BENEFITS OF ONSITE POWER PRODUCTION FOR COTTON GINS

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Abstract

The current EPA policy of treating greenhouse gases as pollutants under the clean air act will increase the cost of what has been relatively inexpensive electricity derived from coal and natural gas. If the demand for electricity exceeds the supply, it is possible that rural agricultural processing operations such as cotton gins may not have access to the electricity needed as a consequence of public demands in urban areas. It is conceivable that a cotton gin can invest in a power plant located at the gin, generating the electricity needed for processing and fueled with cotton gin trash, delivered to the gin with the seed cotton. At 50 kilowatt hours (kWh) per bale, a 20, 40, or 60 bales per hour gin will need a 1, 2, or 3 megawatt (MW) power plant. Using an assumed capital investment of $1 million per MW, the fixed and variable costs per kWh were calculated. The annual production of electricity was calculated as a function of the amount of gin trash harvested with the seed cotton and delivered to the gin. The harvesting method determines the quantity of gin trash per bale. It was assumed that picked cotton contains 150 pounds (lb) per bale; stripped cotton with a cleaner on the stripper has 400 lb per bale and a stripper without a cleaner contains 800 lb/bale. The advantages of having relatively free fuel for power generation in contrast to having the expenses of purchasing and transporting large quantities of fuel to the power generation site are significant. For the purposes of calculating the electricity costs per kWh for ginning cotton, an assumed cost of electricity of $0.15/kWh from a utility provider or grid was used. Several scenarios were evaluated ranging from operating the power plant for the fuel delivered and purchasing electricity from the grid as needed for ginning, to operating the power plant for a fuel supplied and selling the excess electricity. The findings suggested that generating electricity onsite of a cotton gin could be attractive in the future.

Introduction

Electricity is utilized to power the majority of equipment in a cotton gin. The total quantity of electricity used for ginning ranges from 30 to 50 kilowatt hours per bale ginned. The cost of electricity has proven to be a large portion of a gin's overall variable costs. Utilizing a thermal conversion system fueled with cotton gin trash, electricity can be produced onsite to displace electricity purchased by utility providers. The most inexpensive electricity on the grid from utility providers is that generated from coal. Previous research at Texas A&M University focused on utilizing energy in biomass to generate electricity, steam and heat. LePori and Parnell (1988) patented a system for utilizing the biomass energy from agricultural waste products characterizes as having low ash melting points. These fuels are renewable but cannot be combusted. Temperatures associated with combustion result in slagging and fouling problems that can result in failure of the combustion system. The thermal conversion system in the Lepori and Parnell patent, utilized a fluidized bed reactor operating in gasification mode, referred to as fluidized bed gasification (FBG). The FBG produced a low calorific value gas that passes through a series cyclone system for removal of the char prior to combustion. The LCV gas may be used to generate steam or can fuel a generator to produce electricity. In this paper, it was assumed that the efficiency of extracting energy from cotton gin trash to produce electricity was 10%.

The following assumptions were made in this research:

- Cotton gin trash has an energy content of approximately 7,000 BTU/lb.
- Cotton harvested with a spindle harvester averages 150 pounds per bale.
- Cotton harvested by strippers with field cleaners contains 400 pounds of CGT per bale.
- Cotton harvested by strippers without field cleaners contains 800 pounds of CGT per bale.
- A cotton gin will need 50 kWh of electricity per bale and 200,000 BTU per bale for drying (TCGA, 2006).
- A 20 bale per hour (BPH) cotton gin will need a 1 megawatt (MW) power plant.
- A 40 BPH cotton gin will need a 2 MW power plant.
- A 60 BPH cotton gin will need a 3 MW power plant.

- Percent utilization (%U) is equal to the rated capacity multiplied by 0.8 times the number of hours that the gin operates. 80% of the rated capacity is assumed to be the average processing rate of the gin. For example, a gin rated at 20 BPH will average processing 16 BPH. For 100%U, the gin will process 16,000 bales for the season.
- The energy conversion efficiency for producing electricity from gin trash was 10%.
- Figure 1 below, portrays the annual electricity consumed (kWh) for a gin with a 20 BPH rated capacity and a 1000 hour season. Also included are annual production of electricity in kWh for three scenarios - picked (150lb/b), stripped with cleaner (400#/b), and stripped without a cleaner (800#/b) for the power plant versus the potential yearly consumption of electricity for a cotton gin rated at 20 BPH.

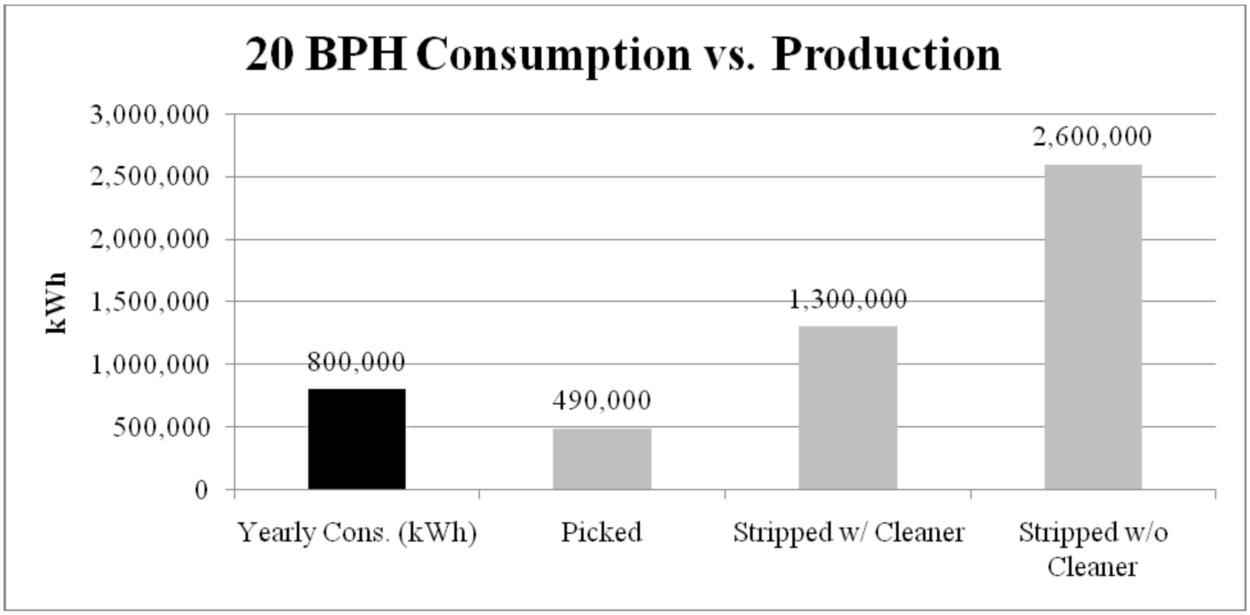

Figure 1. 20 BPH gin power consumption vs. power production.

In addition to electricity and heat production, utilizing CGT as an alternative energy source includes other benefits as well. CGT is a renewable form of biomass and is considered to be a carbon neutral avenue for energy production. Essentially, the carbon dioxide emitted in the process of thermally converting CGT into a viable power source does not create a net increase in greenhouse gases in the earth's ecosystem. It is possible that future legislation will implement a carbon credit system that will give additional subsidiary value to power produced from renewable sources, as opposed to fossil fuels. Additionally, the char removed in the FBG process is activate carbon and may add additional revenue (Capareda, 1990).

Traditional Utilization Methods

A recent survey performed by the USDA (Holt et al., 2004) reported that gin trash disposal was the second most prevalent problem that gin managers face, behind air quality regulations and permitting. Some of the current methods for disposing of CGT include cattle feeding, land application as mulch, and composting. Particularly in west Texas, CGT is primarily used for cattle rations. Although CGT is an adequate material for each of these uses, gin managers typically make only marginal profits, at best. The Texas Cotton Ginner's Association reported that a gin in a worst case scenario (stripper harvested) could see a net loss of $2 per bale ($10 per ton) for CGT, while a gin in a best case scenario might see a net profit of $2 per bale ($10 per ton). At such a small selling price, the disposal of CGT has become more of an expenditure (time, transport cost, etc.) than an addition to the gin's margin.

Other CGT utilization alternatives that are currently being explored are the COBY process (Holt et al., 2003) and the use of CGT as fermentation feedstock for ethanol production. The COBY process consists of a series of grinding, cooking and pressing principles with the addition of starch to form a pelletized fuel source. Beck and Clements (1982) developed a viable design for a 3000 gallon per day ethanol facility using CGT as the fermentation feedstock through cellulose hydrolysis.

Regulatory Policy

Amidst the energy crisis of the late 1970's and early 1980's, the United States Congress passed the Public Utility Regulatory Policies Act (PURPA) to promote increased generation and use of renewable energy (PURPA, 1978). The law created a market for non-utility electric power by forcing electric utilities to buy power from qualifying facilities. A qualifying facility (QF), according to PURPA, is a cogeneration facility or small power production facility which:

a. is a qualifying facility under the PURPA and the Federal Energy Regulatory Commission's (FERC) regulations;
b. is permitted to sell electric energy and capacity to the host utility at the host utility's avoided cost rate;
c. is not owned by an entity primarily engaged in the generation or sale of electric power; and
d. in the case of cogeneration facilities, and small power production facilities under 30 megawatts in size (80 megawatts for geothermal facilities), is largely exempt from the provisions of the Federal Power Act and the Public Utility Holding Company Act.

Section 210 of PURPA was enacted to require each electric utility to offer to purchase available electricity from a QF at a just and reasonable rate, not to discriminate against small power producers and not to exceed the avoided cost of producing the electricity. Avoided cost is described as the marginal cost that the utility would pay for the same amount of energy if they were to acquire it from another source or through the construction of a new power production facility. Revision of PURPA Section 210 in 2006, amended the obligation to purchase in saying "no electric utility shall be required to enter into a new contract or obligation to purchase electric energy from a qualifying cogeneration facility or a qualifying small power production facility under this section if the Commission finds that the qualifying facility has nondiscriminatory access to a viable and reasonable wholesale market". The Electric Reliability Council of Texas (ERCOT) and the Southwest Power Pool (SPP) collectively supply over 90% of the electrical energy in Texas with a combined capacity in 2009, of approximately 82,500 MW. Under ERCOT and SPP jurisdiction, power produced onsite at cotton gins can be marketed to the specific area's power utility under PURPA regulations to determine the best rate for purchase. However, if the utility either does not want part in the endeavor due to exemption of section 210 of PURPA, or the power producer thinks they can get better returns elsewhere, they have the right to make contracts with other utilities, municipalities, cooperatives, brokers, etc. and use the lines of the local utility by paying a per unit tariff for power line rental.

The State Energy Conservation Office (SECO) of Texas is a governmental agency established to promote energy efficiency in the state, while protecting the environment (Texas Renewable Portfolio Standard (TRPS), 2005). SECO administers and delivers numerous renewable energy and energy efficiency programs that stimulate the production and consumption of clean renewable energy in Texas. One particular mandate put in place by SECO is the TRPS. The TRPS was implemented to ensure that public and environmental benefits of renewable energy production and consumption are recognized as the competitiveness of electricity markets increases. Established in Senate Bill 7 in 1999, the current TRPS requires the state's electricity providers (retailers, municipalities, cooperatives, etc.) to collectively generate at least 2,000 MW of renewable energy in 2009. During the 2005 legislative session, the renewable energy mandate was increased to 5,880 MW by 2015 and 10,000 MW by 2025. With the expedited success of current wind energy projects, the current required level of renewable energy production has already been met. However, in order to diversify the electricity generation portfolio of renewable energy in Texas, 500 MW of the 2025 requirement must come from non-wind, renewable energy generation. Each power generator in Texas holds a certain percentage of the entire state's generation capacity. Each utility must also be accountable for that same percentage of the overall TRPS requirement for that year. For example, a competitive retailer that holds 5% of the retail electricity sales in the state in 2009, would be required to account for 100 MW of renewable energy generation capacity.

Enactment of the TRPS also includes the implementation of a Renewable Energy Credit (REC) trading program. One REC is the equivalent of one MW-hr. of clean renewable energy that is generated and metered in the state of Texas. The REC program gives renewable energy producers a marketable commodity that can be sold to other power utilities that have yet to meet their RPS requirements, or used as leverage in contractual negotiations with potential buyers of electricity. The REC program gives electricity providers the ability to fully account for their TRPS capacity requirement without purchasing any generation capacity.

Rationale and Significance

Proposed regulations for limiting greenhouse gas emissions from power plants are cause for concern. The largest emitters of GHG are coal-fired power plants. Coal-fired power plants produce the least costly electricity. If the goal of those who believe that "Global Warming" is happening and it is caused by GHG emissions into the ecosystem, there will be efforts to significantly reduce GHG emissions from these sources. It is likely that electricity costs for rural agricultural operations such as ginning cotton will increase significantly in the near future. Additionally, deregulation of electricity sales in the state of Texas have resulted in dramatic increases in electricity prices in parts of the state. At $1 million per MW in capital investment, an onsite power plant would cost about half as much as the total value of the cotton gin itself ($100,000 per BPH). The price of electricity used to process cotton could potentially double or triple with the possibility that the availability of electricity for cotton gins and other rural agricultural operations may be limited with urban populations having a higher priority. By utilizing a thermal conversion system such as FBG to generate power onsite fueled with cotton gin trash, cotton gins can produce electricity and heat to potentially become energy self sufficient. It is possible that sufficient fuel can result in excess electricity that can supplement income to the cotton gin.

Procedures and Results

Potential Electricity Rate Increase vs. Variable Cost per Bale

Valco and Green (2007) publish results of a ginning cost survey every three years. The latest survey included over 150 gins throughout the cotton belt in 2007. The reported average price of electricity was $0.09 per kWh. For comparison purposes, a hypothetical 20 BPH gin was simulated for 1000 hours in a season. The average non-electricity variable cost was $18 per bale. Recent reports from gin managers in West Texas show that rates with certain electric cooperatives have increased almost two-fold to approximately $0.15 per kWh. (Green 2009) Figure 2 below illustrates the comparison of the impact of recent electricity rates on total variable cost per bale for ginning cotton, and what potential effects rate increases ($0.15, $0.25) might have on the cost of ginning.

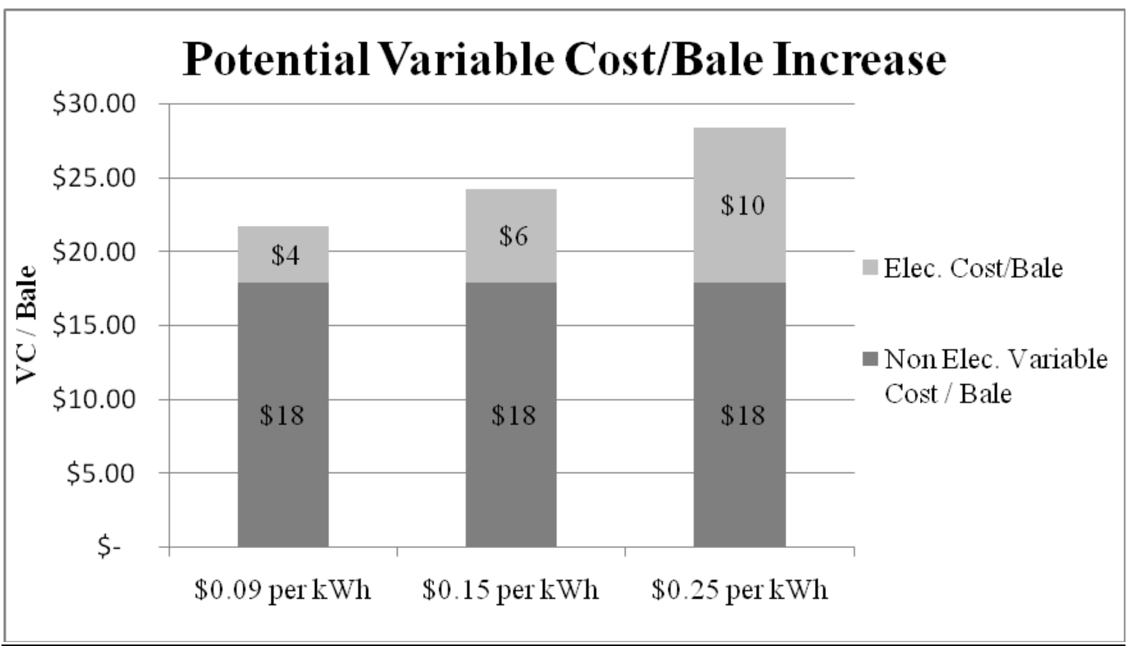

Figure 2. Effects of potential rate increases on variable cost per bale.

Notice that an increase from $0.09 per kWh to $0.15 per kWh poses a 12% increase in total variable cost per bale and an additional increase in cost to $0.25 per kWh carries a 31% increase in variable cost per bale over current costs. These types of increases would result in less profit for the gin and less dividends paid to members of ginning cooperatives. It is possible that if electricity prices continue to rise as they are expected to, the cost of ginning could reach a point where cotton production is no longer profitable. On the contrary, the cost of converting CGT into useable energy would remain the same since there it would cost no more or less to retrieve the waste product. Therefore, as electricity rates increase, onsite generation of electrical power through thermal conversion of CGT becomes more economically viable and potentially profitable.

Onsite Power Production Cost Analysis

A simulation model was developed to quantify the potential cost of electricity produced at an onsite power plant that utilized CGT as biomass feedstock. Developers of the FBG system proposed that an onsite power plant would require $1 million per MW of capacity and would require 1 MW of generation per 20 BPH of ginning capacity. This concept is based on the assumption that a gin, on average, will consume 50 kWh per processed bale of seed cotton. The model is also based on the assumption that actual ginning capacity is calculated as 80% of rated ginning capacity. Tables 1 and 2 below, shows example inputs for the production cost model, ranging from gin capacity to interest rate.

Table 1. Variables for power production cost analysis simulation model.

Process Variables		
Capacity	40	BPH
Feedstock Cost	$ -	/ton
Conversion Efficiency	10%	
kWh consumed	50	/bale
Current Electricity Price	$ 0.15	/kWh

Table 2. Plant cost estimates for power production analysis simulation model.

Plant Costs	Quantity	
Initial Cost	$ 2,000,000.00	
Repair and Maintenance	2%	of I.C.
Labor and Management	8%	of I.C.
Taxes and Insurance	2%	of I.C.
Loan Duration	10	years
Interest Rate	9%	
Variable Maintenance	$ 10.00	/hour
Char Discard	$ 10.00	/hour

The following example demonstrates the process of this model and how it is useful in determining the potential profitability of an onsite power generation plant. Assumptions for the hypothetical power production scenario are as follows:

1. The 40 BPH (rated) gin had an average processing rate of 32 BPH for the entire season.
2. A picked bale, stripped bale with field cleaner and a stripped bale without field cleaner yield 150, 400 and 800 pounds of CGT respectively.
3. 100% of the seed cotton was harvested by a stripper with field cleaner to yield 400 pounds of CGT per processed bale.
4. The gin operated at 125% utilization for this season, or 1250 hours of ginning.
5. The gin uses the available CGT at no cost.
6. Conversion efficiency of the power plant is 10%.
7. The power plant operates for three, eight hour shifts per day.
8. Initial cost for the system was $1 million per MW ($2 million total).
9. Repair and maintenance, management, and taxes and insurance were estimated to be 2%, 8% and 2% of initial cost respectively.
10. Seasonal labor cost is $45 per hour (3 people at $15 per hour).
11. Variable repair cost is assumed on a per hour basis.
12. The initial cost was financed with a 10 year loan at 9% interest compounded yearly.

Output from three simulation runs (power production for gin only, power production plus sale of excess, continuous power production) are described below in Table 3.

Table 3. Electricity production cost results from simulations of a 40 bph gin processing stripped cotton with a cleaner (400lb/b). Run numbers 1, 2, 3 represent scenarios of power production for gin use only, power production plus sale of excess electricity and power production for 6,000 hours per season, respectively.

	Run #1	Run #2	Run #3
Gin Characteristics			
Ginning Season Length (hrs.)	1,250	1,250	1,250
Trash/Hr. Produced (lbs./hr.)	13,000	13,000	13,000
Total kWh needed (kWh)	2.0×10^6	2.0×10^6	2.0×10^6
Power Plant Characteristics			
Total Fuel Input (tons)	4,900	8,000	30,000
Additional Fuel Needed (tons)	0	0	22,000
Fuel Input per Hour (lbs./hr.)	7,800	10,000	10,000
Plant Operation (hrs.)	1,250	1,600	6,000
Additional Fuel Cost ($/ton)	0	0	50
Total Electricity Prod. (kWh)	2.0×10^6	3.3×10^6	1.2×10^7
Power Production Costs			
Labor per Hour ($/hr.)	45	45	45
Variable Maintenance ($)	12,500	16,000	60,000
Char Discard ($)	12,500	16,000	60,000
Total Variable Cost ($)	81,000	104,000	1,500,000
Total Fixed Cost ($)	550,000	550,000	550,000
Total Cost per Year ($)	630,000	660,000	2,100,000
Cost of Biomass kWh ($/kWh)	0.32	0.20	0.17
Normal Elec. Price ($/kWh)	0.15	0.15	0.15

Production cost for the example above (Run #1) is estimated to be $0.20 per kWh. In turn, if reliable electricity can be purchased conventionally from year to year for less than $0.20 per kWh, the proposed power generation facility in this hypothetical situation would not be profitable. However, there are many factors that could quickly make this power plant more economically feasible. First, a rise in electricity rates above the cost of production could make the plant profitable. As the cost of utilizing fossil fuels for power production increases due to more strict limitations on the emissions of GHG's into the atmosphere, it is possible that electricity prices in the future will climb to well above $0.20 per kWh. Recall that the harvesting method in this ginning scenario was 100% stripped with field cleaner at an average of 400 pounds. In the case that more of the cotton was stripped without a field cleaner, each incoming bale of seed cotton would account for more CGT and an overall increase in incoming energy. Figure 3 below, illustrates the 3 different potential configurations of harvesting methods for the example above and their subsequent cost per kWh. (There are additional costs for both the gin and producer when seed cotton with more trash per bale is delivered to the gin that has not been addressed in these simulations.)

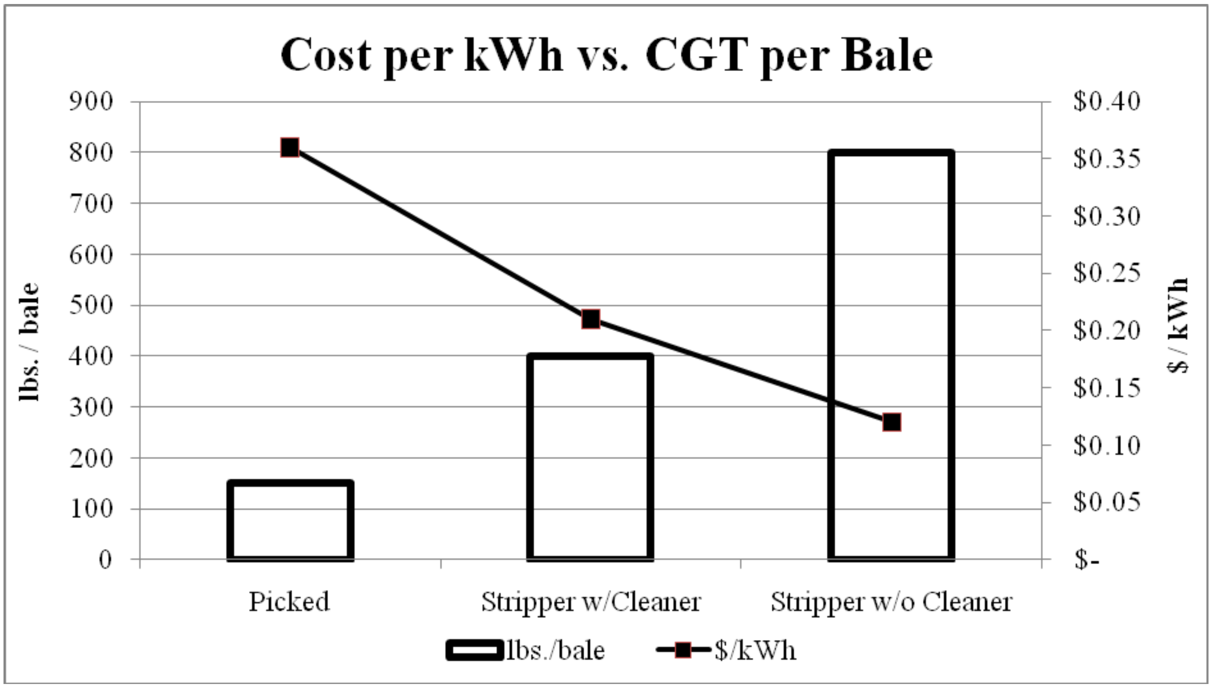

Figure 3. Biomass electricity production cost versus harvester method and subsequent CGT yield per bale.

Some gins traditionally charge producers a fee for delivering cotton that was harvested by a stripper with no field cleaner but, from a power production standpoint, there may be added incentive for the both the gin and the producer to remove field cleaners from harvesters if the economic benefit of additional CGT exceeds the added cost of transporting more modules of seed cotton. Other occurrences that could lower production costs per unit would be an increase in conversion efficiency, increased useful life of the plant and subsequent increase in loan duration, and a higher utilization percentage. Note that any occurrences of increase CGT output of the gin or increase in plant efficiency will also increase the power plant's days of operation.

Profitability of Onsite Power Production

Traditionally, the profitability of power production from the conversion of biomass has been dictated by the cost of transporting the material to the power plant rather than the cost of the fuel itself. The potential for biomass conversion for the generation of electricity from an energy standpoint can rival that of other renewable sources such as wind and solar. However, logistically, retrieving the fuel source and storing it can present potentially insurmountable operation costs. Komor (2004) reported that due to the often awkward bulkiness and low density of most biomass residues, transport cost quickly become prohibitive outside a radius of 50 miles. As a result of the limited service area from a cost standpoint, plant capacities are relatively small. Coincidentally, most biomass fueled power plants become uncompetitive due to higher production costs or the inability to present loads comparative in size to other renewable energy processes. Comparatively speaking, an onsite biomass conversion plant at a cotton gin is not subject to profit inhibiting transportation costs that other biomass conversion facilities are. If the primary goal of a cotton gin is to produce enough power to displace their yearly electricity consumption, there is enough energy available in the CGT onsite to succeed and potentially sell excess electricity back to power companies. Eliminating transportation cost for the fuel source drastically decreases the cost of producing electricity from biomass. As was reported earlier, the typical cost for converting biomass to electricity ranged from $0.20-$0.30 per kWh whereas electricity produced onsite at cotton gins could cost $0.10-$0.20 per kWh.

Potential Marketing Scenarios

Recall that under the jurisdiction of ERCOT and the SPP, local power utilities, municipalities and cooperatives are required to allow qualifying renewable energy generators the use of their power lines for a per unit tariff if they don't intend to by the capacity themselves. This creates many opportunities for the qualifying facility in terms of selling power. Using simple energy conversion calculations, it is apparent that there is sufficient enough energy available in the CGT present at cotton gins to displace the electricity that is bought throughout the ginning season.

However, there are multiple aspects of the electrical power market that must be analyzed to determine the most profitable protocol for managing the electricity produced onsite. The following three examples illustrate different potential scenarios for the best way to utilize and/or market electricity produced onsite.

Power Production for Gin Use Only

The basic goal of this research project is to develop a business plan to integrate an onsite power plant at an agricultural processing facility like a cotton gin and using waste products already on hand, displace the energy they purchase entirely. The section above concentrates on the potential sale of electricity to local utilities or buyers abroad. However, if the necessary relations aren't made between the production facility and their power utility for a power purchase agreement to buy excess electricity, it is possible that this investment could still be profitable just by displacing only the power used at the gin. The proposed size of 1 MW for every 20 BPH of ginning capacity was developed to produce at least enough power for the gin itself to operate. Assumptions for an example scenario of a 40 BPH (rated) gin that will only produce enough power to displace their annual requirement are as follows:

1. The 40 BPH (rated) gin had an average processing rate of 32 BPH for the entire season.
2. A picked bale, stripped bale with field cleaner and a stripped bale without field cleaner yield 150, 400 and 800 pounds of CGT respectively.
3. 100% of the seed cotton was harvested by a stripper with field cleaner to yield 400 pounds of CGT per processed bale.
4. The gin operated at 125% utilization for this season, or 1250 hours of ginning.
5. The power plant operates simultaneously with the gin to supply electricity for the gin.
6. Conversion efficiency of the power plant is 10%.
7. Initial cost for the system was $1 million per MW ($2 million total).
8. Repair and maintenance, management, and taxes and insurance were estimated to be 2%, 8% and 2% of initial cost respectively.
9. Seasonal labor cost is $45 per hour (3 people at $15 per hour).
10. Variable repair cost is assumed on a per hour basis.
11. The initial cost was financed with a 10 year loan at 9% interest compounded yearly.

This power production scenario is described as Run #1 in Figure 3 above.

Depending on how much biomass is delivered to the gin each season, the CGT that is potentially not thermally converted would be discarded in a more traditional manner. Since the costs that are associated with the power plant are spread over a relatively small quantity of electricity each year, the cost per kWh of electricity produced is relatively high at $0.32/kWh. However, it is possible that future legislation and overwhelming demands could push the price of electricity above that point, making a scenario like this viable.

Power Production for Gin plus Sale of Excess Power

The typical ginning season in west Texas and on the plains of Texas takes place between October and February. Coincidentally, that period of the year is the time where electricity demand is at its lowest. For multiple reasons (i.e. air conditioning, irrigation, etc.), the summer months of June through September represent a significantly higher demand of electricity than the winter months. Due to the overall increase in demand of electricity in the warmer months of the year, it seems that it would be most beneficial to the gins producing power to accumulate their CGT from each ginning season and operate the power plant during the summer. Parnell (1983) reported that it was possible to use traditional cotton modeling equipment to compact, cover and store 10 ton CGT modules for extended periods of time. Each gin would require a module builder dedicated solely to the production of CGT modules along with the necessary work force. The process would be conducted simultaneously with the ginning process and would require additional storage area at the rate of 50 modules per acre.

It is possible reach a contract for firm production of power for a given amount of time (weeks, months) based on what the power company needs or how much product the gin will be able to produce in a year consistently. However, hedging the risk of the gin not producing enough biomass to reach the contracted capacity is necessary. It might be most beneficial for the gin to develop a contract based on the amount of product they are fairly certain they will produce for the allotted time period, and then sell the excess on the short term in day-ahead or hour-ahead markets. Additionally, outsourcing entities are available that, for a certain price, will take care of the marketing of the excess power in terms of bidding and regulatory aspects.

Due to the small quantities that biomass-fueled power plants like the one proposed in this paper, an onsite power plant of 1-3 MW in size, most likely cannot compete with wind farms of 50+ MW for base load contracts. Particularly, power utilities have typically bypassed capacities that offer anything less than 20 MW of capacity (Thomas, 2009). However, utilizing biomass for electrical power generation holds a significant advantage over other renewable sources such as wind and solar. Biomass conversion can be started and stopped at the discretion of plant operators, whereas solar and wind systems rely on environmental phenomena that that can't be controlled. For example, wind energy is unpredictable, with overall capacity factors of sometimes only 40-50% (Capareda, 2009). Solar energy can only be collected in daylight hours and relies heavily on weather conditions (i.e. overcast). These types of renewable energy sources can only be relied upon for base load generation, not the start and stop generation that periods of peak demand require. Additionally, there is potential for higher payout in the short term peak demand markets that biomass fueled plants can take advantage of.

The simulation output for the ginning scenario in which the gin uses all of its available CGT for power production that they can sell back to power utilities with an interconnection agreement is detailed in Run #2 of Figure 3 above. Since the yearly cost is broken down over more units, cost per kWh of biomass electricity produced is lowered to $0.20. Regardless if the price of electricity increases dramatically, this scenario is viable since some power suppliers are already charging these higher rates.

6,000 hours of Power Production

It is possible, considering potential increases in electricity prices and demand, that a cotton ginning facility with a supplemental onsite power plant could become a power production facility with a cotton gin on the side. Essentially, the development of this technology coupled with the potential spike in electricity rates could provide the economic feasibility needed to justify power production for 6,000 hours per year. The limiting factor in the development of the proposed power plant for 6,000 hours is the amount of biomass required. Consider again the example of a 40 BPH gin that was described earlier in Run # 2.

1. The 40 BPH (rated) gin had an average processing rate of 32 BPH for the entire season.
2. A picked bale, stripped bale with field cleaner and a stripped bale without field cleaner yield 150, 400 and 800 pounds of CGT respectively.
3. 100% of the seed cotton was harvested by a stripper with field cleaner to yield 400 pounds of CGT per processed bale.
4. The gin operated at 125% utilization for this season, or 1250 hours of ginning.
5. The gin uses the available CGT at no cost.
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7. The power plant operates for three, eight hour shifts per day.
8. Initial cost for the system was $1 million per MW ($2 million total).
9. Repair and maintenance, management, and taxes and insurance were estimated to be 2%, 8% and 2% of initial cost respectively.
10. Seasonal labor cost is $45 per hour (3 people at $15 per hour).
11. Variable repair cost is assumed on a per hour basis.
12. The initial cost was financed with a 10 year loan at 9% interest compounded yearly.

At 125% utilization (1250 operating hours) and 400 pounds of CGT per bale, would result in 8,000 tons of biomass (fuel) per year. The 2 MW power plant operating at 10% conversion efficiency would consume the 400 pounds per bale of CGT supplied by the 32,000 bales per season in 1,600 hours. In this model, it is assumed that the first 1,250 hours of electricity production would be consumed by the gin. There would be sufficient fuel to operate the power plant an additional 350 hours producing 700,000 kWh to be sold back to the grid. To operate the 2 MW power plant for 6,000 hours, an additional 22,000 tons (30,000 tons total) of CGT or other biomass would be required. If the additional 22,000 tons biomass requirement can be obtained and transported to the power plant for $50 per ton, electricity can be produced at approximately $0.17 per kWh. The value of the additional 22,000 tons would be $1.1 million. Output from the simulation run for this continuous power production example is represented by Run #3 in Figure 3 above.

Summary

Given the likelihood of dramatic increases in the price and demand of electricity due to increased emphasis on the regulating GHG emissions, the production of clean renewable energy through the thermal conversion of CGT and other agricultural biomass residues may quickly become viable. Given that the heating capacity of most biomass residues is approximately 7,000 BTU per pound and the conversion efficiency of the FBG system designed at Texas A&M University ranges from 10-20%, there is enough energy available in the CGT accumulated in most cotton ginning processes to displace the energy consumed by that ginning facility each year. As the cotton ginning industry continually pushes to become optimally efficient, the utilization of a waste product to eliminate one of the most prevalent ginning costs makes sense, especially since the CGT has traditionally rendered no enhancement to the gins' bottom line.

There is enacted legislation at both the state and federal level that requires power utilities to purchase clean renewable energy produced by qualifying facilities or, allow the qualifying facility to utilize their power lines to reach a viable market for the electricity they produce. The State Energy Conservation Office of Texas also has in place a renewable portfolio standard that requires power suppliers to account for a certain percentage of a yearly renewable energy quota, starting with 2,000 MW in 2009.

A simulation package has been developed that assists in the analyzation and understanding of the costs associated with the production of electric power onsite at a cotton gin. Cost categories include: annuity on capital investment, taxes and insurance, labor and management, repair and maintenance and feedstock cost. This package was used to analyze three power production scenarios including electricity usage displacement only, the sale of excess power back to power suppliers, and continuous power production. All three scenarios could prove to be economically feasible depending on what the future has in store for the demand and price of electricity derived from fossil fuels.

Future Research

This paper details preliminary work on a research project at Texas A&M University that's purpose is to analyze the potential for a profitable implementation of an onsite power plant at a cotton gin. The overall goal of this project is to develop a comprehensive business plan for implementing small biomass fueled power plants in agricultural processing operations that utilize waste products that previously provided for little or no added profit. Future objectives include: more dynamic relations with potential buyers of electricity that is produced, coordination with the electricity councils in Texas to better understand interconnection principles, the potential utilization of excess syngas produced as drying fuels, and analysis of potential markets for the activated carbon accumulated from the gasification process.

The biofuels research team in the Biological and Agricultural Engineering Department at Texas A&M University, under the direction of Dr. Sergio Capareda, is currently building a mobile version of the fluidized bed gasifier that will be used for this project. The goal is to travel the state with the mobile facility and demonstrate this technology to gin managers and other leaders of the state's agricultural processing community. Additionally, the economic considerations that were described in this paper will be explained in detail to the audiences to show why this technology will benefit them in the future

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