FINAL REPORT

EXPLORING WOODY BIOMASS RETROFIT OPPORTUNITIES IN MICHIGAN BOILER OPERATIONS

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Submitted to:

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Project Partners:

USDA Forest Service Wood Education & Resource Center
USDA Forest Service Economic Action Program
Southeast Michigan RC&D Council
Michigan Department of Natural Resources
Michigan Department of Labor & Economic Growth
Michigan Biomass Energy Program

Submitted by:

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Geodata

Major funding for the Michigan Wood Energy Project is provided by the USDA Forest Service Wood Education and Resource Center and the USDA Forest Service Economic Action Program. Funding for the website and educational tools is provided by the Michigan Department of Labor and Economic Growth's Energy Office. Significant additional technical assistance has been provided by the Michigan Department of Natural Resources.

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Executive Summary

The project team (CTA Architects Engineers, Emergent Solutions, Christopher Allen + Associates, Loracs Creations and Geodata) was contracted by the Southeast Michigan RC&D Council to provide a statewide assessment of the potential to integrate wood fired boiler systems into existing facilities throughout the State of Michigan. Additional technical assistance for the project was provided by the USDA Forest Service, Southeast RC&D Council, Michigan Department of Natural Resources, Michigan Department of Labor and Economic Growth & Michigan Biomass Energy Program (collectively referred to as the Committee).

The report is divided into three sections—Section 1: Background Information; Section 2: Analysis of Existing Boiler Database & Section 3: Tools for Identifying Potential Projects.

Section 1: Background Information:

The project team has provided a summary of recent biomass utilization studies and identified successful conversion projects from throughout the country. The project team has identified the probable costs, savings and simple paybacks that should be anticipated for future conversion projects.

Section 2: Analysis of Existing Boiler Database:

The report describes the process used to examine the database of existing boilers. The project team sorted the existing boiler data base by Size (in British Thermal Units or btu's), Fuel Type, Age, and Use. The results of this information are summarized in Appendix A.

- 59% of boilers in Michigan are smaller than 750,000 btu in size.
- 82% of the boilers in the database are smaller than 2,500,000 btu in size.
- 96% of the boilers in the database are identified as using "gas" as the primary fuel. The project team assumed that these boilers burn natural gas, although it is possible that a significant portion of the boilers burn propane gas at a higher cost than natural gas.
- 22 % of the boilers in the database are less than 7 years old.
- 75% of the boilers are listed as less than 27 years old.
- Less than 4 percent of the boilers in the database are more than 48 years old.
- 84% of the boilers in the database are listed as providing hot water heat or hot water supply.

The project team developed a formula to calculate an estimated existing fossil fuel volume, projected fossil fuel price per million btu (decatherm), projected wood fuel price and cost of a wood fired heating system. The projected cost volume of fossil fuels was developed using a 10% facility utilization factor (FUF) which acts as a placeholder for fossil fuel consumption in lieu of actual fossil fuel or electric consumption. The costs of fossil fuels and electricity were found on the US Department of Energy (DOE) Energy Information Administration and Michigan Department of Labor and Economic Growth (DLEG) Public Service Commission websites. The cost of wood fuels was derived from contacts made with existing wood fuel users throughout the state and five wood pellet fuel suppliers in Au Gres, Grayling, Holland, Kingsford and Weidman. The projected cost of wood fired heating systems was based upon examination of more than 170 project costs from completed and estimated project costs from throughout the country. Although the project costs are mostly from projects in the western United States, projects costs from the eastern United States were included. All costs were normalized to a cost per btu and stated in year 2007 dollars. The data was sorted to establish projects with a simple payback less than 20 years.

- Approximately 2,300 potential projects have simple paybacks of less than 20 years.
- An additional 700 boilers appear to be located in buildings with more than one boiler and may result in projects with simple paybacks less than 20 years.

Section 3: Tools for Identifying Potential Projects.

The final section of the report is focused on the development of a web-based calculator and educational guides to be used on a Southeast Michigan RC&D website. These tools will be used by facility managers and potential project developers to learn more about biomass utilization in existing facilities. The web based calculator requires input of current boiler size, fuel type, cost and volume and provides a brief summary of the results to the user. The user's contact information will be sent to the Southeast Michigan RC&D in order to create a point of contact for follow-up investigation. The website includes educational components such as brief answers to frequently asked questions and links to related websites.

Conclusion and Recommendations:

The analysis of the existing boiler database identifies approximately 2,300 existing boilers with simple paybacks less than 20 years. The report includes a one page summary of each county illustrating the top 35 projects, found in Appendix B. County summaries with more than 35 projects with simple paybacks less than 20 years illustrate all projects with simple paybacks less than 20 years has also been identified in order to further prioritize outreach efforts by the committee.

One barrier to converting existing boilers to wood fired heating systems is the current lack of capacity of existing manufacturers of wood fired heating systems to meet a growing demand for biomass boilers. Entrepreneurs within the state of Michigan are uniquely positioned to meet that need through the use of existing or recently closed manufacturing facilities located throughout the state.

The project team recommends that the committee consider the following next steps:

- *Focus outreach efforts in the counties with the greatest number of potential projects with simple paybacks less than 20 years. This approach may lead to the development of clusters of projects in a county and support the infrastructure to supply wood fuel to multiple locations.*

- *Contact facility managers with multiple boilers in a single facility. The database is sorted in a manner that identifies multiple boilers in the same facility on adjacent lines, making the process of locating facilities with multiple boilers a simple task.*

- *Contact facility managers with simple paybacks less than 20 years located within 50 miles of existing pellet mills, wood fired power generation facilities and the large quantities of urban wood waste in Southeastern Michigan.*

- *Focus outreach efforts through local economic development councils to promote the integration of wood fired heating systems in new facilities (approximately ½ the cost of retrofitting existing facilities).*

- *Work with the Michigan Department of Environmental Quality to address potential projects in non-attainment areas.*

- *Identify existing coal facilities that may be modified to burn wood or to co-fire wood and coal.*

- *Identify clusters of projects within a community that may represent opportunities for combined heat and power projects with district heating and cooling systems. Such projects represent opportunities to meet Governor Granholm's initiative for expanding Michigan's renewable energy portfolio to 10 percent by 2015 and 20 percent by 2025.*

Section 1: Background Information.

This section includes a brief background on biomass energy and a summary of recent biomass utilization studies from throughout the United States of America, conversion success stories, probable project costs and examples of typical simple payback calculations.

1.1 What is Biomass?

Biomass is renewable energy source derived from trees and crops through a process of combustion, distillation or gasification.

The most common means of converting biomass into energy is combustion. Woody biomass in the form of wood chips, “hog” fuel, wood pellets, sawdust and planer shavings may be burned to produce hot water or steam in a boiler or hot air in a furnace for distribution throughout a building or collection of buildings. Wood-fired boilers and furnaces are produced throughout North America and Europe. More than 270 wood fired boilers are in use throughout Michigan.

Woody biomass may distilled into bio-fuels such as ethanol and used as a heating and transportation fuel. Ethanol is more commonly produced from corn and other plant materials with high levels of starch that can be distilled more easily than woody biomass.

Woody biomass can also be ‘gasified,’ or heated in a controlled oxygen environment to produce a low btu-value gas (168 btu/cubic foot versus 1,000 btu/cubic foot for natural gas). This gas can be used as a heating fuel to replace natural gas and propane in gas fired boilers and furnaces. The low btu value of the gas requires modifications to the orifice delivering the gas to the burner. A limited number of manufacturer’s produce woody biomass gasifiers. Gasification of woody biomass results in very low particulate levels and may be utilized in non-attainment areas throughout the state. Gasification of woody biomass also produces tars that can damage combustion equipment if not carefully removed from the gas during the gasification process.

1.2 Combined Heat/Power and District Heating & Cooling

Biomass boilers can be used to produce electrical energy through the use of steam pistons or steam turbines. For example, a wood-fired boiler can produce high pressure steam which drives a piston or turns a turbine to produce power. As the steam passes through the piston or turbine the pressure is reduced, resulting in low pressure steam available to heat buildings and domestic hot water. The power produced may be used to meet on site demands for power, sold to local users or to the general marketplace.

The residual low pressure steam from power production can be used to heat a single facility or campus, or be converted to hot water for domestic use and distribution in a district heating system. For example, District Energy Saint Paul uses biomass feedstock to provide heat, hot water, chilled water and power for the downtown area of Saint Paul, Minnesota.

Absorption chillers can be used to extract cooling from the condensation cycle of steam and produce chilled water for distributed cooling systems. The University of Idaho and Chadron State University in Nebraska use biomass boilers to produce steam heat and chilled water.

Combined heat and power facilities and district heating systems represent an efficient means of consolidating the handling of wood fuel in a central site with full-time professional staff overseeing the fuel handling, ash removal and emissions of the system. The project team has found that combined heat and power systems often require a "steam host" or primary user such as a lumber mill, hospital or correctional facility that has a substantial demand for both heat and power.

The development of combined heat and power facilities and district heating distribution systems could contribute to Governor Granholm's goal of expanding Michigan's renewable energy portfolio to 10 percent by 2015 and 20 percent by 2025. Combined heat and power projects and district heating distribution systems would also reduce the use of fossil fuels used for heating and cooling facilities and communities throughout the state of Michigan.

1.3 Recent Biomass Utilization Studies

In addition to reviewing the conclusions the two assessments for the Montana Fuels for Schools program, the team has examined studies from Eastern Oregon, the General Accounting Office, North & South Dakota, Colorado and the Sierra Club. An executive summary of each of the studies is included below, and linked to the website where applicable.

1.3.1 Assessment: Potential for Expanding the Fuels for Schools Concept to other Institutions and Industries

December 2004

CTA Architects and Engineers
Emergent Solutions
Christopher Allen + Associates
Geodata

The purpose of this study is to assess the potential commercial opportunities and challenges in converting or replacing a significant number of Montana's 7,239 existing boilers with SDU wood-fueled boilers. The first part of the study involves analyzing the limited information available in the State's boiler certificate database. Findings include:

- 59% of boilers in the database are less than 1,000,000 BTU/hr in size. Almost 45% are less than 500,000 BTU/hr in size.
- 89% list "Gas" or "Gas/Oil" as their existing fuel source.
- 62% were installed within the past 20 years, 25% are 21 to 40 years old, 9% are 41 to 60 years old, and 4% are more than 60 years old.
- 62% of the boilers list "Not applicable" as their facility type, but 21% list schools; 5% list churches; 4% list hospitals; 4% list rest home, retirement center, or assisted living facilities; 3% list public assembly; and 0.2% list daycares.
- 68% of the boilers are used for water heating, 16% for steam heating, 8% for hot water supply, 6% for process water, and 1% for power.
- 257 cities in Montana have at least one boiler. 15 cities have more than 100 boilers, 25 cities have more than 50 boilers, 91 cities have 10 or more boilers, and 90 cities have only one or two boilers. As might be expected, the largest cities also have the greatest number of boilers.

The second part of the study uses information presented in the State's boiler database to estimate the potential size and scope of a commercial wood-fired boiler market in Montana. The analysis is based solely on calculations of simple payback through annual fuel savings on a boiler conversion investment. While limited in accuracy, simple payback is an initial indicator, from a facility owner's point of view, of how attractive an investment in conversion might be given current economic conditions. Two scenarios were developed to differentiate between payback periods when boiler replacement is likely necessary and when it is not.

There are many additional issues that would need to be thoroughly analyzed in order to refine this initial assessment of the commercial potential for large-scale boiler conversion. Some of the issues identified by this study include: government programs and drivers, economic development and a service infrastructure, feedstock issues, environmental and political issues, air quality issues, and facility-specific issues.

Successful transition of the Fuels for Schools program to commercialization will depend on the development of a *business ecosystem* that encompasses USFS goals for forest thinning operations and market incentives for conversion to wood-fueled boilers. A complete shift to commercialization requires market-driven economics that support investment in boiler conversion from both the consumer and the vendor perspectives.

The findings of this study indicate the need to pursue four activities to further efforts towards commercialization of the Fuels for Schools concept:

- Engage key stakeholders in next steps
- Assess wood resource viability
- Explore additional partnerships, drivers, and opportunities
- Disseminate information

1.3.2 Biomass Boiler Market Assessment

October 2006

CTA Architects and Engineers

Montana Community Development Corp.

Christopher Allen + Associates

Geodata

The Fuels for Schools (FFS) program is the second phase of a 3-phase U.S. Forest Service (USFS) initiative to facilitate the removal of hazardous fuels from our forests and promote the use of wood biomass as a renewable natural resource as an energy source for heating systems in public and private buildings. The FFS program in Montana now includes four operational biomass boiler heating system projects and 11 more in the design/construction phase. Pre-feasibility assessments have been completed for more than 200 buildings in 60 communities in the region. The work presented in this report is a follow-up to a study completed in December 2004 called Assessment: Potential for Expanding the Fuels for Schools Concept to other Institutions and Industries, which assessed the potential opportunities and challenges presented by converting or replacing existing boilers in the state of Montana with SDU wood-fueled boilers.

Experience gained from the existing and on-going Fuels for Schools projects indicates that opportunities for improving financial attractiveness of a new boiler system can be found in the following five categories:

biomass boiler system equipment, including fuel storage and conveyance*;* boiler building*;* mechanical/electrical within the boiler building*;* mechanical integration*;* fees, permits, and other non-capital costs

Reductions in the cost of biomass boiler system equipment can be found in three areas: (1) The capacity and type of wood storage should be coordinated with the projected volume and rate of wood fuel to be used by the facility. (2) Reducing the cost of the wood handling system can result in significant project cost savings. The cost of automated wood handling systems for wood chips is typically higher than those for wood pellets. (3) Projects with limited vendors (such as small steam pellet boilers) or high wood fuel costs (such as wood pellet projects located far from existing wood pellet production facilities) might be avoided.

Boiler building costs can be reduced by reducing the building size required by reducing space requirements, using less expensive building materials and designs, and re-using space in existing facilities. Biomass boiler installations in new facilities will also have lower reduced building costs.

Non-capital costs for a biomass boiler project include design fees, printing, travel, permits and related costs. The bid timing, duration and contractual relationships between wood boiler system vendors and general contractors also impact total project costs. CTA's experience with biomass projects suggests the following:

- The ideal bid climate is between Mid-January and Mid-March. Biomass projects should plan for at least three week bid duration.
- Bidding requirements are viewed by vendors as too cumbersome and should be simplified.
- The use of design/build, construction manager at risk or performance contracting project delivery methods would increase the level of contractor input in the design of wood heating projects and reduce the time lost to value engineering processes after a bid opening, and reduce potential change orders.
- Bidding using a single contract should avoid any potential schedule or scope conflicts between the general contractor and wood boiler system vendor.
- Minimize time for project closeout.

Factors Impacting Project Viability

For the purposes of this study, project viability for replacing existing boilers with biomass boilers is defined by simple payback, the number of years it would take for annual fuel cost savings (from using less expensive wood biomass rather than fossil fuel) to pay for the cost of the new biomass boiler system. Since almost 90% of the existing boilers in the state use natural gas, the analyses reported are based on natural gas as the existing fuel unless otherwise noted. (As will be illustrated later, with the exception of coal, all other fossil fuels used in boilers in Montana are more expensive on a per-BTU basis than natural gas, thus the economics of conversion would be better than for natural gas.)

Numerous facility-specific factors affect the potential economic and technical viability of a given biomass boiler conversion project; however, our analyses indicate that there are three main factors that are best indicators of potential project viability:

- Existing boilers need to be a minimum of 1 to 1.5 mmBTU/hour output for conversion to biomass to be considered viable.
- Existing annual fuel use needs to be a minimum of 1,000 to 3,000 mmBTU/year of fuel for conversion projects to be viable.
- Existing annual fuel cost needs to be a minimum of $20,000 for conversion project to be viable.

As noted above, with the exception of coal, all other fossil fuels used in boilers in Montana are more expensive on a per-BTU basis than natural gas.

Refining Identification of Potential Customer Base

Based on the assumptions used in this study, the best opportunities for conversion are likely to be in universities, hospitals, and other institutions with larger boiler systems that would have paybacks of less than 10 years. The analyses conducted for this study indicate that there are 91 boilers with paybacks less than 10 years, and 47 boilers with paybacks of less than 7 years.

New Installations

Experience indicates that biomass boiler installations in new construction projects may have greater potential market than boiler conversions. When designing a new building, it is possible to match the biomass system size to the projected heating load. Installations in new facilities also eliminate integration costs associated with conversions. Analyses conducted for this study indicate the potential for boiler installations in new buildings to be a total of 84 to 280 boilers per year.

Feedback from Potential Customers

High initial cost, uncertainly in the reliability of fuel supply, air emissions, space, and increased O&M were recurring concerns among existing and potential biomass consumers. Most potential customers indicated the need for more information - and more specific information. Interviews indicate that facility managers would like to see a payback of less than 10 years without grant funding, but also get grant funding to help minimize initial costs.

Feedback from Manufacturers

The wood heating vendors interviewed all expressed interest in the future of the wood heating system industry in Montana and throughout the west. The majority of wood heating systems have been installed in industrial applications, often related to the wood products industry. Several vendors emphasized the need to maintain a quality wood fuel source in order to minimize potential problems with non-industrial users of wood heating systems. The use of metal building systems and packaged boiler buildings were noted as potential cost savings for future projects.

1.3.3 Renewable Resources Eastern Oregon Biomass Assessment

www.oregon.gov/ENERGY/RENEW/biomass/assessment.shtml

December 2003

Oregon Department of Energy/McNeil Technologies, Inc.

As noted on the Oregon Department of Energy website:

"The goal of this biomass resource assessment was to promote the cost-effective, sustainable use of biomass energy in Baker, Union and Wallowa Counties. The assessment focused on the use of biomass for electric power generation or conversion to ethanol fuel. The objectives were to:

- *Identify how much biomass is generated in the region*
- *Determine how much biomass is available, where it is located, its physical and chemical characteristics and the cost*
- *Provide information on the best locations for a potential biomass site in each county*
- *Evaluate the economic and environmental impacts of biomass use; and*
- *Provide an overview of biomass energy technologies, feedstock requirements, and economic potential to convert biomass to electricity or ethanol.*

The biomass resource in the study area consists of forest biomass, wood products manufacturing residue and agricultural crop harvesting residue. Sources of forest biomass include forest fuels reduction projects, commercial timber harvest, non-commercial thinning and timber stand improvement activities. Wood manufacturing residue consists of bark, sawdust, chips and veneer cores. Agricultural residue consists of straw, grass and leaves left over after harvesting major crops in the region, which include grass seed, spring wheat, winter wheat, oats and barley.

The overall approach to assessing the biomass resource was to first estimate the quantity of material generated from forestry and agricultural activities in the area. Then, taking into account technical and environmental constraints, the study evaluated the quantity of material that could be recovered and made "available" for biomass energy uses.

The assessment found the following quantities of biomass could be available on an annual basis in the three-county area. Amounts are in "green" tons (that is, including the weight of moisture in the biomass).

- *Forest Biomass* *425,934 tons*
- *Wood Products Residue* *310,252 tons*
- *Agricultural Residue* *80,009 tons*
- *Total* *816,195 tons*

The assessment concluded that the use of biomass for electric power or ethanol production would have net economic benefits. These economic benefits would include increased employment in a rural, natural resource-based economy. An estimated six jobs are created for each megawatt (MW) of biomass power capacity that is installed. These jobs include positions at the plant and also in the fuel processing and delivery sectors.

A 15 million gallon per year biomass ethanol facility would employ approximately 30 people at the plant. Approximately 70 people would be employed in feedstock supply and delivery systems, bringing the total economic impact to approximately 100 new jobs. The biomass ethanol plant would require approximately 600,000 green tons of biomass per year. The higher feedstock requirements and sophistication of plant equipment result in a higher employment impact for a biomass ethanol plant than for a biomass power plant."

1.3.4 GAO Testimony before the Subcommittee on Forests and Forest Health, Committee on Resources, House of Representatives.

NATURAL RESOURCES

Federal agencies are engaged in numerous woody biomass utilization activities, but significant obstacles may impede their efforts.

May 24, 2005

Robin Nazzaro, United State Government Accountability Office

"Most woody biomass utilization activities are implemented by the Departments of Agriculture (USDA), Energy (DOE), and the Interior and include awarding grants to businesses, schools, Indian tribes, and others; conducting research; and providing education. Most of the USDA's woody biomass utilization activities are undertaken by the Forest Service and include grants for woody biomass utilization, research into the use of woody biomass in wood products, and education on potential uses for woody biomass. DOE's woody biomass activities focus on research into using the material for renewable energy, while Interior's efforts consist primarily of education and outreach. Other agencies also provide technical assistance or fund research activities.

Federal agencies coordinate their woody biomass activities through formal and informal mechanisms. Although the agencies have established two interagency groups to coordinate their activities, most officials we spoke with emphasized the informal communication—through emails, participation in conferences, and other means—as the primary vehicle for interagency coordination. Internally, DOE coordinates its woody biomass activities through its Office of Energy Efficiency and Renewable Energy, while Interior and the Forest Service—the USDA agency with the most woody biomass activities—have appointed officials to oversee, and have issued guidance on, their woody biomass activities.

The obstacles to using woody biomass cited most often by agency officials were the difficulty of using woody biomass cost-effectively and the lack of a reliable supply of the material; agency activities generally are targeted toward addressing these obstacles. Some officials told us their agencies are limited in their ability to address these obstacles and that incentives—such as subsidies and tax credits—beyond the agencies' authority are needed. However, others disagreed with this approach for a variety of reasons, including the concern that expanding the market for woody biomass could lead to adverse ecological consequences if the demand for woody biomass leads to excessive thinning."

1.3.5 GAO Report to the Chairman, Committee on Resources, House of Representatives

NATURAL RESOURCES

Woody biomass users' experiences offer insights for government efforts aimed at promoting its use.

March, 2006

http://www.gao.gov/new.items/d06336.pdf

"Financial incentives and benefits associated with using woody biomass were the primary factors facilitating its use among 13 users GAO reviewed. Four users received financial assistance (such as state or federal grants) to begin their use of woody biomass, three received ongoing financial support related to its use, and several reported energy cost savings over fossil fuels. Using woody biomass also was attractive to some users because it was available, affordable, and environmentally beneficial.

Several users GAO reviewed, however, cited challenges in using woody biomass, such as difficulty obtaining a sufficient supply of the material. For example, two power plants reported running at about 60 percent of capacity because they could not obtain enough material. Some users also reported that they had difficulty obtaining woody biomass from federal lands, instead relying on woody biomass from private lands or on alternatives such as sawmill residues. Some users also cited increased equipment and maintenance costs associated with using the material.

The experiences of the 13 users offer several important insights for the federal government to consider as it attempts to promote greater use of woody biomass. First, if not appropriately designed, efforts to encourage its use may simply stimulate the use of sawmill residues or other alternative wood materials, which some users stated are cheaper or easier to use than woody biomass. Second, the lack of a local logging and milling infrastructure to collect and process forest materials may limit the availability of woody biomass; thus, government activities may be more effective in stimulating its use if they take into account the extent of infrastructure in place. Similarly, government activities such as awarding grants or supplying woody biomass may stimulate its use more effectively if they are tailored to the scale and nature of the targeted users. However, agencies must remain alert to potential unintended ecological consequences of their efforts."

1.3.6 University of North Dakota

Energy & Environmental Research Center (EERC)

http://www.undeerc.org/programareas/renewableenergy/

Center for Biomass Utilization®

Biomass is a strategic resource in the United States currently comprising only 2% of domestic energy. Increasing the use of biomass can decrease our dependence on foreign oil, improve rural economies, add value to the farm, improve the environment, increase sustainability, and create energy security for local communities and the nation. The Energy & Environmental Research Center (EERC) Center for Biomass Utilization® (CBU®), located on the campus of the University of North Dakota (UND), conducts critical research in biomass utilization. CBU grew out of industry-funded research and development to utilize an array of biomass resources for fuel and energy. Currently, nearly $5 million of activities are funded in CBU through industry investment; local, state, and federal government contracts; and industry–government joint ventures.

What Is Biomass?

Mission
The mission of CBU is to develop technologies for, and promote the use of, biomass for production of biopower, transportation biofuels, and bioproducts as well as mitigate the technical challenges associated with biomass utilization.

Objectives
Specific objectives of CBU include:

- Increasing the use of biomass with coal and other fossil fuel-fired facilities by developing methods for cofiring.
- Investigating the application of biomass fuels for utility and industrial-scale power systems.
- Establishing small-scale distributed energy systems.
- Developing advanced power systems that utilize biomass (gasifiers, fuel cells, ultrasupercritical boilers).
- Researching and demonstrating new bioproducts from agricultural residues, energy crops, and forest residues, such as ethanol, ethanol-derived oxygenates, biodiesel, lactic acid, foods, fiber, and chemicals.
- Conducting outreach activities including education, workshops, and conferences.

1.3.7 Biomass Briefing Paper

January 2005

Jim Williams, Fuels Technician

United States Forest Service Northern Hills Ranger District

Black Hills National Forest, South Dakota

"In order for biomass to be considered a viable source of energy in a particular area, three key things are necessary:

1. *plentiful and sustainable supply of biomass.*
2. *infrastructure capable of harvesting, processing and hauling material.*
3. *Large population base located within the cost effective haul distance of the biomass.*

The Black Hills region has all of these components, making this area a prime place for biomass utilization. The Black Hills cover approximately 1.5 million acres—1.2 million acres are administered by the Black Hills National Forest, the remaining 289,000 acres are in private, state or other federal agency ownership. Timber production is one of the dominant uses of the Black Hills National Forest and is one of the largest industries in this region.

It is estimated that annually 29,000 green tons of biomass are created in delimber piles resulting from timber harvesting. This calculation does not include any biomass created from other vegetation management work (fuels reduction, timber stand improvement) on the District.

It is estimated that an average of 208,000 green tons of biomass are created annually from all vegetation management activities on the entire Black Hills National Forest.

Biomass research and discussions with local foresters indicate that a 50 mile radius from the source of the material is the maximum cost effective distance to haul biomass due to its low value."

1.3.8 Final Report

Evaluating Biomass Energy Opportunities for the Colorado Front Range.

October 31, 2003

http://www.state.co.us/oemc/biomass/overview.html

McNeil Technologies, Inc.

"The project evaluates the potential for bioenergy technology to serve as a market outlet for wood biomass in Colorado's Front Range counties (Boulder, Chaffee, Clear Creek, Custer, Denver, Douglas, El Paso, Fremont, Gilpin, Grand, Huerfano, Jefferson, Lake, Larimer, Las Animas, Park, Pueblo, Saguache and Teller Counties). The study was prompted by concerns over the biomass fuel levels building up in Colorado's forests, particularly the urban-wildland interface and surrounding forest lands. Forest management efforts are being implemented throughout Colorado, and there are few if any market outlets for the biomass material that is being generated through these efforts.

The objective of the work effort is to investigate economically viable bioenergy outlets for small-diameter wood biomass from appropriate forest thinning projects and to reduce the threat of wildfire in Front Range Communities. There are many uses for biomass thinned from overcrowded forests, though most products require only a very small quantity of wood biomass, relative to the quantities available to be removed. Rather than try to increase production of these low-demand products, one option is to use the forest wastes for the potentially large demands of a biomass power industry.

This project consisted of 5 tasks:

1. *Outreach to Communities, Utility Customers and Federal Agencies. Obtain input on public perception of forest restoration activities and biomass power. Conduct a survey of utility customer willingness to pay extra for biomass power and determine federal agency interest in biomass power.*
2. *Boiler Identification and Survey. Create a map and underlying database of utility and large industrial boilers and smaller facility boilers (within Colorado's Front Range area), substantially complete, and in sufficient detail as to prioritize potential candidates for replacement or refurbishment to use biomass fuel.*
3. *Biomass Resource Assessment Update. Provide a county level GIS database (within Colorado's Front Range area) of biomass resource availability and cost from forest restoration activities, urban wood residues, and industry residues.*
4. *Assessment of Biomass Potential. Discuss key opportunities for biomass technology deployment in Colorado.*
5. *Summary Report and Presentations. Document the results of the entire project and prepare recommendations of the best potential opportunities to develop near-term commercially viable outlets for the large quantities of biomass to be generated from forest restoration activities."*

1.3.9 Biomass Guidance

http://www.sierraclub.org/policy/conservation/biomass.asp

Energy Technical Advisory Committee

Sierra Club

Ned Ford, Chair of Energy Technical Advisory Committee.

The Sierra Club has recently posted policy recommendations from the Energy Technical Advisory Committee on their website. According to the website *"Issues surrounding the production of energy by combustion of biomass fuels are complex, sometimes contentious, and involve many different aspects of Sierra Club policy. This guidance is an interpretation of how our existing policies relate to biomass energy issues, rather than a new policy statement. Its purpose is to guide Sierra Club members and the public in understanding our views on many aspect of biomass."*

"This Guidance should be regarded as an assessment of common ground and concerns rather than a resolution of any of the stronger points of contention. It is intended to represent the best thoughts of informed and concerned Club members, and to provide activists with useful information, but concerning issues where both the processes in question and our understanding of them are changing and evolving rapidly, so that embodiment in Club Policy is inappropriate."

"This guidance was prepared by members of the Club's Energy Committee and Environmental Quality Strategy Team (EQST), based on a listserv dialogue among Sierra Club members which lasted approximately six months, starting in October of 1999. The guidance was reviewed and approved by EQST and the Sustainable Planet Strategy Team, which oversees the work of the Energy Technical Advisory Committee, which replaced the Energy Committee at the end of 2000."

"Biomass is considered by many to be a renewable source of energy that does not aggravate global warming because the carbon involved is functioning in a short cycle, and regrowth balances the emissions. However, unsustainable land use practices may release soil carbon to the atmosphere. Accelerated and poorly-managed harvesting of forests and crops as fuel accompanied by the conversion of natural ecosystems to fuel farms will increase global warming and degrade the environment."

"The Sierra Club believes that energy use should be minimized through conservation and efficiency, and that sustainable, renewable energy resources be utilized for human needs. In the near future, efficiency is the only "energy source" which does not incur some environmental damage and which is available immediately in generous supply. Sophisticated building construction, efficient appliances, recycling, modernized industrial processes, "smart" buildings that turn off lights and lower the temperature in unused rooms, programmable thermostats, public transit supplemented by fuel-efficient cars, and many other innovative technologies can reduce energy use tremendously, usually while saving money."

1.4 Key Characteristics of Successful Biomass Conversion Projects

The following project profiles summarize a wide range of projects throughout the United States of America. The profiles of each facility are listed in alphabetical order and include information about the facility, boiler size and type, wood boiler vendor, wood fuel type and year installed. The total project cost and simple payback are listed if known. Key characteristics of each project are noted. Where information for a sub-category is not available the term "NA" is used.

Addison County Courthouse, Middlebury Vermont

Facility Type: *Courthouse*
Existing Fossil Fuel Type/Volume: *Undetermined. Greenfield project.*
Boiler Size: *3,000,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Chiptec*
Wood Fuel Type: *Wood Chips, hardwood mill residue.*
Year Installed: *1994*
Total Project Cost (if known): *$125,000*
Simple Payback (if known): *NA*
Key Characteristics: *Located in the center of Middlebury, Vermont. 100 feet from a shopping mall, supermarket, and adjacent to a town athletic field. Bulkhead fuel door. No external evidence of a wood system. The low project cost is associated with the integration of the wood heating system into a new building.*

Bennington College, Bennington, Vermont

Facility Type: *College Campus*
Existing Fossil Fuel Type/Volume: *Fuel Oil/442,000 gallons.*
Boiler Size: *13,390,000 btu*
Boiler Type: *Steam.*
Wood Boiler Vendor: *AFS Energy Systems*
Wood Fuel Type: *Wood Chips*
Year Installed: *April 2007.*
Total Project Cost (if known): *NA*
Simple Payback (if known): *7 years.*
Key Characteristics: *4800 SF chip storage/ boiler addition to central plant. Project includes energy conservation projects in Administrative buildings and student housing. Campus wide temperature control valves, steam trap replacement.*

Bismarck Public Works Facility, Bismarck, North Dakota

Facility Type: *Office/Storage*
Existing Fossil Fuel Type/Volume: *Natural Gas/1920 dka.*
Boiler Size: *1,000,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *King Coal*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$220,000*
Simple Payback (if known): *14 years*
Key Characteristics: *The wood fired boiler is heated using a semi-automated surge bin system requiring the transfer of chips from a pile adjacent to the surge bin with a small front end loader. Wood fuel is processed on site as a part of a city composting program. Ash produced is disbursed into compost piles.*

Browning School District, Browning, Montana

Facility Type: *High School*
Existing Fossil Fuel Type/Volume: *Natural Gas/11,000 dka.*
Boiler Size: *5,000,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Not yet bid.*
Wood Fuel Type: *Wood Chip*
Year Installed: *Not yet bid.*
Total Project Cost (if known): *Not yet bid.*
Simple Payback (if known): *20 years*
Key Characteristics: *A wood fired heating system was not fully integrated into the building during the design process of a new high school, resulting in the wood fired heating system being housed in a separate building.*

Calumet-Laurium-Keweenaw High School, Calumet, Michigan

Facility Type: *High School*
Existing Fossil Fuel Type/Volume: *Natural Gas & Fuel Oil*
Boiler Size: *7,968,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Wood Energy Systems*
Wood Fuel Type: *Sawdust, Chips and Bark*
Year Installed: *1990*
Total Project Cost (if known): *$400,000*
Simple Payback (if known): *NA*
Key Characteristics: *The School District has purchased sawdust from the nearby Northern Hardwoods mill and other sources based upon availability. A new wood pellet mill in the region is likely to increase the demand for sawdust. The school burns approximately 7 tons per day and pays approximately 150$/7 ton truck load for the fuel (22$/ton). The school could find less expensive fuel if the district owned a live bottom trailer or had more on-site storage. The district currently stores about one half of the annual 1,000 tons of wood fuel needed in nearby warehouses.*

Central Michigan University, Mount Pleasant, Michigan

Facility Type: *97-Building College Campus*
Existing Fossil Fuel Type/Volume: *Natural Gas & Wood*
Boiler Size: *71,530,000 & 72,464,000 (Natural Gas) and 50,000,000 (Wood)*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *Natural Gas: 1961, Wood: Early 1990's, reactivated 2002*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *Central Michigan University returned to burning wood when natural gas prices escalated in 2002. The wood boiler meets 65% of the campus heating requirements and burns 37,000 tons of wood fuel each year at a 2006 price of 26$/ton. Wood fuel comes from within Isabella County and within a 60 mile radius of the campus.*

Central Montana Medical Clinic, Lewistown, Montana
Facility Type: *Hospital*
Existing Fossil Fuel Type/Volume: *Natural Gas/17,800 dka.*
Boiler Size: *8,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *Project canceled.*
Total Project Cost (if known): *$1,262,000 (estimate)*
Simple Payback (if known): *11 years*
Key Characteristics: *Although the project was partially funded from the Montana Fuels For Schools program and the Climate Trust, the project has been canceled. The project is located in a region of Montana with a limited forest products industry infrastructure.*

Central Park Center, Deer Lodge School District, Deer Lodge Montana
Facility Type: *School Pool & Gymnasium*
Existing Fossil Fuel Type/Volume: *Natural Gas/5,000 dka.*
Boiler Size: *1,500,000 btu*
Boiler Type: *Hot Water.*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *Project on Hold*
Total Project Cost (if known): *$566,000*
Simple Payback (if known): *14 years*
Key Characteristics: *The initial bids for the project were approximately 20% higher than projected, and natural gas prices were projected to drop by 20%, resulting in the project being placed on hold.*

Chadron State College, Chadron Nebraska
Facility Type: *College Campus*
Existing Fossil Fuel Type/Volume: *Natural Gas/70,000 dka.*
Boiler Size: *5,000,000 & 8,000,000 btu.*
Boiler Type: *Steam.*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chips.*
Year Installed: *1991*
Total Project Cost (if known): *$1,000,000*
Simple Payback (if known): *NA*
Key Characteristics: *The heats about 20 buildings or about 1.1 million square feet of space. The boiler burns 8,000 tons of wood fuel each year and includes an absorption chiller that uses condensing steam to cool campus facilities.*

City of Craig and Craig School District, Craig, Alaska
Facility Type: *City Pool and School*
Existing Fossil Fuel Type/Volume: *Fuel Oil & Propane/18,750 gallons (Fuel Oil) and 40,000 gallons (propane).*
Boiler Size: *4,000,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Chiptec*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$1,400,000*
Simple Payback (if known): *22 years*
Key Characteristics: *The wood fired boiler provides heat and hot water for a city pool and adjacent school facilities. The community is located in a remote portion of the Alaska panhandle with a mild year round climate.*

Clark Fork Valley Hospital, Plains, Montana

Facility Type: *Hospital*
Existing Fossil Fuel Type/Volume: *Propane/70,000 gallons.*
Boiler Size:*1,200,000-2,400,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Pellet*
Year Installed: *NA*
Total Project Cost (if known): *$250,000-$320,000*
Simple Payback (if known): *6-8 years*
Key Characteristics: *The hospital was expanded in 2004, including additional space in the boiler room and valves in the piping to accommodate a future wood pellet boiler. The project is in development.*

Council School District, Council, Idaho

Facility Type: *K-12 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil/40,000 gallons.*
Boiler Size: *1,875,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2006.*
Total Project Cost (if known): *Unknown (incorporated into a performance contract*
Simple Payback (if known): *NA*
Key Characteristics: *The wood fired boiler is integrated with a heat pump system.*

Darby School District, Darby Montana

Facility Type: *K-12 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil/50,000 gallons.*
Boiler Size: *3,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2003*
Total Project Cost (if known): *$970,000*
Simple Payback (if known): *NA*
Key Characteristics: *First project of the Montana Fuels for Schools program. Wood fired boiler produces steam to heat the existing High School and Junior High School. A steam to hot water heat exchanger provides hot water for kitchen facilities. The project was fully funded by the Fuels For Schools program as a demonstration site for wood heating technology.*

Decker Energy International, Cadillac, Michigan

Facility Type: *Power Plant*
Existing Fossil Fuel Type/Volume: *Wood*
Boiler Size: *300,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *NA*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The 40 megawatt facility burn waste wood.*

District Energy Saint Paul, Saint Paul, Minnesota

Facility Type: *Co-generation of steam, power and chilled water*
Existing Fossil Fuel Type/Volume: *Natural Gas, Fuel Oil & Coal.*
Boiler Size: *NA*
Boiler Type: *NA*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *NA*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility provides heating, cooling and power for downtown St. Paul. Customers use the hot and chilled water to meet their space heating, water heating, processing and air-conditioning needs. Once used in customer buildings, the water is returned to the central plant to be reheated and re-chilled and then re-circulated through the closed-loop piping system.*

District Energy St. Paul uses wood chips (biomass), natural gas, oil or clean-burning coal to fuel its district heating and cooling systems. With the April 2003 startup of an adjacent wood-waste-fired combined heat and power facility, managed by an affiliate, the company reduced its reliance on coal and oil by 80 percent. This produces significant environmental benefits and helps the community solve a local wood waste disposal problem. Our customers benefit from reduced costs, yet another fuel source, and the knowledge that they are using an environmentally sustainable source of "green energy" to heat and cool their buildings.

District energy systems offer many environmental benefits. They increase energy efficiency; reduce air pollution; decrease emissions of ozone-depleting refrigerants; combat global warming; enhance fuel flexibility; facilitate the use of renewable energy; and help manage the demand for electricity.

Eastern Correction Institute, Salisbury, Maryland

Facility Type: *Correctional Facility*
Existing Fossil Fuel Type/Volume: *Fuel Oil*
Boiler Size: *Two boilers 40,000,000 each*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *1987*
Total Project Cost (if known): *$19,500,000*
Simple Payback (if known): *NA*
Key Characteristics: *A stoker boiler with a fuel oil boiler was adapted to burn over-sized wood chips. The wood fired boiler provides steam heat and power using two turbines. The boiler has the capacity to meet all of the power needs of the facility and frequently has the ability to generate more power than needed. Only one local fuel supplier produces the oversized chip fuel needed for the system. Wood fuel costs have risen from a low of 26$/ton to current cost of $40/ton for 54,000 tons per year. A recent investigation determined that making improvements to the system were warranted based on the past performance of the boiler and difference in cost between the fuel oil and wood fuel.*

Eureka School District, Eureka, Montana

Facility Type: *K-12 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil & Propane/37,000 gallons (fuel oil) & 43,000 gallons (propane).*
Boiler Size: *5,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$1,320,000*
Simple Payback (if known): *14 years*
Key Characteristics: *The wood fired boiler provides steam heat for two buildings. Hot water heat is provided for a third building via a steam to hot water heat exchanger.*

Fort Harrison Veterans Administration Hospital, Fort Harrison, Montana

Facility Type: *Hospital*
Existing Fossil Fuel Type/Volume: *Natural Gas (42,000 dka) & Fuel Oil (3,000 gallons).*
Boiler Size: *20,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *NA*
Total Project Cost (if known): *$1,675,000 (estimated).*
Simple Payback (if known): *10 years*
Key Characteristics: *A wood fired heating plant would be built adjacent to the existing steam plant. The facility would be served by two 10 mmbtu boilers in order to more precisely meet the wide difference between summer and winter loading conditions.*

Frenchtown School District, Frenchtown, Montana

Facility Type: *7-12 School*
Existing Fossil Fuel Type/Volume: *Propane/32,000 gallons.*
Boiler Size: *2,000,000*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Pellet*
Year Installed: *NA*
Simple Payback (if known): *35 years*
Total Project Cost (if known): *$250,000-$350,000.*
Key Characteristics: *The existing 80,000 square foot Frenchtown High School will be expanded by an additional 80,000 square feet in 2008. Early in the design process the potential to use locally available wood pellets to heat both the existing high school and new additions was investigated. The existing high school is heated and cooled with a heat pump system with outside air heated in propane fired air handling units. The existing facility uses 22,000 gallons of propane each year.*

An energy model for the proposed additions was developed and used to determine compliance with the Montana Energy Code and to project future propane consumption. The proposed system will use a heat pump and ground water cooling system to heat and cool the facility. A propane fired boiler will be used to provide a 180 degree heating loop to heat the outside air. Although the outside air requirements have increased substantially since the school was originally built in 1980, the additions to the high school are projected to use about 10,000 gallons of propane each year.

Although a wood pellet fired boiler was projected to cost only $100,000 more than a propane fired boiler of similar capacity, displacing most of the existing propane use in the existing air handlers would require an additional $250,000 in order to integrate those systems into the 180 degree boiler system. The school district would need to divert $350,000 from the construction budget to the wood pellet fired boiler project in *order to realize $800,000 of savings over 30 years. The cash flow analysis did not account for the financing costs of the construction funds which would further reduce the effective savings over 30 years to $370,000.*

As a result of this analysis, the Frenchtown School District determined that a wood pellet fired boiler was not appropriate for the project, and that the combination of a well designed building envelop, use of ground water cooling, energy efficient heat pumps and energy efficient 180 degree heating loop provided greater savings without a significant increase in the project costs.

A school addition which replicated the existing heat pump and propane fired heating system is likely to use an additional 12,000 gallons of propane each year. An addition with a conventional roof top air handling heating system would use substantially more propane. The Frenchtown School District will be able to reduce fossil fuel use without converting the system to wood pellets, but provides an instructive lesson in the importance of energy modeling and engineering.

Glacier High School, Kalispell, Montana

Facility Type: *9-12 School*
Existing Fossil Fuel Type/Volume: *Natural Gas/19,000 dka.*
Boiler Size: *6,000,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *PES/Solagen*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$525,000*
Simple Payback (if known): *6 years*
Key Characteristics: *A wood fired heating system was integrated in to the building during the design process of a new 240,000 square foot high school. The low project cost is attributed to the buying power of the overall facility and incorporation into the project during the early stages of design.*

Grayling Generating Station, Grayling, Michigan

Facility Type: *Power Generation*
Existing Fossil Fuel Type/Volume: *Wood & Natural Gas*
Boiler Size: *330,000,000*
Boiler Type: *Steam*
Wood Boiler Vendor: *Zurn Industries*
Wood Fuel Type: *Wood Chips, Wood Waste, Urban Tree Trimmings.*
Year Installed: *1992*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility burns 300,000 tons of wood fuel each year and generates 38,000 kW. The facility burns wood waste from local industries that previously contributed to water pollution in the area. The project was developed to improve water quality, promote economic development and provide power for local industries from a renewable resource.*

Harney District Hospital, Burns, Oregon

Facility Type: *Hospital*
Existing Fossil Fuel Type/Volume: *Propane/11,000 gallons.*
Boiler Size: *750,000 btu.*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *KOB*
Wood Fuel Type: *Wood Pellet*
Year Installed: *2006.*
Total Project Cost (if known): *$269,000*
Simple Payback (if known): *38 years*
Key Characteristics: *The pre-packaged wood pellet boiler and silo is integrated with a heat pump system.*

Hillman Power Plant, Hillman, Michigan

Facility Type: *Power Generation*
Existing Fossil Fuel Type/Volume: *Wood & Natural Gas.*
Boiler Size: *300,000,000*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chips*
Year Installed: *1987*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility burns 230,000 tons of wood fuel each year and generates 20,000 kW.*

Horner Wood Flooring Mill, Dollar Bay, Michigan

Facility Type: *Mill*
Existing Fossil Fuel Type/Volume: *Wood*
Boiler Size: *Three 5,000,000 boilers*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chips, Planer Shavings & Sawdust in suspension.*
Year Installed: *1920 & 1943*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The wood fuel for the boiler includes wood chips, planer shavings and sawdust derived from the manufacturing and kiln drying process, resulting in wood fuel with low moisture content (7-9%), and very high btu value. The facility operates on 100% wood fuel with no fossil fuel back-up. Wood fuel consumption has been reduced through the installation of new combustion technology in existing boilers.*

Kellogg School District, Kellogg, Idaho

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Natural Gas/9,500 dka.*
Boiler Size: *2,000,000*
Boiler Type: *Hot Water*.
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chips.*
Year Installed: *2007.*
Simple Payback (if known): *NA*
Total Project Cost (if known): *Unknown (incorporated into a performance contract*
Key Characteristics: *The wood fired boiler was installed as a part of a performance contract including numerous energy conservation measures focused on reducing the heating, cooling and electrical demands for the facility*.

Middlebury College, Middlebury Vermont

Facility Type: *College Campus*
Existing Fossil Fuel Type/Volume: *Fuel Oil/1,700,000 gallons.*
Boiler Size: *NA*
Boiler Type: *Steam.*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chips.*
Year Installed: *NA*
Total Project Cost (if known): *$3,500,000-$17,500,000 (estimate)*
Simple Payback (if known): *8-11 years*
Key Characteristics: *In 2003, the Biomass Energy Resource Center (BERC) provided a preliminary study of the feasibility of replacing four existing fuel oil boilers with a wood fired combined heat and power (CHP) system. The campus is served from a central heating and power plant. Dual fuel boilers capable of burning*

wood chips and biogas were considered. The project was estimated to generate $440,000 in annual fuel cost savings. A $3,600,000 CHP system was estimated to generate $400,000 in annual fuel costs, $180,000 in annual electricity revenue and $40,000 in Renewable Energy Credits (REC). A $4,700,000 (phase 1) integrated biomass gasification and power plant would replace the oil fired heating and power plant and generate $420,000 in annual fuel cost savings, $2,000,000 in annual electricity revenue and $560,000 in annual REC's. Phase 2 & 3 would cost an additional $12,800,000.

Mid-Peninsula School, Rock, Michigan

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Wood Chips & Fuel Oil.*
Boiler Size: *3,176,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith Manufacturing*
Wood Fuel Type: *Wood Chips & Sawdust*
Year Installed: *1985*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility burns either wood chips at a cost of $36/ton or sawdust at a cost of $32/ton. The fuel is conveyed to the boiler using a chain link conveyor. Trucks typically take 1.5-2 hours to unload the wood fuel. The boiler may be 1,250,000 btu in size.*

Mountain View School District, Kingsley, Pennsylvania

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Fuel Oil*
Boiler Size: *10,800,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chips*
Year Installed: *1991*
Total Project Cost (if known): *$385,000*
Simple Payback (if known): *45 Years at time of construction, 5-8 years using current construction & fuel costs.*
Key Characteristics: *The facility burns 1200 tons of wood fuel per year at a price of $42/ton. The school district has three separate sources of fuel available within the community. The annual fuel savings is currently $176,000 per year. The boiler is located in the 85,00 SF, 700 student elementary school boiler room and is linked to the 110,000 SF, 750 student high school with a hot water heating loop. The buildings are 1,300 feet apart. Existing fuel oil boilers in the High School are used as back up boilers for both buildings.*

Mount Wachusett Community College Gardner, Massachusetts

Facility Type: *College Campus*
Existing Fossil Fuel Type/Volume: *Electric/ 3,400,000 KWH.*
Boiler Size: *8,000,000 btu with fuel oil back-up.*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chips (green hardwood sawmill residue chips).*
Wood Fuel Storage capacity: *85 tons*.
Annual Wood Fuel consumption: *1,000 tons*.
Year Installed: *2002*
Simple Payback (if known): *9 years*
Total Project Cost (if known): *$4,337,911*
Key Characteristics: *The original college campus was built in 1974 and includes 450,000 square feet of electrically heated instruction space. Results of the preliminary study showed potential annual savings of $276,000 with a simple payback on investment (excluding financing) of 8.9 years. College's utility bills have exceeded $750,000 per year. The College has implemented a variety of Energy Conservation Measures (ECMs) including: variable air volume (VA) conversion, installation of variable frequency drives on air handler units, chiller replacements, new efficient lighting, heat pumps, cooling tower replacement, domestic hot water conversion, replacement of unit ventilators and the installation of new domestic hot water heat exchanger. The recent ECMs have reduced total electrical consumption to approximately 8 million KWH at a cost of approximately $670,000. Heating, ventilating, and cooling account for 67.75% of this cost, while lighting, equipment and domestic hot water represent 27.6% and 4.7% respectively. The College was awarded $1,000,000 from the U.S. Department of Energy as part of the FY01 Energy and Water Development Appropriation Bill and was awarded $750,000 from the Massachusetts Technology Collaborative under the auspices of the Massachusetts Renewable Energy Trust Fund. The College has also secured approximately $107,146 in energy rebates from Massachusetts Electric for this project as well as $225,000 from the Massachusetts Division of Capital Asset Management, leaving $1,861,300 to be financed by a Tax Exempt Lease Purchase (TELP).*

The College entered into a shared saving agreement with NORESCO, the principal contractor for this project, which guarantees that the annual energy savings associated with the project ($286,467) will exceed the annual financing charge by a minimum of $8,520, resulting in a positive cash flow in year one of the project. By accelerating the installation of a number of the ECMs, the College also received a 25% bonus rebate of approximately $22,750 from Massachusetts Electric.

The college has partnered with Community Power Corporation of Littleton Colorado to produce combined heat and power from biomass feedstock. This unit is currently in research and development, and is expected to be available for testing in the fall of 2006.
The system originally used a LSR Technologies Inc., Core Separator for emissions controls. In 2004 the emissions control system was replaced with a baghouse system to capture a larger percentage of particulate matter.

North Central Area Junior Senior High School, Powers, Michigan

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Wood Chips & Natural Gas.*
Boiler Size: *3,875,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith Manufacturing*
Wood Fuel Type: *Wood Chip*
Year Installed: *1993*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility burns an average of 800-1,000 tons of wood chips on an annual basis at a cost of $32.50/ton. The heating system was converted from steam to hot water. The school was projected to save approximately $7,500/month when the system was first installed. The system may have been installed prior to 1993.*

North Country Hospital, Newport, Vermont

Facility Type: *Hospital*
Existing Fossil Fuel Type/Volume: *Fuel Oil.*
Boiler Size: *6,500,000 & 16,500,000 btu*
Boiler Type: *290 psi Steam*
Wood Boiler Vendor: *Chiptec.*
Wood Fuel Type: *Wood Chips (varies between 55% mc wet bark to 8% mc veneer materials)*
Year Installed: *2005*
Total Project Cost (if known): *$660,000 (not including turbine and generator)*
Simple Payback (if known): *3 years (fuel oil prices have risen since system was installed)*
Key Characteristics: *The Vermont Community Development Program funded a feasibility study to evaluate the best options for implementing a renewable energy system to meet the heat and power needs of the North Country Hospital. The study recommended that two gasifiers be installed with two 200 bhp 150 psi Hurst boilers and two 150 KW steam turbines. One gasifier was installed.*

The congressionally mandated project funded the purchase and installation of a Chiptec C-14 gasifier, one 500 bhp, 300 psi Hurst boiler and one 265 KW steam turbine. The estimated savings is $400,000 per year at a chip purchase price of $9 per ton.

North Dickinson Schools, Dickinson, Michigan

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Wood Chips & Propane.*
Boiler Size: *NA*
Boiler Type: *NA*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Wood Chip*
Year Installed: *1991*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The facility burns an average of 1,200 tons of wood chips on an annual basis at a cost of $37.50/ton. The facility burns 3,200 gallons of propane at a cost of $1.28/gallon. The school district has found that paying more for a consistent size wood fuel leads to fewer shutdowns.*

Oregon State University Energy Center, Corvallis, Oregon

Facility Type: *University Campus*
Existing Fossil Fuel Type/Volume: *Natural Gas*
Boiler Size: *NA*
Boiler Type: *Steam*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *biodiesel & methane.*
Year Installed: *2008*
Simple Payback (if known): *NA*
Total Project Cost (if known): *$39,000,000*
Key Characteristics: *Oregon State University's central heat plant provides steam heat to most campus buildings. Some buildings also use this energy for cooling. The existing plant was built in 1920 and much of the equipment has been installed over the last 50 to 70 years. The boilers have reached the end of their useful, reliable life and other systems are antiquated, inefficient and in many cases, failing.*

A $39 million replacement facility, currently under design, will generate steam and also generate electricity. This co-generating, or combined heat and power (CHP), technology greatly increases efficiencies by utilizing waste heat from the electrical generation process. A natural gas turbine will generate about 5.5MW. Waste heat from the gas turbine will be run through a heat recovery steam generator. Two back-up boilers are also provided. Total plant capacity will be 250,000 pounds of steam per hour. The systems will be configured for future use of renewable fuels, such as biodiesel and methane.

High-efficiency CHP facilities are being used today on many large college campuses because of high energy efficiency and enhanced reliability. The CHP facility will reduce emissions of nitrogen oxides (NO_X), carbon monoxide (CO), and greenhouse gases such as carbon dioxide (CO_2).

The Energy Center is being designed to the highest level of energy efficiency and will deliver the following benefits:

- *Reduce by at least 30% the fossil fuel needed to produce OSU's electricity.*
- *Reduce air emissions, including an estimated 50-70% reduction in greenhouse gases.*
- *Reduce water consumption by up to 70% compared to conventional power generation.*
- *Provide facilities for sustainable/renewable energy research and demonstration.*
- *Provide facilities for teaching energy and environmental professionals.*
- *Ensure more control over operating costs in an escalating energy market.*
- *Provide power to protect against utility system disruptions.*
- *Minimize transmission losses by generating a large portion of electricity on site.*

The Energy Center building is being designed to LEED green building standards, and is anticipated to achieve a Gold rating, with the possibility of Platinum. Features like rainwater capture for boiler make-up water, and possible onsite wastewater reuse are just two of the innovative features. In addition, the building will include teaching and research facilities in cooperation with OSU colleges. This will provide a vehicle for developing, and testing at a realistic scale, sustainable energy and environmental technology in the future.

Funding is being provided by state bonds, The Climate Trust, and OSU deferred maintenance funds. The new facility should begin operating in fall 2008.

Philipsburg School District, Philipsburg, Montana

Facility Type: *K-12 School*
Existing Fossil Fuel Type/Volume: *Natural Gas/5,000 dka.*
Boiler Size: *3,870,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2004*
Total Project Cost (if known): *$684,000*
Simple Payback (if known): *18 years*
Key Characteristics: *Wood fired boiler provides hot water heat for two adjacent buildings. Additional heating capacity may be used by a nearby hospital.*

Reynolds, Indiana http://www.biotownusa.com

Facility Type: *Community District Heating*
Existing Fossil Fuel Type/Volume: *Natural Gas/8,000,000 dka.*
Boiler Size: *NA*
Boiler Type: *NA*
Wood Boiler Vendor: *NA*
Wood Fuel Type: *Agricultural Waste*
Year Installed: *2007*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *The Indiana State Department of Agriculture has taken the first major step towards converting Reynolds, Indiana, into "BioTown, USA." Launched by Indiana Governor Mitch Daniels in 2005, the BioTown USA project aims to run the tiny town of just over 500 residents entirely on biomass energy and biofuels. Phase I of the project, completed last year, involved installing biofuel pumps to provide the town with E85 (a blend of 85 percent ethanol and 15 percent gasoline) and B20 (a blend of 20 percent biodiesel and 80 percent diesel fuel). The town also replaced its fleet with vehicles able to run on alternative fuels, and 20 lucky town residents were given free two-year leases for new flex-fuel vehicles, which are able to run on E85 or gasoline.*

In 2007, the state broke ground on Phase II of its effort to convert Reynolds to biomass energy. Phase II will involve the construction of a facility with a suite of technologies for converting biomass into electricity, including an anaerobic digester, which uses microorganisms to convert manure into methane; a gasifier, which employs a high-temperature process to convert biomass into a synthetic gas, or "syngas"; and a fast pyrolysis system, which uses high temperatures and an oxygen-free environment to convert biomass into a crude-oil substitute called pyrolysis oil. The methane, syngas, and pyrolysis oil can all be burned as fuel to produce both heat and electricity. The facility is expected to start producing power in late 2007 and will be completed in late 2008.

The community uses an estimated 8 million kilowatt-hours of electricity and nearly 150 million cubic feet of natural gas. The sum total of the town's energy use is estimated at nearly 228 billion Btu (British Thermal Units) of energy. The town and its surrounding county are estimated to produce nearly 17 trillion Btu of potential biomass energy sources in the form of corn grain, soybeans, corn stover (the stalks, leaves, and cobs), sewage waste, grease, and solid waste.

Thompson Falls School District, Thompson Falls, Montana

Facility Type: *K-8 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil/33,000 gallons.*
Boiler Size: *1,600,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Chiptec*
Wood Fuel Type: *Wood Chip & Wood Pellet*
Year Installed: *2005*
Total Project Cost (if known): *$455,000*
Simple Payback (if known): *7 years*
Key Characteristics: *The wood fired boiler is heated using a semi-automated surge bin system requiring the transfer of chips from a pile adjacent to the surge bin with a small front end loader. The system was modified to burn both wood chips and wood pellets.*

Townsend School District, Townsend, Montana

Facility Type: *K-12 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil & Propane/14,000 gallons Fuel Oil/1,880 propane.*
Boiler Size: *2,200,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Solagen*
Wood Fuel Type: *Wood Pellet*
Year Installed: *2007*
Total Project Cost (if known): *$425,000*
Simple Payback (if known): *18 years*
Key Characteristics: *Two existing fuel oil boilers were retrofitted to burn both wood pellets and fuel oil. Whole tree wood pellets with 5% ash content required a pneumatic ash removal system.*

Troy School District, Troy, Montana

Facility Type: *K-6 School*
Existing Fossil Fuel Type/Volume: *Fuel Oil & Electric/6,700 gallons/ 61,580 kwh.*
Boiler Size: *650,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Decton*
Wood Fuel Type: *Wood Pellet*
Year Installed: *2007*
Total Project Cost (if known): *$298,755*
Simple Payback (if known): *24 years*
Key Characteristics: *An existing electric heating/ventilating unit in the gymnasium was added to the boiler load. The existing boiler provides redundancy and capacity for low load and peak load conditions.*

University of Idaho, Moscow, Idaho

Facility Type: *University Campus*
Existing Fossil Fuel Type/Volume: *Natural Gas/550,000 dka.*
Boiler Size: *60,000,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Midwestco*
Wood Fuel Type: *Wood Chip*
Year Installed: *1986*
Total Project Cost (if known): *$3,250,000*
Simple Payback (if known): *NA*
Key Characteristics: *The University of Idaho has been burning approximately 40,000 tons of wood fuel for the past 20 years. The boiler displaces more than 520,000 dka of natural gas each year and includes an absorption chiller that uses condensing steam to cool campus facilities.*

University of Montana-Western, Dillon, Montana

Facility Type: *College Campus*
Existing Fossil Fuel Type/Volume: *Natural Gas /27,000 dka.*
Boiler Size: *13,400,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Chiptec*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$1,400,000*
Simple Payback (if known): *12 years*
Key Characteristics: *Wood fired boiler replaced an existing natural gas boiler. The wood fired boiler heats a small campus of 20 buildings.*

University of South Carolina, Charleston, South Carolina

Facility Type: *University Campus*
Existing Fossil Fuel Type/Volume: *Unknown.*
Boiler Size: *72,000,000*
Boiler Type: *Steam*
Wood Boiler Vendor: *Nexterra*
Wood Fuel Type: *Wood Chip*
Year Installed: *2007*
Total Project Cost (if known): *$16,000,000*
Simple Payback (if known): *NA*
Key Characteristics: *This project was developed by Nexterra and Johnson Controls, a performance contractor. The co-generation facility produces 60,000 pounds of steam per hour and 1.38 MW of electricity that can be used on campus or sold to the grid.*

Victor School District, Victor, Montana

Facility Type: *7-12 School*
Existing Fossil Fuel Type/Volume: *Natural Gas/3,700 dka.*
Boiler Size: *2,600,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2004*
Total Project Cost (if known): *$615,000*
Simple Payback (if known): *40 years*
Key Characteristics: *The wood fired boiler was equipped with a natural gas burner to provide the school district with additional back up capacity. The system was sized to accommodate a proposed expansion of the facility to be constructed in 2007-08.*

Wakefield-Marenisco High School, Wakefield, Michigan

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Natural Gas*
Boiler Size: *3,176,000 btu*
Boiler Type: *Steam*
Wood Boiler Vendor: *Messersmith Manufacturing*
Wood Fuel Type: *Wood Chips*
Year Installed: *1987*
Total Project Cost (if known): *NA*
Simple Payback (if known): *NA*
Key Characteristics: *A local pellet mill went out of business, resulting in a dramatic increase in the cost of wood chips when the hauling distance increased from 5 miles to 300 miles. The School District has not burned wood for the past 5 years as a result. The facility now has 3 natural gas boilers and one wood fired boiler. The facility burned about 750 tons of wood fuel each year.*

Whitefish Township School, Paradise, Michigan

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Propane*
Boiler Size: *1,350,000 btu*
Boiler Type: *Hot Water*
Wood Boiler Vendor: *Messersmith Manufacturing*
Wood Fuel Type: *Pulp Quality Chips*
Year Installed: *1991*
Total Project Cost (if known): *$90,000*
Simple Payback (if known): *12 years*
Key Characteristics: *The wood boiler replaced an existing coal-fired boiler and was able to integrate existing solid fuel conveying equipment. The wood conveying system has been modified to include a pneumatic blower. The boiler has been fitted with a swing-away propane burner. The School District has determined that it is worth paying $75/ton for pulp quality fuel to avoid shutdowns associated with dirt, rocks and irregular lengths of wood. The facility burns approximately 100 tons of wood fuel per year.*

White Pine School District, Ely, Nevada

Facility Type: *School*
Existing Fossil Fuel Type/Volume: *Fuel Oil/12,000 gallons.*
Boiler Size: *3,000,000 btu*
Boiler Type: *Steam.*
Wood Boiler Vendor: *Messersmith*
Wood Fuel Type: *Wood Chip*
Year Installed: *2004.*
Total Project Cost (if known): *Unknown (incorporated into a performance contract).*
Simple Payback (if known): *NA*
Key Characteristics: *This project was the first Fuels For Schools program in Nevada. The boiler/wood chip storage building is constructed using standard metal building systems.*

1.5 Total Project Costs, Projected Savings and Simple Payback Scenarios.

Based upon past feasibility studies and recent projects, the team has summarized the total project costs for a typical project including the cost of the following:

- Feasibility study.
- Detailed engineering investigation.
- Design fees & expenses.
- Building permit costs.
- Air quality permit costs (including engineering fees).
- Chip storage/boiler building costs.
- Mechanical & electrical costs within boiler building.
- Wood fired heating system (including wood handling) costs.
- Stack costs.
- Buried pipe costs.
- Mechanical and electrical integration costs associated with existing boilers.
- Remoteness factor (where applicable).
- Construction contingencies.
- Escalation factors.

1.5.1 Total Project Cost Summaries

Total Project Cost summaries for projects of various sizes are included below. For facilities with small boilers (less than 400,000 btu), the total project cost summary is based upon the assumption that a small wood pellet boiler could be installed in an existing boiler room, fed from bagged pellets, while boilers greater than 400,000 btu would be fed from an adjacent silo.

Boilers greater 1.5 mmbtu and greater in size are estimated to be wood chip boilers located in freestanding boiler buildings.

The project team assumed that as potential projects exceed the 100,000,000 btu size that the total project costs would remain at a constant $0.20/btu, reflecting the probability that a project requiring a 300,000,000 btu boiler would be replaced by three 100,000,000 btu boilers.

Potential projects located in Livingston, Macomb, Monroe, Oakland, Saint Clair, Washtenaw and Wayne counties are projected to have additional costs associated with compliance with PM-2.5 (particulate matter less than 2.5 microns in size) standards for the EPA mandated non-attainment area defined by those county boundaries. Table 1.5.1 includes an estimate of the additional costs associated with including a “bag house” or electro-static precipitator (ESP) to remove particulate less than 2.5 microns is size. Estimating the cost of a “bag house” or electro-static precipitator requires that a design specific to the material burned and is beyond the expertise of the project team. The project team recommended that the project costs remain as developed in this report.

The web-based calculator and website include the following statement regarding project costs: "Projects in Livingston, Macomb, Monroe, Oakland, Saint Clair, Washtenaw and Wayne counties are subject to PM-2.5 EPA non-attainment area standards. In most cases, additional air quality measures are required in this region and will likely result in higher costs. Please see the FAQ's for more information."

A number of boilers in the data base are greater than 1,000,000,000 btu in size. Although these boilers often sorted to the top of the simple payback list, the $200,000,000 price tag for such a facility may restrict project implementation.

Table 1.5.1 A

100,000 Btu Boiler
Installed in Existing Boiler Room

Chip Storage/ Boiler Building:	$0
Wood Heating & Wood Handling System:	$5,545
Silo	$0
20 foot Stack:	$2,500
Mechanical/Electrical within Boiler building:	$0
Buried Pipe	$0
Existing Boiler Room Integration:	$15,000
Air Quality Permit:	$0
Subtotal:	$23,045
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$0
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$3,457
Subtotal:	$28,002
20% Contingency +/- (includes remoteness factor):	$5,600
Subtotal:	$33,602
6% +/- Escalation to bid date (9/2008):	$2,016
Total	**$35,618**

Table 1.5.1 B

200,000 Btu Boiler Installed in Existing Boiler Room	
Chip Storage/ Boiler Building:	$0
Wood Heating & Wood Handling System:	$6,745
Silo	$0
20 foot Stack:	$2,500
Mechanical/Electrical within Boiler building:	$0
Buried Pipe	$0
Existing Boiler Room Integration:	$20,000
Air Quality Permit:	$0
Subtotal:	$29,245
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$5,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$4,387
Subtotal:	$40,132
20% Contingency +/- (includes remoteness factor):	$8,026
Subtotal:	$48,158
6% +/- Escalation to bid date (9/2008):	$2,889
Total	**$51,048**

Table 1.5.1 C

400,000 Btu Boiler Installed in Existing Boiler Room	
Chip Storage/ Boiler Building:	$0
Wood Heating & Wood Handling System:	$13,490
Silo	$15,000
20 foot Stack:	$2,500
Mechanical/Electrical within Boiler building:	$0
Buried Pipe	$0
Existing Boiler Room Integration:	$20,000
Air Quality Permit:	$0
Subtotal:	$50,990
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$5,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$7,649
Subtotal:	$65,139
20% Contingency +/- (includes remoteness factor):	$13,028
Subtotal:	$78,166
6% +/- Escalation to bid date (9/2008):	$4,690
Total	**$82,856**

Table 1.5.1 D

500,000 Btu Boiler Installed in Existing Boiler Room	
Chip Storage/ Boiler Building:	$0
Wood Heating & Wood Handling System:	$50,000
Silo	$15,000
20 foot Stack:	$2,500
Mechanical/Electrical within Boiler building:	$0
Buried Pipe	$0
Existing Boiler Room Integration:	$20,000
Air Quality Permit:	$0
Subtotal:	$87,500
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$5,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$13,125
Subtotal:	$107,125
20% Contingency +/- (includes remoteness factor):	$21,425
Subtotal:	$128,550
6% +/- Escalation to bid date (9/2008):	$7,713
Total	**$136,263**

Table 1.5.1 E

1,500,000 Btu Boiler Installed in Existing Boiler Room	
Chip Storage/ Boiler Building:	$0
Wood Heating & Wood Handling System:	$150,000
Silo	$30,000
30 foot Stack:	$5,000
Mechanical/Electrical within Boiler building:	$0
Buried Pipe	$0
Existing Boiler Room Integration:	$25,000
Air Quality Permit:	$0
Subtotal:	$210,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$5,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$31,500
Subtotal:	$248,000
20% Contingency +/- (includes remoteness factor):	$49,600
Subtotal:	$297,600
6% +/- Escalation to bid date (9/2008):	$17,856
Total	**$315,456**

Table 1.5.1 F

2,500,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$100,000
Wood Heating & Wood Handling System:	$250,000
Silo	$0
50 foot Stack:	$50,000
Mechanical/Electrical within Boiler building:	$50,000
Buried Pipe	$25,000
Existing Boiler Room Integration:	$25,000
Air Quality Permit:	$0
Subtotal:	$500,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$7,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$75,000
Subtotal:	$584,000
20% Contingency +/- (includes remoteness factor):	$116,800
Subtotal:	$700,800
6% +/- Escalation to bid date (9/2008):	$42,048
Total	**$742,848**

Table 1.5.1 G

5,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$100,000
Wood Heating & Wood Handling System:	$300,000
Silo	$0
50 foot Stack:	$50,000
Mechanical/Electrical within Boiler building:	$50,000
Buried Pipe	$25,000
Existing Boiler Room Integration:	$25,000
Air Quality Permit:	$0
Subtotal:	$550,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$7,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$82,500
Subtotal:	$641,500
20% Contingency +/- (includes remoteness factor):	$128,300
Subtotal:	$769,800
6% +/- Escalation to bid date (9/2008):	$46,188
Total	**$815,988**

Table 1.5.1 H

10,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$150,000
Wood Heating & Wood Handling System:	$450,000
Silo	$0
50 foot Stack:	$50,000
Mechanical/Electrical within Boiler building:	$50,000
Buried Pipe	$25,000
Existing Boiler Room Integration:	$25,000
Air Quality Permit:	$5,000
Subtotal:	$755,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$10,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$113,250
Subtotal:	$879,750
20% Contingency +/- (includes remoteness factor):	$175,950
Subtotal:	$1,055,700
6% +/- Escalation to bid date (9/2008):	$63,342
Total	**$1,119,042**

Table 1.5.1 I

10,000,000 Btu Boiler (Located In PM-2.5 Non-Attainment Areas) Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$150,000
Wood Heating & Wood Handling System:	$450,000
Silo	$0
50 foot Stack & Air Quality Controls:	$200,000
Mechanical/Electrical within Boiler building:	$50,000
Buried Pipe	$25,000
Existing Boiler Room Integration:	$25,000
Air Quality Permit:	$10,000
Subtotal:	$910,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$10,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$136,500
Subtotal:	$1,058,000
20% Contingency +/- (includes remoteness factor):	$211,600
Subtotal:	$1,269,600
6% +/- Escalation to bid date (9/2008):	$76,176
Total	**$1,345,776**

Table 1.5.1 J

15,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$200,000
Wood Heating & Wood Handling System:	$650,000
Silo	$0
50 foot Stack:	$50,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$10,000
Subtotal:	$1,110,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$12,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$166,500
Subtotal:	$1,290,500
20% Contingency +/- (includes remoteness factor):	$258,100
Subtotal:	$1,548,600
6% +/- Escalation to bid date (9/2008):	$92,916
Total	**$1,641,516**

Table 1.5.1 K

15,000,000 Btu Boiler (Located In PM-2.5 Non-Attainment Areas) Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$200,000
Wood Heating & Wood Handling System:	$650,000
Silo	$0
50 foot Stack & Air Quality Controls:	$225,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$15,000
Subtotal:	$1,290,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$12,500
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$193,500
Subtotal:	$1,497,500
20% Contingency +/- (includes remoteness factor):	$299,500
Subtotal:	$1,797,000
6% +/- Escalation to bid date (9/2008):	$107,820
Total	**$1,904,820**

Table 1.5.1 L

20,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$250,000
Wood Heating & Wood Handling System:	$800,000
Silo	$0
50 foot Stack:	$50,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$10,000
Subtotal:	$1,310,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$15,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$196,500
Subtotal:	$1,523,000
20% Contingency +/- (includes remoteness factor):	$304,600
Subtotal:	$1,827,600
6% +/- Escalation to bid date (9/2008):	$109,656
Total	**$1,937,256**

Table 1.5.1 M

20,000,000 Btu Boiler (Located In PM-2.5 Non-Attainment Areas) Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$250,000
Wood Heating & Wood Handling System:	$800,000
Silo	$0
50 foot Stack & Air Quality Controls:	$250,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$10,000
Subtotal:	$1,515,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$15,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$227,250
Subtotal:	$1,758,750
20% Contingency +/- (includes remoteness factor):	$351,750
Subtotal:	$2,110,500
6% +/- Escalation to bid date (9/2008):	$126,630
Total	**$2,237,130**

Table 1.5.1 N

25,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$250,000
Wood Heating & Wood Handling System:	$900,000
Silo	$0
75 foot Stack:	$75,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$10,000
Subtotal:	$1,435,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$15,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$215,250
Subtotal:	$1,666,750
20% Contingency +/- (includes remoteness factor):	$333,350
Subtotal:	$2,000,100
6% +/- Escalation to bid date (9/2008):	$120,006
Total	**$2,120,106**

Table 1.5.1 O

25,000,000 Btu Boiler (Located In PM-2.5 Non-Attainment Areas) Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$250,000
Wood Heating & Wood Handling System:	$900,000
Silo	$0
75 foot Stack & Air Quality Controls:	$275,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$15,000
Subtotal:	$1,640,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$15,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$246,000
Subtotal:	$1,902,500
20% Contingency +/- (includes remoteness factor):	$380,500
Subtotal:	$2,283,000
6% +/- Escalation to bid date (9/2008):	$136,980
Total	**$2,419,980**

Table 1.5.1 P

30,000,000 Btu Boiler Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$350,000
Wood Heating & Wood Handling System:	$1,000,000
Silo	$0
75 foot Stack:	$75,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$10,000
Subtotal:	$1,635,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$20,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$245,250
Subtotal:	$1,901,750
20% Contingency +/- (includes remoteness factor):	$380,350
Subtotal:	$2,282,100
6% +/- Escalation to bid date (9/2008):	$136,926
Total	**$2,419,026**

Table 1.5.1 Q

30,000,000 Btu Boiler (Located In PM-2.5 Non-Attainment Areas) Installed in Freestanding Boiler Room	
Chip Storage/ Boiler Building:	$350,000
Wood Heating & Wood Handling System:	$1,000,000
Silo	$0
75 foot Stack & Air Quality Controls:	$300,000
Mechanical/Electrical within Boiler building:	$100,000
Buried Pipe	$50,000
Existing Boiler Room Integration:	$50,000
Air Quality Permit:	$15,000
Subtotal:	$1,865,000
Feasibility Study:	$1,500
Detailed Engineering Investigation:	$20,000
Design Fees, Building Permit, Miscellaneous Expenses 15%:	$279,750
Subtotal:	$2,166,250
20% Contingency +/- (includes remoteness factor):	$433,250
Subtotal:	$2,599,500
6% +/- Escalation to bid date (9/2008):	$155,970
Total	**$2,755,470**

1.5.2 Projected Cost Savings

The projected cost savings for a typical wood fired heating system project include the following items:

- *Current annual heating costs (example: 50,000 gallons of fuel oil @ 2$/gallon or **$100,000**/year.)*
- *Current Operations and Maintenance costs associated with the existing boiler. (example: **$2,500** annual maintenance contract for summer shutdown and cleaning).*
- ***Subtotal: $102,500.***

- *Projected wood heating system costs (assumes 95% of heat is provided by wood heating system) (example: 790 tons @35$/ton or **$27,650**/year).*
- *Projected existing heating system costs (assumes 5% of heat is provided by existing heating system in low load and peak load conditions). (example: 2,500 gallons @ 2$/gallon or **$5,000**/year)*
- *Projected Operations and Maintenance costs associated with the wood fired heating system (assumes that operations and maintenance costs of wood fired heating system will be greater than existing operations and maintenance for existing heating system. (example: 30 minutes per day spent removing ash, clearing wood fuel jambs from the conveying system for 180 day heating season, 90 hours @ 55$/hour including wages and benefits or **$5,000**/year).*
- ***Subtotal: $37,650***

- ***Annual Savings: $64,850** ($102,500-$37,650)*

Detailed investigations of wood fired heating systems typically include the identification of energy conservation measures that may reduce existing heating costs and reduce the volume of existing and wood fuels consumed.

1.5.3 Simple Payback

The simple payback for a typical project is calculated by dividing the total project cost by the projected annual savings. For example, in the scenario described above, if the total project cost for a wood fired heating system was $648,500, the simple payback would be 10 years. If the total project costs were $1,297,000, the simple payback would be extended to 20 years.

As noted in the analysis of the existing database in Section 2 of this report, the projected payback was sorted into categories of less than 1 year, 1-5 years, 6-10 years, 11-15 years, 16-20 years and 21 years or greater. It has been the experience of the project team that very few facility owners or managers are willing to support conversion projects with a simple payback greater than 20 years.

1.5.4 Positive Cash Flow

A detailed analysis of a potential wood fired heating system typically includes a cash flow analysis. The cash flow analysis looks not just at the simple payback of the project, but the impact of borrowing money to finance the project and the impact of the project financing on the overall cash flow for the project.

For example, if a facility manager borrows $648,500 @ 5% for 10 years, the annual payment to the lending institution would be $84,000, negating the $64,850 year one savings noted in section 1.4.2. This deficit can only be over come by accounting for the impact of inflation on the existing heating costs (fuel and operations and maintenance) and wood fired heating system costs (fuel and operations and maintenance). In general existing heating system costs escalate at a more rapid rate than locally available and renewable source of fuel such as wood. Thus, over time, positive cash flow is achieved in spite of negative cash flow during the first few years of a project. In many cases projects must produce significant savings in the first year of operation in order to proceed.

Section 2: Analysis of Existing Boiler Database.

2.1 Review of DLEG/DEQ Boiler Databases

The team reviewed the databases provided by the Committee and determined that both the Michigan Air Pollution Reporting System (MAPRS) and Michigan Air Emissions Reporting System (MAERS) databases contain approximately the same quantity of boilers. The team converted the MAPRS file named michigan_boilers.mbd from access to excel format. The file NIFv3_MAERS_export_1998to2004.mdb contained primarily emissions data, and was not relevant to the study. The team recommended that the MAPRS database be used, subdivided by county and reduced to the following categories:

- *Boiler Number.*
- *Year Installed (The database also includes year of manufacture, but a brief comparison of the year installed and year of manufacture were almost always the same with occasional one or two year differences attributable to standard construction practices where a boiler might be manufactured one year and operational the following year).*
- *Fuel Type (Coal, Gas, Propane, Fuel Oil, Waste, Wood).*
- *Boiler Use (Hot Water Heat, Hot Water Supply, Steam Heat, Process Steam, Power). The term "power" typically refers to boilers producing steam greater than 15 psi. It is possible that the term "power" in this database refers to boilers used to produce electricity.*
- *Location Name (In order to identify multiple boilers in a single facility).*
- *City/State (in order to aid in the identification of communities within counties that may have a greater number of projects suitable for conversion).*
- *Boiler Size (in BTU input).*

2.2 Facility Type

The database does not include a category for Facility Type. An average Facility Utilization Factor (FUF) of 10% has been assigned to all facilities to calculate the simple payback for each boiler project. Although this approach to sorting the data results in overstating the simple payback for office and retail facility boilers and understating the simple payback for power plants, hospitals and detention facilities, sorting the data using an average FUF will identify trends within the database.

The original intent of this study was to quantify the types of boilers in numeric form in order to identify the number of boilers serving various facility types and to assign a Facility Utilization Factor (FUF) to each. The FUF is a placeholder factor (in lieu of gathering actual energy records) that compares average annual energy use to a percentage of the peak capacity of the boiler. This number typically varies between 3-15% depending upon facility type. Power generation facilities may have FUF's of 75% or more.

- *Power Generation* *75%*
- *Detention Centers, Health Care* *15%*
- *Schools* *10%*
- *Office, Commercial* *5%*

As an example, a 5,000,000 btu boiler in a school would be assigned a FUF of 10%, resulting in an estimated 4,380 dka of natural gas per year (5,000,000 btu x 10% x 8760 hours). At 10$/dka, this school's annual heating bill would be $43,000 which would be expected for a facility with a boiler of this size located in Michigan.

After further investigation it was determined that the boiler databases available did not contain a "facility type" category. The team and committee determined that using an average FUF for all boilers would be an effective means of assigning potential fuel use to each boiler. The team has applied a FUF of 10% to all boilers in the database.

The web-based calculator will allow for greater definition of facility type than the general database.

The use of the 10% FUF does not change the ranking of projects but does change the length of the Simple Pay Back and the quantity of projects with simple paybacks less than 20 years. For example if a 5% FUF were to be applied to the database, approximately 263 boilers would have simple paybacks less than 20 years. If a 15% FUF were to be applied to the database, approximately 5,942 boilers would have simple paybacks less than 20 years.

2.3 Errors in Database

A small percentage of most categories in the database include incomplete information, with the exception of btu input where 10 percent of the database contained missing or incorrect information. The team identified this information in the summary as Not Applicable (NA). For example, the btu input size of some of the boilers is listed as zero or in some cases less than 500. For the boilers with values less than 500, the number is likely to represent boiler horse power rather than btu's, but the team did not modify the data provided.

Boilers with btu inputs of less than 50,000 btu's have been culled from the detailed analysis, but accounted for in the gross analysis of categories for each county. In some cases the btu input information is missing. In other cases, the numbers less than 50,000 btu's may be typographic errors (50,000 versus 500,000), or improper coding of the data (500 bhp versus 17,250,000 btu (500 bhp x 34,500 btu). Rather than correct these errors, the team dropped these boilers from the detailed review of simple payback.

During the development of the report the team identified three boilers (South Michigan State Prison, Greenwood Energy Plant & Toyota Technical Center) with paybacks less than 10 years that may have had errors in the boiler size category. The team contacted the boiler operators at those facilities to determine the actual boiler size and corrected the database. The team also identified seven existing wood fired boilers in five facilities that listed the boiler size as “zero” (Grayling Power Station, Horner Flooring, Potlach, Hillman Power and White Pine Power). The team contacted the operators of these facilities, or used web resources to identify the actual boiler size and corrected the database. The committee has identified other boilers in the upper peninsula such as the NEWPAGE boiler in Escanaba that is known to burn more than 400,000 tons of wood fuel each year. The boiler database lists each of the NEWPAGE boilers as natural gas or fuel oil boilers with btu input sizes of zero. The project team was not able to determine which of these boilers has been burning wood fuel.

The database occasionally includes designations of “PROP” or “PROPANE.” It is probable that the use of propane is more widespread than recorded in the database. The database has been modified to change all spellings of propane to “PROPANE.” The database was also modified to correct spellings of “COAL”, “GAS” and “ELECTRIC.”

2.4 Coal Boilers

Coal boilers in each county have been identified for additional investigation beyond the scope of this project. In general the price of coal per decatherm (1 million btu) and the price of wood chips per decatherm are the same. The price of wood pellets per decatherm is greater than the price of coal. As a result of the price similarity between wood chips and coal, no cost savings would be achieved, and thus a simple payback could not be calculated. The greater cost of wood pellets also assures that no cost savings would be achieved.

Existing coal facilities may be good candidates for conversion to wood fuels since the receiving, storage and conveying equipment is in place and the facility users have a history of handling solid fuels. Depending on the form of coal being burned (solid, pulverized, etc), only minor modifications may be required to co-fire coal and wood, or to burn wood fuels exclusively. The lower btu value of wood fuels presents a separate problem for large coal burning facilities. For every ton of coal burned, approximately 2 tons of wood fuel would be burned. In the case of very large facilities (greater than 100,000,000 btus), the available wood fuel in the region and infrastructure for transporting it to facilities may not exist.

Boilers in existing power generation facilities often contain smaller boilers for pre-heating the boiler feed water and larger boilers for power generation. Many power generation facilities operate on standby. The combination of these factors would increase project costs associated with a wood fired boiler because 100% of the boiler capacity may be needed to meet the power demand.

2.5 Cost Difference Between Existing Fuels and Wood Fuels

As noted in the table below, projects with the greatest difference in existing fuel price and wood fuel price will rank higher in terms of simple payback than projects with smaller differences. All fuel costs listed below have been stated in costs per decatherm (1 million btu) and adjusted for system efficiencies.

Table 2.5.A

	Fuel Oil	Propane	Natural Gas	Coal	Electric
	$22.00	$27.00	$13.00	$5.00	$29.00
Wood Chips	-$5.00	-$5.00	-$5.00	-$5.00	-$5.00
	=$17.00	=$22.00	=$8.00	=$0.00	=$24.00
Wood Pellets	-$12.00	-$12.00	-$12.00	-$12.00	-$12.00
	=$10.00	=$15.00	=$1.00	-$7.00	$17.00

The smallest Natural Gas, Fuel Oil, Propane and Electric boilers that would generate a simple payback of less than 10 and 20 years are noted below in table 2.5.B. The identification of the "tipping points" for each of the existing fuel types will allow the committee to focus outreach efforts on projects that are likely to produce simple paybacks of less than 10 and 20 years.

Table 2.5.B

	Fuel Oil	Propane	Natural Gas	Electric
Simple Payback <10 years	5,000,000 btu	2,500,000 btu	25,000,000 btu	1,500,000 btu
Simple payback <20 years	102,150 btu	77,825 btu	6,770,000 btu	71,350 btu

2.6 Impact of Boiler Size on Simple Payback

Since the simple payback calculation is based upon the total project cost and annual fuel savings, projects with large boilers and larger annual fuel savings will rank higher than facilities with small boilers and smaller annual fuel savings.

Boilers between 750,000 and 2.5 million btu's are not clearly wood chip or wood pellet projects. In general the total project costs per btu are higher for this category of boilers and result in longer simple paybacks.

The simple payback calculation is based upon the assumption that a wood fired boiler will be one half the output of the existing boiler in order to size the boiler for a significant base load and avoid the infrequent peak load conditions. Wood fired boilers operate best when in high fire mode, and do not modulate well to low load conditions.

2.7 Sorting of Database by Boiler Size (btu output)

The database has been sorted based upon British Thermal Unit (btu) output in general categories based upon common sizes of wood fired heating systems.

- *less than 750,000 btu*
- *750,001- 2,500,000 btu*
- *2,500,001-5,000,000 btu*
- *5,000,000-10,000,000*
- *10,000,001-15,000,000*
- *15,000,001-25,000,000*
- *25,000,001 and greater*

The quantity of boilers in each category is summarized in Appendix A.

2.8 Sorting of Database by Boiler Age

The boiler database has been sorted according to age into general categories:

- 2000-present
- 1980-1999
- 1960-1979
- 1945-1959
- older than 1944

The age category is less significant than originally projected. Although older boilers are likely to be replaced, the total project cost would be reduced only by the cost of a fossil fuel boiler with equivalent capacity. The total project cost used in this investigation accounts for the fact than boilers less than 1.5 mmbtu could be located in existing boiler rooms rather than in freestanding facilities. In general boiler rooms have become significantly smaller since 1945, reducing the potential to locate a new wood boiler in an existing boiler room. Since very few boilers across the State of Michigan are older than 1945, the team assumed that very few large wood fired boilers could be located in existing boiler rooms.

The team recommends that the committee promote the potential for integrating wood fired heating systems into new facilities through economic development councils and other development organizations.

2.9 Determining Payback

The team sorted the boiler database using the existing boiler size to determine a total project cost, calculate annual fuel savings and determine the simple payback for each potential project.

2.9.1 Determining Boiler Size:

The boiler size is first reduced by 50% to address the problems associated with sizing wood fired boilers to meet infrequent peak load conditions (approximately 15 minutes every 5 years). Fossil fuel boilers typically modulate very well between high and low loads. Wood fired boilers do not. A typical wood fired heating system in an existing building can be designed to meet about half of the peak load and to take advantage of the capacity of the existing fossil fuel boiler for peak loads while maximizing the efficiency of the wood fired boiler to meet 90-95% of a typical annual load.

<u>*Example: Existing 1,000,000 btu boiler*</u>

1,000,000 btu x.5 = 500,000 btu wood boiler

<u>*Example: Existing 10,000,000 btu boiler*</u>

10,000,000 btu x.5 = 5,000,000 btu wood boiler

2.9.2 Calculating Total Project Cost:

The reduced boiler size is multiplied by a cost per btu factor developed by the team that reflects projected and actual project costs from more than 170 projects. This factor changes between each of the boiler size ranges. This factor is relatively high for very small boilers ($0.40/btu for boilers less than 100,000 btus) and falls to $0.36/btu for boilers of 750,000 btus before continuing to decline to a low of $0.08/btu for boilers of 25,000,000 btus. The factor increases again to $0.20/btu as boiler sizes approach 100,000,000 btus. The variations in this equation reflect the team's experience with wood fired heating system projects in facilities with boilers of a wide range of sizes.

The project team assumed that as potential projects exceed the 100,000,000 btu size that the total project costs would remain at a constant $0.20/btu, reflecting the probability that a project requiring a 300,000,000 btu boiler would be replaced by three 100,000,000 btu boilers.

A number of boilers in the data base are greater than 1,000,000,000 btu in size. Although these boilers often sorted to the top of the simple payback list, the $200,000,000 price tag for such a facility may restrict project implementation.

Example: Existing 1,000,000 btu boiler

1,000,000 btu x.5 = 500,000 btu x $0.38/btu = $190,000 Total Project Cost

Example: Existing 10,000,000 btu boiler

10,000,000 btu x.5 = 5,000,000 btu x $0.21/btu= $1,050,000 Total Project Cost

2.9.3 Calculating Annual Savings:

The annual fuel savings is calculated by multiplying the existing boiler size by the 10% FUF and by the difference in cost between the existing fossil fuel and the projected wood fuel. For boilers less than 1.5 mmbtu the wood fuel is assumed to be wood pellets. For projects greater than 1.5 mmbtu, the price for wood chips are used. As noted in table 2.5A, projects with a greater difference in cost between existing fuel and wood fuel will generate greater annual fuel cost savings. The annual fuel savings is reduced by the projected increase in cost for the operations and maintenance of the wood fired heating system. In general only modest increases in operations and maintenance costs are expected for small boilers, and greater increases are expected for larger boilers. The majority of the increase in operations and maintenance costs are associated with ash removal and resolving alarm conditions associated with oversized fuel.

Example: Existing 1,000,000 btu boiler ($13/dka natural gas & $12/dka wood pellets)

1,000,000 btu x.10 FUF = 100,000 btu x 8760/ $1/1,000,000 = $876 Annual Fuel Savings - $500 increase in Operations & Maintenance Costs = $376 Annual Savings.

Example: Existing 1,000,000 btu boiler ($27/dka propane & $12/dka wood pellets)

1,000,000 btu x.10 FUF = 100,000 btu x 8760/ $15/1,000,000 = $13,140 Annual Fuel Savings -$500 increase in Operations & Maintenance Costs = $12,640 Annual Savings.

Example: Existing 10,000,000 btu boiler ($13/dka natural gas & $5/dka wood chips)

10,000,000 btu x.10 FUF = 1,000,000 btu x 8760 hours / $8/1,000,000 btu = $70,008 Annual Fuel Savings-$5,000 increase in Operations & Maintenance Costs = $65,008 Annual Savings.

Example: Existing 10,000,000 btu boiler ($27/dka propane & $5/dka wood chips)

10,000,000 btu x.10 FUF = 1,000,000 btu x 8760 hours / $22/1,000,000 btu = $192,720 Annual Fuel Savings-$5,000 increase in Operations & Maintenance Costs = $187,720 Annual Savings.

2.9.4 Calculating Simple Payback:

The total project cost is divided by a projected annual savings to arrive at the simple payback.

Example: Existing 1,000,000 btu natural gas boiler

$190,000 Total Project Cost / $376 Annual Savings= 505 year Simple Payback

Example: Existing 1,000,000 btu propane boiler

$190,000 Total Project Cost / $12,640 Annual Savings= 15 year Simple Payback

Example: Existing 10,000,000 btu natural gas boiler

$1,050,000 Total Project Cost / $65,008 Annual Savings= 16 year Simple Payback

Example: Existing 10,000,000 btu propane boiler

$1,050,000 Total Project Cost / $187,720 Annual Savings= 6 year Simple Payback

2.10 Identify Best Indicators For Initial Conversion Feasibility.

The team sorted the database using process noted above. Using this process, the ideal conversion candidates have been identified for further investigation.

Past surveys of project drivers for conversion to wood fired boilers have identified three key factors that impact project viability. Those factors include the cost savings, the availability of wood feedstock and environmental impacts. The availability of wood feedstock and environmental impacts have rarely proven to become barrier to project success, but projects that do not generate positive cash flow in a short period of time are less likely to proceed than projects which generate positive cash flow during the first few years of operation. This project driver was originally attributed to private sector facility managers with immediate payback concerns. The team has found that public sector facility managers with limited resources also expect positive cash flow during the first few years of operation.

Based upon past experience the team has identified three factors that have the greatest impact on the financial success of a project—the facility type, boiler size and boiler age. The facility type impacts the annual fossil fuel costs (unit cost x volume), which are substantially higher in hospitals and prisons than schools which are higher than office and commercial facilities. The boiler size impacts project viability at both ends of the spectrum. Many manufacturers produce small wood pellet fired hot water boilers at competitive costs between 200,000 and 750,000 btu. Between 750,000 and 1,000,000 btu, wood pellet boiler become substantially more expensive than fossil fuel boilers without a decrease in wood fuel costs. A very limited number of wood pellet boiler manufacturers provide boilers producing steam. Boilers greater than 1,000,000 btu and less than 2,500,000 btu in size can be readily converted to either wood chip or wood pellet boilers. Above 2,500,000 btu most conversion projects are likely to wood chip boilers.

The impact of boiler age is less clear. Modern boilers are substantially more efficient than boilers installed prior to 1980, with each 20 year period representing dramatic increases in efficiency over previous 20 year periods. Boilers greater than 30 years of age have exceeded the useful service life of the boiler and are likely to be replaced. Engineering practices have also changed over time. Basic rule of thumb calculations for btu's/square foot have been replaced with climate data and energy modeling that allow engineers to identify the optimal size of a boiler with greater certainty of how often the boiler will operate at various levels between low load, moderate loads, high loads and peak loads. In general boilers operate under peak load conditions for very short durations very few years. If a wood fired boiler were to be sized for peak load conditions, it is likely to operate under low to moderate loads under most conditions.

2.11 Results for Individual versus Multiple Boilers.

The database has been sorted in a manner that identifies the simple payback of each individual boiler in the database. The team has noted a number of examples of multiple boilers in a single facility that individually may have a simple payback of greater than 20 years, but collectively have a simple payback less than 20 years.

For example, Alcona High School in Lincoln, Michigan has three 2,200,000 btu natural gas boilers. The simple payback for each individual boiler is projected to be 917 years. If the project is viewed as a combined boiler capacity of 6,600,000 btu's the simple payback is projected to be 20 years.

In Alger County the Alger Correctional Facility in Munising, Michigan has 2 electric and 10 fuel oil boilers with paybacks between 18 and 498 years respectively. If the project is viewed as a combined boiler capacity of 12,374,000 btu's the simple payback is projected to be 15 years.

The Standish Community Hospital in Standish, Michigan is served by three natural gas boilers with simple paybacks between 16 and 24 years. If the project is viewed as a combined boiler capacity of 8,580,000 btu's the simple payback is projected to be 18 years.

Examples such as those provided above occur in almost every county. An additional 700 boilers may have simple paybacks less than 20 years when the combined boiler capacity is considered in the total project costs. The team recommends that the committee review the summaries for each county and consider contacting facility managers with multiple boilers.

2.12 Identifying Biomass Feedstock Sources and Processing Infrastructure.

Access to a sustainable source of wood fuel has been identified as an important factor by potential end users of wood fired heating systems. In addition to identifying potential sources of fuel, the local infrastructure for processing and delivering the wood fuel must exist to bring the fuel to facilities for use. Although the emerald ash borer damage has resulted in millions of tons of wood fuel, those sources may not continue to be available over time. Other considerations include the potential to access wood fuels through urban forestry management programs, such as the very successful urban forestry program in Minneapolis and Saint Paul that serves as a major feedstock for District Energy Saint Paul, one of the largest wood fuel users in the Midwest. Feed stock could also be processed into pellets, for consumption in boilers of all sizes.

The team has used three methods for determining the potential feedstock available in each county—feedstock studies, wood products database and existing wood boiler locations. An overview of each of these methods is presented below. The combined research found in each of the feedstock studies suggests that large quantities of wood fuel are available throughout the state, but that the infrastructure for processing and delivering the fuel may not be in place in all areas. The wood products industry data suggests that the western portion of the Upper Peninsula and the northern and western portion of the Lower Peninsula are within a 50 mile range of existing wood fired power plants, existing wood boilers and pellet mills, suggesting that the infrastructure for processing and hauling wood fuel is active in those areas. Studies of urban wood waste in southeastern Michigan indicate that 58% of urban wood waste may be available as a potential feedstock for wood fired boilers.

Potential project developers should conduct local investigations into the availability and cost of wood fuel in the region before proceeding with a project.

2.12.1 Urban Wood Waste in Michigan

Six recent feedstock studies were reviewed and quantities of wood fuels available in each county were identified. The initial study entitled "Urban Wood Waste in Michigan: Supply and Policy Issues" was prepared by Public Policy Associates in September of 1994. The report identified approximately 659,000 tons of Urban Wood Waste (UWW) is available on an annual basis.

Table 2.12.1A

Table 15. Annual Processing and Capacity Utilization Rates for all UWW Components (in Tons)

UWW Type	Capacity	Quantity	Market Share	Utilization Rate	MMBtus
Pallets	416,000	300,560	46%	72%	4,207,840
Wood Scraps	93,210	58,240	9%	62%	815,360
Construction	258,570	90,610	14%	20%	1,268,540
Demolition	230,100	34,580	5%	15%	484,120
Tree Trim	3,510	2,925	8%	83%	495,837
	0	52,168			
Land Clearing	10,400	7,020	1%	68%	63,180
Plywood/Particleboard	17,770	11,050	2%	62%	154,700
RR Ties	0	20,025	14%		1,330,350
	0	75,000			
Other	17,160	7,150	1%	42%	28,600
Subtotal	537,510	300,528	100%	3	3,825,327

a. Capacity of construction waste is calculated for Detroit, Grand Rapids and Lansing firms only; other
area firms are excluded because capacity was not reported for all firms in other areas.
b. Survey results of urban forestry and utility line clearance operations did not include capacity data.
c. Rail line survey did not include capacity data.
d. this overall capacity utilization rate is based on those firms reporting both capacity and UWW processing. This rate would most likely be greater if all firms reporting quantities of UWW processing included capacity as well.
e. Conversion factors to convert wood type weight to energy units (MMBtus) were obtained from the
Michigan Wood & Paper Residue Study: 7,000 Btu/lb for all types except 4500 Btu/lb for tree trimming and land clearing residue.

Source: Urban Wood Waste in Michigan Final Report September 1994 page 56.

2.12.2 Biomass Feedstock Availability in the United States: 1999 State Level Analysis

The "Biomass Feedstock Availability in the United States: 1999 State Level Analysis" was updated by the authors (Marie E. Walsh and others) in January of 2000. The report identifies estimated annual quantities of Forest Residue, Mill Residue, Agricultural Residue and Urban Wood Waste available throughout the state of Michigan. According to the report, approximately 2,400,000 tons of biomass at a price of less than $30/ton is available on an annual basis.

The National Renewable Energy Laboratory (NREL) issued a report entitled "Highlights of Biopower Technical Assessment: State of the Industry and the Technology" in April of 2003. The report also refers to 2,400,000 tons of biomass available in Michigan, but at a price of $35/ton.

Table 2.12.2A

Table 1-- Estimated Annual Cumulative Forest Residue Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	0	710,000	1,034,000	1,327,900

Table 2-- Estimated Annual Cumulative Mill Residue Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	10,000	932,000	0	1,564,000

Table 3-- Estimated Annual Cumulative Agricultural Residue Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	0	0	680,783	4,265,671

Table 4-- Estimated Annual Cumulative Energy Crop Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	0	0	1,154,228	4,179,308

Table 5-- Estimated Annual Cumulative Urban Wood Waste Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	495,734	826,224	826,224	826,224

Table 6-- Estimated Cumulative Biomass Quantities (dry tons)

	<$20/dry ton (delivered)	<$30/dry ton (delivered)	<$40/dry ton (delivered)	<$50/dry ton (delivered)
Michigan	505,734	2,468,224	3,695,235	12,163,103

Notes: Table 3 in the report notes 84% corn for <$50/dry ton
Table 6 in the report notes a total of 4,627,235 as the cumulative biomass total for <$40/dry ton

Source: Biomass Feedstock Availability in the United States: 1999 State Level Analysis;
Marie E. Walsh, et al, January 2000 pp 3, 6,9,12,16 &19.

2.12.3 Clean Energy from Wood Residues in Michigan

A third study entitled "Clean Energy from Wood Residues in Michigan" was written in June of 2006 by Dulcey Simpkins, the Coordinator of the Michigan Biomass Energy Program.

Figure 4 of the report (Table 2.12.3A below) identifies 6 major power plants currently burning wood in Michigan.

Table 2.12.3A

Figure 4-- Facilities Producing Electric Power from Wood Fuel in Michigan

County	Facility	Tons Per Year	kW Capacity	Tons/kW
Alcona	Viking Energy-Lincoln	150,000	18,000	8.3
Crawford	Grayling Generating Station	300,000	38,000	7.9
Genesee	Genesee Power Station	300,000	39,500	7.6
Missaukee	Viking Energy-McBain	150,000	18,000	8.3
Montmorency	Hillman Power Company	230,000	20,000	11.5
Wexford	Cadillac Renewable Energy	375,000	39,600	9.5
Subtotal		1,505,000	173,100	8.7
Table 1-- Facilities Producing On-Site Electric Power from Wood Fuel in Michigan				
	Upper Peninsula	1,311,115	150,800	8.7
	Lower Peninsula	384,901	44,270	8.7
Subtotal		1,696,016	195,070	
Total		3,201,016	368,170	

Note: Average tons per kW for utility projects is applied to on-site generation to estimate tons of wood fuel consumed.

Source: Clean Energy from Wood Residues in Michigan; Dulcey Simpkins, June 2006 page 12.

Table 1 of the report identifies additional sources of on site power production associate with mills located in both the upper and lower peninsulas. The table has been corrected to locate the Hilman Power Plant is located in Montmorency County.

Table 3 of the report (Table 2.12.3.B) also identifies annual biomass quantities in Michigan (estimated dry tons), by Type and Delivered Price.

Table 2.12.3B

Table 3-- Annual Biomass Quantities in Michigan (est. dry tons), by Type and Delivered Price

Biomass Type	<$20/dry ton	<$30/dry ton	<$40/dry ton	<$50/dry ton
Urban Wood Residue	495,734	826,224	826,224	826,224
Mill Residue	10,000	932,000	1,248,000	1,564,000
Forest Residue	0	710,000	1,034,000	1,327,900
Energy Crops	0	0	1,154,228	4,179,308
Ag Residues	0	0	680,783	4,265,671
Subtotal	505,734	2,468,224	4,943,235	12,163,103

Note: Mill Residue <$40/dry ton is estimated.

Source: Clean Energy from Wood Residues in Michigan; Dulcey Simpkins, June 2006 page 23.

2.12.4 Biomass, Biofuels and Bioenergy: Feedstock Opportunities in Michigan

The fourth study entitled "Biomass, Biofuels and Bioenergy: Feedstock Opportunities in Michigan" was prepared by Robert E. Froese, PhD, RPF in February 2007.

This report includes a series of maps that describe the energy crops and forestry sources of wood fuels at a delivered price of $25/dry ton.

Table 2.11.4A

Forecast Bioenergy Feedstock Supply in Michigan in dry tons per year

Biomass Feedstock	**Potential Supply**	**Currently Available and Underutilized**	**Available at $25/ton Farm gate Price**
Sawmill and pulp mill residues	1,764,796	Negligible	405,903
Logging Residues	869,468	869,468	113,031
Thinning Residues	1,875,978	1,875,978	243,877
Forestry Total	4,510,242	2,745,446	762,811
Urban Wood Waste	1,311,382	1,311,382	314,732
Dedicated Energy Crops	4418226	Negligible	44182
Grand Total	10,239,850	4,056,828	1,121,725

Source: Biomass, Biofuels and Bioenergy: Feedstock Opportunities in Michigan; Robert E. Froese, PhD, RPF, February 2007

2.12.5 Measures of Wood Resources in Lower Michigan: Wood Residues and the Saw Timber Content of Urban Forests.

The fifth study entitled "Measures of Wood Resources in Lower Michigan: Wood Residues and the Saw Timber Content of Urban Forests" was prepared by Samuel Sherrill, PhD and David MacFarlane, PhD in May of 2007.

This report represents a detailed investigation into the potential wood wastes available in 14 counties in southeastern Michigan. The report identifies the volume of wood wastes utilized in several industries as well as the volume of wood waste placed in landfills each year. Table 2.12.15A represents a summary of the findings of the report and converts the cubic yards of wood waste into tons based upon an assumed 24 pounds per cubic foot or 648 pounds per cubic yard.

Table 2.12.5A

Residue Generated in 2005

Residue	Total Amount Generated (CY)	% Used	Total Amount Used (CY)	% Discarded	Total Amount Discarded (CY)	TONS	Landfills (CY)	% discarded sent to landfills	TONS
Pallets, Skids, Crates	505,000	84%	424,000	16%	81,000	26,244	15,000	19%	4,860
Edgings and Cutoffs	2,646,000	40%	1,058,000	60%	1,588,000	514,512	675,000	43%	218,700
Chips, Shavings, Sawdust	480,000	48%	230,000	52%	250,000	81,000	108,000	43%	34,992
Construction Debris	3,828,000	37%	1,416,000	63%	2,412,000	781,488	1,302,000	54%	421,848
Tree Trunks, Limbs, Stumps	84,000	53%	45,000	47%	39,000	12,636	5,000	13%	1,620
Subtotal	**7,543,000**	**42%**	**3,173,000**	**58%**	**4,370,000**	**1,415,880**	**2,105,000**	**48%**	**682,020**

Source: Measures of Wood Resources in Lower Michigan: Wood Residues and the Saw Timber Content of Urban Forests, page 11.

Project team calculated tons sent to landfill based upon the following:

1 CY = 27 CF

1 CF = 24 pounds of wood

1 Ton = 2,000 pounds

example: 1,000 CY = 27,000 CF

27,000 CF x 24 pounds/CF= 648,000 pounds

648,000 pounds/2000 pounds = 324 tons

2.12.6 Potential New Woody Biomass Feedstock Availability in Michigan.

The sixth study entitled "Potential New Woody Biomass Feedstock Availability in Michigan" was prepared by Ray Miller, PhD in February of 2007.

This draft report expands upon past investigations of biomass feedstock and includes estimates of biomass from Existing Commercial Forests and New Woody Biomass On Commercial Forests and Abandoned Cropland.

The report is currently in a draft form and will be updated once additional research has been completed. The report also identifies other sources of non-woody biomass such as switch grass, crop residues and manure.

Table 2.12.6A

Potential New Woody Biomass Feedstock Availability in Michigan

Residue	**Dry Tons**
Potential New Woody Biomass Available From Commercial Forests	24,000,000
Potential New Woody Biomass Available From Energy Plantations on Abandoned Cropland	6,000,000
Subtotal	30,000,000

Source: Draft Report: Potential New Woody Biomass Feedstock Availability in Michigan, Raymond O. Miller

2.13 Natural Resources Wood Products Directory

The second approach for determining access to potential feedstock was derived from a review of the State of Michigan Department of Natural Resources Wood Products Directory. The Wood Products Directory database was queried for the quantity of primary and secondary wood products businesses in each county and can be viewed as an indicator of where those activities are concentrated in the state. The team contacted Anthony Weatherspoon of the Michigan Department of Natural Resources for additional input into the health of the wood products industry in Michigan and determined that new wood pellet mills are projected to be on line in the next 12 months to provide wood pellets for residential markets. The location of these mills will be noted in the final report. Mr. Weatherspoon noted that the majority of wood products are harvested from private and state lands, and that proximity to US Forests is not necessarily an indicator of proximity to woody biomass feedstock.

Table 2.13 A

COUNTY	Primary WPI	All WPI
Alcona	9	24
Alger	5	24
Allegan	9	26
Alpena	10	38
Antrim	4	14
Arenac	5	8
Baraga	5	29
Barry	5	17
Bay	3	16
Benzie	3	10
Berrien	9	46
Branch	3	13
Calhoun	5	22
Cass	7	19
Charlevoix	3	9
Cheboygan	5	23
Chippewa	7	33
Clare	10	19
Clinton	4	15
Crawford	4	16
Delta	12	71
Dickinson	7	40
Eaton	6	22
Emmet	5	16
Genesee	5	26
Gladwin	9	14
Gogebic	4	26
Grand Traverse	3	26
Gratiot	3	14
Hillsdale	2	8
Houghton	5	38
Huron	2	8
Ingham	9	34
Ionia	7	15

Iosco	7	15
Iron	9	71
Isabella	3	8
Jackson	4	14
Kalkaska	0	9
Kalmazoo	5	40
Kent	29	137
Keweenaw	1	9
Lake	2	9
Lapeer	6	12
Leelanau	4	14
Lenawee	7	22
Livingston	4	17
Luce	5	26
Mackinac	7	26
Macomb	9	86
Manistee	2	12
Marquette	10	55
Mason	4	13
Mecosta	5	13
Menominee	19	77
Midland	3	10
Missaukee	2	27
Monroe	4	17
Montcalm	4	10
Montmorency	6	19
Muskegon	3	29
Newaygo	9	19
Oakland	12	111
Oceana	7	12
Ogemaw	8	31
Ontonagon	1	27
Osceola	6	10
Oscoda	18	29
Ostego	4	13
Ottawa	16	87
Presque Isle	11	26
Roscommon	2	10
Saginaw	10	21
Saint Clair	5	20
Saint Joseph	5	27
Sanilac	4	10
Schoolcraft	2	31
Shiawassee	1	8
Tuscola	5	8
Van Buren	3	16
Washtenaw	6	39
Wayne	17	129
Wexford	3	20
	513	2,280

Source:
http://www.michigandnr.com/wood/AllSearch.asp#

2.14 Inventory of Existing Wood Boilers

The third approach to identifying the potential feedstock sources is based upon the quantity of existing wood boilers in each county. Like the use of the wood products industry database, the quantity of existing wood boilers indicates the potential location of the infrastructure for processing and hauling wood fuels. The number and capacity for each boiler is noted in Appendix A.

2.15 Feedstock Availability and Simple Paybacks

Counties with the greatest number of projects with simple paybacks less than 20 years and greatest feedstock availability are identified on the attached maps in Appendix C.

The projected wood fuel volume required for all projects with simple paybacks less than 20 years in each county have been calculated and compared to the potential feedstock available on a sustainable basis. The projected volume of wood fuel associated with those projects is illustrated in Appendix A.

2.16 Impact of Non-Attainment Areas

Seven counties in southeast Michigan have been identified by the United States Environmental Protection Agency as non-attainment areas for PM-2.5 (particulate less than 2.5 microns in size).

The county names and potential projects are listed below:

Livingston	(21)
Macomb	(123)
Monroe	(51)
Oakland	(273)
Saint Clair	(47)
Washtenaw	(108)
Wayne	(316)
Total	(939) 40% of total

The project team recommends that the committee work with the Michigan Department of Environmental Quality to address how potential projects in non-attainment areas may be able to proceed based upon offsetting the use of fossil fuels with comparable particulate emissions levels such as fuel oil and coal. Potential projects in these areas are likely to employ best available control technologies (BACT) such as cyclones or bag houses to reduce particulate emissions. Project costs are likely to increase 10-20% to include the implementation of BACT.

2.17 Spatial Representation of Priority Projects.

As noted in section 2.12 above, the team used a number of methods for determining feedstock availability, wood products industry centers, wood pellet production and wood-fired power generation facilities throughout the state of Michigan. The committee determined that no single feedstock study should be used to identify the quantity of wood feedstock available in a specific county, and that potential project developers should conduct a review of wood fuel availability before proceeding with a project. The committee also determined that existing wood products facilities, wood pellet mills and wood-fired power generation plants are an indicator of the existing infrastructure for processing and handling wood fuel, but not all facilities are operating a full capacity, and many areas are served by smaller networks of loggers, chippers and grinders of wood fuel. As a result, the priority projects developed through the analysis of the existing boiler database have not been overlaid upon the potential feedstock available in a particular county.

The project team has the following observations regarding the existing feedstock studies and potential wood boiler projects locations:

- The majority of the wood-fired power generation facilities are located in the north portion of the Lower Peninsula.
- The majority of the wood pellet mills are located in the north portion of the Lower Peninsula.
- Biomass feedstock from commercial forests and urban wood waste is distributed across almost all counties in the state.
- The majority of the potential projects with simple paybacks less than 20 years are located in the southern half of the Lower Peninsula.
- The combined btu input of the potential projects with simple paybacks less than 20 years are located in the southern half of the Lower Peninsula.
- The potential additional demand for wood feedstock is distributed across the Lower Peninsula.
- The seven county non-attainment area for PM-2.5 in southeastern Michigan is likely to increase project costs by 10-20% depending upon the boiler size. Approximately 40% of the potential projects with simple paybacks less than 20 years are located within the non-attainment area.

Section 3: Tools for Identifying Potential Projects

3.1 Web-Based Calculator.

A web-based calculator (www.michiganwoodenergy.org) was developed by the project team to allow facility managers and potential project developers to determine if a more detailed investigation might be warranted. The intent is to collect enough data from the website user that the Southeast Michigan RC&D could follow up with an email regarding the inquiry and level of interest in considering the conversion of an existing heating system to a wood fired heating system.

The web-based calculator was first tested by team members, secondly with Committee members and finally with invited users such as facility owners or managers who have expressed an interest in converting their boilers to biomass.

The web based calculator works as follows:

1. The web user will enter their email address and select “out of state user” or one of the 83 Michigan counties from a pull down menu.
2. The web user will select one of 7 facility types.

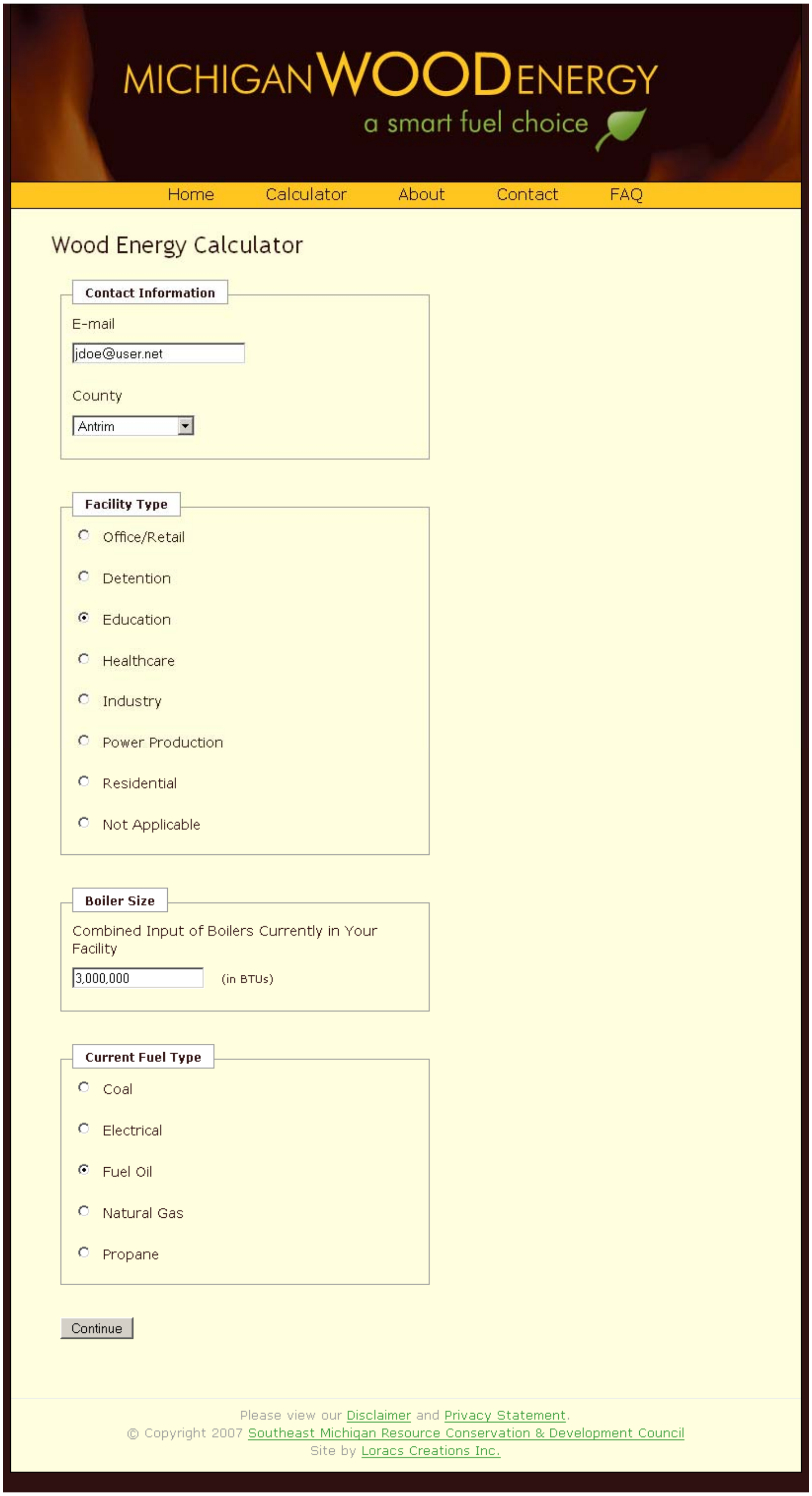
Although this information is not used to calculate fuel usage, it will allow the Southeast Michigan RC&D to determine what types of facility users are most interested in the website and allow the project team to refine the 10% Facility Utilization Factor used for the initial sorting of the database.

3. The web user will enter the combined btu input of the boilers in their facility.

Allowing the web user to enter data required additional programming to determine if the number is valid but results in more accurate project costs.

4. The web user would select fuel type from a preset menu and select “continue’ before proceeding to the next step.

Figure 3.1A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jdoe@user.net
County
Antrim
Facility Type
Office/Retail
Detention
Education
Healthcare
Industry
Power Production
Residential
Not Applicable
Boiler Size
Combined Input of Boilers Currently in Your Facility
3,000,000
(in BTUs)
Current Fuel Type
Coal
Electrical
Fuel Oil
Natural Gas
Propane
Continue
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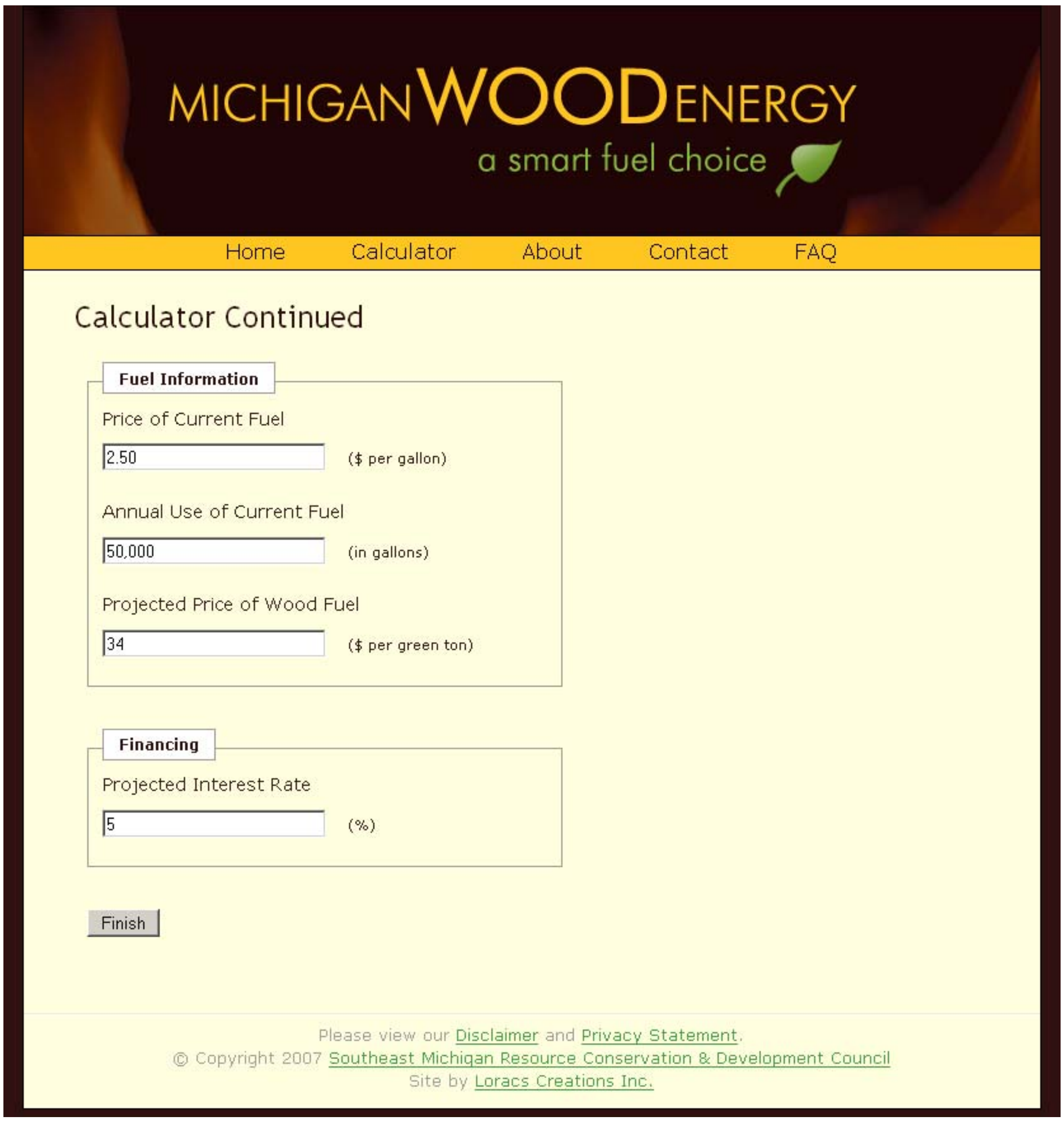
5. Based upon the fuel type selected the web user will enter a known cost of fuel in the units provided, enter the annual fuel volume and projected price of wood fuel in the units provided. The annual fuel volumes are calibrated to wood fuel volumes on the summary page. A default price for wood chip and wood pellet fuel would be provided if none is entered.
6. The web user will enter a projected interest rate. A default rate of 5% would be provided if none is entered.

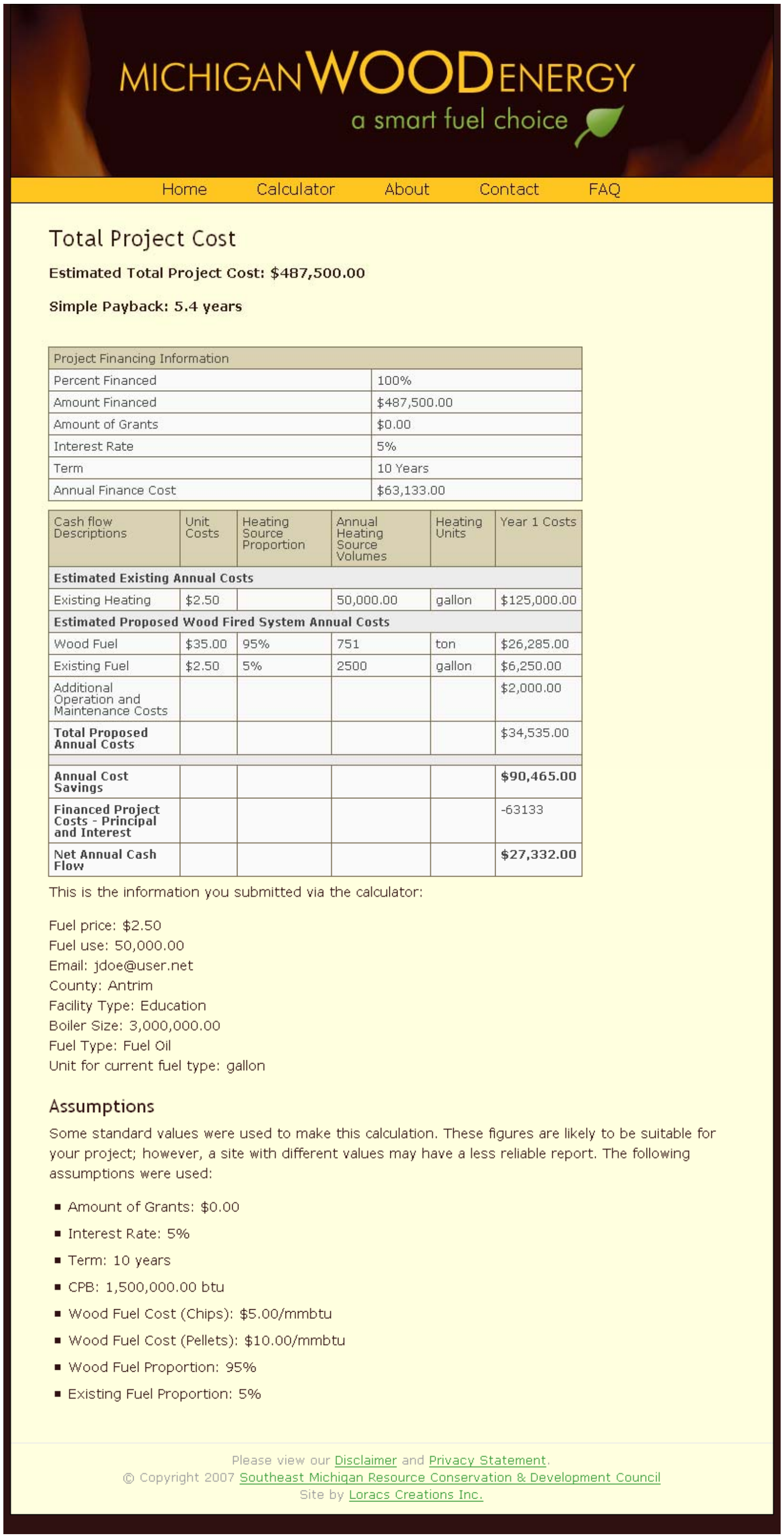
Figure 3.1B



7. The Web user would then select "Finish"

8. The web user would review a summary with the following information:

Figure 3.1C



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Total Project Cost

Estimated Total Project Cost: $487,500.00

Simple Payback: 5.4 years

Project Financing Information	
Percent Financed	100%
Amount Financed	$487,500.00
Amount of Grants	$0.00
Interest Rate	5%
Term	10 Years
Annual Finance Cost	$63,133.00

Cash flow Descriptions	Unit Costs	Heating Source Proportion	Annual Heating Source Volumes	Heating Units	Year 1 Costs
Estimated Existing Annual Costs					
Existing Heating	$2.50		50,000.00	gallon	$125,000.00
Estimated Proposed Wood Fired System Annual Costs					
Wood Fuel	$35.00	95%	751	ton	$26,285.00
Existing Fuel	$2.50	5%	2500	gallon	$6,250.00
Additional Operation and Maintenance Costs					$2,000.00
Total Proposed Annual Costs					$34,535.00
Annual Cost Savings					**$90,465.00**
Financed Project Costs - Principal and Interest					-63133
Net Annual Cash Flow					**$27,332.00**

This is the information you submitted via the calculator:

Fuel price: $2.50
Fuel use: 50,000.00
Email: jdoe@user.net
County: Antrim
Facility Type: Education
Boiler Size: 3,000,000.00
Fuel Type: Fuel Oil
Unit for current fuel type: gallon

Assumptions

Some standard values were used to make this calculation. These figures are likely to be suitable for your project; however, a site with different values may have a less reliable report. The following assumptions were used:

- Amount of Grants: $0.00
- Interest Rate: 5%
- Term: 10 years
- CPB: 1,500,000.00 btu
- Wood Fuel Cost (Chips): $5.00/mmbtu
- Wood Fuel Cost (Pellets): $10.00/mmbtu
- Wood Fuel Proportion: 95%
- Existing Fuel Proportion: 5%

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3.2 Interpreting Your Results.

Step 1A: Please review the data you entered on page one and page two of the calculator. Is your email contact information and county, location correct?
Step 1B: Have you entered the correct facility type, combined boiler size and current fuel type?
Step 1C: Is the current fuel, annual use of current fuel and projected price of wood fuel correct?
Step 1D: Is the projected interest rate correct?

Step 2: Please review the ***Estimated Total Project Cost*** at the top of the total Project Cost report page. The ***Estimated Total Project Cost*** has been calculated based upon the combined boiler size you entered. The ***Simple Payback*** (listed just below the ***Estimated Total Project Cost***) is equal to the ***Total Project Cost*** divided by the ***Annual Cost Savings.***

Step 3: Please review the ***Project Financing Information*** just below the ***Simple Payback.*** The ***Annual Finance Costs*** is based upon 100% of the project being financed for a 10-year term and no grants. You may enter a different interest rate on page two of the calculator.

Step 4: Please review the far right column of the report (Year 1 Costs). The ***Annual Cost Savings*** is equal to the ***Estimated Existing Annual Costs*** minus the ***Estimated Proposed Wood Fired System Annual Costs.*** The ***Estimated Existing Annual Costs*** have been generated from the information you entered for your current fuel cost and volume. The ***Estimated Proposed Wood Fired System Annual Costs*** have been automatically generated by the calculator based upon your existing fuel type and volume. The proposed wood fired system is estimated to meet 95% of the annual load with the existing fuel meeting the remaining 5% of the annual load. The ***Estimated Proposed Wood Fired System Annual Costs*** include ***Additional Operation and Maintenance Costs*** which vary based upon the boiler size you entered.

Step 5: Please review the ***Financed Project Costs.*** The default setting for the calculator is a 5% interest rate for a ten year period for 100% of the ***Total Project Cost***. The ***Total Project Cost*** is based upon the combined boiler size you entered. A lower interest rate results in lower ***Financed Project Costs***. Higher interest rates will increase ***Financed Project Costs***.

Step 6: The ***Net Annual Cash Flow*** is equal to the ***Annual Cost Savings*** minus the ***Financed Project Costs.*** If the ***Net Annual Cash Flow*** is a negative number, the cost of financing the project exceeds the ***Annual Cost Savings*** in year one. If the ***Net Annual Cash Flow*** is a positive number the cost of financing the project is less than the ***Annual Cost Savings*** in year one.

3.3 Educational Guides.

The project team developed the educational guides for this investigation in the form of answers to frequently asked questions (FAQ's). Brief responses to each question would be tied to “more detail” links on the website.

Frequently Asked Questions (FAQ’s):

GENERAL:

What is biomass? Biomass is renewable energy source derived from trees and crops through a process of combustion, distillation or gasification. The most common means of converting biomass into energy is combustion. Biomass may be burned to produce hot water or steam in a boiler or hot air in a furnace for distribution throughout a building or collection of buildings.

BENEFITS:

What are the benefits of using wood as a fuel in my boiler? Many facility managers who chose to heat with wood note the lower fuel cost, stability of fuel prices, use of a local and renewable energy source, the ability receive donations of fuel. Land managers benefit by having an outlet for wood generated by forest thinning operations to remove diseased trees and improve forest health.

More detail:
The primary motivation for many facility mangers to heat buildings with wood is the lower fuel cost. Wood is often less expensive on a per-BTU basis than most other fuels typically used in boilers, including natural gas, propane, and electricity. (Coal is usually equivalent to or cheaper than wood.) In some cases, wood is locally available as a waste material and mutually beneficial arrangements can be made.

Land managers may need to remove dead or excess wood from forests to reduce the risk of forest fires or spread of diseases. On-site burning of is often the least expensive mechanism for removing this material; however, slash burning generates significant air pollution and may not be legal. In these cases, using this wood for fuel in a wood-burning boiler can represent a win-win situation.

Locally harvested wood may also represent a locally available renewable fuel source which is more sustainable than non-renewable fossil fuels by being better for the environment and the local economy.

Additional information: The Fuels For Schools website compares the costs of wood fuels to fossil fuels and electricity. http://www.fuelsforschools.org/cost-installation-operation.html

WOOD FUEL:

Where can I get wood to use as fuel? Wood fired heating systems use wood pellets, wood chips, "hog" fuel. Some wood fired heating systems can use agricultural products such as corn. Wood fuels can be collected from forest thinning projects, from urban wood wastes (tree trimmings, wood pallets and construction debris free from chemical treatments, nails, etc.) and from byproducts of the wood products industry (sawdust, wood chips and planer shavings). Potential project developers should confirm the source and cost of wood fuel before proceeding with a project. Local wood products companies can be found on the Michigan Department of Natural Resources (MDNR) website (www.michigandnr.com/wood), tree service companies or the MDNR's Forest Products Specialist, Anthony Weatherspoon (517) 335-3332 or weathera@michigan.gov.

More detail:
Common thinning practices result in approximately 10 tons of wood waste per acre, not including timber harvested from the site, or mature trees retained on site. If a 100 acre site were to be thinned every 25 years, the site would average 40 tons per year (10 tons x 100 acres = 10,000 tons/25 year thinning cycle = 40 Tons Per Year).

How important is fuel quality? Wood fuel should be free from rocks, chemical treatments, debris, contaminants and over-sized pieces. Burning agricultural waste may cause excessive "clinkers" due to the proportion of silica to wood biomass present in most crops.

AIR QUALITY:

Isn't burning wood bad for air quality? New boilers burn wood efficiently and effectively and produce very little smoke or ash. Emissions from wood boiler are typically lower in Nitrogen Oxides and Sulphur Oxides than fossil-fuel boilers but are usually greater in particulates. Wood boilers can be equipped with pollution control devices that reduce particulates to bring them as low or lower than fossil-fuel boilers, but these devices will increase installation costs. See pages 29-38 of the "Final Report: Exploring Woody Biomass Retrofit Opportunities in Michigan Boiler Operations".

More detail:
The fuels For Schools website http://www.fuelsforschools.org/ includes an air quality link comparing wood fuel emissions to fossil fuels.

When do I need an air quality permit? The Air Pollution Control Rules issued by the Air Quality Division of the Michigan Department of Environmental Quality include exemptions from air quality permits for wood fired boilers less than 6,000,000 btu in size. Please review rule R336.1282 (b) (iii) via the following link: http://www.deq.state.mi.us/aps/ or contact the Michigan Air Permits System (517) 373-7023.

More detail:
Please review the United States Environmental Protection Agency website for non-attainment areas for particulate matter 2.5 microns in size (PM 2.5) in Michigan: http://www.epa.gov/oar/oaqps/greenbk/qindex.html Potential projects within the non-attainment area are likely to require the use of a "baghouse" or electro-static precipitator (ESP) to comply with air quality standards. The cost of a "baghouse" or ESP can be substantial. Potential project developers should confirm all project costs before proceeding with a project.

How tall does the stack need to be? The stack height requirements vary from project to project, based upon the air shed created by the building the boiler is housed within. Air quality engineers can determine the most appropriate stack height for a project.

More detail:
The State of Michigan Department of Environmental Quality Website includes links to model air flow around buildings: http://www.michigan.gov/deq/0,1607,7-135-3310_30151_4198-67158--,00.html

PROJECT COST, FUNDING & SAVINGS:

How much does a wood-burning boiler cost?
The cost of a wood-burning boiler system depends on the amount of heat needed, the amount of additional space needed, the amount of work needed to tie the system into the existing system, and wood fuel storage needs. You can use the web based calculator to approximate the total project cost and projected savings associated with your current boiler, fuel type and fuel costs.

More detail:
Please use the Michigan Wood Energy web based calculator to examine the preliminary project economics for your project:
http://www.michiganwoodenergy.org/dev/calculator/calculator.php?action=form1

Where can I get money to help build my project? Many public facilities have the ability to fund wood fired heating projects with construction funds raised from bonds, grants, low interest loans and through performance contracts.

More detail:
Some wood fired heating projects have been developed using zero interest loans from the US Department of Agriculture Rural Economic Development Loan and Grant (REDLG) USDA REDLG program http://www.rurdev.usda.gov/ga/tredleg.htm . The funds are typically distributed from telephone and electric cooperatives and companies serving the region.

The Climate Trust http://www.climatetrust.org/ in Portland, Oregon has also provided funds linked to the offset and displacement of carbon from the existing fossil fuel used to the wood volume consumed by the wood fired heating system.

Facility mangers might also consider integrating a wood fired heating system project into a performance contract with Energy Service Companies (ESCO's) such as Chevron, Honeywell, Johnson Controls, McKinstry, etc.

The Michigan Biomass Energy Program State http://www.michigan.gov/cis/0,1607,7-154-25676_25753---,00.html can assist potential project developers in locating other funding sources.

How was the simple payback determined? The simple payback is determined by dividing the total cost of installing the new wood burning boiler system by the estimated annual savings.

More detail:
The annual fuel savings is calculated by subtracting the difference in cost between the existing fossil fuel and the projected wood fuel. The annual fuel savings is reduced by the projected increase in cost for the operations and maintenance of the wood fired heating system.

For boilers less than 2.5 mmbtu the wood fuel is assumed to be wood pellets. For projects greater than 2.5 mmbtu, the cost of wood chips is used.

Example: Existing 1,000,000 btu natural gas boiler

$220,000 Total Project Cost / $376 Annual Savings= 585 year Simple Payback

Example: Existing 1,000,000 btu propane boiler

$220,000 Total Project Cost / $12,640 Annual Savings= 17 year Simple Payback

Don't wood fired heating systems cost more to operate? Yes. In general only modest increases in operations and maintenance costs are expected for small boilers, and greater increases are expected for larger boilers. The majority of the increase in operations and maintenance costs are associated with ash removal and resolving alarm conditions associated with oversized fuel.

More detail:
The Fuels For Schools website compares the costs of operating wood fuel heating systems.
http://www.fuelsforschools.org/cost-installation-operation.html

How much money can be saved by switching to wood as a fuel? The amount of money that can be saved by switching from electricity or fossil fuel to wood depends on the cost to install the new system, the annual cost of the fuel you are using now, the annual cost of the wood fuel you would use, and the financing arrangements. You can estimate the amount of money that can be saved annually trying out different values in the online calculator.

More Detail:
One way to determine the economic value of installing a new wood boiler is considering the time it takes for the annual fuel savings to pay for the installation – called the payback period. Different organizations require different payback periods. Private businesses, for example, may require a payback period of 2 to 5 years. Government organizations typically tolerate much longer payback periods. Installations with payback periods greater than 30 years are usually considered poor projects.

What does it mean if my Simple Payback is a negative number? The simple payback is listed as a negative number if the projected cost of wood fuel is greater than the cost of your current fuel. The simple payback may also be listed as a negative number if the projected increase in operations and maintenance cost combined with the projected cost of wood fuel is greater than the current combined operations, maintenance and fuel costs.

What is the difference between Simple Payback and annual cash flow? The simple payback is determined by dividing the total cost of installing the new wood burning boiler system by the estimated annual savings.

The cash flow analysis looks not just at the simple payback of the project, but the impact of borrowing money to finance the project and the impact of the project financing on the overall cash flow for the project.

More detail: For example, if a facility manager borrows $648,500 @ 5% for 10 years, the annual payment to the lending institution would be $84,000, negating a potential $64,850 year one savings for the project. This deficit can only be over come by accounting for the impact of inflation on the existing heating costs (fuel and operations and maintenance) and wood fired heating system costs (fuel and operations and maintenance). In general existing heating system costs escalate at a more rapid rate than locally available and renewable source of fuel such as wood. Thus, over time, positive cash flow is achieved in spite of negative cash flow during the first few years of a project. Positive cash flow can also be enhanced with grants or low interest loans.

PROJECT DETAILS:

Boiler Size:

Why does the web-based calculator assume that a wood fired boiler would be half the size of my existing boiler? In general fossil fuel boilers are sized to meet peak load conditions which occur infrequently, and for very short durations (such as for 15 minutes every 5 years).

More detail: If a wood fired boiler were to be sized to meet the peak load condition it would frequently operate in low and medium fire conditions. Unlike fossil fuel boilers which modulate well between high, medium and low fire, most wood fired boilers perform most effectively in high fire mode. By reducing the size of the wood fired boiler, it will operate in high fire mode more often. An energy model should be developed to determine the optimal size of the wood fired boiler—the size which meets 90-95% of a typical heat load. Existing fossil fuel boilers can be used to meet low load and peak load conditions as necessary.

Schedule:

How long will it take to complete my project? Most projects take at 12-18 months to develop from initial feasibility study through system start up and operation.

More detail:
A typical project schedule should include 1 month for an preliminary assessment, 2 months for a detail engineering study, 6 months to develop the system design, one month to bid, and 6 months to construct. The boiler may take between 3-9 months to construct. A one year warranty period should include quarterly training sessions to assist staff in troubleshooting the operation of the system under various weather conditions.

Energy Conservation:

Why is energy conservation important? Energy conservation projects are likely to reduce the volume of fossil fuels used, and thus reducing the simple payback for a wood fired heating system. Conserving energy assures that renewable resources will be used more effectively. However conserving energy is likely to reduce the amount of fossil fuel used, and thus reduce the simple payback for a wood fired heating system.

More detail:
If wood is cheaper than your current fuel, then the more fuel you currently use, the more economically attractive it will be to switch to a wood-burning boiler. However, facilities may be able to save as much or more in fuel costs by taking steps to conserve energy, such as improving boiler system controls or adding installation. In some cases, conserving energy can reduce existing fuel costs to the point where the fuel cost savings generated by switching to wood do not generate desirable payback periods.

For these reasons, it is recommended that you do an energy audit on your building to determine the economics and results of energy conservation measure before or while considering the costs and benefits of installing a wood boiler.

Existing Heating System:

What about my existing distribution system and controls? In most cases, the existing heat distribution and controls systems will remain unchanged. It is important to convey to the engineering team how you operate your existing system and to describe in detail any problems you have had with the quality and quantity of heat in your facilities.

More detail: Modern wood fired heating systems rely upon sophisticated control systems in order to conserve heat and reduce emissions. Most wood fired heating system control panels can be designed to interface with existing building controls.

Power Generation:

What about power generation? Many wood fired boiler are used to produce steam for both heat and power and are referred to as combined heat and power systems (CHP). Most CHP projects have incorporated a steam host such as a mill or hospital that need a consistent source of steam for heat or industrial processes. The greater the steam flow (measured in pounds per hour), the more power can be generated. Many users produced power for on-site needs and to offset demand charges for power from the grid.

More detail:
The National Renewable Energy Website http://www.nrel.gov/learning/ep_biopower.html, and Turbosteam http://www.turbosteam.com/ websites provide additional resources for project developers.

Conclusion & Recommendations

The analysis of the existing boiler database identifies approximately 2,300 existing boilers with simple paybacks less than 20 years. The location of these potential projects has been identified on a county by county basis in order to further prioritize outreach efforts by the Southeast Michigan RC&D.

One barrier to converting existing boilers to wood fired heating systems is the current lack of capacity of existing manufacturers of wood fired heating systems to meet a growing demand for biomass boilers. Entrepreneurs within the state of Michigan are uniquely positioned to meet that need through the use of existing or recently closed manufacturing facilities located throughout the state.

The project team recommends that the committee consider the following next steps:

- *Focus outreach efforts in the counties with the greatest number of potential projects with simple paybacks less than 20 years. This approach may lead to the development of clusters of projects in a county and support the infrastructure to supply wood fuel to multiple locations.*

- *Contact facility managers with multiple boilers in a single facility. The database is sorted in a manner that identifies multiple boilers in the same facility on adjacent lines, making the process of locating facilities with multiple boilers a simple task.*

- *Contact facility managers with simple paybacks less than 20 years located within 50 miles of existing pellet mills, wood fired power generation facilities and the large quantities of urban wood waste in Southeastern Michigan.*

- *Focus outreach efforts through local economic development councils to promote the integration of wood fired heating systems in new facilities (approximately ½ the cost of retrofitting existing facilities).*

- *Work with the Michigan Department of Environmental Quality to address potential projects in non-attainment areas.*

- *Identify existing coal facilities that may be modified to burn wood or to co-fire wood and coal.*

- *Identify clusters of projects within a community that may represent opportunities for combined heat and power projects with district heating and cooling systems. Such projects represent opportunities to meet Governor Granholm's initiative for expanding Michigan's renewable energy portfolio to 10 percent by 2015 and 20 percent by 2025.*