Assessing the Feasibility of Alternative Switchgrass Markets on Maryland's Eastern Shore

Final Report

A Collection of Recommendations for Switchgrass Use on the Eastern Shore for the Chester River Association

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Prepared for the Chester River Association by
the **Environmental Finance Center**

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Executive Summary

Background

Switchgrass is a native plant long grown on Maryland's Eastern Shore. Historically, it has served as animal fodder or buffer habitat in marginal lands, but the crop holds potential as a renewable fuel source as well. Although it is unclear whether the Eastern Shore has the capacity to grow switchgrass at a scale that would reduce the State's dependence on fossil fuels, there are environmental, social, and economic benefits associated with switchgrass that make examining the potential market for the crop as an alternative fuel worthwhile.

Faced with the challenge of identifying resource management strategies that reduce nutrient loads and meet pending regulatory requirements, the ancillary benefits of expanding the planting of switchgrass become even more potentially significant. Pilot programs that incentivize switchgrass have proven highly popular in the region. Determining the extent to which switchgrass can be a valuable part of Chesapeake Bay restoration depends on the existence of a reliable end-user market that maintains reasonable cost-benefit ratios.

Approach

The Environmental Finance Center (EFC) at the University of Maryland was asked to investigate the market opportunities for switchgrass as an alternative energy source on Maryland's Eastern Shore. This investigation included an extensive series of interviews hosted by the EFC with resource experts who have first-hand experience with the science behind switchgrass production and the economics of agricultural operations, as well as expertise in biofuels production. Between March and June 2011, the EFC communicated with more than 30 individuals and organizations, through informal email correspondence, phone interviews, and formal, in-person meetings. Of those conversations, a majority were with regional experts from the mid-Atlantic.

Findings

A variety of new and existing market opportunities exist for switchgrass as a renewable energy source, each with its own set of benefits and challenges. The grass can be used either in its raw form, which keeps processing costs at a minimum, or in a densified form, which is more easily transported.

Raw Material Uses

Selling switchgrass as a raw material is the easiest, and often most reliable, use of the crop. In its raw form, the grass could be put through a liquid conversion process to produce cellulosic ethanol or a gasification process to create ethane. The economics of these options, however, simply do not bear out given the high input costs associated with these processes and the presence of corn subsidies. Use of the raw grass in traditional or renewable power plants or as a pyrolysis input holds greater potential.

Incorporating switchgrass into traditional, coal-based electricity production provides benefits to both the grower and utility. Because it can be combined with coal in its raw form, little manipulation of the crop is required, which keeps grower processing costs low. In addition, incorporating the grass helps utility companies reduce their carbon demand and meet

renewable portfolio standards. Delmarva Power, Constellation Energy, and NRG Energy each expressed an interest in further discussing this opportunity, although with varying timelines.

The majority of renewable energy power plants in the US incorporate woody biomass into their operations. Wood waste in Maryland is plentiful and often goes unused, suggesting that if sufficient quantities of both feedstocks exist, there could be an opportunity to incorporate switchgrass with other biomass as a part of a renewable energy operation. Fibrowatt, the company that built the world's first three poultry litter fueled power plants in the United Kingdom, is eager to connect a planned Eastern Shore renewable energy plant with local feedstock sources and is interested in further discussions, as well.

Finally, conversion of switchgrass by pyrolysis shows promise as well. This process is not hindered by the enzymatic challenges that make the cost of liquid conversion prohibitive. Maryland-based New Generation Biofuels has expressed interest in using switchgrass in their pyrolysis process, but believe trials to ensure viability and fully demonstrate and quantify results will be necessary.

Densified Material Uses

Compressing switchgrass into pellets or briquettes provides greater environmental and economic benefits while minimizing transportation and other costs. These pellets are used as heating fuel source in both commercial and residential applications. Densified biomass heating produces 90% less greenhouse gas than fossil fuels,[1] and generates lower, more stable heating costs.

Although selling to an existing pelletizing facility would minimize the upfront capital costs of building a desification operation, transportation costs to existing facilities for the quantity being grown and a lack of demand for switchgrass in current operations make this a significantly less feasible option. Building a new pelletizing facility in the region would require major upfront capital investment, but if a sufficient amount of switchgrass could be produced to keep the plant operational, a local plant would minimize transportation costs to growers and could boost local economies.

Show Me Energy in Missouri, Plainview Growers in New Jersey, and Enviro Energy LLC in New York operate well-established pelletizing facilities of varying scales using various inputs. Each has offered to provide some level of mentorship, some for a fee, to the growers of the Eastern Shore should they choose to go the route of building their own facility.

Recommendations

Based on the EFC's findings, there are several key recommendations for moving switchgrass market opportunities forward on the Eastern Shore. They are listed here in order of priority. To build on the opportunities presented in this report will require capacity. A first and critical step regardless of what avenue Eastern Shore switchgrass growers choose to pursue will be to have a dedicated staff person responsible for pursuing the marketplace and funding opportunities described.

[1] Enviro Energy LLC, Retrieved from: http://www.enviroenergyny.com/

Pursue opportunities related to the use of raw switchgrass with energy producers.
Initiating relationships with Constellation Energy and/or NRG Energy will position Eastern Shore switchgrass growers to be "first in line" to be a provider of readily available, easily accessible, and affordable biomass material. This opportunity, above all others, is most likely to offer a cost-effective alternative energy market for the switchgrass being grown in a reasonable timeframe.

Beginning a dialogue with Fibrowatt regarding their interest in using switchgrass as a supplemental fuel source for their planned FibroShore facility would similarly leave growers well-poised should the facility come to fruition. Finally, if concerns over the compatibility of the switchgrass feedstock with their facility and process can be addressed, New Generation Biofuels also offers a viable energy production option.

Consider how best to use existing funding sources.
Although some may require partnering with other agencies, organizations, or academic institutions, there are a number of USDA grants that would be appropriate to tap into for a program of this nature and would enable the Chester River Association (CRA) to leverage the funds they are investing in this program.

Learning from the experience of others if pelletization is a compelling option.
A visit to Enviro Energy LLC could be a critical first step to understanding a successful pelletizing operation. Their knowledge and experience would help CRA and their growers determine the feasibility of creating a facility on the Eastern Shore. If there is serious interest in moving forward with a pelletizing operation, CRA and their growers should seriously consider investing in the consultation of one of the other pelletizers who have offered mentorship services.

Conclusion
Although there is no single clear and immediate answer to developing an alternative fuel market for the switchgrass currently being grown as a part of CRA's incentive program, there do appear to be a number of potential opportunities worthy of further investigation.

Introduction

Switchgrass is a plant native to Maryland long grown on the Eastern Shore. This has historically been for use as animal fodder or buffer habitat in marginal lands, but the crop holds potential as an alternative fuel source as well. Studies have shown that in one Iowa pilot alone, 31 thousand bales of locally-grown switchgrass yielded over 19 million kilowatt hours of electricity, enough to meet the electrical needs of close to 2,000 homes for one year. Burning switchgrass in place of coal also reduced sulfur emissions by 62 tons and CO_2 by more than 50 thousand tons.[2]

Although researchers at the University of Maryland question the Eastern Shore's capacity to grow switchgrass at a scale that would reduce the State's dependence on traditional fuels, there are environmental, social, and economic benefits associated with switchgrass that make it worthwhile to investigate the potential for an alternative fuel based market.

As the region struggles to identify Bay restoration strategies that meet pending regulatory requirements, the ancillary benefits of expanding the planting of switchgrass, particularly on the Eastern Shore, become even more potentially significant. Pilot programs that incentivize growing switchgrass over conventional crops are already in place and have proven highly popular with farmers in the region. Determining the extent to which switchgrass can be a valuable part of Bay clean up solutions depends on the existence of a reliable end-user market that maintains reasonable cost-benefit ratios.

Purpose

The Chesapeake Bay region faces a constant challenge to identify restoration strategies that reduce nutrient loads and meet pending regulatory requirements. Pilot agricultural programs, like the Chester River Association's (CRA) switchgrass project that incentivize growing switchgrass over conventional crops are already in place and have proven highly popular with farmers in the region.

The switchgrass in the CRA program is planted on buffer land in the Chester River Watershed, a major tributary to the Chesapeake Bay.[3] Growing switchgrass on the Eastern Shore can reasonably be expected to deliver environmental, social, and economic benefits. Research Agronomist Robert Mitchell from the United States Department of Agriculture's Agricultural Research Service (USDA ARS) believes that switchgrass is a leading candidate as a biomass energy feedstock, particularly because of its positive environmental impacts, the extent to which it has been researched, and the minimal inputs required.[4]

> ***Switchgrass is a leading candidate for biomass energy feedstock – particularly because the plant is native, well studied, and easily established.***
>
> --Robert Mitchell, Research Agronomist, USDA ARS

[2] Summarized from http://attra.ncat.org/attra-pub/switchgrass.html#ref, 20 December 2010.
[3] Switchgrass Project, Agriculture Program, Chester River Association, Retrieved from: http://chesterriverassociation.org/index.php?tpl_id=default&page_id=agriculture_program
[4] Mitchell, Robert. Telephone interview. 3 May 2011.

Environmental Benefits

Switchgrass reduces nutrient loading to the Chesapeake Bay while softening the impacts of fossil fuel use. The grass is fast-growing, requires little if any fertilizer, has deep root systems that absorb nutrients and reduce erosion, and can be harvested without need for replanting for up to ten years.

Additionally, there are substantial wildlife benefits to planting switchgrass, although research indicates that there are environmental and economic tradeoffs between harvesting switchgrass for wildlife habitat versus biofuel production.[5] When harvesting switchgrass for biofuel production, there are specific establishment and harvesting protocols designed to generate best switchgrass yields for biofuel production, which can be at odds with the best management practices for wildlife purposes.[6]

Social Benefits

The social benefits of switchgrass are best realized with a local market in place. If switchgrass can be used as an alternative energy feedstock, it may be promoted as a local product on the Eastern Shore. A local biomass market has the potential to increase jobs; increase fuel diversity and competition in the energy sector; and reduce the nation's dependence on a foreign energy supply.[7] Overall, biomass spurs local development and plays a role in achieving a national domestic energy sector.

Additionally, with rising electricity prices and the potential blackouts during demand peaks and supply shortfalls, biomass power generation can directly address these issues by providing "reliable, domestically-produced, dispatchable, economically-competitive and environmentally sustainable"[8] electricity.

Economic Benefits

Much like the social benefits of switchgrass, the economic benefits are best realized with a local market in place. The energy potential of the crop is enormous. However, without a dependable end-user market, participating farmers may not profit from the crop to the greatest extent possible. In addition, with a local market, the economic benefits can extend beyond the growers to the end-users and the community as a whole.

Clearly, participating farmers benefit from selling the crop as biomass. If the switchgrass is designed as habitat to sustain wildlife, farmers could potentially generate additional income by incorporating hunting on their property. Again, it should be noted, though, that harvest protocols for maximizing biofuel production can result in tradeoffs with habitat creation.

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[5] Rupp, Susan. Telephone interview. 31 May 2011.

[6] Based on the research and interviews conducted during the study, the following document can be referenced to determine these best practices: Parrish, D. J., Fike, J. H., Bransby, D. I., and Samson, R. 2008. Establishing and managing switchgrass as an energy crop. Online. Forage and Grazinglands doi:10.1094/FG-2008-0220-01-RV. Retrieve here: http://www.plantmanagementnetwork.org/pub/fg/review/2008/energy/

[7] Benefits of Biomass Energy, American Renewables, Retrieved from: http://www.amrenewables.com/biomass-energy/biomass-energy-benefits.php

[8] Ibid.

Currently, minimal research has taken place that looks at the scale of income potential for the wildlife habitat component of switchgrass.

In addition, certain types of end-users will see long-term economic benefits due to lower heating and electricity costs. Finally, a local switchgrass market could create jobs and encourage a more competitive local energy market, which may lower the price of other energy sources and spur economic development within the community.

Approach

The Role of the Environmental Finance Center

The Environmental Finance Center (EFC) at the University of Maryland was asked to investigate the market opportunities for switchgrass as an alternative energy source on Maryland's Eastern Shore. This investigation included an extensive series of interviews hosted by the EFC with resource experts who have first-hand experience with the science behind switchgrass production and the economics of agricultural operations, as well as expertise in biofuels production. These interviews have taken place with entities from both the public and private sector (see Appendix A).

Deliverables

The EFC initially anticipated the following deliverables as a result of this work:

- The EFC would actively participate in all project partner meetings and conference calls.
- The EFC would facilitate an initial half-day meeting of public and private sector agriculture experts in the region.
- The EFC would further investigate leads generated at the experts' forum.
- The EFC would conduct a minimum of five one-on-one consultations with potential end-user stakeholders.
- The EFC would reconvene the team of experts for a half-day review of draft recommendations.
- The EFC would prepare a final report presenting recommendations for the expansion of the switchgrass market.
- The EFC would facilitate an initial dialogue between producer-side stakeholders and end-user stakeholders.

As the interview process evolved, the EFC found it more effective to conduct a greater number of one-on-one and small-group consultations rather than convening multiple experts together simultaneously. The EFC, as a result, has delivered the following:

- The EFC actively participated in all project partner meetings and delivered two interim progress reports to project sponsor(s).
- The EFC conducted more than 35 interviews with public and private entities, all of whom had expertise in an aspect of switchgrass agricultural practices and/or biofuels production.

- The EFC further investigated leads generated in all one-on-one and small-group consultations.
- The EFC conducted a minimum of five one-on-one consultations with potential end-user stakeholders.
- The EFC prepared a final report presenting recommendations for the expansion of the switchgrass market.
- The EFC will facilitate an initial dialogue between producer-side stakeholders and end-user stakeholders.

Interview Process

The interview process began with an initial list of contacts provided to the EFC from the CRA that was augmented with suggestions from a small number of key Chesapeake Bay agricultural experts. Concurrently, the EFC conducted research to identify additional experts in the field involved with growing and researching switchgrass. This resulted in four conversations in February 2011 with regional experts, each of which led to further contacts and research.

As the initial investigation unfolded, it became clear to the EFC staff that there are organizations, individuals, and research institutions promoting switchgrass and other biomasses for alternative energy use across the United States and in Europe. It also became clear that the approach to the study should be organically driven, propelled forward by each conversation. Although the approach focused on a very broad perspective, it was essential to conduct interviews with regional experts as part of the process, as obstacles and opportunities vary geographically. Between March and June 2011, the EFC communicated with more than 30 individuals and organizations, through informal email correspondence, to phone interviews, to formal, in-person meetings with company heads. Of those conversations, a majority were with regional experts from the mid-Atlantic.

The EFC has a catalogue of notes from each interview that, although not included with this report, can be shared with CRA as they build on these recommendations. Many personal lessons of success and failure that were shared with EFC by those interviewed. CRA should find value in heeding these lessons as many spent a great deal of time and money learning how best to develop their respective markets. Most all who were interviewed were open to follow-up conversations to share their experience and research. Contact information is available in an appendix to this report.

Key Findings

An extensive interview process shed light on many potential opportunities for switchgrass use as a renewable energy source, as well as the many challenges to accessing both new and existing markets. Although the current energy climate indicates enormous potential for biomass, there is great risk involved in entering the market. The following is a discussion of the key findings for each potential market investigated.

Liquid Conversion

Cellulosic ethanol is a biofuel made from a wide array of feedstocks, including agricultural waste and dedicated energy crops. In recent years, it has been touted as a promising way to end the nation's dependence on foreign oil. Unlike corn ethanol, cellulosic ethanol does not require fertilizers, pesticides, water, or energy to grow; however, corn ethanol has been more prominent due to existing federal policies and programs. Although cellulosic ethanol requires a more complex refining process compared to corn ethanol, it yields a greater net energy benefit and lower greenhouse gas emissions.[9]

An interview with Daniel Cassidy, biomass expert at the USDA, suggested an optimistic outlook for the future of the cellulosic ethanol market. In Cassidy's opinion, the President's *Growing America's Fuel* initiative will shift which feedstocks are promoted by the USDA from corn to a collection of wood, switchgrass, algae, sorgum, and miscanthus.[10] Many interviews, however, revealed barriers to switchgrass entering the cellulosic ethanol market, which include the high cost of cellulose enzymes[11], the subsidies in place for corn

Growing America's Fuel

An Outcome Driven, Reengineered System

Goals

- Target of 100 million gallons of cellulosic biofuels in 2010
- The Renewable Fuel Standard (RFS2) provisions of the Energy Independence Security Act of 2007 calls for 36 billion gallons of biofuels per year by 2022

Current Situation

- Producing 12 billion gallons of biofuels per year, majority from corn grain ethanol

New Approach

- *Manage for results* – a regional supply chain systems approach, ensuring all fuels are compatible with the US transportation fuel infrastructure
- *Continued support development of first- and second-generation biofuels* – with an additional focus on accelerating third generation biofuels development
- *Support feedstock research and demonstration* – guarantee sustainable supply chain development with minimal transaction costs and benefits farms and rural communities

Growing America's Fuel, The White House, Retrieved from: www.whitehouse.gov/sites/default/.../growing_americas_fuels.PDF

[9] Cellulosic Ethanol, State Energy Conservation Office, Retrieved from: http://www.seco.cpa.state.tx.us/re_ethanol_cellulosic.htm

[10] Cassidy, Daniel. Interview. 28 April 2011.

[11] US Department of Energy Biofuels Program, Retrieved from: http://www.harvestcleanenergy.org/enews/enews_0505/enews_0505_Cellulosic_Ethanol.htm

ethanol, and the lack of a reliable market. Switchgrass' inability to compete with corn grain ethanol was a recurring opinion expressed by the majority of experts and stakeholders engaged.

In order to compete with corn grain ethanol, federal and state support must be in place for all stages of cellulosic ethanol conversion. Making sure to follow the evolution of the President's *Growing America's Fuel* initiative will be imperative for capitalizing on future ethanol opportunities.

EFC observations regarding liquid conversion

After a thorough investigation, it was determined that it is not likely feasible for the Eastern Shore farmers to sell switchgrass for liquid conversion at this time due to the high cost of cellulose enzymes, subsidies in place for corn grain ethanol, and lack of a reliable market.

Gasification

An interview conducted with Dr. Memo Diriker from the Business Economic and Community Outreach Network (BEACON) of the Franklin P. Perdue School of Business at Salisbury University, suggested that there is some potential for switchgrass use for ethane conversion. In Dr. Diriker's opinion, the potential for ethane conversion is much greater than that of cellulosic ethanol because of the current political climate and existing subsidies.[12]

Yet, from a purely economic perspective, gasification is likely too risky an investment if switchgrass is to be a sole input for ethane conversion. Dr. Diriker believes that the most promising option would be to combine switchgrass with other inputs. Combining multiple inputs would generate less uncertainty, a steady supply, and create the ability for demand.[13] This sentiment was reflected in countless conversations, and clearly woody biomass is currently the most prominent biomass feedstock used for biofuel production.

EFC observations regarding gasification

It is not feasible for the Eastern Shore farmers to sell switchgrass for gasification presently because of the high risk involved that hinders capital investments in the gasification process.

Raw Material Use

Current Practices

There are a variety of raw material uses for switchgrass that do not involve using the native grass for energy. For example, the farmers on the Eastern Shore currently sell the switchgrass to mushroom mines in Pennsylvania. In an interview with the Biomass Coordinator at Ernst Conservation Seeds, Dan Arnett provided an example of the economic implications of selling switchgrass to mushroom mines.

In Philadelphia, Pennsylvania, the mushroom industry pays an estimated $150 per ton for the straw/carbon content to be used as mushroom substrate, which on the surface would seem much more appealing than the $60 to $80 per ton paid for pellets. However, this may not be a fair comparison. First, the amount is inflated due to the high price of land in the Philadelphia

[12] Diriker, Memo. Interview. 14 February 2011.
[13] Ibid.

area in comparison to other parts of the region. In addition, this price is largely a factor of growing season conditions. In a wet year, when straw quality is poor but demand remains the same, a higher price can be garnered for good straw due to the limited supply. This price drops considerably in years where large quantities of quality straw are available. Arnett estimates that a $150 per ton season happens perhaps every three to five years, so although pellets may bring in less, they may provide a steadier, more predictable income to growers.[14]

EFC observations regarding current practices

The EFC determined throughout the investigation that the current practices being employed by the CRA farmers should continue until a more profitable option is presented.

Traditional Utilities

Incorporating the use of switchgrass into traditional, coal-based electricity production represents an end-use for switchgrass that is mutually-beneficial for both the farmers and the utility companies. Using switchgrass in this way requires little manipulation of the raw material making this an easy and economically viable use for the crop.

As renewable energy standards in many states increase, utilities may be compelled to consider incorporating biomass into their portfolios; however, transportation costs and changing regulatory requirements led the EFC to focus on the standards for Maryland and Delaware. The Maryland renewable energy portfolio standard requires 5% renewable energy in 2011, increasing each year until it reaches 20% in 2022.[15] The Delaware renewable energy portfolio standard requires 5% compliance with renewable energy in 2010-11, increasing each year until it reaches 25% in 2025-26.[16]

Initial research led to an investigation of two university-based research and demonstration projects. Both projects worked with utility companies to co-fire switchgrass with coal. Interestingly, both states participating in this research do not actually have renewable energy portfolio standards at this time.

In 2007, the University of Kentucky and East Kentucky Power Cooperative began combining switchgrass with coal to generate electricity for East Kentucky Power's Spurlock Station. According to Dr. Ray Smith and Tom Keene with the University of Kentucky, the switchgrass was grown on 20 farms, each with five acres and was used to replace 1-2% of coal. By 2009, 70 tons of switchgrass was harvested, baled, transported, and processed for handling. Since Kentucky has no renewable energy portfolio standards in place, the project goal was to produce switchgrass for biomass in Kentucky to attract the ethanol industry.[17] The long-term sustainability of this practice could be questionable. Considering the volatile price of coal in

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[14] Ibid.

[15] Renewable Energy Portfolio Standard, Maryland Incentives/Policies for Renewables & Efficiency, Database of State Incentives for Renewables & Efficiency, Retrieved from: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MD05R&re=1&ee=1

[16] Renewable Energy Portfolio Standard, Delaware Incentives/Policies for Renewables & Efficiency, Database of State Incentives for Renewables & Efficiency, Retrieved from: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=DE06R&re=1&ee=1

[17] Smith, Ray and Keene, Tom. Telephone interview. 10 March 2011.

comparison to the cost of biomass, and factoring in both the material and transportation costs, it may not always make economic sense for utilities to use biomass.[18] In states with no regulatory driver in place, economic factors will surpass any other reasons for incorporating biomass.

In a similar project, funded through a grant from the US Department of Energy (USDOE), the University of Tennessee, DuPont Danisco Cellulosic Ethanol (DDCE), Genera Energy and the state of Tennessee established a several-thousand-acre switchgrass crop for a biorefinery built by DDCE. The EFC spoke with Dr. Sam Jackson, Vice President for Feedstock Operations with Genera Energy and Institute of Agriculture Research Assistant Professor at the University of Tennessee who explained that once farmers established and harvested switchgrass, the crop was picked up, delivered, and ground down for burning. A large part of the success of this endeavor was the federal support provided to this project, enabling the researchers to pay the farmers $450 per acre per year.[19] Without this level of incentive, he explained, it can be difficult to get farmers

Comparison of Maryland & Delaware Energy Deregulation

During conversations with utility companies, it was brought to the EFC's attention that energy deregulation may lead to greater opportunities in Delaware than Maryland:

Maryland: Energy and gas deregulated

- Prior to legislation, local electric utility in charge of procuring and delivering power to the people in their service territory.
- The Electric Customer Choice and Competition Act of 1999 was passed though the Maryland General Assembly.
- The consumer could choose to continuing purchasing power from the local utility (known as Standard Offer Service (SOS) or Provider of Last Resort (POLR)) or to purchase power from an electric retail supplier. The local utility would still be responsible for the delivery of the power.
- Implications for switchgrass:
  - Increased competition into electricity suppliers' market
  - To compete with low costs may be more harmful to incorporate switchgrass

Delaware: Energy deregulated; gas partial choice

- Delmarva Power & Delaware Tariff are regulated utilities
- Customers of Delmarva Power and Delaware Electric Cooperative have a choice which company will provide their electricity
- Implications for switchgrass:
  - More stringent guidelines compared to MD written in state law about entering electricity supplier market
  - Less choice for consumer, which leads to higher prices but ability to focus on renewable energy standards

Energy Deregulated States in the US, Quantum Gas & Power Services, Ltd., retrieved from: http://www.quantumgas.com/list_of_energy_deregulated_states_in_united_states.html
Electric Regulation in Delaware, Department of State: Delaware Public Service Commission, State of Delaware, retrieved from: http://depsc.delaware.gov/electric.shtml#regulated

[18] Ibid.
[19] Jackson, Sam. Telephone interview. 24 March 2011.

engaged in this type of program, particularly in states that do not have renewable energy requirements.

This was followed several weeks later by a conversation with Matt McArdle of MESA Reduction Engineering & Processing which shed light on the importance of communicating with utility companies and made working with traditional utilities seem more feasible than initially appeared. In his opinion, although other opportunities may exist for switchgrass use, due to the quantity of switchgrass currently being grown on the Eastern Shore and the land capacity for further growth, selling to utility companies represents an easy and mutually beneficial opportunity, although it may not yield as many dollars-per-ton as some other end-uses.[20]

The EFC found that energy companies in the region were very difficult to penetrate as a whole. Names and positions of authority within the utilities were not easily accessible, perhaps in an attempt to limit solicitations or complaints. Utility companies in the region who the EFC was able to communicate with during the investigation include:

1. **Delmarva Power**

   Rob Mitchell with USDA ARS highlighted the opportunity to provide switchgrass to Delmarva Power, promoting the positive impacts of incorporating biomass for renewable energy. He believes that adding as little as 2% renewables can have a measurable economic impact on a utility's carbon demand.[21] Over the course of a series of discussions with Delmarva Power, there did not appear to be significant interest in connecting with this project at the present time, primarily due to the recent shut down of an operational facility. Although there are planned upgrades for another facility, the level of investment Delmarva is making in the facility has made them hesitant to integrate biomass until compatibility with the new system can be assured.

   EFC observations regarding Delmarva Power

   An opportunity to connect with Delmarva Power would be more likely a few years down the road when pending renovations are completed. Although an interesting potential opportunity, this timeline clearly does not suit current switchgrass growers eager for a market now.

2. **Constellation Energy**

   An in-person meeting with Bill Matuszeski, consultant and Former Director of the Chesapeake Bay Program Office led to contacting Constellation Energy. An interview with Constellation Energy representatives John Quinn, Director of Environmental Affairs and Salil Bose, Senior Project Manager provided insight into Constellation's current operations and future prospects. Constellation has six co-firing units in Maryland, two of which are pulverized coal units and one that is a cyclone boiler unit with greater input flexibility. The company has evaluated biomass co-firing, which identified the capital modifications necessary to incorporate biomass into operations, as well as which

[20] McArdle, Matt. Telephone interview. 27 May 2011.
[21] Mitchell, R.

specific types of co-firing units are better-suited to handle biomass.[22] In short, although not an immediate end-use solution, Constellation is genuinely interested in incorporating biomass into its operations and is willing and interested to discuss the potential to work with the Eastern Shore switchgrass farmers. [23]

2011 Constellation Energy EcoStar Grants

In 2011, Constellation Energy provided 85 Community Environmental Projects with EcoStar grants, totaling $355,000. Projects focused on one of the following:

1. Pollution prevention
2. Education and outreach
3. Energy efficiency
4. Conservation
5. Community activism

For more information, contact John Quinn at john.quinn@constellation.com.

Constellation Energy Awards EcoStar Grants to Community Environmental Stewards, citybizlist, April 22, 2011, retrieved from: http://baltimore.citybizlist.com/1/2011/4/22/Constellation-Energy-Awards-EcoStar-Grants-to-Community-Environmental-Stewards.aspx

EFC observations regarding Constellation Energy

Developing a relationship with Constellation Energy could be one of the best and most cost effective ways of building a market for switchgrass as a renewable energy source. Scheduling a meeting to discuss the opportunities with Constellation should be the first step to creating a strong partnership and is strongly encouraged. Salil Bose can coordinate with the Constellation team working on these issues. Working to establish a long-term relationship with Constellation is the EFC's top recommendation for moving a switchgrass biomass market forward.

3. **NRG Energy**

In a follow-up conversation with Matt McArdle, he indicated that NRG Energy is interested in pursuing the opportunity to incorporate switchgrass into their operations. NRG Energy, a Fortune 250 wholesale power generation company headquartered in Princeton, New Jersey, is a parent company to smaller utilities, some of which are located close to the Eastern Shore in Maryland and Delaware.[24] The EFC contacted a couple Delaware utility companies operating under NRG Energy; however, coordinating with NRG Energy may provide further opportunities for the Eastern Shore switchgrass. McArdle is arranging a site visit to the Eastern Shore with a renewable energy representative from NRG Energy.[25]

EFC observations regarding NRG Energy

McArdle is interested in serving as a conduit between CRA and NRG Energy and is eager to coordinate a meeting between the two organizations, a critical first step to take if this has not yet occurred. There is great potential in building a partnership with NRG as they are a parent company to many of the smaller utilities in both Maryland as well as

[22] Quinn, John and Bose, Salil. Telephone interview. 3 June 2011.
[23] To explore these opportunities, contact Salil Bose at Salil.Bose@constellation.com or (410) 787-5223.
[24] About NRG Energy, NRG Energy, Retrieved from: http://www.nrgenergy.com/about/index.htm.
[25] To explore these opportunities, contact Matt McArdle at matt.mcardle@mesareduction.com.

Delaware. Since NRG Energy is the owner of many locally based companies, taking steps to foster a strong partnership could present a number of long-term opportunities for switchgrass use as a biomass feedstock.

Renewable Energy Power Plants

The majority of renewable energy power plants in the US incorporate woody biomass into their operations. The Federal Energy Management Program supports using wood waste as one of the most abundant, cost-competitive, and environmentally friendly resources available.[26] In one Maryland correctional facility alone, a wood-chip fired cogeneration plant is being fed with 50,000 tons of wood chips per year.[27] Many of the experts the EFC spoke with pointed out that wood waste in Maryland is plentiful and much of it goes unused. The Maryland Department of the Environment reported that in 2007, 261,869 tons of natural wood waste was accepted for solid waste management.[28]

Many interviewed also cited a multiple-input approach, incorporating wood waste, switchgrass, and other biomass resources as more effective because it provides steadier feedstock supplies, greater flexibility, less risk, and often better output. After an initial discussion at the Harry R. Hughes Center for Agro-Ecology, Sarah Taylor-Rogers stated her belief that a single feedstock approach would not advance alternative energy goals. Taylor-Rogers mentioned a recent presentation made to Agro-Ecology and others by Fibrowatt, a company founded by Homeland Renewable Energy that built the world's first three poultry litter fueled power plants in the United Kingdom.

> ***Neither wood chips nor switchgrass alone is going to advance the ball to the goal line.***
>
> --Sarah Taylor-Rogers, Assistant Director, Howard R. Hughes Center for Agro-Ecology, Inc.

Fibrowatt representatives Laura Kellogg, Jim Potter, and Eric Jenkins came to the University of Maryland for a meeting with the EFC in April 2011. The meeting's discussion revolved around FibroShore, a potential power plant Fibrowatt is eager to launch on the Eastern Shore. Fibrowatt also has a biomass plant in Minnesota called Fibrominn, the first in the US built in 2007, which operates using more than 600,000 tons of poultry litter and woody biomass per

[26] Biomass Energy — Focus on Wood Waste, Biomass and Alternative Methane Fuels (BAMF) Super ESPC Program Fact Sheet, Federal Energy Management Program, Retrieved from: http://www1.eere.energy.gov/femp/pdfs/bamf_woodwaste.pdf

[27] Ibid.

[28] Annual Report Solid Waste Management In Maryland Calendar Year 2007, Maryland Department of the Environment, November 2008, Retrieved from: http://www.mde.maryland.gov/programs/land/recyclingandoperationsprogram/publications/documents/www.mde.state.md.us/assets/document/solid_waste_annual_report_2007.pdf

year. They anticipate FibroShore could combust as much as 465,000 tons of poultry litter annually.[29]

The majority of those interviewed believed that Maryland has the capacity to incorporate the amount of wood waste needed to sustain an operation with poultry litter, wood waste, and switchgrass. Fibrowatt anticipates great environmental, social, and economic benefits by bringing FibroShore to the region including:

1. Environmental benefits such as significant nitrogen and phosphorous reduction;[30]
2. Social benefits from the jobs created by the construction and operation of the plant and renewable energy production on the Eastern Shore; and
3. Economic benefits from the market providing steady income for farmers[31] and additional biomass supply for the plant.

Fibrowatt is interested in using switchgrass as an input to supplement poultry litter. A formal expression of their interest in using switchgrass in their FibroShore facility appears in Appendix B.[32]

EFC observations regarding FibroShore

It appears that there could be enormous opportunity for incorporating switchgrass with other biomass products, particularly wood waste, as a part of a renewable energy operation; it is less clear whether there were sufficient quantities of both feedstocks available to penetrate this market. The EFC also felt strongly that for this option to be viable, it will require building strong support and collaborating with many entities, both from the state and private sector.

Fibrowatt, however, could be a game changer. Fibrowatt is eager to connect an Eastern Shore renewable energy plant with local feedstock sources, and this could provide a number of advantages to switchgrass growers. If the company is successful in locating a facility on the Eastern Shore in the next year, it will likely be in close proximity to existing CRA switchgrass growers, facilitating transportation of the grass which reduces costs to the grower. In addition, the Fibrowatt facility will be capable of using switchgrass in its natural state, eliminating the need for costly pelletizing. Fibrowatt also anticipates having the storage capacity to protect the biomass from the elements, giving growers the ability to deliver at any time after harvest, further easing the burden to growers.

Pyrolysis

Various interviews suggested that pyrolysis could be an appropriate energy conversion process for switchgrass. Dr. Hilary Mayton, a noted bioenergy feedstock researcher with Cornell University, views gasification and pyrolysis as the most appropriate conversion processes because they convert to either synthetic gas or liquid fuels and in her opinion, have less of an

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[29] FibroShore: Environmental Benefits to the Chesapeake Bay, Fibrowatt, Presentation to the Harry R. Hughes Center for Agro-Ecology, February 2011.
[30] Ibid.
[31] The farmers would only have to transport the raw material to the power plant.
[32] To explore opportunities with Fibrowatt, please contact Laura Kellogg, Environmental Manager at laura.kellogg@fibrowattusa.com or (267) 352-0014.

environmental footprint.[33] Additionally, Dr. Vance Owens with South Dakota State University indicated that the USDOE is increasingly interested in pyrolysis, although not on a large scale. As a Research Agronomist, Dr. Owens provides conversion experts with raw material, and in his experience pyrolysis is promising because it does not need to convert C5 sugars for enzymes, an obstacle faced by other processes.[34]

A Maryland-based company, New Generation Biofuels, has expressed interest in using switchgrass in their pyrolysis process. New Generation Biofuels has provided a formal letter of interest to the EFC which can be found in Appendix C. [35]

EFC observations regarding New Generation Biofuels

The close proximity and strong interest of a company like New Generation Biofuels located in Baltimore and their willingness to come to the Eastern Shore is something that should be considered for CRA. The EFC found that the extensive research conducted by Cornell University and South Dakota State University has shown switchgrass to be an excellent feedstock for pyrolysis. To ensure viability, however, experiments specific to New Generation Biofuels' facilities and processes will likely be necessary to enable New Generation to fully demonstrate and quantify results. A discussion involving CRA, New Generation, and the pyrolysis experts contacted as a part of this research could help shed light on how New Generation might be able to capitalize on existing research and reduce the amount of time and money needed for trials specific to their system.

Switchgrass Densification

Throughout the investigation, it became clear that biomass is often compacted into a smaller size to yield the greatest environmental and economic benefits while minimizing transportation and other costs. Compared to traditional heating methods, pellet stoves and boilers, which are capable of using a densified biomass, produce 90% less greenhouse gases than fossil fuels.[36] Additionally, densified biomass heating generates lower and more stable heating costs, which represents a long-term positive economic outlook for those willing to invest in this type of alternative heating unit.

The densification process – which takes many forms including the most prominently used pelletizing, as well as briquetting and cubing – is widely used across the nation to burn biomass for heating and electricity. Although densification makes transportation easier, creating more end-use options, it also requires a substantial upfront investment that affects both the producer and consumer. The EFC found that most recently established densification operations either utilize government support, invest a substantial amount of personal capital into the operation, or often both. Initial support from the government to offset costs has proven essential to help drive both demand and supply.

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[33] Mayton, Hilary. Telephone interview. 10 May 2011.
[34] Owens, Vance. Telephone interview. 20 May 2011.
[35] To explore opportunities with New Generation Biofuels, please contact Cordell Martin at cmartin@newgenerationbiofuels.com or (443) 623-6829.
[36] Enviro Energy LLC, Retrieved from: http://www.enviroenergyny.com/

Supply-side Findings

Sell to existing pellet operations

The EFC communicated with many individuals who operate pellet mills across the nation, some of which use woody biomass, switchgrass, or a combination of the two inputs. Selling switchgrass to an existing pellet operation is appealing because it requires less upfront investment for the Eastern Shore producers; however, there are many challenges that can hinder the ability to sell to existing operations.

Transportation cost concerns were echoed by many of the experts interviewed. Although there was debate over a precise economically-feasible distance between producers and densification facilities, it was recommended to focus on end-uses somewhere between 30 miles and 100 miles of producers (see Appendix D). Currently there are no pellet mills within this distance from the participating Eastern Shore farmers.

In addition, the quantity of switchgrass and land capacity for additional acres is minimal compared to the switchgrass being grown as inputs for existing operations. For example, Ernst Conservation Seeds is growing 4,000 acres of switchgrass for their pelletizing operation.[37] Show Me Energy founder Steve Flick remarked that some believe an upwards of 100,000 tons of feedstock is necessary for a viable densification operation which would require 20,000 acres of switchgrass with a 5 tons per acre yield.[38]

Finally, most of the existing pellet operations either use woody biomass exclusively or incorporate switchgrass as one of multiple feedstock inputs and have no need for additional switchgrass. A few are self-sustaining and pelletize switchgrass grown on their land. Therefore,

Government Biomass Initiatives

USDA's Biomass Crop Assistance Program (BCAP)

BCAP provides financial assistance to owners and operators of agricultural and non-industrial private forest land who wish to establish, produce, and deliver biomass feedstocks. For more information on this program, please visit BCAP's website.

In May 2011, the EFC spoke with Bob Wevodau of the Maryland Farm Service Agency (FSA). BCAP is the main program that FSA state and regional offices implement. Mr. Wevodau expressed interest in providing support for entities interested in BCAP. If interested in pursuing this initiative, please contact Mr. Wevodau at wevodavri@mda.state.md.us.

USDOE & USDA's Biomass Research & Development Initiative (BRDI)

BRDI is a joint initiative of USDOE and USDA, focusing on biomass research and development. This initiative provides funds in three main areas: (1) feedstocks development; (2) biofuels and biobased products development; and (3) biofuels development analysis.

Funds are not approved by Congress every year. For more information on this program, please visit BRDI's website.

[37] Arnett, D.
[38] Flick, Steve. Telephone interview. 29 April 2011.

in order to densify switchgrass, Eastern Shore producers would need to establish a local operation, which is a costly proposition.

EFC observations regarding existing pellet operations

The many challenges associated with selling switchgrass to existing pellet operations, including transportation costs, quantity of switchgrass, and lack of demand for switchgrass in current operations makes this opportunity impossible at present time.

Build a densification operation

Throughout the investigation, the EFC spoke to a number of owners and operators of densification mills, the majority of whom pelletize. It quickly became clear that if densification was the route Eastern Shore producers were interested in pursuing, a local densification operation would provide the greatest long-term benefit. Creating a local operation minimizes transportation costs, as well as boosts the local economy by providing local jobs and providing a local product that the community can benefit from.

There is a significant shot-term investment needed to establish a local pelletizing plant. Discussed below, the EFC spoke with plant operators and owners whose investment costs ranged from $600,000 to $10 million depending on the scale of production and type of equipment used. In addition to the upfront investment required to build this type of operation, the quantity of feedstock needed to sustain such an operation and the day-to-day production costs prove challenging.

However, if a reliable end-user market can be established, there can be significant long-term economic returns on this investment. Building a densification facility could spur socio-economic development through the generation of jobs for the building, operating, and maintenance of the plant. Conversations with various pelletizing operations provided insight into addressing the timeline, finance, and other obstacles to building a successful densification plant.

Investment Costs

The EFC examined pelletizing operations that function under a variety of circumstances with varying end goals. A significant and common thread among these operations is the substantial amount of money each invested in establishing a densification facility. Investment costs for three operations – Show Me Energy, Plainview Growers, and Enviro Energy LLC, provide case examples:

1. **Show Me Energy, $10 million investment**

   Steve Flick, founder of a large farmer-run cooperative called Show Me Energy, spoke to the EFC about the cooperative's evolution from one farmer's vision to a multimillion dollar company. Initially in 2004, a group of dedicated farmers invested dollar amounts based on their personal capacity into a plan for pellet mill operation. In six weeks, they had leveraged this initial amount into $10 million and began building a pelletizing operation in Missouri. Due to the high level of interest, investment, demand for their pelletized product, and land capacity to grow switchgrass, the operation has proven highly successful. The high demand for their product has allowed them to mentor other groups and build facilities across North America. They currently pelletize multiple inputs

and ship to utilities across the US and locally, use pellets to heat homes as an alternative to propane, and ship pellets to Europe.[39]

Flick suggested that the Eastern Shore look into its spatial landscape, including land area, kilowatt hour growing capacity (biomass versus coal), and export potential (since the East Coast can improve profit margins over the Midwest due to reduced transport costs, particularly to Europe) as its first step towards building a pelletizing operation.[40] He believes that the Eastern Shore *could* be the first switchgrass pelletizing operation on the US east coast, but to make the scenario economically feasible, a production level of at least 10,000 tons would be needed – more than three times the acreage growing now.

EFC observations regarding Show Me Energy

Show Me Energy has created a consulting arm of its company that will, for a fee, establish a turnkey operation for a community like the Eastern Shore. To pursue this, the first step is to sponsor a visit from Steve Flick and his associates so they can provide CRA with a full presentation of what Show Me Energy's services include. The best way to maximize CRA's investment in such as visit would be to include the presentation as a part of a one-day workshop with many stakeholders, interested parties, and potential investors as possible.

If this workshop generates a sufficient amount of interest in moving forward, CRA would then begin coordinating with Show Me Energy engineers to determine if there is an opportunity for a successful operation on the Eastern Shore. If the results of that study prove to be positive, the next phase would involve raising the funds necessary to build a full-scale operation with the complete oversight and direction of Show Me Energy staff.

There are clearly significant costs involved in anything beyond an invitation to give a presentation to CRA. Until it can be definitively determined that a sufficient feedstock supply is available to make this type of operation economically viable, the EFC does not see the logic in investing beyond an initial presentation by Show Me Energy.

2. Plainview Growers, $1.5 million investment

Plainview Growers in Allamuchy, New Jersey heats a seven-acre greenhouse using about 2,000 tons of pellets per season. The shift to biomass heating made economic sense for Plainview Growers as their existing heat was coming from approximately 150,000 gallons of oil (there are no natural gas or propane options in the area) when at $3.75 per gallon was costing the operation as much as $25,000 weekly in fuel costs. Currently the switchgrass is bought from local farmers incentivized to grow the crop, but in the next several years supply will be phased to switchgrass grown on-site to create a self-sustaining system.

Owner of Plainview Growers, Arie Van Vugt, submitted applications to seven different grant opportunities for start-up funds, yet was passed over in favor of solar and wind

[39] Ibid.
[40] Ibid.

projects. As a result, Van Vugt made a significant personal investment into this effort spending $1.5 million, most notably to cover the costs associated with transitioning his traditional boilers to use switchgrass pellets, as well as purchasing a new boiler barn, installing new equipment (finished in May 2008), and building silo fuel storage to accommodate 500 tons of pellets.[41]

EFC observations regarding Plainview Growers

In this scenario, it made sense for Plainview Growers to make the investment in a full scale operation due to factors like the cost of fuel alternatives and sufficient feedstock supply. However, Van Vugt spoke at length about the high learning curve involved with building this type of operation and his many trials and errors. In fact, all of the pelletization experts the EFC spoke with were quick to emphasize the many complications involved in perfecting the pelletizing process, with issues ranging from the lack of lignin found in switchgrass compared to wood to the mechanical change in the dye, and the moisture content of the feedstock. Each difficulty encountered will add to start-up costs.

Van Vugt advised that success hinges on a number of factors. He recommends a regional approach to limit transportation costs, going no further than 25-30 miles beyond the farm. Also, because Plainview Growers uses their own pellets, finding a steady market for the end-product was not an issue. The ability to sell pellets elsewhere is closely tied to cost of wood pellets, which are often cheaper. Should the Eastern Shore choose to pursue development of a pelletizing operation, Van Vugt is willing to serve as a paid advisor to the process. This could be valuable in avoiding many of the barriers and obstacles experienced by Plainview Growers, which would help to reduce start-up costs.

3. Enviro Energy LLC, $600,000-$700,000 investment

Enviro Energy LLC, a pellet fuel manufacturer in central New York, makes use of thousands of acres of grasses harvested from fallow farmland in the central New York area. Working closely with researchers from Cornell University, goldenrod, weeds, and briar proved to be the most effective grasses. In their trials, switchgrass did not initially work well on its own but made a good pellet when 20% goldenrod was added to the mixture.

These pellets are sold for residential use, as well as used as a heat source in a pilot project with municipal highway garages. Instead of buying and installing new equipment, the Miller family, who own Enviro Energy LLC, adapted a pellet mill bought out of bankruptcy from a failed wood pellet operation for between $600,000 and $700,000.

[41] Van Vugt, Arie. Telephone interview. 25 April 2011.

EFC observations regarding Enviro Energy LLC

The EFC found the Enviro Energy LLC approach of great interest because it began from a dairy operation searching for an additional income stream and with pelletizing has developed a secondary business that is expanding to the point where it is now turning a profit. Pellets made by Enviro Energy LLC sold well because that area of New York experiences colder winters than the Eastern Shore and woodstoves are plentiful in that area as an alternative to most costly heating sources.

Enviro Energy LLC is able to keep production costs down by including rotting hay, which there is little competition for as a feedstock. Purchasing used equipment at auction helped to further lower overhead costs. These lower start-up costs enabled the Millers to experiment more with different varieties of grasses to optimize the pelletization process.

A full-day site visit to the New York operation would allow CRA to see first-hand a pelletizing operation that works at a scale similar to what is likely for the Eastern Shore and would be a good first step in exploring the feasibility of pelletizing. In fact, Plainview Growers visited the Miller's operation several times before building their New Jersey operation.

Production Costs

Although the investment expense of building a pelletizing plant represents the majority of the cost involved, production costs are substantial as well. The EFC received a range of answers when investigating typical production cost estimates for manufacturing switchgrass pellets:

How much does it costs to produce switchgrass pellets?		
"The cost for pelletizing ranges widely and I have always had difficulty nailing it down. REAP in Canada has said their producer Coop figures $40 a ton for producing small pellets. For the large pellet or briquettes $25 a ton has been quoted." -- Ray Smith, Ph.D., Department of Plant and Soil Sciences, Forage Extension Specialist, University of Kentucky	*"$25-$40 per ton based on your plant output."* -- Steve Flick, Founder/Board President, Show Me Energy	*"Cost of production is approximately $90 per ton. This does not include fiber/feedstock."* --Dan Arnett, Biomass Coordinator, Ernst Conservation Seeds

Of course, the most important component of production costs is considering what the pellets can be sold for in the marketplace. As with production costs, a range of answers were cited:

What price are switchgrass pellets sold for in the marketplace?		
"A recent quote I heard at the International Biomass meeting in MO was $150 for a bulk ton though I imagine this can be lower." -- Ray Smith, Ph.D., Department of Plant and Soil Sciences, Forage Extension Specialist, University of Kentucky	*For a ton of pellets, "$130-$150"* *For a 45-50 pound bag of pellets, "$4-$5"* -- Steve Flick, Founder/Board President, Show Me Energy	*"Buying a ton in bulk is going to be less than a ton in 40 lb bags. The cost to put the material into 40 lb bags is about $26/ton. The cost to package it in a bulk sack is about $16…we feel that if we can sell them for $155-$160/ton, we will be in the black."* --Dan Arnett, Biomass Coordinator, Ernst Conservation Seeds

Of course there are other considerations when calculating production costs, as well. As Arnett mentioned, wholesale supplies will be cheaper to produce and cheaper to sell. Savings generated from bulks sales can be passed on to the customer.[42] Packaging costs, retailers/distributors' profits, transportation, and the like, also factor into the bottom line.

Feedstock Quantity

Costs are not the only consideration in determining the feasibility of establishing a pelletizing facility. The quantity of switchgrass needed to maintain a successful operation could present an obstacle on the Eastern Shore. According to Flick, in order for a pelletizing plant to be profitable, 10,000 tons of feedstock is needed annually.[43] The tonnage per acre of switchgrass varies widely based on geographical location and agricultural practices, ranging from 2 to 10 tons per acre. Specifically, the northeast tends to yield anywhere from 5 to 8 tons per acre of switchgrass.

Using modest estimates, the 500 acres of switchgrass can be expected to yield 2,500 tons. Although the Eastern Shore has cropland capacity greater than 500 acres of switchgrass, it is doubtful that switchgrass could be grown at a level sufficient enough to sustain a densification operation. Without a more substantial yield, a small-scale operation is the only option, which is not economically viable. Many experts pointed to the greater obstacles that come with small-scale operations, including higher marginal costs to produce pellets and greater problems with equipment that generate lower rates of return. Many of the smaller pellet boilers are produced in Europe, and when problems arise, service and repairs can be difficult to arrange. As an operation gets larger, fewer problems exist, resulting in lower marginal costs and a better product.

A number of experts consulted stressed the economies-of-scale issue that arises with insufficient input levels. This could be addressed by combining feedstocks, and currently, the most prominent biomass feedstock used for densification is woody biomass. The Center for Agro-Ecology felt strongly that there was sufficient wood waste and forestry residue,

[42] Arnett, D.
[43] Flick, S.

particularly when municipal wood waste is considered, to sustain an Eastern Shore facility that could handle multiple feedstocks.

Not only is there an abundance of wood available in Maryland, but the multiple feedstock approach also generates better output. Various experts believe that the composition of wood compared to switchgrass makes a better pellet. Wood has a natural lignin content that creates a good binder for pellets, while grasses tend to need a lignin supplement in order for the product to materialize.[44]

The potential obstacles to building a densification plant are extensive, yet not necessarily insurmountable. Ways to offset current financial barriers to entry include utilizing government funds to offset investment costs, creating a collaborative of farmers willing to invest in the facility, or seeking a private investor.

Demand-side Findings

Local market

The EFC also examined the potential demand-side markets for switchgrass pellets. Biomass heating opportunities fell into two broad categories: commercial/industrial and residential.

Commercial/Industrial Biomass Heating

Commercial/industrial biomass heating opportunities on the Eastern Shore includes poultry houses, greenhouses, universities, school districts, hospitals, and local municipal buildings. These could prove to be the most viable end uses for densified switchgrass given that there is no current demand for residential stoves and the costs associated with installing, operating, and maintaining equipment versus residential applications are less. Additionally, numerous households would need to invest in home heating devices compared with one or two commercial/industrial buildings to utilize the biomass resources, concentrating the financial burden to only a few investors.

Maryland's Eastern Shore is home to thousands of poultry houses, typically heated with propane-based systems. With propane prices in Maryland creeping towards $4 per gallon this past winter, examining the potential for burning switchgrass as an alternative heat source became of interest.[45]

The EFC engaged poultry experts Dr. Brian Fairchild and Mike Czarick with the University of Georgia's Cooperative Extension Service based on their work heating chicken houses with wood pellets. This conversation shed light on the economics of pellet use in this context. Potential economic issues include the cost of pellets in comparison to other feedstocks, the investment needed to install the proper heating system equipment, and increased operations and maintenance.

Poultry houses do not require a heavily processed fuel pellet, so the cost differential between a wood (or switchgrass) pellet and wood chips becomes a significant factor. Based on their research, Fairchild and Czarick estimate the costs of wood pellets at $150 per ton, compared to

[44] Van Vugt, A.

[45] From the Energy Information Administration as viewed on Integrity Energy at http://integrityenergy.com/propane-prices-html/ 30 June 2011.

$50 per ton for wood chips.[46] Burning these pellets also requires a specialized boiler or furnace designed for use with pellets, which they estimate to cost $15,000 to $30,000 installed. In addition to the costs of the pellets themselves, and installation of pellet burning equipment, there are operations and maintenance costs associated with switchgrass pellets that exceed that of other pellet types – the high mineral content of switchgrass results in higher ash output.

The fact that a large initial investment would be needed for the proper equipment, equipment that growers would likely need approval to use from their integrator, has led to little demand for this type of system. Fairchild and Czarick suggested that a more efficient use of switchgrass for poultry house applications might be to use boilers designed to burn hay bales, so that densification of the grass would not be necessary, reducing input costs significantly.

Similarly, the prevalence of greenhouses on the Eastern Shore, which also tend to rely on propane for heat, and knowledge (based on the Plainview Growers' example) that heating greenhouses with switchgrass can be successful suggests that these businesses could be an attractive end-user. Again, as with poultry houses, the initial investment for proper equipment is significant. The EFC contacted several prominent grow houses in and around Chestertown, some referred to us by the Center for Agro-Ecology, however none expressed an interest in further discussion of the option.

The EFC also investigated the possibility of using switchgrass as a heat source for public buildings. The Benton Area School District in Pennsylvania is in the second year of its project to heat their elementary school, middle/senior high school, and maintenance buildings with switchgrass pellets. The switchgrass is grown on seven local farms and donated from Ernst Conservation Seeds. The district estimates that is uses less than 200 acres of switchgrass per heating season annually.

The densification process consists of an onsite mobile briquetting unit from a Vermont-based company called Renewable Energy Resources. The project cost $2.1 million, and the district estimates the return on investment to be within 13 years. Of the total costs, $700,000 was funded by Pennsylvania Department of Environmental Protection and Pennsylvania Economic Development Association grants. An additional $1 million was borrowed by the district, and the remainder was incorporated into the district's budget.[47] Although the Benton Area School District received funds to offset the costs associated with the project, the quantity of switchgrass being used is on a similar scale to what is being produced on the Eastern Shore.

After learning about the success of the Benton Area School District, the EFC contacted the Kent County Public Schools and Washington College. After speaking with representatives from both, there was both curiosity and significant interest, although the investment of time and money needed for such a project would need to be discussed further.[48]

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[46] Fairchild, Brian and Czarick, Mike. Telephone interview. 11 May 2011.

[47] Leighton, Lisa, Benton School District Heats with Locally-grown Switchgrass, LancasterFarming.com, Retrieved from: http://www.lancasterfarming.com/results/AE-0108-Switchgrass

[48] To explore these opportunities, contact John Johnson, Environmental Services Supervisor with Kent County Public Schools at jjohnson@kent.k12.md.us or 410-778-7141 and Briggs Cunningham, Climate Action Coordinator,

EFC observations regarding commercial and industrial boilers

Research results indicate using switchgrass in boilers in poultry houses is not an efficient solution for the Eastern Shore. Beyond the economic obstacle of having to pay more for switchgrass over wood pellets, the larger barrier is that most poultry houses will need written contractual approval from their parent company, or integrator, before switching to a new heating source. Jenny Rhodes, a Queen Anne County poultry farmer who is also a county extension agent, stated that if poultry producers consider investing in a new energy source for their poultry houses, it would most likely be the new technology being promoted by agriculture industry that uses an infrared source of heat that heats the chicks and not the entire room, thus offering considerable savings on heating expenses.

There is, however, an opportunity to better connect with Kent County Public Schools and Washington College to assist them in acquiring a boiler that burns switchgrass. Therefore, selecting a location that is within a short distance to the CRA switchgrass farmers will help to reduce transportation costs, and should be a strong basis for site selection. Note that funding this type of pilot through BCAP, however, will most likely not be an option in the near future since funding, if available at all, is likely to be small and limited to woody biomass.

Additionally, the EFC recommends that the CRA Executive Director contact former Congressman Wayne Gilchrest.[49] Congressman Gilchrest is leading an effort to develop an ecology and agriculture education center along the Sassafras River in Kennedyville, Maryland. This future center has two historic buildings that may be an ideal site for locating a demonstration boiler that uses switchgrass as a fuel source.

Residential Biomass Heating

The residential market for heating homes with densified switchgrass was also explored by the EFC. This type of end use would require a personal investment of, on average, several thousand dollars in a pellet stove on the part of each interested household. However, this would be somewhat offset by reduced heating costs over traditional heat sources. The success of this market would rely heavily on consumer demand for this heating source, which does not appear to currently exist in the region. As previously mentioned, the biological composition of

Stove Technologies

European electricity prices and regulatory requirements have spurred demand that has resulted in a better established market as well as better technologies. Servicing equipment, however, can be problematic as most grass-burning boiler and furnace producers are located in Europe.

In the US, Hearth & Home Technologies makes wood and multiple input stoves, including popular lines from Harman Stoves and Quadra-Fire. Pam Fleming of Day or Night Home and Hearth Services, a Harman Stove dealer in Hanover, Maryland, said state incentives in place to boost the demand for residential stoves often leads homeowners to purchase multiple input stoves, even if they only use wood pellets.

Center for the Environment and Society at Washington College at bcunningham3@washcoll.edu or 1-800-422-1782, ext. 7174.

[49] To explore this opportunity, contact Congressman Gilchrest at gilchrest@dmv.com or 410-348-2018.

switchgrass tends to result in substantial ash content and clinkers, making operations and maintenance of heating systems that use switchgrass more labor intensive. Corinne (Corey) Rutzke, Executive Director of the Northeast Sun Grant Institute of Excellence at Cornell University, provided knowledge about her home heating process using a corn stove. She estimates that she is able to heat her 2,600 square foot home with about 2 acres of corn per season. She has found that using a 50/50 mixture of corn and switchgrass not only burns hotter than wood, but also seems to minimize the negative impact of the moisture and mineral rich grass.[50]

Also mentioned earlier, one of the challenges with attempting to enter the residential heating market is the need for households to have or purchase pellet stove heating systems. However, this could be addressed by finding communities, or pockets of residences at a reasonable scale, with these systems in place already that may be willing to include switchgrass as a feedstock.

Maryland Incentives for Renewables & Efficiency

Tax Incentives

There are two tax exemption programs in Maryland related to energy projects:

(1) The Wood Heating Fuel Exemption – both commercial and residential uses qualify for this exemption which waives all state sales tax (6%) on the sale of wood or "refuse derived" fuels.

(2) The Sales Tax Holiday for Energy Efficient Appliances – which is available to all of the general public. This is usually a period of several days when all sales tax (6%) is waived on the purchase of energy efficient appliances including boilers and furnaces. This also applies to some renewable technologies.

Energy Conservation Rebates for Farms

This program will rebate 8¢ per kilowatt hours saved or $1.50 per gallon of propane saved for the installation of more efficient technologies including furnaces and boilers up to 50% of the total installed project costs.

Maryland Incentives/Policies for Renewables & Efficiency, Database of State Incentives for Renewable & Efficiency, Retrieved from: http://www.dsireusa.org/incentives/index.cfm?getRE=1?re=undefined&ee=1&spv=0&st=0&srp=1&state=MD

Save Our Sky and Protect Our Planet Home-Heating Cooperatives is a corn stove cooperative located in Takoma Park, Maryland. President Sat Jiwan Ikle-Khalsa explained that the cooperative currently uses corn as its sole input; however, due to the volatile nature of corn prices, he expressed interest in exploring other inputs, such as switchgrass. There is also interest from members to diversify feedstocks, some of whom are even willing to pay more for a higher quality

[50] Rutzke, Corinne. Telephone interview. 18 May 2011.

product.[51] Ikle-Khalsa offered to conduct a small-scale demonstration using his personal stove, but in speaking with members of the cooperative who tested switchgrass in their own stoves, he was told switchgrass was found to be sooty, hard to ignite, and oily.

EFC observations regarding residential biomass heating

Findings regarding switchgrass as a residential heating source were not encouraging. The EFC was not able to substantiate Corey Rutzke's experience of burning a mix of corn and switchgrass for efficient heating with other sources. Without evidence to support this practice, and given the anecdotal feedback of Takoma Park Cooperative members and others who were not pleased with the results of using switchgrass, the EFC does not see residential heating with switchgrass to be a viable market on the Eastern Shore, despite the tax incentives available for purchasing a woodstove that uses multiple feedstocks.

European market

The alternative energy market in Europe is much more developed than that of the United States, due in most part to higher electricity prices and stricter requirements for renewable energy inputs.[52] Despite a more robust market, many of the existing US switchgrass operations shipping to Europe expressed disappointment with the return on investment. McArdle mentioned that he does not ship anything to Europe because there is no money to be made.[53] Similarly, General Manager of New England Pellet Charlie Niebling said that they do not ship overseas and chose to focus on end users located 100% in the Northeastern US, particularly because they want to keep the product fairly local and contribute to the nation's reliance on domestic energy.

EFC observations regarding the European market

After a thorough investigation, it was determined that it is not likely feasible for the Eastern Shore farmers to ship a densified product overseas because production and transportation costs will outweigh income derived.

[51] Sat Jiwan Ikle-Khalsa. Telephone interview. 25 May 2011.
[52] Smith, R. and Keene, T.
[53] McArdle, M.

Key Recommendations

Based on the EFC's findings, there are several key recommendations for CRA as the organization works to develop switchgrass market opportunities on the Eastern Shore. They are presented here in order of priority.

To build on the opportunities presented in this report will require capacity. A dedicated staff person responsible for pursuing the marketplace and funding opportunities described would be a wise investment.

Pursue opportunities related to the use of raw switchgrass with energy producers.

Of all the recommendations offered in this report, building a relationship with one of the energy producers engaged as a part of this investigation seems to present the greatest opportunity for the use of the switchgrass being grown as an energy feedstock.

Constellation Energy and NRG Energy in particular are powerful utilities in the region and may soon find themselves looking for better ways to access a steady supply of biomass material to help improve and expand their renewable energy portfolio. Constellation Energy in particular was enthusiastic to establish a relationship with CRA as the company works through internal policies regarding the acquisition of alternative energy in the near future.

Using switchgrass in its raw state has significantly reduced production-end costs over uses that require pelletization.

The EFC believes by initiating these conversations and relationships now, CRA can position themselves with both NRG and Constellation to be "first in line" to be a provider of readily available, easily accessible, and affordable biomass material. Working with energy producers could also enable the expansion of the existing switchgrass to meet demand of this scale, increasing the environmental benefits achieved by growing the crop.

The EFC's secondary suggestion regarding energy producers involves following up with Fibrowatt regarding their interest in using switchgrass as a supplemental fuel source for their planned FibroShore facility. The is no guarantee as to when or if this facility will be built, but given that pelletization is not necessary, the anticipated nearby location of the facility, and the ability to store feedstock onsite, serving as a biomass source for Fibrowatt offers a number of opportunities for growers to reduce production costs.

Finally, New Generation Biofuels also offers an energy production opportunity. However, concerns over the compatibility of the feedstock with their facility and process will require further investigation and New Generation Biofuels will need capital to make these determinations. A group discussion among CRA, New Generation Biofuels, and switchgrass researchers will help to determine the extent which existing research can be capitalized on, what additional trails may be necessary, and the overall feasibility of using switchgrass to create oil. Also of note, senior executives from New Generation Biofuels recently returned from a trip to Asia with Maryland's Governor O'Malley. As a result, new developments may have occurred that would allow collaboration that could place CRA switchgrass at the forefront of future renewable energy agendas for the state.

Consider how best to use existing funding sources.

The USDA grants listed in this report, specifically the Biomass Research & Development Initiative (BRDI) grant offered in conjunction with USDOE, should be seriously pursued by CRA as an opportunity to help support a large scale operation, such as some of the pelletizing plant scenarios discussed in this report. Although future funding is expected to be less than the current level, if CRA is able to organize a partnership with universities, agribusinesses, and other interested parties that promotes research and market opportunities for switchgrass, the USDA is likely to be interested in funding this type of endeavor.

BRDI is a joint USDOE and USDA funding program focused on biomass research and development.

If pelletization is found to be compelling, capitalize on learning from the experience of others and take advantage of offers for mentorship.

Before considering an investment in a pelletizing operation of any scale, a visit with *Enviro Energy LLC* will be a critical first step in order to acquire the knowledge and experience required for the successful processing and pelletizing of switchgrass that would otherwise take CRA many years and dollars to obtain. *Enviro Energy LLC* often hosts visitors from large companies across the United States to share their story of developing a pelletizing operation. They would welcome a tour by CRA and other partners.

Densification makes transporting switchgrass much less expensive, but is a costly process.

If, following such a visit, there is serious interest in moving forward with a pelletizing operation, CRA should assemble an advisory team made up of potential investors, environmental experts, university and extension service staff, and agribusinesses. A one-day event, designed to better inform the advisory group as well as other stakeholder groups in the region, could feature those who have expressed an interest in assisting CRA, such as Arie Van Vugt of *Plainview Growers*, Steve Flick from *Show Me Energy*, and key switchgrass researchers. The different perspectives and experiences will be an easy way to collect information before investing large amounts of time and money building a pelletizing operation. In addition to individual and panel presentations, time for open dialogue among all participants will be valuable. The result should be an inexpensive way

Mentoring Opportunities

Utilizing existing knowledge will be essential to maximizing efficiency in setting up a plant. Many of the owners and operators of pelletizing facilities were more than willing to assist the Eastern Shore with the process of establishing a densification plant. These seasoned experts understand the trial-and-error nature of pelletizing biomass. The following contact information is for the many gracious individuals and organizations willing to contribute their time:

1. Dan Arnett, Ernst Conservation Seeds, dan@ernstseed.com
2. Steve Flick, Show Me Energy, steveaflick@earthlink.net
3. Matt McArdle, MESA Reduction Engineering & Processing, matt.mcardle@mesareduction.com
4. Arie Van Vugt, Plainview Growers, ariev@plainviewgrowers.com

to engage potential investors; generate interest in CRA switchgrass growers; identify the specific opportunities for switchgrass on the Eastern Shore; understand potential barriers to successfully developing a switchgrass pelletizing operation; and discuss strategies for overcoming these barriers.

CRA should reconvene the advisory team shortly after the event in order to consider next steps and whether to proceed with investing in a small- or large-scale pelletizing operation. As a part of this process, contact should be made with *Agri-Recycle* on the Eastern Shore. It is anticipated that their entire pelletizing operation will be completely overhauled in the near future, including new equipment, with the old equipment potentially being available for sale in 2012. The old *Agri-Recycle* equipment should be inspected by experienced pelletizers such as Arie Van Vugt and others knowledgeable with process to see if this equipment would be adaptable and practical for pelletizing switchgrass.

Conclusion

Although there does not appear to be one clear and immediate solution to establishing a market for switchgrass being gown on the Eastern Shore as an alternative fuel, there are a number of opportunities that merit further investigation.

This report is designed to provide CRA guidance on how best to invest their capacity and resources in moving forward with the establishment of an alternative fuel market for switchgrass by detailing which options present the greatest opportunity for success given the current situation.

However, the alternative energy market is continually evolving, often quickly. Innovative technologies and practices are being invested in and promoted by government and nongovernmental agencies alike. As research sheds more light on best practices, the landscape of which opportunities are truly feasible may shift. Staying abreast of new and innovative technologies will be imperative to breaking into the alternative energy market.

Organizational Experience and Key Staff

The EFC is a regional center that has worked with communities and watershed organizations on environmental challenges throughout the Mid-Atlantic region for over fifteen years. The EFC was initially established by the Environmental Protection Agency to assist communities in Maryland, Virginia, West Virginia, Pennsylvania, Delaware and the District of Columbia to identify innovative and sustainable ways of implementing and financing their resource protection efforts. In February of 2007, the EFC merged with the National Center for Smart Growth Research and Education (NCSG), enabling the two centers to work collaboratively on issues such as land use planning, natural resource preservation and urban growth matters.

The EFC has assisted communities and organizations in developing effective sustainable strategies for specific watershed protection goals for a variety of clients including state and local governments, watershed organizations and land trusts. One of the EFC's core strengths is its ability to bring together a diverse array of individuals, agencies, and organizations to develop financing solutions for a wide variety of watershed protection problems. Although exact delivery methods are tailored to best meet the needs of the client, the EFC has assisted communities and watershed organizations with source water protection, stormwater management, land preservation, green infrastructure planning, air quality improvement, energy conservation, low impact development, septic system management, waste management, community outreach and education.

Joanne Throwe, Director

Hired in 2005 as the Environmental Finance Center's (EFC) Agricultural Program Leader, Joanne Throwe became Assistant Director in 2007, Associate Director in 2008, and Director in 2009. In addition, she completed an 18-month assignment working with USDA/CSREES as shared-faculty to assist in the coordination of special agriculture projects. Ms. Throwe works with communities in the Mid-Atlantic region implementing innovative financing solutions for environmental protection. Her work experience includes extensive knowledge about agriculture, green infrastructure, biofuels, ecosystem services and solid waste management. Prior to joining the EFC, Ms. Throwe spent several years as a Development Resource Specialist at USDA's Foreign Agriculture Service and two years as an Agriculture Extension Agent for Peace Corps in the South Pacific. She holds a M.A. in Public Policy and Private Enterprise from the University of Maryland.

Jennifer Cotting, Assistant Director

Ms. Cotting joined the Environmental Finance Center (EFC) in 2004 to manage an EPA funded program designed to help communities and organizations in Region 3 overcome barriers to implementing and financing their watershed protection efforts. As a Program Manager she coordinated a number of the EFC's core programs, with a particular focus on urban greening, tree canopy, and green infrastructure. Her current work as Assistant Director includes these program management tasks, as well as responsibilities for the day-to-day operations of the center and the management of staff and student employees. In addition, Ms. Cotting serves as the EFC's representative to the Green Infrastructure Community of Practice. Prior to joining the EFC, Ms. Cotting worked as an independent consultant developing and implementing environmentally based education and outreach programs for nonprofit organizations and

government agencies. She received her M.S. in Sustainable Development and Conservation Biology from the University of Maryland and her B.A. in Communications from Marymount University.

Monica Billig, Program Assistant

Ms. Billig joined the Environmental Finance Center (EFC) as a program assistant in September 2010 at the start of her graduate student experience at the University of Maryland (UMD). She is currently attending UMD's School of Public Policy, concentrating in social policy and will receive her Master in Public Policy (MPP) in May 2012. Prior to attending UMD, Ms. Billig worked for two years as a Research Associate at edCount, LLC, a Washington, DC based education policy consulting firm specializing in policy related to assessments, standards, and accountability. Ms. Billig received her BA in Economics and a minor in Mathematics from Smith College in Northampton, MA.

Appendix A: Interview Schedule, Contacts, and Summaries

February 2011

Dr. Memo Diriker, Founding Director – The Business Economic and Community Outreach Network (BEACON) of the Franklin P. Perdue School of Business at Salisbury University and

James Garrity, Dashboard Specialist – Maryland Department of Business & Economic Development

- On February 14, 2011 EFC staff met with Dr. Memo Diriker of Salisbury University and James Garrity of the Maryland Department of Business & Economic Development. This discussion focused on cost-benefit factors involved in efficient biofuel production and optimizing on-the-ground investments in a potential switchgrass market.

Tom Stickle, Owner/Farmer – Manona Farms

- On February 21, 2011 EFC staff traveled to Ligonier, Pennsylvania for a half-day site visit with Tom Stickle of Manona Farms, a facility currently growing approximately 500 acres of switchgrass. Discussions revolved around the equipment and technologies available to improve the efficiency of baling and transport of switchgrass, habitat value and hunting income derived from the switchgrass planted, compressing and pelletizing switchgrass for burning, and his experience with a special exception to harvest switchgrass from CRP lands.

Dave Goebel, Chief Operating Officer; Dane Saglio, Chief Financial Officer; Andrea Festuccia, Ph.D., Chief Technology Officer; and Cordell Martin – New Generation Biofuels

- On February 22, 2011, the EFC Director engaged in discussions with New Generation Biofuels, a clean energy technology company focusing on renewable biofuels solutions in Maryland. Discussions about utilizing switchgrass as one of the key sources of biomass material to supply their Baltimore processing plant began but will require future conversations.

Bill Matuszeski, Consultant & the Former Director of the EPA Chesapeake Bay Program Office – Chesapeake Bay Commission

- On February 28, 2011 in a half-day visit to the College Park campus, Bill Matuszeski shared his thoughts on the potential for generating on-site electricity (with overages sold back to the grid), combining switchgrass with other feedstocks, and the feasibility of locating an ethanol facility on the Eastern Shore. Mr. Matuszeski, formerly with the Chesapeake Bay Program, has been heavily involved in the research and production of three Chesapeake Bay Commission reports on the role of biofuels in Bay restoration.

March 2011

Dave Marvel, President – Fruit and Vegetable Growers Association of Delaware

- On March 2, 2011, EFC staff had the opportunity to visit two farming operations in the Harrington, Delaware area to develop a better understanding of the supply-and-demand differences that exist among geographic locations. The first visit was with Dave Marvel,

President of the Fruit and Vegetable Growers Association of Delaware where discussions focused on how limited marginal land opportunities are in this part of Delaware.

TJ Schiff, Farmer – Schiff Farms

- The second farm operation visit on March 2, 2011 was with TJ Schiff of Schiff Farms. He echoed the sentiment that marginal lands in this part of Delaware were minimal. He also sees competition with the poultry industry for wood waste, a glut of hunting opportunities in comparison to demand, and transportation expenses making switchgrass a less favorable planting option for farms in the area.

Ray Smith, Ph.D., Department of Plant and Soil Sciences, Forage Extension Specialist; and Tom Keene, Department of Plant and Soil Sciences, Hay & Marketing Production – University of Kentucky

- On March 10, 2011 EFC staff spoke with Dr. Ray Smith and Tom Keene from the University of Kentucky about their pilot switchgrass projects. Beginning in 2007, the University of Kentucky worked with farmers on 20 farms to grow switchgrass that was co fired with coal and generated for electricity at East Kentucky Power's Spurlock Station. This conversation focused on the challenges and successes they experienced from their research and work in the field.

Dr. Sarah Taylor-Rogers, Assistant Director; and Nancy Nunn, Development Coordinator – Harry R. Hughes Center for Agro-Ecology

- On March 15, 2011 Director and Assistant Director of the EFC met with Sarah Taylor-Rogers and Nancy Nunn from the Harry R. Hughes Center for Agro-Ecology at the University of Maryland. This meeting was focused on the Center's switchgrass test plots they planted with 10 farmers, including the lessons learned and potential opportunities with heating green houses and utilizing Maryland's natural resources.

Dr. Sam Jackson, Vice President for Feedstock Operations & Institute of Agriculture Research Assistant Professor – Genera Energy & University of Tennessee

- On March 24, 2011 EFC staff spoke with Dr. Sam Jackson from the University of Tennessee & Genera Energy. The University of Tennessee and Genera Energy received grant money from the US Department of Energy to harvest, collect, store, and deliver switchgrass to a biorefinery. The discussion revolved around the necessary requirements – transportation, acreage, costs, and pelletizing process – to ensure successful and sustainable use of switchgrass as a renewable energy.

Charles Cawley, State Executive Director – Maryland Farm Service Agency (FSA)

- On March 31, 2011 graduate student EFC staff member spoke with Charles Cawley from Maryland's Farm Service Agency. This conversation provided staff with insight into current opportunities with USDA's Biomass Crop Assistance Program (BCAP) and led to additional conversations with Maryland FSA employees.

April 2011

Dan Arnett, Biomass Coordinator – Ernst Conservation Seeds

- On April 7, 2011 EFC staff had the opportunity to speak with Dan Arnett, head of biomass operations at Ernst Conservation Seeds in Meadville, PA. This contact was initially found through a meeting with Tom Stickle, owner of Manona Farms. Ernst Conservation Seeds has set up demonstration switchgrass pelletizing operations. With this in mind, the conversation focused on the obstacles, costs, and successes they have experienced with switchgrass pelletizing.

Arie Van Vugt, Owner – Plainview Growers

- On April 25, 2011 EFC staff spoke with Arie Van Vugt, owner of Plainview Growers. This contact was initially found during the meeting at the Harry R. Hughes Center for Agro-Ecology. Plainview Growers currently has a 7-acre greenhouse being heated by switchgrass pellets. Mr. Van Vugt provided staff with insight into the start up and operating costs that go into heating a greenhouse, and some necessary requirements for successful operations. Mr. Van Vugt currently buys switchgrass from farmers, but is planning to grow, pelletize, and heat switchgrass to become a self-sufficient operation.

Daniel Cassidy, National Program Leader – US Department of Agriculture (USDA)

- On April 28, 2011 EFC staff had the opportunity to speak with two federal employees heavily involved in federal biomass initiatives as well as have an in-person conversation with a potential end-user. Director of the EFC traveled to the USDA to meet with Daniel Cassidy, National Institute of Food and Agriculture Program Leader. This conversation was geared toward current and future federal endeavors, including the President's Growing America Fuel initiative. This conversation also led to additional contacts working at all levels of government who specialize in biomass efforts.

Laura McCann, Energy Efficiency & Renewable Energy, Biomass Program, Feedstocks – US Department of Energy (USDOE)

- On April 28, 2011 graduate student EFC staff member spoke with Laura McCann, feedstock expert for the Biomass Program at the US Department of Energy. Ms. McCann provided resources and additional contacts working in the area of switchgrass around the country.

Laura Kellogg, Environmental Manager; Jim Potter, Executive Vice President, Business Development; and Eric Jenkins, Vice President, Commercial Development – Fibrowatt

- On April 28, 2011 Laura Kellogg, Jim Potter, and Eric Jenkins of Fibrowatt came to the University of Maryland for an in-person meeting with EFC staff. Fibrowatt is an international company with poultry litter and other local input fueled power plants in the US and UK. This conversation focused on potential opportunities to work with Fibrowatt, as they are currently hoping to develop a power plant on the Eastern Shore and use local inputs.

Steve Flick, Founder/Board President – Show Me Energy

- On April 29, 2011 EFC staff spoke with Steve Flick, Show Me Energy board president. Show Me Energy, a cooperative of farmers who are harvesting, storing, and pelletizing switchgrass, started with a vision and has grown to a multi-million dollar cooperative. This conversation focused on how Show Me Energy grew to mentoring and operating plants across the US. Although interest was expressed to develop a plant on the Eastern Shore, one obstacle to following their footsteps is the amount of land on the Eastern Shore that may inhibit a large-scale operation such as the type they focus on.

May 2011

Bob Wevodau, Agriculture Program Specialist – Maryland's FSA

- On May 2, 2011 EFC staff spoke with Bob Wevodau from Maryland's FSA. Mr. Wevodau provided insight into current and future opportunities with BCAP and the necessary details of the application process.

Dr. Rob Mitchell, Research Agronomist – USDA Agricultural Research Service (ARS)

- On May 3, 2011 Director and Assistant Director of the EFC spoke with Rob Mitchell from the USDA Agriculture Research Service. This conversation focused on USDA's work with switchgrass, European markets, and potential opportunities working with utility companies on the Eastern Shore.

Dr. Hilary Mayton, Bioenergy Feedstock Project – Cornell University

- On May 10, 2011 EFC staff spoke with Hilary Mayton from Cornell University. Dr. Mayton focuses on perennial grasses for conversion of bioenergy through thermal combustion from pellets, burning coal plants, or through thermal pyrolysis. This conversation focused on potential obstacles to burning switchgrass pellets and current best options to pursue (pyrolysis and gasification and working with European markets).

Dr. Brian Fairchild, College of Agriculture and Environmental Sciences, Associate Professor/Extension Poultry Scientist; and Mike Czarick, College of Agriculture and Environmental Sciences, Extension Engineer – University of Georgia

- On May 11, 2011 EFC staff spoke with Dr. Brian Fairchild and Mike Czarick from the University of Georgia. They have participated in extensive pilot projects to heat poultry houses using wood pellets, with farmers who continue to utilize this practice. We initially conducted this interview to uncover opportunities to heat poultry houses, since that is a big market on the Eastern Shore. However, this conversation shed light on the barriers to this process due to economics not generating adequate returns on investment.

Corinne (Corey) Rutzke, Executive Director of the Northeast Sun Grant Institute of Excellence – Cornell University

- On May 18, 2011 Director and Assistant Director of the EFC spoke with Corey Rutzke from Cornell University. Corey works as the executive director of the Northeast Sun Grant Institute of Excellence. Cornell University functions as one of five regional Sun Grant Initiative Centers. This contact was brought to Director of the EFC's attention at a meeting with Daniel Cassidy from USDA. During this conversation, EFC staff gained insight into the Sun Grant Initiative, including the educational outreach being promoted by grant money, stove research being conducted at Cornell University, and became aware of the New York Biofuels Roadmap for alternative biomass in NY state (http://www.nyserda.org/publications/renewablefuelsroadmap/default.asp).

Dr. Vance Owens, Department of Plant Science, Forage & Biomass Crops – South Dakota State University

- On May 20, 2011 EFC staff spoke with Dr. Vance Owens, a research agronomist at South Dakota State University (SDSU). This contact was initially discovered through Laura McCann at the USDOE. Similar to Cornell University, SDSU is also a regional Sun Grant Initiative Center. This conversation focused around the establishment and harvesting practices in place to generate best yields for switchgrass.

Marilyn Buford, Research & Development – US Forest Service

- On May 23, 2011 EFC staff met for a three-quarter day debrief of current progress. During this meeting, the EFC staff spoke with four contacts. First, EFC staff spoke with Marilyn Buford of the US Forest Service. As we learned throughout the project, woody biomass is used heavily around the US. It was therefore imperative to speak with experts in the forestry industry. Ms. Buford provided insight into current and future wood pellet companies throughout the nation.

Pam Fleming, Customer Support – Harman Stoves

- On May 23, 2011 EFC staff spoke with Pam Fleming, a customer support agent in the Maryland area for Harman Stoves. Harman stoves were brought up in numerous conversations as a number one company used to burn wood and multiple input pellets. We spoke with Ms. Fleming about the details of Harman stoves, including the most popular models and the obstacles of using grass pellets. This conversation also shed light on consumer incentives to purchase multiple input stoves.

Bob Miller, Owner – Enviro Energy LLC

- On May 23, 2011 EFC staff spoke with Mr. Miller, owner of Enviro Energy LLC. This small grass and wood pelletizing company uses native grasses, wasted hay, and overgrown crops as inputs to make pellets. The conversation was geared around Enviro Energy's start-up and production costs, the process they use to create pellets, and the end-uses for their pelletizing operation.

Jon Hall

- On May 23, 2011 EFC staff spoke with Jon Hall about an alfalfa cubing plant as an opportunity to procure pelletizing equipment. Jon provided insight into the economic obstacles that make pelletizing a difficult process, especially in the start-up phase.

Gerry Ruestow, Consultant – Delaware County, NY Cooperative Extension

- On May 24, 2011 graduate student staff member spoke with Gerry Reustow. This call was a follow up call with Enviro Energy, LLC. Mr. Reustow works with the Delaware County Cooperative Extension's grass bio-energy projects. These projects use grass pellets from Enviro Energy to heat highway garages. This conversation focused on the grass bio-energy projects, from the obstacles to successes to the future of switchgrass.

Charlie Niebling, General Manager – New England Pellet

- On May 24, 2011 graduate student staff member spoke with Charlie Niebling as a follow-up from the phone conversation with Marilyn Buford. New England Pellet is one of the major wood pellet operations in the nation. This conversation focused on New England Pellet's interest (or lack there of) in using alternative biomass inputs, as well as the reasoning for only selling wood pellets to its Northeast residential and commercial end-user.

Sat Jiwan Ikle-Khalsa, President – Save Our Sky and Protect Our Planet Home-Heating Cooperative

- On May 25, 2011 graduate student staff member spoke with Sat Jiwan Ikle-Khalsa, the president of Takoma Park, Maryland's corn cooperative. This conversation focused on the cooperative's current practices to procure corn, and the potential to include switchgrass as an input. The President was willing to use his personal stove for test trials with switchgrass in the future.

Matt McArdle, Owner – MESA Reduction Engineering & Processing

- On May 27, 2011 EFC staff spoke with Matt McArdle of MESA Reduction Engineering & Processing. Ms. Rutzke from Cornell University provided this contact to the EFC. Mr. McArdle has years of experience working in all phases on biomass processing – from biomass supply (growing, harvesting, delivering) to consulting engineering to conducting feasibility studies. The conversation focused on the potential to work with MESA as a mentor to the Chester River Association to help determine what market opportunity is most appropriate for the Eastern Shore switchgrass.

Dr. Susan Rupp, Department of Wildlife & Fisheries Sciences, **Assistant Professor** – South Dakota State University

- On May 31, 2011 graduate student staff member spoke with Dr. Susan Rupp. Dr. Rupp focuses on wildlife components of native grasses and provided insight and references to the wildlife benefits and tradeoffs of harvesting switchgrass.

June 2011

Dr. John Fike, Associate Professor Forage-Livestock and Biofuels Research – Virginia Technical Institute

- Beginning at the end of May and carrying into June, graduate student staff member corresponded with Dr. John Fike, Virginia Technical Institute agronomist. It was important to speak with Dr. Fike because of the regional differences in switchgrass yields around the country. Since VA Tech is in close proximity to the Eastern Shore (compared to other contacts we spoke with), Dr. Fike provided the necessary information on the establishment and harvesting of switchgrass in Virginia.

John Quinn, Director of Environmental Affairs; and Salil Bose, Senior Project Manager – Constellation Energy

- On June 3, 2011 EFC staff spoke with John Quinn and Salil Bose of Constellation Energy. This conversation focused around the potential to collaborate with Constellation Energy to provide switchgrass to the company to help them reach their mandated renewable energy standards. The EFC plans to keep Mr. Quinn and Mr. Bose informed of the progress of the Eastern Shore farmers in hopes to develop a relationship that may lead to collaboration in the future.

Carl LaVerghetta, Energy Project Manager – Maryland Environmental Service (MES)

- On June 14, 2011 graduate student staff member spoke with Carl LaVerghetta, Energy Project Manager at MES. This contact was initially brought to the EFC's attention by Dr. Memo Diriker of Salisbury University. The conversation focused around MES's efforts working with Salisbury University on a cellulosic ethanol study, current and future opportunities and obstacles in Maryland to use biomass as an alternative fuel source, and MES's involvement with the Chester River Association switchgrass project.

Appendix B: Fibrowatt Letter in Support of using Switchgrass in FibroShore Boiler

Fibrowatt LLC
One Summit Square, Suite 200
1717 Langhorne-Newtown Road
Langhorne, PA 19047
Tel: (267) 352 0014
Fax: (267) 352 0035

Joanne Throw
Director of the Environmental Finance Center
University of Maryland College Park
1210 Preinkert Field House
Bldg. 54
College Park, MD 20742

RE: Letter in Support of using Switchgrass in FibroShore Boiler

Dear Joanne,

Thank you very much for the opportunity to meet with you and your colleagues representing the Environmental Finance Center of The University of Maryland College Park. The meeting was an excellent opportunity to discuss the numerous environmental benefits resulting from the development, financing, construction and operation of the FibroShore poultry litter fired renewable energy project and listen to your interests regarding the use of switch grass as a supplemental fuel in the FibroShore Plant.

As we discussed, the FibroShore project is promoted by Fibrowatt as a mechanism for the Eastern Shore of the Chesapeake Bay to mitigate excess Nitrogen (N) and Phosphorous (P) that currently discharges to the Bay. FibroShore will produce 55 MW of clean, base load, renewable energy from Eastern Shore fuel sources consisting of poultry litter, forestry and agricultural residues, resulting in significant N and P reduction benefits. Additionally it will result in significant reductions in greenhouse gas emissions (GHG) and ammonia, a precursor to production of particulate matter (PM – 2.5). The project will annually utilize a maximum of 465,000 tons (likely to be less) of poultry litter and approximately 80,000 to 144,000 tons of agricultural/forestry biomass to meet the expected power output.

We understand from our discussions that the Environmental Finance Center (EFC) at UMD College Park is promoting the use of switchgrass as a buffer crop at the edges of crop fields to mitigate losses of N and P from fertilizers applied for crop farming. Switchgrass is a perennial crop that once established needs to be harvested to continue healthy growth. FibroShore provides an outlet for the harvest that otherwise has not been identified on the Eastern Shore peninsula and we want to confirm that we have reviewed the unique and beneficial fuel characteristics of switchgrass and are confident that it would be an excellent supplemental fuel for the Project. Both parties agree that the use of switchgrass as a supplemental fuel at FibroShore is beneficial to the switchgrass crop farmer as well and would create an excellent market outlet for any reasonable harvested quantity.

Background to Significance of FibroShore Project and Switchgrass Harvest

EPA TMDL and MD Watershed Implementation Plan (WIP)

In 2009, President Barack Obama signed a federal executive order on Chesapeake Bay restoration and protection, and each watershed state established two-year bay restoration milestones. By the end of 2010, each state was required to release a Phase 1 Watershed Implementation Plan (WIP) for meeting restoration goals, and the federal government released a Chesapeake Bay Total Maximum Daily Load (Bay TMDL) or "pollution diet" establishing specific pollution limits. Under the TMDL, all pollution control measures to fully restore the Chesapeake Bay and its tributaries are required to be in place by 2025, with 60% of the measures complete by 2017. However, Maryland has committed to having measures in place by 2020, with 70% of the measures complete by 2017.

The Maryland WIP calls for reducing N by 10.3 million pounds and P by 0.6 million pounds by 2017 at an estimated taxpayer expense of **$10.8 billion**. Strategies to meet these targeted N and P reductions includes modification of wastewater treatment plants, modifications to storm water management systems, modifications to septic tanks, modification of agriculture sector activities; and managing fertilizer and manure applications.

Regulation and Utilization of Resource-Based Industries on Eastern Shore

The two largest resource-based industries on Maryland's Eastern Shore are poultry and forestry. Closely related to the poultry industry is crop farming, where farmers utilize N and P fertilizers to facilitate crop growth. The Agricultural Sector, including poultry and crop farming is identified as a contributor to N and P loading, and is subject to the EPA Bay TMDL. Both the Poultry and crop farming industries will need to provide measurable ways of calculating N and P mitigation and loading according to Bay TMDL limits.

The FibroShore project serves as an alternative to existing uses of poultry litter, creating a necessary outlet for poultry litter by enabling the poultry industry to stay strong on the Eastern Shore while ensuring N and P loading to the Bay from poultry litter is mitigated. Analysis of FibroShore indicates the project will achieve N and P reduction levels that far exceed WIP reduction goals by annually converting up to 465,000 tons of poultry litter (roughly ½ of the available poultry litter on the Delmarva Peninsula) into 55 MW of renewable power. Extensive analyses reviewed by numerous state officials, NGO's and various environmental groups indicate annual reductions of approximately 15.1 million pounds of N and approximately 1.4 million pounds of P while producing a valuable fertilizer ash. This level of P and N reduction far exceeds the reduction goals of the Maryland WIP. Additionally the project would significantly contribute to the offset of Maryland's $10.8 billion WIP compliance costs. We have seen limited interests in securing any serious level of funding that would achieve the goals identified in the WIP and therefore, the reduction levels achieved by FibroShore are a creative and cost effective alternative deserving absolute attention and consideration.

Related to mitigation of N and P from crop fields, switchgrass has been identified as an effective buffer crop to mitigate N and P edge of field losses from the application of fertilizer. A challenge in managing the lifecycle of the crop has been identification of an outlet for harvested

grasses at the end of the growth season. Moving the harvest to FibroShore for the purpose of a supplemental fuel provides utilization of the switchgrass that benefits both the farmer and the FibroShore plant. The farmer is enabled to grow switchgrass by having an outlet for the perennial harvest and FibroShore is benefited by having certainty in high value supplemental fuel resources.

It should be noted that clean forestry residue is also an established fuel for the FibroShore project. The forestry industry supports FibroShore as currently there is no significant market for clean wood waste on the Eastern Shore. As with litter and switchgrass, the FibroShore project provides certainty of a new market for the Forestry industry.

Thank you for your interest and support and we look forward towards continuing our discussions regarding the FibroShore project and its numerous defined benefits,

James Potter

James Potter

Executive Vice President

Business Development

Homeland Renewable Energy, LLC

Appendix C: New Generation Biofuels Letter in Support of using Switchgrass for Pyrolysis

New Generation BIOFUELS
Advanced Renewable Technology

May 9, 2011

Ms. Joanne Throwe-Director
University of Maryland Environmental Finance Center
1210 Preinkert Field House
Bldg 054
College Park, MD 20742

Dear Ms. Throwe:

On behalf of our team, I am Dave Goebel, Principal Executive and Chief Operating Officer of New Generation Biofuels (NGBF), a renewable biofuel organization based in Columbia, MD with a manufacturing site in Baltimore. Our new European based technology utilizes natural oils, water, and specific additive combinations and through precise measurements and mixing technologies, we create renewable replacements for diesel and distillate fuels that significantly and positively impacts environmental performance. This would include reductions in nitrous oxides, sulfur compounds, greenhouse gases, and carbon footprints. We are very excited about the potential of our technology and are happy that we have a presence in the State of Maryland.

We are highly interested in identifying local feedstocks to optimize the supply chain areas we manage. One of our preferred technologies for feedstocks is the use of pyrolysis oil, a process where substances are exposed to high temperatures for very short periods of time. This process produces gas (usually used to fuel the process), a solid material called bio-char, and an oily fraction called pyrolysis oil or bio-oil depending upon the starting raw materials used. Typically biological materials are the feedstocks used for pyrolysis although a very wide range of materials can be considered except metals and glass.

We have been advised switchgrass is a biological material of interest in Maryland. Being a perennial plant is a big advantage for use as an energy source. Certainly we would be interested in exploring switchgrass and the feasibility of using this in our processes.

We have a protocol we follow-a Phase I feasibility evaluation- to determine if a raw material will qualify as a product we can utilize. In general, the qualification process includes (but may not be limited to):

- Technical Reviews
  - Initial screening using the materials in existing formulations
  - Lab bench studies on formulations
  - Physical characteristics profiling
  - Manufacturing process determination (process transmittal)
  - Pre-application testing
  - Application testing
- Supply Chain
  - Supply/demand profiles and projections
  - Costs and the drivers of those costs (sensitivities)
  - Logistics opportunities and challenges
  - Pricing and financial potential
- Manufacturing and Operations Capabilities/Compatibilities
  - Scale up review and testing
  - Material compatibilities
  - Process capabilities
  - Sequencing
  - Operating windows
- Legislative and Regulatory Review
  - Approvals/applicability that already may exist
  - Opportunities for monetization
  - Restrictions
- Feedback Loop (adjusting the feasibility study depending upon the results)
- Formulation Optimization/Finalization

Many of these activities can occur simultaneously.

At this point we would have essentially determined the commercialization capabilities of the formulation(s) utilizing the raw materials selected, in this case switchgrass.

From a criteria standpoint, we are interested in a number of areas. One of the most important is assuring we can readily incorporate the raw material in our technology. Another key area is the impact that material has on the physical and combustion properties of the final formulated biofuel. The energy content is certainly one of the most important data points as this allows us to calculate the cost per million Btu to determine market viability.

We welcome the opportunity to partner with the University of Maryland and others to determine the feasibility and viability of utilizing switchgrass in our technology. It is an exciting alternative for our consideration and, if it proves to be viable, it is an important opportunity for Maryland and our organization to both benefit in a multitude of ways.

Due to the timeframes involved, it is in our best interest to conduct these evaluations sooner than later if at all possible. There is a potential window of opportunity for us to incorporate new raw materials and formulations in the next heating season which necessitates qualifications occurring well before that time.

The exact cost for a Phase I feasibility study will be difficult to pinpoint; the costs will vary depending upon the results and whether repeat or additional testing is required. In general, Phase I has cost in the neighborhood of $30,000 if things are straightforward and do not require duplicate work or testing.

Our evaluation processes are robust and allow us to make go/no go determinations with high degrees of certainty. With the right support and partnerships, we have an opportunity to utilize a locally produced feedstock. That is important and exciting in many ways.

After Phase I has been completed, we will have a determination of the feasibility utilizing switchgrass as a feedstock for the pyrolysis process. Assuming it is a positive result, we will know what manufacturing accommodations need to be made, if any, and we will have a path forward to the next phases of commercialization.

We appreciate the opportunity to partner with the University of Maryland. It is our hope and belief that there will be additional opportunities for us to work together in other ways within the University system such as collaboration on the physical testing of our products, combustion analysis, design engineering, and application testing.

Please do not hesitate to contact us at any time to progress this Phase I feasibility evaluation. The entire NGBF Team is excited about this opportunity. Not only do we have a presence in Maryland, several on our Team are Terrapin alumni and are looking forward to working with their alma mater.

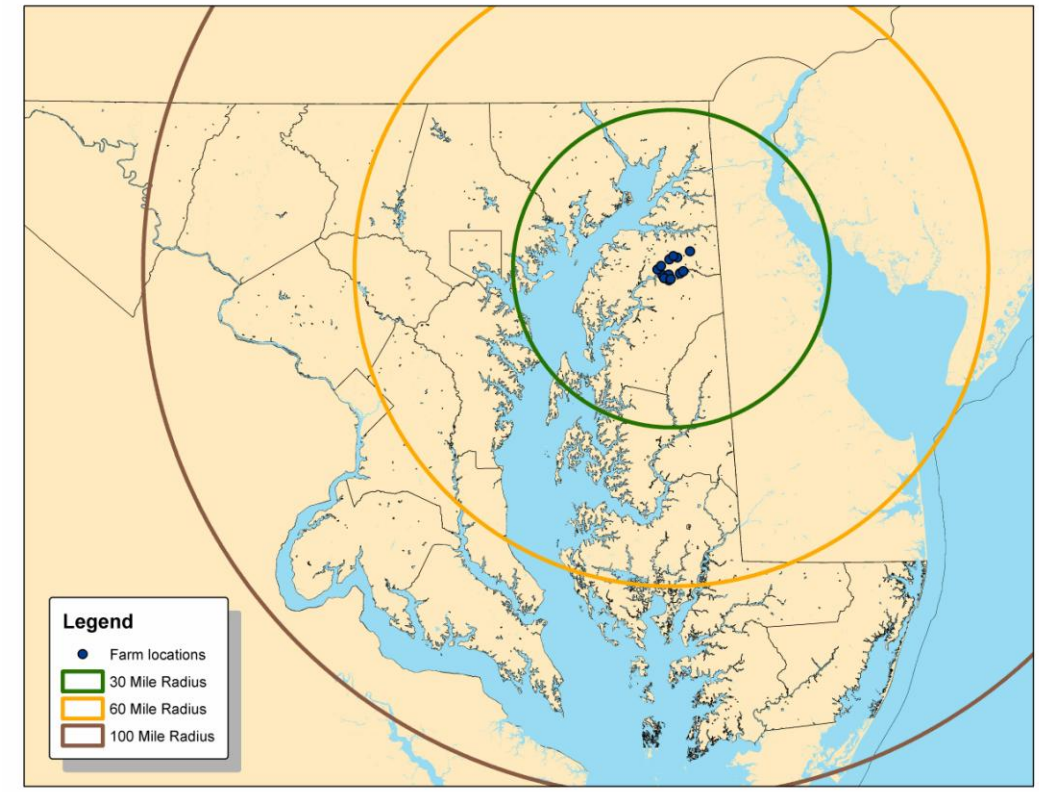
We look forward to hearing from you.

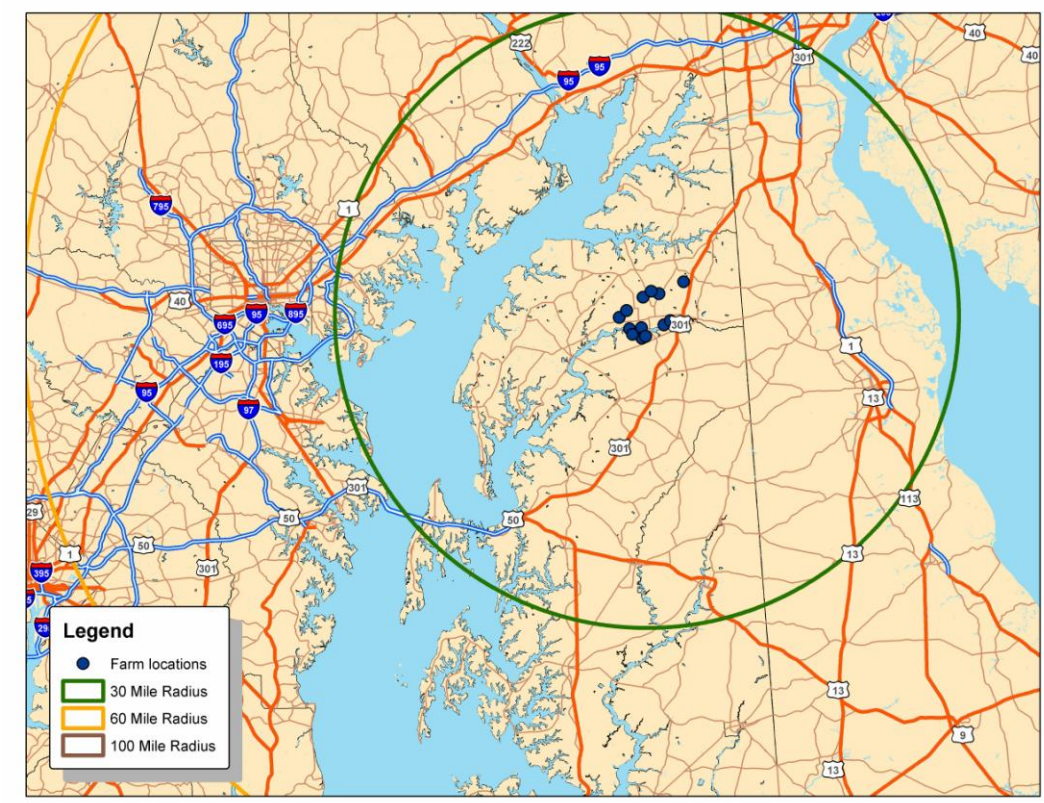
Best regards,

David H. Goebel, Jr.

David H. Goebel, Jr.
Principal Executive and Chief Operating Officer
New Generation Biofuels

Appendix D: Maps of Farm Locations and Recommended Distance





Appendix E: Maps of Farm Locations and Land Use