Job Number: 203.1
May 19, 2015

Angie Lottes
The Watershed Research and Training Center
PO Box 356
Hayfork, CA 96041

Subject: Biomass Equipment Upgrade Pre-Feasibility Study

Dear Angie;

Thank you and the SWET Program for funding the pre-feasibility study for the Almquist Lumber Company's biomass-fueled, hydronic heating system upgrade. Our findings and recommendations are included in this report letter.

Background

Almquist Lumber Company is located on Boyd Road, near the intersection of Highway 299 and Giuntoli Lane, in Arcata, California. The retail store was built, in 2005 and is equipped with a hydronic heating system that heats the concrete floor in the retail space and the base board heaters in the offices and bathrooms. It also feeds fan coils in an air handling system that blows conditioned air into the retail space. The system utilizes a wood-fired boiler fed with woodwaste generated from the onsite sawmill and firewood operation. The owner is not satisfied with the performance of the system as it does not provide adequate heat to the facility and is smokey.

The goal of this Pre-Feasibility Study is to determine if the woodstove/boiler is properly sized to satisfy the heating demand of the building and if sufficient woodwaste (fuel) is available to generate the required heat.

Fuel Characterization

The woodwaste biomass available from the Almquist Lumber Company facility is generated by the onsite sawmill and the firewood operation. The sawmill manufactures dimensional lumber from raw logs and larger dimensional timbers. It generates approximately 3 cyds/day of woodwaste (0.63 cords/day) 5 days per week. The woodwaste stream consists of strips of wood and bark of varying dimensions cut up into smaller pieces that can be fed into the woodstove. It is comprised mainly of soft woods such as redwood and fir but contains some mixed hardwoods such as tan oak, bay, and alder. The sawdust is captured separately and sold or composted.

The firewood operation generates an average of 1 cy/day (0.21 cords/day) 5 days per week of chainsaw cuttings, bark pieces, and small chunks wood. It is comprised of a similar mix of softwood and hardwood. Approximately 0.84 cords/day of woodwaste are available 5 days/week, or $\pm$ 200 cords/yr.

Douglas fir and redwood contains between 20 and 25 million BTUs (MBTU)/cord of seasoned wood (< 20% moisture). The BTU content of the oak is between 25 and 30 MBTU/cord of seasoned wood. The woodwaste is not seasoned "cord wood" but closer to wet hog fuel. Allowing for the higher moisture content, bark and saw dust, it is conservatively estimated that the energy content of the woodwaste stream is 20 MBTU/cord. There are approximately 16.8

MBTU/day (0.84 cords/day x 20 MBTU/cord) available, 5 days/week from the woodwaste generated at the Almquist Lumber Company, or 0.7 MBTU/hr, or 4,368 MBTU/year.

The owner of the facility (Eric Almquist) also owns 440 acres of timberland in the Kneeland area of the Mad River watershed. It is a young, second growth hardwood and conifer, mixed species forest. He has a Nonindustrial Timber Management Plan that includes harvest of timber as well as firewood. He has completed a number of fuel reduction/fire safety thinning projects that have produced large slash piles and lots of tan oak, bay, madrone, and alder firewood. He could produce between 3 and 5 cords/day or 840 to 1,400 cords/year, or 16,800 to 28,000 MBTU/yr.

Hydronic Heating System and Wood-Fired Boiler

What is the heating demand of the retail store and office space? The heating demand specified in the design of the building was 10 BTU/hr/sf. A hydronic system was designed for the 10,300 sf of combined retail and office spaces using warm floors, baseboard heaters and fan coils with air handlers. The total design heating load specified in the construction documents was 103,000 BTU/hr. Hydronic heating systems, especially concrete warm floors are meant to be operated on a continuous basis. Assuming that, during the heating season, the system would be operated 24 hr/day; 2.47 MBTU/day would be required to be delivered to the conditioned space.

How many BTUs will have to be delivered to the hydronic system to provide the required heat to the conditioned space? Hydronic heating systems are fairly efficient at transferring heat to the conditioned space. Assuming a 90% transfer efficiency (10% loss), approximately 114,000 BTU/hr (103,000 / 0.9) would have to be delivered to the hydronic system from the wood stove.

Can the woodstove deliver 114,000 BTU/hr? The heat source for the hydronic system is a wood-fired boiler (Taylor, Model T-750). The manufacturer's brochure that described the performance characteristics of the stove is included as Attachment 1. The rated output capacity is 165,000 BTU/hr (0.165 MBTU/hr) and it says that it can produce up to 0.5 MBTU/hr. The stove appears to be capable of delivering sufficient BTUs.

Are sufficient BTUs available in the woodwaste stream to generate the 165,000 BTU/hr rated output? The efficiency of the T-750 is unknown but many of the wood-fired boilers on the market today claim efficiencies (BTUs transferred to the water / BTUs in the fuel) of up to 90%. Assume the T-750 is 90% efficient. An output of 165,000 BTU/hr will require a fuel input of 183,000 BTU/hr (165,000 / 0.9). Over a 24 hour period, 4.4 MBTU/day of fuel would be required. Approximately 16.8 MBTU/day of fuel is available in Almquist's woodwaste stream. Therefore; is appears that there is sufficient fuel to provide for the rated output.

Even though there is sufficient fuel available and the T-750 appears to be able to meet the required BTU output; the system does not perform as designed. The retail space and offices are cold and the fan coils blow cold air into the store. Furthermore; the woodstove produces a lot of smoke and creosote builds up in the exhaust stack and the flue tubes inside the heat exchanger. The system performs marginally better if it is continuously stoked and tended. *So, what is causing the poor system performance?*

In consultation with the manufacturer, we found that they did not think that the T-750 wasnot large enough for 10,300 sf of commercial space. The T-750 is typically used in residential applications of 4,500 sf or less. Heating requirements for residential space is typically between 35 and 45 BTU/sf/hr. The T-750 seems to be appropriately sized for a 3,500 to 4,500 sf house.

Online sources show a range of 10 and 20 BTU/sf/hr for heating commercial spaces. The 10,300 sf of retail space is housed inside of a metal building with a concrete floor, a 22' high ceiling and a copula (peak elevation 30'). The store's retail space is typically open to the lumber warehouse (unconditioned space) through a 20' wide rollup metal door. During the heating season a plastic hanging curtain is installed to reduce air infiltration. The stove is not run 24 hours per day so the building cools down at night and takes a long time to heat up in the morning. The space could probably use 30 BTU/sf/hr to get up to temperature quicker and 20 BTU/sf/hr to maintain a comfortable temperature. For the purpose of this evaluation, assume 20 BTU/sf/hr (206,000 BTU/hr) is required by the retail and office space.

The manufacturer's literature claims that the stove's maximum output is 0.5 MBTU/hr. Assuming a hydronic system efficiency of 90%; 500,000 BTU/hr input would deliver 450,000 BTU/hr to the conditioned space. Assuming a 90% efficiency conversion of fuel to heated water; 0.55 MBTU/hr of fuel would be needed. Almquist can deliver 0.7 MBTU/hr. It appears that the T-750 could provide the required heat if it was run closer to its maximum capacity and that there is sufficient wood available.

The stove has a temperature-controlled fan and damper that regulates the burn and attempts to maintain the temperature of the output water at 180° F. Higher heating demands from the conditioned space causes the damper to open and the fan to turn on. The wood burns faster, releasing the stored BTUs over a shorter time period. To push the T-750 to its maximum output rating, the thermostat may need to be turned up and the stove stoked more often.

The T-750 has a water jacket that holds 565 gallons. The design drawings and the manufacturer's recommendations include an external tank and heat exchanger that allows for the storage of additional hot water which helps to reduce short cycling of the damper and pump controls. An inspection of the system revealed that the hot water auxiliary storage tank was not installed.

The distribution side of the system includes four hot water distribution pumps, six heating zones, 21 heating loops, two control panels, a number of baseboard heaters and two large fan coils with air handling units. Hot water is pumped through a series of pipes in the concrete floor of the building, in the baseboard heaters and in the fan coils. An inspection of the system revealed that the fan coils had been short-circuited (supply connected to return before the fan coils) and the thermostat controlling the fan coils could not be located. It is assumed that he owner short-circuited the fan coil loop in an attempt to improve the system performance by limiting the circulation of hot water to the concrete floor. The long pipe runs to the fan coils are insulated with 1.5" AP Armaflex pipe insulation. The baseboard heating loop for the office space appears to still be intact but the owner says they do not run it because it is never hot enough. If the stove is supplying the required temperatures to the systems, the problem could be in the mixing valves or the circulation pumps in the base board system.

Energy Use and Demand Assessment

The heating system does not include flow monitoring equipment. There are no records of the thermal energy generated by the woodstove or delivered to the retail and office spaces. Nor is there a record of fuel usage. The temperate climate in Arcata and poor system performance has led to reduced reliance on the hydronic heating system. In recent years much of the office space has been heated with under desk electric heaters and the employees wear warmer clothing during the cold season.

A number of assumptions were made in developing a theoretical estimate of the annual thermal energy used in the store. It is assumed that the building requires 20 BTU/hr/sf. The following heating schedule is assumed; 24 hr/day for 4 months (heating season), 12 hr/day for 4 months (temperate season) and zero hr/day for 4 months (warm season), for a total of 4,380 hours of operation. At 20 BTU/hr/sf; the 10,300 sf of space would require 206,000 BTU/hr for 4,380 hours. The annual heating load for the building is estimated to be 906 MBTU. It could be significantly lower than this.

Electricity use on site is recorded by two separate meters. The PG&E report showing the last two years of monthly kilowatt hour use and demand on each meter is given in Attachment 2. The total net electrical usage is approximately 80,000 kWh/year. Figure 1 shows the billed electric use for the NEM and A10 meters, and the combined electric use. The NEM meter is back fed by a 25 kW photovoltaic system. Solar PV electricity production is not displayed in the Figure 1, as the logged data has not been provided.

Figure 2, shows the monthly peak kW demand billed at the site (53kW, max). This value is charged separately from the kWh use, and represents the largest instantaneous electricity demand at the facility in any 15 minute period during the billing period. Figure 3 is the estimated electricity cost separated by demand and use billing.

A combined heating and power (CHP) system was considered for use in meeting the electrical and heating demands of the Almquist Lumber Company retail store and sawmill. Increasing the size of the existing PV system and possibly upgrading the wood stove was also considered.

CHP system sizing was controlled by the electrical demand, not the heating load. It was determined that approximately 40 kW of onsite generation will offset the remaining electrical use and the majority of electric demand charge. The assumed operation time for this calculation was 2,000 hours per year (running 8 hrs/day, 50 weeks/yr). According to the literature reviewed for CHP systems, approximately 1.15 kg of biomass is required to generate 1 kWh of electricity. This converts to approximately 1,600 kWh/cord for wet Douglas fir (4,200 lbs/cord). The CHP system would require approximately 50 cords/yr of woodwaste to generate 80,000 kWh. Approximately 200 cords/yr of woodwaste are available at the site.

Adding between 70 and 100 kW of capacity to the existing PV system would be sufficient to completely offset the existing electrical demand. This would not satisfy the heating demand. The wood stove may need to be replaced depending on the results of retro commissioning.

Equipment Review

Wood-fired boilers and gasification-based CHP systems were reviewed. The owner requested that only EPA Phase 2 qualified be considered. A list of EPA-qualified systems and their specifications are given in Attachment 3. Four wood stove equipment manufacturers were identified as appropriate for the equipment change out based on their design specifications and EPA regulations;

- Central Boiler, E-Classic 3200
- SteelTech, Heatmaster G400
- Greentech, RS7400-E
- Alternate Heating Systems, Wood Gun E-Series

EPA qualified units are limited in their BTU/hr capacity. It is estimated that at least two of the above referenced wood-fired boilers would be needed in order to meet the building's heating demand. Larger units are available from these same manufacturers. However, units over 500,000 BTU/hr maximum output rating are not EPA qualified. The existing T-750 should be retro-commissioned and tested to see if the output could be pushed to its maximum rated capacity of 500,000 BTU/hr.

Two manufacturers of CHP systems were also reviewed;

- All Power Labs, Power Cube PC-20
- Spanner, HK 45

Two wood-fire CHP units (All-Power Labs PC-20, 20kW each) would satisfy the electric demand and produce approximately 200,000 BTU/hr of "waste" heat. The run time would not satisfy the heating schedule, estimated at 4,380 hours. This rough estimate could be refined to more accurately size a unit (or units) that would satisfy both demands.

The owner abandoned the CHP concept for a number of reasons including the upfront capital cost (Attachment 3) and the ongoing wages for an employee that would be required to operate and maintain the system. In addition, the simplicity and relatively low cost of adding to the existing solar PV system weighed heavily in the decision. The owner may opt to upgrade the wood-fire boiler and again attempt to meet the heating demand by burning biomass.

Conclusions and Recommendations:

We conclude that:

1. The heating demand for the building was underestimated in the original design.
2. The Taylor T-750 is undersized for the actual heating demand of the store. It might be made to work if the output capacity was pushed closer to the rated maximum capacity of 500,000 BTU/hr and the hydronic system was retro-commissioned to confirm its functionality.
3. One EPA-qualified, wood-fired boiler (generally < 300 BTU/hr output rating) could possibly meet the heating demands of the building. Two may be required depending on the actual output of the stoves and the functionality of the hydronic system.
4. A CHP system with an electrical output capacity of approximately 40 kW would be required to offset the existing electrical demand of the facility.
5. The woodwaste stream generated by the sawmill and firewood operations and available from the owner's Kneeland timberland is more than adequate to fuel the hydronic heating system and/or a CHP system.
6. The woodwaste stream is not optimal for the T-750. Most of the stoves specify seasoned cord wood as their fuel. The addition of fines (such as sawdust and chips) can interfere with efficient combustion. Also, fuels with high moisture content will not deliver the anticipated BTUs and will generate more creosote than seasoned wood.

We recommend that the Owner:

1. Dry out the woodwaste prior to burning it to produce a better fuel.

2. Retro-commission the entire heating system. This would include:
    - doing an extended test burn and try to push the output to 500,000 BTU/hr,
    - testing the thermostatically controlled fan and damper operations,
    - monitoring the flow and temperature of the water throughout the system,
    - monitoring the temperature of the components in various parts of the system,
    - testing all controls, set points and pumps.

If the performance of the wood stove and the hydronic heating system can be verified, we further recommend that the Owner:

1. Install the 750-gallon auxiliary storage tank as per the original plans.
2. Reconnect the fan coil loop and possibly replumb the air handler ducting to draw return air from the peak of the retail store space and not from outside.

To satisfy the electrical demand of the facility, we recommend:

1. Installation of an additional 70-100 kW of photovoltaic panels at the facility, or
2. Install a 20 to 40 kW CHP and run it 16 to 8 hours/day (respectively).

Sincerely,

Steve Salzman, P.E.
Principal, Greenway Partners

Attachment 1: Manufacture's Literature for the T-750 Wood-Fired Boiler
Attachment 2: PGE meter records
Attachment 3: Models and Specifications for Wood-Fired Boilers and CHP Units

ATTACHMENT 1

Taylor Water Stove Data Sheets

ATTACHMENT 2

Electricity Use

Figure 1: Almquist Lumber Electricity Use

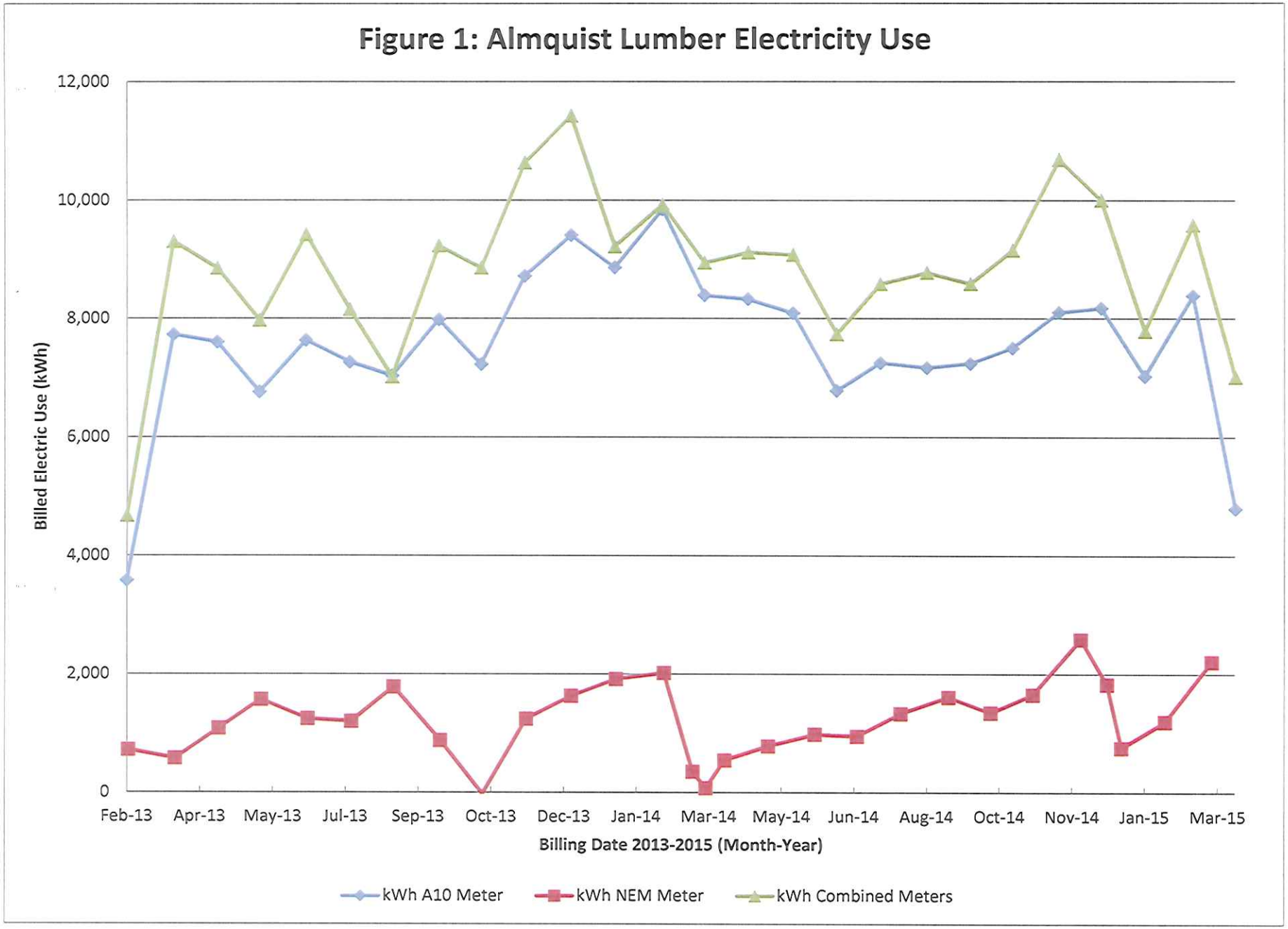


Figure 2: Almquist Lumber Electricity Demand

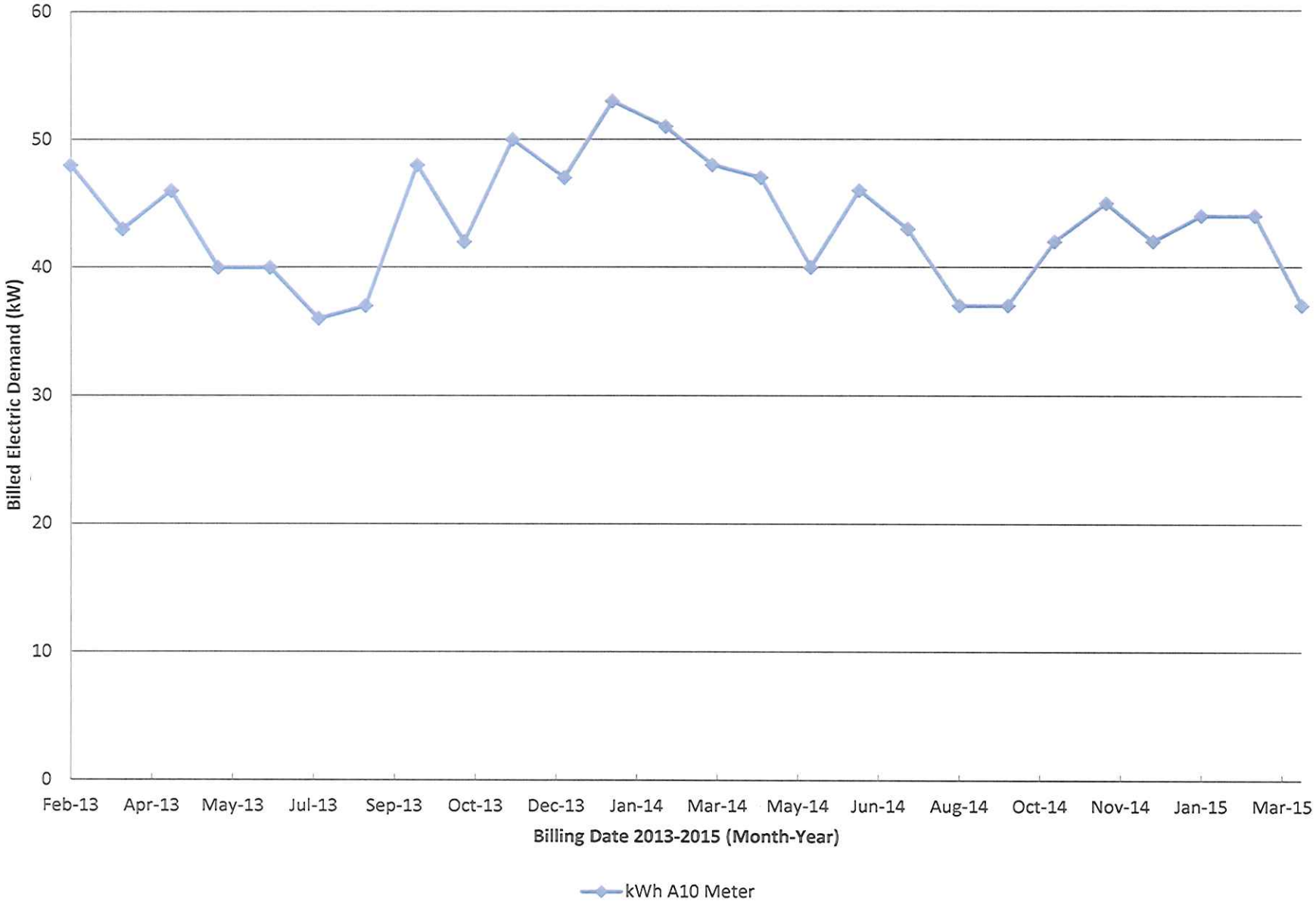
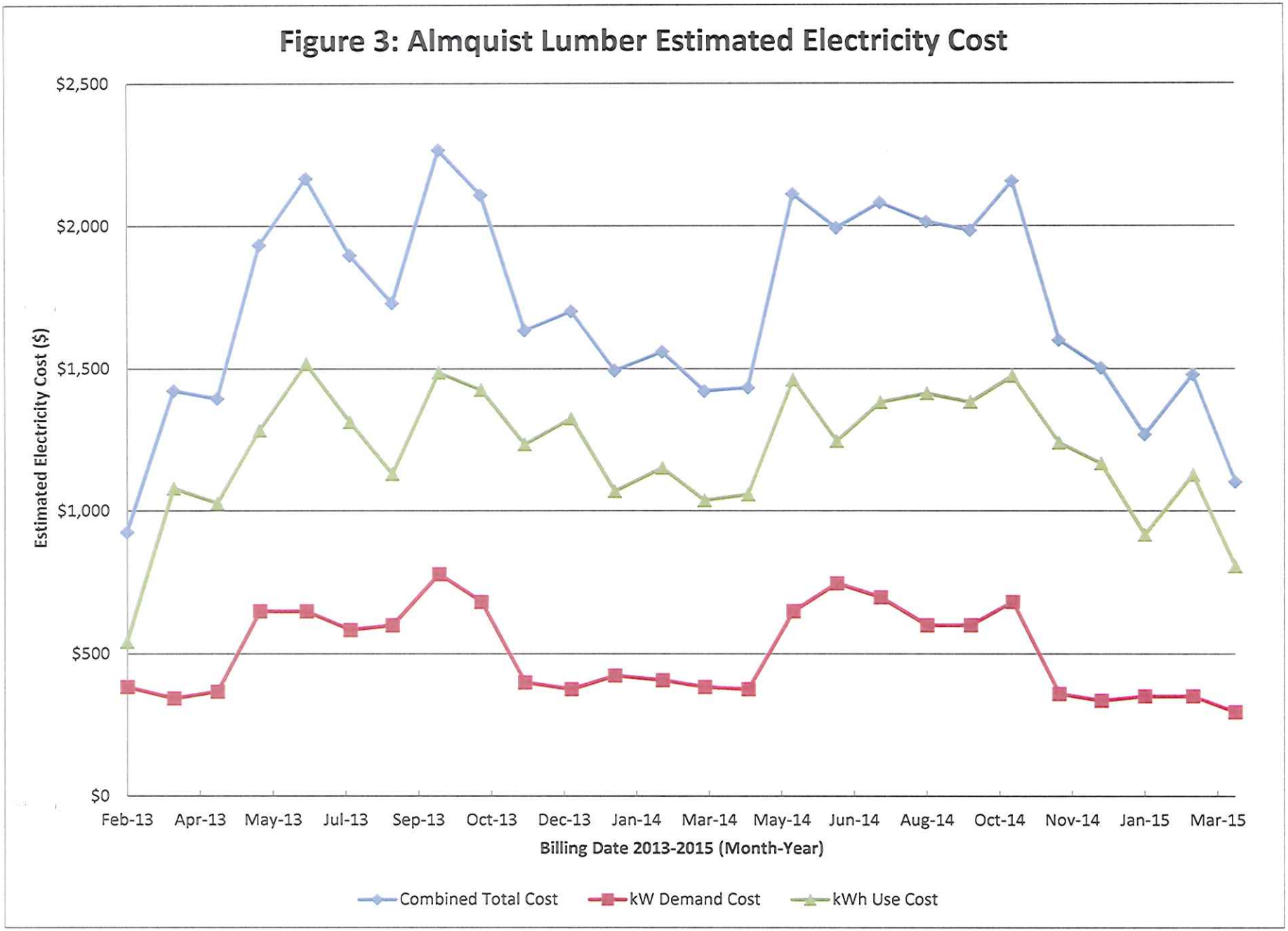


Figure 3: Almquist Lumber Estimated Electricity Cost



Prowood INC (NBY / 8178911)

SA Id: 3983941136 **Open: Y** Bus Act Desc: LUMBER STORE Svc Descriptor: **From Jan 1, 2012 to Mar 27, 2015**

Per Name: PROWOOD INC
Acct Id: 3983941777
Meter #: 1009510011
Billing Addr: 5301 BOYD RD, ARCATA, CA 95521
Service Addr: 5303 BOYD RD, ARCATA, CA 95521

Date	Days	Rate	Gas Charges (Dollars)	Therms	Electric Charges (Dollars)	On-Peak Usage (kwh)	Part-Peak Usage (kwh)	Off-Peak Usage (kwh)	Total Usage (kwh)	Hours	Billing Demand (kW)	Created Demand (kW)	On-Peak Demand (kW)	Part-Peak Demand (kW)	Off-Peak Demand (kW)	Taxes
03/18/2015	29	HA10SX			974.36	0	2,833	1,972	4,805	130	37	37	0	37	32	1.39
02/17/2015	33	HA10SX			1,468.40	0	5,067	3,320	8,387	191	44	44	0	44	29	2.43
01/15/2015	30	HA10SX			1,259.89	0	4,165	2,860	7,025	160	44	44	0	44	29	2.04
Total for 2015:			0.00	0	3,702.65	0	12,065	8,152	20,217	480						5.86
12/16/2014	29	HA10SX			1,404.92	0	4,819	3,359	8,177	195	42	42	0	42	36	2.37
11/17/2014	32	HA10S			1,743.22	0	0	0	8,104	180	45	45	0	0	0	2.35
10/16/2014	29	HA10S			1,895.03	0	0	0	7,502	179	42	42	0	0	0	2.18
09/17/2014	30	HA10S			1,791.47	0	0	0	7,242	196	37	37	0	0	0	2.10
08/18/2014	32	HA10S			1,784.25	0	0	0	7,170	194	37	37	0	0	0	2.08
07/17/2014	30	HA10S			1,882.02	0	0	0	7,253	169	43	43	0	0	0	2.10
06/17/2014	30	HA10S			1,847.68	0	0	0	6,783	147	46	46	0	0	0	1.97
05/18/2014	31	HA10S			1,691.90	0	0	0	8,094	202	40	40	0	0	0	2.35
04/17/2014	30	HA10S			1,367.96	0	0	0	8,332	177	47	47	0	0	0	2.42
03/18/2014	29	HA10S			1,366.54	0	0	0	8,396	175	48	48	0	0	0	2.44
02/17/2014	33	HA10S			1,561.33	0	0	0	9,850	193	51	51	0	0	0	2.86
01/15/2014	30	HA10S			1,419.52	0	0	0	8,863	167	53	53	0	0	0	2.57
Total for 2014:			0.00	0	19,755.84	0	4,819	3,359	95,766	2,174						27.79
12/16/2013	32	HA10S			1,457.49	0	0	0	9,410	200	47	47	0	0	0	2.73
11/14/2013	30	HA10S			1,740.24	0	0	0	8,721	174	50	50	0	0	0	2.53
10/15/2013	29	HA10S			1,711.16	0	0	0	7,229	172	42	42	0	0	0	2.10
09/16/2013	32	HA10S			1,935.04	0	0	0	7,985	166	48	48	0	0	0	2.32
08/15/2013	29	HA10S			1,621.51	0	0	0	7,038	190	37	37	0	0	0	2.04
07/17/2013	30	HA10S			1,664.49	0	0	0	7,268	202	36	36	0	0	0	2.11
06/17/2013	32	HA10S			1,786.94	0	0	0	7,639	191	40	40	0	0	0	2.22
05/16/2013	29	HA10S			1,375.41	0	0	0	6,767	169	40	40	0	0	0	1.96
04/17/2013	30	HA10S			1,200.78	0	0	0	7,608	165	46	46	0	0	0	2.21
03/18/2013	32	HA10S			1,205.28	0	0	0	7,733	180	43	43	0	0	0	2.24
02/14/2013	13	HA10S			555.69	0	0	0	3,587	75	48	48	0	0	0	1.04
Total for 2013:			0.00	0	16,254.03	0	0	0	80,985	1,885						23.50
Total for SA id: 3983941136:			0.00	0	39,712.52	0	16,883	11,511	196,968	4,539						57.15

[CONFIDENTIAL INFORMATION]

Prowood INC (NBY / 8178911)

SA Id: 5768906820 **Open: Y** Bus Act Desc: Svc Descriptor: OFFICE **From Jan 1, 2012 to Mar 27, 2015**

Per Name: PROWOOD INC
Acct Id: 5768906470
Meter #: 1008873151
Billing Addr: 5303 BOYD RD # C. ARCATA, CA 95521
Service Addr: 5303 BOYD RD # C. ARCATA, CA 95521

Date	Days	Rate	Gas Charges (Dollars)	Therms	Electric Charges (Dollars)	On-Peak Usage (kwh)	Part-Peak Usage (kwh)	Off-Peak Usage (kwh)	Total Usage (kwh)	Hours	Billing Demand (kW)	Created Demand (kW)	On-Peak Demand (kW)	Part-Peak Demand (kW)	Off-Peak Demand (kW)	Taxes
03/02/2015	32	NEMS			10.52	0	0	0	2,208	0	0	0	0	0	0	0.00
01/29/2015	30	NEMS			9.86	0	0	0	1,198	0	0	0	0	0	0	0.00
Total for 2015:			0.00	0	20.38	0	0	0	3,406	0						0.00
12/30/2014	10	NEMS			3.29	0	0	0	759	0	0	0	0	0	0	0.00
12/20/2014	18	NEMS			5.91	0	0	0	1,826	0	0	0	0	0	0	0.00
12/02/2014	33	NEMS			10.84	0	0	0	2,585	0	0	0	0	0	0	0.00
10/30/2014	29	NEMS			2,878.81	0	0	0	1,653	0	0	0	0	0	0	4.42
10/01/2014	29	NEMS			9.53	0	0	0	1,349	0	0	0	0	0	0	0.00
09/02/2014	33	NEMS			10.84	0	0	0	1,611	0	0	0	0	0	0	0.00
07/31/2014	30	NEMS			9.86	0	0	0	1,335	0	0	0	0	0	0	0.00
07/01/2014	29	NEMS			9.53	0	0	0	954	0	0	0	0	0	0	0.00
06/02/2014	32	NEMS			10.51	0	0	0	987	0	0	0	0	0	0	0.00
05/01/2014	30	NEMS			9.86	0	0	0	788	0	0	0	0	0	0	0.00
04/01/2014	13	NEMS			4.27	0	0	0	551	0	0	0	0	0	0	0.00
03/19/2014	9	NEMS			2.96	0	0	0	76	0	0	0	0	0	0	0.00
03/10/2014	20	NEMS			13.14	0	0	0	356	0	0	0	0	0	0	0.00
02/18/2014	33	NEMS			21.68	0	0	0	2,016	0	0	0	0	0	0	0.00
01/16/2014	31	NEMS			20.37	0	0	0	1,917	0	0	0	0	0	0	0.00
Total for 2014:			0.00	0	3,021.40	0	0	0	18,763	0						4.42
12/16/2013	31	NEMS			20.37	0	0	0	1,631	0	0	0	0	0	0	0.00
11/15/2013	30	NEMS			2,324.06	0	0	0	1,248	0	0	0	0	0	0	3.70
10/16/2013	29	NEMS			19.05	0	0	0	-21	0	0	0	0	0	0	0.00
09/17/2013	32	NEMS			21.03	0	0	0	886	0	0	0	0	0	0	0.00
08/16/2013	29	NEMS			19.06	0	0	0	1,784	0	0	0	0	0	0	0.00
07/18/2013	30	NEMS			19.71	0	0	0	1,208	0	0	0	0	0	0	0.00
06/18/2013	32	NEMS			21.03	0	0	0	1,250	0	0	0	0	0	0	0.00
05/17/2013	29	NEMS			19.05	0	0	0	1,573	0	0	0	0	0	0	0.00
04/18/2013	30	NEMS			19.71	0	0	0	1,089	0	0	0	0	0	0	0.00
03/19/2013	32	NEMS			21.03	0	0	0	582	0	0	0	0	0	0	0.00
02/15/2013	30	NEMS			19.71	0	0	0	728	0	0	0	0	0	0	0.00
01/16/2013	30	NEMS			19.71	0	0	0	1,067	0	0	0	0	0	0	0.00
Total for 2013:			0.00	0	2,543.52	0	0	0	13,025	0						3.70
12/17/2012	33	NEMS			21.68	0	0	0	1,295	0	0	0	0	0	0	0.00
11/14/2012	30	NEMS			1,039.39	0	0	0	727	0	0	0	0	0	0	1.90

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Service Addr: 5303 BOYD RD # C, ARCATA, CA 95521

Date	Days	Rate	Gas Charges (Dollars)	Therms	Electric Charges (Dollars)	On-Peak Usage (kwh)	Part-Peak Usage (kwh)	Off-Peak Usage (kwh)	Total Usage (kwh)	Hours	Billing Demand (kW)	Created Demand (kW)	On-Peak Demand (kW)	Part-Peak Demand (kW)	Off-Peak Demand (kW)	Taxes
10/15/2012	28	NEMS			18.40	0	0	0	395	0	0	0	0	0	0	0.00
09/17/2012	32	NEMS			21.03	0	0	0	178	0	0	0	0	0	0	0.00
08/16/2012	29	NEMS			19.06	0	0	0	171	0	0	0	0	0	0	0.00
07/18/2012	30	NEMS			19.71	0	0	0	94	0	0	0	0	0	0	0.00
06/18/2012	32	NEMS			21.03	0	0	0	-225	0	0	0	0	0	0	0.00
05/17/2012	31	NEMS			20.37	0	0	0	188	0	0	0	0	0	0	0.00
04/16/2012	28	NEMS			18.40	0	0	0	877	0	0	0	0	0	0	0.00
03/19/2012	32	NEMS			21.02	0	0	0	1,657	0	0	0	0	0	0	0.00
02/16/2012	29	NEMS			19.06	0	0	0	391	0	0	0	0	0	0	0.00
01/18/2012	33	NEMS			18.48	0	0	0	1,126	0	0	0	0	0	0	0.00
Total for 2012:			0.00	0	1,257.63	0	0	0	6,874	0						1.90
Total for SA id: 5768906820:			0.00	0	6,842.93	0	0	0	42,068	0						10.02
Report Total:			0.00	0	46,555.45	0	16,883	11,511	239,036	4,539						67.17

[CONFIDENTIAL INFORMATION]

Pacific Gas and Electric Company

Bundled Commercial Rate Schedule A-10 Time-of-Use

Rates Effective:
March 1, 2015, to Present

Rate Schedule	Customer Charge	Optional Meter Data Access Charge	Season	Demand Charge (per kW)	Time-of-Use Period	Energy Charges (per kWh)	PDP[1] Charges	PDP[2] Credits DEMAND (per kW)	PDP[2] Credits ENERGY (per kWh)	"Average" Total Rate[3] (per kWh)
A-10 TOU Secondary (Table B) Customers with high electric use and medium to high load factors generally benefit under Schedule A-10 TOU. Part of customer's bill varies according to the customer's maximum monthly electric demand.	$4.59959 per meter per day	$0.98563 per meter per day	Summer	$16.23	Peak	$0.17891	$0.90	($2.89)	($0.00641)	$0.18515
					Part-Peak	$0.17087			($0.00641)	
					Off-Peak	$0.14642			($0.00641)	
			Winter	$8.00	Part-Peak	$0.12750		-	-	
					Off-Peak	$0.10654				
A-10 TOU Primary (Table B) Customers with high electric use and medium to high load factors generally benefit under Schedule A-10 TOU. Part of customer's bill varies according to the customer's maximum monthly electric demand.			Summer	$15.22	Peak	$0.16420	$0.90	($2.74)	($0.00608)	$0.17110
					Part-Peak	$0.15846			($0.00608)	
					Off-Peak	$0.13650			($0.00608)	
			Winter	$8.20	Part-Peak	$0.11949		-	-	
					Off-Peak	$0.10231				
A-10 TOU Transmission (Table B) Customers with high electric use and medium to high load factors generally benefit under Schedule A-10 TOU. Part of customer's bill varies according to the customer's maximum monthly electric demand.			Summer	$10.85	Peak	$0.13481	$0.90	($3.04)	($0.00344)	$0.14084
					Part-Peak	$0.12958			($0.00344)	
					Off-Peak	$0.10973			($0.00344)	
			Winter	$6.29	Part-Peak	$0.10392		-	-	
					Off-Peak	$0.08816				

A-10 (Table A) Customers with high electric use and medium to high load factors generally benefit under Schedule A-10. Part of a customer's bill varies according to the customer's maximum monthly electric demand.	$4.59959 per meter per day	$0.98563 per meter per day		Secondary	Primary	Transmission		Secondary	Primary	Transmission				
			Summer	$16.23	$15.22	$10.85		$0.16116	$0.14936	$0.12137	-	-	-	$0.18503
			Winter	$8.00	$8.20	$6.29		$0.11674	$0.11069	$0.09583	-	-	-	

[1]Peak Day Pricing (PDP) (Consecutive Day and Four-Hour Event Option). All Usage During PDP Event. See specific tariff for further details.

[2]Peak Day Pricing (PDP) (Consecutive Day and Four-Hour Event Option). See specific tariff for further details.

[3]Based on estimated forecast. Average rates provided only for general reference, and individual customer's average rate will depend on its applicable kW, kWh, and TOU data.

Summer Season (May-October):

Peak Hours: 12:00 noon to 6:00 pm, Monday-Friday (except holidays)

Partial-Peak Hours: 8:30 am to 12:00 noon AND 6:00 pm to 9:30 pm, Monday-Friday (except holidays)

Off-Peak Hours: 9:30 pm to 8:30 am, Monday-Friday; All day Saturday, Sunday and holidays

Winter Season (November-April):

Partial-Peak Hours: 8:30 am to 9:30 pm, Monday-Friday (except holidays)

Off-Peak Hours: 9:30 pm to 8:30 am, Monday-Friday (except holidays); All day Saturday, Sunday and holidays

This table provided for comparative purposes only. See current tariffs for full information regarding rates, application, eligibility and additional options.

ATTACHMENT 3

EPA Approved Equipment, Specifications, and Quotes

GSERIES

HeatMaster G Series is the most efficient wood furnace we offer. It's an entirely new way to burn wood that [illegible] 50% [illegible]

	G100	G200	G400
Firebox (W" x L" x H")	18 x 18 x 31	28 x 29 x 34	28 x 40 x 39
Water Capacity (US Gallons)	100	195	250
Approximate BTU's	120,000	210,000	350,000
Dimensions (W" x L" x H")	36 x 56 x 74	48 x 72 x 79	51 x 84 x 86

The cleanest, most efficient, easy to use design on the market today

Crafted with premium workmanship and innovative design, our G Series furnaces work with any existing heating system and follow the Heatmaster[SS] standard.

Features include:

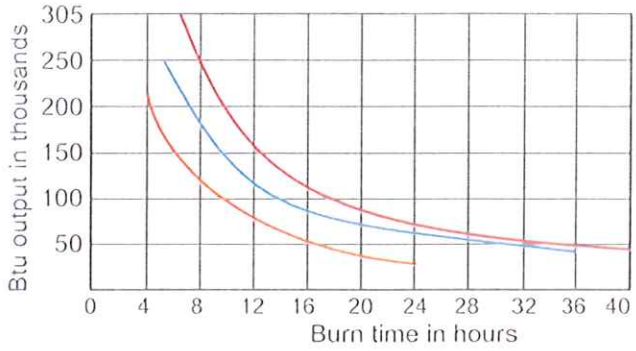
- **EPA Phase 2 Qualified**
- **Approved for Indoor and Outdoor installation**
- **Smoke By-pass**
  Stay clean and smoke free when loading your furnace.
- **Easy Access Rear Door**
  The insulated rear door is built for quick removal and easy access to the rear of the furnace and plumbing.
- **Clean, Maintenance-free Design**
  No brushing tubes, scraping creosote or shovelling ash. Load and clean your furnace in 5 minutes!
- **Heatmaster[SS] Warranty**
  We stand behind every furnace we sell with a Lifetime Limited Workmanship and Corrosion Warranty.
- **Safe Easy-To-Use Dual Firebox Door Latch**
  For your added protection and safety
- **Heavy Duty Multi-layer Insulation**
- **Powder Coat Finish**

E-Classic 3200 Ignition Ready

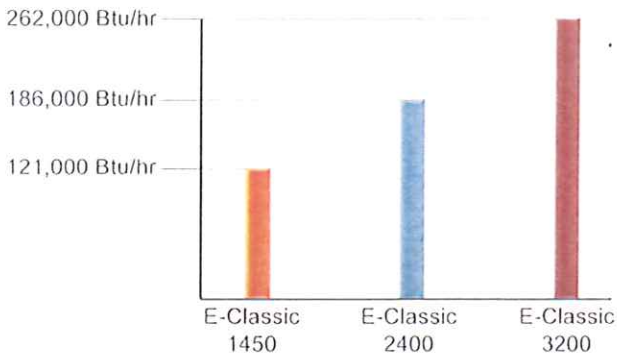
Door	22.5" W x 28.5" H
Firebox	40" L x 48" H x 30" W
Weight	3,240 lbs.
Water Capacity	410 Gallons
3/4" Supply/Return Ports	2 each
1-1/4" Supply/Return Ports	1 each
8-Hr Output Rating	262,000 Btu/hr*
12-Hr Output Rating	175,000 Btu/hr
Manufacturer's Rated Heat Output Capacity	306,000 Btu/hr*

*Based on EPA qualifying test.

How Btu Output Affects Burn Time



8-Hour Output Rating



Based on EPA output ratings. Actual Btu output and burn time will be affected by the type of wood burned, its moisture content and other factors.

VESTA Award Wood Products Category

This award honors innovation in design and technology. The E-Classic 2400 was awarded the Vesta award based on features such as the three-stage innovative combustion technology, FireStar electronic controller, Power Ignition and eco-friendly LED lights. The E-Classic 2400's award-winning performance includes its extremely low emissions and 250,000 Btu/hr rating.

Specifications

MODELS	RS 7200	RS 7300	RS 7400	RS 7500
Estimated Weight	1250	1500	2140	3230
Width	53"	53"	65"	83"
Length	55"	68"	83"	85"
Height	74"	74"	86"	101"
Max Firewood Length	32"	44"	56"	60"
Chimney Size	6"	6"	8"	10"
Door Size	20" x 20"	20" x 20"	24" x 24"	32" x 42"
Supply Size	2-1 1/4	2-1 1/4	2-1 1/4	4-1 1/4
Return Size	2-1 1/4	2-1 1/4	2-1 1/4	4-1 1/4
Water Capacity Appox	150 gals	200 gals	380 gals	620 gals
Fan Capacity	150 cfm	150 cfm	150 cfm	300 cfm
Turbo Draft B	100 cfm	100 cfm	100 cfm	100 cfm
Approximate Sq. Ft	2000 - 3000	4000 - 5000	8000 - 10,000	18,000 - 20,000
Approximate BTU's	165,000	240,000	365,000	500,000
Insulation: Walls	R 30	R 30	R 30	R 30
Insulation: Roof	R 40	R 40	R 40	R 40
Type 409 Stainless	Yes	Yes	Yes	Yes
Domestic Coil 250,000 BTU	Optional	Optional	Optional	Optional
Boiler Coil 500,000 BTU	Optional	Optional	Optional	Optional

Note: BTU's vary with the type of wood burned.

Your Official Local Dealer

Greentech Manufacturing Inc.

2716 Crescent Dr., International Falls, MN 56649

Toll Free: *(866) 361-7355*

Phone: *(218) 283-3416*

Fax: *(218) 283-5786*

www.crownroyalstoves.com

Wood Gun™ E Series Specifications

	E100	E140	E180	E250
BTU/Hour Max	150,000	200,000	230,000	350,000
BTU 8 Hour Avg Output*	100,000	140,000	180,000	250,000
Water Capacity	60 gallons	80 gallons	90 gallons	140 gallons
Fire Box Capacity	6.5 ft^3	10 ft^3	14 ft^3	22 ft^3
Fire Box Length	28"	32"	32"	48"
Standard Door Opening	14" x 14"	14" x 14"	14" x 14"	14" x 14"
Height	58"	64"	66"	74"
Width (cyclone removed)	26"	26"	31"	31"
Depth	44"	48"	48"	66"
Flue Size	6"	6"	6"	8"
Weight (w/o gas/oil)	1,400 lbs	1,650 lbs	2,100 lbs	3,000 lbs
Typical Heating Capacity**	3,000 ft^2	4,000 ft^2	5,000 ft^2	9,000 ft^2

*Based on loading firebox with seasoned hardwood
**Subject to building design/construction
Specifications subject to change without notice

Optional Wood Gun™ Accessories

- Domestic hot water coil
- Draft cycle timer - extends reignition period for times of low demand
- Low water cutoff - safety shutdown if water level drops
- Low temperature shutdown - fan shutdown if fire goes out
- Smoke exhaust hood - 485 CFM
- Fuel oil backup package available with either manual or automatic switchover
- Canister pool heater - carbon steel or stainless steel
- ASME and UL Certified on request

Limited Warranty

Alternate Heating Systems, Inc. boilers and furnaces are warranted against defects in materials and workmanship for the following periods:

- Boiler Vessel - 20 years
- All other components both manufactured by Alternate Heating Systems, Inc. and purchased from vendors will vary in length of warranty from 30 days to 1 year.

A copy of the complete warranty text, detailing coverage, limitations, warranty claim procedure and state law rights is available from Alternate Heating Systems, Inc.

ASME Certification

The American Society of Mechanical Engineers (www.asme.org) certification is available on any of our boiler lines for an additional charge. This certification assures that the pressure vessel has been designed and constructed in accordance with the ASME Code. This certification is required for all commercial installations. The certification is also required for some residential installations depending upon local codes - it is up to the homeowner to determine the need for an ASME certification on any boiler purchased.

UL Certification

UL certification is also available on all Wood Gun boilers for an additional charge. This certification assures that the boiler complies to UL 2523 Standards. Some insurance companies may require this certification and it is the responsibility of the homeowner to determine the need for a UL certification on any boiler purchased.

Alternate Heating

(717) 987-0099

www.woodgun.com

Alternate Heating Systems manufactures alternative fuel burning heating equipment and sells (primarily direct) throughout the US, Canada, and internationally. Call us today to schedule a tour of our facilities, visit our showroom, and see a working demonstration of any boiler models.

Alternate Heating Systems, Inc.
2393 Little Egypt Rd
Harrisonville, PA 17228

Time is the best friend of Truth.

EPA United States Environmental Protection Agency

Burn Wise

Partners - Program Participation - List of Qualified Hydronic Heaters

Burn Wise

Subscribe to BurnWise

EPA's Phase 2 qualified level for hydronic heaters is 0.32 pounds of fine particles per million BTU of heat with a maximum individual test run of 18.0 grams per hour. You can find Phase 1 and Phase 2 models archived here.

A new column has been added titled "Annual Average Efficiency (percent, higher heating value)". This efficiency is the thermal efficiency (also termed delivered efficiency) of the model as calculated in EPA's Method 28 WHH, page 33, www.epa.gov/burnwise/pdfs/owhhphase2agreement.pdf. This efficiency represents the effectiveness of a hydronic heater to deliver the energy contained in a load of wood into the circulating water that heats your home. Hydronic heater thermal efficiencies typically range from 40% - 85%. Thermal efficiency and combustion efficiency are not the same. Combustion efficiency only tells you how much of the wood has burned and has no relationship to how much heat is transferred to your home.

Note about the use of higher heating value (HHV) and lower heating value (LHV) of wood when calculating the delivered efficiency. HHV is the measure of the energy content of a fuel that is most commonly used in North America (8600 Btu/lb). In Europe, the LHV is most commonly used (7988 BTU/lb). If the LHV is used, the efficiency rating of a hydronic heater would be higher than if the HHV is used. The difference is about 8 percentage points. For example, a hydronic heater which has an efficiency rating of 78% based on the LHV would have an efficiency rating close to 70% based on HHV.

"NA" in the efficiency column indicates the model was tested using EPA's previous Method and is not available.

Contact your state or local air quality agency for clarification on the type of wood-burning appliances that may legally be installed in your area.

Phase 2 Qualified White Tag Models*

Manufacturer	Model	Fuel Type	Max Heat Output Rating (BTU/hr)	8-hour Output Rating (BTU/hr)	Annual Average Efficiency (% HHV)	Annual Avg Emission Rate (grams/hr)	Annual Avg Emission Level (lbs/million BTU)
Central Boiler EXIT Disclaimer	Maxim M255 P; Maxim M255 PE	wood pellets; continuous feed	165,215		82	0.8	0.04
Woodmaster EXIT Disclaimer	Flex-Fuel 30 KW indoor/ outdoor	stick wood; batch load	117022		NA	1.5	0.04
Woodmaster EXIT Disclaimer	Flex-Fuel 30 KW indoor/ outdoor	wood pellets; continuous feed	110167		NA	1.3	0.04
Woodmaster EXIT Disclaimer	Flex-Fuel 60 KW indoor/ outdoor	stick wood; batch load	219831		NA	2.6	0.04
Heatmor EXIT Disclaimer	200 SSP	wood pellets; continuous feed	162793		69	1.1	0.07
SteelTech EXIT Disclaimer	Heatmaster G200-2	stick wood; batch load	232000	111315	75	1.7	0.07
SteelTech EXIT Disclaimer	G100	stick wood; batch load	110963		68	1.0	0.07
GARN EXIT Disclaimer	WHS-2000H WHS-2000V	cord wood; batch load	200000	150050	74	1.69	0.07
Polar Furnace EXIT Disclaimer	G3	stick wood; batch load	200645	142533	72	1.96	0.08
Central Boiler EXIT Disclaimer	E-Classic 3200	stick wood; batch load	305777	261506	NA	3.3	0.08
Woodmaster EXIT Disclaimer	Ultra 30	wood pellets	102716		59	1.56	0.09
Hargassner EXIT Disclaimer	WTH 100S	wood pellets; continuous	331832		76	3.9	0.10

		feed					
Woodmaster Exit Disclaimer	Mini Boiler	wood pellets; continuous feed	101577		65	1.36	0.11
Hawken Energy Exit Disclaimer	GX-10	stick wood; batch load	144870	76887	64	2.2	0.14
GARN Exit Disclaimer	WHS-1500H WHS-1500V	cord wood; batch load	177000	87179	65	2.88	0.14
LEI Products Exit Disclaimer	MBB-100	wood pellets; continuous feed	91300		NA	1.99	0.15
Woodmaster Exit Disclaimer	Flex-Fuel 60 KW indoor/ outdoor	wood pellets; continuous feed	179458		NA	2.3	0.16
Central Boiler Exit Disclaimer	E-Classic 1450	stick wood; batch load	214271	120529	78	4.7	0.18
Central Boiler Exit Disclaimer	E-Classic 3250 IR	stick wood; batch load	226196	244174	69	3.8	0.18
Mahoning Outdoor Furnace Exit Disclaimer	Sky Series V	stick wood; batch load	101420	82594	54	2.44	0.18
Polar Furnace Exit Disclaimer	G2	stick wood; batch load	182073	66897	67	3.53	0.19
Piney Exit Disclaimer	Enviro Chip 500	wood chips; continuous	280000		73	5.4	0.19
Webiomass	Woodpecker	wood pellets; continuous feed	153000		72	3.3	0.19
Nature's Comfort Exit Disclaimer	GT-6000	stick wood; batch load	266711	100959	73	5.7	0.22
Piney Exit Disclaimer	Optimizer 250	stick wood; batch load	178112	78252	NA	4.7	0.23
Greentech Exit Disclaimer	RS7400-E	stick wood; batch load	296192	116597	61	8.04	0.23
Steel Tech Exit Disclaimer	G400	stick wood; batch load	335010	180409	74	9.0	0.23
Pro-Fab Industries Exit Disclaimer	Empyre Elite 100 Empyre Elite XT100	stick wood; batch load	82968	48721	NA	2.5	0.24
Wood Boiler Exit Disclaimer	E4	stick wood; batch load	161455	77308	61	4.5	0.25
Marway Welding	Phase 2-200	stick wood; batch load	139576	65336	39	3.75	0.26
Hargassner Exit Disclaimer	WTH 100L/R	wood chips; continuous feed	331320		75	8.8	0.26
Steel Tech Exit Disclaimer	G200	stick wood; batch load	295285	80368	NA	5.6	0.27
Wood Boiler Exit Disclaimer	Blaze HE	stick wood	166109	60000	58	5.29	0.27
Heatmor Exit Disclaimer	400 4S	stick wood; batch load	376409	160599	76	10.7	0.28

ALL POWER LABS

Personal-Scale Power

POWER CUBE - PC20

RENEWABLE
AFFORDABLE
ON-DEMAND
POWER

The **Power Cube PC20** is a sensible solution to the critical global need for low-carbon energy, using agricultural and forestry waste materials to make on-demand renewable energy for a fraction of the cost of comparable diesel power.

APL's unique patented multi-stage gasification architecture, in combination with our innovative gasifier-engine thermal integration, our electronic control system and waste-heat recycling, gives the Power Cube unprecedented biomass fuel flexibility & efficiency; every 1.15 kg of biomass creates a kilowatt hour of power.

More than just electricity, the PC20 also has the option of an integrated Combined Heat and Power (CHP) module, providing up to 30 kW of thermal energy for heating and drying, with no drop in power production.

Quiet, compact and portable, the PC20 is easily transported to where the fuel is and where the power is needed. Its sleek stainless steel enclosure, sound insulation, emission controls and CE conformity allow for installation in almost any setting.

Proudly made in California, the Power Cube PC20 is now available at an affordable price.

SPECIFICATIONS		PC20	PC20 CHP
Maximum Continuous Power Output [1]		50 Hz = 15 kW 60 Hz = 18 kW	50 Hz = 15 kW 60 Hz = 18 kW
Sound Insulation		✔	✔
Sound Level @ 10 meters		65 db(A)	65 db(A)
Emissions - Meeting EU & US targets [2]		✔	✔
Full Enclosure - Stainless Steel Panels		✔	✔
Site Requirements - Well-Ventilated Protected From Rain & Direct Sun		✔	✔
Installed Footprint Not including ash vessel & grid tie enclosure		136 x 136 cm	136 x 136 cm
Shipping Dimensions	PC20 - Crated Accessories- Crated	178 x 178 x 157 cm 125 x125 x 127 cm	178 x 178 x 165 cm 125 x125 x 127 cm
Shipping Weight	PC20 - Crated Accessories- Crated	1175 kg 210 kg	1250 kg 225 kg
CE Conforming		✔	✔

[1] Actual power will vary depending on fuel type, shape, energy density and moisture content.
[2] Emissions: <200 mg/m³ CO, <650 mg/m³ NOx, both @ 5% O_2. Check local emissions requirements.

BIOMASS FEEDSTOCK

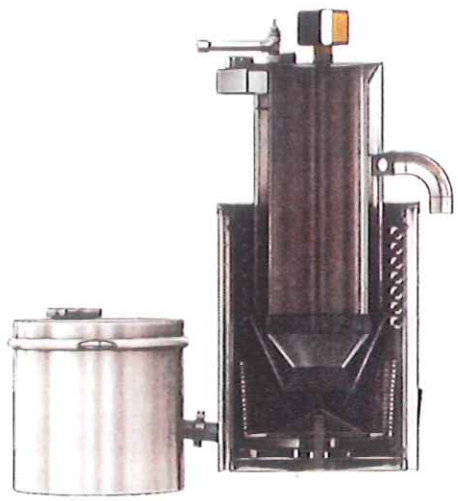
Size	12-40 mm (1/2 inch - 1 1/2 inch)
Moisture Content	10-30% dry basis
Approved and Tested [3] with normal operating procedures	Nut Shells (e.g. Walnut, Hazelnut) Softwood Chips (e.g. Fir, Pine) Hardwood Chips (e.g. Oak, Ash)
Approved and Tested [3] with increased operating effort	Corn Cobs Coconut Shells Palm Kernel Shells
Not Approved Dangerous & Will Void Warranty	Coal Tires Medical Waste Plastic Municipal Solid Waste

[3] Warranty coverage for use with any particular species of feedstock requires specific testing and approval. Visit ***http://www.allpowerlabs.com/fuels*** for the most current information on feedstock suitability.

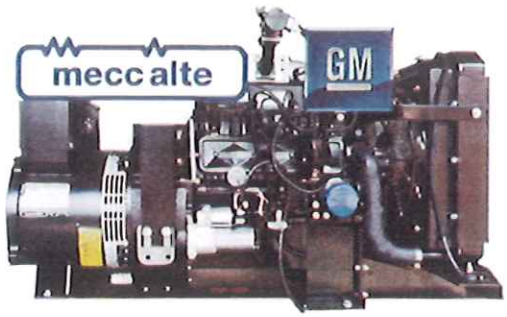
FUEL COST COMPARISON

FUEL	PRICE RANGE
Diesel	€0.50 - €1.00/kWh
Gasoline	€0.70 - €1.50/kWh
LPG/Propane	€0.40 - €0.75/kWh
Gasified Biomass	***€0.00 - €0.25/kWh***

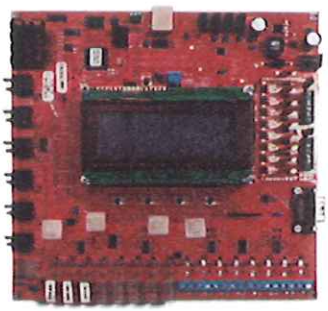
All specifications are subject to change without notice



v5 GEK TOTTI Gasifier



Meccalte NPE32 Genhead GM Vortec 3.0 IC Engine



API Custom Process Control Unit

Deep Sea Grid Tie Control Unit

GASIFIER SYSTEM

FEATURES	PC20	PC20 CHP
GEK TOTTI Gasifier - Multi-stage, Zone-Separated Heat-regenerating, High-Efficiency Architecture	v5	v5
Fuel Moisture Tolerance	30%	30%
Biomass to Power Conversion Efficiency [4] Dry Basis	1.15 kg = 1 kWh	1.15 kg = 1 kWh
High Performance Neutral-Vane Cyclone	✔	✔
Multi-stage Packed Bed Filter	✔	✔
Continuous Char/ash Removal from Gasifier [5] 12-24 hr. service period	✔	✔
Continuous Cyclone Particulate Removal [5] 12-24 hr. service period	✔	✔
Continuous Fuel Feed via Airlock Including hopper, air lock, level sensing & ECU	✔	✔

[4] Energy density of any given feedstock varys depending on various factors such as fixed carbon content.
[5] Char/ash & particulate byproducts vary depending on fuel type, shape, energy density & moisture content.

ENGINE & GENERATOR

FEATURES	PC20	PC20 CHP
GM Vortec 3.0 Liter 4 cylinder, inline, pushrod, industrial engine	✔	✔
Electronic Woodward Governor	✔	✔
Automated Syngas/Air Mixture Control	✔	✔
Exhaust Cleanup [6] Dual Catalytic Converter	✔	✔
Meccalte 12 wire genhead 1 or 3 phase, 50/60 Hz, all common global voltages	✔	✔
Grid Tie System - including controls & contactor	✔	✔
Paralleling Capable	✔	✔

[6] Emissions: <200 mg/m³ CO, <650 mg/m³ NOx, both @ 5% O_2. Check your local emissions requirements.

AUTOMATION SYSTEM

FEATURES	PC20	PC20 CHP
Full Temperature & Pressure Instrumentation	✔	✔
Smart Grate, Fuel & Ash Auger Control	✔	✔
Diagnostic Messages for Error Recovery	✔	✔
User-Configurable Setpoints For all critical systems	✔	✔
Datalogging for Gasifier	✔	✔
Datalogging for Power Generation	✔	✔

COMBINED HEAT & POWER SYSTEM (CHP)

FEATURES	PC20	PC20 CHP
Combined Coolant & Exhaust Heat Recovery Maximum Usable Thermal Output	NA	>30 kWt @ 15 kW
Total System Efficiency - Electricity plus Heat Will vary depending on calculation parameters	NA	>70%

All specifications are subject to change without notice

ALL Power Labs - 1010 Murray Street Berkeley, CA 94710 U.S.A.
+1-510-845-1500 Email: sales@allpowerlabs.com Web: allpowerlabs.com

The Spanner wood cogeneration plant

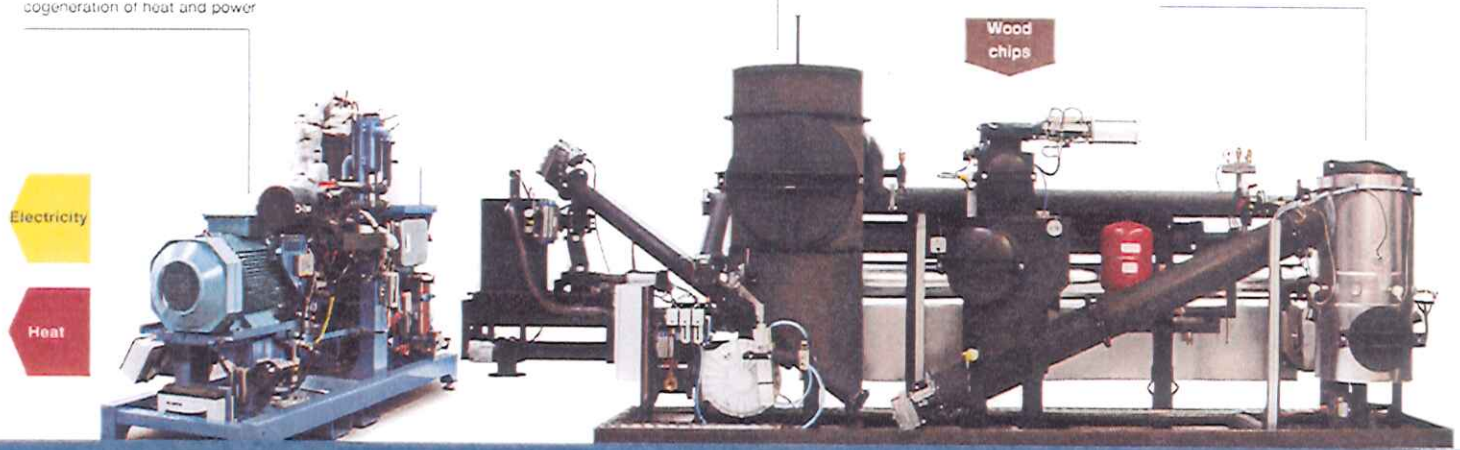
The Spanner wood cogeneration plant consists of the Spanner wood gasifier and the Spanner combined heat and power unit (CHP).

The Spanner wood gasifier is based on a process designed by the inventor Bernd Joos. The heart of the plant, the so-called reformer, produces in a controlled process pure wood gas from natural wood chips. The CHP is operated with the wood gas. The heat generated during the process can be used for the heating of buildings, for drying plants or local heating systems. The generated electricity will preferably be consumed by the owner or fed into the network and then be paid for.

Wood gas CHP
Robust motor, powerful generator, highly-efficient cogeneration of heat and power

Wood gas filter
with integrated self-cleaning

Reformer
Compact fire-bed including temperature monitoring for a controlled wood gas generation



Spanner wood gas CHP

Spanner wood gas generator

The illustration may differ depending on the model

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Technical data:

Name of model	HK 30	HK 45
Electrical power	30 kW	45 kW
Heat power	73 kW	108 kW
Wood chip consumption*	30 kg/h	45 kg/h
Wood chip consumption* for 7,000 operating hours	180 t w.m.	270 t w.m.
Wood chip quality	Size G30 to G40 Max. moisture content 13 % (ideal: < 8 %) Max. fines: < 4 mm grain size: 30 %	
Electrical output Voltage / Frequency	400 V / 50 Hz	
Heat output Feed / return temperature	max. 85°C / max. 60°C	
Dimensions Wood gasifier (LxBxH)	5,272 x 1,540 x 2,300 mm	
Dimensions CHP unit (LxBxH)	2,600 x 924 x 2,196 mm	

*Depending on the quality of the wood chips

We will gladly determine your personal benefits from the use of a wood cogeneration plant for your application. Please do not hesitate to contact us:

Support hotline: + 49 (0) 8773 707 98 - 288

For further information, go to www.holz-kraft.de

Spanner Re²