Feasibility Study of Economics and Performance of Biopower at the Chanute Air Force Base in Rantoul, Illinois

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

Christopher Scarlata and Gail Mosey

Produced under direction of the U.S. Environmental Protection Agency (EPA) by the National Renewable Energy Laboratory (NREL) under Interagency Agreement IAG-09-1751 and Task No. WFD4.1001.

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-7A30-57770
May 2013

Contract No. DE-AC36-08GO28308

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Executive Summary

The U.S. Environmental Protection Agency (EPA), in accordance with the RE-Powering America's Land initiative, selected the Former Chanute Air Force Base site in Rantoul, Illinois, 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 impacts of different biopower options.

The former Chanute Air Force Base was proposed for inclusion on the National Priorities List (EPA ID: IL1570024157). The site is approximately 2,125 acres, with contamination limited to the relatively small Operational Unit 2 (OU2) area on the southeast corner of the base. This leaves ample space to accommodate a renewable energy generation plant. Some of the buildings at OU2 contained oil-water separators, underground storage tanks, and/or sludge pits. Migration of contaminants from OU2 into Salt Fork Creek has been a primary environmental concern.

Biopower is the use of biomass to generate electricity. Biomass consists of plant materials used as a source of fuel. In general, woody biomass has 10% higher energy content than agricultural materials on a dry weight basis. Wood chips are the most common fuel for biopower production in the United States. Biopower system technologies include direct-firing, co-firing, gasification, pyrolysis, and anaerobic digestion. Most biopower plants are direct-fired systems that burn biomass directly to produce steam.

The economic feasibility of a potential biopower system on the Chanute Air Force Base site depends greatly on the cost of feedstock and purchase selling price of the electricity produced. The economics of the potential systems were analyzed with respect to the power market in Champaign County. Given the uncertain development timeline for a biopower system at the site, the financial analysis did not include currently available incentives, as many are set to expire in the next few years. The Village of Rantoul might wish to revisit potential incentives once they have a firmer timeline available for the construction of any renewable energy project. Therefore, the financial analysis is considered to be conservative, and any incentives would improve the returns from the project.

The results of the breakeven analysis are shown in Figure ES-1. The net present value (NPV) is the value in today's dollars of future cash flows generated by a project less than the initial capital investment. Breakeven is defined as the point where NPV equals zero. The colored lines are the breakeven points for biopower plants at 10 MW, 15 MW, and 20 MW. The area above the lines is where the NPV is positive and the project is profitable. The area below the lines indicates a negative NPV, where the project would operate at a loss.

The cost per dry ton of wood chips (on the x-axis) and the price for energy produced in the biopower plant (on the y-axis) were varied across a range of values, as shown. This analysis is meant to inform decision makers at the Rantoul site. For example, if after negotiating with feedstock providers, the site believes they could enter into a contract to purchase wood chips at $80/dry ton, then they would need to determine if consumers would purchase power at a price of $160/MWh to break even with a 20-MW plant. A discussion about ways to improve the process economics is provided in the report.

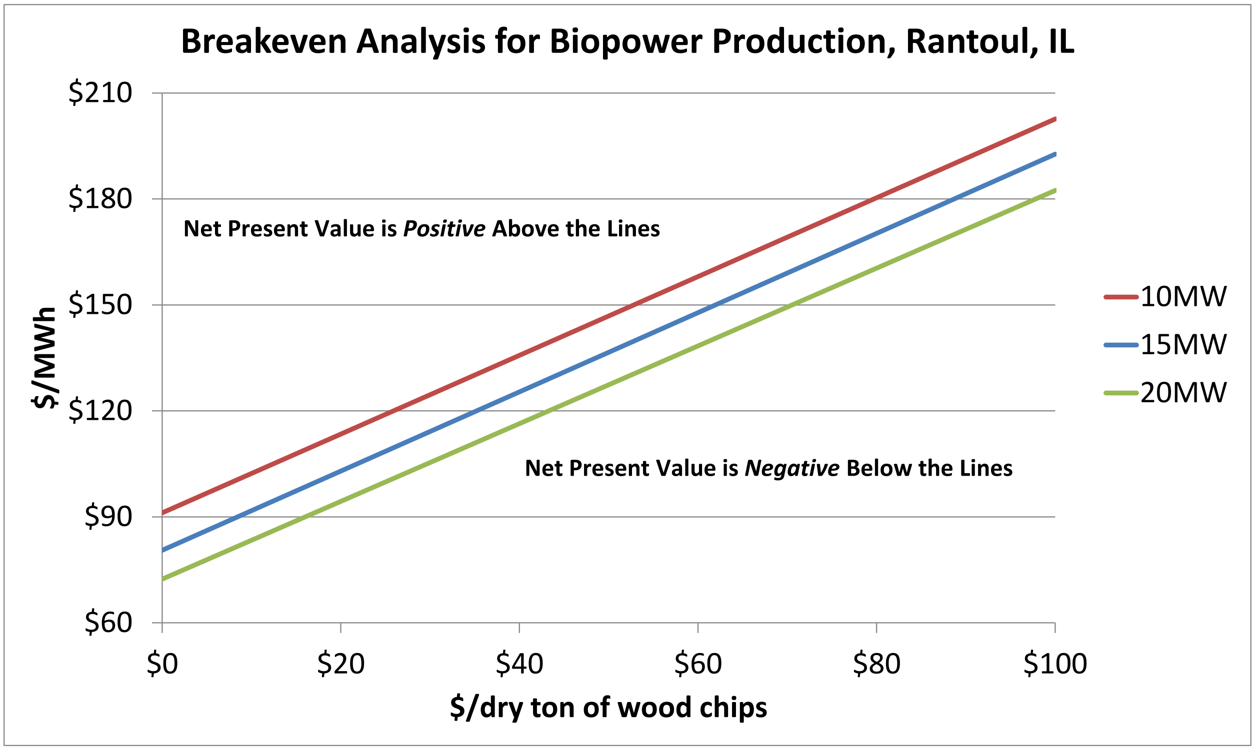

Figure ES-1. Breakeven analysis for biopower production at 10-MW, 15-MW, and 20-MW scales

Note: Wood chips were used as a model feedstock. See text for details.

The Champaign-Urbana metropolitan area is 15 miles from Rantoul and is a potential market for the renewable power produced at the site. Therefore, a biopower plant of up to 20 MW could be built on the former Chanute Air Force Base. However, as mentioned previously, economic feasibility depends on the cost of feedstock and selling price of the electricity produced.

The feasibility study produced a conservative estimate of the financial performance of biopower projects in Rantoul. The results suggested that the cost of electricity from these plants would need to be above market prices in order for the project to break even. Project economics would be more favorable if the site could purchase feedstock at below-market rates, secure more favorable debt and equity terms, or benefit from tax incentives.

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1 Study Background

1.1 Purpose of Study

The EPA Office of Solid Waste and Emergency Response (OSWER) Center for Program Analysis (CPA) developed the RE-Powering America's Land initiative to re-use contaminated sites for renewable energy generation. EPA engaged the U.S. Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) to conduct feasibility studies to assess the viability of developing renewable energy-generating facilities on contaminated sites. The former Chanute Air Force Base (AFB) Superfund site in Rantoul, Illinois, was selected for a feasibility study under this initiative.

Biomass was selected as the renewable energy resource. In this case, the focus was on studying the feasibility of operating a bioenergy plant using woody biomass or agricultural material as feedstock on the site.

1.2 Development of Biopower on Contaminated Sites

One promising use of contaminated sites is to install biomass power (also known as 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,[1] including:

- Preserving greenfields
- Reducing blight and improving the appearance of a community
- Raising property values and creating jobs
- Leveraging access to existing infrastructure, including electric transmission lines and roads
- Enabling potentially contaminated property to be productive

By taking advantage of these potential benefits, biopower can provide a viable, beneficial reuse—in many cases generating revenue on a site that might otherwise go unused.

Most states rely heavily on fossil fuels to operate their power plants. There are 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
- Depending on foreign sources, fossil fuels can be a national security concern

[1] U.S. Environmental Protection Agency (EPA). "Handbook on Siting Renewable Energy Projects While Addressing Environmental Issues," OSWER Center for Program Analysis.

- Generating energy with fewer harmful emissions can be accomplished through renewable energy sources
- Burning fossil fuels contributes to greenhouse gas emissions.

1.3 Scope of Work

For the Chanute site, three sizes of bioenergy facilities producing electricity at 10 MW, 15 MW, and 20 MW were analyzed assuming the use of woody biomass as fuel. A brief comparison of corn stover as a feedstock is provided.

This feasibility study discusses general and site-specific factors relevant to analysis of a bioenergy facility at the Chanute AFB site and is divided into the following sections:

- **Site information**: Provides an overview of the site on which the facility would be located
- **Bioenergy systems overview**: Provides a general introduction to biomass energy as well as related equipment
- **Biomass resource assessment**: Reviews available biomass resource in the area and estimates the delivered cost of wood chips to the site
- **Local bioenergy markets**: Provides a brief overview of potential outlets for heat or power that could be produced from a bioenergy facility
- **Economic analysis**: Documents the results of economic analyses performed using inputs from previous sections
- **Feasibility study discussion**: Reviews the results of the study and proposes next steps.

2 Site Information

The Chanute AFB is located in the Village of Rantoul, Illinois, which is located in Champaign County, 15 miles north of the Champaign-Urbana metropolitan area. According to 2011 data, the population was 12,984 and occupied an area of 8.3 square miles.[2] The population of Champaign-Urbana was 203,000, and it is a potential market for energy produced at the Chanute site.[3]

The base was proposed for inclusion on the National Priorities List (EPA ID: IL1570024157). The site is approximately 2,125 acres with contamination limited to the relatively small Operational Unit 2 (OU2) area on the southeast corner of the base. This leaves ample space to accommodate a renewable energy generation plant. Some of the buildings at OU2 contained oil-water separators, underground storage tanks, and/or sludge pits. Migration of contaminants from OU2 into Salt Fork Creek has been a primary environmental concern.[4]

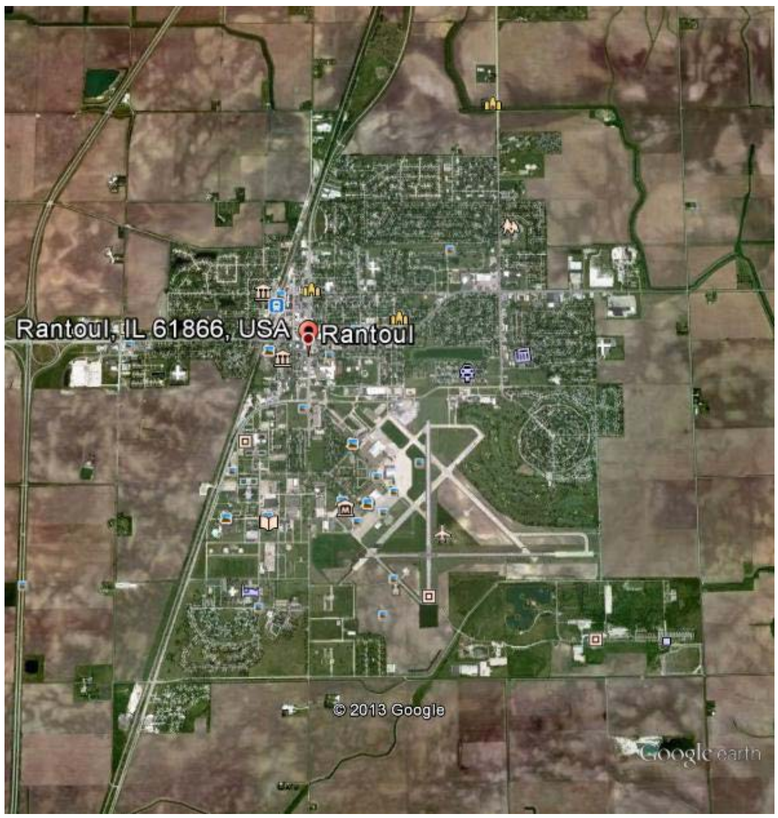

Figure 1. A satellite image of the Village of Rantoul and the subject area including the Chanute AFB

[2] "State and County Quickfacts – Rantoul (village), Illinois." (2013). United States Census Bureau, "http://quickfacts.census.gov/qfd/states/17/1762783.html.

[3] "State and County Quickfacts – Champaign County, Illinois." (2013). United States Census Bureau, http://quickfacts.census.gov/qfd/states/17/17019.html.

[4] "National Priorities List – NPL Site Narrative for Chanute Air Force Base." (2012). U.S. EPA, http://www.epa.gov/superfund/sites/npl/nar1615.htm.

2.1 General Site Considerations

The criteria for a successful bioenergy facility include many factors such as feedstock proximity, delivery access, and access to required utilities. Other considerations include a market for selling energy from the plant and proximity to an electrical substation.

Proximity to communities is also an important consideration. Biomass will be delivered via truck to the site, which will result in more traffic. A route for delivery of feedstock should be considered when selecting a site in this area.

2.2 Site Characteristics

The former Chanute AFB site is managed by the Village of Rantoul. The site has good potential for installing a biomass power generation system as there is ample land available and infrastructure, such as access rail, roads, and utilities. The topography is relatively flat and the existing buildings are distant from one another. The biopower site itself would only require approximately 5–15 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 1. Trucks could enter the site easily off of the highway, which has access to the north side of the former Chanute AFB via West Champaign Avenue. Ready access to transportation could enable high-volume delivery of biomass feedstock at a scale required for a medium-scale biopower facility.

Rail access is available on the west side of Rantoul. Additional infrastructure would be needed to receive and store wood ships delivered by rail (e.g., a feedstock depot).

There is sufficient room on the site to locate a 10- to 20-MW facility. The choice of location is strategic with respect to incoming fuel routes and proximity to an electrical substation. Utilizing existing infrastructure where possible is always of interest; this would reduce capital cost investments for new structures and utility improvements.

2.3 Federal and State Regulations Relevant to a Bioenergy Installation at the Site

The following is a list of regulations and permits that might be required for a bioenergy plant. The size and design of the plant, the method of steam and power generation, and local permitting requirements ultimately determine the requirements. State agencies generally handle permitting. A relatively small plant (less than 20 MW) might not be subjected to all of the codes listed below. This is not an exhaustive list, but it suggests typical requirements.

2.3.1 Federal Regulations

The federal regulations and permits potentially required for a biopower project include:

- National Emission Standards for Hazardous Air Pollutants addresses emission from boilers[5]

[5] "Technology Transfer Network Air Toxics Web Site – Tools and Implementation." (2013). U.S. EPA, http://www.epa.gov/ttn/atw/eparules.html.

- EPA's National Ambient Air Quality Standards declares combustion devices must emit below stated levels[6]
- 2011 EPA Clean Air Act pollution standards require biomass boilers over 10 million Btu/hr for 876 or more hours per year to meet numeric emission standards[7]
- 40 CFR Part 89 limits emissions on non-road internal combustion engines[8]
- 40 CFR Part 60 limits emissions on steam-generating units over 10 million Btu/hour[5]
- 40 CFR Part 63 requires reciprocating internal combustion engines or generators over 300 hp to meet specific carbon monoxide standards[5]
- Resource Conservation and Recovery Act Subtitle D covers solid wastes and says the facility might be considered a waste processing facility[9]
- 40 CFR Part 257 sets disposal standards for owners of non-municipal non-hazardous wastes, which would include a facility accepting food wastes[6]
- National Pollutant Discharge Elimination System addresses wastewater discharge [10]
- Prevention of Significant Deterioration and construction permits require any new major source of pollutants to conduct analysis and use best control technologies [11]
- Risk management plan requires new facilities to develop a plan if certain chemicals are stored.[12]

2.3.2 State Permits

State permits generally require construction, air, water, solid waste, and operating permits.

- Air Quality Permits
- Water Quality Permits; water appropriation permits
- Highway Access Permit
- Possible Easement Rights.

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[6] "Air and Radiation – National Ambient Air Quality Standards." (2012). U.S. EPA, http://www.epa.gov/air/criteria.html.
[7] "Final Air Toxics Standards For Industrial, Commercial, and Institutional Boilers at Area Source Facilities." (2011). U.S. EPA. Accessed January 8, 2013: http://www.epa.gov/airtoxics/boiler/area_final_fs.pdf.
[8] "Code of Federal Regulations. Title 40. Chapter 1 – Environmental Protection Agency. Subchapter C – Air Programs. Parts 50-99." U.S. Government Printing Office. Accessed January 8, 2013: http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR.
[9] "Code of Federal Regulations. Title 40. Chapter 1 – Environmental Protection Agency. Subchapter I – Solid Wastes. Parts 239-282." U.S. Government Printing Office. Accessed January 8, 2013: http://www.gpo.gov/fdsys/browse/collectionCfr.action?collectionCode=CFR.
[10] "Compliance Monitoring - National Pollutant Discharge Elimination System Compliance Monitoring." (2012). U.S. EPA, http://www.epa.gov/compliance/monitoring/programs/cwa/npdes.html.
[11] "New Source Review – PSD - Prevention of Significant Deterioration (PSD) Basic Information." (2011). U.S. EPA, http://www.epa.gov/NSR/psd.html.
[12] "Emergency Management - Risk Management Plan (RMP) Rule." (2013). U.S. EPA, http://www.epa.gov/oem/content/rmp/.

3 Bioenergy Systems

3.1 Feedstock Overview

Biomass consists of plant materials that can be used as a source of fuel. Biomass fuels can come from many different sources. While many of these can be used to produce fuel, their suitability for specific conversion technologies must be evaluated. 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
- Agricultural residues
- Food wastes.

Heat contents of various biomass feedstocks are listed in Table 1.

Table 1. Heat Content Ranges for Various Biomass Fuels on a Dry Weight Basis[13]

Fuel type & source	English	
	Higher Heating Value	
	Btu/lb	MBtu/ton
Agricultural Residues		
Corn stalks/stover	7,587 - 7,967	15.2 - 15.9
Sugarcane bagasse	7,450 - 8,349	14.9 - 16.7
Wheat straw	*6,964 - 8,148*	13.9 - 16.3
Hulls, shells, prunings	6,811 - 8,838	13.6 - 17.7
Fruit pits	8,950 - 10,000	17.9 - 20.0
Herbaceous Crops		
Miscanthus		
switchgrass	7,754 - 8,233	15.5 - 16.5
Other grasses		
Bamboo		
Woody Crops		
Black locust	8,409 - 8,582	16.8 - 17.2
Eucalyptus	*8,174* - 8,432	16.3 - 16.9
Hybrid poplar	*8,183* - 8,491	*16.4* - 17.0
Willow	7,983 - 8,497	16.0 - 17.0
Forest Residues		
Hardwood wood	8,017 - 8,920	16.0 - 17.5
Softwood wood	8,000 - 9,120	16.0 - 18.24
Urban Residues		
MSW	5,644 - 8,542	11.2 - 17.0
RDF	*6,683 - 8,563*	*13.4 - 17.1*
Newspaper	8,477 - 9,550	17 - 19.1
Corrugated paper	7,428 -7,939	14.9 - 15.9
Waxed cartons	11,727 - 11,736	23.5 - 23.5

[13] "Biomass Energy Data Book - Appendix A - Conversions." U.S. DOE EERE, http://cta.ornl.gov/bedb/appendix_a.shtml.

3.2 Overview of Conversion Technologies

Biopower system technologies include direct-firing, co-firing, gasification, pyrolysis, and anaerobic digestion. Most biopower plants are direct-fired systems.

Co-firing refers to mixing biomass with fossil fuels in conventional power plants. Coal-fired power plants can use co-firing systems to significantly reduce emissions, especially sulfur dioxide. Pyrolysis is a thermal process that occurs without oxygen with outputs of syngas, liquids, and charcoal, which can be used to produce heat and power or reformed into liquid fuels and chemical products. Anaerobic digestion is a biological degradation of organic matter without oxygen to produce biogas, which can be used in heat or electricity application.

Gasification systems use elevated 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 are used for turning electric generators instead of propelling a jet. Gas turbines are very efficient, but the overall system efficiency can be further improved by operating them in a combined cycle arrangement. During combined cycle operation, the exhaust gases are used to boil water for steam to provide additional power generation or heat.

The amount of energy that can be produced by a biopower system depends on several factors, including the type of biomass used, 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 2 shows a typical biopower direct-fired system.

Figure 2. Direct-fired biopower system. ***Photo from Stephen Jolley, Wheelabrator Shasta Energy Co., NREL 07163***

These plants burn biomass feedstocks directly to produce steam. The steam drives a turbine, which turns a generator that converts the power into electricity. In some biomass plants, turbine extraction steam from the power plant is also used to provide heat for manufacturing processes or to heat buildings. Such combined heat and power (CHP) systems increase overall energy efficiency. CHP is a practical setup when a large customer requiring heat is located nearby.

Biopower systems normally operate 24 hours per day and 7 days per week, with several weeks of down time per year for maintenance. Plants of this type are not normally cycled with many starts and stops. Frequent cooling and re-heating of the components can lead to fatigue and failure. Therefore, it is more cost-effective to operate around the clock even though power prices 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 for each particular location under consideration.

In this case, the feasibility of power plants of 10 MW, 15 MW and 20 MW were analyzed. The Illinois power market is very competitive, but small biopower plants might have a chance to compete in niche markets where customers demand renewable energy.

3.3 Biopower System Components

A typical direct-fired biopower system has the following components. The components of biopower systems and large-scale biomass heating systems are described in more detail in the following sections.

3.3.1 Major Components

The major components that comprise a typical biopower plant are:

- Fuel receiving, storage, and handling
- Combustion system and steam generator
- Steam turbine and electrical generator
- Air pollution control
- Condenser and cooling tower.

3.3.2 Other Equipment and Auxiliaries

Additional equipment is needed for emissions, waste handling, and the balance of the biopower system:

- Stack and monitoring equipment
- Instrumentation and controls
- Ash handling
- Fans and blowers
- Water treatment

- Electrical equipment
- Pumps and piping.

3.3.3 Fuel Handling

Biomass can be delivered to the site by truck, rail, or barge. It can be delivered as chips or pellets; logs and brush can be processed onsite into chips. Wood chips are typically stored in a fuel yard (exposed or covered) or in storage silos, as shown in Figure 3. Wood pellets are often stored in silos and are easily handled and fed with standard equipment.

Fuel handling may be fully automated or semi-automated requiring some labor. A fully automated system will typically be installed below grade. Wood chips are delivered by truck to the storage bin and conveyor belts automatically feed the boiler. Automated systems are used to serve facilities, such as the 10- to 20-MW biopower plants evaluated in this study. Semi-automated systems are less expensive but require more labor. They typically include above-ground chip storage and a hopper with capacity to supply the boiler for a few days. An operator moves woody biomass from the storage area to the hopper as needed; operator workload is estimated at 60–90 minutes per day.[14]

Figure 3. Biomass storage options: fuel yard and fuel silo. ***Photos by (left) Warren Gretz, NREL 04376 and (right) Gerry Harrow, NREL 15041***

3.3.4 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, which creates steam. The combination of the burning apparatus and the heat transfer surface areas are typically referred to as the boiler.

[14] "Woodchip Fuel Specifications in the Northeastern United States." (2013). Biomass Energy Resource Center. Accessed January 8, 2013: http://www.biomasscenter.org/resources/publications.html.

3.3.4.1 Boilers

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 Btu 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 co-fired with a combination of biomass and coal or other solid fuel.[15]

The traveling grate stoker boiler introduces fuel at one end of the furnace. The grate slowly moves the fuel through the hot zone until combustion is complete and the ash falls off at the opposite end.[16] 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. A fluidized bed boiler introduces feedstock into the bed with a heat transfer medium (e.g., sand).[17] The bed material is fluidized using high pressure air from underneath the grate creating a mixing zone.

3.3.4.2 Steam Turbine

The steam turbine is a key component and a major capital cost for the facility. Higher efficiency turbines are sold at premium prices but can improve plant economy over the life of the turbine. The operating principle of a turbine is that more energy can be extracted from the steam by increasing inlet pressure and decreasing the exhaust pressure. These efforts come at a cost and have to be balanced with the overall plant 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.

3.3.5 Air Pollution Control

Biomass contains lower 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 (NO_x), and particulate matter (PM).

CO emissions are largely a function of combustion quality. Thorough air mixing will oxidize most CO 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 introduces urea or ammonia at specific temperatures to reduce nitrogen oxides into molecular nitrogen (i.e., N_2), 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

[15] "Biomass Combined Heat and Power Catalog of Technologies." (2007). U.S. EPA. Accessed January 8, 2013: http://www.epa.gov/chp/documents/biomass_chp_catalog.pdf

[16] Johnson, N. (2012). "Fundamentals of Stoker Fired Boiler Design and Operation." CIBO Emission Controls Technology Conference. Accessed January 10, 2013: http://www.cibo.org/emissions/2002/a1.pdf.

[17] Crawford, M. (2012). "Fluidized Bed Combustors for Biomass Boilers". ASME. Accessed January 10, 2013: https://www.asme.org/kb/news---articles/articles/boilers/fluidized-bed-combustors-for-biomass-boilers.

known as fabric filters or baghouses. Electrostatic precipitators (ESPs) are also commonly used for particulate removal.

EPA Final Air Toxics Standards for Industrial, Commercial, and Institutional Boilers at Area Source Facilities were released in 2011 and apply to biomass boilers. The following provisions apply to new biomass boilers[18] as mentioned in Section 2.3:

- Boilers with capacity above 10 MMBtu per hour must meet particulate matter limits
- Boilers with capacity below 10 MMBtu per hour must conduct a boiler tune-up every 2 years.

3.3.6 Condenser and Cooling Tower

As the steam exits the 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 from the cooling tower. The steam flows over the tubes, condensing into a hot well at the bottom of the condenser. The cooling water that leaves the condenser is pumped back to the cooling tower, which 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. This creates a large operating cost in areas where water is scarce and expensive. Alternatively, the water can be cooled by an air-cooled system. The capital cost for this equipment is higher and electric power to operate the fans is needed, but no water is consumed with this method.

3.4 Types of Bioenergy Systems

A biopower system should be sized based on both the availability of cost-effective biomass feedstock and the energy requirements of the end user. The most common installation types are described below. In general, these systems can be divided into *thermal energy* only, *power generation* only, and *CHP* systems. The system choice is dependent upon economics and energy markets. The cost of fuel, the sales price of power, and thermal energy are a few of the key economic parameters.

3.4.1 Thermal Energy Only

Figure 4 illustrates a *thermal energy* only system. Biomass energy is converted to steam that is sent to a nearby business that utilizes 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 used for many decades in the United States.

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[18] "Final Air Toxics Standards For Industrial, Commercial, and Institutional Boilers at Area Source Facilities." (2011). U.S. EPA, http://www.epa.gov/airtoxics/boiler/area_final_fs.pdf.

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

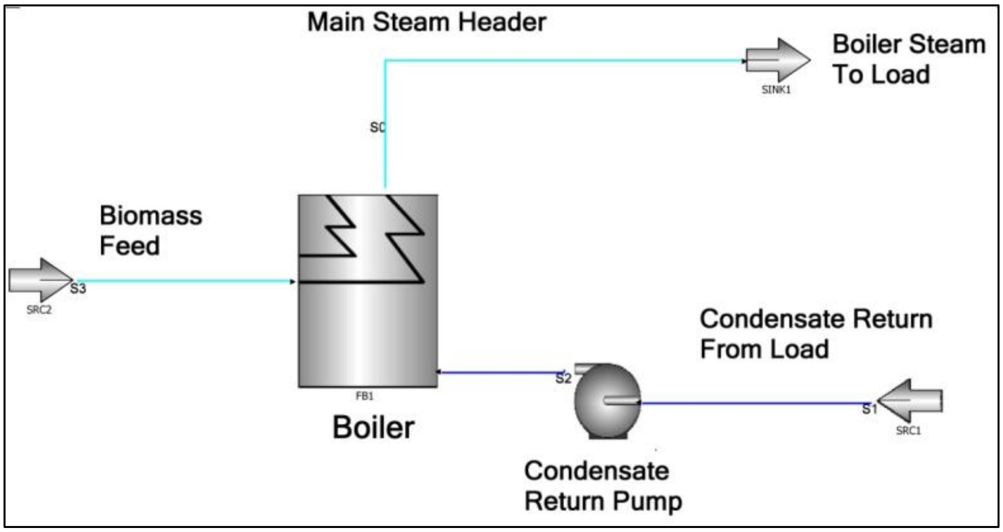

Figure 4. Thermal only biomass energy system

Source: Gregg Tomberlin, NREL

3.4.2 Power Generation Only

Figure 5 illustrates a *power generation* only system. 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, as discussed in Section 3.3.4.

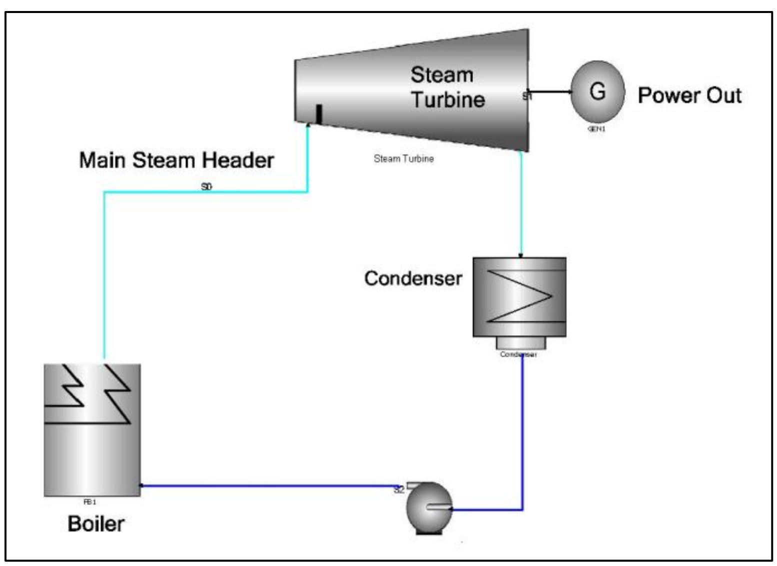

Figure 5. Power generation only biomass energy system (cooling tower not shown)

Source: Gregg Tomberlin, NREL

3.4.3 Combined Heat and Power

CHP is 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 even chilled water for process cooling. Over 60% of biomass power systems in use produce CHP.

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 to meet internal requirements of the facility or to produce steam for sale to a local customer. The steam can be taken from the power process in three primary methods: *main steam extraction*, *extraction turbine*, and *back-pressure turbines*.

Main steam extraction diverts some of the boiler outlet prior to being introduced into the turbine (Figure 6). This high pressure, high temperature steam would typically have to be reduced in pressure prior to use. This is not the most efficient method for optimizing power output, but it avoids the cost of a more expensive extraction turbine (described below). The remaining steam runs through the turbine and then discharges into a condenser (see Section 3.3.4) at vacuum pressure to maximize the electric power generated. Warm condensate is pumped back to the biomass facility where it is reintroduced to the boiler and converted once again to steam.

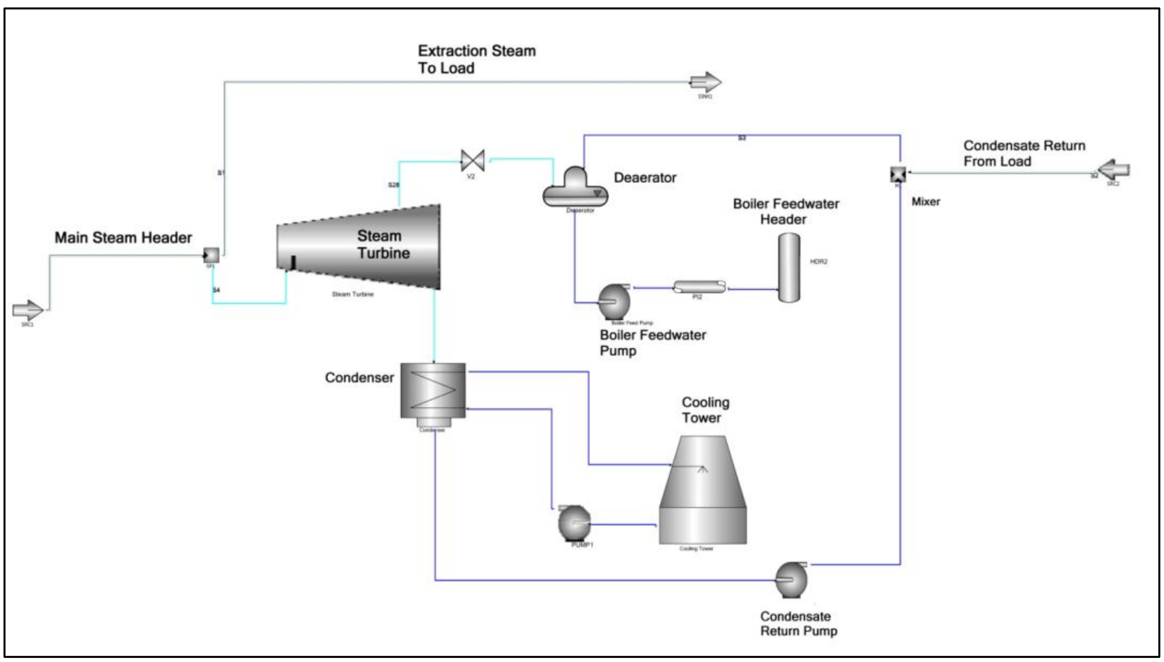

Figure 6. CHP main steam extraction

Source: Gregg Tomberlin, NREL

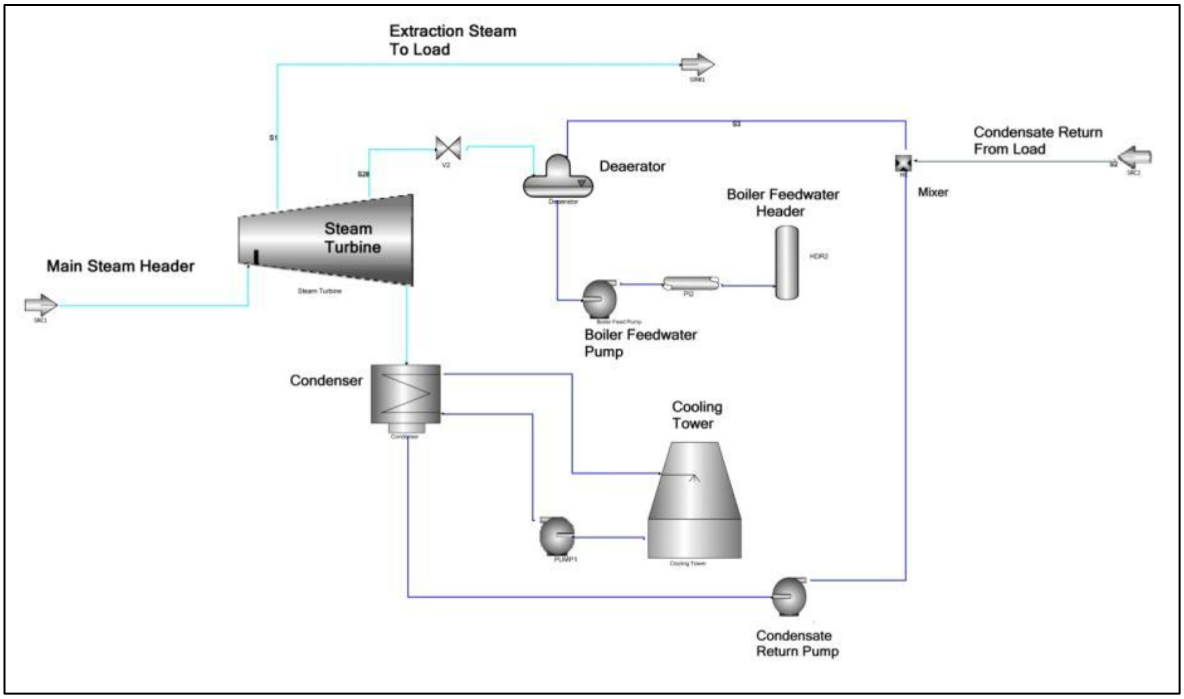

Figure 7. CHP extraction turbine

Source: Gregg Tomberlin, NREL

An *extraction turbine* draws all boiler steam at its inlet and extracts the required process steam at some intermediate point along the turbine steam path (Figure 7). This allows the process steam to produce electric power prior to being diverted, increasing the efficiency of the overall process. Extraction turbines are not normally used in smaller systems (i.e., less than 10 MW) and their cost is typically higher than other turbine designs. The remaining steam continues through the lower pressure stages of the turbine and then discharges into a condenser.

A *backpressure turbine* draws all boiler steam at the turbine inlet but discharges all of the steam at higher pressure as required by the steam customer (Figure 8). 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 is typically condensed by the load, and then returns to the plant as warm condensate to be reheated and reintroduced to the system.

There are two disadvantages to this arrangement. First, the amount of electric power produced is lower due to the geometry of the turbine and the relatively high discharge pressure. Second, if the steam host decreases its steam requirements to less than the full turbine capacity, the turbine must be turned down, or the excess steam must be condensed by way of an external steam condenser.

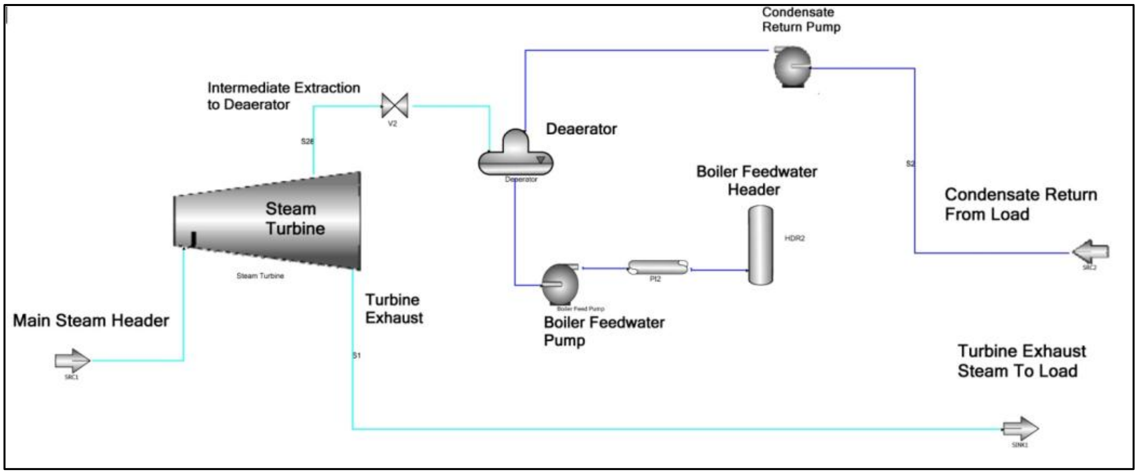

Figure 8. CHP backpressure turbine

Source: Gregg Tomberlin, NREL

3.4.4 District Heating

District heating is defined as a central unit providing heat to nearby buildings and homes through a series of pipes carrying hot water or steam. The inlet pipe delivers hot water at a temperature between 180°F and 250°F. Heat enters a building's conventional system through a heat exchanger. After heat is extracted, an outlet pipe returns water (105°F–160°F) to the central heating plant. Pipes are typically double-walled and buried underground. District heating systems are most common in Scandinavia. In Denmark, district heating provides 60% of thermal energy with 17% derived from biomass.[19] Lower-temperature district heating systems are under development, using hot water as low as 122°F.[20]

Because of the network of piping and heat exchangers and other equipment that must installed for each customer, capital costs are high for district heating systems. Economics work best for district heating when waste heat can be obtained from a nearby power plant at minimal cost, when replacing electric heating systems, and in densely populated areas with high-rise apartments.

Several cities and universities have district heating systems powered by traditional energy sources. Most were built many decades ago.

There are only two district heating systems in the United States that use biomass as an energy source. District Energy St. Paul operates a biomass district heating system in St. Paul, Minnesota,[21] which is also the largest hot water district heating system in the United States. The system operates from a CHP system using waste wood as a fuel source as well as a recently installed solar thermal system. The University of New Hampshire meets all heat and electricity

[19] "Renewable Heat Initial Business Case." (2007). DEFRA and BURR, United Kingdom. Accessed January 8, 2013: http://webarchive.nationalarchives.gov.uk/+/http://www.berr.gov.uk/files/file41432.pdf.

[20] Thorson, J.; Christiansen, C.; Marek, B. (2011). "Experience on Low-Temperature District Heating in Lystrup, Denmark." International Conference of District Energy. Portoroz, Slovenia.

[21] "District Heating." (2013). District Energy St. Paul. Accessed January 9, 2013: http://www.districtenergy.com/technologies/district-heating/.

requirements from a district system using methane from a nearby landfill.[22] Many other universities have district heating systems powered by traditional energy sources.

The Rantoul site is not a good candidate for district heating due to lack of customers that would demand steam.

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[22] "First University In Nation To Use Landfill Gas As Primary Energy Source." (2007). University of New Hampshire Media Relations. Accessed January 9, 2013: http://www.unh.edu/news/cj_nr/2007/aug/kb14landfill.cfm.

4 Biomass Resource Assessment

4.1 Overview of Biomass Feedstock

There are two choices for feedstock to provide biopower at the Rantoul site—woody biomass or agricultural biomass. Woody biomass is the most common feedstock used for biopower in the United States. While there is limited woody biomass in the region near Rantoul, the site has access to rail, opening the possibility of sourcing wood from other regions.

In contrast, Rantoul is located in a top agricultural production region. There is the potential to use agricultural biomass (e.g., corn stover) for biopower production. It is important to note that agricultural biomass presents some specific challenges for biopower production.

First, the energy content of a feedstock like corn stover is about 10% lower than that of wood (Table 1, dry weight basis). Second, agricultural feedstocks tend to have higher ash content when compared to debarked wood. The higher ash content leads to higher operations costs due to increased disposal costs. Third, the high ash content, particularly from potassium and sodium, can create slag. Slag reduces boiler efficiency and requires additional down time for maintenance to clear accumulated slag. There are boilers on the market that are optimized for using agricultural biomass; they are most commonly deployed in Europe where straw is used as a feedstock. Fourth, harvesting stover is not a common practice and no large domestic market exists for supplying it to potential biopower plants.

4.1.1 Woody Biomass

4.1.1.1 Forest Residue

This category includes logging residues and other removable material left after 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.[23]

4.1.1.2 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.[24]

4.1.1.3 Urban and Secondary Mill Residues

This category includes wood residues from municipal solid waste (wood chips and pallets), tree trimming residues from utilities and private tree companies, and construction and demolition sites.[25]

[23] USDA, Forest Service's Timber Product Output Database, 2007.
[24] USDA, Forest Service's Timber Product Output Database, 2007.
[25] U.S. Census Bureau, 2000 Population Data, BioCycle Journal, State of Garbage in America, January 2004; County Business Patterns 2002.

4.1.2 Agricultural Biomass

The agricultural biomass category can include the following crops: corn stover, wheat straw, soybeans, cotton waste, sorghum, rice straw, and sugarcane bagasse. The quantities of crop residues that are potentially available in each county can be estimated considering total grain production, crop to residue ratio, moisture content, the amount of residue left on the field for soil protection, or other agricultural activities.[26]

4.2 Overview of Potential Feedstocks in Illinois and Champaign County

Data from calendar year 2011 from the USDA National Agricultural Statistics Service was used to evaluate the major categories (i.e., >25,000 acres) of land use in the state of Illinois (Figure 9). Corn and soybean production are the dominant categories in the state (13 and 8.5 million acres, respectively).

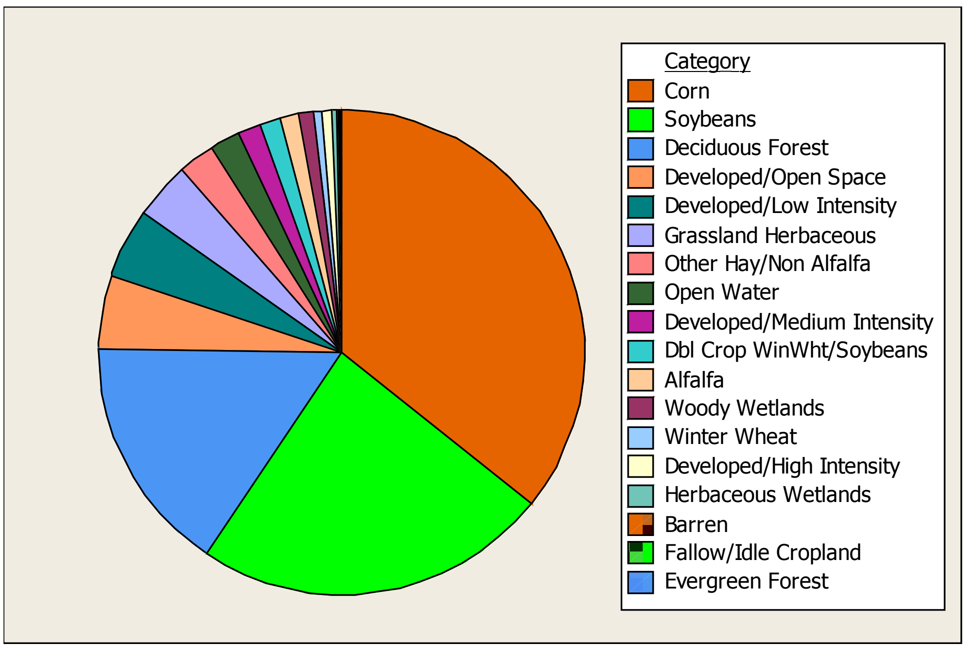

Figure 9. Major categories of land use in Illinois

Source: USDA

Illinois has 5.7 million acres of deciduous forest. Figure 10 is a visual comparison of corn, soybean, and woodland acreage. Corn and soybeans are widely distributed. The forestlands are generally dispersed across the southern and western portions of the state.

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

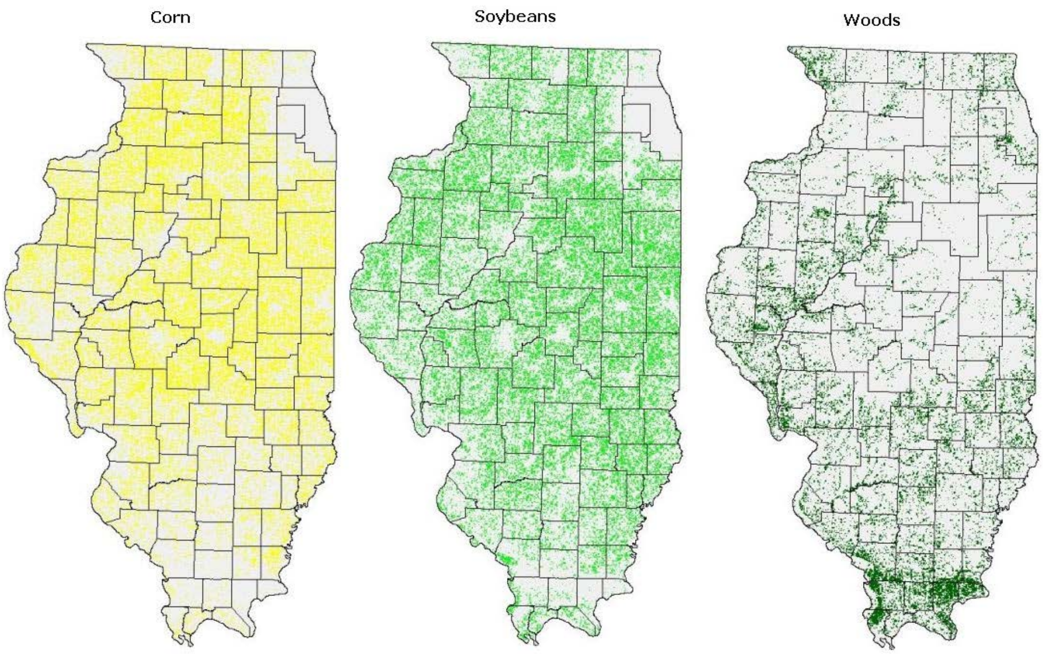

Figure 10. The distribution of corn, soybean, and woodland in Illinois[27]

Rantoul is located in Champaign County, Illinois. The major land use categories for the county are also for corn and soybean production. Forestland is negligible.

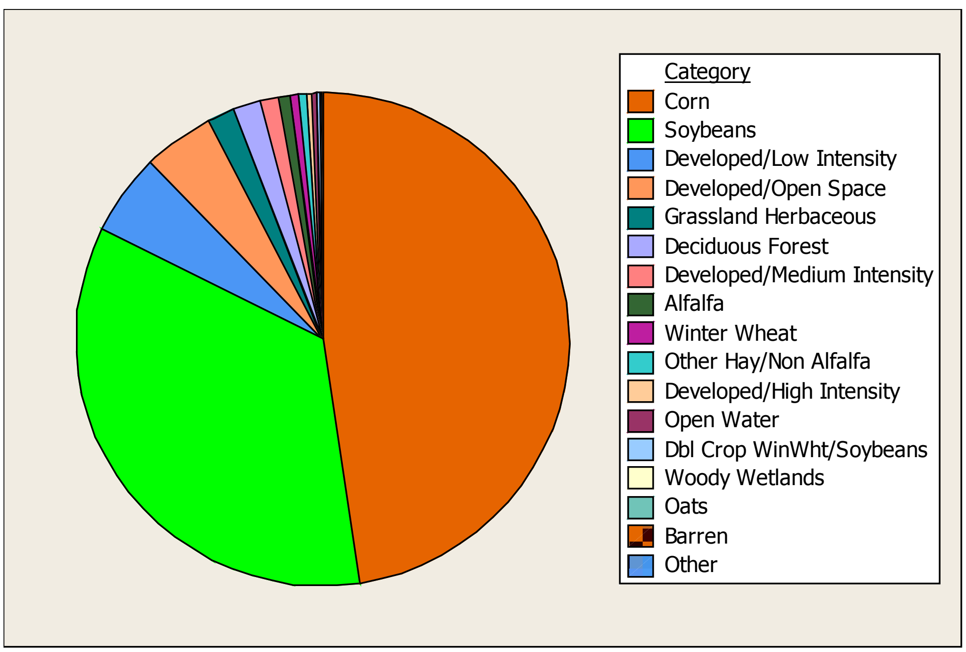

Figure 11. Major categories of land use in Champaign County, Illinois

Source: USDA

[27] "2003 Cropland Data Layer – Illinois." USDA National Agricultural Statistics Service (NASS), http://www.nass.usda.gov/research/cdl/ILall.htm.

4.3 Resources Assessment Results

A preliminary analysis of the forest and related wood-waste resources in the region indicates that there is a marginal availability of woody biomass in the area surrounding Rantoul. Rantoul has good access to rail, opening the opportunity to bring wood chips in from other regions.

The spot price for wood chips delivered to eastern Illinois in the fall of 2012 was approximately $78/bone dry ton or $47/green ton at 40% moisture.[28] A surcharge would apply to biomass prices according to increases in the cost of transportation via the diesel fuel market.

The price for agricultural biomass like corn stover is more challenging to estimate. There is only a nascent market for these feedstocks and there is an absence of reliable pricing data. One source of pricing forecasts is DOE's Office of Biomass Program. Their 2011 Multi-Year Program Plan has set a forecast price for the total corn stover feedstock delivered to the plant gate to be $65.50/dry ton.[29] Local pricing in the Rantoul area will vary and will have similar fuel surcharge costs to the woody feedstocks. The pricing and availability of agricultural feedstocks would need to be negotiated with regional growers—typically within a 25- to 50-mile radius of the site. Transportation costs become prohibitive beyond that distance.

[28] Siegel, R.W. (2013). Personal communication, Center for Clean Energy Research and Education, Eastern Illinois University.

[29] EERE. (2011). *Biomass Multi-Year Program Plan*. DOE/EE-0405. Table 3. http://www1.eere.energy.gov/biomass/pdfs/mypp_april_2011.pdf.

5 Local Bioenergy Markets

Local power market conditions, including energy demand and pricing, are another major consideration for bioenergy facilities.

5.1 Illinois Power Market

Illinois ranked fifth in the nation for power production behind Texas, Florida, California, and Pennsylvania.[30] The state produced 4.5% of the total electricity share of the United States. In addition, the state ranked 28th in power consumed per capita. Illinois is first in the nation for nuclear power generation and a net exporter of electricity, as described in an Energy Information Agency analysis[31]:

> Illinois is one of the top electricity-generating States in the Nation and a leading net exporter of electricity to other States. Coal and nuclear account for over 95 percent of the electricity generated in Illinois, with an even split between the two fuels. With 11 operating reactors at six nuclear power plants, Illinois ranks first among the States in nuclear generation, and generates more than one-tenth of all the nuclear power in the United States.

Nuclear power provides low-cost, reliable energy production and can put downward pressure on energy prices. While this creates a very competitive market today for new energy production, the Illinois electric power market is expected to grow and change, opening opportunities for renewable energy production.

The Illinois Department of Commerce & Economic Opportunity has projected that population of the state will grow by 14% by 2030 and that Champaign County will grow by 12% over the same period.[32] Population growth will fuel demand for more power generation.

In 2007, Illinois adopted a renewable energy standard requiring utilities to produce at least 25% of their power from renewable sources by 2025. Most of that energy must come from wind power, and the remainder can be produced from other qualifying sources like biopower (discussed further below).

Recent statewide electricity prices by sector are shown in Table 2. Illinois ranked 32nd, 9th, and 16th for lowest residential, commercial, and industrial power prices in the United States, respectively. Average U.S. prices for all states are provided for comparison.

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[30] "Illinois - Rankings: Total Net Electricity Generation, December 2012 (thousand MWh)." U.S. Energy Information Administration (EIA), http://www.eia.gov/beta/state/rankings/?sid=IL#series/51.

[31] "Illinois – Profile Analysis." (2009). U.S. EIA, http://www.eia.gov/beta/state/analysis.cfm?sid=IL.

[32] "Population Projections." (2011). Illinois Department of Commerce & Economic Opportunity, http://www.ildceo.net/dceo/Bureaus/Facts_Figures/Population_Projections/.

Table 2. Electricity Prices by Sector in Illinois for 2011 and 2012[33]

	Residential		Commercial		Industrial		All Sectors	
Region	October 2012	October 2011	October 2012	October 2011	October 2012	October 2011	October 2012	October 2011
Illinois	0.1190 $/kWh	0.1285 $/kWh	0.0800 $/kWh	0.0854 $/kWh	0.0581 $/kWh	0.0607 $/kWh	0.0833 $/kWh	0.0886 $/kWh
U.S. Average	0.1203 $/kWh	0.1208 $/kWh	0.1011 $/kWh	0.1025 $/kWh	0.0665 $/kWh	0.0677 $/kWh	0.0976 $/kWh	0.0983 $/kWh

5.2 Renewable Portfolio Standard and State Incentives

In cases where renewable portfolio standards (RPS) exist, power may potentially be sold at premium rates. 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.[34] If the fraction of renewable energy is satisfied in a particular state, implementing additional renewable generation sources becomes more difficult.

Illinois has an RPS that requires the increased use of renewable energy. According to the schedule in Table 3, The Illinois RPS contains goals to produce 25% of electric power from renewable energy by 2026. Under this schedule, 60% of that renewable energy must come from wind generation and 40% can come from other sources, including biopower.

33 "Electric Power Monthly." (2013). U.S. EIA, http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.
34 American Wind Energy Association, www.http://AWEA.org.

Table 3. Schedule for Illinois Renewable Energy Production[35]

Energy Year	Overall Standard (% of Retail Electric Sales to Come from Renewables	Solar Requirement (% of the Standard)	% of Retail Electric Sales from Solar	Wind Requirement (% of the Standard)	% of Retail Electric Sales from Wind
2009	--	--	--	--	--
2010	4.0%	--	--	60%	2.4%
2011	5.0%	--	--	60%	3.0%
2012	6.0%	--	--	60%	3.6%
2013	7.0%	--	--	60%	4.2%
2014	8.0%	--	--	60%	4.8%
2015	9.0%	--	--	60%	5.4%
2016	10.0%	6%	0.60%	60%	6.0%
2017	11.5%	6%	0.69%	60%	6.9%
2018	13.0%	6%	0.78%	60%	7.8%
2019	14.5%	6%	0.87%	60%	8.7%
2020	16.0%	6%	0.96%	60%	9.6%
2021	17.5%	6%	1.05%	60%	10.5%
2022	19.0%	6%	1.14%	60%	11.4%
2023	20.5%	6%	1.23%	60%	12.3%
2024	22.0%	6%	1.32%	60%	13.2%
2025	23.5%	6%	1.41%	60%	14.1%
2026	23.0%	6%	1.50%	60%	15.0%

Illinois offers grants, loans, and tax incentives for renewable energy producers. Biopower producers can qualify for a $500,000 grant if they produce both heat and power.[36]

No incentives were included in this early stage financial analysis of biopower production at Rantoul. Due to the changing landscape of financial incentives and their availability, the Village of Rantoul should consider reviewing incentives if they choose to move forward with building renewable energy generation.

[35] "Illinois: Incentives/Policies for Renewables & Efficiency." (2013). Database of State Incentives for Renewables & Efficiency (DSIRE), http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL04R&re=0&ee=0.
[36] "Renewable Energy: Biogas and Biomass to Energy Grant Program." (2011). Illinois Department of Commerce & Economic Opportunity, http://www.illinoisbiz.biz/dceo/Bureaus/Energy_Recycling/Energy/Clean+Energy/02-BiogasBioMass.htm.

5.3 Thermal Customers

Economic parameters for any biopower site would be improved if a customer were available to purchase steam from the plant. There are no steam customers currently located near the site. Having customers in close proximity is important because the cost of steam piping and condensate return piping is generally cost prohibitive when implemented over long distances (i.e., greater than 1–2 miles). A thermal energy customer must be in place prior to the biomass facility 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; therefore, this was not included in this assessment.

Due to the lack of known feasible thermal customers, neither thermal-only nor CHP systems were further evaluated in this report.

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" including 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 regard to operating costs; larger plants have lower labor costs on a per-kilowatt-hour basis. That is, a 20-MW biopower facility may only have a few more employees than a 10-MW facility.

Techno-economic analysis for biopower production was done using RETScreen software. RETScreen is a publicly available analysis tool for the evaluation of renewable energy projects. For this analysis, biopower production models were built for plants of 10 MW, 15 MW, and 20 MW net energy production. There are multiple inputs to each model; some of the principal inputs are listed below:

Feedstocks[37]	Wood chips (higher heating value 8,470 BTU/lb) Corn straw (higher heating value 7,520 MJ/kg)
Fuel Cost Escalation	1.82% (benchmarked to #2 distillate fuel oil)
Inflation Rate[38]	0.9%
Discount Rate[39]	10.3%
Debt Ratio	50%
Debt Interest Rate	7%
Equity Interest Rate	16%
Depreciation[40]	20 years, straight line
Tax Rate	35%

Feedstock cost and electricity export rate were modeled in the breakeven analysis in Section 6.3. No incentives were included in the analysis in order to provide a conservative estimate of the financial performance of the project.

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[37] RETScreen values.

[38] U.S. Department of Commerce. (2010). "Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis – 2010." FEMP data, http://www1.eere.energy.gov/femp/pdfs/ashb10.pdf.

[39] Based on the analysis in Mendelsohn, M.; Kreycik, c.; Bird, L.; Schwabe, P.; Cory, K. (2012). "The Impact of Financial Structure on the Cost of Solar Energy." Golden, CO: NREL/TP-6A20-53086; http://www.nrel.gov/docs/fy12osti/53086.pdf.

[40] NREL assumptions.

6.2 Capital and Operating Expenses

Table 4 is a summary of the capital expense, operation and maintenance expense, annual fuel expense, and fuel requirement by biopower plant size. These values were entered into the financial models along with the assumptions from Section 6.1 to calculate financial performance.

Table 4. Summary of Capital and Operating Expenses and Fuel Requirement by Plant Size

Plant Size	10MW	15MW	20MW
Capital Expense	$ 42,600,000	$ 58,700,000	$ 71,100,000
Annual Operation and Maintenance Expense	$ 2,800,000	$ 3,300,000	$ 3,700,000
Annual Fuel Cost	$ 6,200,000	$ 9,200,000	$ 11,800,000
Annual Amount of Fuel Required (Dry Tons)	79,400	117,600	151,900

6.3 Breakeven Analysis

The net present value (NPV) is a useful tool for the analysis of capital projects, such as constructing a biopower plant. NPV is the present value (i.e., in today's dollars) of future cash flows generated by a project (e.g., revenue from selling electricity) minus the initial capital investment. Future cash flows are discounted by the cost of debt and equity dollars used to finance the project. The cost of debt and equity is the *weighted average cost of capital*, or simply the *discount rate*. In this case, 10.3% was used for the discount rate, derived from half of the project financing from equity at 16% interest and half from debt at 7%. It was adjusted for taxes at a 35% rate. These values were based on an NREL analysis of comparably sized renewable energy projects.[41]

The breakeven point is where discounted future cash flows for a project offset the initial capital costs. Future cash flows are dependent on a number of factors including inflation, taxes, operating costs, changes in feedstock costs, and the value of electricity sales (as shown in Section 6.1). Note that the NPV calculation is sensitive to the discount rate, and so the following breakeven analysis will change depending on the particular financing terms a particular project is able to receive.

[41] Mendelsohn, M.; Kreycik, C.; Bird, L.; Schwabe, P.; Cory, K. (2012). "The Impact of Financial Structure on the Cost of Solar Energy." Golden, CO: NREL/TP-6A20-53086; http://www.nrel.gov/docs/fy12osti/53086.pdf.

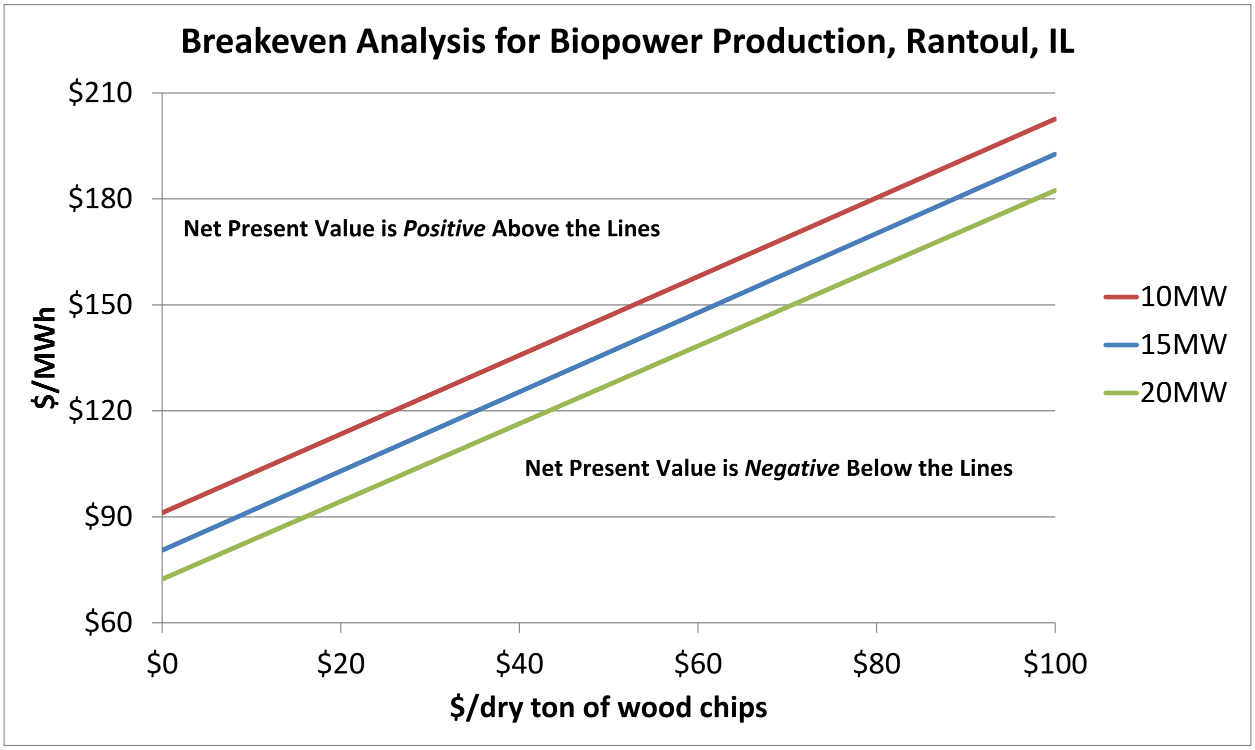

Figure 12. Breakeven analysis for biopower production at 10-MW, 15-MW, and 20-MW scale

Note: Wood chips were used as the feedstock. See text for details.

The results of the breakeven analysis are shown in Figure 12. The colored lines are the breakeven points for biopower plants at 10 MW, 15 MW, and 20 MW. The area above the lines is where the NPV is positive (i.e., where the value of the discounted cash flows is greater than the initial capital investment). The area below the lines indicates a negative NPV.

The cost per dry ton of wood chips (on the x-axis) and the price for energy produced in the biopower plant (on the y-axis) were varied across a range of values as shown. This analysis is meant to inform decision makers at the Rantoul site. For example, if after talking with feedstock providers Rantoul believes they could contract to purchase wood chips at $80/dry ton, then they would need to decide if the market would purchase power at a price of at $160/MWh to break even with a 20-MW plant.

7 Feasibility Study Discussion

A feasibility study was undertaken for the Rantoul site as the preliminary assessment of the utility market, potential resources, and community goals demonstrated that a biopower facility had potential viability. If local officials decide that such a project merits 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 energy.

Assessing the biomass resource in the area was done on a prospective 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 and The Bureau of Land Management would be needed. Markets for biomass 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.

Additional work for a *next-stage* feasibility study would include a heat and mass balance analysis to verify the assumptions used for actual energy production, internal energy usage, and biomass feedstock required. Once this is accomplished, the equipment sizing can be refined 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 updated economic pro forma to reevaluate the financial viability of the project. Other issues to be investigated include incentives, permitting requirements, financing options, and local issues, including job creation and community involvement during the project progression.

The data in Table 5 are from EIA projections for the cost of energy from future power plants (assumes operation in 2017) by fuel source. The EIA data suggest prices for energy from biomass to range from $97.80/MWh to $136.70/MWh. The breakeven values for Rantoul are above the high end of this range once the cost of feedstock reaches $38–$58/dry ton. As mentioned earlier (Section 4.3), the spot price for wood chips in eastern Illinois was $78/bone dry ton, at which the price for energy sold would need to be above $150/MWh to reach breakeven.

Table 5. Estimated Energy Prices for Future Plants Based on EIA Data[42]

Plant Type	Range for Total System Levelized Cost (2010 $/MWh)		
	Minimum	Average	Maximum
Biomass	$ 97.80	$ 115.40	$ 136.70
Conventional Coal	$ 90.50	$ 97.70	$ 114.30
Advanced Coal	$ 102.50	$ 110.90	$ 124.00
Natural Gas-fired			
Conventional Combined Cycle	$ 59.50	$ 66.10	$ 81.00
Advanced Combined Cycle	$ 56.80	$ 63.10	$ 76.40
Conventional Combustion Turbine	$ 91.90	$ 127.90	$ 152.40
Advanced Combustion Turbine	$ 77.70	$ 101.80	$ 122.60
Advanced Nuclear	$ 107.20	$ 111.40	$ 118.70
Wind	$ 77.00	$ 96.00	$ 112.20
Solar Photovoltaic	$ 119.00	$ 152.70	$ 238.80
Solar Thermal	$ 176.10	$ 242.00	$ 386.20
Geothermal	$ 84.00	$ 98.20	$ 112.00
Hydroelectric	$ 57.80	$ 88.90	$ 147.60

Several opportunities for improving the economic performance of this project are listed below:

- Utilize federal and state incentives for renewable energy production
- Secure financing for debt and/or equity at more favorable interest rates. State or federal loan guarantees can help to significantly lower investor risk
- Utilize the production tax credit if Congress offers an extension; it is currently $0.011/kWh for biopower systems, but it is set to expire at the end of 2013
- Find a customer to buy steam from the plant; selling both heat and power improves the economics of a biopower system significantly
- Use the 10% federal investment tax credit for CHP systems, which is available through 2016
- Seek federal grant opportunities on www.grants.gov, especially from USDA and DOE
- View a discussion of other options for renewable energy project financing at http://www.mintz.com/newsletter/2012/Advisories/1573-0112-NAT-ECT/index.htm.

[42] "Levelized Cost of New Generation Resources in the Annual Energy Outlook 2012." U.S. EIA, http://www.eia.gov/forecasts/aeo/electricity_generation.cfm

8 Conclusions

The Champaign-Urbana metro area is 15 miles from Rantoul and is a potential market for the renewable power produced at the site. Therefore, a biopower plant of up to 20 MW could be built on the former Chanute AFB. However, economic feasibility depends greatly on the cost of feedstock and purchase selling price of the electricity produced.

The results of this feasibility study produced a conservative estimate of the financial performance of biopower projects in Rantoul. The results suggested that the cost of electricity from these plants would be above market prices in order for the project to break even. Project economics would be more favorable if the site could purchase feedstock at below market rates, secure more favorable debt and equity terms, or benefit from tax incentives.