S. Urban Wood Waste in Michigan

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Urban Wood Waste in Michigan: Supply and Policy Issues

Final Report
September 1994

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Prepared by:
Public Policy Associates

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Table of Contents

Acknowledgements i

Introduction iii

Literature Review 1
- Urban Wood Waste Generation Estimates and Landfill Tip Fees 1
- State Characterizations of Wood Waste in the Great Lakes Region 2
- Other Studies 10
- Regulation of Urban Wood Waste as Fuel 12
- Competing End Markets: Higher Value-Added Uses for Wood Waste 14

Urban Wood Waste Stream Components 17
- Key Definitions 18
- Developing Used Pallet Generation Estimates 19
- Used Pallet Generation by Market Area 24
- Wood Scrap Generation by Market Area 26
- Construction Debris Generation by Market Area 28
- Demolition Debris Generation by Market Area 31
- Tree Trimming Residue Generation by Market Area 34
- Wood Waste Generation from Land Clearing 37
- Plywood/Particleboard Waste Generation 38
- Used Railroad Ties 39
- Other Wood Waste Generation 42

Wood Processing and Fuel Prices 43

Competing End Markets 47

Issues and Conclusions 49
- New Solid Waste Rules 50
- Proposed Amendments to the Solid Waste Management Act 51
- Conclusions 54

Appendices
- Survey Instruments . . . . . A
- List of Interviewees . . . . . B
- Railroad Track Mileage Data C
- Bibliography . . . . . D
- Summary of Roundtable Discussion . . . . . E

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Introduction

We commenced our project with a review of current literature about wood waste generation, disposal, and end markets which provided an overview of wood waste issues and helped frame the content and our analysis of urban wood waste. This overview includes characterizations by state agencies of wood waste residue generated by primary manufacturing (mills and forest harvesting), secondary wood manufacturing, and urban tree trimming and landscape operations. An earlier report (1991) by the Illinois Department of Energy and Natural Resources, which examined the entire range of operations generating wood waste, provided a helpful basis for this phase of the project.

This review provides an understanding of waste generation research methodologies and the corresponding quality of data. It also includes a brief overview of wood waste regulatory issues and the dynamic character of secondary wood waste markets. Based on the insight gained from the literature review, we moved on to the central phase of the project, which was the execution of original research.

Three survey instruments were designed to elicit data about the types and quantities of urban wood waste (UWW) generated in the Detroit, Lansing, and Grand Rapids markets. The three survey groups included solid waste and recycling coordinators, wood waste brokers and processors, and urban forestry and landscaping operators. Copies of the survey instruments are included as Appendix A.

The first survey instrument consisted of 12 questions and was used as a guide for the discussions with coordinators for the counties of Ingham, Eaton, Clinton, Kent, Macomb, Oakland, and Wayne and the City of Lansing. In all cases, recycling and solid waste coordinators emphasized that they lacked even basic knowledge of urban wood waste types and their generation. They consistently pointed out that the estimates of wood waste in their county solid waste management plans, which are required under the Michigan Solid Waste Management Act (PA 641 of 1978), were arbitrary and unreliable.

The second survey instrument was designed for interviews with UWW processors and haulers. Fifty firms of the 86 listed in the *Michigan Recycled Materials Market Directory: Pallets and Wood Processors/Brokers,* published by the Michigan Office of Waste Reduction Services, were contacted for telephone interviews between June 20 and July 29. Thirty-six firms were excluded because they were outside the study area, not processing or hauling wood waste, or out of business. Of the 50 firms within the scope of the study, 44 agreed to be interviewed and to provide information, for a total response rate of 88%.

The survey instrument used for these interviews consisted of 14 questions designed to elicit data about current and past UWW generation, future trends, processing capacity, and end markets for UWW. This instrument served to guide a structured interview comprised of both open- and closed-ended questions, a format which assured that all key topics of the study were covered while allowing respondents to introduce a broad range of issues. Consequently, a robust picture of the UWW market place and its dynamics was elicited.

Project staff interviewed 19 UWW haulers and processors located in Detroit, four in Lansing, and 11 in Grand Rapids. In addition, 10 firms responded to the survey from other areas, including Flint, Port Huron, Jackson, Battle Creek, Muskegon, and Kalamazoo. Although there was an inclination to aggregate these "other" markets with the targeted study markets, we did not do so. We believe this approach enhances the accuracy of the UWW generation estimates for each market area.

The third survey instrument was designed for interviews with urban forestry departments and landscaping operators. It consisted of five questions and was used in 19 interviews with city and county parks and forestry departments, university grounds departments, and utility tree trimming operations. This survey enabled us to augment our data about the generation and disposition of urban tree trimming residue, which was underreported in our survey of haulers and processors.

Data from the three surveys were tabulated to provide frequency distributions and descriptive statistics over all company sites and major customer locations. Statistics are provided on the quantity of each type or stream of wood waste currently processed or hauled, changes from

past quantities and volumes, estimated handling capacities, and current markets for selling processed UWW. Data regarding these factors were also used to calculate the total quantity of urban wood waste, total number of customers, and capacity utilization rates. In addition, open-ended responses were extremely useful in our effort to understand and describe the trajectory of the UWW market.

Our surveys elicited data reported in both weight and volume measurements. However, in the interest of enhancing the comparability of our data, we utilized conversion factors to obtain a common unit of measurement.

In our reliance on processors and haulers for UWW data, we are restricted to measuring UWW that is hauled and processed by these firms. Our methodology did not allow for measuring the quantities of UWW generated by small quantity generators who landfill or incinerate their UWW as part of their municipal solid waste (MSW) stream or who otherwise dispose of their own UWW. Thus, that quantity of UWW commingled with the overall MSW stream is not assessed or characterized in this study. The magnitude of this UWW generation may be significant, but it is beyond the scope of this study to measure or quantify the extent of the commingled stream.

In addition, interviews were conducted with waste management experts in the automotive and railroad industries; pallet producers; Michigan Department of Natural Resources forest management, air quality, and solid waste management staff; US Environmental Protection Agency (EPA) staff; Michigan legislative staff; major wood-burning cogeneration and electric-generating facility managers and developers; other consultants; and Public Service Commission staff. In all, nearly 120 interviews were conducted.

The strength of this methodology is that data generated from several sources can be compared and refined, thereby increasing the accuracy of our conclusions. It must be emphasized that the quantities of UWW estimated by respondents are self-reported. Nevertheless, we are confident that these reported quantities of processed UWW provide reasonably accurate approximations of recoverable, "clean" UWW in the market study areas. "Clean" in this context refers to uncontaminated and untreated natural wood products and

residue that are generated by a broad range of industrial, commercial, municipal, agricultural, construction, and demolition activities.

The widespread understanding of the value of clean UWW in various secondary end markets creates a relatively strong market for UWW processors and haulers. This also creates a reasonably effective mechanism by which UWW generation can be measured.

On the other hand, underreporting of "treated" UWW generation is certain. "Treated" refers to chemical alteration of the natural wood by binders, adhesives, preservatives, glues, resins, paints, stains, or coatings. It needs to be emphasized that these definitions are evolving terms and not fixed by any regulatory framework. As such, these terms are not as rigorously and exactly defined as other waste stream constituent terms like high-density polyethylene, corrugated cardboard, or even yard waste.

There currently is no reliable way to accurately quantify the generation of those treated UWW streams without extensive and costly empirical field study and measurements. Most treated wood does not currently have secondary end-market potential. It must be landfilled, stockpiled, or otherwise disposed. Most of the treated UWW, then, gets commingled with the other materials disposed as part of the overall MSW stream.

In the following pages, the results of our research are presented. To provide a background and context, this report begins with our literature review. This is followed by the results of the survey research, which encompasses the bulk of the report. Finally, we present a discussion of regulatory issues and policy issues likely to affect UWW markets.

Literature Review

Our purpose here is to examine the existing literature about the types and quantities of urban wood waste generation, associated disposal practices, and end markets for fuel and non-fuel uses.

Urban Wood Waste Generation Estimates and Landfill Tip Fees

The two most recent reports by the United States Environmental Protection Agency (EPA) on the characterization of municipal solid waste were published in 1990 and 1992 and assess data for 1988 and 1990. Estimates of the urban wood waste (UWW) stream changed substantially in these reports. The 1994 report will be published this fall and will contain comparative and more detailed data for 1991-93, particularly about UWW.

Municipal solid waste (MSW), according to the EPA definition, includes durable and non-durable goods, containers and packaging, food wastes, yard wastes, and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Specific examples include appliances, wood pallets, office and classroom paper, newspapers, and disposable tableware.

Generation refers to the amount of materials and products as they enter the waste stream and before materials recovery, composting, or combustion (incineration) takes place.

Recovery is specifically defined as removal from the waste stream for the purpose of recycling and/or composting. Materials that were separated from the waste stream for recycling may simply be stored or, in some cases, sent to a landfill or incinerator. Thus, EPA does not treat wood combustion in cogeneration facilities as recovery of wood materials.

According to the 1990 MSW characterization report, 6.5 million tons of wood waste were generated in 1988, and none of it was recovered. Both figures indicate significant

underreporting. Wood waste was estimated to be 4.2% of MSW weight or 4.1% of MSW volume. Overall, MSW generation was estimated to be 180 million tons per year.

The 1992 MSW characterization report substantially increased the estimate of the wood waste stream, from 6.5 million tons to 12.3 million tons, or 7% of MSW in 1990. According to EPA staff, this estimate was based primarily on National Wooden Pallet and Container Association data that indicates 536 million pallets were produced in 1990. Wood pallet production has steadily increased since 1990.

For the first time, EPA reported a positive value for the recovery of wood waste. That figure is estimated to be 0.4 million tons, or a recovery rate of 3.3%. Recovery estimates, then, are limited to recovery for use by secondary markets for composting and mulch.

The 1992 report represents a substantial improvement in EPA's estimates of the UWW stream. However, this data base remains limited by its virtually exclusive reliance on pallet generation data to characterize the generation of the UWW stream.

Landfill fees continue to increase. According to the National Solid Wastes Management Association, the national average tipping fee for 1992 was $30.21 per ton, up 14% from their 1990 survey. Midwestern tipping fees are below the national average at $27.10, up from $23.15 in 1990. Tipping fees are expected to continue to rise as a result of the implementation of RCRA Subtitle D landfill requirements.

Alternate uses for wood residue include boiler fuel, particleboard, molded products, landscaping, mulch, and animal bedding. Information about the specifics of these markets is detailed below.

State Characterizations of Wood Waste in the Great Lakes Region

Four state reports published since 1991 provide data about wood waste and utilize methodologies relevant to the Michigan urban wood waste study. Each of these reports assesses some aspect of UWW generation, disposal, and markets; none, however, provides an overall characterization or assessment of urban wood waste.

The reports reviewed include studies by the Illinois Department of Energy and Natural Resources on the state's entire wood waste stream (1991), an assessment of wood waste generated by the secondary wood products manufacturing industry in Wisconsin (1993), an assessment of wood and paper residue generated by the Michigan secondary wood products industry (1994), and an assessment of urban tree residue in the Minneapolis/St. Paul area of Minnesota (1992).

Wood Waste Disposal in Illinois. The 1991 Illinois Department of Energy and Natural Resources (IENR) study of wood waste disposal was designed to investigate the feasibility of a ban on landfilling wood waste (including construction and demolition material). This study estimated that 1,425,478 tons of wood waste were generated annually in Illinois. Of this total, 463,319 tons per year were landfilled. The wood waste stream was characterized by five generating sectors and the quantities generated by each are displayed in Table 1.

Table 1. Illinois Wood Waste Generation Estimates

Generating Sector	Annual Generation (in Tons)	% of Wood Waste
Primary wood producers	190,800	13.4%
Secondary wood manufacturing	443,053	31.1%
Construction/demolition debris	507,000	35.6%
Commercial	250,000	17.5%
Residential	34,625	2.4%

Primary wood producers, secondary wood manufacturers, and construction/demolition waste sectors were surveyed for waste stream estimates, and the residential and commercial sector estimates were derived from computer modeling.

Only a small fraction of wood waste generated by primary wood producers was landfilled. The major secondary uses for wood waste by this sector included heating fuel, mulch, livestock bedding, and other wood products. Secondary manufacturers reported that 77% of their wood waste was reused as fuel, compost, or other wood product manufacture. An

estimated 23%, or 102,908 tons, was landfilled. It was reported that these manufacturers were trying to find alternatives to landfilling wood wastes because of rising tipping fees.

IENR staff struggled to derive a reliable estimate of the construction/demolition (C/D) stream. Since C/D waste is commonly commingled with other waste streams, it is very difficult to estimate the amount of C/D disposal in sanitary landfills. Estimates of quantities landfilled in dedicated C/D landfills underreport C/D landfilling, since C/D waste is disposed of in sanitary landfills as well as C/D landfills. Consequently, IENR staff used a C/D waste generation formula of 0.72 lbs/capita/day consisting of 30% wood waste. It is not stated in the report how this formula was derived. The statewide estimate of C/D wood waste was calculated to be 507,335 tons per year. IENR found, then, that C/D wood waste accounts for 40% of the total wood waste disposed of in landfills.

Using the WastePlan model,[1] IENR derived wood waste estimates of 250,000 and 34,625 tons for the commercial and residential sectors, respectively. The data set provided by the model estimated a proportion of total waste that is wood for several commercial sectors and used the number of employees and retail revenue estimates to derive wood waste estimates. Significantly, IENR was unable to quantify the amount of waste that was reused or recycled. According to the report, "pallet recycling...could account for a significant reduction in the amount of commercial wood waste that is actually disposed of by landfilling."

IENR urged the Illinois legislature to take no action on the wood waste ban, stating that pressures from rising landfill fees were acting as an incentive for generators to find alternative uses for wood residue. Since Illinois requires that yard waste be segregated from other MSW for composting, IENR recommended that wood residue be designated for composting as well. Finally, the study recommended that the State Pollution Control Board reconsider its permit procedure in order to encourage coal-fired generating plants to burn wood as well.

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[1]WastePlan is a software program designed for integrated solid waste planning. It analyzes and compares different scenarios for waste generation, collection, composting, recycling, reduction, landfills, and waste-to-energy facilities.

Wisconsin Wood Residue Study: Wood Residue from Manufacturing Excluding Sawmills. The 1993 *Wisconsin Wood Residue Study* was designed to identify the quantity, type, location, and disposal methods of the industrial wood residue stream. This study also considered the potential for industrial development using wood residue through a feasibility analysis of a hypothetical wood residue-fired electrical generation plant. A directory of residue-producing firms was also published in conjunction with the study.

Survey mailings, including two follow-ups, were used to collect data from 5,837 wood-using and non wood-using Wisconsin businesses in 1992. Fifty-six percent (3,251) of the businesses surveyed responded, and 47% of those stated that they generated wood residue. Survey numbers were not adjusted to a green or dry basis but were weighted using a disproportionate stratified sample to provide an aggregate for each industry sampled.

The results of the survey were compiled and analyzed by SIC group, forest survey unit (five geographic regions), number of employees per firm, disposal method, and disposal cost. SIC codes 24 (Lumber and Wood Products) and 26 (Paper and Allied Products) were analyzed separately, since the amount of wood residue each produces would have skewed the results. The objective of the survey was to sample manufacturing and service firms most likely to generate high volumes of wood residue not currently being utilized.

Wisconsin firms produced an estimated 2,152,046 tons of wood residue annually. Wood residue consists of pallets, dunnage (wood packing material), sawdust and sanderdust, chips and shavings, edging and cut-off, and bark. Pallet residue accounted for 133,000 tons annually, and nonpallet residue accounted for 2,019,000 tons. SIC code group 24 (Lumber and Wood Products, excluding sawmills) generated 1,432,000 tons of nonpallet residue and 22,000 tons of pallet residue. Possible uses for the wood waste stream included particle/inorganic bonded board, fireplace logs, molded products, fuel, pulp, animal bedding, and landscape mulch.

The Wisconsin survey showed that mid-size firms generated the most wood residue. Although the authors did not define mid-size firms, it appears that they included firms of 100-249 employees, 50-99 employees, and 20-49 employees. The authors believe there is a

correlation between the number of production employees and the amount of wood residue generated.

Table 2. Wisconsin Estimates of Wood Residue Generation By Number of Employees per Firm				
Number of employees	Number of firms	Pallet Generation	Nonpallet Gen.	Total
5-19	14,402	6,894	364,339	371,233
20-49	4,050	10,929	475,397	486,326
50-99	1,643	54,473	218,854	273,327
100-249	1,188	31,800	568,809	600,609
250-499	347	9,029	184,837	193,866
500+	266	19,662	207,022	226,684
TOTALS	21,896	132,787	2,019,258	2,152,045

As shown in Table 2, Wisconsin firms generated nearly 133,000 tons of pallet residue. Firms with 50-99 employees accounted for 41% of its total production. For nonpallet residue, firms of 100-249 employees generated 28%; firms of 20-49 employees generated 24%; and firms with 5-19 employees generated 18%. The study methodology and data do not permit a determination of the amount of residue generated by each employee.

Nearly 500,000 tons of wood residue were disposed of through various methods. Residue generation was concentrated in the Southeast survey area (70%). This area also experienced the most acute disposal problems.

Disposal methods varied widely by wood waste type. Non-pallet residue (429,000 tons) was predominantly sold (39.8%) or given away (25.4%), while pallet residue (69,000 tons) was predominantly landfilled (28%) or given away (26%). Significantly, 25% of the disposed pallets in Wisconsin were classified as being disposed of by "unknown" means. This figure comes to 17,112 tons per year, or nearly 68.5 tons per day. These pallet residue disposal findings are surprising in light of the findings in our study.

Table 3. Wisconsin Estimates of Wood Residue Disposal by Disposal Method (tons/year)									
Disposal Method	Total Pallets	Dunnage	Saw/ Sander	Chips/ Shaving	Edging/ Cut-off	Bark	Other	Total Nonpallet	Comb. Total
Landfill	19,095	10,134	3,001	5,122	13,016	780	8,779	40,832	59,927
Stockpile	594	104	7,287	6,836	456	31,595	64	46,342	46,936
Sell	6,822	1,784	72,898	88,711	3,753	2,762	1,992	178,722	178,722
Giveaway	17,654	3,056	5,178	6,887	10,077	1,096	83,098	127,392	127,046
Pay to remove	4,373	2,548	5,927	2,549	5,349	0	218	16,591	20,964
Incinerate	3,301	6,115	7,420	7,008	5,738	2,207	2	28,530	31,831
Other	344	113	46	16	45	0	0	220	564
Unknown	254	254	1,092	11,937	2,208	0	87	15,578	32,744
TOTAL	24,148	24,148	102,849	129,066	40,642	94,240	94,240	429,385	498,734

Landfilling was the most common disposal method for dunnage (42% of 24,000 tons). Sale was the most common disposal method for sawdust and sanderdust (71% of 129,000 tons) and for chips and shavings (69% of 129,000 tons). Edging and cut-off residue were predominantly disposed either by landfilling (32%) or giving away (25%). Bark was mainly stockpiled (82% of 38,000 tons). Residue classified as "other" was chiefly given away (88% of 94,240 tons). See Table 3 for more detailed information.

The study concludes with a discussion of the feasibility of building a 25 MW wood-fired electrical generation facility. It was found to be a profitable investment. However, the authors assumed a wood cost of $8 per delivered ton. Our research indicated that wood prices in Michigan are at least twice that amount. Further, transportation costs, which are a major factor in determining fuel prices and the profitability of wood-fired generators, were not included in the Wisconsin assessment.

Michigan Wood and Paper Residue Study: Secondary Wood Products Manufacturers. A survey of secondary wood manufacturing residue generation was published by the Forest Management Division of the Michigan Department of Natural Resources in March, 1994. The survey was conducted in late 1993. Secondary wood manufacturing consists of cabinet

manufacture, furniture manufacture, pallet manufacture, wood boxes, wood products, hardwood dimension or furniture parts, millwork, corrugated sheet pit, paper converter, and other. Secondary wood products manufacturing is distinguished from primary wood products manufacturing in that it does not involve the harvesting of trees or using roundwood in their manufacturing processes.

The survey methodology was based on the 1993 report published by the Wisconsin Department of Natural Resources (Everson and Hubing 1993). The goal of the Michigan study was to facilitate the use of wood and paper residues as raw materials or energy sources.

The report identified location, volumes, and types of wood and paper residues produced by secondary wood products manufacturers in Michigan. The report also compared the amount of each type of residue being landfilled to its potential as an energy source. Finally, the report provided information on the willingness of waste generators to pay or charge for having wastes made available to a power plant or broker.

Results showed that 868,478 tons of wood and pallet wastes are produced annually by the 477 respondents (out of 1,687 surveyed) and 63,623 tons of paper residues. This suggests, according to the report, that the secondary manufacturing industry produces over 3.3 million tons of residue annually. This includes pallets and all other wood residue as well as paper residues from secondary wood product manufacturers. Wood chips comprised the largest amounts of residue at 51.5%. Sawdust was the second largest waste product (22.7%), followed by bark (16.5%). This total can also be divided into "clean" (855,846 tons) and "composite" (21,468 tons) wastes.

The primary means of disposal is use as a fuel: 596,748 tons of wood, or 68.3%, is used annually as an energy source while recycling makes up 24.2% (213,187 tons) of the total. Other unidentified uses accounted for 6.8%, or 58,894 tons. Only a small percentage (.09%), or 6,609 tons, of the total annual wood waste produced by secondary manufacturing was landfilled. Still, the estimated potential represented by the amount of wood landfilled is over 360,000 MMBtu (million British Thermal Units) for survey respondents and 602,000

MMBtus for all secondary manufacturing. Landscaping was a common use for wood residue, especially bark and chips and shavings. Chips and shavings were also commonly recycled as animal bedding.

This study did not provide a geographic analysis by county, SMSA (Standard Metropolitan Statistical Area), or DNR Region. Instead, it reported waste generation by utility company service territory. In contrast, the *Michigan Wood Products Industry Residue Directory,* which uses the same database, is divided by county (MDNR 1994). As a result, it is not feasible to compare or aggregate the secondary manufacturing data with our urban wood waste data to achieve a more comprehensive and precise characterization of UWW.

Urban Tree Residue: An Assessment of Wood Residue from the Seven-County Metro Area of Minnesota. The 1992 *Urban Tree Residue* study by the Minnesota Department of Natural Resources estimated the generation of urban tree residue in the Twin Cities area. As such, this report assessed only one component of the urban wood waste stream. End-use of this stream is important in light of a 1992 Minnesota ban on landfilling tree and shrub waste. The findings of this report may suggest some ramifications of Michigan's yard waste ban, slated to go into effect in March of 1995.

The Minnesota study found that approximately half of the 325,000 tons of urban tree residue produced per year was used. The other half was considered a waste disposal problem. Only 14% of the residue produced any revenue. Of the 86% that did not produce revenue, 41% cost money for disposal. Six basic factors prevented marketing the residue successfully:

1) Excess supply vs. weak demand
2) Too few existing recycling sites and location problems with proposed expansions
3) Lack of public information on the subject
4) Low priority on wood residue recycling
5) Absence of comprehensive public policy
6) Lack of active industry organization

In order to overcome these difficulties, the Minnesota DNR recommended increased coordination between producers such as tree services, utilities, and land developers, and

consumers such as landscapers, firewood users, and homeowners in order to increase demand.

It was also concluded that more sites for recycling were needed, however, social constraints relating to siting make this difficult. Demand for waste wood is only one-tenth of the current available supply. Without market demand, there is no real monetary value to the wood. Since it is illegal to landfill urban tree residue in Minnesota, reuse is essential.

The Minnesota DNR suggested a series of both long- and short-term actions. Short-term actions included creating publicity for free chip mulch, opening at least two new recycling sites, encouraging new chip fuel users, exploring firewood "exchange yards," and increasing the demand wherever feasible. Over the long-term, finding manufacturers who might use the residue as raw material was imperative. Another option was to test the feasibility of stump incineration. In order to implement these provisions, it would be essential to establish control of the material stream and seek legislation providing financial incentives to new users of chip fuel for boilers and cogeneration.

Other Studies

Michigan Timber Industry: An Assessment of Timber Product Output and Use, 1990 (Hackett and Pilon 1993) provides data from a survey of all primary mills in Michigan that use logs and bolts, as well as major consumers of industrial fuelwood. This report includes information on wood residue generation by Michigan primary manufacturing and thus complements the *Michigan Wood and Paper Residue* assessment of secondary wood manufacturing. These two reports set the stage for our study of UWW.

Information is provided for the volumes of the types of wood (hardwood and softwood species) harvested and used for saw and veneer logs, pulpwood, industrial fuelwood, poles, posts, and other products. The data is presented for Michigan's 83 counties and by Forest Survey Unit (Eastern Upper Peninsula, Western Upper Peninsula, Northern Lower, and Southern Lower Peninsula).

Industrial roundwood production in 1990 was 347.3 million cubic feet, down from 355.2 million cubic feet in 1988. Industrial fuelwood production declined from 21.9 million cubic feet to 14.8 million cubic feet, a drop of 32%. Primary mill wood residue used for industrial fuel was 385,130 tons, according to the report. Industrial fuelwood represents approximately 4.3% of industrial roundwood production. There were 355 active mills operating in 1990, an increase of 62 from the industry's low point of 293 in 1975.

The total amount of material harvested from timberland for industrial roundwood was 428 million cubic feet. Of that total, 81.3 million cubic feet, or 19%, was left on the forest floor as logging residue. Residue material includes tops, limbs, cull material, and growing-stock material not used for product. Over 30% of this harvest residue was in the Upper Peninsula.

Ninety-six percent or more of each mill residue class (coarse, fine, and bark) generated in Michigan primary mills was used. Primary wood-using mills, except pulp, particleboard, and waferboard mills, generated 807,000 green tons of coarse residue, 503,000 green tons of fine residue, and 359,000 green tons of bark. Pulpwood mills consumed 59 percent of the coarse mill residue for fiber products. Other industry and households consumed 33 percent of the coarse mill residue for fuel. Fine mill residue and bark were used for industrial fuel, soil conditioner, mulch, livestock bedding, and poultry litter.

Beyond these five studies, little non-proprietary work has been done to analyze the disposal of urban wood residues. The authors of this report are aware of at least two proprietary market studies of urban wood waste. They have been conducted by Resource Recycling Systems, Inc. for the CMS facility under construction in Genesee County and by a California-based firm for the proposed Decker Energy and Wheelabrator facility in Albion.

It should be noted that the problem of utilizing and disposing wood waste is not restricted to the past decade. In the mid-seventies, Woodwastes Utilization and Disposal (Cheremisinoff, et. al., 1976) was published, which related case histories of disposal problems and solutions for areas such as Detroit, Flint, Pontiac, and Lansing. The end-use options identified in this study were similar to those currently utilized or being investigated, including animal bedding, mulch, particleboard, and fuel.

Regulation of Urban Wood Waste as Fuel

As landfill costs increase, waste generators seek more cost effective management of their waste stream. Although the use of wood waste as an energy source is clearly feasible technologically, public acceptance of wood-fueled energy facilities has been limited in many regions of the country. Regulatory confusion and decreasing incentives deter further development of the biomass energy market. These barriers assume several forms.

First, uncertainty over defining wood combustion leads to excessive regulation. The most comprehensive study of the issue, *Wood Products in the Waste Stream: Characterization and Combustion Emissions*, reviews state regulations in California, Connecticut, Vermont, New York, North Carolina, Wisconsin, Washington, Virginia, and New Brunswick (NYSERDA 1993). All of these states consider the use of wood waste for combustion as reuse rather than recycling. In the waste management hierarchy, the best possible use for wood residue would be as a feedstock in another product rather than as a fuel with no opportunity for another cycle of recycling or reuse. Combustion creates ash and air emissions that would be avoided if the wood was transformed into a product with additional uses, such as fiberboard. As a result, use of wood waste for combustion does not contribute to state recycling goals. Several of the states within the study area have adopted recycling goals of 25 to 50 percent. Because the use of wood waste as a fuel does not contribute to this goal, there may be "less incentive for solid waste managers and regulatory staff to review and permit waste wood facilities" (NYSERDA 1993:2-37).

Another set of problems results from a gap between regulatory terminology and technical capacity. Definitions for "clean" and "treated" wood either do not exist or vary from state to state. Of the eight states studied in *Wood Products in the Waste Stream*, seven have specific definitions for clean waste and only four have definitions for treated wood (NYSERDA 1992:2-38). In most states, the combustion of clean wood waste is considered energy recovery, while the combustion of "treated" wood waste is considered incineration. This means that facilities that burn "treated" wood are legally the same as municipal solid waste incinerators.

The NYSERDA report defines three categories of waste wood: urban wood waste, mill residue, and harvested wood. UWW consists of pallet waste, construction and demolition wood waste, and municipal solid waste wood. Mill residue is generated by primary and secondary wood manufacturing. Harvested wood includes site conversion waste wood, silvicultural waste wood, and agricultural residue.

Confusion over the regulatory definition of waste wood is partly derived from having so many regulatory entities involved in the creation of regulatory schemes. Wood waste combustion is, both at different times and at the same time, treated by air quality officials the same as incineration, by utility regulators as energy production, by solid waste officials as municipal waste, and by forest management officials as harvesting residue.

One of the unintended consequences of this regulatory confusion is the risk of creating and supporting public misperception and misunderstanding. The EPA Environmental Appeals Board recently heard a permit appeal raised by several groups in Flint regarding a proposed 35MW cogenerating facility in Genesee County. Criticism focused on toxic emissions that might result from inadequate fuel handling procedures. The permit application included C/D demolition as part of the proposed facility's fuel supply so, concerns were raised over lead and other toxic emissions. The EPA ruled that a comprehensive fuel handling and management protocol would be sufficient to assure that the fuel would not produce toxic emissions (US EPA 1993). It is questionable whether public opposition would have been as great had public discussions centered on the development of a "power plant" rather than an "incinerator," especially when wood combustion emissions are compared with coal-fired plant emissions. The latter, of course, are a major contributor to acid rain and global warming from atmospheric CO_2.

The uncertainty created by the lack of a clear regulatory definition of "treated" wood makes permitting procedures difficult. In Michigan, a test burn of six types of chemically-treated wood at the Viking Energy facility in McBain is scheduled for September 1994 and should provide specific regulatory clarification. Combustion of railroad ties, telephone poles, construction and demolition debris, plywood and particleboard, and TDF (tire-derived fuel) will be analyzed for the impact of their emissions. If the results of air emissions tests for

these materials meet regulatory standards, the wood fuel supply available to power producers will increase substantially.

In addition to regulatory confusion, the use of wood fuel for energy production is hampered by the weakening of incentives. The enactment of the Public Utility Regulatory Policies Act (PURPA) in 1978 worked to encourage entry in the energy market by requiring utilities to purchase power from independent producers (IPPs) at "avoided cost rates." Renewable energy tax credits made investment in independent power projects more feasible. These tax credits were phased out in the 1980's and avoided cost rates have been plummeting.

As a result, independent power producers have been caught in a "scissors crisis:" not only are the incentives to help achieve profitability nonexistent, but the rates that independent producers receive for the energy that they sell to utilities have been plummeting. Swezey, et.al., (1994) advocates broader incentives to encourage entry into the biomass energy market. These include the use of "set-asides" to require that a certain percentage of a state's total power production must come from biomass and "green RFPs" designed only for renewable energy production.

Finally, externalities need to be considered in a broader sense so as to emphasize the economic development potential of biomass energy. Solving these problems are essential to the long-term viability of the wood fuel market. Though an abundant supply of raw materials exists (NYSERDA 1992), it is clear that there remains little interest by investor-owned utilities in the use of wood residue. Refining regulatory policy along the lines suggested in the Swezey study would be a good first step.

Competing End Markets: Higher Value-Added Uses for Wood Waste

Fiberboard, wood/plastic composites, composting agents, and mulch markets compete with wood-fired power plants for urban wood waste. These end markets compete more aggressively with the fuel market as virgin timber prices rise, consumer demand for recycled wood products increases, and technological improvements in recycled wood production reduce costs.

It is clear that a substitution effect exists in the wood waste market: as the price of virgin timber increases, innovations come to the fore. Competitive pressures are more severe in the fiberboard industry, which must often compete with paper mills for raw materials (Blackman 1991:19; Plantz 1994:115). This supply uncertainty has fueled new attempts to secure reliable sources of materials, and urban wood waste is foremost among them. Use of this stream has several advantages.

First, urban wood waste contains many elements already used by fiberboard manufacturers, such as chips and sawdust. Second, technical problems associated with using urban wood are easily surmountable (Suchsland and Woodson 1986:35). Adequate precautions must be taken to remove metals produced in chipping. One processor uses hogged pallets to supply one-third of the yearly production of a hardboard manufacturer in Oregon (Blackman 1991:19). Another Northwest US particleboard mill uses 6,000 tons of recycled wood each month, including construction and demolition debris, in its production. The recycled wood stream represents 15% of its total raw materials supply (Plantz 1994:115).

Most important, new technologies hold the promise of creating fiberboard exclusively from waste wood and other MSW. Two plants are under construction in San Diego and Toronto that will each use 100,000 tons of waste per year to create a completely recycled commodity. Siting such a facility in an urban area close to the fuel supply has another advantage — lower costs. The company, CanFibre, estimates that it can "deliver high quality MDF to the market at a cost up to 45% less than current manufacturers" (Wood Technologies 1994:7).

Another use for waste wood lies in the creation of new wood/plastic composites. Separated wood can be processed into fiber that can be mixed with plastic. Wood flour is mixed with polypropylene to make interior panels for the auto industry. For example, Ford currently uses material that contains 77% wood fiber in the Aerostar minivan. This new material is "useful in a wide variety of commercial applications and value-added products" (Youngquist, et.al. 1993:3). Any type of wood waste can used in this procedure. One Massachusetts firm processes 150 tons per day of construction and demolition debris into wood fiber, which can be made into doors and ceiling tiles (Steuteville 1992 :39).

Wood waste can also be used as a composting agent. It can be added to grass clippings and tree limbs or can serve as a bulking agent for sludge composting. Shredded pallets are attractive because of their very low moisture content (Goldstein 1992:77). Their high carbon to nitrogen ratio also makes them ideal to mix with grass clippings (Logsdon 1992:39).

Finally, wood chips are used as a mulch for landscaping. Many park systems use their shredded tree residue as trail markers and around trees or give it away to the public. Other wood processors sell their waste to nurseries, who in turn dye it for use with their clients. The Forest Service is taking this idea a step further and developing a biodegradable mulch mat for use around tree seedlings (Pieper 1993:42).

Urban Wood Waste Stream Components

This section analyzes and assesses the data for the nine components of the urban wood waste (UWW) stream based on our survey interviews with 44 UWW haulers and processors and 19 urban foresters. Survey data and information about the types and estimated quantities of urban wood waste were supplemented by information obtained in interviews with automotive environmental and materials handling staff, pallet manufacturers, National Wooden Pallet and Container Association (NWPCA) staff, and railroad environmental staff.

It should be kept in mind that written documentation and detailed reports to support these self-reported estimates were rare. However, by comparing generators' estimates of UWW quantities with processors/haulers' estimates of those quantities, a detailed and robust picture emerges. Thus, our study provides the most comprehensive and detailed non-proprietary assessment and characterization of UWW to date for Michigan or the U.S. We found no other study which disaggregated the UWW stream to the level of detail — nine components — employed in this study.

Even in the most definitive study of wood waste to date, conducted by Environmental Risk Ltd. and C.T. Donovan Associates in 1992 for the New York State Energy Research and Development Authority (NYSERDA), UWW was divided only into three components: pallets, construction/demolition, and MSW wood. That study also assessed generation and fuel use of wood waste in eight states, as well as one Canadian province, and included estimates of wood waste generated by harvesting (including site conversion, silviculture, and agriculture) and mill residue generated by primary, secondary, and plywood/veneer manufacturing. Thus, the NYSERDA study quantifies two components treated as UWW in this study — site conversion and plywood/veneer — in categories other than UWW.

Our characterization of UWW relies on data provided by wood waste haulers and processors. These self-reported estimates of the nine components found in the UWW stream establish a strong data base. As a first effort, it is not perfect, but subsequent research of this important

secondary material market will enhance precision. Moreover, by interviewing pallet manufacturers and pallet generators in the automotive industry as well as railroad company staff, we produced a robust and precise understanding of pallets and railroad ties as components of the UWW stream.

Key Definitions

Urban wood waste (UWW) is defined in this study as wood residue generated by municipal, industrial, commercial, construction, and demolition sources. "Urban" denotes the non-forestry origins of this waste stream; it does not literally mean the wood waste was generated only in urban areas. Nine components were identified in the UWW stream: pallets/dunnage, wood scraps, construction debris, demolition debris, railroad ties, tree trimmings, land clearing, plywood/particleboard, and other.

Market areas and the frame of analysis are defined here for the purposes of this study. We focused on the three major urban areas of Detroit, Lansing, and Grand Rapids in southern Michigan. Survey interviews were conducted with 44 UWW processors and haulers in these principal market areas as well as other urban areas in southern Michigan, including Muskegon, Jackson, Battle Creek, Kalamazoo, Port Huron, and Flint. The geographic distribution of these firms is 19 in the Detroit area, four in Lansing, 11 in Grand Rapids, and 10 in "other" urban areas.

Of the 44 respondents, 21 respondents indicated that they have Detroit area customers, seven indicated Lansing area customers, 12 indicated Grand Rapids area customers, and 12 indicated they have customers outside of those market areas.

Some haulers and processors indicated having customers in market areas outside of their facilities' market locations. The geographic distribution of UWW customers included: 37 processors who have customers in one market area, six processors who have customers in two market areas, and one processor who has customers in all three market areas.

For quantity reporting purposes in this report, we use the location of processors' facilities rather than the location of the customers for our frame of analysis. The structure of our

survey questionnaire did not permit precise tracking of UWW generation by customers where respondents indicated customers in more than one market area. Thus, generation estimates correspond to the location of the processing facility rather than the location of the UWW generator. Based on our analysis of the customer location data that we were able to obtain, we believe that this introduces only a slight variation in what the quantities would have otherwise been. Moreover, the location of the processor is more relevant to secondary market considerations than the original location of the generated UWW.

Developing Used Pallet Generation Estimates

The vast majority of the UWW hauling and processing market is in pallets: 93% of the respondents in the processors survey process or haul pallets. Used pallets dominate the UWW market because they are relatively clean, dry, and in abundant supply. They make good fuel and feedstock for secondary products.

Pallet Manufacturing and Characteristics. Pallets are relatively free of contaminants, although steel bands, shrink wrap, and corrugated cardboard are frequently attached to used pallets. Virtually all pallets have steel fasteners. Some pallets are chemically-treated or contaminated by chemical products during on or off-loading. In Michigan, pallet supply comes largely from the automotive industry, particularly in the Detroit area market.

Commonly used pallet sizes include 40"x48", 48"x48", 48"x45", 48"x40", and 42"x42". The flush stringer, double-faced, non-reversible pallet is the most widely used pallet. The 48"x40" pallet, used by the grocery industry, is the most common size.[2]

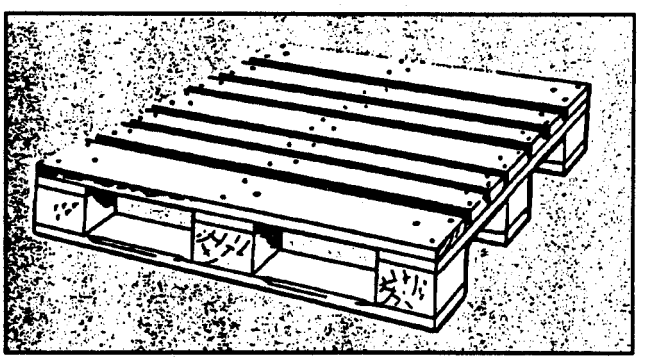

Figure 1: 4-Way Block Design

According to a 1991 study of the national pallet manufacturing industry by Southern Illinois University, Michigan had the largest number of pallet manufacturers in the U.S. with 298

[2]McCurdy, D.R. and J.E. Phelps, "Trends in the U.S. Pallet Industry: 1980, 1985, and 1990," Forest Products Journal, 42(1):28, 1992

firms. The same study estimated that 460 million pallets were produced in the U.S. in 1990. However, a national consultant with extensive experience in municipal solid waste assessment estimated pallet production of 536 million for the same year. Pallet production estimates for Michigan and the U.S. for the last six years are listed in Table 4. It is estimated that Michigan accounts for 5 to 8% of national pallet production, thus Michigan pallet production was between 30 to 47.9 million pallets in 1993.[3] We must rely on this estimate because a survey of Michigan pallet manufacturers was beyond the scope of this study.

Table 4. US & Michigan Pallet Production Estimates (in millions of pallets)

	U.S.	*Michigan(a)*	*Michigan(b)*
1988	465.8	25.3	37.3
1989	505.0	25.2	40.4
1990	536.0	26.8	42.9
1991	540.7	27.0	43.3
1992	565.0	28.3	25.2
1993	599.0	30.0	47.9

(a) Based on 5% of US pallet production
(b) Based on 8% of US pallet production

Sources: Franklin Associates and Public Policy Associates, 1994

The same study found that pallet firms sold 85% of their pallets an average distance of 92 miles from the plant. This average was skewed by a few firms selling nationally, however, the median distance firms sold pallets was only 50 miles from the point of manufacture, suggesting that state pallet production is a reasonably good indicator for state used pallet generation. Furthermore, the use of pallets by the automotive industry is characterized by suppliers delivering their palletized products to automotive manufacturers, resulting in the concentration of used pallet generation at automotive facility locations.

[3]Personal Communication with Bob Moore of Pallox, Inc., a major Michigan pallet producer and member of the National Wooden Pallet and Container Association (NWPCA), who estimated that Michigan production is close to 8% of national pallet production, August 2 and 10, 1994.

Automotive Industry Pallet Use and Waste Reduction. The Michigan-based automotive industry and its suppliers are major pallet generators. We sought to establish how many pallets are used annually by each of the Big Three (GM, Ford, and Chrysler). Estimates of used pallet generation varied substantially.

GM staff estimated that one pallet is used for each car produced and that 15,000 to 20,000 pallets are used per day in GM's North American operations. An approximate estimate of Michigan-based GM pallet use would be in the range of 10,000 pallets per day. GM staff further estimated that 25 to 33% of GM's pallets are reconditioned and reused. GM plants are using both wood and corrugated cardboard pallets, and GM has established a goal of zero waste disposed in landfills by the year 2000.[4]

Chrysler Corporation staff estimated that 20,000 pallets are used per day by Chrysler plants for 250 days per year. The fact that Chrysler reported generating the same level of used pallets as GM illustrates the character of these estimates as broad approximations. Chrysler staff, too, emphasized the zero discharge goal by 2000. It was also pointed out that the automotive industry, through the Automotive Industry Action Group (AIAG), is working with the NWPCA to establish standards for reusable wood containers. As reliance on reusable wood containers and pallets increases, the generation of used pallets by the automotive industry will decrease.[5]

Ford Motor staff stated that they did not know how many pallets are used in their automotive manufacturing operations.[6]

NWPCA staff estimated that five to 10 pallets are used in the production of each car. Interestingly, at least two sources cited a figure of 25 pallets used in the production of each car produced before waste reduction management was instituted over the past six or seven

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[4]Personal Communication with Ken Horvath, General Motors, July 21, 1994.

[5]Personal Communication with Karl Roberts of Chrysler Corp. Materials Handling, June 28, 1994.

[6]Personal Communication with Marshall Guerin, Ford Motor Company, June 27, 1994.

years.[7] We obtained Michigan automotive production data from the Ward's Automotive Yearbook for the past three years and have displayed it in Figure 2. Based on these figures, automotive pallet use for 1993 ranged from a minimum of 2.9 million to a median of 14.6 million up to a maximum estimate of 29.3 million based on one, five, or 10 pallets used per manufactured vehicle for 1993.

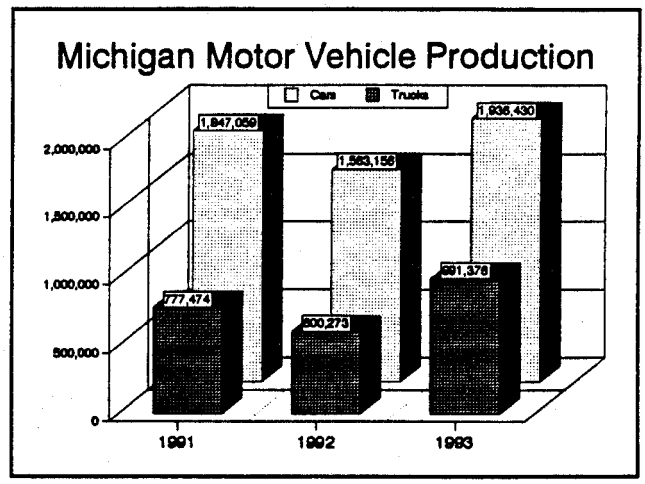

Figure 2

Automotive industry pallet use is probably at the upper end of this range. Until the industry-wide emphasis on waste reduction which began roughly six years ago, the rule-of-thumb estimate of 25 pallets per manufactured car was fairly consistent. A 60% reduction in pallet use, then, would result in a current rule-of-thumb estimate of 10 pallets used per manufactured car. A 60% reduction is clearly a more feasible reduction than a 96% reduction which would be necessary to achieve the use of one pallet per manufactured car suggested by GM staff.

It might also be useful to compare automobile production and pallet production. We can compare Michigan pallet production based on NWPCA estimates and auto industry pallet use, based on this study's estimates. The low estimate of pallets produced in Michigan, 30 million, matches surprisingly well the 29.8 million estimate of pallet use based on auto production figures and 10 pallets per car. Using the larger estimate of state pallet production, 47.9 million, would provide an accurate estimate of pallet use by all industrial users, automotive and others.

Used Pallet Reconditioning Markets. The used wood pallet market is evolving rapidly, and business competition in this market is intense. Pallet reconditioning and recycling competes for used pallets with the industrial wood fuel market, as do landscaping, mulch, composting,

[7]Personal Communication with Sam Baker, Technical Director, National Wooden Pallet and Container Association, June 15 and 20, 1994.

home wood fuel, and recreational surfaces. The continuing high prices of virgin lumber, decreasing supply of public forestlands timber, and perhaps offshore export pressures combine to make the reconditioned pallet market economically attractive to customers and reconditioners. Of 44 respondents interviewed, 29.5% were involved in the pallet reconditioning market. At least one major wood waste processor considers pallet reconditioning more economically appealing than the wood waste fuel market. Reconditioned used pallets are sold for as much as $6 per pallet, and used pallets may command up to $2 for those in very good condition.

Pallet recycling is currently the major market alternative to the wood fuel market. As a higher value-added activity, the pallet recycling market will continue to grow as long as virgin lumber prices remain high. It should also be noted that, while pallet recycling and wood fuel markets compete for used pallets, they also complement each other. We found that 32% of pallet processors recondition pallets *and* use unsalvageable pallets for wood fuel.

Steel nails and bands, dirt, plastic shrink wrap, and corrugated cardboard are the major contaminants in used pallets. Steel is easily removed with magnetic separators. Keeping pallets free of dirt is important and can be a problem if UWW is not handled by adequately trained personnel. Pallets stored in open, unprotected areas for extended periods of time accumulate higher levels of dirt and can make UWW unmarketable. Shrink wrap and old corrugated cardboard (OCC) must be found through visual inspection and manually removed when observed. Moisture content is typically below 15 to 20%. Used pallets represent a reliable source of UWW supply 260 days per year.

The future of the used pallet market is filled with contradictions. With the ever increasing globalization of the economy on one hand and newly developing corporate environmentalism on the other, the pallet industry continues to evolve rapidly. The increasing dispersion of automotive and other manufacturing throughout North America and offshore makes a closed-loop pallet re-use system unfeasible. Further, the increasing pressure to reduce waste and achieve zero waste generation drives the automotive industry to find alternatives to wood pallets or alternative uses for their used wood pallets. The elimination of the use of wood pallets was a concern to 12% of the respondents who process pallets.

Wood pallet alternatives include plastic pallets or corrugated cardboard pallets. Plastic pallets are durable but their strength is suspect, especially in colder climates where low temperatures can cause inflexible plastic to fracture. Loads may also shift on plastic surfaces. Corrugated cardboard is a convenient pallet material since the used pallet generator can bale the old corrugated cardboard (OCC) for recycling. Secondary OCC markets are currently fetching $160 per ton and a ton of baled OCC is far more compact than a ton of used pallets. However, as with most secondary markets, prices are volatile and fluctuate rapidly. Thus, while corrugated cardboard pallets are currently an economically attractive option, no one predicts high OCC prices to continue indefinitely.

Wood pallet rentals may also pose a threat to used pallet generation, according to 15% of the pallet reconditioners. CHEP USA offers a closed-loop pallet recycling system that may reduce used pallet generation in Michigan. Used pallets may be shipped to Chicago, Indianapolis, or its Lansing facility for reconditioning or reuse. Deteriorated pallet wood parts are reused for animal bedding. The CHEP system offers service and durability in the 48"x40" grocery pallet market, but customers may find the system expensive. The company has been operating in the U.S. for about four years.[8] According to CHEP USA staff, Meijers and Spartan Stores are major customers in Michigan.

In spite of processors' concerns about these trends, they are optimistic about the future of their own businesses in the UWW market. Just over 70% predicted increased volumes in the next three to five years, 18.2% predicted decreased future volumes, and 6.8% predicted no change in volumes.

Used Pallet Generation by Market Area

As shown in Table 5, current estimated used pallet generation by the 41 processors and haulers was reported to be 510 TPD (tons per day) and 5,177 CYD (cubic yards per day), for a total of 1,157 TPD.[9] Estimated annual used pallet generation, then, equals 300,820

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[8]Personal Communication with Maggie O'Brien, CHEP USA, September 16, 1994.

[9]This estimate must be regarded as very conservative since we elected to use 50 lbs. as the average pallet weight. We use a formula of five pallets per cubic yard; avg. pallet weight=50 lb., thus, 1 cubic yard=250 lb. and 8 cubic yards=1 ton. Pallets weigh from 30 lbs. for a one-way, expendable pallet to 300 lbs. for a pallet designed

tons. The total capacity for hauling and processing used pallets is an additional 1,600 TPD; thus, capacity is currently being utilized at a rate of 72.3%.

Table 5. Used Pallet Generation and Processing Capacity (in tons)

Location	Daily Generation (TPD)	Capacity (TPD)	Utilization (TPD)	Annual Generation (TPY)
Detroit	708	1,013	69.8%	184,080
Lansing	20	35	57.1%	5,200
Grand Rapids	148	235	62.9%	38,480
Other Area	281	317	88.6%	72,800
Total	1,157	1,600	72.3%	300,560

Nearly 48% of the respondents indicated that pallet volumes had increased in the past three to five years. Almost 7% indicated that volumes decreased, and 45.5% did not answer or did not know.

Approximately 63% of the respondents indicated that the amounts or types of wood waste had changed in the last five years. Twenty-five percent indicated there had been no changes, and 11.4% did not know or did not respond.

Data from 19 UWW processors and haulers in the Detroit area indicate that 708 TPD of used pallets are generated per day. Based on a 260-day year, then, the total annual quantity of used pallets generated is 184,080 tons.

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to support 46 engine blocks. Well-made pallets can perform 5-10 years before joining the UWW stream. Another common pallet is the CPC (Canadian Pallet Council) pallet, a multi-use and reusablee pallet that weighs 88 lb. National Wooden Pallet and Container Association (NWPCA) staff estimated that an average pallet weighs 60-70 lbs. If average pallet weight is increased to 70 lbs., then 1 cubic yard=350 lbs. and 5.7 cubic yards=1 Ton. Thus, the total estimate of pallet generation would be 1,418 TPD.

Detroit area based processors and haulers report that their pallet capacity is 1,013 TPD. Total annual capacity for processing and hauling used pallets is 263,380 tons. Thus, they currently utilize 69.8% of capacity.

Data from four processors in the Lansing area indicate that 20 TPD of used pallets are generated by wood waste generators. The total annual quantity of used pallets is 5,200 tons. Lansing area processors' pallet processing capacity is 35 TPD, or 9,100 TPY. The Lansing market for pallets is currently utilizing 57.1% of capacity.

Eleven Grand Rapids area processors and haulers report that 148 TPD, or 38,480 TPY, of pallets are processed and hauled and a processing capacity of 235 TPD, or 61,100 TPY, with a utilization rate of 62.9%.

Ten processors and haulers in other market areas reported 281 TPD of pallets are processed and hauled, and a capacity of 317 TPD, to produce a utilization rate of 88.6%.

Two respondents with two facility locations aggregated their estimates, and we disaggregated them. This disaggregation was not accomplished perfectly. Thus, we present these market area estimates of used pallet generation as preliminary. However, the total estimate of 1,157 TPD, or 300,820 TPY, based on a response rate of 78.6%, stands as a reasonably accurate estimate of used pallet generation in southern Michigan.

Wood Scrap Generation by Market Area

Wood scraps are the second most predominant UWW material in terms of the number of haulers and processors handling this UWW stream — 43% of the respondents haul or process wood scraps. Our survey findings indicated that 224 TPD of wood scraps are hauled and processed by 19 firms in the Detroit, Lansing, Grand Rapids, and other markets of this study. Annual generation, based on 260 days per year, would be 58,240 tons. Eight respondents indicated that 86 TPD and 10 respondents indicated that 276 CYD of wood

scraps were hauled and processed.[10] One respondent did not report information about quantities hauled or processed.

Table 6. Wood Scraps Generation and Processing Capacity (in tons)				
Location	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit	41.5	80.0	51.9%	10,790
Lansing	25.0	69.0	36.2%	6,500
Grand Rapids	117.0	149.5	78.3%	30,420
Other	40.5	60.0	67.5%	10,530
Total	224.0	358.5	62.5%	58,240

Over 63% (n=12) of the 19 respondents indicated that wood scraps volume had increased over the past five years. A decrease in wood scraps volume was indicated by 26.3%, and 10.5% either did not know or did not answer the question.

Eight respondents indicated that their capacity for hauling and processing wood scraps is 158 TPD. Ten respondents indicated that their capacity is 401 CYD, or 200.5 TPD. Total capacity, then, was 358.5 TPD. The capacity utilization rate was 62.5%.

Six Detroit area respondents reported wood scrap hauling and processing. Three reported hauling and processing a combined total of 35 TPD. Two respondents reported a combined total of 13 CYD, or approximately 6.5 TPD. One respondent did not report any quantity or capacity information. Their combined hauling/processing capacity was 80 TPD. Thus, capacity utilization was 51.9% in the Detroit area market. Estimated annual generation of wood scraps based on our hauling and processing data was 10,790 tons in the Detroit area market.

[10]For wood scraps, we use a conversion rate of 2 CY=1 Ton, or 1 CY=1,000 lb. Thus, we converted 276 CYD to 138 TPD. We note that the Wisconsin DNR calculated dunnage (wooden packing material) to weigh 35 pounds per cubic foot (pg. 35), or 945 pounds per cubic yard, in its 1993 wood residue survey.

Three Lansing area respondents reported wood scrap hauling and processing. Two reported hauling and processing a combined total of 16 TPD, and one reported 18 CYD, or 9 TPD, for a total of 25 TPD. The capacity for hauling and processing wood scraps was estimated to be 69 TPD. The capacity utilization rate, then, was 36.2%. Annual generation of wood scraps based on our processing and hauling data was 6,500 tons.

Six Grand Rapids area respondents reported wood scrap hauling and processing. Two reported their combined hauling and processing of 32 TPD. Four reported 170 CYD, or 85 TPD, totaling 117 TPD of wood scraps hauled and processed in the Grand Rapids area. Annual generation of wood scraps based on our processing and hauling data was 30,420 tons. The combined capacity for respondents reporting both weights and volumes was 149.5 TPD. Thus, the capacity utilization rate for Grand Rapids area respondents in hauling and processing wood scrap was 78.3%.

Four respondents in other southern Michigan market areas reported hauling and processing a combined total of 3 TPD and 75 CYD, or 40.5 TPD of wood scrap. The total reported capacity of the four respondents was 60 TPD for a utilization rate of 67.5%. Annual generation of wood scraps based on our processing and hauling data was 10,530 tons.

Construction Debris Generation by Market Area

The literature generally treats construction debris and demolition debris as one common stream, known as C/D in the literature. However, we designed our survey instrument to elicit responses specific to either construction or demolition debris. We find the physical characteristics of these two streams to be quite different. Since demolition debris wood waste is often contaminated with lead-based paints, this material can pose a significant threat to human health and the environment.

Construction debris, as Donovan points out, contains "wood scraps from laminates used for sheathing and flooring, laminated beams, moldings and casings, dimensional lumber, painted or stained, trim, and siding." Demolition debris wood, in addition to lead-based paints,

contains painted sheathing, plaster, preservatives, asphalt shingles, tar paper, or insulation.[11] Therefore, demolition debris requires greater handling to separate materials than does construction debris.

Estimates of C/D debris generation are deeply problematic. Donovan asserts in the NYSERDA report that wood content of C/D debris varies from 15 to 85% (emphasis added). A study by the Greater Toronto Homebuilders indicated that 40% of residential construction waste is wood and wood products.[12] Thus, our self-reported estimates of C/D generation may be preliminary, but they represent a starting point for assessing a very difficult component of the UWW stream.

As no standardized methodology for collecting data on the generation of MSW, including UWW, currently exists,[13] it is our intent that this study will contribute to the formation and practice of sound protocols for gathering and analyzing waste generation data. By taking one component of the solid waste stream and subdividing it into its constituent parts, we can better understand the sources and parameters of its generation and associated characteristics, particularly in terms of disposal practices and potential for secondary market use.

More than 22.7% (n=20) respondents indicated that they hauled or processed 348.5 TPD of construction debris.[14] The total annual quantity of construction debris processed and hauled was 90,610 tons. The estimated capacity for hauling and processing construction debris was 1,004.5 TPD, or 261,170 TPY. Thus, the capacity utilization rate was 34%.

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[11]Donovan, C.T. and Environmental Risk, Ltd., Wood Waste in the Waste Stream: Characterization and Combustion Emissions, 1992, p.3-6.

[12]ibid., p. 3-6.

[13]Office of Technology Assessment, Facing America's Trash: What Next for Municipal Solid Waste, OTA-024, U.S. Government Printing Office, 1989, p.76. This report emphasized this methodological gap, and interviews with MDNR, local, and private sector waste management staff uniformly corroborated that this gap remains a serious problem for solid waste planning.

[14]Volumes reported in cubic yards were converted to weight measures by calculating 2 cubic yards per ton. We note the wide variance of wood composition discussed in the NYSERDA report as well as noting that the 1994 Oakland County solid waste update revised its C/D conversion from 1:1 to 2 gateyards to 1 ton. A gateyard is a compacted cubic yard of wastes "coming through the gate."

Table 7. Construction Debris Generation (in tons)				
	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit	180.5	969.5	18.6%	46,930.0
Lansing	3.0	5.0	60.0%	780.0
Grand Rapids	12.0	20.0	60.0%	3,120.0
Other*	153.0	10.0	---	39,780.0
Total	195.5	994.5	19.7%	90,610.0

*Daily generation includes two firms, but daily capacity for only one firm. Therefore, the utilization rate cannot be calculated. The data for this group is excluded from the calculation of total utilization rate.

Six Detroit area respondents indicated that they hauled or processed a combined total of 180.5 TPD of construction debris. They reported a combined capacity of 969.5 TPD for a utilization rate of 18.6%. This rate reflects one processor indicating that he is operating at 10% capacity. This processor is able to handle a diverse range of materials, and it is not unlikely that his capacity may be more modest than what was reported. In any event, this capacity rate skews the overall average capacity utilization rate.

Four Detroit respondents reported hauling and processing a combined total of 53 TPD (ranging from 7 to 32 TPD). Two respondents reported 255 CYD, which we converted to 127.5 TPD. The combined total of construction debris hauled or processed in the Detroit area, was 180.5 TPD or 46,930 TPY. These respondents indicated their combined capacity for hauling and processing construction debris was 77 TPD, ranging from 7 to 48 TPD. Two respondents indicated their combined capacity was 1,785 CYD, converted to 892.5 TPD. The total capacity for hauling or processing construction debris in Detroit was determined to be 969.5 TPD.

One Lansing area respondent indicated that he hauled or processed 3 TPD of construction debris. That respondent reported a capacity of 5 TPD, for a utilization rate of 60%. Estimated annual generation of construction debris was 780 tons.

One Grand Rapids area respondent indicated hauling or processing 12 TPD of construction debris and a capacity of 20 TPD for a utilization rate of 60%. Estimated annual generation of construction debris was 3,120 tons.

Two respondents in other southern Michigan market areas hauled or processed 153 TPD of construction debris. One respondent reported 3 TPD. The other reported 300 CYD, converted to 150 TPD. Estimated annual generation of construction debris was 39,780 tons.

The combined capacity for hauling or processing construction debris of these two respondents was 160 TPD. One reported 10 TPD capacity. The other did not report capacity information, so we cannot calculate a capacity utilization for this group.

Demolition Debris Generation by Market Area

Only three respondents reported hauling and processing demolition debris. However, given the regulatory concerns associated with this UWW stream, the small number of firms hauling and processing demolition is not surprising. This may change if regulatory treatment of this UWW stream component is relaxed towards its use as boiler fuel and in other secondary materials.

The EPA Appeal Board's decision and opinion in the Genesee facility air permit appeal (September 1993) suggest that this change in federal regulatory treatment is clearly underway. This decision allows the use of demolition debris as a fuel as long as strict handling standards are established and implemented. The decision specifically allows fuel cleaning, that is, removal of lead-treated wood, as BACT (best available control technology) for lead emissions.

Table 8. Demolition Debris Generation & Processing Capacity (in tons)				
	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit firms	125	875	14.3%	32,500
Lansing	--	--	--	--
Grand Rapids	--	--	--	--
Other*	8	10	--	2,080
TOTAL	125	875	14.3%	34,580

*Daily generation includes two firms, but daily capacity for only one firm. Therefore, the utilization rate cannot be calculated. The data for this group is excluded from the calculation of total utilization rate.

The total amount of demolition debris hauled and processed in our study area, based on the responses from three respondents, is 133 TPD, or 34,580 TPY[15]. A breakdown is shown in Table 8. This amount undoubtedly underreports the demolition debris stream in our study area, but development of a more precise estimate is beyond the scope of our project. The total capacity was reported to be 875 TPD; the utilization rate, then, was 14.3%.

One Detroit area respondent reported hauling 250 CYD, or 125 TPD, of demolition debris. His capacity was estimated to be 1,750 CYD, or 875 TPD. Thus, his capacity utilization rate was 14.3%. His annual estimated processing was 32,500 tons.

In its *1990 Solid Waste Management Plan Update* published in April, 1994, Oakland County estimated C/D generation of 138,430 TPY, or 379.26 TPD, for 1990. No attempt was made to separate out the construction and demolition streams. This estimate was derived from a 1980 survey by Camp Dresser and McKee, which was conducted to assist the development of

[15]We find the same conversion factor we have used for construction debris and wood scrap to be appropriate for demolition debris as well (2 CY=1 Ton).

Oakland County solid waste planning. This C/D stream is composed of concrete, wood scraps, metals, and plastics.[16]

Wayne County solid waste management data estimates that 13.2 million tons of solid waste were generated in 1989, including 6 million tons generated by the residential sector, 4.9 million tons by the commercial sector, 1.4 million tons by the industrial sector, and 870,000 tons in a "special" category including C/D debris. C/D was estimated to be 516,000 TPY.

There was no reported hauling or processing of demolition debris by Lansing or Grand Rapids area haulers or processors. However, Lansing-based Daggett Sand and Gravel hauled 65,000 cubic yards of demolition material in 1991, according to the most current Ingham County Solid Waste report (1992), and deposited that demolition debris in their Type III landfill. We were unable to obtain any further information from the Daggett operation. However, county solid waste staff indicated that Daggett processes and sells as much of its demolition debris in secondary markets as feasible in order to extend the life of their landfill. It is five or six years from reaching its capacity, according to county staff.

The other two counties in the mid-Michigan area, Clinton and Eaton, take a combined total of 25,000 cubic yards of demolition waste to the Daggett facility, based on 1988 estimates in their 1990 solid waste plans. It should be noted that, while these reports characterizing waste deposited at the Daggett facility use the term demolition waste, the same reports also use the term construction debris interchangeably with demolition debris.

Kent County solid waste management data indicated that wood makes up 6.4% of the waste stream, or 97.1 TPD and 35,441 TPY. No attempt was made to disaggregate the C/D stream. In all likelihood, this estimate is based solely on a waste generation per capita rate, and the percentage of composition assigned to wood waste is arbitrary.

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[16]Wood waste generation was estimated to be 19,897 tons/year. This estimate was derived from employee generation factors of 1.05 tons per employee per year in the commercial sector and 6.01 tons/emp./yr in the industrial sector. The wood waste percentage of the total waste stream was calculated to be 2 to 4%, depending on the sector of generation. These generation factors were derived from the 1980 Camp Dresser and McKee survey.

Two respondents in the other market areas reported hauling and processing 3 TPD and 10 CYD, totaling 8 TPD of demolition debris. One respondent reported a capacity of 10 TPD, but the other respondent did not report capacity. The utilization rate, then, for the respondent reporting was 30%.

Tree Trimming Residue Generation by Market Area

The Great Lakes states produced 2.7 million cubic yards of urban tree and landscape residue in 1993, according to a draft report by the International Society of Arboriculture (ISA) Research Trust prepared by the NEOS Corporation. Residue generation was not disaggregated by state.

This report quantified seven categories of urban tree and landscape residue: chips, unchipped logs, tops and brush, mixed wood, fall leaf collection, grass clippings, and whole tree stumps. Commercial tree care firms and electric line maintenance account for 91% of the total national generation of this residue, according to the report.

Our surveys of processors and urban forestry departments provide a strong preliminary assessment of urban tree residue generation. However, a survey of commercial tree care firms was beyond the scope of this project.

Eleven percent of the respondents indicated that they hauled or processed tree trimming residue. Three respondents indicated that they hauled or processed a combined total of 10 TPD, and one respondent indicated 5 CYD, or 1.25 TPD.[17] One did not report any volume or weight. The total reported amount of residue hauled or processed was 11.25 TPD, or 2,925 TPY (based on 260 days/year). The total capacity was estimated to be 13.5 TPD, and the utilization rate was 83%.

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[17]As noted in the 1992 Minnesota study on urban tree residue, the variability of bulk residue density is considerable. That report used conversion factors of 6 yds./ton for tops and brush, 5 yds./ton for mixed material, and 3.3 yds./ton for chips. Since we assume that most of the reported quantities of tree trimming residue are chips, we elect to use 4 yds./tons as our conversion factor. That is also the conversion factor used by the McGraw-Hill Recycling Handbook. We also note that the 1993 Wisconsin Wood Residue Study used a conversion factor of 7.4 yds./ton for chips and shavings.

Table 9. Tree Trimming Residue Generation and Processing Capacity				
	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit Firms	9.0	9.0	100%	2,340
Lansing	--	--	--	--
Grand Rapids	--	--	--	--
Other	2.3	4.5	50%	585
TOTAL	11.3	13.5	83%	2,925

In addition to our survey of processors and haulers, we also conducted a separate telephone survey of 19 city and parks and forestry departments, university grounds departments, and utility tree trimming operations. Responses were received from 16 of the 19 interviews we attempted, giving us a response rate of 84%. Detailed information by area is shown in Table 9.

Four entities responded to our urban forestry residue survey in the Lansing area market: the cities of Lansing and East Lansing, Lansing Board of Water and Light, and Michigan State University. They generated a total of 1,559 tons of urban tree residue from tree trimming and removal operations.

Eleven entities responded to our survey in the Detroit area market, including the cities of Royal Oak, Warren, Farmington Hills, Pontiac, Sterling Heights, Southfield, Waterford, and Detroit, as well as Wayne County and Detroit Edison. Detroit Edison maintains meticulous records of their tree trimming residue. The other respondents relied on estimates, some of which were broad approximations.

For 1993, Detroit Edison generated 132,275 CY of wood chips from their line clearance operations, or 33,068 tons.[18] This level of residue generation will decrease as the company's current line clearance program is completed. Detroit Edison's line clearance program is currently very intensive to combat a problem with downed lines resulting from storm

[18]We used the same conversion factor, 4 yds./ton, for tree residue chips from utility tree trimming operations as we used above for general tree trimming residue.

activity. Thus, the current level of residue generation is expected to decline 25 to 35 percent. However, routine maintenance of lines will continue to generate a substantial level of tree trimming residue.[19]

The city of Detroit is the next biggest generator of urban tree residue with 16,600 tons. Combined with other municipal jurisdictions in the Detroit area, the total residue generated is 17,537 tons.

Results and findings from the Grand Rapids area were incomplete as no estimates were supplied by the city of Grand Rapids or Kent County. Grand Valley State University reported an estimate of four tons per year.

Table 10. Total Tree Trimming Annual Residue Generation (in tons)	
Detroit processors	2,340
Detroit Edison	33,078
Detroit area forestry operations	17,537
Lansing/MSU forestry operations	1,559
Grand Rapids	4
Other area processors	585
TOTAL	55,093

Our total annual urban tree trimming residue generation estimate of 55,093 tons, as shown in Table 10, is very conservative since the response rate from Grand Rapids firms and public forestry agencies was extremely low. In addition, while obtaining data from the commercial tree care industry was well beyond the scope of our study, we attempted to obtain baseline data from tree care/nursery associations in our three market areas. However, we were not able to obtain even preliminary data from these associations. The lack of response from Consumers Power further skews our estimate of the total generation rate.

[19]Personal Communication with Marge Damian, Detroit Edison, July 21, 1994.

Four factors affect the generation of urban tree residue and data reporting:

- budgetary constraints,
- scope of operation,
- jurisdiction, and
- measurability.

Many respondents reported that their departments contracted out their tree trimming and removal operations. Thus, data about these operations were not always complete. Budgetary constraints often restricted operations. For instance, some jurisdictions collected only storm damaged trees. Organizational boundaries also affected amounts reported. Some respondents reported that their county road commissions also trimmed trees and collected residue. Data on these amounts were not obtained nor added to aggregate totals. Finally, residue measurement recordkeeping was a problem for some respondents, who were unable to quantify residue amounts.

Most jurisdictions reported chipping their residue and using the chips in their parks and playgrounds or in compost yards. Many disposal schemes often included free distribution of mulch to the public. However, small amounts were incinerated or landfilled, but these were generally logs that were either too unwieldy for public use as firewood or too large to be chipped with existing equipment.

Future residue production was often viewed as a function of budgetary issues. Some respondents noted that future plans would involve privatization or increased departmental allocations for trimming. Most of the respondents that use chippers for their residue planned to chip more in the future, and one respondent was specifically interested in selling some of his wood residue to a cogeneration facility.

Wood Waste Generation from Land Clearing

Eleven percent of the respondents indicated that they haul or process 27 TPD of land clearing wood waste. The total annual quantity of wood waste generated by land development and clearing was 7,020 tons (based on 260 days/yr).

Two Detroit area respondents reported that they haul or process 10 TPD, or 2,600 TPY, of land clearing wood waste. Reported estimated capacity was 10 TPD, for a utilization rate of 100%. No respondents indicated hauling or processing any of this UWW stream in the Lansing or Grand Rapids area markets.

Table 11: Land Clearing Wood Waste Generation
(in tons)

	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit firms	10	10	100%	2,600
Lansing	--	--	--	--
Grand Rapids	--	--	--	--
Other	17	30	56%	4,420
TOTAL	27	40	68%	7,020

This component of the UWW stream is relatively more specialized and at the low value end of the market. Since stump removal is frequently required as part of land clearing, heavy-duty removal equipment, in addition to a tub grinder, may be required. Thus, the costs are higher than for other UWW component processing. Finally, dirt and other contaminants make land clearing wood waste a problematic feedstock for most secondary market applications. However, land clearing wood waste is an appropriate feedstock for composting where the dirt contamination is not a problem in terms of end-market use.

Plywood/Particleboard Waste Generation

Eighteen percent of the respondents indicated that they haul or process 42.5 TPD (11,050 TPY) of plywood/particleboard, 62.5% reported a combined total of 36 TPD, and 37.5% reported a combined total of 13 YPD, or 6.5 TPD.[20] Their estimated capacity was 67.5 TPD. Thus, the utilization rate was 63%.

Three respondents in the Detroit area market indicated they hauled or processed 6.5 TPD of plywood/particleboard (one respondent reported 2 TPD and two reported 9 CY, or 4.5 TPD)

[20]We use a conversion factor of 2 cubic yards/1 ton.

and estimated capacity of 15.5 TPD (one reported 7 TPD and two reported 17 YPD, or 8.5 TPD). This utilization rate, then, was 42%.

One respondent in the Lansing area market indicated he hauled or processed 1 TPD of plywood/particleboard and estimated capacity of 2 TPD for an utilization rate of 50%.

Three respondents in the Grand Rapids area market indicated they hauled or processed 34 TPD of plywood/particleboard (two respondents reported a combined total of 32 TPD while one reported 4 CYD, or 2 TPD) and estimated capacity of 49 TPD (two respondents reported a combined capacity of 45 TPD and one reported 8 CYD, or 4 TPD) for a utilization rate of 69.4%.

One respondent in an urban market area other than the above indicated that he hauled or processed 1 TPD and estimated capacity of 1 TPD as well for a utilization rate of 100%.

Table 12: Plywood/Particleboard
Waste Generation and Processing Capacity

	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit firms	6.5	15.5	41.9%	1690
Lansing	1	2	50.0%	260
Grand Rapids	34	49	69.4%	8840
Other	1	1	100.0%	260
TOTAL	42	67	62.7%	11,050

Used Railroad Ties

Nationally, there are 750 million railroad ties in the U.S. and Canada, and approximately 12 million of these ties, or 1.6%, are replaced yearly. For 1991 (the most recent year for which data are available), the Michigan Department of Transportation (MDOT) estimates that there were 3,994 commercial railroad miles of track in Michigan. Calculating 3,088 cross

ties per mile and replacing 64 miles of track per year, over 197,000 ties are replaced annually in Michigan, weighing 14,800 tons.[21]

This estimate seriously underreports the total number of railroad ties requiring disposal since short line private track is not included. The length of short line track owned by large manufacturers is not known. This underreporting is further compounded by not including spent ties generated by the consolidation and removal of existing commercial and private rail lines.

Finally, this estimate is based on annual maintenance. Stockpiled inventories of used ties are not included. At least one rail line in Michigan has a heavy backlog of used ties that must be eliminated. Burlington Northern Railroad staff estimated that 100 million additional ties nationally are "strategically stored" along rights-of-way.[22]

Interviews with railroad staff of the three major Michigan rail lines were conducted to obtain preliminary estimates of used railroad ties annually generated and current disposal methods. Their responses may be compared with national data and information about railroad tie disposal.

Nationally, 62% of used ties are sold to contractors, who then sell them to commercial landscapers or lumberyards. One-fifth of old ties are landfilled, 15% are sold to cogeneration facilities, and 3% are stored.[23] These estimates suggest that approximately 28,000 ties per year are removed in Michigan and not used as fuel or sold commercially. However, none of the staff that we interviewed indicated that any used ties produced by their lines were landfilled.

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[21]Personal communication with Peter Conlon, Association of American Railroads, July 21, 1994. Mr. Conlon provided the formula of 3,088 ties per mile and the weight of a tie, which is 150 lbs.

[22]Glavin, Bill, "AREA President Speaks Out on Tie Disposal," Crossties, January/February 1993.

[23]Conlon, Peter, "The Challenge of Crosstie Disposal," Railway Track and Structures, December 1992.

CSX generates nearly 170,000 used ties annually in Michigan. The entire amount is sold to a contractor. In a 1993 roundtable discussion sponsored by Association of American Railroads Transportation Test Center, the Chief Environmental Officer for CSX, W.J. Turner, indicated that his company was primarily storing ties in their railyards. He indicated that liability concerns prevented them from dealing with contractors. As a result, between six and 10 million ties were being stockpiled.

Grand Trunk has similar problems managing its annual generation of 70,000 used ties. Ties are sorted by quality, and the best are sent to a landscape wholesaler in Canada. Grand Trunk is considering chipping the ties and sending them to a cogeneration facility. The respondent estimated that 200,000 to 300,000 ties are stored in rail yards in Michigan.

ConRail annually disposes of 750,000 ties at the Koppers cogeneration facility in Pennsylvania, which relies exclusively on treated wood waste for fuel.

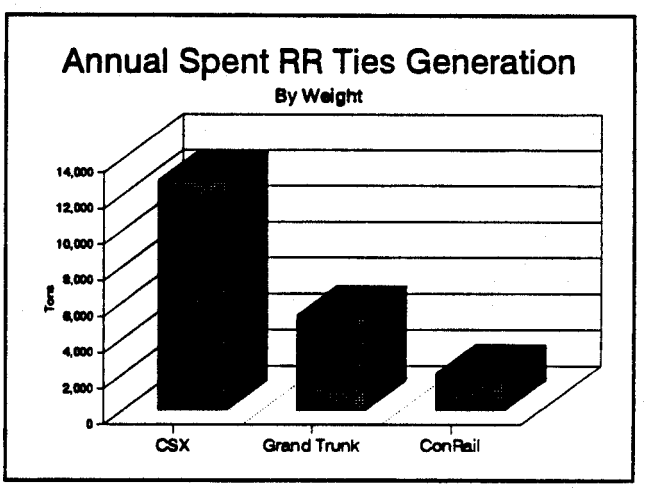

Figure 3

We conservatively estimate that Michigan generates 267,000 ties, or 20,025 tons of ties, per year based on our preliminary survey. However, the key question that lies outside the scope of this study is how many ties are stockpiled by commercial and private lines in the state. Based on our preliminary survey, 1,000,000 ties may be a reasonable estimate, which represents 75,000 tons.

Transportation logistics affect the ability of a rail line to find alternate uses for spent railroad ties. One respondent referred to the prohibitive shipping costs associated with transporting used ties to processing facilities. Since many of these facilities are not accessible to rail lines owned by each rail carrier, these carriers do not want to pay another railroad to transport its waste. Similarly, disposal of spent ties can be logistically difficult. Several operators in a the 1993 roundtable spoke of having to use hundreds of cars to haul spent ties to a processor.

Regulatory issues relating to railroad ties as boiler fuel for energy generation are discussed in a later section of this report. If railroad tie combustion can meet strict Michigan air emission and ash disposal standards, it is likely that the quantification of railroad ties will reveal estimates higher than that of this study.

Other Wood Waste Generation

Eleven percent of the processors surveyed indicated that they haul or process other wood waste in addition to those categories listed above. Most of these firms indicated that they handled sawdust. Chips and waferboard were the other categories identified.

One respondent in the Detroit market processes 3 YPD, or .5 TPD,[24] for a total annual generation of 130 tons. The utilization rate is 50%. Two respondents in the Lansing market process a combined total of 124 YPD, or 21 TPD, for an annual generation rate of 32,240 tons. Their combined utilization rate was 36.2%. One Grand Rapids and other market respondent indicated that they process 6 TPD, or 1,560 TPY. Overall totals are shown in Table 13.

Table 13: Other Wood Waste Generation and Processing Capacity (in tons)

	Daily Generation	Daily Capacity	Utilization Rate	Annual Generation
Detroit firms	0.5	1	50.0%	130
Lansing	21.0	58	36.2%	5,460
Grand Rapids	5.0	5	100.0%	1,300
Other	1.0	2	50.0%	260
TOTAL	27.5	66	41.6%	7,150

[24]Based on the calculations used in both the 1993 Wisconsin survey of secondary wood manufacturing residue generation and the 1994 Michigan survey of the same sector, we use 6 cubic yards per ton. The exact conversion in those surveys is 11.5 pounds per cubic foot.

Wood Processing and Fuel Prices

More than 45% respondents process their own UWW, 50% do not, and 4.5% did not answer this question. Nearly 39% of respondent firms want to add equipment. In some cases, this addition would upgrade or supplement existing equipment. In other cases, acquisition of processing equipment would represent new processing capacity. In all cases except one, respondents indicated that they want to add tub grinders.

Thirty-four percent of the respondents sell processed UWW to wood-burning facilities, including the Dow Corning Midland facility, the two Viking Energy facilities, and the Cadillac facility.

Table 14. Major Wood Combustion Cogeneration and Electric Generating Facility UWW Fuel Users

Facility	Location	Year On-Line	Generating Capacity (MW)	Wood Fuel Use (GT)
Dow Corning	Midland	1981	22.5	290,400
LFC Power	Hillman	1987	18.0	250,000
Viking Energy	McBain	1989	16.2	190,000
Viking Energy	Lincoln	1989	16.2	190,000
AJD Ltd.	Grayling	1992	28.0	330,000
Cadillac	Cadillac	1993	34.0	450,000
Genesee Ltd.	Flint	Spring 1995	35.0	452,000*
Albion Ltd.	Albion	Planning stages	40.0	440,000*
On-Line Capacity			134.9	1,700,400
Planned Capacity			75.0	892,000
TOTAL			209.9	2,592,400

All facilities are independent power producers (IPPs) except the Dow Corning facility. SOURCE: Michigan Wood Products Directory and capacity ratings by Public Policy Associates, which reflect information obtained from facility managers.
*(These figures are projected.)

Wood fuel prices currently range from $12 to $35 per ton, according to seven of the 44 respondents who answered the question. Most did not want to divulge pricing information. The mean price among those who did respond was $21.28, and the median was $21, which fits our knowledge of the Michigan UWW fuel market. Price variations depend on supplier relationships, quality of UWW fuel, and transportation distances. Some facilities pay a premium for wood fuel hauled over 100 miles, for example.

There is considerable disagreement about current and future UWW fuel prices. What is known with certainty is that UWW fuel prices have historically been around $15 per ton. In 1993, the 34-megawatt Cadillac facility went on-line and substantially increased demand for UWW in the winter and early spring. This demand surge spiked prices up to over $30 per ton in early 1994. It was reported that, even with these higher prices, the supply of UWW did not adequately meet demand. Severe winter weather caused transportation and UWW processing delays, which exacerbated the market supply shortage. Facilities were adversely affected, and at least one facility was reportedly close to a shut-down because of the supply problem.

Prices have settled back to the low to mid $20s, according to processors and UWW fuel buyers. The over-$30 per ton fuel prices of early 1994 may be regarded as an aberration resulting from the market's attempt to absorb the spike in demand and prices from the Cadillac facility going on-line. However, it is not at all implausible that prices will rise again from the current $20-23 when the Genesee facility goes on-line in the spring of 1995.

Plans by Decker Energy International, Inc. and Wheelabrator, Inc. to develop a wood-fuel power generating facility in Michigan have been detoured but not derailed. Strong opposition from citizens in Charlotte (a small city located 22 miles southwest of Lansing) caused the developers to relocate the site of the proposed facility to Albion (a small city located about 30 miles south of Lansing, between Jackson and Battle Creek). Public opposition was so intense that the entire local Charlotte election in November 1993 turned on the issue of what the opposition called an incinerator. Citizen opposition was particularly inflamed by the proposed use of tire-derived fuel (TDF) and the accusation that waste would be hauled in from Chicago.

The Decker facility will have a 40 MW capacity and require 215,000 BDT/year of fuel. Should the facility be developed in Albion as currently envisioned, it will be the only facility with good access to the Kalamazoo, Battle Creek, Jackson, and Lansing UWW fuel markets. Thus, this facility would significantly add to the fuel demand for UWW in Michigan.

Yet another qualifier must be added to the discussion of future prices. One market anomaly is that a CMS processor established to supply the Genesee facility (CMS is the developer of the Genesee facility) is currently buying UWW and transporting it to the AJD facility (another CMS facility) in Grayling. As a result, processed UWW is being stockpiled there. Some processors have speculated that the current pinch in supply may already reflect the increased demand of the Genesee facility even though it is not yet on-line. A key processor also pointed out that if virgin timber prices decline, UWW prices will decline also. Virgin timber prices are very sensitive to key economic trends, especially housing starts. Thus, a serious downturn in the national economy would cause both virgin and secondary wood prices to decline. Therefore, any predictions about future virgin timber prices and secondary markets are very problematic. The only safe prediction is that the UWW market will continue to fluctuate as demand and supply seek an equilibrium price.

Finally, UWW prices would almost certainly increase dramatically if a proposed Detroit Edison venture to build a medium-density fiberboard (MDF) facility in Detroit is realized. However, the prospects of this plant being built are uncertain. This proposed plant would require over 100,000 tons of UWW per year, or 400 TPD (based on 250 days/year, according to Detroit Edison). The plant would have a distinct advantage over wood combustion cogeneration facilities since it would be located in the "urban wood waste forest." Transportation costs would be low, and the venture would have the potential ability to pay relatively more than IPPs for processed UWW. For example, if the project were to pay $20 per ton, the processor would realize up to $10 to $14 per ton net return as opposed to $3-$5 per ton in net return in shipping UWW to cogeneration facilities 60 to 100 miles from UWW supply markets.

Competing End Markets

Our survey of processors and haulers elicited data about seven competing end-market uses for UWW (plus an "other" category).

In addition to selling pallet residue for boiler fuel, 30% of respondents indicated that they recondition and recycle used wood pallets. It was emphasized by at least 9% of respondents that pallet reconditioning was a higher value-added use for UWW than boiler fuel. As such, this end-market is relatively more financially attractive. However, in all cases the complementary aspects of pallet reconditioning and using deteriorated pallet residue for boiler fuel was acknowledged. These two end-market options together provide a comprehensive range of use for used pallets that is clearly superior to landfilling or stockpiling.

The second greatest end-market use for UWW was landscaping; 25% of respondents indicated activity in this market. The landscaping market primarily includes using wood for mulch. Mulch use has become increasingly popular with home, commercial, and institutional gardeners and landscapers in recent years. At least one respondent adds different colors to mulch, which some consumers find appealing. This further enhances the value added and increases the market appeal of mulch products. The future of the mulch end-market appears strong with the increasingly greater emphasis on natural and "organic" approaches to gardening and landscaping.

Given the dominance of the boiler fuel market, it is not surprising that firewood was the third most frequently cited competing end-market use; 14% of respondents indicated participation in this market. The level of activity in this market was considerable — from commercial distribution of the product to giving it away on site. The variability may be a function of the volume of UWW processing and hauling and marketing expertise of each firm. The scope of our study precluded a more in-depth understanding of this UWW market.

Few respondents (9%) participated in three other end markets: composting, recreational surfaces, and animal bedding. Composting is frequently included in current municipal recycling programs, and UWW, particularly tree trimming residue and land clearing waste, can be a productive and appropriate feedstock for a good compost mixture.

The variety in the range of the UWW stream precludes simple characterization of the composting end-market for UWW. Since compost operations generally charge tipping fees for UWW, compost operations can become another end-market for UWW processors. Space and technical knowledge requirements for composting are considerable. As discussed in the section on regulatory issues, the future of the legislative yard waste ban is still not resolved, so any predictions about the composting end-market must be very cautious.

The passage of the federal Americans with Disabilities Act (ADA) in 1992 requires the use of handicapper-accessible surfaces for publicly-funded parks and playgrounds. Consequently, a new UWW market in recreational surfaces has developed. As a new and emerging market, this is difficult to analyze in terms of the current and historical data obtained in our survey. Those firms (9%) that indicated activity in this market were optimistic about its growth potential. It is unclear whether UWW processors will enter this end-market as a supplier of both the wood-surfacing product and installation services or exclusively as a product supplier. Our survey elicited information that the labor-intensiveness of installing these surfaces may act as a deterrent to market entry. In addition, technical expertise is essential in installing the surface. A layer of porous material to permit drainage must be installed as a base for the wood chips. Inadequate installation resulting in poorly-drained surfaces will cause rapid deterioration of the wood chip surface.

Animal bedding is a well established alternative end-market use for wood chips and shavings and continues to be an option for 9% of respondents. However, this is not a high-value market activity.

No respondents indicated participation in the composite wood market. However, should the Detroit Edison project to construct a medium-density fiberboard (MDF) facility materialize, the enormous demand for UWW created by this facility would fundamentally alter the

Issues and Conclusions

Regulatory requirements in Michigan for wood-fired electric generating facilities are very strict. Indeed, these requirements appear to be stricter in Michigan than in states like New York and Minnesota, which are known for strict regulatory controls. Currently, wood "treated" with any chemicals or wood contaminated by non-wood materials (lead-based paint, plastic shrink wrap, or corrugated cardboard) is not permitted for use as fuel because of its anticipated impact on toxic air emissions.

The Michigan Department of Natural Resources Air Quality Division (MDNR-AQD) prohibits the emission of any air contaminant which causes injury to human health or safety, other significant life, or property, or "causes unreasonable interference with the comfortable enjoyment of life and property."[25]

A test burn at the Viking Energy facility in McBain scheduled for September, 1994 will provide data to evaluate the use of six fuel types:

1) creosote-treated wood;
2) PCP-(pentachlorophenol) treated wood;
3) CCA-(chromated copper arsenate) treated wood;
4) particleboard/plywood;
5) construction/demolition (C/D) debris; and
6) tire-derived fuel (TDF).

Regulatory concerns include emissions of particulates (PM 10), hydrogen chloride, heavy metals, polychlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs), polynuclear aromatic hydrocarbons, formaldehyde, and benzene for all fuel types. For PCP-treated wood, chlorinated phenols are an additional concern.

Primary areas of environmental concern will likely include NOx from binders in particleboard and plywood, chlorinated organics from the PCP and creosote wood

[25]Michigan Department of Natural Resources Air Quality Regulations, Rule 901.

preservatives, carbon monoxide from the TDF, and arsenic and chromium from CCA-treated wood.

The McBain facility's combustion zone is estimated to be about 1800 degrees Fahrenheit and has a system of mechanical cyclones and a series of two ESPs (electrostatic precipitators) to control fly ash emissions. It is expected that the facility's combustion temperatures and pollution control equipment will allow combustion of these materials without toxic emissions exceding regulatory limits. Railroad ties and C/D debris are the most sizeable UWW streams that will be impacted by this test burn.

State regulatory approval of C/D, railroad ties, and other "treated" wood types as fuel for wood combustion facilities would clearly increase the amount of available UWW supply. As things currently stand, these "treated" UWW types must be disposed of in Type II and Type III landfills and are not currently accepted as an available fuel source. Thus, creating a new disposal option for spent railroad ties, C/D, and other "treated" wood types would augment fuel market supply and provide new market supply sources for wood processors.

Our survey of UWW processors and haulers indicated that no processors or haulers handle railroad ties. However, we know that at least one processor is ready to process ties as soon as regulatory approval is granted. As shown above in Figure 3, we estimated conservatively that 20,025 TPY, or 77 TPD, of ties are generated by Michigan rail lines. If ties were allowed to be used as boiler fuel, more ties would make it into the fuel supply stream.

Our hauler/processor survey also underreported the quantity of demolition debris hauled and processed. Again, the quantity of this UWW component would increase (at least in terms of quantity reporting) if processing demolition debris for fuel purposes were within acceptable regulatory limits.

New Solid Waste Rules

New rules were promulgated October 7, 1993 for the implementation of Public Act 641. An unresolved issue arising from these new rules regards the regulatory treatment of wood combustion. The issue involves determining whether this combustion is primarily waste

disposal or energy generation. The rules state that "waste that is burned as fuel in a boiler, industrial furnace, or power plant which is permitted...(under) Act 348 (the Air Pollution Act) is exempt from regulation under Act 641, the Solid Waste Management Act." However, the rules do not define boiler, industrial furnace, or power plant, which caused concern to the staff of the Michigan Department of Natural Resources.

As a result, an internal working group was formed by MDNR, and recommendations to clarify the status and regulatory treatment of wood combustion were made to the MDNR executive office but were never acted upon. In brief, it appears that power plants and boilers with a specific power output efficiency would be exempt from regulation under the State Solid Waste Management Act. The intent of MDNR staff in examining this issue was to prevent scenarios where unscrupulous operators would call a facility with minimal energy output efficiency a power plant to avoid regulation under the Solid Waste Management Act.

Proposed Amendments to the Solid Waste Management Act

Flow Control. Extensive and very contentious debate has continued for the past several years over solid waste issues, particularly that of flow control. Flow control refers to the intent of jurisdictions to assure compliance with solid waste regulations by controlling volumes of waste and designating the location of their disposal and/or recycling. Under the Michigan Solid Waste Management Act, counties are required to explicitly authorize movement of solid waste between counties. To date, little legislation has been enacted. However, at the behest of Oakland County, legislation was passed in 1994 to reduce the planning interval for county solid waste management plans from 20 to 10 years.

The core of this controversial debate is focused on solid waste flow control. The DNR held a roundtable discussion August 25, 1994 with major stakeholders to garner feedback on three flow control options:

- retain the current system of county-based flow control (no waste export without the authorization of the receiving county),
- establish mandated regional planning where waste can be transported across county lines within each region, and
- abolish all restraints and planning requirements to allow a free market scenario.

County governments and the environmental community were highly critical of any scheme which rejects flow control. Flow control, as argued as the MDNR Roundtable, provides local governments with the ability to evaluate their waste streams and implement integrated solid waste management approaches. A summary of this discussion is included as Appendix E.

In most respects, changes in solid waste flow control will not directly impact the UWW market. However, it is likely that UWW would be impacted at least indirectly. For instance, if a "predatory" landfill market were to operate and tipping fees declined, UWW processors would be forced to cut their tipping fees. That could be very damaging to many processors who operate on thin margins.

Of the limited number of processors who discussed UWW pricing practices, they indicated that their profit margin was derived from tipping fees. Fuel prices essentially covered the cost of processing and transportation. Thus, sharply reduced tip fees would inevitably harm their profitability.

The Carbone Decision. The other major factor affecting local and state regulation of waste management is the U.S. Supreme Court decision in *C & A Carbone, Inc. v. Town of Clarkstown* (New York) on May 16, 1994. In the its opinion, decided by a 6-3 vote, the Court ruled that the Town of Clarkstown's local flow control ordinance was unconstitutional since it violates the Commerce Clause of the U.S. Constitution.

The full impact of the *Carbone* decision cannot yet be determined. However, two suits have been filed in Michigan challenging the State's intrastate flow control provisions. One suit was filed by Waste Management, Inc. in July against Ingham County. The State has filed to intervene in the case. Moreover, Congress is currently considering legislation to permit local flow control of municipal solid waste.

Again, the effects of these developments on UWW may not be direct, and they may be limited. As pointed out above, when wood waste is used as a fuel for boilers, power plants,

or industrial furnaces, it is not covered by the State Solid Waste Management Act. Thus, the direct impact of *Carbone* appears extremely limited on wood waste, particularly as boiler fuel.

Data Requirements and Yard Waste Ban Limitation. More recently, a legislative work group has developed amendments to the State Solid Waste Management Act. Two areas of this group's effort are relevant to this project. First, data reporting requirements for solid waste management plans may be upgraded, although the need for quality data is stymied by the lack of a standardized data collection methodology. Second, a bill (HB 5556) has been introduced in the Michigan legislature to exempt landfill operators from the yard waste disposal ban to go into effect in March, 1995 in cases where the landfill operators manufacture and utilize methane gas.

Stronger data reporting requirements would be helpful to wood waste market development. The absence of reliable waste stream characterization and volume data seriously hinders efforts to encourage greater use of wood waste for fuel and other value-added applications, such as landscape and gardening, recreational surfaces, and composite wood manufacturing.

Difficulties cited by MDNR staff in gathering quality data include issues of proprietary market and processing information, the diverse methods of collection and hauling, and the ever increasing diversity of end points for waste/recycled materials. The level of success achieved by this project to determine the types, quantities, and current disposal methods of wood waste will demonstrate the potential for stricter requirements for quality data reporting of a broader range of specific waste materials.

All interests concerned with waste management in general, and wood waste in particular, agree that accurate and reliable data is necessary to develop the urban wood waste market. Strong support was evident for this project with its goal to successfully execute a sound methodology for gathering accurate and reliable data.

In regard to the bill to exempt certain landfill operators from the implementation of the yard waste ban, it is difficult to assess the impact of such an exemption on the overall status of

current disposal practices of yard waste. However, MDNR staff worry that such legislation would effectively nullify the yard waste ban. If that became the case, demand for other wood waste streams might increase. Currently, compost operators (who have sprung up in significant numbers since the passage of the legislation in 1990 to ban landfilling of yard waste effective in 1995) rely heavily on yard waste, including the brush with its wood constituents, for the appropriate mix of materials for a good compost.

Conclusions

Our final survey estimate of 659,328 tons of urban wood waste annual supply in this market study areas compares with estimates of 507,000 tons of C/D waste in the 1991 Illinois study, 2.2 million tons of wood waste and 133,000 tons of pallet residue in the 1993 Wisconsin study, 325,000 tons of urban tree residue in the 1992 Minnesota study, and 868,478 tons of wood waste generated by Michigan's secondary wood manufacturing sector. It is likely that some overlap exists between our study and the secondary manufacturing study.

By disaggregating the urban wood waste stream to nine components — pallets, wood scraps, construction, demolition, tree trimming residue, land clearing residue, plywood/particleboard waste, railroad ties, and other — we have established a level of detail not previously achieved in urban wood waste studies.

Our survey estimate of 300,560 tons of annual used pallet generation, representing 46% of the UWW market, is relatively consistent with annual state pallet production and the use of pallets by the automotive industry. Our conservative assumptions of pallet weight and associated conversions suggest, however, that our estimate of used pallet generation may be low. These results also make it clear that this is a very volatile market, both in terms of the generation of used pallets and end-use market competition for used pallet residue. It requires close monitoring to anticipate market changes in prices and changes in UWW supply from this UWW source. Pallet reconditioning and lanscaping applications represent highly competitive alternative end-use markets.

The construction and demolition component streams are very difficult to quantify and assess. Commingling of C/D with other MSW streams and the regulatory uncertainty about the uses

of demolition debris make this a highly problematic area. The Dow Corning facility, for example, refuses to accept demolition debris for fuel. The CMS Genesee facility, on the other hand, will use demolition debris for fuel when it goes on-line since it sucessfully prevailed in the EPA air permit appeal process.

Tree trimming residue is an area that bears further investigation since our survey estimates were preliminary and not as comprehensive as our survey of other UWW components. Land clearing also represents a small fraction of UWW generation.

Railroad ties represent a challenging area to assess since our research indicated that this stream may represent a significant quantity of UWW. Our survey estimates may underreport current generation rates from annual maintenance as the quantity of currently stockpiled railroad ties is highly uncertain. The results of the Viking test burn will have extensive implicatins for both C/D and railroad tie waste streams.

The constant interplay of regulatory issues, UWW generation, the need for electric generating facility fuel, and other competing end markets creates a rich matrix of interdependent factors affecting the demand for and prices and supply of urban wood waste. As documented in this study, the dynamics are complex and changes can occur rapidly.

The overall UWW capacity utilization rate of 45% is skewed as a result of the very low capacity utilization rate reported in the demolition processing sector. This demolition capacity rate is highly suspect as is the capacity utilization rate for construction debris; further investigation of these market components is warranted before deriving any conclusions based on capacity utilization.

The capacity utilization rates for used pallets, wood scraps, tree trimming residue, land clearing, and plywood/particleboard processing are based on what we consider to be firmer estimates. These rates suggest there is substantial room for growth in the UWW market. The table below summarizes the processing and utilization data presented in this section.

Table 15. Annual Processing and Capacity Utilization Rates for all UWW Components (in tons)					
UWW Type	Capacity	Quantity	Market Share	Utilization Rate	MMBtus(e)
Pallets	416,000	300,560	46.0%	72.0%	4,207,840
Wood Scraps	93,210	58,240	9.0%	62.0%	815,360
Construction	258,570	90,610	14.0%	20% (a)	1,268,540
Demolition	230,100	34,580	5.0%	15.0%	484,120
Tree Trim(b)	3,510 ---	2,925 52,168	8.0%	83% --	495,837
Land Clearing	10,400	7,020	1.0%	68.0%	63,180
Plywood/ Particleboard	17,550	11,050	2.0%	63.0%	154,700
RR Ties(c)	---	20,025 75,000	14.0%	---	1,330,350
Other	17,160	7,150	1.0%	42.0%	28,600
TOTAL(d)	1,046,500	659,328	100.0%	45.0%	8,848,527

(a) Capacity utilization rate 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.

Moreover, the dominance of smaller, more agile firms (< 15 employees) assures that these firms can quickly adjust and respond to changes in the market. Depending on a firm's financial condition and the capital requirements for making a specific change, timely responses to changes in the market can be anticipated. For example, regulatory approval of railroad ties as boiler fuel could cause tie processing capacity to increase substantially in a short period of time.

While technological and training requirements may be modest in the UWW market, they are by no means absent. It is a market where a modest financial investment and individual initiative can result in a competitive and profitable enterprise. Based on an understanding of this niche market, independent entrepreneurs can become established and thrive in the UWW market. The key elements include:

- knowledge of fuel specifications,
- securing a reliable supply commitment for end-user customers,
- technical capacity to process UWW for fuel, and
- delivering UWW to meet those specifications on time.

It has been estimated that primary forest industry residues could provide the equivalent of about 750 MW of electric power. That is approximately 3.75% of the total electric power capacity of 20,000 MW in the state.[26] Our study estimates that 90 MW of electric generating capacity can be produced from the UWW supply in our study area.[27]

Our study finds that the on-line wood fuel facilities that use urban wood waste for fuel require 1,700,400 TPY and that the total UWW supply is 659,328 TPY, or 39% of the required supply. With the Genesee facility scheduled to go on-line in the near future, the fuel requirements will increase to 2,152,400 TPY.

It is worth noting that the Genesee facility will access the UWW supply stream and rely more heavily than other facilities on urban tree residue and demolition debris, the lower quality components of the UWW supply stream. The implication here is that an effective fuel supply strategy will include a range of supply options that avoid sole reliance on one or another UWW stream.

Wehave noted throughout this report that, while making a substantial contribution to the body of knowledge of urban wood waste, many of the findings and conclusions presented here

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[26]Tom Stanton, *Biomass Energy: It's Not Just for Breakfast Any More*, October, 1993.

[27]Assuming 15,000 Btu/kwl, then 8.8 million Btus is equivalent to 590,000 MWH. Converting to MWH by dividing that figure by 1000, the result is 590 MWH. Finally, assuming a 75% facility availability factor and 8,760 hr/yr, the result is 89.8 MW.

should be considered preliminary. We strongly urge that additional research be conducted to further illuminate the issues we have discussed. This report should serve as an important basis for such work. More broadly, they should inform a variety of parties with important interests in wood waste supply. These parties — generators, processors, haulers, and end users — each have an immediate economic stake in the current status and future direction of this market. Perhaps most important, however, is that policy makers should now have a clearer, more detailed picture of this key component of the solid waste stream. It is the intent and hope of the research team that this will inform the process of devising legislative and regulatory policies that will improve both the economic and environmental landscape of Michigan.

Urban Wood Waste in Michigan

Appendices

APPENDIX A

1994 URBAN WOOD WASTE SURVEY

OF BROKERS AND PROCESSORS

My name is_____. I am calling as part of a seven-state effort funded by the Council of Great Lakes Governors. (*If asked,* this work is being done by Great Lakes Consulting Services). We want to establish some basic information about the generation of urban wood waste in your territory and its current use or disposal. My questions will take about 15 minutes of your time. Is now a good time for you? (*If not, schedule a call back time.*)

RESPONDENT'S
NAME_____TITLE/POSITION_____
COMPANY_____
ADDRESS_____
CITY/STATE/ZIP_____
PHONE(___)_____DATE(s) INTERVIEWED_____

Location of this facility_____
Other facility locations_____

1. What kinds of wood waste do you haul or process?

1___pallets/dunnage
2___wood scraps
3___construction debris
4___demolition waste wood
5___railroad ties
6___tree trimmings (right of way/grounds maintenance)
7___land clearing/conversion
8___plywood/particleboard
9___Other

2. How many wood waste generator customers do you serve?_____

a. Who are your major generators of wood waste?
1._____
2._____
3._____
4._____
5._____
6._____
7._____

b. Are your customers in the____Detroit area?
____Lansing
____Grand Rapids

3. What is the CURRENT WEIGHT and VOLUME of the types of wood waste you haul or process?

	Avg. Amt./day (*or wk., mo., or yr.*) Weight Tons	Volume Cu.Yd.	# of units
Pallets/dunnage	___	____	_____
Construction debris	___	____	_____
Demolition waste wood	___	____	_____
Railroad ties	___	____	_____
Tree trimmings	___	____	_____
Land clearing/conversion	___	____	_____
Plywood/particleboard	___	____	_____
Wood scraps	___	____	_____
Other	___	____	_____

4. Is your company's <u>capacity</u> for hauling and processing wood waste greater than your current hauling and processing?___YES___NO

If YES, what are the amounts of your capacity for the types of wood waste processed by your company?

	Avg. Amt./day (*or wk., mo., or yr.*) Weight Tons	Volume Cu.Yd.	# of units
Pallets/dunnage	___	____	_____
Construction debris	___	____	_____
Demolition waste wood	___	____	_____
Railroad ties	___	____	_____
Tree trimmings	___	____	_____
Land clearing/conversion	___	____	_____
Plywood/particleboard	___	____	_____
Wood scraps	___	____	_____
Other	___	____	_____

5. In your company's business, have the amounts of wood waste or types of wood waste changed in the last five years?___YES___NO___DON'T KNOW

5a. Were the volumes more or less than what they are currently?

	Past Avg. Amt/day(wk/mo/yr) OR +/- change		
Pallets/dunnage	___	____	_____
Construction debris	___	____	_____
Demolition waste wood	___	____	_____
Railroad ties	___	____	_____
Tree trimmings	___	____	_____
Land clearing/conversion	___	____	_____
Plywood/particleboard	___	____	_____
Wood scraps	___	____	_____
Other	___	____	_____

6. What changes in the volumes of wood waste do you foresee in the next 3-5 years in your business?

_____Increased volumes(if so, how much of an increase and why)

_____

_____

_____

_____

____Decreased volumes(if so, how much of a decrease and why)

_____

_____

_____

_____

___Change in wood waste <u>types</u> hauled and processed by your business_____

_____

_____

_____

7. Do you process (hog) your own wood waste?____YES____NO

8. Do you want to add equipment to process wood waste?

___YES___NO

a. If YES, what kind of equipment would you want to obtain?

_____Tub grinder_____Hammermill

_____Other(please identify)

9. Do you sell wood waste for fuel to wood burning facilities?

___YES___NO_____*(please identify)*

10. What are current processed waste wood fuel prices?

_____/ton

10a. What are specification requirements?_____

_____

_____

_____

_____

11. What other end market customers do you sell processed wood waste to?

_____Landscaping

_____Compost material

_____Recreational surface suppliers

_____Composite wood production

_____Other*(please describe)*_____

12. What are prices currently received for these end market sales?

_____Landscaping
_____Compost material
_____Recreational surface suppliers
_____Composite wood production
_____Other

13. What factors currently favor your company's competitive position?_____

_____
_____
_____
_____

14. What barriers does your company currently face or expect to face in the wood waste market?

_____
_____
_____
_____
_____

URBAN WOOD WASTE SURVEY

OF FORESTRY AND LANDSCAPING OPERATORS

My name is_____. I am calling to follow up on our recent letter from Mr. Snyder here at *Public Policy Associates* about our survey to establish some information about the quantities and disposition of wood waste generated in the Detroit, or Lansing, or Grand Rapids area. As you know, disposal practices have changed considerably over the past few years and we want to document these changes and assess future trends. We are conducting this survey for the Great Lakes Biomass Energy Program. My questions will take about 10 minutes of your time. Is now a good time?

RESPONDENT'S
NAME_____TITLE/POSITION_____

COMPANY or GOVERNMENTAL UNIT_____

ADDRESS_____

CITY/STATE/ZIP_____

PHONE_____DATE(s) INTERVIEWED_____

1. Can you state the volume or weight of tree trimming residue generated by your operations?
_____Total Cubic Yards or Tons per week/month/year
(*It is expected that the respondent will report the quantities on a monthly or weekly basis and these quantities will vary depending on the season.*)
Seasonal variation:_____summer(6/15-9/15) _____fall(9/15-12/15)
_____winter(12/15-3/15)_____spring(3/15-6/15)

2. What form is your tree trimming residue in?
(read the following categories and obtain percentages)
_____tops and brush_____chips_____logs_____mixed wood
_____other(please identify)_____

3. How do you currently dispose of your tree trimmings? (*It is possible that there will be more than one disposal option used by the respondent's operation. If so, please obtain percentages of material disposed in each of the following categories.*)
_____Mulching used for own operation
_____Sell for mulch_____price?
_____Give away for mulch
_____Composting used for own operation
_____Take it to composting operation_____fee?
_____Hauled by wood processor/broker for fuel_____fee?

_____Landfill_____fee?
_____Incinerated_____fee?
_____Other(please obtain details)

4. What changes, if any, do you expect in how much tree trimming residue you generate?

_____
_____
_____
_____

5. What changes, if any, do you expect in how you dispose of your tree trimmings?

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

That concludes my questions. Thanks for your cooperation and taking the time to talk with me today.

COORDINATOR SURVEY

URBAN WOOD WASTE PROJECT

We want to establish some basic information about the generation of urban wood waste in your county (or city) and its current disposal. I would like to ask you a few questions that will take about 15 minutes of your time. This survey is a part of a project designed to better understand the current use and potential uses of urban wood waste.

RESPONDENT'S NAME_____POSITION_____

AGENCY_____DATE_____

1. Do you currently compile data on the generation of solid waste in your county (or city)?
___YES___NO

2. Does this data include a separate break out or category for wood waste?___YES___NO

3. What is the estimated quantity of wood waste generated in your county (or city)?

_____lbs._____tons per year/month/week/day(circle one)_____sq. yds.

_____cu. yds._____other

4. Do you consider the estimate of this quantity accurate?___YES___NO
Why or why not

_____

_____

_____

4a. (If the question of methodology has not been addressed above, then ask the following)
What methodology is used to obtain this estimate?

_____

_____

_____

5. Where is wood waste disposed of in your county (or city)?

a) Compost facility_____Name and address

_____Contact name/phone number

b) Wood processors/recyclers_____Name and address

_____Contact name/phone

c) Type III Landfill_____Name and address

d) Type II Landfill_____Name and address

e) Other_____

6. What are the fees for the above?

a)_____b)_____c)_____

d)_____e)_____

7. Can you identify the major generators of wood waste in your county (or city)?

(1)_____(2)_____

(3)_____(4)_____

8. Do you have wood burning facilities in your county (or city)?

____YES____NO____DON'T KNOW_____NAMES

9. Do you know what this facility (facilities) pays for wood chips?____YES___NO

_____If yes, what are prices paid.

10. Please identify the major waste haulers in your county (or city).

(1)_____(2)_____

(3)_____(4)_____

11. What are major factors affecting wood waste generation and processing in your county (or city)?_____

_____

12. Do you have any reports or other written materials that provide the above information? (Please obtain those reports and written materials)._____YES_____NO

APPENDIX B

LIST OF INTERVIEWEES

Ray Ayer, Solid Waste Division, City of Ann Arbor

Samuel Baker, Director of Technical Services, National Wooden Pallet and Container Association

Robin Barfoot, Michigan Public Service Commission

Cara Bouche, Forest Management Division, Michigan Department of Natural Resouces

Mike Brinker, Greater Detroit Resource Recovery Authority

Hunter Brooks, Brooks Associates, Ltd.

Marge Damian, Detroit Edison

Terry DeBlaay, Dow Corning Corporation

Mary Felton, Office of Solid Waste, Environmental Protection Agency

Marshall Guerin, Ford Motor Company

Jim Hamilton, Great Lakes Compost Center

Ken Horvath, General Motors Corporation

John Karrakesh, Viking Energy, Inc.

Steve Kelly, Huron Manistee National Forest, U.S. Forest Service

Jim Kilbaso, Department of Forestry, Michigan State University

Ed King, Detroit Edison

Marshall Klaus, former Recycling coordinator of the City of Lansing

George Lipinski, Austin Environmental Consultants

John McCabe, Solid Waste Alternatives Program, Michigan Department of Natural Resources

Bob Moore, Pallox, Inc.

Dan Moran, Wisconsin Department of Natural Resources

Seth Phillips, Chief, Solid Waste Management Unit, Michigan Department of Natural Resources

Mark Polega, Capital Area Landscape Nurserymen Association

Tracy Rayburn, CRSS Capital, Inc.

Elva Revilla, Legislative Staff, Michigan House of Representatives

Karl Roberts, Chrysler Corporation

Ed Stines, Automotive Industry Action Group (AIAG)

Otto Suchsland, Department of Forestry, Michigan State University

Randy Tellez, Air Quality Division, Michigan Department of Natural Resources

Derrick Vannice, International Society of Arboriculture

Phil Vieth, Minnesota Department of Natural Resources

Jack Whittier, NEOS, Inc.

John Youngquist, Forest Products Laboratory, U.S. Forest Service

MICHIGAN RAILROAD MILEAGE

Independent railroad companies own and operate approximately 4,000 miles of main and branch rail line in Michigan.

MAIN LINE AND BRANCHES			
Operating Railroad *	1990	1991	Change
Adrian & Blissfield Railroad	0.00	19.35	+ 19.35(1)
Amtrak	78.00	78.00	
CSX Transportation	757.00	739.00	- 18.00 (2)
Central Michigan Railway	174.71	174.71	
Chicago & North Western Transp. Co.	165.49	165.49	
Coe Rail	8.10	8.10	
Conrail	451.15	450.87	- 0.28
Delray Connecting Railroad	3.00	3.00	
Detroit River Tunnel	2.20	2.20	
Detroit & Mackinac Railway	330.58	277.25	- 53.33 (3)
Escanaba & Lake Superior Railroad	204.00	204.00	
Grand Trunk Western Railroad	510.17	510.17	
Hillsdale County Railway	45.60	45.60	
Huron & Eastern Railway Co.	141.10	141.10	
Kalamazoo, Lake Shore & Chicago R.R.	14.63	14.63	
Lake Superior & Ishpeming Railroad	45.66	45.66	
Leelanau Transit Co.	28.00	28.00	
Lenawee Countrymark, Inc.	2.80	0.00	- 2.80 (4)
Lenawee County Railroad	3.80	0.00	- 3.80 (5)
Ludington & Northern Railway	3.00	3.00	
Michigan Interstate Railway (Ann Arbor Acquisition Co.)	46.23	46.23	
Michigan Shore Railroad	9.60	9.60	
Michigan Southern Railroad	22.00	22.00	
Mid-Michigan Railroad	61.73	61.73	
Norfolk Southern	79.09	79.09	
Tuscola & Saginaw Bay Railway	439.53	439.53	
Wisconsin Central Ltd.	437.44	425.61	- 11.83 (6)
STATE TOTAL	4,064.61	3,993.92	- 70.69

(1) ASSUMED OPERATIONS ON PORTIONS OF MDOT-OWNED ROW FORMERLY OPERATED BY LENAWEE COUNTY RAILROAD.
(2) TRACKAGE SALE TO DETROIT EDISON AND ABANDONMENTS.
(3) ABANDONMENT BETWEEN GAYLORD - CHEBOYGAN.
(4) TEMPORARY OPERATOR OF PORTION OF FORMER LENAWEE COUNTY RAILROAD. TRACK NOW OPERATED BY ADRIAN & BLISSFIELD RAILROAD.
(5) TERMINATED OPERATIONS.
(6) ABANDONMENT BETWEEN SOO JCT. AND HUMBOLDT JCT.

Source: Michigan Department of Transportation
Prepared by the Statewide Planning Section
with data provided by the Department of Treasury,
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APPENDIX E

SUMMARY OF DEPARTMENT OF NATURAL RESOURCES

ROUND TABLE DISCUSSION ON SOLID WASTE MANAGEMENT PLANNING

AUGUST 25, 1994

At the request of the Environmental Policy Committee of the Natural Resources Commission, Department of Natural Resources (DNR) staff arranged a round table discussion with a cross-section of interested parties to discuss three proposals to address regional planning/intercounty waste flow issues in the Solid Waste Management Planning Program. These approaches are: the regional incentive and county plan control approach contained in the draft Solid Waste Management Act, 1978 PA 641, as amended (Act 641) amendments; the mandatory regional planning/free flow approach presented to the Environmental Policy Committee on July 6, 1994; and a free-market approach with no solid waste management plan imposed controls.

The purpose of the meeting was to foster further discussion toward seeking a resolution of regional planning/intercounty waste flow issues. These issues have been the most difficult to reach consensus on during the statewide review of the Solid Waste Management Planning Program portion of Act 641, that the DNR has conducted for the last several years. Following is a brief summary of the discussions from the August 25, 1994 meeting. Also, attached is a list of participants at the August 25, 1994 discussion. In addition to the participants, approximately 80 interested parties observed the discussions.

Morning Session:

The morning's discussion was a wide ranging analysis of the proposals and overall views of the various participants.

In general, counties and municipalities strongly favored local control for various reasons including: it provides them the ability to evaluate their wastestream and implement integrated solid waste management systems rather than rely solely on low cost disposal for all solid waste management needs; it is necessary in order for them to be able to effectively negotiate for disposal and other services for their citizens; it allows them to generate predictable data and define disposal needs reliably; it ensures their ability to establish public-private partnerships; and it allows citizens to continue to look to local government for management of solid waste issues.

With some exceptions, the solid waste industry favored less local control for the following reasons: A free-market would produce lower disposal costs; competition should be used as a basis for local decisions; and less local restriction should increase consumer choice. Host negotiations in place of the current siting process was suggested. Some waste industry interests favor continued local control as protective of local choice in solid waste management approaches.

A few members of the round table suggested the Department wait for Federal action by the U.S. Congress on interstate waste control legislation so that Michigan can fit into what they do.

Afternoon Session:

During the afternoon, participants were asked to respond to each of the three proposals outlining any necessary adjustments which would make each proposal acceptable. The following summarizes these comments:

PROPOSAL 1 - DNR'S OCTOBER 1993 DRAFT ACT 641 AMENDMENTS BASED ON THE MARCH 1993 WORK GROUP RECOMMENDATIONS.

Regional planning agencies, counties, Michigan Municipal League, Michigan Townships Association, environmental groups, and Ogdon Products Co. were generally supportive of this proposal. Suggested changes included the addition of specific enforcement mechanisms for counties to enforce their plans; use of a direct fund distribution process for county funding instead of a grant program, increased incentives to be provided for waste reduction; and inclusion of industrial waste monofills in planning.

Solid waste industry interests with the exceptions noted in the morning session, industrial monofill interests, and the Michigan Chamber of Commerce felt the proposal was too restrictive on free enterprise. They argued that proposed funding should be used only for planning activities. They suggested the exclusion of certain homogenous industrial waste streams such as coal ash, paper mill sludge, and foundry sands from plan controls and emphasized the potential use for host community negotiations to address local issues.

PROPOSAL 2 - MANDATORY REGION PROPOSAL

Local governmental interests, environmental groups, and Ogdon Products Co. were opposed to mandatory regional planning and preferred the use of incentives to establish regions. They objected to the lack of emphasis on resource recovery. If this proposal were implemented, they felt the size of regions should be established by a committee through a public process.

Most industrial interests were supportive of this proposal and felt region size should be as large as possible.

PROPOSAL 3 - FREE MARKET PROPOSAL

Local governmental interests, environmental groups, and Ogdon Products Co. were opposed to this idea. If this was implemented, it was suggested that State price regulation would be needed and that county and local government would not continue to be involved in the planning process unless a county level veto process for host community siting could be designed.

Industrial interests were generally supportive of this proposal. A few opposed it because it might eliminate smaller operators from the marketplace and therefore eliminate choice and reduce competition. Elimination of export controls and creation of import controls through host community agreements was suggested.

PARTICIPANTS IN THE AUGUST 25, 1994 ROUNDTABLE DISCUSSION

Dan Batts - Landfill Management Co.
Rep. Mary Brown - House of Representatives

Steve Chalker - Ingham County Health Department
James Cleary - City Management Corporation
Michael Csapo - Southwestern Oakland County Resource Recovery Authority
Dan Cummins - Georgia Pacific Co.

Carla Davidson - Southeast Michigan Council of Governments
Timothy Dolehanty - Leelanau County

Dawn Furlong - East Michigan Environmental Council

Terry Guerin - Granger Companies

Russell Harding - Deputy Director, DNR
James Hill - Natural Resources Commissioner
Teresa Horsfall-Dietz for Senator Phil Hoffman
Michelle Hurd-Riddick - Saginaw Action Volunteers for the Environment

Curt Kemppainen - Kent County and President of the Solid Waste Association of North America

Dennis Leonard - Detroit Edison Co.
Robert Line - BFI Waste Systems

Warren McArthur - Michigan State Chamber of Commerce
Pat Mc Avoy - Michigan Township Association
Flora McCormack - Wayne County Department of Public Services
Ann Mason - Clinton County
Rep. Susan Munsell - House of Representatives

Greg Nominelli - Michigan Waste Industries Assoc.

Seth Phillips - DNR
Gary Pitsch - Pitsch Wrecking Co.

Carey Rodgers - Michigan United Conservation Club
Gordon Ruttan - St. Clair County

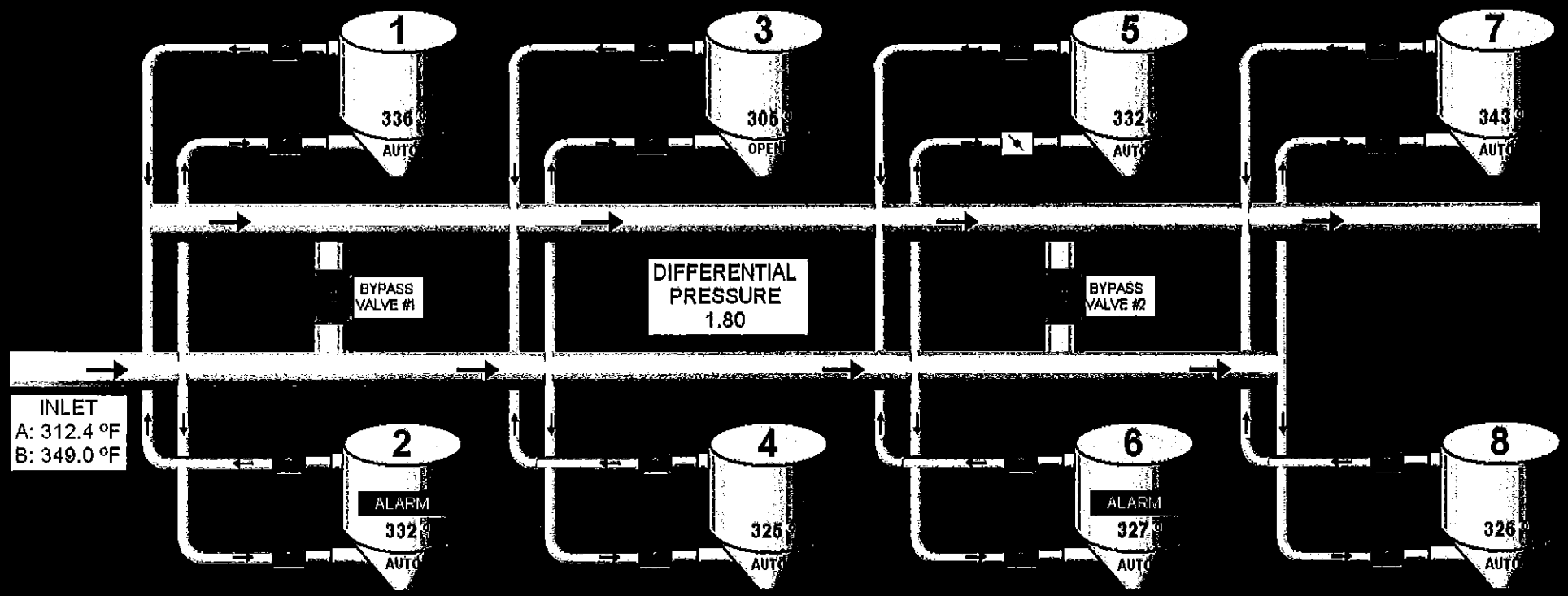
Roger Smith - Oakland County
Genise Smith-Watkins - Michigan Chemical Council
Paula Soos - Ogden Projects Co.
Donald Stypula - Michigan Municipal League
Warren Suchovsky - Menominee County
Larry Sullivan - Charlevoix County
Susan Swindlehurst - Washtenaw County
Jim Sygo - DNR

Kathy Trent - Waste Management, Inc.

Tom Waffen - Southeastern Oakland County Resource Recovery Authority
Bryan Weinart - Michigan Municipal League
Ed Wetherell - City of Riverview

T. WMS Baghouse Screen Shot

BAGHOUSE 8 OVERVIEW



BAGHOUSE MODE | CLEANING MODE | BAGHOUSE TRENDS | BAGHOUSE ALARM RESET | BAGHOUSE ALARM RESET

Cleaning Cycle Not In Progress

Diff. Pressure Cleaning Mode Selected

Tuesday, June 08, 2010 1:14:39 PM | LOGIN | User Name: operator | ALARM SUMMARY | FLUSH CACHE | SERVER STATUS | PRINT

MAIN | BOILER 8 OVERVIEW | FEEDWATER | BOILER 8 DUCT BURNER | BOILER 8 PULSE VALVES | BEARING TEMPS | BFP LUBE OIL SYSTEM | BAGHOUSE | TRENDING OVERVIEW

U. WMS MDNRE Air Quality Permit

Michigan Department of Natural Resources & Environment
Air Quality Division

State Registration Number

B2132

RENEWABLE OPERATING PERMIT STAFF REPORT

ROP Number

MI-ROP-B2132-2010

City of Wyandotte Municipal Power Plant

SRN: B2132

Located at

2555 Van Alstyne, Wyandotte, Michigan 48192

Permit Number: MI-ROP-B2132-2010

Staff Report Date: October 26, 2009

This Staff Report is published in accordance with Sections 5506 and 5511 of Part 55, Air Pollution Control, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451). Specifically, Rule 214(1) requires that the Michigan Department of Natural Resources and Environment (MDNRE), Air Quality Division (AQD), prepare a report that sets forth the factual basis for the terms and conditions of the Renewable Operating Permit (ROP).

TABLE OF CONTENTS

October 26, 2009 STAFF REPORT **3**

February 19, 2010 STAFF REPORT ADDENDUM **8**

April 15, 2010 STAFF REPORT ADDENDUM **9**

Purpose

Major stationary sources of air pollutants, and some non-major sources, are required to obtain and operate in compliance with a ROP pursuant to Title V of the federal Clean Air Act of 1990 and Michigan's Administrative Rules for air pollution control pursuant to Section 5506(1) of Act 451. Sources subject to the ROP program are defined by criteria in Rule 211(1). The ROP is intended to simplify and clarify a stationary source's applicable requirements and compliance with them by consolidating all state and federal air quality requirements into one document.

This report, as required by Rule 214(1), sets forth the applicable requirements and factual basis for the draft permit terms and conditions including citations of the underlying applicable requirements, an explanation of any equivalent requirements included in the draft permit pursuant to Rule 212(5), and any determination made pursuant to Rule 213(6)(a)(ii) regarding requirements that are not applicable to the stationary source.

General Information

Stationary Source Mailing Address:	City of Wyandotte Municipal Power Plant 2555 Van Alstyne Wyandotte, Michigan 48192
Source Registration Number (SRN):	B2132
North American Industry Classification System (NAICS) Code:	221112
Number of Stationary Source Sections:	1
Is Application for a Renewal or Initial Issuance?	Renewal
Application Number:	200700148
Responsible Official:	Melanie McCoy, General Manager 734-324-7111
AQD Contact:	Stephen Weis, Senior Environmental Engineer 313-456-4688
Date Permit Application Received:	November 26, 2007
Date Application Was Administratively Complete:	December 5, 2007
Is Application Shield In Effect?	Yes
Date Public Comment Begins:	October 26, 2009
Deadline for Public Comment:	November 25, 2009

Source Description

The City of Wyandotte's Department of Municipal Services (hereinafter Wyandotte DMS) is a community owned and operated entity that provides electricity, water, telephone, internet and cable television services to residents of Wyandotte. The electricity is generated by the City of Wyandotte Municipal Power Plant (hereinafter power plant), which is the subject of this ROP. The power plant is located on the western shore of the Detroit River, just north of the downtown area of Wyandotte. The facility is bounded by the Detroit River to the east; to the north is Henry Ford Wyandotte Hospital, a small marina and some residences along the marina; to the south is Bishop Park; to the west and southwest is an area that is primarily a mix of residential types of properties (houses, condominiums, a senior apartment complex) as well as one of the City of Wyandotte's libraries.

The process equipment and devices that generate emissions that are released to the ambient air at a facility are referred to as Emission Units for the purposes of the ROP. Among the Emission Units included in the ROP for the power plant are three boilers, identified as Units 5, 7 and 8. Unit 5 is a 22.5 MW natural gas-fired boiler that is used as a back-up to the other two boilers. Unit 7 is a 32.5 MW wall-fired pulverized coal-fired boiler that is capable of firing coal, natural gas and propane. The exhaust air from Unit 7 is directed to an electrostatic precipitator (ESP) to control particulate matter emissions. Unit 8 is a 25 MW circulating fluidized bed boiler capable of firing coal, untreated virgin wood chip waste and tire-derived fuel (TDF). The exhaust air from Unit 8 is directed to a baghouse with limestone injection to control SO_2 and particulate matter emissions.

In addition, Wyandotte DMS operates three 2,000 kW compression ignition diesel-fired engine generators to provide back-up power to the power plant. The generators are located approximately ½ mile north of the power plant, north of the Henry Ford Wyandotte Hospital on James DeSana Drive. The parcel of property on which they are located borders the southern portion of the BASF complex property.

The following table lists stationary source emission information as reported to the Michigan Air Emissions Reporting System in the 2008 submittal.

TOTAL STATIONARY SOURCE EMISSIONS

Pollutant	Tons per Year
Carbon Monoxide (CO)	454
Lead (Pb)	Negligible (0.007)
Nitrogen Oxides (NO_x)	768
Particulate Matter less than 10 microns (PM_{10})	4
Sulfur Dioxide (SO_2)	1793
Volatile Organic Compounds (VOCs)	5

**As listed pursuant to Section 112(b) of the federal Clean Air Act.

See Parts C and D in the draft ROP for summary tables of all processes at the stationary source that are subject to process-specific emission limits or standards.

Regulatory Analysis

The following is a general description and history of the source. Any determinations of regulatory non-applicability for this source are explained below in the Non-Applicable Requirement part of the Staff Report and identified in Part E of the ROP.

The stationary source is located in Wayne County, which is currently designated by the U.S. Environmental Protection Agency (USEPA) as a non-attainment area with respect to the particulate matter standard. Specifically, on December 17, 2004 Wayne County was designated by the U.S. Environmental Protection Agency (USEPA) as a non-attainment area for the particulate matter ($PM_{2.5}$) standard. Wayne County is currently designated as attainment/unclassified for all other criteria pollutants.

The stationary source is subject to Title 40 of the Code of Federal Regulations (CFR), Part 70, because the potential to emit of all criteria pollutants exceeds 100 tons per year. The stationary source is also subject because the facility has emission units subject to Title IV of the Clean Air Act.

The stationary source is subject to the Prevention of Significant Deterioration regulations of 40 CFR, Part 52.21 because the potential to emit of all criteria pollutants is greater than 100 tons per year.

EUUNIT7BLR at the stationary source is subject to the New Source Performance Standards for Fossil Fuel-Fired Steam Generators for Which Construction is Commenced After August 17, 1971 promulgated in 40 CFR, Part 60, Subparts A and D.

EUUNIT8BLR at the stationary source is subject to the New Source Performance Standards for Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978 promulgated in Title 40 of the Code of Federal Regulations (40 CFR), Part 60, Subparts A and Da.

FGWMSENGINES at the stationary source are subject to the Maximum Achievable Control Technology Standards for Stationary Reciprocating Internal Combustion Engines promulgated in 40 CFR, Part 63, Subparts A and ZZZZ.

EUUNIT5BLR, EUUNIT7BLR and EUUNIT8BLR at the stationary source is subject to the federal Acid Rain program promulgated in 40 CFR, Part 72.

EUUNIT5BLR, EUUNIT7BLR and EUUNIT8BLR at the stationary source are subject to the Clean Air Interstate Rule NO_x annual trading program pursuant to Rules 802a, 803, 821, and 830 through 834; they are subject to the Clean Air Interstate Rule NO_x ozone season trading program pursuant to Rules 802a, 803 and 821 through 826; and they are subject to the Clean Air Interstate Rule SO_2 annual trading program pursuant to Rule 420.

The monitoring conditions contained in the ROP are necessary to demonstrate compliance with all applicable requirements and are consistent with the DEQ "Procedure for Evaluating Periodic Monitoring Submittals."

EUUNIT7BLR and EUUNIT8BLR at the stationary source are subject to the federal Compliance Assurance Monitoring (CAM) rule under 40 CFR, Part 64. These emission units have a control device (EUUNIT7BLR has an electrostatic precipitator, EUUNIT8BLR has a baghouse) and potential pre-control emissions of particulate matter greater than the major source threshold level.

The coal processing and conveying equipment, coal storage system, and/or coal transfer and loading systems associated with EUUNIT7BLR and EUUNIT8BLR at the stationary source are subject to the New Source Performance Standards for Coal Preparation Plants promulgated in Title 40 of the Code of Federal Regulations (40 CFR), Part 60, Subparts A and Y.

The emission limitation(s) or standard(s) for carbon monoxide from FGWMSENGINES at the stationary source is/are exempt from the federal Compliance Assurance Monitoring (CAM) regulation under 40 CFR, Part 64, because carbon monoxide is/are addressed by 40 CFR, Part 63, Subpart ZZZZ. Therefore, FGWMSENGINES is exempt from CAM requirements for carbon monoxide.

Please refer to Parts B, C and D in the draft ROP for detailed regulatory citations for the stationary source. Part A contains regulatory citations for general conditions.

Source-wide Permit to Install (PTI)

Rule 214a requires the issuance of a Source-wide PTI within the ROP for conditions established pursuant to Rule 201. All terms and conditions that were initially established in a PTI are identified with a footnote designation in the integrated ROP/PTI document. PTIs issued after the effective date of ROP No. 199600303a are identified in Appendix 6 of the ROP.

Equivalent Requirements

This permit does not include any equivalent requirements pursuant to Rule 212(5). Equivalent requirements are enforceable applicable requirements that are equivalent to the applicable requirements contained in the original PTI, a Consent Order/Judgment, and/or the State Implementation Plan.

Non-applicable Requirements

Part E of the draft ROP lists requirements that are not applicable to this source as determined by the AQD, if any were proposed in the application. These determinations are incorporated into the permit shield provision set forth in Part A (General Conditions 26 through 29) of the draft ROP pursuant to Rule 213(6)(a)(ii).

Processes in Application Not Identified in Draft ROP

The following table lists processes that were included in the ROP application as exempt devices under Rule 212(4). These processes are not subject to any process-specific emission limits or standards in any applicable requirement.

Exempt Emission Unit ID	Description of Exempt Emission Unit	ROP Exemption	PTI Permit Exemption
EUSLPMP	Diesel fuel powered portable water pump.	R336.1212(4)(d)	R336.1285(g)
EUDSLGEN	175 kW diesel fuel-fired emergency generator	R336.1212(4)(b)	R336.1282(b)(ii)

Draft ROP Terms/Conditions Not Agreed to by Applicant

This permit does not contain any terms and/or conditions that the AQD and the applicant did not agree upon pursuant to Rule 214(2).

Compliance Status

The AQD finds that the stationary source is expected to be in compliance with all applicable requirements as of the effective date of this ROP.

Action taken by the DNRE

The AQD proposes to approve this permit. A final decision on the ROP will not be made until the public and affected states have had an opportunity to comment on the AQD's proposed action and draft permit. In addition, the U.S. Environmental Protection Agency (USEPA) is allowed up to 45 days to review the draft permit and related material. The AQD is not required to accept recommendations that are not based on applicable requirements. The delegated decision maker for the AQD is Teresa Seidel, Southeast Michigan District Supervisor. The final determination for ROP approval/disapproval will be based on the contents of the permit application, a judgment that the stationary source will be able to comply with applicable emission limits and other terms and conditions, and resolution of any objections by the USEPA.

February 19, 2010 STAFF REPORT ADDENDUM

Purpose

A Staff Report dated October 26, 2009, was developed in order to set forth the applicable requirements and factual basis for the draft Renewable Operating Permit (ROP) terms and conditions as required by R 336.1214(1). The purpose of this Staff Report Addendum is to summarize any significant comments received on the draft ROP during the 30-day public comment period as described in R 336.1214(3). In addition, this addendum describes any changes to the draft ROP resulting from these pertinent comments.

General Information

Responsible Official:	Melanie McCoy, General Manager 734-324-7111
AQD Contact:	Stephen Weis, Senior Environmental Engineer 313-456-4688

Summary of Pertinent Comments

No pertinent comments were received during the30-day public comment period.

Changes to the Draft ROP

No changes were made to the draft ROP.

April 15, 2010 STAFF REPORT ADDENDUM

Purpose

A Staff Report dated October 26, 2009, was developed in order to set forth the applicable requirements and factual basis for the draft Renewable Operating Permit (ROP) terms and conditions as required by R 336.1214(1). The purpose of this Staff Report Addendum is to summarize any significant comments received on the draft ROP during the 45-day EPA comment period as described in R 336.1214(3). In addition, this addendum describes any changes to the proposed ROP resulting from these pertinent comments.

General Information

Responsible Official:	Melanie McCoy, General Manager 734-324-7111
AQD Contact:	Stephen Weis, Senior Environmental Engineer 313-456-4688

Summary of Pertinent Comments

No pertinent comments were received during the 45-day EPA comment period.

Changes to the February 19, 2010 Proposed ROP

No changes were made to the proposed ROP.

V. WMS Test Burn Boiler Efficiency 15% Biomass

Company..	Wyandotte Municipal Services						
Power Plan	Boiler Unit #8						
Source….		Basin					
		from Battle Creek		del'd by	Truck	for del'y to	WMS

Cost Information:

Mine Cost.		per ton		#1	PRB Coal/TDF	100%
Transport		per ton	Unit # 8	#2	Densified wood cubes	
TOTAL….	$ -	per ton				

COMBUSTION CALCULATIONS

Based on quantities per 10,000 Btu fuel input[a]

1	**Fuel……..**	Coal/Wood Mix			
2		#1	#2	Blend	
3		% Wt	% Wt	% Wt	
4	C	56.61		56.61	
5	H_2	4.80		4.80	
6	S	0.78		0.78	
7	O_2	13.84		13.84	
8	Cl	0.00		0.00	
9	N_2	0.96		0.96	
10	H_2O	11.26		11.26	
11	Ash	11.75		11.75	
12		100.00	0.00	100.00	
13	Btu/lb	8,390		8,390	

Conditions by test or specifications:			
Total Air (Theoretical + Excess)…	%	180	b
Air Temperature to Heater…….	F	80	c
Air Temperature from Heater…….	F	390	d
Fluegas Temperature leaving unit	F	420	e
H_2O per lb of dry air……..	lb	0.013	f
Unburned Fuel Loss……..	%	0.4	g
Unaccounted Loss……	%	1.5	h
Radiative Loss (ABMA)……	%	0.8	I

14	**Quantities per 10,000 Btu fuel input:**		
15	Fuel Burned……. [100(100 - line 10)/line 12]-0.007(line h)……	lb	1.04
16	Theorectical Air line 20	lb	9.05
17	Theorectical Air Correcteed		9.00
	Dry Air		16.20
18	H_2O in Air……. Line 15 x Line f……	lb	0.21
	Water From Fuel		0.65
	Wet Gas from Fuel		1.05
	Total Wet Gas		17.45
	Water in Wet Gas		0.86
	Dry Gas		16.60
	Water in Gas		4.90
19			
20	H_2O in fuel……. 100(8.94X Line 5 + Line 9)/Line 12……..	lb	0.65
21	H_2O in fluegas……. Line 17 + Line 19……	lb	0.86
22	H_2O in fluegas, in %… 100(Line 19/Line 18)……	%	4.90
23	**DRY GAS TOTAL…..**	**lb**	
24			
25	**Losses per 10,000 Btu fuel input:**		
26	Dry Gas Loss 10,000Line g/100……..	%	13.69
27	Water from Fuel 10,000Line h/100……..	%	7.76
	Moisture in Air		0.33
	Unburner Carbon		0.69
28	Radiation…….. 10,000Line I/100……	%	0.40
	Unaccouted for (Margin)		1.50
##	**TOTAL LOSSES…….**	**%**	**24.37**
##	Total Losses, in %….. 100(Line 30/10,000)……	%	24.37
##	Boiler Efficiency, by difference…. 100 - Line 31……	%	**75.63**
##			

NOTES:

a. Source: "Steam/Its Generation and Use"; Babcock & Wilcox; 1978; Chapter 6 Principles of Combustion; page 6-18; Table 12.

b. NO_x temperature of formation is 3250 F; temperatures below this value indicate that NO_x formation is either unlikley or strongly inhibited.

W. WMS Test Burn Boiler Efficiency 30% Biomass

Company..	Wyandotte Municipal Services						
Power Plan	Boiler Unit #8						
Source….		Basin					
		from Battle Creek		del'd by	Truck	for del'y to	WMS

Cost Information:

Mine Cost.		per ton		#1	PRB Coal/TDF	100%
Transport		per ton	Unit # 8	#2	Densified wood cubes	
TOTAL….	$ -	per ton				

COMBUSTION CALCULATIONS

Based on quantities per 10,000 Btu fuel input[a]

1	**Fuel……..**	Coal/Wood Mix			
2		#1	#2	Blend	
3		% Wt	% Wt	% Wt	
4	C	55.01		55.01	
5	H_2	4.95		4.95	
6	S	0.62		0.62	
7	O_2	19.07		19.07	
8	Cl	0.00		0.00	
9	N_2	0.74		0.74	
10	H_2O	9.71		9.71	
11	Ash	9.90		9.90	
12		100.01	0.00	100.01	
13	Btu/lb	8,292		8,292	

Conditions by test or specifications:			
Total Air (Theoretical + Excess)…	%	180	b
Air Temperature to Heater…….	F	80	c
Air Temperature from Heater…….	F	390	d
Fluegas Temperature leaving unit	F	420	e
H_2O per lb of dry air……..	lb	0.013	f
Unburned Fuel Loss……..	%	0.4	g
Unaccounted Loss……	%	1.5	h
Radiative Loss (ABMA)……	%	0.8	I

14	**Quantities per 10,000 Btu fuel input:**		
15	Fuel Burned……. [100(100 - line 10)/line 12]-0.007(line h)……	lb	1.08
16	Theorectical Air line 20	lb	8.72
17	Theorectical Air Correcteed		8.66
	Dry Air		15.60
18	H_2O in Air……. Line 15 x Line f……	lb	0.20
	Water From Fuel		0.65
	Wet Gas from Fuel		1.08
	Total Wet Gas		16.88
	Water in Wet Gas		0.85
	Dry Gas		16.03
	Water in Gas		5.05
19			
20	H_2O in fuel……. 100(8.94X Line 5 + Line 9)/Line 12……..	lb	0.65
21	H_2O in fluegas……. Line 17 + Line 19……	lb	0.85
22	H_2O in fluegas, in %… 100(Line 19/Line 18)……	%	5.05
23	**DRY GAS TOTAL…..**	**lb**	
24			
25	**Losses per 10,000 Btu fuel input:**		
26	Dry Gas Loss 10,000Line g/100……..	%	13.22
27	Water from Fuel 10,000Line h/100……..	%	7.83
	Moisture in Air		0.31
	Unburner Carbon		0.70
28	Radiation…….. 10,000Line I/100……	%	0.40
	Unaccouted for (Margin)		1.50
##	**TOTAL LOSSES…….**	**%**	**23.96**
##	Total Losses, in %….. 100(Line 30/10,000)……	%	23.96
##	Boiler Efficiency, by difference…. 100 - Line 31……	%	76.04
##			

NOTES:

a. Source: "Steam/Its Generation and Use"; Babcock & Wilcox; 1978; Chapter 6 Principles of Combustion; page 6-18; Table 12.

b. NO_x temperature of formation is 3250 F; temperatures below this value indicate that NO_x formation is either unlikley or strongly inhibited.

X. WMS Test Burn Boiler Efficiency Baseline

Company..	Wyandotte Municipal Services						
Power Plan	Boiler Unit #8						
Source….		Basin					
		from Battle Creek		del'd by	Truck	for del'y to	WMS

Cost Information:

Mine Cost.		per ton		#1	PRB Coal/TDF	100%
Transport		per ton	Unit # 8	#2	Densified wood cubes	
TOTAL….	$ -	per ton				

COMBUSTION CALCULATIONS

Based on quantities per 10,000 Btu fuel input[a]

1	**Fuel……..**	Coal/Wood Mix			
2		#1	#2	Blend	
3		% Wt	% Wt	% Wt	
4	C	58.47		58.47	
5	H_2	4.62		4.62	
6	S	0.96		0.96	
7	O_2	7.75		7.75	
8	Cl	0.00		0.00	
9	N_2	1.22		1.22	
10	H_2O	13.07		13.07	
11	Ash	13.91		13.91	
12		100.00	0.00	100.00	
13	Btu/lb	8,504		8,504	

	Conditions by test or specifications:		a
	Total Air (Theoretical + Excess)…	%	180 b
	Air Temperature to Heater…….	F	80 c
	Air Temperature from Heater…….	F	390 d
	Fluegas Temperature leaving unit	F	420 e
	H_2O per lb of dry air……..	lb	0.013 f
	Unburned Fuel Loss……..	%	0.4 g
	Unaccounted Loss……	%	1.5 h
	Radiative Loss (ABMA)……	%	0.8 i

14	**Quantities per 10,000 Btu fuel input:**			
15	Fuel Burned…….	[100(100 - line 10)/line 12]-0.007(line h)……	lb	1.00
16	Theorectical Air line 20		lb	9.43
17	Theorectical Air Correcteed			9.38
	Dry Air			16.88
18	H_2O in Air…….	Line 15 x Line f……	lb	0.22
	Water From Fuel			0.64
	Wet Gas from Fuel			1.01
	Total Wet Gas			18.11
	Water in Wet Gas			0.86
	Dry Gas			17.25
	Water in Gas			4.74
19				
20	H_2O in fuel……	100(8.94X Line 5 + Line 9)/Line 12……..	lb	0.64
21	H_2O in fluegas…….	Line 17 + Line 19……	lb	0.86
22	H_2O in fluegas, in %…	100(Line 19/Line 18)……	%	4.74
23		**DRY GAS TOTAL…..**	**lb**	
24				
25	**Losses per 10,000 Btu fuel input:**			
26	Dry Gas Loss	10,000Line g/100……..	%	14.22
27	Water from Fuel	10,000Line h/100……..	%	7.69
	Moisture in Air			0.34
	Unburner Carbon			0.68
28	Radiation……..	10,000Line I/100……	%	0.40
	Unaccouted for (Margin)			1.50
##		**TOTAL LOSSES…….**	**%**	**24.84**
##	Total Losses, in %…..	100(Line 30/10,000)……	%	24.84
##	Boiler Efficiency, by difference….	100 - Line 31……..	%	**75.16**
##				

NOTES:

a. Source: "Steam/Its Generation and Use"; Babcock & Wilcox; 1978; Chapter 6 Principles of Combustion; page 6-18; Table 12.

b. NO_x temperature of formation is 3250 F; temperatures below this value indicate that NO_x formation is either unlikley or strongly inhibited.

Y. Wood Fuel Availability Study

TRAVERSE
CITY AREA CHAMBER OF COMMERCE

Tino J. Breithaupt
Senior Vice President of Economic Development
Traverse Bay EDC

May 29, 2009

Tania Howard
Biomass Energy Program Coordinator
Department of Labor & Economic Growth, Energy Office
611 W Ottawa
Lansing, MI 48913

RE: PLA-09-35 Progress Report

Dear Ms. Howard:

Please accept this letter as the final report regarding PLA-09-35. This project has been completed. The final report as submitted by Terry DeBlaay has been included with this report.

The project as proposed consisted of a study of the available biomass fuel available in a 50 mile radius from the proposed location for a 36 MW power plant to be located in Rapid River Township, Kalkaska County. The only deviation from the proposed plan was the change of location of the power plant from Rapid River Township to Mancelona Township Jordan Exploration was unable to obtain the zoning amendments needed to allow for the construction of the plant. Jordan Exploration identified a second suitable site in Mancelona Township, three miles from the Rapid River Township. As a result, the name of the project was changed from Rapid River Renewable Energy to Mancelona Renewable Resources. There was no change of ownership.

The major accomplishment for this study was the identification of available fuel sources, the percentage of the total volume of woody biomass needed to sustain the proposed power plant per year. The results of this study will be used to demonstrate the viability of the power plant to prospective investors and financiers. This was a comprehensive study that is believe to be precise and effective and was accomplished in a timely and efficient manner. There were no new problems in carrying out this study. The completed study has been forwarded to the following organizations:

- Patrick Cudney, North Region Director, Michigan State University Extension
- Dana Gallagher, Michigan Farm Bureau
- Mike Dibernardo, Michigan Department of Agriculture
- George Berghorn, Michigan Forest Products Council
- Tom Barnes, Executive Director, Michigan Association of Timbermen
- Lori Phalen, Executive Director, Michigan Association of Conservation Districts

As much of the study was conducted by a third party sub-contractor, Terry DeBlaay, there was no coordinated effort with other organizations in conducting the research for this study.

The results of this study have positively impacted the proposed project to build a biomass based electrical generation facility. Based partly upon the findings, the development company is proposing to move forward and is in the process of purchasing the site to house the facility The

next step will be to enter into a power purchase agreement with a utility, and seek appropriate equity and leveraged financing for the project. The development company also intends to proceed with obtaining plant specifications and an air quality permit.

This project was funded from several sources. In addition to the direct funding from the State of Michigan Energy Office, Jordan Exploration and the Traverse Bay EDC donated the time for Ben Brower, Gail Holland, Sarah Racine and Laura Galbraith as an in kind match.

An actual to proposed budget has been attached to this report. There are several areas that did not meet budget projections; contract services, travel, in-kind time and postage. The original budget was based on an estimate of 80 contract hours to complete the study. The actual time to complete the study was 116 hours. Jordan Exploration has contributed the funds required over and above the grant amount. The original budget also included a travel line item for Terry DeBlaay to travel around the region to make presentations to the above mentioned organizations. After the report was complete, it was determined that a presentation was not needed. As there were no presentations to be made, the time required from Ben Brower and Gail Holland was less than had been anticipated. The final report was also submitted to the above mentioned organizations via e-mail, eliminating the need for printing and postage. The time pledged from the Traverse Bay EDC has remained consistent.

Attachments

- Fuel Study – Final Report
- Final Budget showing original budgeted amounts to actual amounts

If you have any questions, please feel free to contact me directly

Sincerely,

WOOD FUEL AVAILABILITY STUDY

FOR

WOOD FIRED ELECTRICAL GENERATING PLANT

IN

MANCELONA MICHIGAN

Report to Rapid River Renewable Energy, LLC

By
Terry DeBlaay
Randy Kuipers

tdeblaay@yahoo.com
rlkuipers@charter.net

This report was prepared on behalf of Rapid River Renewable Energy, LLC. Submitted on May 5, 2009 to fulfill the requirements of Grant Number PLA-09-35, funded by the U.S. Department of Energy State Energy Program (SEP) and managed by the Michigan Biomass Energy Program, DELEG Bureau of Energy Systems.

Table of Contents

Page

Executive Summary ……. 3

Background Information ……. 4

Woodshed Region …….. 4

Map of Core Supply Areas …… 5

Wood Resources within Woodshed ……. 6

Analysis of Wood Supply …… 7

Forest Sources ……. 7

Sawmill Sources …….. 9

Competition for Wood Fiber …….…. 9

Map of Woodshed Areas for Competing Mills ……. 12

Cost Analysis for Wood Fuel …….…. 13

Strategies for Successful Procurement Program ……. 15

Appendices ……. 17

List of Suppliers ……. 18

Authors Vitae … ……. 19

Availability for Additional Consultation ……. 21

Contact Information for Potential Suppliers ……... 21

Executive Summary

The need for increased electrical generation from renewable sources in Michigan is growing. Part of that need is being addressed by the development of a wood fired electrical generating station at Mancelona. The sole fuel for the proposed plant is wood. Wood is a sustainable and renewable source of boiler fuel. This wood can come from two primary sources; forest/logging suppliers or sawmill residues (sawdust, bark, chipped slabs). Forest sources represent over 70% of the likely supply of wood.

Economic trucking distances and competition from other markets are the limiting factors on wood fuel supply. Most of the wood will need to come from within a 60 mile radius of Mancelona. This includes all or part of 13 counties in the Northwestern portion of Michigan's Lower Peninsula.

Competing markets within the woodshed of the proposed plant include other wood fired electrical generating plants and forest products manufacturing plants. Four of the six biomass electrical generating plants have woodsheds which overlap Mancelona's woodshed. Six forest products manufacturing plants purchase wood fiber within the woodshed of the proposed plant at Mancelona.

Whole tree chips from loggers are the core component of the wood supply. At today's prices this type of fuel will cost between $25 and $30 per green ton FOB Mancelona. The average cost per ton can potentially be reduced by utilizing re-processed logging residues, sawmill residues and alternative fuels.

A comprehensive procurement plan developed and overseen by experienced professionals is highly recommended. Specific input from potential suppliers reinforced the need for critical items in the fuel procurement plan to set the Mancelona plant apart from its competitors.

Background Information

Energy requirements in Michigan are anticipated to expand for the foreseeable future. The majority of electrical generation in Michigan is from non-renewable sources (e.g. coal, natural gas). There is a need to produce more electrical energy from renewable sources. Woody biomass is an important component of this portfolio. Unlike many other states, Michigan is uniquely situated to produce significant portions of its' renewable electrical capacity from woody biomass.

Rapid River Renewable Energy is planning to build a 36 megawatt wood fired electrical generating plant in Mancelona/Kalkaska region. In preparation for this venture, they wisely decided to conduct a wood fuel feasibility study to determine the economic availability of wood to fuel the proposed plant. The information included in this study will provide a factually based platform from which to launch a successful wood fuel procurement program.

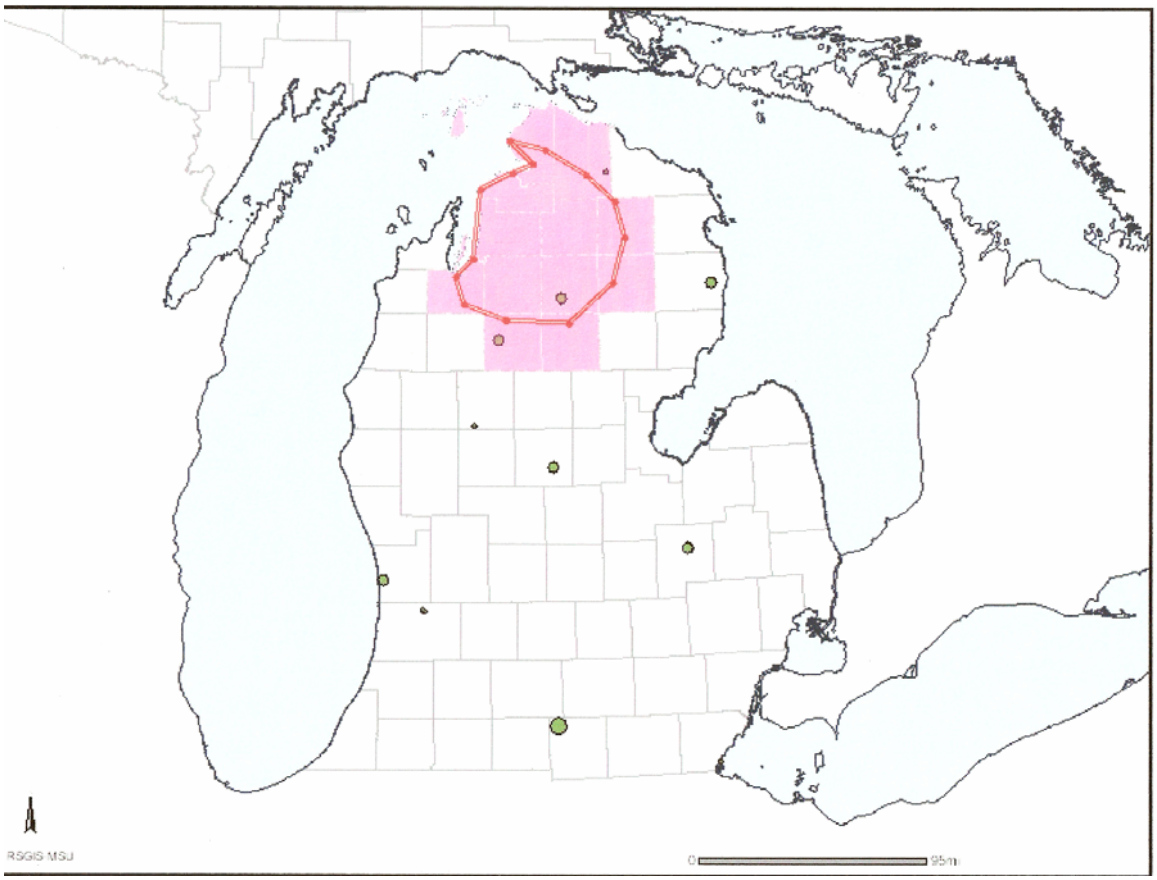
Michigan's forest products industry has a long history. Because of the abundant forests in northern Michigan, there have been many forest based manufacturing plants built throughout the state in the past 100 years. These include paper, corrugated medium, engineered wood products (e.g. OSB, particle board, MDF, hardboard, plywood), sawmills, and electrical generating plants.

Recent declines in Michigan's economy and an overall malaise in the global forest products industries has wrought some heretofore unseen changes in our forest based industries. The current condition of Michigan's forest products industries must be viewed from both the positive opportunities it presents as well as the negative impacts it may have. On the positive side, there is less competition for the available wood fiber.

Wood shed Region

The area from which wood fuel can realistically be expected to be drawn includes the 13 counties listed in the table on page 6 and outlined in color in Map 1 on page 5. The woodshed area is determined by the economic trucking distance from the proposed plant. The economic trucking distance includes the cost of diesel fuel, the proximity to competing markets, the price paid for wood at the plant, and the number of loads per day a truck can generate from a given work site. We will assume a maximum trucking distance of 60 miles. This distance can go up or down depending on the factors listed above.

The following map shows the geography of the area from which wood fuel can be procured. The circle on the map defines a 50 mile radius from Mancelona. The thirteen highlighted counties define the woodshed area for the proposed plant.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Wood Resources within the Woodshed

The following table details the acres of timberland and the timber volume by county within the thirteen county region describing the woodshed for this project. There are 3,182,000 total acres of timberland within this thirteen county area. The total volume of merchantable timber within the wood shed is 57,068,000 cords.

We assume a 3% per year growth rate on this forested acreage. This results in an annual addition of 1,712,040 cords of wood per year to the forest land within the described 13 county woodshed region. We assume 3.3 green tons per cord. Therefore the region is adding 5,649,732 green tons of total woody biomass per year.

The power plant will use approximately 400,000 green tons of wood fuel per year. This is 7.0% of the annual growth within the woodshed region. In financial terms this is synonymous with using 7.0% of the interest and none of the principal.

Counties within Wood Shed Region		
County	Forested Acres (x 1,000)	Timber Volume (Thousand Cords)
Emmet	206	4260
Cheboygan	349	6466
Charlevoix	164	4262
Antrim	164	3824
Otsego	171	4484
Montmorency	294	5245
Grand Traverse	174	3173
Kalkaska	261	4752
Crawford	296	3663
Oscoda	323	4431
Wexford	275	5483
Missaukee	235	3488
Roscommon	270	3537
Total	3182	57068

The information on this table is from the 2007 USDA FIA data; http://199.128.173.26/fido/output; and the Michigan Forest Analysis Resource Bulletin NC-179.

Analysis of Wood Supply

The total volume of wood that should be considered as potential supply for this project can be separated into two categories; forest sources and sawmills.

Forest sources consist of logging operations. For the purpose of determining supply volumes for a power plant, logging operations need to be limited to whole tree chipping suppliers. Round wood producers (those that produce wood as pulp wood or logs) cannot be considered as suppliers unless they are willing to invest in converting their operations to include whole tree chipping as part of their operational portfolio.

Sawmill sources include sawdust, bark and chipped slabs.

Forest Sources

There is a large gap between total volume of wood growing and that which is available. Wood availability is a complex and fluid issue to accurately assess. The following factors contribute to the availability of forest sources of wood.

Logging contractors are an obvious key. Without an adequate number of logging contractors, all the wood in the world will do no good. There has been a steady decline in the number of logging contractors in the past several years. Reasons for this decline include the loss of major markets for forest products. These losses include Menasha Corporation in Otsego, SAPPI in Muskegon, and Georgia Pacific in Gaylord. The wooden pallet business has also shrunk. The pallet business has been closely tied to automotive manufacturing and with the shrinking auto sector we have lost many pallet manufacturers. The overall down turn in the economy has caused many other forest products manufacturing companies to slow production or close their business altogether.

The result of the loss of markets for forest products is the parallel loss of logging contractors. We have personal knowledge of several logging contractors that have permanently relocated to southern states.

With the annual increase in woody biomass, fewer loggers, and the prospect of emerging markets this could be viewed as a very good time for astute business people to seize this opportunity. However, recent history has taught those in the logging business to become cynical. Long term commitments were made by major markets and then reneged on. Pricing promises were made and then changed. Many loggers invested a lot of capital to switch from round wood to chips (or visa versa) only to be told that the product they switched to was no longer going to be purchased.

Logging contractors have learned to not trust what they are told by the markets they supply to. During the 1970's and 1980's it was common for loggers to have loyal relationships backed up with long term contracts with the markets they supplied. During the 1990's corporate mergers and hostile takeovers changed operational strategies for major corporations. Forest products companies historically understood the long term nature of the forestry business. Things have changed so that short term economic decisions drive most business strategies. As a result the logging contractors that have survived have learned to trust their own instincts, resist the promises of mutually loyal business relationships, and supply wood products to the markets which are most profitable in the near term. They have also positioned themselves to have multiple markets. Very few, if any, logging contractors commit themselves to one market.

Another factor in the availability of forest sources of wood is the private landowner. Until recently, the real estate development value of land out weighed the forestry value. Forest land got broken up into smaller and smaller parcels with each parcel having a residence on it. This forest fragmentation has resulted in two things; first many parcels are too small to be commercially viable for a logging operation and second, many landowners have urban values and do not want to manage their forest land through timber harvesting. Therefore a certain percentage of forest land within the woodshed of this project will not be available for logging purposes.

The price paid for standing timber is another factor in the availability of forest sources of wood fuel. Free market principles drive the cost of standing timber (stumpage) on private land. Some landowners will not harvest their timber unless the price exceeds their perceived value for the timber. This perceived stumpage value is usually too high to work in the price matrix for a wood fired power plant.

The price of stumpage on public land (county, state, federal) is partially determined by the free market and partially by the government agency pre-determining the value of the timber.

Lastly, soil and weather conditions, and other logging restrictions determine availability of forest sources of wood. Seasonally wet soils and adverse weather conditions restrict the amount of time available for timber harvesting activities. On public land logging restrictions include: snowmobile trails, ORV trails, loose bark season (spring), oak wilt, emerald ash borer, Indiana bat, red shouldered hawk, threatened and endangered species, riparian zone protection, retention areas, and a host of others. Loggers have to have contingency plans for myriad conditions.

Taking all of these factors into consideration and applying the 58 years of combined experience of the authors we apply a 60% availability factor to the timber volumes reported on page 6. We believe that of the 5,649,732 green tons of additional volume grown each year 3,389,839 tons would be available within some combination of the availability factors listed above. Annual power plant needs are still only 11.8% of this projected available annual growth.

We did not segregate this volume of timber growth by product class. Some of this growth is in hardwood logs, some in conifer logs, and some in pulpwood. It would require significant investment of time and resources to break out the portion of the annual timber growth that could be considered as having no higher value than boiler fuel. Since the plant needs represent only 11.8% of the annual growth, it can be safely assumed that all other markets combined would not absorb over 88.2% of the annual growth.

Sawmill Sources

Sawmills have three sources of waste wood. These include sawdust, bark, and slab wood. Not all sawmills have all three of these products. The sawmills we contacted within the wood shed region of Mancelona are all selling their mill waste to existing markets. To acquire some of this material the sawmills will need to be convinced that it is in their best interest to sell some of their mill waste to a new market.

This can be best achieved by working with sawmills close to Mancelona. This would reduce the trucking costs of transporting their wood waste. Another argument can be made to sawmills to sell some of their wood waste to a new location in order to diversify their markets. Of course the economics of such a decision would have to make sense to the sawmill owners. As a last resort, the procurement staff could try to persuade a mill to change markets by just paying them more; this is a last course strategy and is not recommended.

Competition for Wood Fiber

In spite of the apparent surplus of woody biomass, it needs to be remembered that there are a number of competing markets for the wood currently being produced from the forestlands within the woodshed region of the proposed electrical generating plant in Mancelona.

Competing markets can be segregated into two groups. One group includes the eleven buyers of wood fuel in the Lower Peninsula. Included in this group are the eight existing wood fired electrical generating plants: Cadillac, McBain, Grayling, Hillman, Lincoln, Filer City, Flint, and Mount Pleasant; and six

manufacturing plants that purchase wood fiber: PCA in Manistee, SAPPI in Muskegon, DPI in Alpena, LP in Newberry, New Page in Muskegon, and Versa in Quinnesec.

Four of these plants are too far from Mancelona to be considered competitors for wood fuel; these would be the wood fired power plants in Lincoln, Mount Pleasant, Muskegon, and Flint. The five power plants within Mancelona's woodshed (Cadillac, McBain, Grayling, Filer City, and Hillman) have a combined annual wood usage of approximately 1,000,000 greens tons per year.

DPI in Alpena buys about 70,000 tons of wood fuel per year. They are currently paying $24 per ton. Filer City is buying about 80,000 tons per year of fuel wood to burn with their coal. They are paying $22-$24 per ton depending on distance from the mill. The wood fired electrical generating plants are currently paying $17-$26 per ton delivered to the plant. Variations in prices depend on distance from the plant, product being purchased, inventory levels at the plant, and delivery volumes (bonuses for larger volumes).

There are six major forest products manufacturing facilities that buy wood within the woodshed region of the proposed plant in Mancelona. These include: PCA in Filer City, Weyerhaeuser in Grayling, DPI in Alpena, New Page in Escanaba, Potlatch in Gwinn, Versa in Quinnesec, and LP in Newberry. These plants are potential competitors for the wood fiber required to fuel a new power plant.

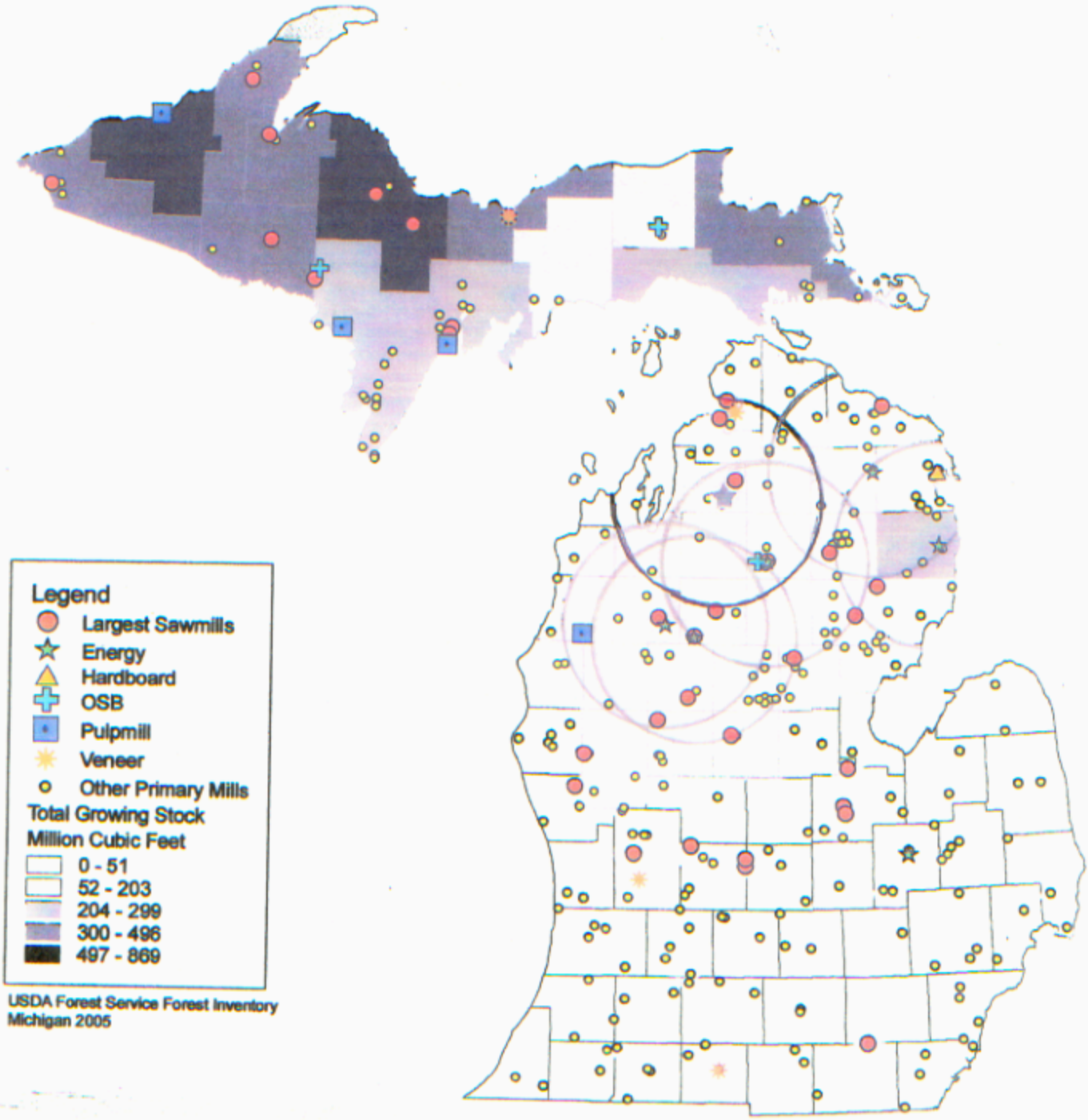
Other manufacturing facilities that utilize forest products and should be considered potential competitors include the following. Green house operations in Ontario are currently purchasing wood chips in Michigan to fuel boilers for seasonal heat needs. Wood carpet markets buy chips to use for playgrounds; they use only clean sawmill chips. Landscape markets are seasonal in Michigan (spring and summer), but typically pay more than boiler fuel prices and often divert logging residues away from power plants. There are wood pellet plants in Weidman (Maeder Brothers) and White Pigeon. The plant in White Pigeon is probably too far away to be much of a concern to the Mancelona location.

There are a number of sawmills within the woodshed that purchase wood. Sawmills use the large trunk portion of the tree, not the smaller pulpwood portion of the tree. As such, they are a net asset to a power plant by bringing wood to market that might not otherwise find its way into the supply system. Therefore we treat sawmills as assets to a wood fired electrical generating plant.

Several new wood using manufacturing plants have been announced. None of them are yet under construction, but they need to be considered as possible future competitors for wood fiber. They are listed below with estimated wood usage rates.

- Wood pellet plant in Gaylord – 90,000 tons/year
- Wood pellet plant in White Cloud – 100,000 tons/year (2009 start up?)
- Consumers Energy biomass plant in SW MI area – 300,000 tons/year
- Coal Fired power plant – Rogers City – 200,000 to 300,000 tons/year
- Wood Ethanol plant – Kinross – 1,000,000 tons/year
- Wood Ethanol plant – Muskegon – 250,000 tons/year
- Others?

Map 2. Wood shed areas of competing mills.



Lighter colored circles = 50 mile radius of existing biomass plants
Darker circle = 50 mile radius of Mancelona

Cost Analysis of Wood Fuel

The cost per ton for wood fuel will be determined by market forces. In the case of a new wood fired electrical generating plant these forces are already in place as a result of a well established market for fuel wood.

In the past there was a noticeable difference in prices paid between the five biomass plants in northern Michigan. Grayling was usually the lowest because their transportation costs were the lowest. Cadillac had wide swings because of fluctuating inventory levels, and a failure to develop secure supplier relationships. McBain, Hillman, and Lincoln remained consistently in the middle of the pack. Prices averaged between $15 and $18 per ton for a number of years.

In the past 18-24 months prices have steadily increased to their current level. This increase was due to rising diesel fuel costs, a decrease in the number of chipping contractors, increasing stumpage rates, and a settling out of supply streams between individual plants. As a result, the current price for forest sources of chips is about $24 per green ton. And most plants are running short on inventory going into the spring break up for 2009. It is likely that the price will escalate to $26-$30 per green ton in order to build needed inventories.

Logging residues that are processed with a horizontal grinder can typically be purchased for less than whole tree chips. These products can usually be purchased for $5-$7 per ton less than whole tree chips. At today's prices ground logging residues can be purchased for about $17-$19 per ton.

Logging residues come from stockpiled tops from tree length operations or bark/branches from flail de-barking at chipping operations. Both of these sources need to be re-ground in the woods with a portable grinder (usually a horizontal grinder/hammer mill). The fuel quality from this type of wood is low (dirt, fractured ends). Most power plants have material handling systems that limit the volume of this type of wood. It also has a higher ash content than chips (a down stream cost), and causes boiler slagging from higher dirt content. It can, however, be the lowest priced source of wood fuel. It will cost about $2 - $3 per ton for the material and $12 per ton for processing costs. Trucking costs vary depending on distance to the mill.

Power plant designers should consider innovative material handling systems that allow for unimpeded use of ground logging residues. Increased volumes of this type of material could give the plant at Mancelona a competitive advantage.

Alternative fuels should be considered as companion fuels for wood. The two most common are TDF (tire derived fuel) and paper pellets. Both have been used in existing power plants. Sorted trash from landfill tipping floors should be avoided. There are too many problem issues with trash (air quality permit issues, ash disposal issues, fuel contamination issues, etc.). TDF has the best potential because it is available, will flow through material handling systems with wood, stabilizes boiler temperatures, and can reduce overall fuel costs. Pelletized paper creates problems with wind borne contamination in the wood yard, and increased ash output. MDEQ air permits can be amended to allow for alternative fuels. These amendments can be costly and time consuming, but are usually worth the effort. BAT (Best Available Technology) is normally required to amend existing air permits. The authors have extensive experience with acquisition and use of alternative fuels. This opportunity is discussed in the section on the availability for additional consultation on page 19.

The projected start up date for the proposed Rapid River Renewable Energy plant in Mancelona is about three years. The prices quoted in this report could change significantly by 2012.

Strategies for a Successful Procurement Program

Long term (3-5 year) supply contracts should be negotiated and signed as soon as possible. This will assure the plant of a known volume of wood, put a sense of security into the market place and allow suppliers the time needed to secure financing, purchase equipment and line up stumpage. Make sure there is enough financial strength in the company to stick with the agreements. Annual cost of living increases built into the long term contracts could be a key to securing supplier loyalty. The worst thing that could be done would be to back out on a price and volume agreement in the first few years of operation. It takes a long time to establish a good reputation, and only a short while to create a bad one. There is a certain amount of skepticism regarding biomass energy plants among the logging community. It will require a well thought out procurement plan to overcome this cynicism. Requesting input from the supplier base would create some “buy in” and commitment from the eventual pool of suppliers. Several logging contractors we spoke with commented on their desire to have long term contracts.

Many suppliers we spoke with have logging equipment that is not being used. There was general agreement among most of these suppliers to bring equipment out of moth balls if the right market opportunities exist. Several logging contractors we spoke with have sold off equipment as the forest products sector declined in recent years. However, most of them said they would be interested in purchasing chipping equipment if a secure market developed. Financial offers to help suppliers purchase needed logging equipment would be welcomed by most suppliers, and would secure supplier loyalty for the long term.

Whole tree chips should represent at least 60-70% of the wood fuel. They are the most secure source. As shown in the wood resources section of this report, there is an abundant supply of standing timber. Chip volumes can be increased upon request, sawmill residues are fixed. Chips flow best through handling systems at power plants (belts, bins, chutes). They are clean sources of fuel (free from dirt and contaminants) and result in lower ash output in the boiler. The only down side to whole tree chips is that they will likely be the highest cost wood fuel at a biomass energy plant.

Try to acquire as much sawmill residue as possible close to the plant. Consider subcontracting the trucking, sawmills are in the business of making lumber. The easier you can make residue disposal for a sawmill the higher your chances of redirecting some of this wood to your power plant. This type of fuel represents a good opportunity to lower overall wood fuel costs.

Wood yard construction can have a large influence on supply. Suppliers want to get in and out quickly. The truck dump should go directly on the ground, not into a hopper. The scaling procedures should be simple. Design it so the drivers can scale in their own loads and operate the dump themselves. 24/7 dump hours are a big plus. Service is a key factor.

RRRE may want to consider helping selected suppliers in financing portions of their harvesting systems. This would assure additional infrastructure in the woods, and secure some long term supplier loyalty for the procurement program.

Several potential suppliers we contacted expressed an interest in having a wood fuel procurement staff to work with. Most of the biomass power plants purchase "gate wood". This means that wood is purchased from whoever shows up at the gate. With this scenario the secretarial person inputs daily delivery tickets to generate payment, and someone else (often the plant manager) oversees the supply contracts and tries to manage the wood inventory level. This method of wood fuel procurement is not very efficient. Examination of the recent performance of wood fuel programs at existing power plants demonstrates wildly fluctuating inventory levels, pricing instability, and high levels of dissatisfaction with the suppliers.

Having a procurement manager to draft, implement and maintain a comprehensive procurement plan would set Mancelona apart from the other wood fuel markets. This distinction could provide another competitive advantage. A procurement manager needs to be a high level professional person with extensive experience. It may seem as though this is an unnecessary labor cost. However, the right person can easily justify their expense by creating a seamless fuel procurement plan. This plan would maintain consistent inventory levels, provide predictable pricing structures, and create long term supplier stability.

APPENDICIES

List of Potential Suppliers
Authors Vitae
Availability for Additional Consultation
Contact Information for Potential Suppliers

POTENTIAL SUPPLIERS					
SUPPLIER	COUNTY	TYPE *	GREEN TONS **	DELIVERED PRICE ***	MILES TO PLANT ****
Woodlands Harvesting	Alpena	WTC	25000	28	60
Fahl FP	Antrim	SMC	16000	21	5
Moeke Lumber	Antrim	SMC	5000	20	4
Silver Leaf Mill	Antrim	SMC	16000	22	15
Fritz FP	Benzie	WTC	10000	26	50
Baumgarten FP	Cheboygan	SMC	5000	24	68
Jaroche Bros	Cheboygan	SMC	8000	24	45
Chris Muma FP	Gladwin	WTC	30000	30	80
Shawn Muma Logging	Gladwin	WTC	30000	30	80
Lake Ann Hdwdws	Grand Traverse	SMC	3000	21	50
Yates FP	Iosco	WTC	20000	28	90
Blake FP	Kalkaska	WTC	40000	26	20
Rothig FP	Lake	WTC	50000	30	80
John Doyle & Sons	Mecosta	WTC	30000	28	85
Robert Gentz FP	Manistee	WTC	30000	30	90
Bisballe FP	Missaukee	WTC	40000	28	50
Lutke FP	Missaukee	WTC	20000	28	50
Mid-Michigan Logging	Missaukee	WTC	30000	25	50
Roger Bazuin & Sons	Missaukee	WTC	40000	30	50
Willie Outman FP	Missaukee	WTC	25000	26	50
Biewer sawmill	Missaukee	SMC	10000	30	50
Carroll's FP	Montmorency	WTC	25000	26	40
T R Timber Co	Ogemaw	WTC	30000	30	70
Stuckman FP	Otsego	WTC	30000	25	25
Al Lamberson	Otsego	WTC	20000	28	26
Elenz Inc	Otsego	WTC	25000	28	25
Timberline Logging	Otsego	WTC	35000	28	25
E H Tulgestka & Sons	Presque Isle	WTC	5000	28	75
Precision Forestry	Presque Isle	WTC	20000	28	70
Housler Sawmill	Wexford	SMC	4000	28	40
		Total Tons	677000		

* WTC = Whole Tree Chip; SMC = Sawmill Chip

** These are volumes to Mancelona; actual volumes may be higher or lower.

***This is dollars per ton delivered to Mancelona in 2009 dollars

**** Miles from suppliers home base, miles from harvest location could be less.

Authors Vitae

Terry DeBlaay

Academic
Michigan Technological University, Master of Science in Wildlife Ecology, 1980
Michigan Technological University, Bachelor of Science in Forestry, 1978
Grand Rapids Junior College, Associates of Science, General Studies, 1976

Work Experience
Timberline Logging, Gaylord, MI, 2008 – Present
Forester: responsible for stumpage acquisition for whole tree chipping crew, scheduling job locations and moves for two chipping crews, timber cruising, property boundary location, harvest boundary location, timber sale contract implementation.

Fahl Forest Products, Mancelona, MI, 2004 – 2008
Forester: responsible for stumpage procurement of 1,000,000 board feet of hardwood grade logs per year, supervision of all aspects of the timber harvest (timber sale contracts, MDEQ permits, county surface water permits, county road permits, performance bonds on roads, property boundary location, identifying and marking trees for harvest), pricing of timber purchases to meet annual pricing goals.

Northern Timberlands, Inc., Alpena, MI, 2000 – 2004
General Manager: responsible for all operational decisions for a $10 million annual budget, met contractual supply obligations with Georgia Pacific in Gaylord (150,000 tons/yr), Louisiana Pacific in Gwinn (50,000 cords/yr), Biewer Lumber in McBain (25,000 cords/yr), Beaver Log Homes in Kalkaska (25% of their annual usage), many smaller mills; supervised staff of three field foresters, one yard manager, one office manager; ensured stumpage procurement to meet all market obligations.

Hillman Power Company, Hillman, MI, 1994 – 2000
Procurement Supervisor: responsible for all procurement activities related to supplying wood fuel to a 20 megawatt wood fired electrical generating plant; tasks included securing and managing supply contracts with whole tree chippers, sawmills, wood residue grinders; purchase of tire derived fuel (TDF); inventory control.

Dow Corning Corp., Midland, MI, 1980 – 1994

Biologist/Forester for seven years, Department supervisor for seven years: supervise logging contractors, property and harvest boundary location, timber cruising, timber sale contract administration, timber pricing negotiations, supervise field staff and office staff, negotiate annual wood supply contracts, manage wood inventory levels for a 18 megawatt wood fired co-generation station.

Randy Kuipers

Academic

Michigan State University, Bachelors of Science in Forestry, 1977

Work Experience

Randy Kuipers Consulting Forester, LLC, Holland, MI 2007 – present.

Owner of forestry consulting business. Work with private forest landowners implementing forest and wildlife management. Work with four whole tree chip producers that supply energy chips, pellet chips and paper chips to various markets in SW Michigan. Work with private landowners and public owners of timberlands administering log sales, red pine saw timber sales and timber stand improvement projects. Assisted in the writing of two wood procurement plans for private industry.

Georgia Pacific, Gaylord, MI 2006

Wood Procurement Manager for six months until mill closed. Responsible for procurement of virgin fiber from southern wood shed (300,000 tons/yr.). Worked with whole tree chip producers and private landowners to supply the raw material needs of the Gaylord plant.

Menasha Corporation, Otsego, MI, 1984 – 2005

Woodlands Manager in charge of procuring 220,000 green tons of virgin wood fiber per year. Supervised senior forester and was key member of Menasha's leadership team. Monitored other chip markets that might threaten Menasha's fiber supply. Developed forest management plans for private forest landowners. Maintained 1 ½ - 2 year stumpage inventory at levels to run the Otsego Mill. Maintained excellent relationships with 20 sawmill and whole tree chip suppliers. Negotiated chip pricing and long term fiber supply contracts.

Availability for Additional Consultation

Developing a project of this magnitude is a daunting task. Gathering the best available information at the outset can allow for a smooth start up. This report contains comprehensive information on the wood fuel availability portion of this project. However, there are many other aspects to developing a biomass energy production facility. The authors have extensive experience in several of these fields. We are open to discussions pertaining to developing other elements of this project. Listed below are some possible areas for consideration.

- Developing a wood fuel procurement plan
- Implementing a wood fuel procurement plan
- Investigating alternative fuel sources (TDF, paper, etc)
- Consulting with plant designers on wood yard layout and design

Contact Information for Potential Suppliers

Information gathered from the suppliers listed in the “Potential Suppliers” list in the appendix includes some of the following: name, address, phone number, e-mail address, logging equipment owned, current markets for forest products, volumes currently delivered, pricing structures for current markets, interest in a new market at Mancelona, potential volumes to a new market, additional equipment needed for a new market, pricing requirements for a new market, and desired operational structure for a new market. Because of the large volume of data gathered from the potential suppliers, it is not listed in this report. The results of this raw data have been synthesized and are contained in the body of the report. This contact information is available upon request from the authors.

PROJECT BUDGET SHEET
Fuel Availability Study for
Rapid River Renewable Resources

	Jordan Exploration / Rapid River Renewable		Biomass Energy Grant		Traverse Bay EDC*		Total	
	Projected	Actual	Projected	Actual	Projected	Actual	Projected	Actual
Personnel								
Benjamin Brower	$ 2,000.00	$ 1,350.00					$ 2,000.00	$ 1,350.00
40 hrs at $50 per hour								
Gail Holland	$ 2,000.00	$ 1,400.00					$ 2,000.00	$ 1,400.00
40 hrs at $50 per hour								
Sarah Racine					$ 1,000.00	$ 800.00	$ 1,000.00	$ 800.00
20 hrs at $50 per hour								
Laura Galbraith					$ 1,000.00	$ 300.00	$ 1,000.00	$ 300.00
20 hrs at $50 per hour								
Contractual								
Terry DeBlaay		$ 1,800.00	$ 4,000.00	$ 4,000.00			$ 4,000.00	$ 5,800.00
80 hrs at $50 per hour								
Travel								
Terry DeBlaay								
Mileage - 1500 miles at $.349/mile			$ 524.00	$ -			$ 524.00	$ -
Travel expenses			$ 1,000.00	$ -			$ 1,000.00	$ -
Benjamin Brower								
Travel expenses	$ 100.00	$ -					$ 100.00	$ -
Gail Holland								
Travel expenses	$ 100.00	$ 3.49					$ 100.00	$ 3.49
Other								
Postage			$ 100.00	$ -			$ 100.00	$ -
TOTAL COSTS	$ 4,200.00	$ 4,553.49	$ 5,624.00	$ 4,000.00	$ 2,000.00	$ 1,100.00	$ 11,824.00	$ 9,653.49
Percentage	36%	**47%**	48%	**41%**	17%	**11%**		

** In-kind match*

Z. Wood Waste Processing and Utilization in Southeastern Michigan

Wood Waste Processing and Utilization in Southeastern Michigan

May, 2009

This study was funded by the Southeast Michigan Resource Conservation and Development Council and the U.S. D.A. Forest Service.

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Wood Waste Processing and Utilization in Southeastern Michigan

Executive summary

This project conducted a qualitative and quantitative study of wood waste processing and disposal yards in southeastern Michigan. The goal of the study was to characterize wood waste supply patters and evaluate the recovery efficiency and potential alternatives. To achieve this goal, the network of Michigan State University extension agents was used in combination with the Michigan Department of Natural Resources processing facilities lists and local directories to establish a reliable list of wood collection and processing facilities operating in the 16 counties included in the study. Calls were made to all yards to confirm that they accept and use wood, with only those that also processed wood included in the study. A mail-in questionnaire survey was used to derive information on wood waste supply flows and sources to generate information necessary for characterizing facilities, and to identify product types and quantities produced by wood waste yards. Several yards were visited to validate trends obtained from the survey and generate additional technical information on processes and wood utilization patterns. Results of the study indicate that 180 wood waste yards were operating in the 16 counties included in the study. These yards employ an average of 6 employees per yard for a total of 1082 employees in the industry. The total volume of wood entering yards was quantified at 235 million cubic feet (5.3 million metric tons), mainly from land clearing and tree removal. The wood waste supply was used to produce a total of 71.8 million cubic feet (1.6 million tons) of new products (wood chips, mulches, firewood, etc…) which were mainly sold locally. The overall conversion rate was estimated at 30% for the entire industry, clearly indicating room for improvement. The industry was estimated to contribute about $40 million to Michigan's economy. However, in the last few years, the housing slump and the overall economic downturn has seriously affected yards' activities by causing sharp reductions in wood supply from land clearing and tree removals going into wood waste processing facilities. The improvement of conversion rates and value-added product development at these processing facilities would require fundamental changes in the equipment, qualifications, and processes used by tree service companies in their field operations. Tree service companies, who are the first handlers of the wood resource, play a critical role in the identification, sorting, and preliminary processing of log material which was the highest potential for value-added products. In addition to traditional solid wood products, wood waste processing facilities should consider wood pellets as a viable alternative product. Other potential new products include wood composites (OSB, particleboard, and wood plastic composites), as well new biobased products such as feedstock for ethanol and syngas for biofuels production.

Introduction

Wood wastes include a large spectrum of wood products from primary and secondary processing such as bark, slabs, sawdust, chips, planer shavings, sander dust, end trims, used or scrapped pallets, and construction wood wastes. However, wood wastes also include logs, branches, and brush from urban tree removals and land clearing for construction, farming and industrial projects.

Large amounts of wood wastes, residues and solid wood are generated annually in the United States. According to McKeever (2003), in 2001 an estimated 234 million metric tons of residue was generated from traditional timber extraction, forest conversion to non-forest uses, primary processing, and demolition of buildings and structures. USDA Forest Service analysis reported that 104 million tons of woody residuals were available for recovery in the U.S., with wood and Municipal Solid Wastes (MSW) and construction and demolition debris streams comprising 28 million tons (McKeever 2003). Regional analysis indicates that the Midwest has 21.2 million tons of recoverable wastes including 2.2 million tons of MSW, 1.5 million tons from construction wastes, 2.6 million tons of demolition wastes, 5.6 million tons of logging residues, and 2.8 million tons of other types of woody residuals (McKeever 2003). A study of wood residue utilization in Pennsylvania indicated that round wood companies utilized or disposed of 120 million cubic feet (Murphy et al. 2007). The residues collected consisted of 20% bark, 45% coarse, and 35% fine residues (Murphy et al. 2007). Past study reports from several other states have reported large quantities of residues generated. Approximately 7.5 million tons were generated in Mississippi in 1994 (Short et al. 1996), 5 million tons in Wisconsin in 1992 (Hubing 1993), and 7.0 million tons in Louisiana in 1994 (De Hoop et al., 1994).

The situation in Michigan is very similar to national averages. A case study of Mid-Michigan Recycling (reported by the USDA Forest Service) revealed that the company recycles about 200,000 tons of urban wood annually by producing boiler fuel for the Genesee Power Station in Flint (Forest Products Laboratory, 2002). A recent study gives a more complete picture of the annual wood resource availability in southeastern Michigan, reporting that 7.5 million cubic yards of urban wood residues are generated annually in this region, with 58% of the material being discarded (Sherrill and MacFarlane, 2007).

The majority of wood waste recovery programs in Michigan and nationally are generally targeted towards low-end markets such as chips, and mulches, which pay the equivalent of $0.25 for a recovered wood pallet, while higher-end markets using value-added products could pay 20 to 32 times as much for an equivalent amount of wood (Forest Products Laboratory, 2002). In Michigan, these residues have been traditionally mulched and used for bedding, compost or as fuel for energy cogeneration. However, a good proportion of wood waste ends up in landfills. A study conducted by the Forest Products Laboratory estimated that wood wastes accounted for about 17% of the total wastes received at municipal landfills in the United States (Forest Products Laboratory, 2002). In addition Sherrill and MacFarlane (2007) estimated that two million cubic yards of wood waste enters southeastern Michigan landfills each year.

Despite the high value-added potential of some of the removed material, the preferred processing method for all wood wastes going into disposal yards is still grinding for conversion into bedding material for landscape purposes or fuel for cogeneration. Several studies have shown that there are several value-added options for conversion of waste wood. For example, a manufacturer in North Carolina patented a process that converts end-trims, construction and demolition wastes, scrap pallets, and yard trimmings into top soil and compost (Alderman et al. 1999). Wood wastes have also been effectively converted into wood fuel pellets for use in residential stoves, or included as filler in the manufacturing of wood composites. Additionally, several USDA Forest Service publications also highlight case studies from local governments and private businesses across the county that have been successful in demonstrating creative and profitable uses for managing waste wood (Bratkovich, 2001; Cesa, et al. 2003; Forest Products Laboratory, 2002). A study conducted by Chow and Zhao (1992) indicated that Medium Density Fiberboards (MDF) manufactured from red lauan, white meranti ash, birch, oak, lindens, true firs, Douglas and larch achieved equal or better strength properties compared to service class hardboard and plywood. Haviarova et al (2001) manufactured and tested solid and laminated school desk frames from salvage woody residues, and concluded that strong and durable school furniture can be produced by small scale facilities from local woody material using low technology processes.

In Michigan, the wood disposal situation has drastically changed since the Emerald Ash Borer (EAB) infestation was discovered during the summer of 2002. The Michigan Department of Agriculture estimates that more than 25 million ash trees have been killed and more than 700 million trees are at risk due to the EAB infestation (McCullough and Siegert 2007; Nzokou et al. 2006). The EAB infestation has caused an increase in green wood going into the waste stream due to the removal of dead trees in cities and woodlots around the state. Several reports and field observations have indicated that significant amounts of Michigan's quality logs from removed ash and other tree species entered wood waste processing facilities and were converted into low value products.

To alleviate the negative impact of the EAB in the state, several research and extension efforts are being developed by the Southeast Michigan Resource and Development Council (SEMIRCD), Michigan State University (MSU), the Michigan Department of Natural Resources (DNR) and other partners to demonstrate and promote value-added utilization of resources with good potential. Although the early focus was on ash trees, other hardwood species available are also included in this effort. Ash wood is best known as the wood mostly used for sporting goods manufacturing, such as baseball bats in the United States. Ash has been used for tool handles and steam bending for armchairs and other curved products. Its relatively high strength, flexibility, light weight, shock absorbency and split resistance favor its uses in furniture making. Other uses of ash in the fabrication of value added products include lumber and veneer for furniture, paneling, flooring, interior joinery, cabinetry and pallets (Nzokou et al. 2006). If properly sorted and processed, quality logs currently going into disposal yards can be used for such value-added products.

An important necessary step in developing green wood or waste wood into a viable resource is to quantify the amounts that are available by source and type of material, analyze current production patterns, and identify the potential for alternative value-added

options. A clear understanding of factors that affect the production and utilization of wood in disposal yards is critical to maximizing the economic values of these resources. Several questions need to be answered in order to assess the full potential of this sector and to propose strategies to enhance the production of higher-value products:

- How many wood disposal yards operate in southeastern Michigan?
- How many of these yards accept logs?
- What types of products are produced from these logs?

The goal of this study is to assess resource flow patterns for waste and green wood entering recycling yards and landfills in southeastern Michigan and to evaluate the potential for a better use of these resources. The specific objectives are to:

1- Estimate the quantity of green wood and wood residues entering disposal and recycling yards in southeastern Michigan and to characterize their composition,
2- Quantify and characterize products exiting the yards, and
3- Conduct a technical study of model disposal yards, and estimate the economic potential of the various processing and product alternatives.

Survey Methods and Approaches

This study focused on 16 counties in southeastern Michigan. These 16 counties were also included in the wood waste generation survey study conducted by Sherrill and MacFarlane (2007). A survey methodology was developed to identify yards, collect data, quantify results, and make generalizations for the study area.

Study population

We first started by creating a list of disposal yards and wood waste processing facilities in the study area. The list was compiled by combining companies listed as such in the Michigan Department of Natural Resources database, the local telephone directory listings, and lists available from the SEMIRCD for disposal yards. A telephone call was made to each company on the list and those who reported not dealing with wood were removed. Wood collection sites that did not report doing any further processing in the telephone surveys were also removed from the list. The corrected list for each county was forwarded to MSU Extension county directors for validation and correction and the final target population for the study was established. A total of 180 yards were retained in the study from the 16 counties. The breakdown of yards per county is presented in Table 1.

Survey instrument and data collection

To estimate the quantity and types of resources entering the yards and the amount and value of products generated, a questionnaire was developed to gather the necessary data. The questionnaire was evaluated by the SEMIRCD and the DNR and pretested with two disposal yards to clarify the wording and include additional questions necessary to achieve the study's objectives. The questionnaire was mailed to the 180 facilities

identified in October 2007. A postcard reminder was mailed in March 2008 and a second questionnaire sent out to non-respondents in May 2008.

The first section of the questionnaire asked categorical questions to obtain basic information about the company. We also gathered information to identify the provenance of the woody material entering the yard, the type and characteristics of the manufacturing facility, the species processed, the number of employees, the product types, and total volumes produced in their facility. The second section of the questionnaire focused on types of products processed at the facility, current markets, the marketing strategy of the yard, as well as identifying bottlenecks to higher productivity. The full questionnaire is included as Appendix 1. Following the mailing survey, personal phone calls (14 total) were made to respondents who provided insufficient or unclear answers to fill gaps observed in the responses received.

Table 1: Number of surveys mailed and response rate by county

County	Mailed	Responded	Response rate
Genesee	20	5	25.0%
Ingham	12	3	25.0%
Jackson	6	1	16.7%
Lapeer	8	3	37.5%
Lenawee	4	0	0.0%
Livingston	11	4	36.4%
Macomb	15	5	33.3%
Monroe	6	2	33.3%
Oakland	36	10	27.8%
Saginaw	8	2	25.0%
Shiawassee	5	0	0.0%
St Clair	4	1	25.0%
Washtenaw	8	3	37.5%
Wayne	37	3	8.1%
	180	**42**	**23.3%**
Landfills and Disposal Facilities		24	

The counties with the highest number of yards were Wayne (37), Oakland (36), Genesee (20), Macomb (15), Ingham (12) and Livingston (11). The response rate varied widely, with several counties having response rates well above 30% (Lapeer and Washtenaw 37.5%, Livingston 36.4%, Macomb and Monroe 33.3%). The average response rate for all counties was 23.3%, which is within range of typical response rates for survey studies. No positive response was received from any of the landfills that were contacted. A recent study indicated that 2 million cubic yards were disposed in landfills each year (Sherrill and MacFarlane 2007). However, all landfill employees contacted by phone indicated that they did not have any quantifiable amount of activities related to wood and declined to be included into the response to this survey. However, it is well known that many landfills use large quantities of wood as landfill cover, even though it is illegal under Michigan law to dispose of wood in landfills.

Estimation procedure

Companies were classified into types based on their size, equipment and processing capacity, and the number of employees. Companies responding to the survey that own any three combinations of large equipments including chipper, stump grinder, chip van, and truck with dump bed, and also had at least 10 full time employees were considered large processing facilities. All other respondents were classified as small processing facilities. Data collected from respondents was extrapolated to determine first, the quantities of wood waste entering yards, and second, the types and volumes of products processed from these yards. This extrapolation was conducted through a method previously used by Adelman et al. (1999) and Alderman et al. (2000)) summarized as follows:

1. The reported quantities (volumes, number, types) for each product (e.g., logs, brush, chips, bark, and sawdust) was divided by the reported number of employees of each respondent sample frame to calculate wood residues production per employee for each product type, as related to their equipment and processing facilities.
2. The average (mean) production per employee for each product type was multiplied by the determined total industry wide employment to generate an estimate of the total production.
3. Board footage, square footage, linear footage, tonnage production and consumption estimates, for each company were made by the same method.
4. By repeating these calculations for each sample frame and adding up, we were able to develop estimates for the entire region.

Yard visits

Field studies of seven yards were conducted to generate information to confirm resource flow patterns developed from the mail-in survey, quantify inputs and yields, and identify potential alternatives and bottlenecks. The initial study plan was to focus these studies to two specific yards. However, due to unforeseeable circumstances that delayed the beginning of the study, one of the two yards was out of business before the scheduled field visit. As consequence, an adjustment to the initial protocol was made and field visit extended to seven yards. These companies were selected based on their reported production patterns to cover the range of products generated from disposal yards.

During these visits, through a guided discussion with the owner or manager (see questions used in appendix 3), technical information including, the yard size, total number of employees, major equipments, type of wood products/residues accepted, and products produced recorded. This data was used for cross validation of the mail in survey data. No large disparity was observed between the face to face interviews data and mail in survey responses. Averages derived from the study were presented to yard owners and trends observed discussed and validated. Extended discussions were also conducted to assess their strategic vision for the future of wood wastes processing in Southeastern Michigan.

Characterization of wood waste processing facilities

The 180 yards identified and included in this study collectively provided 1082 full time employments. The average number of employees for a large yard was 7.5 employees, while a small yard typically employed only 4.8 employees (Table 2). About 78.5% of the large yards reported having their own field crews for logging and harvesting operations, while only 31% of smaller yards had their own field crews.

Table 2: Employment statistics

Characteristics	Large yard	Small yard	Total
Average number of employees per yard	7.5	4.8	
Estimated total number of employees all yards	440.0	582.0	1,082.0
% of businesses with own field crews	78.5%	31.0%	

The data clearly indicates that larger yards were more likely to have their own field crews, providing them with a more reliable resource of raw materials compared to smaller yards which depended more on drop-offs from other tree care companies.

The equipment ownership data for large and small yards are presented in Table 3. The most common equipment available in larger yards included chainsaws (100% response), log splitters (78.6%), trucks with dump bed (78.6%), whole tree chippers (64.3%), hand chipper (64.3%), stump grinders (57.1%), and forklifts (50%).

Table 3: Equipment ownership among wood disposal yards (according to yard size)

Equipment	Large	Small	Equipment	Large	Small
Aerial lift	0.00%	3.40%	Kiln/air-dry area	7.10%	3.40%
Backhoe	14.30%	10.30%	Loader	14.30%	13.80%
Band mill	7.10%	10.30%	Log splitter	78.60%	31.00%
Bulldozer	35.70%	6.90%	Portable mill	7.10%	10.30%
Chainsaws	100%	48.30%	PTO chipper	14.30%	3.40%
Chip van	42.90%	6.90%	Pup-dump	14.30%	0.00%
Chipper with chip box	42.90%	6.90%	Screener	0.00%	3.40%
Circular mill	7.10%	3.40%	Skidder	11.80%	0.00%
Coloring unit	0.00%	3.40%	Slabsaw	7.10%	0.00%
Denailer	0.00%	3.40%	Stump grinder	57.10%	17.20%
Edger	7.10%	3.40%	Stump grinder	7.10%	0.00%
Excavator	7.10%	0.00%	Truck scales	7.10%	0.00%
Fork lift	50.00%	24.10%	Truck with dump bed	78.60%	48.30%
Forwarder processor	0.00%	3.40%	Tub grinder	21.40%	0.00%
Hand chipper	64.30%	20.70%	Whole tree chipper	64.30%	0.00%
Horizontal grinder	7.10%	3.40%	Wood working equipment	14.30%	27.60%

Smaller yards were much less likely to own much wood processing equipment. The most commonly available equipment included chainsaws (48.3%), trucks with dump beds (48.3%), log splitters (31.0%), and wood working equipment (27.6%). The specific types of equipment often owned at small yards clearly indicate their tendency to be independent by maintaining the ability to deliver processed products (by having a truck with dump bed), producing other products such as firewood (with commonly owned log splitters) or creating solid wood products (using wood working equipment).

Raw material sourcing and supply

About two-thirds of the businesses surveyed (65.1%) reported using wood supplies originating from tree removals. The second most prominent wood sources came from land clearing (44.2%), followed by pallets and crates (16.3%) and mill wastes (11.6%)

Table 4: Characteristics of wood waste processing facilities in southeastern Michigan

	Waste types	% of business using this supply
Supply	Land clearing	44.2%
	Pallets/crates	16.3%
	Mill waste	11.6%
	Tree removals	65.1%

All companies interviewed reported being affected by the national economic conditions and the declines in new housing development (which result in declines in land clearing activities). As result, wood waste processing facilities have had to rely more on other tree removals for their supply of raw material.

A limited number of yards (12.2%) reported charging a tipping fee to accept wood wastes in their yards (Table 5). Companies with organized procedures for screening material arriving at their yards and charging fees seemed to be large well established facilities. The average tipping fee charged was $14 per cubic foot for logs, $18.67 for stumps, $11 for brush and branches, and $12.50 for pallets and scrap wood. The average price charged is affected by the difficulty in processing the material and by potential for converting the wood waste into useful salable products. Raw materials that are very difficult to process with low potential for salable products (such as stumps) are generally charged the highest fees, and material (such as brush and branches) that are easy to move around and process are charged the lowest fees. Logs were charged a medium fee because although they are generally converted into high-value products, the amount of energy needed for the conversion is also higher than other materials such as branches and pallets.

Table 5: Average tipping fee charged by wood waste yards (per cubic yard)

% of businesses that charge a tipping fee for any material		Logs	Stumps	Brush and branches	Pallets and scrap wood
12.2	**Average**	$14.00	$18.67	$11.00	$12.50
	Min	$10.00	$13.00	$10.00	$10.00
	Max	$18.00	$25.00	$13.00	$15.00

Few yards (17.1%) reported regularly buying raw material for their processing facilities (Table 6). The three types of products purchased include logs (at the average price of $3.32/cu ft), sawdust (at $0.30/cu ft), and shredded bark at ($0.72/ cu ft).

Table 6: Average price paid by wood waste yards for wood supply (per cubic foot)

% of businesses that buy materials		Average paid for logs per cu ft	Average paid for sawdust per cu ft	Average paid for shredded bark per cu ft
17.1	**Mean**	$3.32	$0.30	$0.72
	Min	$3.00	$0.15	$0.55
	Max	$3.64	$0.40	$0.90

Yards willing to pay for raw material supply generally relied significantly more on tree removals for their supplies and had to provide financial incentives for tree service companies to travel extra miles to dump selected wood materials in their yards.

The estimate of the total materials going into wood waste processing facilities is summarized in Table 7. Wood chips, logs, branches and brush, mulch and stumps were the main categories from land clearing and tree removals.

Table 7: Source of supply of wood waste yards in southeastern Michigan

	Types	*Small*	*Large*	*Total*	*Total from source*	*Percentage of total supply*
Land clearing	Wood chips	2,323,346	25,832,749	28,156,095	**143,139,730**	**60.86%**
	Logs	155,382	67,357,723	67,513,105		
	Branches and brushes	1,908	39,868,241	39,870,149		
	Mulch	Nd	7,530,465	7,530,465		
	Stump	Nd	69,916	69,916		
	Source total	**2,480,636**	**140,659,094**	**143,139,730**		
Pallets	Scrap pallets	Nd	408,420	408,420	**498,333**	**0.21%**
	Wood chips from pallets	Nd	89,913	89,913		
	Source total	**0**	**498,333**	**498,333**		
Sawmill residues	Mixed	Nd	12,960,149	12,960,149	**12,960,149**	**5.51%**
Tree removals	Wood chips	2,375,271	36,579,861	38,955,132	**78,582,152**	**33.41%**
	Logs	249,291	3,801,489	4,050,781		
	Branches and brushes	2,726,578	32,204,589	4,931,168		
	Mulch	Nd	481,933	481,933		
	Stump	Nd	163,138	163,138		
	Source total	**5,351,140**	**73,231,010**	**48,582,152**		
	Total wood supply	**7,831,776**	**227,348,586**	**235,180,362**	**235,180,362**	

The total volume of wood material entering processing facilities in southeastern Michigan was 235 million cu ft (5.3 million tons) coming from four primary sources: land clearing (143 million cu ft), tree removals (78.5 million cu ft), sawmill residues (12.9 million cu ft), and pallet materials (0.49 million cu ft). The comparison of the relative size of supply sources indicate that land clearing remains the major source of material for wood waste processing facilities, accounting for 60.86% of their total supply, followed by tree removals that contribute 33.41% of the total supply. Small residues account for 5.51% and pallet materials account for less than a quarter of a percent.

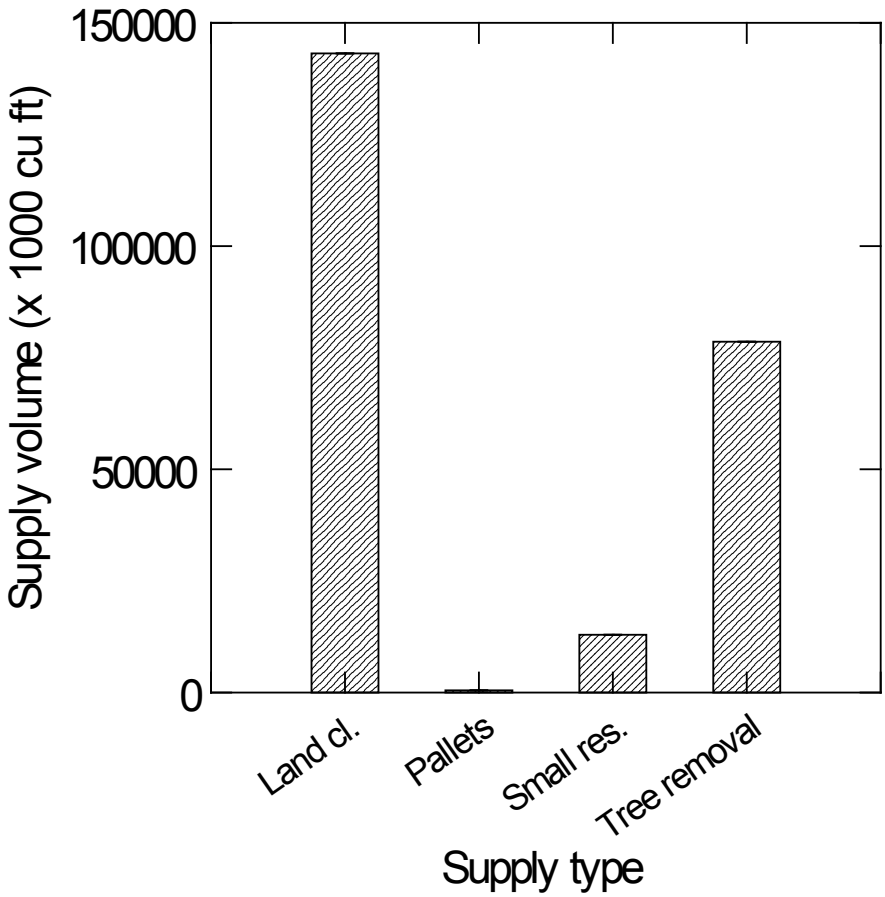

Figure 1: Wood waste supply in processing facilities in southeastern Michigan

Land clearing

A look into each of these major sources indicates that logs from land clearing (contributing 67.5 million cu ft) were the main form of material from this source used by wood waste processing facilities. Other major forms included branches and brush (39.8 million cu ft) and wood chips (28.1 million cu ft). Mulch contributed only 7.5 million cu ft and supplies delivered as stumps were negligible.

Analysis of land clearing sources (Figure 2) show that logs contributed a large proportion of wood supply from land clearing, contributing about 47% of the total supply for land clearing source. This is followed by banches and brushes, and wood chips that combine to make up about 47% of the land clearing source (Figure 2). Material from tree removals were essentially made up of wood chips and branches and brushes. For both supply sources,almost all of the material (99.8%) was collected in larger yards with only negligible amounts reported by smaller yards.

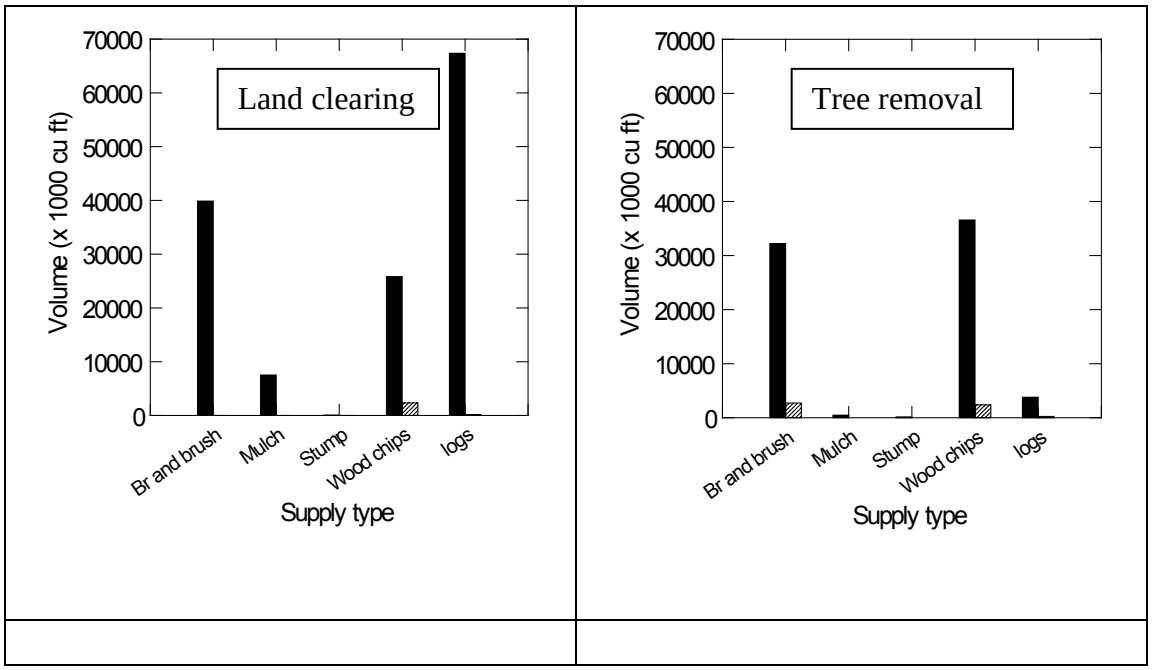

Figure 2: Breakdown of the raw material forms from land clearing and tree removal sources to wood waste processing facilities in southeastern Michigan. Black shaded bars are large yards and stripes are smaller facilities.

Tree removals

The other major source of wood supplies came from tree removals by tree service companies. The bulk of the supply from this source was delivered in the form of wood chips (38.9 million cu ft), followed by branches and brush (4.9 million cu ft), and logs (4 million cu ft).

Wood chips were the most important type of material supplied from tree removals contributing 49% of the total supplies from that source (Figure 2). Branches and brush were also very important, contributing about 44% of the total supply. Just 5% of the wood supply from tree removals was delivered to wood yards as logs. This is certainly a result of the limited ability of tree removal companies to handle logs as conseqence of their lack of heavy lifting and trucking equipment.

An additional 2.9 million cu ft of material classified as sawmill residues was also supplied to wood waste processing facilities. The bulk of this material was generated from hardwood sawmills located in southern Michigan. These residues were made up of chips, sawdust, and bark material. Much of this material was purchased, as more than 17% of the respondents reported buying and using sawmill residues as part of their supply. The average price paid was $0.30 per cu ft for sawdust, and $0.72 per cu ft for shredded bark. Processing facilities paid an average of $3.32 per cu ft when mill residues were supplied as logs. The higher price paid is due to the high return potential for logs compared to sawdust and shredded bark.

Pallets

While much less than the land clearing, tree removal, and sawmill resiudes sources, pallets do still contribute a significant amount of the wood waste channeled to processing facilities in southeastern Michigan. Most pallets manufactured in eastern United States are made with hardwoods, and over 500 million wood pallets are manufactured annually. Of these, more than 200 million are intended for one time use. The data from the current study indicate that pallets contributed 0.48 million cu ft to the total wood supply to processing facilities in southern Michigan. This volume corresponds to about 5.2 million pallets (1 pallet = 60 lbs, 1 ton = 44 cu ft) for the region, coming mainly from scrap pallets and chipped pallets from industrial wastes. The regional pallet volume corresponds to about 1% of the nationwide pallet production.

General trends

When looking at all wood sources, most logs entering the processing facilities are shipped to yards cut into small, easy-to-handle sizes. The survey results indicated that only 5% of the total volume of logs received (0.08 million tons) arrived in “millable” condition, that is, of timber quality with logs at least ten inches in diameter and at least eight feet long.

A large number of wood waste processing facilities (85%) reported a change in the volume of solid wood collected during the past few years, seeing a 75 to 85% decrease in wood supplies since 2001. The bulk of the decrease is reported to have occurred between 2005 and 2007, when facilities observed about a 50% drop in wood supply. The decrease was generally attributed to drops in land clearing activities for new construction caused by the slowdown in new housing development. Facilities reported receiving more industrial pallets and crates, and most of their woody debris as brush. Two other factors were identified as deterrents for the disposal of wood wastes to various yards in southern Michigan. These include the increase in imports of cheap wood composite pallets from various overseas sources and the creation of subsidized free disposal yards by the EAB eradication programs.

Production

Wood waste processing facilities were involved in the production of a number of wood products listed in Table 8. The most commonly produced commodities include wood

chips (generated by 51.2% of the facilities), firewood (48.8%), mulches (23.3%), lumber (23.4%), and sawlogs (13.9%). Other products of less significance were compost, pallets, finished wood products, industrial fuels, top soil, and playground material.

Table 8: Products generated by processing facilities in southeastern Michigan

	Product types	% of businesses
Products	**Woodchips**	51.1
	Firewood	48.8
	Mulch	23.2
	Lumber	23.2
	Sawlogs	13.9
	Compost	9.3
	Pallets	6.9
	Finished wood products	6.9
	Industrial Fuel	2.3
	topsoil	2.3
	Playground surfacing	2.3

All yards surveyed produced a combination of the products listed in Table 8. Larger yards generally combined wood chips, mulches, industrial fuels, and composts. Some also sorted good logs and marketed them as sawlogs. Some of the smaller yards also produced lumber and firewood.

The total production was 71.9 million cu ft (1.6 million tons), essentially made up of mulches (30.2 million cu ft or 42% of the total production), and woodchips (27.7 million cu ft or 38.6% of the total production) (Table 9).

Table 9: Estimated total production from wood waste yards (cu ft)

Type	Large	Small	Total	Percentage of total production
Mulch	24,183,767	6,013,906	30,197,674	**42.0%**
Woodchips	25,967,930	1,822,568	27,790,498	**38.7%**
Firewood	3,002,058	1,808,149	4,810,207	**6.7%**
Industrial Fuel	4,687,483	ND	4,687,483	**6.5%**
Logs	2,494,882	ND	2,494,882	**3.5%**
Compost	ND	1,309,051	1,309,051	**1.8%**
Sawn products	326,366	94,325	420,691	**0.6%**
PC&S	ND	183,402	183,402	**0.3%**
Total production	**60,662,487**	**11,231,402**	**71,893,889**	
Percentage	**84.38%**	**15.62%**		

Woodchips and mulches combined to represent 80.6% of the total production from yard processing facilities. Other products generated included firewood (4.8 million cu ft), industrial fuels (4.6 million cu ft), logs (2.5 million cu ft), and compost (1.3 million cu ft).

The breakdown by processing facility size indicates that about 84% of the total production comes from larger yards, while just 16% is produced in smaller yards (Figure 4). The larger production of larger yards correlates very well with the relative proportion of the total supply going into these yards. The data presented in Table 7 indicate that more than 95% of the wood wastes going into yards went into yards considered as large in this survey.

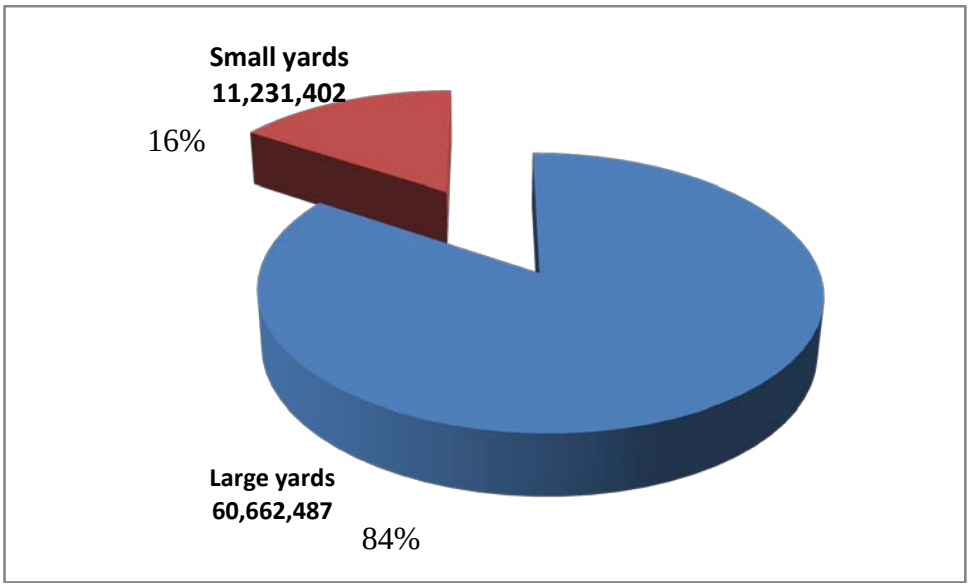

Figure 4**:** Total production from wood waste processing facilities in southeastern Michigan (in cu ft, by yard type)

The breakdown of the total production by yard size shows that the bulk of the wood chips and mulch production came from larger yards (Table 9). Most of the industrial fuels, and logs were also marketed from larger yards. The total production of firewood was more evenly distributed between larger and smaller yards (Table 9). The data also clearly indicated that the production from wood wastes processing facilities is predominantly geared towards landscape materials with mulch and wood chips accounting for 81% of the total production (Figure 5). Firewood and industrial fuels combine for 13% and logs represent only 3% of the total production.

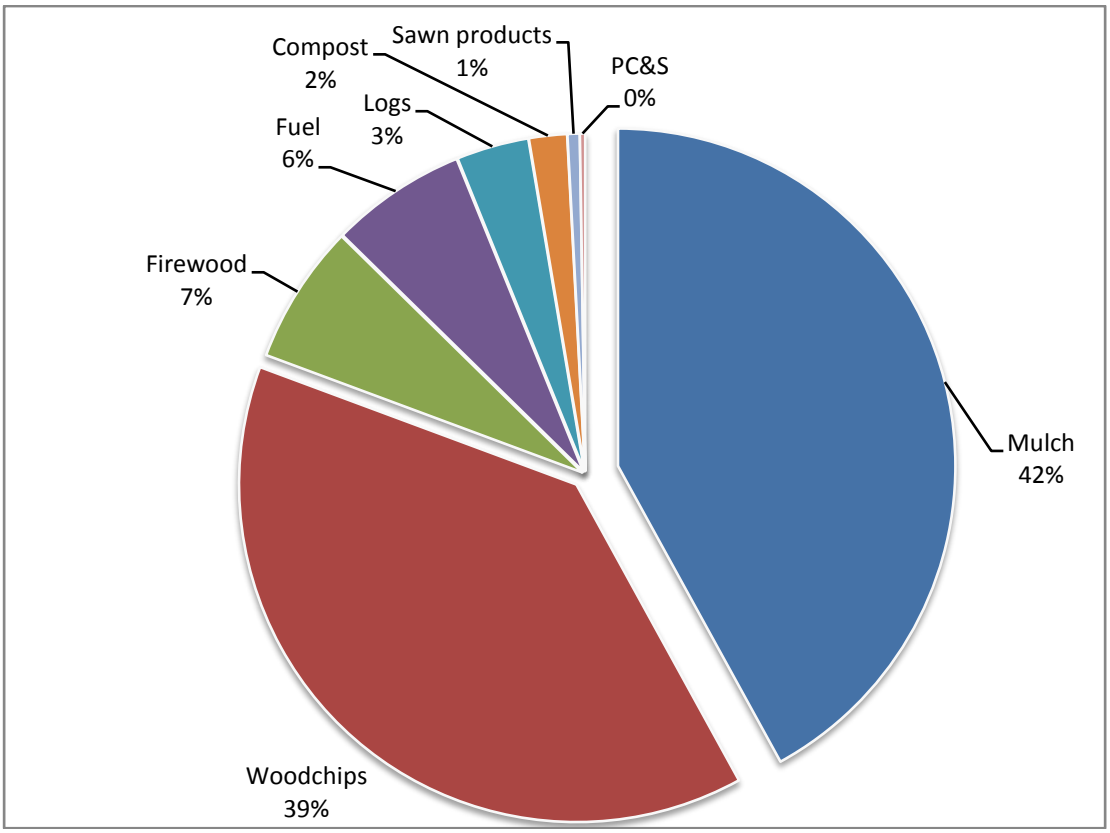

Figure 5: Breakdown of production from wood waste processing facilities in southeastern Michigan

Reported selling price varied with the product type and the level of processing (Table 10). Mulch prices varied from $12 to $16 per cubic yard for hardwood mulch, $20-26 per cubic yard for cedar mulch, and $20-24 per cubic yard for colored mulch. Compost prices range from $10.5 to $15 per cubic yard. Wood chips were $2.5-4.0 per cubic yard, and firewood was reported to be sold between $45 and $75 per cord.

Table 10: Price ranges for various products from wood waste processing facilities in Southeastern Michigan

Product	Price range ($/cu yard)*
Harwood mulch	12.00 - 16.00 ($/cu yard)*
Dyed mulch	20.00 - 24.00 ($/cu yard)
Cedar mulch	20.00 - 26.00 ($/cu yard)
Compost	10.50 – 15.00 ($/cu yard)
Wood chips	2.50 – 4.00 ($/cu yard)
Firewood	45.00 – 75.00 ($/cord)**

* one cu yard = 27 cu ft ** one cord = 128 cu ft

Yard visits

Data collected from the various yards included in the field studies were generally in agreement with survey information. The general production and marketing scheme of most yards visited was largely skewed towards wood chips and mulches with only very limited potential for solid wood products. Owners interviewed indicated several reasons for low production and marketing of solid wood products, including the cutting down of logs into short unusable length during land clearing operations, the lack of interest from large owners to embark in primary processing, transportation issues, and the high cost for improving log processing in the field. However all owners visited are considering high value added markets for yard products, and three major product types mentioned are: the production pellets, exports of mulch and chips to value added markets in larger metropolitan areas and Canada, and production of fuel for home stoves. Some of the large owners also vehemently complained about the Emerald Ash Borer eradication program as responsible for the decline in the market.

Discussion and evaluation of economic impact and potential alternative products

The supply and production data shown in the sections above clearly indicate that wood waste processing facilities have a very important economic impact, creating more than 1,000 permanent jobs in the region, while also processing and marketing significant volumes of material necessary for southeast Michigan landscapes and energy plants. Based on product levels and average selling prices for the various products, the industry contributes about $40 million into the local economy. However, for a better understanding of the full potential of wood waste processing facilities, a detailed evaluation of the industry is necessary.

Wood wastes supplied to processing facilities traditionally come from land clearing, tree removals, pallets, crates, and sawmill residues with the largest proportion coming from the first two sources listed. Consequently, these woods are harvested in conditions where land has been cleared for other purposes (land clearing) or in situations where trees are removed from the landscape because of reasons other than their use as wood product. Consequently trees are not pre-inspected or evaluated for their wood product potential before they are harvested and processed. Furthermore, tree removal companies that usually perform harvesting and processing operations in the field have no direct interest, incentive, or equipment to process and handle large logs in the field. As a result, logs are usually cut down into small pieces for ease in their handling, thereby limiting the amount of intact wood available for the highest-value products. Another difficulty in maximizing value-added potential arises from the uncertainty about the quantities and species any wood waste processing facility can expect to receive in any given period. These factors pose serious supply challenges to any yard wishing to specialize in the production of any high-end wood product.

As a practical measure, processing facilities try as best as they can to separate the material coming into yards. The most desirable option for high-value utilization of wood

waste is the reuse of wood as a building material or interior wood products. However, several barriers exist. Very little lumber-quality wood is available for reuse due to the fact that logs are processed into short pieces during harvesting operations. The total volume of timber quality logs coming into yards is currently too low (less than 5%) to justify any serious effort to develop solid wood products. It is conceivable that wood obtained from trees from woodlots cleared for construction and wood waste from arborists or salvage operations can be milled and used for such items as furniture, trim work, cabinetry, or flooring rather than cut into short logs and disposed for low-end uses. However, appropriate infrastructure, training, equipment, and markets will be necessary to change the current situation.

Based on our observations, it is possible to increase the relative proportion of quality logs going into yards from 5% to 30%. This will raise the total volume of good quality logs from 0.08 million tons to 0.48 million tons or 21 million cubic feet. Consequently, significant changes in the quality of products coming into yard will follow, potentially increasing the interest of yard owners and managers in new alternative products. Despite the current outlook, several processing facilities are looking to take advantage of the new market conditions by developing higher-value end products. The most commonly mentioned product was wood pellets for both the domestic market (fuel for home use) and for the export market to Canada.

Another option for reuse would be to divert high quality material towards the creation of engineered wood from the wood waste. Engineered wood is the term given to material derived from smaller pieces of wood that are bound together through a variety of glues, resins, and other chemicals to make a wood-like product. Engineered woods that can be considered in this situation include particleboard, OSB, and wood plastics composites. The technical process of manufacturing these composites with wood waste material from yards is certainly feasible if clean and premium materials are used. However, it would be helpful to evaluate success of manufacturing various types of wood composites using combinations of high and low quality material (wood, bark and species combinations) to study the possibility of recycling just lower value material from yards. In addition to the technical study, a cost benefit analysis would have to be conducted to fully assess the economic potential of using yard wastes for wood composite products.

With the growing international emphasis on bioeconomy, a potential market for wood waste is the conversion of wood chips to ethyl alcohol (ethanol) through conventional fermentation technologies. This can be done chemically, using acid hydrolysis or biochemically using enzymes. The resulting product must be purified and the alcohol distilled to concentrate it enough for use as a fuel. Biomass feedstock can also be used to produce biofuels. Thermal processes can also be used to convert the biomass directly to a synthesis gas (syngas) composed of carbon monoxide and hydrogen. Syngas can then be cleaned and used in commercial units to produce methanol. However, it is clear that wastes from processing yards would have to be combined with wood from other sources to supply this market. Therefore, clear standards about the properties and conditions of the raw material would need to be developed to maintain the efficiency of these biochemical processes.

Conclusion

The goal of this study was to assess the situation of wood waste resources in southeastern Michigan and to evaluate the potential for a better use of wood waste resources. The study identified a total of 180 wood wastes yards and 23 landfills operating in southern Michigan (16 counties). These yards employ an estimated 1,082 employees. Wood waste processing facilities in Michigan are usually small, family-owned businesses, employing an average of six employees per company. Most companies have been in operation for several years and have expanded as new markets developed.

The wood wastes supplied to processing facilities came from four major sources including land clearing (60%), tree removals (33.4 %), sawmill residues (5.5%) and waste pallets (0.2%). About 12% of the processing sites charge tipping fees, ranging from $10 to $25 per ton depending on the type of material. Some yards also paid for certain types of wood supplies including logs ($3.32/cu ft), hardwood sawdust ($0.30/cu ft) and shredded bark ($0.72/cu ft). The total volume of wood waste supply going into yards in southeastern Michigan was evaluated at 235 millions cu ft, corresponding to 5.3 million tons for the entire region.

The total production from yards was 71.9 million cu ft, corresponding to 1.6 million tons. This corresponds to a conversion rate of about 30%. The low conversion rate is due to a combination of factors, including the composition of raw material coming into processing facilities, inappropriate or poor sorting procedures for incoming materials at entry point or throughout the yard, and low yield production practices. Major products generated include woodchips (38.6%), mulches (42%), wood for industrial fuel (6.5%), and firewood (6.7%). Other products include compost, logs, and sawn products. The survey showed that the bulk of this production (84%) came from large yards. However, the study also showed that smaller facilities (16% of the production) were more flexible and more likely to produce a more diverse product line.

Technical analyses conducted in the field coupled with survey responses indicated that less than 5% of the total volume of logs entering yards was of timber quality. The main bottleneck for the quality of log materials coming into yards results from the methods used by tree service companies in the field. Analysis conducted indicated that with proper equipment and training, the proportion of quality logs coming into wood waste processing facilities can be increased to 30% creating a large enough supply to justify a strategic shift towards value-added solid wood products. The data also show a very low conversion rate for products entering processing facilities, partly due to the lack of an efficient sorting and characterization of wood waste materials arriving at processing facilities for best potential utilization. Processing facilities could create a sorting mechanism at their gate that will determine the potential endues for each load coming into the yard. Sawdust, sanderdust, and fines could be directed to production of products such as pellets for fuel, or industrial fuels. Bark, chips and other mixed residues could be processed for landscape products, while larger wood residues and logs are directed

towards the production of solid wood products such as trims, garden stakes, fence pickets, flower boxes, and flooring. Other value-added options include using some of the woody biomass for wood composites manufacturing, and using biomass as feedstock for the production of ethanol or syngas. It will obviously be very difficult for any single wood waste processing facility to integrate all these potential product lines into their unit. However, high level of wood waste utilization efficiency and yield can be achieved through the establishment of partnerships within the industry and with other potential partners. Such relationships will help identify and develop potential markets for value added products, and facilitate the transportation, storage, and marketing of value added products. Achieving greater value added utilization for wood wastes demands a realistic approach that combines market conditions, assembling all technological resources available, and educating stakeholders about the environmental and economical advantages of increasing the competiveness of processing facilities operating in southeastern Michigan.

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Appendixes

Appendix 1

Questions for MSUE Country Extension Directors

Questions about Disposal yards and contact info

1. Are there any wood disposal yards in our county (any yards that accept and process unused mill waste and/or lumber otherwise destined for landfills i.e. from land clearing, urban tree removal, fuel reduction, habitat improvements, salvage or precommercial thinning operations)?

2. What is the name and address of each of these yards?

3. Can you provide contact info for the individual(s) responsible for the operation of these yards?

4. Can you give me a little background info on these yards (i.e. public or private? subsidized? When was it started? Was it originally subsidized through MDA emergency grants?)

General questions to help design the surveys

5. Do any of these yards produce high end (or value added) products as opposed to chips or dust for feedstock, fuel, lawn care animal bedding etc...

    a. If so do all of these yards charge a tipping fee? Do any of them rely solely on selling product for income

    b. If not do all of these yards charge a tipping fee? Do any of them rely solely on selling product for income

    c. Do these high end products sell well? Is there a market specifically for them?

6. Do the yards typically use all of the wood entirely or is their often a significant amount of waste from them (i.e. processing residue or unacceptable wood).

7. Are these yards customers primarily local governments (state, city etc..) and industries? Do NIPFs constitute a significant portion?

8. Do you know how well records of transactions are kept at these facilities?
    a. Are species and/or wood type known and recorded?

9. You have worked with these companies for much longer than I have, Is there any advice you can give me?

Appendix 2: Survey questionnaire for the study

Wood Waste Processing and Utilization in Southeastern Michigan

Please answer the following questions as accurately as you can. All of the information you provide will be kept strictly confidential.

General questions about this business

1. What county is your business located in? _____

2. How many full time employees does your business employ? _____

3. How many part time employees does your business employ? _____

4. What equipment does your business own? (in the space provided before each of the following equipment types please enter the number of that type owned)

_____ Chainsaw	_____ Band sawmill	_____ Circular sawmill
_____ Portable sawmill	_____ Whole tree chipper	_____ Hand fed chipper
_____ PTO chipper	_____ Chipper /w chip box	_____ Stump Grinder
_____ Tub grinder	_____ Horizontal Grinder	_____ Coloring unit
_____ Log splitter	_____ Box truck	_____ Truck /w dump bed
_____ Pup-dump	_____ Forklift	_____ Bulldozer
_____ Backhoe	_____ Truck Scales	

_____ Other, please specify _____

5. Does your business routinely rent any of the equipment mentioned in question 4 or pay another company for the services of the equipment.

Yes / No

6. What structures does your business own? (in the space provided before each of the following structure types please enter the number of that type owned)

_____ Yard	_____ Shed	_____ Office building	_____ Office
_____ Warehouse		_____ Retail Store	_____ Workshop

_____ Other, please specify _____

7. What structures does your business rent? (in the space provided before each of the following structure types please enter the number of that type rented)

_____ Yard	_____ Shed	_____ Office building	_____ Office
_____ Warehouse		_____ Retail Store	_____ Workshop

_____ Other, please specify _____

Questions about your business' wood utilization

This business was chosen for this survey because it utilizes certain types of wood, the following questions are designed to characterize the amount of each of these wood types that are used, how this business processes this wood and what products are produced from it. For the purposes of this study, the term "utilizing" wood includes selling or giving away wood that will be used by the receiver as a product or to make a product; this includes the state certified marshalling yards. The term "disposing" of wood only applies to providing a final resting place for wood that will never be used (i.e. landfills).

8. Does your business utilize wood from any of the following sources? (check all that apply)

   A. ____ Land clearing
   B. ____ Reclaimed lumber
   C. ____ Pallets, Boxes, Skids and/or Dunnage
   D. ____ Sawmill waste (cuttings, chips, sawdust, side rippings etc…)
   E. ____ Tree removals (tree services)
   F. ____ City tree removals (municipal foresters)

9. Does your business dispose of wood from any of the sources mentioned in question 8 on its property?

   Yes / No

10. Does your business harvest any trees itself? Yes / No

11. a. Does your business accept any of these wood types from other businesses or individuals?

    Yes / No

    b. If so, how much of these wood types do you receive from other businesses, as a percentage of the total amount of these wood types that your business utilizes?

    ____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
    ____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

    c. Does your business charge a fee to accept this wood? Yes / No

    d. Does your business pay to get these wood types? Yes / No

12. What products does your business produce from this wood? (check those that apply)

A. ____ Firewood
B. ____ Woodchips/Mulch
C. ____ Lumber
D. ____ Sawlogs
E. ____ Finished products (cabinetry, flooring, etc….)
F. ____ Pallets, Boxes, Skids and/or Dunnage
G. ____ Compost
H. ____ Other, please specify _____

13. a. Does your business measure the amount of unused wood waste that leaves it's property for disposal by the number of truckloads, by weight or by volume. (please circle all that apply)

Truckload / Weight / Volume

Other, please specify _____

Please fill out whichever of the following apply:

b. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business remove in 2005? _____

c. **Weight** Please estimate the weight, in US tons, of this wood your business removed in 2005. _____

d. **Volume** Please estimate the number of cubic yards of this wood that your business removed in 2005. _____

e. **Other** Please estimate the amount of this wood that your business removed in 2005. _____

14. In what form does this unused wood leave your property? (check all that apply)

____ Woodchips ____ Sawdust ____ Cuttings/Side rippings ____ Logs
____ Miscellaneous tree parts ____ Damaged wood parts or products
____ Other, please specify _____

15. About what percentage of this waste is produced as a basic function of your businesses operation (i.e. sawmill waste)?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

16. a. About what percentage of this waste is wood that was unusable when your business received it?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. What are the three most common reasons that this wood was unusable? (please check 3)

____ Chemical treatments ____ Contains foreign objects
____ Is a glued product such as plywood or fiberboard
____ Paint ____ Physical damage ____ Rot ____ Unusable species
____ Received more than could be used
____ Other. please specify _____

c. Of the three reasons you checked in question 16.b. which is the most common?

_____

d. About what percentage of the total unused wood was the due to the reason you specified in question 16.c..

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

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The following sections correspond to the different categories in question 8 and are labeled A through F in the same manner. You may skip the sections that do not apply to you.

A. Wood from land clearing

17. From what kinds of businesses does your business you receive this wood from?

    ____ Tree services ____ Construction contractors ____ City foresters

    ____ Other, please specify _____

18. In what form do you receive this wood? (check all that apply)

    ____ Wood chips ____ Logs ____ Firewood

    ____ Other, please specify _____

19. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

    Truckload / Weight / Face cords / Volume

    Other, please specify _____

    Please fill out whichever of the following apply:

    a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

    ____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
    ____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

    - How many truckloads of this wood did your business receive in 2005?

      _____

    b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

    c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

20. What are the three most common tree species that you receive from this source?

____Oak ____ Hard Maple ____ Soft Maple ____ Ash
____ Walnut ____ Aspen ____ Cottonwood ____ Willow
____ Black Locust ____ Spruce ____ Fir ____ Pine
____ Other Hardwood ____ Other Softwood (Conifer) ____ Exotics
____ ??I don't know??
____ Other, please specify _____

a. Of the three species that you marked above which is the most common?

_____

b. Approximately what percent of the wood you receive is this species?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

B. Reclaimed lumber

21. From what kinds of businesses does your business you receive this wood from?

____ Construction contractors ____ Landfills
____ Recycling centers ____ Demolition companies

____ Other, please specify _____

22. In what form do you receive this wood? (check all that apply)

____ Wood chips ____ Pallets, Boxes or Skids
____ Lumber/Lumber fragments

____ Other, please specify _____

23. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by board feet or by volume? (please circle all that apply)

Truckload / Weight / Board feet / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

  _____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Board Feet** Please estimate the number of board feet of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

C. Pallets, Boxes, Skids and/or Dunnage

24. From what kinds of businesses does your business you receive this wood from?

____ Shipping companies ____ Other companies

____ Other, please specify _____

25. In what form do you receive this wood? (check all that apply)

____ Wood chips ____ Pallets, Boxes or Skids

____ Other, please specify _____

26. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight or by number of individual units?

Truckloads / Weight / Units

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

  _____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Units**
- Please estimate the number of used pallets that your business received in 2005. _____
- Please estimate the number of used skids that your business received in 2005. _____
- Please estimate the number of used boxes that your business received in 2005. _____

d. **Other** Please estimate the amount of this wood that your business received in 2005. _____

D. Sawmill waste

27. From what kinds of businesses does your business you receive this wood from?

____ Sawmills
____ Other, please specify _____

28. a. What kinds of sawmill waste does your business use, sell or give away?

____ Chips ____ Sawdust ____ Cuttings ____ Side rippings

b. If you marked more than one of the categories in question 21.a. which one is the primary sawmill waste type?

_____

c. Approximately what percent of the wood you receive fits into the category you specified in question 21.b.?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

29. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight or by volume? (please circle all that apply)

Truckload / Weight / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

_____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Volume** Please estimate the number of cubic yards of this wood that your business received in 2005. _____

d. **Other** Please estimate the amount of this wood that your business received in 2005. _____

E. Tree removals

30. From what kinds of businesses does your business you receive this wood from?

____ Tree services ____ Construction contractors

____ Other, please specify _____

31. In what form do you receive this wood? (check all that apply)

____ Wood chips ____ Logs ____ Firewood

____ Other, please specify _____

32. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

Truckload / Weight / Face cords / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

_____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

33. What are the three most common tree species that you receive from this source?

____Oak ____ Hard Maple ____ Soft Maple ____ Ash
____ Walnut ____ Aspen ____ Cottonwood ____ Willow
____ Locust ____ Spruce ____ Fir ____ Pine
____ Other Hardwood ____ Other Softwood (Conifer) ____ Exotics
____ ??I don't know??
____ Other, please specify _____

a. Of the three species that you marked above which is the most common?

_____

b. Approximately what percent of the wood you receive is this species?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

F. City tree removals

34. In what form do you receive this wood? (check all that apply)

____ Wood chips ____ Logs ____ Firewood

____ Other, please specify _____

35. Does your business measure the amount of wood it receives from this source by the number of truckloads, by weight, by number of face cords or by volume? (please circle all that apply)

Truckload / Weight / Face cords / Volume

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold.

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005?

  _____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Face Cords** Please estimate the number of face cords of this wood that your business received in 2005. _____

d. **Volume** Please estimate the volume in cubic yards of this wood that your business received in 2005. _____

e. **Other** Please estimate the amount of this wood that your business received in 2005. _____

36. What are the three most common tree species that you receive from this source?

____Oak ____ Hard Maple ____ Soft Maple ____ Ash
____ Walnut ____ Aspen ____ Cottonwood ____ Willow
____ Locust ____ Spruce ____ Fir ____ Pine
____ Other Hardwood ____ Other Softwood (Conifer) ____ Exotics
____ ??I don't know??
____ Other, please specify _____

a. Of the three species that you marked above which is the most common?

_____

b. Approximately what percent of the wood you receive is this species?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

==========

If you answered yes to question 9 above please fill out this section.

Waste Disposal

37. Does your business measure the amount of clean wood it receives by the number of truckloads, or by weight? (please circle all that apply)

Truckload / Weight

Other, please specify _____

Please fill out whichever of the following apply:

a. **Truckload** Please estimate the average volume, in cubic yards, that the truck(s) that carry this wood hold

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100

- How many truckloads of this wood did your business receive in 2005? _____

b. **Weight** Please estimate the weight, in US tons, of this wood your business received in 2005. _____

c. **Other** Please estimate the amount of this wood that your business received in 2005. _____

38. From what types of sources do you receive this wood?

____ Demolition ____ Tree services ____ City foresters ____ Haulers

39. a. Is any of this wood reused, sold or given back to the public? Yes / No

b. If so, approximately what percent is reused, sold or given away?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

==========

The following sections correspond to the different categories in question 10 and are labeled A through H in the same manner. Please fill out those that apply to your business and skip those that do not.

A. Firewood

40. a. How many face cords of firewood made from this wood did you sell in 2005? (a face cord is a 4x8ft stack of 16 inch long fire wood and is one third of a cord)

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

b. How many face cords of firewood made from this wood did you give away in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

c. How many face cords of firewood made from this wood did you use personally in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

41. To whom do you sell or give away this firewood? (check all that apply)

____ Homeowners ____ Retailers
____ Other, please specify _____

42. a. Approximately what percent of this firewood goes to individual Homeowners?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of this firewood goes to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of this firewood goes to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

d. Approximately what percent of this firewood goes to personal use?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

B. Woodchips/Mulch

43. a. How many cubic yards of mulch made from this source did you sell in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

b. How many cubic yards of mulch made from this source did you give away in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

c. How many cubic yards of mulch made from this source did you or your business use personally in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

44. To whom do you sell or give this mulch? (check all that apply)

____ Homeowners ____ landscaping services ____ landscaping retailers

____ Other, please specify _____

45. a. Approximately what percent of this mulch goes to individual Homeowners?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of this mulch goes to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of this mulch goes to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

d. Approximately what percent of this mulch is used by you or your business?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

C. Lumber

46. a. How many board feet yards of lumber made from this source did you sell in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

b. How many board feet of lumber made from this source did you give away in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

c. How many board feet yards of lumber made from this source did you or your business use personally in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

47. To whom do you sell or give this product? (check all that apply)

____ Homeowners ____ lumber retailers
____ Wood product manufacturers
____ Other, please specify _____

48. a. Approximately what percent of this lumber goes to individual Homeowners?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of this lumber goes to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of this lumber goes to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

d. Approximately what percent of this lumber is used by you or your business?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

D. Sawlogs

49. What is the average diameter of the logs you sell or give to sawmills?

____ 10-<12in ____ 12-<14in ____ 14-<16in ____ 16-<18in
____ 18-<20in ____ 20-<22in ____ 22-<24in ____ >24in

50. a. How many sawlogs from this source did you sell in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

b. How many board sawlogs from this source did you give away in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

c. How many sawlogs from this source did you or your business use personally in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

E. Finished products

51. What finished products do you manufacture using this wood?

____ Flooring ____ Cabinetry ____ Furniture ____ Fencing
____ Doors ____ Trim/Molding ____ Arts & Crafts

____ Other, please specify_____

52. a. How many board feet from this source where used to manufacture products that were sold in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

b. How many board feet from this source where used to manufacture products that were given away in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

c. How many board feet from this source where used to manufacture products that were used personally or by your business in 2005?

____ 0-<5,000 ____ 5000-<10,000 ____ 10,000-<15,000
____ 15,000-<20,000 ____ 20,000-<25,000 ____ 25,000-<30,000
____ 30,000-<35,000 ____ 35,000-<40,000 ____ 40,000-<45,000
____ 45,000-<50,000 ____ 50,000-<55,000 ____ 55,000-<60,000
____ >60,000

53. To whom do you sell or give your products? (check all that apply)

____ Homeowners ____ Retail outlets
____ Other, please specify _____

54. a. Approximately what percent of your products go to individual consumers?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of your products go to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of your product goes to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

d. Approximately what percent of your products are used by you or your business?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

F. Pallets, Boxes, Skids and/or Dunnage

55. a. Please estimate how many pounds of these products made from this wood did you sell in 2005? (a face cord is a 4x8ft stack of 16 inch long fire wood and is one third of a cord)

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

b. Please estimate how many pounds of these products made from this wood did you give away in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

c. Please estimate how many pounds of these products made from this wood did you use personally in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ >250

56. To whom do you sell or give away these products? (check all that apply)

____ Shipping companies ____ Other businesses
____ Other, please specify _____

57. a. Approximately what percent of these products go to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of these products go to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of these products go elsewhere?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

G. Compost

58. On average, what volume of woodchips does your company use to produce one cubic yard of compost?

_____

59. a. How many cubic yards of compost made using this wood did you sell in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ 250-<300
____ 300-<350 ____ 350-<400 ____ 400-<450 ____ 450-<500
____ 500-<600 ____ 600-<700 ____ 700-<800 ____ >800

b. How many cubic yards of compost made using this wood did you give away in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ 250-<300
____ 300-<350 ____ 350-<400 ____ 400-<450 ____ 450-<500
____ 500-<600 ____ 600-<700 ____ 700-<800 ____ >800

c. How many cubic yards of compost made using this wood did you or your business use personally in 2005?

____ 0-<10 ____ 10-<20 ____ 20-<30 ____ 30-<40 ____ 40-<50
____ 50-<60 ____ 60-<70 ____ 70-<80 ____ 80-<90 ____ 90-<100
____ 100-<150 ____ 150-<200 ____ 200-<250 ____ 250-<300
____ 300-<350 ____ 350-<400 ____ 400-<450 ____ 450-<500
____ 500-<600 ____ 600-<700 ____ 700-<800 ____ >800

60. To whom do you sell or give this compost? (check all that apply)

____ Homeowners ____ landscaping services ____ landscaping retailers

____ Other, please specify _____

61. a. Approximately what percent of this compost goes to individual Homeowners?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%

____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of this compost goes to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of this compost is used by you or your business?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

H. Other

62. a. Approximately how many units from this wood were sold in 2005?

_____

b. Approximately how many units from this wood were given away in 2005?

_____

c. Approximately how many units from this wood were used personally or by your business in 2005?

_____

63. To whom do you sell or give your products? (check all that apply)

____ Homeowners ____ Retailers ____ Service businesses

____ Other, please specify _____

64. a. Approximately what percent of your product goes to individual consumers?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

b. Approximately what percent of your product goes to other businesses?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

c. Approximately what percent of your product goes to marshalling yards?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

d. Approximately what percent of this product is used by you or your business?

____ 0-10% ____ 11-20% ____ 21-30% ____ 31-40% ____ 41-50%
____ 51-60% ____ 61-70% ____ 71-80% ____ 81-90% ____ 91-100%

Appendix 3: Questions used during yard visits

1. What is the size of the yard? (sq ft, ac)

2. What is the total number of full time employees?

3. What is the total number of part time employees?

4. Do you own any equipment that is not in the yard at the moment?

5. About how much "waste" wood is processed by this yard every year?

6. What kinds of wood does this yard accept? (Ask about survey categories if they are not mentioned.)
   a. About what percent of you overall supply is represented by each of these categories?
   b. Our survey shows…. percent of supply from these categories. Do these numbers characterize your wood supply as well?

7. Has your wood supply pattern changed in the last few years? (if so) How?

8. How does the supply this year compare with the supply in 2005? 2006?

9. Is this change more or less the same across all wood supply types?

10. Did the introduction of tipping fees effect supply?
    a. If so by approximately how much?

11. What types of companies bring the various types of wood you accept?
    a. Are there any clear characteristics that these companies have in common? (such as company size)
    b. Did either the types of companies or there characteristics change with the end of subsidies/introduction of tipping fees?

12. From how far away do companies typically bring wood from?

13. How far do companies seem to be willing to travel?
    a. Do you think that they would be willing to travel further if there were no tipping fee? Did this distance change with the introduction of tipping fees?
    b. What is the furthest that a company has traveled?
    c. Where there extenuating circumstances involved?
    d. Does it seem to you that the companies are just looking for somewhere to get rid of or dump the wood? Do you need to do something to motivate them to use your yard?

14. What do you feel is the most significant deterrent to companies using your yard? (the fee, travel time or costs, the hassle, don't know about your company)

15. Do you feel that your yard and services are sufficiently well known? or: Is lack of knowledge about your services a problem?

16. Approximately what percent of the total wood supply do these categories represent?

17. Is there a large amount of seasonal variation in your wood supply?
    a. How much does wood supply increase/decrease in the winter?
    b. Is the standing supply today typical for this time of year?
    c. Is employment seasonal as well? What is employment at the peaks and throughout the season?

18. What tipping fees do you charge?
    a. our survey shows …. Does this seem reasonable to you?

19. What products do you sell? (Ask about categories from the survey if they are not mentioned.)
    a. Do you have a price list available? (if no) What is the average price charged for each of these products?
    b. About what percent of you overall sales are represented by each of these products?
    c. Our survey shows…. percent of supply from these categories. Do these numbers seem reasonable to you?
    d. What limits the amount sold of the most valuable product you sell? (Consumer demand, wood supply, wood supply quality etc…)
        I. (If value added products sold) what percent of logs received are converted to high value products.
        II. What limits this amount?

20. What types of consumers buy your products?
    a. (for businesses that sell value added products) why do you believe that consumers buy the products from you rather than conventional dealers?

21. For how long does wood typically stay in the yard from receiving to sale?

22. What do you think is the biggest obstacles to a more efficient waste wood utilization system?

23. Do you see any other problems in the business you are in that you would like to mention?

24. How have these supply changes affected your products?

AA. Woody Biomass Retrofit Opportunities in Michigan Boiler

FINAL REPORT

EXPLORING WOODY BIOMASS RETROFIT OPPORTUNITIES IN MICHIGAN BOILER OPERATIONS

9/28/2007

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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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Table of Contents

Executive Summary ..... *iv*

Section 1: Background Information. *1*
1.1 What is Biomass? *1*
1.2 Combined Heat/Power and District Heating & Cooling *1*
1.3 Recent Biomass Utilization Studies *2*
1.4 Key Characteristics of Successful Biomass Conversion Projects *13*
1.5 Total Project Costs, Projected Savings and Simple Payback Scenarios. *29*

Section 2: Analysis of Existing Boiler Database. *41*
2.1 Review of DLEG/DEQ Boiler Databases *41*
2.2 Facility Type *41*
2.3 Errors in Database *42*
2.4 Coal Boilers *43*
2.5 Cost Difference Between Existing Fuels and Wood Fuels *44*
2.6 Impact of Boiler Size on Simple Payback *44*
2.7 Sorting of Database by Boiler Size (btu output) *45*
2.8 Sorting of Database by Boiler Age *45*
2.9 Determining Payback *46*
2.10 Identify Best Indicators For Initial Conversion Feasibility. *49*
2.11 Results for Individual versus Multiple Boilers. *50*
2.12 Identifying Biomass Feedstock Sources and Processing Infrastructure. *50*
2.13 Natural Resources Wood Products Directory *59*
2.14 Inventory of Existing Wood Boilers *61*
2.15 Feedstock Availability and Simple Paybacks *61*
2.16 Impact of Non-Attainment Areas *61*
2.17 Spatial Representation of Priority Projects. *62*

Section 3: Tools for Identifying Potential Projects *63*
3.1 Web-Based Calculator *63*
3.2 Interpreting Your Results *67*
3.3 Educational Guides. *68*

Conclusion & Recommendations *76*

APPENDIX A……..*A1-A12*
APPENDIX B……..*B1-B102*
APPENDIX C……..*C1-C15*

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.

Example: Existing 1,000,000 btu boiler

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

Example: Existing 10,000,000 btu boiler

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.

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

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

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

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.

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

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.

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

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.

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

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.

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

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.

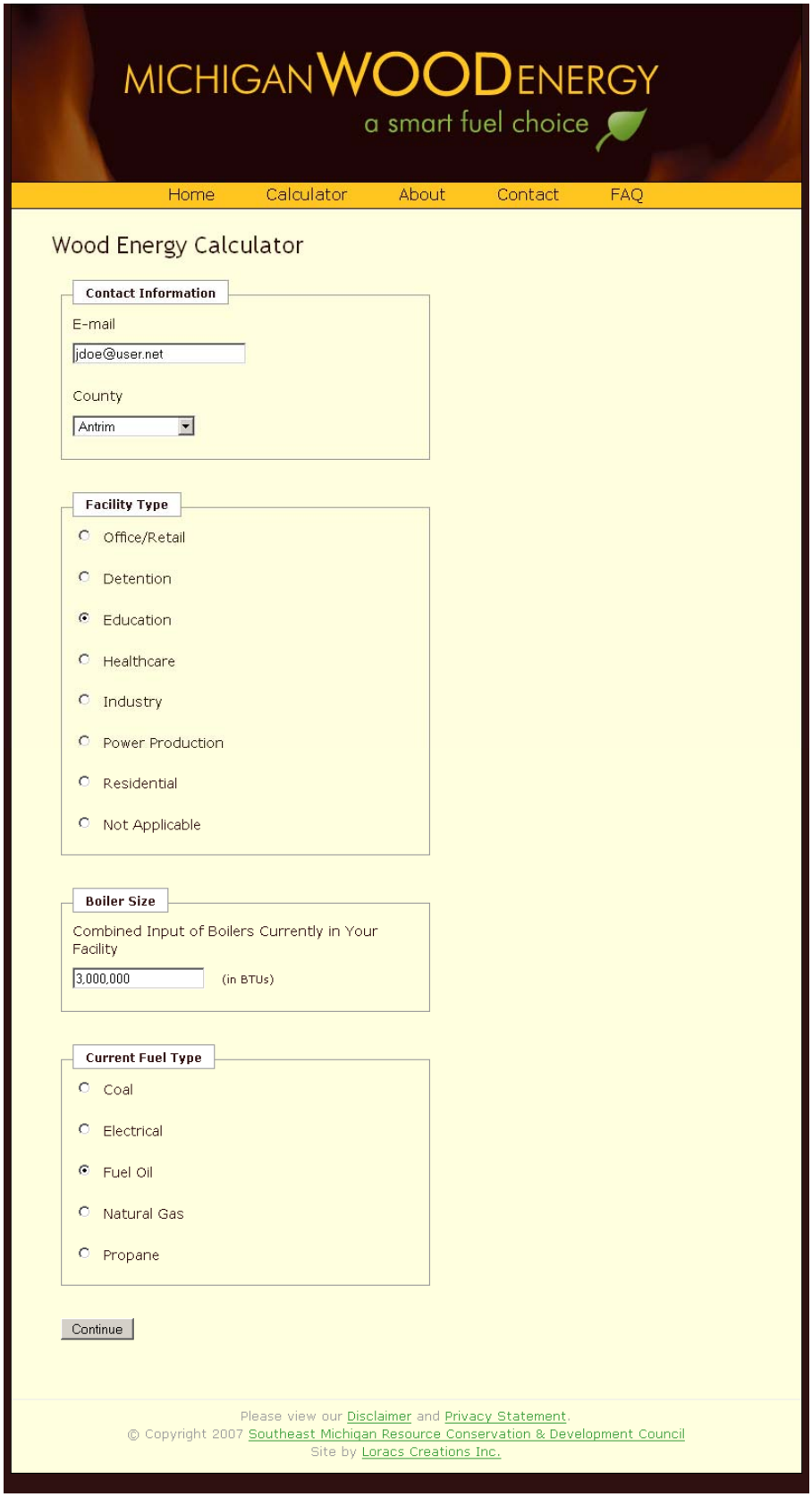
Although this information is not used to calculate fuel usage, it will allow the Southeast Michigan RC&D to determine what types of facility users are most interested in the website and allow the project team to refine the 10% Facility Utilization Factor used for the initial sorting of the database.

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


MICHIGAN WOOD ENERGY
a smart fuel choice
Home
Calculator
About
Contact
FAQ
Wood Energy Calculator
Contact Information
E-mail
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
Please view our Disclaimer and Privacy Statement.
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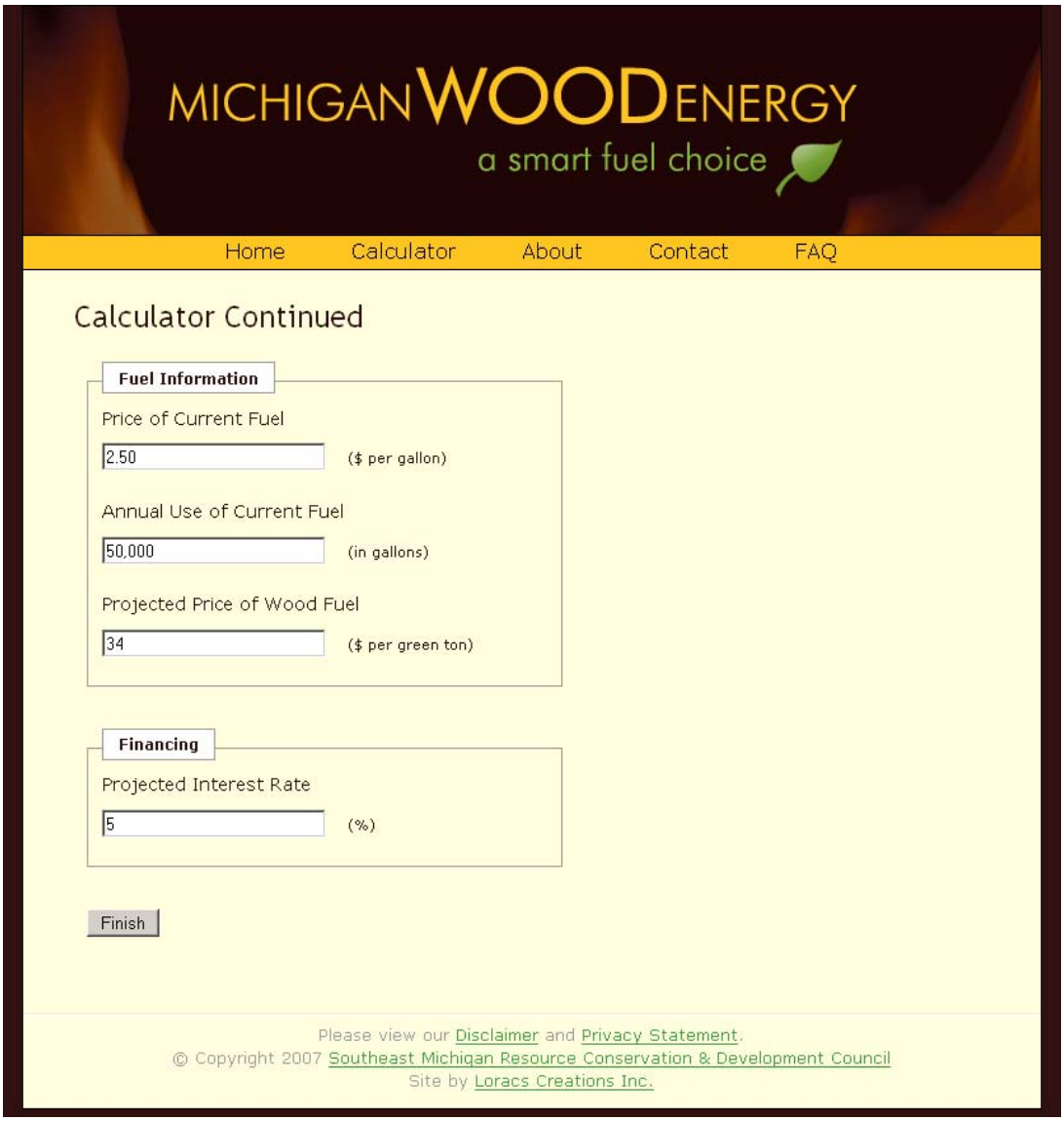
Site by Loracs Creations Inc.

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

MICHIGAN WOOD ENERGY
a smart fuel choice

Home Calculator About Contact FAQ

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.*

BB. Wyandotte Sample Test Plan

Wyandotte fuel cube testing - June 7-8-9-10

Coal / rubber feed

Vendor | Approx.$

Test protocol to start with baseline Spring creek PRB coal w/40% recycled tire inputs
Samples taken every 30 minutes using two feeders - one gallon paint can sample containers
8 hrs with 16 samples taken from each belt for total 32 sample cans
8 hrs with 16 samples taken from each belt for total 32 sample cans - for biomass test at 30%
8 hrs with 16 samples taken from each belt for total 32 sample cans - for biomass test at 15%
Total sample cans = 96

Analysis
Unload each sample to manually remove tire chunks - weigh out the mass of each and record
Split each sample to 1/4 or 1/8 and set aside for composite analysis
Assemble composite sample for both the coal & the rubber.

Analyze composite
bulk density
structure
moisture
Tumble index (coal only)

Outside sample analysis - Split sample for outside analysis

Coal	Ultimate / Proximate / ash chemistry / ash fusion / Cl	SGS	$600
Rubber	Ultimate / Proximate / ash chemistry / ash fusion / Cl	SGS	$600
Coal	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater / NTS	$650
Rubber	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater / NTS	$650
Low level Hg		Frontier GeoScience	$400
		subtotal	$2,900

Biomass

Samples taken every 30 minutes using the existing limestone bin / feeder
8 hr at 30% biomass = 16 sample cans
8 hr at 15% biomass = 16 sample cans
Total sample cans = 32

Analysis

Unload each sample and analyze
Moisture
Structure

Split each sample to 1/4, 1/8 or as needed to produce composite sample
Note: keep samples enclosed to minimize loss / addition of moisture
Analyze composite
Bulk Density
BTU (run 3 samples & average)
Drop
Tumble
Moisture
Structure

Outside sample analysis - Use Split of composite sample for outside analysis

Biomass	Ultimate / Proximate / ash chemistry / ash fusion / Cl	SGS	$600
Biomass	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater / NTS	$650
Low level Hg		Frontier GeoScience	$400
		subtotal	$1,650

Ash Samples

Samples taken every 30 minutes - one gallon paint can sample containers
8 hrs with 16 samples taken during baseline test with only coal / rubber
8 hrs with 16 samples taken during biomass test at 30% (approx. 4.1 nt/hr feed rate)
8 hrs with 16 samples taken during biomass test at 15% (approx. 2.0 nt/hr feed rate)
Total sample cans = 48

Unload each sample and split for composite sample
Moisture
Carbon / Sulfur
Loss on Ignition

Analyze composite
Bulk Density
BTU (run 3 samples & average)
Moisture
Structure

Outside sample analysis - Use Split of composite sample for outside analysis

Ash Base	ash chemistry / ash fusion / Cl / LOI / Carbon/Sulfur	SGS	$479
	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater/NTS	$650
	Low level Hg	Frontier Geoscience	$400
	TCLP test	Whitewater/NTS	$650
30% test	ash chemistry / ash fusion / Cl / LOI / Carbon/Sulfur	SGS	$479
	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater/NTS	$650
	Low level Hg	Frontier Geoscience	$400
	TCLP test	Whitewater/NTS	$650
15% test	ash chemistry / ash fusion / Cl / LOI / Carbon/Sulfur	SGS	$479
	RCRA Metals (TCLP) (primary & secondary metals)	Whitewater/NTS	$650
	Low level Hg	Frontier Geoscience	$400
	TCLP test	Whitewater/NTS	$650
		subtotal	$6,537

Grand total outside services estimate = $11,087

CC. GHG Calculations

GHG Emission Calculations

Combustion Data and MMBtu Calculations

Baseline Test

During the baseline test, 11.4 tons (22,800 pounds) per hour of the bituminous coal/TDF fuel was combusted (8 tons per hour coal; 3.4 tons per hour TDF). This fuel mixture was approximately 60% bituminous coal and 40% TDF. Based upon prior analytical data, the heat content of comparable bituminous coal and TDF were 8,683 Btu/pound, and 13,500 Btu/pound, respectively. Using the mass of coal and TDF combusted and the Btu value of each fuel, we can estimate that the bituminous coal contributed 138.9 MMBtu/hour, while the TDF contributed 91.8 MMBtu/hour (total 230.7 MMBtu/hour).

$$\frac{16{,}000\ lbs}{hr} \times \frac{8683\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 138.9\ MMBtu/hour \quad \text{(Bituminous coal component)}$$

$$\frac{6{,}800\ lbs}{hr} \times \frac{13{,}500\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 91.8\ MMBtu/hour \quad \text{(TDF component)}$$

30% Biomass Test

During the 30% biomass test burn, 12.8 tons (25,600 pounds) per hour of a 30% biomass, coal/TDF blended fuel was combusted (4.5 tons per hour biomass, 5.8 tons per hour bituminous coal, and 2.5 tons per hour TDF). The biomass had a heat content of 7,985 Btu/pound. Based upon prior analytical data, the heat content of comparable bituminous coal and TDF were 8,683 Btu/pound, and 13,500 Btu/pound, respectively.

$$\frac{9{,}000\ lbs}{hr} \times \frac{7985\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 71.9\ MMBtu/hour \quad \text{(Biomass component)}$$

$$\frac{11{,}600\ lbs}{hr} \times \frac{8683\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 100.7\ MMBtu/hour \quad \text{(Bituminous coal component)}$$

$$\frac{5{,}000\ lbs}{hr} \times \frac{13{,}500\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 67.5\ MMBtu/hour \quad \text{(TDF component)}$$

15% Biomass Test

During the 15% biomass test burn, 13.1 tons (26,200 pounds) per hour of a 15% biomass, coal/TDF blended fuel was combusted (3 tons per hour biomass, 7.1 tons per hour bituminous coal, 3 tons per hour TDF). The biomass had a heat content of 7,985 Btu/pound. Based upon prior analytical data, the heat content of comparable bituminous coal and TDF were 8,683 Btu/lb, and 13,500 Btu/lb, respectively.

$$\frac{6{,}000\ lbs}{hr} \times \frac{7985\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 47.9\ MMBtu/hour$$ (Biomass component)

$$\frac{14{,}200\ lbs}{hr} \times \frac{8683\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 123.3\ MMBtu/hour$$ (Bituminous coal component)

$$\frac{6{,}000\ lbs}{hr} \times \frac{13{,}500\ Btu}{lb} \times \frac{1\ MMBtu}{1{,}000{,}000\ Btu} = 81.0\ MMBtu/hour$$ (TDF component)

<u>Baseline Test – GHG Calculations</u>

Eqs. 1 & 2 - Baseline Test – CO_2 Calculation

Bituminous coal component:

$$\frac{93.46\ kg\ CO_2}{MMBtu} \times \frac{138.9\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 28{,}619.0\ \frac{lbs\ CO_2}{hour}$$

TDF component

$$\frac{112.84\ kg\ CO_2}{MMBtu} \times \frac{91.8\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 22{,}836.7\ \frac{lbs\ CO_2}{hour}$$

Total CO_2 from fossil fuels = 51,455.7 lbs CO_2/hour

Emission Factor Reference: Table 12.1, *The Climate Registry* "General Reporting Protocol," May 2008

Eq. 3 - Baseline Test – CH_4 Calculation

$$\frac{1.0\ g\ CH_4}{MMBtu} \times \frac{230.7\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.51 \frac{lbs\ CH_4}{hour}\ x\ 21\ CH_4 GWP = 10.7\ lbs\ CO_2 e/hr$$

Note: the GRP does not have an emission factor for CH_4 from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Eq. 4 - Baseline Test – N_2O Calculation

$$\frac{61.1\ g\ N_2O}{MMBtu} \times \frac{230.7 MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 31.08 \frac{lbs\ N_2O}{hour}\ x\ 310\ N_2O\ GWP = 9{,}633.6\ lbs\ CO_2 e/hr$$

Note: the GRP does not have an emission factor for N_2O from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

<u>30% Biomass Test – GHG Calculations</u>

Eqs. 5, 6 & 7 – 30% Biomass Test – CO_2 Calculation

Biomass component:

$$\frac{93.87\ kg\ CO_2}{MMBtu} \times \frac{71.9\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 14{,}879.3\ \frac{lbs\ CO_2}{hour}$$

Emission Factor Reference: Table 12.2, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal component:

$$\frac{93.46\ kg\ CO_2}{MMBtu} \times \frac{100.7\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 20{,}748.3\ \frac{lbs\ CO_2}{hour}$$

Emission Factor Reference: Table 12.1, *The Climate Registry* "General Reporting Protocol," May 2008

TDF component

$$\frac{112.84\ kg\ CO_2}{MMBtu} \times \frac{67.5\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 16{,}791.7\ \frac{lbs\ CO_2}{hour}$$

Total CO_2 from fossil fuels = 37,540.0 lbs CO_2/hour

Emission Factor Reference: Table 12.1, *The Climate Registry* "General Reporting Protocol," May 2008

Eqs. 8 & 9 – 30% Biomass Test – CH_4 Calculation

Biomass component (biomass wood/wood waste boiler emission factor used):

$$\frac{9.3\ g\ CH_4}{MMBtu} \times \frac{71.9\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 1.5\frac{lbs\ CH_4}{hour}\ x\ 21\ CH_4 GWP = 31.0\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal/TDF component

Note: the GRP does not have an emission factor for CH_4 from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

$$\frac{1.0\ g\ CH_4}{MMBtu} \times \frac{168.2\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.37\frac{lbs\ CH_4}{hour}\ x\ 21\ CH_4 GWP = 7.8\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Eqs. 10 & 11– 30% Biomass Test – N_2O Calculation

Biomass component (biomass wood/wood waste boiler emission factor used):

$$\frac{5.9\ g\ N_2O}{MMBtu} \times \frac{71.9\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.9\frac{lbs\ N_2O}{hour}\ x\ 310\ N_2O\ GWP = 289.9\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal/TDF component

Note: the GRP does not have an emission factor for CH_4 from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

$$\frac{61.1\ g\ N_2O}{MMBtu} \times \frac{168.2\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 22.7 \frac{lbs\ N_2O}{hour}\ x\ 310\ N_2O\ GWP = 7{,}023.7\ lbs\ CO_2e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

<u>15% Biomass Test – GHG Calculations</u>

Eqs. 12, 13 & 14 – 15% Biomass Test – CO_2 Calculation

Biomass component:

$$\frac{93.87\ kg\ CO_2}{MMBtu} \times \frac{47.9\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 9{,}912.6\ \frac{lbs\ CO_2}{hour}$$

Emission Factor Reference: Table 12.2, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal component:

$$\frac{93.46\ kg\ CO_2}{MMBtu} \times \frac{123.3\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 25{,}404.8\ \frac{lbs\ CO_2}{hour}$$

Emission Factor Reference: Table 12.1, *The Climate Registry* "General Reporting Protocol," May 2008

TDF component

$$\frac{112.84\ kg\ CO_2}{MMBtu} \times \frac{81.0\ MMBtu}{hr} \times \frac{1\ lb}{0.4536\ kg} = 20{,}150.0\ \frac{lbs\ CO_2}{hour}$$

Total CO_2 from fossil fuels = 45,554.8 lbs CO_2/hour

Emission Factor Reference: Table 12.1, *The Climate Registry* "General Reporting Protocol," May 2008

Eqs. 15 & 16 – 15% Biomass Test – CH_4 Calculation

Biomass component (biomass wood/wood waste boiler emission factor used):

$$\frac{9.3\ g\ CH_4}{MMBtu} \times \frac{47.9\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.98 \frac{lbs\ CH_4}{hour}\ x\ 21\ CH_4 GWP = 20.6\ lbs\ CO_2e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal/TDF component

Note: the GRP does not have an emission factor for CH_4 from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

$$\frac{1.0\ g\ CH_4}{MMBtu} \times \frac{204.3\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.45 \frac{lbs\ CH_4}{hour}\ x\ 21\ CH_4 GWP = 9.5\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Eqs. 17 & 18 – 15% Biomass Test – N_2O Calculation

Biomass component (biomass wood/wood waste boiler emission factor used):

$$\frac{5.9\ g\ N_2O}{MMBtu} \times \frac{47.9\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 0.6 \frac{lbs\ N_2O}{hour}\ x\ 310\ N_2O\ GWP = 193.2\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008

Bituminous coal/TDF component

Note: the GRP does not have an emission factor for CH_4 from TDF; therefore, the emission factor for a bituminous fluidized bed combustor was used for the combined heat input of the mixed bituminous coal/TDF fuel.

$$\frac{61.1\ g\ N_2O}{MMBtu} \times \frac{204.3\ MMBtu}{hr} \times \frac{1\ lb}{453.59\ g} = 27.5 \frac{lbs\ N_2O}{hour}\ x\ 310\ N_2O\ GWP = 8{,}531.2\ lbs\ CO_2 e/hr$$

Emission Factor Reference: Table 12.5, *The Climate Registry* "General Reporting Protocol," May 2008