Combined Heat and Power (CHP) Level 1 Feasibility Analysis

Prepared for

Company A

Anytown, USA

CHP

EPA COMBINED HEAT AND POWER PARTNERSHIP

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Company A
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1. Executive Summary

The EPA CHP Partnership has performed a Level 1 Preliminary Economic Analysis of the installation of a combined heat and power (CHP) system at the planned Company A dry mill ethanol facility in Anytown, USA.[1] The purpose of this analysis is to determine whether CHP is technically appropriate at this site and whether CHP would offer significant potential economic benefit to Company A, in order for the company to make a decision about whether to fund a more comprehensive study. The analysis has incorporated data on the electrical and thermal needs of the site, anecdotal data regarding site operations and existing equipment, and interviews with site personnel about the planned energy needs of the facility. The results indicate that the site is potentially a good candidate for a biomass-fueled CHP project.

To run an economic analysis of a system with this level of data required the use of simplifying assumptions and averages. This preliminary analysis should therefore be considered an indicator of technical and economic potential only. The EPA CHP Partnership does not design or install CHP systems and cannot guarantee the economic savings projected in this analysis. Where assumptions have been made, they are intended to be realistic or conservative. These assumptions will be detailed in the following report and suggestions will be provided as to the scope of engineering that would be part of a Level 2 Feasibility Analysis if Company A chooses to proceed to the next step of project development.

Construction is planned to begin in one year for the initial phase of a 108 million gallon per year (MGY) ethanol plant outside of Anytown, USA. The plant will be built in two phases, each with a capacity of 54 MGY. Steam needs for the first phase of 54 MGY capacity will be provided by packaged natural gas boilers. The Level 1 CHP analysis evaluated CHP as an option for the planned second phase of the facility, also sized at 54 MGY. The analysis evaluated two biomass-based boiler options—each generating approximately 3.1 megawatts (MW) of power through backpressure steam turbines before sending 150 psig steam to the ethanol production process. The CHP systems were evaluated in comparison to a baseline that assumed natural gas boilers without power generation. A 5.3 MW gas turbine CHP system and a non-CHP biomass boiler were also analyzed for comparison. The two biomass CHP options were evaluated to represent two biomass fuel supply scenarios: 1) the first option is based on purchasing local biomass fuel resources (45% moisture) at an average price of $15.00 per ton; 2) the second option

[1] The analysis was performed by Energy and Environmental Analysis, Inc,1655 N. Fort Myer Drive, Arlington, VA, 22209. EEA is a technical subcontractor supporting the EPA CHP Partnership.

is based on receiving biomass wastes (40% moisture) from local suppliers that would pay Company A a $20.00 per ton tipping fee. Table 1 presents the economic comparison of the various options. The comparisons are based on an average displaced electricity price of $0.0467/kilowatt-hour (kWh) and an average projected natural gas price of $9.40/million British thermal units (MMBtu).

Table 1 – Economic Comparison of CHP Options

	Base System - Natural Gas Boilers/ no CHP	Boiler/Steam Turbine CHP - Purchased Wood Fuel	Boiler/Steam Turbine CHP - Wood Waste Fuel	Gas Turbine CHP	Boiler/No CHP - Purchased Wood Fuel
CHP System Capacity (kW)	n/a	3,100	3,100	5,300	n/a
Net Installed Costs	n/a	$19,202,296	$19,202,296	$5,925,700	$15,709,240
Purchased Electricity Costs	$2,118,312	$926,565	$926,565	$143,182	$2,118,312
Natural Gas Boiler Costs	$14,765,520	$3,168,073	$3,168,073	$3,513,720	$3,168,073
CHP Fuel Costs	$0	$2,467,713	($3,016,094)	$12,576,875	$2,262,071
Incremental O&M Costs	$0	$893,172	$1,020,768	$253,764	$791,095
Standby Charges	$0	$111,600	$111,600	$190,800	$0
Annual Operating Costs	$16,883,832	$7,567,123	$2,210,912	$16,678,341	$8,339,550
Annual Operating Cost Savings	n/a	$9,316,709	$14,672,920	$205,491	$8,544,282
Simple Payback, Years	n/a	2.1	1.3	28.8	1.8

Conclusions from this preliminary analysis include:

- Both the biomass-based CHP systems and the gas turbine CHP system are good matches with the planned steam and power needs of the second phase of the Anytown, USA facility.

- The biomass-based CHP systems represent significant savings in operating costs compared to the natural gas boiler baseline. Annual cost savings range from approximately $9,300,000 for option 1 (based on purchased wood supplies) to close to $15,000,000 for option 2 (where Company A is paid to accept wood wastes). Simple paybacks for both biomass CHP options are 2.1 years or less.

- Installation of a biomass boiler represents a significant energy cost savings for Company A even without CHP. A wood boiler system without the steam turbine generator would generate about $8,500,000 in annual operating cost savings compared to the natural gas boiler baseline. Adding the steam turbine generator increases the annual savings by close to $800,000 at an estimated incremental capital cost of $3,500,000.

- Anytown, USA might offer incentives for biomass systems that could further enhance the economics of the CHP systems.

2. Preliminary Analysis Details and Assumptions

Facility Description

Company A is about to break ground on a $150 million state-of-the-art ethanol plant to be located in Anytown, USA. When completed, the plant will produce 108 millions gallons of ethanol a year, as well as co-products consisting of distillers dried grains with solubles (DDGS) and carbon dioxide (CO_2). The plant will be constructed in two 54 MGY phases. Phase 1 ground breaking and construction start-up is planned to begin within one year. The plant is expected to run continuously 24 hours a day, 350 days per year (8,400 hours/year).

Energy Requirements and Costs

Energy is the second largest cost of production for dry mill ethanol plants, surpassed only by the cost of the corn itself. The Company A facility will use significant amounts of steam for mash cooking, distillation, and evaporation. Steam needs for the first phase of 54 MGY capacity will be provided by three 1800 horsepower, packaged, natural gas boilers (180 MMBtu/hr total capacity). Natural gas will also be used for drying by-product solids (DDGS). Electricity will be used for process motors, grain preparation, and a variety of plant loads. As summarized in Table 2, each of the 54 MGY phases of the project are projected to have an average electricity demand of 5.4 MW and an average steam demand of 136,000 lb/hr of 150 psig steam (150 MMBtu/hr).[2] The three Phase 1 natural gas boilers have 30 MMBtu of excess steam capacity that will be utilized by Phase 2. Company A has secured a five-year contract for purchased power at an average rate of $0.0467/kWh. Company A also projects a long term delivered price of natural gas of $9.40/MMBtu.

[2] The facility will eventually include an adjacent CO_2 recovery plant that will have an average electric demand of 3,500 kW.

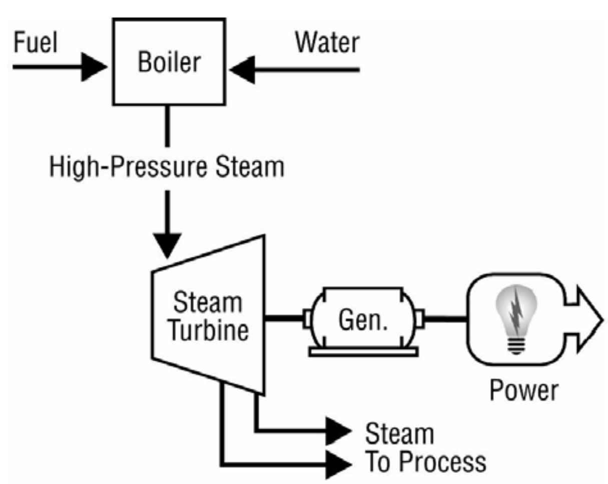
Table 2 –Projected Energy Requirements and Cost Summary

	Phase 1	Phase 2
Average Peak Electric Demand (kW)	5,400	5,400
Annual Average Electricity Consumption (kWh)	45,360,000	45,360,000
Average Steam Demand (lb/hr)	136,000	136,000
Average Steam Demand (MMBtu/hr)	150	150
Annual Steam Consumption (MMBtu)	1,260,000	1,260,000
Existing Boiler Capacity[3] (MMBtu/hr)	150	30
Annual Operating Hours	8,400	8,400
Average Purchased Power Costs ($/kWh)	$0.0467	
Projected Delivered Natural Gas Price ($/MMBtu)	$9.40	

Combined Heat and Power Options

Several CHP options were evaluated. All were designed to provide the 109,000 lb/hr of 150 psig steam required by the Phase 2 facility. Two are based on generating high pressure steam (800 psig, 700°F) in a biomass/wood-fired boiler, expanding this steam through a back pressure steam turbine to generate power, and using the low pressure steam (150 psig, 400°F) exhausting from the turbine for process needs (Figure 1). Both boiler/steam turbine CHP options are technically identical—a 110,000 lb/hr stoker boiler and a 3.1 MW back pressure steam turbine generator. The difference between the options is in the biomass/wood waste fuel sources. The first option is based on purchasing locally available wood waste resources (45% moisture) at an average price of $15.00/ton. The second option is based on utilizing urban wood wastes and other biomass wastes (turkey litter) from nearby sources (average of 40% moisture) and receiving a tipping fee of $20.00/ton.

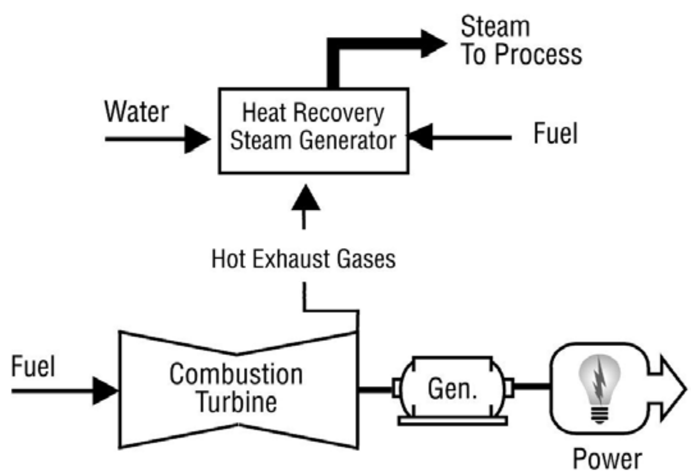
Figure 1: Boiler/Steam Turbine CHP



[3] Phase 1 includes three 1800 horsepower boilers that have 30 MMBtu/hr of excess steam capacity that will be utilized by Phase 2.

A gas- or combustion turbine-based CHP system was included in the analysis for comparison. Gas turbines have long been used in CHP applications, and the steam that can be generated from hot turbine exhaust matches the steam conditions (temperature and pressure) that the Company A facility requires. In this option, shown in Figure 2, a 5.3 MW packaged gas turbine, fueled by natural gas, drives an electric generator. Energy in the high temperature (900 to 1000°F) exhaust from the gas turbine is recovered to generate steam in the heat recovery steam generator (HRSG). Because the steam produced in the HRSG will be less than the plant steam requirements, duct burners would be used to generate additional steam. (The turbine exhaust still has about 15% oxygen which is sufficient to support further combustion.)

Figure 2: Gas Turbine CHP



A final option considered in this analysis was a non-CHP biomass/wood waste boiler. This system is similar to the boiler/steam turbine CHP options except that the boiler generates lower pressure steam (150 psig), which is sent directly to the ethanol process without generating power in a steam turbine. The key performance parameters of all four options are presented in Table 3.

Table 3 – CHP System Key Performance Parameters

System	Wood Boiler/Steam Turbine 1	Wood Boiler/Steam Turbine 2	Gas Turbine/HRSG	Wood Boiler/No CHP
Generating Capacity, kW	3,100	3,100	5,300	0
Boiler Efficiency, %	70%	70%	90%[4]	70%
Gas Turbine Electric Efficiency, %	n/a	n/a	26.9%[5]	n/a
Boiler/HRSG Outlet Steam Pressure, psig	800	800	150	150
Process Steam Pressure, psig	150	150	150	150
Unfired HRSG Steam Flow, lbs/hr	n/a	n/a	26,000	n/a
Steam Flow to Process, lbs/hr	109,000	109,000	109,000	109,000
Availability	98%	98%	95%	98%

Screening Analysis

Electricity Production

The average power demand for Phase 2 of the dry mill ethanol facility is estimated to be 5,400 kilowatts (kW); annual Phase 2 electricity consumption is estimated to be 45,360,000 kWh based on 8,400 hours per year operation. Assuming system availabilities of 98% for the boiler/steam turbine systems and 95% for the gas turbine, the CHP systems will provide 56% (boiler/steam turbine CHP) to 93% (gas turbine CHP) of Phase 2 electricity needs. Table 4 shows the electricity supply balance for the Phase 2 facility for the no-CHP base case and for the four options analyzed.

Table 4 – Annual Electricity Generation

System	Base Case	Wood Boiler/Steam Turbine 1	Wood Boiler/Steam Turbine 2	Gas Turbine/HRSG	Wood Boiler/No CHP
Average Demand, kW	5,400	5,400	5,400	5,400	5,400
Generating Capacity, kW	0	3,100	3,100	5,300	0
Purchased Electricity, kWh	45,360,000	19,841,000	19,841,000	3,066,000	45,360,000
Generated Electricity, kWh	0	25,519,000	25,519,000	42,294,000	0

<u>Recommended Activities for Level 2</u>: Electric demand for Phase 2 appears to be relatively level based on the initial data provided by Company A; however, assumptions on peak, average, and base electric loads should be reviewed in detail and specific seasonal and/or daily variations should be identified and included for system sizing and detailed economic calculations. A detailed electric profile would enable an accurate

[4] Supplemental steam raising efficiency for gas turbine HRSG duct burner
[5] Higher Heating Value efficiency, based on Manufacturer A's packaged gas turbine

analysis of purchased power savings and would ensure that the system is sized correctly for the application.

Budgetary Installation Costs

Preliminary budgetary cost estimates were developed for each option and included the following equipment:

- Wood boiler/steam turbine CHP options – 110,000 lb/hr stoker boiler (800 psig, 700°F); wood receiving and preparation yard and equipment; 3.1 MW backpressure (150 psig exhaust) steam turbine generator; basic switchgear and controls; an electrostatic precipitator and ancillaries

- Gas turbine CHP – Manufacturer A[6] packaged gas turbine generator; 150 psig HRSG with supplemental firing capability (110,000 lb steam/hour); basic electrical switchgear and controls

- Wood boiler/no CHP – 110,000 lb/hr stoker boiler (150 psig); wood receiving and preparation yard and equipment; an electrostatic precipitator and ancillaries

Budget costs are based on a turnkey installation and include engineering, labor, and commissioning. The cost estimates were based on published data and discussions with turbine developers and boiler/HRSG suppliers, with engineering rules-of-thumb applied for the cost of additional equipment and engineering, installation, and permitting costs. Total installed cost estimates for the four systems are detailed in Table 5 below.

[6] In a customized feasibility analysis, the EPA CHP Partnership would name actual equipment manufacturers to form the basis of this analysis.

Table 5 – Budgetary Cost Estimates

CHP System	Gas Turbine/HRSG	Wood Boiler/Steam Turbine 1	Wood Boiler/Steam Turbine 2	Wood Boiler/No CHP
Design Capacity (kW)	5,300	3,100	3,100	0
Turbine Genset Cost, $/kW	$450	$300	$300	n/a
Turbine Genset Cost	$2,385,000	$930,000	$930,000	$0
HRSG ($300/kW)	$1,060,000	-	-	-
Wood Handling/Prep Yard	-	$2,000,000	$2,000,000	$2,000,000
Stoker Boiler		$5,500,000	$5,500,000	$4,750,000
Electrostatic Precipitator and Ancillaries		$1,700,000	$1,700,000	$1,700,000
Other Equipment (e.g., interconnect, ancillaries)*	$861,250	$1,519,500	$1,519,500	$1,267,500
Total Equipment Cost	*$4,306,250*	*$11,649,500*	*$11,649,500*	*$9,717,500*
Construction (60% of total equipment cost)	$2,583,750	$6,989,700	$6,989,700	$5,830,500
Engineering (7% of Total Equip + Construction)	$482,300	$1,304,744	$1,304,744	$1,088,360
Permitting/siting (3% of Total Equip + Construction)	$206,700	$559,176	$559,176	$466,440
Contingency (3% of Total Equip + Construction)	$206,700	$559,176	$559,176	$466,440
Total Installed Costs	*$7,785,700*	*$21,062,296*	*$21,062,296*	*$17,569,240*
Costs, $/kW	$1,469	$6,794	$6,794	n/a

** Other Equipment costs assumed to be 25% of genset and HRSG equipment costs for gas turbine CHP, assumed to be 15% of genset, boiler, wood handling and ESP equipment costs for wood-fired systems*

Adoption of any of the above options would avoid the purchase of an additional 110,000 lb/hour of natural gas packaged boiler capacity for Phase 2. This avoided capacity is estimated to represent $1,860,000 in avoided costs, which were credited against the total costs outlined above for each option ($1,060,000 for boilers and ancillaries; $800,000 for installation and engineering).

Recommended Activities for Level 2: Following the electrical and system size/application decisions detailed in the previous sections, substantial preliminary design engineering (30%) would enable an accurate installation cost to be determined for each option considered in the Level 2 analysis. Assumptions about the availability of excess capacity from the existing (Phase 1) natural gas boilers and the estimate of avoided boiler costs need to be confirmed. Installation cost issues will have the single biggest impact on the return on investment for the project.

Emissions

Wood-fired systems of this size are assumed to require electrostatic precipitators for exhaust clean-up based on pending EPA rules. The gas turbine system is assumed to be able to meet emission requirements with dry low nitrogen oxide (NOx) combustion; no exhaust clean-up requirements are included in the analysis.

Recommended Activities for Level 2: This analysis did not consider the existing emissions at the Phase 1 facility nor how the introduction of wood or gas-fired CHP might affect overall emission levels at the facility (both Phase 1 and 2) or permitting (Prevention of Significant Deterioration [PSD]) thresholds. The level 2 analysis should evaluate costs associated with ongoing environmental compliance and reporting, and determine any additional requirements CHP might trigger. Once a decision to proceed with the project has been made, the site should engage qualified consultants to manage the environmental compliance, including confirmation of any anticipated requirements for emission permits and reporting processes and securing of construction permits.

Utility Interconnection

All options considered here would be designed to operate in parallel with the utility and will need to meet the local electric utility's interconnection and safety requirements.[7]

Recommended Activities for Level 2: Engage in preliminary discussions with the servicing utility regarding interconnection and capture all costs associated with meeting interconnection requirements.

Maintenance

Incremental maintenance requirements for each system on a per kWh basis are provided in Table 6. The costs for the wood/biomass boiler systems include incremental non-fuel operations and maintenance (O&M) costs for the boiler and electrostatic precipitator, wood yard and preparation, and steam turbine and generator. The costs were estimated to be slightly less for the wood boiler/no CHP system because of the absence of O&M costs for the steam turbine generator (estimated to be $0.004/kWh). The O&M costs for the gas turbine system are based on a service contract with the turbine supplier. Significant incremental labor costs are also included in the table for the wood/biomass systems to reflect the operation of the wood yard and fuel preparation facilities and for the complexities of the stoker boiler itself. An incremental labor cost was added to the

[7] "Parallel" with the utility means the on-site generation system is electrically interconnected with the utility distribution system at a point of common coupling at the site (common busbar) and facility loads are met with a combination of grid- and self-generated power. Interconnection requires various levels of equipment safeguards to ensure power does not feed into the grid during grid outages. A parallel configuration is in contrast to "grid isolated" operation, wherein the CHP system serves either the entire facility or an isolated load with no interconnection with the utility's distribution system. Grid isolated systems typically require increased capacity to cover facility peak demands and redundancy for back-up support.

boiler/steam turbine option 2 (using urban wood wastes and turkey litter) to reflect the additional efforts required to blend fuel stocks and process waste deliveries.

Table 6 – CHP System Non-Fuel O&M Costs

System	Wood Boiler/Steam Turbine 1	Wood Boiler/Steam Turbine 2	Gas Turbine/HRSG	Wood Boiler/No CHP
O&M Costs, $/kWh	$0.0200	$0.0200	$0.0060	$0.0160
Incremental Labor Costs, $/kWh	$0.0150	$0.0200	$0.0000	$0.0150

Recommended Activities for Level 2: A detailed maintenance proposal from the vendor of the equipment selected in the final design should be provided and the costs included in the final economic analysis.

Power Reliability – CHP System as Backup Power

The primary benefit of a CHP system is that it produces power for less money than separate heat and power. An additional benefit can be the use of the onsite capacity to provide backup generation in the event of a utility outage. In certain applications, the value of this additional reliability can outweigh all other factors in the investment decision.

In order to implement this capability, there are added costs to tie into the existing electrical systems that are beyond the scope of this level of analysis. Those costs can include engineering, controls, labor, and materials. The engineering required to analyze the existing electrical system, determine critical loads, provide a design, and determine cost to provide backup power from the system can be fairly costly.

The justification for this additional cost should be financial: it pays to do it if there is a way to account for the benefits in the financial analysis. One simple method is to offset the turnkey cost of a similarly sized backup generator against the incremental cost of the CHP system. There are other ways to account for the reliability benefits using assumptions of avoided catastrophic revenue losses due to utility blackouts. Regardless of how the benefits are quantified, it is important to provide some estimate that captures reliability benefits to balance the incremental costs associated with this added capability.

Recommended Activities for Level 2: If islanded operation in the event of a utility outage is desired, the engineering firm hired to perform the Level 2 analysis should be experienced in electrical design and use of CHP as a backup system. Extensive review of the site’s existing electrical system and identification of critical loads should be considered along with the system sizing criteria previously discussed in order to come up with the optimal system to meet the facility’s needs.

Baseline Energy Costs

As indicated earlier, Company A has secured a five-year contract for purchased power at an average rate of \$0.0467/kWh. Company A also projects a long term delivered price of natural gas of \$9.40/MMBtu. These prices were utilized in the analysis to estimate displaced power savings and for natural gas savings and costs. The price for locally available wood waste (45% moisture) was estimated to be \$15.00/ton based on Company A's information, which was used as the basis for the economic screening for boiler/steam turbine CHP option 1 and for the wood boiler/no CHP option. The boiler/steam turbine CHP option 2 was based on using urban wood wastes and biomass waste (40% moisture) that would be delivered to Company A along with a \$20.00/ton tipping fee. Table 7 summarizes the energy cost assumptions utilized in the economic analysis.

Standby charges of \$3.00/kW per month were assumed for the screening analysis. These charges are roughly equivalent to the cost of installing emergency diesel generators at the facility. Standby and backup services are needed to provide power to the facility when the onsite generators are down either for scheduled maintenance or for an unexpected outage.

Table 7 – Energy Cost Assumptions

	Wood Boiler/Steam Turbine 1	Wood Boiler/Steam Turbine 2	Gas Turbine/HRSG	Wood Boiler/ No CHP
Purchased Electricity Price, \$/kWh	\$0.0467	\$0.0467	\$0.0467	\$0.0467
Delivered Natural Gas Price, \$/MMBtu	\$9.40	\$9.40	\$9.40	\$9.40
Wood/Biomass Price, \$/ton	\$15.00	-\$20.00[8]	n/a	\$15.00
Wood/Biomass Moisture, %	45%	40%	n/a	45%
Standby Rates, \$/kW/month	\$3.00	\$3.00	\$3.00	n/a

Along with system installation costs, energy rates have the most dramatic impact on return on investment for a CHP system. The sensitivity of project economics to changes in displaced electric rates is included in the Economic Analysis section of this report.

<u>Recommended Activities for Level 2</u>: The average electricity price of \$0.0467 is a composite of demand and energy charges. A Level 2 analysis would need to evaluate the tariff schedule in detail, making sure to reflect the entire range of requirements and charges and the impact of peak demands and system downtime. In addition, the servicing utility will most likely have specific rates and requirements for standby and backup power that need to be reflected in the analysis.

[8] The negative price reflects a \$20.00/ton tipping fee paid to Company A for accepting urban wood waste and biomass waste (turkey litter).

3. Economic Analysis

Annual fuel and electricity consumption is shown in Table 8 for the non-CHP natural gas base case and for the four options evaluated as part of this analysis. The CHP systems provide 76% to 78% of the Phase 2 steam demand, depending on CHP system availability (assumed to be 98% for the boiler/steam turbine systems and 95% for the gas turbine system); 20% of Phase 2 steam demand is provided by the excess capacity of the existing Phase 1 natural gas boilers.

Table 8 – Energy Consumption Summary

	Base System - Natural Gas Boilers/ no CHP	Boiler/Steam Turbine CHP - Purchased Wood Fuel	Boiler/Steam Turbine CHP - Wood Waste Fuel	Gas Turbine CHP	Boiler/No CHP - Purchased Wood Fuel
Purchased Power, kWh	45,360,000	19,840,800	19,840,800	3,066,000	45,360,000
Generated Power, kWh		25,519,200	25,519,200	42,294,000	0
Nat Gas Boiler Steam, MMBtu/yr	1,256,640	269,623	269,623	299,040	269,623
CHP Steam, MMBtu/yr		987,017	987,017	957,600	987,017
Nat Gas Boiler Fuel, MMBtu/yr	1,570,800	337,029	337,029	373,800	337,029
CHP Fuel, MMBtu/yr		1,538,208	1,538,208	1,337,965	1,410,024

Table 9 provides annual operating savings and simple payback calculations for each CHP option based on an average displaced electricity price of $0.0467/kWh and a delivered price for natural gas of $9.40/MMBtu. Annual operating savings range from $222,000 for the gas turbine CHP system, to close to $14,700,000 for the wood boiler/steam turbine CHP system utilizing urban wood and other biomass wastes (this option includes tipping fees of $20.00/ton paid to Company A). The wood boiler/steam turbine CHP system fueled by purchased wood waste ($15.00/ton) provides $9,300,000 in annual operating savings. The wood boiler/no CHP option based on purchased wood wastes provides $8,500,000 in annual operating savings. Simple paybacks range from more than 28 years for the gas turbine system to 2.1 years or less for the wood-based systems. Additional details supporting Tables 8 and 9 are included in the appendix.

Table 9 – Economic Results

	Base System - Natural Gas Boilers/ no CHP	Boiler/Steam Turbine CHP - Purchased Wood Fuel	Boiler/Steam Turbine CHP - Wood Waste Fuel	Gas Turbine CHP	Boiler/No CHP - Purchased Wood Fuel
CHP System Capacity (kW):	n/a	3,100	3,100	5,300	n/a
Net Installed Costs:	n/a	$19,202,296	$19,202,296	$5,925,700	$15,709,240
Purchased Electricity Costs	$2,118,312	$926,565	$926,565	$143,182	$2,118,312
Natural Gas Boiler Costs	$14,765,520	$3,168,073	$3,168,073	$3,513,720	$3,168,073
CHP Fuel Costs	$0	$2,467,713	($3,016,094)	$12,576,875	$2,262,071
Incremental O&M Costs	$0	$893,172	$1,020,768	$253,764	$791,095
Standby Charges	$0	$111,600	$111,600	$190,800	$0
Annual Operating Costs	$16,883,832	$7,567,123	$2,210,912	$16,678,341	$8,339,550
Annual Operating Cost Savings:	n/a	$9,316,709	$14,672,920	$205,491	$8,544,282
Simple Payback, Years	n/a	2.1	1.3	28.8	1.8

The economics of this project are driven not only by the price of wood waste fuel compared to natural gas prices, but also by the price of electricity that the onsite generation displaces. Figure 3 maps the sensitivity of the simple payback calculations to the average price of displaced electricity for the wood boiler/steam turbine CHP system 1 and for the wood boiler/no CHP system (both based on $15.00/ton purchased wood costs). The simple payback of the CHP system approaches the payback of the non-CHP wood boiler system as displaced electricity prices increase. Both have a 1.84 year payback at an average electricity price of $0.09/kWh.

Figure 3 – Sensitivity to Electricity Price

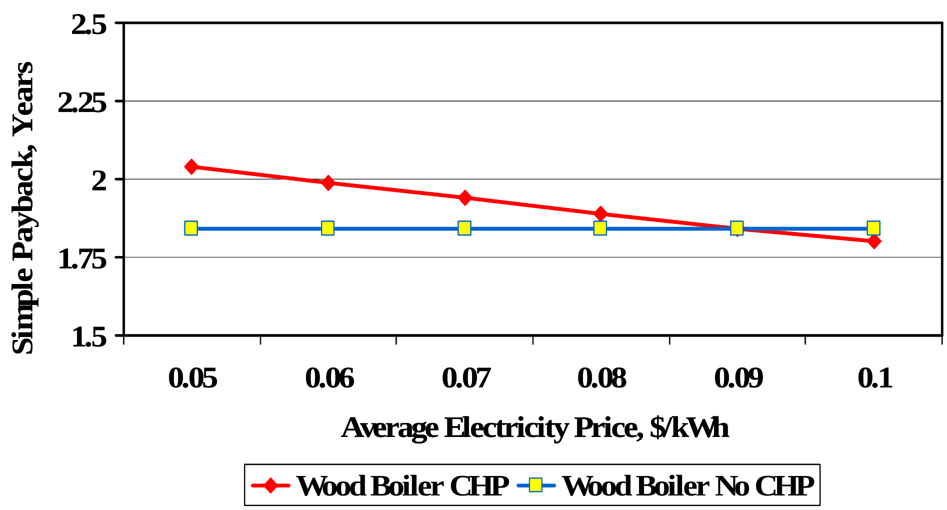
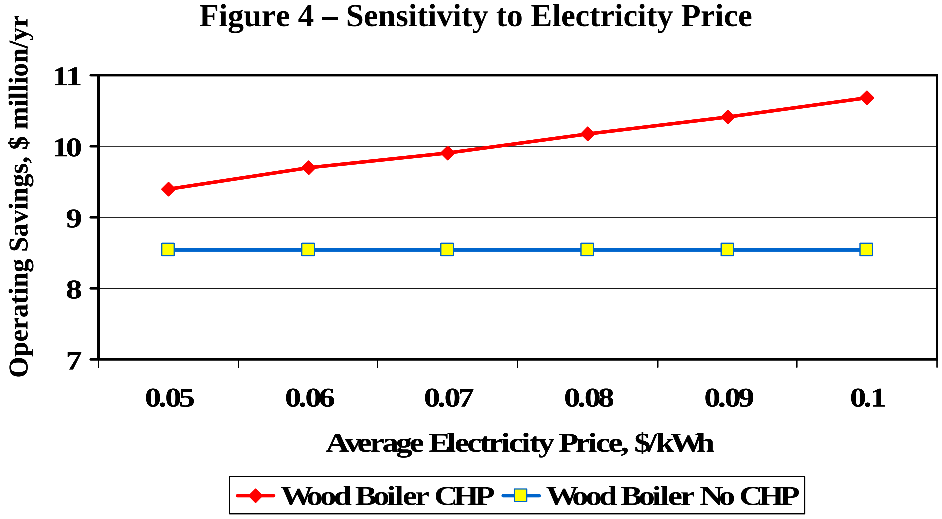


Figure 4 shows the sensitivity of the annual operating cost savings to the average price of displaced electricity for the wood boiler/steam turbine CHP system 1 and for the wood boiler/no CHP system (both based on $15.00/ton purchased wood costs). Annual cost savings increase significantly for the CHP system with rising electricity prices. Annual operating cost savings at $0.09/kWh are $10,400,000 for the CHP case compared to $8,500,000 for the wood boiler/no CHP option.

Figure 4 – Sensitivity to Electricity Price



Potential CHP and Biomass Incentives in Your State, USA

In a customized site-specific feasibility analysis, the EPA CHP Partnership will identify local, state, and federal incentive opportunities that encourage the use of CHP and biomass technologies and that could apply to the project being evaluated.

4. Conclusions

This analysis evaluated CHP as an option for the planned second phase of Company A's ethanol facility, sized at 54 MGY. The analysis included two biomass-based boiler options each generating approximately 3.1 MW of power through backpressure steam turbines before sending 150 psig steam to the production process. The CHP systems were evaluated in comparison to a baseline that assumed natural gas boilers without power generation. A 5.3 MW gas turbine CHP system and a non-CHP biomass boiler were also analyzed for comparison. The two biomass CHP systems represent two biomass fuel supply scenarios: 1) based on purchasing local biomass fuel resources (45% moisture) at an average price of $15.00 per ton; 2) based on receiving biomass wastes from local suppliers (40% moisture) that pay Company A a $20.00 per ton tipping fee.

Conclusions from this preliminary analysis include:

- Both the biomass-based CHP systems and the gas turbine CHP system are good matches with the planned steam and power needs of the second phase of the Company A facility.

- The biomass-based CHP systems represent significant savings in operating costs compared to the natural gas boiler baseline. Annual cost savings range from approximately $9,300,000 for the option based on purchased wood supplies to close to $15,000,000 for the option where Company A is paid to accept urban wood wastes and other biomass wastes. Simple paybacks for both biomass CHP options are 2.1 years or less.

- Installation of a biomass boiler represents a significant energy cost savings for Company A even without CHP. A wood boiler system without the steam turbine generator would generate about $8,500,000 in annual operating cost savings compared to the natural gas boiler baseline. Adding the steam turbine generator increases the annual savings by close to $800,000 at an estimated incremental capital cost of $3,500,000.

- Anytown, USA might offer incentives for biomass systems that could further enhance the economics of the CHP systems.

Appendix

Agri Ethanol Products LLC - Phase 2					
Plant Consumption Details					
Average Power Demand, kW		5,400			
Average Process Steam Demand, lb/hr		136,000			
Average Process Steam Demand, MMBtu/hr		150.0			
Excess Boiler Capacity, MMBtu/hr		30.0			
Net Average Process Steam Demand, MMBtu/hr		120.0			
Operating Hours		8,400			
Annual Power Consumption, kWh		45,360,000			
Annual Thermal Consumption, MMBtu		1,256,640			
Plant annual power to heat ratio		0.1			
Natural Gas Boiler Efficiency %		80%			
Standby Rate $/kW		$3.00			
Average Gas Cost $/MMBtu		$9.40	$9.40	$9.40	$9.40
Average Wood Cost, $/ton			$15.00	-$20.00	$15.00
Moisture Content, %			45%	40%	45%
Average Wood Cost, $/MMBtu			$1.60	-$1.96	$1.60
Average Cost of Power ($/kWh):		$0.0467	$0.0467	$0.0467	$0.0467
CHP Options					
Prime Mover		**Gas Turbine CHP**	**Boiler/Steam Turbine 1**	**Boiler/Stean Turbine 2**	**Wood Boiler/no CHP**
CHP Electric Capacity, kW		5,300	3,100	3,100	0
Boiler Efficiency, %			70%	70%	70%
Steam Output, PSIG			800	800	150
Steam Output, F			650	650	400
Steam Flow, lb/hr			109,000	109,000	109,000
Duct Burner Efficiency, %		91.0%			
Electrical Efficiency, HHV		26.9%			
MMBtu/hr Thermal Provided (unfired)		28.6	120.0	120.0	120.0
MMBtu/hr Thermal Provided (fired)		120.0			
Power to Heat Ratio		0.2	0.1	0.1	0.0
System Availability, %		95%	98%	98%	98%
System Hours of Operation		7,980	8,232	8,232	8,232
Power Generated Annually, kWh		42,294,000	25,519,200	25,519,200	0
Thermal Energy Generated Annually					
CHP Thermal, MMBtu/yr		228,228	987,017	987,017	987,017
Duct Burner Thermal, MMBtu/yr		729,372			
Capital Cost, $		$7,785,700	$21,062,296	$21,062,296	$17,569,240
CHP Capital Costs, $/kW		$1,469	$6,794	$6,794	na
Capital Cost Credit, $		($1,860,000)	($1,860,000)	($1,860,000)	($1,860,000)
Net Capital Cost, $		$5,925,700	$19,202,296	$19,202,296	$15,709,240
O&M Cost, $/kWh		$0.0060	$0.0200	$0.0200	$0.0160
CHP Incremental Labor, $/kWh		$0.0000	$0.0150	$0.0200	$0.0150
Economics					
Energy Summary					
	Base System	**Gas Turbine CHP**	**Boiler/Steam Turbine 1**	**Boiler/Steam Turbine 2**	**Wood Boiler/No CHP**
Purchased Power, kWh	45,360,000	3,066,000	19,840,800	19,840,800	45,360,000
Generated Power, kWh		42,294,000	25,519,200	25,519,200	0
Nat Gas Boiler Steam, MMBtu/yr	1,256,640	299,040	269,623	269,623	269,623
CHP Steam, MMBtu/yr		957,600	987,017	987,017	987,017
Nat Gas Boiler Fuel, MMBtu/yr	1,570,800	373,800	337,029	337,029	337,029
CHP Fuel, MMBtu/yr (CHP system + duct burner)		1,337,965	1,538,208	1,538,208	1,410,024
Cost Summary					
Electricity Costs:	$2,118,312	$143,182	$926,565	$926,565	$2,118,312
Boiler Fuel Costs:	$14,765,520	$3,513,720	$3,168,073	$3,168,073	$3,168,073
CHP Fuel	n/a	$12,576,875	$2,467,713	($3,016,094)	$2,262,071
CHP O&M	n/a	$253,764	$510,384	$510,384	$408,307
CHP Incremental Labor	n/a	$0	$382,788	$510,384	$382,788
Standby Costs	n/a	$190,800	$111,600	$111,600	$0
Total Annual Costs	$16,883,832	$16,678,341	$7,567,123	$2,210,912	$8,339,550
Annual Cost Savings		$205,491	$9,316,709	$14,672,920	$8,544,282
Simple Payback (Years):		28.8	2.1	1.3	1.8