Feasibility Study of Economics and Performance of Biomass Power Generation at the Former Farmland Industries Site in Lawrence, Kansas

A Study Prepared in Partnership with the Environmental Protection Agency for the RE-Powering America's Land Initiative: Siting Renewable Energy on Potentially Contaminated Land and Mine Sites

Gregg Tomberlin and Gail Mosey

Produced under direction of the Environmental Protection Agency (EPA) by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-09-1750 and Task No. WFD6.1001.

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-7A30-56962
March 2013
Contract No. DE-AC36-08GO28308

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Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721

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Acknowledgments

The National Renewable Energy Laboratory (NREL) thanks the U.S. Environmental Protection Agency (EPA) for its interest in securing NREL's technical expertise. In particular, NREL and the assessment team for this project are grateful to the former Farmland Industries facility managers, engineers, and operators for their generous assistance and cooperation.

Special thanks go to Dave Corliss, Eileen Horn, and Matt Bond from the City of Lawrence, Kansas, and to Shelley Brodie from EPA for hosting the site visit. The authors would also like to thank Diane Stoddard, Assistant City Manager for the City of Lawrence; Lura Matthews and Shea Jones of EPA; and Katie Brown, American Association for the Advancement of Science (AAAS) Science & Technology Policy fellow.

Executive Summary

The U.S. Environmental Protection Agency (EPA), in accordance with the RE-Powering America's Land initiative, selected the former Farmland Industries site in Lawrence, Kansas, for a feasibility study of renewable energy production. The National Renewable Energy Laboratory (NREL) was contacted to provide technical assistance for this project. The purpose of this study was to assess the site for a possible biopower system installation and estimate the cost, performance, and site impacts of different biopower options.

The former Farmland Industries Nitrogen Plant sits on 467 acres at the southern edge of Lawrence, Kansas. The plant formerly produced nitrogen-based fertilizer products but closed in 2001. The site is contaminated primarily with nitrate and ammonia and requires considerable remediation, which is ongoing. Approximately 300 acres of the site (65%) is not contaminated, allowing for redevelopment activities to take place concurrent with the remediation activities.

After some initial assessment work, it was determined that the prospective site in Lawrence would not be a good candidate for a biomass facility. A full feasibility study was not undertaken for this site as the preliminary assessment of the utility market, potential resources, and community goals demonstrated that a biopower facility had limited viability. The primary reason is that Kansas state regulations would require the city to enter a power purchase agreement (PPA) with the utility in order to sell the power not consumed on site. Currently, the state's renewable portfolio standard (RPS) is being met by wind power in central and western Kansas; therefore, there wasn't much demand for the power, and the potential PPA rate was too low to justify economically. Higher rates for renewable energy were not available because the renewable energy required to satisfy the state's RPS is currently provided by wind power in central and western Kansas. Energy from biomass power generation at the size range envisioned would not be competitive at this rate. The availability of abundant, low-cost biomass feedstock is another key component for a successful project. The biomass resources available for this site are limited and would require transport distances that would further harm the project economics. Additionally, it was learned that the office park planned for this site is intended to be more corporate than industrial, and the truck traffic from biomass fuel hauling is incompatible with this concept.

The feasibility of biopower systems installed on the Resource Conservation and Recovery Act (RCRA) site is highly impacted by the available biomass resource, operating status, ground conditions and restrictions, distance to transmission lines, and distance to major roads. Based on these factors, the implementation of a biomass facility at this location was not pursued. Consequently, a full feasibility study was not performed and our focus was turned to a more concise report that illustrates the basics of biomass power projects, the effort that was undertaken, and the key factors that affect the decision-making process. This report will cover some of the information gathered, illustrate more specifically the barriers encountered, and provide lessons learned from this process. This document outlines the key factors in determining if a biopower system is the appropriate technology for the context and can therefore serve as a guide for other cities considering how best to meet their renewable energy goals.

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1 Site Background

The former Farmland Industries site is located in Lawrence, Kansas. Lawrence is the sixth-largest city in Kansas and is the county seat of Douglas County. Lawrence is a college town and home to the University of Kansas and Haskell Indian Nations University. The population of Lawrence is 87,643.[1]

Under the RE-Powering America's Land initiative, the U.S. Environmental Protection Agency (EPA) provided funding to the National Renewable Energy Laboratory (NREL) to support a feasibility study of biomass renewable energy generation at the former Farmland Industries site in Lawrence, Kansas. The site is approximately 467 acres, of which approximately 300 acres are uncontaminated. The site operated as a nitrogen chemical plant and was in operation from 1954 to 2001.

The site has an aging substation located near the entrance that is to be relocated and updated with new electrical equipment. The site was a large industrial consumer of electricity and retains most of the associated infrastructure. Site access roads remain in service.

Feasibility assessment team members from NREL, the City of Lawrence, Kansas, and EPA conducted a site assessment visit on April 25, 2012, to gather information integral to this feasibility study. Information such as biomass resources, transmission availability, on-site uses for heat and power, community acceptance, and ground conditions were considered.

[1] "U.S. Census 2010." U.S. Census Bureau, July 2010. http://www.census.gov/2010census/.

2 Development of Biopower on the Former Farmland Industries Site

One very promising and innovative use of contaminated sites is to install biomass power (biopower) systems. Biopower systems work well on these sites where there is an adequate biomass fuel supply and favorable power sales rates.

The cleanup and reuse of potentially contaminated properties provides many benefits, including[2]:

- Preserving greenfields
- Reducing blight and improving the appearance of a community
- Raising property values, creating jobs
- Allowing for access to existing infrastructure, including electric transmission lines and roads
- Enabling potentially contaminated property to return to a productive and sustainable use.

Most states rely heavily on fossil fuels to operate their power plants. There are many compelling reasons to consider moving toward renewable energy sources for power generation instead of fossil fuels, including:

- Using fossil fuels to produce power may not be sustainable
- Burning fossil fuels can have negative effects on human health and the environment
- Extracting and transporting fossil fuels can lead to accidental spills, which can be devastating to the environment and communities
- Fluctuating electric costs are associated with fossil fuel-based power plants
- Burning fossil fuels may contribute to climate change
- Generating energy without harmful emissions or waste products can be accomplished through renewable energy sources.

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[2] *Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues.* U.S Environmental Protection Agency, OSWER Center for Program Analysis. http://www.epa.gov/oswercpa/docs/handbook_siting_repowering_projects.pdf.

3 Biopower Systems

Biomass consists of plant materials and animal waste used as a source of fuel. Biopower, or biomass power, is the use of biomass to generate electricity. Biopower system technologies include direct-firing, cofiring, gasification, pyrolysis, and anaerobic digestion. Most biopower plants use direct-fired systems which burn biomass directly to produce steam.

Co-firing refers to mixing biomass with fossil fuels in conventional power plants. Coal-fired power plants can use cofiring systems to significantly reduce emissions, especially sulfur dioxide emissions. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into synthesis gas, a mixture of hydrogen and carbon monoxide. The synthesis gas, or "syngas," can then be chemically converted into other fuels or products, burned in a conventional boiler, or used instead of natural gas in a gas turbine. Gas turbines are very much like jet engines, only they turn electric generators instead of propelling a jet. Highly efficient to begin with, they can be made to operate in a combined cycle, in which their exhaust gases are used to boil water for steam, a second round of power generation, and even higher efficiency.

Biomass fuels can come from many different sources. While most all of these can be used to produce fuel, their suitability for specific conversion technologies must be assessed. Typically, biomass for energy generation comes from the following sources:

- Wood, including forest residue, primary and secondary mill residues, wood pellets, and briquettes
- Fast-growing energy crops grown specifically for energy use (fast-growing trees, grasses)
- Agricultural and animal residue
- Food waste.

The amount of energy that can be produced by a biopower system depends on several factors, including the type of biomass, the technology employed, and numerous economic factors. Biopower systems can be sized to supply internal energy needs only or sized larger to feed energy to the grid for sale. Figure 1 shows a typical biopower direct-fired system.

Figure 1. Direct-fired biopower system. ***Photo by Mike McPheeters, NREL 07892***

These plants burn biomass feedstocks directly to produce steam. This steam drives a turbine, which turns a generator that converts the power into electricity. In some biomass applications, the turbine exhaust steam from the power plant is also used for manufacturing processes or to heat buildings. Such combined heat and power systems greatly increase overall energy efficiency. These systems normally operate 24 hours per day and 7 days per week with several weeks of downtime per year for maintenance and repairs. Plants of this type are not normally "cycled" with many starts and stops. Frequent cooling and reheating of the components leads to fatigue and failure making it better to operate constantly even though power rates are lower during off-peak hours. While direct-fired units are most common, the NREL biomass assessment team uses several tools to assess the optimal facility fuel, technology, plant size, and configuration.

Following the successful collection of biomass resource data, an analysis to determine the ideal system size must be conducted. System size depends highly on the average energy use of the facilities on the site, power purchase agreements (PPA), incentives available, and utility policy.

3.1 Types of Biopower Systems

Different types and sizes of biopower systems are considered depending on a several key variables. These include resource quantities and quality, thermal customer availability, local power purchase rates, and geographical considerations. Large plants range upward of 75 MW power production and smaller systems can be as small as a few megawatts if a thermal customer is available. The most common installation types are described below. In general, these systems can be divided into thermal energy only, power generation only and combined heat and power (CHP) categories. The system choice is mostly dependent upon economics. The cost of fuel, the rate that power can be sold, and the rate available for the sale of thermal heat are a few of the key economic parameters.

3.1.1 Thermal Energy Only

Figure 2 illustrates a thermal energy-only system. Biomass energy is converted to steam that is sent to a nearby steam customer that purchases the thermal energy in the steam for heating, cooling, manufacturing, or any other number of industrial uses. The steam is condensed as the energy is extracted, and the warm condensate is pumped back to the biomass facility where it is reintroduced to the boiler and converted once again to steam. This type of system can be economical as the inefficiencies associated with generating electrical power on a small scale are avoided, and the capital costs for a steam turbine, condenser, cooling tower, circulating water pumps, and other items are not incurred. High pressure, superheated steam is not required, making the boiler less expensive and easier to operate. This system is common and has been implemented for many decades in this country.

Finding a steam customer that is close enough to accept steam without lengthy piping systems is often challenging. In many cases where a steam customer is present, it also makes sense to generate both steam and electricity.

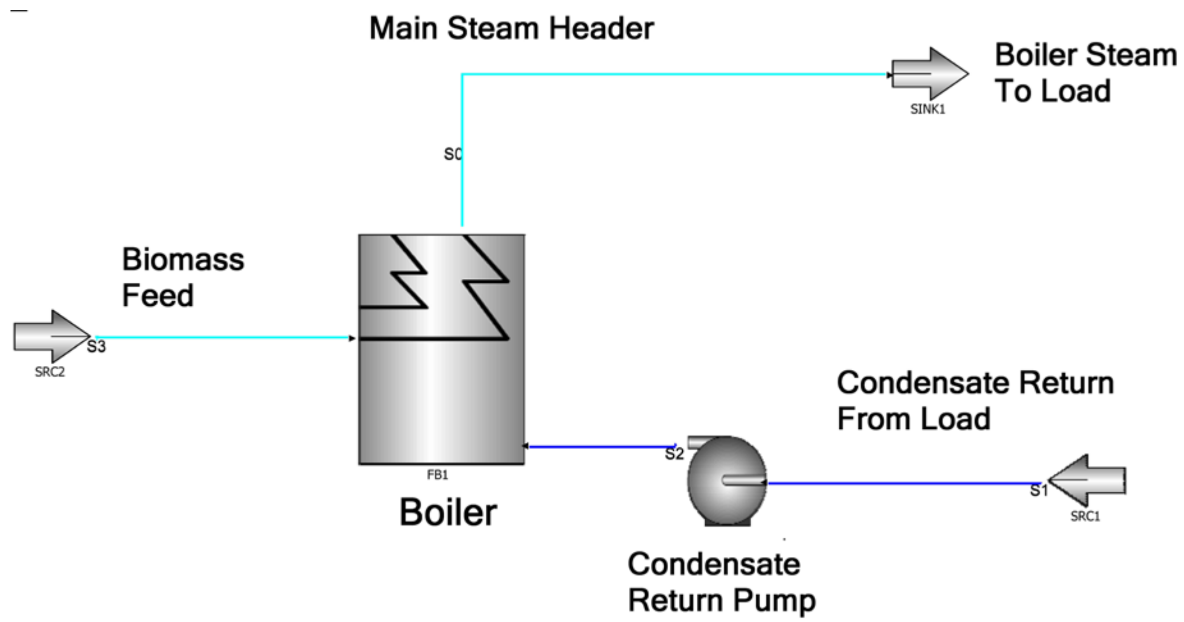

Figure 2. Thermal-only biomass energy system

3.1.1 Power Generation Only

Figure 3 illustrates a power generation-only system. In this case, biomass energy is converted into high pressure, superheated steam for introduction into a steam turbine. The turbine generates electricity at the most efficient rate practical, depending on the size of the system. The steam is condensed at near vacuum to maximize efficiency. This is accomplished in a condenser, which uses cooling water that comes from either an evaporative cooling tower or a dry-type air-cooled condenser. This type of system is economical if the power can be sold at a profitable rate and the cost of the biomass is not excessive.

Often, the power can be sold at higher than average rates due to requirements from renewable portfolio standards (RPS) or other incentives. An RPS is a regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal. RPS regulations vary from state to state.

The RPS mechanism generally places an obligation on electricity supply companies to produce a specified fraction of their electricity from renewable energy sources. Certified renewable energy generators earn certificates for every unit of electricity they produce and can sell these along with their electricity to supply companies. Supply companies then pass the certificates to some form of regulatory body to demonstrate their compliance with their regulatory obligations.[3] If the fraction of renewable energy is satisfied in a particular state, implementing additional renewable generation sources becomes more difficult.

[3] American Wind Energy Association. www.AWEA.org.

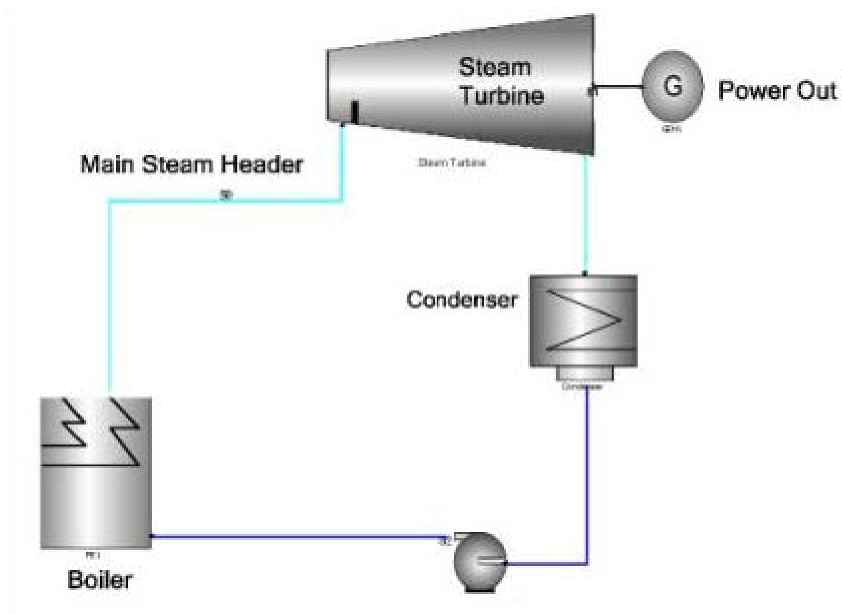

Figure 3. Power generation-only biomass energy system

3.1.1.1 Combined Heat and Power (CHP)

CHP is technically the concurrent generation of multiple forms of energy in a single system. CHP systems can include reciprocating engines, combustion or gas turbines, steam turbines, microturbines, and fuel cells. These systems are capable of utilizing a variety of fuels, including natural gas, coal, oil, and alternative fuels. While generating electric power, the thermal energy from the system can be used in direct applications or indirectly to produce steam, hot water, or chilled water for process cooling.

For biomass direct-fired systems, the most common CHP configuration consists of steam from a biomass-fired boiler directed to a steam turbine. Steam is extracted at some point in this process to provide heat internal to the facility or steam for sale to a local steam customer. The steam can be taken from the power process via three primary methods:

1. Main-steam extraction
2. Extraction turbine
3. Back-pressure turbine.

Main-steam extraction extracts some of the boiler outlet steam prior to being introduced into the steam turbine. This high pressure, high temperature steam would typically have to be reduced in pressure and temperature prior to its final use. This is not the most efficient method for optimizing power output but avoids the cost of a more expensive extraction turbine, which is described below. The remaining steam runs through the entire length of the turbine and then discharges into a condenser at very low pressure (vacuum) to maximize the electric power generated. The condenser circulates large quantities of cooling water that is cooled by evaporation in a cooling tower or by an air-cooled condenser. By far the most common cooling method is a cooling tower, as it is less expensive and requires less power to operate although a large quantity of water is evaporated. An air-cooled condenser is more expensive but is advantageous where large volumes of water are not available or water is expensive.

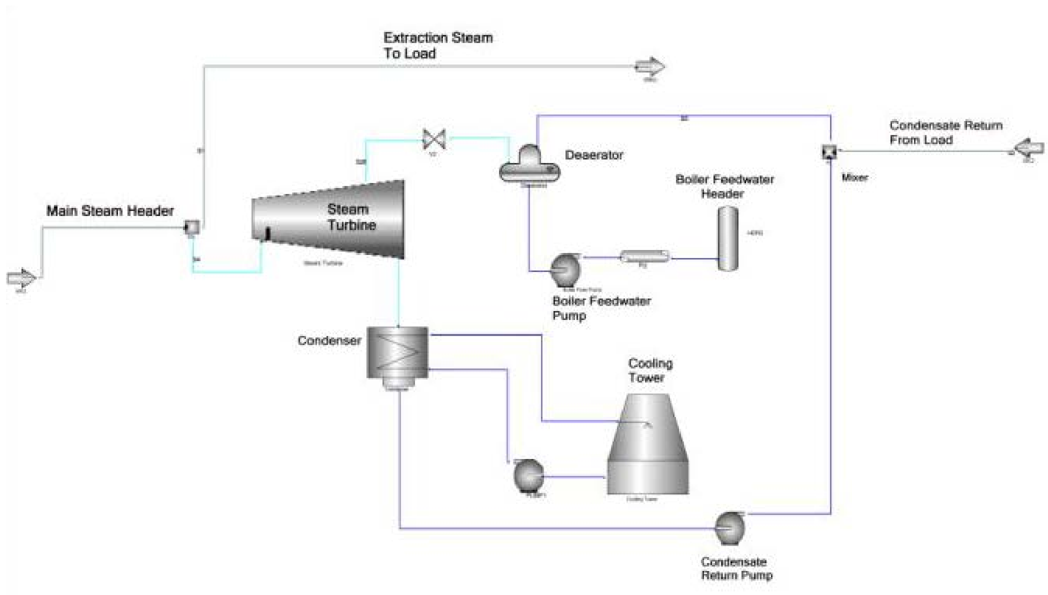

Figure 4. CHP—Main steam extraction

The **extraction turbine** accepts all of the boiler steam at its inlet and extracts the required process steam required at some intermediate point along the turbine steam path. This allows for the process steam to produce electric power prior to its extraction, increasing the efficiency of the overall process. This cost for an extraction turbine is typically higher and is not normally utilized in smaller systems (less than 10 MW). The remaining steam continues through the lower pressure stages of the turbine and then discharges into a condenser.

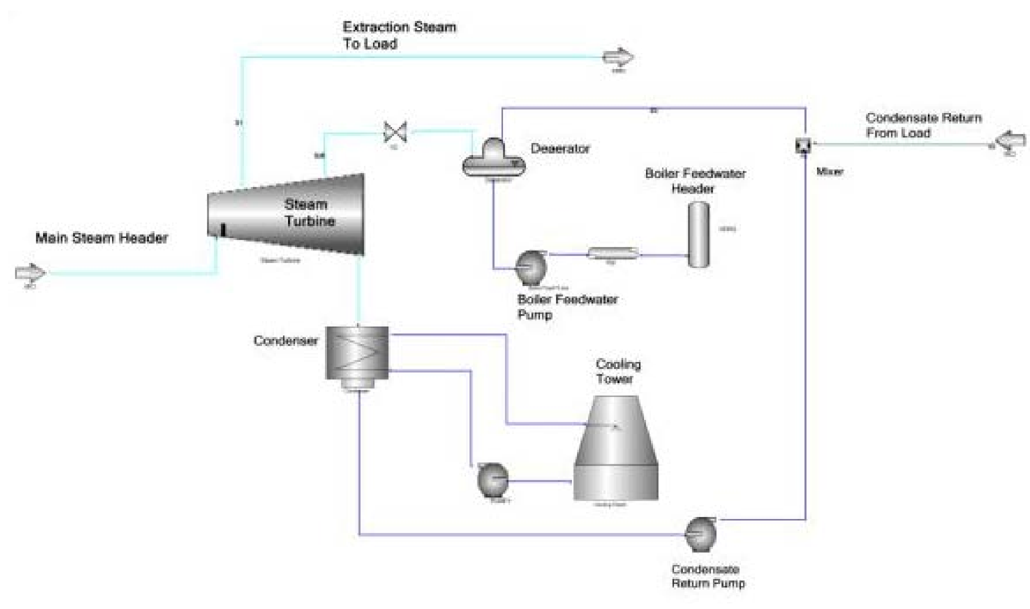

Figure 5. CHP—Extraction turbine

The **back-pressure turbine** accepts all boiler steam at the steam turbine inlet but discharges all of the steam at a higher pressure at the turbine exhaust. This pressure coincides with the pressure required by the end steam user. There are considerable cost savings with this approach. The steam turbine is much less expensive because the lower-pressure sections of a turbine are the largest and costliest. There is no need for a condenser, a cooling tower, or large circulating water pumps to push the cooling water through the condenser. The steam customer typically condenses the steam and returns it to the plant as warm condensate to be reheated and reintroduced to the system.

There are two disadvantages to this arrangement. Firstly, the amount of electric power produced is greatly reduced due to the shortening of the turbine and the relatively high discharge pressure. Secondly, if the steam customer reduces its steam requirements to a number less than the full steam turbine capacity, the steam turbine must be either turned down or the excess steam must be condensed by way of an external steam condenser, which would also require a cooling water source.

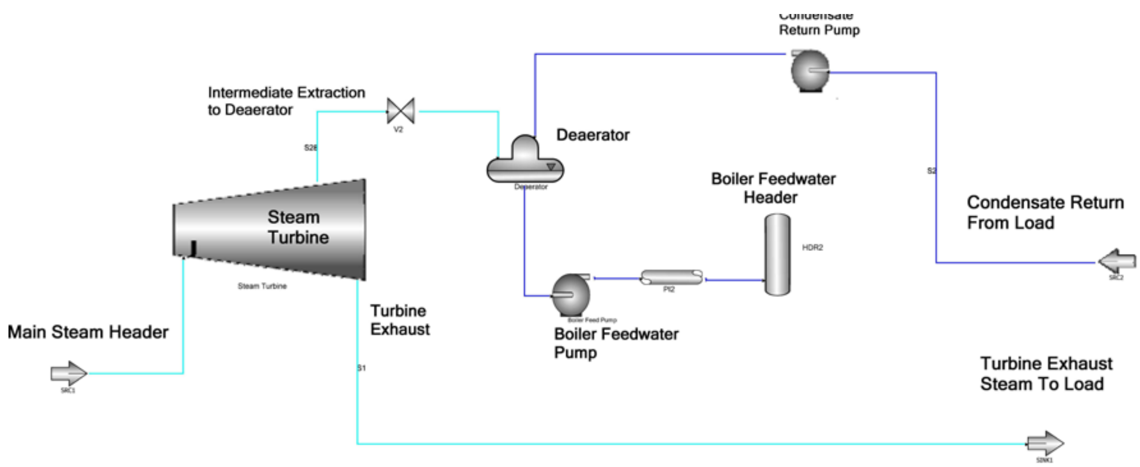

Figure 6. CHP—Back-pressure turbine

3.2 Biopower System Components

A typical direct-fired biopower system has the following components:

- Major Components
  - Fuel receiving, storage and handling
  - Combustion system and steam generator
  - Steam turbine
  - Air pollution control
  - Condenser and cooling tower
- Other Equipment and Auxiliaries
  - Stack and monitoring equipment
  - Instrumentation and controls

- Ash handling
- Fans and blowers
- Water treatment
- Electrical equipment
- Concrete
- Structural steel
- Pumps and piping
- Buildings.

3.2.1 Fuel Handling

Biomass can be received at the site by truck, rail, or barge. It can be delivered as chips or pellets or logs and brush that can be processed into chips on site. Wood chips are typically stored in a fuel yard (exposed or covered) or in storage silos as shown in Figure 7 below. Wood pellets are stored in silos and are easily handled and fed with standard equipment.

Figure 7. Biomass storage options—fuel yard. ***Photo by Warren Gretz, NREL Pix 06374***

3.2.2 Combustion System and Steam Generator

The most common system for converting solid biomass fuel into energy is a direct-fired combustion system. The fuel is typically burned on a grate or in a fluidized bed to create hot combustion gases that pass over a series of boiler tubes transferring heat into water inside the tubes creating steam. The combination of the burning apparatus and the heat transfer surface areas are typically referred to as the "boiler."

Boilers are differentiated by their configuration, size, and the quality of the steam or hot water produced. Boiler size is most often measured by the fuel input in millions of british thermal units per hour (MMBtu/hr), but it may also be measured by output in pounds per hour of steam produced. The two most commonly used types of boilers for biomass firing are stoker boilers and fluidized bed boilers. Either of these combustion systems can be fueled entirely by biomass fuel or cofired with a combination of biomass and coal or other solid fuel.[4]

In a stoker grate, the grate slowly moves the fuel through the hot zone until combustion is complete and the ash falls off at the opposite end. The fuel is either dropped onto the grate and travels away from the feeder, or it is thrown to the opposite end and comes back toward the feeder. The latter is called a "spreader stoker." In a fluidized-bed boiler, fuel is introduced into the bed with a heat transfer medium (typically sand). The bed material is fluidized using high pressure air from underneath the grate, creating a good mixing zone.

3.2.3 Steam Turbine

The steam turbine is a key component and major cost element for the facility. In many cases, additional cost can result in increased turbine efficiency, which must be assessed with regard to overall plant economics. The higher the steam inlet pressure and the lower the steam exhaust pressure, the more energy can be extracted from the steam. These both come at a cost and have to be balanced with the system economics. Typically, smaller systems use lower-pressure steam and larger systems can afford to operate at higher pressures, yielding more power production to compensate for the increased capital costs.

3.2.4 Air Pollution Control

Biomass is a relatively clean fuel and contains very small quantities of the pollutants commonly found in coal and other solid fuels. The primary pollutants of concern in biomass combustion are carbon monoxide (CO), nitrogen oxides (NOx), and particulate matter (PM).

Carbon monoxide emissions are largely a function of good combustion. Good air mixing will oxidize most CO molecules into carbon dioxide ($CO_{2)}$, which is not a regulated pollutant. The control of nitrogen oxides is not always required but can be controlled by either selective non-catalytic reduction (SNCR) or selective catalytic reduction (SCR). SNCR is accomplished by the introduction of nitrogenous reagents (urea or ammonia) at specific temperatures, creating a reducing reaction. SCR is a similar process but also uses a catalyst to achieve higher removal efficiencies.

For particulate matter, the small ash particles are captured in the fabric of large bags, and the bags are pulsed occasionally to dislodge the dust into an ash hopper for removal. These systems are known as fabric filters or "baghouses." Electrostatic precipitators (ESPs) are also commonly used for particulate removal.

3.2.5 Condenser and Cooling Tower

As the steam exits the steam turbine, it is condensed for reuse in the cycle. The most common method is to use a steam surface condenser and a cooling tower. The surface condenser is a large vessel filled with tubes that circulate cool water. The steam flows over the tubes, condensing into a hot well at the bottom of the condenser. The warm cooling water that leaves the condenser is

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[4] "Biomass Combined Heat and Power Catalog of Technologies." U. S. Environmental Protection Agency Combined Heat and Power Partnership, September 2007. http://www.epa.gov/chp/documents/biomass_chp_catalog.pdf.

pumped back to a cooling tower that uses evaporative cooling to cool the water for reintroduction into the condenser.

A large amount of water is lost due to evaporation from the cooling tower, and that water needs to be replaced on a continuous basis. In areas where water is scarce and expensive, this introduces a large operating cost. In these cases, the water is commonly cooled by an air-cooled system. The capital costs for this equipment is higher and the electric power to operate the fans is higher, but little water is consumed with this method.

4 Biomass Resource Assessment

A resource assessment was performed, reviewing the availability of biomass fuel potential in the area.

4.1 Biomass Types Assessed

The following types of biomass assessed were forest residue, primary mill residues, urban and secondary mill residues, and fast-growing energy crop residues.

4.1.1 Forest Residue

This category includes logging residues and other removable material left after carrying out silviculture operations and site conversions. Logging residue comprises unused portions of trees, cut or killed by logging and left in the woods. Other removable materials are the unutilized volume of trees cut or killed during logging operations.[5]

4.1.2 Primary Mill Residues

This category includes wood materials (coarse and fine) and bark generated at manufacturing plants (primary wood-using mills) when round wood products are processed into primary wood products. These residues include slabs, edgings, trimmings, sawdust, veneer clippings and cores, and pulp screenings.[6]

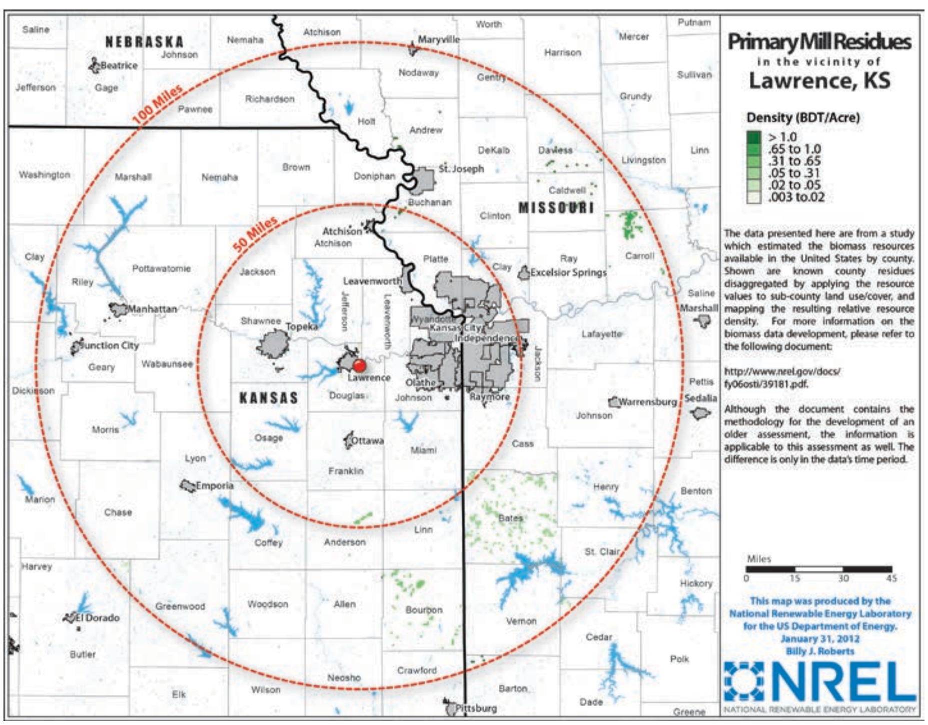

Figure 8. Primary mill residues near Lawrence, Kansas

[5] USDA, Forest Service's Timber Product Output Database, 2007.
[6] USDA, Forest Service's Timber Product Output Database, 2007.

4.1.3 Urban and Secondary Mill Residues

This category includes wood residues from municipal solid waste (MSW) (wood chips and pallets), tree trimming residues from utilities and private tree companies, and construction and demolition sites.[7]

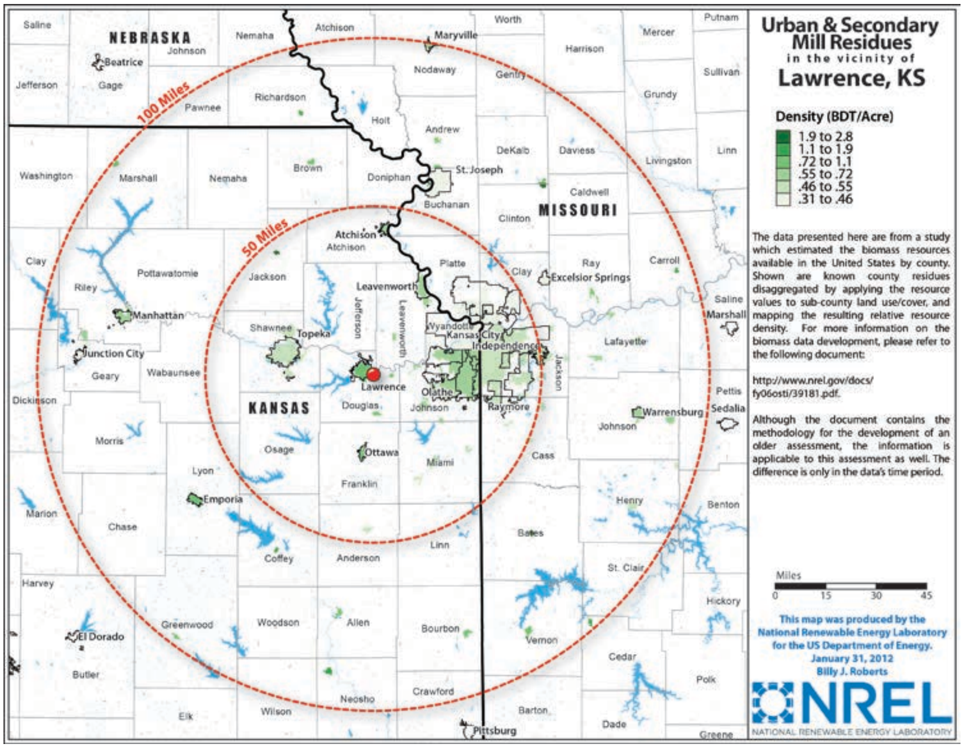

Figure 9. Urban and secondary mill residues near Lawrence, Kansas

4.1.4 Fast-Growing Energy Crop Residues

This category includes the following crops: corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed. The quantities of crop residues that can be available in each county are estimated using total grain production, crop to residue ratio, moisture content, and taking into consideration the amount of residue left on the field for soil protection, grazing, and other agricultural activities.[8]

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[7] U.S. Census Bureau, 2000 Population Data; Kaufman, S.; Goldstein, N.; Millrath, K.; Themelis, N. "State of Garbage in America." BioCycle Journal (45:1), January 2004. http://www.biocycle.net/2004/01/the-state-of-garbage-in-america; County Business Patterns, 2002.

[8] USDA, National Agricultural Statistics Service; 5-year average: 2003-2007.

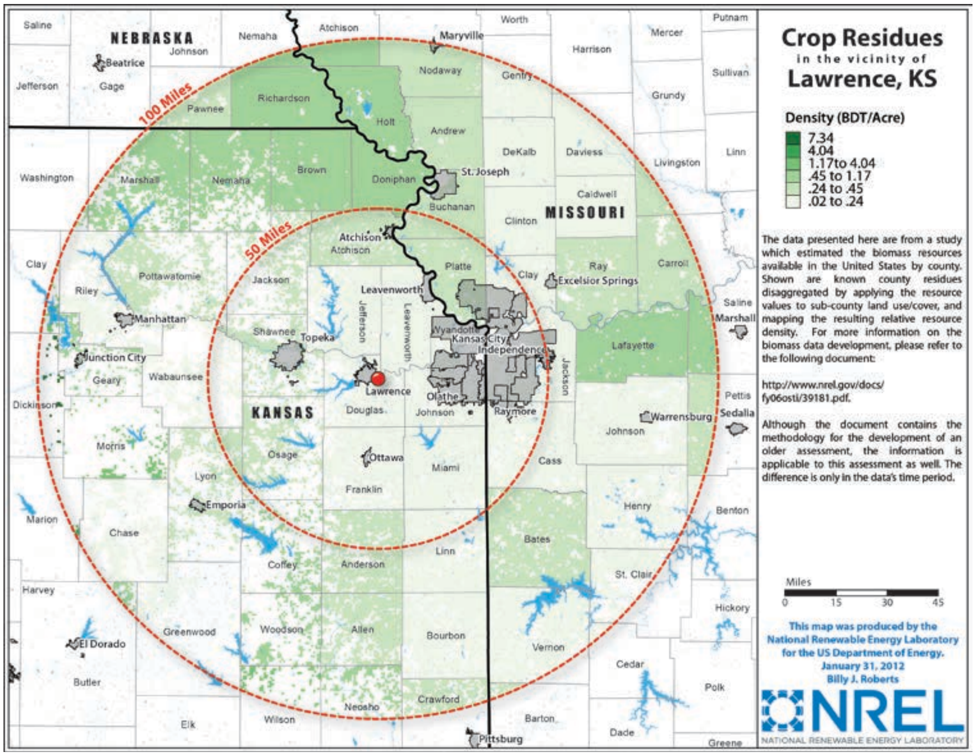

Figure 10. Crop residues near Lawrence, Kansas

4.2 Resources Assessment Results

Based on the biomass resource maps shown herein, woody biomass is the only resource with sufficient quantities and availability to be considered. A preliminary analysis of the forest and related woody-waste resources in the region indicates there is a marginal availability of woody biomass in the area surrounding Lawrence. Research indicates that biomass resources are more substantial in the eastern part of the state around Kansas City. The cost for biomass chips was not determined because the project was not pursued for other reasons. It is reasonable to assume the cost would be between $25 and $40 per green ton.

The data used in this analysis is derived from a nationwide biomass resource assessment completed by NREL in 2008. More information about the assessment is available at http://www.nrel.gov/gis/biomass.html.

5 Proposed Installation Location Information

This section summarizes the findings of the NREL biomass assessment site visit on April 25, 2012.

5.1 General

The former Farmland Industries site is managed by the city of Lawrence. The site is well suited in many aspects for a biomass power generation system as there are about 300 acres of uncontaminated site available, including infrastructure such as access roads, buildings, and utilities. The topography is relatively flat and the existing buildings are distant from one another. The biopower site itself would only require approximately 6 to 10 acres, depending on the size and fuel storage requirements.

The site has some desirable qualities, including being located off of a main multi-lane highway as shown in Figure 11. Trucks could enter the site easily off of the main highway, which has direct access to the Kansas City area. Ready access to transportation could enable high-volume delivery of biomass feedstock at a scale required for a large-scale biopower facility. Figure 12 shows an overview of the site looking northeast.

Given the existing infrastructure, the large blocks of land suitable for redevelopment, the existing substation and the adjacent highway, the site is very suitable for a biomass plant or any number of industrial installations.

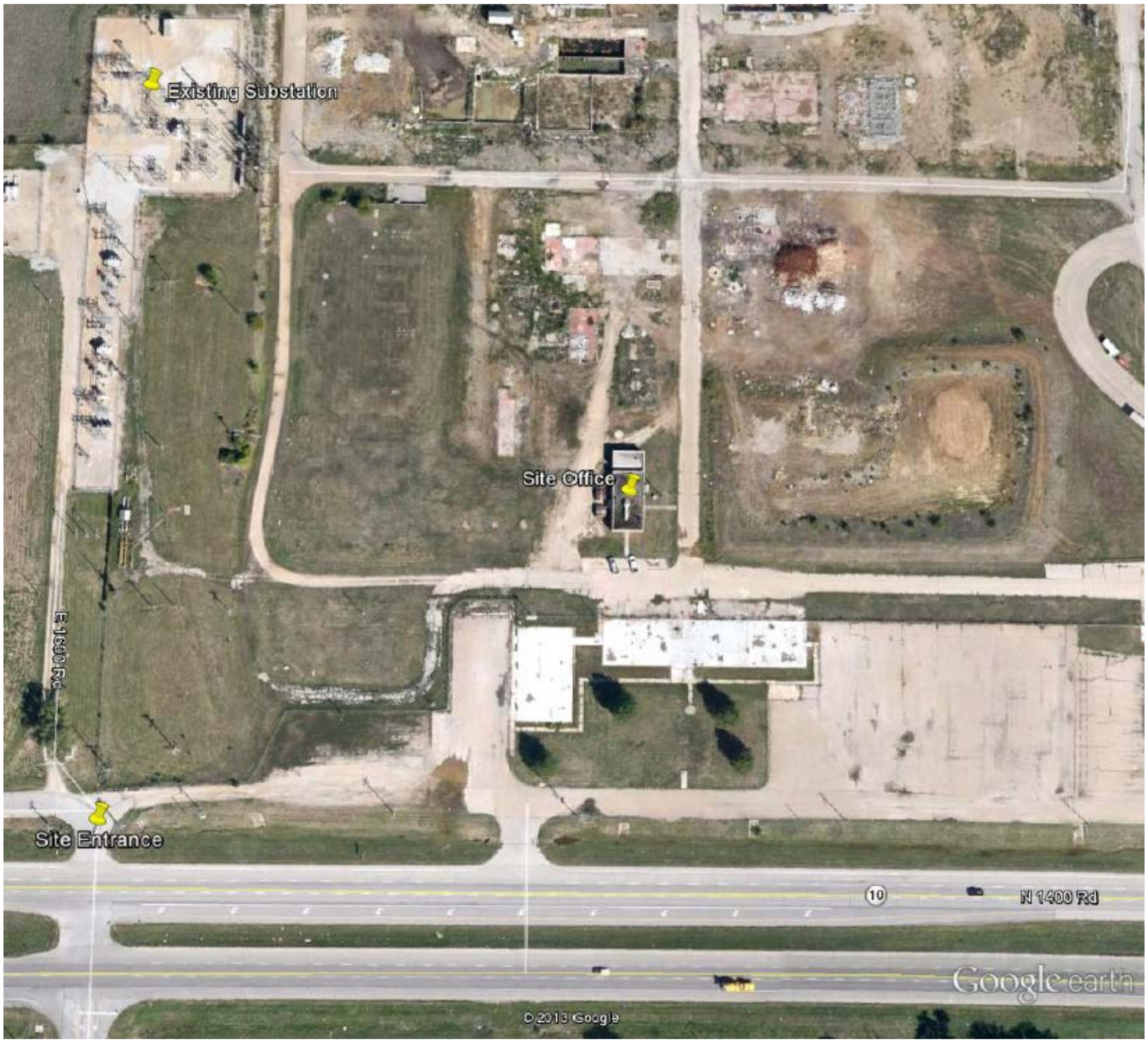

Figure 11. Former Farmland Industries site—Entrance plan view.

Illustration done in Google Maps

As shown in Figure 12, there are large expanses of relatively flat land, which also makes it a good quality candidate for a biopower system.

Figure 12. Former Farmland Industries site. ***Photo by Gregg Tomberlin***

5.2 Utility-Resource Considerations

A potential electrical tie-in point for a biopower system at the former Farmland Industries site would be at the site substation, which is currently located near the site entrance from 23rd Street. However, this substation is currently scheduled to be relocated with many of the older components replaced. The relocation is estimated to be a few hundred feet to the north of the existing site, which will still be a viable distance.

Figure 13. Existing substation. ***Photo by Gregg Tomberlin***

5.3 Biopower Facility Siting Issues

There is plenty of room on the site to locate a 5-MW to 10-MW facility. The keys for choosing a location are strategic with respect to incoming fuel routes, proximity to the substation, and proximity to any potential steam customers that may be identified. Utilizing existing infrastructure where possible is always of interest, reducing capital cost investments for new structures and utility improvements. The building shown in Figure 14 was identified as a possible candidate for a facility. The building size was adequate and a conveyor from outside of the building ran through the upper section of the building, which could be used for fuel delivery.

Figure 14. View of empty structure on site. ***Photo by Gregg Tomberlin***

Given the economic parameters associated with this project (low power sales rates), steam sales revenue was deemed necessary for any possibility of success. Steam customers cannot be located long distances from the steam generator as the cost of steam piping and condensate return piping could quickly become too excessive to be practical. East Hills Business Park is located relatively close to the Farmland Industries site, making a thermal-only or a combined heat and power option possible if a good steam customer could be identified at this industrial complex.

The proprietors within East Hills Business Park were identified and contacted, but unfortunately, there were no substantial steam users at this park or anywhere else in the immediate area. A thermal energy customer must be in place prior to the biomass facility's construction so that financing can be based upon revenues from a long-term energy contract with the customer. Financing in anticipation of future tenants is impractical.

5.4 Former Farmland Industries Energy Usage and Costs

Currently at the Farmland Industries site, the electrical loads are very small and are primarily the result of power used for water pumps. A summary of bills from Westar Energy is shown in Table 1.

Table 1. Current Site Electrical Loads

Period	Year	Use (kWh)	Cost
Feb	2012	12,000	$2,097
Jan	2012	24,000	$2,218
Dec	2011	24,000	$2,208
Nov	2011	24,000	$2,362
Oct	2011	12,000	$850
Sep	2011	12,000	$881
Jul	2011	24,000	$3,118
Jun	2011	24,000	$3,931
May	2011	24,000	$3,756
Apr	2011	36,000	$4,240
Mar	2011	36,000	$4,087
Feb	2011	12,000	$3,166
Dec	2010	24,000	$3,430

The site anticipates a substantial increase in electrical load as development is undertaken over the next few years. Potential loads will be electrical, thermal, or both, which warrants a reassessment at some future date. At this time however, financing additional power generation with such a small demand would be difficult because a power project typically requires a long-term contract for the sale of power in the form of a PPA.

6 Biopower Economics and Performance

6.1 Assumptions and Input Data for Analysis

The installed cost of biomass power generation systems is estimated based on several key factors, including the equipment arrangement, plant size, and geographical factors. These costs include permitting, engineering, equipment, construction, commissioning, and all soft costs such as development fees and the costs for financing. The economics of a biopower system depend on incentives, plant costs, labor costs, biomass resource costs, and the sales rate for electricity and thermal energy.

Operational costs are a key component. These facilities offer good quality job opportunities to the local community. The economy of scale is critical with regards to operating costs. While larger plants are more efficient, cost per kilowatt is also lower due to labor costs. For example, a 20-MW biopower facility may only have a few more employees than a 10-MW facility.

6.2 Incentives and Financing Opportunities

The Database of State Incentives for Renewable Energy (DSIRE) provides a summary of renewable energy incentives available across the nation. The only relevant opportunity for this proposed facility is the regulation for the RPS as discussed earlier.

Kansas House Bill 2369, enacted in May 2009, established an RPS for Kansas that requires the state's investor-owned utilities and cooperative utilities to generate or purchase a certain amount of their electricity from eligible renewable resources. The Kansas Corporation Commission (KCC) established rules and regulations to administer the portfolio standard on October 27, 2010 (K.A.R. 82-16), and the 2009 legislation set the basic ground rules for the standard.

The required generation capacity can be produced by wind, solar thermal, photovoltaics (PV), dedicated crops grown for energy production, cellulosic agricultural residues, plant residues, methane from landfills or wastewater treatment, clean and untreated wood products such as pallets, existing hydropower, new hydropower that has a nameplate rating of 10 MW or less, fuel cells using hydrogen produced by an eligible renewable resource, and other sources of energy that become available in the future and are certified as renewable by the KCC.

The compliance schedule is as follows. Note that each year's requirement refers to the average of each utility's one-hour retail peak demand for the previous 3 years.

2011-2015: 10%
2016-2019: 15%
2020 onward: 20%.[9]

Many of the investor-owned and cooperative utilities in Kansas have utilized wind power generation to meet the requirements of the RPS. Because the RPS has been satisfied through 2015 for the local utility, there is a limited incentive for the utility to pursue a new biopower facility at this time. However, this opportunity and others can be easily reassessed in future years.

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[9] Database of State Incentives for Renewables & Efficiency (DSIRE), 2012-2013. U.S. Department of Energy. http://www.dsireusa.org/.

7 Feasibility Study Discussion

A full feasibility study was not undertaken for this site as the preliminary assessment of the utility market, potential resources, and community goals demonstrated that a biopower facility had limited viability. If the project merited further study, additional work would need to be performed to verify project parameters used in the technical and economic analyses. The key economic drivers for this type of project are the feedstock availability and cost, and the price for the sale of electric and thermal energy.

Assessing the biomass resource in the area can be easily done on a preliminary basis utilizing software tools. In order to verify these assumptions, further scrutiny is required that typically consists of a combination of site visits and phone calls to potential suppliers of the biomass. Collaboration with government entities like the U.S. Forest Service Bureau of Land Management would be done also. Markets for wood are always in flux and setting up the chain of supply is very important. The chain of supply includes the long-term supplier, processing, and delivery and storage issues.

If a project was likely or had more favorable conditions, the feasibility study could be used to engage in discussions with utilities. Long-term agreements would be discussed and evaluated with utilities to ascertain their level of interest and willingness to engage in a PPA. If all or part of the plant revenue is from thermal energy sales, a long-term contract should be negotiated on a preliminary basis with the energy customer as well. The long-term stability of the customer will also be a factor for lenders when conducting financial modeling for the project.

Additional work for a full study would also include a heat and mass balance to verify the actual energy production, internal energy usage, and biomass feedstock required. Once this is accomplished, the equipment sizing can be deduced and an equipment cost estimate can be generated. This cost would be combined with the costs for construction, utilities and facility operation and maintenance for inclusion into an economic pro forma that evaluates the viability of the project.

Other issues are also investigated, including permitting requirements, potential financing options, and local issues such as job creation and community involvement during the project progression.

8 Conclusions

This site will likely not proceed with the installation of a biomass power generation facility for a number of reasons. The City of Lawrence has expressed an interest in renewable energy but has concerns regarding truck traffic and its negative effects on the proposed office park given the nature and operation of a biopower facility. For example, a large number of heavy trucks rolling through an office park carrying wood chips would undermine the intent for a quiet office working environment. Other renewable energy sources may be more compatible with the planned reuse of the site. A number of the site characteristics (such as useable acreage, site slope, distance to roads, and distance to the substation and transmission infrastructure) that made this site favorable for biopower can be leveraged for other renewable energy generation. However, the lack of incentives and current status with regard to the RPS would likely remain an obstacle in the current market conditions

Further, the project would still not be feasible due to the low cost of electricity in the area and the lack of operating loads on the site. Without the ability to sell power back to the utility at a higher rate, selling thermal energy became the only other viable option and a thermal customer was not currently available. Additionally, there were no other incentives or subsidies identified that could substantially improve the economics.

Biomass energy sales can be very profitable in the right scenarios. The economics at the former Farmland Industries site proved to be inadequate at this time. Screening potential candidates for key technical, political, and economic factors at an early stage is critical. Preliminary analyses can distinguish between good candidates and poor ones early on, saving time and money that can be employed to address more site options.