Feasibility Study for Biomass Heating of Buildings and Snow Melting at the Sierra at Tahoe Mountain Resort

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1. Executive Summary

TSS Consultants has made an in depth feasibility study of the use of biomass-fired furnaces and boilers to provide heat to buildings and for the melting of snow at the Sierra at Tahoe Mountain Resort (SAT). The availability and estimated cost of biomass in the Lake Tahoe area have been determined. Capital and operating costs have been estimated and compared with the current use of propane for heating buildings and manual removal of snow. Environmental and permitting issues were evaluated.

1.1. Results

The results of this feasibility study are as follows:

- The quantity of biomass required to replace propane in heating the existing Large Maintenance Building, the Base Main Lodge, Administration Building, the proposed Tenta structure and for snowmelt has been estimated for average and estimated maximum snowfall years. The maximum annual biomass required to heat all structures and for snow removal is 374 BDT
- There is a sufficient quantity of biomass (wood fuel) in the Lake Tahoe area to supply the needs of SAT for a period of 20 years at an un-escalated price of $40-50/BDT delivered to SAT.
- Conversion of the Large Maintenance Building to heating with wood promises large savings in heating costs and provides a very high return on the capital invested to convert. Conversion is economically advantageous for either a 5-year or 10-year tax depreciation period.
- Using manually fuel-fed boilers, heating the Base Main Lodge, Administration building and proposed Tenta with wood fuel is also economically advantageous. The expected returns on invested capital are not as high as for the Large Maintenance Building but still far above what is considered an acceptable return.
- Addition of snowmelt removal using wood fuel requires a large additional capital outlay to install high temperature heating tubes in the snowmelt area. Since propane fuel is not currently used to remove snow, there is no additional savings from substituting wood fuel for propane to remove snow. For the hand-fed boilers, snowmelt results in a negative net present value (NPV) indicating a return on equity less than the hurdle rate of 15%. Addition of snowmelt capability for the entire 36,394 square feet of snowmelt area is therefore nor economical. However, if the snowmelt area is reduced to 20-24,000 square feet, addition of snowmelt capability becomes just economical.

- Using an automated fuel feed and ash removal boiler instead of manual fed boilers increases the capital cost considerably. However, heating the Base Main Lodge, Administration building and proposed Tenta with wood fuel is still economically advantageous with an automated boiler but a lower return on investment is realized than for the hand-fed boilers. Addition of snowmelt capability for the entire 36,394 square feet of snowmelt area results in a large negative NPV indicating a return on investment well below the assumed hurdle rate of 15%. However, if the snowmelt area is reduced to approximately 9,000 square feet, the NPV would approach zero, indicting a 15% return on equity investment.
- For the economics of converting to wood fuel, all of the cases depend heavily on the ability to realize the benefits of income tax depreciation. Since the project does not generate sufficient tax liability to use all of the tax depreciation, advantageous project economics depend on being able to use the tax depreciation to reduce income tax liability from other SAT operations.
- Conversion of the Large Maintenance Building to wood heat would require an equity investment of about $9,000; conversion of the Main Base Lodge, Administrative Building, and Tenta to wood heat using a manually fuel-fed boiler would require an equity investment of about $27,000. Use of an automated boiler instead of manually fed boilers would require an equity investment of about $64,000. Adding snowmelt capability would require an additional equity investment of about $100,000. All of these equity investments represent 25% of the total capital required and assume that the remaining 75% could be borrowed at an interest rate of 8%.
- Based on the fuel availability analysis, it is estimated that there are approximately 7,568 BDT per year of biomass fuel economically available for the project. Assuming that SAT biomass thermal units utilize 374 BDT of biomass fuel annually, then a 20.2:1 fuel cover ratio exists. Fuel coverage ratio represents the net availability of fuel relative to new demand (e.g., SAT facility) in the marketplace. The higher the fuel coverage ratio, the more fuel is forecast to be available. Private financial markets and project developers prefer a fuel coverage ratio ranging from at least 2:1 to 3:1. Thus, given the current fuel coverage ratio for SAT biomass project, more than adequate biomass fuel resources would be available.
- Any of the thermal units appear to be permittable by the EL Dorado Air Quality Management District at the facility.

1.2. Recommendations

Based on the results of this study, TSS has the following recommendations:

- TSS recommends that SAT should convert from heating with propane to heating with wood fuel.
- In the choice between manually fuel-fed boilers for the Main Base Lodge, Administration Building, and Tenta area, SAT should evaluate which mode of operation best fits its needs. If the manually fed boilers are acceptable, they should be used since they provide a higher return on invested capital. If manually fuel-fed boilers are not acceptable operationally, then install the automated boiler.
- Addition of snowmelt capability can be incorporated but only if the snowmelt area is substantially reduced.

2. Introduction

TSS Consultants (TSS) was retained by the High Sierra Resource Conservation and Development Council to perform a preliminary study of the potential for a bioenergy project to be located at the Sierra at Tahoe Mountain Resort (SAT). The project would utilize woody biomass to potentially generate electricity and/or heat to supply the energy needs of SAT and sell excess electricity into the public electrical grid.

A preliminary letter report by TSS dated May 12, 2009 was delivered to SAT (copy is contained in Appendix A. The report findings were that a biomass-fired electric generating facility was probably not feasible due primarily to the inability to utilize sufficient heat from the power plant. However, due to the large difference in the cost of propane currently used for heating at SAT and the estimated cost of biomass fuel, a preliminary evaluation using biomass to provide heat only proved promising and deserved a more detailed examination.

This study and report provides a more in depth examination of the use of biomass-fired furnaces and boilers to provide heat to buildings and for the melting of snow at SAT. The availability and estimated cost of biomass in the Lake Tahoe area are determined. Capital and operating costs are estimated and compared with the current use of propane for heating buildings and manual removal of snow. Environmental and permitting issues are evaluated and recommendations provided.

3. Biomass Fuel Required

There are four areas at SAT that have potential for heating with biomass. These are the Large Maintenance Building, Main Base Lodge, and Administration Building, which are currently heated with propane, the Tenta, a new enclosure/building that will be heated with propane, and the snowmelt area adjacent to the Main Base Lodge and around the planned Tenta. The snowmelt area is not currently heated; snow is removed from the area manually. The estimated heat loads of these buildings/areas and the quantity of biomass required for each area are as follows:

3.1. Large Maintenance Building

Heat required to heat the Large Maintenance Building (Figure 1) is based on the quantity of propane used during the 2007/2008-ski season. Usage for the shop propane tanks for a 13-month period was 26,111 gallons. These tanks serve both the Large Maintenance Building and the Small Maintenance Building. Per SAT, about 75% of the propane use is for the Large Maintenance Building. The estimated use for the Large Building is therefore 19,583 gallons, which was further reduced (conservatively) another 4% to provide an estimated 12 month use. This 18,800 gallons of propane at 71,000 Btu/gal, provides 1335 MMBtu/yr of heat load for the Large Maintenance Building. Detailed calculations are included in a spreadsheet in Appendix B ("Buildings").

Figure 1. Large Maintenance Building

The quantity of biomass to provide the heat load was calculated by assuming the heat value of biomass to be 8,500 Btu/lb and making an adjustment for the difference in efficiency of burning propane and biomass. The efficiency of burning propane is already included in the propane usage, and the biomass burning efficiency was assumed to be 15% less. The adjusted biomass heat is 1570 MMBtu/yr and the biomass required to supply this quantity of heat is 92 bone dry tons (BDT). These calculations are also shown in Appendix B ("Buildings"), as well as an estimated monthly distribution. Monthly use of propane was not available so the estimated monthly heat load for the building was based on the monthly heat load at the South Lake Tahoe High School.

3.2. Main Base Lodge and Administration Building

The quantity of biomass required to heat the Main Base Lodge was estimated in the same manner as for the Large Maintenance Building. However, there is a separate propane tank for the Lodge and Administration Buildings, so there was no reduction from the 21,467 gallons used during the 2007/2008 season (except for 4% to provide 12 months of usage). The estimated annual biomass required for the Main Base Lodge and Administration building is 101 BDT.

3.3. Tenta Structure

Heat required for the Tenta structure is not positively known since the structure has not been constructed yet and no historical annual use exists. However, the design engineers estimated peak heat loads for the proposed structure. Peak loads at a ski area would tend to occur during the day when skiing and other activities are taking place. During the night, use would decrease due to a reduction in activity at the structure. Using the peak loads, an average use was estimated assuming that the peak use would decrease to 40% of peak for sixteen hours and operate at peak for eight hours. The resulting average (see Appendix B, "Tenta"), was compared with the average for the Base Main Lodge and Administration building to arrive at the monthly heat use. This comparison resulted in use for the Tenta to be about 59% of the use for the Base Main Lodge and Administration building. The estimated annual biomass required for the Tenta structure is 59 BDT.

3.4. Snowmelt

The area where snow is planned to be melted is shown in Figure 2 (gray area). The area of 36,394 square feet was calculated by scaling it from an architectural/engineering drawing of SAT facility. The calculations are included in a spreadsheet in Appendix A (tab-Snowmelt). The heat required to melt an average of 300 inches of snow per year was calculated using an average rate of snowfall during a storm (2 in/hr) and the heat required to melt the snowfall (44 watts/sq. ft.). These values were taken from published literature for the Lake Tahoe area. The heat required was estimated to be about 820.3 million Btus/yr, which when converted to the quantity of biomass required was 48

BDT/yr. This quantity was increased by 25% to 60 BDT/yr to allow for boiler efficiency and estimated high temperature water (HTW) line losses. See Appendix B - "Snowload Heat").

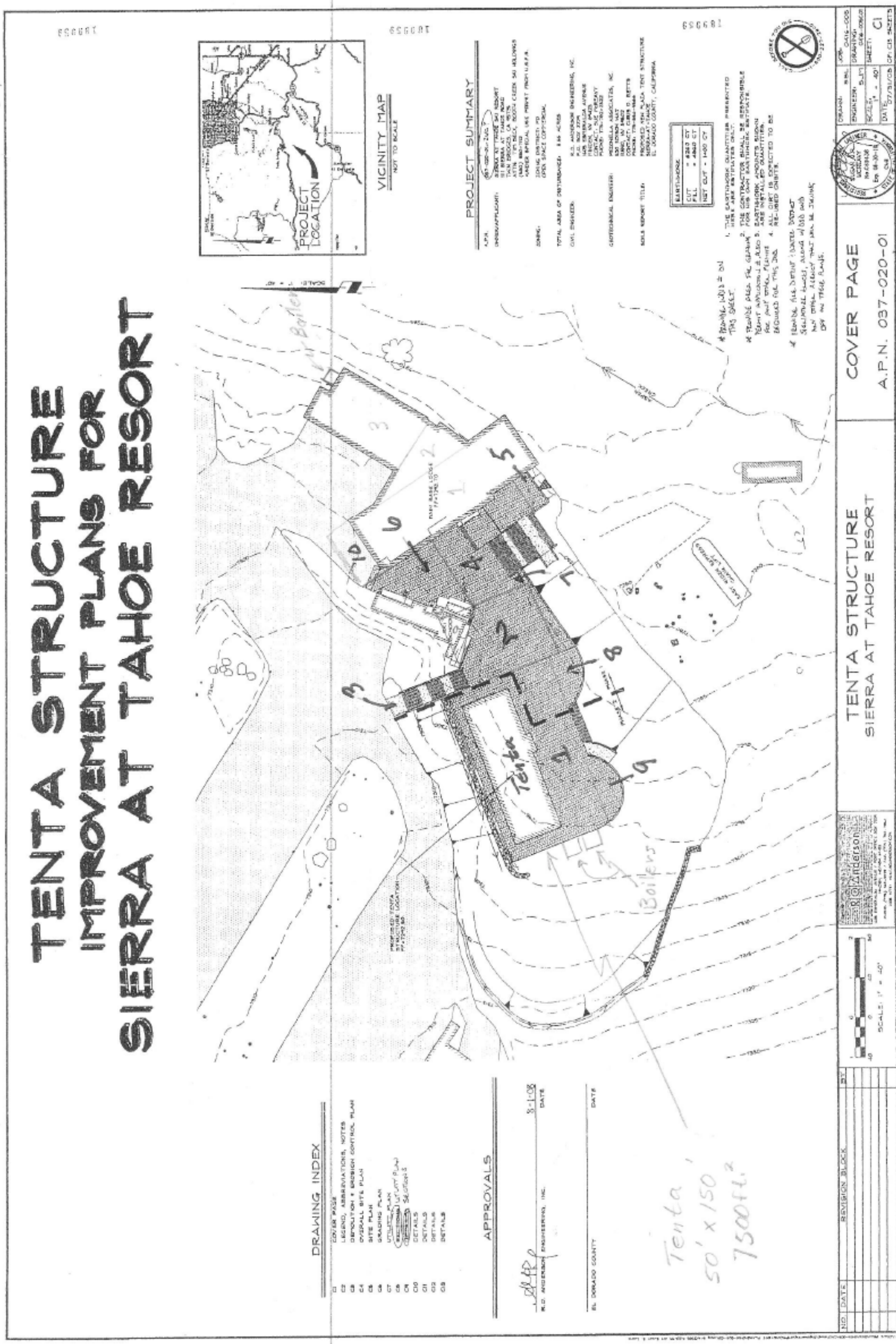
3.5. Total Biomass Required

The total estimated biomass required for an average snowfall of 300 in/yr is shown in Table 1 below. A maximum snowfall of 600 in/yr would double the biomass required for snowmelt resulting in a total annual quantity of biomass of 373 BDT. The next section will assess the availability and potential price of this quantity of biomass in the Lake Tahoe for the next 20 years.

Table 1. Estimated Biomass Required for Sierra At Tahoe Facilities (BDT/Year)

MONTH	LARGE MAINT. BLDG.	LODGE & ADMIN.	TENTA	SNOWMELT	TOTAL
Jan	16	18	10	11	55
Feb	13	14	8	8	43
Mar	14	15	9	9	47
Apr	10	11	7	7	35
May	8	8	5	5	26
June	0	0	0	0	0
July	0	0	0	0	0
Aug	0	0	0	0	0
Sept	0	0	0	0	0
Oct	5	6	3	4	19
Nov	9	10	6	6	31
Dec	17	19	11	11	58
Total	**92**	**101**	**59**	**60**	**313**

Figure 2. Tenta Structure and Snow Melt Area



4. Biomass Fuel Assessment

4.1. Introduction

This biomass fuel assessment provides an analysis of economically and environmentally available woody biomass material, costs to deliver this fuel and specific steps necessary to facilitate fuel procurement for the previously described biomass heat and boiler systems for SAT. Most of the woody biomass fuel available for SAT is recoverable as a byproduct of hazardous fuels treatment activities conducted within a 20-mile radius of SAT.

4.2. Summary of Fuel Availability Analysis

TSS estimates, per Table 2 below, that there is a total of 26,068 BDT of forest-sourced biomass fuel that is practically available on an annual basis from within the Target Study Area (TSA) for SAT. Current and potential demand for over 50% of this material is primarily from the regional biomass power generation sector at 14,000 BDT per year (including biomass power plants that are planned). Other value-added uses (soil amendment, firewood, composite panels) currently are estimated to utilize approximately 7,000 BDT per year from the TSA. Table 2 summarizes these market dynamics.

Table 2. Biomass Availability and Usage for Material Generated Within the SAT TSA (BDT/Year)

FUEL TYPE	AVAILABLE
Hazardous Fuels Reduction Residuals – Inside the Lake Tahoe Basin portion of the TSA	4,330
Hazardous Fuels Reduction Residuals – Outside the Lake Tahoe Basin portion of the TSA	1,200
Forest Thinning and Harvest Residuals – For entire TSA	20,538
PRACTICALLY AVAILABLE TOTAL	**26,068**
MARKETS	**CURRENT & POTENTIAL DEMAND**
Operating Biomass Power Generation Facilities	5,000[1]
Planned Biomass Power Generation Facilities	9,000
Soil Amendment/Soil Restoration	3,000
Firewood	500
Composite Panels	1,000
MARKET DEMAND TOTAL	**18,500**
MARKET ADJUSTED TOTAL AVAILABLE	**7,568**

[1]This figure is subject to change based on whether Sierra Pacific Industries (Loyalton) and the Northern Nevada Correctional Center facilities are re-started.

Based on this fuel availability analysis, TSS estimates that there are approximately 7,568 BDT per year of biomass fuel economically available within the TSA. Assuming that SAT biomass utilization equipment is scaled at around 1 million Btu/hour[2] of thermal energy output and utilizes 374 BDT of biomass fuel annually, then a 20.2:1 fuel cover ratio exists. Fuel coverage ratio represents the net availability of fuel relative to new demand (e.g., SAT facility) in the marketplace. The higher the fuel coverage ratio, the more fuel is forecast to be available. Private financial markets and project developers prefer a fuel coverage ratio ranging from at least 2:1 to 3:1. Thus, given the current fuel coverage ratio for SAT biomass project, more than adequate biomass fuel resources would be available.

TSS also confirmed that fuel supply chain infrastructure is robust and active in the region. Several forest treatment and harvesting contractors contacted are available and interested in supplying biomass fuel to SAT should it move forward with using biomass fuel as a substitute for propane fuel as described.

4.3. Target Study Area

The Sierra at Tahoe biomass thermal energy project is projected to utilize approximately 374 BDT on an annual basis. This represents about 30 truck loads (each transporting approximately12.5 BDT) per year of woody biomass material. TSS experience in the region, and based upon specific investigation for this study, confirms that this relatively small volume of biomass fuel should easily be available within a 20 mile radius of SAT. Thus, TSS has set the TSA for this analysis using a 20-mile radius. Figure 3 highlights the TSA (black, circular perimeter) as well as a one-hour drive time projection for transport of biomass fuel (red, jagged perimeter).

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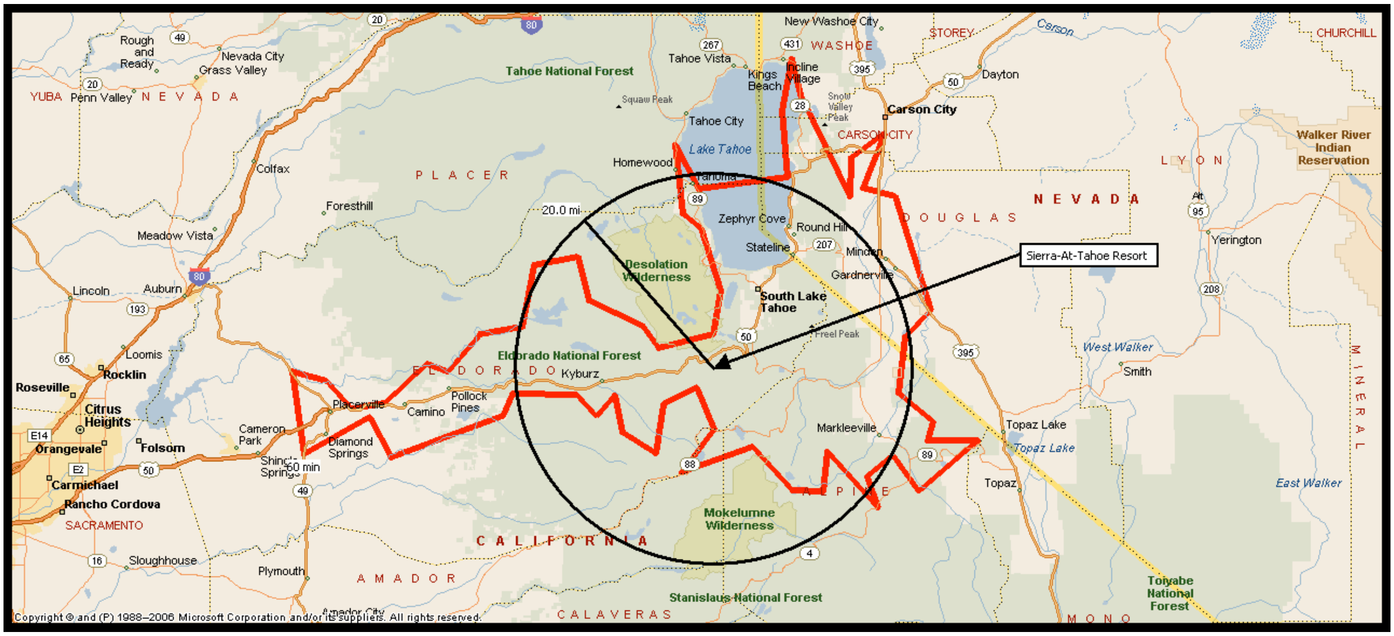
[2]British thermal units per hour is a common unit of measurement for thermal energy systems.

Figure 3. Sierra at Tahoe TSA
(20-mile perimeter in black and 1-hour transport zone in red)



4.4. Wood Fuel Sources

The TSA is a heavily forested region that is primarily managed by the USDA Forest Service - Eldorado National Forest and the Lake Tahoe Basin Management Unit. Forest management activities as described below, such as forest fuels treatment (thinning of small trees and brush) and timber harvest operations (forest thinning and restoration) typically generate significant quantities of woody biomass material suitable as fuel.

Fuels Treatment Activities

Between 2000 and 2009, more than 7.2 million acres were impacted by wildfires in California.[3] Due to significant public concern regarding wildfire threat within California and the TSA, there is a robust and concerted effort to actively treat hazardous forest fuels. In particular, the Congress has allocated significant resources (staff and funding) to actively treat forest fuels within the Lake Tahoe Basin (LTB). Due to the very active nature of fuels treatment within the LTB, this analysis reports on fuel availability from the LTB separately. It is anticipated that a major source of biomass fuel for the SAT

[3]Data provided by the California Department of Forestry and Fire Protection.

facility will be secured as a result of fuels treatment activities within the LTB (particularly the southern portion of the LTB), which lies within the TSA boundaries.

Hazardous Forest Fuels Removal in the Lake Tahoe Basin Region

A major consequence of wildfire suppression efforts of the past century has been a significant buildup of forest fuels. This unnatural accumulation of hazardous fuels represents a serious threat to forest ecosystems and communities. During the past 10 years, the LTB has experienced wildfire events on approximately 4,500 acres. Due to the fact that much of the LTB is accessible by road and that fire response infrastructure is well equipped and highly organized, most wildfires have not exceeded 100 acres in size. However, the Angora Fire of 2007 was an exception, consuming 3,100 acres and 254 homes over the span of 48 hours and is an indication of the wildfire threat that exists in the Lake Tahoe basin. Fortunately, no lives were lost.

It is anticipated that hazardous forest fuels reduction activities planned within the LTB will generate significant volumes of biomass material available as biomass fuel. Significant state and federal resources have been allocated to strategically treat forest fuels in the LTB. Ten fire management agencies are actively treating forest fuels within the LTB.

These ten fire management agencies are involved in current planning efforts to address fuels and forest health within the LTB including:

- **10-Year Fuel Reduction and Wildfire Prevention Strategy for the Lake Tahoe Basin** - Fire and land management agencies operating within the LTB have crafted a 10-year fuel reduction and wildfire prevention strategy. Completed in December 2007, this document sets general plans and goals for coordinated fuels treatment activities within the LTB (focused primarily on lands managed by the USDA Forest Service). This strategy is currently being implemented and increased fuels treatment activities have ramped up hazardous fuels removal. An updated version of this plan is currently being drafted.

- **Biomass Utilization Strategic Plan for the Lake Tahoe Basin** - TSS Consultants has been retained to assist the LTB fire and land management agencies with development of a biomass utilization strategic plan. Sponsored by the California Tahoe Conservancy and the Nevada Fire Safe Council, this planning effort seeks to set biomass recovery and utilization goals with specific metrics (acres treated, tons removed). All seven fire districts, state agencies (California Tahoe Conservancy, Nevada Division of Forestry, California State Parks and CAL Fire), USDA Forest Service and the Tahoe Regional Planning Agency are coordinating to provide historic data on accomplishments (acres treated, tons removed). This historic data, along with a five-year forward-looking forecast, will provide key data on potential fuel availability. A draft biomass utilization strategic plan is currently being reviewed and should be finalized in December 2010. Data from this strategic plan was utilized for this report.

These two planning efforts are complementary and will facilitate continued fuels treatment coordination across agency jurisdictions and land ownership within the LTB.

Draft findings from the Biomass Utilization Strategic Plan include a five-year forecast of fuels treatment activities planned within the LTB. Summarized below are the draft findings as of September 2010 (note that these findings are subject to change).

Important data provided in the draft five-year forecast for the LTB:

- Fuels treatment activities are planned for over 6,740 acres per year within the LTB.
- Biomass fuel could be recovered from about one-third of these fuels treatments (approximately 2,235 acres per year).
- Potentially available biomass fuel of 28,860 BDT could be generated annually as a byproduct of fuels treatment activities within the LTB.
- An average of approximately 13 BDT are potentially available per acre of fuels treatment implemented.

Approximately 25% of the 28,860 BDT per year that is potentially available within the LTB is considered to be located within the TSA. This results in an estimate of 7,215 BDT of potentially available biomass fuel from the LTB that is located within the TSA. In addition there are operational considerations that need to be addressed to assess the volume of biomass material considered to be practically available. Operational challenges include road systems that are inadequate for chip transport, challenging topography (steep slopes or sensitive soils) and economics of biomass processing and transport. Considering these factors, together with TSS' past experience with forest biomass collection, processing and transport, it is estimated that approximately 60% or 4,330 BDT per year of biomass fuel is considered practically available from the LTB.

In certain regions where fuels treatment activities have occurred for some time (such as the LTB), the initial round of treatments will have addressed a large portion of the hazardous fuels. Subsequent maintenance treatments will likely produce less biomass material. The 40% reduction from potentially available to practically available biomass fuel (7,215 BDT reduced to 4,330 BDT) takes this dynamic into account.

Hazardous Forest Fuels Removal Outside the Lake Tahoe Basin Region

As residential development has continued to spread into forested areas of California including El Dorado and Amador Counties it has become more and more important to maintain well-managed fuel breaks within these wildland urban interface (WUI)[4] areas. In addition, counties in these forested regions are promoting fuel reduction programs that encourages homeowners to clear and remove vegetation from around residences and in the WUI. By reducing hazardous fuels near homes the communities located within the WUI are more defensible and fire safe.

Several counties in California have established Fire Safe Councils that are assisting with coordination of fuels treatment activities including the development of Community Wildfire Protection Plans (CWPP). CWPP are being utilized to strategically locate fuel breaks adjacent to communities, provide for evacuation routes, and implement strategies for long-term maintenance of fuel breaks.

El Dorado County has established the El Dorado County Fire Safe Council and Amador County has the Amador Fire Safe Council. Both of these organizations are actively engaged in promoting fuels reductions activities within the TSA. Discussions with the Fire Safe Councils' leadership[5] confirmed that approximately 150 acres per year of fuels treatment activities are conducted by these Councils at locations within the TSA. TSS estimates that 60% or 90 acres are located near road systems that accommodate biomass recovery and transport. Experience in the region indicates that about 8 BDT/acre can be recovered from these fuels treatment activities. Approximately 720 BDT of biomass material are practically available per year from fuels treatment activities sponsored by the Fire Safe Councils operating outside the LTB.

In addition to the Fire Safe Councils, the USDA Forest Service is actively conducting fuels treatment activities outside the LTB within the TSA. The Placerville and Amador Ranger Districts on the Eldorado National Forest are currently treating about 400 acres per year per year[6] using mastication, and pile/burn techniques. Approximately 6 to 8 BDT of woody biomass is recoverable per acre. Assuming that 200 acres of these projects are located on topography that will allow biomass recovery (< 35% slope and roads that will accommodate chip vans) and that 6 BDT per acre is recoverable, then there is approximately 1,200 BDT per year of practically available biomass from fuels treatment activities on the Eldorado National Forest within the TSA.

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[4]Wildland Urban Interface is that region where residential development borders wildlands.
[5]El Dorado County Fire Safe Council – Vicki Yorty, Amador County Fire Safe Council - Cathy Koos-Breazeal
[6]Data provided by Eldorado National Forest staff – Joan McNamara Forest Fuels Officer.

4.5. *Forest Thinning and Harvest*

Forest thinning and restoration operations typically remove larger trees (10 inches diameter[7] and larger) than the forest fuels reduction activities. These larger trees are harvested and processed into sawlogs for delivery to local sawmills. Residuals from these operations can provide significant volumes of woody biomass material. Typically available as limbs, tops and unmerchantable[8] logs, these residuals are byproducts that can be readily collected, processed, and transported by truck. This biomass material can be a relatively economic raw material fuel supply and is an excellent biomass fuel source. Currently most of the residuals generated during forest thinning and restoration operations are piled and burned due to very limited opportunities to market this material as biomass fuel.

Woody biomass fuel availability studies traditionally rely on data regarding historic forest harvest levels to estimate residuals. This information can provide insight in determining historic trends and benchmarks to show actual forest harvest activities over time—activities that generate volumes of byproducts (as noted above) that are potentially available as biomass fuel.

The California Board of Equalization (BOE) monitors commercial timber harvest levels to facilitate collection of timber harvest taxes. Data for timber harvest levels by county is available from the BOE and was used in this analysis to calculate timber harvest trends over time in the two counties that make up most of the TSA; El Dorado and Amador counties. Note that timber harvest levels are monitored using thousand board foot (MBF)[9] measure. Table 3 below summarizes 2005 through 2009 historic timber harvest data for El Dorado and Amador counties.

Table 3. 2005 to 2009 Forest Harvest Volume in El Dorado and Amador Counties (MBF Per Year)

COUNTY	2005	2006	2007	2008	2009	FIVE YEAR AVERAGE	PERCENT WITHIN TSA	HARVEST WITHIN TSA
El Dorado	90,019	99,508	91,055	44,726	20,181	69,098	60%	41,459
Amador	87,852	27,274	18,297	24,626	5,927	32,795	45%	14,758
TOTALS						**101,893**		**56,217**

7Commercial sized timber is typically 10 inches and larger. Diameter is measured at 4.5 feet above ground level.
8Logs that do not meet specifications due to size or defect. Defects include disease or insect damage.
9MBF is one thousand board feet measure. One board foot is a solid wood board measured 12 inches square by 1 inch thick.

The five-year average for timber harvest activity within the TSA is approximately 56,217 MBF. Based upon TSS's experience with biomass recovery, as well as interviews with logging and wood waste processing contractors and private and public land managers, the recovery factor estimate for biomass fuel processed from forest harvest residuals ranges from as low as 0.5 BDT of woody biomass (tops and limbs) to as high as 1.5 BDT that could be generated from each MBF of sawlog volume (MBF) harvested. For the purposes of this analysis TSS utilized a recovery factor of 0.9 BDT per MBF for biomass fuel processed from forest harvest residuals biomass (tops and limbs). Using the 0.9 BDT recovery factor and the 56,217 MBF average annual harvest for the TSA results in 50,595 BDT of potentially available biomass fuel from forest harvest activities.

Not all forest harvest operations lend themselves to ready recovery of harvest residuals. Steep slopes, remote locations, and road systems that will not accommodate large chip trucks (for transport of biomass fuel) will limit the volume of biomass fuel recovered from forest harvest activities. For this reason, not all of the potentially available forest harvest residuals (50,595 BDT) are recoverable. TSS' experience in the region suggests that approximately 40% of harvest operations are conducted on topography and road systems that will accommodate recovery of biomass fuel. Approximately 20,238 BDT per year of timber harvest residuals are practically available within the TSA.

The Eldorado National Forest also conducts pre-commercial thinning operations to control stocking levels of plantations there were established following fire events or commercial logging. Forest staff[10] estimate that forest-wide there are approximately 80,000 acres of plantations with many in need of thinning. Conservative estimates are that about 100 acres per year of plantations within the TSA could be thinned if treatment funding is available. Of these acres about 50 acres are forecast to be on road systems that would accommodate biomass removal. Assuming 6 BDT per acre recovery on these 50 acres results in approximately 300 BDT of biomass material that is practically available from pre-commercial thinning operations within the TSA.

Table 4 provides a summary of the forest-sourced biomass material practically available within the TSA.

[10] Eldorado National Forest staff – Tony Valdes, Natural Resources Staff Officer.

Table 4. Forest-Sourced Biomass Fuel Practically Available Within the TSA (Expressed as BDT/Year)

HAZARDOUS FUELS RESIDUALS INSIDE THE LTB	HAZARDOUS FUELS RESIDUALS OUTSIDE THE LTB	FOREST THINNING AND HARVEST RESIDUALS	TOTAL
4,330	1,200	20,538	26,068

Competition For Woody Biomass Material

Woody biomass material that is not practically or economically recoverable is typically piled and burned, chipped and scattered or left on site. However, biomass material generated within the Sierra at Tahoe TSA that is economically recoverable is utilized for a variety of value-added products including:

- Fuel for biomass power generation facilities;
- Furnish for composite panel manufacturers;
- Feedstock for soil amendment/landscape cover;
- Raw material for firewood.

The primary competing use for biomass material generated within the TSA is for power generation.

4.6. Biomass Power Generation Facilities

California has the highest concentration of operating biomass plants in the United States. There are currently 30 operating plants with the capacity to produce about 600 megawatts (MW)[11] of power.

Operating Biomass Power Plants Sourcing Biomass Fuel from the TSA

Although there are no operating biomass power generation facilities in the TSA there are three biomass power generation facilities are currently sourcing wood fuel from the

[11]One megawatt (MW) of power is the equivalent of 1,000 kilowatts. One MW is enough power generation to sustain between 750 and 1,000 homes.

TSA: Sierra Pacific Industries (Lincoln, California), Rio Bravo (Rocklin, California), and Honey Lake Power (Wendel, California). At one time there were five operating biomass plants sourcing fuel from the TSA. However, two facilities (see discussion below) have recently curtailed operations.

Idle Biomass Power Plants that have Sourced Biomass Fuel from the TSA

The two biomass power generation facilities, which have recently curtailed operations, are Sierra Pacific Industries at Loyalton, California and the Northern Nevada Correctional Center at Carson City, Nevada.

- **Sierra Pacific Industries – Loyalton, California** - Originally developed as a 20 MW cogeneration facility providing power and process steam for a collocated sawmill complex, this plant first entered commercial service in 1989. In 2001 the sawmill was closed and the power plant was converted to a generation facility producing only power for sale to NV Energy. On August 20, 2010, Sierra Pacific Industries announced (see Appendix A, SPI Press Release) plans for the immediate closure of the Loyalton facility due to fuel supply issues.

- **Northern Nevada Correctional Center – Carson City, Nevada** - Collocated at the Northern Nevada Correctional Center (NNCC), this 1.2 MW cogeneration plant entered commercial service in 2007. Initially designed to be operated and maintained using prisoner labor, this facility experienced operational and fuel sourcing issues early on. Due to the complexity of plant operations and maintenance, outside contractors were retained. Fuel sizing has been a challenge from the start due to a fuel handling system that did not account for local fuel characteristics. In May 2010, the NNCC announced plans to close the facility (see Appendix B, May 24, 2010 Bio Energy News article). The facility ceased operations in August 2010 and has been put up for sale by the State of Nevada.

Table 5 summarizes the operational biomass power plants that have historically (and currently) source biomass fuel from the TSA.

Table 5. Biomass Power Plants Currently Sourcing Fuel from the TSA

FACILITY AND LOCATION	GENERATION CAPACITY (MW)	DISTANCE FROM SIERRA AT TAHOE (MILES)	ANNUAL FUEL USAGE (BDT)	ANNUAL FUEL VOLUME SOURCED FROM THE TSA (BDT)
Rio Bravo				

FACILITY AND LOCATION	GENERATION CAPACITY (MW)	DISTANCE FROM SIERRA AT TAHOE (MILES)	ANNUAL FUEL USAGE (BDT)	ANNUAL FUEL VOLUME SOURCED FROM THE TSA (BDT)
Rocklin, CA	25	79	180,000	1,000
Sierra Pacific Industries Lincoln, CA	25	87	200,000	2,000
Honey Lake Power Wendel, CA	32	170	200,000[12]	2,000
TOTALS	**82**		**580,000**	**5,000**

Planned Biomass Power Plants

Several biomass power generation facilities are being planned and could be sited within Central/Northern California in the next several years. Two planned facilities would, if successful in achieving full development and entering commercial service, likely source biomass fuel from the TSA. These include the Lake Tahoe Basin Biomass Energy facility at Kings Beach, California and the Buena Vista Biomass Power facility at Ione, California.

Table 6 summarizes biomass power plants that are in early stage development and may source fuel from the TSA.

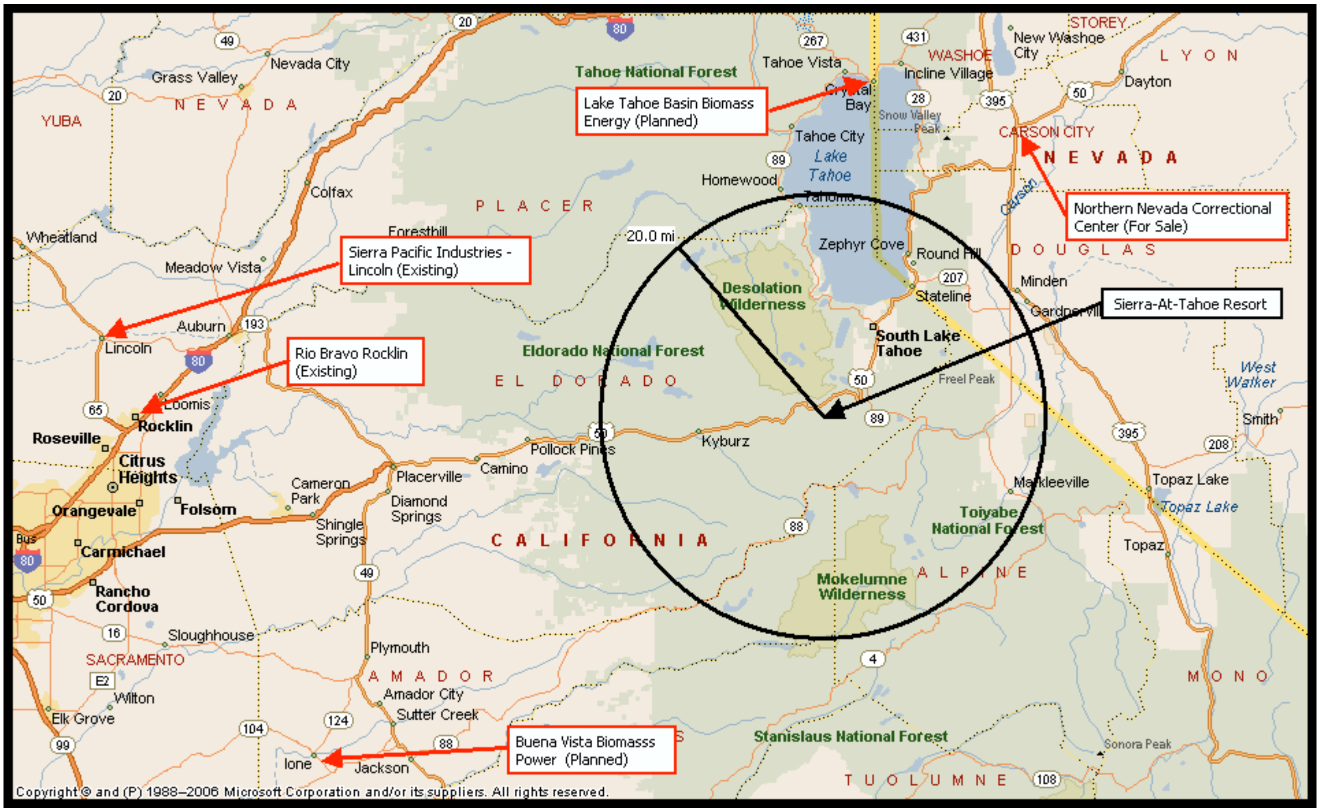
Table 6. Biomass Power Plants That May Source Fuel from the TSA

FACILITY AND LOCATION	GENERATION CAPACITY (MW)	DISTANCE FROM SIERRA AT TAHOE (MILES)	ANNUAL FUEL USAGE (BDT)	ANNUAL FUEL VOLUME SOURCED FROM THE TSA (BDT)
Lake Tahoe Basin Biomass Energy Kings Beach, CA	1 to 3	51	10,000 to 30,000	2,000
Buena Vista Biomass Power Ione, CA	18	73	120,000	7,000
TOTALS	**19 to 21**		**130,000 to 150,000**	**9,000**

Figure 4 highlights the location of the biomass power plants – both existing and planned that may source fuel from the TSA.

[12] Operating at a reduced capacity due to constrained fuel supply.

Figure 4. Existing and Planned Biomass Facilities That May Source Fuel From the TSA



4.7. Other Value-Added Uses

While the most significant market for biomass material generated within the TSA is for use as biomass fuel in the production of renewable energy, there are other value-added uses to be considered including the following.

- **Firewood:** The U.S. Forest Service (Eldorado NF, and Lake Tahoe Basin Management Unit), California Tahoe Conservancy, and Nevada State Parks issue personal use and commercial firewood permits. Much of the firewood generated is for residential use. This is a fairly consistent and predictable market.
- **Landscape Cover and Soil Amendment:** There are several commercial-scale businesses sourcing raw material from the TSA that serve the landscape cover, soil amendment and soil restoration markets. Due to the recent downturn in the

national economy and overall reduction in new housing starts, the markets for this material are very depressed. Most of the soil amendment businesses are not paying for delivered material but will accept it for free or charge a nominal disposal fee.

- **Composite Panels:** The one composite panel manufacturer (SierraPine Composite Solutions in Rocklin, CA) is currently operating on a curtailed basis due to the depressed housing market and is not actively sourcing raw material from forest fuels treatment activities. From time to time, Sierra Pine will arrange for purchase of forest-sourced material.

Table 7 describes the soil amendment, firewood, and composite panel markets that have historically sourced biomass material generated within the TSA.

Table 7. Current Markets for Woody Biomass Material Generated Within the TSA

FACILITY AND LOCATION	DISTANCE FROM SIERRA AT TAHOE (MILES)	VALUE- ADDED USE	ANNUAL BIOMASS MATERIAL USAGE (BDT)	ANNUAL VOLUME SOURCED FROM THE TSA (BDT)
Full Circle Compost Minden, NV	43	Landscape products - compost and mulch	2,000 to 3,000	1,000
Bently Agrowdynamics Minden, NV	43	Landscape products - compost and mulch	4,500 to 5,000	1,500
Firewood	NA	Thermal energy (typically for residential heating)	500 to 700	500
SierraPine Composite Solutions Rocklin, CA	79	Composite panel products	40,000 to 72,000	1,000
Integrated Environmental Restoration Services Tahoe City, CA	NA	Soil restoration activities primarily in the LTB	250 to 1,250	500
TOTALS			**47,250 to 81,950**	**4,500**

4.8. Fuel Availability

TSS estimates that there is a total of 26,068 BDT of forest-sourced biomass fuel that is practically available on an annual basis from within the Sierra at Tahoe TSA (see Table 8 below). Current and potential demand for over 50% of this material is primarily from the regional biomass power generation sector at 14,000 BDT per year (including biomass power plants that are planned). Other value-added uses (soil amendment, firewood, composite panels) currently are estimated to use approximately 7,000 BDT per year from the TSA. Table 8 summarizes these market dynamics.

Table 8. Biomass Availability and Usage for Material Generated Within the TSA (Expressed as BDT/Year)

FUEL TYPE	AVAILABLE
Hazardous Fuels Reduction Residuals – Inside the LTB	4,330
Hazardous Fuels Reduction Residuals – Outside the LTB	1,200
Forest Thinning and Harvest Residuals - For entire TSA	20,538
PRACTICALLY AVAILABLE TOTAL	**26,068**
MARKETS	**CURRENT & POTENTIAL DEMAND**
Operating Biomass Power Generation Facilities	5,000[13]
Planned Biomass Power Generation Facilities	9,000
Soil Amendment/Soil Restoration	3,000
Firewood	500
Composite Panels	1,000
MARKET DEMAND TOTAL	**18,500**
MARKET ADJUSTED TOTAL AVAILABLE	**7,568**

Based on this fuel availability analysis, TSS estimates that there are approximately 7,568 BDT per year of biomass fuel economically available within the TSA. Assuming that SAT biomass utilization equipment is scaled at around 1 million Btu/hour[14] of thermal energy output and utilizes 374 BDT of biomass fuel annually, then a 20.2:1 fuel cover ratio exists. Fuel coverage ratio represents the net availability of fuel relative to new demand (e.g., SAT facility) in the marketplace. The higher the fuel coverage ratio, the more fuel is forecast to be available. Private financial markets and project developers prefer a fuel

[13]This figure is subject to change based on whether Sierra Pacific Industries (Loyalton) and the Northern Nevada Correctional Center facilities are re-started.
[14]British thermal units per hour is a common unit of measurement for thermal energy systems.

coverage ratio ranging from at least 2:1 to 3:1. Thus, given the current fuel coverage ratio for SAT project, more than adequate biomass fuel resources would be available.

4.9. Fuel Characterization

The primary biomass fuel types targeted for utilization by the SAT facility have been utilized as fuel by California biomass power generation facilities since the mid 1980s. Due to this developed infrastructure, TSS has access to fuel testing records that provide historic trends regarding physical fuel characterization. Potential biomass fuel delivered to SAT would have a heating value of 8,500 to 8,800 Btu per dry pound, ash residual of 2% to 7%, and moisture content ranging from 35% to 50%.

4.10. Current Fuel Market Pricing

Wood fuel pricing within the TSA is trending downward as demand for wood fuel has dropped. Recent curtailments at Sierra Pacific Industries at Loyalton and the Northern Nevada Correctional Center at Carson City have removed demand for 132,000 BDT from the marketplace (Northern California, Western Nevada region). As with any market commodity, pricing is impacted by supply and demand. Due to current demand dynamics, fuel supply is up and pricing is down.

In consideration of the logistical impacts, the supply/demand balance in the TSA, and market intelligence gathered from existing biomass fuel suppliers and buyers, TSS has developed a fuel price estimate. Table 9 provides a summary of the estimated fuel price ranges that operating biomass power plants are paying for delivered biomass fuel sourced from the TSA. A range of fuel prices is provided due to the fact that biomass is typically procured based on quality (higher prices for better quality fuel) and sometimes haul distance (higher prices for fuel transported longer distances).

Table 9. Wood Fuel Pricing Within the TSA

FUEL TYPE	ESTIMATED PRICE RANGE ($/BDT)
Hazardous Fuels Reduction Residuals	$42 to $55
Forest Thinning and Harvest Residuals	$35 to $50

4.11. *Optimized Fuel Blend And Pricing*

Based upon TSS' experience with biomass fuel procurement and knowledge of the current wood fuel markets within the TSA, an optimized fuel blend for the SAT facility would be based on fuel availability and pricing. Both of the fuel types considered exhibit very similar characteristics and quality and thermal energy production should be able to operate on a full range of fuel blends using these fuel types.

Fuel availability is dependant upon forest operations and market demand. Most forest management operations are conducted from May through November. Occasionally winter operations are conducted in the TSA (primarily within the LTB). However, winter operations require hard-pack snow, which is completely dependant upon weather conditions.

4.12. *Off-Site Fuel Storage*

Due to the seasonal thermal energy demand and biomass fuel usage at SAT, biomass fuel deliveries would be necessary from October through May (reverse timing of typical forest operations as noted above). SAT has limited capacity for fuel storage on site during the winter months. Based on TSS's' on-site observations, it is anticipated that a maximum of 30 BDT (two truck load equivalent) could be stored on site. For the purposes of fuel procurement planning, TSS recommends that off-site fuel storage be arranged so that wintertime deliveries of fuel to SAT are assured. Preliminary discussions with local forest harvest contractors indicate an interest in arranging off-site storage. Off-site storage does represent an added expense, as fuel must be stored, then re-loaded into trucks for just in time delivery to SAT.

4.13. *Fuel Pricing*

Discussions with local fuel processing and transport contractors demonstrate a high level of interest to provide biomass fuel to the SAT facility. In order to facilitate delivery to SAT, several accommodations, over and above typical fuel delivery arrangements are required:

- Off-site storage,
- Use of self-unloading van,
- Just in time winter month delivery.

Considering current biomass fuel market pricing and the accommodations listed above, TSS estimates that biomass fuel pricing for delivery of fuel to SAT will need to be in the $40 to $45 per BDT range. This pricing includes the expenses associated with off-site storage and assumes that off-site storage can be arranged. Factors that may impact fuel pricing such as diesel fuel costs are assumed to remain relatively flat during the next few years.

4.14. Fuel Procurement

Securing biomass fuel at the scale required for SAT (approximately 30 truckloads per year) is a relatively straightforward procedure. The key is contracting with a reputable commercial-scale contractor. There are currently several commercial-scale contractors actively treating forest fuels and/or processing thinning/forest harvest residuals within and adjacent to the TSA. The current downturn in forest-sourced fuel demand will likely impact these contractors short-term due to reduced demand and pricing for biomass fuel in the region. However, as planned biomass power generation facilities (Lake Tahoe Basin Biomass Power and Buena Vista Biomass Power) enter commercial operation there will be additional demand for biomass fuel.

4.15. Contracting For Fuel

Once a prioritized list of potential fuel suppliers has been generated, targeted negotiations for short-term or long-term fuel supply contracts can commence. A phased-in approach with key potential suppliers is important. Examples of tasks to consider when contacting fuel suppliers and commencing negotiations are outlined below.

- Make initial contact. Provide SAT biomass project overview, projected fuel usage requirements and fuel specifications. Secure pertinent data (contact information, historic fuel production, fuel types generated, current equipment mix).

- Meet in the field to view operations firsthand. Secure two fuel samples, one for testing (moisture content and ash content) and one to review with the SAT facility operations team.

- Confirm current markets available for fuel supplier and current pricing.

- Once the preferred fuel supplier is selected, approach with one of the following:
    - Letter of Intent (LOI), or

- Letter of Intent/Term Sheet (LOI/TS).

- Once LOI or LOI/TS is signed, begin negotiations for short-term or long-term fuel supply agreement.

- Secure fuel supply using a spot (short-term) or long-term fuel purchase agreement.

4.16. Fuel Procurement Agreements

While a Letter of Intent will serve to confirm the prospective fuel suppliers' interest in providing fuel, it is not considered a binding agreement. There are a number of fuel procurement agreement types and each has a specific purpose. Summarized below is a brief description of fuel procurement agreements commonly utilized in Northern California.

- Letter of Intent. A non-binding agreement to formally begin discussions regarding fuel availability and pricing. This is typically the initial agreement, one that brings the parties to the table.

- Binding Letter of Intent. Similar to the letter of intent but with language that "binds" the parties to a commitment for fuel volume and pricing. This is commonly used by project developers seeking project financing. It demonstrates to the private financial markets that binding commitments for fuel are available.

- Spot Purchase Agreement. Fuel procurement agreement with a duration of less than one year. Defines delivery schedule, fuel specifications, volume committed, and pricing. May have defined monetary incentives for delivery of quality fuel (low ash, high Btu) and/or for pro-rated volumes of fuel (higher fuel delivery volumes equal higher delivered prices).

- Long-Term Purchase Agreement. Similar to spot purchase agreement, but the contract term is two to five years in length. Fuel pricing may be indexed to account for increases in labor and diesel fuel costs. Typically, the Consumer Price Index and New York Mercantile Exchange diesel price index are utilized if price indexing is considered.

4.17. Fuel Procurement Organization

Considering the relatively small scale of fuel procurement activities required to maintain wood fuel deliveries (374 BDT per year) to the SAT, TSS recommends that the fuel procurement services be managed by SAT operations manager.

4.18. Observations

Summarized below are observations generated during the course of this fuel availability review and fuel procurement plan effort.

Off Site Fuel Storage

Currently the proposed SAT biomass energy system is in early phase design and as such the fuel storage and handling system is still being reviewed. It is assumed that due to the relatively constrained site at SAT, the fuel storage area will only be able to accommodate around 30 BDT of fuel. Due to the seasonal availability of forest-sourced fuel, the need for winter deliveries into SAT, and the relatively small fuel storage capacity there will be a need for off-site storage of fuel. Contact with several local fuel supply contractors indicated a willingness to make arrangements for off-site storage.

Fuel Collection Innovation

Within Northern California, there has been some very innovative development of biomass fuel supply chain infrastructure. For example, Placer County has implemented a biomass collection program that provides bins for collection of woody biomass material generated in the course of conducting fuels treatment activities by Placer County residents, contractors, and fire agencies.

Due to the demonstrated success of the Placer Biomass Program, other communities have replicated this model. A similar program is now underway in the South Lake Tahoe area. Managed by the Nevada Division of Forestry, the biomass recovery program has been using biomass bins to collect processed biomass for use as fuel at the Northern Nevada Correctional Center (NNCC) biomass cogeneration plant. Now that the NNCC facility has closed permanently, the Nevada Division of Forestry is seeking alternative value-added markets, such as facilities needing biomass fuel for thermal energy production.

Community Support for Small Thermal Energy Facilities

Contact with numerous forestland managers, fuel supply contractors, fire safe councils and other stakeholders in the region indicated that there is very strong community support for biomass-fired thermal energy production at SAT. Due to the large number of forested acres needing treatment in the region and the lack of value-added markets for biomass generated as a byproduct of these operations, there exists much community support for innovative approaches for improved biomass utilization.

5. Heating Technology and Economic Feasibility

Heating buildings and snow removal areas at SAT using biomass for fuel will require addition of equipment to handle the biomass, furnaces, and boilers to convert the woody biomass to heat and delivery systems to provide the heat to the buildings and snowmelt area. Capital will be required to purchase and install the equipment, and operating costs will be incurred in operating and maintaining the heating systems. This section provides a description of possible heating systems and equipment, estimates the capital and operating costs that would be incurred, and performs an economic assessment to see if heating with biomass provides an economic advantage to current operations.

5.1. Large Maintenance Building

The large maintenance building is approximately 8,000 square feet in area and currently heated using propane. Woody biomass could be used to heat the building by installation of a hot-air shop heater manufactured by Biomass Combustion Systems, Inc. (BCS; www.biomasscombustion.com). BCS makes heaters in 250,000, 500,000, and 800,000 Btu/hr sizes (Appendix D). The average heat load for the large maintenance building for December assuming 24-hours/31 days operation was about 350,000 Btu/hr. Therefore the 500,000 Btu/hr (about 15 horsepower) size should meet the maximum typical heat load but still provide a cushion of capacity to meet peak loads and for unusually cold periods. This heater is 40 inches in width, 82 inches in length, 87 inches high, and weighs 4,300 pounds.

This heater could be installed outside the building on a concrete pad and deliver hot air through ducts into the building. Base costs and a rough estimate of shipping, installation and ducting cost were provided by BCS. TSS have added costs for a concrete pad on which to mount the heater outside the building, electrical work, and design/engineering. These costs could be less if existing propane ducting could be used or if some of the work was performed by SAT maintenance personnel. Some sort of enclosure (at least a roof over the heater) might also be required, for which we have added a cost. The estimated capital cost for the heater is:

Table 10. Estimated Capital Cost of Large Maintenance Building Shop Heater

Item	Cost-$
Heater-500,000 Btu/hr	14,500
Sales tax @ 8%	1,160
Shipping	1,500

Item	Cost-$
Concrete pad	3,000
Ducting	2,000
Electrical	2,000
Enclosure	3,000
Fuel Storage	5,000
Engineering	3,000
Subtotal	30,160
Contingency @ 5%	1,758
Total Cost	**$36,918**

Without a complete engineering design, these costs are conceptual or representative of what actual costs will be. However, the estimated costs should be within 10-20% of what would actually be incurred.

Operating costs incurred with the shop heater should be minimal. Initial start-up requires setting and starting a fire in the heater, but once operating, adding fuel is required only about every two hours if chipped wood is used. Cordwood can also be used, although cordwood tends to be considerably more expensive than chipped wood. Even if fuel is not continued to be added, the furnace can be banked so that coals will remain for 12-18 hours, allowing the heater to be brought quickly up to full operation by just adding fuel. Operation of the heater could be performed by existing maintenance building personnel. The cost of fuel delivery and offsite storage during winter months when fuel cannot be harvested has been included by increasing the price of wood fuel by $5/BDT. TSS has therefore, not assumed any additional cost for operation. However, there may be additional costs for property taxes and insurance. For these, TSS assumed $4,000/yr. Ash disposal was assumed to be $0 since it can be deposited in the normal waste disposal from SAT.

The heater appears to be relatively maintenance free. However, there will probably be higher maintenance costs than incurred with propane heating. TSS therefore assumed $1,000/yr. in additional maintenance costs.

To estimate the economic feasibility of converting the large maintenance building to a wood-burning heating unit, TSS employed a discounted cash flow model. This model uses the difference in fuel costs (in this case between wood and propane) and compares this savings with the additional costs of installing and operating the wood-fired heating units. The cost of propane was assumed to be $18.80/per million BTUs, and the cost of wood fuel was $2.95/MMBtu based on a fuel price of $50/BDT.

TSS assumed private financing with 25% equity requiring at least a 15% return (ROE) and 75% debt at a cost of 8%. TSS has shown the results using two tax depreciation write-off periods, 5-year and 10-year. Realization of the tax depreciation will require tax liability from operation of SAT or other operations against which the tax depreciation can be deducted to reduce income taxes. A fuel cost of $40/BDT is also shown to show the impact from a change in the price of wood fuel. The results from the model calculations are as follows in Table 11:

Table 11. Model Calculations for Heater

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	117.8%	101.4%
$50/ton	112.1%	95.9%

TSS assumed that a 15% return on the equity portion of a private investment would be satisfactory to investors. Assuming that this is true, installation of a wood-burning heater in the large maintenance building to replace the use of propane for heat would seem to be economically advantageous if the capital costs were depreciated for income tax purposes over either a 5-year or 10-year period. The estimated capital costs are not precise since a detailed engineering design has not been performed. However, the results of the analysis are not particularly sensitive to capital cost and an increase from $36,918 to $50,000 results in a reduction in ROE from 117.8% 95.9%, still well above what is considered acceptable. The discounted cash flow model covers a period of twenty years and it was assumed that wood fuel could be obtained at an initial cost of $40-50/ton with deliveries for twenty years and with the price escalated at a rate no higher than propane and other fossil fuels. In addition, the analysis assumes that the benefit of accelerated tax depreciation could be realized. The model inputs and output are shown in Appendix C.

The shop heater used in the analysis must be refueled by hand. If an automated feeder system was added, the additional capital cost would be approximately $80,000, resulting in a total cost of $116,918. The data in Table 11 is shown below assuming this increase in capital cost Table 12.

Table 12. Model Calculations for Heater with Automated Feeder

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	41.5%	29.2%
$50/ton	38.9%	26.8%

As can be seen, the ROE is reduced substantially from addition of an automated feeder system but the ROE is still satisfactory for either 5-year or 10-year tax depreciation. Addition of an automated feed system would seem to depend on SAT's preference in not having to periodically manually feed the furnace.

5.2. Main Base Lodge, Administration Building, Tenta, and Snowmelt

These areas are considered together because they could be supplied heat from the same source, that is, a high temperature water (HTW) boiler or boilers located adjacent to the Lodge and Tenta. TSS analyzed heating these areas with two types of boilers; hand-fed as was assumed for the Large Maintenance Building and automatic feed which will require additional capital cost.

Hand-Fed Boilers

Based on the heat loads for the buildings and snowmelt area, three 500,000 Btu/hr boilers should be sufficient. Although a heavy snowfall may not be melted immediately as it fell, it would be melted within a relatively short period of time. For example, if the snowfall was heavy during a ski day, it might accumulate until ski operations ceased in the afternoon and more boiler capacity could be applied to melting snow. Except under extreme unusual snowfall conditions, all snow should be melted before the commencement of the following day's ski operations. The boilers can be located inside the buildings but were assumed to be located outside. The design for the boiler heating would be such that HTW could be supplied by any of the three boilers to the Base Main Lodge, Tenta, and snowmelt area. The Administration building could be supplied only by the boiler located on the northeast side of the Base Main Lodge. If the boilers were located inside one or more buildings, this delivery assumption could change. The boilers assumed used are Econoburn, Model EBW-500 (www.econburn.com). These boilers are 76 inches high, 41 inches wide, 63 inches deep, and weigh 3,405 pounds.

Capital cost for the HTW system consists of the boilers, distribution lines, space and hot water heating units, and hot water pipes installed in the concrete snowmelt areas. The cost for snowmelt pipes assumes installation in newly poured concrete. The estimated cost calculations are detailed in the Appendix B spreadsheet "Costs" and summarized here.

Table 13. Estimated Capital Cost of Three Hand-Fed Boilers to Supply the Base Main Lodge, Administration Building, Tenta, and Snowmelt

Item	Cost-$
Boilers-3-500,000 Btu/hr	42,000
Sales tax @ 8%	3,360
Shipping	4,500
Concrete pads	9,000
Ducting	12,000
Electrical	6,000
Enclosure	15,000
Heating Units	10,000
Distribution piping	20,000
Piping to Admin Bldg.	2,700
Engineering	10,000
Subtotal	134,560
Contingency @ 5%	6,728
Total Cost	**$141,288**

As with the Large Maintenance Building, without a complete engineering design, these costs are conceptual or representative of what actual costs will be. However, they should be within plus/minus 10-20% of what would actually be incurred. A complete engineering design might also use a different configuration of boilers and a different manufacturer than what was assumed in this study (Appendix D - Econoburn EBW-500).

Operating costs incurred with the boilers should also be minimal. The boilers will have to be manually fueled with wood lengths not exceeding 33 inches. The boilers can also be fed with chipped wood provided the size of the wood is greater than ½ inch. If smaller, the wood chips can clog the air nozzles feeding the boiler from below the stoker grate. According to the manufacturer, refueling is required only 3-4 times per day although it could be more often when they are operated at full capacity. Like the shop heater the boilers could probably be banked overnight so that boiler feeding would take place only during daylight operating hours. Operation of the boilers could probably be performed by existing SAT personnel. As for the Large Maintenance Building, the cost of fuel includes delivery and offsite storage during the winter months. We have therefore, not assumed any additional cost for operation. However, there may be additional costs for property taxes and insurance. For these, we have assumed $6,000/yr. Ash disposal was assumed to be $0 since it can be deposited in the normal waste disposal from SAT.

The boilers appear to be relatively maintenance free. However, there will probably be higher maintenance costs than incurred with propane heating. TSS has therefore assumed $5,000/yr. in additional maintenance costs.

To estimate the economic feasibility of converting the Main Lodge, Administration building and Tenta to wood-burning boilers, TSS employed the same discounted cash flow model used in analyzing the Large Maintenance Building with the savings from the difference in propane and wood fuel costs to heat the areas shown as revenue in the model and the costs of wood fuel shown as an expense.

The same financing was also used and the results calculated using a 5-year and 10-year period over which capital costs were deducted for income tax purposes. The results from the model calculations are as follows:

Table 14. Model Calculations for Three Boilers

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	67.1%	52.9%
$50/ton	63.7%	49.6%

As in the analysis of the Large Maintenance Building, TSS assumed that a 15% return on the equity portion of a private investment would be satisfactory to investors. Assuming that this is true, installation of HTW boilers to supply heat to the Main Lodge, Administration building and Tenta, to replace the use of propane for heat would seem to be economically advantageous using either a 5-year or 10-year income tax depreciation period.

The three boilers assumed in the above analysis are sufficient to also provide heat for snowmelt, and if snowmelt were not undertaken, two boilers should be sufficient. This would reduce the capital costs in the above analysis from $141,288 to $109,137 (See Appendix B, “Costs”). Operating costs are assumed to decrease from $6,000 to $4,000 and maintenance costs from $5,000 to $3,500. The results from the model calculations using two boilers are as follows:

Table 15. Model Calculations for Two Boilers

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	91.8%	76.3%
$50/ton	87.7%	72.3%

Adding snowmelt capability will incur considerable additional capital cost. There are about 36,000 square feet of snowmelt area and hot water tubes would be imbedded in the concrete to provide heat to the entire area. The additional capital cost of adding snowmelt capability is as follows:

Table 16. Estimated Additional Capital Cost to Add Snowmelt Capability

Item	Cost-$
Snowmelt tubes	
36,394 sq. ft. @ $11/sq. ft.	$400,333

The cost of $11/sq. ft. for materials and installation of hot water tubes in the snowmelt area was obtained from a company that has installed snowmelt systems in the Sierra Nevada area.

This additional capital cost is added to the $141,288 for the buildings with three boilers used and the DCF model rerun. There is no additional saving on fuel cost since propane is not currently being used for snowmelting. All inputs to the model remain the same as for the Main Lodge, Administrative building, and Tenta case except the capital cost. The result is at first a positive net cash flow for a year or two, which then becomes negative cash flow for the remainder of the 20 years. Return on equity does not calculate due to the changes in cash flow from negative to positive and then to negative, but the net present value (NPV) at a discount rate of 15% is a negative $30,393. The investment rule is to accept investments that result in a positive NPV and to reject those that have a negative NPV. The negative NPV makes the addition of snowmelt capability economically unacceptable. The results of the analysis are presented in the following table.

Table 17. Model Calculations for Snow Melting

Wood Fuel Cost Case	NPV Achieved – 5-yr depreciation	NPV Achieved – 10-yr depreciation
$40/ton	$-30,393	$-60,661
$50/ton	$-35987	$-66,255

If propane were used for snowmelt instead of wood, the additional annual cost for fuel above the wood fuel cost would be approximately $16,000. Melting snow with propane would not seem to be a good economical choice.

Addition of snowmelt capability might still be made economically acceptable by reducing the area of snow removal. If the 36,394 square feet were reduced to 20-

24,000 square feet, the NPV would approach zero for the $40/ton, 5-year depreciation case indicating a 15% ROE.

Automated Boilers

Boilers are available that are more or less completely automated. By automated, it is meant that the wood fuel is automatically fed to the boiler depending on the demand for heat, and the ash (with additional capital investment) is automatically removed and deposited in a collection bin. Due to the automation, the capital cost of these systems is considerably more than the cost for hand fed boilers.

A boiler by Skanden (www.skanden.com), a Danish company, is typical of an automated boiler (Appendix D). One, 250 kilowatt (853,000 Btu/hr) Skanden boiler would meet the heat load for the Base Main Lodge, Administrative Building, Tenta and snowmelt. This boiler is 8 ft long, 4 ft wide, 8 ft high and weighs 4,400 pounds. The estimated installed cost for this boiler including automated ash removal is as follows:

Table 18. Estimated Capital Cost Of Automated Boiler To Supply The Base Main Lodge Administration Building, Tenta, and For Snowmelt

Item	Cost-$
Boiler- 853,000 Btu/hr	119,000
Multiclone	10,700
PC Connection & fuel feed	9,000
Automated ash removal	28,000
Sales tax @ 8%	13,336
Shipping	10,000
Installation	3,000
Training & startup	10,000
Electrical	2,000
Heating Units	10,000
Distribution piping	20,000
Piping to Admin Bldg.	2,700
Engineering	5,000
Subtotal	242,736
Contingency @ 5%	12,137
Total Cost	**$254,873**

As with the hand-fed boilers, without a complete engineering design, these costs are conceptual or representative of what actual costs will be. However, these costs should be within 10-20% of what would actually be incurred. A complete engineering design might also use a different manufacturer than what was assumed in this study (Appendix D – Skanden-250 kilowatt boiler).

Operating costs incurred with the boiler should also be minimal. The boiler would have to be monitored periodically, and this could probably be performed by existing SAT personnel. TSS has therefore, not assumed any additional cost for operation. However, there may be additional costs for property taxes and insurance. For these, TSS assumed $8,000/yr. Ash disposal was assumed to be $0 since it can be deposited in the normal waste disposal from SAT.

The boiler appears to be relatively maintenance free. However, there will probably be higher maintenance costs than incurred with propane heating. TSS has therefore assumed $5,000/yr. in additional maintenance costs.

To estimate the economic feasibility of converting the Main Lodge, Administration building and Tenta to the automated wood-burning boiler, TSS employed the same discounted cash flow model used in analyzing the hand-fed boilers and Large Maintenance Building with the savings from the difference in propane and wood fuel costs to heat the areas shown as revenue in the model and the costs of wood fuel shown as an expense.

The same financing was also used and the results calculated using a 5-year and a 10-year depreciation period for income taxes. The results from the model calculations are as follows:

Table 19. Model Calculations for Automated Biomass Boiler

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	34.3%	23.2%
$50/ton	31.6%	20.8%

As in the analysis of the Large Maintenance Building, TSS assumed that a 15% return on the equity portion of a private investment would be satisfactory. Assuming that this is true, installation of HTW boilers to supply heat to the Main Lodge, Administration building and Tenta, to replace the use of propane for heat would seem to be economically advantageous if a either 5-year or 10-year period was used for income tax depreciation.

The Skanden automated boiler can be operated without the automated ash removal system, which is offered as an option. This would require periodic manual removal of the ash from the boiler. When the automated ash removal system cost of $28,000 is removed, the total capital cost becomes $223,121. The results using this capital cost are:

Table 20. Model Calculations for Automated Ash Removal System Removed

Wood Fuel Cost Case	ROE Achieved – 5-yr depreciation	ROE Achieved – 10-yr depreciation
$40/ton	40.3%	28.8%
$50/ton	37.6%	26.3%

Removal of the cost of automated ash removal improves the economic results but not significantly, and may not be worth forgoing.

Addition of snowmelt capability and the additional $400,333 in capital cost to the Skanden boiler with ash removal results in the following economic returns:

Table 21. Model Calculations for Biomass Boilers and Snow Melting

Wood Fuel Cost Case	NPV Achieved – 5-yr depreciation	NPV Achieved – 10-yr depreciation
$40/ton	$-90,543	$-123,273
$50/ton	$-98,452	$-131,183

Addition of snowmelt capability to the Skanden boiler is not economical for either period of tax depreciation.

Addition of snowmelt capability might still be made economically acceptable by reducing the area of snow removal. If the 36,394 square feet were reduced to about 9,000 square feet, the NPV would approach zero for the $40/ton, 5-year depreciation case indicating a 15% ROE.

6. Environmental Review

Given the nature of the project, only air emissions are the principal environmental issue for this feasibility study. This section of the study will review the air emissions and air quality standards that may be applicable to the biomass thermal units.

6.1. Air emissions and air quality standards

The SAT project site lies within the jurisdiction of the El Dorado County Air Quality Management District (EDAQMD).

EDAQMD District Requirements

The permitting of biomass combustion units within the EDAQMD is initially dependent on two EDAQMD rules:

Rule 232.2 A. Biomass Boilers Applicability

This rule applies to boilers and steam generators with rated heat inputs of greater than or equal to 5 million BTU per hour and which have a primary energy source of biomass consisting of a minimum of 75 percent of the total annual heat input.

Rule 501.1 D. 2. Exemption, Combustion and Heat Transfer Equipment

Any combustion equipment that has a maximum heat input of less than 1,000,000 Btu per hour (gross) and is equipped to be fired exclusively with purchased quality natural gas, liquefied petroleum gas or any combination thereof. The ratings of all combustion equipment used in the same process will be accumulated to determine whether this exemption applies.

In regards to Rule 232.2 A, none of the biomass thermal units evaluated neither meet nor exceed 5 MMBtu per hours, separately or combined. Thus, this section of the EDAQMD rules does not trigger the requirement of a full permit.

In regards to Rule 501 D. 2. A representative of the EDAQMD[15] confirmed that this rule could apply to the biomass thermal units. However, the Air Pollution Control Officer (APCO – the head of the air district) has discretion on whether or not to conduct the permitting process on thermal units under 1 MMBtu/hour. Thus, the Skanden unit and the Biomass Combustion unit could require a permit if the APCO determines one is necessary. However, the EDAQMD representative said this would generally be a much

[15] Steve McKinney, Senior Air Quality Engineer

simpler permitting process that their full permitting process, as they would have the discretion in which various New Source Review rules they apply. Furthermore, given the relatively small size of the units, post construction emission source tests would not be needed (a very considerable cost savings), as the EDAQMD would rely on either vendor-supplied source test results, or rely on the U.S. Environmental Protection Agency AP-42 default emission factors for wood-fired combustion units (further discussion below).

In regards to the Econoburn (rated at 0.5 MMBtu/hour each) units being combined into a single facility, such as Econoburn units at the Lodge, Tenta, and snowmelt area, where three of the units might be used, a full permit would be required. Such a permit would be to examine all the requirements of New Source Review and Best Available Control Technology (BACT) analysis. This would add time and potential extra costs.

EDAQMD Emission Standards

In addition to the above rules regarding the potential need for permitting of the thermal units, the various emissions standards set by EDAQMD must also be considered and compared to the potential emissions from the thermal units themselves. Table 22 below outlines the three key emissions areas that one must be concerned about with the subject thermal units.

Table 22. EDAQMD Emission Standards

Major Stationary Source*		
NOx	25 TPY**	
VOC	25 TPY	
CO	100 TPY	
PM	100 TPY	
SOx	100 TPY	
Best Available Technology (BACT) Analysis ^		
NOx	10 lbs/day	1.37 TPY
VOC	10 lbs/day	1.37 TPY
CO	550 lbs/day	100 TPY
PM	80 lbs/day	14.6 TPY
SOx	55 lbs/day	10 TPY
Offset Requirement^^		
NOx	5,000 lbs/quarter	10 TPY
VOC	5,000 lbs/quarter	10 TPY
CO	7,500 lbs/quarter	15 TPY

PM	7,500 lbs/quarter	15 TPY
SOx	12,500 Lbs/quarter	25 TPY

** as defined in EDAQMD Rule 101.2*

***Tons Per Year*

^per EDAQMD Rule 523.3 A

^^per EDAQMD Rule 523.3 B

The numerical standards in Table 22 can then be compared to the emission values calculated from the size of the thermal units, their potential usage per year (in MMBtu/year and projected hours on-line, and emission factors supplied by either the vendors or taken from Tables 1.6-1 and 1.6-2 of the EPA' s AP-42, Compilation of Emission Factors. Only Nitrogen Oxides (NOx), Particulate Matter (PM), and Carbon Monoxide (CO) are included below as Sulfur Oxides (SOx), and Volatile Organic Compounds (VOC) would be extremely low in all three of the units based on the AP-42 default values.

Table 23. Thermal Units Potential Emission Calculations

Vendors	Vendor Source Test Emission Factors (lbs/MMBTU)	Pounds per year	Tons per year	EPA AP-42 Emission Factors	Pounds per year	Tons per year
Biomass Combustion Systems, Inc.						
500,000 Btu/hour						
Large Maintenance Building						
1570 MMBtu/yr						
3140 hours/year						
NOx	0.05	78.5	0.04	0.22	345.4	0.17
PM	0.086	135.02	0.07	0.56	879.2	0.44
CO	N/A*			0.6	942	0.47
Skanden						
All buildings and snowmelt						
853,000 Btu/hour						
5080 MMBtu/year						
5955 hours/year						
NOx	0.128	650.24	0.33	0.22	1117.6	0.56
PM	0.014	71.12	0.04	0.56	2844.8	1.42
CO	0.024	121.92	0.06	0.6	3048	1.52

Vendors	Vendor Source Test Emission Factors (lbs/MMBTU)	Pounds per year	Tons per year	EPA AP-42 Emission Factors	Pounds per year	Tons per year
Econoburn						
All buildings and snowmelt						
3 X 500,000 Btu/hour						
5080 MMBtu/year						
5955 hours/year						
NOx	0.13	660.4	0.33	0.22	1117.6	0.56
PM	N/A			0.56	2844.8	1.42
CO	N/A			0.6	3048	1.52

** N/A - Not available from vendor*

As can be seen in the comparison of the EDAQMD standards for being a major air pollutant source, needing full BACT analyses, or needing emission offsets, none of the units appear to exceed the tons per year thresholds shown in Table 22, whether vendor supplied or AP-42 supplied emission factors. Nor does it appear that they would exceed the daily thresholds of needing full BACT analyses, or the quarterly thresholds for needing emission offsets. Thus, if permitting is required by the APCO is should be fairly simple. However, the EDAQMD representative did state an air application for whatever thermal units are to be ultimately used must be submitted so that the EDAQMD can determine even if permits are needed or not.

Other Permit Considerations

The EDAQMD representative also noted that SAT has several emergency backup diesel-fired generator, necessary for continued operations of the facility's ski lifts in the event of an electric power outage. If a permit application is submitted for any of the thermal units, the EDAQMD will have to consider the potential emissions from the diesel units and add the biomass thermal unit emission to determine a total emission profile. If this total exceeds any of the Major Source thresholds, then the SAT facility would have to file for Title V air quality permit for the entire facility. This would be more of a paperwork burden for the SAT facility in meeting its air quality compliance obligations to the EDAQMD.

7. Findings and Recommendations

7.1. Findings

The results of this feasibility study are as follows:

- The quantity of biomass required to replace propane in heating the existing Large Maintenance Building, the Base Main Lodge, Administration Building, the proposed Tenta structure and for snowmelt has been estimated for average and estimated maximum snowfall years. The maximum annual biomass required to heat all structures and for snow removal is 374 BDT
- There is a sufficient quantity of biomass (wood fuel) in the Lake Tahoe area to supply the needs of SAT for a period of 20 years at an un-escalated price of $40-50/BDT delivered to SAT.
- Conversion of the Large Maintenance Building to heating with wood promises large savings in heating costs and provides a very high return on the capital invested to convert. Conversion is economically advantageous for either a 5-year or 10-year tax depreciation period.
- Using manually fuel-fed boilers, heating the Base Main Lodge, Administration building and proposed Tenta with wood fuel is also economically advantageous. The expected returns on invested capital are not as high as for the Large Maintenance Building but still far above what is considered an acceptable return
- Addition of snowmelt removal using wood fuel requires a large additional capital outlay to install high temperature heating tubes in the snowmelt area. Since propane fuel is not currently used to remove snow, there is no additional savings from substituting wood fuel for propane to remove snow. For the hand-fed boilers, snowmelt results in a negative net present value (NPV) indicating a return on equity less than the hurdle rate of 15%. Addition of snowmelt capability for the entire 36,394 square feet of snowmelt area is therefore nor economical. However, if the snowmelt area is reduced to 20-24,000 square feet, addition of snowmelt capability becomes just economical.
- Using an automated fuel feed and ash removal boiler instead of manual fed boilers increases the capital cost considerably. However, heating the Base Main Lodge, Administration building and proposed Tenta with wood fuel is still economically advantageous with an automated boiler but a lower return on investment is realized than for the hand-fed boilers. Addition of snowmelt capability for the entire 36,394 square feet of snowmelt area results in a large negative NPV indicating a return on investment well below the assumed hurdle rate of 15%. However, if the snowmelt area is reduced to approximately 9,000 square feet, the NPV would approach zero, indicting a 15% return on equity investment.

- For the economics of converting to wood fuel, all of the cases depend heavily on the ability to realize the benefits of income tax depreciation. Since the project does not generate sufficient tax liability to use all of the tax depreciation, advantageous project economics depend on being able to use the tax depreciation to reduce income tax liability from other SAT operations.
- Conversion of the Large Maintenance Building to wood heat would require an equity investment of about $9,000; conversion of the Main Base Lodge, Administrative Building, and Tenta to wood heat using a manually fuel-fed boiler would require an equity investment of about $27,000. Use of an automated boiler instead of manually fed boilers would require an equity investment of about $64,000. Adding snowmelt capability would require an additional equity investment of about $100,000. All of these equity investments represent 25% of the total capital required and assume that the remaining 75% could be borrowed at an interest rate of 8%.
- Based on the fuel availability analysis, it is estimated that there are approximately 7,568 BDT per year of biomass fuel economically available for the project. Assuming that SAT biomass thermal units utilize 374 BDT of biomass fuel annually, then a 20.2:1 fuel cover ratio exists. Fuel coverage ratio represents the net availability of fuel relative to new demand (e.g., SAT facility) in the marketplace. The higher the fuel coverage ratio, the more fuel is forecast to be available. Private financial markets and project developers prefer a fuel coverage ratio ranging from at least 2:1 to 3:1. Thus, given the current fuel coverage ratio for SAT biomass project, more than adequate biomass fuel resources would be available.
- Any of the thermal units appear to be permittable by the EL Dorado Air Quality Management District at the facility.

7.2. Recommendations

Based on the results of this study, TSS has the following recommendations:

- TSS recommends that SAT should convert from heating with propane to heating with wood fuel.
- In the choice between manually fuel-fed boilers for the Main Base Lodge, Administration Building, and Tenta area, SAT should evaluate which mode of operation best fits its needs. If the manually fed boilers are acceptable, they should be used since they provide a higher return on invested capital. If manually fuel-fed boilers are not acceptable operationally, then install the automated boiler.
- Addition of snowmelt capability can be incorporated but only if the snowmelt area is substantially reduced.

Appendix A: Letter Report Dated May 12, 2009

May 12, 2009

Mr. Andrew Bray
Director of Mountain Operations
Sierra at Tahoe, Inc.
1111 Sierra at Tahoe Road
Twin Bridges, CA 95735

RE: Potential for Bioenergy Project at Sierra at Tahoe Ski Resort

Dear Mr. Bray:

TSS Consultants (TSS) was retained by the High Sierra Resource Conservation and Development Council to perform a first stage preliminary study of the potential for a bioenergy project to be located at the Sierra at Tahoe Ski Resort (Resort). The project would utilize local and sustainable woody biomass to potentially generate electricity and/or heat to supply the energy needs of the Resort and sell excess electricity into the public electrical grid.

TSS has reviewed the information, requested by TSS, and provided by the Resort including electric and thermal use for 2007 and 2008 and plot plans of your existing buildings and future building plans. Based on this information, TSS has performed a preliminary analysis of the feasibility of installation of an electric generating unit at the Resort utilizing forest residue and other types of wood as fuel for the power plant. Alternatively, TSS has also analyzed the installation of biomass furnaces to supply only the Resort's thermal needs in lieu of use of the propane that is currently be used to meet thermal needs. The following sections discuss these two alternatives for the implementation of bioenergy at the Resort.

A Combined Heat Power (CHP) Unit at the Resort

The ability to utilize residual heat from a biomass electric generating facility has a significant impact on the cost of the electricity generated and therefore the economic feasibility of implementation of a CHP unit. If a large percentage of the residual heat can be utilized, installation of a CHP unit is usually economically feasible. Conversely, if only a small portion of the heat is usable, installation of CHP is usually not feasible. To deliver the heat to its point of use, additional capital must be invested and this reduces the economic feasibility and can offset the gain from use of the heat, particularly when the heat load is located a considerable distance from the CHP unit and/or when existing buildings must be converted from their present heating system to a system that can utilize the heat from the CHP unit. If part of the heat load is for snow removal, heat tubes must be installed in sidewalks, parking lots and other paved areas. If the snow removal tubes must be installed in existing concrete or asphalt, the additional capital cost increases substantially.

The smallest biomass fueled CHP unit that might be economically feasible is on the order of 1-1.5 Mw gross electrical output. This size of CHP unit generates residual heat of approximately 160,000 MMBtu/yr. when the unit is operated at a capacity factor of 90% (7,884 hrs/yr). TSS has calculated the Resort heat use for both the main lodge and the shops at about 3,400 MMBtu/yr. The heat load for the current Resort is therefore only about 2% of the residual heat available from the CHP unit. Adding heat that will be required in your proposed "Tenta" structure and heat that could be used to remove snow from the proposed plaza area would increase the heat load. TSS does not know with any precision how much this would be but assuming that it was the same as the lodge, the load would increase to about 5,000 MMBtu/yr or only about 3% of the heat available. Typically, CHP units become feasible when 60-70% of the residual heat can be utilized. The Resort's electrical load is not critical because whatever is not used at the resort can be sold into the public electrical grid.

To illustrate the economic feasibility of a CHP unit at the Resort TSS utilized its CHP financial model to calculate the price that electricity generated by the unit would have to be sold to make the CHP unit feasible. Since the method used to finance the unit is unknown at this time, TSS assumed two financing scenarios. One scenario would be with private financing and assuming that 25% of the capital cost would be equity at a cost of 15%/yr and the remaining 75% would be debt at a cost of 8%/yr. This scenario would also receive a 30% Investment Tax Credit to offset federal income taxes. The second scenario would be with a federal loan equal to the capital cost of the unit, with a zero rate of interest. In both cases, the cost of biomass fuel was assumed to be $35 per bone dry ton (which may be on the low side if only forest-sourced biomass if used) and the value of the heat replaced (currently provided with propane at a price of $1.33/gal) by using residual heat was assumed to be $19/MMbtu. The prices of electricity that would have to be received from an electric utility to enter the public electrical grid are:

Private Financing	24.5 ¢/kwhr
Federal Grant	11.5 ¢/kwhr

The highest price that the Resort would likely receive from the sale of electricity from the CHP would the "Feed-In Tariff" which has been authorized by the California Public Utilities Commission in December 2008. This tariff requires some California utilities (including PG&E, the likely utility to buy any Resort generated electricity) to pay biomass facilities of up to 1.5 MW in size, a price called the Market Price Referent or MPR. The published MPR prices for a unit beginning operation in 2010 are about 10.2 ¢/kwhr for a 10 year contract, 10.7 ¢/kwhr for a 15 year contract, and 11.4 ¢/kwhr for a 20 year contract. This would make a CHP unit at the Resort marginally economically feasible if the unit could be completely financed with a federal grant and not economically feasible if the project had to use private financing.

<u>Biomass-Burning Furnaces to Replace Propane Heat</u>

The Resort is currently using propane for heating the lodge, two maintenance buildings and an administration building. The current cost of the propane is $1.33/gallon. A gallon of propane contains a standard 71,000 BTUs This translates into a cost $18.80 per million BTU. The cost of wood fuel in the Tahoe area is assumed to be $35-$45/ton. The heating value of wood is approximately 8,500 BTU/lb. This translates into a cost per million BTU of $2.00-$2.60. This large cost differential warrants investigation of the use of wood fuel to replace the current use of propane for heating.

Whether it would be economically feasible to replace the current propane heating system with a wood-burning system depends on a number of factors. Key factors are the capital cost of purchasing the wood-burning equipment, the ability and cost to convert existing heating systems to a wood-burning system, and the likelihood of the current differential cost between propane and wood continuing into the future. Potential permitting issues may also be a factor but were not examined in this brief study.

A cursory look at the Resort plot plan indicates that wood-burning shop heaters would be required for each of the buildings. Two large units for the existing lodge and planned "Tenta" structure, a medium size unit for one of the maintenance buildings and small units for the second maintenance building and the administration building would probably be required. A rough estimate of the capital cost of these units is as follows:

Size	Output	Cost*	Ship/Taxes	Installation	Total Cost
Large	800,000 Btu/hr	$20,900	$2,600	$2,000	$25,500
Large	800,000 Btu/hr	$20,900	$2,600	$2,000	$25,500
Medium	450,000 Btu/hr	$14,500	$2,100	$1,500	$18,100
Small	250,000 Btu/hr	$9,000	$1,450	$1,000	$11,450
Small	250,000 Btu/hr	$9,000	$1,450	$1,000	$11,450
Total					**$92,000**

**cost quote from typical unit manufacturer.*

These costs are an order of magnitude and not precise estimates based on engineering studies. The bare capital costs are from a heater manufacturer but the other costs are more rough estimates. In addition, the heater unit sizes have not been precisely matched to the building loads, but based on inspection of the building plot plans supplied to TSS by the Resort and the past use of propane from the lodge tank and the shop tanks. Conversion costs from the existing heating systems to a wood-fueled system are not known and are not included in the above costs.

To estimate the feasibility of converting to wood-burning heating units, TSS employed another TSS developed discounted cash flow model. This model uses the difference in fuel costs (in this case between wood and propane) and compares this savings with the additional costs of installing and operating the wood-fired heating units. In addition to the above capital costs there would also be costs to convert the existing heating units to the wood-fired units, heater conversion costs, wood handling and storage, wood delivery costs, and operation and maintenance costs associated with the wood-fired heating units but not with the current use of propane. We do not have firm estimates of these additional costs but have rather arbitrarily assumed the following:

Capital Costs	$
Heating Units	92,000
Heater Conversion	40,000
Wood Handling & Storage	25,000
Total	**147,000**
Operating Costs	**$/yr**
Labor	25,000
Maintenance	15,000
Fuel Delivery	15,000
Ash Disposal	464
Total	**57,964**

We have assumed private financing with 25% equity requiring at least a 15% return (ROE) and 75% debt at a cost of 8%. TSS has shown the results assuming that the project would be eligible for a 30% investment tax credit (ITC) under the American Recovery and Reinvestment Act of 2009 (H.R. 1), and results if it were not eligible. Receipt of the 30% ITC has a substantial impact on the ROE achieved. The results from the model calculations are as follows:

Wood Fuel Cost Case	ROE Achieved – 30% ITC	ROE Achieved – 0% ITC
$35/ton	76.5%	23.5%
$45/ton	72.7%	20.9%

TSS assumed that a 15% return on the equity portion of a private investment would be satisfactory to investors. Assuming that this is true, installation of wood-burning heaters to replace the use of propane for heat would seem to be economically advantageous even if the 30% investment tax credit were not allowed on the project. However, as previously stated many of these estimated costs are not definitive and could change with a more detailed analysis. The discounted cash flow model covers a period of twenty years and it was assumed that wood fuel could be obtained at an initial cost of $35-45/ton with deliveries for twenty years and with the price escalated at a rate no higher than propane and other fossil fuels.

<u>Recommendations for Further Study</u>

- A heat only system at the Resort appears to economically based on the evaluation and its assumptions above. A more complete analysis of wood fuel availability and costs is recommended.

- Additional work to determine more precise costs of operation and maintenance (O&M) and other capital costs beside the biomass burning furnace capital costs is recommended

- Further analysis of the fuel cost difference between propane and wood should be carried out to determine the probability of the cost differential remaining in the future.

- CHP could still be determined to be economically feasible if the Resort was willing to take on the challenge of operating (possibly just owning and contracting out the operations). There are emerging vendors attempting to fill the small unit market. However, air quality district regulations are extremely stringent and as such would require additional research and evaluation regarding the siting of such a unit at the Resort.

TSS is available to carry out the recommendations described above. Please let us know. I can be reached via phone @ 916.638.8811 x104 or by email @ fatoxic@tssconsultants.com.

Respectfully yours,

Frederick Tornatore
Director of Environmental Technology and Services
TSS CONSULTANTS

&

David Augustine
Senior Associate
TSS CONSULTANTS

CC: Kay Joy Barge
High Sierra Resource Conservation and Development Council

Appendix B: Heat Loads and Biomass Fuel Quantity Calculations

Summary

ESTIMATED BIOMASS REQUIRED FOR SIERRA AT TAHOE RESORT - IN BONE DRY TONS					
Month	Large Maint. Bldg	Lodge & Admin	Tenta	Snowmelt*	Total
Jan	16	18	10	11	55
Feb	13	14	8	8	43
Mar	14	15	9	9	47
April	10	11	7	7	35
May	8	8	5	5	26
June	0	0	0	0	0
July	0	0	0	0	0
August	0	0	0	0	0
Sept	0	0	0	0	0
Oct	5	6	3	4	19
Nov	9	10	6	6	31
Dec.	17	19	11	11	58
Total	**92**	**101**	**59**	**60**	**313**

*** Average snowfall @ 300 inches per year**

ESTIMATED BIOMASS REQUIRED FOR SIERRA AT TAHOE RESORT - IN BONE DRY TONS					
Month	Large Maint. Bldg	Lodge & Admin	Tenta	Snowmelt*	Total
Jan	16	18	10	22	66
Feb	13	14	8	17	52
Mar	14	15	9	18	56
April	10	11	7	13	42
May	8	8	5	10	30
June	0	0	0	0	0
July	0	0	0	0	0
August	0	0	0	0	0
Sept	0	0	0	0	0
Oct	5	6	3	7	22
Nov	9	10	6	12	37
Dec.	17	19	11	22	69
Total	**92**	**101**	**59**	**121**	**374**

*** Average snowfall @ 600 inches per year**

ESTIMATED HEAT REQUIRED FOR SIERRA AT TAHOE RESORT - IN MMBTU					
Month	Large Maint. Bldg	Lodge & Admin	Tenta	Snowmelt*	Total***
Jan	276	302	177	185	663
Feb	216	236	139	144	518
Mar	234	256	150	154	560
April	178	195	114	113	422
May	129	141	83	82	306
June	0	0	0	0	0
July	0	0	0	0	0
August	0	0	0	0	0
Sept	0	0	0	0	0
Oct	92	101	59	62	222
Nov	155	170	99	103	372
Dec.	291	320	187	185	691
Total	**1,570**	**1,721**	**1,009**	**1,025**	**3,755**

***Average snowfall year-300 Inches**

****Includes Base Main Lodge, Administration Bldg. and Tenta**

*****Includes Base Main Lodge, Administration Bldg. Tenta, and snowmelt area**

ESTIMATED BIOMASS USE FOR HEATING LARGE MAINTENANCE BUILDING, MAIN BASE LODGE & ADMIN

Seasonality Heating Load-Tahoe Area*		
Month	Use	%
Jan	29,166	17.5%
Feb	22,833	13.7%
Mar	24,730	14.9%
April	18,822	11.3%
May	13,634	8.2%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	22	0.0%
Oct	9,790	5.9%
Nov	16,400	9.9%
Dec.	30,857	18.6%
Total	**166,254**	**100.0%**

*Based on boiler use at South Tahoe High School-Therms 2002

Monthly Use For Large Maintenance Building-MMBtu*		
Month	Use	%
Jan	234	17.5%
Feb	183	13.7%
Mar	199	14.9%
April	151	11.3%
May	109	8.2%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	0	0.0%
Oct	79	5.9%
Nov	132	9.9%
Dec.	248	18.6%
Total	**1,335**	**100.0%**

*MMBtu-Based on total propane use from shop tanks-3/4 for large maintenance building assumed. Thirteen month use reduced by 4% to provide 12 months usage

Monthly Use For Main Base Lodge & Admin Bldg-MMBtu*		
Month	Use	%
Jan	257	17.5%
Feb	201	13.7%
Mar	218	14.9%
April	166	11.3%
May	120	8.2%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	0	0.0%
Oct	86	5.9%
Nov	144	9.9%
Dec.	272	18.6%
Total	**1,463**	**100.0%**

*MMBtu-Based on total propane use from lodge tank Thirteen month use reduced by 4% to provide 12 months usage.

Estimated Biomass Required to Heat Large Maintenance Building				
Month	**Propane Heat**	**Eff. Adj.***	**Biomass Heat**	**BDT****
Jan	234	0.85	276	16
Feb	183	0.85	216	13
Mar	199	0.85	234	14
April	151	0.85	178	10
May	109	0.85	129	8
June	0	0.85	0	0
July	0	0.85	0	0
August	0	0.85	0	0
Sept	0	0.85	0	0
Oct	79	0.85	92	5
Nov	132	0.85	155	9
Dec.	248	0.85	291	17
Total	**1,335**		**1,570**	**92**

*Estimated efficiency difference between propane heaters and biomass heaters. Biomass heater 15% less efficient than propane.
**Assumes HHV of biomass fuel equal to 8500 Btu/lb.

Estimated Biomass Required to Heat Main Base Lodge				
Month	**Propane Heat**	**Eff. Adj.***	**Biomass Heat**	**BDT****
Jan	257	0.85	302	18
Feb	201	0.85	236	14
Mar	218	0.85	256	15
April	166	0.85	195	11
May	120	0.85	141	8
June	0	0.85	0	0
July	0	0.85	0	0
August	0	0.85	0	0
Sept	0	0.85	0	0
Oct	86	0.85	101	6
Nov	144	0.85	170	10
Dec.	272	0.85	320	19
Total	**1,463**		**1,721**	**101**

*Estimated efficiency difference between propane heaters and biomass heaters. Biomass heater 15% less efficient than propane.
**Assumes HHV of biomass fuel equal to 8500 Btu/lb.

SNOWMELT AREA MEASURED FROM DRAWING-TENTA STRUCTURE

Scale: 14mm = 80 feet

	14	80

Area 1

	Length	Width	Area sq.ft.
mm	20	32	
feet	114	183	20,898

Tenta

mm	9	27	
inches	51	151	7,788
Net Area 1			**13,110**

Area 2

mm	17	14	
feet	94	77	7,273

Plus 2b

mm	3	14	
feet	17	77	661

Minus 2a

mm	7	9	
feet	40	51	1,029
Net Area 2			**6,906**

Area 3

mm	15	4	
feet	86	23	**1,959**

Area 4

mm	18	12	
feet	103	69	**7,053**

Area 5

	Length	Width	Area sq. ft.
mm	7	3	
feet	37	17	**637**

Area 6

mm	14	14	
feet	80	80	**3,200**

Area 7

mm	3	10	
feet	17	57	**490**

Area 8

	Radius	Circle area	Adjust	
mm	6			
feet	34	3,691	0	**923**

Area 9

mm	6			
feet	34	3,691	0	**1,218**

Area 10

	Length	Width	
mm	11	5	
feet	63	29	**898**

TOTAL ESTIMATED AREA FOR SNOWMELT					
Area 1				13,110	sq. ft.
Area 2				6,906	
Area 3				1,959	
Area 4				7,053	
Area 5				637	
Area 6				3,200	
Area 7				490	
Area 8				923	
Area 9				1,218	
Area 10				898	
Total area				**36,394**	sq. ft.

ESTIMATED HEAT FOR SNOWMELT-AVERAGE YEAR

Snow Load Assumptions			
			Lake Tahoe Area Facts & Statistics
Average annual snowfall at Sierra Tahoe	300	in	www.virtualtahoe.com
Average rate of snowfall during storm	2	in/hr	http://irc.nrc-cnrc.gc.ca/bpubs
Heat required to melt snowfall	44	watts/ft^2	http://irc.nrc-cnrc.gc.ca/bpubs
Hours of snow falling	150	hr/yr	(annual snowfall)/(rate of snowfall)
Heat Required per year	6600	watts/ft^2	(hrs snow falling)(heat required to melt snow)
Btus required per square foot/year	22539	Btus/ft^2/yr	(watts)(3.415 Btu/watt)
Estimated snowmelt area	36,394	sq. ft.	
Btus/sq. ft./year	22539		
Heat required per year	820,282,121	Btus	
Biomass heating value	8500	Btu/lb	
Net biomass required	48	BDT/yr	
HTW Boiler efficiency & line loss	80	%	
Gross biomass required	60	BDT/yr	

MONTHLY BIOMASS REQUIRED FOR SNOWMELT-AVERAGE YEAR

Monthly Biomass Use For Snowmelt-BDT

Month	Use	%
Jan	11	18.0%
Feb	8	14.0%
Mar	9	15.0%
April	7	11.0%
May	5	8.0%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	0	0.0%
Oct	4	6.0%
Nov	6	10.0%
Dec.	11	18.0%
Total	**60**	**100.0%**

Monthly Heat Use For Snowmelt-MMBtu

Month	Use	%
Jan	185	18.0%
Feb	144	14.0%
Mar	154	15.0%
April	113	11.0%
May	82	8.0%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	0	0.0%
Oct	62	6.0%
Nov	103	10.0%
Dec.	185	18.0%
Total	**1025**	**100.0%**

SNOWFALL AT DONNER SUMMIT*

Estimated Average-1990-2005-Max. 1995

Month	%	Ave. in	Max in.
Jan	18%	54	108
Feb	14%	42	84
Mar	15%	45	90
April	11%	33	66
May	8%	24	48
June	0%	0	0
July	0%	0	0
August	0%	0	0
Sept	0%	0	0
Oct	6%	18	36
Nov	10%	30	60
Dec.	18%	54	108
Total	**100%**	**300**	**600**

ESTIMATED HEAT FOR SNOWMELT-MAXIMUM YEAR

Snow Load Assumptions		
Maximum annual snowfall at Sierra Tahoe	600	in
Average rate of snowfall during storm	2	in/hr
Heat required to melt snowfall	44	$watts/ft^2$
Hours of snow falling	300	hr/yr
Heat Required per year	13200	$watts/ft^2$
Btus required per square foot/year	45078	$Btus/ft^2/yr$
Estimated snowmelt area	36,394	sq. ft.
Btus/sq. ft./year	45078	
Heat required per year	1,640,564,243	Btus
Biomass heating value	8500	Btu/lb
Biomass required	97	BDT/yr
HTW Boiler efficiency & line loss	80	%
Gross biomass required	121	BDT/yr

MONTHLY BIOMASS REQUIRED FOR SNOWMELT-MAXIMUM YEAR

Monthly Biomass Use For Snowmelt-BDT

Month	Use	%
Jan	22	18.0%
Feb	17	14.0%
Mar	18	15.0%
April	13	11.0%
May	10	8.0%
June	0	0.0%
July	0	0.0%
August	0	0.0%
Sept	0	0.0%
Oct	7	6.0%
Nov	12	10.0%
Dec.	22	18.0%
Total	121	100.0%

MAIN BASE LODGE AREA MEASURED FROM DRAWING-MAIN BASE LODGE

Scale: 14mm = 80 feet

	14	80	

Area 1

	Length	Width	Area sq.ft.
mm	33	10	
feet	189	57	10,776

Area 2 (triangle)

mm	19	8	
feet	109	46	2,482

Area 3

mm	19	11	
feet	109	63	6,824

TOTAL ESTIMATED AREA FOR MAIN BASE LODGE					
Area 1				10776	sq. ft.
Area 2				2482	
Area 3				6824	
Area 1 story				20,082	sq. ft.
No. Stories				1.5	
Total Area				**30122**	sq. ft.
Ratio of Areas: Tenta to Main Lodge				25%	

Area of Tenta

Length:	150	ft
Width:	50	ft
Area:	7,500	sq ft

Ratio:

Tenta	7500
Main Ldg	30122
Ratio	25%

Tenta Peak Heat Loads (per Capital Engineering Consultants, Inc.)

Lockers, Food Prep	272,000	Btu/hr
Rental/Demo	68,000	
Restrooms	16,000	
Domestic Hot Water	64,000	
Total	420,000	Btu/hr

Tenta Average Loads

Percent peak 16 hrs	40%	
Percent peak 8 hrs	100%	
Average Use	252,000	Btu/hr

Averag Use Main Lodge & Admin Bldg

December Use	320,000,000	Btu
December Hours	744	hrs
Average Use	430,108	Btu/hr

Ratio: Tenta/Lodge **59%**

ESTIMATED CAPITAL COSTS-BIOMASS CONVERSION-SIERRA AT TAHOE

Large Maintenance Building			
Capital Costs		**Cost**	
Heater-500,000 Btu/hr		$14,500	Biomass Combustion System; W-50 in, L-82 in,
Sales Tax @ 8%		$1,160	H-87 in.; Weight-4,300 lbs.
Shipping		$1,500	
Concrete pad		$3,000	
Ducting		$2,000	
Electrical		$2,000	
Enclosure		$3,000	
Fuel storage		$5,000	
Engineering		$3,000	
Subtotal		$35,160	
Contingency @ 5%		$1,758	
Total Cost		**$36,918**	All labor included

O&M Costs			
Operators		$0	Assumes maintenance personnel will
Maintenance		$1,000	operate heater
Property tx & ins.		$4,000	
Wood fuel			See DCF Spreadsheet
Total		**$5,000**	

Revenue/Savings			
Propane heat		1335	MMBtu/yr
Propane cost		18.8	$/MMBtu
Propane Savings		**$25,096**	per yr.

Base Main Lodge, Admin Bldg., Tenta-3 Econoburn Boilers					
Capital Costs	**Number**	**Unit Cost**		**Total Cost**	
Boilers-500,000 Btu/hr	3	$14,000		$42,000	Econoburn-Dale Furman-716-785-2873
Sales Tax @ 8%	0.08			$3,360	
Shipping	3	$1,500		$4,500	
Concrete pads	3	$3,000		$9,000	
Ducting	3	$4,000		$12,000	
Electrical	3	$2,000		$6,000	
Enclosure	3	$5,000		$15,000	
Heating units	20	$500		$10,000	
Distribution piping	1000	$20		$20,000	Within main lodge, Tenta, & snowmelt area
Piping to Admin Bldg	90	$30		$2,700	
Engineering		$10,000		$10,000	
Subtotal				$134,560	
Contingency @ 5%				$6,728	
Total Cost				**$141,288**	

Snowmelt Area					
Snowmelt piping	36,394	11		**$400,333**	Unit cost from Alpine Plumbing & Construc.
					John Martin 760-934-6432

O&M Costs-3 Boilers			
Operators		$0	Assumes existing personnel will operate boilers
Maintenance		$5,000	
Property tx & ins.		$6,000	
Wood fuel			See DCF Spreadsheet
Total		**$11,000**	

Revenue/Savings			
Propane heat		#REF!	MMBtu/yr
Propane cost		18.8	$/MMBtu
Propane Savings		**#REF!**	per yr.

One boiler Horsepower = 33,520 Btu/hr

Base Main Lodge, Admin Bldg., Tenta-2 Econoburn Boilers				
Capital Costs	**Number**	**Unit Cost**		**Total Cost**
Boilers-500,000 Btu/hr	2	$14,000		$28,000
Sales Tax @ 8%	0.08			$2,240
Shipping	2	$1,500		$3,000
Concrete pads	2	$3,000		$6,000
Ducting	2	$4,000		$8,000
Electrical	2	$2,000		$4,000
Enclosure	2	$5,000		$10,000
Heating units	20	$500		$10,000
Distribution piping	1000	$20		$20,000
Piping to Admin Bldg	90	$30		$2,700
Engineering		$10,000		$10,000
Subtotal				$103,940
Contingency @ 5%				$5,197
Total Cost				**$109,137**

O&M Costs-2 Boilers		
Operators		$0
Maintenance		$4,000
Property tx & ins.		$3,500
Wood fuel		
Total		**$7,500**

Base Main Lodge, Admin Bldg., Tenta-1 Skanden Boiler					
Capital Costs	**Number**	**Unit Cost**		**Total Cost**	
Boiler-853,000 Btu/hr	1	$119,000		$119,000	Quote from Skanden
Sales Tax @ 8%	0.08			$9,520	
Shipping	1	$10,000		$10,000	Estimate from Skanden
Multiclone	1	$10,700		$10,700	Quote from Skanden
PC Connection & fuel feed	1	$9,000		$9,000	Quote from Skanden
Auto ash removal	1	$28,000		$28,000	Quote from Skanden
Sales Tax @ 8%	0.08			$3,816	
Installation	1	$3,000		$3,000	
Training & startup	1	$10,000		$10,000	Quote from Skanden
Electrical	1	$2,000		$2,000	
Heating units	20	$500		$10,000	
Distribution piping	1000	$20		$20,000	
Piping to Admin Bldg	90	$30		$2,700	
Engineering		$5,000		$5,000	
Subtotal				$242,736	
Contingency @ 5%				$12,137	
Total Cost				**$254,873**	

O&M Costs-1 Skanden Boiler		
Operators		$0
Maintenance		$5,000
Property tx & ins.		$8,000
Wood fuel		
Total		**$13,000**

Appendix C: Financial Analysis Spreadsheets

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Large Maintenance Building Heated

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	117.8%
NPV of Cash Flow	41573

Fuel Cost - Base Year ($/ton)	40

Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	36,918

Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	1,335
Annual Heat Revenue - $	25,098

Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	1,571
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	92
Annual Fuel Cost - $	3,696
Ash Created - %	5%
Ash Created - Tons	5
Ash Disposal Cost - $/Ton	30

Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	1,000
Insurance/Property Tax ($/y)	4,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	5,000

Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	36,918
Salvage Value (%)	2
Total Equity Invested ($)	9,230
Total Debt Invested ($)	27,689
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	2,820
Debt Reserve ($)	2,820

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	27,689	2,820	2215	605
2	27,083	2,820	2167	653
3	26,430	2,820	2114	706
4	25,724	2,820	2058	762
5	24,962	2,820	1997	823
6	24,139	2,820	1931	889
7	23,250	2,820	1860	960
8	22,290	2,820	1783	1,037
9	21,253	2,820	1700	1,120
10	20,133	2,820	1611	1,210
11	18,923	2,820	1514	1,306
12	17,617	2,820	1409	1,411
13	16,206	2,820	1297	1,524
14	14,683	2,820	1175	1,646
15	13,037	2,820	1043	1,777
16	11,260	2,820	901	1,919
17	9,341	2,820	747	2,073
18	7,268	2,820	581	2,239
19	5,029	2,820	402	2,418
20	2,611	2,820	209	2,611

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Expenses											
Fuel		3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696
Other Operating Expenses		5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Total Expense		8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696
Operating Cash Flow		16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402
Income Tax											
Debt Interest		2,215	2,167	2,114	2,058	1,997	1,931	1,860	1,783	1,700	1,611
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		7,384	11,814	7,088	4,253	4,253	2,126				
MACRS-10		0	0	0	0	0	0	0	0	0	0
Taxable Income		6,804	2,422	7,200	10,092	10,153	12,345	14,543	14,619	14,702	14,792
Federal Tax		2,449	637	2,508	3,384	3,306	4,093	4,809	4,760	4,788	4,817
State Tax		653	233	691	969	975	1,185	1,396	1,403	1,411	1,420
Investment Tax Credit		0									
Total Income Tax		3,103	869	3,199	4,353	4,281	5,278	6,205	6,164	6,199	6,237
Debt Payment		2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820
Owner's Equity	-9,230										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-9,230										
Cash Flow	-9,230	10,480	12,713	10,383	9,229	9,302	8,304	7,378	7,419	7,383	7,345
IRR	117.8%										
NPV	41,573										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Expenses										
Fuel	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696
Other Operating Expenses	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Total Expense	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696
Operating Cash Flow	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402
Income Tax										
Debt Interest	1,514	1,409	1,297	1,175	1,043	901	747	581	402	209
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	0									
Taxable Income	14,889	14,993	15,106	15,228	15,360	15,502	15,655	15,821	16,000	16,194
Federal Tax	4,849	4,883	4,920	4,960	5,003	5,050	5,100	5,155	5,213	5,277
State Tax	1,429	1,439	1,450	1,462	1,475	1,488	1,503	1,519	1,536	1,555
Investment Tax Credit										
Total Income Tax	6,278	6,322	6,370	6,422	6,478	6,538	6,603	6,673	6,749	6,831
Debt Payment	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820
Owner's Equity										
Debt Reserve										
Return of Debt Reserve										0
Debt Outlay (No cost financing only)										
Salvage Value Recovered										738
Total Owner's Capital										
Cash Flow	7,304	7,260	7,212	7,161	7,105	7,044	6,979	6,909	6,833	7,489

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 10-yr Depreciation
Case: Large Maintenance Building Heated

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	101.4%
NPV of Cash Flow	39646

Fuel Cost - Base Year ($/ton)	40

Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	36,918

Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	1,335
Annual Heat Revenue - $	25,098

Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	1,571
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	92
Annual Fuel Cost - $	3,696
Ash Created - %	5%
Ash Created - Tons	5
Ash Disposal Cost - $/Ton	30

Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	1,000
Insurance/Property Tax ($/y)	4,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	5,000

Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	36,918
Salvage Value (%)	2
Total Equity Invested ($)	9,230
Total Debt Invested ($)	27,689
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	2,820
Debt Reserve ($)	2,820

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	27,689	2,820	2215	605
2	27,083	2,820	2167	653
3	26,430	2,820	2114	706
4	25,724	2,820	2058	762
5	24,962	2,820	1997	823
6	24,139	2,820	1931	889
7	23,250	2,820	1860	960
8	22,290	2,820	1783	1,037
9	21,253	2,820	1700	1,120
10	20,133	2,820	1611	1,210
11	18,923	2,820	1514	1,306
12	17,617	2,820	1409	1,411
13	16,206	2,820	1297	1,524
14	14,683	2,820	1175	1,646
15	13,037	2,820	1043	1,777
16	11,260	2,820	901	1,919
17	9,341	2,820	747	2,073
18	7,268	2,820	581	2,239
19	5,029	2,820	402	2,418
20	2,611	2,820	209	2,611

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Expenses											
Fuel		3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696
Other Operating Expenses		5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Total Expense		8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696
Operating Cash Flow		16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402
Income Tax											
Debt Interest		2,215	2,167	2,114	2,058	1,997	1,931	1,860	1,783	1,700	1,611
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0				
MACRS-10		3,692	6,645	5,316	4,253	3,404	2,721	2,418	2,418	2,418	2,418
Taxable Income		10,496	7,591	8,972	10,092	11,002	11,751	12,124	12,201	12,284	12,374
Federal Tax		3,778	2,370	2,968	3,323	3,612	3,850	3,959	3,973	4,001	4,030
State Tax		1,008	729	861	969	1,056	1,128	1,164	1,171	1,179	1,188
Investment Tax Credit		0									
Total Income Tax		4,786	3,099	3,829	4,292	4,668	4,978	5,123	5,145	5,180	5,218
Debt Payment		2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820
Owner's Equity	-9,230										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-9,230										
Cash Flow	-9,230	8,796	10,484	9,754	9,291	8,914	8,604	8,460	8,438	8,402	8,364
IRR	101.4%										
NPV	39,646										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098	25,098
Expenses										
Fuel	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696
Other Operating Expenses	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
Total Expense	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696	8,696
Operating Cash Flow	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402	16,402
Income Tax										
Debt Interest	1,514	1,409	1,297	1,175	1,043	901	747	581	402	209
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	1,215									
Taxable Income	13,674	14,993	15,106	15,228	15,360	15,502	15,655	15,821	16,000	16,194
Federal Tax	4,495	4,925	4,920	4,960	5,003	5,050	5,100	5,155	5,213	5,277
State Tax	1,313	1,439	1,450	1,462	1,475	1,488	1,503	1,519	1,536	1,555
Investment Tax Credit										
Total Income Tax	5,808	6,364	6,370	6,422	6,478	6,538	6,603	6,673	6,749	6,831
Debt Payment	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820	2,820
Return of Debt Reserve										0
Salvage Value Recovered										738
Cash Flow	7,775	7,218	7,212	7,161	7,105	7,044	6,979	6,909	6,833	7,489

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated-3 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	141,288
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	6,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	11,000
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	67.1%
NPV of Cash Flow	65397

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	141,288
Salvage Value (%)	2
Total Equity Invested ($)	35,322
Total Debt Invested ($)	105,966
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	10,793
Debt Reserve ($)	10,793

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	105,966	10,793	8477	2,316
2	103,650	10,793	8292	2,501
3	101,150	10,793	8092	2,701
4	98,449	10,793	7876	2,917
5	95,532	10,793	7643	3,150
6	92,381	10,793	7391	3,402
7	88,979	10,793	7118	3,675
8	85,304	10,793	6824	3,969
9	81,336	10,793	6507	4,286
10	77,050	10,793	6164	4,629
11	72,421	10,793	5794	4,999
12	67,422	10,793	5394	5,399
13	62,023	10,793	4962	5,831
14	56,192	10,793	4495	6,298
15	49,894	10,793	3992	6,801
16	43,093	10,793	3447	7,345
17	35,747	10,793	2860	7,933
18	27,814	10,793	2225	8,568
19	19,247	10,793	1540	9,253
20	9,993	10,793	799	9,993

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total Expense		18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557
Operating Cash Flow		32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767
Income Tax																					
Debt Interest		8,477	8,292	8,092	7,876	7,643	7,391	7,118	6,824	6,507	6,164	5,794	5,394	4,962	4,495	3,992	3,447	2,860	2,225	1,540	799
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		28,258	45,212	27,127	16,276	16,276	8,138														
MACRS-10		0	0	0	0	0	0	0	0	0	0	0									
Taxable Income		-3,968	-20,737	-2,452	8,615	8,848	17,238	25,649	25,943	26,260	26,603	26,973	27,373	27,805	28,272	28,775	29,319	29,907	30,542	31,227	31,967
Federal Tax		-1,428	-7,328	-166	3,186	2,888	5,900	8,638	8,453	8,557	8,670	8,791	8,922	9,064	9,217	9,382	9,561	9,753	9,961	10,186	10,429
State Tax		-381	-1,991	-235	827	849	1,655	2,462	2,490	2,521	2,554	2,589	2,628	2,669	2,714	2,762	2,815	2,871	2,932	2,998	3,069
Investment Tax Credit		0																			
Total Income Tax		-1,809	-9,319	-402	4,013	3,737	7,555	11,100	10,943	11,078	11,223	11,380	11,550	11,733	11,931	12,145	12,375	12,624	12,893	13,184	13,498
Debt Payment		10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793
Owner's Equity	-35,322																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					2,826
Total Owner's Capital	-35,322																				
Cash Flow	-35,322	23,783	31,293	22,376	17,961	18,237	14,419	10,874	11,031	10,896	10,751	10,594	10,424	10,241	10,043	9,830	9,599	9,350	9,081	8,790	11,302
IRR	67.1%																				
NPV	65,397																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 10-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated-3 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	141,288
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	6,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	11,000
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	52.9%
NPV of Cash Flow	58021

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	141,288
Salvage Value (%)	2
Total Equity Invested ($)	35,322
Total Debt Invested ($)	105,966
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	10,793
Debt Reserve ($)	10,793

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	105,966	10,793	8477	2,316
2	103,650	10,793	8292	2,501
3	101,150	10,793	8092	2,701
4	98,449	10,793	7876	2,917
5	95,532	10,793	7643	3,150
6	92,381	10,793	7391	3,402
7	88,979	10,793	7118	3,675
8	85,304	10,793	6824	3,969
9	81,336	10,793	6507	4,286
10	77,050	10,793	6164	4,629
11	72,421	10,793	5794	4,999
12	67,422	10,793	5394	5,399
13	62,023	10,793	4962	5,831
14	56,192	10,793	4495	6,298
15	49,894	10,793	3992	6,801
16	43,093	10,793	3447	7,345
17	35,747	10,793	2860	7,933
18	27,814	10,793	2225	8,568
19	19,247	10,793	1540	9,253
20	9,993	10,793	799	9,993

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total Expense		18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557
Operating Cash Flow		32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767
Income Tax																					
Debt Interest		8,477	8,292	8,092	7,876	7,643	7,391	7,118	6,824	6,507	6,164	5,794	5,394	4,962	4,495	3,992	3,447	2,860	2,225	1,540	799
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0														
MACRS-10		14,129	25,432	20,345	16,276	13,027	10,413	9,254	9,254	9,254	9,254	4,648									
Taxable Income		10,161	-957	4,329	8,615	12,098	14,963	16,394	16,688	17,006	17,349	22,325	27,373	27,805	28,272	28,775	29,319	29,907	30,542	31,227	31,967
Federal Tax		3,658	-696	1,592	2,952	4,057	4,969	5,385	5,441	5,545	5,658	7,437	9,083	9,064	9,217	9,382	9,561	9,753	9,961	10,186	10,429
State Tax		975	-92	416	827	1,161	1,436	1,574	1,602	1,633	1,665	2,143	2,628	2,669	2,714	2,762	2,815	2,871	2,932	2,998	3,069
Investment Tax Credit		0																			
Total Income Tax		4,633	-788	2,007	3,779	5,219	6,405	6,959	7,043	7,178	7,323	9,581	11,711	11,733	11,931	12,145	12,375	12,624	12,893	13,184	13,498
Debt Payment		10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793	10,793
Owner's Equity	-35,322																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					2,826
Total Owner's Capital	-35,322																				
Cash Flow	-35,322	17,341	22,762	19,967	18,195	16,755	15,569	15,015	14,931	14,796	14,651	12,393	10,263	10,241	10,043	9,830	9,599	9,350	9,081	8,790	11,302
IRR	52.9%																				
NPV	58,021																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated-2 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	109,137
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	3,500
Insurance/Property Tax ($/y)	4,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	7,500
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	91.8%
NPV of Cash Flow	84731

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	109,137
Salvage Value (%)	2
Total Equity Invested ($)	27,284
Total Debt Invested ($)	81,853
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	8,337
Debt Reserve ($)	8,337

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	81,853	8,337	6548	1,789
2	80,064	8,337	6405	1,932
3	78,132	8,337	6251	2,086
4	76,046	8,337	6084	2,253
5	73,793	8,337	5903	2,433
6	71,359	8,337	5709	2,628
7	68,731	8,337	5498	2,838
8	65,893	8,337	5271	3,065
9	62,827	8,337	5026	3,311
10	59,517	8,337	4761	3,576
11	55,941	8,337	4475	3,862
12	52,080	8,337	4166	4,171
13	47,909	8,337	3833	4,504
14	43,405	8,337	3472	4,864
15	38,540	8,337	3083	5,254
16	33,287	8,337	2663	5,674
17	27,613	8,337	2209	6,128
18	21,485	8,337	1719	6,618
19	14,867	8,337	1189	7,148
20	7,719	8,337	618	7,719

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses											
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Total Expense		15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057
Operating Cash Flow		36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267
Income Tax											
Debt Interest		6,548	6,405	6,251	6,084	5,903	5,709	5,498	5,271	5,026	4,761
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		21,827	34,924	20,954	12,573	12,573	6,286				
MACRS-10		0	0	0	0	0	0	0	0	0	0
Taxable Income		7,891	-5,062	9,062	17,611	17,791	24,272	30,768	30,995	31,241	31,506
Federal Tax		2,841	-2,095	3,437	6,027	5,796	8,123	10,238	10,095	10,175	10,262
State Tax		758	-486	870	1,691	1,708	2,330	2,954	2,976	2,999	3,025
Investment Tax Credit		0									
Total Income Tax		3,598	-2,581	4,307	7,717	7,504	10,453	13,192	13,071	13,175	13,287
Debt Payment		8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337
Owner's Equity	-27,284										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-27,284										
Cash Flow	-27,284	24,332	30,511	23,623	20,213	20,426	17,477	14,738	14,859	14,755	14,643
IRR	91.8%										
NPV	84,731										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses										
Fuel	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Total Expense	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057
Operating Cash Flow	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267
Income Tax										
Debt Interest	4,475	4,166	3,833	3,472	3,083	2,663	2,209	1,719	1,189	618
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	0									
Taxable Income	31,792	32,101	32,434	32,795	33,184	33,604	34,058	34,548	35,078	35,649
Federal Tax	10,356	10,457	10,567	10,685	10,813	10,951	11,099	11,260	11,434	11,621
State Tax	3,052	3,082	3,114	3,148	3,186	3,226	3,270	3,317	3,367	3,422
Investment Tax Credit										
Total Income Tax	13,408	13,539	13,681	13,833	13,998	14,177	14,369	14,577	14,801	15,044
Debt Payment	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337
Return of Debt Reserve										0
Salvage Value Recovered										2,183
Cash Flow	14,522	14,391	14,249	14,097	13,932	13,753	13,561	13,353	13,129	15,069

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; No ITC
Case: Main Lodge, Administration Bldg. and Tenta Heated-2 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE
Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	109,137
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	3,500
Insurance/Property Tax ($/y)	4,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	7,500
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	76.3%
NPV of Cash Flow	79034

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	109,137
Salvage Value (%)	2
Total Equity Invested ($)	27,284
Total Debt Invested ($)	81,853
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	8,337
Debt Reserve ($)	8,337

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	81,853	8,337	6548	1,789
2	80,064	8,337	6405	1,932
3	78,132	8,337	6251	2,086
4	76,046	8,337	6084	2,253
5	73,793	8,337	5903	2,433
6	71,359	8,337	5709	2,628
7	68,731	8,337	5498	2,838
8	65,893	8,337	5271	3,065
9	62,827	8,337	5026	3,311
10	59,517	8,337	4761	3,576
11	55,941	8,337	4475	3,862
12	52,080	8,337	4166	4,171
13	47,909	8,337	3833	4,504
14	43,405	8,337	3472	4,864
15	38,540	8,337	3083	5,254
16	33,287	8,337	2663	5,674
17	27,613	8,337	2209	6,128
18	21,485	8,337	1719	6,618
19	14,867	8,337	1189	7,148
20	7,719	8,337	618	7,719

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500	7,500
Total Expense		15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057	15,057
Operating Cash Flow		36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267	36,267
Income Tax																					
Debt Interest		6,548	6,405	6,251	6,084	5,903	5,709	5,498	5,271	5,026	4,761	4,475	4,166	3,833	3,472	3,083	2,663	2,209	1,719	1,189	618
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0														
MACRS-10		10,914	19,645	15,716	12,573	10,062	8,043	7,148	7,148	7,148	7,148	3,591									
Taxable Income		18,805	10,217	14,301	17,611	20,301	22,515	23,620	23,847	24,092	24,357	28,201	32,101	32,434	32,795	33,184	33,604	34,058	34,548	35,078	35,649
Federal Tax		6,770	3,028	4,795	5,846	6,700	7,404	7,725	7,769	7,849	7,936	9,311	10,582	10,567	10,685	10,813	10,951	11,099	11,260	11,434	11,621
State Tax		1,805	981	1,373	1,691	1,949	2,161	2,268	2,289	2,313	2,338	2,707	3,082	3,114	3,148	3,186	3,226	3,270	3,317	3,367	3,422
Investment Tax Credit		0																			
Total Income Tax		8,575	4,009	6,168	7,536	8,649	9,565	9,993	10,058	10,162	10,274	12,018	13,663	13,681	13,833	13,998	14,177	14,369	14,577	14,801	15,044
Debt Payment		8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337	8,337
Owner's Equity	-27,284																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					2,183
Total Owner's Capital	-27,284																				
Cash Flow	-27,284	19,355	23,921	21,762	20,394	19,281	18,365	17,937	17,872	17,768	17,656	15,912	14,267	14,249	14,097	13,932	13,753	13,561	13,353	13,129	15,069
IRR	76.3%																				
NPV	79,034																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Base Main Lodge, Administrative Bldg., Tenta & Snowmelt Area Heated-3 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Boilers for Buildings	141,288
Snowmelt Equipment	400,333
Wood Handling & Storage	
Total Capital Costs	541,621
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	6,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	11,000
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	#NUM!
NPV of Cash Flow	-30393

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	541,621
Salvage Value (%)	2
Total Equity Invested ($)	135,405
Total Debt Invested ($)	406,216
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	41,374
Debt Reserve ($)	41,374

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	406,216	41,374	32497	8,877
2	397,339	41,374	31787	9,587
3	387,752	41,374	31020	10,354
4	377,398	41,374	30192	11,182
5	366,216	41,374	29297	12,077
6	354,140	41,374	28331	13,043
7	341,097	41,374	27288	14,086
8	327,011	41,374	26161	15,213
9	311,797	41,374	24944	16,430
10	295,367	41,374	23629	17,745
11	277,623	41,374	22210	19,164
12	258,459	41,374	20677	20,697
13	237,761	41,374	19021	22,353
14	215,408	41,374	17233	24,141
15	191,267	41,374	15301	26,073
16	165,194	41,374	13216	28,158
17	137,036	41,374	10963	30,411
18	106,625	41,374	8530	32,844
19	73,781	41,374	5902	35,472
20	38,309	41,374	3065	38,309

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total Expense		18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557
Operating Cash Flow		32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767
Income Tax																					
Debt Interest		32,497	31,787	31,020	30,192	29,297	28,331	27,288	26,161	24,944	23,629	22,210	20,677	19,021	17,233	15,301	13,216	10,963	8,530	5,902	3,065
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		108,324	173,319	103,991	62,395	62,395	31,197														
MACRS-10		0	0	0	0	0	0	0	0	0	0	0									
Taxable Income		-108,055	-172,339	-102,245	-59,820	-58,925	-26,762	5,479	6,606	7,823	9,138	10,557	12,090	13,746	15,534	17,466	19,551	21,804	24,237	26,864	29,702
Federal Tax		-38,900	-62,042	-36,808	-21,535	-21,213	-9,634	1,972	2,378	2,816	3,290	3,801	4,352	4,949	5,592	6,288	7,038	7,849	8,725	9,671	10,693
State Tax		-10,373	-16,545	-9,815	-5,743	-5,657	-2,569	526	634	751	877	1,013	1,161	1,320	1,491	1,677	1,877	2,093	2,327	2,579	2,851
Investment Tax Credit		0																			
Total Income Tax		-49,273	-78,587	-46,623	-27,278	-26,870	-12,203	2,498	3,012	3,567	4,167	4,814	5,513	6,268	7,084	7,964	8,915	9,943	11,052	12,250	13,544
Debt Payment		41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374
Owner's Equity	-135,405																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					10,832
Total Owner's Capital	-135,405																				
Cash Flow	-135,405	40,666	69,979	38,016	18,671	18,263	3,596	-11,106	-11,619	-12,174	-12,774	-13,421	-14,120	-14,875	-15,691	-16,571	-17,522	-18,550	-19,659	-20,857	-11,319
IRR	#NUM!																				
NPV at 15%	-30,393																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 10-yr Depreciation
Case: Base Main Lodge, Administrative Bldg., Tenta & Snowmelt Area Heated-3 Econoburn Boilers

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Boilers for Buildings	141,288
Snowmelt Equipment	400,333
Wood Handling & Storage	
Total Capital Costs	541,621
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	85%
Annual Heat Produced (MMBtu/yr)	3,212
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	189
Annual Fuel Cost - $	7,557
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	6,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	11,000
Taxes & Royalties	
Federal Income Tax Rate (%)	36.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	#NUM!
NPV of Cash Flow	-60661

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	541,621
Salvage Value (%)	2
Total Equity Invested ($)	135,405
Total Debt Invested ($)	406,216
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	41,374
Debt Reserve ($)	41,374

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	406,216	41,374	32497	8,877
2	397,339	41,374	31787	9,587
3	387,752	41,374	31020	10,354
4	377,398	41,374	30192	11,182
5	366,216	41,374	29297	12,077
6	354,140	41,374	28331	13,043
7	341,097	41,374	27288	14,086
8	327,011	41,374	26161	15,213
9	311,797	41,374	24944	16,430
10	295,367	41,374	23629	17,745
11	277,623	41,374	22210	19,164
12	258,459	41,374	20677	20,697
13	237,761	41,374	19021	22,353
14	215,408	41,374	17233	24,141
15	191,267	41,374	15301	26,073
16	165,194	41,374	13216	28,158
17	137,036	41,374	10963	30,411
18	106,625	41,374	8530	32,844
19	73,781	41,374	5902	35,472
20	38,309	41,374	3065	38,309

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses											
Fuel		7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses		11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total Expense		18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557
Operating Cash Flow		32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767
Income Tax											
Debt Interest		32,497	31,787	31,020	30,192	29,297	28,331	27,288	26,161	24,944	23,629
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0				
MACRS-10		54,162	97,492	77,993	62,395	49,937	39,917	35,476	35,476	35,476	35,476
Taxable Income		-53,892	-96,512	-76,247	-59,820	-46,468	-35,482	-29,997	-28,870	-27,653	-26,339
Federal Tax		-19,401	-34,744	-27,449	-21,535	-16,728	-12,773	-10,799	-10,393	-9,955	-9,482
State Tax		-5,174	-9,265	-7,320	-5,743	-4,461	-3,406	-2,880	-2,772	-2,655	-2,529
Investment Tax Credit		0									
Total Income Tax		-24,575	-44,009	-34,768	-27,278	-21,189	-16,180	-13,679	-13,165	-12,610	-12,010
Debt Payment		41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374
Owner's Equity	-135,405										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-135,405										
Cash Flow	-135,405	15,968	35,402	26,161	18,671	12,582	7,573	5,072	4,558	4,003	3,403
IRR	#NUM!										
NPV at 15%	-60,661										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses										
Fuel	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557	7,557
Other Operating Expenses	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000
Total Expense	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557	18,557
Operating Cash Flow	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767	32,767
Income Tax										
Debt Interest	22,210	20,677	19,021	17,233	15,301	13,216	10,963	8,530	5,902	3,065
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	17,819									
Taxable Income	-7,262	12,090	13,746	15,534	17,466	19,551	21,804	24,237	26,864	29,702
Federal Tax	-2,614	4,352	4,949	5,592	6,288	7,038	7,849	8,725	9,671	10,693
State Tax	-697	1,161	1,320	1,491	1,677	1,877	2,093	2,327	2,579	2,851
Investment Tax Credit										
Total Income Tax	-3,312	5,513	6,268	7,084	7,964	8,915	9,943	11,052	12,250	13,544
Debt Payment	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374	41,374
Owner's Equity										
Debt Reserve										
Return of Debt Reserve										0
Debt Outlay (No cost financing only)										
Salvage Value Recovered										10,832
Total Owner's Capital										
Cash Flow	-5,295	-14,120	-14,875	-15,691	-16,571	-17,522	-18,550	-19,659	-20,857	-11,319

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; ITC
Case: Main Lodge, Administration Bldg. and Tenta Heated-1 Skanden Boiler
No Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	223,121
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	3,033
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	178
Annual Fuel Cost - $	7,137
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000
Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	30
Income other than energy	
Debt Reserve Required?	No

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	89.3%
NPV of Cash Flow	78094

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	223,121
Salvage Value (%)	2
Total Equity Invested ($)	55,780
Total Debt Invested ($)	167,341
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	17,044
Debt Reserve ($)	17,044

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	167,341	17,044	13387	3,657
2	163,684	17,044	13095	3,949
3	159,735	17,044	12779	4,265
4	155,469	17,044	12438	4,606
5	150,863	17,044	12069	4,975
6	145,888	17,044	11671	5,373
7	140,515	17,044	11241	5,803
8	134,712	17,044	10777	6,267
9	128,445	17,044	10276	6,768
10	121,677	17,044	9734	7,310
11	114,367	17,044	9149	7,895
12	106,472	17,044	8518	8,526
13	97,946	17,044	7836	9,208
14	88,738	17,044	7099	9,945
15	78,792	17,044	6303	10,741
16	68,052	17,044	5444	11,600
17	56,452	17,044	4516	12,528
18	43,924	17,044	3514	13,530
19	30,394	17,044	2432	14,613
20	15,782	17,044	1263	15,782

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137
Operating Cash Flow		31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187
Income Tax																					
Debt Interest		13,387	13,095	12,779	12,438	12,069	11,671	11,241	10,777	10,276	9,734	9,149	8,518	7,836	7,099	6,303	5,444	4,516	3,514	2,432	1,263
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0														
MACRS-10		22,312	40,162	32,129	25,704	20,572	16,444	14,614	14,614	14,614	14,614	7,341									
Taxable Income		-4,513	-22,070	-13,721	-6,954	-1,454	3,072	5,331	5,795	6,297	6,838	14,697	22,669	23,351	24,088	24,883	25,743	26,671	27,673	28,755	29,924
Federal Tax		-1,534	-7,356	-3,945	-1,917	-267	1,092	1,712	1,796	1,952	2,119	4,774	7,228	7,199	7,428	7,674	7,940	8,228	8,538	8,874	9,236
State Tax		-433	-2,119	-1,317	-668	-140	295	512	556	604	656	1,411	2,176	2,242	2,312	2,389	2,471	2,560	2,657	2,761	2,873
Investment Tax Credit		-66,936																			
Total Income Tax		-68,904	-9,475	-5,262	-2,584	-407	1,387	2,224	2,353	2,556	2,776	6,185	9,404	9,441	9,740	10,063	10,412	10,788	11,195	11,634	12,108
Debt Payment		17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044
Owner's Equity	-55,780																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					4,462
Total Owner's Capital	-55,780																				
Cash Flow	-55,780	83,047	23,618	19,405	16,727	14,550	12,756	11,919	11,790	11,587	11,367	7,958	4,739	4,702	4,403	4,080	3,731	3,355	2,948	2,509	6,497
IRR	89.3%																				
NPV	78,094																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; No ITC
Case: Main Lodge, Administration Bldg. and Tenta Heated-1 Skanden Boiler
No Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	223,121
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	3,033
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	178
Annual Fuel Cost - $	7,137
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000
Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	28.8%
NPV of Cash Flow	27480

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	223,121
Salvage Value (%)	2
Total Equity Invested ($)	55,780
Total Debt Invested ($)	167,341
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	17,044
Debt Reserve ($)	17,044

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	167,341	17,044	13387	3,657
2	163,684	17,044	13095	3,949
3	159,735	17,044	12779	4,265
4	155,469	17,044	12438	4,606
5	150,863	17,044	12069	4,975
6	145,888	17,044	11671	5,373
7	140,515	17,044	11241	5,803
8	134,712	17,044	10777	6,267
9	128,445	17,044	10276	6,768
10	121,677	17,044	9734	7,310
11	114,367	17,044	9149	7,895
12	106,472	17,044	8518	8,526
13	97,946	17,044	7836	9,208
14	88,738	17,044	7099	9,945
15	78,792	17,044	6303	10,741
16	68,052	17,044	5444	11,600
17	56,452	17,044	4516	12,528
18	43,924	17,044	3514	13,530
19	30,394	17,044	2432	14,613
20	15,782	17,044	1263	15,782

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137
Operating Cash Flow		31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187
Income Tax																					
Debt Interest		13,387	13,095	12,779	12,438	12,069	11,671	11,241	10,777	10,276	9,734	9,149	8,518	7,836	7,099	6,303	5,444	4,516	3,514	2,432	1,263
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0														
MACRS-10		22,312	40,162	32,129	25,704	20,572	16,444	14,614	14,614	14,614	14,614	7,341									
Taxable Income		-4,513	-22,070	-13,721	-6,954	-1,454	3,072	5,331	5,795	6,297	6,838	14,697	22,669	23,351	24,088	24,883	25,743	26,671	27,673	28,755	29,924
Federal Tax		-1,534	-7,356	-3,945	-1,917	-267	1,092	1,712	1,796	1,952	2,119	4,774	7,228	7,199	7,428	7,674	7,940	8,228	8,538	8,874	9,236
State Tax		-433	-2,119	-1,317	-668	-140	295	512	556	604	656	1,411	2,176	2,242	2,312	2,389	2,471	2,560	2,657	2,761	2,873
Investment Tax Credit		0																			
Total Income Tax		-1,968	-9,475	-5,262	-2,584	-407	1,387	2,224	2,353	2,556	2,776	6,185	9,404	9,441	9,740	10,063	10,412	10,788	11,195	11,634	12,108
Debt Payment		17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044	17,044
Owner's Equity	-55,780																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					4,462
Total Owner's Capital	-55,780																				
Cash Flow	-55,780	16,110	23,618	19,405	16,727	14,550	12,756	11,919	11,790	11,587	11,367	7,958	4,739	4,702	4,403	4,080	3,731	3,355	2,948	2,509	6,497
IRR	28.8%																				
NPV	27,480																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated-1 Skanden Boiler
Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	34.3%
NPV of Cash Flow	29820

Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	254,873
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	3,033
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	178
Annual Fuel Cost - $	7,137
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000
Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	254,873
Salvage Value (%)	2
Total Equity Invested ($)	63,718
Total Debt Invested ($)	191,155
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	19,470
Debt Reserve ($)	19,470

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	191,155	19,470	15292	4,177
2	186,978	19,470	14958	4,511
3	182,466	19,470	14597	4,872
4	177,594	19,470	14208	5,262
5	172,332	19,470	13787	5,683
6	166,649	19,470	13332	6,138
7	160,511	19,470	12841	6,629
8	153,883	19,470	12311	7,159
9	146,724	19,470	11738	7,732
10	138,992	19,470	11119	8,350
11	130,642	19,470	10451	9,018
12	121,624	19,470	9730	9,740
13	111,884	19,470	8951	10,519
14	101,366	19,470	8109	11,360
15	90,005	19,470	7200	12,269
16	77,736	19,470	6219	13,251
17	64,486	19,470	5159	14,311
18	50,175	19,470	4014	15,456
19	34,719	19,470	2778	16,692
20	18,027	19,470	1442	18,027

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses											
Fuel		7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137
Operating Cash Flow		31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187
Income Tax											
Debt Interest		15,292	14,958	14,597	14,208	13,787	13,332	12,841	12,311	11,738	11,119
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		50,975	81,559	48,936	29,361	29,361	14,681				
MACRS-10		0	0	0	0	0	0	0	0	0	0
Taxable Income		-35,080	-65,331	-32,346	-12,382	-11,961	3,174	18,346	18,876	19,449	20,067
Federal Tax		-11,927	-21,067	-8,865	-3,154	-3,663	1,470	6,134	5,819	5,996	6,188
State Tax		-3,368	-6,272	-3,105	-1,189	-1,148	305	1,761	1,812	1,867	1,926
Investment Tax Credit		0									
Total Income Tax		-15,295	-27,339	-11,971	-4,343	-4,811	1,774	7,895	7,631	7,864	8,115
Debt Payment		19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470
Owner's Equity	-63,718										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-63,718										
Cash Flow	-63,718	27,012	39,056	23,688	16,060	16,528	9,943	3,822	4,086	3,854	3,603
IRR	34.3%										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses										
Fuel	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137
Other Operating Expenses	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137
Operating Cash Flow	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187
Income Tax										
Debt Interest	10,451	9,730	8,951	8,109	7,200	6,219	5,159	4,014	2,778	1,442
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	0									
Taxable Income	20,735	21,457	22,236	23,077	23,986	24,968	26,028	27,173	28,409	29,745
Federal Tax	6,395	6,619	6,860	7,121	7,402	7,706	8,035	8,389	8,772	9,186
State Tax	1,991	2,060	2,135	2,215	2,303	2,397	2,499	2,609	2,727	2,855
Investment Tax Credit										
Total Income Tax	8,386	8,678	8,995	9,336	9,705	10,103	10,533	10,998	11,499	12,041
Debt Payment	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470
Owner's Equity										
Debt Reserve										
Return of Debt Reserve										0
Debt Outlay (No cost financing only)										
Salvage Value Recovered										5,097
Total Owner's Capital										
Cash Flow	3,332	3,039	2,723	2,381	2,012	1,614	1,184	719	218	4,773

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 10-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated-1 Skanden Boiler
Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
ROE Required	15
Fuel Cost - Base Year ($/ton)	40
Capital Costs ($)	
Heaters	
Heater Conversion	
Wood Handling & Storage	
Total Capital Costs	254,873
Heat Sales - Base Year	
Annual Heat Sales (MMBtu/yr)	2,730
Annual Heat Revenue - $	51,324
Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	3,033
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	178
Annual Fuel Cost - $	7,137
Ash Created - %	5%
Ash Created - Tons	9
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000
Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0
Income other than energy	
Debt Reserve Required?	No
Interest Rate on Debt Reserve (%/yr)	5

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	23.2%
NPV of Cash Flow	17088

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Enter: Yes or No

Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	254,873
Salvage Value (%)	2
Total Equity Invested ($)	63,718
Total Debt Invested ($)	191,155
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	19,470
Debt Reserve ($)	19,470

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	191,155	19,470	15292	4,177
2	186,978	19,470	14958	4,511
3	182,466	19,470	14597	4,872
4	177,594	19,470	14208	5,262
5	172,332	19,470	13787	5,683
6	166,649	19,470	13332	6,138
7	160,511	19,470	12841	6,629
8	153,883	19,470	12311	7,159
9	146,724	19,470	11738	7,732
10	138,992	19,470	11119	8,350
11	130,642	19,470	10451	9,018
12	121,624	19,470	9730	9,740
13	111,884	19,470	8951	10,519
14	101,366	19,470	8109	11,360
15	90,005	19,470	7200	12,269
16	77,736	19,470	6219	13,251
17	64,486	19,470	5159	14,311
18	50,175	19,470	4014	15,456
19	34,719	19,470	2778	16,692
20	18,027	19,470	1442	18,027

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137	7,137
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137	20,137
Operating Cash Flow		31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187	31,187
Income Tax																					
Debt Interest		15,292	14,958	14,597	14,208	13,787	13,332	12,841	12,311	11,738	11,119	10,451	9,730	8,951	8,109	7,200	6,219	5,159	4,014	2,778	1,442
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0														
MACRS-10		25,487	45,877	36,702	29,361	23,499	18,784	16,694	16,694	16,694	16,694	8,385									
Taxable Income		-9,593	-29,649	-20,112	-12,382	-6,099	-929	1,652	2,182	2,755	3,373	12,350	21,457	22,236	23,077	23,986	24,968	26,028	27,173	28,409	29,745
Federal Tax		-3,262	-9,767	-5,870	-3,553	-1,670	-117	592	688	865	1,057	4,089	6,892	6,860	7,121	7,402	7,706	8,035	8,389	8,772	9,186
State Tax		-921	-2,846	-1,931	-1,189	-586	-89	159	209	264	324	1,186	2,060	2,135	2,215	2,303	2,397	2,499	2,609	2,727	2,855
Investment Tax Credit		0																			
Total Income Tax		-4,183	-12,614	-7,801	-4,742	-2,255	-206	750	897	1,130	1,381	5,275	8,952	8,995	9,336	9,705	10,103	10,533	10,998	11,499	12,041
Debt Payment		19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470	19,470
Owner's Equity	-63,718																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					5,097
Total Owner's Capital	-63,718																				
Cash Flow	-63,718	15,900	24,331	19,518	16,459	13,972	11,923	10,967	10,820	10,587	10,336	6,443	2,765	2,723	2,381	2,012	1,614	1,184	719	218	4,773
IRR	23.2%																				
NPV	17,088																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 5-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated, Snow Removed-1 Skanden Boiler
Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
Heat Replaced (Bldgs Only)	2730
ROE Required	15
Fuel Cost - Base Year ($/ton)	40

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	#NUM!
NPV of Cash Flow	-90543

Capital Costs ($)	
Boilers and Piping	254,873
Snow Melt	400,333
Wood Handling & Storage	
Total Capital Costs	655,206
Heat Sales - Base Year	
Annual Heat Required (MMBtu/yr)	3,755
Annual Heat Revenue - $	51,324

0

Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	4,172
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	245
Annual Fuel Cost - $	9,817
Ash Created - %	5%
Ash Created - Tons	12
Ash Disposal Cost - $/Ton	0
Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000
Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-5
Investment Tax Credit (%)	0

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Income other than energy	
Debt Reserve Required?	No

Enter: Yes or No

Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	655,206
Salvage Value (%)	
Total Equity Invested ($)	163,802
Total Debt Invested ($)	491,405
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	50,051
Debt Reserve ($)	50,051

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	491,405	50,051	39312	10,738
2	480,666	50,051	38453	11,597
3	469,069	50,051	37526	12,525
4	456,544	50,051	36524	13,527
5	443,017	50,051	35441	14,609
6	428,407	50,051	34273	15,778
7	412,629	50,051	33010	17,040
8	395,589	50,051	31647	18,404
9	377,185	50,051	30175	19,876
10	357,310	50,051	28585	21,466
11	335,844	50,051	26868	23,183
12	312,661	50,051	25013	25,038
13	287,623	50,051	23010	27,041
14	260,582	50,051	20847	29,204
15	231,378	50,051	18510	31,540
16	199,838	50,051	15987	34,064
17	165,774	50,051	13262	36,789
18	128,985	50,051	10319	39,732
19	89,254	50,051	7140	42,910
20	46,343	50,051	3707	46,343

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Revenue																					
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses																					
Fuel		9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817
Operating Cash Flow		28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507
Income Tax																					
Debt Interest		39,312	38,453	37,526	36,524	35,441	34,273	33,010	31,647	30,175	28,585	26,868	25,013	23,010	20,847	18,510	15,987	13,262	10,319	7,140	3,707
Tax Depreciation																					
SL		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MACRS-5		131,041	209,666	125,800	75,480	75,480	37,740														
MACRS-10		0	0	0	0	0	0	0	0	0	0	0									
Taxable Income		-141,847	-219,612	-134,818	-83,496	-82,414	-43,505	-4,503	-3,140	-1,668	-78	1,640	3,494	5,497	7,660	9,997	12,520	15,245	18,188	21,367	24,800
Federal Tax		-48,228	-70,038	-38,670	-23,988	-25,295	-12,102	-111	-921	-465	28	560	1,134	1,755	2,425	3,149	3,931	4,775	5,686	6,671	7,734
State Tax		-13,617	-21,083	-12,943	-8,016	-7,912	-4,177	-432	-301	-160	-7	157	335	528	735	960	1,202	1,464	1,746	2,051	2,381
Investment Tax Credit		0																			
Total Income Tax		-61,845	-91,121	-51,613	-32,004	-33,207	-16,278	-543	-1,222	-625	21	717	1,470	2,283	3,161	4,109	5,132	6,238	7,432	8,722	10,115
Debt Payment		50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051
Owner's Equity	-163,802																				
Debt Reserve	0																				
Return of Debt Reserve																					0
Debt Outlay (No cost financing only)	0																				
Salvage Value Recovered																					0
Total Owner's Capital	-163,802																				
Cash Flow	-163,802	40,301	69,577	30,069	10,460	11,664	-5,265	-21,000	-20,322	-20,919	-21,564	-22,261	-23,014	-23,826	-24,704	-25,652	-26,676	-27,782	-28,976	-30,266	-31,659
IRR	#NUM!																				
NPV	-90,543																				

RETURN ON INVESTMENT - LEVELIZED COST OF HEAT MODEL
WOOD HEAT FACILITY - BIOMASS FIRED

Sierra at Tahoe - Private Financing-25% Equity-$40/ton Fuel Cost; 10-yr Depreciation
Case: Main Lodge, Administration Bldg. and Tenta Heated, Snow Removed-1 Skanden Boiler
Automated Ash Removal

This computer model allows the user to calculate the return on equity (ROE) on a capital investment in a biomass fired heating facility, given operating expenses, the prices for heat, and the cost of fuel, other operating expenses and income taxes.

If the sales price of heat is known, the model calculates the ROE that would be achieved
If the sales price of heat is not known, the heat sales price can be adjusted until the ROE Achieved equals the ROE Required providing the sales price necessary to achieve the required ROE

If the project is financed with 100% debt, adjust the sale price of heat (cell B25) until the NPV of Cash Flow is 0. Income tax rates (cells B82 & B83) must be set to 0 if the investing entity is non-profit.

Input values are highlighted in green
Calculated values are highlighted in blue
Key output values are highlighted in lavender

Heat Sales Price - Base Year	
Heat ($/MMBtu)	18.8
Heat Replaced (Bldgs Only)	2730
ROE Required	15
Fuel Cost - Base Year ($/ton)	40

If financing includes equity, adjust heat sales price until ROE Achieved equals ROE Required.

ROE Achieved	#DIV/0!
NPV of Cash Flow	-123273

Capital Costs ($)	
Boilers and Piping	254,873
Snow Melt	400,333
Wood Handling & Storage	
Total Capital Costs	655,206

Heat Sales - Base Year	
Annual Heat Required (MMBtu/yr)	3,755
Annual Heat Revenue - $	51,324

0

Heat Cost--Base Year	
Heater Efficiency - %	90%
Annual Heat Produced (MMBtu/yr)	4,172
Heating Value of Fuel - Btu/lb.	8,500
Annual Fuel Use - Tons	245
Annual Fuel Cost - $	9,817
Ash Created - %	5%
Ash Created - Tons	12
Ash Disposal Cost - $/Ton	0

Expenses--base year	
Labor Cost ($/y)	
Maintenance Cost ($/y)	5,000
Insurance/Property Tax ($/y)	8,000
Utilities ($/y)	0
Ash Disposal ($/y)--use negative value for sales	
Administrative and General ($/y)	0
Fuel Delivery	
Other Operating Expenses ($/y)	0
Total Non-Fuel Expenses ($/y)	13,000

Taxes & Royalties	
Federal Income Tax Rate (%)	34.00
State Income Tax Rate (%)	9.60
Production Tax Credit ($/kWh)	0.000
Number of years PTC received	5
Royalty Payment (% of total revenue)	0
Tax Depreciation Method	M-10
Investment Tax Credit (%)	0

SL = Straight line depreciation
M-5 = MACRS-5 five year schedule depreciation
M-10 = MACRS-10 ten year schedule depreciation

Income other than energy	
Debt Reserve Required?	No

Enter: Yes or No

Interest Rate on Debt Reserve (%/yr)	5
Annual Debt Reserve Interest ($/y)	0

Escalation

Escalation--Fuel (%/y)	0.00
Escalation for Production Tax Credit (%/y)	0.00
Escalation - Electricity sales price (%/yr)	0.00
Escalation--Heat sales price (%/y)	0.00
Escalation - Capacity payments ($/yr)	0.00
Escalation--Other (%/y)	0.00

Financing

Debt ratio (%)	75.00
Equity ratio (%)	25.00
Interest Rate on Debt (%/y)	8.00
Economic Life (y)	20
Rate of equity required (%/y)	15.00
Weighted Cost of Capital (%/y)	9.75
Total Cost of Plant ($)	655,206
Salvage Value (%)	
Total Equity Invested ($)	163,802
Total Debt Invested ($)	491,405
Capital Recovery Factor (Equity)	0.1598
Capital Recovery Factor (Debt)	0.1019
Annual Debt Payment ($/y)	50,051
Debt Reserve ($)	50,051

Debt Schedule

Year	Remaining Principal	Annual Payment	Annual Interest	Principal Reduction
1	491,405	50,051	39312	10,738
2	480,666	50,051	38453	11,597
3	469,069	50,051	37526	12,525
4	456,544	50,051	36524	13,527
5	443,017	50,051	35441	14,609
6	428,407	50,051	34273	15,778
7	412,629	50,051	33010	17,040
8	395,589	50,051	31647	18,404
9	377,185	50,051	30175	19,876
10	357,310	50,051	28585	21,466
11	335,844	50,051	26868	23,183
12	312,661	50,051	25013	25,038
13	287,623	50,051	23010	27,041
14	260,582	50,051	20847	29,204
15	231,378	50,051	18510	31,540
16	199,838	50,051	15987	34,064
17	165,774	50,051	13262	36,789
18	128,985	50,051	10319	39,732
19	89,254	50,051	7140	42,910
20	46,343	50,051	3707	46,343

Tax Depreciation Schedule

Year	MACRS--5 year	MACRS--10 year	Straight Line--20 year
1	0.2000	0.1000	0.0500
2	0.3200	0.1800	0.0500
3	0.1920	0.1440	0.0500
4	0.1152	0.1152	0.0500
5	0.1152	0.0922	0.0500
6	0.0576	0.0737	0.0500
7	0.0000	0.0655	0.0500
8	0.0000	0.0655	0.0500
9	0.0000	0.0655	0.0500
10	0.0000	0.0655	0.0500
11	0.0000	0.0329	0.0500
12	0.0000	0.0000	0.0500
13	0.0000	0.0000	0.0500
14	0.0000	0.0000	0.0500
15	0.0000	0.0000	0.0500
16	0.0000	0.0000	0.0500
17	0.0000	0.0000	0.0500
18	0.0000	0.0000	0.0500
19	0.0000	0.0000	0.0500
20	0.0000	0.0000	0.0500
	1.0000	1.0000	1.0000

Annual Cash Flow ($)

Year		1	2	3	4	5	6	7	8	9	10
Revenue											
Heat Sales		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve		0	0	0	0	0	0	0	0	0	0
Total Revenue		51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses											
Fuel		9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817
Other Operating Expenses		13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense		22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817
Operating Cash Flow		28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507
Income Tax											
Debt Interest		39,312	38,453	37,526	36,524	35,441	34,273	33,010	31,647	30,175	28,585
Tax Depreciation											
SL		0	0	0	0	0	0	0	0	0	0
MACRS-5		0	0	0	0	0	0				
MACRS-10		65,521	117,937	94,350	75,480	60,410	48,289	42,916	42,916	42,916	42,916
Taxable Income		-76,326	-127,883	-103,368	-83,496	-67,344	-54,054	-47,419	-46,056	-44,584	-42,994
Federal Tax		-25,951	-40,989	-30,971	-25,015	-20,172	-16,180	-14,358	-14,111	-13,655	-13,163
State Tax		-7,327	-12,277	-9,923	-8,016	-6,465	-5,189	-4,552	-4,421	-4,280	-4,127
Investment Tax Credit		0									
Total Income Tax		-33,278	-53,266	-40,894	-33,030	-26,637	-21,370	-18,910	-18,533	-17,935	-17,290
Debt Payment		50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051
Owner's Equity	-163,802										
Debt Reserve	0										
Return of Debt Reserve											
Debt Outlay (No cost financing only)	0										
Salvage Value Recovered											
Total Owner's Capital	-163,802										
Cash Flow	-163,802	11,734	31,722	19,351	11,487	5,093	-174	-2,633	-3,011	-3,608	-4,254
IRR	#DIV/0!										

Year	11	12	13	14	15	16	17	18	19	20
Revenue										
Heat Sales	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Interest on Debt Reserve	0	0	0	0	0	0	0	0	0	0
Total Revenue	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324	51,324
Expenses										
Fuel	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817	9,817
Other Operating Expenses	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Total Expense	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817	22,817
Operating Cash Flow	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507	28,507
Income Tax										
Debt Interest	26,868	25,013	23,010	20,847	18,510	15,987	13,262	10,319	7,140	3,707
Tax Depreciation										
SL	0	0	0	0	0	0	0	0	0	0
MACRS-5										
MACRS-10	21,556									
Taxable Income	-19,917	3,494	5,497	7,660	9,997	12,520	15,245	18,188	21,367	24,800
Federal Tax	-5,368	1,838	1,755	2,425	3,149	3,931	4,775	5,686	6,671	7,734
State Tax	-1,912	335	528	735	960	1,202	1,464	1,746	2,051	2,381
Investment Tax Credit										
Total Income Tax	-7,280	2,174	2,283	3,161	4,109	5,132	6,238	7,432	8,722	10,115
Debt Payment	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051	50,051
Owner's Equity										
Debt Reserve										
Return of Debt Reserve										0
Debt Outlay (No cost financing only)										
Salvage Value Recovered										0
Total Owner's Capital										
Cash Flow	-14,263	-23,717	-23,826	-24,704	-25,652	-26,676	-27,782	-28,976	-30,266	-31,659
IRR										

NPV	-123,273

Property of TSS Consultants, Sacramento, CA
Contact Fred Tornatore, 916-601-0531, or
David Augustine, 916-359-6303

Appendix D: Biomass Heater and Boiler Vendor Information

BIOMASS COMBUSTION SYSTEMS, INC.

Fuel your Profits with Wood

BCS WOOD FIRED INDUSTRIAL SHOP HEATERS

COST-EFFECTIVE • TIME-TESTED • DURABLE

CONTROLLING BUSINESS COSTS

Managing fuel costs in the current climate of fluctuating fuel prices is difficult. Wouldn't you like to reduce and control your fuel cost…and not just for this season, but for years to come? Convert your low cost wood to fuel and immediately reduce your operating costs, but more importantly, gain control over ever-unpredictable and rising fuel prices. Imagine, one ton of dry wood is the BTU equivalent of 85 gallons of heating oil and 115 therms of natural gas! Heating with wood is a proven investment for the long term.

DURABILITY

Since 1985, this proven design has been heating commercial and industrial buildings with wood. Designed to last, their compact all-steel construction is ruggedly built to withstand years of hand-firing. BCS fireboxes are engineered with extra thick steel end walls, which unlike refractory fireboxes, will not crack and break with repeated hand-firing. In addition, our unique cylindrical firebox design allows for natural expansion and contraction thereby reducing stress on the steel.

EFFICIENT COMBUSTION

When properly operated, our EPA-approved systems are virtually smoke-free with no impact on neighbors or the environment. BCS' patented After Burner Chamber minimizes unsafe particle emissions by re-burning flue gases through four separate right angle turns, maximizing combustion. Smoke will not escape when loading wood either. An induced draft fan located at the top of the system creates negative pressure in the firebox causing smoke to go up the chimney when the loading door is open. This feature enables many of our systems to be installed directly on the shop floor.

MAINTENANCE

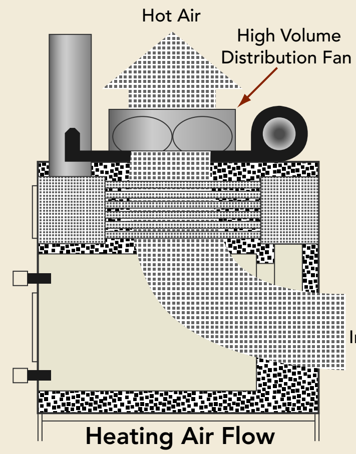
BCS all-steel systems' simple, straightforward design makes them easy to operate and maintain. Featuring front and rear access for cleaning, the system is easy to clean and operate.

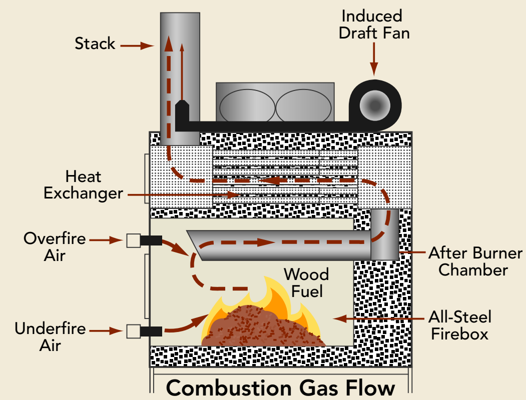
DEPENDABLE SERVICE

These furnaces have been successfully field-tested for over 20 years and we stand by our product. In fact, we invite you to talk with one of our many satisfied customers to get a feel for the advantages of using a BCS Shop Heater.

SPECIFICATIONS
800,000 BTU PER HOUR SHOP HEATER

FIREBOX	
3/4″ steel end walls	
5/8″ plate steel cylinder	
36″ diameter firebox x 60″ length	
35.34 cu. ft. volume	
15″ x 22″ loading door	
Induced draft/forced draft fan with 1 HP motor	
12″ diameter stack	
OVERALL DIMENSIONS	
Width: 48″	**Length:** 88″
Height: 108″	**Weight:** 6,000 lbs.
HEAT EXCHANGER	
(32) 2″ diameter tubes x 48″ length	
(2) 17″ x 17″ clean-out doors	
30″ tube axial fan – 9,000 cfm@1/2 s.p., 2 HP	
SAFE CLEARANCES	
Allow for at least 36″ from sides, 36″ from back	
48″ from front, 18″ from flue connector	
12″ from ducting and plenums	





SPECIFICATIONS
500,000 BTU PER HOUR SHOP HEATER

FIREBOX	
1/2″ steel end walls	
3/8″ plate steel cylinder	
30″ diameter firebox x 57″ length	
21.5 cu. ft. volume	
12″ x 18″ loading door	
Induced draft/forced draft fan with 1/2 HP motor	
10″ diameter stack	
OVERALL DIMENSIONS	
Width: 40″	**Length:** 82″
Height: 87″	**Weight:** 4,300 lbs.
HEAT EXCHANGER	
(20) 2″ diameter tubes x 47.25″ length	
10″ x 24″ clean-out door	
24″ tube axial fan – 6,900 cfm@1/2 s.p., 1.5 HP	
SAFE CLEARANCES	
Allow for at least 36″ from sides, 36″ from back	
48″ from front, 18″ from flue connector	
12″ from ducting and plenums	

SPECIFICATIONS
250,000 BTU PER HOUR SHOP HEATER

FIREBOX	
3/8″ steel end walls	
5/16″ plate steel cylinder	
26″ diameter firebox x 40″ length	
11.2 cu. ft. volume	
10.5″ x 15″ loading door	
Induced draft/forced draft fan with 1/2 HP motor	
8″ diameter stack	
OVERALL DIMENSIONS	
Width: 34″	**Length:** 60″
Height: 75 1/2″	**Weight:** 2,200 lbs.
HEAT EXCHANGER	
(17) 2″ diameter tubes x 26″ length	
8″ x 20 1/2″ clean-out door	
18″ tube axial fan – 3,100 cfm@1/2 s.p., 3/4 HP	
SAFE CLEARANCES	
Allow for at least 36″ from sides, 36″ from back	
48″ from front, 18″ from flue connector	
12″ from ducting and plenums	

All output ratings are based on burning dry wood.

FEATURES AND BENEFITS

DURABLE ALL-STEEL FIREBOX

- **Rugged Steel Construction**
  Won't chip or crack like refractory brick
- **Thickened Steel End Walls**
  Built to withstand repeated hand-firing
- **Cylindrical Design**
  Accommodates heat expansion without stress to steel
- **Patented After Burner Chamber**
  - Multistage, maximum flue gas combustion
  - Virtually smoke-free operation

THE HEAT EXCHANGER

- **Large Heating Capacity**
  - Firebox functions as primary heat exchanger
  - Multiple tube secondary heat exchanger
- **Convenient Cleanout Design**
  Shortens maintenance time while enhancing combustion efficiency. Cleanout rod and brushes included.

HEATING AIR FLOW

- **High Volume Heat Distribution Fan**
- **Maximum Heat Output To Facility**

COMBUSTION AIR FLOW

- **Induced Draft System**
  - Powerful induced draft optimizes combustion
  - Safe and clean burning
  - Smoke and odor-free loading

EASE OF OPERATION

- **Over Fire/Under Fire Valves**
  Adjusts air flow for optimal combustion and heat management
- **Intelligent Thermostat**
  Automatically controls fan to conserve electricity
- **Firebox Dual Temperature Monitor**
  Monitors fuel loading requirements and stack temp for heat exchanger performance
- **Twenty Year Time-Tested Design**

OPTIONS

- **AFS- Automated Feeding System**
- **Green Fuel Forced Draft Kit**
- **Over 20 Years of References Available**

UL, CSA and Emission Test Results Available

Biomass Combustion Systems, Inc.
67 Millbrook St. / Suite 502 / Worcester, MA 01606
Phone 508-798-5970 / **Fax** 508 798-5971
Email info@biomasscombustion.com

www.biomasscombustion.com

BIOMASS COMBUSTION SYSTEMS, INC.
67 MILLBROOK ST., SUITE 502
WORCESTER, MA 01606
508-798-5970 - FAX 508-798-5971

B.C.S. Shop Heaters

OPERATION & MAINTENANCE MANUAL
HAND FIRED SYSTEMS

8-09

TABLE OF CONTENTS

This publication is intended for use by trained personnel to operate and maintain BCS Shopheating Furnaces. Read this manual carefully before beginning.

Installation is to be performed only by a qualified installer.

Save These Instructions.

Refer to markings on shop heater for additional information.

SECTIONS MARKED BY THIS SYMBOL CONTAIN IMPORTANT SAFETY INFORMATION. READ AND FOLLOW COMPLETELY.

WARNING! RISK OF FIRE OR EXPLOSION! DO NOT BURN GARBAGE, GASOLINE, DRAIN OIL OR ANY OTHER FLAMABLE LIQUID.

CAUTION – HOT SURFACES
KEEP CHILDREN AWAY
DO NOT TOUCH DURING OPERATION

DOOR SHOULD ONLY BE OPENED FOR FUEL LOADING AND CLEANING. DOORS SHOULD REMAIN CLOSED AT ANY OTHER TIME.

INSPECT AND CLEAN FLUES AND CHIMNEY REGULARLY

OPERATION

1.1 INTRODUCTION

THIS STOVE WAS DESIGNED TO BURN WOOD ONLY. IT IS NOT DESIGNED TO BURN PAPER, PLASTICS OR WASTE MATERIALS.

Shop Heater furnaces are designed to need minimum attention and maintenance while providing a reliable, efficient source of heat and means of waste wood elimination. These instructions will give you an understanding of the operating principles involved, thus making it easier to adjust the burner to meet your specific needs.

1.2 INITIAL START UP - COLD BURNER

DO NOT USE CHEMICALS OR FLUIDS TO START THE FIRE
DO NOT BURN GARBAGE, GASOLINE, NAPHTHA, ENGINE OIL OR OTHER INAPPROPRIATE MATERIALS

It is necessary to use newspaper and kindling when firing up a cold burner, similar to the way a campfire is started. In normal continuous operation this will not be necessary, as a sufficient bed of coals will remain for 12-18 hours

1. Setting up air valves. The following valve settings are a good starting point but may not be optimum for your situation. Check for negative pressure by turning on the induction fan and placing a piece of paper over the fully open inlets of the intake manifolds. Pressure should be enough to hold the paper to the inlet without sucking it in. After determining that negative pressure exists, remove paper and turn off fan. Turn the over fire (upper) air valve to the full open position, and open the under fire (lower) air valve to the middle position. Further adjustments will depend on the emission and heat output from your burner.

2. Load the firebox. Begin by loading crumpled newspaper into the front of the firebox. Place a layer of kindling on top of the newspaper 4-6 inches deep, not too tightly packed so as to allow adequate air infiltration. Any small, preferably dry pieces of wood will do. Place progressively larger pieces on top of the pile ending with full size pieces of fuel. Do not fill the firebox more than one third full and never block the under fire air nozzles when loading the burner.

3. Ignite the pile of kindling by lighting the newspaper. Allow it to burn for a minute, making sure that the fire catches, before closing the burner door.

4. Turn on the induced draft fan switch.

NOTE: THE INDUCED FAN ALWAYS REMAINS RUNNING WHENEVER THE BURNER IS IN OPERATION. THE ONLY EXCEPTION TO THIS IS IF THE BURNER OVERHEATS; THE INDUCED DRAFT FAN WILL AUTOMATICALLY TURN OFF TO PREVENT OVERHEATING.

Due to the mass of metal in these systems, it will take from 10 to 30 minutes for the burner to become hot enough to turn on the thermostatically controlled hot air/cooling fan. The very first time the burner is fired there will be a small amount of smoke from the paint. You may also hear an occasional crack because the burner has tack welds in certain areas to aid in fabrication that are designed to break as the burner first heats up.

1.3 REGULAR OPERATON

INSPECT FLUE PIPES, JOINTS AND SEALS REGULARLY TO ENSURE THAT SMOKE AND FLUE GASES ARE NOT DRAWING INTO, AND CIRCULATED BY THE AIR CIRCULATION SYSTEM

DANGER – RISK OF FIRE OR EXPLOSION – BURN WOOD ONLY DO NOT BURN GARBAGE, GASOLINE, DRAIN OIL OR OTHER FLAMMABLE LIQUIDS

The key to clean and efficient burning is multistage combustion. The first stage of combustion, the primary stage, burns the fuel with oxygen from the under fire air supply. This results in heat and smoke, which is unburned gases and particulate. In the secondary stage of combustion, BCS furnaces burn the smoke and much of the particulate with over fire air to make the final exhaust cleaner and to obtain more heat and energy.

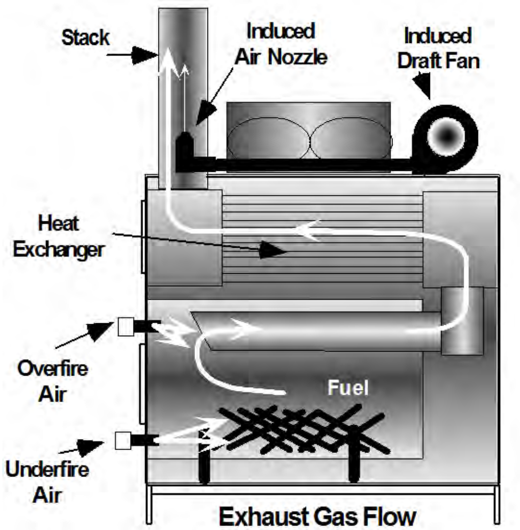
As the operator there are three aspects of the combustion process that you control:

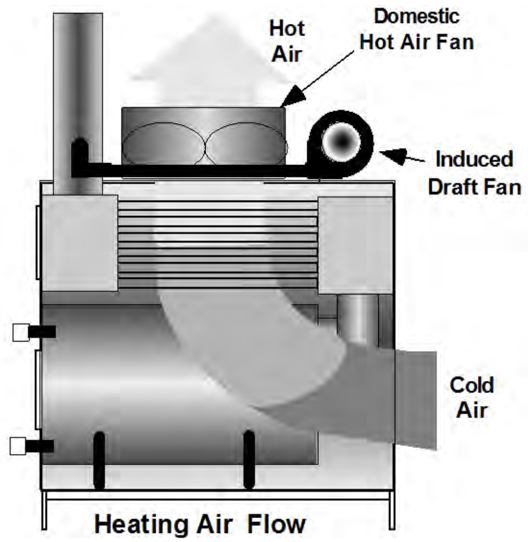
1. The amount of under fire air going into the burner. This is controlled by the lower of the two hand valves at the front of the burner.
2. The amount of over fire air going into the burner. This is controlled by the top hand valve at the front of the burner.
3. The amount of fuel fed to the burner.

1.4 UNDER FIRE AIR FLOW DETERMINES FUEL CONSUMPTION

The under fire air is the throttle on the burner. The more under fire air coming in the faster the fuel will burn. Wood is both a solid and gaseous fuel. The under fire air consumes the solids and liberates the gases in the fuel during the combustion phase.

Too much under fire air may cause a dark smoke emission that indicates too much gasification producing a fuel rich smoke mixture. Too little under fire air will cause a white smoke that indicates a cold fire - the smoke is not burning. A vigorous fire is necessary for gaseous ignition, and it is vital from an emissions standpoint that the firebox temperatures rise rapidly above 500°F.





1.5 OVER FIRE AIR AFFECTS THE QUALITY OF EMISSIONS

The over fire air controls the emissions and, therefore, the combustion efficiency of the burner. It is this gaseous combustion efficiency that is the most important determinant of high total efficiency and low emission rates. Since more than half of wood's fuel value comes from its gaseous combustion, proper control of this secondary combustion is very important.

Enough over fire air must be provided to allow clean burning, but excessive over fire air will cool the firebox and decrease efficiency.

To optimize:

1. Slowly turn down the over fire air allowing time after each adjustment for the fire to adapt to the new conditions. Continue until the unit starts to emit black smoke.

2. Slowly open the over fire air valve until the smoke disappears. This would be the optimum setting for the current conditions - fuel type, moisture content and size.

See 1.9 TROUBLESHOOTING for more information regarding eliminating smoke.

1.6 STORING WOOD

Wood should be stored out of the weather whenever possible so rain and snow do not reduce the productive BTU content of the fuel. Do not store fuel within the listed "safe clearances" or within the space required for refueling, ash removal or other routine maintenance operations

1.7 LOADING THE FIREBOX

When the burner needs to be loaded, the thermostatically controlled hot air/cooling fan will start to cycle on and off every few minutes and the firebox temperature will have dropped significantly. Leave the induced draft fan on during loading to maintain the draft.

It is recommended that seasoned or dry wood be burned to minimize creosote buildup and maintenance requirements. Greener wood will reduce the output of the furnace.

CAUTION: ALWAYS STAND TO THE SIDE OF, OR BEHIND THE LOADING DOOR WHEN OPENING, AND ALWAYS OPEN SLOWLY. OPENING THE DOOR TOO QUICKLY CAN CAUSE FLAME AND SMOKE TO BE PULLED OUT THE FRONT OF THE BURNER WHICH CAN CAUSE INJURY TO THE OPERATOR.

1. Open loading door. (Close valve first if system is force drafted)

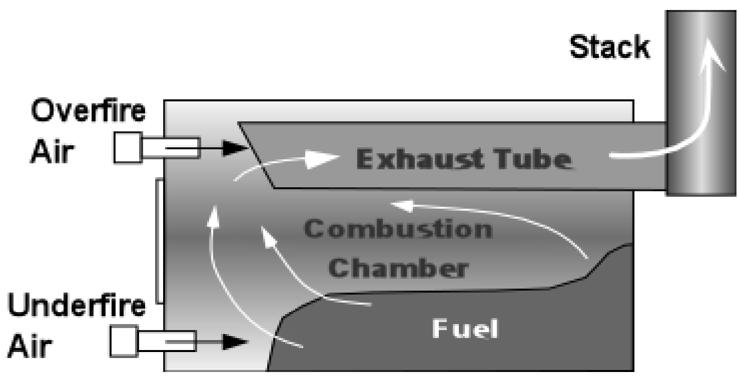
DO NOT OPERATE WITH FUEL OR ASH REMOVAL DOORS OPEN

2. Use the ash hoe supplied with the burner to push the ashes to the rear of the firebox. (If there are too many ashes to accomplish this easily, refer to the section on cleaning the burner.) Then rake the hot coals forward, keeping them well below the lower edge of the loading door and in front of the nozzles. Hot coals are lighter than ashes and will tend to stay on top of the pile as the ashes are pushed back.

NOTE: DO NOT BLOCK THE UNDERFIRE AIR NOZZLES WITH ASHES OR HOT COALS.

3. After the hot coals have been brought to the front, load the burner and shut the door. It will not take a large amount of hot coals to ignite the new fuel. With some experience you will easily judge when there are not enough hot coals and more kindling is necessary, or when there are too many coals. With small pieces of dry fuel, too many coals may cause dark smoke by igniting an excessive amount of fuel thus creating too large a fire.

The amount of fuel that can be loaded into the burner depends greatly upon the moisture content and the size of the pieces being burned. The reason being that wood, as stated before, is both a solid and gaseous fuel. Small pieces gasify more quickly than larger pieces due to the larger surface area to volume ratio, and dry pieces gasify more quickly than green pieces because the lack of moisture allows them to heat up more quickly. Small dry pieces therefore gasify quickest of all and you must leave room in the burner for the gases to develop and be burned off in the secondary phase of combustion. You will also find that fuels that gasify quickly, deliver their heat more rapidly. Therefore you can give these fuels less under fire air than you would give to green fuel and receive the same amount of heat output.



As a starting point load the firebox 1/3 full of fuel, placing it behind the raked forward pile of coals. As the wood burns and releases its gases the additional 2/3 volume of the firebox area is needed as a combustion space for these gases. Since every customer's wood fuel is different, use this recommendation as a starting point and adjust from there. Wood fuel that is green or that consists of large chunks will gasify more slowly (than small pieces of dry fuel) and customers using this fuel may be able to load their burner as much as 1/2 full, but should never load more than that amount. An overloaded burner will generally produce a dark colored emission even with the over fire valve fully open. It can also create "puffing" (see trouble shooting section below) with small amounts of smoke "puffing" out the door. This occurs because the amount of over fire air is insufficient for the size (rate of gasification) and unburned gases are going up the stack in the form of carbon. In addition, the combustion process may now extend out of the firebox and into the heat exchanger. This can cause damage to stove components not made to withstand the direct flame of combustion.

If a burner is overloaded, do not open the loading door until the pile of fuel has burned down. Turn off the underfire air valve and wait for the charge to burn down.

1.8 OPERATING TEMPERATURES

The recommended operating temperatures will provide for both low emissions and long equipment life. Operating your burner near the low end of the operating range will contribute to a longer life and less maintenance for your burner, while operating near the high end of the range will yield greater fuel consumption and produce more heat output. The importance of operating your equipment within its specified temperature limits cannot be over stressed. 90+% of the damage we have observed with all makes of burners is temperature related.

SHOP HEATER RECOMMENDED OPERATING RANGE
800°-1200° Fahrenheit

The operating range and high temperature limit are dictated by the temperature limits of the steel construction. Generally, the recommended high temperature limit will provide a reasonable operating margin so that the steel will not yield to thermal expansion, a point at which the burner will sustain damage if operated for an extended period of time.

SHOP HEATER HIGH TEMPERATURE LIMIT
1250° Fahrenheit

NOTE: DO NOT EXCEED 1250 DEGREES F. IN FIREBOX; IT WILL CAUSE DAMAGE TO THE EXHAUST TUBE!

1.9 OPERATING FURNACE DURING A PROLONGED POWER OUTAGE

This furnace may be operated during a power outage although without the induced draft fan and warm air distribution fans it will not produce its full rated capacity. If the outage occurs when the furnace is not operational, a small fire should be built initially to develop a natural draft up the stack.

2.0 **TROUBLESHOOTING**

Excessive Coals

Under certain circumstances, a large bed of coals may form in the burner, filling 1/4 of the firebox or more. This has been observed when burning kiln dried Douglas fir and Philippine mahogany scrap such as 6 x 6 cutoffs, etc., or this situation may occur simply by attempting to load the firebox before the previous load has had sufficient time to burn down. When this condition occurs, rake the pile of coals towards the front of the burner, but do not add additional fuel at this time. Raking the coals forward in this manner will achieve a higher burning rate and must be done to reduce the pile of coals before adding more fuel. Adding more fuel on too large a pile of coals may cause an excessively large fire resulting in dark smoke out of the stack.

White Smoke

The fire is burning too cold to ignite the gaseous fuel in the secondary phase of combustion and this is going up the stack as white smoke. Heat up the firebox by adding additional under fire air, reducing over fire air, or, if the fire is very small, by adding fuel. Do not mistake steam for white smoke. Steam forms just above a hot stack leaving a short distance of clear exhaust between the stack and the steam plume and steam dissipates quickly. White smoke on the other hand comes out of the stack and does not dissipate but drifts off.

Black Smoke

More gas is being generated by the fuel than can be burned in the secondary combustion phase. The result of this incomplete combustion is a fuel rich mixture going up the stack as black smoke. Cut back on the amount of under fire air or add more over fire air if that valve is not already full open.

Puffing

The gaseous flame goes out from a lack of over fire oxygen, then fresh oxygen comes in, is consumed in a puff as the fire reignites, and the cycle repeats itself. The burner has been overloaded. The fire is too large for the burner and is not getting sufficient over fire air. Close the under fire air valve and open the over fire air valve in an attempt to reduce the size of the fire. In the event of puffing, do not open the loading door as it will extend this cycle. This rhythmic puffing or fluttering is due to the excessive production of combustible gases from an overabundance of small pieces of dry wood or dry wood with glues. Load small dry pieces in small quantities only.

NOTE: IN THE EVENT OF PUFFING, DO NOT OPEN THE FIREBOX LOADING DOOR!

Negative Pressure

If your building has a total loss saw dust collection system or spray paint booth, then your building probably has negative pressure within it (if your outside doors blow open or slam shut due to suction in your building, then you have this problem) and your burner will also have this problem. Since your chimney is connected to the outdoors and the burner sits inside your shop, a severe down draft backwards through the chimney can occur.

Because the proper flow of flue gases can be reduced or reversed by the negative pressure, your burner room must be operated at a neutral or positive pressure. This can be accomplished by ducting air from the area to be heated to the rear air inlet on the burner, using the hot air/cooling fan to pressurize the burner room, thus using the burner room as a positive pressure plenum, and having ductwork or vents to direct the heated air to its destination.

Weak Induced Draft

Check for blockage of the fan inlet, hose or nozzle. Check for a breach in the connection between the induced draft fan and the induced draft nozzle. Check for a blocked stack by opening the upper cleanout doors and looking up the stack with a mirror. Also check for proper rotation of the induced draft fan (towards outlet). An induced draft fan rotating in the wrong direction will produce only about 1/3 the draft of a fan with the correct rotation

MAINTENANCE

2.1 REGULAR CLEANING

1. Establish a routine for the storage of fuel, care of the appliance, and firing techniques.

2. Check daily for creosote buildup until experience shows how often cleaning is necessary.

3. Be aware that the hotter the fire is, the less creosote is deposited, and that weekly cleaning may be necessary in mild weather, even though monthly cleaning may be enough in colder months. A small intense fire is preferable to a large smoldering fire to reduce the amount of creosote deposition.

4. Have a clearly understood plan to handle a chimney fire.

Ash Removal

Ashes should be removed from the firebox when they start to have an adverse effect on primary air flow. Ash is also a great insulator and can slow the transfer of heat out of the firebox.

The optimum time for ash removal is when the burner is relatively cool, typically first thing in the morning after it has cooled down overnight. Use the ash hoe to bring the ashes to the front of the burner, and then push the hot coals to the rear of the burner to separate them from the ashes. Remove ashes with a short handled shovel, a scoop, or a similar tool, and then rake the hot coals to the front of the burner in preparation for loading fuel. Add kindling if necessary. Observe proper precautions when storing ashes for later disposal.

Disposal of ashes;
Ashes should be placed in a metal container with a tight fitting lid. The closed container of ashes should be placed on a noncombustible floor or on the ground well away from all combustible materials, pending final disposal. If the ashes are disposed of by burial in soil or otherwise locally dispersed, they should be retained in the closed container until all cinders have thoroughly cooled.

NOTE: ASH CAN RETAIN ENOUGH HEAT TO BE A FIRE DANGER FOR MANY DAYS AFTER REMOVAL FROM THE BURNER, STORE IN A SAFE METAL CONTAINER FOR AT LEAST 2 WEEKS BEFORE DISPOSAL.

Frequency of ash removal depends to a large extent on the type of fuel burned. Experience has shown that the burning of bark results in the greatest ash build-up due to dirt and mineral content. Burning clean lumber results in the lowest ash build-up.

Heat Exchanger Tube Cleanout

Over a period of time, soot gradually builds up in the heat exchanger tubes and causes poor heat transfer and a restriction of exhaust gas flow. The net result is a considerable increase in the amount of heat energy wasted up the stack. In some cases restrictions in the heat exchanger may cause smoking out the loading door.

Tube cleanout is needed when the stack temperature remains consistently high (100-200 degrees above the stack temperature of clean burner), typically at least every 8 weeks. Frequent cleaning will result in more efficient furnace operation.

Tube cleanout:

1. Open the access door to the heat exchanger tubes.

2. Attach the fine wire brush to the clean out rod and mount this assembly on an electric drill.

3. Run this tool, in forward rotation, down the length of each tube 2 or 3 times to loosen the soot. Deposits of soot will collect at the front and back ends of the heat exchanger as you clean the tubes.

4. After cleaning all the tubes, clean the collected soot at the front and rear of the heat exchanger. If the furnace had been shut down and is cold, a vacuum cleaner can be used to clean the soot out of each tube after the tool has been run through it.

The use of the fine wire, followed by a thorough vacuuming of the heat exchanger tubes on a cold heat exchanger will yield the best possible results when the tubes are cleaned regularly. The coarse wire brush should be used only when necessary to remove the few heavy deposits that may be left by the fine brush. Use the coarse brush only after the fine brush has been used or it may grab in the tubes.

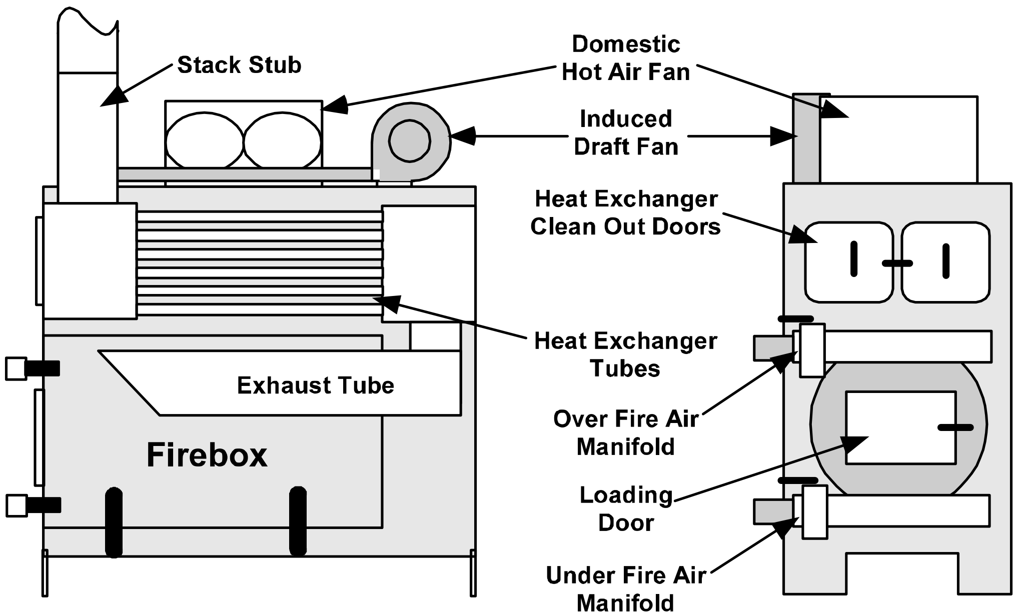
Creosote – Formation and Need for Removal. When wood is burned slowly, it produces tar and other organic vapors, which combine with expelled moisture to form creosote. The creosote vapors condense in the relatively cool chimney flue of a slow-burning fire. As a result, creosote residue accumulates on the flue lining. When ignited, this creosote makes an extremely hot fire. The chimney connector and chimney should be inspected at least twice monthly during the heating season to determine if a creosote buildup has occurred. If creosote has accumulated, it should be removed to reduce the risk of a chimney fire.

2.2 LONG-TERM MAINTENANCE

CLEANING OF THE HEAT EXCHANGER, FLUE PIPE, CHIMNEY AND DRAFT INDUCER IF USED, IS ESPECIALLY IMPORTANT AT THE END OF THE HEATING SEASON TO MINIMIZE CORROSION DURING THE SUMMER MONTHS BY ACCUMULATED ASH

Stack Cleanout

Over a period of time, soot and scale may gradually build up in the stack or may fall to the bottom of the stack. Inspect your stack for buildup once or twice a year. If necessary use a flue brush to clean the inside of the stack. Soot and debris can be removed through the Heat Exchanger Clean out Doors at the front of the burner.



Specifications subject to change without notice

Exhaust Tube

The exhaust tube or "afterburn chamber" which runs down the top of the inside of the firebox, reburns the flue gasses as they leave the firebox. This heavy wall pipe is the only component in the furnace which has heat on both sides of it so it wears faster then the other cooled components. Under normal operating conditions this tube could need to be replaced every four to six years. Operating the furnace at temperatures higher then 1200 degrees, or burning particleboard, will shorten the life expectancy of this exhaust tube. The furnace is designed to make exhaust tube replacement relatively simple and inexpensive.

NOTE: It is important to maintain the exhaust tube in good condition. If heat causes the exhaust tube to close up over time the air flow through the furnace will be reduced as will the output of the furnace. If heat causes the exhaust tube to shorten, the rear of the heat exchanger will be exposed to excessive heat.

NEVER-SEEZ

Burner doors that become difficult to swing open and shut over time can be freed up by applying a small amount of NEVER-SEEZ to the hinges.

The stainless nozzles in your burner have been installed with NEVER-SEEZ on the threads. If they are removed for any reason, apply a generous amount of NEVER-SEEZ or a similar anti-seize compound to the threads before reinstalling.

The two 6” threaded clean out plugs at the rear of the furnace have NEVER-SEEZ applied and have been screwed in tight for shipping. After removing them to clean ash from the furnace, re-apply NEVER-SEEZ and install them snug but not tight.

Ductwork

The inside and the top of the ductwork attached to your BCS burner system may collect a significant layer of dust over time which should be considered a fire hazard. Check your ductwork periodically and clean out accumulations of material.

Nozzles

Just inside the firebox door are three under fire and three over fire nozzles. They are 2-3/8 inches wide by 6 inches long, made of stainless steel, and screwed into the front of the stove. These nozzles are expendable extensions of the under fire and over fire air manifolds.

Check the condition of the nozzles at least twice a year; if the nozzles have become thin and/or have shortened due to deterioration replace them. Replacement nozzles are available from BCS. Use a pipe wrench or strap wrench to remove the old nozzles. Coat the threads of the new nozzles generously with NEVER-SEEZ or a similar lubricant and install.

SAFETY

3.1 TRAINED PERSONNEL

You should restrict the operation of the burner to authorized and trained personnel. A properly trained employee will save money while an untrained one can inadvertently cause costly damages to your wood burning system or your shop. Be sure to obtain operating instructions for your equipment and familiarize employees with these.

3.2 OPERATOR SAFETY

Your operator should use care when opening the door of a hot furnace, for example to load more fuel or to check on its location. We recommend that the operator wear a face shield, gloves, and non-flammable clothing before opening the door.

3.3 SAFETY LABELS

Make sure that all applicable safety labels are posted in clearly noticeable locations. Safety labels to be posted by each burner are provided at no charge to our customers. Please contact BCS if you need additional labels.

Place this caution notice on wall near firebox door, in view of operator.

Environmental

January 25, 2008

Charlie Cary
Biomass Combustion Systems
67 Millbrook Street, #505
Worcester, MA 01606

RE: Wood Furnace Emissions Testing Results
CK Project 3225

Dear Mr. Cary:

CK Environmental, Inc. (CK) performed particulate matter (PM), condensable particulate matter (CPM), nitrogen oxides (NOx), and carbon monoxide (CO) emissions testing of a 36" Shop Heater with a heat input rating of 999,000 BTU/hr using EPA Reference Methods 1-5/202, 7E and 10. Furnace emissions exhausted to the atmosphere through a 12 inch (nominal) diameter stack. This report presents the results of testing performed December 5, 2007.

The subject unit burns milled wood scraps from a sash and window manufacturing process. A representative sample of wood was submitted to Desert Analytics for analysis. A copy of the analytical report is located in Appendix B. The heating value of the sample "as received" by the laboratory was 8,474 BTU/lb. This value was used to calculate pollutant emission rates (lbs/MMBtu).

Three 1-hour test runs were performed. PM and CPM samples were submitted to Maxxam Analytical, Inc. for analyses. Table 1 presents a summary of results. The heat input during testing averaged 0.94 MMBtu/hr which resulted in an average total particulate (PM & CPM) emission rate was 0.086 lbs/MMBtu. NOx emissions averaged 0.050 lbs/MMBtu.

Sampling was conducted by trained personnel with extensive experience in Reference Method sampling. All sampling and analyses were conducted in strict accordance with the following EPA test procedures, including quality control procedures found in the EPA Quality Assurance Handbook for Air Pollution Measurement Systems.

EPA Methods 1-5	- Determination of Particulate Matter (PM) Emissions from Stationary Sources
EPA Method 3A	- Determination of Oxygen (O2) and Carbon Dioxide (CO2) Concentration Emissions from Stationary Sources
EPA Method 7E	- Determination of Nitrogen Oxide (NOx) Emissions from Stationary Sources
EPA Method 10	- Determination of Carbon Monoxide (CO) Emissions from Stationary Sources
EPA Method 202	- Determination of Condensable Particulate Matter (CPM) from Stationary Sources

CK's entire equipment inventory is on a schedule of routine maintenance and calibration. All calculations were conducted in accordance with the equations found in the individual Methods. Emission rate calculations were checked by a second individual to ensure that they are correct. These specific procedures validate the results obtained during the test program. The majority of CK's emissions testing work is performed for compliance purposes, which require strict

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QC procedures. This testing program was performed using those same procedures.

Supporting documentation is enclosed with this report. Field data sheets together with reduced data worksheets are located in Appendix A. Appendix B contains laboratory reports.

Please contact me (toll free 888-CKE-0303 or kkelley@ckenvironmental.com) should you have any questions regarding the performance, or finding, of this testing program.

Sincerely,

Kevin J. Kelley
Program Manager

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Table 1 – Summary of Results

TEST NUMBER:		1	2	3	
DATE:		12/6/2007	12/6/2007	12/6/2007	
START TIME :		0951	1133	1420	
	UNITS				**AVERAGE**
PROCESS CONDITIONS					
Wood Feed Rate	lb/hr	120	107	107	111
SAMPLE CONDITIONS					
Meter Volume	dscf	45.50	46.31	44.93	45.58
Isokinesis	%	99.7	99.6	98.2	-
Total Particulate Catch	mg	52.1	52.5	41.2	-
STACK CONDITIONS					
Stack Gas Flowrate	dscf/min	580	590	580	580
Average Stack Temperature	°F	198	201	175	191
Water Vapor in Stack Gas	%	2.5	3.2	3.1	3.0
CO_2 in Stack Gas	%	3.9	2.4	2.6	3.0
O_2 in Stack Gas	%	16.6	18.3	17.9	17.6
CO in Stack Gas	ppm	315	485	205	335
MEASURED EMISSIONS					
NOx in Stack Gas	ppm	14.1	9.1	11.0	11.4
NOx Emission Rate	lbs/hr	0.059	0.038	0.046	0.048
NOx Emission Rate	**lb/MMBtu**	**0.058**	**0.042**	**0.050**	**0.050**
Particulate Emission Concentration	gr/dscf	0.0177	0.0175	0.0142	0.0164
Mass Emission Rate	lbs/hr	0.087	0.088	0.070	0.08
Fuel Heating Value	BTU/lb	8474	8474	8474	8474
Heat Input	MMBTU/hr	1.017	0.907	0.907	0.943
Particulate Emissions	**lb/MMBtu**	**0.086**	**0.097**	**0.077**	**0.086**

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APPENDIX A

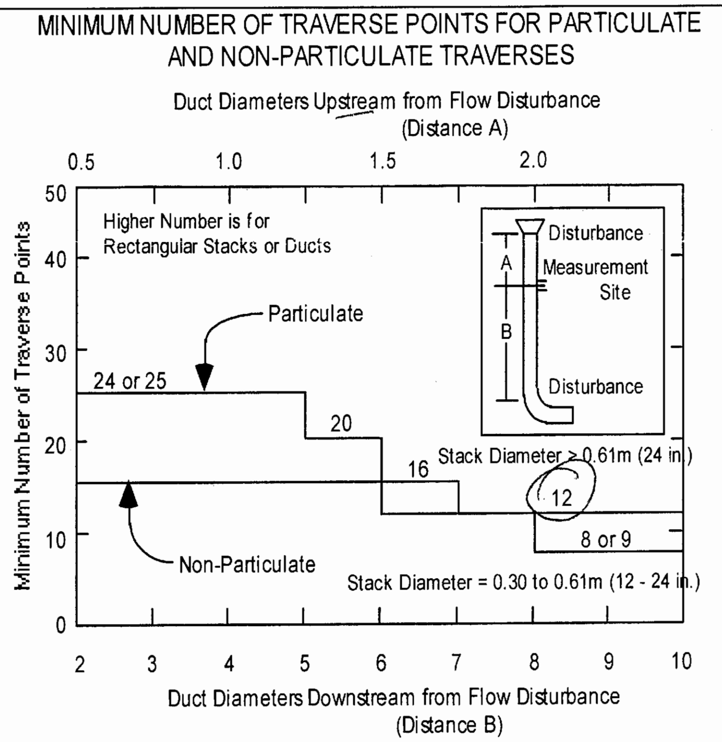
FIELD DATA SHEETS

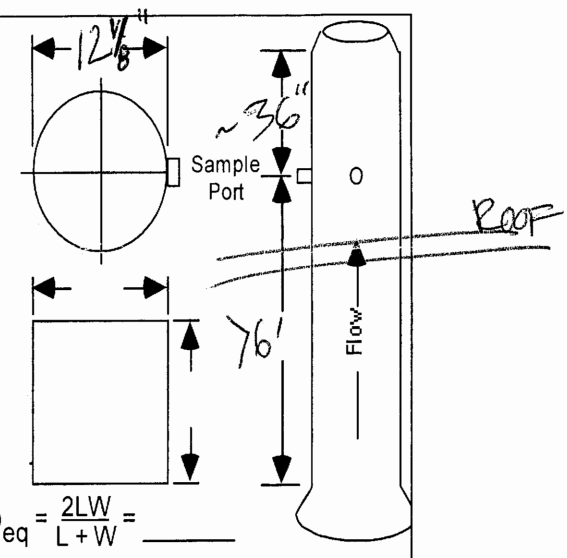
EPA Method 1

Sample and Velocity Travers[e]
for Stationary Sources

Firm Biomass Combustion @ Boston Sash
Date 12/5/07 Project No.
Location Wood-fired furnace stack
Diameters Upstream 3
Diameters Downstream 76

Total Traverse Points Required 12
Number of Ports 2
Points Per Port 6
Probe Traverses: Horizontal
Vertical





$D_{eq} = \frac{2LW}{L+W} =$ ______

Cross-Sectional Layout For Rectangular Stac[k]

Traverses	Matrix
9	3x3
12	4x3
16	4x4
20	5x4
25	5x5

Point On A Diameter	Location of Traverse Points in Circular Stacks* Number of Traverse Points on a Diameter 4	6	8	10	12	Traverse Point Location Distance From Wall	Nipple Size	Total Distance
1	6.7	4.4	3.2	2.6	2.1	0.5	2"	2.5
2	25.0	14.6	10.5	8.2	6.7	1.8	↓	3.8
3	75.0	29.6	19.4	14.6	11.8	3.6	↓	5.6
4	93.3	70.4	32.3	22.6	17.7	8.5	↓	10.5
5		85.4	67.7	34.2	25.0	10.4	↓	12.4
6		95.6	80.6	65.8	35.6	11.6	↓	13.6
7			89.5	77.4	64.4			
8			96.8	85.4	75.0			
9				91.8	82.3			
10				97.4	88.2			
11					93.3			
12					97.9			

*Percent of Stack Diameter from Inside Wall to Traverse Point

ESZ 1.6676
Alte 1.6893
Y = 0.9942
1.0083

EPA Method 2

Velocity Traverse and
Flow Rate Determination

Pre-test flow

Firm: Biomass Combustion @ Boston Sash
Date: 12/6/07 Project No. ________
Location: Woodfired Furnace Stack

Round Stack or Duct:
Diameter (in): 12 1/8" (12.125") Area ________ ft^2

Rectangular Stack or Duct:
Stack Length (in) ________ Area ________ ft^2
Stack Width (in) ________
Barometric Pressure; Pb = ________ in. Hg
Stack Static Pressure; Pg = -0.04 in. H2O
Stack Gas Moisture Content; % H2O = ________
Stack Gas Molecular Weight; (wet) Mw = ________
Pitot Tube No. ________ Cp = 0.84
Field Tester(s) ________
Test Start Time: ________ Finish: ________

Schematic of Traverse Point Locations

Cyclonic Flow Angle: + Ø Clockwise
- Ø Counterwise

PORT	POINT	dP (Inch H2O)	SqRoot dP	Ts (°F)	± Ø	Pitots Reversed for Negative Flow?	RADIANS	SqR dP*cosØ
A	1	0.06		108				
	2	0.065		125				
	3	0.07		136				
	4	0.065		141				
	5	0.065		144				
	6	0.055		136				
B	1	0.05		94				
	2	0.06		104				
	3	0.065		116				
	4	0.07		121				
	5	0.06		126				
	6	0.05		124				
		AVERAGE					AVERAGE	

Absolute Gas Temperature; Tst = Ts + 460° ________ ° R
Absolute Gas Pressure; Ps = Pb + Pg/13.6 ________ in. Hg
Gas Velocity; Vs = (85.49)Cp(??P*cosØ)avg?(Tst avg/(Ps*Mw)) ________ ft/sec
Actual Gas Flow Rate; Qa = (Vs)(60)(A) #VALUE! acfm
Standard Gas Flow Rate; Qs = Qa(528°R/Tst)(Ps/29.92) ________ scfm
Dry Standard Gas Flow Rate; Qsd = Qa(528°R/Tst)(Ps/29.92)((100-%H2O)/100) ________ dscfm

Particulate Test Data Worksheet

CLIENT: BioMass Combustion SOURCE/LOCATION: Boston Sash PROJECT NUMBER: 3225 TEST NUMBER: DATE: TIME :			1 6-Dec-07 0950-1050	2 6-Dec-07 1133-1233	3 6-Dec-07 1420-1520	AVERAGE
TEST DATA INPUT	SYMBOL	UNITS				
Barometric Pressure	Pbar	in. Hg	30.00	30.24	30.25	
Stack Area	A	ft2	0.80	0.80	0.80	
Nozzle Diameter (in.)	Dn	in.	0.441	0.441	0.441	
Total Sampling Time	Ø	min.	60	60	60	
Calibration Factor	Y	-	1.008	1.008	1.008	
Pitot Coefficient	Cp	-	0.84	0.84	0.84	
Average Square Root of Velocity Head	Sq Rt dPavg	in. H2O	0.244	0.249	0.240	
Average Orifice Pressure Drop	?H	in. H2O	1.75	1.82	1.69	
Average Meter Temperature	Tm	°F	42	49	45	
Average Stack Pressure	Pg	in. H2O	0.06	0.06	0.06	
Average Stack Temperature	Ts	°F	198	201	175	
Meter Volume @ Meter Conditions	Vm	ft3	42.62	43.63	41.99	
Total Water Collected	Vlc	ml	24.7	32.9	31.0	
CO2 in Stack Gas	CO2	%	3.9	2.4	2.6	
O2 in Stack Gas	O2	%	16.6	18.3	17.9	
CO in Stack Gas	CO	%	0	0	0	
Filter			31.7	33.6	26.0	
Front-half rinse			8.7	4.0	3.9	
Condensibles			11.7	14.9	11.3	
Total Particulate Catch	PMt	mg	52.1	52.5	41.2	
FUEL						
Hydrogen in Fuel	H2	%				
Carbon in Fuel	C	%				
Sulfur in Fuel	S2	%				
Nitrogen in Fuel	N2	%				
Oxygen in Fuel	O2	%				
Gross Calorific Volume of Fuel	HHV	Btu/lb				
CALCULATED VALUES						
Meter Volume	Vmstd	dscf	45.50	46.31	44.93	45.58
Water Vapor in Stack Gas	Bws	%	2.5	3.2	3.1	3.0
Molecular Weight of Stack Gas (dry)	Md	g/g-mole	29.29	29.12	29.13	29.18
Molecular Weight of Stack Gas (wet)	Ms	g/g-mole	29.01	28.76	28.78	28.85
Average Velocity of Stack Gas	Vs	ft/min	914	935	883	911
Actual Stack Gas Flowrate	Q	acf/min	733	750	708	730
	Qs	scf/min	590	606	595	597
Stack Gas Flowrate	Qsd	dscf/min	575	586	577	579
Isokinetics	I	%	99.7	99.6	98.2	-
EMISSION CONCENTRATION						
Particulate Emission Concentration	PCgr	gr/acf	0.01	0.01	0.01	0.01
Particulate Emission Concentration	PCgrsd	gr/dscf	0.018	0.017	0.014	0.016
Particulate Emission Concentration	PClbsd	lb/dscf	2.52E-06	2.50E-06	2.02E-06	2.35E-06
Particulate Emission Concentration	PCµgm	µg/dscm	40,461	40,057	32,406	37,641
EMISSION RATE						
Particulate Emission Rate	PER	lb/hr	0.087	0.088	0.070	0.082

EPA Method 5

Particulate Test Data Sheet

Client/Firm: Biomass Combustion @ Boston Sash
Location: Woodfired Furnace Stack
Project No.: ______ Test Number: 1
Testers Initials: KSL Test Date: 12/6/07
Test Time(min): 60 Start Time: 0951
Min Per Point: 5 End Time: ______

Assumed Moisture: 5 (%)
Pb = ______ (in Hg)
Nozzle Size: 0.441
Nozzle No.: 155006
C/K Factor: 29.14

Module No.: ES2
dH@ = 1.6676
Cp = 0.84
Y = 1.0080
Probe No.: ______
Pitot No.: ______
Filter No.: 2006090606

Signature of Train Operator:

Rectangular Stack: Length (in) ______ Width (in) ______
Circular Stack: Diameter (in) 12.125 Area (ft^2) ~~0.00~~
Train Leak Checks: Pre-Test 0.01 cfm 8 in Hg
Post-Test 0.01 cfm 10 in Hg
Orsat Leak Check: Pre-Test ______ Post-Test ______
Pitot Leak Check: Pre-Test ______ Post-Test ______
Final Orsat Analysis ______ O2% ______ CO2%

	Port	Point	Time (min)	Meter Volume (ft^3)	dP (in H2O)	dH (in H2O)	Stack (°F)	Probe (°F)	Htr Box (°F)	Filter (°F)	Cond Out (°F)	Module Meter In (°F)	Module Meter Out (°F)	Vacuum (in Hg)	Comments
951	A	1	0	371.240	0.07	2.04	342	237		212	39	40	34	2	Static Pressure: in H2O
956		2	5	375.4	0.07	2.04	235	239		232	34	43	35	3	dP ~~dH~~
1001		3	10	379.0	0.06	1.89	236	239		234	36	44	36	3	0.045 1.31
1006		4	15	383	0.60	1.75	204	237		230	37	46	37	3	0.05 1.46
1011		5	20	386.4	0.055	1.6	184	236		236	41	46	38	3	0.055 1.60
1016		6	25	389.4	0.05	1.46	93	239		237	42	47	39	3	0.06 1.75
			30	393											0.065 1.89
1021	B	1			0.05	1.46	93	237		236	44	47	39	3	0.07 2.04
1026		2		296.2	0.05	1.46	162	239		237	44	47	39	3	0.075 2.19
1031		3		299.5	0.055	1.6	184	239		236	46	47	39	3	
1036		4		302.6	0.06	1.75	224	239		237	48	49	40	3	
1041		5		306	0.07	2.04	270	239		237	48	49	41	6	
1046		6		310.0	0.075	2.04	270	240		236	52	51	43	6	
1051		END		313.911											

Final Reading: ______
Total Volume: ______
Average ______
Avg Square Root dP ______
Average of In & Out Meter Temperatures ______

Impinger Recovery

Impinger Number	Vol or Wt Initial	Vol or Wt Final	Total Catch
1	100	103	3
2	100	109	9
3	0	2	2
4			
Other(s)			
Silica Gel	702.8	713.5	10.7

Total Moisture Catch: ______
Calculated Moisture Content: 24.7

Rev 9/95 TMC

EPA Method 5

Particulate Test Data Sheet

Signature of Train Operator:

Client/Firm	Biomass Combustion @ Boston Sash	Assumed Moisture	(%)	Module No.	ES2
Location	Wood Fired Furnace Stack	Pb =	(in Hg)	dH@ =	1.6676
Project No.		Test Number	2	Cp=	0.84
Testers Initials	KSC	Test Date	12/6/07	Y =	1.0080
Test Time(min)	60	Start Time	1133	Nozzle Size	0.441
Min Per Point	5	End Time		Nozzle No.	155006
				C/K Factor	29.14
				Probe No.	MS-16
				Pitot No.	
				Filter No.	2006090604

Rectangular Stack: Length (in)		Width (in)	
Circular Stack: Diameter (in)	12.125	Area (ft^2)	0.00
Train Leak Checks: Pre-Test	<0.01 cfm	10	in Hg
Post-Test	<0.01 cfm	17	in Hg
Orsat Leak Check: Pre-Test		Post-Test	
Pitot Leak Check: Pre-Test		Post-Test	
Final Orsat Analysis		O2%	CO2%

	Port	Point	Time (min)	Meter Volume (ft^3)	dP (in H2O)	dH (in H2O)	Stack (°F)	Probe (°F)	Htr Box (°F)	Filter (°F)	Cond Out (°F)	Module Meter In (°F)	Module Meter Out (°F)	Vacuum (in Hg)	Comments
1133	1A	1	0	314.257	0.07	2.04	309	255		210	37	47	44	5	Static Pressure: in H2O
1138		2	5	318.1	0.07	2.04	213	254		232	41	49	44	6	
1143		3	10	321.9	0.07	2.04	219	255		236	43	51	44	7	dP dH
1148		4	1148 15	325.8	0.06	1.75	241	253		236	44	51	45	6	0.045 1.31
		5	1153 20	329.4	0.06	1.75	232	254		239	46	52	46	6	0.05 1.46
		6	1158 25	332.9	0.05	1.46	151	[illegible]		236	49	52	46	5	0.55 1.60
		6	1203 30	336.3	0.05	1.46	90	237		237	51	52	46	5	0.6 1.75
		5	1208 35	339.4	0.05	1.46	142	255		240	52	52	47	6	0.65 1.89
		4	1213 40	342.6	0.06	1.75	194	257		239	54	53	47	8	0.7 2.04
		3	1218 45	346.2	0.07	2.04	245	257		234	55	53	47	9	0.75 2.19
		2	1223 50	350.1	0.07	2.04	239	257		240	55	53	47	10	
		1	1228 55	354.0	0.07	2.04	246	257		240	58	54	48	10	
		END	1233 60	357.889											

Final Reading:
Total Volume:
Average
Avg Square Root dP
Average of In & Out Meter Temperatures

Impinger Recovery

Impinger Number	Vol or Wt Initial	Vol or Wt Final	Total Catch
1	679.6	682.1	2.5
2	689.8	704.1	14.3
3	526.6	530.7	4.1
4			
Other(s)			
Silica Gel	806.3	818.3	12

Total Moisture Catch: ______ **Calculated Moisture Content:** 32.9

Rev 9/95 TMC

EPA Method 5

Particulate Test Data Sheet

Signature of Train Operator:

Client/Firm: BIOMASS COMBUSTION @ BOSTON SASH
Location: WOOD FIRED FURNACE STACK
Project No.:
Testers Initials: KJC
Test Time(min): 60
Min Per Point: 5

Test Number: 3
Test Date: 12/6/07
Start Time: 1420
End Time:

Assumed Moisture: (%)
Pb = (in Hg)
Nozzle Size: 0.441
Nozzle No.: 155006
C/K Factor: 29.14

Module No.: ES2
dH@ = 1.6676
Cp= 0.84
Y = 1.0080
Probe No.: MS-16
Pitot No.:
Filter No.: 2006 09 0605

Rectangular Stack: Length (in) ______ Width (in) ______
Circular Stack: Diameter (in) 12.125 Area (ft^2) 0.00
Train Leak Checks: Pre-Test 0 cfm 10 in Hg
Post-Test 0 cfm 12 in Hg
Orsat Leak Check: Pre-Test ______ Post-Test ______
Pitot Leak Check: Pre-Test ______ Post-Test ______
Final Orsat Analysis ______ O2% ______ CO2%

Port	Point	Time (min)	Meter Volume (ft^3)	dP (in H2O)	dH (in H2O)	Stack (°F)	Probe (°F)	Htr Box (°F)	Filter (°F)	Cond Out (°F)	Module Meter In (°F)	Module Meter Out (°F)	Vacuum (in Hg)
A	1	1420 0	358.052	0.65	1.89	194	255		218	36	42	42	4
	2	1425 5	361.8	0.60	1.75	197	254		232	39	44	42	4
	3	1430 10	365.3	0.60	1.75	219	253		234	42	46	41	4
	4	1435 15	368.9	0.60	1.75	202	253		239	43	47	41	5
	5	1440 20	372.4	0.50	1.46	158	255		236	46	49	42	4
	6	1445 25	375.7	0.45	1.31	74	255		236	47	49	42	4
	6	1450 30	378.9	0.45	1.31	65	254		240	48	49	43	4
	5	1455 35	382.0	0.5	1.46	98	253		237	50	49	43	5
	4	1500 40	385.7	0.55	1.6	172	256		237	53	49	43	5
	3	1505 45	388.6	0.65	1.89	233	255		234	57	50	43	7
	2	1510 50	392.3	0.70	2.04	249	256		233	59	51	44	8
	1	1515 55	396.1	0.70	2.04	235	254		232	59	51	44	8
	END	1520 60	400.044										

Final Reading: ______
Total Volume: ______
Avg Square Root dP ______
Average ______
Average of In & Out Meter Temperatures ______

Comments

Static Pressure: ______ in H2O

dP	dH
0.45	1.31
0.50	1.46
0.55	1.60
0.60	1.75
0.65	1.89
0.70	2.04
0.75	2.19

Impinger Recovery

Impinger Number	Vol or Wt Initial	Vol or Wt Final	Total Catch
1	713.6	715.7	2.1
2	724.3	737.6	13.3
3	523.2	527.8	4.6
4			
Other(s)			
Silica Gel	785.3	796.8	11.5

Total Moisture Catch: ______

Calculated Moisture Content: 31.5

Rev 9/95 TMC

WOOD LOAD Run 1 = 20 lbs/10 min

Run 2+3: 17 lb/10 min

Environmental

SYSTEM CALIBRATION SHEET

PLANT: BOSTON SASH / BIOMASS COMB DATE: 12/6/07

TEST LOCATION: BIOMASS BLR OPERATOR: MK

FUEL: WOOD SYSTEM RESPONSE TIME: ______

		O_2		CO_2		CO		SO_2		NOx	
		RANGE: 25		RANGE: 20		RANGE:		RANGE:		RANGE:	
		ZERO	SPAN	ZERO	SPAN	ZERO	SPAN	ZERO	SPAN	ZERO	SPAN
RUN: 1	ANALYZER CAL RESPONSE	0.1	11.1	0.0	11.2	0.1	292			0.2	251.0
START TIME: 09:50	INITIAL SYSTEM CAL RESPONSE	0.7	10.7	0.0	11.0	2.6	282			0.7	246
END TIME: 10:50	SYSTEM BIAS	0.0	1.6	0.0	0.0	0.5	2.0			0.10	1.0
	FINAL SYSTEM CAL RESPONSE	0.0	10.5	0.4	11.1	3.2	279.5			0.7	250.6
	SYSTEM BIAS	0.4	3.4	2.0	0.5	0.6	2.7			0.1	0.1
	SYSTEM DRIFT	0.4	0.8	2.0	0.5	0.1	0.5			0.0	0.9
	NON CAL. CORR. AVERAGE	16.6		3.9		315.3				14.1	
RUN: 2	INITIAL SYSTEM CAL RESPONSE	0.0	10.5	0.4	11.1	3.2	279.5			0.7	250.6
START TIME: 11:33	SYSTEM BIAS	0.4	2.4	2.0	0.5	0.6	2.7			0.1	0.1
END TIME: 12:33	FINAL SYSTEM CAL RESPONSE	0.2	10.8	0.0	10.7	4.0	278.5			0.2	238.5
	SYSTEM BIAS	0.4	1.2	0.0	2.5	0.8	2.8			0.0	2.7
	SYSTEM DRIFT	0.8	1.2	2.0	2.0	0.2	0.2			0.1	2.6
	NON CAL. CORR. AVERAGE	18.3		2.4		485.				9.1	
RUN: 3	INITIAL SYSTEM CAL RESPONSE	0.2	10.8	0.0	10.7	4.0	278.5			0.2	238.5
START TIME: 14:20	SYSTEM BIAS	0.4	1.2	0.0	2.5	0.8	2.8			0.0	2.7
END TIME: ______	FINAL SYSTEM CAL RESPONSE	0.3	10.6	0.2	10.5	3.6	282.1			0.6	241.5
	SYSTEM BIAS										
	SYSTEM DRIFT										
	NON CAL. CORR. AVERAGE	17.9		2.6		204.5				11.0	

SYSTEM BIAS = [(SYSTEM RESPONSE - ANALYZER RESPONSE) / HIGH CYLINDER VALUE] * 100

ERROR MUST NOT EXCEED 5% OF HIGH CYLINDER VALUE

SYSTEM DRIFT = [(INITIAL SYSTEM RESPONSE - FINAL SYSTEM RESPONSE) / HIGH CYLINDER VALUE] * 100

ERROR MUST NOT EXCEED 3% OF HIGH CYLINDER VALUE

– MONARCH TIME = 1 HR AHEAD OF ACTUAL

– RUN 2 @ REDUCED FEED RATE

CK Environmental, Inc.
1020 Turnpike St., Suite 8
Canton, MA 02021 USA
Toll-free: 888-CKE-0303
International: 781-828-5200
Fax: 781-828-5380
www.ckenvironmental.com

Ck Environmental

ANALYZER CALIBRATION SHEET

PLANT: BIOMASS COMB @ BOSTON SASH DATE: 12/6/07
TEST LOCATION: BIOMASS BLR OPERATOR: MK
FUEL: WOOD

GAS	RANGE	CYLINDER VALUE	ANALYZER RESPONSE	ABSOLUTE DIFFERENCE	ANALYZER CAL. ERROR
O_2	ZERO	0.0	0.1	0.1	0.4
	MID	10.96	11.1	0.1	0.4
	HIGH	21.1	21.0	0.1	0.4
CO_2	ZERO	0.0	0.0	0.0	0.0
	MID	11.12	~~17.6~~ 11.2	0.1	0.5
	HIGH	17.6	17.6	0.0	0.0
CO	ZERO	0.0	0.1	0.1	0.0
	MID	292	292	0.0	0.0
	HIGH	496	492.0	4.0	0.8
SO_2	ZERO	0.0			
	MID				
	HIGH				
NOx	ZERO	0.0	0.2	0.2	0.1
	MID	245	251.0	6.0	1.2
	HIGH	503	499.9	3.1	0.6

ANALYZER CAIBRATION ERROR = [(ANALYZER RESPONSE - CYLINDER VALUE) / HIGH CYLINDER VALUE] * 100

ERROR MUST NOT EXCEED 2% OF HIGH CYLINDER VALUE

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APPENDIX B

LABORATORY REPORT

DESERT ANALYTICS
A Columbia Analytical Services, Inc. Company

November 29, 2007

Client: CK Environmental, Inc.
1020 Turnpike St.
Suite 8
Canton, MA 02021

Attn: Becky Travis

Project: PO 3670RGT

Date Received: November 12, 2007

Certificate of Analysis

Analyses	*Method*	*Sample ID*	Wood Fuels 12 blocks					
		Date/Time						
		Lab #	DA07-8874					
		units	*As Received*	*Moisture Free*	*As Received*	*Moisture Free*	*As Received*	*Moisture Free*
Proximate Analysis								
Moisture	***E871***	%	5.42					
Ash	***D1102***	%	0.49	0.51				
Ultimate	***D3176***							
Carbon		%	47.96	50.71				
Hydrogen		%	6.21	5.92				
Nitrogen		%	0.06	0.06				
Oxygen			45.27	42.77				
Sulfur		%	0.012	0.012				
Heating Value	***D5865***	*BTU/lb*	8,474	8,960				

Notes:

RV Poulsen
Ralph V. Poulsen, Lab Director

3860 S. Palo Verde Rd.
Suite 303
Tucson, AZ 85714
520.623.3381

Your Project #: 3225
Site: BOIMASS COMBUSTION

Attention: Kevin Kelley
CK ENVIRONMENTAL
1020 Turnpike St
Unit 8
Canton, MA
USAE 2021

Report Date: 2008/01/03

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A7D8796
Received: 2007/12/13, 12:00

Sample Matrix: Filter
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Particulates in Acetone Rinse (M5/315)	3	2007/12/27	2008/01/02	BRL SOP-00109	EPA 5/315
Particulates on Filter (M5/315/NJATM1)	3	2007/12/19	2007/12/22	BRL SOP-00109	EPA 5/315/NJATM1
Final Volume of Acetone Probe Rinse	3	2007/12/21	2007/12/27		

Sample Matrix: Impinger Solution
Samples Received: 6

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Extractable Condensables (M202)	3	2007/12/22	2007/12/30	BRL SOP-00118	EPA 202
Non Extractable Condensibles (M202)	6	2007/12/27	2008/01/02	BRL SOP-00118 / BRL SOP-00109	EPA 202
Volume of DCM Received	3	2007/12/22	2007/12/22		
Final Volume of Impinger	6	2007/12/22	2007/12/22		

MAXXAM ANALYTICS INC.

ANCY SEBASTIAN, C.Tech.
Senior Project Manager, Air Toxics

AMS/ams
encl.

../2

5555 North Service Road, Burlington, Ontario, Canada L7L 5H7 Tel: (905) 332-8788 Toll Free: (800) 668-0639 Fax: (905) 332-9169

Your Project #: 3225
Site: BOIMASS COMBUSTION

Attention: Kevin Kelley
CK ENVIRONMENTAL
1020 Turnpike St
Unit 8
Canton, MA
USAE 2021

Report Date: 2008/01/03

CERTIFICATE OF ANALYSIS
-2-

PM Released by :
ANCY SEBASTIAN, C.Tech.
Senior Project Manager, Air Toxics

Total cover pages: 2

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Maxxam Job #: A7D8796
Report Date: 2008/01/03

CK ENVIRONMENTAL
Client Project #: 3225
Project name: BOIMASS COMBUSTION
Sampler Initials:

RESULTS OF ANALYSES OF FILTER

Maxxam ID		W41526	W41527	W41528		
Sampling Date		2007/12/06	2007/12/06	2007/12/06		
	Units	**RUN 1**	**RUN 2**	**RUN 3**	**RDL**	**QC Batch**
Particulate Weight in Acetone Rinse	mg	8.7	4.0	3.9	0.5	1434814
Volume	ml	69	63	80	1	1433658
Particulate Weight on Filter	mg	31.7	33.6	26.0	0.30	1433657

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: A7D8796
Report Date: 2008/01/03

CK ENVIRONMENTAL
Client Project #: 3225
Project name: BOIMASS COMBUSTION
Sampler Initials:

RESULTS OF ANALYSES OF IMPINGER SOLUTION

Maxxam ID		W41530	W41531	W41532	W41533		
Sampling Date		2007/12/06	2007/12/06	2007/12/06	2007/12/06		
	Units	**M202-A H2O/MECL2**	**M202-B H2O/MECL2**	**M202-C H2O/MECL2**	**M202-RUN 1 H2O**	**RDL**	**QC Batch**
Extractable Condensibles	mg	43	2	3	N/A	1	1432143
Non-Extractable Condensibles	mg	0.9	1.3	1.4	7.8	0.5	1434806
Volume	ml	50	50	50	460	1	1433966
DCM Volume	ml	50	50	45	N/A	1	1433965

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam ID		W41579	W41580		
Sampling Date		2007/12/06	2007/12/06		
	Units	**M202-RUN 2 H2O**	**M202-RUN 3 H2O**	**RDL**	**QC Batch**
Non-Extractable Condensibles	mg	11	7.4	0.5	1434806
Volume	ml	500	420	1	1433966

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

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Maxxam Job #: A7D8796
Report Date: 2008/01/03

CK ENVIRONMENTAL
Client Project #: 3225
Project name: BOIMASS COMBUSTION
Sampler Initials:

Test Summary

Maxxam ID W41526 **Collected** 2007/12/06
Sample ID RUN 1 **Shipped**
Matrix Filter **Received** 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Particulates in Acetone Rinse (M5/315)	BAL	1434814	2007/12/27	2008/01/02	VP2
Particulates on Filter (M5/315/NJATM1)	BAL	1433657	2007/12/19	2007/12/22	HA2
Final Volume of Acetone Probe Rinse		1433658	2007/12/21	2007/12/27	VP2

Maxxam ID W41527 **Collected** 2007/12/06
Sample ID RUN 2 **Shipped**
Matrix Filter **Received** 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Particulates in Acetone Rinse (M5/315)	BAL	1434814	2007/12/27	2008/01/02	VP2
Particulates on Filter (M5/315/NJATM1)	BAL	1433657	2007/12/19	2007/12/22	HA2
Final Volume of Acetone Probe Rinse		1433658	2007/12/21	2007/12/27	VP2

Maxxam ID W41528 **Collected** 2007/12/06
Sample ID RUN 3 **Shipped**
Matrix Filter **Received** 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Particulates in Acetone Rinse (M5/315)	BAL	1434814	2007/12/27	2008/01/02	VP2
Particulates on Filter (M5/315/NJATM1)	BAL	1433657	2007/12/19	2007/12/22	HA2
Final Volume of Acetone Probe Rinse		1433658	2007/12/21	2007/12/27	VP2

Maxxam ID W41530 **Collected** 2007/12/06
Sample ID M202-A H2O/MECL2 **Shipped**
Matrix Impinger Solution **Received** 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Extractable Condensables (M202)		1432143	2007/12/22	2007/12/30	LJD
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Volume of DCM Received		1433965	2007/12/22	2007/12/22	LJD
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

Maxxam ID W41531 **Collected** 2007/12/06
Sample ID M202-B H2O/MECL2 **Shipped**
Matrix Impinger Solution **Received** 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Extractable Condensables (M202)		1432143	2007/12/22	2007/12/30	LJD
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Volume of DCM Received		1433965	2007/12/22	2007/12/22	LJD
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

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Maxxam Job #: A7D8796
Report Date: 2008/01/03

CK ENVIRONMENTAL
Client Project #: 3225
Project name: BOIMASS COMBUSTION
Sampler Initials:

Test Summary

Maxxam ID W41532
Sample ID M202-C H2O/MECL2
Matrix Impinger Solution

Collected 2007/12/06
Shipped
Received 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Extractable Condensables (M202)		1432143	2007/12/22	2007/12/30	LJD
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Volume of DCM Received		1433965	2007/12/22	2007/12/22	LJD
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

Maxxam ID W41533
Sample ID M202-RUN 1 H2O
Matrix Impinger Solution

Collected 2007/12/06
Shipped
Received 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

Maxxam ID W41579
Sample ID M202-RUN 2 H2O
Matrix Impinger Solution

Collected 2007/12/06
Shipped
Received 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

Maxxam ID W41580
Sample ID M202-RUN 3 H2O
Matrix Impinger Solution

Collected 2007/12/06
Shipped
Received 2007/12/13

Test Description	Instrumentation	Batch	Prepared	Analyzed	Analyst
Non Extractable Condensibles (M202)		1434806	2007/12/27	2008/01/02	VP2
Final Volume of Impinger		1433966	2007/12/22	2007/12/22	LJD

5555 North Service Road, Burlington, Ontario, Canada L7L 5H7 Tel: (905) 332-8788 Toll Free: (800) 668-0639 Fax: (905) 332-9169

Maxxam Job #: A7D8796
Report Date: 2008/01/03

CK ENVIRONMENTAL
Client Project #: 3225
Project name: BOIMASS COMBUSTION
Sampler Initials:

GENERAL COMMENTS

Unable to read the label on the DCM jars. Therefore the bottles are logged as A,B,C and analyzed separately for both extractable and condensible particulate. In-house RODI water was used during extraction.

RESULTS OF ANALYSES OF FILTER

Particulates on Filter (M5/315/NJATM1): W41526-01R*LPC*
W41527-01R*LPC*
W41528-01R*LPC*

LPC=Loose particle in container

Results relate only to the items tested.

5555 North Service Road, Burlington, Ontario, Canada L7L 5H7 Tel: (905) 332-8788 Toll Free: (800) 668-0639 Fax: (905) 332-9169

CK ENVIRONMENTAL
Attention: Kevin Kelley
Client Project #: 3225
P.O. #:
Project name: BOIMASS COMBUSTION

Quality Assurance Report

Maxxam Job Number: GA7D8796

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
1432143 LJD	Spiked Blank	Extractable Condensibles	2007/12/30	110, RDL=1	108	mg	70 - 130
	Spiked Blank DUP	Extractable Condensibles	2007/12/30	110, RDL=1	105	mg	70 - 130
	Method Blank	Extractable Condensibles	2007/12/30	ND, RDL=1	--	mg	
1434806 VP2	Method Blank	Non-Extractable Condensibles	2008/01/02	ND, RDL=0.5		mg	
1434814 VP2	Method Blank	Particulate Weight in Acetone Rinse	2008/01/02	ND, RDL=0.5		mg	

ND = Not detected
SPIKE = Fortified sample

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Validation Signature Page

Maxxam Job #: A7D8796

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

FRANK MO, B.Sc., Inorganic Lab. Manager

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CAEAL have approved this reporting process and electronic report format.

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CK ENVIRONMENTAL, INC.
1020 Turnpike Street, Suite 8 Canton, Massachusetts 02021
Phone 781.828-5200 Fax 781.828-5380

CHAIN OF CUSTODY DOCUMENT

CK Client Name: BioMass Combustion	**Project Location**	**CK P.O. No.:**	**Laboratory**
Project Name:	Boston Sash	**Sample Date(s):** 12/6/2007	Maxxam Analytical
CK Project No.: 3225	Dighton, MA	**Date Shipped:** 12/12/2007	
CK Project Manager: Kevin Kelley		**Cooler No.:** N/A	
CK Field Team: Kevin Kelley		**COC Seal No.:** N/A	**Attn: Sample Custodian**
Turnaround Time (Please Circle): Rush Priority Standard		**Other:** ______	

Item	Sample ID Code	Date	Volume	Sample Location	Sample Fraction	Sample Matrix	Analytical Parameters	Special Instructions
1	Run 1	12/06/07			Filter #2006090606		PM by EPA M5	
2	Run 1	12/06/07			P&N rinse	acetone	PM by EPA M5	
3	Run 1	12/06/07			Impinger Catch & Rinse	DI water	CPM by EPA 202	
4	Run 1	12/06/07			MeCl2 Rinse	MeCl2	CPM by EPA 202	
5	Run 2	12/06/07			Filter #2006090604		PM by EPA M5	
6	Run 2	12/06/07			P&N rinse	acetone	PM by EPA M5	
7	Run 2	12/06/07			Impinger Catch & Rinse	DI water	CPM by EPA 202	
8	Run 2	12/06/07			MeCl2 Rinse	MeCl2	CPM by EPA 202	
9	Run 3	12/06/07			Filter #2006090605		PM by EPA M5	
10	Run 3	12/06/07			P&N rinse	acetone	PM by EPA M5	
11	Run 3	12/06/07			Impinger Catch & Rinse	DI water	CPM by EPA 202	
12	Run 3	12/06/07			MeCl2 Rinse	MeCl2	CPM by EPA 202	

Field Notes and Misc. Comments:

Sign & date C-O-C form and return original copy with final data report.

Relinquished by (Print Name): **Kevin Kelley** Signature: [signature]	Date: 12/12/2007 Time:	Received by: FEDEX Fed. Ex. Office: Tel #: Tracking #:	Date: 12/12/2007 Time: Hrs	Analytical Laboratory Notes: COC Seal Intact: ☐ Yes ☐ No Cooler Temperature: ______ Degrees F Comments:
Relinquished by: FEDEX Fed. Ex. Office: Tracking #:	Date: Time:	Received by Lab (Print Name): Signature:	Date: Time:	

WHITE COPY - ORIGINAL COPY (Completed copy to be returned with Final Report) YELLOW COPY - LABORATORY COPY PINK COPY - ORIGINATOR / CK PROJECT FILE COPY

Residential & Commercial
Heating Solutions

Econoburn

High-Efficiency Wood-Fired Boilers

the best built, most efficient wood-fired boiler on the market!

Save money on all your heating and hot water bills!

An Econoburn™ high-efficiency wood-fired boiler will save you hundreds, and quite possibly *thousands* of dollars on your yearly heating costs.

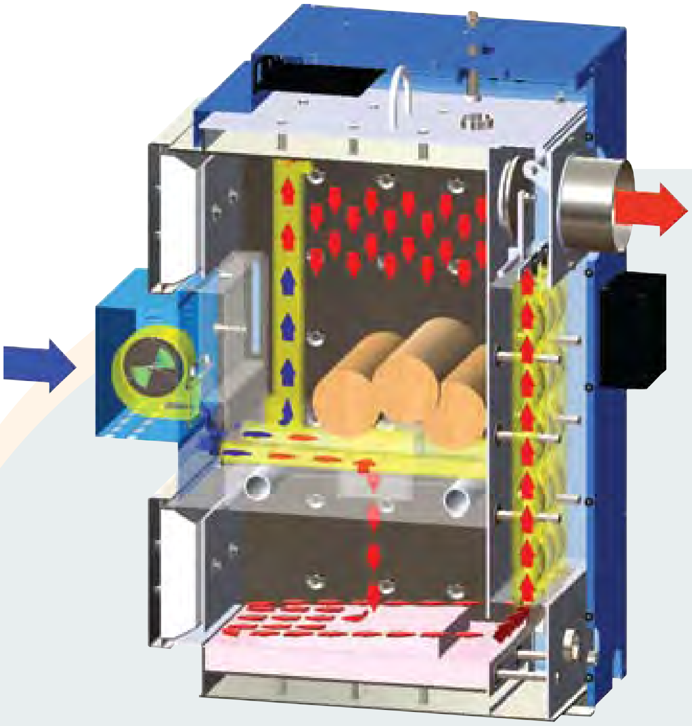
Whether your home or business utilizes forced air, radiant floor, or a traditional hot water baseboard heating system, Econoburn™ boilers will save you money. Our furnaces utilize gasification burning technology to produce an amazing 93.1% combustion efficiency.

Actual Econoburn™ Combustion Chamber

Typical installations

In both commercial and residential applications, Econoburn™ boilers can operate as a main furnace or integrate seamlessly in tandem with your existing hot water boiler, or furnace.

How wood gasification increases burning efficiency... and saves you money!



As wood is burned in the firebox, fresh air is blown downward through the logs and coals. This hot smoke and air mixture is forced into the combustion chamber and mixed with a second jet of super-heated air creating a torch-like combustion of the retained gases - a process called wood gasification.

The result: almost all the gases are burned, with little residual soot or creosote. The extra energy is transferred to Econoburn's™ full jacket heat exchanger and used to heat your home!

Producing combustion temperatures approaching 2,000 degrees, wood gasification consumes much less wood and produces significantly less smoke than outdoor wood boilers. The gasification process enables Econoburn™ boilers to achieve an overall heating efficiency of roughly 90%. This amazing system results in immediate, tangible benefits, including: more hot water for heating and domestic uses, almost *complete* fuel efficiency, and enormous savings in your yearly fuel bill!

Why Choose Econoburn™?

50 years of metal fabricating experience combined with state-of-the-art manufacturing equipment and ISO 9001-2000 facilities have made Econoburn™ the Best Built, Most Efficient wood-fired boiler made today. Econoburn™ boilers are constructed of 1/4″ ASME Grade 36 carbon steel. What's more, for even greater strength and durability, all our products are *double-welded* by our expert assembly team.

We are proud of the Econoburn™ boiler. Proud of how much money it saves families. Proud that our boilers are made by hard-working men and women... right here in North America.

In fact, so proud are we of our boilers, that we have introduced the Econoburn™ 25-year unconditional warranty: America's Best-Built, Most Efficient wood-fired boiler now comes with the single best warranty in the industry!

Safe and Environmentally Friendly

As safe to operate as a hot water heater, Econoburn™ boilers provide unmatched safety and reliability. Econoburn™ wood boilers operate at temperatures that far exceed typical outdoor wood boilers. These high temperatures mean the wood burns cleaner and more efficiently; there is virtually no waste which means very minimal smoke, creosote, or ash. What's more, burning wood, nature's oldest renewable fuel, releases a similar amount of CO_2 as if the wood slowly decomposed on the forest floor.

25-Year Limited Warranty

An Econoburn™ high-efficiency wood-fired boiler is an important investment in your home. That's why we build our boilers to last a lifetime. In fact, we are so confident in our boiler that we provide a comprehensive 25-year warranty to protect your peace of mind. The warranty covers the pressure vessel for 25 years against defects in material and workmanship and all other boiler parts for a period of 5 years! Simply operate your boiler in accordance with the Installation and Operating Manual and you are covered. We even offer a simple transfer process should you sell your home.

*"I am very pleased with my Econoburn 150…
This winter, I heated my 2,700 sq ft home with only
six cords of maple....
Never been so comfortable!"*

Wade Clements
Canada

Your Authorized Econoburn™ Dealer:

Econoburn

High-Efficiency Wood-Fired Boilers

Econoburn Boilers
2 Central Ave.
Brocton, NY 14716
Phone 1-866-818-5162
Email info@econoburn.com
Fax 1-716-792-2098
www.econoburn.com

Econoburn Technical Datasheet

Models

EBW-100

EBW-150

EBW-200

EBW-300

EBW-500

EBW-150-O

EBW-200-O

Econoburn Highlights

- Saves homeowners money... burns HALF the wood!
- Integrates seamlessly with any existing hot water boiler or furnace.
- Achieves an amazing 87% thermal effiiciency!
- Burns cleanly with minimal residual smoke, creosote, or ash.
- Constructed with double-welded 1/4" ASME grade 36 carbon steel.
- Available in sizes from 100,000 to 500,000 BTU.
- Covered by the industry's best 25-year warranty!

Econoburn
High-Efficiency Wood-Fired Boilers

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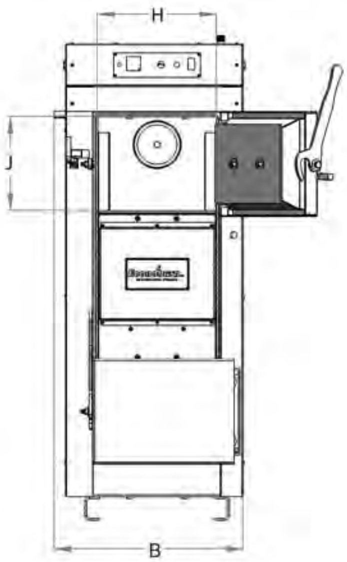
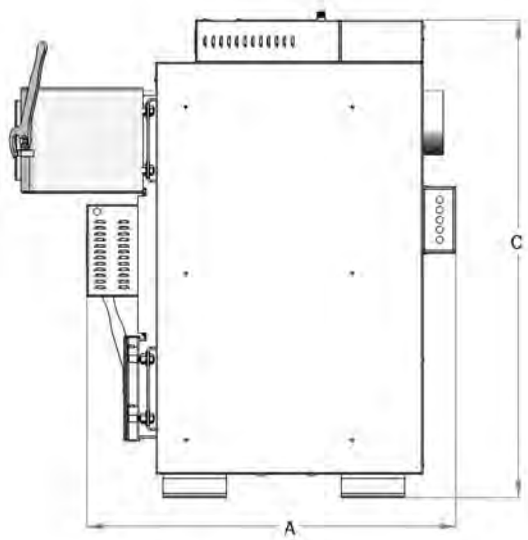
Indoor Boiler

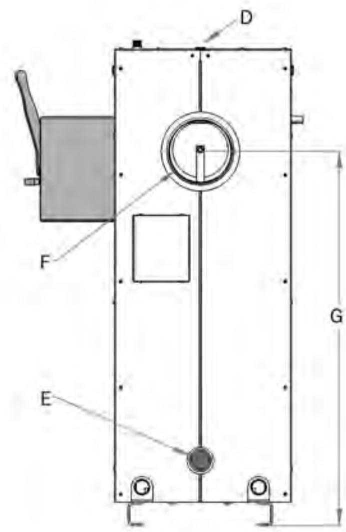
Front



Side

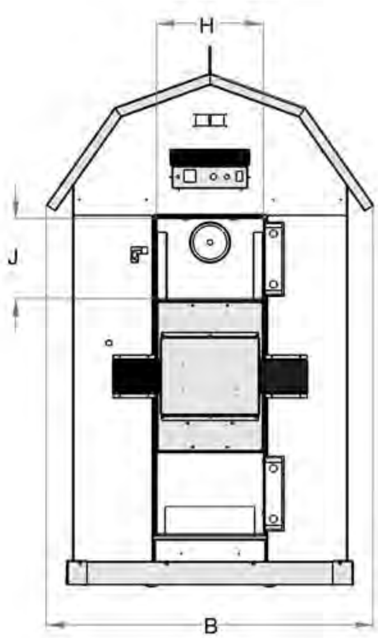


Rear

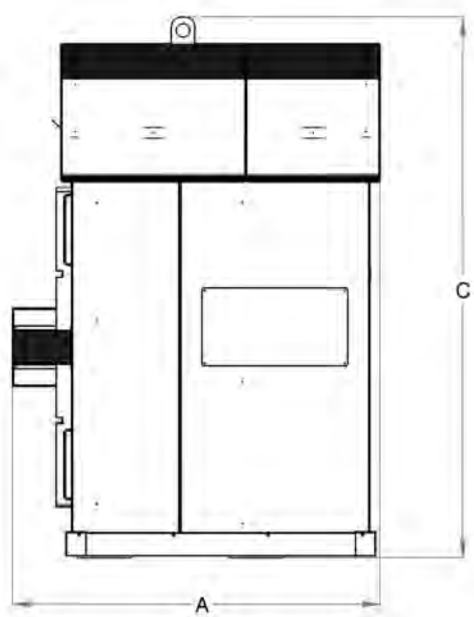


Outdoor Boiler

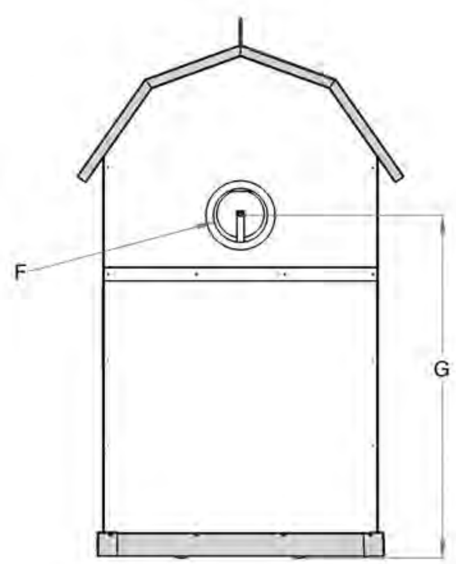
Front



Side



Rear



Models: EBW-100, EBW-150, EBW-200, EBW-300, EBW-500, EBW-150-O, EBW-200-O

Specifications

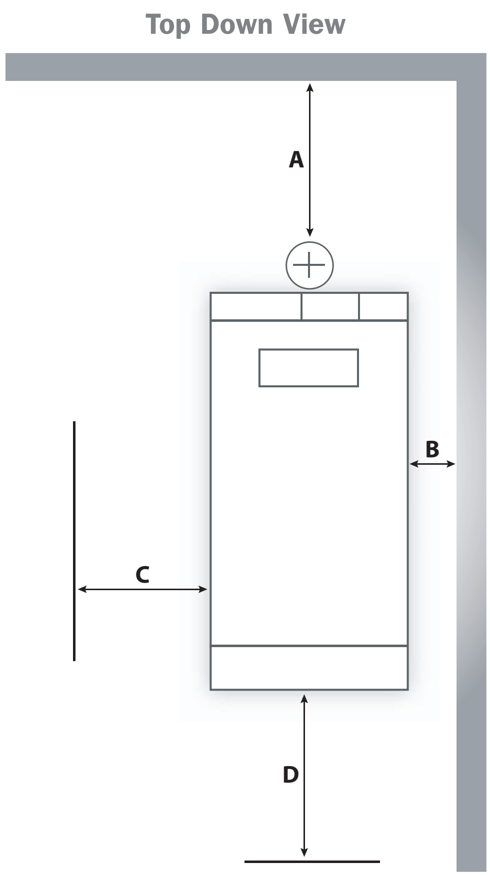
Boiler Model	Key	EBW-100	EBW-150	EBW-200	EBW-300	EBW-500	EBW-150-O	EBW-200-O
Design Application		Indoor	Indoor	Indoor	Indoor	Indoor	Outdoor	Outdoor
BTU Output		100,000	150,000	200,000	300,000	500,000	150,000	200,000
Boiler Dimensions								
Depth	A	47"/ 119.4cm	47"/ 119.4cm	47"/ 119.4cm	50"/ 127cm	63"/ 160cm	54.25"/137.8cm	54.25"/137.8cm
Width	B	25"/ 63.5cm	26"/ 66cm	30"/ 76.2cm	36"/ 91.4cm	41"/ 104.1cm	48.4"/ 122.9cm	48.4"/ 122.9cm
Height	C	60.25"/153cm	63.75"/161.9cm	64.25"/163.2cm	70"/ 177.8cm	76"/ 193cm	80"/ 203.2cm	80.5"/ 204.5cm
Weight Empty		1,560 Lbs/708 kg	1,670 Lbs/757 kg	1,980 Lbs/898 kg	2,515 Lbs/1,141 kg	3,405 Lbs/1,544 kg	~1,800 Lbs/816 kg	~2,100 Lbs/953 kg
Firebox Dimensions								
Depth		23"/ 58.4cm	23"/ 58.4cm	23"/ 58.4cm	26"/ 66cm	32"/ 81.3cm	23"/ 58.4cm	23"/ 58.4cm
Width		15"/ 38.1cm	16"/ 40.6cm	21"/ 53.3cm	24"/ 61cm	27"/ 68.6cm	16"/ 40.6cm	21"/ 53.3cm
Height		25"/ 63.5cm	28"/ 71.1cm	29"/ 73.7cm	33"/ 83.8cm	39"/ 99.1cm	28"/ 71.1cm	29"/ 73.7cm
Maximum Log length		21"/ 53.3cm	21"/ 53.3cm	21"/ 53.3cm	33"/ 83.8cm	33"/ 83.8cm	21"/ 53.3cm	21"/ 53.3cm
Firebox Door Height	J	12"/ 30.5cm	12"/ 30.5cm	12"/ 30.5cm	12"/ 30.5cm	12"/ 30.5cm	12"/ 30.5cm	12"/ 30.5cm
Firebox Door Length	H	15"/ 38.1cm	15.75"/ 40cm	20.5"/ 52.1cm	23.5"/ 59.7cm	27.5"/ 69.9cm	15.75"/ 40cm	20.5"/ 52.1cm
Piping Data								
Water Volume		30 Gal / 114 L	37 Gal / 140 L	42 Gal / 159 L	79 Gal / 299 L	95 Gal / 360 L	37 Gal / 140 L	42 Gal / 159 L
Supply Pipe (female connection)	D	2"	2"	2"	2.5"	4"	2"	2"
Return Pipe (female connection)	E	2"	2"	2"	2.5"	4"	2"	2"
Min Boiler Loop Size		1-¼"	1-¼"	1-½"	2"	3"	1-¼"	1-½"
Fill / Drain Valve Size		3/8"	1-¼"	1-½"	1-½"	1-½"	1-¼"	1-½"
Flue Dimensions								
Flue Outlet Diameter	F	8"	8"	8"	8"	12"	8"	8"
Height to Center of Flue	G	47.25"	50.75"	51.25"	57"	61.5"	50.75"	51.25"
Operating Data								
Max Operating Temperature		210° F / 99° C						
Max Operating Pressure		30 PSI / 207 kPa						
Output Temperature (range)		170° F - 200° F / 77° C - 93° C						
Specified Fuel		Wood (recommended moisture content: 15-22%)						
Minimum Draft Required		-0.02 to -0.06 inch WC / -0.005 kPa to -0.015 kPa						
Flue Gas Temperature		280° F - 400° F / 138° C - 204° C						
Electrical Data								
Boiler Power Requirement		110 volt, 15 amp						
Electrical Consumption (watts)		100	175	175	175	200	175	175
Aquastat Overheat Setting		220° F / 104° C						
Electrical Consumption		< 5 amps						

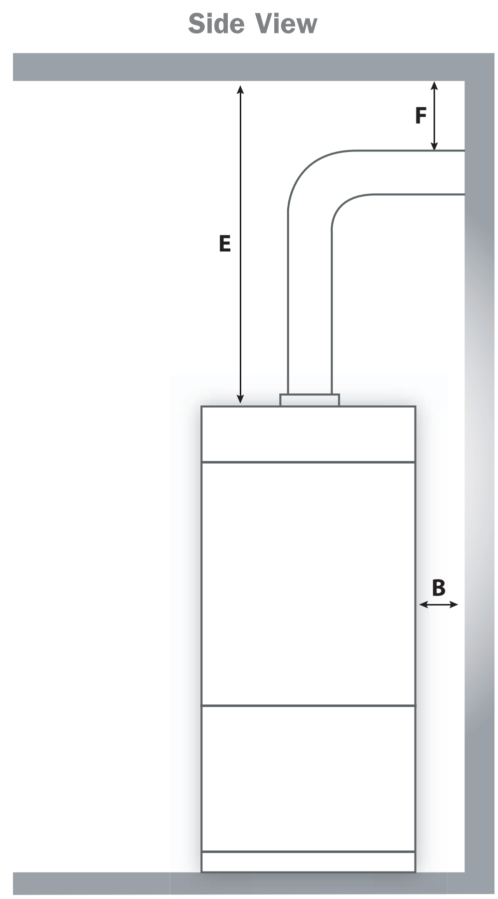
Rev 01.20.10

Specifications subject to change without notice.

ph: 1-866-818-5162 fax: 1-716-792-2098 e-mail: info@econoburn.com

Clearance to Combustibles





Clearances to Combustibles

Measurement	Key	Recommend Service	Safety	Notes
Backwall to Appliance	A	24"	18"	Minimum distance to allow clearance for the flue pipe
Sidewall to Appliance (R)	B	18"	0"	Minimum distance
Sidewall to Appliance (L)	C	24"	0"	Minimum distance on left side to allow clearance for the turbulator arm
Front of Appliance	D	48"	16"	Required distance for cleaning the boiler
Ceiling to Appliance	E	28"	16"	Required distance for cleaning the boiler
Combustibles to Pipe	F	18"	18"	Minimum distance

Choose the Boiler Size

We recommend performing a detailed heat load calculation to use in calculation to determine boiler size. It is also useful to calculate the capacity of the heat supply system (commonly forced air ducts or baseboard) to ensure adequate distribution. Important note: square foot-based load calculations are often not as accurate as a structure's heat load and can vary widely depending on the building's age and construction.

Connect to the Chimney

It is critical to provide the Econoburn boiler with a properly functioning chimney. Indeed, a good chimney ensures that the boiler will benefit from a continuous draft and will prevent combustion products from spilling into the building. The boiler must be connected to either a tile-lined masonry chimney or a Type UL 103 HT (ULC S629 in Canada) all-fuel chimney with a height conforming to local codes. The minimum flue diameter is equal to the flue collar size (or 6" for the EBW-100). For maximum boiler performance, we recommend a draft of -0.02 to -0.05 inches of water column.

Ensure Appropriate Access to Combustion Air

Like any combustion appliance, the Econoburn boiler consumes a small amount of air as it operates. Accordingly, for every 100,000 BTU input of all combustion appliances found within a connected space, provide for combustion air equal to any combination of the following: 1) 50 sq inches of free area opening to the outside and/or 2) 6,667 cubic feet of continuous interior space. For the indoor model, provide combustion air that is at least 30 degrees (do not connect the boiler directly to outside air). The outdoor model comes standard with an air intake system designed to pre-heat its combustion air. Do not store flammable liquids or materials (including gasoline, propane, paint, bleach, etc.) in the same room as the boiler.

Place the Boiler

The Econoburn indoor boiler must be protected from the weather. Install the boiler in a weather-tight, protected space on a non-combustible floor base. Although the boiler is approved for 0"clearance to combustibles on the sides and 18" on the back, it is best to allow for a service area equal to 18" on the right side, 24" on the left side, and 24" in the back. To allow room for loading and servicing, allow for 48" free space in front of the boiler.

Install the Power Supply

The Econoburn requires a 120 VAC, 60 hertz power supply. The electrical connection should come from a 15 amp dedicated circuit breaker. Install an emergency switch within easy reach of the boiler. Please follow all electrical codes.

pH and Anti-Freeze Concerns

System pH should be between 8.0-8.6. Anti-freeze may be utilized, but may impact the heat transfer efficiency. Use only anti-freeze approved for heating systems.

Design and System Plumbing

Since Econoburn boilers operate as pressurized systems (closed loop), they do not require a plate heat exchanger. Copper, iron, or oxygen-barrier plastic tubing are all acceptable piping materials. Insulation is a must for any piping exposed to unconditioned spaces (outdoors or indoors). The boiler output and the length of piping will determine the required piping size.

Econoburn
High-Efficiency Wood-Fired Boilers

2 Central Avenue
Brocton, NY 14716
phone: **1-866-818-5162**
e-mail: **info@econoburn.com**
fax: **1-716-792-2098**
web: **www.econoburn.com**

Trade Price List

Effective 4/1/10

HIGH EFFICIENCY WOOD-FIRED BOILERS

INDOOR MODELS

BOILER MODEL	BTU OUTPUT (MBH)	WATER CAPACITY (Gallons)	THERMAL EFFICIENCY	SUPPLY / RETURN	FLUE DIA.	SHIPPING WEIGHT (lbs)	TRADE PRICE
EBW-100	100	30	87%	2"	8"	1560	$6,995
EBW-150	150	37	87%	2"	8"	1670	$7,995
EBW-200	200	42	87%	2"	8"	1980	$8,995
EBW-300	300	79	87%	2.5"	8"	2515	$9,995
EBW-500	500	95	87%	4"	12"	3405	$13,995
EBW-100-H ASME	100	30	87%	2"	8"	1560	$7,995
EBW-150-H ASME	150	37	87%	2"	8"	1670	$8,995
EBW-200-H ASME	200	42	87%	2"	8"	1980	$9,995

OUTDOOR MODELS

BOILER MODEL	BTU OUTPUT (MBH)	WATER CAPACITY (Gallons)	THERMAL EFFICIENCY	SUPPLY / RETURN	FLUE DIA.	SHIPPING WEIGHT (lbs)	TRADE PRICE
EBW-150-O	150	37	87%	2"	8"	1800	$9,295
EBW-200-O	200	42	87%	2"	8"	2100	$10,295
EBW-300-O	300	79	87%	2.5"	8"	2789	$11,495
EBW-150-HO ASME	150	37	87%	2"	8"	1800	$10,295
EBW-200-HO ASME	200	42	87%	2"	8"	2100	$11,295

H-ASME Models known to be required for MA, MI, NJ, RI, WI. Verify local codes for boiler model suitability

Insulated class "A" vent pipe should be used for maximum safety. Primary/Secondary piping is recommended

STANDARD EQUIPMENT (ALL MODELS):

Fully assembled boiler constructed of 1/4" ASME Grade A36 carbon steel with 18 gauge powder coated jacket, Honeywell L4006 high limit aquastat and well; Grundfos UPS 15-58FC circulator. Turbulator cleanout assembly; Heavy duty EBM gasification draft fan; Rigging hook access for ease of boiler placement. Combination temperature/pressure gauge; 30psi ASME relief valve. Completely installed and wired safety control system with overtemp alarm and spill circuit consisting of: Microprocessor based integrated boiler control; Wiring for control of primary/secondary pumps

STANDARD EQUIPMENT (OUTDOOR):

All items included with the indoor model plus; Simpson Dura-Vent T with Cleanout, Rain Cap, and 24" Vent Pipe, pump isolation valves, Amtrol Extrol expansion tank.

Note: (Shipped on reinforced skid and wrapped with a polyethylene cover to protect from moisture and dust).

The Next Generation of Heating Technology

Skanden

Local, renewable energy made easy.

Imagine the Next Generation of Heating Technology

"Skanden Energy continues to demonstrate a remarkable commitment to this project.... they are a reliable team and an excellent company to work with."

Quenten Clark

Superintendent of Maine School Administrative District 58

It's Here Today

Environmentally friendly
Ultra-low emissions
Over 90% efficient
Easy maintenance
Proven reliability
Lower and more stable fuel costs

MultiFuel (340,000- 20,000,000 BTUs)

Minis available in 34,000-300,000 Btus

Skanden Multifuel Heating System

A Skanden Multifuel Heating System is environmentally friendly, over 90% efficient and easy to use. It cleans itself automatically, and can be controlled via the internet. Instead of buying fossil fuels, it combusts locally produced inexpensive biomass of up to 50% moisture. Converting to a Skanden Multifuel Heating System will cut your heating bills and earn you carbon credits. You will also be able to buy your fuel locally, which creates jobs in your community, generates tax revenue and stimulates the local economy.

Scandinavian Technology- World leaders in Biomass

Our MultiFuel Heating Systems are based on Danish technology developed by Reka, the world leader in biomass heating. Reka's biomass gasification heating system, first introduced in 1979, led Scandinavia to convert to over 30% biomass heating. Since 1979, Reka has continued perfecting their combustion and fuel feeding technology. They hold dozens of patents in the field. In 2009, Reka obtained all necessary approvals for the U.S. market, including the ASME stamp. Skanden has exclusive U.S. rights for Reka equipment.

Fuels

Pellets

Switch Grass

Wood Chips

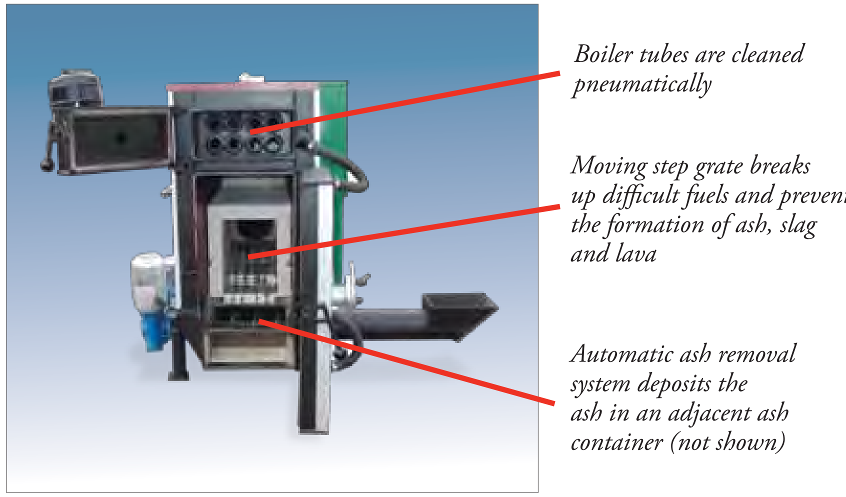
Agricultural Waste

Advanced Technology Increases Efficiency, Lowers Emissions and Eases Maintenance

All aspects of combustion are precisely controlled to maximize efficiency, minimize emissions and ease maintenance. Everything from oxygen level, to exhaust, is regulated to maintain combustion at 2000°. This ensures that all energy is utilized and not released up the stack in the form of harmful emissions. Biomass fuel is fed in through the front, ensuring uniform combustion, and gasified on a large moving step grate, minimizing the formation of slag, glass, and klinkers. Ashes are automatically removed and deposited in a large ash container adjacent to the boiler. Our unique 4-pass design forces hot gasses past heat exchange tubes four times, three of which are convection passes, maximizing heat transfer and efficiency. Boiler tubes are continually cleaned pneumatically (compressed air). A thorough cleaning is still recommended every summer, but our large doors make cleaning a snap.

Biomass Heating- An Investment in Your Community

An investmment in a Skanden Heating System is an investment in your community. Skanden trains local contractors, building their expertise so they can distribute and install our equipment. Money spent on biomass fuel remains in the community, creating local jobs (for truckers, chipping operators, property owners and others involved with fuel supply), generating tax revenue, and stimulating the local economy.



MultiFuel Mini (68,000 BTUs)

Fuel Costs

Fuel Type	Price/Unit	BTU/Unit	$/Mill BTUs
Electricity	$0.12/kw	3,412	$35.17
Propane	$2-4/gal	91,333	$21.90-$43.80
#2 Oil	$2-4/gal	138,690	$14.42-$28.84
Natural Gas	$1.25/therm	100,000	$12.50
Wood Pellet	$175/ton	16,500,000	$10.61
Wood Chip	$40/ton	9,300,000	$4.64
Waste	Free	Varies	Free

Customized Total Solutions

A Skanden Heating System is not just the most advanced boiler available. It is a total customized solution, comprised of fuel storage and feeding mechanisms, biomass boilers, exhaust system filtration and chimneys.

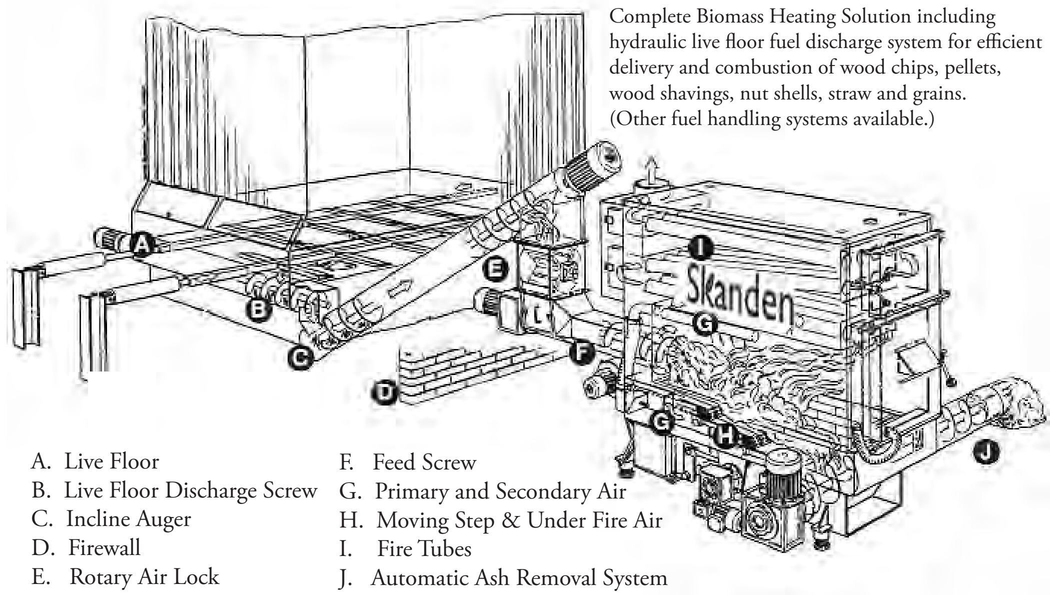
Fuel Feeding and Storage

Skanden offers different types of storage bins and feeding mechanisms, to accommodate pellets, wood chips, switch grasses, waste products, and other biomass. We offer a hydraulic live floor fuel discharge systems for wood chips. We have equipment that reliably cuts grasses and straw and feeds it into augers. Our pellet silos can be custom painted to match adjacent architecture.

Hydraulically unloaded Storage Systems for wood chips

Grass Cutter and Feeding System for cutting and feeding switch grasses, miscanthus, straw, and similar into boilers.

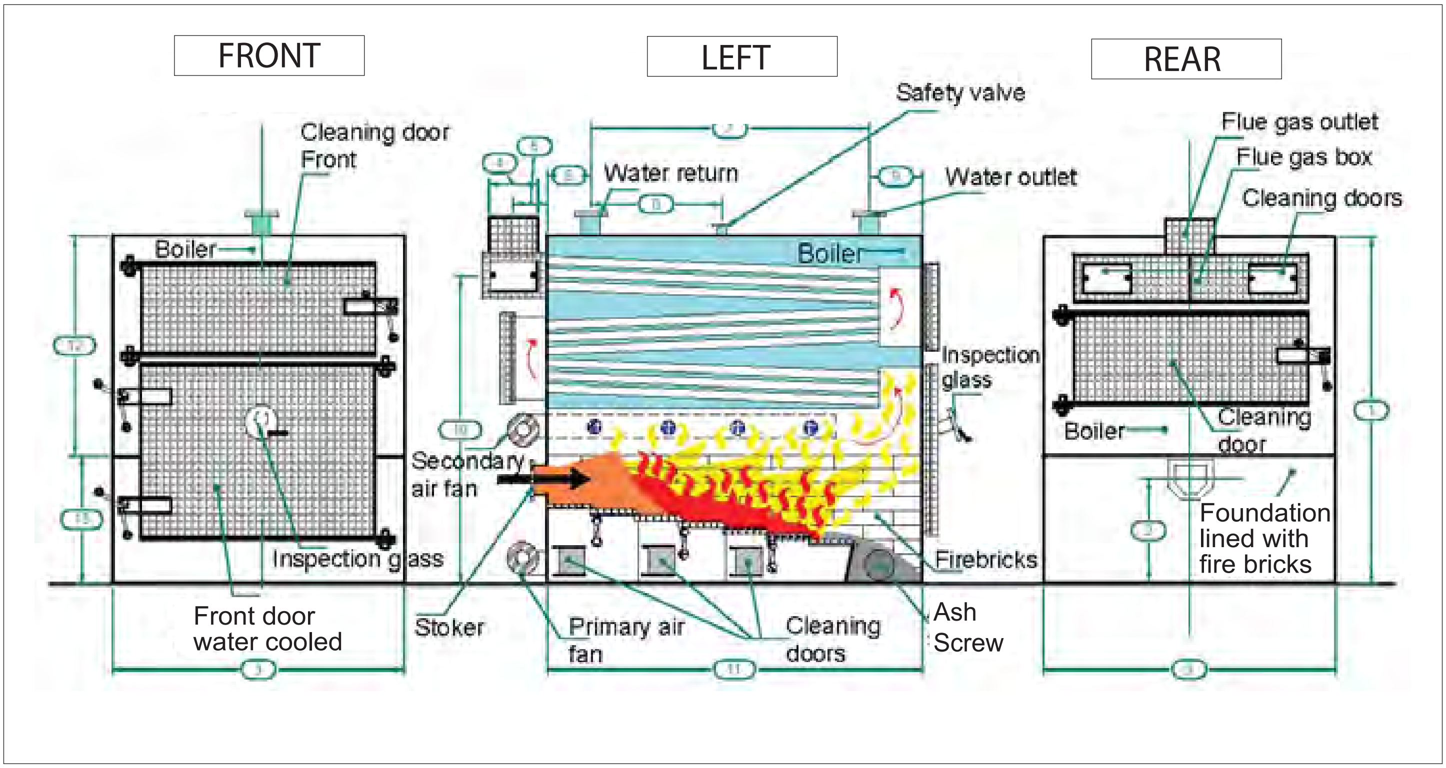
Pellet Silo



Complete Biomass Heating Solution including hydraulic live floor fuel discharge system for efficient delivery and combustion of wood chips, pellets, wood shavings, nut shells, straw and grains. (Other fuel handling systems available.)

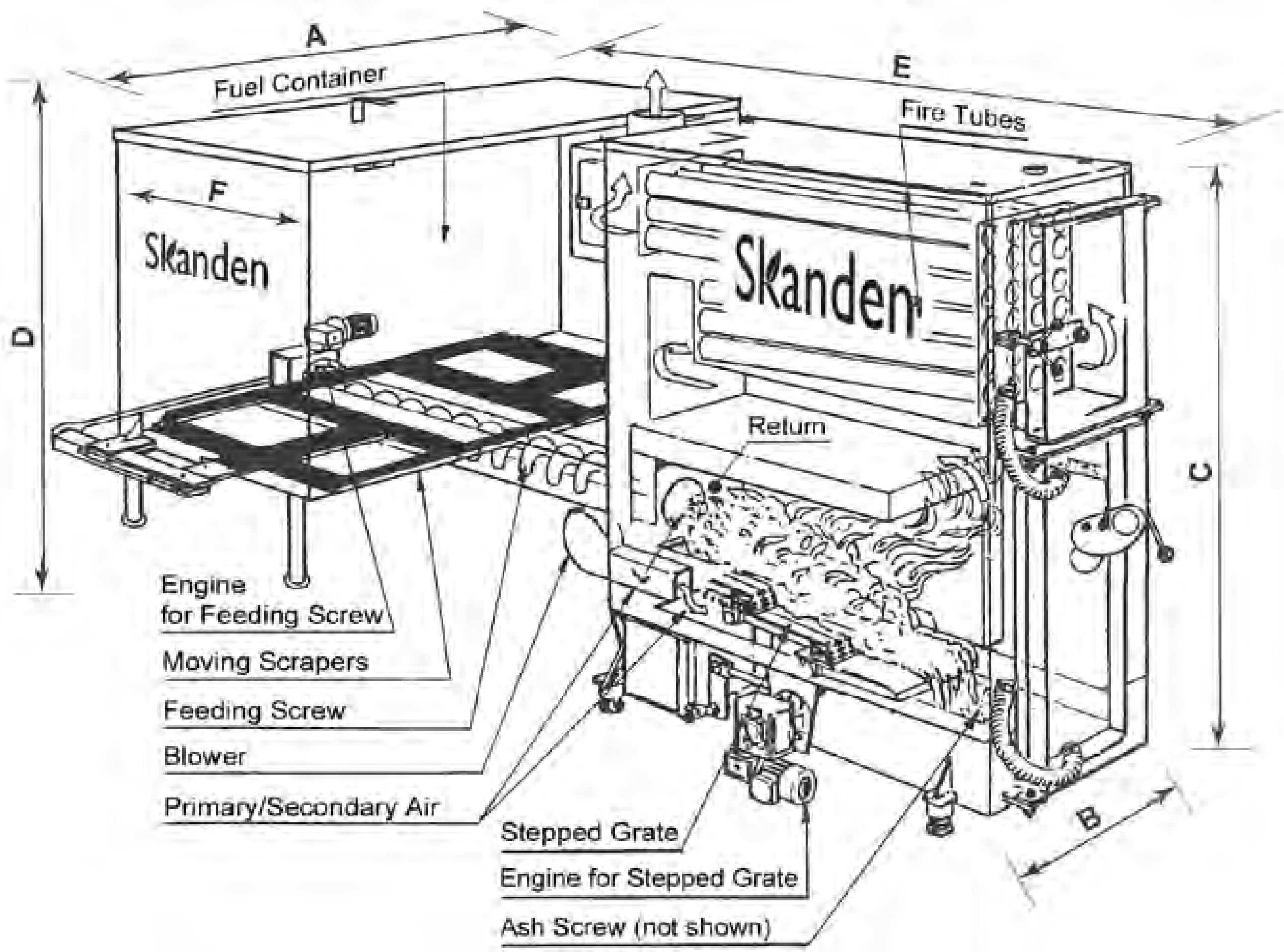
A. Live Floor
B. Live Floor Discharge Screw
C. Incline Auger
D. Firewall
E. Rotary Air Lock
F. Feed Screw
G. Primary and Secondary Air
H. Moving Step & Under Fire Air
I. Fire Tubes
J. Automatic Ash Removal System

MultiFuel Boiler Dimensions



DIMENSIONS																
BOILER SIZE	kW	100	160	200	300	400	500	600	750	1000	1300	1500	2000	2600	3000	3500
	BTU	341,200	545,920	682,400	1,023,600	1,364,800	1,706,000	2,047,200	2,559,000	3,412,000	4,435,600	5,118,000	6,824,000	8,871,200	10,236,000	11,942,000
1 Overall height	in	88.4	94.5	93.1	103.9	108.9	106.5	106.3	121.5	128.7	144.9	152.8	158.9	159.6	206.3	206.3
2 Floor to CL stoker	in	30.9	35.8	35.8	34.6	35.0	35.0	36.6	43.3	43.3	43.3	43.3	51.2	51.8	64.6	64.6
3 Overall width	in	39.0	36.6	48.7	51.8	53.9	60.4	60.4	60.4	60.4	67.8	67.8	92.1	92.1	106.3	106.3
4 Flue diameter	in	8.5	8.5	8.5	9.8	9.8	9.8	11.8	11.8	11.8	13.8	13.8	23x23	23x23	19.7	21.7
5 CL Flue to boiler back	in	9.8	10.6	9.8	9.4	9.4	9.4	9.4	13.8	11.8	12.6	12.6	23.6	23.6	15.7	15.7
6 Boiler back-CL return flange	in	12.6	12.6	15.7	13.0	14.6	21.2	15.4	20.3	28.7	28.7	28.7	66.1	66.1	76.0	76.0
7 CL outlet-inlet flanges	in	37.4	55.1	59.1	53.9	56.7	52.9	63.0	77.6	71.1	78.7	78.7	88.6	88.6	90.6	90.6
8 CL relief flange-inlet flange	in	14.2	23.6	29.5	26.8	27.2	26.5	31.5	41.1	38.2	39.4	39.4	44.5	44.5	54.3	54.3
9 Front to CL outlet flange	in	9.4	21.7	15.7	22.4	18.1	28.9	24.8	31.3	28.7	28.3	28.3	23.6	23.6	23.6	23.6
10 Floor to CL smoke box	in	78.7	80.7	86.4	92.1	102.0	100.8	100.4	112.4	117.3	133.5	104.3	100.4	101.2	174.0	174.0
11 Overall length	in	69.7	99.0	90.6	99.2	99.2	109.4	109.4	138.9	139.0	145.7	145.7	178.3	178.3	190.2	190.2
12 Overall height	in	50.0	51.2	50.0	60.8	65.7	63.4	63.4	72.8	72.8	89.0	96.9	96.7	96.7	129.9	129.9
13 Combustion box height	in	38.4	43.3	43.1	43.1	43.1	43.1	42.9	48.6	55.9	55.9	55.9	62.2	63.0	76.4	76.4
Stoker screw dia.	in	5.9	5.9	5.9	7.1	7.1	7.1	7.9	9.8	9.8	9.8	9.8	11.8	11.8	15.7	15.7
Ash screw dia.	in	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9	5.9
Outlet flange (PN 16)	in	2.0	2.0	2.5	2.5	3.0	4.0	4.0	4.0	5.0	6.0	6.0	8.0	8.0	8.0	8.0
Return flange (PN-16)	in	2.0	2.0	2.5	2.5	3.0	4.0	4.0	4.0	5.0	6.0	6.0	8.0	8.0	8.0	8.0
Safety valve flange (PN-16)	in	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0	5.0	6.0	6.0	6.0
Boiler weight empty	lb	3300	3960	4180	4620	5280	7260	7920	8800	12760	15400	16940	22440	24200	30800	34100
Bottom section wt.	lb	2860	3300	3300	3960	6380	6600	7700	8800	9240	12100	12980	17600	17600	26400	28600
Water content	gal	264	304	330	370	476	608	687	819	1374	1321	1480	2774	2642	4412	4359
Water content	lb	2193	2522	2741	3070	3947	5044	5701	6798	11403	10964	12280	23025	21929	36621	36182
Test pressure	psi	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4	76.4
Design pressure	psi	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5
Door swing radius	in	21.7	27.6	27.6	31.5	31.5	39.4	45.3	43.3	43.3	45.3	45.3	45.3	45.3	47.2	47.2

MultiFuel Mini Dimensions



TYPE	OUTPUT	PRINCIPLE DIMENSIONS (In Inches)							
MultiFuel Mini	BTUs	A	B	C	D	E	F	Pipe Stub (forward return)	Fire Tubes
20kW	68,000	23.6	27.6	49.2	52.4	106.3	25.6	2"	8.5
30kW	102,000	23.6	27.6	55.9	52.4	106.3	25.6	2"	8.5
60kW	205,000	23.6	27.6	55.9	52.4	106.3	25.6	2"	8.5
80kW	273,000	23.6	27.6	55.9	52.4	106.3	25.6	2"	8.5

Skanden
Local, renewable energy made easy.

207.512.5699
lcolban@skanden.com
www.skanden.com

To: David Augustine, TSS Consultants
From: Laura Colban, Skanden Energy
Date: October 5, 2010

Re: Proposal for 200 and 250 kw MultiFuel 50 (for 30-50% moist fuels) for ski resort

Our quote for a 200 kw (682,410 Btus) MultiFuel 50 is $110,000; a 250 kw (853,000 Btus) is $119,000. This includes:

200/250kw 4 pass ASME-stamped stainless steel boiler, with:

- Ash removal screws, to automatically remove ash from the step grate
- Large diameter 4.5mm thick seamless stainless steel heat exchange tubes
- Moving step-grate, cast iron with chrome and nickel, traveling time is adjustable via control panel, grate elements can be exchanged without special tools.
- Stoker screw 180mm and casing, fitted with fire safety equipment
- Firelock 280mm
- Electronic Control Box in splash proof cabinet, including oxygen control unit with lambda sensor
- Exhauster with cooling disk and v-belt drive and vibration dampers
- Flexible bellows for exhauster (id fan)
- Frequency transmitters w/ pressure diff. transmitter for control of exhauster
- Ash box
- Instruction manuals, including drawings showing this exact entire system set-up.

The following options are also available:

$ 5,000	2 sets of soot blowers for 200 kw or 250kw, which will pneumatically clean both sides of all boiler tubes (recommended for high ash fuels, such as grasses, waste, and bark chips; not necessary for high quality clean debarked wood)
$ 2,600	Air compressor for soot blowers, with filter (this is required to operate soot blowers)
$ 10,200	Multicyclone for 200kw boiler flue gas cleaning, incl. small cyclones, cone, soot box on wheels
$ 10,700	Multicyclone for 250kw boiler flue gas cleaning, incl. small cyclones, cone, soot box on wheels
$ 1,000	PC connection
$ 5,000	Touch screen
$ 1,075	Alarm card and sms for text message alarms
$ 2,000/meter	fuel feeding auger (to transport chips from bin to boiler)

$ 28,000 Hydraulic discharge (installation is easy- just bolting, no welding) for 3.5 x 6 meter/2, with dosing screw, including:

- 1 pc. Hydraulic station with oil tank, pump motor, safety valve, manometer, filter, inspection glass, oil switch and two way valve.
- 2 pc. Hydraulic cyclinders
- 2 pc. Scrapers with carriers
- 4 pc. Cast-in irons for scrapers
- 2 pc. Anchor irons for scrapers
- 1 pc. 4 meters combined dosing worm (variable speed) and transport screw 180mm
- 1 pc. 4 meters screw case with lid
- 2 pc. Level sensors
- 1 pc. Microswitch for overdosing.

$ TBD Flue gas ducts (breaching), priced according to drawings (approx. $3500 for our last installation)

$ TBD Supervision, training and start-up Assistance (At a minimum, we will insist on assisting with drawings and pre-install issues for 8 hours, assisting with start-up and training for 2 days, and either 1 visit for tune-up or 30 days online monitoring. Minimum assistance is $8000, plus travel expenses from Sumner, ME. Additional assistance is $100/hour.)

The above quoted hydraulic discharge system may be larger than you need. Other configurations are sizes are available.

Prices are FOB Denmark. We estimate freight at $8-10,000. Freight various tremendously with oil prices ad with import/export patterns between the US and Europe.

This quote is subject to currency fluctuations and is valid for 30 days. It is based on an exchange rate in the range of 5.7-6.1 DKK = US$1. 30% due upon order; 70% due 2 weeks before shipping from Denmark.

Thank you,

Laura A. Colban
Skanden Energy

DANAK

Test Reg. No. 300

DANISH TECHNOLOGICAL INSTITUTE

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TEST REPORT (Translation of original Danish report)

Date: 2006.09.25 | Report No.: 300-ELAB-1131 |

Initials: ABR/KWI/MART | Order No.: 15 55 99 | Number of appendices: 4

Requested by:

Contact person: Alf Larsen

Company: Maskinfabrikken REKA www.reka.com

Address: Vestvej 7

Postcode/town: DK-9600 Aars Country: Denmark

Tel.: +45 98 62 40 11 Fax: +45 98 62 40 71

Product: Automatic biofuel boiler

Manufacturer: REKA Type: HKRST-FSK 30

Nominal output: 36-37 kW Fuel: Wood pellets and chips

Deadlines:

Date of receipt: 2006.05.17

Date of testing: 2006.08.02 - 2006.08.18

Procedure: Testing of biofuel boiler according to DS/EN 303-5.

Result: Requirements in accordance with DS/EN 303-5 Class 3 were met.

Remarks: See page 2. This is a translation of the Danish test report dated 2006.09.20. In case of doubt, the Danish version of the test report prevails.

Terms: Testing has been carried out on the conditions stated overleaf in compliance with the guidelines laid down for the laboratory by DANAK (Danish Accreditation) and in compliance with DTI's General Terms and Conditions Regarding Commissioned Work Accepted by the Danish Technological Institute (DTI), August 1999. The test results apply to the tested samples only. This test report may be reproduced in extracts only if the laboratory has approved the extract in writing.

Place: Danish Technological Institute, Energy Laboratory **Date:** KM 25 SEP. 2006

Signature: Kim Winther
M.Sc., B.Com.

DANAK (Danish Accreditation)

DANAK was established in 1991 in pursuance of the Danish Act No. 394 of 13 June 1990 on the promotion of Trade and Industry.

The requirements to be met by accredited laboratories are laid down in the Danish Agency for Trade and Industry (Erhvervsfremme Styrelsens) Statutory Order on accreditation of laboratories to perform testing etc. and GLP inspection. The Statutory Order refers to other documents in which the criteria for accreditation are specified further.

The standards DS/EN ISO/IEC 17025 "General requirements concerning the competence of testing and calibration laboratories" and DS/EN 45002 "General criteria for the assessment of testing laboratories" describe fundamental criteria for accreditation. DANAK uses guidance documents to clarify the requirements in the standards, where this is considered to be necessary. They will mainly be drawn up by the "European co-operation for Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with a view to obtaining uniform criteria for accreditation worldwide. In addition, DANAK draws up Technical Regulations concerning specific demands on accreditation that are not included in the standards.

In order to obtain accreditation it is i.a. required:

- that the laboratory and its personnel are not subject to any commercial, financial or other types of pressure which might influence their technical judgement,
- that the laboratory operates a documented quality control system,
- that the laboratory has technical equipment, facilities and premises of a certain standard at its disposal in order to carry out the service it is accredited to perform,
- that the laboratory management and personnel have technical competence and practical experience in the performance of the service the laboratory is accredited to perform,
- that the laboratory has established guidelines for traceability and uncertainty calculations,
- that accredited testing or calibration is performed in accordance with fully validated and documented methods,
- that the laboratory keeps records which contain sufficient information to permit the repetition of the accredited test or calibration,
- that the laboratory is subject to supervision carried out by DANAK on a regular basis,
- that the laboratory shall take out an insurance, which covers liability in connection with the performance of accredited services.

Reports carrying DANAK's logo are used when reporting accredited services and show that they have been performed in accordance with the rules concerning accreditation.

Unofficial translation for

DANAK, Technical guidelines
No. RL 4 of 20 June 2001
q:\kvalitet & akkreditering\danak-engelsk.doc

Appendices:

a) Drawings of the biofuel boiler: 6 pieces
b) Photos of the biofuel boiler in total: 11 pieces
c) Installation and operating instructions, version 99/3 of 1999.09.14 (rev. 2003.05.09)
d) Data plate.

The appendices are kept separately.

1 Remarks

1. Shielding of the movable parts around the storage hopper shall be carried out according to the Machinery Directive
2. The operating temperature must be limited to 80 °C to prevent overheating.

2 Description of the biofuel boiler

REKA HKRST 30 is an automatically fired boiler for firing with finely divided solid fuel. The fuel is transported via an auger from the fuel hopper to a movable combustion grate, where the combustion air is supplied via an air fan. The boiler is a welded steel sheet boiler with boiler tubes.

The boiler's control system is based on an electronic three-stage boiler controller with lambda probe. The boiler is provided with a sprinkler to prevent back-burning in the storage hopper.

Settings on boiler during testing:

- Boiler thermostat (nominal): .... 80 °C
- Boiler thermostat (partial load): .... 78°C
- Air amount BL3 (nominal): 080
- Air amount BL1 (partial load): 002
- O_2 modification, step 3 (nominal): .... -35
- O_2 set point, step 2 (standard): .... 8 %
- O_2 modification, step 1 (partial load): .... +008
- Auger, pulse t1 PRG 1 (partial load, wood pellets): .... 0.3 s
- Auger, pulse t3 PRG 1 (full load, wood pellets): .... 1.20 s
- Auger, pulse t1 PRG 3 (partial load, wood chips): .... 2.10 s
- Auger, pulse t3 PRG 3 (full load, wood chips): .... 9 s
- Auger, pause: ....Variable
- Valve for primary air: .... Approx. 20 % open
- Valve for secondary air: .... Approx. 95 % open

Combustion system:

- Type: .... Vertical pellet burner auger
- Burner: ....Movable step grate
- Fuel auger drive motor (el): ....0.55 kW
- Motor for vibration movements: ....0.09 kW
- Air fan: ....G2E120, 230V, 80W, 2350 r/min.

Boiler:

- Type: .... Welded steel sheet boiler
- Height (exclusive adjustable plinth): .... Approx. 1150 mm
- Width: .... Approx. 600 mm
- Length: .... Approx. 1195 mm
- Water content: .... Approx. 220 l
- Flue gas tube: .... ø250 mm
- Water side connection, inlet: ....1”
- Water side connection, return: ....1”

Safety equipment:

- Boiler thermostat, type: .... Electronic
- Safety thermostat, type: ....FIRT STB/83 T80
- Safety heat exchanger, type: ....None
- Valve for safety circuit: ....None
- Fire extinguishing equipment: .... Thermostatic sprinkler

3 Test equipment

Test rig and equipment are constructed in accordance with EN 303-5 and EN 304.

Rack 3			
Instrument	**Type**	**Traceability**	**No.**
Data acquisition unit	HP 34970A	DANAK 200	270-A-1509
Pc	Amitech Pentium	-	-
$CO/CO_2/O_2$ analyzer	H & B Uras 14	-	270-A-1501
Pressure gauge	Autotran 700	ELAB	270-A-1578
Heated hose	Winkler	-	270-A-1495
Probe	M & C	-	270-A-1479
Flue gas temperature sensor	Type K	ELAB	270-A-1528
Ambient temperature sensor	Type K	ELAB	270-A-1527

Test rig 2			
Instrument	**Type**	**Traceability**	**No.**
Water flow meter	0-3.2 m^3/h	DANAK 200	270-A-1511
Water temperature sensor	Pt100 (inlet)	DANAK 200	270-A-1261-1
Water temperature sensor	Pt100 (return)	DANAK 200	270-A-1261-2
Gas meter	IGA AC-5M	IGA	270-A-1475

Other equipment			
Instrument	**Type**	**Traceability**	**No.**
NO analyzer	H&B Radas 2	-	270-A-1502
Converter	H&B CGO-K	-	270-A-1503
FID analyzer	M&A Thermo-Fid	-	270-A-1751
Heated hose	Winkler	-	270-A-1753
Probe	M & C	-	270-A-1752
Adiabatic calorimeter	-	IVC, Kemi	-
Span gas, CH_4	Air Liquide	Cofrac	270-A-1729-1
Span gas, CO/CO_2	Air Liquide	Cofrac	270-A-1727-3
Span gas, NO/SO_2	Air Liquide	Cofrac	270-A-1725-1
Zero gas, N_2	Air Liquide	Cofrac	270-A-1731-1
Data acquisition software	N.I. Labview	-	TI-DOP ver. II
Dust measuring equipment	Ströhlein	-	270-A-1330
Surface thermometer	Technoterm 5500	DANAK 200	270-A-976
Water gauge meter	ELAB	-	270-A-1759
Scale (dust)	Mettler PC 440	ELAB	270-A-947
Scale (humidity)	Mettler PJ6	ELAB	270-A-997
Scale (boiler)	Sauter E/40-E2100	ELAB	270-A-0551
Scale (fuel)	Sauter 60 kg	ELAB	270-A-484

4 Requirement on construction etc.

	Reference paragraph in EN303-5	Requirement met
4.1 General requirements		
Safety during normal use	4.1.1	Yes
4.2 Requirement on documentation		
Drawings	4.1.2.1	Yes
Quality manual	4.1.2.2	Yes
Data plate	7.1-7.2	Yes
Technical information	8.1	Yes
Operating instructions	8.2	Yes
4.3 Requirement on welded steel sheet boilers		
Execution of welding work	4.1.3.1	*
Welding seams and fillers	4.1.3.2	*
Parts of steel subject to pressure	4.1.3.3	*
Minimum wall thickness and tolerances	4.1.3.4	*
4.4 Requirement on safety and design		
Venting etc.	4.1.5.1	Yes
Cleaning of heating surfaces	4.1.5.2	Yes
Inspection of flame	4.1.5.3	Yes
Water tightness	4.1.5.4	Yes
Replacement and spare parts	4.1.5.5	Yes
Water side connections	4.1.5.6	Yes
Thermostat pockets	4.1.5.7	Yes
Thermal insulation	4.1.5.8	Yes
Leakages in flue gas system	4.1.5.10	Yes
Requirement on temperature control at open expansion	4.1.5.11.1	Yes
Requirement on temperature control at closed expansion	4.1.5.11.2	Yes [1]
Storage hopper	4.1.5.12	Yes
Ash chamber	4.1.5.13	Yes
Safety during automatic fuel supply	4.1.5.14.2	Yes
Accessories/fittings	4.1.5.15	Yes
Electric safety	4.1.5.16	*

[1] The maximum adjustable operating temperature on the controller must be limited to 80 °C.

* Not included in this report. Please refer to the manufacturer's EU declaration of conformity.

5 Test results

5.1 Water side resistance

Equivalent temperature difference at nominal output	Water flow	Drop of pressure
20 K	1.75 m^3/h	11.4 mbar
10 K	3.50 m^3/h	43.8 mbar

5.2 Leakage test

Since the boiler is operating with a negative pressure in the combustion chamber, there are no requirements on leakage flow.

5.3 Surface temperatures

	Measured temperature	Allowed limit
Boiler door, average of 5 measurements	63°C	+ 100 K
Boiler's underside, average of 5 measurements	32 °C	+ 65 K
Handles being touched during operation Plastic and similar materials	32 °C	+ 60 K
Boiler's surface, average of 5 measurements	37 °C	-
Ambient temperature	23 °C	-

5.4 Functions check

The biofuel boiler is rapidly disconnectable, DS/EN303.5 paragraph 4.1.5.11.2 a), and therefore the safety equipment includes a temperature controller and a safety thermostat with a manual reset device. The boiler's thermostats have been tested in accordance with DS/EN303-5, paragraph 5.13.

	Measured temperature	Allowed limit
Temperature controller (set point 90 °C)	89 °C *)	100 °C
Safety thermostat	96 °C	110 °C

*) To prevent overheating in case of power failure, the electronic boiler control will however be limited to an operating temperature of maximum 80 °C in the future.

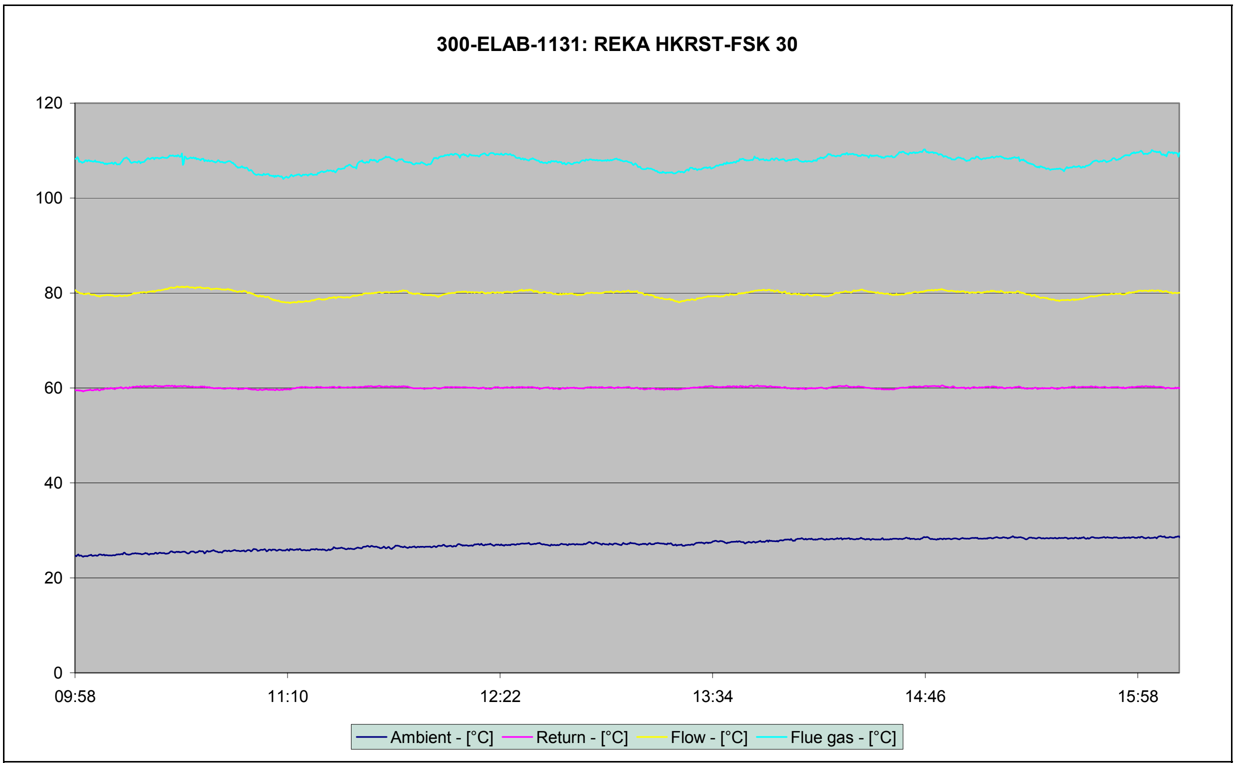
5.5 Test pressure of boiler shell

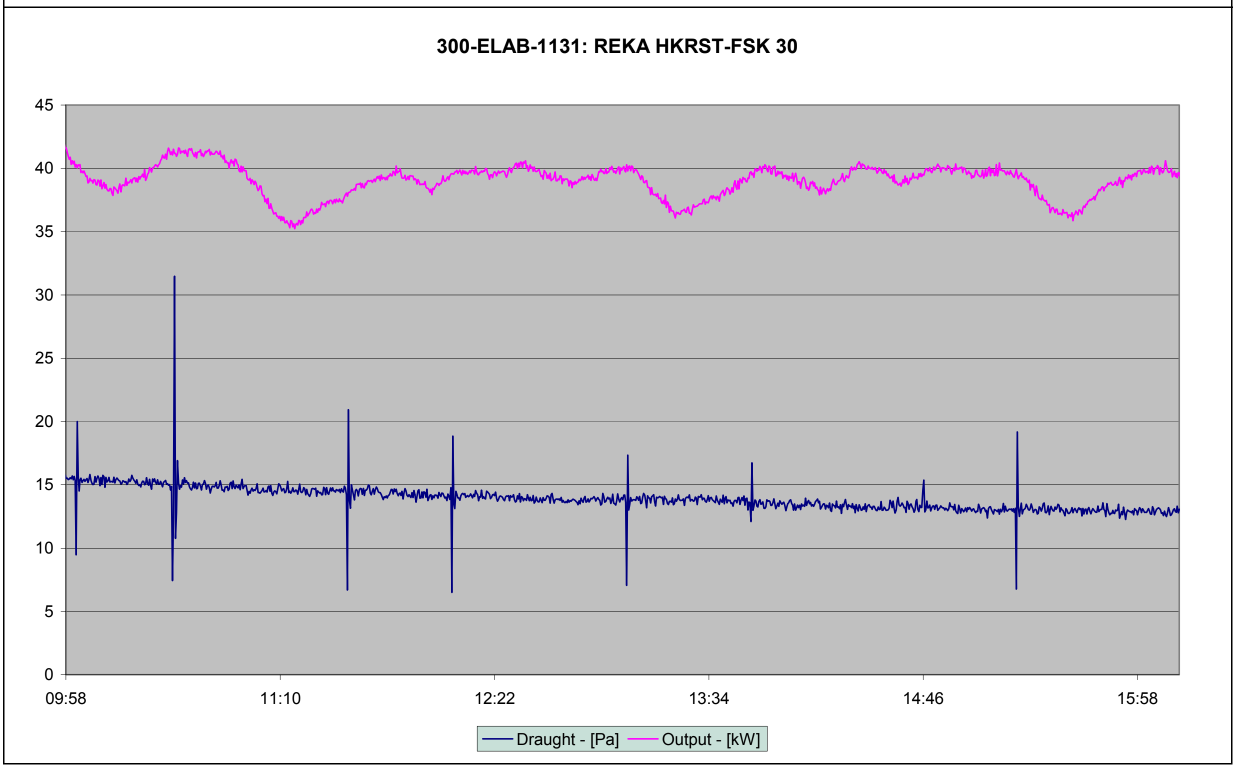
The necessary tests cf. DS/EN303-5, paragraph 5.4 are carried out by the manufacturer.

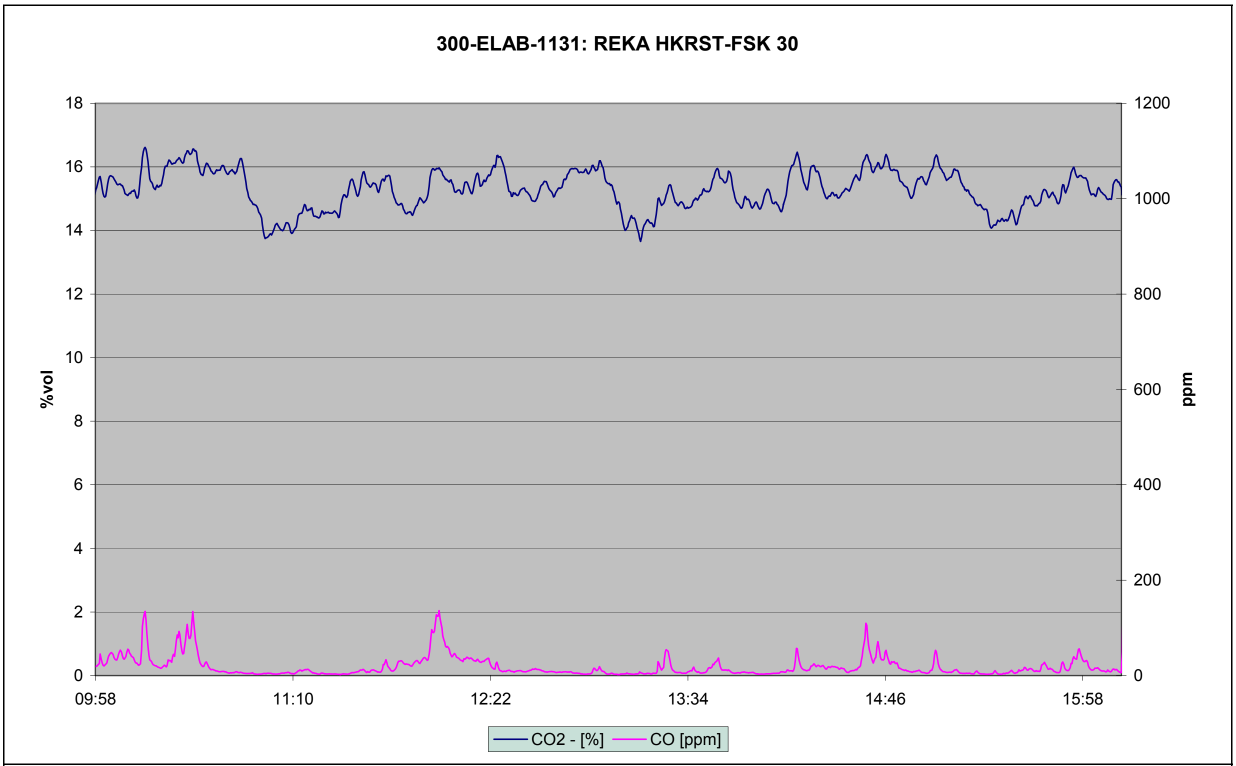
5.6 Test results at nominal output on wood pellets

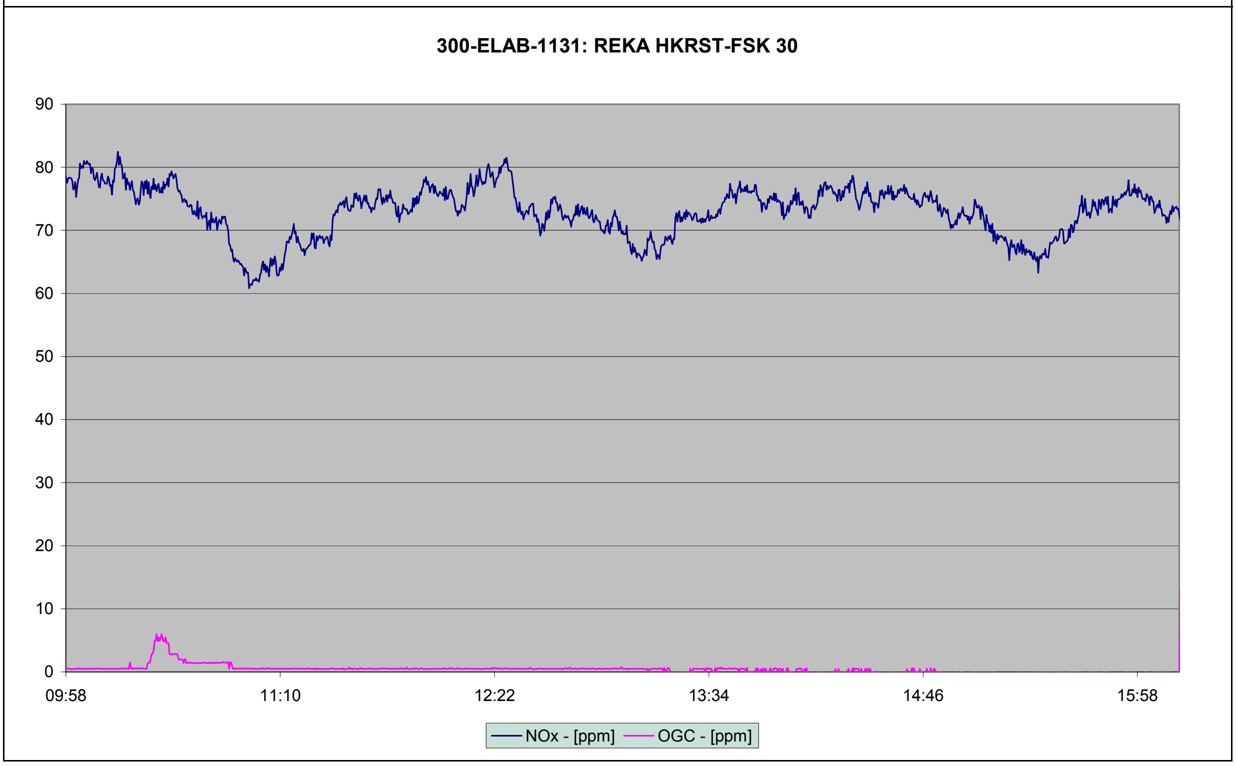
Measurement	Result	Requirement (Class 3)
Return temperature	60.08 °C	-
Inlet	79.85 °C	-
Water flow	1.73 m^3/h	-
Heat output	39.01 kW	-
Test duration	6.23 h	-
Fuel consumption	8.42 kg/h	-
Calorific value (dry)	17639 J/g	-
Water content in the fuel	5.2 %	-
Heat input	41.25 kW	
Efficiency	94.6 %	77 (Class 3) 77 (Denmark) 81 (Austria)
Ambient temperature	27 °C	-
Flue gas temperature	108 °C	>180 °C (Recommended)
Chimney draught	14 Pa	<32 Pa
Flue gas volume flow	76.8 m^3/h	-
Flue gas mass flow	71.9 kg/h	-
CO_2 measured	15.3 $\%_{vol}$	-
Dust, measured	15 mg/m_n^3	-
Dust at 10% O_2	10 mg/m_n^3	150 mg/m_n^3 (Class 3)
Dust at 13% O_2	0.01 g/m_n^3	0.15 g/m_n^3 (Germany)
Dust	5 mg/MJ	60 mg/MJ (Austria)
CO measured	0.0019 $\%_{vol}$	-
CO at 10% O_2	0.0013 $\%_{vol}$	-
CO at 10% O_2	16 mg/m_n^3	3000 mg/m_n^3 (Class 3)
CO at 13% O_2	12 mg/m_n^3	4000 mg/m_n^3 (Switzerland)
CO at 13% O_2	0.0116 g/m_n^3	4 g/m_n^3 (Germany)
CO	8 mg/MJ	500 mg/MJ (Austria)
NO_x (as NO_2) at 10% O_2	0.0050 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	103 mg/m_n^3	-
NO_x (as NO_2)	49 mg/MJ	150 mg/MJ (Austria)
OGC (as CH_4) at 10% O_2	0.00 $\%_{vol}$	-
OGC (as C) at 10% O_2	0 mg/m_n^3	100 mg/m_n^3 (Class 3)
OGC (as C)	0 mg/MJ	40 mg/MJ (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1131: REKA HKRST-FSK 30
120
100
80
60
40
20
0
09:58
11:10
12:22
13:34
14:46
15:58
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1131: REKA HKRST-FSK 30
45
40
35
30
25
20
15
10
5
0
09:58
11:10
12:22
13:34
14:46
15:58
Draught - [Pa]
Output - [kW]

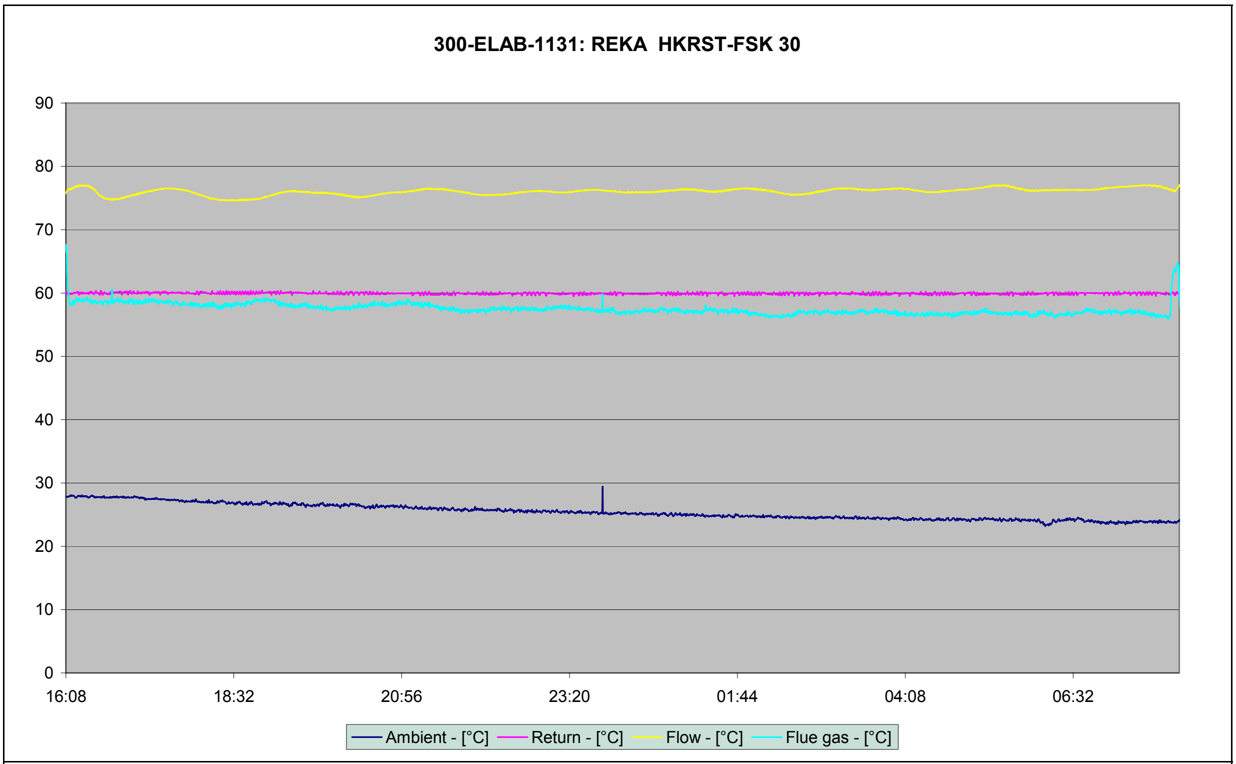

300-ELAB-1131: REKA HKRST-FSK 30
%vol
ppm
18
16
14
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
09:58
11:10
12:22
13:34
14:46
15:58
CO2 - [%]
CO [ppm]

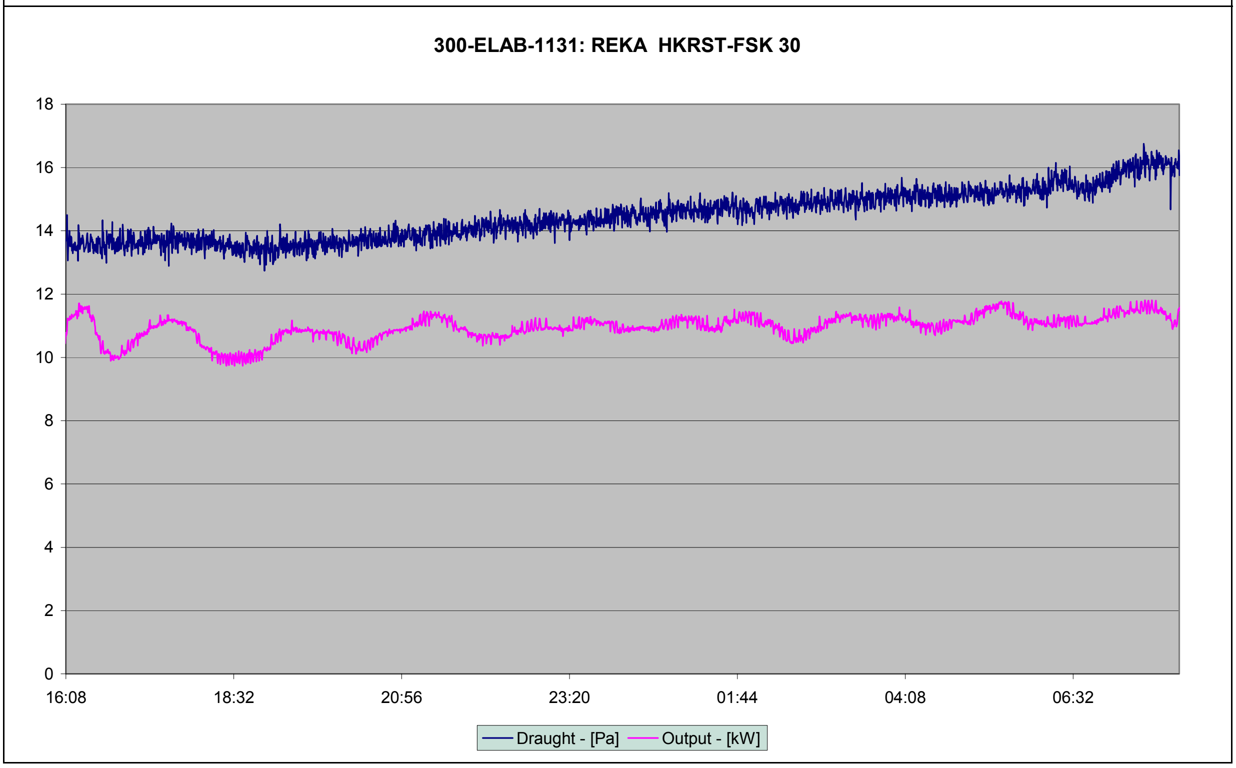

300-ELAB-1131: REKA HKRST-FSK 30
90
80
70
60
50
40
30
20
10
0
09:58
11:10
12:22
13:34
14:46
15:58
NOx - [ppm]
OGC - [ppm]

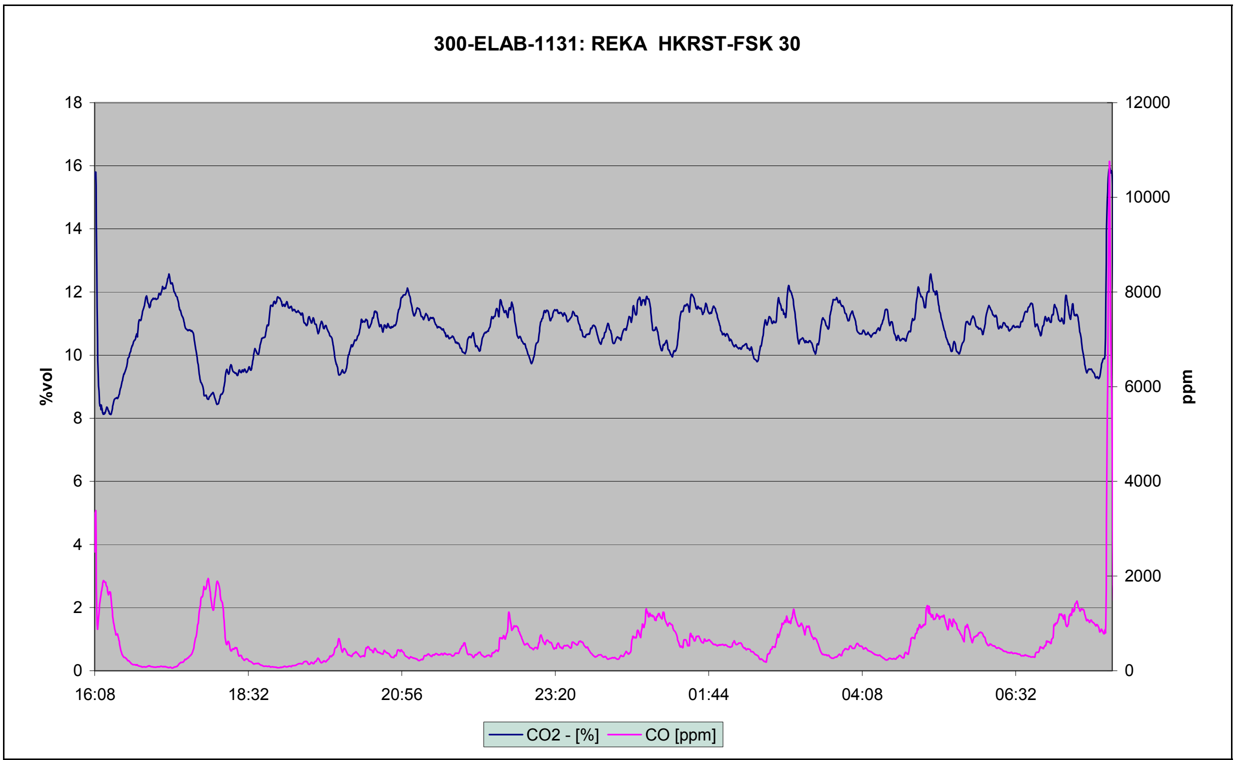
5.7 Test result at lowest output on wood pellets

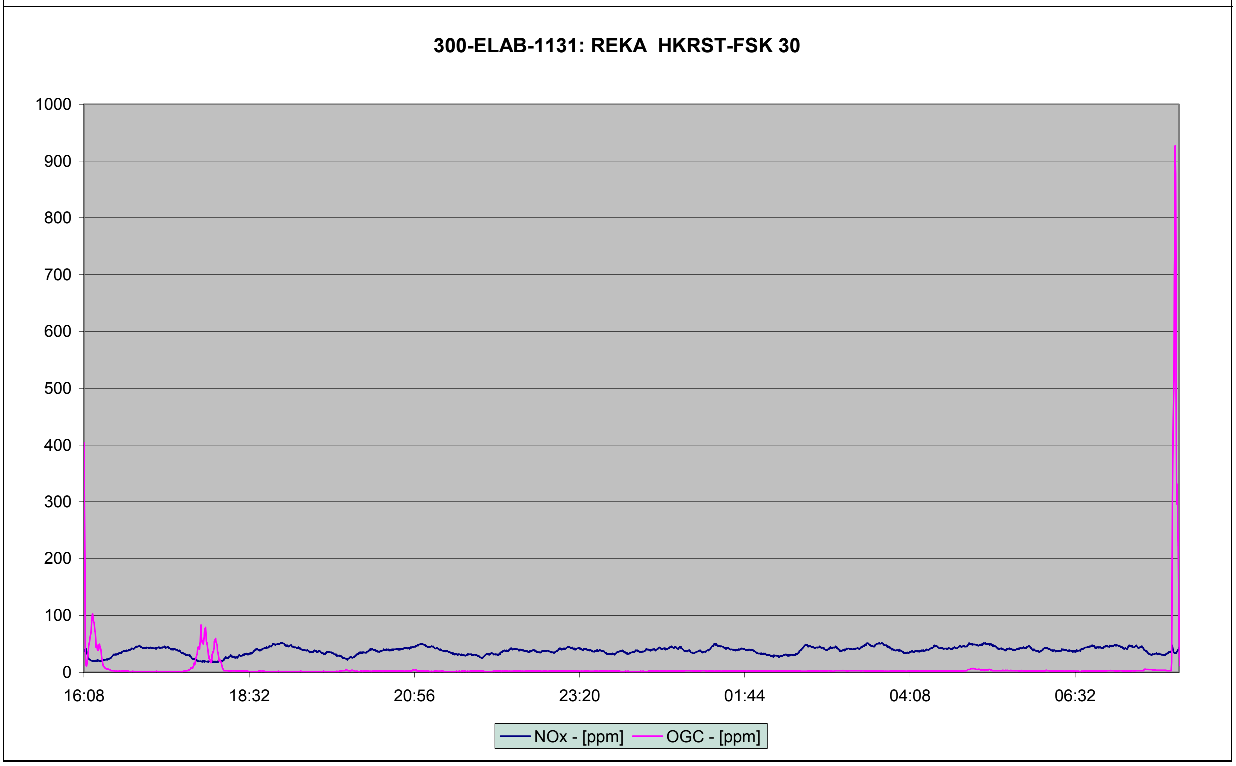
Measurement	Result	Requirement (Class 3)
Return temperature	59.93 °C	-
Inlet	76.03 °C	-
Water flow	0.59 m^3/h	-
Heat output	10.95 kW	-
Test duration	15.91 h	-
Fuel consumption	2.64 kg/h	-
Water content in the fuel	5.1%	-
Heat input	12.93 kW	-
Efficiency	84.7 %	76 % (Class 3) 80 % (Austria)
Ambient temperature	25 °C	-
Flue gas temperature	57 °C	-
Chimney draught	14 Pa	<31 Pa
Flue gas volume flow	28.4 m^3/h	-
Flue gas mass flow	30.5 kg/h	-
CO_2 measured	10.8 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	0.0037 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	76 mg/m_n^3	-
NO_x (as NO_2)	36 mg/MJ	150 mg/MJ (Austria)
CO measured	0.0573 $\%_{vol}$	-
CO at 10% O_2	0.0555 $\%_{vol}$	-
CO at 10% O_2	694 mg/m_n^3	3000 mg/m_n^3 (Class 3)
CO at 13% O_2	504 mg/m_n^3	-
CO	330 mg/MJ	500 mg/MJ (Austria)
OGC (as CH_4) at 10% O_2	0.008 $\%_{vol}$	-
OGC (as C) at 10% O_2	4 mg/m_n^3	100 mg/m_n^3
OGC (as C)	2 mg/MJ	40 mg/MJ (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1131: REKA HKRST-FSK 30
90
80
70
60
50
40
30
20
10
0
16:08
18:32
20:56
23:20
01:44
04:08
06:32
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1131: REKA HKRST-FSK 30
18
16
14
12
10
8
6
4
2
0
16:08
18:32
20:56
23:20
01:44
04:08
06:32
Draught - [Pa]
Output - [kW]

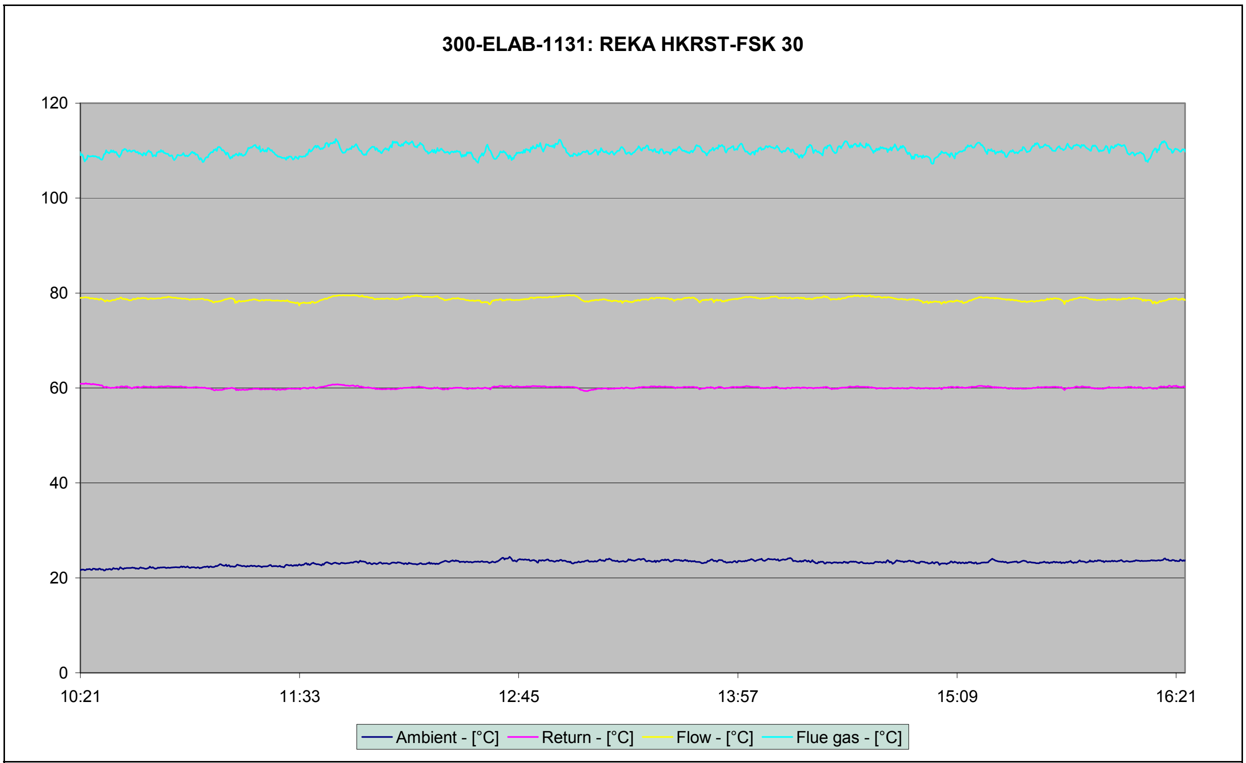

300-ELAB-1131: REKA HKRST-FSK 30
%vol
ppm
18
16
14
12
10
8
6
4
2
0
12000
10000
8000
6000
4000
2000
0
16:08
18:32
20:56
23:20
01:44
04:08
06:32
CO2 - [%]
CO [ppm]

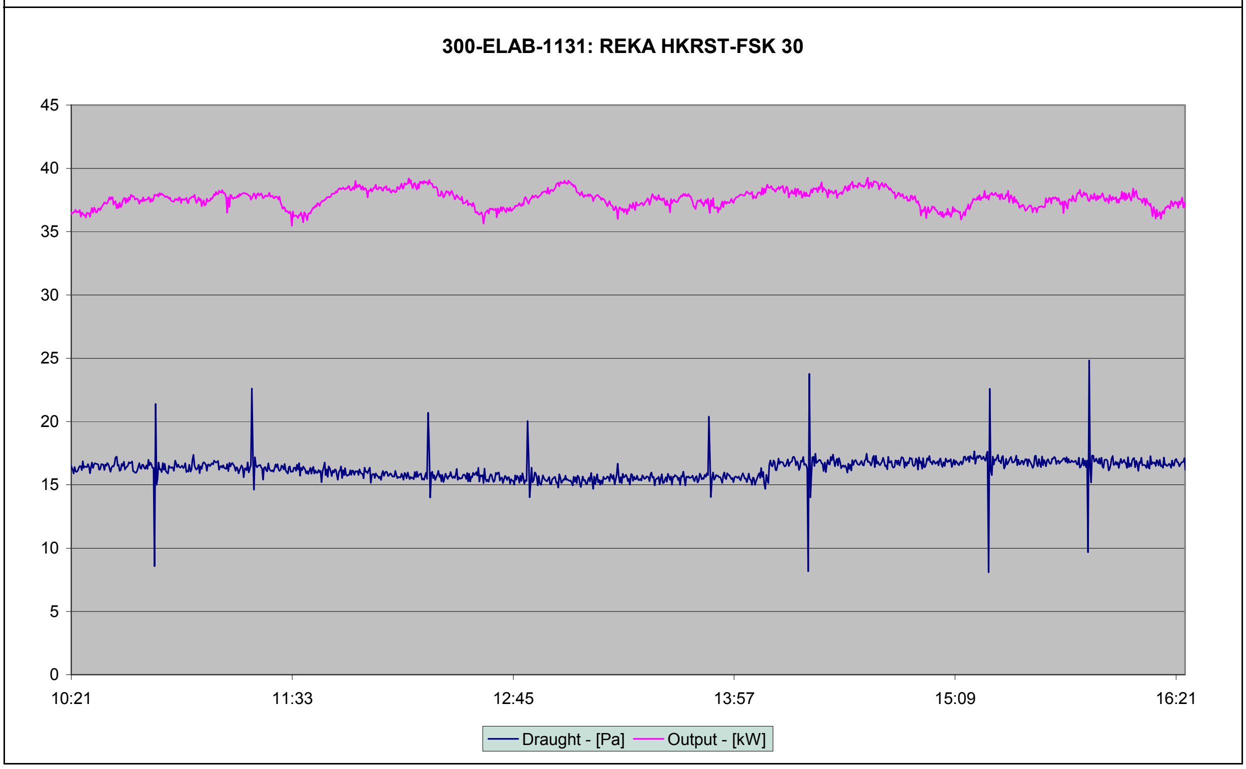

300-ELAB-1131: REKA HKRST-FSK 30
1000
900
800
700
600
500
400
300
200
100
0
16:08
18:32
20:56
23:20
01:44
04:08
06:32
NOx - [ppm]
OGC - [ppm]

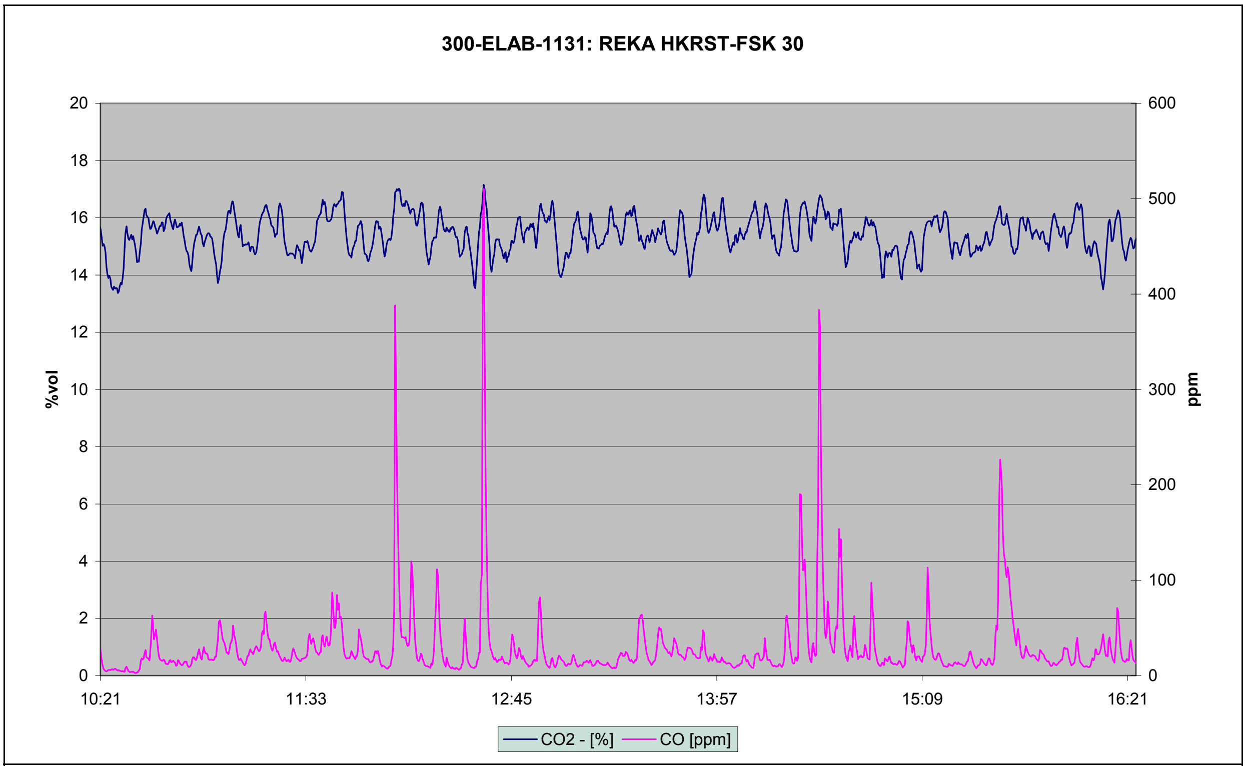
5.8 Test results at nominal output on wood chips

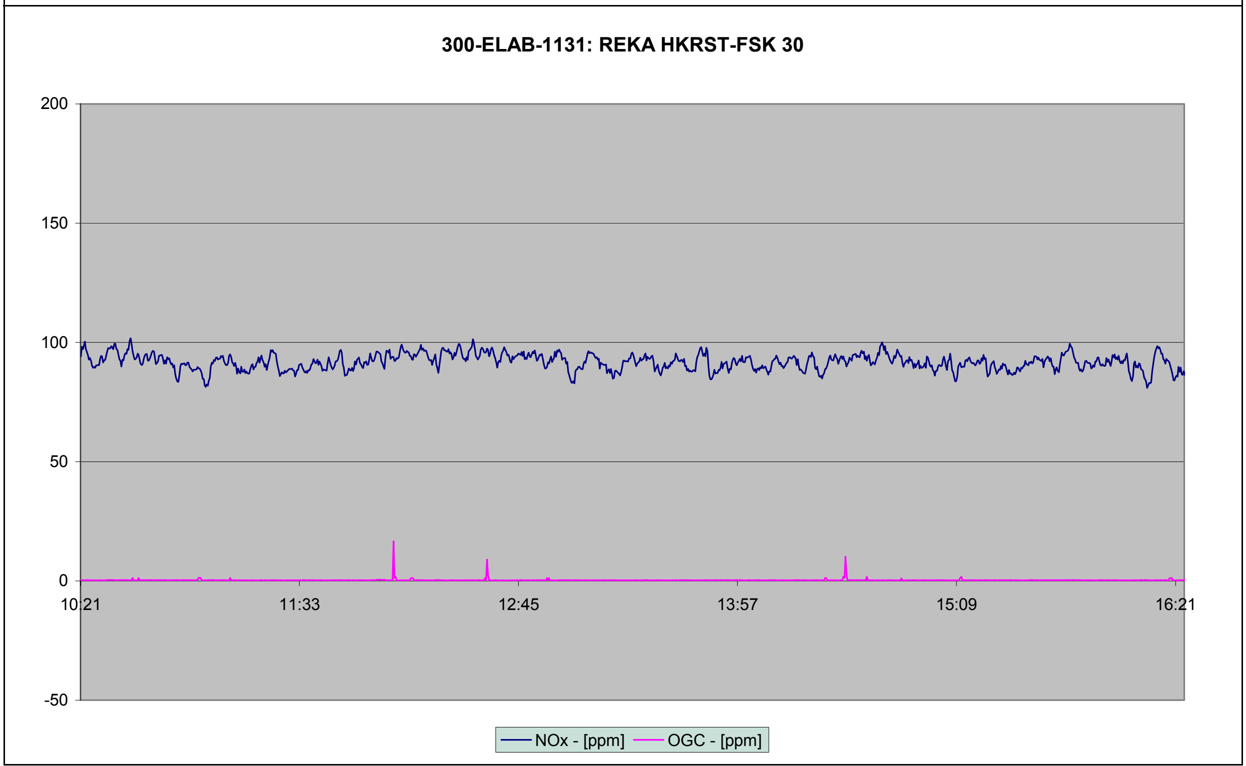
Measurement	Result	Requirement (Class 3)
Return temperature	60.10 °C	-
Inlet	78.73 °C	-
Water flow	1.76 m^3/h	-
Heat output	37.60 kW	-
Test duration	6.05 h	-
Fuel consumption	11.01 kg/h	-
Calorific value (dry)	13186 J/g	-
Water content in the fuel	25.9 %	-
Heat input	40.33 kW	
Efficiency	93.2 %	75 % (Class 3) 75 % (Denmark) 78 % (Austria)
Ambient temperature	23 °C	-
Flue gas temperature	110 °C	>180 °C (Recommended)
Chimney draught	16 Pa	<26 Pa
Flue gas volume flow	82.5 m^3/h	-
Flue gas mass slow	75.3 kg/h	-
CO_2 measured	15.4 $\%_{vol}$	-
Dust, measured	21 mg/m_n^3	-
Dust at 10% O_2	14 mg/m_n^3	150 mg/m_n^3 (Class 3)
Dust at 13% O_2	0.01 g/m_n^3	0.15 g/m_n^3 (Germany)
Dust	7 mg/MJ	60 mg/MJ (Austria)
CO measured	0.0029 $\%_{vol}$	-
CO at 10% O_2	0.0020 $\%_{vol}$	-
CO at 10% O_2	25 mg/m_n^3	3000 mg/m_n^3 (Class 3)
CO at 13% O_2	18 mg/m_n^3	4000 mg/m_n^3 (Switzerland)
CO at 13% O_2	0.0181 g/m_n^3	4 g/m_n^3 (Germany)
CO	12 mg/MJ	500 mg/MJ (Austria)
NO_x (as NO_2) at 10% O_2	0.0062 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	128 mg/m_n^3	-
NO_x (as NO_2)	64 mg/MJ	150 mg/MJ (Austria)
OGC (as CH_4) at 10% O_2	0.00 $\%_{vol}$	-
OGC (as C) at 10% O_2	0 mg/m_n^3	100 mg/m_n^3 (Class 3)
OGC (as C)	0 mg/MJ	40 mg/MJ (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1131: REKA HKRST-FSK 30
120
100
80
60
40
20
0
10:21
11:33
12:45
13:57
15:09
16:21
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1131: REKA HKRST-FSK 30
45
40
35
30
25
20
15
10
5
0
10:21
11:33
12:45
13:57
15:09
16:21
Draught - [Pa]
Output - [kW]

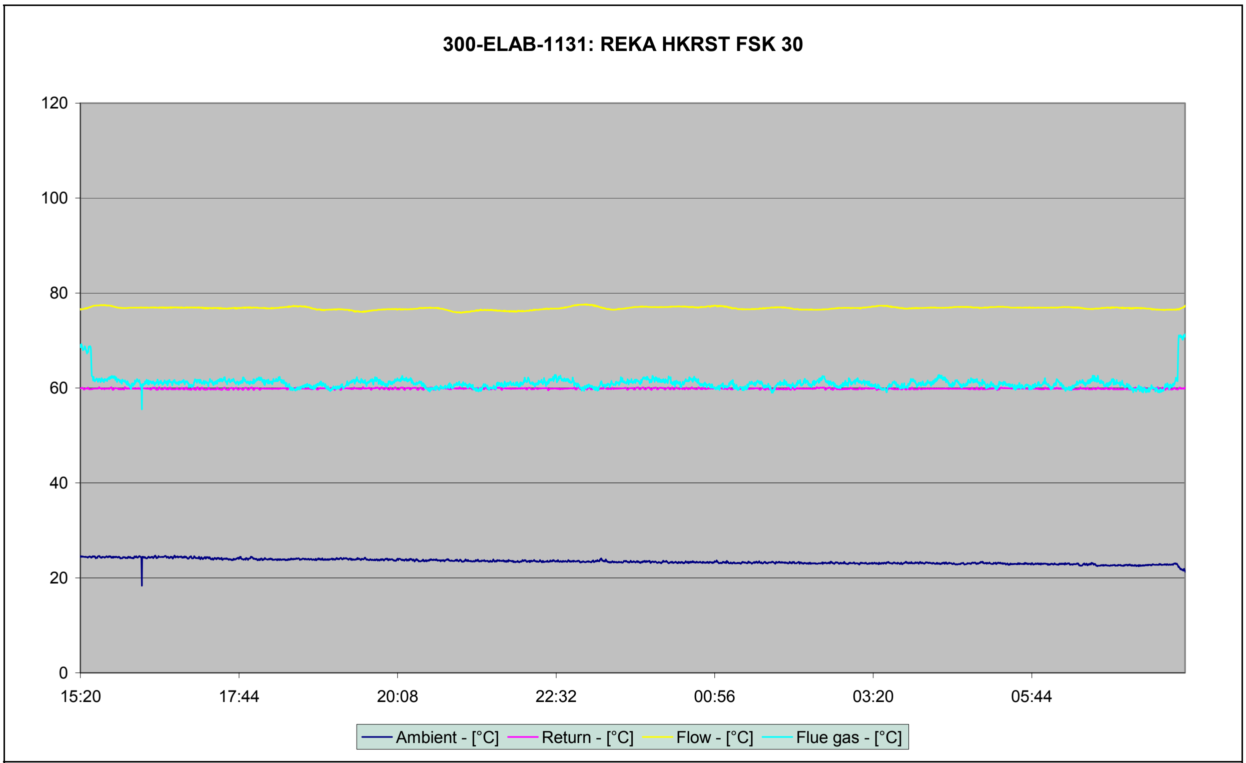

300-ELAB-1131: REKA HKRST-FSK 30
%vol
ppm
20
18
16
14
12
10
8
6
4
2
0
600
500
400
300
200
100
0
10:21
11:33
12:45
13:57
15:09
16:21
CO2 - [%]
CO [ppm]

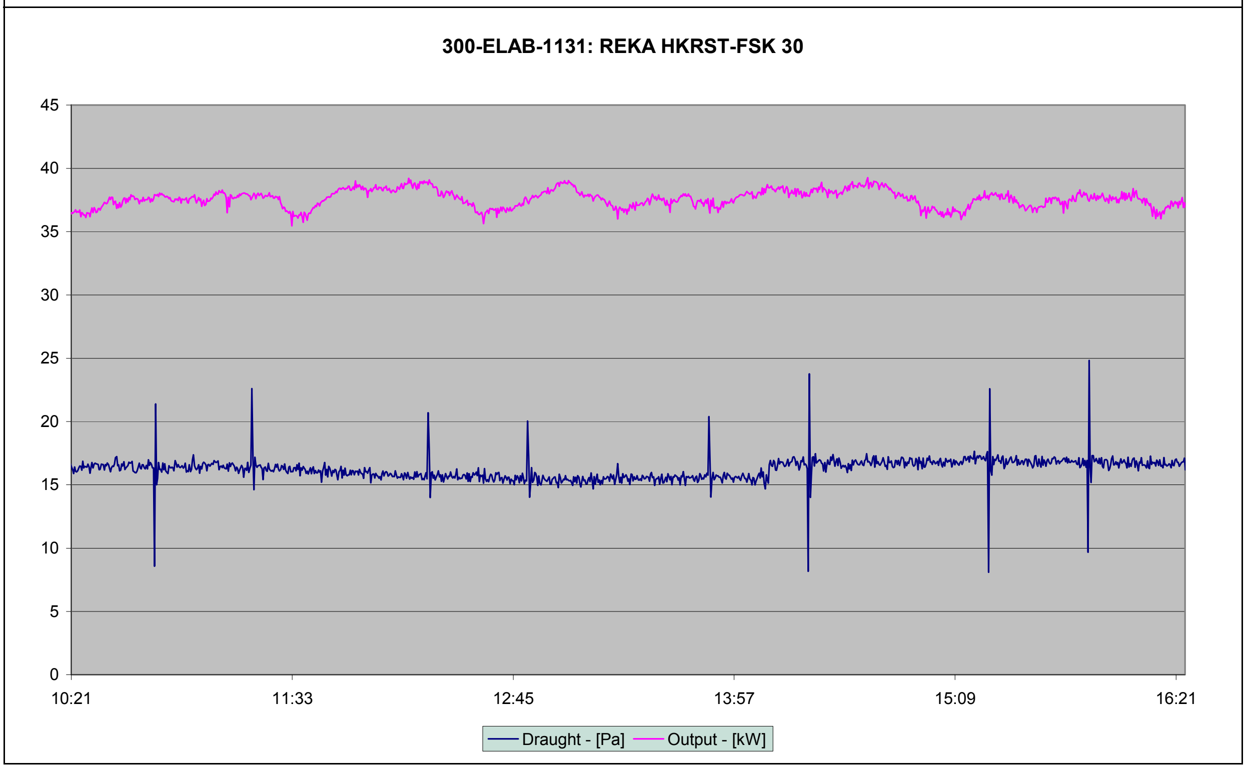

300-ELAB-1131: REKA HKRST-FSK 30
200
150
100
50
0
-50
10:21
11:33
12:45
13:57
15:09
16:21
NOx - [ppm]
OGC - [ppm]

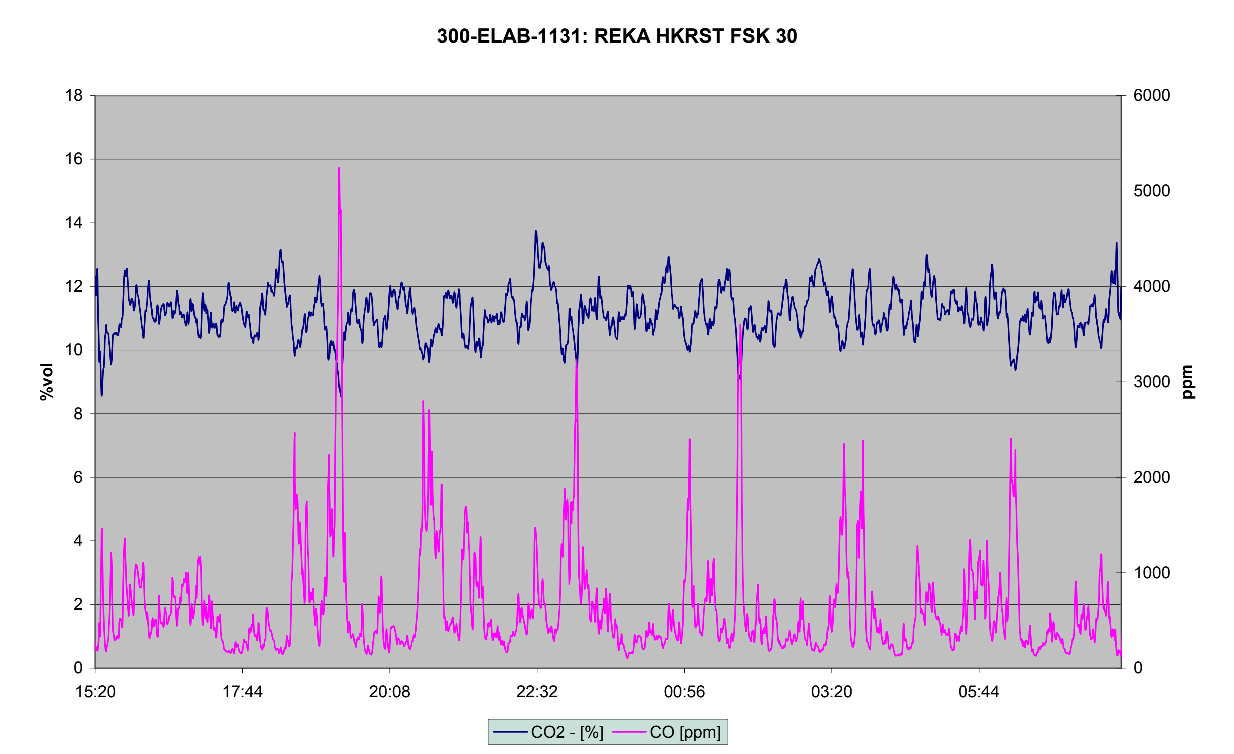
5.9 Test results at lowest output on wood chips

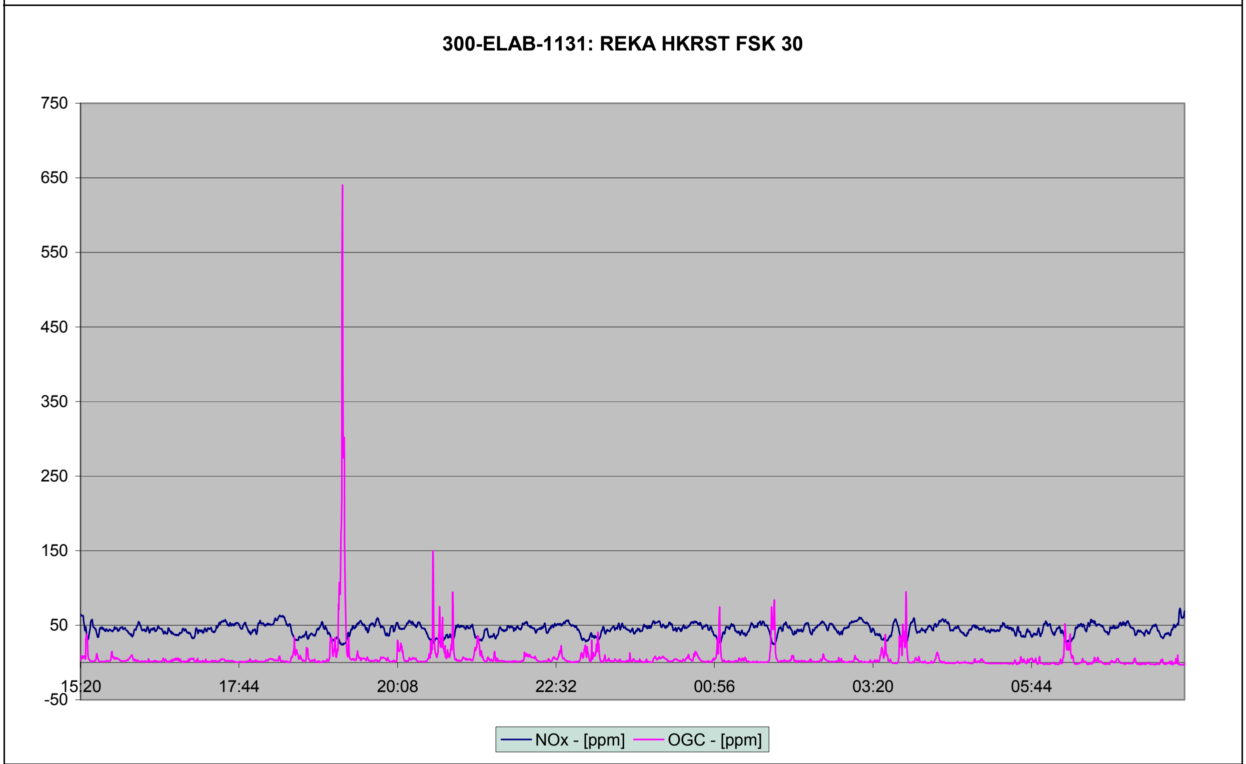
Measurement	Result	Requirement (Class 3)
Return temperature	59.87 °C	-
Inlet	76.83 °C	-
Water flow	0.54 m^3/h	-
Heat output	10.51 kW	-
Test duration	16.72 h	-
Fuel consumption	3.27 kg/h	-
Water content in the fuel	24.3 %	-
Heat input	12.27 kW	-
Efficiency	85.7 %	76 (Class 3) 80 (Austria)
Ambient temperature	23 °C	-
Flue gas temperature	61 °C	-
Chimney draught	12 Pa	<32 Pa
Flue gas volume flow	28.6 m^3/h	-
Flue gas mass flow	30 kg/h	-
CO_2 measured	11.2 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	0.0042 $\%_{vol}$	-
NO_x (as NO_2) at 10% O_2	86 mg/m_n^3	-
NO_x (as NO_2)	43 mg/MJ	150 mg/MJ (Austria)
CO measured	0.0611 $\%_{vol}$	-
CO at 10% O_2	0.0574 $\%_{vol}$	-
CO at 10% O_2	717 mg/m_n^3	3000 mg/m_n^3 (Class 3)
CO at 13% O_2	522 mg/m_n^3	-
CO	356 mg/MJ	750 mg/MJ (Austria)
OGC (as CH_4) at 10% O_2	0.0006 $\%_{vol}$	-
OGC (as C) at 10% O_2	3 mg/m_n^3	100 mg/m_n^3 (Class 3)
OGC (as C)	2 mg/MJ	40 mg/MJ (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1131: REKA HKRST FSK 30
120
100
80
60
40
20
0
15:20
17:44
20:08
22:32
00:56
03:20
05:44
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1131: REKA HKRST-FSK 30
45
40
35
30
25
20
15
10
5
0
10:21
11:33
12:45
13:57
15:09
16:21
Draught - [Pa]
Output - [kW]


300-ELAB-1131: REKA HKRST FSK 30
%vol
ppm
18
16
14
12
10
8
6
4
2
0
6000
5000
4000
3000
2000
1000
0
15:20
17:44
20:08
22:32
00:56
03:20
05:44
CO2 - [%]
CO [ppm]


300-ELAB-1131: REKA HKRST FSK 30
750
650
550
450
350
250
150
50
-50
15:20
17:44
20:08
22:32
00:56
03:20
05:44
NOx - [ppm]
OGC - [ppm]

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www.teknologisk.dk

TEST REPORT (Translation of original Danish report)

Date: 2006.09.25	Report No.: 300-ELAB-1132	
Initials: ABR/KWI/MART	Order No.: 15 56 00	Number of appendices: 4

Requested by:	Contact person:	Alf Larsen	
	Company:	Maskinfabrikken REKA	www.reka.com
	Address:	Vestvej 7	
	Postcode/town:	DK-9600 Aars	
	Tel.:	+45 98 62 40 11	Fax: +45 98 62 40 71
Product:	Automatic biofuel boiler		
	Manufacturer: REKA		Type: HKRST-FSK 60
	Nominal output: 59-60 kW		Fuel: Wood pellets and chips
Deadlines:	Date of receipt:	2006.05.17	
	Date of testing:	2006.06.14 - 2006.07.20	

Procedure: Testing of biofuel boiler according to DS/EN 303-5.

Result: Requirements according to DS/EN 303-5 Class 3 were met.

Remarks: See page 2. This is a translation of the Danish test report dated 2006.09.20. In case of doubt, the Danish version of the test report prevails.

Terms: Testing has been carried out on the conditions stated overleaf in compliance with the guidelines laid down for the laboratory by DANAK (Danish Accreditation) and in compliance with DTI's General Terms and Conditions Regarding Commissioned Work Accepted by the Danish Technological Institute (DTI), August 1999. The test results apply to the tested samples only. This test report may be reproduced in extracts only if the laboratory has approved the extract in writing.

Place: Danish Technological Institute, Energy Laboratory

Date: KWI 25 SEP. 2006

Signature: Kim Winther
M.Sc., B.Com.

DANAK (Danish Accreditation)

DANAK was established in 1991 in pursuance of the Danish Act No. 394 of 13 June 1990 on the promotion of Trade and Industry.

The requirements to be met by accredited laboratories are laid down in the Danish Agency for Trade and Industry (Erhvervsfremme Styrelsens) Statutory Order on accreditation of laboratories to perform testing etc. and GLP inspection. The Statutory Order refers to other documents in which the criteria for accreditation are specified further.

The standards DS/EN ISO/IEC 17025 "General requirements concerning the competence of testing and calibration laboratories" and DS/EN 45002 "General criteria for the assessment of testing laboratories" describe fundamental criteria for accreditation. DANAK uses guidance documents to clarify the requirements in the standards, where this is considered to be necessary. They will mainly be drawn up by the "European co-operation for Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with a view to obtaining uniform criteria for accreditation worldwide. In addition, DANAK draws up Technical Regulations concerning specific demands on accreditation that are not included in the standards.

In order to obtain accreditation it is i.a. required:

- that the laboratory and its personnel are not subject to any commercial, financial or other types of pressure which might influence their technical judgement,
- that the laboratory operates a documented quality control system,
- that the laboratory has technical equipment, facilities and premises of a certain standard at its disposal in order to carry out the service it is accredited to perform,
- that the laboratory management and personnel have technical competence and practical experience in the performance of the service the laboratory is accredited to perform,
- that the laboratory has established guidelines for traceability and uncertainty calculations,
- that accredited testing or calibration is performed in accordance with fully validated and documented methods,
- that the laboratory keeps records which contain sufficient information to permit the repetition of the accredited test or calibration,
- that the laboratory is subject to supervision carried out by DANAK on a regular basis,
- that the laboratory shall take out an insurance, which covers liability in connection with the performance of accredited services.

Reports carrying DANAK's logo are used when reporting accredited services and show that they have been performed in accordance with the rules concerning accreditation.

Unofficial translation for

DANAK, Technical guidelines
No. RL 4 of 20 June 2001
q:\kvalitet & akkreditering\danak-engelsk.doc

Appendices:

a) Drawings of the biofuel boiler: 6 pieces
b) Photos of the biofuel boiler in total: 11 pieces
c) Installation and operating instructions, version 99/3 of 0999.09.14 (rev. 2003.05.09)
d) Data plate.

The appendices are kept separately.

1 Remarks

1. Shielding of the movable parts around the storage hopper shall be carried out according to the Machinery Directive
2. The operating temperature must be limited to 80 °C to prevent overheating.

2 Description of the biofuel boiler

REKA HKRST 60 is an automatically fired boiler for firing with finely divided solid fuel. The fuel is transported via an auger from the fuel hopper to a movable combustion grate, where the combustion air is supplied via an air fan. The boiler is a welded steel sheet boiler with boiler tubes.

The boiler's control system is based on an electronic three-stage boiler controller with lambda probe. The boiler is provided with a sprinkler to prevent back-burning in the storage hopper.

Settings on boiler during testing:

- Boiler thermostat (nominal): .... 80 °C
- Boiler thermostat (partial load): .... 76 °C
- Air amount BL3 (nominal): 080
- Air amount BL1 (partial load): 004
- O_2 modification, step 3 (nominal): .... -30
- O_2 set point, step 2 (standard): .... 8.0 %
- O_2 modification, step 1 (partial load): .... +15
- O_2 set point, step 3 (nominal): ....Approx. 5.5%
- O_2 set point, step 1 (partial load): ....Approx. 9.5%
- Auger, pulse t1 PRG 1 (partial load, wood pellets): ....0.63 s
- Auger, pulse t3 PRG 1 (full load, wood pellets): ....2.00 s
- Auger, pulse t1 PRG 3 (partial load, wood chips): ....3.40 s
- Auger, pulse t3 PRG 3 (full load, wood chips): .... 17 s
- Auger, pause: ....Variable
- Valve for primary air: .... Approx. 10% open
- Valve for secondary air: .... Totally open

Combustion system:

- Type: ....Horizontal pellet burner auger
- Burner: ....Movable step grate
- Fuel auger drive motor (el): ....0.55 kW
- Motor for vibration movements: ....0.09 kW
- Air fan:....................G2E160, 230V, 240W, 2100 r/min.

Boiler:

- Type: .... Welded steel sheet boiler
- Height (exclusive adjustable plinth): .... Approx. 1150 mm
- Width: .... Approx. 700 mm
- Length: .... Approx. 1195 mm
- Water content: .... Approx. 330 l
- Flue gas tube: .... ø215 mm
- Water side connection, inlet: ....1”
- Water side connection, return: ....1”

Safety equipment:

- Boiler thermostat, type: ....Electronic
- Safety thermostat, type: ....FIRT STB/83 T80
- Safety heat exchanger, type: ....None
- Valve for safety circuit: ....None
- Fire extinguishing equipment: .... Thermostatic sprinkler

3 Test equipment

Test rig and equipment are constructed in accordance with EN 303-5 and EN 304.

Rack 3			
Instrument	**Type**	**Traceability**	**No.**
Data acquisition unit	HP 34970A	DANAK 200	270-A-1509
Pc	Amitech Pentium	-	-
$CO/CO_2/O_2$ analyzer	H & B Uras 14	-	270-A-1501
Pressure gauge	Autotran 700	ELAB	270-A-1578
Heated hose	Winkler	-	270-A-1495
Probe	M & C	-	270-A-1479
Flue gas temperature sensor	Type K	ELAB	270-A-1528
Ambient temperature sensor	Type K	ELAB	270-A-1527

Test rig 1			
Instrument	**Type**	**Traceability**	**No.**
Water flow meter	0-3.5 m^3/h	DANAK 200	270-A-1175
Water temperature sensor	Pt100 (inlet)	DANAK 200	270-A-1494
Water temperature sensor	Pt100 (return)	DANAK 200	270-A-1493
Gas meter	IGA AC-5M	IGA	270-A-1475

Other equipment			
Instrument	**Type**	**Traceability**	**No.**
NO analyzer	H&B Radas 2	-	270-A-1502
Converter	H&B CGO-K	-	270-A-1503
FID analyzer	M&A Thermo-Fid	-	270-A-1751
Heated hose	Winkler	-	270-A-1753
Probe	M & C	-	270-A-1752
Adiabatic calorimeter	-	IVC, Kemi	-
Span gas, CH_4	Air Liquide	Cofrac	270-A-1729-1
Span gas, CO/CO_2	Air Liquide	Cofrac	270-A-1727-3
Span gas, NO/SO_2	Air Liquide	Cofrac	270-A-1725-1
Zero gas, N_2	Air Liquide	Cofrac	270-A-1731-1
Data acquisition software	N.I. Labview	-	TI-DOP ver. II
Dust measuring equipment	Ströhlein	-	270-A-1330
Surface thermometer	Technoterm 5500	DANAK 200	270-A-976
Water gauge meter	ELAB	-	270-A-1759
Scale (dust)	Mettler PC 440	ELAB	270-A-947
Scale (humidity)	Mettler PJ6	ELAB	270-A-997
Scale (boiler)	Sauter E/40-E2100	ELAB	270-A-0551
Scale (fuel)	Sauter 60 kg	ELAB	270-A-484

4 Requirement on construction etc.

	Reference paragraph in EN303-5	Requirement met
4.1 General requirements		
Safety during normal use	4.1.1	Yes
4.2 Requirement on documentation		
Drawings	4.1.2.1	Yes
Quality manual	4.1.2.2	Yes
Data plate	7.1-7.2	Yes
Technical information	8.1	Yes
Operating instructions	8.2	Yes
4.3 Requirement on welded steel sheet boilers		
Execution of welding work	4.1.3.1	*
Welding seams and fillers	4.1.3.2	*
Parts of steel subject to pressure	4.1.3.3	*
Minimum wall thickness and tolerances	4.1.3.4	*
4.4 Requirement on safety and design		
Venting etc.	4.1.5.1	Yes
Cleaning of heating surfaces	4.1.5.2	Yes
Inspection of flame	4.1.5.3	Yes
Water tightness	4.1.5.4	Yes
Replacement and spare parts	4.1.5.5	Yes
Water side connections	4.1.5.6	Yes
Thermostat pockets	4.1.5.7	Yes
Thermal insulation	4.1.5.8	Yes
Leakages in flue gas system	4.1.5.10	Yes
Requirement on temperature control at open expansion	4.1.5.11.1	Yes
Requirement on temperature control at closed expansion	4.1.5.11.2	Yes[1]
Storage hopper	4.1.5.12	Yes
Ash chamber	4.1.5.13	Yes
Safety during automatic fuel supply	4.1.5.14.2	Yes
Accessories/fittings	4.1.5.15	Yes
Electric safety	4.1.5.16	*

[1] The maximum adjustable operating temperature on the controller must be limited to 80 °C.

* Not included in this report. Please refer to the manufacturer's EU declaration of conformity.

5 Test results

5.1 Water side resistance

Equivalent temperature difference at nominal output	Water flow	Drop of pressure
20 K	5.1 m^3/h	120 mbar
10 K	2.56 m^3/h	30 mbar

5.2 Leakage test

Since the boiler is operating with a negative pressure in the combustion chamber, there are no requirements on leakage flow.

5.3 Surface temperatures

	Measured temperature	Allowed limit
Boiler door, average of 5 measurements	75 °C	+ 100 K
Boiler’s underside, average of 5 measurements	65 °C	+ 65 K
Handles being touched during operation Plastic and similar materials	47 °C	+ 60 K
Boiler’s surface, average of 5 measurements	50 °C	-
Ambient temperature	30 °C	-

5.4 Functions check

The biofuel boiler is rapidly disconnectable, DS/EN303.5 paragraph 4.1.5.11.2 a), and therefore the safety equipment includes a temperature controller and a safety thermostat with a manual reset device.

The boiler’s thermostats have been tested in accordance with DS/EN303-5, paragraph 5.13.

	Measured temperature	Allowed limit
Temperature controller (set point 90°C)	86 °C *)	100 °C
Safety thermostat	94 °C	110 °C

*) However, to prevent overheating in case of power failure, the electronic boiler control will be limited to maximum 80 °C operating temperature in the future.

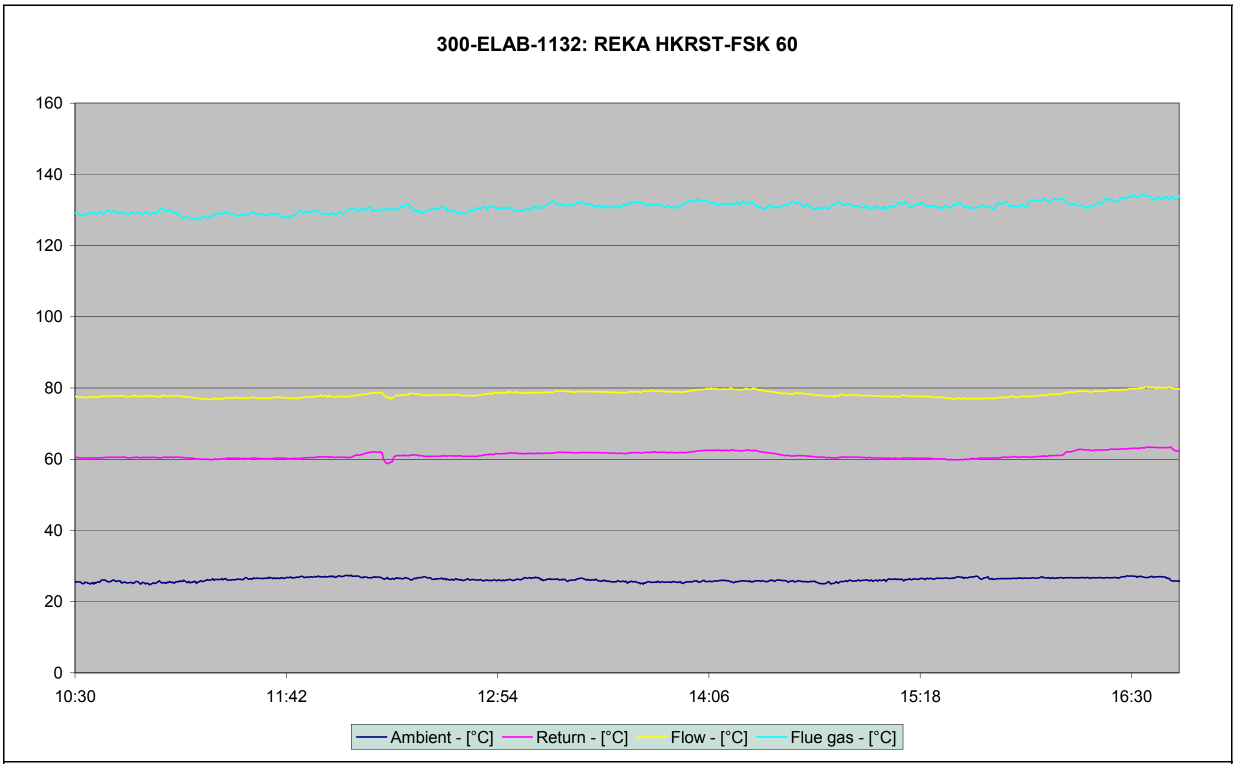
5.5 Test pressure of boiler shell

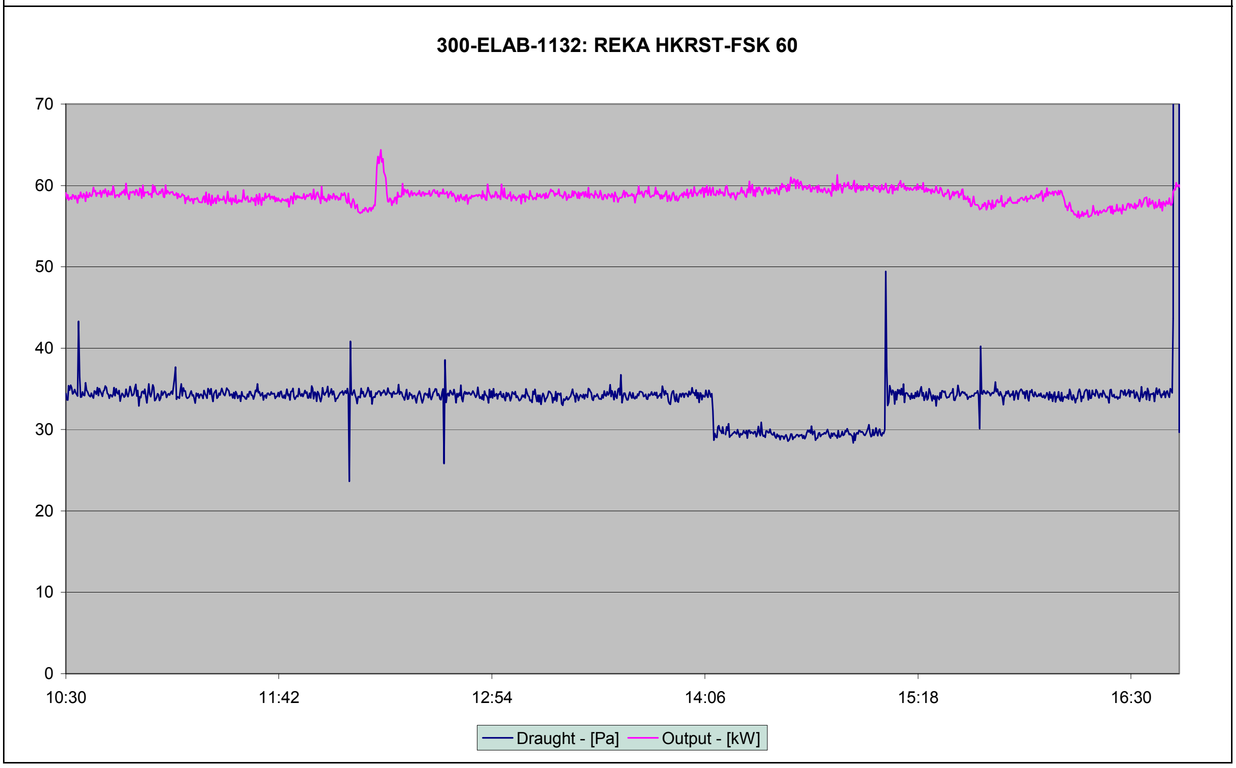
The necessary tests cf. DS/EN303-5 paragraph 5.4, are carried out by the manufacturer.

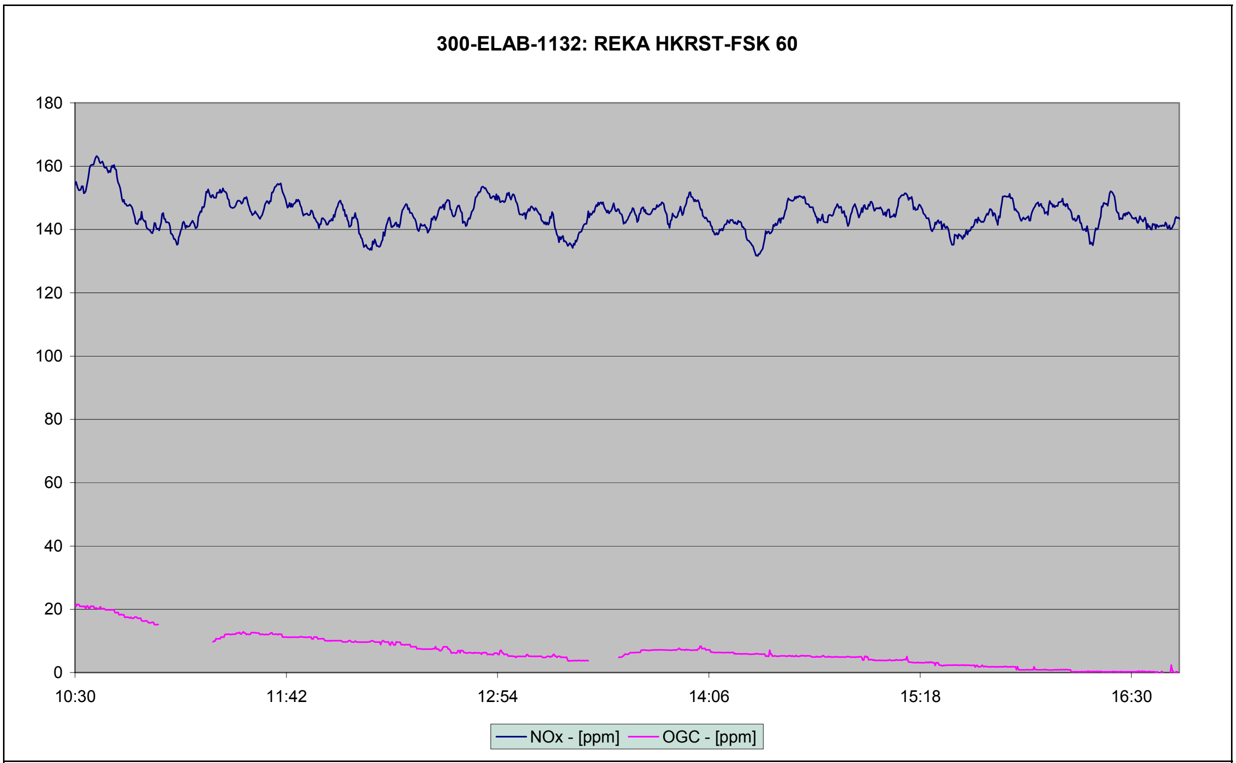
5.6 Test results at nominal output on wood pellets

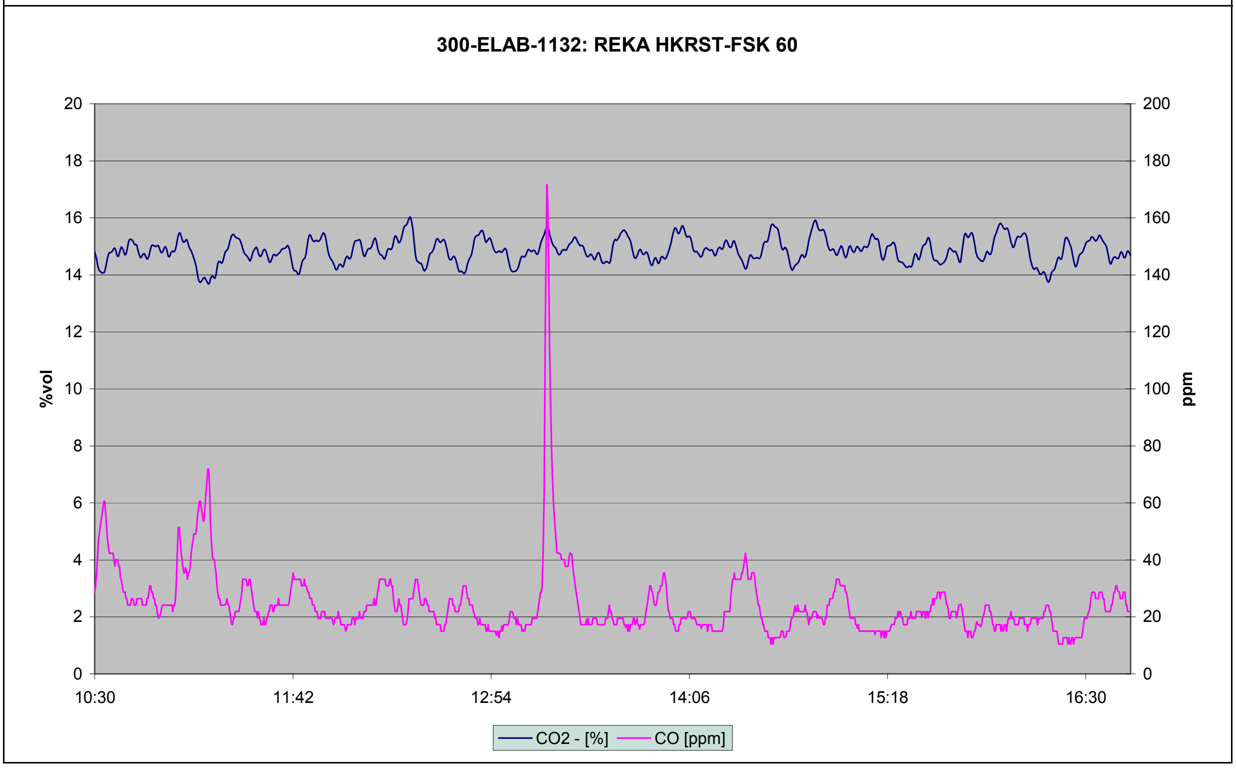
Measurement	Result	Requirement
Return temperature	61.15 °C	
Inlet temperature	78.24 °C	
Water flow	3.00 m^3/h	
Heat output	58.69 kW	
Test duration	6.27 h	
Fuel consumption	13.18 kg/h	
Water content	6.3 %	
Calorific value	17632 J/g	
Heat input	64.54 kW	
Efficiency	90.9 %	78 (Class 3) 78 (Denmark) 82 (Austria)
Ambient temperature	26 °C	
Flue gas temperature	131 °C	
Chimney draught	34 Pa	36 (Max.)
Flue gas volume flow	128.9 m^3/h	
Flue gas mass flow	113.6 kg/h	
CO_2	14.9 $\%_{vol}$	
Dust measured	29 mg/m_n^3	
Dust at 10% O_2	20 mg/m_n^3	150 (Class 3)
Dust at 13% O_2	0.01 g/m_n^3	0.15 (Germany)
Dust emission	10 mg/MJ	60 (Austria)
CO measured	0.0025 $\%_{vol}$	
CO at 10% O_2	0.0017 $\%_{vol}$	
CO at 10% O_2	22 mg/m_n^3	2500 (Class 3)
CO at 13% O_2	0.0158 g/m_n^3	2 (Germany)
CO at 13% O_2	16 mg/m_n^3	4000 (Switzerland)
CO emission	10 mg/MJ	500 (Austria)
NO_x (NO_2) at 10% O_2	0.0103 $\%_{vol}$	
NO_x (NO_2) at 10% O_2	211 mg/m_n^3	
NO_x emission (NO_2)	99 mg/MJ	150 (Austria)
OGC (CH_4) at 10% O_2	0.0005 $\%_{vol}$	
OGC (C) at 10% O_2	3 mg/m_n^3	80 (Class 3)
OGC emission (C)	1 mg/MJ	40 (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1132: REKA HKRST-FSK 60
160
140
120
100
80
60
40
20
0
10:30
11:42
12:54
14:06
15:18
16:30
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1132: REKA HKRST-FSK 60
70
60
50
40
30
20
10
0
10:30
11:42
12:54
14:06
15:18
16:30
Draught - [Pa]
Output - [kW]

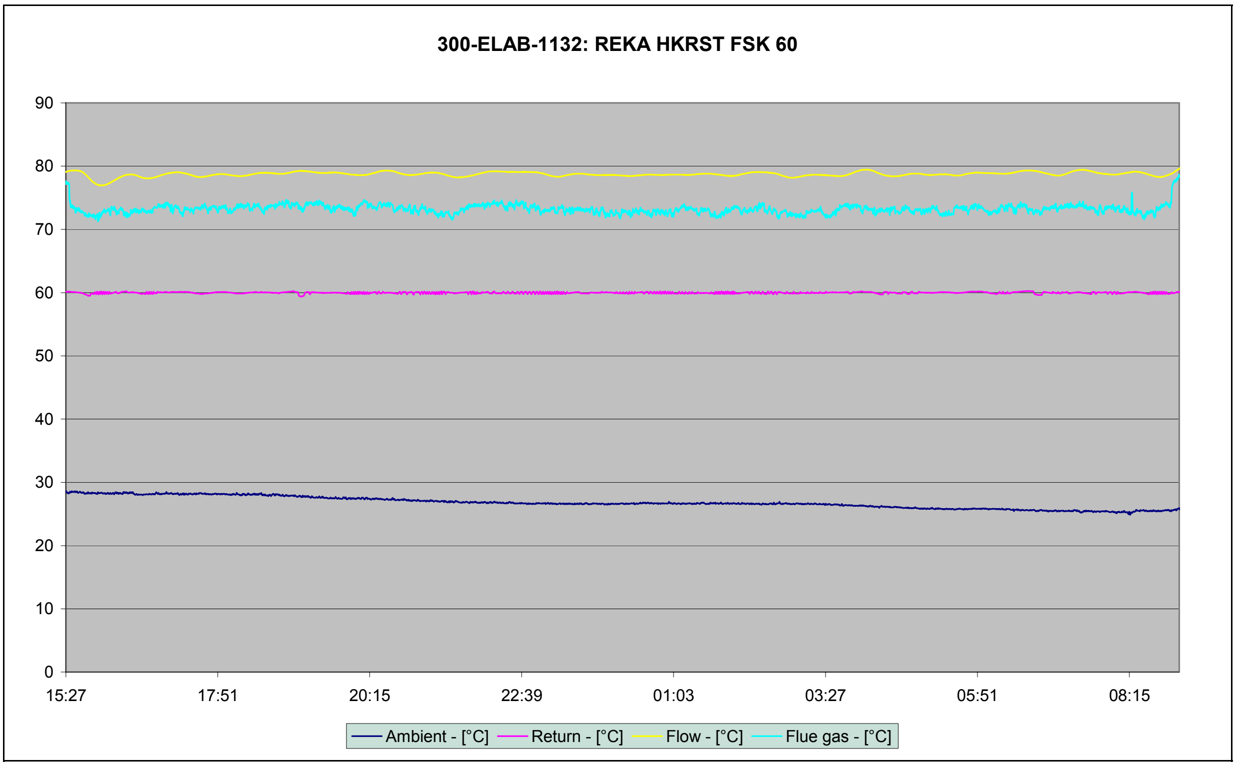

300-ELAB-1132: REKA HKRST-FSK 60
180
160
140
120
100
80
60
40
20
0
10:30
11:42
12:54
14:06
15:18
16:30
NOx - [ppm]
OGC - [ppm]

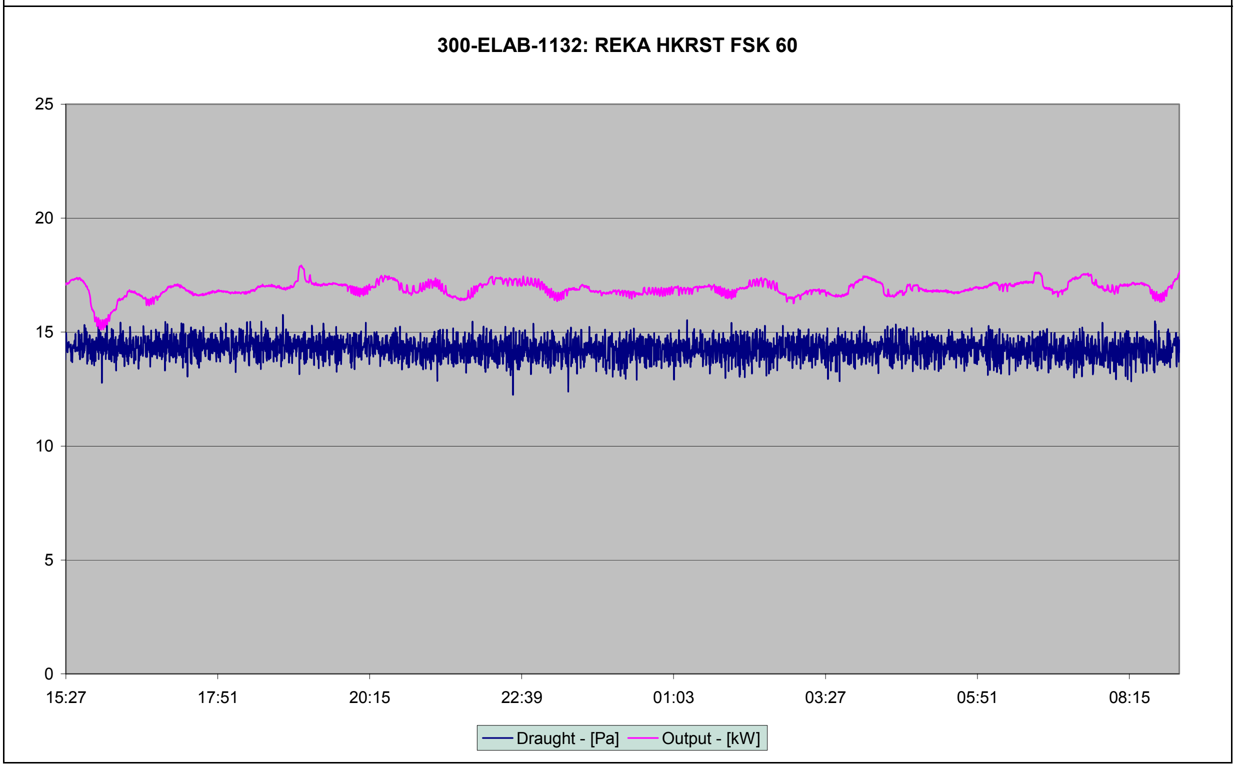

300-ELAB-1132: REKA HKRST-FSK 60
%vol
ppm
20
18
16
14
12
10
8
6
4
2
0
200
180
160
140
120
100
80
60
40
20
0
10:30
11:42
12:54
14:06
15:18
16:30
CO2 - [%]
CO [ppm]

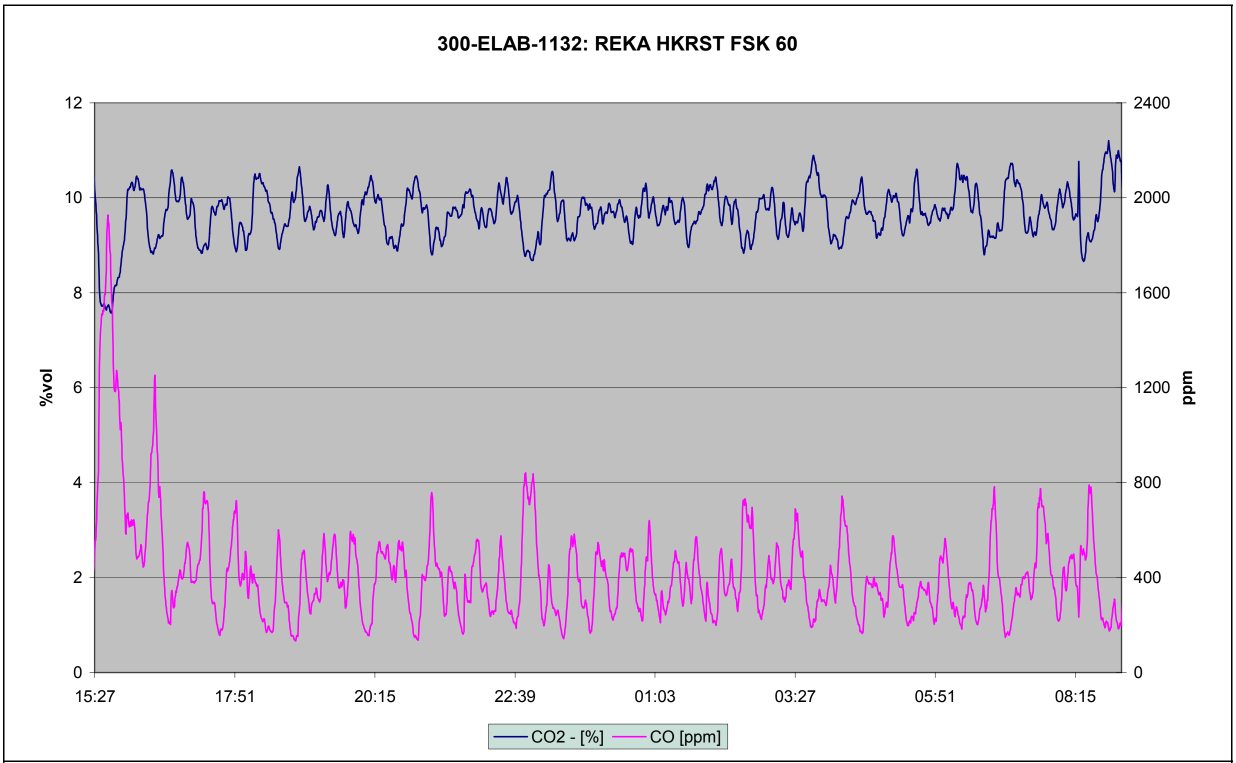
5.7 Test results at lowest output on wood pellets

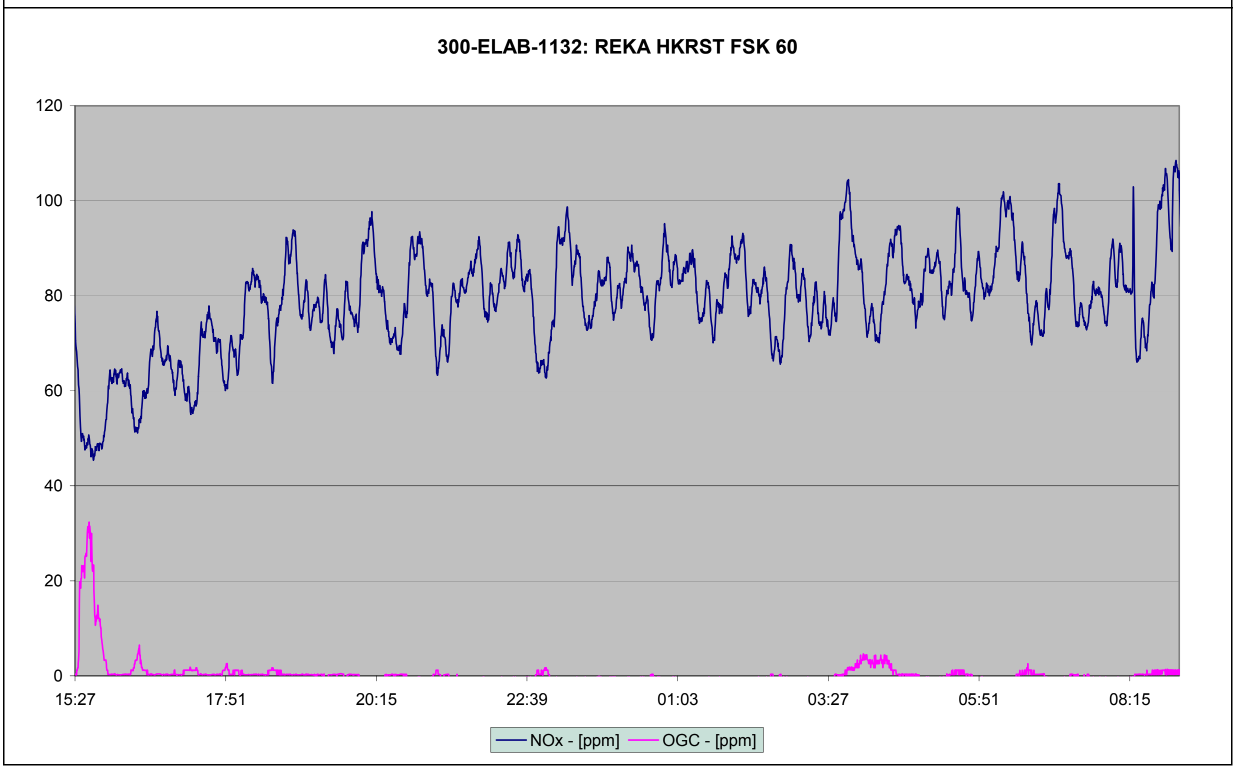
Measurement	Result	Requirement
Return temperature	59.98 °C	
Inlet temperature	78.74 °C	
Water flow	0.79 m^3/h	
Heat output	16.89 kW	
Test duration	17.59 h	
Fuel consumption	3.90 kg/h	
Water content	6.0 %	
Calorific value	17687 J/g	
Heat input	19.15 kW	
Efficiency	88.2 %	(Class 3) 82 (Austria)
Ambient temperature	27 °C	
Flue gas temperature	73 °C	
Chimney draught	14 Pa	36 (Max.)
Flue gas volume flow	48.2 m^3/h	
Flue gas mass flow	49.3 kg/h	
CO_2	9.7 $\%_{vol}$	
CO measured	0.0417 $\%_{vol}$	
CO at 10% O_2	0.0454 $\%_{vol}$	
CO at 10% O_2	567 mg/m_n^3	2500 (Class 3)
CO at 13% O_2	0.4127 g/m_n^3	2 (Germany)
CO at 13% O_2	413 mg/m_n^3	4000 (Switzerland)
CO emission	264 mg/MJ	750 (Austria)
NO_x (NO_2) at 10% O_2	0.0086 $\%_{vol}$	
NO_x (NO_2) at 10% O_2	177 mg/m_n^3	
NO_x emission (NO_2)	82 mg/MJ	150 (Austria)
OGC (CH_4) at 10% O_2	0.0001 $\%_{vol}$	
OGC (C) at 10% O_2	0 mg/m_n^3	80 (Class 3)
OGC emission (C)	0 mg/MJ	40 (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1132: REKA HKRST FSK 60
90
80
70
60
50
40
30
20
10
0
15:27
17:51
20:15
22:39
01:03
03:27
05:51
08:15
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1132: REKA HKRST FSK 60
25
20
15
10
5
0
15:27
17:51
20:15
22:39
01:03
03:27
05:51
08:15
Draught - [Pa]
Output - [kW]

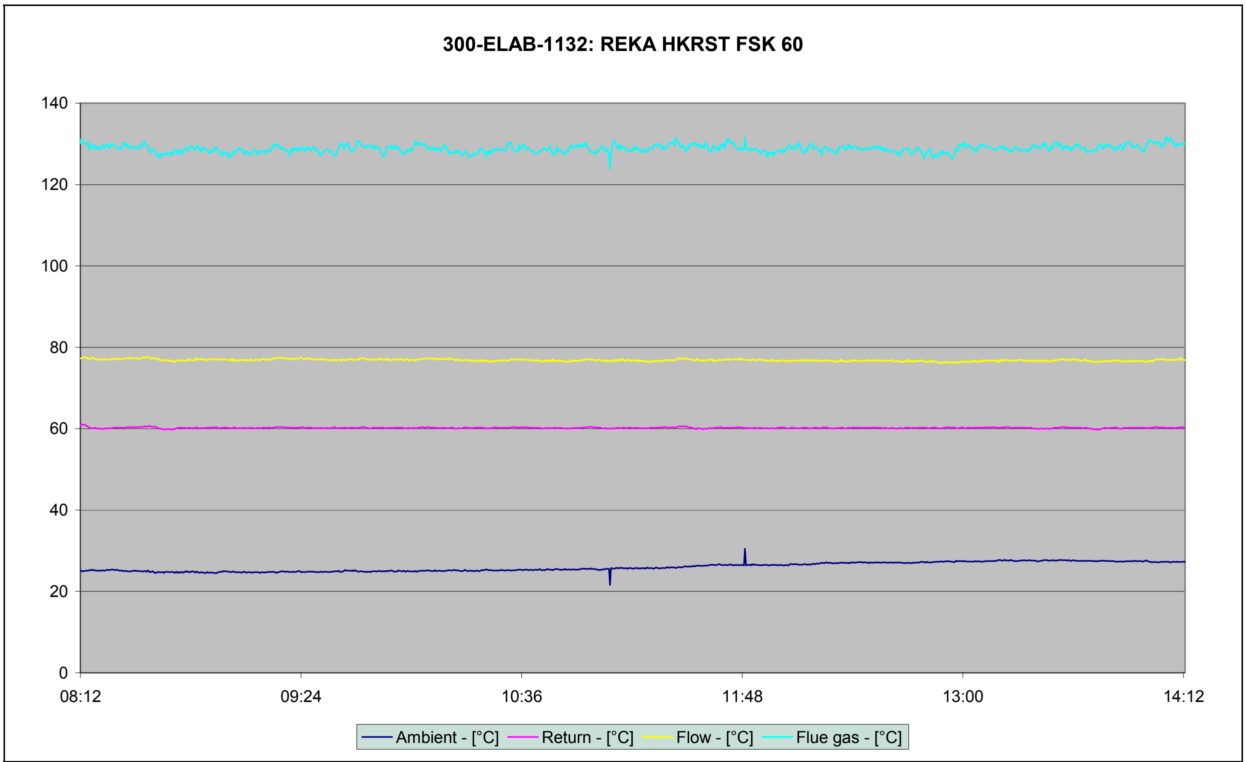

300-ELAB-1132: REKA HKRST FSK 60
%vol
ppm
12
10
8
6
4
2
0
2400
2000
1600
1200
800
400
0
15:27
17:51
20:15
22:39
01:03
03:27
05:51
08:15
CO2 - [%]
CO [ppm]

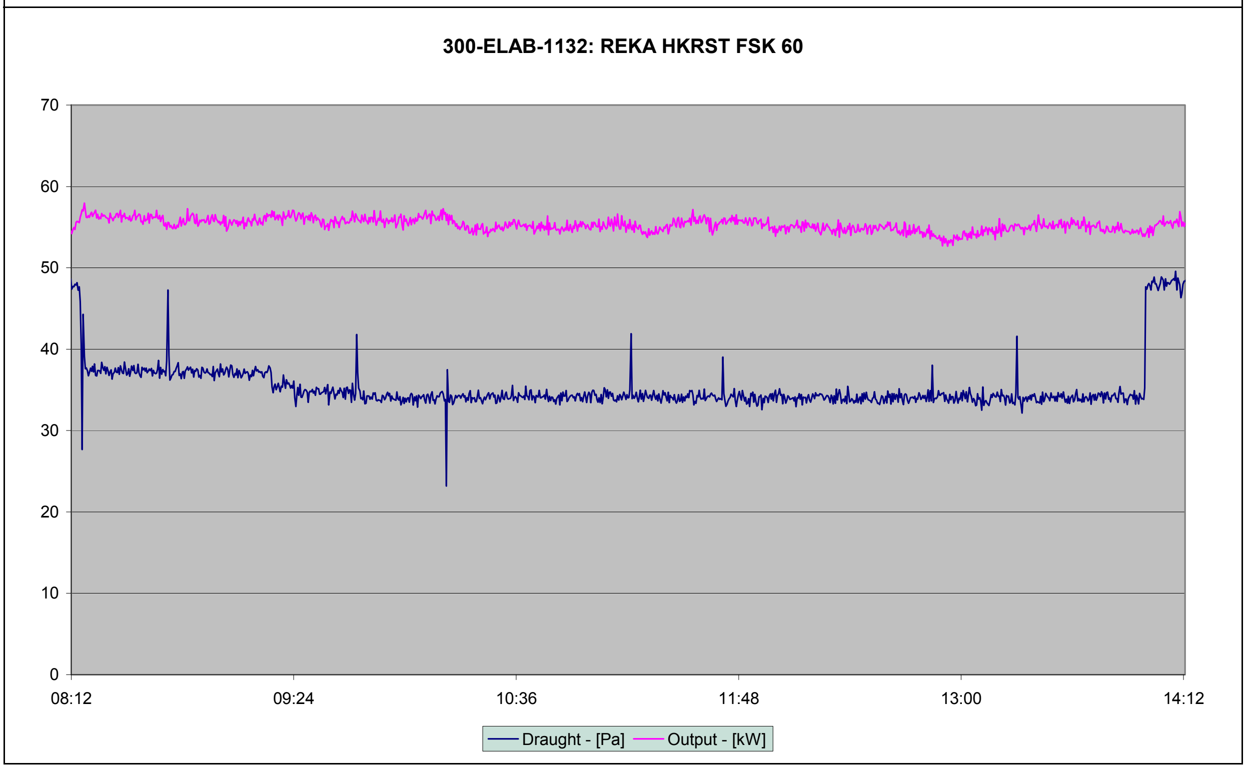

300-ELAB-1132: REKA HKRST FSK 60
120
100
80
60
40
20
0
15:27
17:51
20:15
22:39
01:03
03:27
05:51
08:15
NOx - [ppm]
OGC - [ppm]

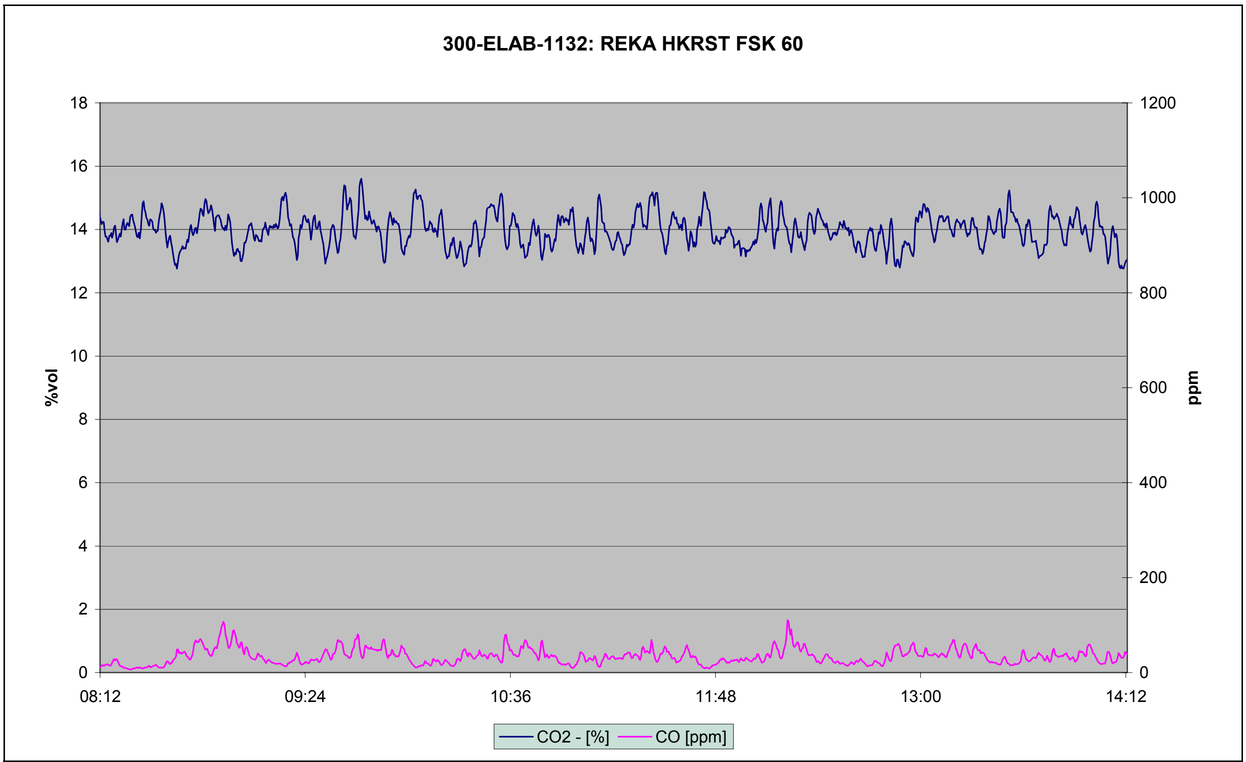
5.8 Test results at nominal output on wood chips

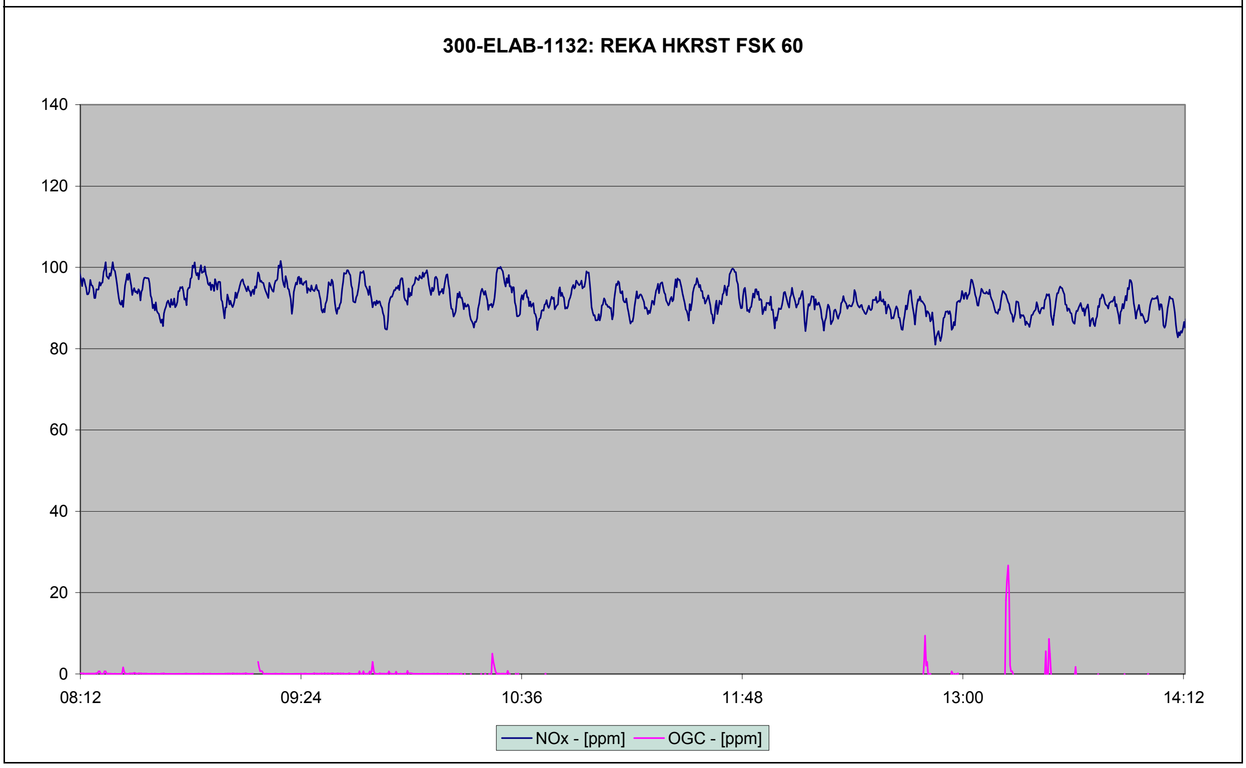
Measurement	Result	Requirement
Return temperature	60.21 °C	
Inlet temperature	76.85 °C	
Water flow	2.91 m^3/h	
Heat output	55.29 kW	
Test duration	6.01 h	
Fuel consumption	16.23 kg/h	
Water content	24.0 %	
Calorific value	13606 J/g	
Heat input	61.33 kW	
Efficiency	90.1 %	78 (Class 3) 82 (Austria)
Ambient temperature	26 °C	
Flue gas temperature	129 °C	
Chimney draught	35 Pa	36 (Max.)
Flue gas volume flow	141.6 m^3/h	
Flue gas mass flow	123.5 kg/h	
CO_2	14.0 $\%_{vol}$	
Dust measured	27 mg/m_n^3	
Dust at 10% O_2	20 mg/m_n^3	150 (Class 3)
Dust at 13% O_2	0.01 g/m_n^3	0,15 (Germany)
Dust emission	10 mg/MJ	60 (Austria)
CO measured	0.0034 $\%_{vol}$	
CO at 10% O_2	0.0026 $\%_{vol}$	
CO at 10% O_2	32 mg/m_n^3	2500 (Class 3)
CO at 13% O_2	0.0232 g/m_n^3	2 (Germany)
CO at 13% O_2	23 mg/m_n^3	4000 (Switzerland)
CO emission	16 mg/MJ	500 (Austria)
NO_x (NO_2) at 10% O_2	0.0069 $\%_{vol}$	
NO_x (NO_2) at 10% O_2	142 mg/m_n^3	
NO_x emission (NO_2)	71 mg/MJ	150 (Austria)
OGC (CH_4) at 10% O_2	0.0000 $\%_{vol}$	
OGC (C) at 10% O_2	0 mg/m_n^3	80 (Class 3)
OGC emission (C)	0 mg/MJ	40 (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1132: REKA HKRST FSK 60
140
120
100
80
60
40
20
0
08:12
09:24
10:36
11:48
13:00
14:12
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1132: REKA HKRST FSK 60
70
60
50
40
30
20
10
0
08:12
09:24
10:36
11:48
13:00
14:12
Draught - [Pa]
Output - [kW]

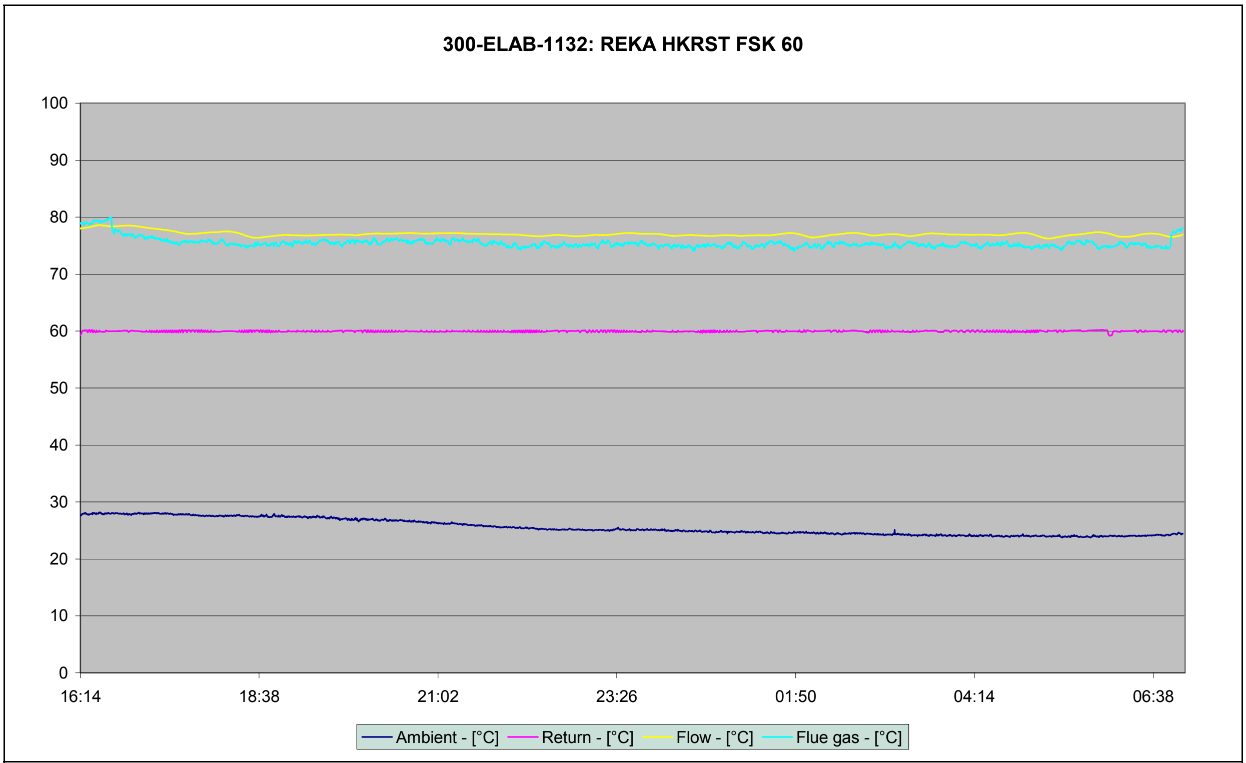

300-ELAB-1132: REKA HKRST FSK 60
%vol
ppm
18
16
14
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
08:12
09:24
10:36
11:48
13:00
14:12
CO2 - [%]
CO [ppm]

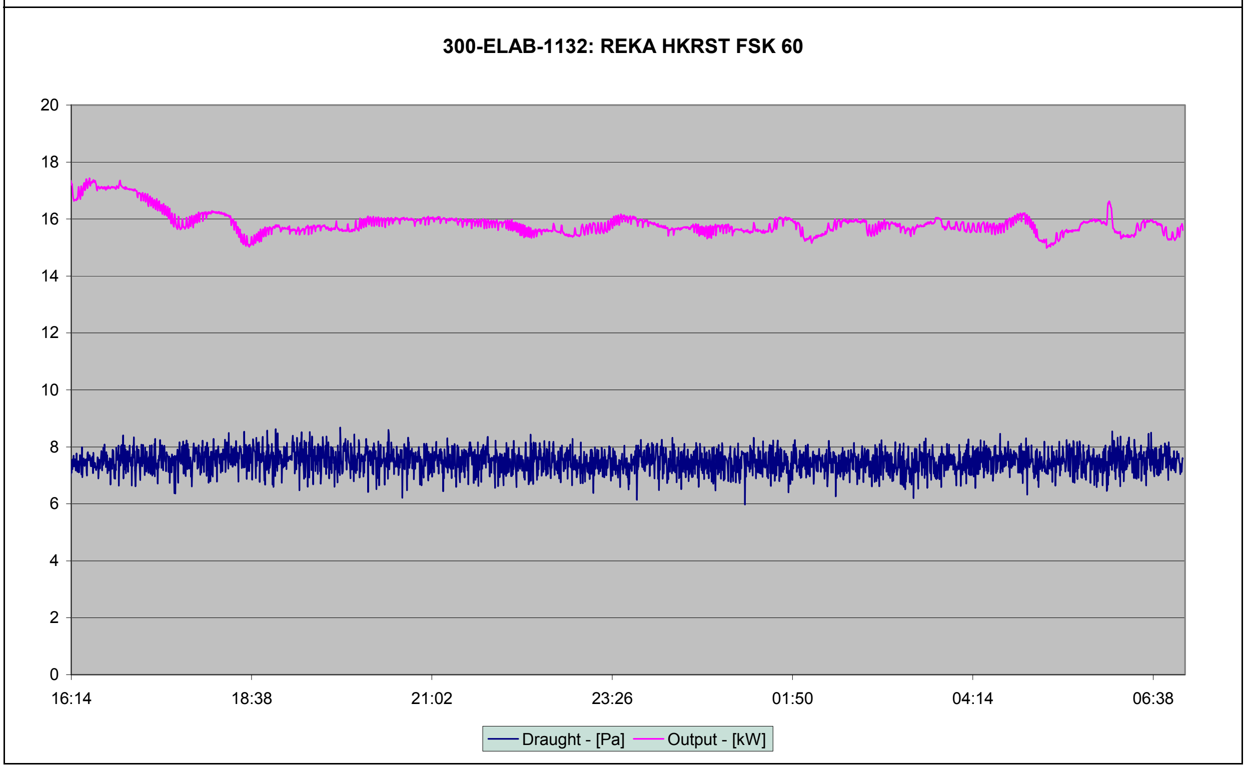

300-ELAB-1132: REKA HKRST FSK 60
140
120
100
80
60
40
20
0
08:12
09:24
10:36
11:48
13:00
14:12
NOx - [ppm]
OGC - [ppm]

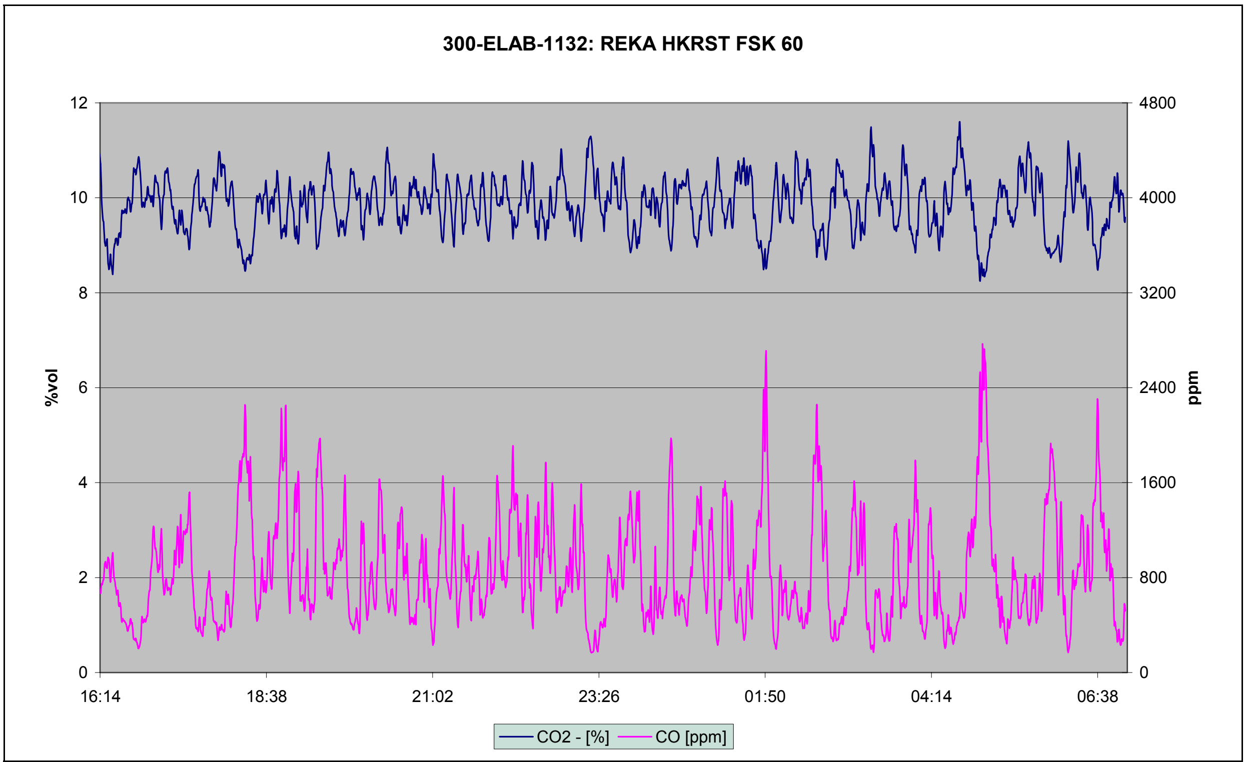
5.9 Test results at lowest output on wood chips

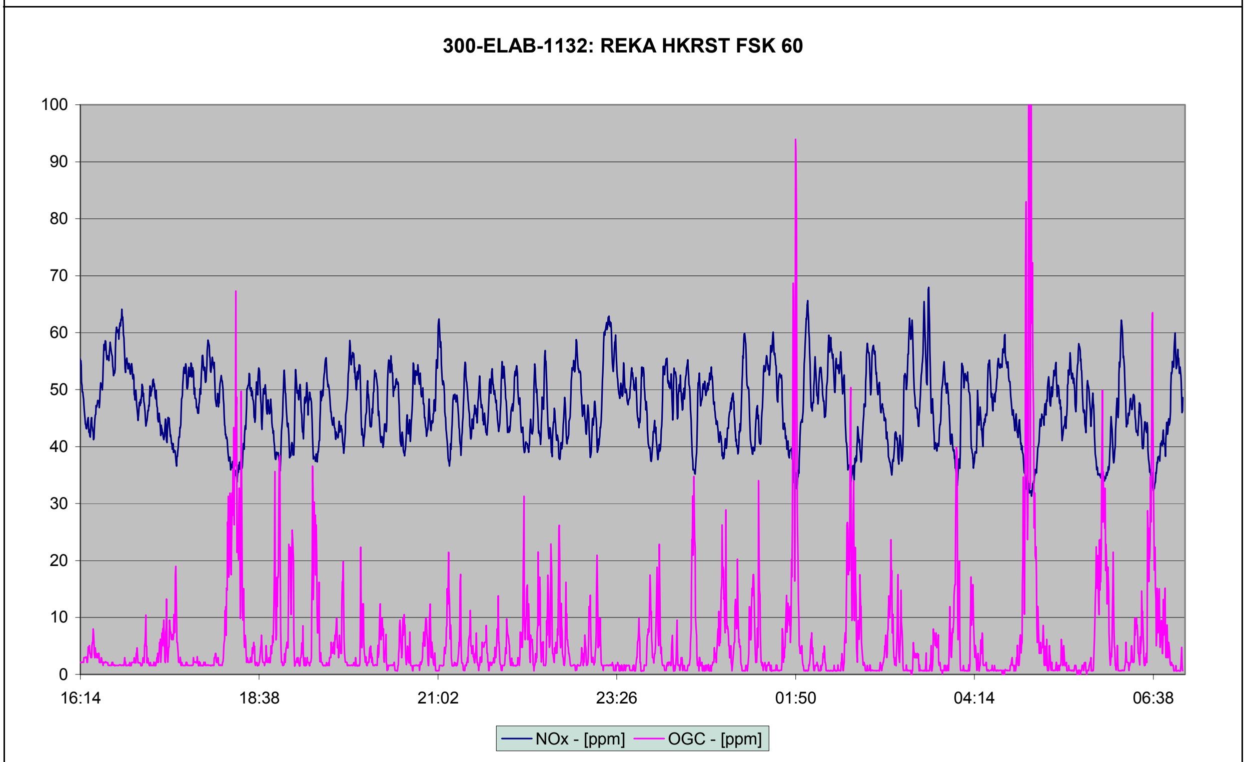
Measurement	Result	Requirement
Return temperature	59.96 °C	
Inlet temperature	77.04 °C	
Water flow	0.81 m^3/h	
Heat output	15.84 kW	
Test duration	14.83 h	
Fuel consumption	4.73 kg/h	
Water content	22.9 %	
Calorific value	13838 J/g	
Heat input	18.20 kW	
Efficiency	87.0 %	(Class 3) 82 (Austria)
Ambient temperature	26 °C	
Flue gas temperature	75 °C	
Chimney draught	7 Pa	36 (Max.)
Flue gas volume flow	49.0 m^3/h	
Flue gas mass flow	49.3 kg/h	
CO_2	9.9 $\%_{vol}$	
CO measured	0.0850 $\%_{vol}$	
CO at 10% O_2	0.0904 $\%_{vol}$	
CO at 10% O_2	1130 mg/m_n^3	2500 (Class 3)
CO at 13% O_2	0.8216 g/m_n^3	2 (Germany)
CO at 13% O_2	822 mg/m_n^3	4000 (Switzerland)
CO emission	557 mg/MJ	750 (Austria)
NO_x (NO_2) at 10% O_2	0.0050 $\%_{vol}$	
NO_x (NO_2) at 10% O_2	102 mg/m_n^3	
NO_x emission (NO_2)	50 mg/MJ	150 (Austria)
OGC (CH_4) at 10% O_2	0.0007 $\%_{vol}$	
OGC (C) at 10% O_2	4 mg/m_n^3	80 (Class 3)
OGC emission (C)	2 mg/MJ	40 (Austria)

All emission values are stated on the basis of dry flue gas.


300-ELAB-1132: REKA HKRST FSK 60
100
90
80
70
60
50
40
30
20
10
0
16:14
18:38
21:02
23:26
01:50
04:14
06:38
Ambient - [°C]
Return - [°C]
Flow - [°C]
Flue gas - [°C]


300-ELAB-1132: REKA HKRST FSK 60
20
18
16
14
12
10
8
6
4
2
0
16:14
18:38
21:02
23:26
01:50
04:14
06:38
Draught - [Pa]
Output - [kW]


300-ELAB-1132: REKA HKRST FSK 60
%vol
ppm
12
10
8
6
4
2
0
4800
4000
3200
2400
1600
800
0
16:14
18:38
21:02
23:26
01:50
04:14
06:38
CO2 - [%]
CO [ppm]


300-ELAB-1132: REKA HKRST FSK 60
100
90
80
70
60
50
40
30
20
10
0
16:14
18:38
21:02
23:26
01:50
04:14
06:38
NOx - [ppm]
OGC - [ppm]

Subject: FW: Econoburn Wood Gasification Boiler - Inquiry
Date: Thursday, August 19, 2010 2:03 PM
From: David Augustine <daugustine@tssconsultants.com>
To: Frederick Tornatore <fatoxic@tssconsultants.com>

Here is the information on a wood-fired boiler.

From: Tammy Wahl [mailto:twahl@dunkirkmetalproducts.com]
Sent: Thursday, August 19, 2010 12:57 PM
To: David Augustine
Subject: Econoburn Wood Gasification Boiler - Inquiry

Dear David,

It was a pleasure speaking with you today regarding the ski resort project that you are working on, thank you for your inquiry regarding Econoburn – the best built, most efficient wood-fired boiler on the market! An Econoburn boiler can save your customer hundreds or even thousands of dollars. To get you started, I have attached an informational brochure, trade price list along with an Econoburn specifications sheet.

Current testing data with 30% moisture content wood:

Wood Moisture Content	30%	(15% to 22% is ideal)
Stack temp F	346 deg F	
Oxygen	10.50%	
Co2	9.98%	
CO (PPM) Range	300 to 5000 depending upon where we are at the burn cycle	
NOX (PPM)	54%	
Efficiency	84% to 87%	
CO2-IR	9.51%	
Hpa absolute pressure	986.1	

Please do not hesitate to call and speak with our Engineer/Tech Support Manager, Dale Furman should you have any additional technical questions our toll-free number is 866-818-5162 or Mobile 716-785-2873.

Econoburn boilers are *amazingly* efficient. Indeed, Econoburn's gasification process produces **combustion efficiencies of over 93%!** What's more, since Econoburn operates so efficiently, it produces very little soot or creosote.

Econoburn boilers are built to last a lifetime. We use π" ASME grade steel throughout the boiler – our competitors use only 1/8” steel in the outer jacket. Plus, we double weld and double test all the boiler seams. We are so confident in the quality of our boilers, **we back each Econoburn with a 25-year warranty** on the pressure vessel and a 5-year bumper-to-bumper warranty – the best warranty anywhere!

Since there is not yet an authorized Econoburn dealer in your area, we will be happy to work with you directly. A local heating professional will be able to perform the necessary heatloss calculation and install your boiler (we provide a detailed installation manual with every boiler).

If you have any questions please or need any additional information do not hesitate to contact me. Our toll-free number is 866-818-5162. I will be happy to assist you in any way possible.

Thank you again for your inquiry, and I look forward to continuing our conversation soon.

Warm Regards,
Tammy Wahl, Sales

Econoburn
2 Central Avenue
Brocton, NY 14716
716-792-2095 office
716-792-2098 fax