110. We urge TVA to continually monitor the marketplace and quickly adopt breakthrough technologies to improve energy efficiency. Examples are magnetic induction lamps and wafer LED lighting. TVA should also participate in the research and development of breakthrough EE technologies. (*Commenter: Courtney Piper - TBLCEE*)

Response: TVA's partnership with the Electric Power Research Institute (EPRI) affords access to their research into cutting edge technologies and opportunities for participation in demonstrations and testing in both laboratory settings and field deployments. In addition, TVA participates in numerous organizations and services such as the Consortium for Energy Efficiency, Association of Energy Services Professionals, and E Source that gather and share information on energy efficiency efforts and research around the world. As TVA develops plans to implement the EEDR portfolio in the recommended IRP strategy, it will lean heavily on these resources to create new programs and improve implemented programs on an ongoing basis.

2.10.10. Lighting

111. Require customers to install outdoor lights that shut off in twilight times. (*Commenter: Ernest Smith*)

Response: TVA's primary approach to energy efficiency is to provide information, advice, incentives, and marketplace promotion rather than mandated requirements. These methods have been successful in the past, and as a wholesale provider of electricity to power distributors who serve the majority of consumers in the Valley, TVA does not dictate end-use policies outside the scope of safety and system integrity. TVA is, however, striving to identify all cost-effective efficiency opportunities and create programs to deliver energy savings beneficial to consumers and rate-payers across the Valley.

2.10.11. Rental Property Incentives

112. My family income is close to the poverty line and we rent an old house with poor energy efficiency. Our power bill is a significant portion of our income. While you have numerous energy efficiency programs focused on homeowners, you offer little that helps a renter. I urge you to consider programs targeting renters such as on-meter financing. (*Commenter: Dana Beasley Brown*)

Response: Promotion of energy efficiency among landlords has been a perennial challenge for all utilities, and it is one of the topics TVA is considering for implementation of the EEDR portfolio in the recommended IRP strategy. One approach under consideration is the creation of a home energy efficiency scorecard that would inform homebuyers and renters of the projected energy usage for homes and apartments similar to the EPA Energy Guide labels on appliances and mileage ratings on cars. This approach would encourage builders, homeowners, and landlords to improve the performance of their properties to make them more competitive in the marketplace. TVA is also considering alternatives for direct support of improvements to the extent possible by tenants such as basic weatherization. Weatherization assistance is currently available through TVA's online energy audit available at www.energyright.com which helps consumers identify improvement opportunities and supplies a free energy savings kit.

2.10.12. Roofing

113. TVA's EEDR programs should support the use of energy-conserving roofing such as Ultra Cool metal roofing. Advanced roofing systems such as this can also be successfully integrated with solar PV and solar thermal systems. (*Commenter: Gerard Heininger - EI*)

Response: TVA is assessing a broad range of technologies and delivery mechanisms for the implementation of the EEDR portfolio in the recommended IRP strategy. Technologies such as energy-conserving roofing, if they provide positive cost/benefit impacts for consumers and can be delivered through cost-effective utility program designs, would be considered for inclusion in the plan.

2.10.13. Weatherization Assistance

114. TVA should increase its weatherization assistance for homes and small businesses. Inadequate weatherization is a major contributor to the TVA region's poor ranking in home energy use. A focus of this assistance should be on low-income households. We applaud TVA's recent assistance with the Recovery and Reinvestment Act-funded state weatherization assistance programs and urge TVA to make weatherization assistance for low-income households a long-term priority. (*Commenters: Lisa Archer, Margie Buxbaum, Jason Campbell, Gloria Lathem-Griffith - MEC, Linda Park, Grace Safer, Don Scharf, Sue A. & Steven M. Williams*)

Response: TVA expects to continue its support of weatherization assistance efforts with state and local governments, which provide the opportunity to leverage available funds in a very cost-effective manner. In addition, TVA is examining the expansion of the weatherization efforts contained in the current In-Home Energy Evaluation, Self Audit, and Heat Pump programs for residential consumers and the Energy Right Solutions for Business program for commercial and industrial consumers.

2.11. Energy Storage

2.11.1. Need for More Energy Storage

115. Add Energy Storage to Strategy E. With its high level of intermittent renewable generation, the performance of Strategy E would be greatly improved with more energy storage, such as pumped hydro. (*Commenters: Nelson Buck, Michael J. Crosby - TEC/BCAAT, Garry Morgan, Don Safer - TEC*)

Response: Additional energy storage has been included in all strategies considered in the final IRP and EIS, except for the Baseline Plan Resource Portfolio.

2.11.2. Pumped Hydro Energy Storage

116. During the public presentations on the draft IRP and EIS, TVA mentioned plans for improving the efficiency of pumped storage facilities. Please describe these efficiency improvements. (*Commenter: Russ Land*)

Response: TVA has completed the modernization of its Raccoon Mountain Pumped Storage Plant, which included the installation of more efficient turbines and new generator stators as well as a variety of other mechanical and electrical equipment upgrades. Several of the alternative strategies considered in the IRP and EIS, including the Recommended Planning Direction strategy, include the construction and operation of a new pumped storage facility. TVA has begun feasibility studies of this facility, which will include additional engineering studies for improving the system design beyond the current state of the art.

117. TVA has an opportunity to greatly increase its pumped storage capacity by rebuilding or replacing generators at its 9 main river dams to give them pumping ability. This could add 8,000 MW of capacity. At Guntersville Dam, for example, turbines with pumping ability and modifications to about 5 miles of the downstream channel could add about 2,000 MW of energy. This would affect the water levels in Guntersville and Wheeler Reservoirs by about 1 foot. If all 9 main river dams were given pump storage ability, it would provide enough storage for several weeks of TVA demand without significant problems. It would also provide critical national peak load improvements needed for integrating intermittent

wind and solar generation. The operation of Raccoon Mountain pumped storage plant could be more effective if coordinated with operation of Nickajack Dam pumped storage. The disruption to system flows would be trivial if not unnoticed. (*Commenter: Paul Noel - NEC*)

Response: The operation of Raccoon Mountain Pumped Storage Plant has always been closely coordinated with the operation of both Nickajack and Chickamauga hydro plants so that there is minimal impact on the Nickajack Reservoir level, which is among the most stable in the TVA hydro system. Conversion of TVA's main river dams to pumped storage operation would require the rebuild of the dams at an exorbitant cost. In addition, the environmental impacts of converting conventional hydro to pumped storage operation could be significant and adversely impact other uses, such as recreation. TVA's experience with Hiwassee Unit 2, which has this capability, provides a good example of the constraints of operating a mainstream dam in a pumped storage mode. A separately designed and constructed pumped storage facility appears to be the most cost-effective and reliable route to follow if additional capacity of this type is added to the TVA system.

118. TVA should build more pumped storage facilities. (*Commenters: Stephen Levy - TSEA, Paul Noel - NEC*)

Response: Comment noted. TVA incorporated and analyzed additional pumped storage capacity into the strategies it evaluated in response to this and similar comments.

119. What would be the cost of constructing and operating another pumped hydro energy storage facility? (*Commenter: Stephen Levy - TSEA*)

Response: Symbiotics LLC estimated in a fall 2010 Utility Industry Infocast that the cost of installed pumped storage capacity currently runs in the $1400-2500/kW range. We estimate that a plant similar to TVA's Raccoon Mountain Pumped Storage Plant (1600 MW capacity) would cost on the order of $4-5 billion. Detailed engineering and an in-depth financial analysis are necessary to pinpoint the actual cost of a new pumped storage facility.

2.11.3. Utility-Scale Battery Storage

120. Utility-scale battery storage, while still experimental, is being implemented by some utilities. During the IRP planning period, it is very likely to be commercially available. The IRP recognizes the need for storage but only considers large centrally located facilities. Distributed battery storage can better match distributed renewable generation. TVA should reconsider its exclusion from full consideration in the plan. (*Commenter: Nelson Buck*)

Response: TVA recognizes the benefits of distributed storage in the integration of intermittent renewable generation. Distributed storage facilities were evaluated during the IRP options screening process, but eliminated from further consideration due to their current lack of proven, commercial availability and high cost. TVA will continue to monitor the development of distributed storage facilities and assess them for consideration in future IRPs. In 2001, TVA began construction of a battery storage facility in Mississippi, its Regenesys plant, but construction was stopped after the company which owned the technology being installed ceased supporting it. TVA is currently testing the use of battery storage in conjunction with photovoltaic generation in electric vehicle charging stations as a method to reduce the impact of vehicle charging on the power system.

2.12. Environmental Impacts

2.12.1. Impacts of Coal and Nuclear Generation

121. Coal and nuclear generation result in unacceptable environmental impacts that persist for generations. These impacts result from coal ash, nuclear waste, and air and water pollutants, including thermal pollution. TVA should become a national leader in protecting our air, water and land resources. (*Commenters: Lisa Archer, Jason Campbell, Joanne Logan, Linda Park, Grace Safer, Maxine Strawder - PCUUF, Gary Verst - SC*)

Response: The impacts of generating electricity from coal and nuclear fuel are summarized in EIS Chapter 7. TVA has recently taken steps to reduce its reliance on coal generation, and the strategies analyzed in the IRP and EIS further reduce this reliance on coal while increasing nuclear generation and generation by other sources with low air pollutants, including CO_2, emissions. The management of nuclear waste continues to be a national debate and efforts are continuing to create a national depository for such waste. In the interim, TVA provides for storage of this waste at its facilities as do other entities which produce such waste. The proportion of generating facilities using open-cycle cooling will also decrease in the future, resulting in reduced thermal impacts to rivers and reservoirs.

122. The continued discharge of millions of gallons of hot water from thermal generating plants into area rivers harms aquatic life. (*Commenter: Margie Buxbaum*)

Response: TVA operates its thermal generating plants within the limits of NPDES permit requirements for thermal discharges. These requirements help ensure that impacts to aquatic life are kept to acceptable levels. TVA also monitors aquatic life downstream of the plants to confirm the impact of its plants on aquatic life. TVA's analyses assume that all future thermal plants will use closed-cycle cooling, which will also result in reduced thermal discharges.

2.12.2. Mitigation of Impacts

123. Other than the mitigation of environmental impacts resulting from compliance with regulations and the selection of less CO_2-intensive generation in the future, the DEIS does not discuss any other types of mitigation activities that could be implemented to further reduce environmental impacts. We recommend that the FEIS discuss the types of mitigation that would be considered when TVA develops projects to implement the resource plan. (*Commenter: Heinz J. Mueller - EPA*)

Response: FInal EIS Section 7.7 contains a discussion of potential mitigation measures.

2.13. Environmental Justice

124. The DEIS does not contain an Environmental Justice determination under Executive Order 12898. The full analysis depends on the details, but a determination at a commensurate level with the rest of the document should be made. (*Commenter: Kim Franklin - USCOE*)

Response: TVA is not subject to this Executive Order, but it does address Environmental Justice as a matter of policy in its NEPA reviews when appropriate. The objective of an Environmental Justice analysis is to determine the potential for activities to impact low-income and minority populations to a greater extent than the population as a whole. This requires consideration of minority and low-income populations and percentages, a fairly site-specific analysis. That level of analysis is routinely done by TVA when it proposes to implement energy-resource activities. For example, TVA has made Environmental Justice determinations for the generating facilities presently under construction and for the proposed construction and/or completion of both a single nuclear unit at the Bellefonte site (see TVA 2010c) and two AP1000 units at the Bellefonte site (see TVA 2008c). TVA will analyze potential Environmental Justice impacts during the planning of future site-specific implementing actions. TVA works closely with the local power distributors to develop and implement energy efficiency programs targeting all populations in the TVA region. TVA has also assisted state and local agencies in the development and implementation of energy efficiency programs, such as home weatherization assistance, focused on low-income populations.

2.14. Greenhouse Gas Emissions

2.14.1. Impacts of Greenhouse Gas Emissions

125. The DEIS does not adequately describe the climate change impacts that will result from TVA's GHG emissions. As stated in the DEIS and elsewhere, TVA emits over 1% of all United States GHG emissions and is among the largest GHG emission sources. (*Commenters: Abigail Dillen - Earthjustice, Heinz J. Mueller - EPA*)

Response: The role of manmade GHG emissions in and the impacts of climate change continue to be the subject of serious debate, including the capabilities and adequacy of climate change models which are still being developed. It would require substantial speculation and involve substantial uncertainty to assess how TVA’s GHG emissions may contribute to climate change effects which are world wide. The Final EIS contains a discussion of TVA’s anticipated GHG emissions and how climate change could affect TVA’s power system. Under almost all of the strategies evaluated in the IRP, including its recommended strategy, GHG emissions on the TVA system would substantially decline.

126. The Final IRP and FEIS should explicitly reference the draft guidance on analyzing the impacts of GHGs in NEPA assessments that was issued by the Council of Environmental Quality in February 2010. The FEIS should also provide the assessments suggested by the guidance. (*Commenter: Heinz J. Mueller - EPA*)

Response: This guidance is cited in the Final EIS, which also contains a discussion of anticipated GHG emissions and how climate change could affect TVA's power system.

2.14.2. Pricing Greenhouse Gas Emissions

127. In all but one planning scenario considered in the IRP, TVA assumes that federal legislation will result in a carbon price in the near term. Per ton, TVA assumes a cost in each scenario of at least $15 and as high as $27. TVA also assumes that these costs will be in effect no later than 2014 and possibly as early as 2012. Given the results of the November 2, 2010 elections and the fact that the Obama Administration has abandoned cap and trade legislation, IRP modeling assumptions based on carbon pricing are unfounded. (*Commenter: Kipp Coddington - MMCC*)

Response: EPA is proceeding with regulating GHG emissions from coal-fired power plants and TVA does foresee constraints on carbon emissions within the IRP planning horizon.

Admittedly, there is uncertainty over a cap and trade requirement and how carbon emission requirements would affect fossil fuel generation. The IRP scenarios were developed to provide an understanding of how the planning strategies will perform under various conditions by testing ranges of uncertainties, including GHG requirements. A modest range of CO_2 prices ($0/ton to upwards of $27/ton, initially) and differences in timing (2012-2014) were analyzed. These ranges were developed as a proxy for a range of potential GHG emission reduction requirements, given the uncertainty over GHG legislation and regulation. TVA reexamined potential GHG emission reduction requirements when developing the new Scenario 8 and found no need to change the range of requirements described in the original Scenarios 1-7.

128. TVA has assumed a $0 cost estimate for GHG requirements under Scenario 3. This is not reasonable as regulation of GHG emissions is beginning in 2011. The impact of this $0 GHG price assumption is that the potential cost and risk of developing additional GHG-emitting resources, or failing to reduce TVA's current GHG emissions, is artificially reduced. TVA should revise Scenario 3 to include a non-zero, but modest, price on carbon. (*Commenter: Sam Gomberg - SACE*)

Response: The IRP scenarios were developed to evaluate the planning scenarios against a range of potential future conditions, including different levels of GHG emission requirements and different CO_2 prices. Scenario 3 tests a potential future with no GHG emission reduction requirements while the other scenarios test different potential GHG reduction requirements and non-zero CO_2 prices. The GHG regulation that came into existence on January 1, 2011 that affects fossil-fueled power plants applies primarily to new plants, not existing plants.

2.14.3. Quantifying GHG Emissions

129. In the DEIS, lifecycle GHG emissions of various fuels are compared. The lifecycle data for natural gas, however, is not for shale gas, which is likely to be an increasingly important fuel source for TVA. Recent studies suggest lifecycle GHG emissions from shale gas are greater than from other sources of natural gas. The EIS should describe lifecycle GHG emissions from shale gas. (*Commenter: Kipp Coddington - MMCC*)

Response: Comment noted. The lifecycle GHG emissions data for natural gas-fueled generation presented in the DEIS was based on studies of the more traditional natural gas sources. Relatively little information is available on lifecycle GHG emissions from shale gas. Sections 7.3.1 and 7.6.4 of the Final EIS contain a discussion of GHG emissions from shale gas.

130. Related to Draft IRP Figure 7-11 and Strategy D, it is not clear whether the CO_2 footprint for Strategy D includes lifecycle GHG emissions for nuclear energy. As noted in the DEIS, while nuclear power does not directly emit CO_2, there are quantifiable lifecycle CO_2 emissions. We recommend clarifying the magnitude of lifecycle GHG emissions associated with nuclear power in the Final IRP. (*Commenters: Stewart Horn, Heinz J. Mueller - EPA*)

Response: Comment noted. As part of the analysis of the alternative strategies, TVA quantified the direct emissions at the generating sources. Life-cycle emission rates are described for the various generating options.

131. The DEIS does not describe the lifecycle GHG emissions of using liquefied natural gas (LNG). In the event that the anticipated increase in shale gas production is not sustained, TVA may have to use LNG. Lifecycle GHG emissions from LNG are higher than for conventionally sourced natural gas. (*Commenter: Kipp Coddington - MMCC*)

Response: Section 7.3.1 of the EIS notes that life-cycle GHG emissions from the use of liquefied natural gas are greater than those from conventionally sourced domestic natural gas.

2.14.4. Reducing Greenhouse Gas Emissions

132. Adopt a plan that minimizes TVA's impact on climate change by prioritizing reductions in GHG emissions. Developing the Valley's energy efficiency and renewable energy resources can end our dependence on fossil fuels and help protect the Valley's natural treasures and biodiversity. Our way of life depends on TVA taking steps now to minimize its impact on global climate change. (*Commenter: Michael Agceda, R. Apson, Ann Aytenly [sic], David W. Belt, Jason Brown [sic], Charle A. Bucawfal [sic], J. Candien [sic], William F. Farming [sic], Lauren Gearhardt, Ransly Goodheart [sic], Steven Green, Larry Gregory [sic], Megan Hollusam [sic], Missy J. [sic], Gary Jehin [sic], Michael Jones, Robert Lindamood [sic], Joanne Logan, Hannah Long, Mary Masten, W. McGill, Carson McKinney, Mann McQueen [sic], Elaine Montgomery, John P. Oeyal, Cornelia Overton, Wilford M. Past, K. R. [sic], Nancy J. Reans, D. Richardson, Susan Routan, Madeline Shely [sic], Ariel Spioan [sic], Lauren J. Stein, Anne Wael [sic], Luke Waring, T.V. Williams [sic], Astor Williams [sic]*)

Response: Comment noted. The goal of the IRP is to produce the least cost plan that finds the best balance of providing competitive rates, delivering reliable power, and meeting TVA's commitment to environmental stewardship, including GHG reductions. The IRP strategy being recommended to the TVA Board includes idling of coal plants and substantial increases in EEDR and renewable energy resources. These activities should substantially reduce TVA GHG emissions.

133. How is TVA prioritizing carbon emission reduction given that Congress is unlikely to regulate carbon emissions in the next few years and that many in Congress want to prohibit EPA from regulating carbon emissions? (*Commenter: Amy Walls*)

Response: TVA agrees that there is substantial uncertainty regarding legislation regulating carbon emissions, both when and if it is going to be enacted. However, EPA is proceeding to regulate carbon emissions and has announced plans for regulations directed at coal-fired power plants. Under its 2008 Environmental Policy, TVA established the objective of stopping the growth in volume of emissions and reducing the rate of carbon emissions by 2020 by supporting a full slate of reliable, affordable, lower-CO_2 energy-supply opportunities and energy efficiency.

134. In the likely event that life-cycle GHG emissions will be regulated, TVA's plans to replace coal plants with new natural gas plants will not be cost-effective. Most coal plant GHG emissions are during combustion, which would be controlled by CCS. Gas plants have high upstream GHG emissions during gas extraction, processing, and transport which would not be controlled by CCS. Thus for plants with CCS, life-cycle gas plant GHG emissions may be higher than life-cycle coal plant GHG emissions. (*Commenter: Kipp Coddington - MMCC*)

Response: Recent studies by Jaramillo et al. (2007) and NETL (2010) show that GHG emissions from the production, processing, and transport of domestic and liquefied natural gas (LNG) are greater than from the production, processing, and transport of coal. With the inclusion of GHG emissions associated with the generating plant and carbon capture and storage, life-cycle GHG emissions from a domestic gas NGCC plant with CCS are lower than those from both SCPC and IGCC plants with CCS. These sources differ on whether life-cycle emissions from a LNG NGCC plant with CCS are lower than those of coal plants with CCS.

135. The GHG emission reductions under the various scenarios are inadequate. On a per capita basis, TVA's GHG emissions are very high and should be reduced by 90% by 2050. The IRP strategies do not make enough progress towards this goal. As is evident from the text of the draft IRP and EIS, TVA continues to frame its understanding of climate change as a debate and has not adequately addressed the potential for climate change, including extreme weather events, in the TVA region. (*Commenter: Louise Gorenflo - TCSC*)

Response: Compared to TVA's current average direct CO_2 emissions, all of the strategies considered in the IRP represent a significant decrease of CO_2 emissions during the planning horizon of 2010-2029, and many align with proposed legislation such as the American Clean Energy and Security Act's (H.R. 2454) target of 40 percent reduction (from 2005 levels) by 2030. TVA has addressed the potential physical impacts of climate change on the TVA region and is a co-sponsor of the Energy Power Research Institute’s (EPRI) study 'Potential Impacts of Climate Change on Natural Resources in the Tennessee Valley Authority Region,' published in November 2009 that provided information for doing this. The report was based on data from the Fourth Assessment Report of the Interagency Panel on Climate Change published in 2007, and provided information on possible climate change impacts across the TVA service region. This report notes that there is uncertainty about the effects of climate change on the TVA region.

136. The IRP and EIS should analyze energy portfolios that would result in much greater reductions in GHG emissions. At a minimum, an alternative should achieve the 80% GHG reduction by 2050 target established by the American Clean Energy and Security Act (H.R. 2454). (*Commenter: Abigail Dillen - Earthjustice*)

Response: Compared to TVA's current average direct CO_2 emissions, all of the IRP strategies being considered represent a marked and significant emissions decrease during the planning horizon of 2010-2029, and many align with proposed legislation such as the American Clean Energy and Security Act's (H.R. 2454) target of 40% reduction (from 2005 levels) by 2030. TVA expects to continue this trend of achieving deep emission reductions though targets for 2050 would be included in the planning horizon of subsequent IRPs.

137. The likely eventual requirement for CCS on both coal and natural gas-fired power plants favors maintaining existing coal plants instead of constructing new gas-fired plants. Recent studies show that retrofitting coal plants with CCS is more economical than replacing coal plants with new gas plants that are later retrofitted with CCS. (*Commenter: Kipp Coddington - MMCC*)

Response: CCS technology was considered in the IRP analyses. The technology is not currently considered developed at a commercial utility scale; therefore, resource options utilizing CCS were restricted to new IGCC plants beginning operation no sooner than 2025.

At such a time when CCS is considered feasible, any retrofits of coal or gas plants with CCS would be evaluated based on regulatory requirements and cost-effectiveness.

138. TVA is subject to Executive Order 13514 on Federal Sustainability, and thus must reduce GHG emissions by 28 percent by 2020. While direct emissions from electric power production may be excluded from this target where appropriate, the IRP and EIS do not explain why TVA is exempting its entire electrical generating system from this emission reduction requirement. TVA should develop strategies that achieve this 28 percent reduction. (*Commenter: Abigail Dillen - Earthjustice*)

Response: The commenter is correct that the referenced Executive Order specifically exempted direct emissions of GHGs associated with electricity generation from the emission reduction targets. Regulation of emissions from electricity generation is being addressed in other ways, including proposed legislation and EPA regulatory efforts. As required by the executive order, TVA submitted a Sustainability Plan on June 2, 2010, and the Office of Management and Budget approved that plan in August 2010. Consistent with this Executive Order, TVA has established GHG reduction targets of between 17 percent and 21 percent by 2020 compared to a 2008 baseline, depending on the category of emissions. TVA intends to achieve these reductions primarily by (1) improving the energy efficiency of its buildings; (2) improving the reliability and efficiency of its hydro-generation portfolio; (3) reducing solid waste disposal; (4) utilizing higher fuel efficiency standards for new cars and light trucks; and (5) increasing the use of employee telecommuting and employee car-pooling. These are the kinds of activities which are the focus of this Executive Order. While TVA direct emissions are exempted from the Executive Order, compared to TVA's current average direct CO_2 emissions, all of the IRP strategies being considered represent a marked and significant emissions decrease during the planning horizon of 2010-2029 (see Final EIS Section 7.6.2), and many align with proposed legislation such as the American Clean Energy and Security Act's (H.R. 2454) target of 40% reduction (from 2005 levels) by 2030.

2.14.5. Regulating Greenhouse Gas Emissions

139. GHG emissions regulations taking effect in January 2011 will make it difficult to satisfy Prevention of Significant Deterioration requirements for new fossil-fueled generating facilities. TVA does not seem to have adequately accounted for this in its plants to replace existing coal-fired plants (which would not be subject to Prevention of Significant Deterioration (PSD) permitting) with new natural gas-fired plants. (*Commenter: Kipp Coddington - MMCC*)

Response: TVA agrees that EPA's regulation of GHG emissions will make the process of obtaining permits for new fossil-fueled power plants more complicated and difficult. It could similarly affect obtaining permits for major upgrades of existing fossil-fueled plants.

EPA is proceeding with rulemaking for GHG emissions from coal-fired utilities, including regulations that became effective on January 2, 2011 that apply primarily to new plants. TVA has taken account of these regulations, as they apply to new sources, by: 1) designing all IRP scenarios to conform to current and likely regulatory requirements, including PSD, and 2) embedding the costs of compliance with environmental regulations in the cost characteristics of the various resource options considered in the portfolio analyses.

140. TVA assumes that all new coal-fired generating capacity must be equipped for carbon capture and sequestration. TVA does not, however, address the potential requirement for equipping new natural gas-fired generating capacity with CCS. Deploying CCS on both coal and natural gas plants will likely be necessary to meet GHG reduction policy goals. By not considering CCS for future gas plants, TVA is inappropriately penalizing future coal-fired plants. (*Commenter: Kipp Coddington - MMCC*)

Response: There is significant uncertainty about the timing and specifics of future GHG emission reduction requirements and TVA agrees that CCS could be required on future natural gas-fired generating facilities. However, coal-fired plants have been the target of many efforts to regulate GHGs and it seems reasonable to assume that any requirement to use CCS will target coal plants first. As with other assumptions made in order to complete the IRP analyses, TVA will continue to monitor GHG emission reduction requirements and the development of CCS and consider this in future IRPs, if appropriate.

141. While Congress has recently deferred regulating GHGs, their regulation by the Environmental Protection Agency begins in 2011. This presents a financial risk to TVA and its customers. This financial risk should be explained and reflected in the IRP analysis. (*Commenter: Luis Martinez - NRDC*)

Response: Comment noted. EPA is proceeding with regulating GHG emissions from coal-fired utilities, and TVA anticipates constraints on carbon emissions within the IRP planning horizon, although there is uncertainty over how carbon requirements would affect fossil fuel generation. To account for this uncertainty, the IRP scenarios include a modest range of CO_2 prices ($0/ton to upwards of $27/ton, initially) and of the timing of implementation. These ranges were developed as a proxy for a range of CO_2 requirements. Additionally, the financial implications of the IRP strategies are represented by the Present Value of Revenue Requirements (PVRR), which includes the costs of environmental compliance requirements. The PVRR and the associated financial risk metrics thus include the potential costs of regulation of CO_2 and other GHGs.

2.15. Hydroelectric Generation

2.15.1. New Hydroelectric Generation

142. The IRP states there is 1,770 MW of feasible hydropower capacity. Please describe the projects underway or planned to develop this generating capacity. (*Commenter: Garry Morgan*)

Response: The IRP states that about 1,700 MW of feasible small- and low-head hydropower were estimated to be available using the Energy Efficiency and Renewable Energy study prepared by the Department of Energy in 2006. After considering the cost of these projects, TVA is reviewing the possible addition up to 144 MW of combined additional units at existing hydroelectric power plants and existing dams by 2029. This additional capacity was identified as feasible in a recent renewable energy assessment. TVA is also evaluating the option to extend the hydro modernization program (e.g., measures that achieve capacity and efficiency gains at existing hydro power plants) by approximately 90 MW.

2.15.2. Upgrades to Existing Hydro Facilities

143. Instead of building all-new, non-renewable generating facilities, TVA should prioritize upgrades to its existing hydroelectric fleet. TVA has recently neglected these facilities. (*Commenter: Garry Morgan*)

Response: TVA has a Hydro Modernization (HMOD) program to address gaining additional capacity in the existing hydro system. TVA's HMOD program began in 1992 to address reliability issues on aging units and increase capacity and efficiency on some portion of those units. To date, 57 hydro units have been modernized. Those projects have provided peaking capacity gains of 565 MW and average efficiency gains of 4.8 percentage points. The program has exceeded the initial capacity gain expectations by nearly 45%. There are 49 units that have not yet been modernized. Due to the increased age and smaller performance gains of these units, they are being prioritized based on equipment condition and risk to reliability. As each unit is studied for modernization, potential performance gains will be evaluated to determine if the extra expenditure is economically justified and site-specific environmental analyses will be conducted, as appropriate. Projects are ongoing at Nickajack and Watts Bar to modernize an additional three units. Those units are expected to add 11 MW of peaking capacity to the system by the end of 2013.

144. TVA's hydroelectric generation can be greatly increased by upgrading the existing hydro plants. These upgrades should use the very best turbines, super conductors, etc. Wilson Dam could be upgraded to about 3,000 MW capacity, Wheeler to 1,800 MW, and Guntersville to 1,200 MW. The system-wide potential capacity increase is about 8,000 MW. This would greatly increase peak load generating capacity without greatly altering river flows. (*Commenters: Sandra Kurtz - BEST, Paul Noel - NEC*)

Response: The stated 8,000 MW is not achievable utilizing TVA's current system of dams. TVA has a Hydro Modernization (HMOD) program to address gaining additional capacity in the existing hydro system utilizing the current most advanced, best proven available technology. TVA's HMOD program began in 1992 to address reliability issues on aging units and increase capacity and efficiency on some portion of those units. To date, 57 hydro units have been completed. Those projects have provided peaking capacity gains of 565 MW and average efficiency gains of 4.8 percentage points. The program has exceeded the initial capacity gain expectations by nearly 45%. There are 49 units that have not yet been modernized. Due to the increased age and smaller performance gains of these units, they are being prioritized based on equipment condition and risk to reliability. As each unit is studied for modernization, potential performance gains will be evaluated to determine if the extra expenditure is economically justified. Projects are ongoing at Nickajack and Watts Bar to modernize an additional three units. Those units are expected to add 11 MW of peaking capacity to the system by the end of 2013.

2.16. Integrated Resource Planning

2.16.1. Bias for Nuclear Energy

145. The IRP shows a strong bias towards nuclear energy and against the more environmentally friendly and lower cost alternatives of energy efficiency and renewable energy sources. While describing nuclear energy as clean, the IRP fails to address the impacts of mining and producing fuel and disposing of spent fuel. It also fails to address the fact the construction of new nuclear plants cannot be financed without large government subsidies. (*Commenter: William Reynolds*)

Response: TVA's least cost planning approach considers all feasible resource options, including but not limited to, nuclear, energy efficiency, and renewable resources. Cost information for all potential resource options was developed from a range of standard accepted sources and TVA's experience, and does not include bias for or against any resource options. The computer models that TVA used in its IRP evaluations selected nuclear power when it was the lowest cost option for meeting future resource needs. The Recommended Planning Direction strategy is a diverse approach that includes increases in nuclear power, renewables, EEDR, and gas-fueled generation. The description of nuclear energy as clean in the IRP is largely based on the fact that nuclear generation does not result in the direct emission of GHGs or other air pollutants. Other environmental impacts of nuclear and other types of generation are described in the Final EIS. TVA receives no government subsidies for the construction of generating facilities, including nuclear plants.

2.16.2. Cost of Implementing a Strategy

146. The draft IRP acknowledges TVA's $30 billion debt limit. The capital needed to fund the resource plan implementation will require the issuance of new debt or an increase in rates. We are opposed to financing capital improvements from rates collected during the year the costs are incurred. Therefore, an issuance of new debt appears necessary. While the distributors are willing to work with TVA to persuade Congress to increase the debt limit, we do not believe this is the sole solution and urge TVA to work with the distributors to seek additional solutions. (*Commenters: Dana Jeanes - MLGW, George B. Kitchens - JWEMC, Lanny Night, Jack W. Simmons - TVPPA*)

Response: TVA’s primary means of raising capital for major investments are power revenues, bonds and less traditional forms of financing agreements. TVA employs a set of financial guiding principles to guide its use of rates and borrowing, which are consistent with sound utility practice to use financing to build assets, and then collect the cost of construction from consumers who will benefit from the new asset while it is in service. TVA will continue to engage in communication with distributors of TVA power as well as other stakeholders about TVA’s financial flexibility issues.

147. The Draft IRP states that '“a majority of capital expenditures in the short term (prior to 2108) may have to be funded solely from rates.” Please explain what happens in 2018. How will the impact on ratepayers through 2018 differ from that after 2018? (*Commenter: W.R. Kendrick*)

Response: This comment is about the short-term rate metric which does not address debt or rates after 2018. The short-term rate metric provides a representation of the revenue requirements for the period 2011-2018 expressed on a per MWh basis. This metric was developed to focus on the near-term impacts to system cost in recognition of TVA’s current debt cap of $30 billion and the likelihood that a majority of capital expenditures in the short term (prior to 2018) may have to be funded solely from rates. By considering both short-term rates and the present value of revenue requirements, TVA is better able to evaluate the cost implications of the various strategies. Including both short-term and total revenue requirements facilitates a trade-off analysis of alternative resource plans and allows TVA to more explicitly evaluate funding implications, consistent with stakeholder concerns about increasing rate pressures.

148. TVA identified the optimized portfolios as those with the lowest net Present Value of Revenue Requirements (PVRR) subject to a number of constraints, including environmental compliance requirements. However, TVA provides no information on what the requirements are, how TVA will comply with them, and the cost of this compliance. Without this information, it is not possible to determine whether the chosen optimized portfolios are reasonable. The financial risk ranking metrics are also dependent on these undisclosed compliance information. (*Commenter: Frank Rambo - SELC*)

Response: Regulatory compliance costs are an integral part of the assumptions used in the case analysis done for the IRP. These compliance assumptions and the associated costs impact nearly all cost parameters from capital to fuel expenses to maintenance and other fixed costs, and these assumptions and cost impacts vary across the seven scenarios used in the study. In addition, the probability assessment done to assess risk and uncertainty for key study variables includes ranges that encompass alternative regulatory frameworks. A discussion of these key regulatory assumptions and a general description of the relationship among the variables most impacted by those assumptions is included in Chapter 6 of the Final IRP report.

149. We are concerned that TVA did not fully consider the costs associated with GHG emissions and other environmental impacts of each energy source. These costs are often lowest with energy conservation and renewable energy. (*Commenter: Adam Snyder - CA*)

Response: The costs of compliance with both existing and emerging environmental regulations are embedded in the cost characteristics of the various resource options and thus considered in the portfolio analyses. The various scenarios consider a range of potential future environmental regulations (see EIS Table 2-1) and their associated compliance costs. Life-cycle emission analyses of various technologies were also conducted.

150. What are TVA's debt limit and TVA's current debt? Will the cost of the capital needs for implementing a strategy exceed the debt limit? (*Commenter: Chip Estes*)

Response: TVA's current debt limit is $30 billion, and the current debt level is about $26 billion. In the IRP study, debt financing is capped at a planning target of $28 billion to ensure that the debt limit is not exceeded, with any capital needs in excess of the debt cap financed through rate increases.

2.16.3. Disaster Planning

151. How do the scenarios address disaster planning—the potential for very low probability but wide-reaching events such as natural disasters (e.g., weather events, earthquakes), major equipment failure, or human-caused actions that severely cripple power plants or transmission lines? (*Commenters: Charles Jones, Jackie Tipper Posey*)

Response: The IRP study does not explicitly model impacts of disasters or particular site-specific events that may impact the operation of the TVA power system. The potential effects of extreme events, such as those listed in the comment, are considered during the planning and design of components of the power system and may also be included in TVA's normal annual capacity planning process.

Energy Education and Public Relations

152. TVA could increase public involvement in its IRP process by opening its power plants to public tours. Tours can be restored/initiated at nuclear, hydro, coal, gas, and pumped storage plants with no increased threat to facility security. Providing these tours would greatly increase public knowledge and involvement in energy issues. (*Commenter: Paul Noel - NEC*)

Response: Comment noted.

2.16.4. Frequency of Plan Revision

153. Make integrated resource planning an ongoing process with regular public review. This formal revision process should occur on a 3- to 5-year cycle. (*Commenters: Julia Aepping [sic], Michael Agceda, Debra K. Agner, Grace Ashford, R. Apson, Lain Arubin [sic], Donald L. Audley [sic], W. R. Avery [sic], Moonis Roger Axley [sic], Ann Aytenly [sic], Kris B. [sic], Lauren B. [sic], M. B. [sic], M. Balangen [sic], April Bart, Darrell Bawlslin [sic], David D. Beaty, David W. Belt, Cameron Z. Bennett, Mark Betts [sic], Paul Bevney [sic], Dave Bordenkircher, Paul Boring, Deanna Bowden, Jenny Bowers, M. Boyd, Nancy Brannon, Jason Brown [sic], Harry E. Bryant, Charle A. Bucawfal [sic], Jessica Buchanan, Paula Bunanek [sic], Mark A. Burnett, Melissa A. Burt, Kelvin Butler, Marisa J. Butler [sic], Laura C. [sic], Lisa C. [sic], Teresa Campbell, J. Candien [sic], Bruce Chicre [sic], Brenda Chinck [sic], James S. Collins, A. M. Conisin [sic], Cliff Corker, Arqunsia Cornwall, Josh M. Cox [sic], Thomas V. Cullen, Lori Curt [sic], H. Dwayne Cutshoul, Gary D. [sic], Lacy Damiles [sic], Erika Davidson, Marge Davis, Roeyn Davis [sic], Courtney Day, April Dixon, I. Drelsecn [sic], Randy L. Dry [sic], Torri Dunn, Whodong Ebechnop [sic], Patricia Eleand [sic], Laura Elis, Juliana Ericson, R. Wray Estes, Peggy Evans, William F. Farming [sic], Douglas Felker, Melanie Felker, Heather Finolti, Sarah E. Flower, Charles Foster, Shanequa Fountain, Vita French, Robyn Galochee [sic], Katherine Gamt [sic], Heather Gapsby [sic], Elizabeth C. Garber, Elizabeth Gazaway [sic], Lauren Gearhardt, Joel Gearhardt, Robin L. Gerahann [sic], Danielle Gerhard, Kathy S. Gleeland [sic], Sam Gomberg - SACE, Ransly Goodheart [sic], Tony Gorton, Steven Green, Larry Gregory [sic], Karen Gulk [sic], Ava Gunter, Joshua Guthrey, Mary Alan Guy [sic], P.N. H. [sic], Steven H. [sic], Jane C. Hardy, Whitaker M. Haskins, Meredith Hayes, Rick Held, Larry Hendrix, Redel Hesh [sic], Kristen Hickey, R.M. Hill, Jessica Hill, Chloe Hirst, Megan Hollusam [sic], Cathy L. Hook [sic], Steven R. Horton, Katherine Huddleton [sic], Jaun K. Hudson [sic], Lauren Hulson [sic], Cee J. [sic], Missy J. [sic], Dana Jeanes - MLGW, Gary Jehin [sic], Rofail H. Jenu, [sic], C. Johnson, D. K. Johnson [sic], N.D. Johnson [sic], Michael Jones, Glenda Jordan, Raphael Y. Junit [sic], Ivan Juny [sic], Sam K. [sic], R.R. Karpsal [sic], Barbara Kelly, Chrys Kemp [sic], Sara Keubbing [sic], J. Kewisn [sic], P. Kneuman [sic], Scott Kramer, David Brent Kulovich, Sandra Kurtz, William Kurtz, S. Kurtz, R.C. Last, Eric Lewis, Robert Lindamood [sic], Joanne Logan, Hannah Long, John M. [sic], Burton Mandrell [sic], Julia Mangrin, Selma Marks [sic], Luis Martinez - NRDC, Mary Masten, Annie Mattson [sic], Nancy McFadden, W. McGill, Ralph McKenzie, Laura K. McKenzie, Carson McKinney, Paula McLen [sic], Mann McQueen [sic], Rebecca Meade, Laura Miller, Michael Miller [sic], Austin Milt, Karen Monalan [sic], Elaine Montgomery, Barbara Mott, Catherine Munay, Lauren N., J. N., Marissa N. [sic], John M. Nald [sic], Aesthor Nievons [sic], Josh O. [sic], John P. Oeyal, Ann Olsen, Margaret F. Olson [sic], Janet Osborn, Cornelia Overton, Elsa Parker [sic], Jon Parker [sic], Wilford M. Past, Erwin Peritt [sic], Kotel Perry, Zaria Person [sic], Stefan Peter-Contesse, Courtney Piper - TBLCEE, Norm Plate, Sara F. Plemons, Patricia Poat, Jennifer Porter, John F. Post, Justin Post, Patricia Post, Mrs. James S. Powers, W. J. Pruit, Cody R. [sic], K. R. [sic], Keith Rainy [sic], Frank Rambo - SELC, Nancy J. Reans, D. Richardson, Arnold C. Ringe [sic], Gordon Robinson, Madeline*

Rogers, Mercedes Rodriguez, Phillip Roll [sic], Ruth F. Rothe, Susan Routan, Kathy S., Tanya S. [sic], Don Safer - TEC, Melinda Sanede [sic], Feris J. Schlery, Cody Semabayl [sic], Susan Shannon [sic], Judy Sheffield, Madeline Shelly, Jane L. Shelton, Madeline Shely [sic], V.C. Shriever [sic], Roxanna Shohadaee [sic], Jack W. Simmons - TVPPA, Jack Slede [sic], Michelle Smith, Jennifer Sneed, Adam Snyder – CA, Ariel Spioan [sic], Jamie K. Stand [sic], Lauren J. Stein, Karl Stirs [sic], Carolyn N. Stokes, Henry Stokes, Paulrann P. Stocks [sic], Kathy Stone [sic], A. Suny [sic], Lauren Szoech, Karen T. [sic], Bill Terry [sic], Andy Todd, Nancy G. Van Vallanburgh, B.S. Vick [sic], Dorthy W., G.R. W., Anne Wael [sic], Chuck Walker, Paula D. Ward, Luke Waring, Jan H. Watson [sic],Chad Watters [sic], Cassie F. Watts, Mona Whitehead, Dean Whitworth, Paul Wieland, Astor Williams [sic], Debbie Williams, R.T. Williams, T.V. Williams [sic], Adelle Wood, Linda W. Woodcock, Kevin R. Woods, J. Y. [sic], Schean Yearke [sic])

Response: TVA agrees that it is important to update its IRP on a regular basis and has committed to doing this. The next IRP process will begin by 2015 and will include public input.

154. TVA should review the final plan on an annual basis to make necessary adjustments due to changes in the economy, power demand, legislation, and regulations. This annual review does not necessarily have to be a public process. (*Commenter: George B. Kitchens - JWEMC*)

Response: TVA's annual business planning process reviews changes in the economy, power demand, legislation, and regulations. TVA has committed to begin another IRP study no later than 2015.

2.16.5. Incorporation of EEDR into Resource Plan

155. Energy efficiency should be the first resource loaded in the formulation of a portfolio due to its low-cost relative to new generation resources. It is the most cost-effective resource available, can be brought online quickly, does not burden transmission and distribution infrastructure, and has no environmental compliance costs. (*Commenter: Donald Gilligan - NAESC*)

Response: Comment noted. The EEDR portfolios considered in the draft IRP were represented as scheduled transactions in the capacity planning model. This technique gives EEDR a priority over other resource options that might be selected in the planning study by loading the EEDR portfolios first, prior to considering other resource options (except for renewable resources, which were treated in a similar manner).

2.16.6. Need for Power Forecast

156. Please explain the drops in the existing firm capacity occurring in 2013 and in 2021 shown on Draft IRP Figures 1-2 and 3-7. (*Commenter: Nick Crafton*)

Response: The decreases in the existing capacity values shown in both figures are due to the idling of coal units and the expiration of existing power purchase agreements occurring under the Baseline Plan Resource Portfolio.

157. The description of the need for power forecast does not provide enough information. For example, no data or statistical measures of the load forecast are provided. An

unjustifiably high sales growth forecast could lead to overreliance on traditional generation options. TVA should provide a more realistic, better substantiated forecast. (*Commenter: Frank Rambo - SELC*)

Response: The IRP scenario analysis approach used a range of load forecasts to produce a no regrets strategy. Eight different scenarios were evaluated, each with its own load forecast. The range of load forecasts considered is described in Final IRP Figures 4-3, 4-4, and 6-3. Statistical measures of TVA's load forecast accuracy are described in Final IRP Section 4.1.2.

158. The need for power forecast in the high growth Scenario 1 is unrealistically high. There is no historical data to support an annual growth rate of 2% throughout the 20-year planning period. The 1.1% medium growth rate in Scenario 7 is also higher than historical data support. These high rates are based, in part, on assumed correlations with population growth and economic growth rates. Data from other states show that these correlations are, at best, weak. TVA should revise the demand growth rates to a more realistic range of 0% (low), 0.7% (medium), and 1.2% (high). (*Commenter: Sam Gomberg - SACE*)

Response: Scenario 1 was designed to represent an upper bound on the possible capacity needs of the TVA system. This scenario functions as a stress case and shows the most aggressive resource plan (most resource additions) that could be expected to occur on the system, and therefore, provides an appropriate boundary condition for selection of a preferred planning strategy.

2.16.7. Planning Process

159. At its August 20, 2010 meeting, the TVA Board and CEO Kilgore, by voting to adopt the 'TVA Vision' and complete Bellefonte Nuclear Plant Unit 1 in 2018, essentially selected IRP Alternative Strategy C with a high growth scenario. The major differences between the Board's decision and Strategy C are a much lower level of coal plant layups, the addition of small modular nuclear units not addressed in the IRP, and the lack of action on a pumped storage hydroelectric facility. By already making most of the decisions on an IRP strategy, TVA foreclosed the IRP as a public process and left little to be decided in April 2011. (*Commenters: Louise Gorenflo - TCSC, Sandra Kurtz - BEST, Nancy McFadden, Don Safer - TEC, Steven Sandheim - SC/TSVC*)

Response: On August 20, 2010, the TVA Board announced its renewed Vision for TVA. While this was an important pronouncement because it confirmed and sharpened TVA’s existing goals, those goals remain aspirational in nature. The IRP process represents a further refinement and detailing of this strategic direction. In other words, the IRP helps transition aspirational goals to implementation activities. The next step after the IRP is initiating implementation activities which will have their own decisionmaking and analytical processes, including more site-specific environmental reviews when appropriate.

Completion of Bellefonte Unit 1 was not approved by the Board. The Board only approved additional funding for some activities. These activities include initial engineering design, asset preservation and facilities preparation, regulatory framework development and procurement of long-lead components. These activities help preserve completion of this unit as a viable energy option for TVA. It is anticipated that the Board will be asked to do approve completion and operation of the unit in April 2011, taking into account the IRP results.

The major differences between the coal capacity idling announced at the Board meeting and IRP Strategy C are that the Board announcement contained a lower level of coal generation idling; the nine units to be idled lack the environmental controls to necessary to meet higher emission standards and several have among the highest operating costs in TVA's coal fleet. The nine are being idled initially, but are expected to be retired eventually.

As explained in the Final EIS, small modular nuclear units are not considered a resource option in the IRP. They could be an action that helps implement the Vision, but this requires additional decisionmaking and review.

A new pumped storage facility is included in some IRP strategies, including the Recommended Planning Strategy. TVA is conducting more detailed feasibility studies of a new pumped storage facility and has not proposed building such a facility.

160. Because of the Kingston coal ash spill, TVA currently has a problem with its credibility on public safety issues. Safety issues are also a concern for the utility industry in general, as evidenced by the Connecticut combined cycle plant explosion and other recent incidents. While some parts of TVA seem to take safety very seriously, we hope the rest of TVA can rise to this level. How are public safety issues and the related risks addressed in the resource planning process? (*Commenter: Bob Alexander*)

Response: Public safety issues are not explicitly addressed in the IRP study. However, safety considerations are part of the design criteria for all the generating resources considered in the study, and the costs and unit characteristics included in the models reflect that design criterion.

161. Because TVA did not limit opportunities for input to its customers (distributors and directly served customers), the IRP may not be as executable as it otherwise would have been. Much of the public input came from groups or individuals that have no direct customer relationship with TVA. (*Commenter: George B. Kitchens - JWEMC*)

Response: Comment noted. Input from TVA's direct customers of course is very important and TVA sought and obtained that input in several ways. However, as a federal agency with a public mission, it is both necessary and proper to seek input from the entire range of interests in the Tennessee Valley region. In addition, the National Environmental Policy Act requires TVA to use an open public process in EIS processes.

162. How does the planning process evaluate and compare the risk associated with planning, obtaining approvals and financing, and constructing a new generating plant on time and within budget with the risk of achieving planned energy efficiency and demand response reductions? Please describe these risks. (*Commenter: Lanny Night*)

Response: These risk considerations are described in Final IRP Section 8.3.4 - Other Considerations.

163. How was the availability of the draft IRP and EIS advertised to the public? I saw little notice of it in my local media. (*Commenter: Jackie Tipper Posey*)

Response: TVA placed two advertisements in the major newspapers and issued press releases to media in the vicinity of each public meeting. Online advertisements were placed on websites of a major newspaper and television station in the area of each public meeting as well as other major media markets in the TVA region. TVA also announced the meetings on its website and its Facebook page. Finally, notifications of the availability of the Draft IRP and EIS, along with information on the meetings, were sent to everyone who participated in the project scoping or otherwise asked to be notified of project developments and notice of the availability of the EIS was published in the *Federal Register*.

164. Please explain the process used in determining the generation mix, i.e., does TVA conduct a formal Request for Proposals in which all resource options (including existing) must bid into an RFP? If so, what entity oversees this process? (*Commenter: W.R. Kendrick*)

Response: The process used to identify the least cost resource plans identified in the draft IRP is described in Chapter 5 (Section 5.4). The process does not involve bidding into any RFP, but rather, uses information about the projected costs and performance characteristics of various resource options to develop a least cost 20-year power supply plan based on minimizing total revenue requirements over the study period.

165. The draft IRP and EIS do not provide adequate information on the costs and benefits of various resource options. This includes both, assumed current costs and future cost trends. Absent this information, it is not possible to determine whether TVA has undervalued or overvalued the resource alternatives. (*Commenter: Frank Rambo - SELC*)

Response: The IRP provides data on resource plan cost, financial risks, and strategic considerations that are used to compare planning strategies and thereby inform the decision about the components of a recommended planning strategy. The IRP also provides the details of each resource plan’s unit addition schedule, and the EIS provides a review of the environmental impacts associated with resources selected in these plans. In keeping with industry practice, detailed cost estimates for each candidate resource option and data input to the planning models are not included in the report.

166. The goal of the IRP should be to develop a plan that results in a reliable and economical supply of electricity. This is essential since our economy is so dependent on electricity. (*Commenter: Vic Dura*)

Response: Comment noted. Low-cost and high reliability are among the major goals of the IRP planning process.

167. The public meeting to discuss the draft IRP and EIS that was held in the Memphis area was in an obscure location. Attendance may have been greater if it was in a better known location. (*Commenters: Don Richardson - SC, Kevin Routan - CGSC*)

Response: Comment noted. Both negative and positive responses were received about the meeting locations. Because of the difficulty in finding a location that meets everyone's needs, TVA also conducted webcasts for each meeting to increase opportunities for public participation.

168. The selection of the IRP strategy to be implemented is to be made by the TVA Board of Directors. Because of the importance of this selection decision, it should be delayed until all of the Board members are in place and have served sufficient time to be knowledgeable with TVA operations. (*Commenter: Laurence T. Britt*)

Response: TVA's new Directors were sworn in during October 2010 and have been briefed extensively on the IRP, its recommendations, and its potential impacts. They will have been in place a full six months at the time of their expected April 2011 IRP decision. The terms of TVA's Board members are staggered, and it is likely that TVA will have 'new' Board members frequently in the future. It would be a disservice to the public TVA serves if it continually deferred important decisions because of Board vacancies or new Board members.

169. TVA appears to be concerned about a slow decrease in the system load factor in recent years. This has resulted in higher costs for TVA and hence consumers/ratepayers. One means of increasing the system load factor is by shifting some of the peak load and energy to off-peak hours. We are aware of steps TVA is implementing to do this and these should be better described in the IRP. Please also provide more information on the effects of each strategy on load factor, including how the recent wind power contracts will affect system load power by mostly delivering off-peak power. (*Commenter: Jack W. Simmons - TVPPA*)

Response: Although a smoother load shape (higher load factor) allows units to run more optimally and lower overall costs, the IRP did not evaluate any strategies specifically designed to modify the system load factor. A review of selected scenarios shows that the system continues to exhibit a load factor in the 50-52% range, even when the impacts of the energy efficiency and demand response (EEDR) programs are considered as an adjustment to load. The planning strategies themselves do not impact load factor, which is a measure of the load shape, with the exception of the impacts associated with the EEDR portfolios. The wind power contracts will impact the system dispatch, especially in the low load periods, but those impacts are captured in the plan costs computed as a part of the study.

170. Unlike other types of generation, the amount of renewable generation is a defined input rather than an amount selected by the optimization process. TVA should use sensitivities to determine the optimal amount of renewable energy. We believe this will result in larger amounts of renewable energy. (*Commenter: Jimmy Glotfelty - CLEP*)

Response: During the draft phase of the IRP, five planning strategies were designed to test various aspects of resource decisions that TVA might make in response to different futures. To ensure that sufficient renewable resource options were selected to meaningfully impact the overall resource plan, three different renewable portfolios were developed ranging from 1,500 to 3,500 MW capacity. In the final phase of the IRP, an optimization was performed to assess the preferred level of renewables, as suggested, that should be included with other resources as part of the recommended planning strategy. In the optimization analysis, the model picked the lowest levels of renewables allowed, not higher levels. However, based on stakeholder input, TVA chose to include the mid range of renewables in the Recommended Planning Direction. See Final IRP Sections 6.6, 8.2, and 8.3 for a description of the optimization process and Final IRP Appendix D for a description of the development of the renewable energy portfolios.

171. We support and commend TVA's effort to develop its first integrated resource plan since the 1995 Energy Vision 2020. This planning process, with extensive public involvement, is necessary for TVA to meet the region's future energy demand while fulfilling its statutory mandates while reducing many environmental impacts. (*Commenters: Mark Bishop, Gray Cassity - BES, Michael J. - TEC/BCAAT, Gary Dillard - WRECC, Abigail*

Dillen - Earthjustice, Nancy Givens - WKU/KSES/BGGP, Jimmy Glotfelty - CLEP, Sam Gomberg - SACE, Gerard Heininger - EI, Dana Jeanes - MLGW, Brett R. Kerr - CC, George B. Kitchens - JWEMC, Luis Martinez - NRDC, Garry Morgan, Tom Nelson - DESI, Leonard K. Peters - KEEC, Frank Rambo - SELC, Chris Shugart - PE, Jack W. Simmons - TVPPA, Adam Snyder - CA, Jon Wolfe)

Response: Comment noted.

172. What is the rationale for limiting the Monte Carlo analysis to only 72 iterations? A Monte Carlo analysis typically requires a much larger number of iterations (usually thousands) to develop a stable distribution of values. (*Commenter: Heinz J. Mueller - EPA*)

Response: The technique used in the production costing and financial analysis model is a stratified Monte Carlo method. TVA has conducted tests of this method and determined that 72 iterations is sufficient to accurately represent the probability distribution curve. More than 72 draws are made in the model, but only 72 are retained to populate the sectors of the distribution.

173. While TVA has apparently provided the Stakeholder Review Group with detailed information used during the planning process, much of this information has not been included in the draft IRP or EIS or otherwise shared with the public. We are concerned about this lack of transparency as public disclosure is a central purpose of the National Environmental Act (NEPA). The lack of this information, as also noted in other comments, also makes it difficult to make an informed assessment of the alternatives, including the cost estimates and rationales for choosing model input characteristics. (*Commenter: Frank Rambo - SELC*)

Response: Transparent communication is an important part of the IRP process. The presentations for each of the Stakeholder Review Group meetings were posted on TVA's external web site soon after the meetings so that they could be considered by the general public. These presentations as well as additional information can be found at http://www.tva.com/environment/reports/irp/index.htm.

2.16.8. Planning Scenarios

174. By the end of the planning period, renewable energy may be one of the only types of generation not severely restricted by problems with climate change, pollution, waste disposal, foreign fuel sources, and safety concerns. TVA should consider a scenario that includes two or three times the current 9,400 MW of renewable energy and EEDR to address this situation. (*Commenter: Nelson Buck*)

Response: The scenario planning process being used in the IRP is intended to identify potential resources that can be combined to form a planning strategy. That strategy has a broad directional character that allows for adjustments in terms of composition as future conditions change. The kind of situation described in this comment would be considered in future IRP updates as appropriate.

175. How do the planning scenarios address the likelihood of economic distortion resulting from greatly increased interest rates for a protracted period of time? This would greatly affect financing of TVA construction projects and the ability to inexpensively raise funds. (*Commenter: Charles Jones*)

Response: This type of macroeconomic impact is considered in the design of the scenarios (see Final IRP Figure 6-3). Across the various futures represented by the seven scenarios there are variations in economic assumptions, including higher interest rates. In addition, the probabilistic analysis performed as part of the study also considers swings in key input variables that could represent changes associated with economic fundamentals.

176. The assumptions for the Environmental Outlook uncertainty for many planning scenarios are unreasonably low, need clarification, or both. TVA states that coal plants will require various emission controls by certain years, yet does not provide the necessary detail to support the assumptions. Similarly, TVA does not describe the actual control devices necessary to comply with the 'HAPs MACT.' These unexplained or implausible assumptions minimize the risk and costs associated with carbon-intensive resources, such as coal, and prevent the necessary reasonable comparison of alternatives. (*Commenter: Frank Rambo - SELC*)

Response: As outlined in Chapter 5 of the IRP, specific numerical values or dates for each uncertainty were defined for each of the scenarios. The Environmental Outlook assumptions included: (1) an aggressive EPA regulatory schedule leading to additional compliance requirements and (2) command and control regulations for Hazardous Air Pollutants (HAPs) that drive plant by plant compliance. The timing for installation of emission controls and HAPs requirements were varied across the scenarios to ensure a robust analysis. Drivers for clean air controls, in addition to HAPs, are presumed to be the Transport Rule (once finalized) and the National Ambient Air Quality Standards (NAAQS). The Transport Rule is assumed to replace the Clean Air Interstate Rule with stringent limits for SO_2 and NOx beginning in 2012 and some additional reductions in 2014, coupled with SO_2 and NOX emission limits to be set by state programs to attain NAAQS. HAPs will likely require strict emission rate-based limits on each plant to control mercury, acid gases, and metals.

177. The assumptions for the GHG requirements uncertainty in the Economic Malaise Scenario are unreasonable. Given that EPA is beginning to regulate GHG emissions, the cost of CO_2 emissions will be higher than the assumed $0/ton. These unexplained or implausible assumptions minimize the risk and costs associated with carbon-intensive resources, such as coal, and prevent the necessary reasonable comparison of alternatives. (*Commenter: Frank Rambo - SELC*)

Response: The purpose of the scenarios is to provide a range of potential future conditions that is used to analyze the performance of the planning strategies. The Economic Malaise Scenario describes a future with low growth in power demand and no additional regulatory requirements for emissions and other air pollutants, energy efficiency, or use of renewable energy. The other scenarios consider various levels of new regulatory requirements and a range of costs of CO_2 emissions.

178. The planning scenarios address a relatively narrow set of power demand forecast curves that represent various businesses as usual models and assume a return to historically 'normal' conditions. While this approach is useful, TVA should also use scenarios that consider radically different future conditions such as extreme climate change, rapid increase in fuel costs driven by fuel depletion, long term depression, and the transition from a growth economy to a steady state economy. (*Commenter: Louise Gorenflo - TCSC*)

Response: The scenario planning process used in the IRP study is intended to test a suite of planning strategies against a range of potential future conditions defined by the scenarios. While some scenarios are based on historically normal conditions, others incorporate higher growth (Scenario 1) and markedly lower growth (Scenarios 3 and 6) conditions. The selection of the preferred alternative strategy is largely based on its performance across the range of conditions defined by the scenarios. In future IRPs, TVA will continue to consider a broad range of future conditions, including potentially extreme conditions. The IRP strategic direction approved by the TVA Board for implementation will be subject to tuning through the annual planning process and IRP updates to best position TVA to be successful in its core mission. The scenarios represent various long-term outlooks that help TVA identify the robustness of alternative resource plans. Extreme conditions, such as those identified in this comment, could be part of future sensitivity testing of a recommended planning strategy.

179. There is a real need for seriously dealing with GHG emissions; this should be done sooner rather than later. Your Scenario 6 - Carbon Regulation Creates Economic Downturn is alarming. Please give a more detailed explanation of the assumptions made in defining this scenario. (*Commenter: Steve Pearson - AAFB*)

Response: This scenario was developed based on recommendations of the Stakeholder Review Group. The scenario assumes that stringent CO_2 regulations are passed without a global climate treaty. This results in the cost of electricity being much higher in the United States than in many developing countries. As a result, large multi-national industries move factories and production processes that consume large amounts of electricity from the United States to overseas, resulting in an economic downturn.

180. TVA needs to seriously address and plan for the Game-Changing Technology 'gadget' in Scenario 4. Many of these gadgets already exist in various forms. They will cause a gradual decline in demand for grid-based power over the next 10 to 15 years and a precipitous decline at about 20 years. After 45 years, there will be no demand for grid-based power. (*Commenter: Paul Noel - NEC*)

Response: Comment noted.

2.16.9. Purchased Power

181. The IRP strategies restrict the use of purchased power in meeting TVA's future energy needs. In order to provide the lowest cost and overall best resources for TVA customers, TVA should consider a competitive procurement process that captures all available options in an open, transparent, and fully competitive mechanism. Through this process, all supply options, including existing resources, would be evaluated on an equal basis. (*Commenters: Mike Chapman - ME/KE, Tina Lee - KP, Peter Robertson - ANGA*)

Response: The IRP planning strategies do not restrict the use of purchased power. They instead include an annual limit on maximum power purchases to properly reflect constraints on the transmission network or other operational limits. These constraints are necessary to prevent the planning model from selecting an amount of purchased power that either cannot be reliably delivered or may not be available for the duration of the planning study.

182. There are 16 natural gas-fueled Independent Power Producer plants in or adjacent to the TVA region with about 12,000 MW of capacity. Many of these plants are underutilized.

TVA should consider greater utilization of these facilities in its scenario analysis. These plants could replace aging coal-fired plants at significant cost savings to TVA and provide significant environmental benefits. (*Commenters: Mike Chapman - ME/KE, Peter Robertson - ANGA*)

Response: The IRP study uses both potential purchased power agreements (PPAs) and market power supplies as options in the analyses. The IRP does not attempt to identify specific sources for these options, but presents a quantity of power expected to be available in a projected price range. These details are not disclosed in the IRP in order to protect TVA's ongoing negotiations for power supplied by other producers. PPAs and market power purchases are part of all the planning strategies evaluated in the IRP. Available capacity of independent power producers will continue to be part of TVA's resource mix, and may be part of the strategy that allows higher quantities of existing coal-fired resources to be idled. The details of that strategy will be developed as part of follow-up studies after the conclusion of the IRP.

183. We question the pre-determined limits on the amount of capacity from any single source, particularly purchased power. This is contrary to the plan's goal to "ensure that TVA can meet the demand for electricity on its system in a cost-effective, reliable manner." TVA should avail itself of any and all capacity that is available. Limiting purchased power to 900 MW will not allow rate power to take advantage of the low-cost of purchased power and to avoid the inherent risks with new self-build facilities. (*Commenters: Brett R. Kerr - CC, Tina Lee - KP*)

Response: The purchased power limit of 900 MW identified in the draft IRP report (see Figure 5-12) represents an annual cap on market purchases, not a total cap over the study period. This limit has been set to ensure that the optimization model would not select an unrealistically high level of market purchases in any one year simply because that option happened to be the lowest cost alternative in that year. Specific decisions about purchased power agreements (PPAs) are not being made in the IRP cases, but would be the outcome of more focused analyses of options in response to a solicitation or other assessment of market opportunities.

184. While the draft EIS briefly discusses current power purchase agreements (PPAs), neither the draft IRP or EIS discuss purchased power as a potential future resource other than for a few renewable options. We are particularly concerned that TVA is not addressing the large potential for promoting the development of recycled energy facilities through PPAs. The final IRP and EIS should describe how purchased power was modeled and address the potential for purchasing power from recycled energy facilities. (*Commenter: Sam Gomberg - SACE*)

Response: Purchased power is one of several options considered in the IRP. This option is included in the study in three ways: potential transactions from specific projects are included as options in the model database, market purchases are included as resource options along with the renewable energy purchases also included in the list of possible future resources. The planning strategies evaluated in the IRP are comprised of various combinations of resources selected over a 20-year period, and all strategies include various levels of market purchases throughout the study period. In some scenarios, long-term PPAs are selected as part of the resource mix. To protect TVA's ongoing confidential negotiations regarding additional purchased power supplies, and the forecasts of market power prices, no project or price details have been included in the IRP or EIS. Purchased power is selected as part of the resource plans based on cost, so the source of that power can be variable. Conventional sources, renewable energy sources, or recycled energy facilities are potential sources of purchased power if the cost of power from those sources is at or below the price used in the model. The IRP does not attempt to identify the composition of sources for any power purchases included in the planning strategies; the selection of specific sources would be the subject of competitive solicitation of offers conducted after the conclusion of the IRP study.

2.16.10. Resource Plan Implementation

185. Constructing and implementing a 'smart grid' distribution system will be essential for successful implementation of some components of the IRP. Much of this must be done by the distributors. TVA should consider financial incentives in the form of payments or credits for the distributors making self-initiated and self-financed smart grid improvements. These improvements are essential to reducing demand that would otherwise be met by building new generating capacity or purchasing off-system power and benefit the whole TVA region. (*Commenter: Jack W. Simmons - TVPPA*)

Response: TVA plans to continue to work closely with the Tennessee Valley Public Power Association (TVPPA) and its individual members to demonstrate the effective deployment of smart grid systems and develop informed policies regarding their widespread use. While not essential to every aspect of energy efficiency implementation, smart grid technology has the potential to play a key role in the accomplishment of cost-effective implementation of some energy efficiency and demand response efforts. TVA is committed to a dialogue with TVPPA and distributors on how smart grid deployment can best be accomplished and will continue to pursue new opportunities to partner with distributors to increase the knowledge base for all concerned.

186. How much flexibility will TVA have in implementing the IRP once it has been completed and the Board approves a strategy? TVA will have to adjust to changing circumstances that will arise in the future. (*Commenter: Amy Walls*)

Response: The alternative strategies described in the IRP provide strategic direction rather than prescribed capacity additions. This approach gives TVA flexibility in implementing the selected strategy and assures that the selected strategy will perform well within the range of the various scenarios. TVA has also committed to updating the IRP at regular intervals, with the first update beginning no later than 2015.

187. Implementation of the IRP will require innovative approaches to selecting and financing power generation. We urge TVA to accelerate its efforts to involve the Seven States Power Corporation in this. Seven States involves the TVA distributors in the financing and ownership of generating facilities. The distributors desire this equity position and a stronger role in planning the future power supply. (*Commenters: Dana Jeanes - MLGW, George B. Kitchens - JWEMC, Jack W. Simmons - TVPPA*)

Response: Comment noted. TVA and Seven States Power Corporation are currently working together to evaluate financing options and opportunities.

188. In order to successfully implement the EEDR portfolio, the TVA distributors will need to install additional infrastructure. The planning, design, installation, and funding of this infrastructure appear to be the responsibility of the distributors. The distributors, however,

need for TVA to coordinate with them on the additional infrastructure system needs and requirements. This is necessary to assure the appropriate system designs, equipment purchases, and installations are completed in time to meet the power system needs. How is TVA coordinating this work by distributors? (*Commenters: Alfred Dyson - DETS, Jack W. Simmons - TVPPA*)

Response: TVA fully recognizes that successful implementation of EEDR initiatives is highly dependent on the cooperation of local power distributors. Since the inception of TVA's EEDR organization and its efforts in EEDR over the last four years, TVA has focused on communication and coordination with power distributors in the design and implementation of programs. This has primarily been through the Tennessee Valley Public Power Association (TVPPA) committee structure and dialogue with individual power distributors. As with programs developed thus far, TVA will continue to seek the involvement of power distributors in design teams and will continue to discuss planning and development issues in the forums afforded by the Rates and Contracts, Energy Services, Technology Applications, and other TVPPA committees. In addition, input from individual distributors will continue to be a key ingredient in the development process.

The timing and development of infrastructure by distributors as well as staffing issues are important considerations in implementing the recommended strategy identified in the IRP process. TVA is engaged in an ongoing dialogue with power distributors to identify the challenges posed and potential solutions. In cooperation with several power distributors across the Valley, TVA is demonstrating a variety of technologies to learn the intricacies of their deployment and operation as well as how to best integrate their use with the operations of both power distributor and TVA delivery systems. Such demonstrations will provide fundamental information on the costs, staff impacts, and other issues associated with wide-scale infrastructure changes that can be shared with the entire power distributor community in the Valley. Given the early stages of these demonstrations, a detailed description of the complete role of power distributors is not feasible in the IRP document, but an attempt to address the overall importance of the power distributors' role will be made.

189. The environmental reviews of project-specific actions taken in implementing the IRP should include assessments of wetlands, surface waters, erosion and sediment control, air emissions, solid and hazardous wastes, biological resources, significant natural communities and geologic sites, and historic and cultural resources. They should also consider pollution prevention techniques, waste minimization and recycling, and other measures to reduce and mitigate potential environmental impacts. (*Commenter: Ellie Irons - VDEC*)

Response: Comment noted. TVA routinely considers these topics in its environmental reviews of specific proposals.

190. The full involvement of the local power distributors is essential for the successful implementation of the new resource plan. This is particularly true for the energy efficiency and demand response programs, time-of-use rate implementation, smart grid initiatives, and integration of electric vehicle charging stations, as the distributors, rather than TVA, are the direct contact with most customers/ratepayers. Although there is some recognition of the role of distributors in the draft IRP, there is a lack of detail on this aspect of implementation. (*Commenters: Robert Kieffer - HES, Jack W. Simmons - TVPPA*)

Response: Comment noted. The commenter is correct in the assessment that full involvement by the distributors of TVA power is essential for the successful implementation of the new resource plan. The final IRP has expanded the recognition of this role of the distributors.

191. We look forward to participating in the project-specific review of future implementing actions. (*Commenter: Karen Anderson-Cordova - GDNR*)

Response: Comment noted. As appropriate, TVA will involve the pertinent federal and state agencies and the general public in the project-specific environmental reviews of future implementing actions.

192. We recognize the importance of EEDR in TVA's resource planning and acknowledge that the TVA region has a large potential for energy conservation. We are concerned, however, with how TVA is addressing the uncertainties in achieving the aggressive demand reduction goals. If the goals are not met, load shedding, contingent supply, and transmission facilities may be needed. The most suitable contingent supply is natural gas generation. (*Commenter: Peter Robertson - ANGA*)

Response: Uncertainty analysis has been a key part of the IRP study, and the risk associated with achieving projected EEDR reductions was a part of that analysis. This risk was analyzed through the stochastics (Monte Carlo simulation) performed as part of the financial cost computed for each of the planning strategies. TVA’s annual planning process will continue to assess the effectiveness of the EEDR portfolio and may recommend hedging strategies to ensure system reliability.

193. We urge TVA to provide more detail about how changes in the selected resource plan/strategy will be made in practice as conditions evolve. One particular aspect of interest to distributors is our understanding that some changes in strategy will be implemented by simply passing costs on to customers through the new Fuel Cost Adjustment provisions. For example, costs of additional purchased power incurred by not meeting EEDR targets would be passed to customers through the fuel cost provisions. Similarly, what would be the effects of existing generating asset performance being lower than expected (as recently occurred with Browns Ferry Nuclear Plant)? (*Commenter: Jack W. Simmons - TVPPA*)

Response: Depending on the level of other assets available, purchased power might be used to make up for limited duration shortfalls in EEDR targets or poor performance by generating facilities. However, the IRP process is designed to minimize the risk of these occurrences by finding the least-cost plan that also has a reasonable level of financial risk as well as non-quantifiable risks. It should be noted that short-term power purchases are also made when there are less expensive resources available from third-party suppliers.

194. We urge TVA to work closely with the distributors through the Tennessee Valley Public Power Association (TVPPA) committee structure to successfully implement the resource plan. The TVPPA committees represent the geographical and size diversity of the distributors as well as both municipal and cooperative distributors. Within the committee process, there must be full, transparent, and effective communication of TVA's operational, financial and strategic planning. (*Commenter: Jack W. Simmons - TVPPA*)
Response: TVA remains committed to working closely with the distributors of TVA power to successfully implement the resource plan. TVA will work with TVPPA through its committee

process to assure full, transparent, and effective communication as implementation plans are developed.

195. While we strongly support the IRP process, we are concerned that the TVA Act does not require the TVA Board of Directors to act in accordance with IRP results. This could impact the effectiveness of the IRP process and result in inconsistent strategic direction. (*Commenter: Sam Gomberg - SACE*)

Response: The commenter is correct that under the TVA Act, the TVA Board of Directors has the authority to set TVA's strategic direction. Consistent with this, the IRP process is structured to present to the TVA Board the results of the IRP process and a recommended strategy. As the ultimate strategic decision maker for TVA, the Board is free to approve that strategy or to adopt some other strategy as long as it is within the borders of the IRP environmental analysis or is preceded by a revised environmental analysis. This is fully consistent with the IRP process and expectations for it.

2.16.11. Sensitivity Testing

196. Does the IRP test sensitivity to likely National Renewable Energy Standards? If so, what assumptions were used in this testing? (*Commenter: Harold Danks - AC*)

Response: The IRP does not explicitly test specific national RES targets, but the design of the scenarios used in the study does reflect some consideration of potential federal legislation about renewable energy standards that was under discussion in Washington in the fall of 2009.

2.16.12. Stakeholder Review Group

197. How were the members of the Stakeholder Review Group selected? The membership includes several statewide organizations. There does not, however, appear to be any representation from the Memphis area. (*Commenter: Alfred Dyson - DETS*)

Response: TVA considered a number of different individuals when identifying possible members of the Stakeholder Review Group with the objective of achieving a balanced cross section of governmental, power distribution, civic, and non-governmental interests. To keep the size of the group manageable, TVA decided that recruiting some members from statewide organizations like TVPPA and the Chamber of Commerce would bring to the Review Group perspectives that would encompass more local viewpoints. Purposefully trying to bring in members from specific locations would have led to concerns about favoring some locations over others absent creating a very large group. TVA did hold two public meetings on the IRP in or near Memphis.

198. Please explain the role of the Stakeholder Review Group in more detail. For example, how deeply were they involved in developing the various scenarios and strategies? (*Commenter: Rita Harris - SC*)

Response: TVA and the Stakeholder Review Group (SRG) met on approximately 16 days in workshops and working sessions over the course of the IRP planning process. TVA presented each step of the process in detail to solicit input and feedback. Particular attention was spent on the scenarios and strategies used in the study. Several of the scenarios were based on suggestions from the SRG. The input and feedback, as well as challenges made by the SRG, were quite valuable in producing the IRP. Most of the material presented during the SRG meetings and meeting minutes are available at http://www.tva.com/environment/reports/irp/meeting_reports.htm.

199. Will TVA expand its Stakeholder Review Group to include the Technical Director of the Tennessee Solar Energy Association as the advocate for solar energy and energy storage? (*Commenter: Stephen Levy - TSEA*)

Response: The mission of the Stakeholder Review Group will be complete once the IRP is issued in the near future. It is expected that the current group will be dissolved at that time.

2.16.13. Strategy Evaluation Metrics

200. Draft IRP Section 5.5.2.1 and Appendix A, Air Impact (and related DEIS Section 7.6) use CO_2 emissions as a surrogate for emissions of other air pollutants (sulfur dioxide, nitrogen oxides, mercury). Please provide a more detailed discussion of the rationale behind the use of CO_2 as a surrogate. We note that the emissions of these pollutants, as graphed in the DEIS, decrease at different rates. Please also provide more detail on the underlying assumptions used to estimate future emissions. (*Commenters: Heinz J. Mueller - EPA, Sue A. & Steven M. Williams*)

Response: Model results provided data on the production of four emissions: carbon dioxide (CO_2), sulfur dioxides (SO_2), nitrogen oxides (NO_x) and mercury (Hg) by generation source, though it was suspected that evaluating the strategies on the basis of all four emissions would give the same results (i.e. declining emissions trends) as just using CO_2 alone. Emission trend plots were developed to confirm this assumption and CO_2 was used as a surrogate of air emission trends for the IRP evaluation. Additional detail of the environmental metrics can be found in IRP Appendix A. Regarding the difference in emission trend plots, the slopes of the decreases in CO_2 emissions illustrated in Appendix A of the IRP and in Section 7.6 of the EIS do differ from the slopes of decreases in emissions of other air pollutants, as do the proportional amounts of emission decreases. Emission trends charts presented in the IRP and EIS, while correctly showing emissions declines, represent two separate measures. The emission charts shown in Section 7.6 of the EIS are the projected emissions trends for air pollutants (SO_2, NOx, Hg, and CO_2) for specific selected strategies by scenario. For example, SO_2 emission trend lines for Strategy E in Scenario 2 are shown in Final EIS Figure 7-2, while figures provided in Appendix A of the IRP are emission trends using the environmental metric methodology.

201. How would the metric scorecards change if you assumed that GHGs were not legislated or otherwise a concern in the future? Would either Strategy A or D score better? (*Commenter: Nick Crafton*)

Response: If GHG reductions were not required by legislation or a concern going forward, all of the Strategies would perform better, but Strategy A would most likely improve the most. This affect is shown in the scorecard results for Scenario 3, which represented a view of the future that did not include any CO_2 compliance costs.

202. Strategy E scores very close to and slightly lower than Strategy C. How would Strategy E have scored if it had incorporated pumped hydro storage? (*Commenter: Garry Morgan*)

Response: Pumped-storage hydro has a slightly negative impact to the scores of the strategies, mostly due to the resource being a very capital intensive alternative that does not have sufficient quantifiable operating benefits that can be represented in a planning model to fully offset its high construction costs. Therefore, incorporating a pumped storage plant into Strategy E would have a slightly detrimental effect on its scorecard results.

203. The alternative strategies have differing effects on human health due to the varying levels of air pollutants, water pollutants, and solid wastes. Please add a strategic metric that compares the potential human health effects of the various strategies and scenarios. (*Commenter: Dana Beasley Brown*).

Response: Federal environmental standards typically are set at levels protective of human health and are reviewed regularly by EPA to ensure those levels remain appropriate for all populations including sensitive populations. In development of the IRP strategies and scenarios, TVA assumed compliance with regulatory requirements and that this would sufficiently protect human health. Creating a human health impact metric, assuming this could be done without substantial uncertainty, would not serve as a meaningful means of distinguishing among strategies because of this. We recognize, however, that this could be debated and some assert that environmental standards are insufficient, and as such, would also be considering and protecting human health.

204. TVA should add a scorecard metric that addresses residential electrical use intensity. Because much of the future growth in power demand is predicted to come from the residential sector, this metric would address an important factor that is not otherwise adequately measured. (*Commenters: Dana Beasley Brown, Louise Gorenflo - TCSC*)

Response: The scorecard designed for the IRP captured key metrics that relate to the fundamentals of TVA’s mission. While the metrics selected do not include a specific measure of residential electric use, the study did evaluate multiple levels of energy efficiency programs which include efficiency improvements in many areas including, but not limited to, residential HVAC, lighting, and improved insulation. The impacts from these programs are captured in the plan costs and risks, along with the strategic metrics that are a part of the scorecard. So the scorecard has an indirect measure of reduced consumption in the residential sector and that impact can be seen in the scorecards.

2.17. IRP Strategies/Alternatives

2.17.1. Amount of EEDR and Renewable Energy Generation

205. I encourage TVA to develop and implement increased energy efficiency efforts and renewable energy production, especially local renewables. This, along with the transition from coal-fueled generation, will result in significant environmental benefits and provide customers with new energy choices and reliable service. (*Commenters: Mary Agee, Brent Bailey - 25X25, Lawrence Carroll, Ty Gorman, Courtney Piper - TBLCEE, Jackie Tipper Posey, Joab D. Silverglade, Sue A. & Steven M. Williams, Louise A. Zeller - BREDL*)

Response: Comment noted. The Recommended Planning Direction strategy includes 3,600 MW of EEDR and 2,500 MW of renewables, a portion of which would be generated in the TVA region. This strategy also includes the idling of up to 4,700 MW of coal generation.

206. I urge TVA to rely on renewable generation, particularly solar and wind, coupled with greatly increased energy conservation and demand management for all future energy needs. These resources will provide cheaper, cleaner, and safer alternatives than coal and nuclear energy. (*Commenters: W. R. Avery [sic], Darrell Bawlslin [sic], David D. Beaty, Mark Betts [sic], Mark A. Burnett, Kelvin Butler, Marisa J. Butler [sic], Lester Dean, Randy L. Dry [sic], Juliana Ericson, Tom Ferguson, Kathleen R. Ferris - BEST/CENDIT, Norman Ferris, Robyn Galochee [sic], Elizabeth C. Garber, Richard Gilbert, Nancy Givens - WKU/KSES/BGGP, Jane C. Hardy, Rick Held, Cathy L. Hook [sic], N.D. Johnson [sic], D. K. Johnson [sic], Raphael Y. Junit [sic], Nancy McFadden, Laura Miller, Karen Monalan [sic], Josh O. [sic], Elsa Parker [sic], Barbara Peach, Stefan Peter-Contesse, Patricia Poat, Justin Post, Mrs. James S. Powers, Don Safer - TEC, Steven Sandheim - SC/TSVC, Susan Shannon [sic], Richard & Marian Taschler, Paula D. Ward, Cassie F. Watts, Kevin R. Woods, Schean Yearke [sic], James E. Zubko*)

Response: Comment noted. Renewable resources and EEDR are part of all the strategies evaluated in the IRP. While these resources do offer benefits to the TVA system in terms of reduced environmental impact, and enable the agency to move closer to its goals regarding cleaner energy sources, by themselves renewables and EEDR cannot offer the low-cost and reliable power TVA is obligated to provide its customers. TVA is continuing to pursue a diversified portfolio that includes these and other resources and will be evaluating an increased role for both EEDR and renewables in future planning studies. See Final IRP Appendices C and D for an explanation of the development of the renewable resources and EEDR portfolios included in the IRP strategies.

2.17.2. Diversity of Generating Sources

207. Natural gas currently represents less than 4% of TVA's generation capacity and this proportion does not change markedly under the proposed strategies. This is a much lower proportion than the current 24% national average. As TVA states, a diversity of fuel sources is desirable. In this context, natural gas is underrepresented in TVA's fuel mix. Increased gas capacity would also provide more reliable back-up capacity to support the increase in intermittent renewable generation capacity. (*Commenter: Peter Robertson - ANGA*)

Response: Including purchased power and short-term market purchases, the majority of which come from gas-fired units, in 2011 natural gas is projected to account for 25% of total capacity and about 31% of capacity by 2029 in the mid-range scenarios studied in the IRP. In addition, gas-fired generation and purchases account for about 8% of energy produced over the same time frame. Natural gas capacity is an option in the IRP and is selected by the models when cost-effective.

208. Under all strategies, including the Diversity Focused Resource Portfolio, the true diversity in power generating resources is lacking. Almost all power will be from coal, nuclear, and natural gas facilities with no more than 4% from renewables. This lack is not consistent with public sentiment and policy or with local private-sector trends in alternative energy production. (*Commenter: Courtney Piper - TBLCEE*)

Response: The diversity of the resource portfolios produced in the IRP is a result of the assumptions on cost and performance of resource options, along with targets related to minimum levels of some key resource types such as renewables and energy efficiency. Overall, the diversity of the resource portfolios, when considering both TVA's existing generating assets and the resources recommended in each planning strategy, achieves a level sufficient to mitigate the risk of dependency on any one generating source and can be adjusted in response to future developments when the IRP is updated.

209. We encourage TVA to diversify its energy options in order to lessen reliance on fossil fuels, create new economic opportunities, and protect the environment. (*Commenters: Adam Snyder - CA, Gregg Weathers - WRECC*)

Response: Comment noted. All of the alternative strategies reduce reliance on coal-fired generation and the action alternatives/strategies increase the diversity of TVA's generating sources.

210. While I support the use of diverse energy sources, I am concerned about the intermittent generation from solar and wind resources. Does TVA have enough rapid-response backup generating capacity to compensate for the intermittent generation? Natural gas plants can often provide this capacity. (*Commenters: Mike Chapman - ME/KE, Charles Jones*)

Response: TVA's peaking generation is currently sufficient to compensate for variations in the wind power purchases modeled in the IRP. The reserve margin may need to be increased if large amounts of renewables are integrated into the generation portfolio, which could lead to the addition of quick-start generation (generally gas-fired combustion turbine units).

211. While we would prefer that all new capacity additions be from renewable sources, particularly solar, we realize this approach is not realistic. Renewable energy is life-cycle cost effective but has high initial costs and takes time to implement. We believe a balanced generation portfolio with heavy emphasis on renewables and energy conservation is the best approach. (*Commenters: A. Morton Archibald - ASA, Adam Snyder - CA*)

Response: TVA agrees that renewables should play a role in the resource mix, and that implementing these resources into the mix will take time. As these resources gain efficiencies in operations and costs, TVA will continue to evaluate them as part of a balanced portfolio.

2.17.3. Energy Imports

212. Reducing and eventually eliminating imported energy of all types should be a focus of all strategies and scenarios. The United States transfers a significant amount of its wealth to other countries to import energy, and much of our defense spending is to maintain these energy imports. (*Commenter: Eric Lewis*)

Response: Comment noted. TVA does not currently depend on imported fuel for the generation of electricity. New generation options considered in the IRP continue to focus on domestic fuel sources.

2.17.4. General Preferences

213. I support strategies that provide prudent environmental regulation, minimal requirements for renewable generation, increased emphasis on application of smart-grid technologies, and a focus on lowest cost of production. (*Commenter: Tom Martin - WRECC*)

Response: Comment noted.

2.17.5. Opposed to Strategy D - Nuclear Focused Resource Portfolio

214. I oppose Strategy D - Nuclear Focused Resource Portfolio. More nuclear energy would result in unacceptable environmental impacts. (*Commenter: Marcella Green*)

Response: Comment noted. Strategy D was eliminated from further consideration in the Draft IRP and EIS. The amount of nuclear capacity added in the retained Strategy C and in the Recommended Planning Direction is close to that of Strategy D. TVA has and will continue to carefully evaluate the potential environmental impacts of each nuclear capacity addition it may propose.

2.17.6. Prefer Strategies E and C

215. We prefer elements of alternative strategies E and C, with emphasis on E because it maximizes the use of renewable power and the reduction of conventional coal generation. Strategy C is attractive by offering a more diversified generating portfolio, including the IGCC facility which would continue to use domestic coal. Both strategies emphasize diversity in generation, renewables, EEDR, and lower-carbon emitting resources. (*Commenter: Heinz J. Mueller - EPA*)

Response: Comment noted. TVA's preferred alternative is the Recommended Planning Strategy which is more similar to Strategy C than to B or E and has moderate levels of EEDR and renewable generation. Its amount of coal unit idling, 4,000 MW, is greater than that of Strategy C and approaches the amount of Strategy E.

2.17.7. Prefer Strategy E - EEDR and Renewables Focused Resource Portfolio

216. I prefer Strategy E - EEDR and Renewable Focused Resource Portfolio. Relative to other strategies, Strategy E reduces the use of nuclear energy, has the most use of renewable energy, and has the greatest reduction in energy use. (*Commenters: Dana Beasley Brown, Trevor Casey - GES, Michael J. Crosby - TEC/BCAAT, Nancy Givens - WKU/KSES/BGGP, Marcella Green, Sheila Green - NCDA, Gregory Hogue - USDI, Gilbert J. Hough - RSI, Andrew Johnson - TSEIA, Christine Johnson - LSE, Nelson Lingle - RSI, Eric Matravers, Andrew Pitner, Rachel Tuck, Gary Verst - SC, Edward Zubko - GES, Edward Zuger - CCSC III*)

Response: Comment noted.

217. While we prefer Strategy E - EEDR and Renewables Focused Resource Plan, its EEDR target is not aggressive enough. Other utilities are successfully meeting larger EEDR targets. (*Commenter: Michael J. Crosby - TEC/BCAAT*)

Response: While the Recommended Planning Direction strategy includes a lower level of EEDR than included in Strategy E, TVA will continue to develop and implement programs to achieve a Southeast leadership position in EEDR. Goals and targets will be revisited when TVA begins the next IRP study, no later than 2015. See Final IRP Appendix C for a description of the development of TVA's EEDR portfolio.

2.17.8. Range of Reasonable Alternatives/Strategies

218. I urge TVA to analyze a strategy consisting of the following:
- A high level of EEDR
- Idling of 5000 MW of coal capacity
- 3 new 800-MW pumped storage hydro units with solar and wind power units for pumping
- New 890-MW combined cycle natural gas units as needed, including the conversion of Bellefonte to natural gas combined cycle

This strategy would employ more local workers and cost less than new nuclear plants. (*Commenter: Garry Morgan*)

Response: The IRP considered several different planning strategies in multiple scenarios (views of the future), and each of these resulted in the development of a possible power supply plan. While the study did not evaluate the specific combination of resources mentioned in this question, a case was analyzed that considered the idling of about 4,700 MW of coal capacity combined with a substantial energy efficiency portfolio (5,100 MW), a renewable portfolio of about 1,500 MW, one pumped hydro plant and gas-fired units as needed. This case also includes the addition of nuclear units at the Bellefonte site, but does not represent the least cost plan. Eliminating the nuclear units and adding more gas units pumped storage hydro plants would tend to increase the cost of this plan beyond the cases already analyzed due to the added capital investment required, the increased exposure to fuel price risk and carbon penalties, and the uncertainty of additional intermittent resources in the generating mix. The recommended strategy attempts to balance these resource components across the scenarios tested by proposing a more moderate amount of these resources combined with a slightly lower level of idled coal capacity.

219. The IRP and EIS analyze a No-Action Alternative (Strategy B) and two Action Alternatives (Strategies C and E). The differences between Strategies C and E are very small (see DEIS Figure 7-1) and neither differs greatly from Strategy B. No alternative maximizes the potential for sustainable energy resources, particularly the development of renewable generation, EEDR, small-scale distributed generation, or coal plant retirements. Consequently, TVA has failed to analyze a reasonable range of alternatives as required by NEPA. (*Commenter: Abigail Dillen - Earthjustice*)

Response: This comment fails to provide sufficient specificity to be able to model this kind of strategy. The five alternative strategies developed for the Draft IRP and EIS encompass a wide range of resource options and portfolios consistent with the purpose and need of the IRP. This range of alternative strategies was then narrowed to the three analyzed in detail according to the defined evaluation criteria. One of the alternative strategies eliminated from further consideration included the smallest amounts of renewable generation, EEDR, and coal capacity idled. In analyses conducted after release of the Draft IRP and EIS, described in Final IRP Chapter 8, the amount of renewable generation (including small scale distributed renewable generation), EEDR, and coal capacity idled was allowed to vary, rather than treated as defined model inputs. This permitted the model to select higher amounts of the energy resources featured in this comment. The results of these analyses produced an optimized strategy which best meets the purpose and need of the IRP.

220. The IRP and EIS must include an alternative that would entirely eliminate dependence on coal-fired generation by 2030. All of TVA's coal plants are operating beyond their intended life-spans and few units are equipped with the pollution controls necessary for compliance with the Clean Air Act. Most do not use appropriate water treatment systems to

control thermal pollution or the discharge of harmful pollutants such as mercury, arsenic, and selenium. They also discharge ash and scrubber sludge to unlined surface impoundments, some of which are classified as 'high hazard.' The continued operation of most coal capacity under all alternatives also contradicts TVA's stated purpose of sustainable energy production. (*Commenter: Abigail Dillen - Earthjustice*)

Response: The preliminary strategies analyzed in the Draft IRP and EIS considered a maximum of about 7,000 MW of idled coal capacity. After consideration of their financial and strategic metrics, the strategies with the highest and lowest amounts of idled coal capacity were eliminated from further consideration, mostly because of financial impacts. The remaining strategies, as well as the Recommended Planning Direction defined in the Final IRP and EIS, consider a range of 2,400 to 4,700 MW of idled coal capacity. The process used in determining the idled coal capacity in the Recommended Planning Direction is described in Sections 6.5 and 8.3 of the Final IRP. The impacts asserted in this comment were considered in TVA's environmental analyses.

TVA disagrees with the commenter's assessment of the TVA coal plants. To date, TVA has installed scrubbers on 17 of its coal-fired units and switched to lower-sulfur coals at 41 coal-fired units to reduce SO2 emissions. To reduce NOx emissions, TVA has installed SCRs on 21 of its largest coal-fired units, installed selective non-catalytic reduction systems on two coal-fired units (although TVA is no longer operating one of these systems because of technical challenges), installed High Energy Reagent Technology systems on seven coal-fired units, installed low-NOx burners or low-NOx combustion systems on 47 coal-fired units, and optimized combustion on 10 coal-fired units. TVA has also been operating NOx control equipment year round (except during maintenance periods) since October 2008. To reduce particulate emissions, TVA has equipped all of its coal-fired units with scrubbers, mechanical collectors, electrostatic precipitators, or baghouses. As a result of these actions, emissions of NOx have been reduced by 89 percent below peak 1995 levels, and emissions of SO2 have been reduced by 90 percent below 1977 levels. These actions have also resulted in reduced emissions of hazardous air pollutants, including mercury, at some units.

Additionally, TVA plants are operating in compliance with thermal discharge permits and TVA has announced plans to invest between $1.5 billion and $2.0 billion over an eight to ten year period to convert from wet ash and gypsum storage facilities to dry storage facilities in advance of any regulatory requirement for dry storage. The "high-hazard" classification that TVA identified for some of its impoundments is not related to the integrity of the impoundments or the likelihood of their failure and is not related to facility discharges or emissions. It only signifies that if the impoundment failed the lives of individuals downstream of the dam would be at risk.

Strategy C Is Second Best

221. Strategy C is my second choice for the preferred strategy. Although it does include new nuclear plants, it has a relatively large level of coal plant layups and EEDR. (*Commenter: Gary Verst - SC*)

Response: Comment noted.

2.18. Natural Gas

2.18.1. Availability and Deliverability Risk

222. The draft IRP identifies a risk in the availability and deliverability of natural gas resulting from the finite capacity of the natural gas infrastructure. This risk is described as increasing as natural gas generation capacity increases. We believe this risk is overstated as recent reports show an abundant supply, including a supply close to the TVA region, short drill-to-production time, and large recent increases in delivery and storage capacity. (*Commenters: Michelle Bloodworth - ANGA, Peter Robertson - ANGA*)

Response: Potential risk in natural gas transportation may be offset by a variety of factors including the expansion of interstate and intrastate pipeline systems, increased non-conventional production like shale gas, and utilization of natural gas storage opportunities where needed. The potential for significant production of natural gas from shale plays in non-traditional supply regions and certainly opens the possibility of gas flowing in different directions in the future as opposed to strictly from the Gulf of Mexico to the consuming regions. TVA reviews fuel deliverability for all fuels as well as electricity transmission as needed to ensure a reliable system for serving native load.

2.18.2. Cost of Natural Gas Generation

223. For the $275 million+ currently being spent for the Bellefonte Nuclear Plant Unit 1, TVA could construct a 1,000-MW natural gas-fueled combined cycle generating plant. (*Commenter: Sherman Fox*)

Response: TVA does not believe that a combined cycle plant of the size suggested could be constructed for $275 million. TVA recently finished construction of a 540-MW combined cycle plant at a cost of over $400 million and is currently constructing a 900-MW plant at a forecasted cost of over $800 million. These costs are consistent with industry trends for new combined cycle facilities.

224. Natural gas-fueled generation has significant levelized cost of energy advantages over other baseload generation (e.g., nuclear, integrated gasification combined cycle, and supercritical pulverized coal). Other cost advantages include reduced time, risk, and cost of permitting and construction. It is unclear to us whether all of these factors are fully addressed in the modeling process. (*Commenter: Peter Robertson - ANGA*)

Response: Natural gas units may have certain cost advantages over other resource types, but these resources also have limitations that often do not make them the most economic choice for all generating duty cycles or capacity requirements. The IRP models consider all cost and performance characteristics of each generating technology when selecting which resources are added in a given year of the planning study. See Comment 23 for a comparison of costs of various generating technologies.

2.18.3. Environmental Impacts of Natural Gas-Fueled Generation

225. Gas extraction using hydraulic fracturing (fracking) results in significant risks to water supplies and other environmental impacts. We urge TVA to not use gas extracted by this method. (*Commenters: Nancy Givens - WKU/KSES/BGGP, Nancy McFadden, Kevin Routan - CGSC, Don Safer - TEC, Bruce Wood - BURNT*)

Response: Comment noted. The potential for hydraulic fracturing to affect water supplies and other environmental resources is noted in EIS Section 7.6.4. The magnitude of impacts to water resources is poorly known and is currently the subject of studies by EPA and others.

226. The environmental benefits of natural gas generation relative to coal include greatly reduced CO_2, sulfur dioxide, nitrogen oxide and particulates emissions, no mercury emissions, no ash or gypsum, and reduced wastewater discharges and cooling water use. (*Commenter: Peter Robertson - ANGA*)

Response: Comment noted. The environmental attributes of natural gas-fueled generation are incorporated into the scenario planning input data and the environmental impact analysis.

227. TVA, like other utilities and the natural gas industry, is assuming that there will be a large, low-cost supply of shale gas. The DEIS does not explicitly consider the environmental impacts associated with shale gas production and the draft IRP does not account for the likely future regulatory costs associated with shale gas production. (*Commenter: Kipp Coddington - MMCC*)

Response: TVA evaluates the risks in both supply and demand for natural gas in the future. Supply risks typically include potential restrictions, regulation, or legislation that would either prevent or restrict production or cause production to become more expensive because of environmental concerns. The demand risk considerations include the potential for natural gas growth to continue due to competitive advantages of emission levels and capital requirements compared to other technologies as a whole over time. If utilities increase gas generating capacity by a significant amount, it may have an impact on the demand for natural gas, where if all other factors could be held constant, this would potentially place upward pressure on natural gas prices. These supply and demand risks are reflected in the ranges of natural gas price forecasts included in the various scenarios. Potential environmental impacts associated with shale gas production are discussed in Sections 7.3.1 and 7.6.4 of the Final EIS.

2.18.4. Natural Gas Price and Supply Forecasts

228. Mississippi Gasification, LLC is developing a petcoke-to-Substitute Natural Gas (SNG) facility in Moss Point, Mississippi. This project will produce pipeline-quality SNG from petroleum coke using proven gasification technology and incorporating carbon capture and sequestration. The SNG will be available to utilities in the southeast, including TVA, via existing major interstate natural gas pipelines. We urge TVA to seriously consider purchasing this SNG which will be available in 2015-2016 and can be contracted for 30 years. The price of SNG is de-linked from the natural gas market and is less volatile. Use of SNG would provide TVA with significant long-term savings and a fuel with low criteria pollutant and GHG emissions. (*Commenter: Dexter Cook - MG*)

Response: TVA will consider fuel sources from both within and outside the TVA region as long as the resources meet both reliability and economic needs of the TVA. TVA has a process for reviewing proposals for the sale of power from such facilities as well as an active role in discussions with potential suppliers of power and fuel to the TVA.

229. The draft IRP relies on projections of natural gas prices that appear too high when compared with reference market forecasts. TVA forecasts are based on the NYMEX Henry Hub market price forecast. Other forecast approaches, such as that of Crossborder Energy, use different sampling techniques to reduce volatility. This other approach results in lower price forecasts, particularly after 2020. Because of the importance of natural gas price forecasts in the IRP process, we urge TVA to re-evaluate and better explain its price forecasts. (*Commenter: Sam Gomberg - SACE*)

Response: TVA forecasts natural gas both at the Henry Hub as well as delivered lcoations to facilities which require TVA gas to generate electricity. To address the volatility of the market curves, TVA uses ranges of natural gas forecasts to study plans and recommendations. This addresses both the price forecast as well as the width of the range of prices to allow for robust planning and decision analysis across time. Gas forecasts are updated each year for normal TVA business plans, and the next IRP will also incorporate ranges of natural gas prices as well.

230. The forecast price of natural gas that TVA is using for the 'base case' appears to be $6-8/mmBTU. It is higher for three more scenarios. These costs are higher than forecasts over the next 20 years by EIA, Henry Hub, NYMEX, and EPA, which range up to $6.99. As the highest projected cost from each of these sources is below the mid-range of the TVA base case, we request that TVA revise its model inputs on natural gas prices. (*Commenters: Michelle Bloodworth - ANGA, Peter Robertson - ANGA*)

Response: TVA reviews all of our commodity forecasts in the TVA annual business processes and updates are made wherever new information is available. By incorporating ranges of gas prices (instead of just one deterministic case) TVA evaluates potential impacts of decisions across varying prices for a comprehensive impact. Another IRP will begin in 2015, and assumptions and forecasts will be updated for then-current market conditions as well.

231. TVA appears to be basing its increased future reliance on natural gas-fueled generation, in part, on the natural gas industry and Energy Information Administration (EIA) forecasts of an abundant supply of shale gas. Both the natural gas industry and EIA have a record of overly optimistic supply forecasts. Incorrect forecasts have resulted in construction of gas plants that have never operated and subjected ratepayers to high rate volatility. TVA should reassess its planned increased reliance on abundant natural gas supplies. (*Commenters: Kipp Coddington - MMCC, Jack W. Simmons - TVPPA*)

Response: Potential increased reliance upon natural gas or analysis of closing coal-fired plants is driven by several factors including the up-front capital costs of controls, operating costs, useful remaining plant life, and overall TVA Environmental Strategies. The costs in these analyses involve both fixed and variable costs. Evaluating new capacity for electric generation also requires a comprehensive evaluation of all such variables for both the unit that may be retired as well as the likely replacement generation. In many cases, natural gas generation was the recommended replacement of choice due to a combination of factors that include both fixed and variable costs combined to be the least-cost solution for TVA. TVA gas price forecasts include a variety of factors on both future supply and future demand that acknowledge both uncertainty in future non-conventional gas supplies like shale as well as potential growth in future demand, such as more electric utilities expanding their fleets with natural gas generators.

232. Under all of the alternative strategies, TVA would close coal-fired plants and increase its reliance on natural gas-fired generating capacity. This places TVA customers at significant risk of future increases in the price of natural gas. TVA's natural gas price forecasts seem to be based in part on unproven assumptions that production of shale gas will continue to increase and that its price will be low and stable. TVA should better explain its natural gas price forecasts and the risk of future gas supply and price volatility. (*Commenter: Kipp Coddington - MMCC*)

Response: The recommendation or analysis of closing coal-fired plants would be driven by several factors including the up-front capital costs of controls, operating costs, useful remaining plant life, and overall TVA environmental goals. The costs in these analyses involve both fixed and variable costs. Evaluating new capacity for electric generation also requires a comprehensive evaluation of all such variables for both units that may be retired as well as the likely replacement generation. In many cases, natural gas generation was the recommended replacement of choice due to a combination of factors that include both fixed and variable costs combined to be the least-cost solution for TVA. TVA gas price forecasts include a variety of factors on both future supply and future demand that acknowledge both uncertainty in future non-conventional gas supply like shale as well as potential growth in future demand, such as more electric utilities expanding their fleets with natural gas generators.

233. We question whether TVA's natural gas purchase practices take full advantage of opportunities to mitigate the risk of future price volatility. According to the draft EIS (p. 43) and TVA's 10-K, gas is purchased under contracts with terms of 1 year or less. Longer term purchase contracts could greatly mitigate risks and reduce the future costs of natural gas. (*Commenter: Peter Robertson - ANGA*)

Response: TVA is actively engaged in utilizing a variety of pricing mechanisms, including spot, monthly, seasonal, and multi-year physical and financial transactions for the purpose of limiting the economic risks associated with the price of natural gas. Due to a diversified portfolio of assets, TVA is able to manage all commodity risk in an integrated manner through a comprehensive commodity strategy

2.18.5. Natural Gas-fueled Generation

234. In the charts you display of energy production by type, why is there no minimum percentage for combined cycle and combustion turbines? The minimum should at least be as much as is in the fleet today. (*Commenter: Thad Huguley - HCG*)

Response: The referenced charts portray the energy production from the new resource additions selected by the modeling process in the IRP study. They do not include the generation from TVA's existing generating facilities, including gas-fired units.

235. In the late 1990s, TVA issued a study showing the feasibility of a 2,000-MW natural gas combined-cycle plant at Bellefonte. While a CC plant this large may not now be feasible there, TVA should build a 890-MW CC plant at Bellefonte instead of the planned nuclear plant. (*Commenter: Garry Morgan*)

Response: The IRP study includes many resource options as candidates for selection in each of the planning strategies being evaluated. Among those options are combined cycle plants in the 900-MW range, and several of those are selected in various scenarios. In most cases, the IRP does not specify the site at which these new resources would be added, and it does not identify a combined cycle plant at Bellefonte as an option. Completing the nuclear units at Bellefonte also was evaluated in the IRP. The commenter is correct, TVA did evaluate the merits of converting the unfinished nuclear units at Bellefonte relative to other generating technologies, including an NGCC plant. Because there is no natural gas supply on that site, TVA determined that a natural gas pipeline would have to be built to the site ranging in length from 22 to 50 miles. TVA did not proceed with this proposal.

236. Under all of the alternative strategies, natural gas-fueled generation is restricted to no more than 13% of TVA's portfolio in 15 years. Given its abundant, low-cost future supply and role in facilitating buildout of renewable generation, why is natural gas playing such a small role in the future? (*Commenter: Thad Huguley - HCG*)

Response: Gas-fired generation is not restricted in any of the strategies evaluated in the IRP study. Gas units are added when cost-effective in almost all of the scenarios considered in the study, except in those scenarios where there is limited growth. The utilization of these resources depends on the overall resource mix in each case.

237. We support the increased use of natural-gas fueled generation as a cleaner energy source during the period between the shut-down of coal-fired generation and implementation of long-term clean options with emphasis on conservation and renewables. (*Commenters: Stewart Horn, Adam Snyder - CA*)

Response: Comment noted. The Recommended Planning Direction strategy includes the idling of up to 4,700 MW of coal generating capacity, increased natural gas-fueled generation, and increased emphasis on EEDR reductions and renewable generation.

2.19. NEPA Compliance/Adequacy

2.19.1. Cumulative Impacts Assessment

238. The cumulative impacts analysis is inadequate. While this is a programmatic document, the cumulative impacts analysis can be from a commensurate level. (*Commenter: Kim Franklin - USCOE*)

Response: The cumulative impact analysis is appropriate for the proposed action.

2.19.2. Scope of Impact Assessment

239. While we recognize that this is a programmatic DEIS, we request that you address anticipated major changes to commercial navigation traffic patterns on the Tennessee and Cumberland Rivers that are related to energy production. (*Commenter: Kim Franklin - USCOE*)

Response: Aside from the occasional transportation of large components of generating facilities by barge, the major changes to commercial navigation traffic on the Tennessee and Cumberland Rivers would result from the idling of coal generating capacity and the associated reductions in coal delivery by barge. Although none of the coal units identified for idling to date at the Shawnee, Widows Creek, and John Sevier plants receive coal by barge, the future idling of additional coal units could result in an annual reduction of several million tons of coal shipments by barge on the Tennessee River.

240. While we recognize this is a programmatic EIS, please note that Corps of Engineers hydropower operations would still be subject to existing water management plans or these plans would have to be modified, including NEPA coverage, if they are proposed for modification. (*Commenter: Kim Franklin - USCOE*)

Response: Comment noted. Modifications to hydropower facilities not under TVA's control, including USCOE hydropower operations, are not assumed in any of TVA's analyses. Improvements to TVA hydropower facilities were addressed.

241. Will TVA consider the environmental impacts of energy sources where TVA is purchasing from the private sector and use that information in its purchasing decisions? (*Commenter: Kim Franklin - USCOE*)

Response: TVA does consider the environmental impacts of its purchases of energy from specific facilities if TVA's purchase causes the generating facility to be constructed or change operations.

2.20. Nuclear Energy

2.20.1. Amount of Nuclear Generating Capacity

242. Adopt a plan that minimizes the amount or stops the use of nuclear power to meet future energy demand. Nuclear power is expensive, environmentally damaging and dangerous to human health. Use energy efficiency and renewable energy as cheaper, cleaner, and safer alternatives. (*Commenters: Lisa Archer, W. R. Avery [sic], Kent Baake - CES, Darrell Bawlslin [sic], David D. Beaty, Mark Betts [sic], Mark A. Burnett, Ruth Busch, Kelvin Butler, Marisa J. Butler [sic], Jason Campbell, Mary H. Clarke - TCV, Lester Dean, Randy L. Dry [sic], Ann Ercelawn, Juliana Ericson, Tom Ferguson, Kathleen R. Ferris - BEST/CENDIT, Norman Ferris, Robyn Galochee [sic], Elizabeth C. Garber, Nancy Givens - WKU/KSES/BGGP, Marcella Green, Jane C. Hardy, Rita Harris - SC, Rick Held, Cathy L. Hook [sic], Stewart Horn, Christine Johnson - LSE, D. K. Johnson [sic], N.D. Johnson [sic], Raphael Y. Junit [sic], Sandra Kurtz - BEST, Gloria Lathem-Griffith - MEC, Joanne Logan, Nancy McFadden, Laura Miller, Karen Monalan [sic], Josh O. [sic], Linda Park, Elsa Parker [sic], Barbara Peach, Stefan Peter-Contesse, Patricia Poat, Jackie Tipper Posey, Justin Post, Mrs. James S. Powers, Ryan Riddle, Don Safer - TEC, Grace Safer, Steven Sandheim - SC/TSVC, Don Scharf, Susan Shannon [sic], Danville and Beverly Sweeton, Richard & Marian Taschler, Paula D. Ward, Cassie F. Watts, Sue A. & Steven M. Williams, Bruce Wood - BURNT, Kevin R. Woods, Schean Yearke [sic] Louise A. Zeller - BREDL, James E. Zubko, Edward Zuger III - CCSC*)

Response: Modeling sensitivities were performed to determine the impact of a 'no nuclear' strategy. The results were much higher costs due to the elimination of a low-cost option as well as increased risks due to a reduction in portfolio diversity. The potential impacts of nuclear generation have been addressed in this EIS.

243. It appears to be inevitable that TVA is going to build and operate more nuclear plants. Regardless of regulatory requirements, TVA should commit to doing this in a manner that results in the lowest possible environmental impacts and implement a rigorous environmental self-inspection and monitoring program. (*Commenter: Chris Pamplin*)

Response: TVA makes decisions on whether to build and operate nuclear plants only after thorough and detailed evaluation, and in a deliberate manner. The process is open to public comment and participation. One of the major areas for evaluation and public participation is consideration of environmental impacts. The environmental studies related to completion of Bellefonte Unit 1 have demonstrated that the option to complete Unit 1 offers significant environmental benefits and presents fewer environmental impacts than non-nuclear options for providing additional base load generation. Full time environmental professionals are staffed at each of the operating nuclear facilities to provide continuous inspection and monitoring of daily operations and activities.

244. TVA appears to be biased towards nuclear energy in this planning effort. This bias is due to vested interests with the nuclear industry and TVA's past experiences operating nuclear plants. (*Commenters: Stewart Horn, Garry Morgan, Bruce Wood - BURNT*)

Response: TVA is not biased towards nuclear power. The IRP least cost planning effort considers all feasible resource options. Nuclear power is selected by the models where it is the lowest cost option for meeting future resource needs. The recommended IRP strategy is a diverse approach that includes increase in nuclear power, renewables, EEDR and gas generation.

245. I support the proposed increase in nuclear generating capacity. Nuclear energy is clean, reliable, and low-cost in the long run. (*Commenters: William Cummings - KCC, Vic Dura, Annette Gomberg, John Hamilton, Valerie Hargis, Joe Horton, J. Michael Meece*)

Response: Comment noted.

246. With the recent decision to work on completing Bellefonte Unit 1, TVA has prematurely accelerated its nuclear program. The rationale for this recent decision was that the preliminary IRP results indicated a strong likelihood that BFN Unit 1 would be needed to meet demand in 2018 and would facilitate higher levels of coal plant retirements. This need, however, is not supported for several of the scenarios. It is also likely that it could have been met by more aggressive development of renewables and energy efficiency measures. Specific problems with BFN include radioactive releases, lack of longterm spent fuel storage, Karst terrain, high water consumption, need to derate during heat waves, increased debt, and high investment risk. (*Commenters: Sam Gomberg - SACE, Stewart Horn*)

Response: Analysis shows that completing BLN 1 is supported in all scenarios except very low or negative load growth scenarios. Sensitivity modeling analysis was conducted to determine if aggressive development of renewables and/or EEDR would change this finding. This analysis did not change the results or the original conclusions concerning the need for BLN 1. Specific concerns related to BLN were addressed in the project specific SEIS. TVA has not made the decision to complete BLN Unit 1. The TVA Board approved the budget for some activities to help preserve BLN 1 as a viable resource option and its consideration in the IRP.

2.20.2. Bellefonte Nuclear Plant

247. Please explain the status of the proposal to complete a nuclear unit at Bellefonte. What decisions have been made to date, what work on the plant is presently occurring, and what decisions remain to be made? (*Commenter: Robert Campbell*)

Response: The TVA Board authorized funding for Bellefonte 1 for FY 2011 in the amount of $248 million for the purpose of performing preliminary engineering, developing the regulatory licensing basis, and establishing contracts for procurement of components with long lead times. The Board further determined that any decision regarding construction completion would follow the completion of this IRP.

248. TVA has essentially committed to completing Bellefonte Nuclear Plant. This is not the best option because: 1) the design is over 40 years old; 2) the Babcock & Wilcox (B&W) design has had more than its share of problems, i.e., Alloy 600, reactor heads - Davis Bessie, Chrystal River secondary containment problems, Three Mile Island disaster; 3) containment cable issue; 4) the plant is nearly scrapped out; 5) the detailed scoping, estimating, and planning (DSEP) is still incomplete; and 6) unresolved quality control issues brought up by the NRC including radiography and welding. (*Commenter: Sherman Fox*)

Response: TVA extensively studied multiple options for new baseload generation, including nuclear options, before proceeding deliberately in a phased approach with work related to Bellefonte Unit 1. Bellefonte Unit 1 offers the potential to add significant value to customers by avoiding certain costs associated with new construction, despite the fact that much of the equipment may have to be refurbished or replaced. To address the specific concerns raised:

1) The design is based on an evolutionary improvements to many of the reactors operating in the U.S. today and incorporates improvements over earlier B&W designs. Additional design and material improvements will be incorporated if a decision is made to complete the unit.

2) Alloy 600 components in steam generators, the reactor vessel head, and other the plant systems will be replaced or mitigated. Many of the recommended improvements from Three Mile Island lessons learned have already been incorporated in the improved 205 design and TVA plans to incorporate additional improvements if a decision is made to complete the facility. The Crystal River 3 containment delamination event occurred while that unit was safely shut down and an access port was being cut through the containment wall for replacement of its steam generators. That event is being carefully reviewed; however, the Bellefonte units have access hatches suitable for this purpose as part of original design which eliminates the need for cutting into the containment structure.

3) The containment cable failure in 2009 resulted from hydrogen-induced stress corrosion cracking of a coupling between one of the 185 vertical tendons (cable) and its bedrock anchor. This type of failure is not unique in the industry and TVA is evaluating replacing the anchor heads on the tendons with a redesigned component made of improved materials. Bellefonte’s tendons, as well as all other safety structures and components will be thoroughly inspected prior to operation to ensure they will function as designed to protect safety of the public, the plant and employees.

4) The plant is still substantially intact and only limited portions of the plant and equipment were removed during a short investment recovery period.

5) The DSEP was intended to provide a bounding cost and schedule estimate and identify major project risks. It has been completed and accomplished this. Detailed schedules for project completion are developed commensurate with project approvals.

6) Quality assurance issues have been identified as an important project risk and programs are being developed to ensure all quality requirements will be verified as part of completion. Plant quality during construction was considered the best among TVA projects at the time of deferral. Quality records have been maintained.

249. Why is TVA outsourcing development work at Bellefonte Nuclear Plant to a foreign company? This work should be done by local or at least U.S. companies. (*Commenter: Jackie Tipper Posey*)

Response: Virtually all of the commercial nuclear power plants operating today in the U.S. were designed by General Electric, Westinghouse, Combustion Engineering, or Babcock & Wilcox. The Bellefonte plant is a Babcock & Wilcox 205 design. When AREVA was formed in 2001, it acquired the rights to the Babcock & Wilcox 205 design. TVA negotiated a contract with AREVA for work at Bellefonte primarily due to its ownership of the plant's design. Although AREVA's parent corporation is a foreign entity, AREVA is incorporated in Delaware with its operations spread between 41 U.S. locations with substantial facilities in Lynchburg, Virginia and Charlotte, North Carolina. Much of AREVA's work will involve U.S. workers and suppliers.

2.20.3. Cost of Nuclear Power Plants

250. Given the extensive work to be done at Bellefonte Nuclear Plant, I question TVA's estimate that it will cost $1 billion less than building a new plant. The completion of Watts Bar Unit 2 is costing more (and taking longer) that originally estimated. (*Commenter: Sherman Fox*)

Response: TVA has spent several years studying the costs of additional nuclear generation. The process used to estimate the overall costs and schedule has proven successful for Browns Ferry 1 and Watts Bar 2 to date. The completion cost and schedule for Watts Bar 2 are still forecasted to be within the targets established when the project was recommended and approved in 2007. TVA cost estimates for Bellefonte options include benchmarking new nuclear costs against those of other utilities building the same plant design, utilizing TVA's known costs for recovering or completing plants with similar work scope, and utilizing an independent external contractor to evaluate the cost and schedule risk of options for completing existing units and construction of new units.

251. How are the costs of decommissioning nuclear plants and long-term handling of radioactive waste, including spent fuel, addressed in the IRP? (*Commenters: Sandra Kurtz - BEST, Jackie Tipper Posey*)

Response: Projected amounts for these specific costs are included in either the total capital cost or the ongoing operating cost of the nuclear units considered in the IRP.

252. How much will the Bellefonte nuclear plant cost to build? (*Commenters: Chip Estes, W.R. Kendrick*)

Response: The estimated costs of Bellefonte Units 1 and 2 in the IRP cases are about $4500/kW and about $3350/kW, respectively (expressed in 2009 $). These capital costs include allowance for funds used during construction and projected transmission interconnection costs, and the Unit 1 cost includes common facilities shared by both units. In the event that additional units are sited at this location, those future units would use the different AP1000 technology with a unit cost estimated at $5700/kW in 2009$, including additional transmission interconnection costs and an allowance for funds used during construction.

253. I am concerned about the cost and construction time for nuclear power plants. Watts Bar Nuclear Plant was completed at several time the original time and cost estimates. I hope that these factors are considered in the planning process and that TVA can find more efficient ways of building a nuclear plant. (*Commenter: Chris Christie*)

Response: The original construction cost and schedule for Watts Bar Unit 1, like many nuclear plants constructed during the same timeframe, were significantly exceeded before completion of the plant in 1996. TVA now utilizes a rigorous process called detailed scoping, estimating, and planning (DSEP) prior to the approval of any new nuclear project. The DSEP is intended to thoroughly understand the project scope, cost, schedule and risk. The DSEP process has proved successful for the restart of Browns Ferry 1. To date, the completion of Watts Bar 2 remains within the cost and schedule estimates presented to the TVA Board when the project was approved in 2007.

254. Large nuclear plants suffer from a long cost / short benefit situation. The cost commitment for such plants extends for long after they are decommissioned. (*Commenter: Paul Noel - NEC*)

Response: Comment noted.

255. Nuclear energy is not the most cost-effective source of clean energy. Recent studies have found the delivered cost of nuclear power to the end user as high as $0.1975/kWh. And other utilities such as Constellation have recently cancelled plans for new reactors due to cost concerns. Energy efficiency and renewable energy are more cost-effective long-term solutions. (*Commenters: Garry Morgan, Ricci Phillips - TTCD, Amy Walls, Louise A. Zeller - BREDL*)

Response: TVA's IRP study indicates that a combination of nuclear, energy efficiency and renewable resources, along with some additional gas-fired units, comprises the best performing strategy across the range of scenarios. The cost of power from particular resources depends on many assumptions about fuel prices, unit costs and operating characteristics. Variations in these assumptions can dramatically change the all-in cost calculation. For example, on a levelized cost of electricity basis, TVA projects the cost of a nuclear unit at around $0.070/kWh.

256. Nuclear plants are too expensive, in part because they need to be rebuilt every 25-30 years. (*Commenter: Mary H. Clarke - TCV*)

Response: Nuclear plants are initially licensed by the NRC for 40 years and most are expected to operate much longer than this by renewing the original license to allow for extended operation. As with all types of generating plants, infrastructure must be repaired or replaced over time and the decisions to do so are based on the overall cost of providing reliable electricity to the customers. In nuclear plants, for example, steam generators are replaced when the efficiency of the original equipment declines. Although it costs millions of dollars to replace such components, doing so increases the plant's efficiency and extends the life of the facility. This makes the best use of existing assets and lowers the overall delivered cost of power over the long term. While components and equipment will often need replacement, remaining portions of the plant such as the concrete structures are not replaced.

257. One of our concerns about the cost of nuclear power is the liability issue. Although the Price-Anderson Act provides some liability insurance, it would likely be inadequate if a disaster occurs. Similarly, no private companies appear willing to finance nuclear energy without government-backed loan guarantees. (*Commenter: Steven Sandheim - SC/TSVC*)

Response: Under the Price-Anderson Act, nuclear plant licensees are required to maintain financial protection equal to the maximum available amount provided by the private insurance market. A secondary level of insurance is managed by American Nuclear Insurers (ANI) on behalf of the Nuclear Regulatory Commission using what is known as retrospective premiums. Should any loss exceed the primary limit of $375 million, ANI would collect the retrospective premiums due from power reactor operators and administer the disposition of funds. Currently, there are 104 commercial nuclear power reactors in operation in the United States and each is liable for retrospective premiums up to $117.495 million per reactor should the primary limit of liability be exceeded. Effective January 1, 2010, the total amount available for third-party nuclear liability claims in the event of an accident at a commercial nuclear power reactor is approximately $12.6 billion—the largest amount of nuclear liability capacity of any country in the world. Financing development and construction of nuclear projects is unrelated to the Price-Anderson Act. However, TVA does not finance construction and development of nuclear facilities with government-backed loan guarantees.

258. TVA appears to have estimated inappropriately low-costs for the AP1000 nuclear reactor. The levelized cost given to the Stakeholder Review Group (and posted on the IRP project website) is $71/MWh. This is about 30% lower than the cost calculated with the California Energy Commission's (CEC) Cost of Generation Model. We recommend that TVA re-evaluate and better explain its estimated costs for both the AP1000 and the completion of the Bellefonte B&W units. (*Commenter: Sam Gomberg - SACE*)

Response: There is a large discrepancy between the fixed and variable O&M costs in the CEC's Cost of Generation Model and in TVA's model; this discrepancy has a significant impact on the cost of generation. Levelized costs are also highly sensitive to assumptions such as discount rate and capacity factor. TVA has an advantage in discount rate, since its debt costs are much lower than those of other entities which causes less interest during construction to be booked to plant costs and recovered through rates. Further discrepancies in plant capacity and capacity factor leads to fewer MWh in the CEC cost of generation, and therefore also increases the $/MWh cost estimate.

259. What is the expected cost/kW of the potential non-site specific nuclear units? (*Commenter: W.R. Kendrick*)

Response: Non-site specific nuclear units have an expected cost of $3,700/kW to $4,300/kW.

2.20.4. Nuclear fuel cost and availability

260. The cost and availability of fuel for future nuclear plants is going to be a serious problem. World supplies of uranium are limited. The cost is currently depressed by decommissioning nuclear weapons and this will end soon. (*Commenters: Paul Noel - NEC , Jackie Tipper Posey*)

Response: While uranium is a finite resource, there are sufficient identified reserves to supply the projected demand through this century according to a recent study published by MIT titled “The Future of the Nuclear Fuel Cycle”. This supply can be extended even further if recycling of nuclear fuel is expanded as several countries are doing today. The cost of uranium does fluctuate like other commodities, although, historically, the changes in the price of nuclear fuel take place over longer periods of time than those of fossil fuels such as coal, natural gas and petroleum. While future nuclear fuel prices are expected to increase, the fuel costs for nuclear represent a smaller portion of the total generation costs and the impact on the price of electricity when fuel prices change is less for nuclear.

261. TVA is apparently planning to use down-blended weapons-grade uranium to fuel its nuclear plants. Other utilities have considered this and rejected it for cost and other reasons. We urge you to reconsider this. (*Commenter: Kevin Routan - CGSC*)

Response: TVA has been safely using down-blended uranium as fuel for several years at its Browns Ferry nuclear plant. TVA is now evaluating the feasibility of doing something similar using mixed oxide fuel (combination of plutonium and uranium) as part of a program to reduce the U.S. stockpiles of excess weapons-grade materials. Mixed oxide fuel made from recycled nuclear fuel has been safely used in a number of other countries for many years. Mixing plutonium from weapons materials with uranium for use in commercial power plants is expected to offer a safe alternative for disposal of surplus weapons materials. The public is being given an opportunity to comment on this program through a separate environmental impact review process currently being conducted by the Department of Energy. Additional information about this initiative is available at http://nnsa.energy.gov/nepa/spdsupplementaleis.

Nuclear Plant Health and Safety
262. Nuclear plants are likely targets for terrorism. (*Commenter: Tom Ferguson*)

Response: TVA believes that the possibility of a terrorist attack affecting operation of one or more units at the Bellefonte site, or TVA’s operating nuclear plants, is very remote and that postulating potential health and environmental impacts from a terrorist attack involves substantial speculation. Notwithstanding the very remote risk of a terrorist attack affecting operations, TVA increased the level of security readiness, improved physical security measures, and increased its security arrangements with local and federal law enforcement agencies at all of its nuclear generating facilities after the events of September 11, 2001. These additional security measures were taken in response to advisories issued by NRC, and subsequent rule changes which required greater security.
263. Nuclear power plants release radioactive gases and liquids into the environment during normal operations and as a result of accidents. These releases are a threat to human health that is not discussed in the IRP. (*Commenters: Tom Ferguson, Kathleen R. Ferris - BEST/CENDIT*)

Response: Environmental reviews referenced in the IRP that were completed for TVA’s nuclear projects address radiological effects from both normal operations as well as potential accidents associated with nuclear plants. All expected and potential doses are taken into account as part of the safety and environmental reviews that are conducted in advance of any decision to proceed with plant construction and operation by both TVA and the NRC. Radiological releases and dose to plant workers and the public are within the applicable NRC limits and do not present a significant risk to the public or the surrounding environment.

264. The production of plutonium by nuclear plants present a safety and proliferation risk. (*Commenter: Tom Ferguson*)

Response: Nuclear plants are designed to safely use the plutonium produced during operation by the nuclear fuel fission process. Once the fuel is discharged, the plutonium is contained within the used fuel along with the other byproducts of the nuclear process. In addition to the high security in place to protect nuclear plants, the high level of radioactivity associated with used fuel also increases the resistance to proliferation of the plutonium produced in nuclear plants. These highly radioactive fuel assemblies weigh thousands of pounds each making transport difficult and hypothetical theft extremely dangerous. Furthermore, very expensive and sophisticated equipment and a very large quantity of used fuel would be necessary to produce enough plutonium to be useful for proliferation purposes. The Nuclear Regulatory Commission, an independent Federal regulator, imposes stringent security requirements and ensures TVA compliance through close oversight, including on-site inspections.

265. TVA has reported hundreds of 'events' at its nuclear plants since the 1980s. There have also been numerous unplanned shut downs, including the 1975 Browns Ferry fire and more recent fire safety problems. The continued operation of the nuclear plants is not safe. (*Commenters: Tom Ferguson, Kathleen R. Ferris - BEST/CENDIT, Norman Ferris*)

Response: The safe operation of TVA’s nuclear facilities is continuously monitored by independent groups within TVA as well as the NRC. Under the NRC’s reactor oversight process, if the NRC determines that a plant cannot be operated without significant risks to the public or the environment, the operating license for the facility will be revoked. NRC’s most-recent review of all three of TVA’s operating nuclear facilities has determined that they are operating in a manner that allows them to be placed in the category of reactors that the NRC classifies as presenting minimal risk to the public and the environment, and subject to routine monitoring and inspection.

2.20.5. Small Modular Nuclear Units

266. Small modular nuclear units (5 to 100 MW) are practical and offer many advantages over traditional 1000+ MW units. TVA should promote their development. (*Commenter: Paul Noel - NEC*)

Response: TVA is currently investigating a demonstration project utilizing small modular reactors, and this technology is part of the agency's ongoing commitment to research. TVA is currently working with the Department of Energy and Oak Ridge National Labs to evaluate, develop, and build up to six small modular nuclear reactor modules in Oak Ridge, Tennessee.

267. TVA has announced its intention to build a small modular unit nuclear plant. This plant is not incorporated in the IRP strategies which use other resource options to meet the apparent need for power. Please explain how the IRP accommodates small modular nuclear units. (*Commenter: Sandra Kurtz - BEST*)

Response: Small modular nuclear units were not considered in the IRP strategies as they are still in the early stages in terms of maturity and are not widely available. As part of TVA's Technology Innovation mission, TVA has begun studies to determine more detailed information on cost and schedule for these plants so that they may be considered in future planning.

2.20.6. Spent Nuclear Fuel and Nuclear Waste

268. There is presently no safe, long-term solution to disposing of spent nuclear fuel. The current practice of on-site storage is, at best, a short-term interim solution. (*Commenters: Lisa Archer, Jason Campbell, Lester Dean, Kathleen R. Ferris - BEST/CENDIT, Norman Ferris, Nancy Givens - WKU/KSES/BGGP, Rita Harris - SC, Garry Morgan, Jackie Tipper Posey, Kevin Routan - CGSC, Don Safer - TEC, Grace Safer, Paul Sanderson*)

Response: While there is no current U.S. facility to permanently dispose of spent nuclear fuel, it is being safely stored until a decision regarding final disposition can be made. The NRC has a long-standing position regarding the safety and lack of environmental impact from current spent fuel storage methods, known as the Waste Confidence Decision, and recently completed an update to this position. After a thorough evaluation of the risks associated with the methods currently used to store spent fuel, the NRC concluded that spent fuel generated in any reactor can be stored safely and without significant environmental impacts for at least 60 years beyond the licensed life for operation (which may include the term of a revised or renewed license) of that reactor in a combination of storage in its spent fuel storage basin and at either onsite or offsite independent spent fuel storage installations. Further, the NRC believes there is reasonable assurance that sufficient mined geologic repository capacity will be available to dispose of the commercial high-level radioactive waste and spent fuel generated in any reactor when necessary.

269. TVA should pursue the reprocessing of spent nuclear fuel instead of continuing to rely on the eventual construction of a permanent spent fuel storage facility. Fuel reprocessing would provide additional nuclear fuel and greatly reduce the volume of spent fuel requiring storage. (*Commenter: Alfred G. Orillion - SA*)

Response: TVA supports the establishment of a national policy regarding the recycling of spent (used) nuclear fuel. This is a current topic of discussion in the U.S., and TVA will continue its role of informing that discussion.

270. TVA's nuclear plants currently generate large amounts of low level nuclear waste, and this will increase with the proposed new nuclear plants. Tennessee leads the nation in processing and disposal of Class A, B, and C nuclear wastes, and this is proposed to increase in the future at Oak Ridge and Erwin. Some of this waste eventually enters local landfills. This nuclear waste is not safe and, partly because of it, nuclear energy is not clean. (*Commenters: Don Safer - TEC, Steven Sandheim - SC/TSVC, Sue A. & Steven M. Williams*)

Response: Low level radioactive waste disposal sites are regulated by the NRC. Class A, B and C wastes must be disposed of in such facilities in accordance with all applicable local, State and Federal laws in a manner that will protect the public in the near and long term. TVA’s low level waste storage and disposal activities are and will continue to be conducted in strict accordance with all such requirements. TVA currently ships its Class A low level waste to a facility in Utah. Class B and C wastes are being safely stored onsite in engineered facilities. None of TVA’s low-level radioactive waste is placed in Tennessee landfills, which are not licensed to receive this type of waste.

2.20.7. Thorium Reactors

271. Is TVA considering using thorium reactors to generate electricity? (*Commenter: Russ Land*)

Response: No, not during the 20-year IRP planning period.

2.20.8. Timing of New Nuclear Plants

272. The various IRP portfolios show no new nuclear plants before 2018. Please explain how the 2018 date was determined. (*Commenter: J. Michael Meece*)

Response: This date is based on the time required to complete a nuclear unit and the timing of the forecasted need for new baseload generation. The date also reflects TVA's commitment to gradually reduce the environmental impacts from electrical generation in the Tennessee Valley. Watts Bar Nuclear Plant Unit 2 is scheduled to be completed and generating power by the end of 2012.

273. When is Watts Bar Nuclear Plant scheduled to be completed and generating power? (*Commenter: Alfred Dyson - DETS*)

Response: Watts Bar Unit 2 is scheduled to be completed and generating power by the end of FY2012.

274. When would the potential new units at Bellefonte be completed and generating power? (*Commenter: Alfred Dyson - DETS*)

Response: The portfolios associated with the moderate to high growth scenarios include the completion of Bellefonte Unit 1 between 2018 and 2022 and the completion of Bellefonte Unit 2 between 2020 and 2024. Projected dates for the completion of Bellefonte Unit 3 range from 2024 to 2028. Four of the 20 portfolios include the completion of Bellefonte Unit 4 in 2026 or 2027. TVA expects to conduct additional site-specific environmental reviews if it proposes to proceed with units other than Unit 1 at the Bellefonte site.

2.20.9. Types of New Nuclear Plants

275. A problem in the nuclear industry and TVA's nuclear program is the lack of standardized nuclear plant designs. TVA should use a standardized design for all new nuclear generating plants. (*Commenter: Alfred G. Orillion - SA*)

Response: TVA recognizes that there are many advantages to design standardization. Because TVA has existing assets that have the potential to provide additional generating capacity at a reduced cost, TVA has evaluated both the completion of the existing units at Bellefonte and the construction of new units using the standardized AP1000 design. This evaluation determined that there continues to be value in the partially-completed non-standard Bellefonte units, but beyond these partially constructed units, design standardization is probably the best option for nuclear generation. In order to realize some benefits from standardization even with those facilities where construction has already begun, TVA has standardized its management and procurement practices, as well as procedural requirements to the extent that it is practical.

2.21. Other

2.21.1. Comments Out Of Scope

276. We encourage TVA to do the following:
- Support professional forest management activities on TVA lands to maximize carbon sequestration and use of biomass products to mitigate carbon emissions.
- Provide educational activities and resources to encourage natural resource management, conservation practices that sustain water quality, and energy conservation through strategic urban tree plantings within its regional jurisdiction.
- Support and participate in implementing each Forest Assessment & Resource Strategy within its regional jurisdiction.
(*Commenter: Neil Letson - AFC*)

Response: These activities are outside the scope of the IRP. TVA is, however, addressing them in the Natural Resources Plan available at
http://www.tva.com/environment/reports/nrp/index.htm.

2.21.2. General Support for Process

277. The Department appreciates that TVA has formulated alternatives for this DEIS that would
reduce the emissions of air pollutants, including greenhouse gases, from its power supply portfolio. To varying degrees, each of the five alternatives described in the DEIS would increase TVA's reliance on renewable energy sources. Encouraging the timely and responsible
development of renewable energy, while protecting and enhancing the Nation's water, wildlife, and other natural resources, is one of the Department's highest priorities.
(*Commenter: Gregory Hogue - USDI*)

Response: Comment noted.

278. We appreciate your work in the development of the IRP. As you complete it, we urge you to remain focused on the following items: reliability, flexibility, environmental stewardship, and price. All of these items are very important to industrial customers (including international corporations) as well as other types of customers. (*Commenter: Steven Sax*)

Response: Comment noted. Our vision is to be one of the nation's leading providers of low-cost and cleaner energy by 2020. Every initiative that TVA pursues will be linked to the following six focus areas. By accomplishing them, TVA will realize its vision and continue to meet the needs of the people in the Valley. - Low rates - High reliability - Responsibility - Cleaner air - Greater energy efficiency - More nuclear generation

2.21.3. No Comment

279. We have no comments at this time. (*Commenter: Michael J. Hinton - NRCS*)

Response: Comment noted.

2.21.4. No Conflict with Existing or Proposed Activities

280. We have reviewed your proposal and have found no conflict with existing or proposed planning activities. We may wish to comment further at a later time. (*Commenters: Joe W. Barker - SWTDD, Terrence J. Bobrowski - ETDD, Sam H. Edwards - GNRC, Barbara Jackson - GSC*)

Response: Comment noted.

2.21.5. Regulation and Permitting

281. The states where TVA operates do not have adequate regulation and permitting programs to properly oversee TVA's operations. The ash spill at TVA's Kingston Fossil and problems with the New Johnsonville ash landfill are evidence of this deficiency. (*Commenter: Bruce Wood - BURNT*)

Response: TVA energy-related activities are subject to a large number of regulatory requirements and permitting programs and compliance with those requirements is overseen by federal and state regulatory agencies, depending on the program in question. Many federal environmental statutes also allow enforcement by citizens. TVA literally has spent billions of dollars on controls and equipment to be able to comply with applicable requirements and has in place comprehensive processes and procedures to help assure compliance. Respecting the operation of coal ash landfills, EPA is considering whether additional regulation of such facilities is necessary.

Rate Structure

Rates for Low Income Customers

282. Utility bills are among the largest expenses for the already large and growing low income population in the TVA region. Relative to other parts of the country, the energy burden of low income Valley residents is disproportionately large. TVA should work with its distributors to develop a lifeline rate structure with a low-priced small initial block of power for customers meeting income or means requirements. (*Commenter: Louise Gorenflo - TCSC*)

Response: Comment noted.

2.22. Renewable Energy

2.22.1. Amount of Additional Renewable Generation - General

283. According to the draft IRP, the planned expansion of renewable generation, particularly from solar and wind resources, is relatively small. These sources are cleaner and safer than the continued use of coal and increased use of nuclear power, and we urge TVA to aggressively increase the use of renewable generation. (*Commenters: Kent Baake - CES, Mary H. Clarke - TCV, Ann Ercelawn, William Goggin, Rita Harris - SC, Ellie Irons - VDEC, Eric Lewis, Nelson* Lingle - RSI, *Joanne Logan, Lainie Luse, Michael Lussier, Ryan Riddle, Janice Weber, Scott Wills - TTCGC, Jon Wolfe, Edward Zubko - GES*)

Response: Comment noted; as described in the EIS, the environmental impacts of renewable generation on several but not all environmental resources are less than those of coal-fired and nuclear generation. TVA developed two portfolios of renewable additions, a 2,500 MW portfolio incorporated into Strategy C and the Recommended Planning Direction, and a 3,500 MW portfolio incorporated into Strategy E. See Final IRP Appendix D for a description of their development. These portfolios include reasonable deployment schedules based on cost, technological maturity, regional resource availability, resource diversity, and anticipated federal legislation/regulation and tax policy factors. These factors are continually reviewed for TVA planning efforts, and will be incorporated accordingly to support the anticipated growth in TVA's use of renewable generation.

284. The draft IRP and EIS limit the amount of biomass-fueled generation in the TVA region to a maximum of 456 MW of capacity. The EIS, however, shows a much greater potential that is similar to the results of other studies of the regional biomass potential. Additional analyses by Larson & McGowin and by Southern Alliance for Clean Energy show that TVA could develop at least 1,100 MW of in-Valley biomass generation capacity using readily available low-value woody biomass. A large amount could also be developed using other biomass fuels. (*Commenter: Sam Gomberg - SACE*)

Response: TVA acknowledges that the technical potential to generate power from biomass is much larger than the amounts of biomass additions included in the renewable portfolios. The two renewable portfolios incorporated into Strategies C and E, as well as the Recommended Strategy, contain about 465 MW of additional biomass-fueled capacity. This amount is based on reasonable deployment schedules, factors described in the response to the preceding comment, and factors specific to biomass generation. These biomass-specific factors include: the disseminated nature of biomass and need for reliable and cost-effective fuel procurement and delivery infrastructure; low energy density (energy content per volume of material) and high moisture content of biomass relative to fossil fuels; the need for fuel processing, handling and boiler feed equipment; high fuel cost per unit of energy; and high chlorine and alkali levels in some biomass could adversely affect boiler materials. Significant regulatory uncertainty also exists with respect to the definition of renewable biomass and its eligibility in meeting any future renewable energy and GHG reduction mandates, as well with as the future emission limits (and corresponding emission control equipment and costs) required for producing power from biomass.

285. The draft IRP and EIS limit the development of in-Valley wind resources to 360 MW. This is a small fraction of the wind potential identified in the draft EIS, the 2005 Carson and Raichle study, and a recent NREL study. TVA should reassess the in-Valley wind development potential by either removing the 360 MW constraint used in the modeling or using a much larger fixed model input value. (*Commenters: Sam Gomberg - SACE, J. Michael Meece, Garry Morgan*)

Response: TVA recognizes that the technical development potential for in-Valley wind resources (and most renewable and fossil fuel resources, as well) is much higher than the 360 MW included in the IRP strategies. As with other types of renewable generation, this amount is based on reasonable deployment schedules and consideration of cost, technological maturity, regional resource availability, diversified resource portfolio, and anticipated federal legislation/regulation and tax policy factors. Identification of locations with the greatest wind resource is critical to the development of the in-Valley wind potential. In support of the Department of Energy's Wind Powering America 20% by 2030 program and in partnership with the Tennessee Valley and Eastern Kentucky Wind Working Group, TVA is supporting a wind research study by NREL to identify the best non-ridgetop (i.e., in the middle and western portions of the TVA region) wind resource areas. Following this study, TVA plans to conduct further wind tower measurements at the identified sites to confirm resource potential, especially at higher elevations ($\geq$100m). These analyses can be pursued to support the next update of the IRP.

286. The focus on the development of renewable generation in the IRP is on large wind projects requiring large infrastructure and land investments. How will TVA support and incorporate the use of energy from small, dispersed renewable generating facilities? (*Commenter: Tom Nelson - DESI*)

Response: TVA currently supports small, dispersed renewable generation (solar, wind and biomass installations with less than 200 kW of capacity) through the Generation Partners program. The power generated through this program is marketed through TVA's related Green Power Switch program. As described in EIS Section 3.4, TVA recently issued a renewable energy standard offer to purchase renewable energy from installations between 200 kW and 20 MW. Wind projects are typically more attractive on a larger scale due to higher energy production levels from commercial scale turbines (typically at least 1.5 MW) and cost declines associated with economies of scale from installing multiple-turbine wind farms. Technologies that are better suited for distributed generation, such as solar, are incorporated into the renewable portfolios considered in the IRP.

287. TVA should commit to producing half of its electricity from renewables by 2025. (*Commenters: Jeff Deal, James Randolph*)

Response: TVA has a goal of providing half of its electricity from non-carbon emitting, clean energy resources, which include conventional hydropower and nuclear, by 2020. TVA believes that a goal of providing half of its energy from renewable resources by 2025—a goal much higher than that in most state renewable portfolio standards—has not been demonstrated to be politically, economically, or technically feasible. One of the major problems with incorporating a significant percentage of renewable energy resources is the intermittent nature of wind and solar resources. The intermittency requires additional, dispatchable, fossil-fuel based generation (e.g., natural gas-fired turbines) and/or additional energy storage capacity to backup the wind and solar when it is not generating power. Despite these obstacles, renewable energy additions will play an important and increasing role in TVA's future energy portfolio.

288. While there are merits to renewable generation, much of it is intermittent. It does not appear possible for TVA to develop enough economical and environmentally acceptable energy storage to rely on renewable generation to provide a large portion of the needed base load capacity. (*Commenter: Vic Dura*)

Response: The IRP does not consider any energy storage options specifically for integration of intermittent renewable resources. However, Strategy C and the Recommended Planning Strategy include an additional pumped-storage hydro facility to provide for energy storage on a system-wide basis.

289. With the relatively small amount of proposed new renewable generating capacity, TVA is missing an opportunity to be a national leader in this area. (*Commenter: Adam Matar*)

Response: The Recommended Planning Direction strategy includes a large increase in renewable generating capacity. While this increase may not make TVA a national leader in renewable generation, TVA will achieve some of the same goals and benefits of renewable portfolio standards, notably the avoidance of emissions of some GHGs and other air pollutants, through its clean energy generation goal.

2.22.2. Biomass

290. I encourage TVA to use grasses as fuel for generating electricity. Several varieties of grasses, including Giant Miscanthus and switchgrass, are currently available that can produce 20-25 tons/acre with a BTU value close to the BTU value of wood. Unlike wood, grasses harvested in the fall have very low moisture content. Grasses also minimize the carbon debt as they are harvested annually. (*Commenter: Bradley Jackson*)

Response: TVA recognizes native grasses and other energy crops as potential fuels for electric power generation. However, there are a number of logistic, technical, and economic issues that must be resolved. These include: their disseminated nature; low energy density (energy content per volume of material); the need for processing, depending on the generating facility; high cost per unit of energy; and the high chlorine and alkali levels in some grasses which could adversely affect boilers. TVA also has concerns about the use of potentially invasive grasses, such as Giant Miscanthus. TVA acknowledges that the use of grasses may result in less carbon debt and have a better short- and long-term carbon balance than some other biomass fuels, particularly if fertilizer and other energy inputs during their cultivation, harvesting, and transport are low.

291. I oppose your plan to burn forest biomass to generate electricity. Whether classified as whole trees, logging residues, or unmerchantable timber, burning forest biomass will result in deforestation, loss of soil carbon and soil fertility, increased air pollution, and loss of wildlife habitat, native forest ecosystems, and old growth. (*Commenters: Anonymous, Dennis Haldeman, Valerie Hargis, Regina Jay*)

Response: Comment noted. TVA is evaluating several biomass fuel options, as well as potential biomass generating capacities and facility locations. TVA will assess the potential project-specific environmental impacts when it proposes a biomass-fueled generation facility. This assessment will consider sourcing area impacts.

292. In the 1990s, TVA considered and ultimately rejected proposals for barge terminals associated with chip mills which would process whole trees into wood chips for export to global paper manufacturers. TVA recognized the potential for significant impacts to occur from the forest harvesting to supply the chip mills. Other chip mills are currently operating in the TVA region. It now appears that TVA's use of wood biomass fuels would result in many of the same impacts. (*Commenter: Louise Gorenflo - TFC*)

Response: Comment noted. TVA agrees that the use of wood biomass fuels can have many of the same environmental impacts from harvest and transportation as does the use of wood chips for producing pulp and other forest products. TVA has performed fuel availability studies and will perform additional studies of fuel availability and associated environmental impacts as it considers potential biomass projects.

293. In the IRP, TVA states it is conducting fuel availability surveys and assessing the feasibility of converting coal-burning units to biomass units. The IRP does not state how or when the results of these studies will be incorporated into TVA's resource planning. (*Commenter: Courtney Piper - TBLCEE*)

Response: TVA is assessing the potential for existing coal-fired units to be converted to biomass, including Shawnee Fossil Plant Unit 10. A preliminary cost estimate of the conversion was scheduled to be completed in January 2011. If warranted, a detailed fuel availability study and a detailed cost estimate will be prepared in 2011. The decision to convert this or other coal-fired units to biomass will depend on a unit-specific assessment of: (1) direct financial costs/risks along with other impacts related to the environment and economy for a specific biomass conversion project; (2) costs, risks, and other impacts from alternative traditional and non-traditional sources of supply; (3) federal legislation and regulations relating to renewable energy and environmental requirements; and (4) future TVA renewable energy requirements and initiatives. Such a proposal would be subjected to additional environmental review.

294. Instead of burning biomass, TVA should be converting it to synthetic gas and biochar, and then using the biochar as a soil supplement and to sequester carbon. Numerous studies have shown the feasibility of this process. (*Commenter: Erich J. Knight - SG*)

Response: The IRP analysis considered multiple resource options for meeting projected capacity needs. Potential resource options were evaluated with the following criteria: a developed or proven technology, or one that has reasonable prospect of becoming commercially available by 2029; available within the TVA region or importable through market purchases; and reasonably economical and contributes to the reduction of emissions of air pollutants. The conversion of biomass to gas and biochar, in TVA's opinion, does not currently meet all of the necessary criteria.

295. IRP Strategies C and E include a large increase in the use of biomass for generation, most of which is apparently wood. Much of the readily available, inexpensive wood supply is already utilized and TVA would be competing for this resource. This could increase the cost of wood for everyone. (*Commenter: Bradley Jackson*)

Response: Comment noted. TVA is evaluating various biomass technologies and capacities. Based on the technology, capacity, and facility location, different fuel blends and quantities will be required. The associated costs, including those affecting other users of biomass, will be reviewed in detail during the review of any proposed biomass projects.

296. Methane from landfills is a major source of GHG emissions. TVA should work to reduce landfill methane emissions by increasing electrical generation by landfill gas and by promoting increased recycling and composting to reduce the volume of waste entering landfills. (*Commenters: Kevin Routan - CGSC, Bruce Wood - BURNT*)

Response: Currently, TVA periodically co-fires methane from a nearby sewage treatment plant at Allen Fossil Plant and purchases 7.1 MW of landfill gas generation. Increased levels of methane gas generation are included in the IRP renewable portfolios associated with Strategies D and E, as well as the Recommended Planning DIrection. Additionally, TVA supports recycling and sustainability efforts that reduce the volume of waste entering landfills and has committed to reducing its waste generation.

297. Please incorporate the development of Waste-to-Energy plants into your scenarios. The Nashville Thermal Plant and the Gallatin resource recovery plant operated efficiently and cleanly for many years. Studies by EPA have shown the benefits of modern WTE plants include: 1) clean source of steam and power generation; 2) reduced traffic congestion by eliminating long hauls to distant landfills; 3) reduced GHG emissions; 4)

reduced consumption of imported diesel; and 5) reliable steam and electric energy at a reasonable price. (*Commenters: John R. Holladay - LGCRE, John Norton - NE*)

Response: Municipal solid waste (MSW) facility ownership and operation is a niche business model that TVA does not plan to pursue at this time. There is uncertainty associated with future emission standards and emission control requirements from these sources. Additionally, recently proposed federal legislation would require local governments to provide residential recycling services in order for MSW to be considered a renewable energy fuel source. Currently, these recycling practices are not common in the TVA region. However, TVA would, consistent with other power purchase agreements, consider waste-to-energy facilities that were determined to be competitive with forecasted electricity prices at the time those contracts were evaluated, and subject to appropriate environmental review. If this situation changes, TVA would consider this kind of facility in future IRPs.

298. Some of the state agriculture departments and universities in the TVA region have programs to research and assist in the development of biofuels. Is TVA working with these programs? Has TVA considered providing grants to help fund these programs? (*Commenter: Robin Minor*)

Response: TVA is and has been working with some of these programs located in the states TVA serves, but TVA's focus is power generation and not biofuels. TVA is working closely with entities in Kentucky and Tennessee on developing biomass-fueled generation. TVA has also worked with the Mississippi Technology Alliance on biomass projects in the past. Although TVA does not normally provide grants, TVA does fund specific studies and collaborate with others on technology development by providing in-kind labor or facilities.

299. The DEIS does not state the amount of biomass (in particular, the amount of wood/forest biomass) that would be need for the anticipated 500+ MW of biomass generating capacity. (*Commenter: Louise Gorenflo - TFC*)

Response: TVA is evaluating several biomass generation technologies for the 456 MW biomass capacity addition identified in renewable portfolios. Depending on the actual generation technology and capacity, fuel usage will vary. Fuel availability studies have been completed that indicate ample fuel is available for this capacity. Additional fuel availability studies will be conducted as potential biomass projects are studied in more detail.

300. The dismissal of the use of municipal solid waste (MSW) as a fuel source (Draft IRP pp. 73-74) is based on inaccurate assumptions. MSW is recognized as a renewable fuel by EPA, Internal Revenue Service, and numerous statutes and regulations. Waste-to-Energy (WTE) plants result in greater life-cycle reductions in GHGs and other emissions than does TVA's preferred waste alternative, generation from landfill methane. With WTE plants, recycling rates are higher, transportation is reduced, less land is consumed, and 10 times the amount of energy is recovered from a ton of waste. Air emissions from modern WTE plants are lower than landfill emissions. We urge you to incorporate WTE as a future energy resource. (*Commenters: John R. Holladay - LGCRE, Ted Michaels - ERC*)

Response: See response to Comment 297.

301. The draft EIS assigns zero or low CO_2 and lifecycle GHG emissions to the biomass generation options that could use woody biomass as feedstock. This requires the assumption that woody biomass is from wood waste and not whole trees. As not all

biomass is carbon neutral, TVA should better define the types of biomass it proposes to use and, if necessary, analyze their GHG emissions in more detail. (*Commenter: Frank Rambo - SELC*)

Response: Comment noted. TVA is evaluating various biomass technologies and capacities. Based on the technology, capacity, and facility location, different fuel blends and quantities will be required. The associated GHG emissions will be reviewed in detail as potential project studies are completed and additional environmental reviews are conducted.

302. The draft IRP and EIS claim that the use of biomass to generate electricity is carbon neutral. They do not, however, address the full life-cycle emissions of burning biomass or conduct a full accounting of carbon emissions. There is no mention of carbon emissions from indirect land use changes. There is also no mention of the carbon debt resulting from burning trees for fuel - the fact that the large amount of carbon released when trees are burned takes many years to be sequested by forest regrowth. Thus burning trees results in increased carbon emissions over at least the short term. The initial carbon emissions per unit of electricity generated are high relative to fossil fuels. (*Commenters: Louise Gorenflo - TFC, Dennis Haldeman, Louise A. Zeller - BREDL*)

Response: Comment noted. The projected carbon emission estimates of the alternative strategies and portfolios are based on direct anthropogenic emissions and TVA has assumed these emissions are zero, i.e., carbon neutral, for biomass-fueled generation. This approach is supported by industry practice as both The Climate Registry Electric Power Sector Protocol and the IPCC Guidelines for National Greenhouse Gas Inventories currently quantify and report biogenic emissions from the combustion of biomass separately from other emissions. EPA and others, including TVA, recognize the potential for carbon emissions resulting from indirect land use changes due to the use of biomass fuels. In part because of the need for additional research on these emissions, EPA announced on January 12, 2011, that it would defer for three years the application of the preconstruction permitting requirement to biomass and other biogenic C02 emissions. Additional information on carbon emissions from indirect land use changes and the carbon debt has been added to Section 7.3.3 of the Final EIS.

303. The impacts of harvesting trees to fuel the proposed biomass-fueled generating facilities are not described in the DEIS. The proposed 500+ MW of biomass generating capacity from co-firing, boiler conversion, and dedicated facilities could consume a few million tons of wood per year. Supplying this with logging residue, whole trees, and/or wood chips would have significant impacts over large areas. (*Commenter: Louise Gorenflo - TFC*)

Response: Section 7.3.3 of the Final EIS contains a description of the potential impacts of harvesting trees to fuel biomass-fueled generating facilities. Additional environmental reviews that would be conducted for proposed specific biomass facilities would address these kinds of sourcing area impacts.

304. The use of biomass fuels results in the release of harmful air pollutants, including fine particulate matter, sulfur oxides, carbon monoxide, volatile organic compounds, nitrogen oxides, polycyclic aromatic hydrocarbons, dioxin, and other toxic substances. Several medical organizations oppose biomass incineration due to the unacceptable health risks. (*Commenter: Louise Gorenflo - TFC*)

Response: Comment noted. Although air quality problems have been associated with some biomass-fueled generating facilities, including some using municipal solid waste, numerous biomass-fueled generating facilities are operating in compliance with applicable air quality standards.

305. TVA should engage the Valley's forest management community to develop best management practices for the sustainable use of trees for energy while maintaining the diversity and integrity of natural forests. (*Commenter: Louise Gorenflo - TFC*)

Response: Comment noted. TVA will carefully evaluate the potential impacts of the biomass fuel cycle in its assessment of any biomass-fueled generating facilities. This assessment will consider the diversity and integrity of natural forests and the need for additional best management practices specific to fuel acquisition and transportation.

306. TVA should establish a policy that it will not use biomass derived from food sources or that would result in the conversion of cropland used for food production. (*Commenter: Nancy Givens - WKU/KSES/BGGP*)

Response: TVA shares the concern of using biomass derived from food sources and the concern of converting cropland used for food production to grow biomass for electric power generation. These issues will be considered when TVA evaluates the use of use non-waste biomass to generate electricity with a proposed specific biomass facility.

307. TVA should establish a policy to not use garbage, animal waste, or other waste materials as fuels for generating power. (*Commenter: Louise A. Zeller - BREDL*)

Response: Although there is little use of these fuels for generating renewable energy in the TVA region, they are being used successfully and with relatively low environmental impacts elsewhere. TVA is unlikely to use these fuels in TVA-owned facilities in the near future but TVA would consider purchasing power generated by these fuels after appropriate consideration of the facility-specific environmental impacts.

308. We support the increased generation from woody biomass. This will reduce reliance on fossil fuels and reduce the emissions of GHGs and other criteria air pollutants. (*Commenter: Neil Letson - AFC*)

Response: Comment noted. TVA anticipates a sizeable portion of the increased renewable generation that is included in most strategies will be from woody biomass.

309. We urge TVA to establish strong environmental standards for the use and procurement of all wood used to generate electricity. These standards should include procurement from forests with approved management plans, a transparent self-monitoring and reporting process to promote sustainable procurement practices, and wood supply impact assessments based on formal scientific criteria and available for public comment. (*Commenter: Louise Gorenflo - TFC*)

Response: Comment noted. TVA will carefully evaluate these issues in the assessment of any proposed generating facilities that would use wood fuels.

2.22.3. Cost of Renewable Energy

310. How much is TVA paying for a megawatt-hour of wind energy delivered to the TVA system under the recent out-of-region wind power purchase agreements? (*Commenter: Stephen Levy - TSEA*)

Response: Specific contract terms between TVA and power providers are considered restricted information and therefore not publicly released because they contain confidential and proprietary commercial information. The release of this information could harm TVA's competitive position in electric power markets and its ability to negotiate various types of important commercial contracts on favorable terms. However, all new wind contracts were determined to be competitive with forecasted market electricity prices at the time those contracts were evaluated, taking into consideration the anticipated wind power generation profile and the corresponding market prices on an hourly basis.

311. How much is TVA willing to pay for a megawatt-hour of energy from a solar PV facility in the 1-20 megawatt capacity range? (*Commenter: Stephen Levy - TSEA*)

Response: Renewable projects of this size, including solar PV, are subject to the terms of TVA's relatively new Renewables Standard Offer, which currently has a time-weighted average price of 5.611¢/kWh. To learn more about this offer, see www.tva.com/renewablestandardoffer.

312. I am opposed to the use of intermittent renewable generation, especially solar and wind. These sources are too expensive, both in the cost of the power they generate and the cost of backup generating systems and/or storage systems to mitigate their intermittent availability. (*Commenter: Joe Horton*)

Response: TVA is also concerned about the implications of introducing intermittent renewable resources into the power system, especially as these resources are added in increasing proportions. There are four primary challenges associated with intermittent renewables: 1) hours of no output over the entire region; 2) rapid hour-to-hour changes in output; 3) high cost of transmission to deliver energy to load centers; and 4) generation during periods of low demand. In addition, the fact that both wind and sun are intermittent means that these resources have lower capacity factors than traditional baseload resources. They can also strain or cause the need for increased quickly dispatchable backup power, and present other operational challenges in terms of integration into the generation and delivery system. The Federal Energy Regulatory Commission is considering new guidance to improve integration of renewable energy resources and mitigation of operational issues and costs associated with variable energy resources.

313. The draft IRP and EIS do not provide cost estimates for the development of renewable resources in the TVA region. Therefore, we are unable to determine whether the estimates used in the modeling, particularly for solar PV and wind, are too high. Similarly, there is no discussion of forecasted cost trends for renewables. Please provide these cost estimates. The levelized cost estimate for solar PV provided to the Stakeholder Review Group and posted on the IRP website is unreasonably high compared to PV costs elsewhere. (*Commenters: Sam Gomberg - SACE, Jackie Tipper Posey, Frank Rambo - SELC*)

Response: Cost estimates for renewables are based on best available information, but TVA welcomes the opportunity to review additional information. Renewables generally have a higher cost than traditional capacity at the IRP target levels (2,500 and 3,500 MW). Existing state renewable energy mandates and current state and federal subsidies (e.g., tax incentives) are likely to be the largest drivers of renewable energy development. The scenarios developed for the IRP assume a range of potential future federal renewable energy standards from 0 to 5 percent in 2012 and 30 percent in 2030 of adjusted total retail sales. For the IRP renewables portfolios, lifetime solar costs in the Tennessee Valley were assumed to be about $5,400 per kilowatt of capacity, including all costs (both capital and operating and maintenance). Lifetime wind costs were in the range of $4,500-$4,600 per kW, again including all costs. The costs for energy from in-Valley wind and solar were similar, at about $160/MWh and $170/MWh, respectively. Costs for wind energy from outside the Tennessee Valley were much lower (about $80/MWh), due to substantially stronger and more consistent winds in parts of the Midwest and Great Plains, resulting in much higher capacity factors for wind turbines. (All cost figures are stated in constant 2010 dollars.)

314. TVA is presently paying $0.12/kWh for renewable energy. If TVA greatly increased its use of renewable energy at $0.12/kWh as a replacement for coal-fired or nuclear energy, what would be the effect on consumer rates? (*Commenter: Russ Land*)

Response: This price is paid by TVA's Generation Partners program which purchases power that is resold by TVA's Green Power Switch program. Green Power Switch participants pay a premium for power generated by local renewable resources. This price does not represent the price TVA would otherwise pay in the marketplace for renewable power and is greater than TVA's costs of generating power from some other resources.

315. What is the projected cost/kW for modifying coal units to burn biomass, both through co-firing and conversion for biomass-only firing? (*Commenter: W.R. Kendrick*)

Response: The IRP did not directly assess the option for conversion of existing coal units to co-firing or full operation on biomass fuels. However, these potential conversions are included in the biomass components of the renewable portfolios that were evaluated. The actual cost of unit modifications or conversion is dependent on a number of factors including the unit being converted and the biomass fuel source that would be used. In some of the screening studies completed at the beginning of the IRP process, TVA estimated that a partial conversion to biomass (equivalent to about 20MW of output) for a standard pulverized coal unit could be around $400/kW.

316. While we support the increased generation of electricity from less-polluting sources and increased energy efficiency efforts, we urge caution in committing to large amounts of high-cost and intermittent renewable generation. This could conflict with TVA's mission of low-cost, reliable power. The use of these resources can increase in the future as costs decrease and the power system is better able to accommodate their intermittent generation. (*Commenter: William Cummings - KCC;* Jeannine Hillmer - Praxair)

Response: Comment noted. TVA's vision is to be one of the nation's leading providers of low-cost and cleaner energy by 2020. With the exception of renewable energy purchased through the Generation Partners program, TVA's purchases of renewable energy, as well as renewable generation developed by TVA, are designed to be cost-competitive with forecasted market electricity prices during the time the power is delivered consistent with the obligation to provide low-cost power in the TVA Act.

2.22.4. Development in TVA Region

317. The US is losing its technological lead in innovation in renewable energy. TVA should help reverse this loss by aggressively promoting the development, generation, and use of renewable energy in the TVA region. This can be done by promoting meaningful power purchase agreements for locally generated renewable energy, particularly solar, and encouraging local small businesses in this field. The TVA region states lag behind many states in this area, including several with poorer renewable resources that those of the TVA region. (*Commenters: Navin Rao - Sentinx, Edward Zubko - GES, James E. Zubko*)

Response: TVA is investing in technology innovations for renewable demonstrations and evaluating business models for renewable generation. TVA's renewable generation portfolio, including development of resources within the TVA region, will play a significant role in achieving TVA's vision of being the one of nation's leaders in clean generation. Strategies B and E, as well as the Recommended Planning Direction, include increased renewable generation.

318. TVA is not making a meaningful commitment to developing the Valley's renewable resources, particularly at a utility scale. This is evident because TVA has 1) not conducted the studies necessary to fully define the Valley's renewable; 2) developed strategies that show little difference in the amounts of renewable energy; 3) has not committed significant budget or staff to developing the Valley's renewable resources; and 4) made no mention of renewables in the August 2010 vision announcement. (*Commenters: Sam Gomberg - SACE, Annette Gomberg*)

Response: At the end of 2010, TVA's renewable energy portfolio consisted of over 4,400 MW of renewable energy capacity from both TVA-owned and purchased hydropower and energy generated by wind, solar, wastewater treatment gas, and landfill gas. TVA has secured contracts for more than 1,200 MW of additional renewable energy from wind, solar, biomass and landfill gas. Although not specifically mentioned in the August 2010 vision announcement, these and future renewable additions will play a significant role in achieving TVA's goal of being one of the nation's leading providers of cleaner energy by 2020. TVA has assessed renewable energy potential both in and near the Valley and has committed to developing a significant renewable resource portfolio, along with a commensurate budget and staff. TVA expects to continue to increase its renewable resource portfolio and align future renewable energy plans with TVA's vision, mission, policies and principles. As other commenters point out, however, renewable resources have potential issues that need to be carefully considered, especially at the project- or site-specific level.

319. TVA should adopt a plan that makes a serious commitment to aggressively developing the Valley's renewable energy resources including solar, wind and bioenergy. Developing these resources will create jobs, strengthen local economies and create a clean, healthier environment for all Valley residents. (*Commenter: Julia Aepping [sic], Donald L. Audley [sic], Kris B. [sic], M. Balangen [sic], April Bart, Dave Bordenkircher, Paul Boring, Deanna Bowden, Jenny Bowers, M. Boyd, Nancy Brannon, Harry E. Bryant, Jessica Buchanan, Paula Bunanek [sic], Melissa A. Burt, Kelvin Butler, Laura C. [sic], Lisa C. [sic], Teresa Campbell, Bruce Chicre [sic], James S. Collins, A. M. Conisin [sic], Cliff Corker, Josh M. Cox [sic], Thomas V. Cullen, Lori Curt [sic], H. Dwayne Cutshoul, Lacy Damiles [sic], Erika Davidson, Marge Davis, Roeyn Davis [sic], Courtney Day, I. Drelsecn [sic], Whodong Ebechnop [sic], Patricia Eleand [sic], R. Wray Estes, Peggy Evans, Douglas Felker, Melanie Felker, Heather Finolti, Sarah E. Flower, Vita French, Katherine Gamt [sic],*

Heather Gapsby [sic], Elizabeth C. Garber, Elizabeth Gazaway [sic], Joel Gearhardt, Danielle Gerhard, Kathy S. Gleeland [sic], Tony Gorton, Karen Gulk [sic], Ava Gunter, Mary Alan Guy [sic], Steven H. [sic], Meredith Hayes, Larry Hendrix, Kristen Hickey, R.M. Hill, Jessica Hill, Chloe Hirst, Steven R. Horton, Katherine Huddleton [sic], Jaun K. Hudson [sic], Lauren Hulson [sic], Cee J. [sic], Rofail H. Jenu, [sic], C. Johnson, Ivan Juny [sic], Barbara Kelly, Chrys Kemp [sic], Sara Keubbing [sic], J. Kewisn [sic], P. Kneuman [sic], Scott Kramer, David Brent Kulovich, Sandra Kurtz, William Kurtz, S. Kurtz, R.C. Last, John M. [sic], Julia Mangrin, Annie Mattson [sic], Nancy McFadden, Ralph McKenzie, Laura K. McKenzie, Paula McLen [sic], Rebecca Meade, Michael Miller [sic], Barbara Mott, Catherine Munay, Lauren N., J. N., Marissa N. [sic], Margaret F. Olson [sic], Janet Osborn, Jon Parker [sic], Erwin Peritt [sic], Kotel Perry, Zaria Person [sic], Norm Plate, Sara F. Plemons, Jennifer Porter, John F. Post, Patricia Post, Keith Rainy [sic], Arnold C. Ringe [sic], Madeline Rogers, Mercedes Rodriguez, Phillip Roll [sic], Ruth F. Rothe, Kathy S., Tanya S. [sic], Melinda Sanede [sic], Feris J. Schlery, Cody Semabayl [sic], Judy Sheffield, Madeline Shelly, V.C. Shriever [sic], Roxanna Shohadaee [sic], Michelle Smith, Jamie K. Stand [sic], Karl Stirs [sic], Carolyn N. Stokes, Henry Stokes, A. Suny [sic], Lauren Szoech, Karen T. [sic], Bill Terry [sic], Andy Todd, Nancy G. Van Vallanburgh, Dorthy W., Jan H. Watson [sic], Mona Whitehead, Dean Whitworth, Paul Wieland, Debbie Williams, R.T. Williams, Adelle Wood, Linda W. Woodcock, Kevin Woods, J. Y. [sic])

Response: TVA has announced a renewed vision to become one of the nation's leading providers of low-cost and cleaner energy by 2020. TVA's renewable resource portfolio, including development of resources within the Valley, will play a significant role in achieving this vision, and as such most of the alternative strategies being evaluated in the IRP include an increased reliance on renewable generating resources. Further detail on renewable resources considered within the IRP can be found in Final EIS Section 5.4. Future specific renewable additions would be assessed on cost, technological maturity, regional resource availability, diversified resource portfolio, and anticipated federal legislation/regulation and tax policy factors. Although in-Valley resources are limited by some of these factors, TVA agrees that economic development and the potential for local job growth have been and will continue to be an important consideration in the development of many TVA programs and initiatives. TVA will continue to align future renewable energy plans with TVA's vision, mission, policies and principles.

320. TVA should develop wind and solar generating facilities at the sites of the proposed new pumped hydro facilities. Due to their siting requirements, the pumped storage facilities would likely have good wind and solar resources and the storage facilities could store the renewable energy for delivery during peak demand periods. (*Commenter: Garry Morgan*)

Response: Comment noted. Combining storage with intermittent renewable resources, such as wind or solar, is a good match. Developing a diverse energy portfolio that optimally balances various generation source types (base load, intermediate, and peaking) will be a key component in developing TVA's future energy mix.

321. TVA should establish a Feed-In Tariff (FIT) for renewable energy producers that guarantees a long term fair price for each renewable kWh generated and placed on TVA's grid. (*Commenters: Jeff Deal, James Randolph*)

Response: TVA has recently established a Renewable Energy Standard Offer which guarantees a long term price for renewable energy. A standard offer is very similar to a FIT. For details of the standard offer, see http://www.tva.com/renewablestandardoffer/index.htm.

The Generation Partners contract/purchase agreement also guarantees a fixed price for a 10-year period.

322. TVA should prioritize the use of renewable energy generated in the TVA region over importing renewable energy from elsewhere. This will create local jobs, support local industries, and increase the reliability of the TVA power grid. It will also help TVA meet its mission of improving the quality of life in the TVA region through economic development. (*Commenters: Margie Buxbaum, Mary H. Clarke - TCV, Michael J. Crosby - TEC/BCAAT, Wyldon Fishman - NYSES, Sam Gomberg - SACE, Annette Gomberg, Stewart Horn, Gilbert J. Hough - RSI, Andrew Johnson - TSEIA, Christine Johnson - LSE, Gloria Lathem-Griffith - MEC, Lainie Luse, Linda Park, Leonard K. Peters - KEEC, Ricci Phillips - TTCD, Courtney Piper - TBLCEE, Don Scharf*)

Response: Comment noted. Renewable additions will play a role in achieving TVA's vision to become one of the nation's leading providers of low-cost and cleaner energy by 2020. Future renewable additions are assessed on cost, technological maturity, regional resource availability, resource portfolio diversification, and anticipated federal legislation/regulation and tax policy factors. Although in-Valley resources are limited by some of these factors, TVA agrees that economic development and the potential for local job growth have been and will continue to be an important consideration in the development of many TVA programs and initiatives. TVA will continue to align future renewable energy plans with TVA's vision, mission, policies and principles.

2.22.5. Financing

323. TVA should establish a program to encourage the development of pooled neighborhood investments in distributed solar and other renewable generating facilities. (*Commenter: Ann Ercelawn*)

Response: Neighborhood or community solar projects are becoming very popular around the country and TVA is currently researching different models to promote them. Once TVA determines which models have been the most successful, TVA will consider a partnership to pilot one or more projects in the TVA region.

324. TVA should establish creative financing options for homeowners and businesses to finance the installation of renewable energy generation. These could include loans paid back through power bills and lease arrangements. (*Commenters: A. Morton Archibald - ASA, Nancy Givens - WKU/KSES/BGGP*)

Response: TVA will continue to evaluate the best methods to help consumers finance renewable generation systems. We will leverage the relationships we have with financial institutions and look for partnerships to address consumer needs. One of the methods we implemented in 2010 was to provide a signed tri-party agreement before the customer installed the renewable generation system. This change made it easier for customers to get financing since they had a guaranteed 10-year contract.

325. TVA should increase its financial support for customers to install renewable generation beyond the current $1,000 payment. This amount is too small to be of much significance. TVA should also consider grants for solar hot water heating systems. (*Commenters: Stewart Horn, Chad Ice, Elizabeth Tancig - SC*)

Response: TVA through Generation Partners pays $1,000 to each new participant to offset startup costs and agrees to buy 100% of the green power each system produces. TVA pays the retail electric rate, along with any fuel cost adjustment, plus a 12 cent premium per kilowatt-hour for solar and 3 cents per kilowatt-hour for wind, biomass and hydro. The contract term for TVA to purchase the renewable generation is 10 years providing the customer with credits on their monthly utility bills. As an example, over ten years, TVA would pay over $12,000 for a 4-kW system solar system for a home plus the $1,000 up front incentive. TVA will consider solar hot water heating systems in its development of EEDR programs.

2.22.6. Generation Partners/Green Power Switch Programs

326. Continue and expand the Generation Partners program. (*Commenters: Ruth Busch, Chris Christie, Daniel Joranko - TAP, Jackie Tipper Posey, Kevin Routan - CGSC*)

Response: TVA will continue to support customer owned renewable generation in the Valley through Generation Partners and is committed to refining program elements and processes through continuous improvement efforts to reach even more customers.

327. Do Green Power Switch customers pay for the wind power that TVA is importing from outside the TVA region? (*Commenter: Jackie Tipper Posey*)

Response: No. All renewable energy purchased by Green Power Switch customers is generated in the TVA region.

328. The Generation Partners program has been slow to yield large production increases due to a lack of education about renewable energy; lack of sufficient incentives and creative financing mechanisms; competing media messages against conservation, energy efficiency and renewable energy and for coal and nuclear; and the reluctance of homeowners and businesses to invest during the economic downturn. How is TVA addressing these issues? (*Commenter: Nancy Givens - WKU/KSES/BGGP*)

Response: The Generation Partners program has seen significant growth in the last year after TVA redesigned the incentive structure and contracting process, increased the size of qualifying systems from 50 kW to 200 kW, and added biomass and micro hydro as additional qualifying resources in late 2009. As of December 2010, over 600 projects have been approved for Generation Partners, with a total capacity of over 60 MW. TVA will continue to evaluate possible improvements to support customer-owned renewable generation in the Valley.

329. The IRP strategies do not incorporate the generating resource potential contributed by TVA's Generation Partners program. This successful program is rapidly growing, yet continuing to be considered a pilot by TVA with undefined long-term goals. It, and the associated Green Power Switch program, would grow more rapidly if TVA made a long-term commitment to it and focused it on local jobs and local renewable energy projects. (*Commenter: Annette Gomberg*)

Response: The energy generated by TVA's Generation Partners program is not included in the renewable portfolios evaluated in the IRP. It is instead considered an end-use generation program and included as a component of TVA's EEDR portfolios (see EIS Section 3.5). The commenter is correct in stating that Generation Partners is a pilot program. However, TVA continues to enroll participants and contract for purchasing energy they generate for 10 years. TVA is working with the local power distributors and others to make Generation Partners an established program.

330. TVA states that it does not participate in net-metering. However, I have a friend who generates his electricity and is paid for electricity he generates but does not consume. Please explain how this works. (*Commenter: Robert Barkley*)

Response: TVA offers Generation Partners through participating power distributors instead of net metering. Generation Partners differs from net metering because consumers are paid for all of their renewable generation, not just any excess that they put back on the grid. TVA pays each new participant in Generation Partners $1,000 to offset startup costs and agrees to buy 100 percent of the green power each system produces. TVA also pays the retail electric rate, along with any fuel cost adjustment, plus a 12-cent premium per kW-hour for solar and 3 cents per kW-hour for wind, biomass and hydro. For more information on Generation Partners go to www.generationpartners.com or contact your local power distributor.

331. What were the projections and actual numbers for Green Power Switch subscribers, amount of green power generated, and amount of green power sold for the last couple years? What are the projections for the current year? (*Commenter: Chris Christie*)

Response: Green Power Switch (GPS) participation has declined annually at a rate of between 5-7 percent over the past two fiscal years. It is forecasted that this trend will continue into FY2011, with only 11,400 participants in the program (~5 percent decline from the previous year) by September 2011. GPS sales have increased by ~7.5 percent each year since 2009, and the current forecast is that sales will increase by another 7 percent in FY2011. Additional information is listed below.

	FY2009 (actual)	FY2010 (actual	FY2011 (projected)
Total GPS customers	12,858	12,019	11,400
Total green power sales	87,306 MWh	93,482 MWh	100,000 MWh

2.22.7. Purchasing Options

332. TVA should adopt a policy that requires distributors to allow customer-owned renewable energy generating systems to connect to the grid and sell excess power back to TVA. This option is presently not available in much of the TVA region. (*Commenter: A. Morton Archibald - ASA*)

Response: TVA's Generation Partners program achieves this. TVA pays each new participant in Generation Partners $1,000 to offset startup costs and agrees to buy all of the renewable energy they generate. TVA pays the standard electric rate, along with any fuel cost adjustment, plus a 12-cent premium for solar and 3 cents per kilowatt hour for wind, biomass and hydro. The participant pays the standard electric rate plus any fuel cost adjustment for the power they consume. There are currently 114 power distributors participating in Generation Partners. As of December 2010, over 600 projects are approved for Generation Partners, totaling over 60 MWs.

333. TVA should adopt an aggressive Feed-In Tariff (FIT) for in-Valley renewable generation. A FIT offers the advantages of only paying for the power delivered, protecting

ratepayers by establishing a stable power purchase price and improving project financing through guaranteed contract terms and reliable revenue streams. The region would also benefit from increased local renewable generation through local employment, increased diversity of the power portfolio, strengthened power grid, and reduced pollution and greenhouse gas emissions. (*Commenter: Wyldon Fishman - NYSES*)

Response: A variant of the FIT is currently being used by TVA's new Renewable Standard Offer program, although in a limited program quantity and with pricing that varies by date and time of delivery but not by generation technology. Details are available at http://www.tva.gov/renewablestandardoffer/. The feed-in tariff and related power acquisition mechanisms will be considered during the development of future renewable energy plans, while recognizing that TVA strives to balance goals related to both low-cost and cleaner energy.

2.22.8. Qualifying Facilities

334. The IRP makes little mention of the future use of energy generated by qualifying facilities as defined by the Public Utility Regulatory Policies Act. What role will these have in TVA's future portfolios and is TVA considering changes that would make future purchases from these facilities easier to implement? (*Commenter: Tom Nelson - DESI*)

Response: Existing qualifying facility agreements are described in Section 3.4 of Final EIS. The requirements to be a qualifying facility are established by law and TVA adheres to these in its treatment of and response to such facilities.

2.22.9. Renewable Energy Potential

335. The alternative strategies contain virtually no additions of renewable energy after 2020. This constraint is unreasonable and artificially skews model results towards non-renewable generating options. (*Commenter: Sam Gomberg - SACE*)

Response: The growth in renewables capacity mostly tapers off after 2020 due to higher cost and/or regulatory uncertainty. Existing state renewable energy mandates and current state and federal subsidies (e.g., tax incentives) continue to be the largest drivers of renewable energy development for the nation. Future state and/or federal mandates, as well as future tax policy, are unknown and will significantly impact future development of renewable energy resources. Additionally, TVA intends to begin preparing another IRP no later than 2015. At that time, renewable portfolio composition and timing will be reevaluated.

336. The draft IRP and EIS fail to consider alternatives that address the full potential for the development of renewable resources in the TVA region. Under Strategy E, which purports to maximize reliance on renewable and EEDR resources, regional wind and solar PV development are each limited to 360 MW. This is a small fraction of the region's potential as described by studies cited in the DEIS, as well as by a recent Navigant Energy Consulting study. The potential for regional biomass energy development is also much greater than the 465 MW assumed in the draft IRP and EIS. Several cited studies, as well as a recent woody biomass inventory by Larson & McGowin, show an additional potential of 6,800 to 12,700 MW of regional renewable generation.
(*Commenters: Abigail Dillen - Earthjustice, Gilbert J. Hough - RSI, Frank Rambo - SELC*)

Response: New renewables incorporated into the IRP were based on two pre-determined portfolios of 2,500 and 3,500 MWs. These amounts do not represent resource potentials, rather reasonable deployment schedules for various resource capacities were developed based on cost, technological maturity, regional resource availability, resource portfolio diversity, and anticipated federal legislation/regulation and tax policy factors. Moreover, it is important to recognize that modest anticipated growth in demand for electricity limits the rate at which new renewable resources can be integrated into the power supply in a cost-effective manner. As this situation changes, TVA anticipates reexamining the merits of renewable resources in future IRP updates.

337. While we support Strategy E, it does not go far enough in taking advantage of the renewable energy potential in the TVA region. This is particularly true for solar energy. The DEIS (pages 128-129) describes a very large regional potential for PV, yet Strategy E only includes 175 MW of PV by 2020. (*Commenters: Gilbert J. Hough - RSI, Andrew Johnson - TSEIA, Rachel Tuck*)

Response: IRP planning strategies were developed to test a broad range of business options that TVA could adopt, including renewable additions. New renewables incorporated into the IRP were based on two pre-determined portfolios amounts of 2,500 and 3,500 MWs respectively. These amounts do not represent resource potentials, rather reasonable deployment schedules for various resource capacities were developed based on cost, technological maturity, regional resource availability, diversified resource portfolio, and anticipated federal legislation/regulation & tax policy factors. Moreover, it is important to recognize that modest anticipated growth in demand for electricty limits the rate at which new renewable resources can be integrated into the power supply in a cost-effective manner. As this situation changes, TVA anticipates reexamining the merits of renewable resources in future IRP updates.

2.22.10. Small and Low Power Hydro

338. Small and low power hydro is a viable, economic option in the TVA region. This option, however, is not considered in the IRP. (*Commenter: Tami Freedman - CGSC*)

Response: The potential for small and low power hydro development is described in Section 5.2.3.1 of the Final IRP and Sections 4.17.3 and 4.17.3 of the Final EIS. Although not explicitly stated in the draft documents, Strategy E - EEDR and Renewables Focused Resource Portfolio included the development of 144 MW of small and low power hydro generating capacity.

2.22.11. Solar Energy

339. A recent report by Navigant Consulting estimates that TVA could integrate much higher penetration level of PV, up to 5,200 MW of capacity, by 2030 with little or no additional infrastructure-related costs. The most aggressive renewable energy portfolio in the draft IRP and EIS (350 MW of PV) only include 7 to 16 percent of this reasonable PV potential. (*Commenters: Lawrence Carroll, Sam Gomberg - SACE, Andrew Johnson - TSEIA*)

Response: IRP planning strategies were developed to test a broad range of business options that TVA could adopt, including renewable additions. New renewables incorporated into the IRP were based on two given portfolios amounts of 2,500 and 3,500 MWs. These amounts do not represent resource potentials, rather reasonable deployment schedules for various resource capacities were developed based on cost, technological maturity, regional resource availability, diversified resource portfolio, and anticipated federal legislation/regulation and tax policy factors. TVA continues to review additional information as it develops and will be updating our renewable portfolios when the next IRP is developed. That effort is planned to begin no later than 2015.

340. Distributed solar generation facilities have the advantages of balancing local loads and not stressing the entire grid structure. The advantages of this local distributed generation are becoming critical as major transmission lines reach maximum load thresholds, especially during peak demand periods when solar generation is greatest. (*Commenters: A. Morton Archibald - ASA, Courtney Piper - TBLCEE, Kevin Routan - CGSC, Lynn Strickland - PS, Thomas Tripp - BFMC*)

Response: TVA recognizes that there can be advantages to distributed generation. Cost, efficiency, and generation/transmission system impacts must all be considered when comparing distributed and traditional centralized utility generation. Distributed generation can introduce complications in system protection, dispatch, control, and metering, and often does not have the advantages of scale economies associated with centralized generation. TVA currently purchases power from numerous distributed generation facilities through the Generation Partners program and other power purchase agreements and anticipates purchasing power from distributed generation through the new Renewable Standard Offer (see Final EIS Section 3.4).

341. For solar energy, prioritize development of rooftop systems. These reduce building HVAC needs, are rarely shaded, and do not occupy land. Suitable commercial and industrial roof space is abundant in many load areas such as Memphis. (*Commenters: A. Morton Archibald - ASA, Reuben Harris, Jim Mann, Paul Noel - NEC , Kevin Routan - CGSC, Lynn Strickland - PS, Elizabeth Tancig - SC*)

Response: Rooftop systems can be a viable approach to solar energy in the TVA region and suitable roof space is abundant in some areas. The Generation Partners program and new Renewable Standard Offer provide opportunities for rooftop PV systems to be deployed across the TVA region. Although rooftop solar is one approach, there are other PV applications that also warrant consideration, such as ground-mounted PV with one or two-axis tracking capability to increase the conversion of sunlight to electricity.

342. Promote local development of solar energy by establishing standardized liability insurance requirements to enable installers to consistently sell solar systems that make financial sense to customers and installers. These requirements should follow solar industry standards and not require extraneous costs that limit development through the Generation Partners program. (*Commenter: Christine Johnson - LSE*)

Response: While TVA promotes growth of the renewable energy in the Valley through Generation Partners and other programs, each power distributor has the ability to determine their own interconnection requirements, including any liability insurance requirements. TVA provides them with information on industry standards but does not dictate how they run their businesses.

343. The draft IRP and EIS do not adequately assess the potential for solar PV development in the TVA region. While the draft EIS notes a potential for 30,000 MW of

rooftop PV in 2015, a recent report by Southern Alliance for Clean Energy (SACE) shows a potential for about 46,000 MW of solar capacity from both rooftop and ground-mounted systems. Given this available capacity, the strategies should include much larger amounts of solar energy. (*Commenters: Nelson Buck, Ann Ercelawn, Sam Gomberg - SACE, Charles Grotzke, Christine Johnson - LSE, Nelson Lingle - RSI, Jim Mann, Adam Matar, Ricci Phillips - TTCD, Paul Sanderson, Joab D. Silverglade, Fred Stanback*)

Response: The rooftop potential indicated in the EIS is for 2015, while the SACE report extended the date until 2030. Additionally, the EIS projections only discuss rooftop potential and do not include the addition of ground-mounted systems. Both the TVA and SACE analysis use the same NREL report as the basis for their resources potential assumptions and therefore should be viewed as complementary rather than contradictory. Additional amounts of solar PV can be considered in future IRP updates and take advantage of the further development of this technology.

344. The draft IRP does not appear to address the forecast decline in the installed cost of solar PV. Please address this. PV module costs fell by 50 percent during 2009 and are forecast to continue to decrease. The average levelized cost of energy over a 25 year period in Tennessee ranged from $0.23 to $0.12/kWh, depending on system size, and is forecast to decrease to $0.14 to $0.04/kWh by 2013. A recent Navigant Consulting study also forecasts dramatic cost decreases. (*Commenters: Sam Gomberg - SACE, Annette Gomberg, Gilbert J. Hough - RSI, Andrew Johnson - TSEIA, Thomas Tripp - BFMC*)

Response: Although solar PV costs have declined rapidly in recent years, it is still a relatively expensive generation option. Additionally, intermittency and dispatchability concerns are barriers that must be overcome for solar PV to provide a large portion of TVA's power. However, renewable additions, such as solar energy, will play a role as TVA increases the proportion of its generation from non-carbon emitting sources. Additional amounts of solar PV can be considered in future IRP updates and take advantage of the further development of this technology.

345. The IRP strategies do not fully exploit the synergies between peak solar power production and TVA's summer peak load requirements. While the IRP indicates that solar has a capacity factor of 17 percent, the coincident solar production peak enhances its value and its economic potential. TVA should consider more in-region solar generation as an economical peaking power source. (*Commenters: Annette Gomberg, Andrew Johnson - TSEIA, Courtney Piper - TBLCEE, Lynn Strickland - PS, Thomas Tripp - BFMC*)

Response: Although solar PV is more coincident with summer peak in comparison to other renewable sources, such as wind, it is still a relatively expensive generation option.

346. The strategies in the draft IRP do not include the potential use of space-based solar energy. This is an emerging supply source as shown by Pacific Gas & Electric's power purchase agreement with Solaren. It is likely to become commercially available within TVA's 20-year planning period. (*Commenter: Richard McNeil*)

Response: TVA evaluated potential resource options using screening criteria described in Section 5.1 of the FInal IRP and Section 5.2 of the FInal EIS. Based on these criteria, space-based solar energy was not considered to be a viable resource option. As with other potential resource options, TVA will monitor the development and commercial availability of space-based solar energy and reconsider its use in future IRPs.

347. The use of distributed PV systems operated by homeowners and businesses in combination with electric vehicles can be an important part of smart grid systems, with benefits from reducing demand for vehicle charging and providing a source of power storage during peak demand times. How was this factored into the IRP's solar PV portfolios? (*Commenter: Thomas Tripp - BFMC*)

Response: Comment noted. Synergistic relationships which leverage the benefits of various technology options, such as with distributed renewable energy, electric vehicles, and smart grid, will play an increasing role in the development of TVA's renewable energy portfolio and in future integrated resource planning. The IRP renewable portfolios represent reasonably achievable resource potentials while allowing for flexibility in selecting various deployment options.

348. TVA should develop a solar lease program implemented through the distributors where TVA or other developers install solar PV and solar thermal on customers' property. The customers then make monthly payments through their power bills, which include credits for the energy generated. Utilities and developers in much of the country have implemented similar programs. (*Commenters: Tami Freedman - CGSC, Reuben Harris*)

Response: Comment noted. There are many approaches for implementing solar PV and other renewable energy technologies which TVA will consider in the future. The Generation Partners program is the closest current approach to this proposed business model.

349. TVA should more aggressively promote the adoption of customer-owned PV facilities by holding workshops to explain their use and installation. (*Commenter: Alfred G. Orillion - SA*)

Response: TVA promotes education on solar and other renewable energy by sponsoring public events such as tours, conferences, meetings, and home shows throughout the year. TVA also works with local power distributors and environmental groups to support Earth Day events. Generation Partners has an educational video on the website www.generationpartners.com.

350. TVA undervalues solar generation, especially in the Generation Partners and Renewable Standard Offer programs. In each of these, TVA retains the Renewable Energy Credits. The current value of these RECs is roughly equivalent to the premium that TVA pays for the solar energy. At the macroeconomic level, the cost to TVA is negligible. TVA should therefore maximize the production of this low-cost energy. TVA should also consider paying higher premiums as the value of RECs increases in the future. (*Commenter: Andrew Johnson - TSEIA*)

Response: TVA has renewed its vision to help lead the Tennessee Valley region and the nation toward a cleaner and more secure energy future. Renewable energy is one component of a comprehensive strategy to accomplish the vision. TVA's economic criteria are designed to balance TVA's mission of affordable electricity, economic and agricultural development, environmental stewardship, integrated river system management, and technological innovation. Pricing for renewable energy is set in a manner that balances the aspects of this mission. TVA will continue to refine renewable energy efforts just as was recently done in the 2009 redesign of Generation Partners. In this redesign, TVA expanded resources, increased the maximum size of qualifying systems, and created an innovative incentive structure. The incentive structure is designed so that customers get a premium in addition to the retail rate and fuel cost adjustment. The new Renewable Standard Offer provides developers a long term power purchase contract for renewable projects. TVA has designed flexible renewable energy efforts to meet changing markets and will continue to seek stakeholder input on future plans for renewable energy.

2.22.12. TVA Development of Renewable Generation

351. One of the reasons given in the draft IRP for TVA's reluctance to develop renewable generation is that it does not have the in-house expertise to develop these resources. We question this reasoning as numerous other utilities have successfully used the expertise of consultants and commercial developers to expand their renewable resources. (*Commenter: Sam Gomberg - SACE*)

Response: Comment noted. This statement was an error and has been removed from the Final IRP. TVA has a few hundred employees working in the field of renewable energy (including hydropower), and extensive experience with renewable energy. TVA also collaborates extensively with others (e.g., Electric Power Research Institute, Department of Energy, Oak Ridge National Laboratory) on renewable energy issues.

352. Please better describe the amount of renewable generation that TVA intends to develop and the amount TVA intends to purchase from the marketplace. As a leader among utilities, TVA should also lead in the development of renewables. The current tax incentive situation may change and TVA should be aggressively assisting others in renewable development and in research and development efforts. (*Commenters: Nelson Buck, Robin Minor*)

Response: Due to TVA's current inability to obtain tax incentives or grants, most renewable additions are expected to be through power purchase agreements. The renewable addition portfolios associated with the various alternative strategy are described in Section 5.4.3 of the Final EIS and Appendix D of the Final IRP. These descriptions differentiate TVA-generated and purchased power. The Recommended Planning Direction, with the 2,500 MW renewable portfolio, recommends TVA capitalize on opportunities to make cost-effective renewable additions. As such, the contribution and mix of renewable generation to TVA’s portfolio will continue to be evaluated and will align with TVA's vision, mission, strategies, policies and principles.

353. The Draft IRP (pages 70 and 71) states that TVA does not intend to develop renewable generation (except for upgrades to existing hydroelectric facilities). This position is contrary to the requirement in Executive Order 13514 on Federal Sustainability that agencies “increase agency use of renewable energy and implement renewable energy generation projects on agency property.“ (*Commenter: Abigail Dillen - Earthjustice*)

Response: In addition to development of renewable generation resources on agency property, Executive Order 13514 allows agencies to meet renewable energy objectives through contracted purchases of renewable energy and/or renewable energy credits from generation resources not located on agency property. TVA uses a combination of resources to address Executive Order 13514, including purchases of renewable energy through TVA distributors under the Green Power Switch program and use of renewable energy from modernization of TVA's existing hydroelectric facilities. TVA is also considering options to generate power from biomass at its own facilities. Details of TVA’s renewable energy use can be found at http://www.tva.com/abouttva/energy_management/index.htm.

2.22.13. Wind Energy

354. Develop wind energy with hyperbolic towers on high ridges. These towers are shaped similar to cooling towers and would have contain a horizontal wind turbine. With the higher wind speeds on ridges, they could have an internal wind speed of 125 to 150 mph and generate about 200 MW while producing little noise. (*Commenter: Paul Noel - NEC*)

Response: TVA evaluated potential resource options using screening criteria described in Section 5.1 of the IRP and Section 5.2 of the EIS. Based on these criteria, wind generation with hyperbolic towers was not considered to be a viable resource option. As with other potential resource options, TVA will monitor the development and commercial availability of wind generation with hyperbolic towers and reconsider its use in future IRPs.

355. I understand you propose to build a wind farm on Signal Mountain, which according to wind resource maps has low wind speeds. Your resources would be better spent on solar PV, which is more appropriate for the area and has much less visual impact. (*Commenter: Elizabeth Tancig - SC*)

Response: TVA briefly considered constructing a small windfarm on Signal Mountain near Chattanooga in 1999. This windfarm was instead built on Buffalo Mountain near Oak Ridge, Tennessee. TVA has no plans at this time to construct a windfarm or purchase power from a windfarm on Signal Mountain.

356. Please describe how the anticipated decrease in the cost of wind turbines and improvements in turbine efficiency and capacity factor are considered in the planning process. (*Commenters: Jimmy Glotfelty - CLEP*)

Response: Although wind costs have declined in recent years, other factors such as geographic resource potential, various market drivers, and operations and maintenance costs must be considered. Wind turbines do continue to grow in height, size, and capacity potential, however with these advances also come new potential risks. These risks include increased frequency in equipment failure rates, maintenance cycles, and rises in maintenance labor costs due to safety concerns associate with working on larger scale turbines. These variables are still being understood and analyzed in the wind industry and will likely require further investigation and optimization as turbines continue to grow in size. Due to these uncertainties, cost declines were not strongly considered. Additionally, cost is only one of several factors considered in developing reasonable deployment schedules for the various renewable resource options.

357. The IRP does not address the generation of power by small wind turbines. These are economical options in much of the area. (*Commenter: Tami Freedman - CGSC*)

Response: Small scale wind power is one of the sources of renewable energy that TVA purchases through the Generation Partners program. TVA purchased about 9 MWh of energy from small scale wind in FY2010 and anticipates purchasing more in the future.

358. We agree with the finding in the IRP that wind energy generated outside the TVA region is one of the most abundant and lowest cost sources of renewable energy. Wind energy from the Great Plains, in particular, has a high capacity factor and the main constraint on its availability is the lack of adequate transmission. (*Commenter: Jimmy Glotfelty - CLEP*)

Response: Comment noted. As described in Final EIS Section 7.3.3, TVA anticipates that wind energy generated outside the TVA region will be a major component of its renewable energy portfolio during the IRP planning period.

2.23. Research and Development

359. TVA should increase its support for research and development in clean energy, particularly for the emerging renewable energy manufacturing sector in the region. This is critical to long-term economic expansion. One method is by supporting innovation clusters. (*Commenter: Daniel Joranko - TAP*)

Response: Comment noted. TVA recognizes the importance of research and development in the clean energy sector and invests in research and development of a variety of focus areas to help enable TVA to meet future challenges. These focus areas include many aspects of clean energy in support of TVA's vision to become one of the nation's leading providers of low-cost and cleaner energy by 2020. TVA agrees that economic development and the potential for job growth associated with clean energy, including the renewable energy manufacturing sector, is an important consideration and is one of the focus areas of its economic development efforts.

2.24. Transmission System

2.24.1. New Transmission Facilities

360. Does TVA plan to construct direct current (DC) transmission facilities? (*Commenter: Russ Land*)

Response: In general, DC is not an economic choice for transmission within the TVA system. TVA presently has no plans to construct DC facilities but continues to monitor the technology and economics, and would consider it as an option in some situations.

361. TVA should support the development of long-distance, high-capacity transmission lines to transmit wind energy from the Great Plains to the southeastern US. The high voltage, direct current (HVDC) lines proposed by various companies would allow TVA to import large quantities of wind energy, and to profit by wheeling this power to other utilities. HVDC is a proven technology with high reliability and lower land requirements than alternating current lines of similar capacity. (*Commenters: Jimmy Glotfelty - CLEP, Chris Shugart - PE*)

Response: TVA has recently established contracts for purchase of wind power through existing AC transmission lines. TVA recognizes that long distance high capacity transmission lines could be an important component of transmitting wind energy from the Midwest to the Northeast and Southeast, if that is determined to be a desirable and/or economic goal for its customers. TVA is presently working with several developers in a non-preferential manner to evaluate possibilities for long distance imports through HVDC lines. TVA generally supports these transmission infrastructure upgrades while endorsing no specific projects. The IRP includes consideration of scenarios with large renewable portfolios that would require a new high capacity corridor, within which transmission development proposals might provide a valuable service if economic and other practical issues are favorably resolved. Control of a high volume of variable wind generation and constructing dedicated transmission in “cross-over” states are significant issues. It is also noted that some of the advantages claimed for HVDC lines may not be realistic.

2.24.2. Reliability and Capacity Upgrades - Existing Facilities

362. How is TVA protecting the transmission and distribution grid from natural and manmade electro-magnetic pulse? (*Commenter: John Poparad*)

Response: TVA continues to monitor the technology and risks associated with geomagnetically induced currents (GIC) from sunspots such as the events in 1989 and 2003, and other sources of electro-magnetic pulse, and contributed to a recent white paper on the subject by EPRI. TVA has replaced many protective relays across the system which may have been susceptible to mis-operation during GIC events. TVA has a number of sensors in its system capable of monitoring GIC. In addition, TVA participates in an on-going North American Electric Reliability Corporation Task Force, and is a member of the Transmission Forum where this topic is considered.

363. TVA should invest in upgrading the transmission grid to reduce transmission losses. (*Commenter: John Hamilton*)

Response: Losses in a transmission grid are unavoidable but are relatively small, typically 2-3% of the power transmitted. Losses in the lower voltage distribution systems that TVA sells power to are typically a few percent higher. While service upgrades to provide additional delivery points for supplying power to distribution systems are typically driven by increased capacity requirements, the selection of the optimum alternative is typically driven by relative loss reductions. For transmission systems, potential line losses are considered when designing transmission lines. Conductors are selected based on a present worth analysis of the cost of losses over the assumed life of the line, to provide the economically optimum solution. This applies to both new transmission lines and upgraded lines. The other major source of losses in a transmission system is the large power transformers. As for transmission lines, potential losses are considered in an economically optimum design process.

364. Upgrades to the existing transmission and distribution systems will be necessary to successfully implement the EEDR portfolio. Please describe how you intend to implement the necessary smart grid technology and associated time of day metering. (*Commenter: Sandra Kurtz - BEST*)

Response: The majority of benefits from smart grid technology are obtained from the lower voltage distribution systems that TVA sells power to. However, there are some benefits available in the transmission system. TVA has worked with EPRI over several years and is currently developing a investigation roadmap for the next 10 years that will consider the following: Location Disturbance Application, Advanced Situational Awareness with Phasor Measurement Units (PMUs), Model Validation with PMUs, FACTS Devices , Universal Transformers, IEC 61850 in Substations, CIM Planning Architecture, CIM Operations Architecture, Common Visualization across Interties, Protection Relays with proven PMU capability, Demand Response packages fully operational, Partial Discharge Sensors, Electric Vehicle Charging, Smartwires Technology , Disturbance Location Software, Data Handling and Analytics, Improved Engineering Specs for Existing Tech, Asset Health Sensing Technologies, and an Oscillation Monitoring Tool. TVA is also partnering with EPRI, TVPPA, and distributors on a Smart Grid roadmap for distribution systems. This roadmap works to develop the business case for distributors to address major future impacts such as time-of-use rates, meter reading, load control, customer engagement, planning and forecasting, distribution operations and efficiency, and electric transportation. TVA is managing the interaction and gaps between the Transmission and Distribution roadmap efforts. Additionally, TVA is partnering with 19 power distributors on a smart-grid pilot. This pilot is to test demand response products and the different types of smart grid distribution and communication systems needed. TVA has established a Smart Grid Executive Steering Committee to coordinate TVA and distributor evolving smart grid roadmaps. Smartgrid is being considered by TVA for adoption as a technology development focus area.

365. Utilities typically use static ratings for transmission lines based on fixed weather assumptions. These ratings result in underutilization of the system most of the time. The use of Dynamic Line Ratings allows the system operator to better adapt to actual weather conditions and safely increase line transfer capacity by 10 to 30%. Is TVA considering incorporating Dynamic Line Ratings into the IRP as an option for meeting future energy demand and improving environmental, economic, and operating efficiencies? (*Commenter: Rob Lamneck - NEU*)

Response: Dynamic line ratings are not typically used in long term planning processes such as the Integrated Resource Plan since actual weather conditions cannot be predicted accurately. However, one of the main weather conditions which contributes to line ratings is the ambient temperature. TVA already uses a range of ambient temperatures from 0 to 40 degrees Celsius for line ratings. These ratings typically provide additional transmission capacity during winter, spring, and fall when ambient temperatures are cooler.

2.25. Vegetation and Wildlife

366. The final EIS should identify the 30 bird species of conservation concern breeding in the TVA region and describe the potential impacts on them. It should also address impacts to migratory birds in the TVA region. (*Commenter: Gregory Hogue - USDI*)

Response: The Final EIS includes a citation to this list of birds of conservation concern. An analysis of the potential impacts to these birds is beyond the scope of this programmatic EIS and would be addressed as appropriate when specific resources are proposed for development.

2.26. Water Resources

2.26.1. Availability of Cooling Water / Cooling Capacity

367. The availability of cooling water and/or cooling capacity in area rivers will become more limiting if climate trends in air and water temperatures continue to rise. Is there consideration of additional cooling towers to reduce water use and/or thermal discharges? (*Commenter: Kim Franklin - USCOE*)

Response: The IRP did not explicitly consider additional cooling towers for existing plants, but the cost of new units added to the system in each planning strategy does reflect water treatment consistent with expected regulations, including the cost of cooling towers if applicable. Other studies are currently underway at TVA to address the issue of cooling water discharge and river temperatures.

368. With increasing frequency of drought cycles and increasing summer power demand, the cooling capacity of the Tennessee and Cumberland Rivers is exhausted. TVA should therefore reconsider large nuclear and combustion turbine plants that require large volumes of cooling water. (*Commenter: Paul Noel - NEC*)

Response: Generating resources (supply and demand side) considered in the IRP analysis are optimized based on least cost, with costs imbedded for operating expenses, taxes, and debt. Imbedded within these costs are operational and compliance cost considerations for water regulations. All IRP strategies were developed to conform to likely regulatory requirements. As TVA considers regulations specific to hydrothermal discharges, it anticipates hydrothermal releases and plant intakes to require re-focused biological analysis and, in some cases, additional cooling capacity for discharge permit renewals. New constructions would require closed cycle cooling with minimized thermal discharge to the receiving waters.

2.26.2. Water Conservation

369. TVA should support water conservation efforts by its customers. This would reduce demand on dwindling water resources, stimulate the economy, and reduce energy demand. An example of practical water conservation is installation of rainwater collection systems. (*Commenter: Stewart Horn*)

Response: The promotion of water conservation efforts, including rainwater collection systems, is a component of the water resources management activities that TVA is presently considering in the development of the Natural Resource Plan. See http://www.tva.com/environment/reports/nrp/index.htm for more on this plan. TVA agrees that water conservation efforts frequently reduce energy demand.

2.26.3. Water Resources Impact Assessment

370. How much water does TVA consume at each of its nuclear facilities? (*Commenter: Stewart Horn*)
Response: Water consumption by TVA nuclear facilities, as well as by other TVA generating facilities, is described in Final EIS Sections 4.7 and 7.3 (Table 7-1). The projected water consumption for the various alternative strategies is described in Final EIS Sections 7.3 (Table 7-2) and 7.6.3.

371. The DEIS does not adequately describe the impacts to water quality that would result from the continued operation of coal plants. It states that TVA would continue to meet water quality standards through compliance with National Pollution Discharge Elimination System (NPDES) permit requirements. However, it does not address the fact that TVA is not presently meeting water quality standards and that several TVA plants are operating under expired NPDES permits. TVA's effluent discharges, including those resulting from seepage from unlined settling ponds, are presently causing adverse impacts to groundwater and surface water. (*Commenter: Abigail Dillen - Earthjustice*)

Response: State Water Quality Standards consist of designated uses for streams and water quality criteria applicable to those uses. The criteria apply to the in-stream concentration and not at the “end of pipe” for the discharge where mixing and assimilation in the receiving stream occurs. With each NPDES permit renewal application for its fossil plants, TVA submits analytical data for discharges of organic and inorganic compounds. These data include historical compliance monitoring results and the results of the most recent NPDES permit renewal monitoring. The permit writer uses these data, ambient water quality data, and documented stream flows to analyze the reasonable potential for exceeding the applicable (in-stream) water quality criteria. Based on these analyses, TVA facilities are meeting applicable state water quality criteria including those for heavy metals.

TVA has consistently submitted applications for renewal of the NPDES permits for its power generating facilities no later than 180 days prior to permit expiration as required by state and Federal regulations. 40 CFR Part 122.21(d)(2) states that permittees with a currently effective permit shall submit a new application 180 days before the existing permit expires. 40 CFR Part 122.6 states that the conditions of an expired permit continue in force until the effective date of a new permit that provided the permittee has submitted a timely and complete application for a new permit. While several expired permits have not been yet been renewed, TVA continues to operate in compliance with the terms and conditions of those expired permits as provided for in 40 CFR Part 122.6.

TVA is not aware of any documented impacts to surface waters resulting from its effluent discharges or seepage from unlined settling ponds. TVA routinely performs biological monitoring in the reservoir system including areas in the immediate vicinity of the generating facilities. As discussed above, NPDES permit conditions are established to ensure that discharges to surface waters are restricted as necessary to maintain compliance with applicable water quality standards. Groundwater at TVA fossil plants is monitored regularly, and results are reported to the states. TVA follows all permit requirements for groundwater monitoring and works with state and federal officials to make sure any groundwater issues are properly addressed.

372. The draft IRP and EIS are not consistent in their discussion and assessment of impacts to water resources. The EIS provides an overview of how power generation can affect water resources. Its assessment of impacts to water resources is restricted to water use and water consumption. An environmental strategic metric in the IRP uses heat releases as a proxy for impacts to water resources. While heat releases are important, they are not an adequate proxy for other water resource issues. (*Commenter: Frank Rambo - SELC*)

Response: In developing the criteria for the environmental impact metric, TVA wanted to create a metric representing the trade-offs between energy resources rather than identifying a single resource with “best” environmental performance. The final evaluation criteria relies on some surrogate measures as a proxy for environmental impacts, but when used comparatively with the other attributes provides a reasonable and balanced method for evaluating planning strategies. By considering air, water, and waste in the IRP scorecard, coupled with the broader qualitative discussion of anticipated environmental impacts in the EIS, a robust comparison of the environmental footprint of the planning strategies better informs the selection of the preferred strategy.

CHAPTER 3

3.0 INDEX OF COMMENTERS

Following is a list of the commenters and their affiliations. In many cases, hand-written names were difficult to read and the names listed below are TVA's best interpretations. Thirty-seven comments were received which lacked the name of the commenter.

B

C

D

E

F

G

H

L

M

N

O

P

R

S

T

V

W

Y

Z

CHAPTER 4

4.0 COMMENT LETTERS FROM FEDERAL AND STATE AGENCIES

Comment Letters from Federal Agencies

USACE Nashville District Comments to TVA IRP DEIS

1. Discussion of cumulative impacts is almost nonexistent. The EIS would benefit from a Cumulative Impact Analysis under the 11 step process from the CEQ Manual: "Considering Cumulative Effects under the National Environmental Policy Act." It is understood this is a programmatic document, but the analysis can be from a commensurate level.

2. There is no Environmental Justice determination under Executive Order 12898. The EO is merely mentioned in a Table. As with cumulative impacts, a full analysis depends on the details, but a Determination at a commensurate level with the rest of the document should be made.

3. Suggest adding a table for comparisons discussed in Chapter 6 for Strategies B, C, and E.

4. Will TVA consider environmental impacts from energy sources where TVA is purchasing from the private sector and use that information in its purchasing decisions?

5. On 19 Oct 2009 USACE provided comments during the scoping period. We understand site specific issues associated with construction and operation of power facilities is not addressed in this programmatic DEIS, but will be addressed in site/action specific evaluations. Therefore, USACE resubmits the following comments to be addressed relative to potential issues related to the USACE Programs and/or Operations in the Tennessee and Cumberland River Basins:

   - Any major changes to commercial navigation traffic patterns on the two rivers that are related to energy production.
   - Cooling water discharges at the Gallatin and Cumberland Steam Plants. Is consideration being given to adding cooling towers in lieu of or in conjunction with the use of river water for cooling? This would become more limiting if climate trends in air and river temperature continue to rise.
   - Corps hydropower operations would still be subject to existing water management plans or these plans would have to be modified, including NEPA coverage, if they are proposed for modification.

rec'd 10/14/10

United States Department of Agriculture

NRCS

Natural Resources Conservation Service
4407 Bland Road, Suite 117
Raleigh, North Carolina 27609

Michael J. Hinton, ASTC-Easements & WR
Fax: (919) 873-2103
Fax: (919) 873-2156
Email: mike.hinton@nc.usda.gov

September 30, 2010

Mr. Charles P. Nicholson
NEPA Compliance Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Mr. Nicholson:

Thank you for the opportunity to provide comments on the Draft Environmental Impact Statement (EIS) for the Integrated Resource Plan for Tennessee Valley Authority.

The Natural Resources Conservation Service does not have any comments at this time.

If you need additional information, please feel free to contact me at (919) 873-2103. Also, in the future please address all correspondence to Mr. J. B. Martin, Jr., State Conservationist.

Sincerely,

Michael J. Hinton
Assistant State Conservationist for Easements & Water Resources

Helping People Help the Land

An Equal Opportunity Provider and Employer

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

ER 10/839
9043.1

November 3, 2010

Charles P. Nicholson
National Environmental Policy Act Project Manager
Tennessee Valley Authority
400 West Summit Hill Dr., WT 11D
Knoxville, TN 37902

Re: Comments for the Draft Environmental Impact Statement (DEIS) for Tennessee Valley Authority's (TVA) Integrated Resource Plan

Dear Mr. Nicholson:

The Department of the Interior (Department) has reviewed the Draft Environmental Impact Statement (DEIS) dated September, 2010, for the Tennessee Valley Authority's (TVA) Integrated Resource Plan (IRP). The IRP and its associated DEIS address the demand for electrical power in the TVA service area, the power generation options available for meeting that demand, and the potential environmental and socio-economic impacts of the options. The purpose of the IRP is to evaluate TVA's current portfolio and alternative future portfolios in order to choose a strategy for serving the area's electrical energy needs over the next 20 years.

The region considered in the DEIS includes the Tennessee River watershed and parts of the Cumberland, Mississippi, Green, and Ohio Rivers where TVA power plants are located. This area comprises 202 counties in seven states and approximately 59 million acres. The DEIS considers effects on some resources, such as air quality, beyond the TVA region. The Department offers the following comments.

DEIS Alternatives

The Department appreciates that TVA has formulated alternatives for this DEIS that would reduce the emissions of air pollutants, including greenhouse gases, from its power supply portfolio. To varying degrees, each of the five alternatives described in the DEIS would increase TVA's reliance on renewable energy sources. Encouraging the timely and responsible development of renewable energy, while protecting and enhancing the Nation's water, wildlife, and other natural resources, is one of the Department's highest priorities. The DEIS identifies three of the five alternatives for further consideration: (1) Baseline Plan Resource Portfolio (the "no-action" alternative); (2) Diversity Focused Resource Portfolio (Strategy C), and (3) Energy

Efficiency and Demand Response and Renewable Focused Resource Portfolio (Strategy E). TVA will identify a preferred alternative in the final IRP and EIS.

We note that Strategy E appears to minimize environmental impacts in several important categories, including:

- emissions of sulfur dioxide, nitrogen oxide, mercury, carbon dioxide;
- volume of water used and consumed by thermal generating facilities;
- coal consumption, coal ash production, and related fuel cycle impacts resulting from mining, processing, and transportation;
- nuclear fuel cycle impacts.

Accordingly, we believe Strategy E would likely have the least impacts to resources of concern to the Department. Due to its greater reliance on solar and wind energy; however, Strategy E has the greatest land requirements of the three alternatives selected for further consideration, but all three strategies involve a commitment of several thousand acres of land for new generating facilities. For this reason, we encourage close coordination between TVA and the bureaus of the Department in finalizing the IRP (see comments below on Endangered and Threatened Species), and thereafter in project-specific environmental reviews.

Endangered and Threatened Species

The DEIS does not contain a Biological Assessment with TVA's determination of effects on resources protected under the Endangered Species Act (ESA). All of the alternatives considered would involve constructing new power generation facilities of various types and associated transmission system upgrades within the TVA region, which could affect listed species and designated critical habitats. Anticipated impacts to ESA-protected resources are not specifically addressed in the DEIS; instead, TVA acknowledges the need to consult with the Fish and Wildlife Service during facility siting and review processes (DEIS section 7.2). We appreciate the difficulty of undertaking this task in advance of identifying a preferred alternative and its associated facilities and upgrades; however, we believe some level of consideration of endangered species impacts should inform the selection of a preferred alternative. Therefore, the Department recommends that TVA consider a programmatic ESA consultation with the Fish and Wildlife Service as part of its further evaluation of the alternatives in the final IRP and EIS. A programmatic consultation, even if limited to an evaluation of the preferred alternative, would prepare TVA and the Department for project-specific consultations that would occur as the IRP is implemented. If TVA determines that it lacks sufficient information about the effects of the alternatives on ESA-protected resources at this time to support a general programmatic consultation, we recommend that the final IRP and EIS describe in greater detail when and how programmatic and project-specific consultations would occur in the future.

Specific Comments

Section 4.9; Wildlife Population Trends. The DEIS states that *"Over 30 species of birds breeding in the TVA region are considered to be of conservation concern (USFWS 2008)."* The final EIS should identify these species, and in a corresponding section in Section 7 (Anticipated

Environmental Impacts), describe the potential impacts of implementing the IRP to these species. In addition to breeding birds, this section should also address migratory birds in the TVA region.

Section 4.10; Endangered and Threatened Species. The final EIS should include tables that list the species that compose the following categories that are described in this section:

- *"Thirty-seven species of plants, one lichen, and 109 species of animals in the TVA region area are listed under the ESA as endangered or threatened species or formally proposed for such listing by the U.S. Fish and Wildlife Service. An additional 31 species in the TVA region have been identified by the U.S. Fish and Wildlife Service as candidates for listing under the ESA. Several areas across the TVA region are also designated under the ESA as critical habitat essential to the conservation of listed species."*
- *"Thirty-seven species listed under the ESA occur in the immediate vicinity of the TVA reservoir system and are potentially affected by its operation."*
- *"TVA transmission lines also cross many streams supporting listed aquatic species."*

The final EIS should also identify potential impacts to these species as a result of implementing the IRP.

The scientific name for the pink mucket mussel is given as *Obovaria retusa* -- the correct name is *Lampsilis abrupta.*

The Department appreciates the opportunity to comment on the IRP DEIS. Let me know if you have questions or concerns about our comments. I can be reached on (404) 331-4524 or via email at gregory_hogue@ios.doi.gov.

Sincerely,

Gregory Hogue
Regional Environmental Officer

cc: Jerry Ziewitz - FWS
Mary E. Jennings – FWS
OEPC – WASH

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4
SAM NUNN
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA GEORGIA 30303-8960

November 8, 2010

Mr. Charles P. Nicholson
NEPA Manager
Tennessee Valley Authority
400 West Summit Hill Drive WT 11C
Knoxville, TN 37902

Subject: EPA NEPA Review Comments on TVA's DEIS for the "Integrated Resource Plan, TVA's Environmental and Energy Future"; General Tennessee Valley (TN, AL, MS, KY, GA, NC, VA); CEQ No. 20100379; ERP No. TVA-E09815-KY

Dear Mr. Nicholson:

The U.S. Environmental Protection Agency (EPA) has reviewed the subject Tennessee Valley Authority (TVA) Draft Environmental Impact Statement (DEIS) in accordance with our responsibilities under Section 102(2)(C) of the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act. The IRP provides options (future condition scenarios, alternative planning strategies, and resource planning portfolios) for TVA's future generation of electricity to sustainably supply the Tennessee Valley's projected need for power with a 15% reserve margin.

In the mid-1990s, EPA had provided comments on TVA's last energy planning IRP EIS (*Energy Vision 2020*: EV2020). Once final, the new IRP would supersede the adopted portfolios of EV2020 through 2029. We commend TVA for its overall development of a comprehensive energy plan and EIS and, specifically, for strategic planning that de-emphasizes conventional coal and pursues less polluting power generation strategies. We also appreciate TVA's introduction of the EIS to us in a presentation at our EPA offices in Atlanta on July 13, 2010.

Accompanying the IRP DEIS was a separate Draft IRP document. While we have concentrated on the NEPA review and comment of the DEIS, we have also provided some review comments on the Draft IRP. Our comments are provided for TVA's consideration during its development of the Final EIS (FEIS) and the Final IRP.

Overview

Currently, TVA's 2010 power capacity of 37,000 MW primarily consists of coal-fired and nuclear energy resources. Within the next few years, TVA plans to bring online the 880-MW John Sevier Combined Cycle (CC) plant and the 1,180-MW Unit 2 of the Watts Bar Nuclear Plant. Coal-fired generation capacity would be reduced for all

IRP strategies, while reliance on other strategies would increase. Although not without impacts, the strategies proposed by TVA would reduce emissions of criteria air pollutants (National Ambient Air Quality Standards: NAAQS), air toxics (Hazardous Air Pollutants: HAPs) and greenhouse gases (GHGs) compared to actual conventional coal strategies.

EPA Expectations

Relative to TVA's future electricity generation, EPA's main concerns center on air quality, water quality/quantity and climate change effects. From our perspective, EPA would support an emphasis on demand-side reductions (increased technological efficiency and conservation incentives) to reduce the need for power; increased development of renewable ("green") power using diverse traditional and emerging generators[1]; additional nuclear capacity using state-of-the-art reactor technologies; increased use of natural gas and clean coal fossil fuel technologies[2]; decommissioning ("layups") and repowering of traditional coal power plants; reduced water consumption technologies and increased waste heat reuse designs; and power purchases (as needed) from sources which minimize environmental impacts while TVA's own capacities from such sources is maximized. These generation strategies could increase customer efficiency/conservation and green power capacity, reduce the volume of air emissions including GHGs such as CO_2 (in terms of CO_2 equivalents: CO_2e) and reuse or sequester generated CO_2; continue to make use of domestic natural gas resources as well as domestic coal resources through clean coal technologies; minimize water consumption required for cooling water and the volume of thermal effluent discharged; minimize the need to transmit electricity and transport feedstocks through strategically locating generators close to users where possible; and other benefits attendant with power industry advances that can be expected over the next 20 years.

Planning Options

TVA considered six conditions (Scenarios 1-6) for future power generation as well as re-considering their current planning approach (Scenario 7). These future condition scenarios are that: 1) the economy recovers dramatically; 2) the environmental focus is a national priority; 3) there will be a prolonged economic malaise; 4) there will be a game-changing technology; 5) there will be a reduced dependence on foreign energy sources; and 6) carbon regulation will create an economic downturn. Of these, we suspect that Scenario 5, and possibly 4, appear the most likely to eventuate. However, based on similarities in capacity expansion plans, TVA paired Scenarios 1 with 4, 2 with 5, and 3 with 6, with 7 being considered somewhat unique. Only Scenarios 1, 2, 3 and 7 were retained after DEIS pairing and examination (pg. 156).

---

[1] For examples, efficient hydropower generation and development of wind and solar (conventional photovoltaic and solar concentration technologies) and possibly current/wave energy, where appropriate. EPA recognizes that availability of such resources, especially wind and solar, is uneven due to the Tennessee Valley's meteorology and topography.

[2] For examples, Combined Cycle (CC) and Combined Turbine (CT) technologies for natural gas and Integrated Gasification Combined Cycle (IGCC) technology for clean coal.

Five planning strategy alternatives were also considered: A) limited change in the current resource portfolio; B) baseline plan resource portfolio (No Action); C) diversity focused resource portfolio; D) nuclear focused resource portfolio; E) EEDR (energy efficiency and demand response) and renewables focused portfolio. These were evaluated under the retained Scenarios 1, 2, 3 and 7 (Tables 6-4 to 6-6). Although TVA did not identify a preferred alternative strategy, alternatives A and D were eliminated, while B, C and E were further considered.

For each scenario of a planning strategy alternative, a 20-year resource plan (portfolios) was developed. A total of 35 portfolios were prepared to find an optimum resource option to meet the power generation needs over the 20-year planning period.

EPA agrees with the TVA elimination of a strategy with only limited change (Strategy A), since it would likely not be effective enough over the next 20 years since renewables and other emerging technologies would not be sufficiently emphasized. Similarly, the current baseline plan (Strategy B) would likely also not be adequate but as the No Action Alternative, would be carried forward in the EIS consistent with NEPA. The TVA-eliminated nuclear focused strategy (Strategy D) may also be too oriented toward one generating technology. We further agree that TVA-retained strategy planning action alternatives E and C both have attributes for long-term implementation since they both reduce conventional coal generation and increase renewables, natural gas and nuclear capacities. We note from Tables 6-5 and 6-6 that Strategy E proposes a cumulative reduction of 4,730 MW of fossil fuel layups and elevated capacities for renewables (to 1,157 MW) and EEDR (to 6,043 MW), while Strategy C proposes such elevations at a lower capacity (3,252 MW (layups); 954 MW (renewables); 4,638 MW (EEDR)).[3]

Air Quality Impacts

Air quality impacts from GHGs, criteria air pollutants and HAPs are addressed in detail in the enclosed *Detailed Comments*. Specific EPA recommendations regarding air quality impacts are provided in this enclosure and are also summarized below.

EPA Recommendations

Our recommendations for the Final IRP and FEIS consist of an overall NEPA recommendation for alternatives (planning options) and several recommendations specific to air quality.

[3] The FEIS should disclose the percentage of TVA's grid capacity generated from renewables for Strategies B, C and E. We note that states having adopted a Renewable Portfolio Standard (RPS) require that a range of 8-40% of their electricity be generated by renewable sources. Although there currently is no Federal RPS, EPA would support an aggressive TVA emphasis on renewables for the IRP planning period.

* *Alternatives*: Based on the information provided in the DEIS, EPA prefers elements of alternative planning strategies E and C, with emphasis on E since it maximizes renewable power implementation and a reduction in conventional coal plants under the four scenarios reviewed (and in fact appears to replace capacity lost by coal layups with the addition of renewables capacity: pp. S-11, S-12). Strategy C is environmentally attractive by offering a diversified approach to power generation (e.g., includes IGCC in 2025 whereas strategy E does not) which allows for greater flexibility over the planning period and may (in the case of IGCC) continue to utilize domestic coal supplies. As such, EPA supports elements of both strategies that promote greater emphasis on diversity in power generation, renewables, customer efficiency/conservation, and use of cleaner technology for carbon-based resources. We also recommend that the rationale for eliminating Scenarios 4-6 be further discussed in the FEIS.

* *Air Quality* – Several recommendations on air quality impacts are detailed in the enclosure. Topics of some of these specific recommendations include: 1) documenting the effects of changing climate on TVA power production; 2) use of CO_2 as a surrogate for emissions reductions for other pollutants; 3) disclosure of the true GHGs emissions associated with nuclear power; 4) acknowledgement of the Council on Environmental Quality's (CEQ) draft guidance on GHGs analyses in NEPA reviews as well as completion of any already relevant assessments; 5) re-evaluation of the literature to ensure accuracy in stated values; 6) consideration of potential HAPs emitted by a TVA facility; 7) discussion of the PM2.5 NAAQS regarding attainment, and 8) discussion of types of on-site mitigation at power generation facilities that are in addition to the less-air-pollutant-intensive generation methods.

EPA DEIS Rating

EPA commends TVA for its overall development of a comprehensive energy plan and EIS that de-emphasizes conventional coal and pursues less polluting power generation strategies over the 20-year planning period. However, TVA has not yet identified (pg. 157) an alternative planning strategy in the DEIS, and TVA's power generation approach for the next planning period remains unclear. EPA therefore rates this DEIS as an "EC-2" (Environmental Concerns, with additional information requested) and recommends that strong consideration be given to an alternative similar to planning strategy E, modified to give greater emphasis on diversity in power generation, renewables, customer efficiency/conservation, and use of cleaner technology for carbon-based resources. Regarding our request for additional information, we recommend clarification of air quality information described in the enclosed *Detailed Comments*.

EPA appreciates the opportunity to review this DEIS. Should you have questions on our comments, please contact Chris Hoberg of my staff at 404/562-9619 or hoberg.chris@epa.gov.

Sincerely,

Heinz J. Mueller, Chief
NEPA Program Office
Office of Policy and Management

Enclosure: *Detailed Comments*

DETAILED COMMENTS

Air Quality Comments

DRAFT INTEGRATED RESOURCE PLAN (IRP) COMMENTS

1. **Figure 5-2, Key Uncertainties.** While discussed in more detail in the DEIS, we recommend that Figure 5-2 in the Final IRP include, as a key uncertainty, the impact of a changing climate on TVA's ability to provide low-cost reliable energy into the future. For example, how will increasing surface temperature affect summer peak demand (and thus, the prediction of resource needs)?

2. **Page 91, Monte Carlo Simulation.** The document describes the Monte Carlo analysis as having employed only 72 iterations to describe the uncertainty associated with each of the portfolios. A Monte Carlo analysis typically requires a much larger number (usually in the thousands) of iterations to develop a stable distribution of values. What is the basis for limiting this analysis to only 72 iterations?

3. **Section 5.5.2.1 and Appendix A, Air Impact (and the corollary discussion in the DEIS Section 7.6).** We recommend making a stronger argument for using carbon dioxide (CO_2) as a surrogate for emissions reductions for other air pollutants (sulfur dioxide or SO_2, nitrogen oxides or NO_x, and mercury or Hg) in out years. Specifically, it would be helpful to provide additional detail on the underlying assumptions used to estimate emissions in out years. These assumptions are critical to the resulting conclusion that CO_2 can act as a surrogate for emissions reductions for other air pollutants. In addition, it would be helpful to point out that in the IRP Section 5.5.2.1 and Appendix A, the four future "scenarios" are not explicitly displayed (whereas they are in the DEIS, Section 7.6). In other words, the discussion of emission trends in the DEIS shows a more detail view (by breaking out four future "scenarios") than is illustrated in the comparable graphs in the IRP. For the reader, this can cause some confusion, particularly when comparing the CO_2 graphs between the IRP (*i.e.*, Figure A-1) and the DEIS (*i.e.*, 7-6). It is also not clear from the discussion for any pollutant whether the emissions estimated in any year are only direct emissions from sources producing electricity or full life-cycle emissions associated with the production of electricity. An explicit statement to that effect would be helpful. Presumably, they are only direct emissions, although we would encourage TVA to include significant associated indirect emissions as well (*e.g.*, CO_2 emissions associated with processing uranium for nuclear power, criteria pollutant emissions associated with mining, processing, and transporting coal, etc.)

4. **Section 5.5.2.1, Air Impact.** The Final IRP (and FEIS) should explicitly state why this suite of pollutants (SO_2, NO_x, Hg, and CO_2) was selected to represent air pollution issues associated with power generation. The discussion should also

explicitly state why other pollutants (*e.g.*, particulate matter, methane, etc.) are not included in this suite of indicator pollutants.

5. **Figure 7-11, Planning Strategy D.** It is not clear from the discussion whether the CO_2 Footprint in Planning Strategy D includes lifecycle greenhouse gas emissions for nuclear energy. As noted in the DEIS, while nuclear power does not directly emit CO_2, there are life-cycle emissions that can result in CO_2 emissions.[4] We recommend making an explicit statement in the Final IRP (and FEIS) clarifying the magnitude of the greenhouse gas emissions associated with nuclear power.

DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)

General Comment

Other than the mitigation of environmental impacts garnered through *de facto* regulatory implementation and the selection of less CO_2-intensive generation methods in out years, the DEIS does not discuss any other types of mitigation activities that could be implemented to further reduce environmental impacts (*e.g.*, the use of clean diesel options during construction of projects). We recommend that the FEIS discuss, if only generally, that there is a range of such activities that can and will be considered in the development of any given on-the-ground project.

Climate Change

1. **CEQ Draft Guidance on GHG Analysis within NEPA.** On February 18, 2010, CEQ proposed four steps to modernize and reinvigorate NEPA. In particular, CEQ issued draft guidance for public comment on, among other issues, when and how Federal agencies must consider greenhouse gas emissions and climate change in their proposed actions.[5] The draft guidance explains how Federal agencies should analyze the environmental impacts of greenhouse gas emissions and climate change when they describe the environmental impacts of a proposed action under NEPA. It provides practical tools for agency reporting, including a presumptive threshold of 25,000 metric tons of carbon dioxide equivalent (CO_2e) emissions from the proposed action to trigger a quantitative analysis, and instructs Federal agencies how to assess the effects of climate change on the proposed action and their design. The draft guidance does not apply to land and resource management actions and does not propose to regulate greenhouse gases.

   While this guidance is not yet final (and thus, not required), we recommend that both the Final IRP and FEIS explicitly reference the draft guidance, describe the

[4] Sovacool, BK. Valuing the Greenhouse Gas Emissions for Nuclear Power: A Critical Survey. Energy Policy 36 (2008), 2940-2953.

[5] http://www.whitehouse.gov/sites/default/files/microsites/ceq/20100218-nepa-consideration-effects-ghg-draft-guidance.pdf

elements of the draft guidance, and to the relevant extent, provide the assessments suggested by the guidance. For example, DEIS Section 7.6.2 gives only a cursory evaluation of the impact of climate change on the TVA service area and the ability of the various planning scenarios' to supply reliable energy under changing climatic conditions. Likewise, DEIS Section 4 does not discuss to any appreciable extent the impact of climate change on the affected environment (*e.g.*, the impact of climate change on wildlife population trends in the TVA service area). We recommend providing a more in-depth analysis of these points since they constitute a key uncertainty in the overall planning process.

2. **Page 61.** The first paragraph under Table 4-5 references "non-combustion uses of fossil fuels in industrial processes". It would be useful to provide a parenthetical example of such a use.

3. **Page 169 (Table 7-2).** Does the IGCC with CCS value given for CO_2 emissions (108.0 tons/GWh) represent emissions after CCS or prior to CCS? A clarifying footnote would be helpful.

4. **Section 7.3.1, Coal-New Facilities.** This section should include a description of additional air pollutants (only CO_2 is described).

5. **Page 172.** The first paragraph lists a range of:

   12 to 61 tons CO_2e*/GWh with an average of 22.2 tons* CO_2e*/GWh*

   Sovacool (see footnote 4 above) reports a range of:

   1.4 grams of CO_2e *per kWh (g* CO_2e*/kWh) to 288 g* CO_2e*/kWh, with an average value of 66 g* CO_2e*/kWh*

   This correlates to a range of:

   1.5 tons CO_2e *per GWh (t* CO_2e*/GWh) to 317 t* CO_2e*/GWh, with an average of 73 t* CO_2e*/GWh (assuming one ton = 907,185 g)*

   We recommend TVA re-evaluate the literature to ensure the accuracy of the stated range of values.

6. **Page 176, last paragraph of Section 7.3.3.** This states that "Spath and Mann (2004) calculated a rate of -452 CO_2-eq/GWh for a 60 MW direct-fired boiler using wood waste". The DEIS does not say what the mass units are for the "-452 value" (grams, tons, etc.).

   The Spath and Mann citation[6] provides a value of -410 g CO_2e/kWh for a 600 MW biomass direct-fired reference case. Is this the value that was meant to be

[6] http://www.nrel.gov/docs/fy04osti/32575.pdf

cited? In any event, given this comment and the prior comment, we recommend TVA review and confirm the various values cited from the literature and explicitly clarify what units are being used in the Draft IRP and DEIS, particularly those used for conversions (*e.g.*, the document should state what type of "tons" – American short tons, metric tonnes, etc. – are used in the documents).

Hazardous Air Pollutants (HAPs)

1. **Section 4.3, Air Quality.** We are pleased to see that this section addresses HAPs. Section 4.3 notes that in 2008, TVA emitted approximately 28 million pounds of TRI pollutants, of which acid gases (including the HAPs hydrochloric and hydrofluoric acid) comprise about 99 percent of emissions. The other 1 percent was made up of heavy metals, many of which are also HAPs.

2. **DEIS Summary (Page S-15) and Section 7.6.1, Air Quality (Page 179).** These sections note, "Under all these alternative strategies, there will likely be a substantial beneficial cumulative impact on regional air quality." Hazardous air pollutants generally have local impacts, so evaluation of their potential impacts should be considered locally rather than regionally. While regional air quality benefits are important, they should not be used to justify or offset increases in local concentrations of HAPs. When TVA considers the potential impacts of a facility, those evaluations should include the potential impacts of HAPs in the vicinity of the facility.

3. **Chapter 7, Anticipated Environmental Impacts.** This chapter seems to focus on criteria air pollutants and greenhouse gases, with minimal mention of hazardous air pollutants. Given the large emissions of HAPs from TVA facilities, they should be addressed in this chapter for the FEIS.

Criteria Air Pollutants

1. **Page S-13.** This page incorrectly states that the only nonattainment area in the TVA region is a few counties in the eastern part of the state (Chattanooga and Knoxville) for PM2.5. In fact, Knoxville is also currently nonattainment for the 1997 8-hr ozone standard, but has clean data and EPA has proposed redesignation to attainment (comment period ends November 8, 2010).

2. **Section 4.3, page 70.** Same comment as above applies for the discussion regarding ozone in the Knoxville area.

3. **Particulate Matter (pp. 70-73).** The document does not discuss the nonattainment status of the Chattanooga and Knoxville areas for PM2.5.

4. **Page 75.** The discussion on lead does not mention that Bristol, TN has a violating monitor for the 2008 lead standard. That area will be designated nonattainment for lead in the next few days.

Editorial Comments

1. **Page 59.** The last part of the last sentence of the first paragraph is broken away from the remainder of the sentence by an intervening paragraph.

2. **Page 186.** Second paragraph, last sentence, last phrase (after the semicolon) seems to be an incomplete statement.

3. **Page 203, Section 7.7.** First sentence appears to be a mistake (the adoption of an alternative strategy has no environmental impacts). All realistic alternative strategies will have some environmental impacts.

4. **Page S-13.** The table key for this summary table could have defined "EEDR" as the "Energy Efficiency and Demand Response", as defined in the DEIS-appended Glossary, Acronyms and Abbreviations (pg. 232).

5. **Pages 158-160.** We note that Tables 6-5 and 6-6 (Strategy C and E) use the heading "Fossil Layups" while Table 6-4 (Strategy B) uses "Coal Layups". Was there an intended difference? Would Strategy C and E also decommission natural gas plants in addition to coal plants?

6. **Page iv.** Tables 6-4 to 6-6 are not listed in the Table of Contents (List of Tables).

Comment Letters from State Agencies

Alabama

Name: Neil Letson

Comments: Our State Forester (Linda Casey) asked me to submit these comments on behalf of the Alabama Forestry Commission.

1) TVA should develop woody biomass capacities to reduce its reliance on fossil fuels. The increased use of biomass fuels will reduce their emissions of CO_2, NO_x, SO_2, and Hg, thus improving compliance with air quality issues and mandates.
2) TVA should support professional forest management activities on its own lands to maximize carbon sequestration and use of biomass products to mitigate carbon emissions.
3) TVA should provide educational activities and resources to encourage natural resource management, conservation practices that sustain water quality, and energy conservation through strategic urban tree plantings within its regional jurisdiction.
4) TVA should support and participate in implementing each Forest Assessment & Resource Strategy within its regional jurisdiction.

Thanks for the opportunity for input. Good luck.

close window

Georgia

Rec'd 10/27/10

OFFICE OF PLANNING AND BUDGET

Sonny Perdue
Governor

Debbie Dlugolenski
Director

GEORGIA STATE CLEARINGHOUSE MEMORANDUM
EXECUTIVE ORDER 12372 REVIEW PROCESS

TO: Charles Nicholson
Tennessee Valley Authority
400 W. Summit Hill Drive, WT 11D
Knoxville, TN 37902

FROM: Barbara Jackson BJ
Georgia State Clearinghouse

DATE: 10/22/2010

PROJECT: Draft EIS: Integrated Resource Plan - TVA's Environmental & Energy Future

STATE ID: GA100922003

The applicant/sponsor is advised that DNR's Wildlife Resources Division was included in this review but did not comment within the review period. Should they submit comments within the next two weeks, we will forward to you.

The applicant/sponsor is advised to note important comments from DNR's Historic Preservation Division.

Provided that future coordination is conducted with HPD as requested, the State level review of the above-referenced proposal has been completed, and the proposal found to be consistent with those state or regional goals, policies, plans, fiscal resources, criteria for Developments of Regional Impact (DRI), environmental impacts, federal executive orders, acts and/or rules and regulations with which the state is concerned.

/bj
Enc.: DNR/EPD, Oct. 4, 2010
GEFA, Oct. 4, 2010
DNR/HPD, Oct. 15, 2010

Form NCC
Oct. 2008

AN EQUAL OPPORTUNITY EMPLOYER
Office: 404-656-3855 270 Washington Street, S.W., Atlanta, Georgia 30334 Fax: 770-344-3568

\ Voicemail Fax
D Remote ID: R page of

GEORGIA STATE CLEARINGHOUSE MEMORANDUM
EXECUTIVE ORDER 12372 REVIEW PROCESS

TO: Barbara Jackson
Georgia State Clearinghouse
270 Washington Street, SW, Eighth Floor
Atlanta, Georgia 30334

FROM: MR. F. ALLEN BARNES
GA DNR-EPD DIRECTOR'S OFFICE

APPLICANT: Tennessee Valley Authority

PROJECT: Draft EIS: Integrated Resource Plan - TVA's Environmental & Energy Future

STATE ID: GA100922003

FEDERAL ID:

DATE:

☒ This project is considered to be consistent with those state or regional goals, policies, plans, fiscal resources, criteria for developments of regional impact, environmental impacts, federal executive orders, acts and/or rules and regulations with which this organization is concerned.

This project is not consistent with:

☐ The goals, plans, policies, or fiscal resources with which this organization is concerned. (Line through inappropriate word or words and prepare a statement that explains the rationale for the inconsistency. (Additional pages may be used for outlining the inconsistencies. Be sure to put the GA State ID number on all pages).

☐ The criteria for developments of regional impact, federal executive orders, acts and/or rules and regulations administered by your agency. Negative environmental impacts or provision for protection of the environment should be pointed out. (Additional pages may be used for outlining the inconsistencies. Be sure to put the GA State ID number on all pages).

☐ This project does not impact upon the activities of the organization.

NOTE: Should you decide to FAX this form (and any attached pages), it is <u>not</u> necessary to mail the originals to us. [770-344-3568]

RECEIVED
OCT 0 4 2010
GEORGIA
STATE CLEARINGHOUSE

Form SC-3
Aug. 2010

GEORGIA STATE CLEARINGHOUSE MEMORANDUM
EXECUTIVE ORDER 12372 REVIEW PROCESS

TO: Barbara Jackson
Georgia State Clearinghouse
270 Washington Street, SW, Eighth Floor
Atlanta, Georgia 30334

FROM: MS. JILL STUCKEY
GEORGIA ENVIRONMENTAL FACILITIES AUTHORITY

APPLICANT: Tennessee Valley Authority

PROJECT: Draft EIS: Integrated Resource Plan - TVA's Environmental & Energy Future

STATE ID: GA100922003

FEDERAL ID:

DATE: 10/28/10

☒ This project is considered to be consistent with those state or regional goals, policies, plans, fiscal resources, criteria for developments of regional impact, environmental impacts, federal executive orders, acts and/or rules and regulations with which this organization is concerned.

This project is not consistent with:

☐ The goals, plans, policies, or fiscal resources with which this organization is concerned. (Line through inappropriate word or words and prepare a statement that explains the rationale for the inconsistency. (Additional pages may be used for outlining the inconsistencies. Be sure to put the GA State ID number on all pages).

☐ The criteria for developments of regional impact, federal executive orders, acts and/or rules and regulations administered by your agency. Negative environmental impacts or provision for protection of the environment should be pointed out. (Additional pages may be used for outlining the inconsistencies. Be sure to put the GA State ID number on all pages).

☐ This project does not impact upon the activities of the organization.

NOTE: Should you decide to FAX this form (and any attached pages), it is <u>not</u> necessary to mail the originals to us. [770-344-3568]

RECEIVED
OCT 04 2010
STATE CLEARINGHOUSE

Form SC-3
Aug. 2010

GEORGIA
DEPARTMENT OF NATURAL RESOURCES

HISTORIC PRESERVATION DIVISION

CHRIS CLARK
COMMISSIONER

DR. DAVID CRASS
DIVISION DIRECTOR

October 15, 2010

Barbara Jackson
Georgia State Clearinghouse
270 Washington Street, SW, Eighth Floor
Atlanta, Georgia 30334

Re: Draft EIS: Integrated Resource Plan – Tennessee Valley Authority's Environmental & Energy Future
Statewide, Georgia
GA-100922-003

Dear Ms. Jackson:

The Historic Preservation Division (HPD) has received information concerning the above referenced undertaking. Our comments are offered to assist the Tennessee Valley Authority (TVA) in complying with the provisions of Section 106 of the National Historic Preservation Act of 1966, as amended.

HPD has received the document entitled "Draft Integrated Resource Plan: TVA's Environmental & Energy Future Environmental Impact Statement." We look forward to future coordination with TVA on Section 106 compliance for future activities as appropriate.

If we may be of further assistance, please do not hesitate to contact Elizabeth (Betsy) Shirk, Environmental Review Coordinator, at (404) 651-6624.

Sincerely,

Karen Anderson-Cordova
Program Manager
Environmental Review & Preservation Planning

KAC/ECS

cc: Charles Nicholson, TVA, IRP@tva.gov

RECEIVED
OCT 15 2010
GEORGIA
STATE CLEARINGHOUSE

254 WASHINGTON STREET, SW | GROUND LEVEL | ATLANTA, GEORGIA 30334
404.656.2840 | FAX 404.657.1368 | WWW.GASHPO.ORG

Kentucky

STEVEN L. BESHEAR
GOVERNOR

LEONARD K. PETERS
SECRETARY

ENERGY AND ENVIRONMENT CABINET
OFFICE OF THE SECRETARY
500 MERO STREET
12TH FLOOR, CAPITAL PLAZA TOWER
FRANKFORT, KY 40601
TELEPHONE: (502) 564-3350
FACSIMILE: (502) 564-3354
www.eec.ky.gov

November 15, 2010

Mr. Charles P. Nicholson
National Environmental Policy Act Project Manager
Tennessee Valley Authority
400 West Summit Hill Dr., WT 11D
Knoxville, TN 37902

RE: Tennessee Valley Authority Integrated Resource Plan Comments

Thank you for providing the Commonwealth of Kentucky, Energy and Environment Cabinet the opportunity to comment on the Tennessee Valley Authority Integrated Resource Plan. The TVA plays an important role in Kentucky's energy industry and economy. The TVA provides 22% of the electricity consumed in Kentucky with large fossil plants and approximately one quarter of Kentucky's hydro resources.

We agree with the plan's emphasis on energy efficiency and demand response and encourage you to aggressively pursue energy efficiency for all classes of customers: residential, commercial and industrial. Efficiency improvements in the industrial sector could be an important factor in maintaining our manufacturing base as energy prices increase.

We also agree with your analysis that biomass and hydropower are important renewable resources for this region. We encourage you to consider repowering Shawnee Unit 10 (slated for idling) with biomass. We also suggest that you consider biomass generation on a distributed basis in your Kentucky service area and that you maximize the potential of hydropower.

Finally, the Energy and Environment Cabinet appreciates your effort to balance energy needs, environmental concerns, and economic development in this plan. Your ability to continue providing affordable electricity in an environmentally responsible way is critical to the economic and social wellbeing of southern Kentucky.

Sincerely yours,

Leonard K. Peters
Secretary

KentuckyUnbridledSpirit.com

An Equal Opportunity Employer M/F/D

North Carolina

North Carolina
Department of Administration

Beverly Eaves Perdue, Governor | Moses Carey, Jr., Secretary

November 10, 2010

Mr. Charles P. Nicholson
Tennessee Valley Authority
400 West Summit Hill Drive
WT 11D
Knoxville, TN 37902-1401

Dear Mr. Nicholson:

Re: SCH File # 11-E-0000-0086; DEIS; Integrated Resource Plan (IRP) and programmatic EIS. View document at http://www.tva.com/environment/reports/irp

The above referenced environmental impact information has been submitted to the State Clearinghouse under the provisions of the National Environmental Policy Act. According to G.S. 113A-10, when a state agency is required to prepare an environmental document under the provisions of federal law, the environmental document meets the provisions of the State Environmental Policy Act. Attached to this letter for your consideration are the comments made by agencies in the course of this review.

If any further environmental review documents are prepared for this project, they should be forwarded to this office for intergovernmental review.

Should you have any questions, please do not hesitate to call.

Sincerely,

Sheila Green
State Environmental Review Clearinghouse

Attachments

cc: Region A

Mailing Address:
1301 Mail Service Center
Raleigh, NC 27699-1301

Telephone: (919)807-2425
Fax (919)733-9571
State Courier #51-01-00
e-mail state.clearinghouse@doa.nc.gov

Location Address:
116 West Jones Street
Raleigh, North Carolina

An Equal Opportunity/Affirmative Action Employer

NCDENR

North Carolina Department of Environment and Natural Resources

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

MEMORANDUM

TO:	Sheila Green State Clearinghouse
FROM:	Melba McGee Project Review Coordinator
RE:	11-0086 Tennessee Valley Authority Integrated Resource Plan DEIS
DATE:	November 9, 2010

The Department of Environment and Natural Resources has reviewed the proposed project.

Several areas need further clarification as noted in the attached comments. We ask that the applicant work with our commenting agencies to ensure that the division's concerns are adequately addressed prior to finalizing project plans.

Thank you for the opportunity to comment on this project.

Attachments

1601 Mail Service Center, Raleigh, North Carolina 27699-1601
Phone: 919-733-4984 \ FAX: 919-715-3060 Internet: www.enr.state.nc.us

One NorthCarolina *Naturally*

North Carolina Department of Environment and Natural Resources
Division of Parks and Recreation

Beverly Eaves Perdue, Governor | Dee Freeman, Secretary | Lewis Ledford, Director

August 12, 2009

MEMORANDUM

TO: Melba McGee, Environmental Coordinator
Office of Legislative and Intergovernmental Affairs

FROM: Amin Davis, Environmental Review Coordinator *AMD*
Division of Parks and Recreation

SUBJECT: TVA Integrated Resource Plan & Programmatic Environmental Impact Statement

REFERENCE: Project No. 10-0010

Dear Melba,

The North Carolina Division of Parks and Recreation (DPR) has reviewed the above-referenced project information available for review at http://www.tva.gov/environment/reports/energyvision2020/. DPR understands that the Tennessee Valley Authority (TVA) has completed an Integrated Resource Plan (IRP) and Environmental Impact Statement (EIS) as part of its Energy Vision 2020 initiative to identify and select a long-range strategy that will enable TVA to meet the electricity needs of its customers from 1996 to 2020. The EIS evaluates potential environmental consequences of alternative energy strategies to the TVA power service area which comprises 201 counties within a 58 million-acre region; 15 of these counties are situated in North Carolina.

DPR is concerned about the indirect and cumulative adverse impacts of "distant sources" of facility operations associated with Energy Vision 2020 on the recreational resources and ecological integrity of State Parks (SP) and State Natural Areas (SNA) that are owned by the State of North Carolina and managed by DPR. DPR is also concerned about the potential adverse effects these distant sources may have on the recreational visitor experience, human health, climate change, and future DPR land acquisitions.

In addition, the "Seventeen Categories of Natural Areas Appendix" (Part 5 of Technical Document 1 - Comprehensive Affected Environment) does not include the following DPR holdings: Bear Paw SNA, Beech Creek Bog SNA, Elk Knob SP, Gorges SP, Sugar Mountain Bog SNA, and Yellow Mountain SNA. In addition, Grandfather Mountain and Mount Mitchell Registered SNA's are now state parks managed by DPR. Please see attached map for the location of these holdings. DPR respectfully requests that TVA update their records to accurately reflect the current status of these eight holdings.

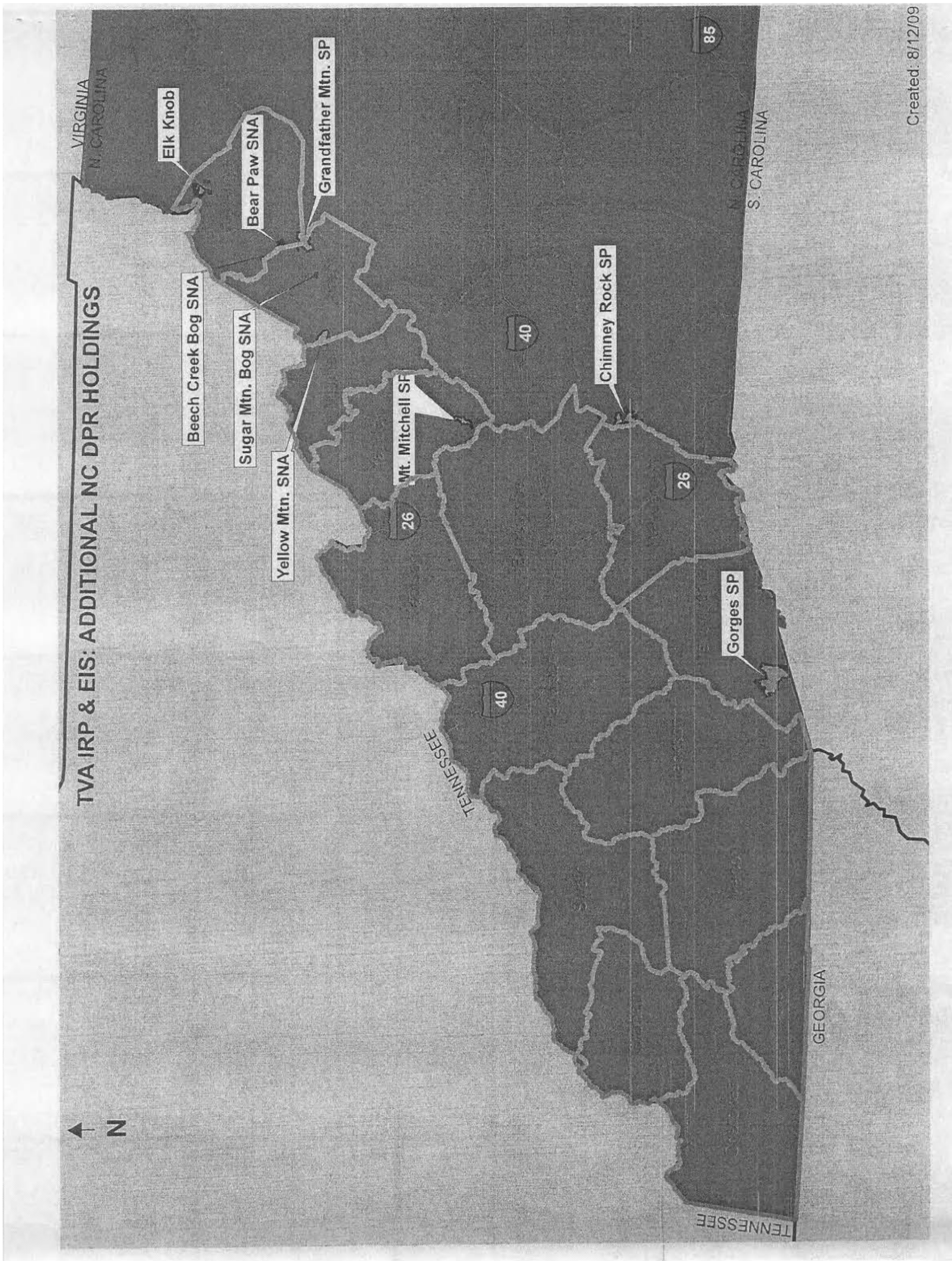
1615 Mail Service Center, Raleigh, North Carolina 27699-1615
Phone: 919-733-4181 \ FAX: 919-715-3085 \ Internet: www.ncparks.gov

Please let me know if I can provide further information. DPR appreciates the opportunity to comment on this proposed project. If we can be of further assistance, please do not hesitate to contact me at 919-715-7584 or amin.davis@ncdenr.gov.

Attachment: Additional NC DPR Holdings Map

CC via email: Adrienne Wallace, Chimney Rock SP Superintendent
Brian Strong, DPR Natural Resources Section Head
Carol Tingley, DPR Regional Planning Section Head
Jack Bradley, Mount Mitchell SP Superintendent
Larry Trivette, Elk Knob SP Superintendent/ Acting Mount Mitchell SP Superintendent
Linda Pearsall, Natural Heritage Program Director
Marshall Ellis, DPR Mountain Region Biologist
Mike Lambert, DPR Chief of Operations
Steven Pagano, Gorges SP Superintendent
Tom Jackson, DPR West District Superintendent

1615 Mail Service Center, Raleigh, North Carolina 27699-1615
Phone: 919-733-4181 \ FAX: 919-715-3085 \ Internet: www.ncparks.gov


TVA IRP & EIS: ADDITIONAL NC DPR HOLDINGS
N
Elk Knob
Bear Paw SNA
Grandfather Mtn. SP
Beech Creek Bog SNA
Sugar Mtn. Bog SNA
Yellow Mtn. SNA
Mt. Mitchell SP
Chimney Rock SP
Gorges SP
VIRGINIA
N. CAROLINA
S. CAROLINA
TENNESSEE
GEORGIA
40
26
85
Created: 8/12/09

NCDENR

North Carolina Department of Environment and Natural Resources

Division of Water Resources

Beverly Eaves Perdue
Governor

Thomas A. Reeder
Director

Dee Freeman
Secretary

November 3, 2010

MEMORANDUM

FROM: Jim Mead, SEPA Review Coordinator - DWR *Jim Mead*

TO: Melba McGee, Environmental Projects Officer - DENR

SUBJECT: Tennessee Valley Authority Integrated Resource Plan
Draft Environmental Impact Statement
DENR Project No. 11-0086

The Division of Water Resources (DWR) has reviewed the draft EIS for the Tennessee Valley Authority's (TVA) Integrated Resource Plan (IRP). Our comments are as follows:

Our concerns pertain to reservoir levels and any additional impacts on TVA reservoirs in North Carolina that may occur in the future as a result of the strategies selected in the IRP. Likewise we are concerned with flows in rivers downstream of TVA projects in NC that may experience additional impacts as a result of implementation of the IRP.

Section 7.6.3. Water Resources, page 189 of the DEIS states, "*All of the alternative strategies result in an increase in the volume of water used and consumed for cooling coal, natural gas, and nuclear facilities.*" The IRP proposes waiting until a specific project is designed to evaluate its impacts. However, we believe that the impacts which result from the different IRP alternative strategies should be evaluated and displayed in this FEIS.

The evaluation of projects and rivers in the North Carolina portion of the TVA system should utilize river basin hydrologic models that are based solely on data that is of public record and open to public review and comments.

We appreciate this opportunity to comment and would be glad to discuss our comments with you or the TVA.

cc: Steve Reed & Tom Fransen, DWR

1611 Mail Service Center, Raleigh, North Carolina 27699-1611
Phone: 919-733-4064 \ FAX: 919-733-3558 Internet: www.ncwater.org

North Carolina Wildlife Resources Commission

Gordon Myers, Executive Director

MEMORANDUM

TO: Melba McGee, Environmental Coordinator
Office of Legislative and Intergovernmental Affairs
North Carolina Department of Environment and Natural Resources

FROM: Dave McHenry, Mountain Region Coordinator
Habitat Conservation Program

DATE: November 1, 2010

SUBJECT: Scoping comments on Tennessee Valley Authority's Integrated Resource Plan and Draft Environmental Impact Statement
OLIA No. 11-0086

Biologists with the North Carolina Wildlife Resources Commission (Commission) reviewed the Tennessee Valley Authority's (TVA) Integrated Resource Plan (IRP) and draft environmental impact statement (EIS). This document outlines various management and operational directions that TVA may pursue through the year 2020 to provide reliable energy to the Tennessee Valley region while also meeting resource stewardship needs. Our comments are provided under provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and the National Environmental Policy Act (42 U.S.C. 4332 (2)(c)).

As described in the IRP/EIS, TVA operations, primarily coal-fired generation, emit sulfur dioxide, nitrogen-oxides, carbon dioxide, mercury, and other pollutants that contribute to acid deposition, mercury accumulation in aquatic food webs, and possibly accelerated climate change in the Tennessee Valley region and beyond. These impacts are harming or have the potential to harm inland fisheries and wildlife and their uses in North Carolina as follows:

1. Acid deposition is contributing to the decline of high elevation spruce forest that is important habitat for northern flying squirrel (US – Endangered) in the southern Appalachians. This forest type is rare

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

and perhaps the second most endangered ecosystem in the region. It is at risk primarily because of the exotic balsam wooly adelgid (*Adelges piceae*), but also due to acid precipitation (NCWRC 2005, and references therein).

2. Acid deposition causes pH suppression in high elevation, southern Appalachian streams that support brook trout. Historical declines of brook trout populations in the region have been extensive due to poor land management practices, but recent losses can be partly attributed to stream acidification (Hudy and Thieling et al. 2008, and references therein). Brook trout are a popular sport fish and a priority species in the management of North Carolina's fisheries (NCWRC 1989).
3. Recent data collected from fish fillets in TVA's Lake Fontana and Lake Santeetlah (non-TVA reservoir) in North Carolina suggest that mercury levels in the Little Tennessee River basin are a risk to human health. Fish consumption advisories were issued in 2008 for walleye in these reservoirs and there is a statewide advisory for the consumption of other fishes that are high in mercury (see www.epi.state.nc.us/epi/fish/current.html). Analyses of samples from other lakes in the western North Carolina region are pending. The Commission recommends that TVA consult with the NC Department of Health and Human Services regarding fish contaminant data it has or is collecting in western North Carolina.
4. The southern Appalachians are the southernmost range of trout in the eastern United States. Brook trout have an upper thermal tolerance threshold of 25.3°C (Harshbarger 1975, and references therein) with optimal growth occurring at 12-16°C (Baldwin 1956, Cormick *et al.* 1972). Trout streams in North Carolina are typically 20.0°C or less with an upper maximum of 22.2°C (Ratledge and Louder 1967). Increased water temperatures from poor land management practices have markedly reduced the extent of brook trout in the southeast (EBTJV 2006). Global climate change could render uninhabitable much of the remaining brook trout streams in the southern Appalachians (Meisner 1990).

Because of these issues, the Commission encourages TVA to pursue more demand-side and renewable source capacity in future management and operations in lieu of fossil fuel based sources, which currently account for about 60 % of capacity. This could be accomplished in part by increasing TVA's integration of customer-based conservation incentives and wind power, nuclear, and solar photovoltaic facilities into future operations. Strategy E in the EIS would utilize the most of these alternatives and thereby achieve the largest reduction in carbon dioxide emissions. The Commission supports incorporating additional emission control technologies, particularly at TVA's four coal-fired nearest to the North Carolina mountains, to reduce acid deposition, mercury accumulation, and other air-related environmental degradation.

The Commission appreciates the opportunity to provide comments regarding effects of TVA's operations on inland fishery and wildlife resources in North Carolina. Please call me at (828) 456-2546 ext. 24 if you have any questions about or need to discuss these comments.

cc: Goudreau, C. - NC Wildlife Resources Commission, Fisheries Management
Wheeler, P. – NC Wildlife Resources Commission, Fisheries Management

Citations:

Baldwin, N.S. 1956. Food consumption and growth of brook trout at different temperatures. Transactions of the American Fisheries Society 86:323-328.

Cormick. J.H., K.E.F. Hokansen, B.R. Jones. 1972. Effects of temperature on growth and survival of young trout. Journal of Fisheries Research Board of Canada 29(8):1107-1120.

EBTJV (Eastern Brook Trout Joint Venture). 2006. Eastern brook trout: status and threats. Prepared by Trout Unlimited, Arlington, Virginia, for the Eastern Brook Trout Joint Venture. 36 p.

Harshbarger, T.J. 1975. Factors affecting regional trout stream productivity. Pages 11-27 *In:* Southeastern Trout Resource: Ecology and Management Symposium Proceedings. October 24-25, 1975, Blacksburg, Virginia.

Meisner, J.D. 1990. Effect of climatic warming on the southern margin of the native range of brook trout *Salvelinus fontinalis.* Canadian Journal of Fisheries and Aquatic Sciences. 47:1065-1070.

NCWRC (North Carolina Wildlife Resources Commission). 1989. Casting the future of trout in North Carolina: A plan for management of North Carolina's trout resources. Division of Boating and Inland Fisheries, North Carolina Wildlife Resources Commission.

NCWRC (North Carolina Wildlife Resources Commission). 2005. North Carolina wildlife action plan. Raleigh. NC.

Ratledge, H.M. and D.E. Louder. 1967. Cold-water stream studies: Federal Aid in Fish Restoration F-13-R. 48 p. N.C. Wildlife Resources Commission, Division of Inland Fisheries, Raleigh.

NCDENR

North Carolina Department of Environment and Natural Resources
Division of Water Quality
Coleen H. Sullins
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

October 27, 2010

MEMORANDUM

TO: Melba McGee
Department of Environment and Natural Resources

THRU: Jeff Manning, Supervisor
Basinwide Planning Unit

FROM: Hannah Stallings, SEPA Coordinator

SUBJECT: Cherokee, Graham, Swain, Clay, and Union Counties
TVA's Draft EIS – Integrated Resource Plan and Programmatic EIS
DWQ#14324; DENR#11-0086

The Division of Water Quality (DWQ) has reviewed the subject document. The TVA projects in North Carolina are hydro- related (not coal burning facilities). TVA has gone through the FERC relicensing process recently and DWQ gave comments through that process. TVA should take care to reduce emissions from its coal combustion facilities in neighboring states to reduce the potential for atmospheric deposition of pollutants into North Carolina's surface waters. Installation of any electrical transmission projects in North Carolina should use sediment and erosion control best management practices to protect water quality.

Please contact me at 807-6434 if I can be of any further assistance.
Thank you.

Cc: Roger Edwards – ARO

1617 Mail Service Center, Raleigh, North Carolina 27699-1617
Location: 512 N. Salisbury St. Raleigh, North Carolina 27604
Phone: 919-807-6300 \ FAX: 919-807-6492 \ Customer Service: 1-877-623-6748
Internet: www.ncwaterquality.org

One NorthCarolina *Naturally*

Department of Environment and Natural Resources

Reviewing Office: ARO

INTERGOVERNMENTAL REVIEW - PROJECT COMMENTS

Project Number: 11-0086 Due Date: 11/3/2010

After review of this project it has been determined that the ENR permit(s) and/or approvals indicated may need to be obtained in order for this project to comply with North Carolina Law. Questions regarding these permits should be addressed to the Regional Office indicated on the reverse of the form. All applications, information and guidelines relative to these plans and permits are available from the same Regional Office.

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
☐	Permit to construct & operate wastewater treatment facilities, sewer system extensions & sewer systems not discharging into state surface waters.	Application 90 days before begin construction or award of construction contracts. On-site inspection. Post-application technical conference usual.	30 days (90 days)
☐	NPDES - permit to discharge into surface water and/or permit to operate and construct wastewater facilities discharging into state surface waters.	Application 180 days before begin activity. On-site inspection. Pre-application conference usual. Additionally, obtain permit to construct wastewater treatment facility-granted after NPDES. Reply time, 30 days after receipt of plans or issue of NPDES permit-whichever is later.	90-120 days (N/A)
☐	Water Use Permit	Pre-application technical conference usually necessary	30 days (N/A)
☐	Well Construction Permit	Complete application must be received and permit issued prior to the installation of a well.	7 days (15 days)
☐	Dredge and Fill Permit	Application copy must be served on each adjacent riparian property owner. On-site inspection. Pre-application conference usual. Filling may require Easement to Fill from N.C. Department of Administration and Federal Dredge and Fill Permit.	55 days (90 days)
☐	Permit to construct & operate Air Pollution Abatement facilities and/or Emission Sources as per 15 A NCAC (2Q.0100 thru 2Q.0300)	Application must be submitted and permit received prior to construction and operation of the source. If a permit is required in an area without local zoning, then there are additional requirements and timelines (2Q.0113).	90 days
☐	Permit to construct & operate Transportation Facility as per 15 A NCAC (2D.0800, 2Q.0601)	Application must be submitted at least 90 days prior to construction or modification of the source.	90 days
☐	Any open burning associated with subject proposal must be in compliance with 15 A NCAC 2D.1900	N/A	60 days (90 days)
☐	Demolition or renovations of structures containing asbestos material must be in compliance with 15 A NCAC 20.1110 (a) (1) which requires notification and removal prior to demolition. Contact Asbestos Control Group 919-707-5950.		
☐	Complex Source Permit required under 15 A NCAC 2D.0800		
☒	The Sedimentation Pollution Control Act of 1973 must be properly addressed for any land disturbing activity. An erosion & sedimentation control plan will be required if one or more acres to be disturbed. Plan filed with proper Regional Office (Land Quality Section) At least 30 days before beginning activity. A fee of $65 for the first acre or any part of an acre. An express review option is available with additional fees. (as needed per project		20 days (30 days)
☐	Sedimentation and erosion control must be addressed in accordance with NCDOT's approved program. Particular attention should be given to design and installation of appropriate perimeter sediment trapping devices as well as stable stormwater conveyances and outlets.		(30 days)
☐	Mining Permit	On-site inspection usual. Surety bond filed with ENR Bond amount varies with type mine and number of acres of affected land. Any arc mined greater than one acre must be permitted. The appropriate bond must be received before the permit can be issued.	30 days (60 days)
☐	North Carolina Burning permit	On-site inspection by N.C. Division Forest Resources if permit exceeds 4 days	1 day (N/A)
☐	Special Ground Clearance Burning Permit - 22 counties in coastal N.C. with organic soils	On-site inspection by N.C. Division Forest Resources required "if more than five acres of ground clearing activities are involved. Inspections should be requested at least ten days before actual burn is planned."	1 day (N/A)
☐	Oil Refining Facilities	N/A	90-120 days (N/A)
☐	Dam Safety Permit	If permit required, application 60 days before begin construction. Applicant must hire N.C. qualified engineer to: prepare plans, inspect construction, certify construction is according to ENR approved plans. May also require permit under mosquito control program. And a 404 permit from Corps of Engineers. An inspection of site is necessary to verify Hazard Classification. A minimum fee of $200.00 must accompany the application. An additional processing fee based on a percentage or the total project cost will be required upon completion.	30 days (60 days)

	PERMITS	SPECIAL APPLICATION PROCEDURES or REQUIREMENTS	Normal Process Time (statutory time limit)
☐	Permit to drill exploratory oil or gas well	File surety bond of $5,000 with ENR running to State of NC conditional that any well opened by drill operator shall, upon abandonment, be plugged according to ENR rules and regulations.	10 days N/A
☐	Geophysical Exploration Permit	Application filed with ENR at least 10 days prior to issue of permit. Application by letter. No standard application form.	10 days N/A
☐	State Lakes Construction Permit	Application fees based on structure size is charged. Must include descriptions & drawings of structure & proof of ownership of riparian property.	15-20 days N/A
☐	401 Water Quality Certification	N/A	60 days (130 days)
☐	CAMA Permit for MAJOR development	$250.00 fee must accompany application	55 days (150 days)
☐	CAMA Permit for MINOR development	$50.00 fee must accompany application	22 days (25 days)
☐	Several geodetic monuments are located in or near the project area. If any monument needs to be moved or destroyed, please notify: N.C. Geodetic Survey, Box 27687 Raleigh, NC 27611		
☐	Abandonment of any wells, if required must be in accordance with Title 15A. Subchapter 2C.0100.		
☐	Notification of the proper regional office is requested if "orphan" underground storage tanks (USTS) are discovered during any excavation operation.		
☐	Compliance with 15A NCAC 2H 1000 (Coastal Stormwater Rules) is required.		45 days (N/A)
☐	Tar Pamlico or Neuse Riparian Buffer Rules required.		
*	Other comments (attach additional pages as necessary, being certain to cite comment authority)		

REGIONAL OFFICES

Questions regarding these permits should be addressed to the Regional Office marked below.

☒ **Asheville Regional Office**
2090 US Highway 70
Swannanoa, NC 28778
(828) 296-4500

☐ **Mooresville Regional Office**
610 East Center Avenue, Suite 301
Mooresville, NC 28115
(704) 663-1699

☐ **Wilmington Regional Office**
127 Cardinal Drive Extension
Wilmington, NC 28405
(910) 796-7215

☐ **Fayetteville Regional Office**
225 North Green Street, Suite 714
Fayetteville, NC 28301-5043
(910) 433-3300

☐ **Raleigh Regional Office**
3800 Barrett Drive, Suite 101
Raleigh, NC 27609
(919) 791-4200

☐ **Winston-Salem Regional Office**
585 Waughtown Street
Winston-Salem, NC 27107
(336) 771-5000

☐ **Washington Regional Office**
943 Washington Square Mall
Washington, NC 27889
(252) 946-6481

Tennessee

EAST TENNESSEE DEVELOPMENT DISTRICT

Rec'd 9/27/10

September 22, 2010

Mr. Charles P. Nicholson
NEPA Compliance Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, TN 37902

Dear Mr. Nicholson:

SUBJECT: Result of Regional Review
Tennessee Valley Authority - Draft Environmental Impact Statement (EIS) for the Integrated Resource Plan

The East Tennessee Development District has completed its review of the above mentioned proposal, in its role as a regional clearinghouse to review state and federally-assisted projects.

ETDD review of this proposal has found no conflicts with the plans or programs of the District or other agencies in the region. However, ETDD or other reviewing agencies may wish to comment further at a later time.

We appreciate the opportunity to work with you in coordinating projects in the region.

Sincerely,

Terrence J. Bobrowski
Executive Director

TJB/tc

P.O. Box 249 Alcoa, TN. 37701-0249
Phone: (865)273-6003 Toll Free: (866)683-6003 Fax: (865)273-6010
Web Page: http://www.discoveret.org/etdd

GNRC
GREATER NASHVILLE
REGIONAL COUNCIL

September 30, 2010

Rec'd 10/4/10

Charles P. Nicholson, NEPA Compliance Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, Tennessee 37902

Re: Environmental Impact Statement For The Integrated Resource Plan For TVA
GNRC #2011-10

Dear Mr. Nicholson :

In accordance with the Project Review Process (approved by the Executive Committee at the April 1995 Executive Board Meeting), the Greater Nashville Regional Council has reviewed the above referenced project.

Our evaluation reveals no conflict with existing or proposed planning activities. We are notifying you that your proposal is deemed acceptable on the basis of information now available to this office, and received final approval by the Executive Committee at our GNRC Annual Meeting on September 28, 2010.

We may wish to comment further at a later time. This letter should be attached to your application. If we can be of further assistance, please do not hesitate to contact us.

Sincerely,

Sam H. Edwards

Sam H. Edwards
Executive Director

SHE/pyc

501 UNION ST. ¶ SIXTH FLOOR ¶ NASHVILLE, TN 37219-1705 ¶ 615 862-8828 ¶ FAX 615 862-8840
E-MAIL gnrc@gnrc.org ¶ WEB www.gnrc.org ¶ SAM H. EDWARDS, EXECUTIVE DIRECTOR

Rec'd 10/15/10

SOUTHWEST TENNESSEE
SWTDD
DEVELOPMENT DISTRICT

27 Conrad Drive
Suite 150
Jackson, TN 38305-2850
731-668-7112
731-668-6421
swtdd@swtdd.org

October 8, 2010

Mr. Charles P. Nicholson
NEPA Compliance Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, Tennessee 37902

Subject: DRAFT ENVIRONMENTAL IMPACT STATEMENT (EIS) FOR THE INTEGRATED RESOURCE PLAN

Dear Mr. Nicholson:

The Southwest Tennessee Development District is responding to your request for our agency's assessment of the document referenced above.

We have reviewed the information you sent and find no conflicts with the draft document and any needs, plans, or priorities of our agency.

If you require additional review, please contact Jeff Reece, Environmental Programs Coordinator for SWTDD, at 731-668-6408 or jreece@swtdd.org.

Sincerely,

Joe W. Barker
Executive Director
Southwest Tennessee Development District

JWB/jr

Name: Bob Alexander
Tennessee Department of Environment and Conservation, Div. of Water Pollution Control

Comments: Comment on Chapter 4, Affected Environment:

A number of water bodies are listed as "None" under the heading Fish Consumption Advisories in Table 4-9, page 96. For these waters, TDEC has posted Fish Consumption Advisories, per http://tn.gov/environment/wpc/publications/pdf/fishmercurylevels.pdf, and shown below:

Clinch River portion of Norris Reservoir
Hiwassee River embayment of Chickamauga Reservoir
South Holston Lake
Watauga Lake
Cherokee Lake
Douglas Lake

Virginia

Rec'd 11/4/10

COMMONWEALTH of VIRGINIA

DEPARTMENT OF ENVIRONMENTAL QUALITY
Street address: 629 East Main Street, Richmond, Virginia 23219
Mailing address: P.O. Box 1105, Richmond, Virginia 23218
TDD (804) 698-4021
www.deq.virginia.gov

Douglas W. Domenech
Secretary of Natural Resources

David K. Paylor
Director

(804) 698-4000
1-800-592-5482

November 1, 2010

Mr. Charles P. Nicholson
NEPA Compliance Manager
Tennessee Valley Authority
400 West Summit Hill Drive, WT 11D
Knoxville, Tennessee 37902

RE: Draft Programmatic Environmental Impact Statement: Tennessee Valley Authority, Integrated Resource Plan (DEQ 10-137F)

Dear Mr. Nicholson:

The Commonwealth of Virginia has completed its review of the above-referenced draft programmatic environmental impact assessment (PEIS). The Department of Environmental Quality (DEQ) is responsible for coordinating Virginia's review of environmental documents prepared pursuant to the National Environmental Policy Act and responding to appropriate officials on behalf of the Commonwealth. The following agencies, locality and planning district commission joined in this review:

Department of Environmental Quality
Department of Game and Inland Fisheries
Department of Agriculture and Consumer Services
Department of Conservation and Recreation
Department of Historic Resources
Department of Mines, Minerals and Energy
Mount Rogers Planning District Commission
Lee County

The State Corporation Commission, Lenowisco Planning District Commission, Cumberland Plateau Planning District Commission, Scott County, Wise County, Russell County, Grayson County, Smyth County, Washington County, City of Bristol and the Town of Abingdon also were invited to comment.

PROPOSED ACTION

The Tennessee Valley Authority (TVA) has submitted a draft PEIS for review as part of its Integrated Resource Plan. According to TVA, the purpose of the plan is to help TVA achieve environmental sustainability and meet electricity needs during the next 20 years. According to the TVA, planning process steps include developing planning strategies encompassing various approaches TVA can take on issues and future conditions (scenarios) used in evaluating the strategies. Capacity expansion plans (portfolios) are then developed for each combination of strategies and scenarios. The PEIS evaluates three final alternative strategies: 1) the Baseline Plan (No Action alternative); 2) the Diversity Focused Plan and 3) Energy Efficiency-Demand Response and Renewables Focused Plan. Under all of these strategies, coal-fired generation decreases and reliance on renewable resources increases. The strategies add varying amounts of new nuclear and natural gas-fueled generation. Air emissions decrease under all strategies. All alternatives would require the construction of new or upgraded transmission facilities. Renewable generation options are expected to be through power purchase agreements with non-TVA generators. At this time, TVA does not have a preferred alternative strategy.

The primary study area is the combined TVA power service area and the Tennessee River watershed, which consists of 59 million acres. In Virginia, TVA serves Lee and Scott counties and portions of Washington and Wise counties, covering approximately 1,941 square miles. TVA owns a 9 kilowatt solar energy facility in Scott County and a substation and nearly 11 miles of transmission line in Virginia. In addition, the upper half of the South Holston Reservoir extends into Virginia, and TVA manages about 250 acres around the reservoir. According to the PEIS, the locations of most of the future energy-generating facilities are not known. As a result, the PEIS describes general impacts mostly at a regional level.

COMMONWEALTH OF VIRGINIA COMMENTS

1. Water Quality and Wetlands. According the PEIS (page S-15), the potential for water quality impacts would decrease under all alternative scenarios. However, all of the scenarios would increase the volume of water use and consumption (evaporated) for cooling generating plants.

1(a) Agency Jurisdiction. The State Water Control Board promulgates Virginia's water regulations, covering a variety of permits to include Virginia Pollutant Discharge Elimination System Permit, Virginia Pollution Abatement Permit, Surface and Groundwater Withdrawal Permit, and the Virginia Water Protection (VWP) Permit. The VWP Permit is a state permit which governs wetlands, surface water and surface water withdrawals/impoundments. It also serves as § 401 certification of the federal Clean Water Act § 404 permits for dredge and fill activities in waters of the United States. The VWP Permit Program is under the Office of Wetlands and Water Protection/Compliance within the DEQ Division of Water Quality Programs. In addition to central office staff who review and issue VWP permits for transportation and water withdrawal projects, the six DEQ regional offices perform permit application reviews and issue permits for the covered activities.

1(b) Agency Comments Pertaining to Future Projects.

Wetland Delineation

The DEQ Office of Wetlands and Water Protection (OWWP) states that a wetland delineation should be conducted to determine the location, extent and type of surface waters present at future project sites. The delineation should be conducted using the 1987 U.S. Corps of Engineers (Corps) Wetlands Delineation Manual, which defines wetlands for the Clean Water Act Section 404 permit program. The improvements should be designed to avoid and minimize impacts to surface waters to the greatest extent practicable.

Application and Permitting Process

If impacts to state waters are proposed, a Joint Permit Application (JPA) should be submitted to the Virginia Marine Resources Commission (VMRC). The DEQ Southwest Regional Office (SWRO) will make the final permit decision regarding potential impacts to state waters.

If unavoidable impacts to wetlands or surface waters are proposed, a Virginia Water Protection (VWP) permit may be required for the proposed project. DEQ provides 401 certification to the Corps' nationwide and general permits. Compensation for unavoidable impacts may also be required.

If the project qualifies for a Nationwide Permit 12 (NWP 12) from the Corps and if the impacts to streams are less than 1500 linear feet, then a VWP permit is not necessary. If (a) stream impacts exceed the thresholds outline above, or (b) the project proposes to permanently impact more than one half (1/2) acre of wetlands, or (c) the project does not qualify for a NWP 12 from the Corps, then a VWP permit may be required from DEQ.

Unavoidable permanent impacts to all wetlands or to streams in excess of three hundred linear feet will require mitigation through the creation, enhancement or preservation of wetlands or streams within the project's watershed, or through the purchase of mitigation bank credits.

DEQ implements its own state laws and regulations regarding activities in surface waters, regardless of the federal laws and regulations that may apply, such as those of the Federal Energy Regulatory Commission (FERC).

For purposes of a VWP permit for surface water withdrawals, the timing of application submittal is important when a FERC license is also being sought. To avoid delays in the VWP permit process, applicants should have clearly a defined project purpose and need, alternatives analysis, and infrastructure details at the time of applications such that DEQ staff can determine what if any impacts will occur to beneficial uses.

Applicants seeking a VWP permit for surface water supply involving a reservoir should consider the feasibility of flow release augmentation as a component of the project. Applicants for VWP permits for surface water withdrawals can expect the permit to contain limits on the volume or rate of surface water to be withdrawn and a requirement to pass certain flows downstream to protect beneficial uses.

DEQ coordinates all applications for VWP permits with other state resource agencies and must fully consider comments and recommendations made by those agencies. Applicants should be prepared to address comments made by these agencies, and if a federal license applies, the comments and recommendations made by any federal resource agencies as well. Studies and surveys may be required that are season-dependent. Mitigation of species impacts may be required.

Future projects may have the potential to intercept shallow, localized aquifers during trenching activities, requiring temporary dewatering of the work area. Discharge of any trench water associated with groundwater infiltration should be performed in accordance with National Pollutant Discharge Elimination System (NPDES) permit conditions. The registration statement for 9VAC25-120 (VAG 83) - Petroleum Contaminated Sites, Ground Water Remediation and Hydrostatic Tests is available on the DEQ website at *www.deq.virginia.gov/export/sites/default/vpdes/pdf/VAG83RegistrationStatement2008.pdf.*

Protection and Mitigation Methods

- Once a final strategy has been developed, any activities requiring instream work should be performed in the dry, utilizing cofferdams, stream diversions and/or working during low flow conditions.
- Heavy equipment should work from uplands to the greatest extent possible and utilize mats and strict erosion and sediment controls for work that must be conducted from within surface waters.
- Caution should be taken to ensure prevention of the release of any oil or fuel from heavy equipment into surface waters.
- All disturbed stream beds should be restored to their original contours prior to redirecting the stream into the work area.
- For larger stream crossings, TVA should address the feasibility of using directional drilling to bore beneath the channels and completely avoid impacts to the stream beds.
- Restore temporary impact areas to their original contours and revegetate with the same or similar species.
- DEQ encourages consideration of off-stream water storage to supplement natural sources in times of low flow, declining aquifer levels, and low precipitation.

1(c) Agency Recommendations. DEQ has the following recommendations:

- Conduct pre-application coordination with all applicable state agencies, including DEQ (Allen Newman at 276-676-4804) and VMRC (Justin Worrell at 757-247-8063), that may have jurisdiction over the proposed project.
- Conduct wetland delineations at future project sites.
- Contact DEQ SWRO (including Allen Newman, Water Permit Manager, at 276-676-4804) for permit coverage and requirements regarding hydrostatic test discharge water.
- Ensure that environmental documents for site-specific projects include adequate descriptions of wetlands and surface waters within the project area and proposed project site, potential impacts, protection and mitigation methods, coordination with appropriate agencies, and permitting and regulatory requirements, including local requirements, and any other applicable information.

2. Subaqueous Lands.

2(a) Agency Jurisdiction. The Virginia Marine Resources Commission (VMRC) regulates encroachments in, on or over state-owned subaqueous beds as well as tidal wetlands pursuant to § 28.2-1200 through 1400 of the *Code of Virginia.*

The VMRC serves as the clearinghouse for the Joint Permit Application (JPA) used by the:

- Corps for issuing permits pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act;
- DEQ for issuance of a VWP permit;
- VMRC for encroachments on or over state-owned subaqueous beds as well as tidal wetlands; and
- local wetlands board for impacts to wetlands.

The VMRC will distribute the completed JPA to the appropriate agencies. Each agency will conduct its review and respond.

2(b) Agency Recommendation. Contact VMRC (Justin Worrell at 757-247-8063) for information on submitting a JPA for future construction projects in Virginia.

3. Erosion and Sediment Control, and Stormwater Management.

3(a) Agency Jurisdiction. The Department of Conservation and Recreation (DCR) Division of Soil and Water Conservation (DSWC) administers the Virginia Erosion and Sediment Control Law and Regulations (VESCL&R) and Virginia Stormwater Management Law and Regulations (VSWML&R).

3(b) Recommendations.

- Ensure that future site-specific projects are in accordance with the following laws and regulations, as applicable:

  - Virginia Erosion and Sediment Control Law §10.1-563.D;
  - Virginia Erosion and Sediment Control Regulations §4VAC50-30-30 and §4VAC50-30-40;
  - Virginia Stormwater Act §10.1-603.1 *et seq.*;
  - Virginia Stormwater Management Program Permit Regulations §4VAC50 *et seq.*

- Site-specific environmental documents should adequately describe site conditions, potential impacts, protection and mitigation methods, permitting and regulatory requirements, including local requirements, and any other applicable information.

Questions regarding annual erosion and sediment control specifications should be directed to DCR (Larry Gavan at 804-786-4508). Specific questions regarding the VSMP General Permit for Construction Activities requirements should be directed to DCR DSWC (Holly Sepety at 804-225-2613).

4. Air Quality Impacts. The PEIS (page S-15) states that all three alternative strategies will result in significant long-term reductions in total emissions of sulfur dioxide, nitrogen oxides (NOx) and mercury.

4(a) Agency Jurisdiction. DEQ's Division of Air Quality is responsible for carrying out the mandates of the Virginia Air Pollution Control Law, as well as meeting Virginia's federal obligations under the Clean Air Act. The objective is to protect and enhance public health and the environment by controlling present and future sources of air pollution. The division ensures the safety and quality of the air in Virginia by monitoring and analyzing air quality data, regulating sources of air pollution, and working with local, state and federal agencies to plan and implement strategies to protect Virginia's air quality.

4(b) National Ambient Air Quality Standards. The primary goals of the Federal Clean Air Act are the attainment and maintenance of the National Ambient Air Quality Standards (NAAQS) and the prevention of significant deterioration of air quality in areas cleaner than the NAAQS. The NAAQS establish the maximum limits of pollutants that are allowed in the outside ambient air. The Environmental Protection Agency (EPA) requires the submission of a State Implementation Plan (SIP) that includes laws and regulations necessary to enforce the plan and shows how the air pollution concentrations will be reduced to levels at or below these standards (attainment). Once pollution levels are within the standards, the SIP must also demonstrate how the state will maintain the air pollution concentrations at the reduced levels (maintenance).

The standards have been attained for most pollutants in most areas. However, attainment for the pollutant, ozone, has proven problematic. While ozone is needed at the earth's outer atmospheric layer to protect us from the sun's ultraviolet and other harmful rays, excess concentrations at the surface have an adverse effect on animal and plant life. Ozone is formed by a chemical reaction between volatile organic compounds (VOCs) and NO_X in the presence sunlight. When VOC and NO_X emissions are reduced, ozone is reduced.

4(c) Ozone Attainment Area. According to the DEQ Air Division, the TVA coverage area in Virginia is located in an ozone attainment area.

4(d) Agency Recommendations. Site-specific environmental documents should address the applicable regulatory requirements for air emissions due to the construction and operation of any proposed facility or transmission line, including 9VAC5-50-60 *et seq.* governing fugitive dust emissions; 9VAC5-130 *et seq.* for open burning; and 9VAC5-40-5490 *et seq.* for asphalt paving operations. Permits may be required for any boilers or fuel-burning equipment for any proposed facility.

4(e) Agency Comment. The DEQ Division of Air Program Coordination states that site-specific projects in Virginia are subject to additional review.

5. Solid and Hazardous Wastes and Hazardous Materials. The PEIS (page S-16) states that the largest amounts of solid waste produced by the alternative strategies are coal ash and scrubber waste.

5(a) Agency Jurisdiction. Solid and hazardous wastes in Virginia are regulated by DEQ, the Virginia Waste Management Board and EPA. They administer programs created by the federal Resource Conservation and Recovery Act, Comprehensive Environmental Response Compensation and Liability Act, commonly called Superfund, and the Virginia Waste Management Act. DEQ administers regulations established by the Virginia Waste Management Board and reviews permit applications for completeness and conformance with facility standards and financial assurance requirements. All Virginia localities are required, under the Solid Waste Management Planning Regulations, to identify the strategies they will follow on the management of their solid wastes to include items such as facility siting, long-term (20-year) use, and alternative programs such as materials recycling and composting.

5(b) Agency Comments. The DEQ Waste Division states that the scope of this multi-state project is extensive. For each area in Virginia where any work is to take place, the applicant needs to conduct an environmental investigation on and near the property to identify any solid or hazardous waste sites or issues before work can commence. This investigation should include a search of waste-related databases (table attached).

5(c) Agency Recommendations.

- For future projects, conduct an environmental investigation on and near the property for each area in Virginia where any work is to take place to identify any solid or hazardous waste sites or issues before work can commence, and include a search of waste-related databases.

- DEQ encourages all projects and facilities to implement pollution prevention principles, including:

  - the reduction, reuse and recycling of all solid wastes generated; and
  - the minimization and proper handling of generated hazardous wastes.

- Site-specific environmental documents should describe how solid waste, hazardous waste and hazardous materials will be managed in accordance with all applicable federal, state and local environmental laws and regulations, including the following state and federal laws and regulations:

  - Virginia Waste Management Act (Code of Virginia Section 10.1-1400 *et seq.*);
  - Virginia Hazardous Waste Management Regulations (VHWMR) (9VAC20-60);
  - Virginia Solid Waste Management Regulations (VSWMR) (9VAC20-80);
  - Virginia Vegetative Waste Management Regulations (9VAC20-101 *et seq.*);
  - Virginia Regulations for the Transportation of Hazardous Materials (9VAC20-110);
  - Resource Conservation and Recovery Act (RCRA) (42 U.S.C. Section 6901 *et seq.*, and the applicable regulations contained in Title 40 of the Code of Federal Regulations); and
  - U.S. Department of Transportation Rules for Transportation of Hazardous materials (49 Code of Federal Regulations Part 107).

Contact the DEQ Waste Division (Paul Kohler at 804-698-4208) for additional information.

6. Natural Heritage Resources.

6(a) Agency Jurisdiction. The mission of DCR is to conserve Virginia's natural and recreational resources. The DCR Division of Natural Heritage's (DNH) mission is conserving Virginia's biodiversity through inventory, protection and stewardship. The Virginia Natural Area Preserves Act, 10.1-209 through 217 of the Code of Virginia, was passed in 1989 and codified DCR's powers and duties related to statewide biological inventory: maintaining a statewide database for conservation planning and project review, land protection for the conservation of biodiversity, and the protection and ecological management of natural heritage resources (the habitats of rare, threatened and endangered species, significant natural communities, geologic sites, and other natural features).

6(b) Agency Comment. DCR states that it supports green energy initiatives (renewable resources) with proper siting criteria.

6(c) Agency Findings. According to the information currently in DCR's files:

- There are many natural heritage resources and conservation sites (table attached) within the project area.
- Future projects may either overlie or be adjacent to a karst landscape characterized by sinkholes, caves, disappearing streams and large springs. Discharge of runoff to sinkholes or sinking streams, filling of sinkholes and alteration of cave entrances can lead to surface collapse, flooding, erosion and sedimentation, groundwater contamination and degradation of subterranean habitat for natural heritage resources.

6(d) State Natural Area Preserves. DCR's files do not indicate the presence of any State Natural Area Preserves under the agency's jurisdiction in the TVA service area.

6(e) Threatened and Endangered Plant and Insect Species. Under a Memorandum of Agreement established between the Virginia Department of Agriculture and Consumer Services (VDACS) and DCR, DCR has the authority to report for VDACS on state-listed plant and insect species.

- Listed plant and insect species are included in the attached table of natural heritage resources in the TVA area.
- VDACS states that several federally- and state-listed endangered and threatened plant and insect species are known to occur within the TVA Power Service boundary in Virginia. Suitable habitat to support other listed species also occurs within the TVA boundary.

6(f) Agency Recommendations. DCR and VDACS have the following recommendations:

- Coordinate with DCR DNH to access potential impacts to natural heritage resources as individual projects are identified.
- Since new and updated information is continually added to the Biotics Data System, contact DCR DNH at (804) 786-7951 for site-specific information.
- Continue to evaluate impacts to natural resources regarding development and maintenance planning and implementation.

7. Wildlife Resources.

7(a) Agency Jurisdiction. DGIF, as the Commonwealth's wildlife and freshwater fish management agency, exercises enforcement and regulatory jurisdiction over wildlife and freshwater fish, including state or federally listed endangered or threatened species, but excluding listed insects (Virginia Code Title 29.1). DGIF is a consulting agency under the U.S. Fish and Wildlife Coordination Act (16 U.S.C. sections 661 *et seq.*) and provides environmental analysis of projects or permit applications coordinated through DEQ and several other state and federal agencies. DGIF determines likely impacts upon fish and wildlife resources and habitat, and recommends appropriate measures to avoid, reduce or compensate for those impacts.

7(b) Agency Comments.

- Overall, DGIF states that it supports energy plans that hope to reduce reliance on sources of energy resulting in high emissions of air pollutants and other adverse impacts upon the environment. DGIF also supports consideration of renewable energy sources and those that result in a reduction of such impacts.
- The Tennessee Valley in Virginia is known to support a globally significant diversity of species which deserves protection and which should be considered during the development of any energy projects in the region.
- DGIF is willing to assist TVA in the review of energy projects to evaluate impacts upon wildlife, planning for such projects, and integrating the protection of Virginia's natural resources into energy projects.

7(c) Agency Recommendations.

- Closely coordinate and integrate the development of the Integrated Resources Plan with TVA's Natural Resources Plan to ensure that TVA's energy projects meet its goals.
- Ensure that planning for the protection of the natural resources in the Tennessee Valley is part of the energy development planning process.
- Closely coordinate with DGIF to ensure that any new energy projects or significant changes or upgrades to existing energy projects located in Virginia, or which may affect natural resources in Virginia, are protective of the unique wildlife known from the Tennessee Valley.

Contact DGIF (Amy Ewing at 804-367-2211) for assistance and additional information.

8. Historic Architectural Resources.

8(a) Agency Jurisdiction. The Department of Historic Resources (DHR) conducts reviews of projects to determine their effect on historic structures or cultural resources under its jurisdiction. DHR, as the designated State's Historic Preservation Office, ensures that federal actions comply with Section 106 of the National Historic Preservation Act of 1966, as amended, and its implementing regulation at 36 CFR Part 800. The preservation act requires federal agencies to consider the effects of federal projects on properties that are listed or eligible for listing on the National Register of Historic Places. Section 106 also applies if there are any federal involvements, such as licenses, permits, approvals or funding. DHR also provides comments to DEQ through the state environmental impact report review process.

8(b) Agency Comment. DHR states that it will respond directly to the TVA.

9. Geologic and Mineral Resources.

9(a) Agency Jurisdiction. The Virginia Department of Mines, Minerals and Energy (DMME), through its six divisions, regulates the mineral industry, provides mineral research and offers advice on wise use of resources. The Department's mission is to enhance the development and conservation of energy and mineral resources in a safe and environmentally sound manner in order to support a more productive economy.

9(b) Agency Comment. DMME states that it will not comment on this project.

Additional information about the geology and mineral resources of Virginia is available on the DMME website at *www.dmme.virginia.gov/divisionmineralresources.shtml.*

10. Pollution Prevention. DEQ advocates that principles of pollution prevention be used in the planning of construction projects. Effective planning will help to ensure that environmental impacts are minimized. However, pollution prevention techniques also include decisions related to construction materials, design and operational procedures that will facilitate the reduction of wastes at the source. The DEQ Office of Pollution Prevention provides information and technical assistance relating to pollution prevention techniques. If interested, please contact Sharon Baxter at (804) 698-4344.

11. Local and Regional Comments.

11(a) Jurisdiction. In accordance with the Code of Virginia, Section 15.2-4207, planning district commissions encourage and facilitate local government cooperation and state-local cooperation in addressing, on a regional basis, problems of greater than local significance. The cooperation resulting from this is intended to facilitate the recognition and analysis of regional opportunities and take account of regional influences in planning and implementing public policies and services. Planning district commissions promote the orderly and efficient development of the physical, social and economic elements of the districts by planning, and encouraging and assisting localities to plan for the future.

11(b) Comments. The Mount Roger Planning District Commission states that it is in agreement with TVA's conclusions. However, TVA should include more green technology in its plans. A large power company like the TVA needs to create more opportunities to use green power sources, including solar and the recycling of waste material into energy. Lee County has no comment.

The Lenowisco Planning District Commission, Cumberland Plateau Planning District Commission, Scott County, Wise County, Russell County, Grayson County, Smyth

County, Washington County, City of Bristol and Town of Abingdon did not respond to DEQ's request for comments.

REGULATORY AND COORDINATION NEEDS FOR FUTURE PROJECTS

1. Surface Waters and Wetlands. Conduct pre-application coordination with all applicable state agencies, including DEQ (Allen Newman at 276-676-4804) and VMRC (Justin Worrell at 757-247-8063), that may have jurisdiction over the proposed project. Contact DEQ SWRO (Allen Newman, Water Permit Manager, at 276-676-4804) for permit coverage and requirements regarding hydrostatic test discharge water.

2. Subaqueous Lands. Contact VMRC (Justin Worrell at 757-247-8063) for information on submitting a JPA regarding site-specific projects.

3. Natural Heritage Resources.

- Contact the DCR DNH at (804) 786-7951 for an update on natural heritage information for site-specific projects.
- Coordinate with DCR DNH at (804) 786-7951 to access potential impacts to natural heritage resources as individual projects are identified.

4. Protected Species. Closely coordinate with DGIF (Amy Ewing at 804-367-2211) to ensure that any new energy projects or significant changes or upgrades to existing energy projects located in Virginia, or which may affect natural resources in Virginia, are protective of the unique wildlife known from the Tennessee Valley.

5. Site-Specific Reviews.

- DEQ encourages TVA to submit site-specific environmental documents as required under the National Environmental Policy Act (NEPA) and the State Corporation Commission's laws and regulations. Other state approvals which may apply to future site-specific projects may not be included in this review. TVA must ensure that future projects in Virginia are constructed and operated in accordance with all applicable federal, state and local laws and regulations.
- Site-specific environmental documents should be submitted to the DEQ Office of Environmental Impact Review (Attention: Ms. Ellie Irons), P.O. Box 1105, Richmond, VA 23218. Please submit one hard copy for DEQ and each affected locality and associated planning district commission as well as 16 compact discs (CDs) with electronic copies or provide a website or FTP site for distribution during a coordinated review.

CONCLUSION

Thank you for the opportunity to review the PEIS. We look forward to reviewing future, site-specific projects located in Virginia as well as those located outside the Commonwealth with the potential to affect Virginia's environment and natural resources. Detailed comments of reviewing agencies are attached for your review. Please contact me at (804) 698-4325 or Julia Wellman at (804) 698-4326 for clarification of these comments.

Sincerely,

Ellie L. Irons, Manager
Office of Environmental Impact Review

Enclosures

cc: Dave Barrett, Mount Rogers PDC
Glen Skinner, Lenowisco PDC
Jim Baldwin, Cumberland Plateau PDC
Mark K. Reeter, Washington County
Dane Poe, Lee County
Rufus Hood, Scott County
Shannon C. Scott, Wise County
James A. Gillespie, Russell County
Jonathan Sweet, Grayson County
Ediwn Whitmore, Smyth County
James F. Rector, City of Bristol
Greg Kelly, Town of Abingdon

ec: Amy Ewing, DGIF
Robbie Rhur, DCR
Keith Tignor, VDACS
Paul Kohler, DEQ ORP
Kotur S. Narasimhan, DEQ OADA
Allen Newman, DEQ SWRO
Roger Kirchen, DHR
David Spears, DMME
Melanie Allen, VDOT
Wayne Smith, SCC