STEAM PLANT REPLACEMENT FEASIBILITY ANALYSIS SUMMARY

FINAL

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1 PURPOSE

As requested by the Los Alamos National Laboratory (LANL) Utilities and Institutional Facilities (U&I), Strategic Management Solutions, LLC (SMSI) developed a conceptual level thermal and economic model to evaluate the feasibility of replacing the aged steam heating system that serves the Laboratory's core campus area. LANL is contemplating fully utilizing an existing Combustion Gas Turbine (CGTG, installed in 2008), to produce electricity, and to drive a Heat Recovery Steam Generator (HRSG) and Steam Turbine Generator to provide the primary heating source (either steam or heating hot water [HHW]), along with replacing the central boiler plant. Additionally, LANL is evaluating refurbishment and repair of the steam distribution system (piping, manholes, traps, and related), including an alternative to replace the existing steam distribution system with a HHW distribution system. Additional variants include, installing distributed boilers in selected buildings, and modifying all of the buildings on the central system with domestic hot water heating systems to eliminate building heating (from the central system) during the summer.

Because capital funding to undertake this effort is unlikely to be provided as a line item or through other means from the US Department of Energy (DOE) and National Nuclear Security Administration (NNSA), LANL is considering utilizing third party financing through an Energy Performance Saving Contractor (ESPC) approach. DOE has existing contracts with ESPC firms that provide financing for these and other types of energy related efforts. The ESPC firm provides the funding for installation and operation of the new systems and is paid back through a combination of electricity sales, steam/heat sales, a share of the energy savings, and other items as estimated in the analysis.

2 APPROACH

SMSI developed a conceptual level thermal and economic model to evaluate systems technical and financial performance from the perspective of a third party ESPC firm. The overall model is structured in two basic parts:

1. *Thermal model (MS Excel spreadsheet):* Analyzes the system operations on a daily historical average to forecast heat and electricity output as well as energy and commodity consumption (natural gas, electricity, water, and water treatment chemicals). The thermal model evaluated full year and partial year (9 month) operations for all noted alternatives, including the existing operation (as a baseline for comparison). The configuration of the steam and HHW systems is based on the pre-conceptual information in References 1, 2, and 3.
2. *Economic model (series of MS Excel spreadsheets):* Economic models were prepared for each alternative and comprehensively consider annual costs and revenues using Net Present Value (NPV) techniques and such items as interest rates, discount rates, commodity escalation, project life, and other items. Costs consist of those of the ESPC such as: initial capital costs (design, procurement, construction); ongoing operations, maintenance, and repair; and commodities and consumables. Revenues include: electricity sales (from the CGTG set); steam sales to LANL; and cost sharing from reduced maintenance and energy efficiency. Cost sharing savings are based on inputs provided by LANL and data extracted by SMSI. Capital cost estimates are pre-conceptual and parametric. Costs do not include those of LANL (except as noted to extend the high pressure gas line) as those cannot be financed by the ESPC.

The thermal model is linked to the economic model so that changes to the thermal performance can be varied to evaluate economic sensitivity. The various economic model workbooks are also linked so that inputs can be varied to evaluate the impact of changes to such items as capital investment, interest rates, and other items.

3 ALTERNATIVES EVALUATED

SMSI evaluated the economic feasibility for the combined alternatives (which include new central plant and distribution systems) and for a new steam distribution system only (without changes to the central plant). The alternatives are as follows:

Combined Alternatives (Central Plant and Distribution System)

Alternatives with Full Year Operations

- Alternative 1 (Base Case): CGTG Operations 90% of time, Retain Existing Steam Plant (but with new boilers), No Repairs to Steam Distribution System
- Alternative 3: CGTG Ops 90% of the time, HRSG Heat Recovery (including electrical generation), Steam Boilers, No Repairs to Steam Distribution System, No Building Modifications or Distributed Boilers

Alternatives with No Central Heat During Summer and Repair the Distribution System

- Alternative 2 (Modified Base Case): CGTG Ops 90% of time, Retain Existing Steam Plant (but with new boilers), Repair Steam Distribution System, Modify Buildings for No Summer Heat from Central Plant
- Alternative 4: CGTG Operations 90% of the time, HRSG Heat Recovery (including electrical generation), New Steam Boilers, Repair Existing Steam Distribution System, Distributed Boilers in Some Bldgs, Modify Buildings for No Summer Heat from Central Plant, New High Pressure Gas Line Extended to Steam Plant
- Alternative 5: CGTG Operations 90% of the time, HRSG Heat Recovery (including electrical generation), Hot Water Heat Distribution System, Central HW Boilers, Distributed Boilers in Some Buildings, Modify Buildings for No Summer Heat from Central Plant

(Note: The “Base Case” is essentially similar to a “No Action Alternative” with the exception that the CGTG operates to produce electricity 90% of the year to offset the costs associated with producing heat for LANL.)

Distribution Only Alternatives (without CGTG operations)

- Alternative 2(DO): Retain Existing Steam Plant, No Distributed Boilers, Repair Steam Distribution System
- Alternative 4(DO): Repair Existing System, Repair Distribution System, Install Distributed Boilers, Modify Buildings for No Summer Heat

These alternatives were evaluated to identify which were economically feasible. Based on the results of the initial analysis, sensitivity analyses (varying capital cost, interest rates, commodity

costs, unit electrical costs, etc.) were performed to envelope the economics of the most feasible alternative.

4 KEY ASSUMPTIONS

1. The entire project will be financed, designed, and constructed by a 3rd party - potentially one of DOE's Energy Savings Performance Contractors (ESPC).
2. Consistent with Reference 2, the 3rd party will transfer the asset to LANL/NNSA/DOE once it is constructed, to avoid costs associated with insurance and liability, and given the nature of the LANL site (government owned). LANL/DOE/NNSA will enter into a contract with the ESPC firm to guarantee payment of the capital cost and payment for annual services as well as supply of steam heat. The ESPC will also be able to sell the electricity to the grid from the CGTG and STG at full market rates to recover their investment.
3. The CGTG can only be operated to produce electricity 90% of the year, maximum (i.e., 0.90 x 365 x 24 = 7,884 hours). The 90% limitation is due to regulatory constraints.
4. The 3rd party will operate the plant for 30 years and the 3rd party will maintain the plan through a long term agreement.
5. Interest rates, discount rates, escalation, and other economic variables are as shown on the attached spreadsheets.
6. The maintenance, operations, repair, and other costs are based on the variable MSS costs from the References 3 and 4, which are consistent with Reference 2 (2007 NORESCO Report).
7. Based on References 3 and 4, LANL spends approximately $3.2M per year on central plant maintenance (variable in-house craft costs) and $1.1M per year on variable steam distribution system maintenance and repair costs. Further, based on our analysis, we calculate that LANL spends approximately $1.8M per year to produce the steam. Thus, the total approximate annual cost of steam heat (operations, maintenance, and repair) is $6.1M. This represents the maximum savings used in the model that are available to be shared.
8. Economic feasibility is based on a NPV analysis and resulting cash flows.
9. The model utilized the gas and electric commodity prices from the 10/31/2012 LANL analysis as well as inputs provided to SMSI at the October 22, 2012 meeting (Reference 5).
10. For the distribution system (piping, traps, valves, etc.) the model utilized annual repair and replacement allocation as specified by LANL in the statement of work.
11. The Statement of work to SMSI was as modified and reflected in SMSI Activity Work Plan (10/11/2013). Key to this is that SMSI prepared a thermal analysis on a daily, not hourly, basis.
12. Other inputs and assumption as noted in the model spreadsheets.

5 RESULTS AND ANALYSIS

The results are summarized in Tables 1 and 2. The interactive model enables LANL to vary numerous inputs and develop additional "what-if" combinations. This conceptual level tool allows management to quickly evaluate both system and financial information for decision making.

This initial analysis, based on a likely set of parameters, indicates that any of the combined alternatives (central plant and distribution systems) can be economically feasible if LANL is willing to supplement the ESPC revenue with a share of the cost savings (estimated at 85% here) and if the distribution system can be sufficiently evaluated to determine if the repair portion will operate and be as efficient as predicted. Currently, LANL spends about $6.1M per year on steam operations (energy and commodities) and maintenance and repair. Significant energy savings accrue from repairing the steam distribution system.

Alternatives 1 and 2 appear to be the most attractive because the capital costs are low and the complexity of construction is relatively low. Alternative 2 can be shown to be particularly attractive because it repairs the steam distribution system, provides distributed boilers in some facilities, and only provides heat from the central plant 9 months of the year.

The long payback periods (over 20 years) for Alternatives 3, 4, and 5 may not be attractive to some firms, for which liquidity may preclude them from tying up capital for that long.

Varying the savings to near 0 results in longer payback periods for Alternatives 3, 4, and 5 of near or over 30 years, making the alternatives infeasible. (See the "Sensitivity Analysis" tab in the Combined Economic Analysis spreadsheet).

In the distribution system only alternative set, Alternative 4(DO) appears to be the only feasible alternative based on the Benefit-to-Cost ratio, although the long payback period of may make it marginally attractive. The advantage to LANL and DOE/NNSA is that it provides energy and cost savings associated with more efficient distribution, partial year operations, and distributed boilers, as well as the savings share for the ESPC contractor. Alternative 2(DO) is not feasible in that it does not present enough cost savings or efficiencies to offset the capital and operations costs.

Table 1 –Economic Summary for Combined Alternatives

Adjustable Parameters	Interest rate	4.5%	Adjust here	
	Discount Rate	3.0%	Adjust here	
	Energy/Commodity Escalation	3.5%	Adjust here	
	OM&R Escalation Rate	3.0%	Adjust here	
	Loan Term	20	years	Adjust here
	Unit Rate of Electricity Sales	**$ 66.45**	**MW-hr**	Adjust in Electricity & Gas Forecast
	ESPC Savings Share of avoided LANL Costs	85%	Adjust here	

	Economic Metrics					Energy Metrics						
Option	**NPV Benefit Cost Ratio**	**Total Contractor Capital Investment**	**Rounded Net NPV (@ 30 yrs)**	**Rounded Nominal Cash Flow**	**Payback Period (Yrs)**	**Natural Gas Consumed (MM BTU/year)**	**Electricity Used (MW/yr) (Compressor and/or HHW Pumps)**	**Electricity Delivered (MW/yr)**	**Heat Produced by Gas (MM BTU/yr)**	**Heat Delivered to Facilities by Gas (MM BTU/yr)**	**Heat Efficiency (Del/Prod)**	**Conclusion**
Alternative 1 (Base Case): CGTG Ops 90% of time + Retain Exist. Steam Plant (but w/ new boilers) + No R/R to Steam Dist. System (Full Year Operations)	1.35	$ 5,000,000	$ 104,000,000	$ 183,000,000	5	2,100,000	6,600	180,000	412,000,000	212,000,000	51%	**Feasible**
Alternative 2: CGTG Ops 90% of time + Retain Exist. Steam Plant (but w/ new boilers) + Repair Steam Dist. System + Modify Bldgs for No Summer Ops (9 month ops)	1.44	$ 16,700,000	$ 152,000,000	$ 269,000,000	8	2,000,000	6,600	180,000	303,000,000	209,000,000	69%	**Feasible**
Alternative 3: CGTG Ops 90% + HRSG Heat + Steam Boilers + No R/R to Exist Steam Dist. System & No Repairs or Bldg Mods (Full Year Operations)	1.39	$ 93,400,000	$ 201,000,000	$ 374,000,000	21	2,100,000	6,600	250,000	412,000,000	212,000,000	51%	**Marginal / Feasible - distribution system not repaired; payback period may be too long**
Alternative 4: HRSG Heat + New Steam Boiler + Repair Existing Steam Dist. System + Dist. Boilers in Some Bldgs + Modify Bldgs for No Summer Ops (9 month ops) + New HP Gas Line	1.41	$ 115,200,000	$ 217,000,000	$ 408,000,000	23	2,000,000	2,200	250,000	303,000,000	209,000,000	69%	**Marginal / Feasible - payback period potentially too long**
Alternative 5 (HHW System): HRSG + Hot Water Heat Dist. System + HW Boilers + Some Dist. Boilers + Modify Bldgs for No Summer Heat (9 month ops)	1.23	$ 136,000,000	$ 137,000,000	$ 280,000,000	31	1,900,000	10,500	240,000	273,000,000	212,000,000	78%	**Marginal / Feasible - payback period too long**

Table 2 –Economic Summary for Distribution Only Alternatives

Adjustable Parameters	Interest rate	4.5%	Adjust here	
	Discount Rate	3.0%	Adjust here	
	Energy/Commodity Escalation	3.5%	Adjust here	
	OM&R Escalation Rate	3.0%	Adjust here	
	Loan Term	20	years	Adjust here
	Unit Rate of Electricity Sales	**$ 66.45**	**MW-hr**	Adjust in Electricity & Gas Forecast
	ESPC Savings Share of avoided LANL Costs	85%	Adjust here	

Option	NPV Benefit Cost Ratio	Total Contractor Capital Investment	Rounded Net NPV (@ 30 yrs)	Rounded Nominal Cash Flow	Payback Period (Yrs)	Conclusion
Distribution Only Alternatives with No Central Heat During Summer + Repair Steam Dist. System						
Alternative 2(DO): Exist. Steam Plant, No Dist. Boilers, Fix Steam Dist. System	**0.64**	$ 11,700,000	$ (30,000,000)	$ (49,000,000)	**31**	**Infeasible - not enough savings to offset capital expenses**
Alternative 4(DO): Repair Existing System (No Summer Heat + Fix Piping + Install Dist. Boilers)	**1.46**	$ 23,100,000	$ 54,000,000	$ 100,000,000	**20**	**Marginally Feasible - relies on cost savings share but payback may be too long**

6 NEXT STEPS

As management considers which alternative is the most appealing, LANL should consider the following activities to refine the analysis and to prepare for further interactions with the ESPC firms and DOE/NNSA approvers and management:

- Develop a scope of work and supporting documentation package for use in the request for proposal (and/or request for information) from the ESPC firms. The package should anticipate questions from the ESPC firms and provide summary level answers.
- Analyze and evaluate the potential and feasibility of a supplementary duct heater (on the HRSG) to optimize electricity production.
- Analyze and evaluate and study the feasibility of pipe lining technology to rehabilitate in-situ the piping distribution system.
- Develop and evaluate approaches and alternatives for project execution, phasing, and constructability. This would include the sequence and approach to repair, replace, and/or rehabilitate the distribution piping system. A plan should be developed to construct the HRSG, STG, and central plant, as well as modifications to interfacing and related systems. Additionally, LANL should develop a plan that meshes the ESPC with LANL operations and existing conditions as it will have a major influence on ESPC pricing. The approach should recognize that the ESPC will have to work around LANL operations. By communicating the interface requirements, change orders can be reduced and implementation improved, and thus overall project risk reduced.

7 REFERENCES

1. Steam Plant Project Report, September 29, 2009, Bechtel National, Inc. (Frederick, MD)
2. Energy Savings Performance Contract, Initial Proposal Submission, DOE Contract No. DE-AM36-98GO10326, September 25, 2007, NORESCO (Amarillo, TX)
3. Feasibility Evaluation Spreadsheet, LANL, October 31, 2012
4. LANL Spreadsheet "131209XU50_XURP DATA.xlsm," December 10, 2013 (provides cost data for existing steam heating operation and maintenance).
5. October 22, 2013 Meeting Minutes, Subtask 2.10 – Steam Plant Feasibility Analysis, prepared by Dennis Basile (SMSI) and transmitted to Joe Klose (LANL), on October 25, 2013
6. Estimate No. 14-00124, Installation of New High Pressure Gas Line, New Compressor Building, and Natural Gas Compressor, January 7, 2014, prepared by LANL (Michelle Bernak, Sam Montoya, R. J. Roybal; checked by Scott Marriott)

8 SPREADSHEET ATTACHMENTS

Provided electronically in MS Excel® format

1. Thermal Analysis
2. Combined Economic Analysis
3. Distribution System Economic Analysis
4. Option 1 Capital Cost Estimate (steam system)
5. Option 2 Capital Cost Estimate (heating hot water system)
6. Piping - Steam & Hot Water Distribution System Annual Repair and Replacement Cost Estimate
7. LANL O&M Cost Allocation
8. Approximate Reconciliation of Bechtel Estimate (2009) to SMSI Estimate (2013)