White Paper

Renewable Fuel Heating Plant Feasibility Assessment

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EXECUTIVE SUMMARY

This white paper explores the feasibility of a renewable fuel heating plant (RFHP). The RFHP would displace natural gas used to heat South Table Mountain (STM) site buildings. The renewable fuel would be a biomass resource, primarily Front Range forest thinnings generated by the Federal Healthy Forest Initiative/National Fire Plan.

The overall conclusion of this preliminary assessment is that the RFHP is viable project. There were no issues identified that would be project “showstoppers”. It is recommended that the project be considered for implementation.

The technology that would be utilized is a wood fueled boiler and balance of plant equipment. Wood fueled boilers are commercially available and suitable for STM heating requirements. A suitable location for the RFHP has been identified, adjacent to the FTLB Central Plant. This is a central location that cost effectively accommodates pipe connections with the SERF/S&TF and potentially the proposed RSF.

The technology that would be utilized is a wood fueled boiler and balance of plant equipment. Wood fueled boilers are commercially available and suitable for STM heating requirements. A suitable location for the RFHP has been identified, adjacent to the FTLB Central Plant. This is a central location that cost effectively accommodates pipe connections with the SERF/S&TF and potentially the proposed RSF. The optimum size for the RFHP is based on displacing 80% of the annual STM natural gas use.

There is a long-term supply of wood fuel and at a cost sufficiently below natural gas that supports the financial viability of the RFHP. The estimate for the RFHP boiler, fuel system, building and the piping connection to the SERF/S&TF is $900K. The savings estimate is $126,560 annually. The simple payback is seven to eight years.

If NREL is prepared to fund a feasibility study and commit FY 2006 GPP funds to implement the RFHP, the use of GPP funding is the recommended approach. If it is not feasible to commit the GPP funds, the ESPC approach is recommended. The RFHP project capital cost and economics make it of interest to third party developers.

INTRODUCTION

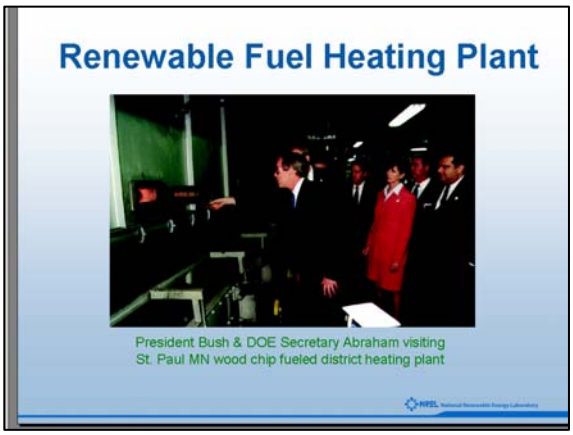
This white paper explores the feasibility of a renewable fuel heating plant (RFHP). The RFHP would displace natural gas used to heat South Table Mountain (STM) site buildings. The renewable fuel would be a biomass resource, primarily Front Range forest thinnings generated by the Federal Healthy Forest Initiative/National Fire Plan.

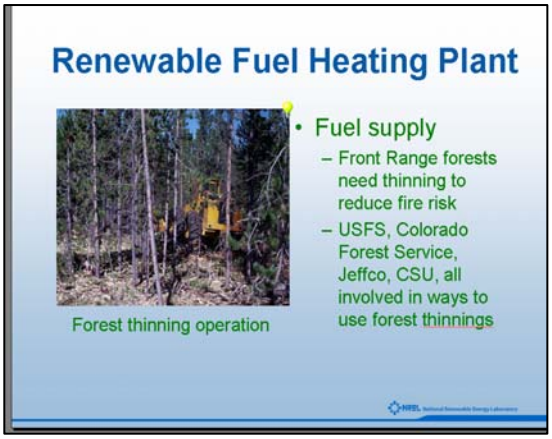
The primary benefit of the RFHP would be a cost effective reduction in the use of natural gas as well as providing a hedge against future increases in natural gas prices. Other benefits include:

- Support of the Healthy Forest Initiative (utilization and creation of demand for forest thinnings)
- Reduction in green house gas emissions (no net C02 from biomass)
- “Walking the talk” with a significant sustainability project
- Use of renewable energy resource (more significant than the Windsource purchase)
- Support and regional demonstration of EERE renewable energy technology
- Potential use of DOE energy savings performance contracting (ESPC) program
- Potential source of LEED's points for new DOE/ NREL buildings.

The project concept was the idea of Chris Gaul. An initial assessment identified wood fueled boiler technology as viable; the long-term availability of a competitively priced fuel source; a suitably sized heating load; compatibility with the existing heating central plant equipment; and a workable STM siting location. This initial finding of feasibility resulted in the next step of proceeding with a more in depth feasibility assessment.

A preliminary feasibility assessment of the proposed RFHP has been completed. The findings of this assessment are included herein. They include a project description, cost benefit analysis, site wide utility considerations, environmental and community considerations (including ES&S) and implementation options.

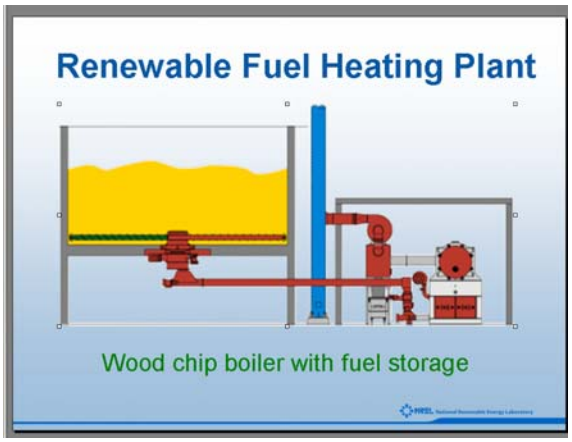


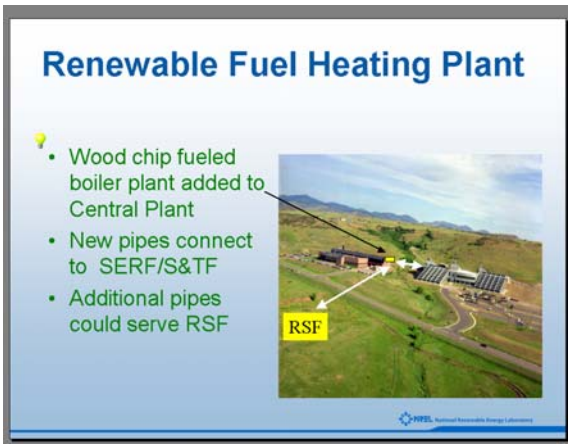


PROJECT DESCRIPTION

The technology that would be utilized is a wood fueled boiler and balance of plant equipment. Wood fueled boilers are commercially available and suitable for STM heating requirements. Wood fueled boiler plants typically include automated fuel handling, ash handling, and integrated controls. They are commonly used domestically in wood rich areas such as New England. Several U.S. and European firms manufacture wood-fueled boilers.

A suitable location for the RFHP has been identified, adjacent to the FTLB Central Plant. This is a central location that cost effectively accommodates pipe connections with the SERF/S&TF and potentially the proposed Research Support Facility (RSF).





Plant Sizing

The optimal RFHP size is based on serving the FTLB Central Plan, SERF and S&TF loads. Initially, the RFHP was considered to serve the FTLB Central Plant load only. Although the option that includes the SERF/ S&TF loads increases the project cost, fuel cost savings are more than doubled. The initial cost estimate for this larger project was in the range of $1.0M. Critically, a project of this larger size is needed to attract interest from third party project developers.

The wood fueled boiler would be sized and operated to displace the maximum amount of natural gas. It would not be intended to provide all of the heating requirements of STM on the coldest winter day. The existing natural gas fueled boilers would remain fully operational and supplement the RFHP when heat loads exceed its capacity. To

optimize fuel cost savings, the existing natural gas fueled boiler(s) would be operated only as backup during fall and spring transitional weather as well as on the coldest days when heat load exceeds RFHP capacity.

Based on these assumptions, the optimum size for the RFHP would displace 80% of the annual STM natural gas use.

COST BENEFIT ANALYSIS

Cost Estimate

A preliminary project cost estimate was provided by Bioenergy Corp, a Denver based consulting firm with experience in designing wood fueled plants. The cost information was derived from a similar biomass-fueled district heating system in Albuquerque, NM. The estimate for the RFHP boiler, fuel system, building and the piping connection to the SERF/S&TF is $900K.

Savings Estimate

Total Natural Gas Use. The annual fuel savings estimate would be 80% of the total natural gas use of the Central Plant, SERF and S&TF. The total use is estimated using the actual FY03 Central Plant and SERF natural gas use. The use estimate for the S&TF is based on the Title II Final Daylighting/Energy Analysis study dated June 30, 2003.

Central Plant	197,000
SERF	194,000
S&TF	61,000
Total	452,000 therms

The third largest STM natural gas use is the operation of the AFUF/PDU high-pressure steam boiler used primarily for research. The PDU boiler used 22,600 therms in FY03. This steam boiler uses only 5% of the natural gas consumed by Central Plant and SERF. It is not considered a viable wood fuel conversion application.

Equivalent Wood Fuel to Displace Natural Gas. The energy content (heating value) of wood varies only slightly by wood type relative to the impact of moisture content. At the same moisture content, wood types contain about the same energy. The dry wood heating value is 8,500 Btu/lb. For this analysis, a conservative 5,000 Btu/lb is used for wood with an expected moisture content of 40%.

The wood fuel required is 3,616 tons/year (refer to calculations below, equations (1), (2) and (3)). It is assumed that wood fuel and natural gas boilers have comparable conversion efficiencies.

Refer to equation (1) for the calculation of the heating value of wood on a per ton basis.

Wood heating value/ton = Wood heating value (40% moisture) X lbs/ton (1)
= 5,000 Btus/lb X 2,000 lbs/ton
= 10,000,000 Btus/ton or 100 therms/ton
(Note: 1 therm = 100,000 Btus)

Refer to equation (2) for the calculation of the therms per year of natural gas use that would be displaced by wood fuel.

Wood use (therms/year) = Total natural gas use (therms/year) X % natural gas use displaced by wood (2)
= 452,000 therms/year X 80%
= 361,000 therms/year

Refer to equation (3) for the calculation of wood fuel use required annually to displace the estimated 80% natural gas use.

Wood use (tons /year) = Therms/year use X heating value/ton (3)
= 361,000 therm/year X 100 therms/ton
= 3,616 tons/year

Wood Fuel Availability and Price. Colorado Front Range forests have an abundance of small diameter trees with limited commercial value. Present forest thinning fuel reduction efforts under the Healthy Forest Initiative/National Fire Plan provide private contractors with as much wood as they can use. What is not used for firewood is chipped. Sometimes chips are blown back onto the forest floor and other times they are

used for landscape mulch. It is the mulch industry that affords the RFHP with a long term, stable renewable fuel supply.

In addition to forest thinnings a substantial amount of wood waste from urban forestry and recycled scrap lumber is converted into mulch. Recycled lumber is also a high quality fuel.

The issue of wood fuel availability and cost was investigated through a local major supplier, A1 Organics. A1 Ogranics is the largest mulch operation in Colorado. Based on the annual wood fuel requirement of 3,616 tons, A1 Organics estimates the RFHP annual consumption at 17,000 loose cubic yards of wood chips. To put the RFHP consumption in perspective, A1 Organics annual capacity is some 350,000 loose yards. Furthermore, the RFHP would need the most wood chip fuel during the coldest months when landscape mulch sales are at their lowest. The opportunity to supply wood chips for the RFHP would provide a mulch supplier a more balanced revenue stream for businesses that do 85% of their annual sales between March and May.

Issues affecting wood chip price were also investigated with A1 Organics. The RFHP needs wood chip fuel with a target price of $2.00/Million Btu ($0.20/therm) delivered. It is anticipated that this price level is supportable in the near to mid term and potentially in the long term given the significant supply of wood fuel from forest thinning activities. Within certain specifications for chip size, moisture content, and cleanliness the fuel supplier has flexibility to determine the most effective manner to deliver fuel.

If the RFHP were to go forward, an expanded market for the forest fuel reduction woodchips would result. The impact would be to reduce price. This is exactly the synergistic arrangement Front Range forest management authorities have been seeking (a market pull for wood chips to stimulate forest thinning projects). The current demand for woodchips from the recently implemented forest fuel reduction activities is relatively low.

A1 Organics chips in the high country 12 times a year for forest fuel reduction projects. Presently landowners must bear the whole chipping cost and the high price limits how much forest thinning is accomplished. If there was a market for wood chips then forest thinning expense would be carried by the landowner and in this case NREL, lowering costs for both parties. A1 Organics estimated their forest thinning work would double with such an arrangement.

<u>Natural Gas Price.</u> DOE GO procures natural gas on behalf of NREL through special negotiated natural gas delivery contracts. The Central Plant and SERF are covered under these contracts. The price from the summer 2004 was $0.55/therm. This is the natural gas price used in this assessment. Natural gas prices are currently in the range of $0.70-.80/therm. They are expected to stay at these levels or increase further. $0.55/therm was used in this analysis to be conservative.

The annual savings attributable to displacing natural gas use with wood fuel is calculated below.

The price differential between natural gas and wood chip fuel on per therm basis is $0.35/therm. Refer to the calculation (equation (4)) below.

Wood savings/therm = Natural gas price/therm – wood fuel price/therm (4)
= $0.55 - $0.20
= $0.35/therm

The annual savings using wood fuel is $126,560. Refer to calculation (equation (5)) below.

RFHP annual savings = Annual natural gas displaced by wood fuel X fuel price differential (5)
= 361,600 therms/year X $0.35/therm
= $126,560

Simple Payback

The simple payback for the RFHP is 7-8 years. Refer to the calculation (equation (6)) below.

RFHP simple payback = Capital cost / annual savings (6)
= $900,000/$126,560/year
= 7.11 years

Consistent with simple payback calculations, no allowances have been made for operating and maintenance costs, financing costs, time value of money, etc. With regard to operating and maintenance costs, the RFHP is envisioned to utilize automated operation.

SITE UTILITY CONSIDERATIONS

The RFHP would be the next step and centerpiece of the overall site utility strategy that is included in the 2003 General development Vision (GDV) for the STM campus. In the long-term, the RFHP tied to a central distribution loop would likely be the most cost-effective development scenario for the STM campus.

As the STM is developed, the optimum strategy (most energy efficient) for the supply systems for building heating and cooling is a utility distribution loop. This loop would connect the FTLB, SERF, S&TF, proposed RSF and other new major buildings in the central and eastern portions of the STM campus with chillers and boilers operating in several central plant locations. Chilled and hot water would be piped to each building. Currently central plants serve the FTLB, OTF, TTF, and AFUF with the SERF central plant being expanded to serve the S&TF.

The primary advantage of this concept is to operate multiple chillers more efficiently. Central plants accommodate operation strategies that fully load one or more chillers, rather than running multiple chillers at part load. This saves on utility costs because it reduces peak demand and saves energy. Another major advantage is that multiple buildings can be controlled from one location, which allows for reduced time for operations and maintenance. This saves operation labor costs. If a distribution loop is utilized in the overall site utility scheme, the RFHP could be incorporated to serve multiple buildings. The hot water generated could be distributed to multiple buildings through the utility distribution loop.

Utilizing a distribution loop approach and going forward with the RFHP would facilitate a strategic approach that addressed the goals outlined in the GDV.

- A wood-fired plant offers DOE/NREL the least expensive way to generate a significant portion of its site-wide load from a renewable resource now.
- A long-term element of the GDV is to provide utilities to the STM with 100% renewable energy including hydrogen. The central utility loop and the RFHP offer the first-step towards this long-term vision. The RFHP could be viewed as the centerpiece for the initial concept but the first step in a "plug and play" philosophy and concept to move to 100% renewable power for the STM.
- If the S&TF is connected to a central utility loop, up to three LEED's points would be facilitated. This approach would provide insurance that a Gold LEED rating is achieved.
- The RFHP would position DOE/NREL to negotiate with the RSF developer. The opportunity created by the RFHP is that it presents an alterative to installing a full sized dedicated boiler and chiller in the RSF building. The developer could consider installing some 600 feet of piping to connect to the proposed distribution loop. This would facilitate use of the excess chiller capacity that exists in the FTLB\SERF\ST&F. A smaller or less costly chiller could then be installed in the RSF (for redundancy). Preliminary estimates indicate that chiller capacity to cover the

RSF exists. Without this type of strategic campus-wide thinking, the RSF developer will install his own boiler and chiller and DOE/NREL will ultimately be responsible for operating it in the long-term.

- A goal of a LEED Platinum rating has been established for the proposed RSF. With the availability of the RFHP, three LEED points (for renewable energy) could potentially be secured for the RSF developer. This would free up funding earmarked for LEED points thus allowing for use of these funds for additional efficiency measures in the RSF.

OTHER PROJECT CONSIDERATIONS

In determining the feasibility of the RFHP a number of other considerations must be reviewed. These include environmental and local community impacts.

Environmental Impacts

The environmental impact needs to be considered from both a positive and negative point of view. Woody biomass is considered a renewable resource, and as such, its use has a minimal impact on global warming. In general, biomass combustion is considered carbon neutral. From the standpoint of GHG accountability including the Laboratory's EPA Climate Leaders Partnership reduction goal, the RFHP would represent a net reduction in GHG emissions.

Although the size of the RFHP is relatively small, it would represent a small market outlet for forest residues generated through forest fuel reduction efforts in the Front Range forest areas, including Jefferson County. The benefits of forest fuel reduction, e.g., reduced fire risk, watershed protection, property protection, wildlife protection, and reduced health risks are well known and documented. However, much of the residue removed from the forest is either open pile burned or land filled. The RFHP would reduce the smoke and air pollution that results from open burning and reduce the amount of material sent to landfills.

There are issues and regulations associated with potential contaminants if treated or otherwise contaminated wood is mixed with clean residues. Thus, only forest thinnings and clean urban residues would be used.

The RFHP would have emissions resulting from the wood fuel combustion. The primary pollutants include particulates, nitrogen oxides, and carbon monoxide.

The RFHP would need to meet the regulated limits of the pollutants. The table below provides representative values for regulated pollutant limits in Colorado and California, along with representative emission levels from comparable biomass facilities. In

general, a biomass combustion system can be designed to meet the standards. The RFHP would utilize any necessary pollution control equipment.

	Units	Colorado Regulations	California	Typical AP-42 Emission Factors	ChipTec
Opacity	%	20			
PM	lb/MMBtu feed	0.275*		0.22 - 0.3	0.1-0.2
NOx	lb/MMBtu	NA	0.35	0.49	0.3
	ppmv@12% CO2		115 or 50% reduction		
SO2	lb/MMBtu feed	1.2		0.6	0.025
CO	ln/MMBtu feed	NA		0.06	0.3
Total Organic Compounds	lb/MMBtu	NA		0.025	0.06
Fugitive Dust					

* for 10 MMBtu/hr fuel

Other environmental considerations that would need to be addressed include NEPA, air permitting, safety issues, updating the Environmental Assessment, etc. NEPA and permitting processes would need to be implemented if the RFHP were to go forward. Preliminarily, ES&S does not anticipate issues with either of these processes or other issues. The STM Environmental Assessment would need to be modified to include the RFHP.

Local Community Impacts

Local community perceptions and impacts of the RFHP would be paramount factors in determining feasibility. Community acceptance is required. Based on lessons learned from the installation of f biomass facilities, the primary issues that need to be addressed include the impact of truck traffic on the local neighborhood, dust, smoke (particulates), and odors.

<u>Traffic impact.</u> Wood fuel density varies with chip size and moisture content. Delivery trucks may carry 13 to 27 tons. Assuming a truck would carry 20 tons, the estimated annual truck traffic is calculated by equation (7) below.

Annual truck traffic = annual tons wood fuel/year ÷ tons/truck (7)
= 3,616 tons/year ÷ 20 tons/truck
= 181 trucks/year

According to Site Entrance Building reports, an average of 30 semi-trucks per week currently enter the STM site. Over a 30-week heating season, 900 delivery trucks would enter the site. Therefore, wood fuel deliveries would increase heating season semi-truck traffic by some 20%. There would be no fuel deliveries May-September.

On site fuel storage is planned for 3-5 days. Consequently, fuel deliveries would average one to two trucks Monday through Friday.

A1 Organics indicated that they would take the RFHP wood ash to blend into their mulch. It is assumed that other mulch vendors would also be interested in this mineral-rich ash to fortify mulch.

Dust, Odor and Smoke Emissions. These remaining issues can be addressed by designing a closed facility with indoor wood storage. The photos below show a small wood combustion system with indoor wood storage. This addresses the dust and odor issue. The other issue is smoke emissions from the exhaust stack. The use of a bag house would eliminate particulates, and the complete combustion required to control NOx and CO would help ensure that there are no visible organics.

IMPLEMENTATION OPTIONS

As noted, the preliminary RFHP cost estimate is $900,000. Three options for financing the project have been identified: 1) General Plant Project (GPP) funding; 2) DOE Departmental Energy Management Program (DEMP) funding and 3) energy savings performance contracting (ESPC). The viability of these options is discussed below.

GPP Funding

Funding the wood-fired boiler implementation with General Plant Project (GPP) funding would be the least expensive option for NREL in terms of project costs as no financing costs are incurred by the project. This option would allow DOE/NREL to be fully in control of performance specifications and equipment selection. In addition, DOE/NREL would realize the entirety of the energy cost savings upon acceptance of the RFHP installation. The downside of using GPP funds is that the cost of this project would require half of the annual GPP budget. Further, the earliest opportunity to allocate funds for the project would be FY 2006.

The first step in this option would be to form a project team. Second, an engineering firm would be selected and funded to develop a feasibility study to determine RFHP economics. This effort is expected to cost approximately $30,000 and would take 60 to 90 days to complete. If the RFHP is determined to be cost effective, Site Operations would request GPP funding from the FY 2006 budget for project implementation.

DEMP Funding

Over the past few years, the Departmental Energy Management Program (DEMP) has provided funding for energy projects at DOE facilities under an annual call for projects. While it is certainly expected that this effort will continue, funding is always subject to budget constraints. If a DOE/NREL's application were successful, it is not likely that DEMP would provide more than half of the RFHP costs. At best, DEMP funding would be a viable method of partially offsetting the amount of GPP funding needed for RFHP implementation.

Successfully acquiring funding from DEMP would require first conducting a feasibility study ($30,000 and 60-90 days as noted above). If the feasibility study confirms that the RFHP would indeed be cost effective, an application for project funding would be submitted during fall of 2005 as part of DEMP's Request for FY 2006 Energy Management Retrofit Projects. Projects are prioritized for selection based on savings to investment ratio (SIR) and cost sharing. Renewable energy projects are also viewed favorably. While this option would allow leveraging of funding to offset project costs, DOE/NREL would likely have to share control of the project with DEMP. There is typically a long lead-time for project approval.

ESPC Financing

Energy Savings Performance Contracting (ESPC) is a contracting method in which an energy service company (ESCO) provides and finances energy efficiency and renewable energy projects. These projects are paid for from the energy and energy-related cost savings. The ESCO guarantees that installed energy efficiency and renewable energy projects will result in a specified level of cost savings to the Federal customer, which will be sufficient to pay for the project. The agency uses the

guaranteed cost savings to pay for the improvements over the life of the contract. After the contract ends, all additional cost savings accrue to the agency.

An ESPC requires a time commitment for project management costs. However, an ESPC requires no DOE/NREL funding for project implementation. The project would be paid for out of the utility budget using the energy savings resulting from the RFHP installation and distribution system upgrade. This option would require DOE/NREL to use the savings to pay for the project rather than realize the savings upon project completion. The ESC, however, would guarantee the performance of the equipment and the annual savings to be realized. The ESCO would also arrange for a long-term fuel contract.

In addition, the ESCO would conduct a walk-through energy audit and provide an initial proposal outlining estimated project scope, costs, and savings. This proposal, while not as detailed as a conceptual design included in an NREL-funded feasibility study, would provide sound engineering estimates at no cost to NREL. The feasibility study would determine if this project would generate enough savings to be financed. If the project appears to be cost effective, an investment grade audit would be performed to verify costs and savings. DOE/ NREL would then decide whether to award a delivery order to the ESCO to move forward with project implementation.

The first step in initiating an ESPC would be to form a project team. This team would include a DOE Contracting Officer from DOE GO, a NREL FEMP representative with ESPC experience, a National Bioenergy Center representative with biomass plant experience, ES&S and Site Operations. The second step would be the selection of an ESCO to begin the survey to develop an initial proposal. This effort is likely to take about two months, with an investment grade audit requiring another two to three months. If DOE/NREL decides to begin an ESPC process soon, it is probable that the RFHP installation could begin by the end of FY 2005.

Recommendations

The recommendations for proceeding depend on the funding DOE/NREL is able to commit. If NREL is prepared to fund a feasibility study and commit FY 2006 GPP funds to implement the RFHP, the use of GPP funding is the recommended approach. DOE/NREL would benefit directly from the resulting energy cost savings upon acceptance of the boiler installation and will pay no financing costs for the equipment.

If it is not feasible to commit the GPP funds necessary to implement the RFHP, the ESPC approach is recommended. While the RFHP would be financed by a third party, DOE/NREL would be committing the savings to pay for the RFHP over the term of the contract. An ESCO would provide an initial proposal at no cost and the work could begin immediately. A long-term fuel supply source (essential to assure savings) could be more

easily implemented under this option. Responsibilities for operation and maintenance, repair and replacement services would be negotiated.

Funding from DEMP is not recommended as a stand-alone approach. However, an application for funds could be filed in addition to pursuing another option. If DEMP approves partial RFHP funding, GPP funds would be offset if GPP funds were to be used to fund the project. DEMP funds cannot be used to offset ESPC costs.

CONCLUSIONS

The overall conclusion of this preliminary assessment is that the RFHP is viable project. There were no issues identified that would be project “showstoppers”. It is recommended that the project be considered for implementation. The following are the major conclusions of the assessment.

- The technology that would be utilized is a wood fueled boiler and balance of plant equipment. Wood fueled boilers are commercially available and suitable for STM heating requirements.
- A suitable location for the RFHP has been identified, adjacent to the FTLB Central Plant. This is a central location that cost effectively accommodates pipe connections with the SERF/S&TF and potentially the proposed RSF.
- The optimum size for the RFHP is based on displacing 80% of the annual STM natural gas use.
- There is a long-term supply of wood fuel and at a cost sufficiently below natural gas that supports the financial viability of the RFHP.
- The estimate for the RFHP boiler, fuel system, building and the piping connection to the SERF/S&TF is $900K. The savings estimate is $126,560 annually. The simple payback is seven to eight years.
- In the long-term, the RFHP tied to a STM central distribution loop would likely be the most cost-effective development scenario for the STM campus.
- The RFHP can be designed to meet environmental standards. The RFHP would utilize any necessary pollution control equipment.
- If NREL is prepared to fund a feasibility study and commit FY 2006 GPP funds to implement the RFHP, the use of GPP funding is the recommended approach. If it is not feasible to commit the GPP funds, the ESPC approach is recommended. The RFHP project capital cost and economics make it of interest to third party developers.