Preliminary Feasibility Study for a Biomass Power and Thermal Heat Facility located at the Parlin Fork Conservation Camp

Prepared for:

North Coast RC&D Council

California Department of Forestry and Fire Protection (CALFIRE)

Prepared by:

TSS Consultants
2724 Kilgore Road
Rancho Cordova, CA 95670

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ACKNOWLEDGMENTS

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- Phil Giles, North Coast RC&D Council
- Doug Wickizer, CALFIRE
- Dave Barsi, CALFIRE
- Steve Horne, CALFIRE

1. Executive Summary

TSS Consultants (TSS) has conducted a preliminary feasibility study to evaluate existing technologies that produce electrical energy and heat from biomass materials with low air emissions and low water use/discharge, and other attributes that will allow the technology to be utilized at the California Department of Corrections' Parlin Fork Conservation Camp (PFCC) located in the Jackson Demonstration State Forest (Mendocino County, CA). The study assessed the possibility of combined heat and electrical power (CHP) generating technology, utilizing locally available fuels (i.e. woody biomass fuels easily accessible in the Jackson Demonstration State Forest and region and obtainable with no new access road construction in the forest) that would otherwise be wasted resources. Biomass technologies, both direct combustion and gasification systems were evaluated, with the goal of being technically and environmentally compatible and permittable in the PFCC area.

1.1. Results

The results of this preliminary feasibility study are as follows:

- Of the biomass utilization technologies reviewed, three technologies were further reviewed and evaluated. These three technologies were:
  - Phoenix Energy - gasification
  - Nexterra – gasification
  - Envio Energie – direct combustion
- It appears that a new biomass facility using all three of the technology leaders could be permitted at the potential PFCC site for construction and operation. However, the direct combustion system of Envio Energie would require a wastewater disposal system of some kind, which may be difficult to do on the site. A wastewater disposal pond would likely be necessary and land area constraints may prohibit this. In addition, the Envio technology would require a process water supply that appears unobtainable currently at the site
- To develop a biomass power plant using the three technologies, TSS analyses show that the prices needed with wood fuel at $35/BDT for the electric output would range from $0.12/kilowatt hour (kWh) to $0.15/kilowatt hour using low-interest loan financing at 3.5%. If a grant were obtained, this would lower dramatically to $0.072/kilowatt hour to $0.105/kilowatt hour. This would be the kWh price the facility would need from the utility that would purchase the electrical output of the biomass power plant.

- If a grant was obtained, given the current feed-in tariff from PG&E, the project could realize income from the Phoenix Energy facility at $0.037/kilowatt hour
- Regarding cogeneration potential at the PFCC site, only an estimated 15 percent of the residual heat could be utilized. Use of 100% of the waste heat is not practical, but use of 60% is feasible assuming a continuous use thermal host was available at the facility site (giving an overall thermal efficiency of about 80% for the facility). Using 60% of the residual heat would decrease the needed electricity price for the Phoenix Energy grant $35/BDT case to $0.014/kWh. Unfortunately, this is not the case at the PFCC site, and a biomass facility sited there would have to rely primarily on electricity sales.

1.2. Recommendations

Based on this analysis TSS has the following recommendations:

- As it appears that a new biomass power plant facility may be viable at the potential PFCC site, particularly if its capital costs are funded by a grant or even part of the state budget (assuming no payback of capital funds).
- The Phoenix Energy system has the lowest capital cost and therefore may be the easiest to fund via a grant or from state funds.
- A Phoenix Energy system of the same size evaluated in this assessment is under construction in the San Joaquin Valley. Operations are planned for Spring 2010. That project should be monitored closely to see if vendor claims are correct and equipment operates at commercial quality.
- The Phoenix Energy system reportedly has the lowest emissions. Their pending installation in the San Joaquin Valley should be monitored as an emissions source test is required by the district.
- Given the water supply constraints at the PFCC site, direct combustion power plant systems would not be recommended.

2. Introduction

TSS Consultants was retained by the North Coast Resource Conservation and Development Council (NCRCDC), under a grant from the California Association of Resource Conservation and Development Councils and the U.S. Forest Service, to conduct a study for the California Department of Forestry and Fire Protection (CALFIRE) to evaluate existing technologies that produce electrical energy and heat from biomass materials with low air emissions and low water use/discharge, enough to be able to be permitted and with other attributes that will allow the technology to be utilized at the Parlin Fork Conservation Camp. The study assesses the possibility of combined heat and electrical power (CHP) generating technology, utilizing locally available fuels that would otherwise be wasted resources. Biomass technologies, both direct combustion and gasification systems were evaluated, with the goal of being environmentally compatible and permittable within Mendocino County

3. Project Approach & Methodology

3.1. Introduction

The primary objective of this study is to assess the feasibility of developing a sustainable electrical energy and heat producing facility that would use as fuel that has been traditionally underutilized:

- Woody biomass that is generated as a result of regional fuels treatment activities.
- Woody biomass from traditional logging and forest restoration activities.

This study provides a project assessment with the goal of being environmentally sound, socially compatible, and economically viable, employing appropriate combined heat and electrical power (CHP) generating technology and utilizing locally available fuels that are underutilized.

3.2. Background

The PFCC is located in Mendocino County, eleven miles east of Fort Bragg, off of Highway 20 (see Exhibit 3.1 below). Established on August 8, 1949, it is the oldest camp in northern California and the second oldest in the state. It was first operated by the California State Prison, San Quentin. In the early 1960's the California Correctional Center (CCC) assumed responsibility for the camp. For a short period during the late 1960's, the camp operated as a federal facility for illegal immigrants. The California Department of Corrections and Rehabilitation (CDCR) regained the camp, and it was operated by CCC until 1972, when the Sierra Conservation Center (SCC) assumed responsibility for all of the Departments interests in the Conservation

Exhibit 3-1: Regional Location of Parlin Fork Conservation Camp

Camp Program. Then, in 1982 the camps were split geographically north and south. CCC administered camps north of Sacramento and SCC administered camps south of Sacramento. The PFCC again was administered by CCC and continues to be so today under the California Department of Correction and Rehabilitation.

The California Department of Forestry and Fire Protection (CAL FIRE) staff includes one Division Chief, ten Fire Captain B's, one Heavy Equipment Mechanic, one Chief Plant Operator (water and sewer system maintenance) and a half-time Office Technician. CDCR utilizes one Lieutenant, one Sergeant, and eight Officers to provide correctional supervision at Camp and on emergency assignments.

The primary mission of the camp is to provide inmate fire crews for fire suppression principally in Mendocino County, but crews may respond statewide. In addition to fire suppression, inmate hand crews provide a work force for conservation projects. The in-camp project supervised by CALFIRE is a sawmill, which provides low cost lumber for state construction projects. This saw mill is proposed to receive new equipment and increase it's lumber output to a roughly estimated 100,000 board feet of lumber per month[1].

The PFCC is located in the Jackson Demonstration State Forest that is the largest of CALFIRE's eight demonstration state forests. The Jackson State Forest and the surrounding region have a long history of industrial logging activity, which began in 1862 and continued under private ownership until the State of California purchased of the property in 1947. Today, more forest growth occurs each year than is harvested. Recently (January 2008) a Management Plan was adopted by the State Board of Forestry to actively manage the state forest for a variety of goals

CALFIRE is intending to restart commercial timber harvest operations in the State Forest. In addition, CALFIRE is undertaking hazardous forest fuels reduction activities to significantly reduce the possibility of catastrophic wildfire. These forest thinnings can produce a significant volume of woody biomass material that can become a disposal issue. Because this biomass material currently has very little commercial value, it is currently disposed of by pile burning, chipping and spreading, or hauling it to disposal sites at considerable expense. Utilizing woody biomass generated from the thinning of hazardous forest fuels to generate electrical power and heat is a conversion option that the project proponents would like to pursue. A biomass fuels assessment study has been previously performed which indicates that ample woody biomass would be available for a power plant of this size.

[1] Personal communication with Doug Wickizer, CALFIRE, September 21, 2009

This project seeks to utilize and dispose of forest by-products (woody biomass) and other woody biomass fuels, in the production of energy, at minimum, in the form of electricity and heat. This project would assess the feasibility of employing technologies that are able to utilize woody biomass from forest-based operations in the form of woody biomass generated from fuels treatment activities.

TSS utilized its extensive database of biomass technology companies to compile appropriate and available technical, operational, and environmental information on over 50 companies/vendors. TSS then systematically reviewed the benefits, challenges and trade-offs of differing technologies to ascertain which particular technology might be best suited for the particular application. For the PFCC site, TSS recommends addressing the following parameters:

- Air emissions and air quality standards.
- Ash composition.
- Site Considerations such as land use constraints, water supply, etc.
- Community, regulators and stakeholder acceptance.
- Market product viability.
- Project economics.
- Water use.
- Power/Heat – current demand on site
- Estimated Capital Investment

3.3. Potential Project Site and Parameters

For this biomass power technology assessment, the PFCC site was considered as a candidate site for the biomass power plant with some potential waste heat load for heating the proposed reconstructed camp (planned for th3 2012 timeframe. In addition there is a small sawmill operated by inmates on the PFCC site that could use waste heat (or produced steam) in a kiln for drying the lumber (estimated to be an average of 100,000 board feet a month when the camp acquires proposed new sawmill equipment). The location and aerial of the PFCC site is shown in Exhibits 3-2 and 3-3. Exhibits 3-4 and 3-5 display photos on the most promising site for the biomass power plant (adjacent to the sawmill).

For this project assessment, the amount of sustainable woody biomass fuel that would be sustainably available for the power plant was set at approximately

8,000 to 10,000 bone dry tons (BDT) per year. This would allow for a power plant facility to be sized at approximately 1 MW (or larger depending on technology) and also be able to supply waste heat for cogeneration purposes.

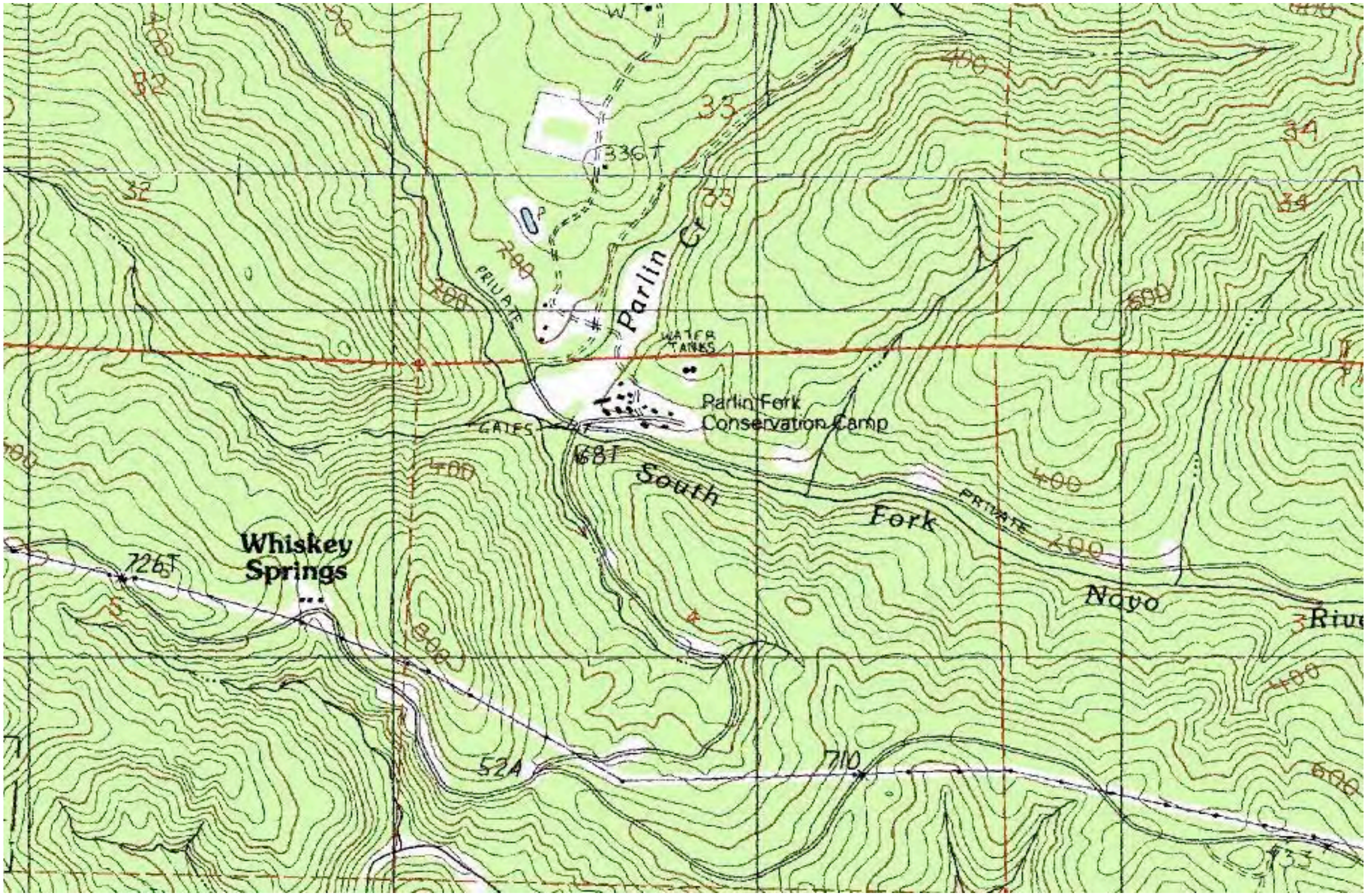

Exhibit 3-1. Parlin Fork Topographic Map

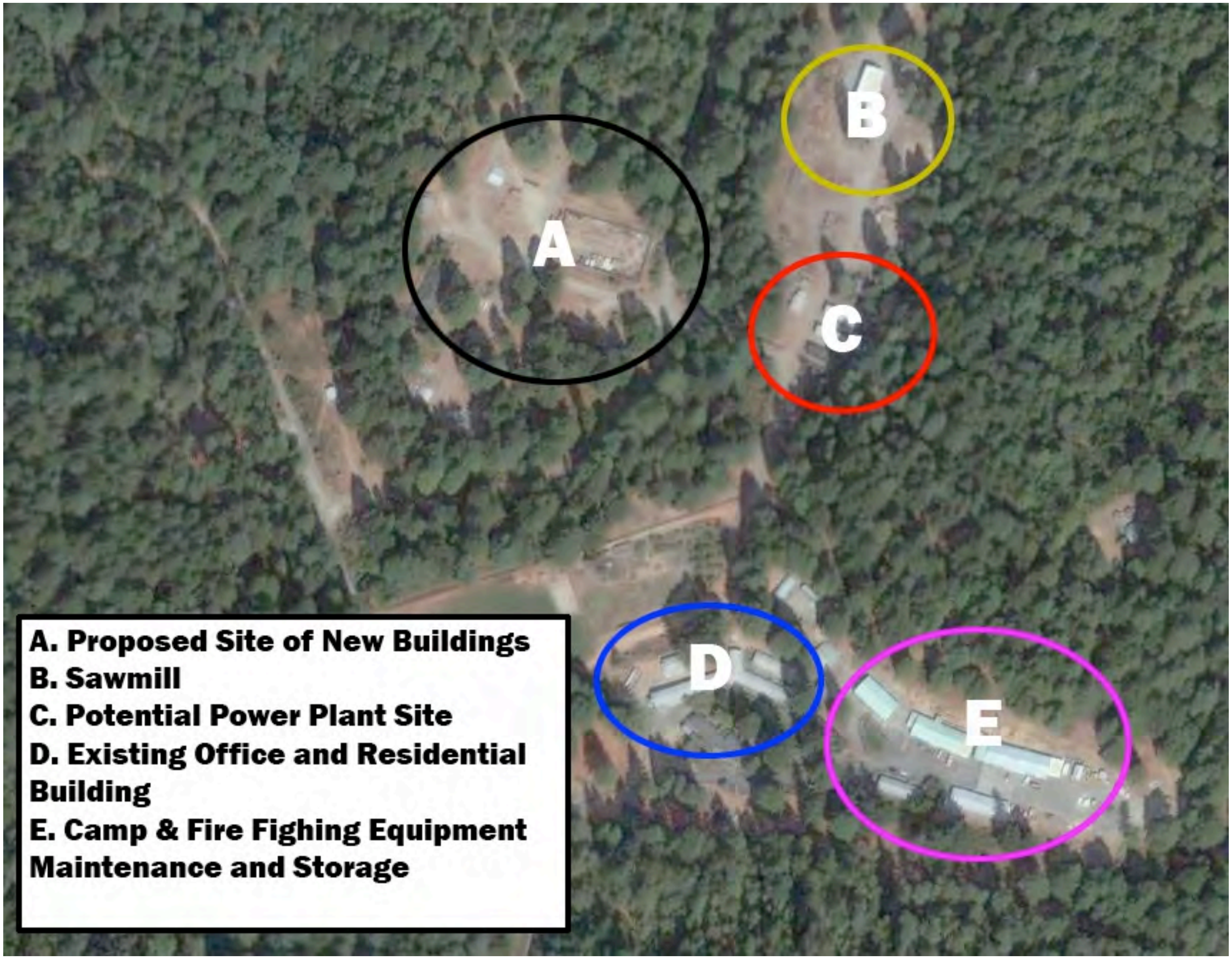

Exhibit 3-2. Parlin Fork Layout

Exhibit 3-3. Sawmill and log yard

Exhibit 3-4. Potential power plant site

4. Technology Assessment

Biomass utilization was assessed to provide electricity and utilization of combined heat and power (CHP) applications. TSS has developed a technology assessment framework that has been utilized in conducting several other biomass technology assessments. The technology assessment framework consists of the following:

- Technology database review;
- Initial selection of technology vendors;
- Prepare and disseminate Statement of Interest;
- Review of responses with technology matrix summary;
- Selection of final technology vendor(s), with continuing follow-up.

4.1. Findings

The technology assessment involved the systematic review of a large database of biomass utilization companies, which resulted in the initial selection of 31 technology vendors to be the recipients of a Statement Of Interest (SOI). Of the 31 technology vendors that received the SOI, TSS received responses from 11 vendors. This technology evaluation process has been ongoing and in this time there has been rapid emergence of potentially viable advanced technologies vendors. As a result of these new technology options, an additional 3 vendors were added to the total responses; which brings the total number of responsive vendors to 14. The 14 vendors were evaluated with ultimately 3 companies being chosen for further financial analysis in Section 5.

4.2. Technology Description

4.2.1. Biomass Utilization

Biomass, such as woody wastes from forest residues, agriculture residues and agriculture processing by-products, biosolids from wastewater treatment, and municipal solid waste (MSW) can be supplied to energy conversion systems and converted to useful steam, heat, or combustible gases. These energy conversion systems vary widely but fall under two basic categories, gasification and direct combustion.

4.2.2. Gasification

Gasification is the thermochemical conversion of organic solids and liquids into a synthetic gas (syngas) under very controlled conditions of heat and strict control of air or oxygen. The syngas formed by gasification is composed primarily of hydrogen (H_2), methane (CH_4), and carbon monoxide (CO). Gasification also produces carbon char (also commonly named 'biochar') and ash that remain as solids and must be disposed of or may be used for other products (e.g., ash as a soil amendment).

The syngas can be used as a primary fuel in electrical generating units such as a reciprocating internal combustion engine or in a gas turbine. It can also be used as fuel to produce steam or hot water for heating and/or manufacturing processes. In addition to producing syngas from biomass, there are several processes and technologies attempting to produce commercially viable liquid fuels such as ethanol and "green" diesel from biomass (also known as biodiesel). Exhibit 4-1illustrates one form of a gasification system.

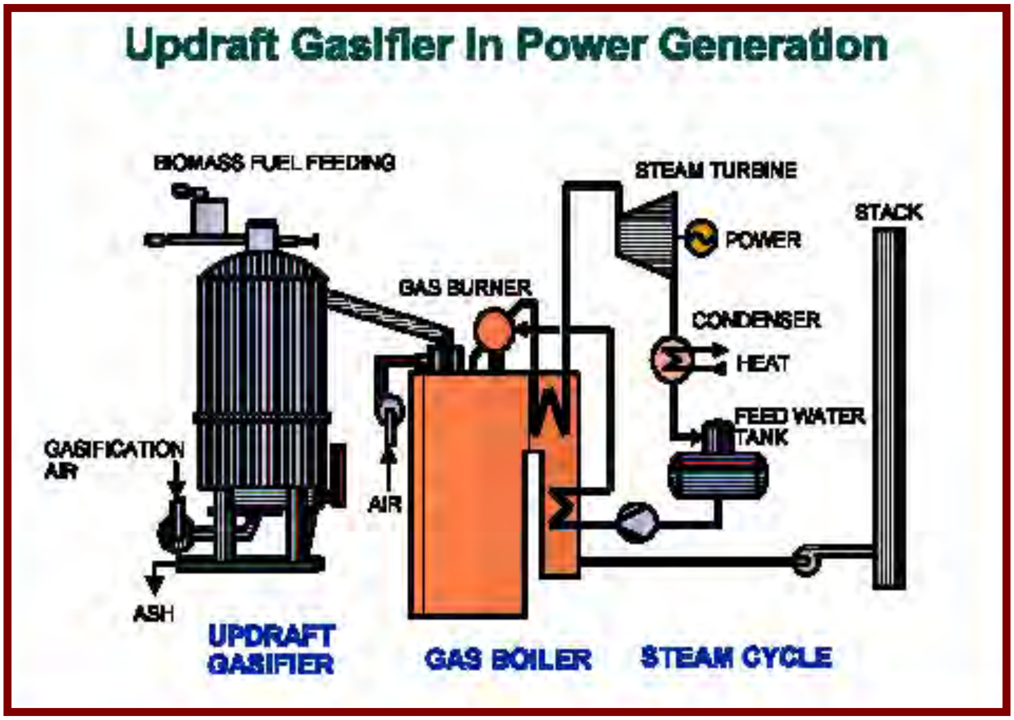

Exhibit 4-1: Small Gasification System Schematic

The earliest uses of gasification date back to the production of city gas from coal in the late 1800's. Gasification of coal has been in commercial use for more than 50 years with the syngas used to produce chemicals. More recently, gasification of coal has been applied to power generation at a few large integrated gasification combined cycle (IGCC) plants in the U.S. and others outside the U.S.

Biomass-based syngas delivered to an IGCC process allows for significant efficiency increases over direct combustion energy production. However, gasification of biomass fuel feedstock is not as commonly applied as IGCC within the U.S. Gasification of biomass resources is currently on the upswing in Europe and there is much interest in the U.S. Technological challenges exist for biomass-based syngas production such as the clean up of syngas to remove impurities that would potentially damage engine and fuel components of an internal combustion system. Advanced technologies (such as a technology analyzed in this report) are beginning to produce biomass-based syngas at rates that are competitive with natural gas rates and traditional direct combustion biomass energy production.

4.2.3. Direct Combustion

In direct combustion systems, the biomass fuel is directly burned (combusted) in some type of furnace or combustion unit that then supplies heat to a boiler. Most commercial biomass power applications today use boilers in conjunction with a steam turbine to generate electricity. Common boilers used for biomass direct combustion systems include traditional stoker boilers and bubbling fluidized bed boilers. Each boiler technology allows for and requires differing fuel specifications, which requires careful analysis to select boiler technology that is appropriate for available fuels and project conditions.

Exhibit 3-2 illustrates a direct combustion system flow process.

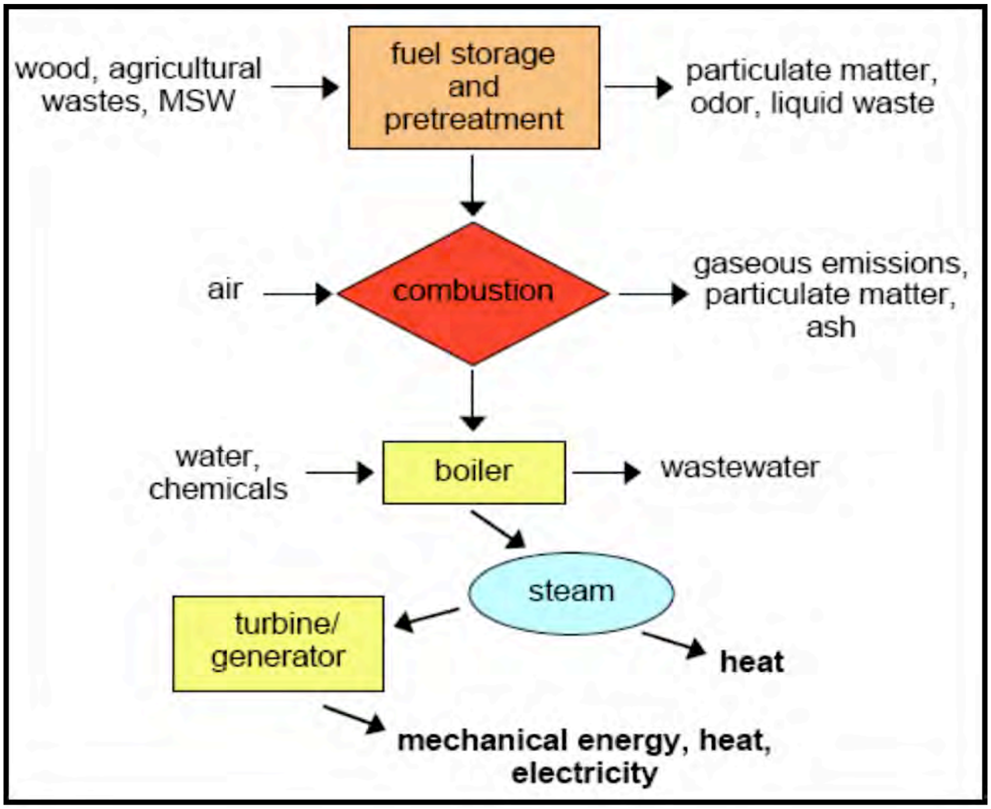

Exhibit 4-2: Direct Combustion System Process Flow Diagram

4.3. Technology Database Review

TSS maintains a very large database on various biomass gasification and combustion technologies and vendors of those technologies. This database contains information on nearly 250 biomass combustion and gasification technology vendors worldwide. The database was created from numerous private and public sectors sources.

This large database was examined with the technology goals of the project in mind, i.e., gasification or very clean (i.e. low air emissions) combustion technologies. Thirty-one (31) technology vendors were identified to receive the Statement of Interest (SOI – see Section 4.4 below). The list of the 31 recipients can be found in Appendix B.

4.4. Statement of Interest

As opposed to a more formal Request for Proposals, the SOI format was considered more suitable for a preliminary feasibility assessment. The SOI format allows for the collection of requested information from prospective vendors for a project that is not fully defined and has not yet proceeded into the initial stages of consideration. A copy of the SOI is contained in Appendix A.

The SOI was prepared with the following parameters and information requests.

- Project overview – location and type of project proposed;
- Project objective – select woody biomass CHP technology that can be used at the PFCC;
- Technology requirement – gasification or low emissions direct combustion;
- Air emissions – facility to be located in the Mendocino County Air Quality Management District (MCAQMD), facility must meet all MCAQMD air quality standards;
- Feedstock parameters – principally forest residues from harvesting and thinning activities. Some saw milling residuals;
- Interconnection – with the Pacific Gas & Electric local grid;
- Project schedule – operational 2010/2011
- Selection for further consideration criteria – six criteria include base load (24/7 generation) ability, good operating capacity, technical and commercially viable technology, environmental impacts (air emissions, water use, and wastewater generation), and estimated capital and operating costs;
- Contents of response submittal – responses to include description of technology, potentially needed infrastructure, potential environmental impact, estimated turnkey price, and statement of technology vendor qualifications;
- Contact – TSS contact information supplied.

The SOI was sent electronically to the 49 vendors listed in Appendix B.

4.5. Initial Selection of Vendors

Of the 31 recipients, 11 vendors responded sufficient information to consider and evaluate their proposal for the PFCC. A list of the 31 vendors that the SOI was distributed to is listed as follows.

- Advanced Recycling Equipment
- Black & Veatch
- Chiptec
- Community Power
- Detroit Stoker
- Emery Energy
- Enerwaste
- Envio Energie
- Envirocycler
- Frontline Energy
- GEM Americas

- Grand Teton
- HIS Prime Energy
- Hurst Boiler
- Interstate Waste Technologies
- Johnson Controls
- Nexterra
- Nova Fuels
- Phoenix Energy
- Power Energy
- Powerhouse Energy
- Prime Energy
- Siemens
- Taylor Recycling
- Thermo Energy
- Thermogenics
- Torgtech
- Wartsila
- West Biofuels
- Xylowatt
- Zilkha Biomass Energy

Eleven of the identified technology vendors appeared to submit enough information to conduct the next step of the selection process.

4.6. Review of Responses

The following technology vendors that submitted enough information for evaluation were:

Advanced Recycling Equipment, Inc. (St. Marys, PA) - Direct Combustion

Primenergy, LLC (Houston, TX) – Gasification

EnerWaste, Inc. (New York, NY) – Gasification

Nexterra, (Vancouver, BC) **-** Gasification

GEM Americas, Inc. (Toronto, ON) – Gasification.

PowerHouse Energy (Pasadena, CA) – Gasification

Johnson Controls (St. Louis, MO) – Gasification.

Xylowatt (Charlerol, Belgium) – Gasification

Emery Energy (Salt Lake City, UT) – Gasification

Zilkha Biomass Energy (Houston TX) – Combustion/Turbine

Envio Energie (Troy, MT) – Direct Combustion

Phoenix Energy (San Francisco, CA) - Gasification

4.7. Technology Matrix

A technology evaluation matrix was prepared and used to rank the responses to the SOI. The evaluation criteria consisted of:

- Proven Technology: Are there actual units of similar size with operating history in the field on a commercial scale and sold to commercial entities?

- Biomass Utilization Experience: Does the equipment have a history of using biomass as raw material?

- Air Emissions (projected): Has the equipment demonstrated control of air emissions to comply with Mendocino County APCD emission requirements?

- Water Supply/Wastewater Emissions: What are water supply needs and wastewater discharge requirements? Water supply is critical at the PFCC facility.

- Capital Costs: Does the company have actual experience installing units, with actual capital investment and operating costs?

- User Friendly Operation (Projected): Does the technology company have demonstrated ability to operate units using trained local personnel?

A weighted score of 0 to 10 was given in each of the above categories (10 being highest and most responsive to the evaluation criteria category). A total of 60 points was the maximum achievable for any given technology vendor. The matrix evaluation follows in Table 4-1.

Weighted Value Range: 0 to 10 10 = highest rank 0 = lowest rank

	Vendor and Lead Contact	Technology	Biomass Utilization Experience	Air Emissions	Water/ Wastewater Impacts	Capital Costs	User Friendly Operation	Total Points	
1	Advanced Recycling Equipment, Inc. St. Marys, PA Don Kunkel dkare@alltel.net	7	9	7 (with controls)	4	8	8	**43**	Need
2	Primenergy, LLC Houston, TX Bill Tietze btietz@primenergy.com	**7**	**7**	4	4	0 (no capital costs given)	**7**	**29**	No ca to sta
3	EnerWaste, Inc. New York, N.Y. Robert Stoodley rstoodley@aol.com	**7**	**7**	4	4	5	4	**31**	Not c range cycle
4	GEM Americas, Inc. Toronto, ON Douglas Weltz Douglas_weltz@gemamericainc.com	6	5	5	7	3	4	**30**	Lots cost 3 MV
5	PowerHouse Energy Pasadena, CA Kevin Butler KButler@powerhouseenergy.net	6	5	8	8	6	6	**39**	Capit very
6	Nexterra Vancouver, BC Darcy Quinn	7	9	8	9	5	6	**46**	Gasif
7	Xylowatt Charlerol, Belgium Frederic Dalimier dalimier@xylowatt.com	7	6	5	7	4	6	**35**	Cap c contr
8	Emery Energy Salt Lake City, UT Ben Phillips bphillips@emeryenergy.com	6	5	7	7	5	5	**35**	Capit

Weighted Value Range: 0 to 10 10 = highest rank 0 = lowest rank									
	Vendor and Lead Contact	Technology	Biomass Utilization Experience	Air Emissions	Water/ Wastewater Impacts	Capital Costs	User Friendly Operation	Total Points	
9	Zilkha Biomass Energy LLC Houston, TX Jeffrey McMahon jmcmahon@zilkhabiomass.com	6	8	6	8	7	6	**41**	Will I therr
10	Envio Energie Troy, MT Jeff Staska	8	9	7	7	7	7	**45**	
11	Phoenix Energy San Francisco, CA Gary Stengel	7	7	9	8	8	6	**45**	

DEFINITIONS:

Proven Technology: Are there actual units of similar size with operating history in the field on a commercial scale and sold to commercial entities?
10 = Many same scale units operating over 5 years with same design and fuels.
5 = Some similar scale units operating over 2 years with similar design and fuels.
0 = No same size units operating in the field.

Biomass Utilization Experience: Do they have experience in biomass utilization?
10 =Experience in combusting woody biomass forest residuals.
5 = Experience in combusting woody biomass, but not necessarily forest residuals.
0 = No experience in combusting woody biomass.

Air Emissions (projected): Demonstrated ability to control air emissions to comply with Best Available Control Technology (BACT) standards.
10 = Demonstrated ability to control air emissions to an “ultra-clean” level.
5 = Demonstrated ability to control air emissions to meet AZ standards.
0 = No demonstrated ability to control air emissions.

Water/Wastewater Impacts: Technology requires water and discharges water.
10 = Requires little water for process and discharges a minimal quantity of water
5 = Requires considerable water for process and discharges a considerable quantity of water that cannot go to sewer or storm drain.
0 = Requires a lot of water and discharges a lot of wastewater that cannot go to sewer or storm drain.

Capital Costs: Actual experience in installing units pursuant to total capital cost budget.
10= Demonstrated ability to complete turnkey project in accordance with a capital budget.
5 = Demonstrated ability to complete their portion of the budget, but not turnkey.
0 = No installation experience to date.

Weighted Value Range: 0 to 10 10 = highest rank 0 = lowest rank									
	Vendor and Lead Contact	Technology	Biomass Utilization Experience	Air Emissions	Water/ Wastewater Impacts	Capital Costs	User Friendly Operation	Total Points	
User Friendly Operation (Projected): Demonstrated ability to operate units with training of local personnel. 10 = Demonstrated user-friendly operation with minimally trained local personnel. 5 = Systems operated with trained personnel, imported from outside the local region. 0 = No systems operating.									
Total Points: Simple arithmetic summing of rankings; no attempt at weighting score by category.									

4.8. Selection of Final Technology Vendors

The top three scores were selected as potential candidates for the project and were to be included in the financial analysis task (Section 5). These were:

- Nexterra
- Envio Energie
- Phoenix Energy

The highest three scoring technologies selected for this final evaluation step are discussed below.

<u>Nexterra</u>

Nexterra has proposed the use of technology that gasifies biomass into syngas, and then proposes to send that syngas to an internal combustion engine. Major advantages of Nexterra's proposal include the high thermal efficiencies of internal combustion versus direct combustion technology, 45% compared to 20%, respectively, while a major drawback is that the technology is not widely dispersed in the U.S.

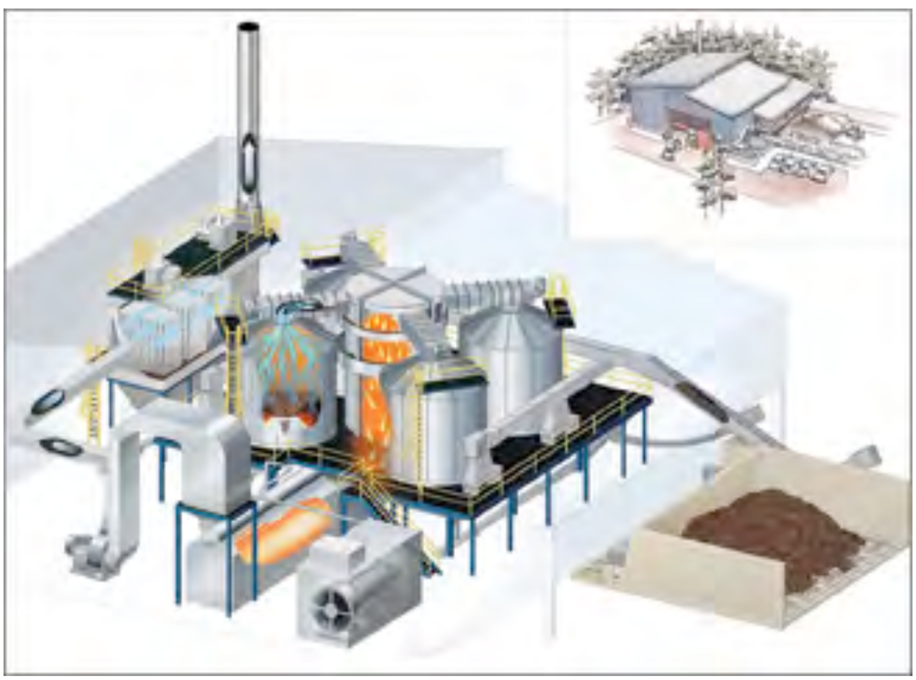

Exhibit 4-3. Nexterra Gasification System

Exhibit 4-4. Nexterra Gasification Unit Operating at a Plywood Facility

Nexterra's technology proposes gasifying biomass in their proprietary gasifier that partially oxidizes biomass material at high temperatures (1500-1800 °F) and long residence times. The 'dirty' syngas is then delivered to a tar cracker and filter for clean up before being delivered to an internal combustion engine. Nexterra proposes the use of a GE Jenbacher IC engine. Nexterra has confirmed they have an agreement with GE to use the Jenbacher engine on clean syngas from their proprietary process.

Air emissions for Nexterra's gasification technology combined with a Jenbacher were estimated using Chapter 3.2 (gas-fired reciprocating engines) of the U.S. EPA AP-42 emission factors handbook for all constituents except NOx (for NOX, the manufacturer supplied emission factor was used), and engine specifications from Jenbacher on their Type 6 engine. This resulted in the following:

- CO: 2.81 lb/hr (12.3 tons/year)
- NO_x: 5.04 lb/hr (22 tons/year)
- SO_2: 0.01 lb/hr (0.04tons/year)
- VOC: 1.05 lb/hr (4.6 tons/year)
- PM10: 0.0007 lb/hr (0.003 tons/year)

These emissions may be on the high estimate due to the fact that AP-42 numbers are usually on the conservative side.

Capital Cost Estimate: Nexterra provides an estimate of $4,000 - $6,000/MW, however TSS estimates that the cost of the facility would likely be $5,000 - $7,000/MW due local inexperience installing and operating this technology.

Envio Energie

Envio Energie (Envio) has proposed to provide PFCC with cogeneration combined heat and power (CHP) products that meet PFCC's needs while addressing environmental concerns that may affect the permitting process of this particular technology. Envio technology in essence is a modified version of a fixed-bed moving grate furnace system.

Envio has developed their technology in Sweden and Norway and has a significant number of facilities in operation in Scandinavia. Since 1984, Envio has developed over 100 facilities in Norway and Sweden, mainly heat and steam plants. Envio installed their first CHP plant in 2005.

Exhibit 4-5. Envio Energie CHP Plant – Ljungby, Sweden
16 MW Thermal, 3 MW Electrical

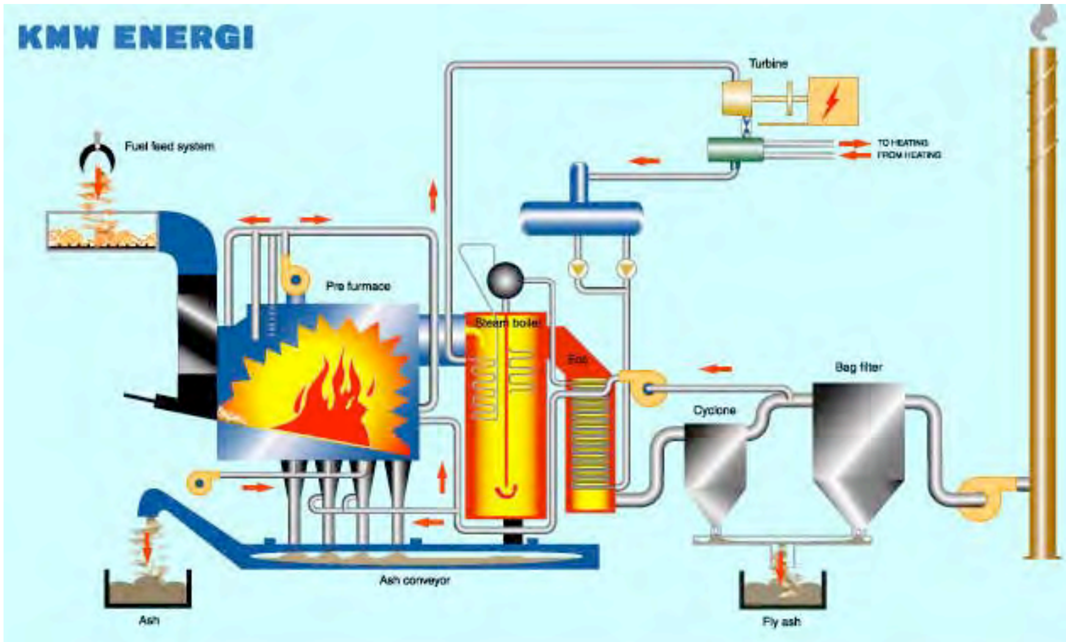

Exhibit 4-6. Boiler System Schematic

Envio has noted that a facility similar to the PFCC design would have the following criteria pollutant emissions.[2]

- CO: 2.63 lb/hr (11.5 tons/year)
- NO_x: 2.63 lb/hr (11.5 tons/year)
- SO_2: Negligible (before baghouse)
- VOC: 0.11 lb/hr (0.48 tons/year)
- PM: 0.519 lb/hr (2.27 tons/year after ESP)

As indicated by the criteria pollutant emission rates listed above, emission control technologies may be required to reduce the level of pollutants in flue gas prior to venting. These technologies may include the use of an electrostatic precipitator (ESP) for particulate matter (PM) controls, or the use of SO_X emission controls if the composition of sulfur in fuels presents a SO_X issue (which should not given that the biomass fuel proposed for PFCC will principally be forest-sourced woody biomass).

Water use estimates for the CHP system are based upon the amount of process steam that is required in order to supply the steam and generation needs of the facility. Approximately 5-8 gallons per minute of feed water would be necessary to operate the

[2] Emission limits are based on an assumption of clean fuel that has a composition of 49% carbon, 6% hydrogen, 43% oxygen, 0.3% nitrogen, and 1.7% ash

facility. This may be problematic at the PFCC site due to water constraints (See Section 6.1.2 below)

Water losses and wastewater discharge are expected from the facility. Make-up water needs would be approximately 3.5 gallons per minute. As a result, prior to the discharge of wastewater away from the facility, it will have to be treated to reduce the water hardness and remove any pollutants to permittable concentrations. A water softening unit and reverse osmosis unit will be required to treat this water before it is discharged or recycled back into the steam and power generation process.

Envio's CHP system has various modular additions that can aid in the clean up of ash content, bottom ash and fly ash content. Ash content in waste stream of the combustion unit is mainly dependent on the quality and ash content of the fuel input. Envio's units that have been deployed in Sweden have shown the operation of ash distributors that aid in the collection and distribution of ash into transport vehicles to remove the bottom ash from the site. Within the western United States, depending on ash quality and further treatment, ash could potentially be sold as a soil amendment.

Capital Cost Estimate: Envio estimates that the construction of a utility-grade CHP facility including emission controls, ash handling, fuel handling system, turbine (extraction/condensing) and generator, with all associated equipment, would exceed $6M per installed megawatt. This estimate does not account for permitting costs and fees, site preparation (although Envio offers to provide civil site work for an additional fee), external connections, grid connection, and water and wastewater to/from the building housing the CHP unit.

Phoenix Energy

Phoenix Energy proposes a gasification process that is similar in general concept to the Nexterra proposal. The Phoenix Energy system is distinctly different than the Nexterra model in how it handles biomass feedstock. The Phoenix technology proposal is a gravity-fed gasifier that contains all the components of the process in a vertical column. Feedstock enters the top of the vessel where drying occurs. The next section of the process vessel is where pyrolysis occurs and combustible hydrogen and methane are released from the feedstock in a partial oxidation reaction. This is the syngas that is produced from the pyrolysis reaction. Feedstock continues further down the vessel where it further decomposes and ash exits the bottom of the vessel. Ash collected here can then be stored and removed from site. Gases and fly ash are blown into filters which removes ash components and the syngas is then enters the combustion chamber.

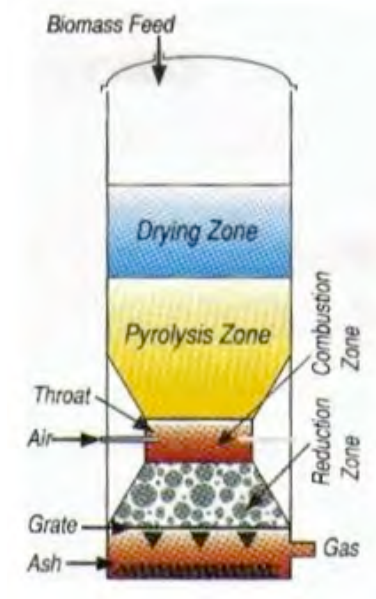

Exhibit 4-7. Phoenix Energy Concept Diagram

Phoenix highlights this downdraft orientation of their technology for more full oxidation of biomass feedstock leading to more full reduction of tar in the syngas compared to updraft orientation gasifiers. Phoenix states that there is a 99% reduction in tars compared to updraft gasifiers and fluidized bed gasifiers. Syngas cleanup is conducted using a low-volume and recycled water scrubber.

Unlike the Nexterra unit, Phoenix Energy does not specify a particular favorable IC engine that is preferential for their system.

Air emissions are expected to not exceed limits set by MCAQMD. Phoenix Energy has previously agreed to the following emissions from its gasifier and associated IC engine[3]:

- CO: 0.88 lb/hr (3.36 tons/year)
- NO_x: 0.17 lb/hr (0.65 tons/year)
- SO_2: 0.05 lb/hr (0.19 tons/year)
- VOC: 0.17 lb/hr (0.65 tons/year)
- PM10: 0.08 lb/hr (0.31 tons/year)

Capital Cost Estimate: Phoenix Energy has noted that they would be able to provide turn-key services for a biomass gasification, IC engine unit, fuel feed equipment, and associated emissions equipment for $3.5M. Annual 0perations and maintenance would be in the $250,000 range.

[3] Authority to Construct Engineering Evaluation, San Joaquin Valley Air Pollution Control District, 7/28/08 – Assume 7,644 operating hours per year

5. Financial Analysis

The estimated project economics of the final technology vendors, Phoenix Energy, Nexterra, and Envio Energie are analyzed in this section. Wood fuel from the PFCC area was assumed to be available at 22-30 tons/day and have a heating value of 8,500 Btu/lb.

The top three vendors were analyzed using one hundred percent public debt and with a full grant from the government for the capital investment required. Wood fuel prices of $35, and $45 per ton were used in the analysis. The public debt financing case was analyzed for each of the vendors with one hundred percent debt at 3.5% interest (as a low interest loan from the CA Department of General Services program) and with a grant of one hundred percent of the capital cost with zero capital cost to the project. This resulted in four cases calculated for each of the three technologies for a total of 12 calculated costs of electricity from the proposed facility. An important assumption in the financial analysis is the quantity of residual heat from the facility that can be utilized to meet thermal loads.

5.1. Estimated Heat Load

The co-location of a biomass power plant with a thermal host has the potential to improve the economics of both the power plant and the thermal host. Waste heat from an electric power generation system can substitute for heat obtained from natural gas, propane, fuel oil, or coal. Using the waste heat produced as a byproduct of the electrical generation process to heat buildings and to meet other thermal needs, allows the biomass power plant to have two potential revenue streams, i.e. electric power and heat. At the potential PFCC site the waste heat from the power plant could be used to heat buildings (space heating and hot water), as well as for drying lumber produced by the sawmill.

The following sections provide an estimate of the thermal load at the potential PFCC site.

Buildings

The heat and electrical loads for the proposed buildings at the PFCC site were estimated based on the heat and electrical loads of the existing buildings at the site[4].

Based on propane use supplied by PFCC for 2008 and part of 2009[5], the average annual use was about 65,000 gallons of propane. At the heating value for propane of 91,600 Btu/gal, the average annual use would be about 6,000

[4] See attached information provided by the Parlin Fork Conservation Camp in Appendix __
[5] See Appendix B

MMBtu. Additional information supplied by PFCC indicated that thermal use would be reduced by about 40% in the winter and 20% in the summer for an approximate total annual reduction in thermal use of 30%. This would reduce the annual thermal demand from buildings to about 4,200 MMBtu/yr.

Based on past electrical use supplied by PFCC, the current average electrical use at the site is 22,000-25,000 Kwhrs/month. This is about 3% of the net electricity that would be generated by a 1.5 MW nominal biomass power plant.

Sawmill

The thermal and electrical use of the new sawmill has not been determined at this time. It is anticipated that the sawmill will produce about 100,000 board feet of lumber per month. The energy requirements include electricity to run the saws and other equipment in the sawmill and heat to kiln dry the lumber. A typical quantity of heat required kilning dry pine and fir is 2.7 MMBtu/1000 BF of lumber[6]. Assuming 100,000 BF of lumber per month or 1,200,000 BF/yr, the heat requirements would be 3,240 MMBtu/yr.

Thermal Load

The total annual thermal load for PFCC is the sum of the building heat load and heat for drying the sawmill lumber, or about 7,400 million Btus. This is the quantity of heat that was assumed to be recovered from the power plant and utilized in the buildings and lumber drying kilns.

Estimated Percent of Heat Load Utilized

The typical thermal residual heat available from a 1 .5 MW biomass electrical generating plant is about 50,000 MMBtus/yr. The estimated heat load of 7,400 MMBtus/yr at PFCC would be able to utilize only about 15% of this residual heat.

PFCC Electrical Requirements

The electrical requirements for the buildings and sawmill at PFCC could be met with electricity generated by the biomass power plant or through purchase from the local utility as is currently done. There could be a difference in the cost that electricity could be sold into the electrical grid for and what PFCC would pay the local utility to meet its needs. This difference is not expected to be substantial and has not been incorporated into the analyses. All of the electricity available from the power plant has been assumed to be sold into the

[6] Based on average heat required to kiln dry lumber at the Warm Springs Forest Products Industries sawmill in Warm Springs, Oregon.

grid and none used at the site other than for power plant auxiliary use.

5.2. *Estimated Cost of Electricity*

Using a standard financial model, TSS found that based on the parameter inputs in Table 5-1, the costs of electricity are as shown in Table 5-2 for the two financing assumptions. These costs represent the prices that would have to be obtained for the electricity generated to make the facility economically feasible.

As stated above in Section 3.9.1, the use of waste heat from the electric power plant in a CHP arrangement can add to the revenues that a power plant could receive. However, given the relatively low percentage of waste heat that the PFCC facility would need, the proposed biomass power plant will need to rely primarily on the sale of electric power as its operating revenue source.

Table 5-1. Technology Specifications Used for Biomass Power Plant Financial Analysis

Parameter	Envio Energie	Nexterra	Phoenix Energy
Plant size (MW net)	1.25	1.7	0.83
Total net output (MWh/year)	9,855	13,403	6,544
Capacity factor - %	90	90	90
Operations (days/year)	329	329	329
Fuel volume (BDT/year)	8,999	10,770	5,358
Fuel cost ($/BDT)	$35, $45	$35, $45	$35, $45
Production Tax Credit ($/kWh)	0	0	0
Project capital cost ($million)	6.15	8.15	3.65
Amount of residual heat utilized – MMBtu/yr	7496	7485	7446
Sales price for heat ($/MMBtu)*[7]	$11	$11	$11
Project O&M cost excluding Fuel ($/year)	$550,700	$250,000	$250,000

The prices of electricity calculated for each of the three final technology vendors in Table 5-2 represent two financial scenarios and two fuel costs. Using the

[7] This is the equivalent price of using waste heat from the power plant to offset the cost of heating with propane. $11.00 per MMBtu is approximately the price that PFCC has been paying for propane

financial model and the inputs from Table 5-1Table 4-1, the scenarios calculated are as follows:

Financing with 100% Debt:

This scenario assumes that the facility would be developed using funds obtained from the State Financial Marketplace. Currently, there are no lenders posting interest rates for energy management financings (Energy $Mart). However, there are lenders posting interest rates for GS $Mart which provides financing for an “Installment Purchase” of assets. The interest rate posted under this category is 3.5%, and this is the interest rate assumed for the 100% debt financing cases[28]. The scenario was calculated using fuel costs of $35 and $45 per bone dry ton and the resulting prices of electricity for Phoenix Energy are $0.1199, and $0.1279 per kWh. A similar scenario and the resulting prices are shown for the other two finalists, Nexterra and Envio Energie.

Financing with Grant Funds:

In this scenario, funds for the project would be obtained through a grant. The funds would not have to be repaid so there would be no capital costs to the project. Consequently the prices for electricity for the grant cases are considerably less than the prices for the cases financed with debt that incur the cost of repaying the principal and interest of the debt. This scenario was also calculated using fuel costs of $35 and $45 per bone dry ton and the resulting prices of electricity for Phoenix Energy are $0.0768 and $0.0848 per kWh. A similar scenario and the resulting prices are shown for the other two finalists, Nexterra and Envio Energie.

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[8] www.ORIM.dgs.ca.gov/marketplace/default.htm

Table 5-2: Estimated Electricity Prices

Company	Financing	Fuel Cost/BDT	Price kWh needed
Phoenix Energy	Financing with 100% debt at 3.5% interest for 20 years	$35	11.99¢
	Financing with 100% debt at 3.5% interest for 20 years	$45	12.79¢
	Financing 100% with grant; no capital cost to project	$35	7.68¢
	Financing 100% with grant; no capital cost to project	$45	8.48¢
Nexterra	Financing with 100% debt at 3.5% interest for 20 years	$35	12.81¢
	Financing with 100% debt at 3.5% interest for 20 years	$45	13.61¢
	Financing 100% with grant; no capital cost to project	$35	7.18¢
	Financing 100% with grant; no capital cost to project	$45	7.98¢
Envio Energie	Financing with 100% debt at 3.5% interest for 20 years	$35	15.15¢
	Financing with 100% debt at 3.5% interest for 20 years	$45	16.07¢
	Financing 100% with grant; no capital cost to project	$35	10.52¢
	Financing 100% with grant; no capital cost to project	$45	11.43¢

The financial models used to calculate the electricity prices in Table 5-2 is shown in Appendix C. Presented below in Exhibit 5-1 is a graphical representation of the fuel cost sensitivity analysis for the three technology vendors using the 100% debt funded scenario with the cost of woody biomass fuel at $35 and $45 per bone dry ton. Presented in Exhibit 5-2 is a similar graphical representation using the low interest loan-funding scenario.

<u>Income From Sale of Electricity</u>

The prices shown in Table 5-2 are what must be received for the project to break even. However, if a price greater than these prices could be obtained from an electric utility or other purchaser, then the project would achieve a positive income.

Pacific Gas & Electric Company's Electric Schedule E-SRG, Small Renewable Generator PPA shows prices that PG&E will pay to renewable generators of not more than 1.5 MW. For facilities beginning in the year 2010, the prices vary by length of contract and are as follows:

- Ten year contract - 10.175 cents/kwhr
- Fifteen year contract - 10.748 cents/kwhr
- Twenty year contract - 11.390 cents/kwhr

Assuming that PFCC entered into a 20-year contract with PG&E, Table 5-3 shows the annual income that could be realized from each of the cases in Table 5-2 with a price less than 11.39 cents/kwhr. For the three technologies, each of their grant financing cases has a price less than 11.39 cents/kwhr, except for the $45/BDT case for Envio Energie. While Nexterra appears to offer the greatest potential for income, it would require a grant of $10,150,000, while the Phoenix alternative would require a grant of only $3,650,000.

Table 5-3. Potential Income from Sale of Electricity

Technology Grant Cases	Generation Kwhrs	Break Even Price Cents/kwhr	PG&E Price Cents/Kwhr	Difference in Price Cents/Kwhr	Income - $
Phoenix					
$35/BDT	6,543,720	7.68	11.39	3.71	242,772
$45/BDT		8.48		2.91	190,422
Nexterra					
$35/BDT	13,402,800	7.18	11.39	4.21	564,258
$45/BDT		7.98		3.41	457,035
Envio Energie					
$35/BDT	9,855,000	10.52	11.39	0.87	85,739
$45/BDT		11.43		-0.04	N/A

5.3. *Effect From Increased Thermal Use*

The ability to utilize residual heat from the biomass electric generating facility has a significant impact on the cost of the electricity generated. Only an estimated 15 percent of the residual heat could be utilized. Use of 100% of the waste heat is not practical, but use of 60% is feasible assuming a continuous use thermal host was available at the facility site (giving an overall thermal efficiency of about 80% for the facility). Using 60% of the residual heat would decrease the needed electricity price for the Phoenix Energy grant $35/BDT case to $0.014/kWh. Unfortunately, this is not the case at the PFCC site, and a biomass facility sited there would have to rely primarily on electricity sales.

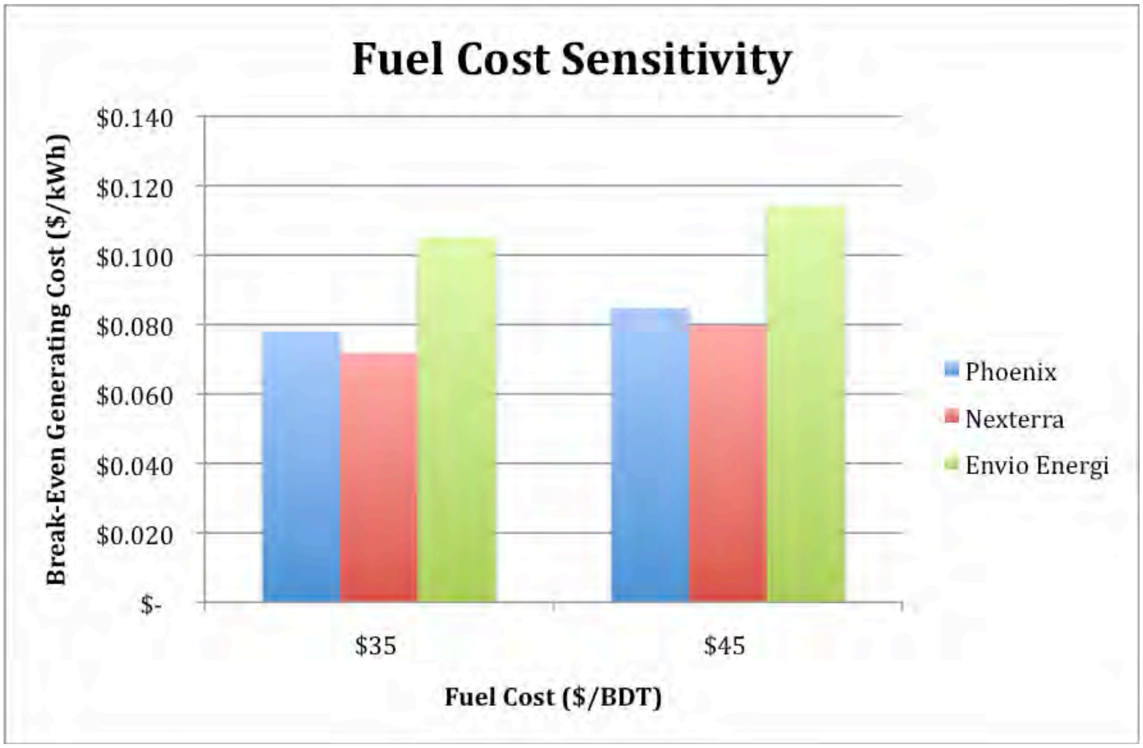

Exhibit 5-1. Fuel Cost Sensitivity Analysis – Electrical Production

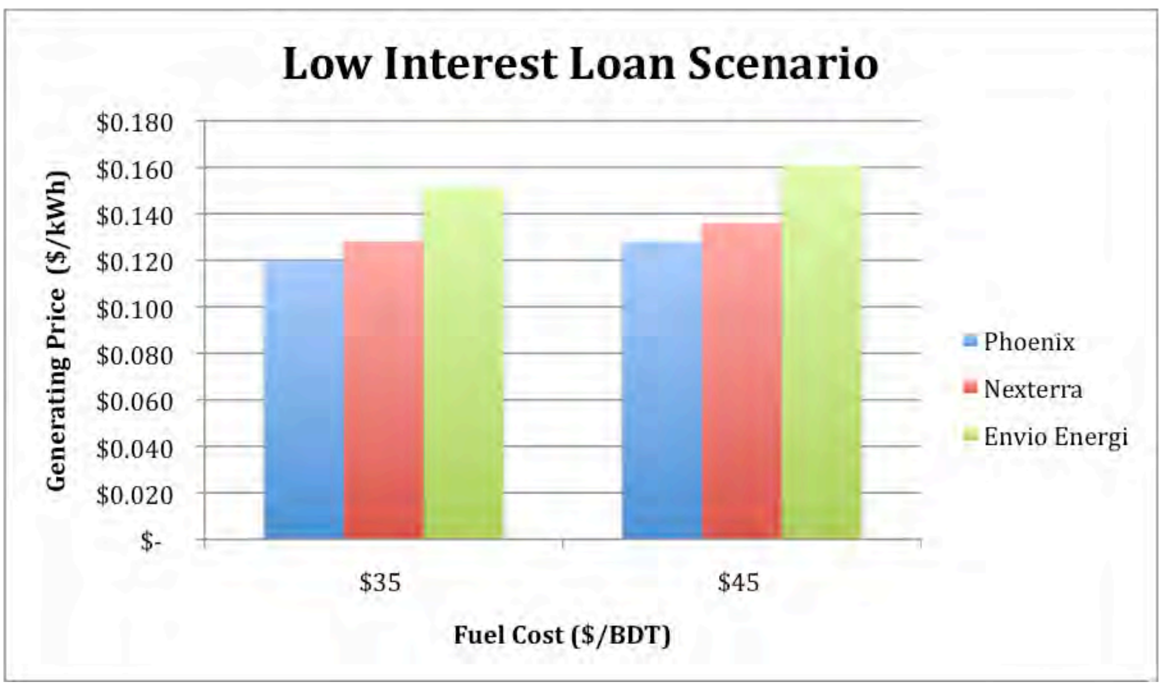

Exhibit 5-2. Low Interest Loan Break-Even Scenario

6. Environmental Review

Criteria to be used in the preliminary site assessment include:

- Air Quality
- Water Supply /Wastewater
- Solid Waste (ash)
- Land Use
- Noise
- Transportation
- Geology/Soils
- Power Transmission/Distribution

6.1. Air emissions and air quality standards

The PFCC project site lies within the jurisdiction of the Mendocino County Air Quality Management District (MCAQMD). Per MCAQMD Rule 1-200 (a) such a project must obtain an air quality permit (Authority to Construct) prior to construction and operation of a facility that emits air contaminants.

<u>Mendocino Air Quality Management District Requirements</u>

In conducting the air quality permitting process in the MCAQMD, the permitting process illustrated in Exhibit 6-1 below is initially dependent on the level of the air contaminants to be emitted. An application for air quality permit must be submitted to the MCAQMD, which requires the applicant to submit information sufficient to describe the nature and amounts of emissions; the location, design, construction, and operation of the source; and to submit any additional information requested by the District. The emissions information submitted is then subjected to whether or not there is a "significant" emission potential from the proposed facility.

The significance level of air contaminants potentially emitted from a proposed source is defined in Rule 1-130 and is as follows

> **Significant Emissions:** The potential of a new or modified source to emit air contaminants that would equal or exceed any of the following rates, calculated on the basis of 24-hour emissions profiles:

Air Contaminant	Significant Emissions Rate
CO	550 lbs. per day (22.9 lb/hour)
NOx	220 lbs. per day (9.2 lb/hour)
SOx	220 lbs. per day (9.2 lb/hour)
PM	135 lbs. per day (5.6 lb/hour)
PM-10	80 lbs. per day (3.33 lb/hour)
VOC	220 lbs. per day (9.2 lb/hour)

If the potential source does not exceed the significant rate threshold, then the permitting process does not have to include the New Source Review process and Best Available Control Technology analysis. If the significance level is not exceeded the MCAQMD could simply assign permit air emissions limits, conduct a California Environmental Quality Act (CEQA) review, with public notice, and issue the air quality permit. If a significance level were exceeded, the New Source Review process would be required with a BACT review for the various air contaminants listed above are exceeded in significance (Rule 1-220 (b)).

Table 6-1 compares the estimated emissions from the three technologies with the MCAQMD levels of significance. As can be seen in the table, all three technologies fall under the significance level, thus allowing for a shorter permitting process.

Table 6-1: Comparison of Technologies to MCAQMD Levels of Significance (in lbs/hour)

Air pollutant	Phoenix	Envio Energie	Nexterra	MCAQMD Significant Emission
CO	0.88	2.63	2.81	22.9
NOx	0.17	2.63	5.04	9.2
SOx	0.05	Neg.	0.01	9.2
VOC	0.17	0.11	1.05	9.2
PM10	0.08	0.519	0.0007	3.33

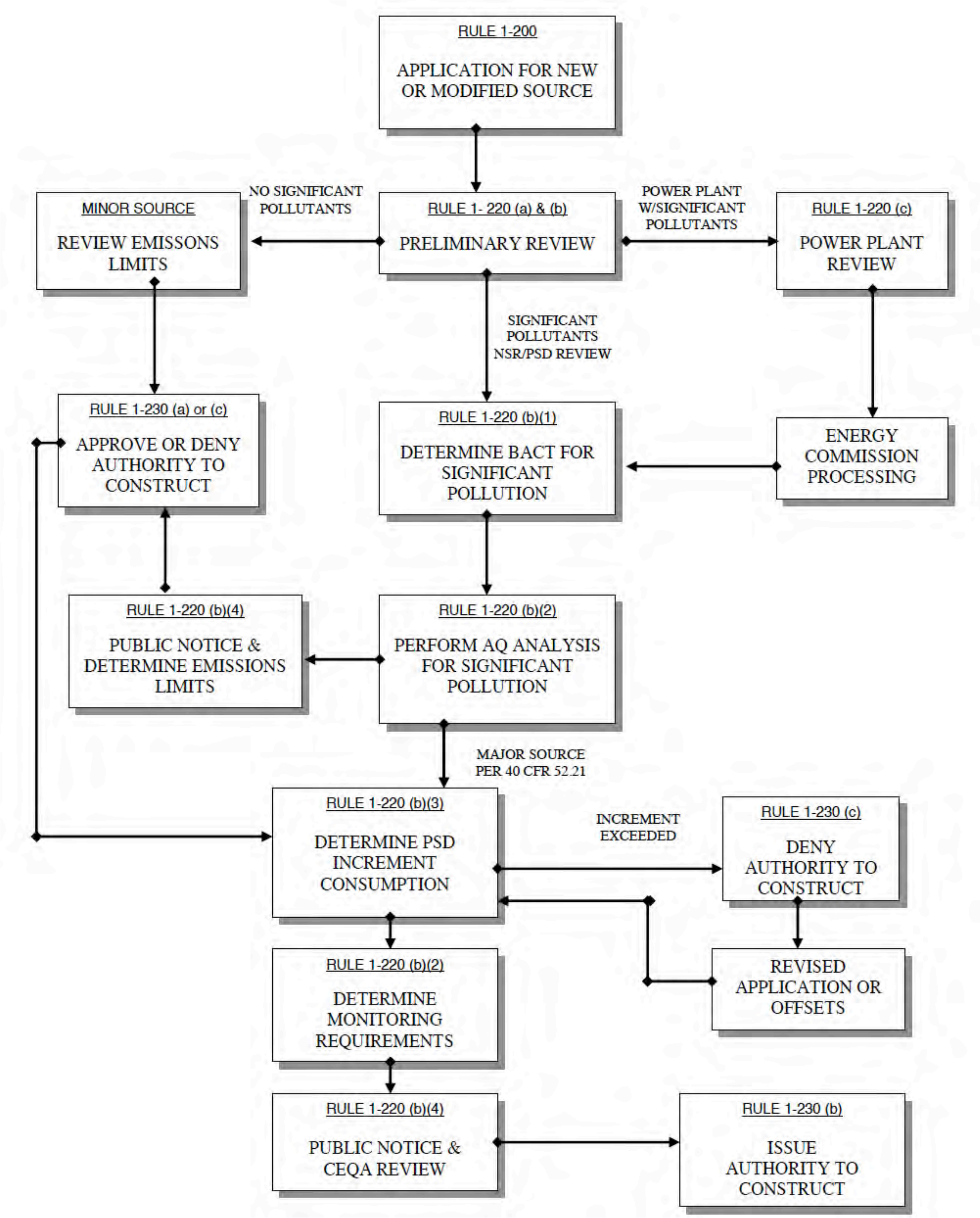

Exhibit 6-1. MCAQMD Permitting Process

6.2. *Water use/wastewater discharge*

Available water supply at the PFCC site is a significant constraint. Previous wells drilled to locate potential ground water supplies have been unsuccessful. Current water supply for the PFCC site is from the Noyo River, and is available up to 25,000 gallons per day. The PFCC reportedly uses and average of 19,000 per day[9]. Thus, up to 6,000 gallons a day might be available for a small power plant facility, however this extra water is based on an average usage, not firm. So, the water available for a small power plant could be much less.

The lack of water is particularly difficult for a steam cycle turbine generator, such as Envio Energie. A 1 to 2 MW unit would require approximately 5 to 8 gallons per minute (gpm) that would be 7,200 to 11,500 gallons per day. About a quarter of that amount would need to be discharged. As they is no industrial or commercial sewer system on site (or nearby), nor could such wastewaters be discharged to local streams, a steam cycle power plant would be extremely difficult to site at the PFCC site.

The gasification systems on the other hand, require little or no water, as they do not rely on the generation of steam to energize an electrical turbine. The reciprocating engine that drives the electrical generator uses the syngas from the gasifier. The Phoenix Energy gasification system uses a syngas cleanup system that does use some water for syngas cleanup and does have a very small cooling tower that cools and recycles water for the cleanup. There is some loss of water through evaporation, but should be less than 2,000 gallons per day. The water used in the gas cleanup is recycled and there is no discharge of the water. Nexterra has a non-water based syngas cleanup system.

6.3. *Solid Waste (Ash)*

Solid waste from a small power plant consists almost completely of ash from the combustion of woody biomass in a controlled system, such as a boiler, or gasification in a gasifier, yields approximately 3% ash per volume of woody biomass input. Therefore, 8,000 BDT of woody biomass would yield approximately 240 tons of ash per year.

This ash will either be disposed of in an appropriately permitted facility, or a product use for the ash will have to be found (i.e., use in building materials, road sub-base materials, or returned to the forest as a soil amendment). As the woody biomass to be used in the power plant will all be forest-sourced, it can be expected that the ash will be non-hazardous per California and federal regulations, i.e., it should not contain any constituents that would make it hazardous such as heavy metals.

[9] Memo from Steve Home, Chief Plant Operator PFCC to Dave Barsi, CALFIRE, July 28, 2009

However, to insure this, analytical sampling will be conducted on the ash during the initial operations.

6.4. Site Considerations - Land Use Conformance, Constraints and Noise

The PFCC is located within the boundaries of the Jackson Demonstration State Forest, on land owned by the State of California. In discussions with the Mendocino County Planning Department, land use on the site would be under the responsibility of the state. The compatibility of a small biomass power plant would have to be determined by the state, primarily through the California Environmental Quality Act (CEQA) process.

Through the CEQA process, the actual project to be constructed and operated would require to be described in some detail so an environmental assessment could be conducted to determine whether a Negative Declaration, Mitigated Negative Declaration, or an Environmental Impact Report must be conducted. This process will address any potential environmental impacts

Given the current use of a portion of the property, in part, for small sawmill (to be expanded), a small biomass power plant should be a compatible use. As mentioned above in Section 3, an appropriate site for the power plant would be next to the sawmill directly, particularly since there appears to be adequate space in the sawmill for a power plant and fuel yard and a drying kiln (which will use waste heat from the power plant) would also be sited in the same area.

The proposed facility will emit noise during operation of the gasification system and electrical generation on a 24/7 basis. The noise level should itself not be a nuisance. If a gasification system with reciprocating engines is installed, the engines should be placed in an insulated building to lessen the noise level.

6.5. Transportation

The supply of woody biomass to a power plant facility at PFCC can be brought to the facility in several ways: 1) as unground forest thinning and slash, 2) as whole logs, 3) woody biomass previously ground prior transport to the site, and as residuals from the onsite sawmill. However, assuming all woody biomass fuel would have to be brought to the PFCC site, and assuming 8,000 to 10,000 BDT is needed annually, this translate to about 2 large truck trailers per day. Along State Highway 20, which is the access route to the PFCC site, CALTRANS reports that the annual average daily traffic is 2,600 vehicles. Of these vehicles, 723 are reported to be trucks [10]. An

[10] CALTRANS, 2007 Annual Average Daily Truck Traffic on the California State Highway System, September 2008

average of two additional trucks to supply biomass fuel to PFCC would be an insignificant increase (0.27%).

6.6. Geology/Soils

The potential site of a small biomass power plant, located near the PFCC sawmill, is currently a relatively level area, principally formed of alluvial materials deposited by the adjacent Parlin Fork. The soils of the site should not present a problem to construction and operation.

The site is located in a medium level earthquake hazard zone, and approximately 15 miles west of the San Andreas Fault Zone (submerged offshore in the Pacific Ocean). The proposed plant will have to take seismic engineering of structures into account during design and construction.

6.7. Power Transmission

Pacific Gas and Electric (PG&E) reports that there is a need for electrical load stabilization between Fort Bragg and Willets. An electrical power plant at PFCC would aid in such stabilization.

There may be the need for a small substation for a power plant sited at the PFCC site. Power lines from the facility to the grid may be adequate, but will need to determined in an interconnect study.

7. Findings and Recommendations

7.1. Findings

The results of this preliminary feasibility study are as follows:

- Of the biomass utilization technologies reviewed, three technologies were further reviewed and evaluated. These three technologies were:
  - Phoenix Energy - gasification
  - Nexterra – gasification
  - Envio Energie – direct combustion
- It appears that a new biomass facility using all three of the technology leaders could be permitted at the potential PFCC site for construction and operation. However, the direct combustion system of Envio Energie would require a wastewater disposal system of some kind, which may be difficult to do on the site. A wastewater disposal pond would likely be necessary and land area constraints may prohibit this. In addition, the Envio technology would require a process water supply that appears unobtainable currently at the site
- To develop a biomass power plant using the three technologies, TSS analyses show that the prices needed with wood fuel at $35/BDT for the electric output would range from $0.12/kilowatt hour (kWh) to $0.15/kilowatt hour using low-interest loan financing at 3.5%. If a grant were obtained, this would lower dramatically to $0.072/kilowatt hour to $0.105/kilowatt hour. This would be the kWh price the facility would need from the utility that would purchase the electrical output of the biomass power plant.
- If a grant was obtained, given the current feed-in tariff from PG&E, the project could realize income from the Phoenix Energy facility at $0.037/kilowatt hour
- Regarding cogeneration potential at the PFCC site, only an estimated 15 percent of the residual heat could be utilized. Use of 100% of the waste heat is not practical, but use of 60% is feasible assuming a continuous use thermal host was available at the facility site (giving an overall thermal efficiency of about 80% for the facility). Using 60% of the residual heat would decrease the needed electricity price for the Phoenix Energy grant $35/BDT case to $0.014/kWh. Unfortunately, this is not the case at the PFCC site, and a biomass facility sited there would have to rely primarily on electricity sales.

7.2. Implications and Recommendations

Based on this analysis TSS has the following recommendations:

- As it appears that a new biomass power plant facility may be viable at the potential PFCC site, particularly if its capital costs are funded by a grant or even part of the state budget (assuming no payback of capital funds).
- The Phoenix Energy system has the lowest capital cost and therefore may be the easiest to fund via a grant or from state funds.
- A Phoenix Energy system of the same size evaluated in this assessment is under construction in the San Joaquin Valley. Operations are planned for Spring 2010. That project should be monitored closely to see if vendor claims are correct and equipment operates at commercial quality.
- The Phoenix Energy system reportedly has the lowest emissions. Their pending installation in the San Joaquin Valley should be monitored as an emissions source test is required by the district.
- Given the water supply constraints at the PFCC site, direct combustion power plant systems would not be recommended.

Appendix A: Solicitation of Interest

Appendix B: Facility Supplied Energy and Water Information

Appendix C: Financial Analysis Spreadsheets