Converting the Escanaba Generating Station Feedstock from Coal to Biomass

Table of Contents

Acknowledgments

All of the information contained in this document related to market pricing, conversion cost estimates, engineering costs, fuel costs and other outsourced services or estimates were solicited from electric industry experts, other utilities, and vendors and suppliers of the Escanaba Electric Department. All the information in this document is presented as the best available information at the time of development of this document.

Background

In 1958, the City of Escanaba constructed a power generation facility consisting of 2 identical 12.5 MW Allis-Chalmers steam turbines. These turbines were coupled with 2 identical Allis-Chalmers generators and 2 identical Babcock & Wilcox boilers. The equipment was designed to operate with the use of Central Appalachian coal. Over the years, the supply and cost of Central Appalachian coal remained available and affordable. The City of Escanaba began to see this trend change in the early 2000's, which has since been reflected in higher electrical rates for the utility customer over the last several years.

In June, 2007 the City of Escanaba, in partnership with Wisconsin Public Power, Inc. (WPPI), received the results of a feasibility study from Sargent & Lundy. This study contained cost estimates for various sizes and technologies of new coal fired power generating plants that could be constructed in Escanaba. These cost estimates were very high and the study was put on hold. The City's next step in the electrical energy supply plan was to request proposals for wholesale power, which were received in July, 2007. Two of the respondents indicated an interest in partnering with the City of Escanaba in converting the existing Escanaba Generating Station to biomass. Power generated from biomass is considered a renewable energy source. The State of Wisconsin has a Renewable Portfolio Standard (RPS) requirement of Wisconsin utilities, and it is expected that the State of Michigan will also have an RPS standard in the near future. Power generated from biomass is relatively more expensive than fossil fuel generated power, but due the RPS requirements, it is still marketable. Biomass is available in two forms. The first is wood chips or ground wood. The second form of biomass available is a processed product that is commonly referred to as "cubes" or "briquettes". This paper will cover both of these forms of biomass.

City administration, with Electric Advisory Committee (EAC) assistance, gathered information on biomass availability and cost estimates from experts in the forestry industry. These experts all felt that the most likely fuel source for the Escanaba Generating Station would be timber harvesting residuals such as tree tops, branches, and sub-merchantable timber. These timber harvesting residuals would be delivered as wood chips or ground wood to the Escanaba Generating Station.

The City of Escanaba shared this information with the two utilities that had expressed an interest in converting the plant to biomass and asked each utility to submit a more detailed proposal. The proposals both said that they would be interested in buying biomass generated power from Escanaba if it could be produced and sold at a reasonable price. The most common form of renewable energy currently being constructed is wind energy. These proposals said that these utilities would be willing to pay slightly more for biomass energy as it is available at all times, whereas wind generation is not available at all times.

Both utilities recommended that the City of Escanaba consider selling the plant to another utility or an independent power producer. Converting the plant to biomass is made more viable be including the benefit of the federal production tax credits for renewable fuels, which could be utilized by a commercial taxable entity.

Believing that considerable changes would have to be made to the plant, requests for proposals (RFPs) for a biomass conversion study were sent to four (4) engineering firms in April of 2008. Proposals were received from six (6) firms and were opened on May 6, 2008. An RFP review committee was formed to review and independently score each proposal so that a recommendation could be made to the Electric Advisory Committee, who in turn would make a recommendation to the City Council and citizens of the community. In the course of the review, the scoring results unanimously determined that the proposal from Jansen Combustion and Boiler Technologies, Inc of Kirkland, WA was the best proposal received for the following reasons: Responsiveness to the RFP, firm qualifications and experience, project team qualifications, and firm resources. The cost included with the Jansen proposal was $148,000 and would cover all expenses needed to perform a comprehensive conversion study. In that this proposed study would be needed and the price of this study is substantial, the City of Escanaba is now at the point where a decision needs to be made as to whether to proceed with this proposed biomass fuel conversion study or to choose another course of action.

The second form of biomass fuel available to the City of Escanaba would not require as many changes to the plant, but it would require a storage facility and other fuel handling equipment. The information on this type of fuel was obtained after the biomass conversion RFPs had been received, so it was not addressed by the engineering firms that submitted proposals on May 6, 2008. Cost comparisons utilizing wood cubes are included in this paper.

Discussion

Both the wood chips and wood cubes are quite different from the Central Appalachian coal that the Escanaba Generating Station was designed to burn. The wood chips contain about 1/3 of the heat value of Central Appalachian coal, while the cubes contain about 2/3 of the heat value. Being that both of these biomass fuels have lower heat content, more of each has to be burned to get the same amount of energy as compared to the coal. There is much less ash in the wood, which reduces ash disposals costs, but can create operational issues within the boilers. The moisture content of wood chips is much higher than coal, while the cubes have very low moisture content. Both of the biomass fuels contain less sulfur than the coal. Appendix A lists some of the major characteristics of wood chips, wood cubes, and the West Ridge coal currently used.

Current Assets

The Escanaba Generating Station has been in service for fifty years. The average age of electric generating stations in Michigan is 48 years. The Escanaba Generating Station consists of 2 identical 12.5 MW steam turbines supplied by Allis-Chalmers. These

turbines are coupled to identical Allis-Chalmers generators and are powered by 2 identical Babcock & Wilcox boilers. The boilers operate at 600 psi and 825 degrees F and can produce 125,000 pounds of steam per hour. The coal is delivered into the plant via dump trucks from the C. Reiss coal dock near the plant. The coal is fed into the boilers by Alstom stokers. The coal is burned on traveling grates inside the boilers and electrostatic precipitators are used to control particulate emissions discharged by the boilers.

Future Assets

Should the Escanaba Generating Station be converted to wood chips, it is expected that many of the components of the plant would have to be replaced. Wood chips have a high moisture content, which can cause operational issues. The bunkers would have to be altered to address the stickiness of the wood chips. The combustion air system may have to be redesigned and resized to supply more air to the boilers. Additionally, the combustion air may have to be pre-heated to help drive the moisture out of the wood chips to improve the combustion process. Without a combustion air pre-heating upgrade, the steam production capacity of the boilers would be greatly reduced. Even with pre-heated combustion air, it is believed that plant capacity would be reduced somewhat. The stokers and grates would have to be replaced to accommodate the wood chips. A fuel storage building may be needed to store the chips. A truck dumper may also be needed to unload the trucks delivering the chips. It should also be noted that the heat rate at the plant will most likely be degraded. Heat rate is defined as how efficiently the plant converts the heat energy in the fuel to electrical energy. The Escanaba Generating Station has an average heat rate of 14,500. This means it takes 14,500 Btu of thermal energy from the fuel to make 1 kWh of electric energy. A degraded heat rate of 16,000 is used in some of the columns in the calculations found in Appendix B.

Should the Escanaba Generating Station be converted to wood cubes, it is expected that many of the existing components of the plant could be used. The cubes have a very low moisture content and are dusty, so more dust collection may be needed. A fuel storage building or silo would be needed to keep the cubes dry. A truck dumper may also be needed to unload the trucks delivering the cubes.

Estimated Costs

Throughout the recent proposal process, informal biomass fuel (i.e. wood chips or ground wood) conversion cost estimates were received from various engineering firms. These estimates were in the range of $20,000,000 to $30,000,000 for the Escanaba Generating Station. While these engineering firms had little knowledge of the details of the Escanaba Generating Station, they are experienced in stoker fired generating plants and have completed numerous studies and actual conversions. As an example, the New Ulm (MN) Public Utilities Commission recently received the results of a phase 1 study to convert one (1) of their boilers from natural gas to a mix of 90% PRB coal, with the remaining 10% being biomass and refuse derived fuel. The estimated cost of conversion is $28.8M +/- 30%. There are some differences in the New Ulm study compared to what

could be expected for Escanaba. They are looking at a mix of fuels which would increase the costs. However, this is for only 1 boiler, while the Escanaba Generating Station has 2 boilers, which would increase Escanaba's costs. It is reasonable to believe that these 2 differences would cancel each other out somewhat, giving real world validity to the informal cost estimates received through this process.
A major cost component of all electric generating stations is the fuel cost. As stated earlier, the Escanaba Generating Station is currently burning a western bituminous coal that costs $95/ton delivered to Escanaba. This coal contains 12,300 Btu/pound. Energy is typically priced in dollars per million British thermal units (Btu) ($/MMBtu). The current cost for the Escanaba Generating Station fuel is $3.862/MMBtu.

In discussions with local forestry experts, it was estimated that wood chips delivered to Escanaba could range from $22 to $30/ton. These estimates were obtained in late 2007 and are highly dependent on the cost of diesel fuel. Diesel fuel is a major factor in the cost of wood chips due to the diesel powered equipment used in the harvesting, gathering, forwarding, chipping, and hauling of the chips. With the increase of diesel costs recently, the $30/ton estimate will be used in all calculations. The heat content and moisture content of wood chips varies between species of wood and experiences seasonal differences. Experts in the forestry industry advised that 4,500 Btu/lb and 45% moisture were good averages to use in all calculations. Wood chips containing 4,500 Btu/lb at $30/ton equals $3.333/MMBtu.

The $30/ton figure used above may be low if all of the announced regional biomass fuel consuming projects are completed. Listed below are the known regional new biomass fuel consumption projects:

- L'Anse Warden Electric Power Plant
- Ontonagon biomass based briquette plant
- NewPage Chemrec process
- Renewafuel biomass fuel cube plant at K.I. Sawyer
- Northern Michigan University biomass fueled combined heat and power plant
- Biomass based ethanol plant in Chippewa County in the eastern UP

The City of Escanaba recently requested a quotation for wood cubes. The quoted price received was $100/ton plus actual shipping charges. An estimated cost of $10/ton for delivery was obtained from a forestry industry expert. These cubes contain 8,000 Btu/lb, which results in a cost of $6.875/MMBtu.

Conclusion(s)

While there are many estimates used in these cost estimates, it is clear that converting the Escanaba Generating Station to wood chips would be a substantial investment for the City of Escanaba. From Appendix B, the best case scenario of using wood chips delivered to Escanaba for $30/ton, with a maintained heat rate, $25,648,000 capital investment, and 20 years for debt repayment shows a total cost of $15,327,595 to generate 163,000 MWh. This equates to $94.03/MWh. As stated in both utility's proposals, they would be willing to purchase biomass energy for slightly more than wind

energy. The energy from many utility scale wind projects located in good wind resource areas sells in the range of $55 to $65/MWh. The worst case scenario found in Appendix B shows a total cost of $23,412,713 for 163,000 MWh, or $143.64/MWh.

Possible Courses of Action

1) Proceed with the proposed biomass study from Jansen for $148,000. This would yield an estimated conversion cost +/- 30%. The generation costs are estimated to be slightly lower than the current operation utilizing West Ridge coal. The debt repayment required is estimated to be quite high, which results in total costs higher than the current operation.

2) Table the proposal from Jansen as the costs for conversion are estimated to be very high. Spreading the debt repayment required for the conversion costs out over 20 years yields generation costs in the mid $90's/MWh as shown in Appendix B. Biomass energy in that price range does not compare very well to wind energy that is available in the $55 to $65/MWh range.

3) Solicit proposals from engineering firms to further investigate the costs associated with converting the plant to burn wood cubes. While it is believed that only moderate changes would have to be made to the plant, the additional expenses associated with fuel handling as well as the cost of the fuel make this a very expensive option.

4) Solicit proposals from other utilities and independent power producers to buy the Escanaba Generating Station for a biomass fuel conversion.

Appendix A – Major characteristics of various fuel types

	Western bituminous	Wood Chips	Wood Cubes
Heat Content, Btu/lb	12,300	4,500	8,000
Moisture, %	7	45	<5
Sulfur, %	1.3	<0.1	<0.1
Ash, %	12	6	<5
Cost per ton	$95	$30	$110
Cost range ($/MMBtu)	$3.862	$3.333	$6.875

Appendix B – Cost Estimates

Key assumptions used for all comparisons:

City load = 163,000 MWh/yr
Escanaba Generating Station Heat Rate = 14,500 Btu/kWh
Total fixed plant operating costs (e.g., salaries, maintenance, etc.) for coal and both biomass fuels= $5,000,000
Heat content for Central Appalachian and western bituminous = 12,300 Btu/lb
Heat content for wood chips = 4,500 Btu/lb, wood cubes = 8,000 Btu/lb
Interest rate for debt repayment = 5.00%
The Escanaba Generating Station will produce all power used for City Load, i.e. no purchased energy
Conversion costs include $148,000 for Jansen study, plus $500,000 for bond preparation

Various scenarios used for comparisons:

1) Full service supply contract, Party #3

2) Full service supply contract, Party #1

3) "As-is" with West Ridge coal

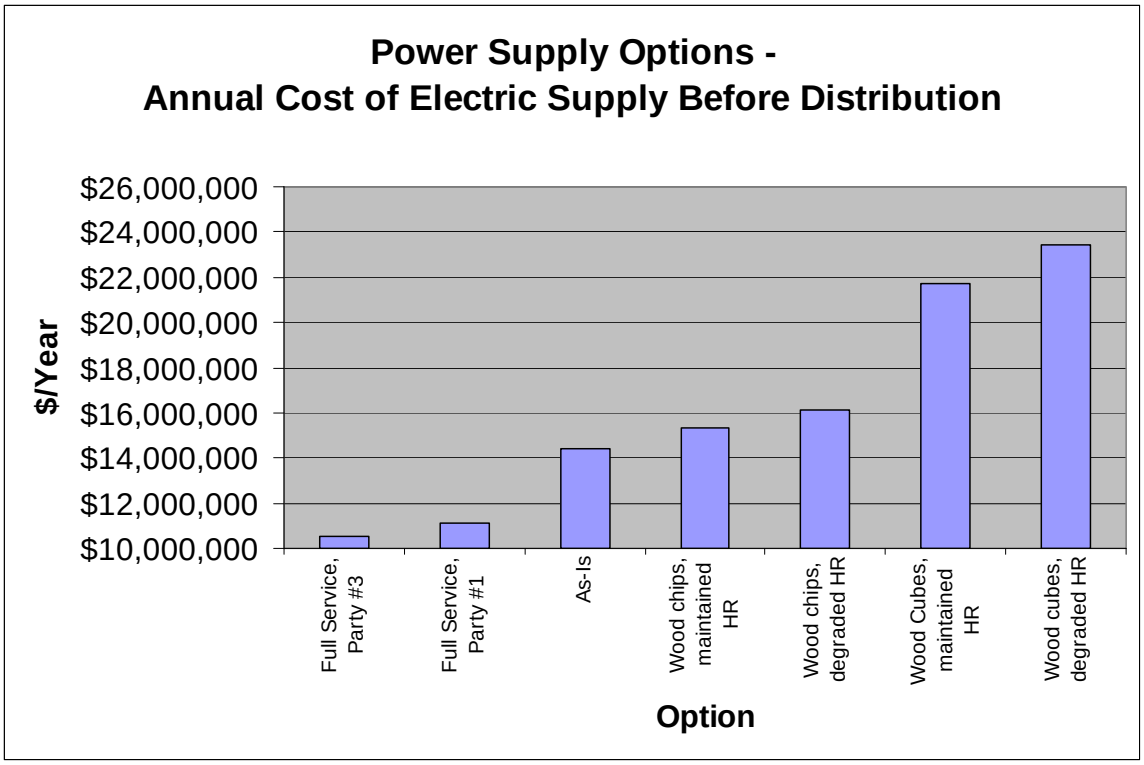
4) Wood chips, delivered to Escanaba for $30/ton, maintained Heat Rate
   $25,648,000 conversion cost
   20 years for debt repayment

5) Wood chips, delivered to Escanaba for $30/ton, degraded Heat Rate
   $25,648,000 conversion cost
   20 years for debt repayment

6) Wood cubes, delivered to Escanaba for $110/ton, maintained Heat Rate
   $5,000,000 conversion cost
   20 years for debt repayment

7) Wood cubes, delivered to Escanaba for $110/ton, degraded Heat Rate
   $5,000,000 conversion cost
   20 years for debt repayment

Power Supply Option	Full Service Supply Contract Party 3	Full Service Supply Contract Party 1	Present Operation Westridge Coal	Convert Plant to Wood chips Maintained Heat Rate	Convert Plant to Wood chips Degraded Heat Rate	Convert Plant to Wood cubes Maintained Heat Rate	Convert Plant to Wood cubes Degraded Heat Rate
Power Plant							
Fuel Type			Western Bit	Wood chips	Wood chips	Wood cubes	Wood cubes
$/Ton			$95.00	$30.00	$30.00	$110.00	$110.00
$/MMBtu			$3.862	$3.333	$3.333	$6.875	$6.875
$/Yr			$9,127,337	$7,878,333	$8,693,333	$16,249,063	$17,930,000
Qty, Tons/Yr			96,077	262,611	289,778	147,719	163,000
Heat Value, Btu/lb			12,300	4,500	4,500	8,000	8,000
City Load, MWh/Yr	163,000	163,000	163,000	163,000	163,000	163,000	163,000
Fixed Total Costs			$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Power Plant Heat Rate, Btu/kWh			14,500	14,500	16,000	14,500	16,000
Est Cap Investment	$0	$0		$25,648,000	$25,648,000	$5,000,000	$5,000,000
Interest Rate	5.00%	5.00%		5.00%	5.00%	5.00%	5.00%
Years for repayment	20	20		20	20	20	20
Yearly Payment	$0	$0		$2,058,062	$2,058,062	$401,213	$401,213
Generation Cost, $/MWh							
Variable							
Fuel			$56.00	$48.33	$53.33	$99.69	$110.00
Ash Disposal			$1.60	$2.40	$2.40	$0.50	$0.50
Fixed			$30.67	$30.67	$30.67	$30.67	$30.67
Total, $/MWh	$64.42	$68.10	$88.27	$81.41	$86.41	$130.86	$141.17
Total Generation costs, $/Yr	$10,500,460	$11,100,300	$14,388,137	$13,269,533	$14,084,533	$21,330,563	$23,011,500
Debt Repayment	$0	$0		$2,058,062	$2,058,062	$401,213	$401,213
Total Costs, $/Yr	**$10,500,460**	**$11,100,300**	**$14,388,137**	**$15,327,595**	**$16,142,595**	**$21,731,775**	**$23,412,713**
Annual Savings versus 08-'09 Westridge coal, $/Yr	$3,887,677	$3,287,837	$0	-$939,458	-$1,754,458	-$7,343,638	-$9,024,576


Power Supply Options -
Annual Cost of Electric Supply Before Distribution
$26,000,000
$24,000,000
$22,000,000
$20,000,000
$18,000,000
$16,000,000
$14,000,000
$12,000,000
$10,000,000
$/Year
Full Service, Party #3
Full Service, Party #1
As-Is
Wood chips, maintained HR
Wood chips, degraded HR
Wood Cubes, maintained HR
Wood cubes, degraded HR
Option