The Economic Effect of Biomass Use in Stevens County, MN

Luke Toso, Student Researcher

8/18/2008

ABSTRACT

The economic effects of using biomass for energy have been evaluated at a national level but very little literature has been written regarding biomass on a local scale. The purpose of this paper was to study the effects of biomass use at a local level, in Stevens County, MN. The paper will discuss transportation, storage, and labor costs involved with biomass use, but its focus will be to evaluate the potential effects of a carbon market on a local level. This study looked at different programs offered that have the potential to make biomass use economically competitive when used as an alternative for fossil fuels. This study can be used by local farmers to look at the future possibilities for biomass use, and how its potential costs can be recouped with the use of a carbon market.

INTRODUCTION

Carbon dioxide (CO_2) levels have increased dramatically in the past few decades due to the burning of fossil fuels. Carbon dioxide absorbs infrared radiation when it is in the atmosphere, trapping thermal energy. Increasing amounts of atmospheric CO_2 is causing more sunlight to be captured, and as a result, the earth's climate is changing. Politicians and consumers alike are attempting to mitigate this global climate change through government policies and the use of alternative energy as a replacement for fossil fuels (Smith 2006).

Bioenergy, an alternative energy source that uses biomass as a fuel source, has been studied as a replacement for fossil fuels but there are issues concerning its use. Biomass has a much lower energy density than fossil fuels and therefore more is needed to produce an equal amount energy. Therefore, it may only be cost effective to use biomass energy in agricultural areas, because as the distance biomass travels increases, transportation costs also increase (Petrolia, 2006). Additionally, in order for biomass to be profitable to producers and consumers, harvesting and transporting biomass must be done within close proximity to a biomass refinery (approximately 50 miles). Too far would make the marginal cost higher than the marginal revenue, decreasing the profit margin the biomass firm could earn.

After biomass delivery to the processing facility, storage and labor costs can become another concern. Since harvesting biomass does not typically take place during the winter months in most Midwest states, proper storage is a necessity in order to have a constant energy flow to the processing facility throughout the year. Acquiring storage space has monetary and potential opportunity costs for its use. Biomass, being an agricultural product, also decomposes over time, so applying proper storage techniques needs to occur in order to keep the biomass in usable condition; keeping biomass in usable condition can result in a higher energy yields per unit of biomass utilized. Additionally, biomass is much more labor intensive to utilize compared to fossil fuels. Labor is involved when moving biomass from the storage area to the facility site and in the actual running of the biomass facility.

These costs have the potential to be recouped in the future through government policies. One such government policy in use in Europe is a cap and trade system used to mitigate CO_2 emissions. There, a set amount of credits are given to emit CO2, and those that wish to go above their credit allowance must buy from those willing to sell.. The US has a voluntary carbon trading system under the Chicago Climate Exchange (CCX), which provides programs to landowners to sequester carbon. The sequester of carbon can earn credit benefits that can be sold on the exchange for cash. The US has considered using a cap and trade system, but has examined other policies as well.

A carbon tax is a policy that politicians and scientists have considered which would put a direct price on every ton of CO_2 emitted. This would be a more straightforward policy compared to a cap and trade system because it would be cheaper to implement and transparent. That is, it would be easier to monitor and enforce. Proponents of the idea have argued that the money generated from this program could be used for alternative energy research and development.

Government programs and economic costs discussed here have been analyzed in previous research on a national and state level, but this study looks at the economics of biomass use a local level, in Stevens County, MN. Local landowners looking to use a carbon market to offset biomass production costs can use this data to look at potential future profits of biomass use.

BIOMASS USE

Biomass gasification, a form of bioenergy used today, is a viable source of renewable energy but there are issues with its use. Gasification is the incomplete combustion of biomass resulting in the production of combustible gases, known as synthesis gases, or "producer gases" (Rajvanshi, 1986). Producer gases are used for direct heating purposes, powering of internal combustion engines, and production of important industrial chemicals, one of which is methanol (used as an alternative to petroleum). Gasifiers can be fueled from crop residues taken from fields after crops are harvested, but concerns have been raised about the effects on the soil when crop residue is removed. Typically, crop residues are left on the soil, replenishing nutrients lost when crops are harvested. Removing too much residue can result in increased fertilizer inputs in the future. With the increasing price of nitrogen-based fertilizers, this can become increasingly more expensive for landowners. To help recoup some of these costs, the ash created gasifying corn stover could be used as fertilizer, although further research needs to be done in order to examine the viability of this system. Other forms of alternative energy, such as biofuels, do not remove crop residue but instead use the crop itself.

Biofuels are made by the conversion of crop biomass through varying processes to a fuel source used primarily in the transportation sector.   This process differs from fossil fuels in that crop biomass is recently expired organic matter already in the carbon cycle. Fossil fuels have been out of the carbon cycle for millions of years and when burned, add additional carbon to the atmosphere. Ethanol is a biofuel currently produced from corn or sugarcane. Corn is used in the US for ethanol production, while in Brazil, sugarcane based ethanol is produced. Currently, it is required by law to mix with ethanol with gasoline to power internal combustion engines.

The viability of ethanol as an alternative for gasoline has been questioned (Runge, 2006, et al). Some believe that manufacturing ethanol has raised the price of corn beyond a price at which ethanol companies can purchase it at. At the same time, prices for corn-based food have increased, fueling an argument known as “food for fuel.” Some landowners are also taking land out of the Conservation Reserve Program (CRP) to produce crops because of the current high prices. Conservation Reserve land is typically not profitable for row crop production. By taking this land out of the reserve and putting it into agricultural production, it may cause future problems such as the depletion of nutrients, requiring high inputs of fertilizers in the future. Soil quality may also diminish, causing potential problems for landowners. These issues have moved some researchers away from using crop based biofuels to cellulosic ethanol.

Cellulosic ethanol is chemically identical to corn and sugarcane based ethanol, but has the advantage that cellulosic grasses are can be sustainably produced without the need for high agricultural inputs. Current research has focused on Switchgrass and miscanthus as a basis for cellulosic ethanol because of their high levels of cellulose (Thorsell, 2004). One concern acknowledged with this process is the considerably large facilities needed in order to be cost effective compared to corn and sugarcane based ethanol. With this large economy of scale, switchgrass based ethanol will not be viable unless this obstacle is overcome (Runge, 2007).

STEVENS COUNTY, MN

Stevens County is located in western Minnesota with a total area of 575 square miles according to the US Census Bureau. Of that land, 489.5 sq. miles (313,292 acres) is farmland, 112,116 acres of it devoted primarily to corn production, and 116,631 is devoted to soybean production (USDA, 2007 estimates). This study focuses on the biomass gasifier located in

Morris, the county seat of Stevens County, as an example of community scale renewable energy project. The University of Minnesota, Morris (UMM) has focused on using biomass available in the area to fuel the gasification plant, planned for commissioning in the summer of 2008.

The purpose of this gasification plant was to decrease the carbon footprint of the campus, while at the same time replacing the natural gas fired boiler. With the commissioning of the gasification plant and the addition of another two wind turbines, UMM will be carbon neutral by 2010. The gasification plant will theoretically decrease natural gas spending by over eighty percent by using corn stover as a primary fuel source. The money previously spent on natural gas, instead of going to Canada, Louisiana, Kansas, and overseas, will be spent in the local area, stimulating local economy in a number of different ways. From buying crop residue to fuel the plant, to hiring local transportation agencies to ship it, almost all sectors of the local agricultural economy will benefit.

POTENTIAL COSTS OF BIOMASS USE IN STEVENS COUNTY, MN

Transportation

Biomass has a lower energy density than fossil fuels, and therefore more is necessary in production to gain an equivalent amount of energy. The gasification plant in Morris, MN, will require about 10,000 tons of corn stover annually, while other biomass plants require much more (Cooper, 1998). This amount of biomass can pose a problem to transportation logistics, because as the distance the biomass needs to travel increases, the cost to transport the biomass increases. The increase in cost can then decrease the energy cost benefit gained when utilizing the biomass.

Transportation costs can be broken down into two categories: variable and fixed costs (Searcy et al, 2007). Variable costs depend on the number of trips that a truck must take, and the distance of each trip. Variable costs will increase as the number of work hours or miles increase, and will not change significantly at a per mile or per hour basis. Fixed vehicle costs depend on the amount of miles a truck travels. This study examines variable costs in terms of how many trips a truck will have to take in order to carry so many tons of biomass. Fixed costs are identified as loading and unloading biomass at the harvest and storage sites, respectively.

Table 1 shows calculations for transportation costs for the biomass plant in Morris, with current and maximum capacity as well as larger facility transportation costs. Assuming different costs per loaded mile, from 0-25, 26-100, and greater than 100 miles, transportation costs were estimated using data from a study done by Petrolia, 2008.

Currently, coordinators at the gasification plant are looking to buy biomass within the local community. Although there are no strict definitions of where the "local community" lies, biomass is typically being purchased within at 50-mile radius, with the exception of a biomass purchase from Moorhead, MN (about 100 miles away). Considering the 100-mile distance as a benchmark, transport of biomass would cost $266 per ton. At a 50-mile radius, the cost would be $149 per ton. To transport the 10,000 tons of biomass needed to run the gasification facility for a year, it would cost around $59,500 at a 50-mile radius. This is a high estimate because it assumes truckloads will come from 50 miles away, and no closer.

Storage Costs and Potential Availability

At peak capacity, the biomass gasification plant will use 1.5 tons of biomass per hour, while utilizing approximately 1 ton per hour at average capacity. This biomass will need to be on hand at all times, incurring storage costs and the need for storage space. Currently, there are two storage lots in use for the Morris gasification plant with a total area of 2.93 acres. There are about 1340 tons on that land, with a potential to hold as much as 4,000. More space may be necessary in order to hold the 10,000 tons of biomass needed annually, although this may not be economic due to volatility in land costs.

The rent was the primary cost taken into account when calculating storage cost and was estimated at $85.00 per acre (Hachfeld et al., 2008). Taking into account the current tons per acre at Morris, the values were then extrapolated to take into account 10,000 tons of biomass storage, and 50,000 tons of biomass storage. Also taken into account was the necessary space for facilities at storage sites that included spacing between rows, possible storage structures, scales, etc. The Morris facility will need 23.3 acres of storage space, costing about $1,983 per year.

Labor Costs

Utilizing stored biomass requires labor inmoving the biomass from storage sites to the facility, and with the running of the facility itself. The planners of the gasification plant in Morris, MN, have discussed multiple ways to minimize labor costs in the long run. Initially, there was discussion to simply use boiler operators currently under employment at the natural gas-fired boiler to fire the gasification plant. This idea was abandoned, and grounds crew workers would be used. There are issues with this plan of action because grounds crew employees would be taken away from normal day-to-day tasks. To ameliorate this problem, the use of an aggregator has been discussed. An aggregator would be hired to store and deliver biomass to the plant on a daily basis. Discussion focuses on hiring a construction company to do the delivery because the equipment they own is already under commission. This plan of action would be beneficial for construction companies in the winter months, when equipment would normally not be in use. In 2007, a request for proposal was sent out to parties interested. The only bid was $25/ton of biomass delivered, and was higher than simply using campus employees (Table 3).

Labor costs at the Morris plan are substantially higher than private sector wages because UMM has senior personnel with an above average benefit package. In the labor cost calculations, it was assumed that a typical boiler operator would earn $33.50/hr and a material handler would earn $30/hr (Table 3). Both include benefits. Overall, the cost of labor at the biomass plant including material handling would cost $578,660 as shown in Table 3. This, being a cumulative total of biomass operations and material handling, does not take into account the fact that the only additional cost that the biomass plant operation incurs over the natural gas powered boiler is the material handling. The boiler operators that stuff the natural gas plant are not additional, and would be paid regardless if the gasifier was built. Material handling costs $174,719 per year, and is the only additional labor cost of the biomass plant. It does not include fuel and machinery costs, or time lost to other functions.

Summary of Costs

Costs of a biomass plant stem from the fact that biomass has a lower energy content when compared to fossil fuels, and therefore more is needed in order to gain the equivalent amount of energy. Opportunity costs have not been discussed in this study because of the in depth modeling that would be required.

On a university campus, costs of biomass use are substantially higher than in the private sector. Labor wages increase substantially over that of private sector wages because of senior personnel and an above average benefits package. Storage costs are a factor because there are issues with storing the large amounts of biomass needed near a university campus, due to the detrimental aesthetical value of the biomass stored on university land.

Transportation, storage, and some labor costs can be mitigated by hiring an aggregator to haul biomass to and from the plant, using storage space already owned by the company. The costs of an aggregator have been discussed, and at its current price, are not economic to put into practice. This may be because of the lack of competition for the aggregator position.

Costs in this section have focused mostly on UMM's costs involving the biomass plant, but little attention has been paid to the costs incurred by the biomass producers themselves. Concerns have been raised regarding the costs that could be incurred from the removal of crop residues from the land, raising the inputs (e.g. fertilizer) needed in the future. Farmers looking to produce biomass can use a carbon market to recoup costs, although the market is in its preliminary stages.

THE CARBON MARKET

Background to the Carbon Market

As the United States moves towards climate change legislation, discussion has shifted from the science of global climate change to policy options to slow the emission of CO_2 and other GHGs. Currently, there is no economic cost to emit CO_2 into the atmosphere. Policymakers, therefore, are looking to put a price on CO_2, so that firms would have to start treating it as a commodity with a cost, not just a byproduct of production.

One approach is a direct tax on carbon, which would put a price upon every ton of carbon emitted into the atmosphere and would include both personal and industrial emissions (Schlesinger, 2006). The government would set its price, and each firm that emits carbon would have to pay the price. One benefit that has been discussed with the direct carbon tax is its transparency; Carbon dioxide emissions could be directly monitored and measured. This tax would only be viable if it were set high enough. Too low of a cost, and the marginal cost that a firm would incur when emitting CO_2 would be insignificant to offset its marginal profits, and emissions would not decrease.

With recent spike in the cost of petroleum, a carbon tax is increasingly unpopular because it would continue to increase the cost of not only petroleum, but also other fossil fuels associated with CO_2 emissions. Gasoline taxes would increase, and power plants that use fossil fuels for energy would displace the costs of the tax upon consumers. It is argued, however, that the money generated from the tax could be used to fuel alternative energy markets. Regardless, many politicians are moving away from a tax based mitigation system to a market based system.

In a cap and trade system, a market based mitigation system, a cap, or allowance, is set at the amount of CO_2 that can be emitted by a polluter. A set number of allowances are issued by the government to firms that emit CO_2, limiting the overall amount that can be released. If a firm wanted to increase their emissions of CO_2, they must buy permits from those firms who are willing to sell their excess allowances. Over time, the cap would decrease, forcing firms to innovate or buy additional permits from those who are willing to sell. A cap and trade system was used to mitigate SO_2 emissions in the 1990s to stop the formation of acid rain. Using a market based cap and trade system, the SO_2 system was able to reduce emissions ahead of schedule, and at 30 percent of the projected cost, demonstrating the viability of the system (Chameides, 2007).

A cap and trade system also allows for growth in renewable energy markets by offering carbon offsets, or credits, to firms that prevent CO_2 from being emitted into the atmosphere.

Carbon credits seek to reduce the current stock of carbon dioxide in the atmosphere through programs that prevent carbon dioxide emissions and that remove carbon dioxide already present in the atmosphere (Landowner's Guide to Carbon Sequestration Credits, 2007). A single carbon credit is equal to the removal or prevention of one metric ton of carbon, and can be sold on the carbon market for cash. This can help renewable energy systems to become cost competitive to fossil fuels by helping recoup some of the costs incurred from entering the market. Trading credits on any carbon market would create price fluctuations much like that in a typical stock market and would be governed by supply and demand. A market for GHG trading is already in place in both Europe and the US.

Currently, the Chicago Climate Exchange operates a voluntary carbon market in the United States. Firms can choose to buy credits on the market to offset their emissions. Although the market is voluntary, once entered it is a legally binding contract. If a cap and trade system were to be put into affect on a national level, involvement in this market would become mandatory, like in the European Union under the Emissions Trading Scheme. There, emissions can be offset through the Clean Development Mechanism, which allows industrialized countries to invest in projects that reduce emissions in developing countries as an alternative to more expensive emissions reductions in their own countries (Article 12, Kyoto Protocol). Additionally, alternative energy facilities can earn credits that can be sold on the carbon market.

Carbon Market on a Local Level

A carbon market has been studied on a national level, but little attention has been paid to how it will affect local communities. On a local level, carbon credits offer promise to reimburse farmers looking to use marginal land (land that is not currently profitable for commercial crop use) for use in carbon sequestration projects. Carbon sequestration is defined as the capture and secure storage of carbon dioxide that would otherwise be emitted or remain in the atmosphere. Photosynthetic plants naturally capture carbon dioxide to be used in photosynthesis, which splits the oxygen from the carbon and fixates the carbon in plant matter, such as roots and stems. Because trees store vast amounts of carbon in their trunks and roots, they can be used to sequester large amounts of carbon. Farmers can utilize this process to earn carbon credits for any land that they put into a carbon sequestration project, although there are issues with this process.

These carbon sequestration projects raise some concerns due to the issue of permanence; how long will the carbon captured in the tree stay as terrestrial carbon (carbon stored in biomass)? Constructing a wind turbine will prevent a certain amount of carbon dioxide from entering the atmosphere because it prevents the burning of fossil fuels that would otherwise be used for energy production. The amount of carbon prevented from entering the atmosphere can be calculated by finding the amount of carbon that would otherwise enter the atmosphere if the construction of the turbine were not undergone. Therefore, carbon credits can be easily calculated and awarded to that activity. Carbon sequestration projects, on the other hand, cannot permanently prevent carbon from entering into the atmosphere. They prevent the carbon from entering the atmosphere for a period of time, but after awhile, a tree holding the carbon may die and the carbon will be released back into the atmosphere.

There are two main approaches that have been discussed in regards to this issue of permanence (Chomitz, 2000). The first approach seeks to provide reasonable assurance of indefinite sequestration. This approach is difficult to achieve because unpredictable forces of nature may occur (known as stochastic events), such as lightning striking a stand of trees causing all of them to burn down. Providing partial credits according to the perceived risk that they will be maintained for a period of time, having obligations that temporary sequestration projects will lead to permanent sequestration projects in the future, and sequestration credits to finance research and development into emissions-saving technologies are mechanisms that can provide reasonable assurance for indefinite sequestration projects.

The second approach acknowledges the fact that carbon sequestration is not likely permanent and looks at the environmental impacts of limited term carbon sequestration projects, allotting credits in proportion to the time period that the carbon would be sequestered. This approach is known as the ton-year approach and would accrue credits from each year that a ton of carbon would be withheld from the atmosphere. A quantity of ton-years would be equivalent to a permanent ton. Temporary credits would still be able to be sold on the carbon market for cash after a certain period of time.

In the United States, the carbon-trading system in operation is the Chicago Climate Exchange (CCX) which operates on a voluntary basis. The CCX sells carbon credits in bundles, so an aggregator is used to buy several landowners' credits, combining them for sale on the exchange. Aggregators choose when to sell the credit on the market and within 24 hours of the sale the aggregator receives payment for the sale. Depending on the aggregator, at varying times during the year sales are totaled and payments are given to the landowners. The current contracts offered by the CCX are valid until 2010 because, as one analyst from the Delta Institute speculates, the CCX is waiting to see how the government handles carbon credit mitigation policy before committing to operate for another term. It is likely that if the US government does put into place mandatory climate change policy, the CCX will likely continue to operate, but relinquish regulatory and rulemaking control to the Environmental Protection Agency (EPA).

Contracts currently in progress still stress the idea that carbon sequestration projects need to address the issue of permanence, and promote renewing contracts after the year 2010.

Since the CCX is currently on a voluntary basis only, making carbon credits in the US lower than those in countries where carbon mitigation is mandatory. The average price for a carbon credit in the US in 2007 was approximately $4.00 per credit. On the European Climate Exchange (ECX), carbon is selling for approximately €25.00 per credit in 2007 (about $39.74, with an exchange rate of 1.58579: 1). If a mandatory carbon mitigation strategy were to be put into place in the US, this price has the potential to increase dramatically (Table 4).

Programs Offered by the Chicago Climate Exchange

One program offered by the CCX to sequester carbon to livestock farmers are anaerobic methane digesters. They use methane from manure, typically generated by cattle, and convert it to energy to be used for power. This type of practice sequesters 18.25 metric tons of CO_2 per ton of methane per year. Currently, this is the only program offered by the CCX specifically to mitigate GHG emissions from livestock and therefore has a higher carbon credit benefit than programs offered to cash crop farmers. Programs offered on land carbon sequestration have less carbon credit benefit but have far more opportunities to do so.

One of the primary programs offered by the CCX to sequester carbon on agricultural land is conservational tillage. Projects implement no-till or low till practices on agricultural lands. Low and no-tillage practices tend to release less carbon stored in the soil back into the atmosphere compared to normal tillage practices. Typically, these methods are calculated to benefit .4 to .6 metric tons of CO_2 per acre per year. It is required that crop residues are left on the soil surface, rather than plowing them into the soil. Weeds are then controlled through the use of cover crops or herbicides rather than cultivation. This management style can also increases water holding capacity, which can translate to higher crop yields.

If farmers have cropland that is marginal, or not profitable to cultivate under current crop prices, they can enlist in grass or tree planting programs. Planting of perennial grasses sequesters 1.0 metric tons of CO_2 per year and provides a valuable habitat for wildlife and forage for livestock. Tree plantings or forestry projects must take into account a baseline measurement in order to quantify the amount of carbon sequestered. Baseline measurements can vary by entity, but the CCX uses January 1, 1990 to measure against current levels. Projects include afforestation (a process used to establish forests on land that is not currently forest), reforestation via plantings, forest enrichment (increasing plant density), and passive reforestation. Tree plantings in the upper Midwest average 3 to 4 metric tons of CO_2 per acre per year with the top end averaging around 7 tons per acre per year. These rates will eventually decrease as the age of the trees increases over time because the rates are directly correlated with tree growth. During the early stages of planting, trees sequester the most carbon as they grow. Older trees tend to grow less than younger trees, and therefore sequester less carbon. This decrease in rate does not happen until 20-25 years after the trees have been planted, and sometimes longer depending upon the species.

Viable forestry projects have some startup costs that could make them unprofitable, but there are many incentives available to decrease these costs, making it economically viable to enroll. Table 4 outlines ways in which landowners can recoup startup costs. They are split into two tables. The first outlining payments awarded from agencies outside the US government, while the second table outlines government programs available to landowners looking to enroll in these types of programs (Table 4).

Without startup costs and maintenance costs taken into account, carbon credits can profit to landowners looking to sequester carbon. Landowners should not pursue carbon credits as a single means of income, though, under the US voluntary system. A landowner planting trees on 100 acres of land, sequestering 3, 4, and 7 metric tons of carbon per acre can make $835.20, $1,113.60, and $1,948.80 per year, respectively (Table 5). With the price of corn at increasing due to a rise in demand caused by ethanol, more money can be earned by transferring this land to crop production under the current system.

If the United States were to adopt a mandatory carbon mitigation system much like that adopted in the European Union, carbon credit prices would rise considerably. The average price of carbon credits in Europe for 2007 averaged €25.00, which at an exchange rate of 1.58579 Euros per US dollar would make the carbon credit price about $39.64. Taking into account this amount per credit and disregarding startup and maintenance costs, a landowner planting trees on 100 acres of soil, sequestering 3, 4, and 7 metric tons of carbon could have the potential to make $8,705.56, $11,607.41, and $20,312.98, respectively (Table 5).

In its current state, carbon credits in the US cannot offer large profit margins to landowners. If a system were to be put into place in the US much like the one in Europe, profit from carbon credits has the potential to increase. Numbers listed in this study are only theoretical, and show only a potential for the market. Therefore, they should not be used to forecast the future of the carbon market in the US.

CONCLUSION

With the increasing price of fossil fuels and concerns over global climate change, interest has shifted to implementing alternative energy sources for power production. Bioenergy is an expanding renewable energy market that offers many benefits to the global community to offset fossil fuel energy production. A biomass gasification plant in Morris, MN, has the potential to offset up to 90 percent of fossil fuel cost by buying biomass in the form of corn stover to fuel the plant. Not only that, but it will directly stimulate the local economy by buying crop residues from landowners in the area with dollars that would otherwise be spent overseas on fossil fuels.

A concern raised with bioenergy is the low energy density that biomass has in comparison to fossil fuels because of the increased costs in transportation, storage, and labor costs. Transporation costs within a 100 mile radius of the facility were estimated at $106,500 annually. Labor costs at the UMM biomass plant were estimated at $578,860, but the material handling cost, the only addionality to the construction of the biomass plant, were estimated at $174,719 (Table 3). Annual storage costs were estimated at $1,983. To mitigate labor and storage costs, an aggregator may be hired in order to store the biomass and transport it to the plant. Currently, a proposal was considered, but the costs were too high to be economic (Table 3). In the long term, it can become uneconomic for producers to remove biomass from the soil, but there are programs to alleviate this concern.

Currently, there are programs available to landowners to recoup the costs of biomass processing and projects available to turn marginal land into carbon sequestration projects. These projects can mitigate carbon dioxide emissions while at the same time earning carbon credits that can be traded on the Chicago Climate Exchange. Since the US carbon trading system is voluntary, credit prices are lower than in those countries with mandatory cap and trade systems. Credits are selling on average for $4.00 per credit on the US market, while in the EU, credits are selling for almost $40.00. If a mandatory system were to be put in place, landowners would have the potential to earn substantially more profit in carbon sequestration projects than under the current voluntary system (Table 5).

It is difficult at this time for some alternative energy projects to be economic because fossil fuels are still relatively cheaper to utilize for energy production. However, it is also a time of transition, and leadership in alternative energy field is needed. In the future, a carbon market will alleviate costs to both landowners and consumers seeking to use bioenergy as an alternative to fossil fuels, but now steps need to be taken in order for climate change mitigation to gain a foothold.

REFERENCES

Abboud, Leila. "Economist Strikes Gold in Climate-Change Fight." Wall Street Journal 13 Mar. 2008. 9 June 2008 <http://online.wsj.com/public/article/SB120535230851631199.html>.

Bird, Lori, Edward Holt, and Ghita Levenstein Carroll. "Implications of carbon cap-and-trade for US Voluntary renewable energy markets." Energy Policy 36 (2007): 2063-73.

Broder, John M. "Senate Opens Debate on Politically Risky BIll Addressing Global Warming." The New York Times 3 June 2008.

Chameides, William, and Michael Oppenheimer. "Carbon Trading Over Taxes." Science 315 (2007): 1670

Chomitz, Kenneth M. "Evaluating Carbon Offsets from Forestry and Energy Projects: How do they Compare?" World Bank Policy Research Working paper 2357 (2000).

Cooper, J, M Braster, and E Woolsey. "Overview of the Chariton Valley Switchgrass Project: A Part of the Biomass Power for Rural Development Initiative." BioEnergy (1998).

Fargione, Jospeh, Jason Hill, David Tillman, and Stephen Polasky. "Land Clearing and the Biofuel Carbon Debt." Science 319.5867 (2008)

Hachfeld, Gary, William Lazarus, and Dale Nordquist. "Cropland Rental Rates for Minnesota Counties." Ag Business Management University Extension (2008).

McCarl, Bruce A., and Uwe A. Schneider. "Economic Potential of Biomass Based Fuels for Greenhouse Gas Emission mitigation." Environmental and Resource Economics 24.4 (2003): 291-312

Petrolia, Daniel R. "The Economics of Harvesting and Transporting Corn Stover for Conversion to Fuel Ethanol: A Case Study for Minnesota." Staff Paper Series Department of Applied Economics (2006).

Rajvanshi, Anil K. Biomass Gasification. 1986. Nimbkar Agricultural Research Institute. 18 May 2008 http://nariphaltan.virtualave.net/gasbook.pdf

Runge, C. Ford, and Benjamin Senauer. "How Biofuels Could Starve the Poor." Real Clear Politics (2007). 26 June 2008 http://www.realclearpolitics.com/articles/2007/04/how_biofuels_could_starve_the.html

Runge, C. Ford. "Swtichgrass biofuel? No time soon." StarTribune 16 Apr. 2007 [Minneapolis, MN] .

Schlesinger, William H. "Carbon Trading." Science 314 (2006): 1217.

Searcy, Erin , Peter Flynn, Emad Ghafoori, and Amit Kumar. "The Relative Cost of Biomass Energy Transport." Applied Biochemistry and Biotechnology 136.140 (2007): 639-52.

Smith, Pete. "Bioenergy: not a new sports drink, but a way to tackle climate change." Biologist 53.1 (2006): 23-29.

Tillman, David, Jason Hill, and Clarence Lehman. "Carbon Negative Biofuels from Low-input High-diversity grassland biomass." Science 314.5805 (2006): 1598-600.

Thorsell, Sara, Francis M. Epplin, Raymond L. Huhnke, and Charles M. Taliaferro. "Economics of a coordinated biorefinery feedstock harvest system: lignocellulosic biomass harvest cost." Biomass Bioenergy 27 (2004): 327-37.

"Trading Dirt." Economist 5 June 2008. 11 June 2008 http://www.economist.com/world/unitedstates/displaystory.cfm?story_id=11511539>.

Trimac Consulting Servic. "Trucking operation business viability and truck costing model for transportation of grain." (2000).

Linda, Ulland, Scheer Kent, and Dean Current. "A Landowner's Guide to Carbon Sequesrtation Credits." Central Minnesota Reginaol Sustainable Development Parnership (2007).

Vangstad, Mike, Chief Operating Engineer, Plant Services. Personal Communication, July 2008

TABLE 1: Transportation Costs at the Biomass Plant in Morris, MN

	Per ton*	Current Capcity, Morris	Max Capcity, Morris	Larger Facilities
Tonage	1	1,340	10,000	50,000
Number of Semi Trips	1	53.60	400.00	2,000.00
Distance from facility: 25	$90	$4,824	$36,000	$180,000
50 miles	$149	$7,973	$59,500	$297,500
100 miles	$266	$14,271	$106,500	$532,500
200 miles	$456	$24,455	$182,500	$912,500
Loading and Unloading Costs	$1	$1,541	$11,500	$57,500

Assumptions	
Cost per loaded mile (0-25)	$3.60
Cost per loaded mile (26-100)	$2.35
Cost per loaded mile (>100)	$1.90
Tons per Semi Load	25
Per ton Unloading and Stacking	$1.15

*Considers full truckload

TABLE 2: Land Storage Costs at the Biomass Plant in Morris, MN

Costs

	Current Morris	Expected Morris	Other Facilities
Tonage	1340	10000	50000
Space for material (acres)	2.93	6.67	33.33
Facility Space (acres)	7.33	16.67	83.33
Total Space (acres)	10.26	23.33	116.67
Total Annual Costs	$872	$1,983	$9,917

Assumptions

$85.00	Land Rental ($/acre) Based Hachfeld et al., 2008
2.5	Factor used to determine additional space needed for biomass (row spacing, scale, facilities, ect.)
1500.00	Tons per acre

TABLE 3: Labor Costs of a Biomass Plant in Morris, MN

Biomass Plant Labor Costs	Per day	Per week	Per month	Per year
First shift	$536	$3,484	$15,097	$181,167
Second shift	$268	$2,144	$9,291	$111,487
Third shift	$268	$2,144	$9,291	$111,487
Total	$1,072	$7,772	$33,678	**$404,141**
Material Handling				
First shift	$240	$1,680	$7,280	$87,359
Second shift	$240	$1,680	$7,280	$87,359
Total				**$174,719**
Cost per ton				$19.41
Aggregator cost per ton				$25
Total Costs, Labor and Material Handling				**$578,860**

Assumptions

Biomass Plant Wages				Time Assumptions	
$33.50	per hour w/ benefits			8	hours per shift
Operators per shift		Weekends		7	days per week
2	operators, first shift (7am-3pm)	1	operator, first shift	4.3333	weeks per month
1	operator, second shift (3pm-11pm)	1	operator, second shift	12	months per year
1	operator, third shift (11pm-7am)	1	operator, third shift		
Material Handling Wages					
$30	per hour w/ benefits				
Operators per shift		Weekends			
1	operator, first shift (7am-3pm)	1	operator, first shift		
1	operator, second shift (3pm-11pm)	1	operator, second shift		

TABLE 4 : PROGRAMS AVAILIBLE FOR SEQUESTRATION PROJECTS

Cost Reducing Opportunities	Practices Covered	Percent of Costs Covered	Landowner Involvement	Other
Environmental Quality Incentives Program (EQIP) – Critical Area Planting	Planting of permanent vegetative cover in mixed native grasses	50 % of up to: Earthwork: $1000/acre Fertilizer: $35/acre Veg Cover: $260/acre Weed Control: $10/acre	Implementation of practices and performing upland treatment actions and adequately addressing potential adverse impacts to conservation	-One time payment of $40/acre -Up to 10 acres may be enrolled -Must be on lands that would have been planted as row crops
EQIP – Residue Management	Low-till farming and no till farming methods	100% up to $30/acre	Implementation of practices and performing upland treatment actions and adequately addressing potential adverse impacts to conservation	-Annual payment of $30/acre/yr for up to three years -Up to 250 acres can be enrolled.
EQIP – Forest Site Preparation	Clearing of previous vegetation to allow for installation of new forests	50% of costs up to $130/acre	Implementation of practices and performing upland treatment actions and adequately addressing potential adverse impacts to conservation	Must be accomplished through forest management plan. Forrest Site Preparation procedures and guidelines need to be followed in conjunctions with Tree and Shrub Establishment for seedlings and planting.
EQIP – Tree/Shrug Establishment	Planting conifers and hardwoods along with site preparation, seed, stock, planting and necessary tending.	50% of up to: Tree Planting, Conifers: $270/acre Hardwood: $310/acre Veg Cover: $350/acre Site Prep: $110/acre	Implementation of practices and performing upland treatment actions and adequately addressing potential adverse impacts to conservation	Covers between 400 and 800 trees per acre and weed control will be accomplished within 24 months of planting to prevent the growth of buckthorn and other invasive species.
EQIP – Restoration and Management of Declining Habitats	Planting conifers and hardwoods, along with permanent native ecosystem mix of perennial vegetative cover.	50% of up to: Tree Planting, Confiers: $270/acre Hardwood: $310/acre Veg Cover: $350/acre Site Prep: $110/acre	Implementation of practices and performing upland treatment actions and adequately addressing potential adverse impacts to conservation	A detailed plan is required in order to being reforestation, with specifications outlined in the NRCS practice standard.
Continuous CRP Cost-Share Assistance	Establishment of perennial vegetations on previously cropped land	UP to %50	Establishment of approved cover on eligible cropland	Land must have been cropped four out of the previous six years.
Erosion, Sediment Control & Water Quality Cost Share Program	Stabilizing critical areas, along with the installment of field windbreaks, strip cropping, and terraces	Up to 75% for high priority practices and 50% for secondary.	Permanently protect and improve soil and water quality	Contact local Soil and Water Conservation District for further information.

Government Payments	Practices Covered	Payment Forms	Landowner Involvement	Other
Sustainable Forest Initiative act (SFIA) http://cfc.cfans.umn.edu/nryb/nrr SFIA_NRR.pdf	Dedication of land to sustainable forest management	Annual payment based on Market vs. Current use values with minimum payments of $1.50/acre, but typically around $5.00/acre	Must have a forest management plan written by an approved writer and an 8 year covenant restricting the woodland form being developed	Annual incentive payments are treated as taxable income to property owner, not a rebate on property taxes
Conservation Reserve Program (CRP)	Conversion of specified, usually highly erodible, land into conservation practices such as perennial grasses or trees.	Payments are based upon the productivity of the land in traditional farming methods	Implementation of practices and must provide contracts when applying for Carbon Credits.	Continuous CRP and CREP are still being accepted and the practices allowed dovetail well with carbon sequestration programs even with President Bush's proposal that no new General CRP contracts be awarded during 2007 and 2008.
Forest Legacy Program (FLP)	Dedication of sustainable forest management	One type payment equal to the difference in the market value of the property before and after easement restrictions are set in place.	Prepare multiple resource management plan as a part of the conservation easement acquisition	Landowner must surrender development rights to the property in exchange for a one time payment and the federal government may fund up to 75% of projects costs, with at least 25% coming from private, State or local sources.

NOTE: Table adapted from A Landowners Guide to Carbon Sequestration Credits, and can be found online at http://www.cinram.umn.edu/publications/landowners_guide1.5-1.pdf

TABLE 5 : Income from of a Voluntary Carbon Market vs. a Mandatory Carbon Market

A case study between the United States and the European Union

Income of Carbon Credits in the United State's Voluntary Carbon Economy, 2007

	mT/acre/year	Acres Enrolled	Carbon Sequestered (mT)	Reserve Pool Credits (20%)	8% Aggregator Fee	CCX Fee of $.20/mT	**Total Income from Carbon Credits**
Conservation Farming	0.4	100	40	32	$10.24	$6.40	**$111.36**
	0.5	100	50	40	$12.80	$8.00	**$139.20**
	0.6	100	60	48	$15.36	$9.60	**$167.04**
Grass Plantings	1	100	100	80	$25.60	$16.00	**$278.40**
Tree Plantings	3	100	300	240	$76.80	$48.00	**$835.20**
	4	100	400	320	$102.40	$64.00	**$1,113.60**
	7	100	700	560	$179.20	$112.00	**$1,948.80**

Income of Carbon Credits with European prices and US Programs

	mT/acre/year	Acres Enrolled	Carbon Sequestered (mT)	Reserve Pool Credits (20%)	8% Aggregator Fee	CCX Fee of $.20/mT	**Total Income from Carbon Credits**
Conservation Farming	0.4	100	40	32	$101.49	$6.40	**$1,160.74**
	0.5	100	50	40	$126.86	$8.00	**$1,450.93**
	0.6	100	60	48	$152.24	$9.60	**$1,741.11**
Grass Plantings	1	100	100	80	$253.73	$16.00	**$2,901.85**
Tree Plantings	3	100	300	240	$761.18	$48.00	**$8,705.56**
	4	100	400	320	$1,014.91	$64.00	**$11,607.41**
	7	100	700	560	$1,776.08	$112.00	**$20,312.98**

PRICE INDEX

Average Price of Carbon Credit under Voluntary US Carbon Economy, 2007	Price of Carbon Credit under Mandatory European Cap and Trade, 2007	Exchange Rate	Price of European Carbon Credit in US Dollars
$4.00	€ 25.00	1.58579	**$39.64**