A PROTOCOL FOR CO-DIGESTION SYSTEMS AS A SOURCE OF CARBON OFFSETS FOR THE DUKE CARBON OFFSETS INITIATIVE

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ABSTRACT

The mission of the Duke Carbon Offsets Initiative (DCOI) is to help Duke University achieve its commitment to carbon neutrality by 2024. DCOI also seeks to effect environmental change at the local, state, regional and national levels. In pursuit of these goals, DCOI is interested in working with North Carolina swine farmers to develop carbon offset projects. Julian Barham is a Johnston County swine farmer and early adopter of several environmentally progressive technologies. His recently installed anaerobic digester combines food and swine waste to produce a biogas that can be used to power a boiler or generator. This process helps to minimize the greenhouse gases emitted by his farm, and also presents an opportunity for the creation of carbon offsets, a possibility that we are exploring on behalf of DCOI. Additionally, we are investigating other potential revenue streams that Mr. Barham could access now that the digester has come online. These include grant proposals for funding of an electricity generator, and the possibility of renewable electricity sales, among others. If Mr. Barham's waste-to-energy anaerobic digestion project produces as many offsets as anticipated, it would fulfill 27% of Duke University's offset obligation.

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INTRODUCTION

Motivated by everything from moral responsibility to financial benefit, parties around the world are taking action to mitigate their contributions to climate change. One of these individual actors is Duke University, which has pledged to reduce its greenhouse gas emissions and become carbon neutral by 2024. In 2009, the University established the Duke Carbon Offsets Initiative (DCOI) to develop a strategy for the University to meet its offset goals in a way that reaches beyond the basic benefits of greenhouse gas emissions reductions to support projects with significant environmental, economic, and societal co-benefits for the Durham community, North Carolina, and the southeastern United States. DCOI has recognized that swine farmers can play a unique role in combating the challenge of climate change and that their prevalence in North Carolina offers the Initiative numerous opportunities to partner on projects that will both achieve Duke University's goals and provide numerous benefits for the farmers.

Waste-to-energy projects using anaerobic digesters to convert methane gas released by animal waste into renewable electricity are beginning to appear across the country. These projects are proving to be of particular interest to swine farmers in North Carolina as they look for methods to reduce the environmental impact of their farming operations and for new sources of revenue. Anaerobic digestion is a process whereby organic matter is broken down by microbes in an environment devoid of oxygen resulting in a biogas (50-80% methane), carbon dioxide, and a nutrient-rich effluent. The biogas is then used to fuel an electricity generator. These types of projects have numerous environmental benefits, including a reduction in greenhouse gas emissions from the swine waste itself, the production of renewable energy that will lead to a reduction in the need for electricity from non-renewable sources, and a reduction in swine waste storage issues, including the pollution of waterways from contaminated runoff— a significant issue in North Carolina. Anaerobic digestion electricity generation projects also provide farmers with a new source of revenue through electricity sales.

DCOI is interested in how it can help to facilitate these projects, which will generate carbon offset credits that it can purchase to help meet its carbon neutrality goal. Specifically, this paper explores what financial opportunities are available for a North Carolinian swine farmer that wants to install a waste-to-energy project on his farm and what combination of revenue streams will make these projects financially viable. To facilitate answers to these questions, we used Barham Farms, a swine farm in central North Carolina, as a case study. We used our experience with Barham Farms to create an Excel-based funding model illustrating the different financial components of swine waste-to-energy anaerobic digestion projects, which can be used by farmers looking to take on this type of project in the future.

This report outlines the different pieces of the funding model, demonstrated through the example of Barham Farms. First, we provide some important background information. In the second section, we explain the grant process through applications to fund the purchase of an electricity generator for Barham Farms. The next section is a discussion of carbon offsets, including an explanation of the offsets market and the specific challenges faced by Barham Farms. We then discuss renewable energy generation, which includes the process of electricity sales and the generation and sale of Renewable Energy Certificates. We bring all of these pieces together in our funding model and illustrate the results when run for both Barham Farms and for another farmer with a similar situation. Lastly, we offer recommendations for DCOI and swine farmers looking to take on these waste-to-energy projects in the future. We hope that our funding model will prove useful for DCOI as it strives to support projects that work towards Duke's goal of carbon neutrality while also providing environmental, economic, and social benefits for North Carolina. We also hope that our work with Barham Farms will demonstrate to other North Carolinian swine farmers that engaging in environmentally friendly practices, such as waste-to-energy anaerobic digestion projects, can provide them with a more financially secure future while also protecting the environment and helping to combat climate change.

BACKGROUND

Barham Farms is owned and operated by Julian Barham, an engineer-turned-swine-farmer who has been a leader in his field by consistently pioneering environmentally-conscious practices on his farrow-to-wean swine farm. As a farrow-to-wean farm, Barham Farms is responsible for swine during the period from birth to weaning, thus, it is involved in the process of removing the pigs from the sow and moving them to the nursery. Barham Farms keeps an average of 4,000 swine.

In December 2011, Mr. Barham completed the installation of an anaerobic digester with a capacity of 750,000 gallons on his farm, which has begun to utilize the methane generated by his swine waste. Methane (CH_4) is a potent greenhouse gas (GHG), which can be formed as a by-product of microbial respiration reactions that occur under anaerobic conditions. This occurs when manure is stored in waste lagoons or ponds and when food waste is disposed of in landfills. If the methane is not captured, it is released in to the atmosphere, where it has a global warming potential of 21 times that of carbon dioxide. [1] Along with the swine waste, Mr. Barham is also adding food waste to the digester, which he is collecting from local restaurants, schools, and grocery stores. The addition of the food waste in the digester increases the energy potential and efficiency of the biogas, and also helps mitigate the enormous amount of food waste sent to landfills every year.

The diversion of this food waste into the digester results in fewer methane emissions from landfills, and also allows Mr. Barham to generate additional carbon offset credits that can be purchased by DCOI. A carbon offset represents one ton of carbon dioxide equivalent (CO_2e) emissions and is created when the biogas is sequestered, destroyed or avoided. Because methane is 21 times more potent as a greenhouse gas than CO_2, destroying one ton of methane will generate 21 tons of carbon offsets. An organization typically purchases carbon offsets to "offset" its own GHG emissions. For example, they can be used to offset a company's Scope I emissions (i.e. direct emissions). Duke University estimates that it will need to purchase 183,000 tons CO_2e of offsets per year to achieve its neutrality goal in 2024.

[1] http://www.epa.gov/outreach/scientific.html

Along with the biogas, the anaerobic digester also creates carbon dioxide and a nutrient-rich effluent. Mr. Barham plans to pump the CO_2 generated in the digester into his greenhouses to increase the production of his cucumbers. He also has plans to utilize the nutrient-rich effluent as a fertilizing product for his agricultural fields and may even market it to other farmers. By using all of the products generated in the digester, Mr. Barham's system is extremely efficient, creating an environmentally-beneficial closed-loop system.

The next phase in Mr. Barham's waste-to-energy anaerobic digestion project is the purchase and installation of a 1 megawatt (MW) electricity generator to fully utilize the biogas created in the digester. Currently, the biogas is used to operate a boiler, which heats the farm's greenhouses. At present, the production of the digester is limited by the amount of food waste it receives. Input of food waste is between 20 and 40 tons a week, though the digester is permitted to receive 145 tons per day, seven days a week. Barham Farms is in discussion with other local food-waste sources, and expects to approach permitted food-waste capacity soon. Currently, the digester is running in a mesophilic state, meaning the internal temperature is moderate (between 20 and 45 degrees Celsius). Once the digester is running consistently and at capacity, it will enter a thermophilic state (55 to 60 degrees Celsius), which allows for increased efficiency in output.

When the digester is running at capacity, it can be used to fuel two small generators which Barham Farms already owns until the purchase of the larger 1 MW generator is complete. A 60 kilowatt (kW) generator will be used to run one of the gestation barns at the hog house, and a 120 kW generator will be used to offset the pumps and processing equipment at the digester.[2] The smaller generators will run until the larger generator is ready to come online. While this self-generation of electricity is beneficial to both the Farm and the environment, the potential for cost-recovery is small due to the size of the generators. Installing the larger 1 MW electricity generator will allow Mr. Barham to generate enough electricity to sell back into the grid as well as Renewable Energy Certificates (RECs), making it much more likely that he can recoup his investment and make the project financially successful.

[2] Personal communication via email. February 20, 2012.

GRANT FUNDING

The financial hurdles for waste-to-energy anaerobic digestion projects are extremely high— the combined cost for the anaerobic digester and the electricity generator for Barham Farms is approximately $2.75 million.[3] Most North Carolinian farmers do not have this amount of money readily available to invest, and straight funding through loans would present a significant burden that could deter many farmers from taking on this type of project. Fortunately, the US government has recognized the value of farm waste-to-energy projects and has made funding available through federal level grants. Unfortunately, these grants are very competitive with funding levels that vary each year dependent on Congressional allocation. The US Department of Agriculture (USDA) is the main source of funding for these projects through two major programs: the Rural Energy for America Program and the Conservation Innovation Grant.

The Rural Energy for America Program (REAP) is administered through the Rural Development office of the USDA. Anaerobic digestion energy projects, as well as solar, geothermal, hydro, wind, and ocean energy projects, are all eligible for grant or combined grant and loan funding under REAP. REAP funding has been instrumental in assisting farmers throughout the nation in installing anaerobic digestion energy generation systems, many of whom have stated that the high capital costs and low electricity payments would have made the project infeasible had they not received outside USDA funding.[4] The announcement for the 2012 REAP grant cycle was made on January 20, 2012 with a budget allocation of $25.4 million, with a minimum of $12.5 million for grant projects and a maximum of $48.5 million in guaranteed loans. REAP funding is distributed at the state level with each state receiving an allocation of the available funds for projects located in their state. Those projects that are unable to be funded by the state can be entered into a highly competitive competition for a limited amount of reserved federal funding.

Allocated funding for REAP for the 2011 fiscal year was $70 million, however, the funding for REAP in 2012 was only $25.4 million, a sixty percent cut over the allocation for 2011. This is reflected in North Carolina's 2012 REAP allocation, which went from $1.8 million

[3] Anaerobic digester project cost approximately $1.75 million, as quoted by Julian Barham, while the electricity generator cost is estimated to be $1,517,680 per the Conservation Innovation Grant application.
[4] Testimony from farmers who have received REAP grant funding is available at: http://farmenergy.org/success-stories/anerobic-digesters. See Hunter Haven Farm and Patterson Dairy Farms.

in 2011 to only $290,000 for 2012.[5] Due to this drop in funding, North Carolina is only considering funding smaller projects, those costing less than $50,000, which puts Barham Farms' electricity generator addition out of consideration for REAP funding from state level funds. Although Mr. Barham could still apply for funding for his electricity generator from the limited national funds, this would require an outlay of money for a feasibility study with no guarantee of funding from the competitive national process. We recommend that Mr. Barham not undertake this feasibility study and not apply for the REAP grant, however, we advise future farmers undertaking waste-to-energy projects to revisit the opportunity for REAP funding.

The Conservation Innovation Grant (CIG) is administered by the Natural Resources Conservation Service under the USDA, and seems to offer the greatest opportunity for funding of waste-to-energy projects. CIG awards up to $1 million or 50% of the project, (duration of the project must be 1-3 years), and has a 50% non-federal funds matching requirement. The goal of the CIG program is "to stimulate the development and adoption of innovative conservation approaches and technologies."[6] The CIG has a 2012 funding level of approximately $20 million, is administered at the national level, and requires a pre-proposal in order to be selected to submit an application. The 2012 pre-proposal application consisted of a cover sheet, which is the Standard Form 424 Application for Federal Assistance, a 2-3 page project description, and budget information in the form of Standard Form 424A Budget Information Non-Construction Programs. As these were the pre-proposal requirements for 2012, the required information could change yearly so new applicants should always read through the application checklist.

We assisted Barham Farms with the CIG pre-proposal application for 2012, a copy of which can be found in Appendix I, to assist with funding for his electricity generator. The pre-proposal application deadline was January 31, 2012 and we were notified on February 29 that we were selected to submit a full proposal. We again assisted Barham Farms with the full application, which consisted of a cover sheet (Standard Form 424 Application for Federal Assistance), a project description of 12 pages maximum, bibliographies/resumes, an assessment of environmental and social impacts, budget information, (Standard Form 424A Budget Information for Non-Construction Programs), a State Conservationist Letter of Review, Certification, (Standard Form 424V- Assurances, Non-Construction Programs), a DUNS

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[5] Phone conversation with David Thigpen, Business Programs Specialist, USDA, Raleigh office, February 13, 2012.
[6] Natural Resources Conservation Service, Conservation Innovation Grant 2012 announcement, http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046372.pdf.

number, and the CCR Registration, (both the DUNS and the CCR are described below). Applications for the full proposal were due by April 6, 2012, with the award notifications announced by July 20, 2012. All projects applying for the 2012 CIG may not officially begin until September 1, 2012, which means Mr. Barham would not be able to install his generator until September 1, (although he can continue to run the digester and his smaller electricity generators in the meantime). The full grant proposal can also be found in Appendix I.

The most important resource for federal grants is **www.grants.gov**, which is a searchable database that houses all grant announcements as well as the application system. Submission of federal grants is done through this system, email submission, or traditional mail, depending on the grant. In order to apply for federal grants, a farmer needs both a DUNS number and a CCR registration number:

- DUNS number: Any business that contracts with the government or applies for/receives a grant from the government needs to have a D-U-N-S number from Dun & Bradstreet (D&B). It is free to register, and information can be found and requests can be made at http://fedgov.dnb.com/webform or https://iupdate.dnb.com/iUpdate/mainlaunchpage.htm.
- CCR registration: In order to receive federal funding, the farmer must also register with the Central Contractor Registration, which is also free and can be done at https://www.bpn.gov/ccr/.

The EPA's voluntary AgSTAR program, a joint effort by the EPA, USDA, and Department of Energy which promotes the capture of methane from animal waste, provides a thorough database of current projects, funding opportunities, and tools that makes it a very useful reference. It also provides a quick guide to federal opportunities for waste-to-energy projects, available.[7]

The federal agencies are the most important and most likely the only sources where farmers wishing to take on anaerobic digestion energy projects will be able to find sufficient financial help. Funding at the North Carolina state level and from other institutions, specifically foundation funding, is essentially non-existent, especially after the economic downturn. For example, the North Carolina Department of Commerce offered grant opportunities through the Green Business Fund program meant to incentivize and assist small businesses with developing environmentally conscious technologies and renewable energy projects and businesses. Initially

[7] See http://www.epa.gov/agstar/documents/agstar_federal_incentives.pdf.

funded by the state when it began in 2007, it was later funded through the American Recovery and Reinvestment Act (ARRA). The last cycle of the Green Business Fund money from the ARRA was awarded in 2011, and the state has decided not to continue funding the program in the future.

As mentioned previously, funding from other sources like foundations is also extremely limited for these types of projects. We assisted Barham Farms with an application for a $10,000 grant from Rural Advancement Foundation International (RAFI) in conjunction with the North Carolina Tobacco Trust Fund Commission. This grant is intended to supplement lost revenue to tobacco farmers and to help farmers remain in their profession. The Barham Farms RAFI application can be found in Appendix I. Although $10,000 is small considering the overall cost of the project, the application gave us a starting point for the CIG grant and would have contributed to the CIG matching requirement. Information on the RAFI grant program can be found online.[8] The grant is awarded semi-annually with another funding cycle beginning in June 2012. Although Barham Farms was not awarded the RAFI grant, we recommend that future farmers apply for it while continuing to search for more foundation grant opportunities, always keeping in mind that these sources are very limited.

The grant search and application process can be very daunting and time consuming, and thus, any farmer who wishes to apply for grants for a waste-to-energy project must understand the significant time investment this will require. It may be difficult for a farmer to add this workload on top of his normal farming operations, and this could prove to be a barrier preventing other farmers from taking on these types of projects in the future. We recommend that farmers look for outside assistance with grant applications, particularly to their local farm bureau, and suggest that DCOI, if unable to assist the farmer with the search and application process, at least offer itself as an editing, review, and advising center if it wishes to be involved in these types of projects in the future. In the course of assisting Barham Farms with the grant application process, we have a few recommendations for future farmers beginning the grant process:

- Grant spreadsheet: A useful method for keeping track of grant applications is to create a grant spreadsheet that lists all the relevant information, (deadlines, matching requirements, website, notification date, etc.).

[8] http://www.rafiusa.org/programs/tobacco/tobacco.html.

- Consider the grant criteria: Each grant application usually includes the criteria that will be used to judge the project. Using this checklist as a guide for writing the grant helps to ensure the success of the grant in covering all the aspects important to the funder.
- Use specifics: A large difference between the Barham Farms RAFI grant application and the CIG application is the amount of information specific to the actual project. Rather than vague statements about climate change, use specific information on the benefits of the project for methane/carbon reductions from the farm, energy generated, emissions avoided from landfills, etc. Numbers are important, and the clearer the project benefits are, the better.
- Keep audience in mind: Do not assume that the people reviewing the application have a firm grasp on anaerobic digestion or the technicalities of the waste-to-energy process. Explain the project and process in detail, but do not include too much technical jargon.
- Resources:
    - **Farmenergy.org**- A website that contains up-to-date information on farm energy programs, information on financing, actions on government agencies, and news stories. They also publish success stories from alternative energy projects, including a section on anaerobic digesters, which can serve as a resource for practices and pitfalls as well as an avenue for outreach for any successful projects.
    - **EPA AgSTAR program[9]-** An important database that contains tools, funding opportunities, and information on current anaerobic digestion projects.
    - **Database of State Incentives for Renewables & Efficiency[10]-** A searchable database of all the financial incentives listed by state for renewable energy projects as well as relevant rules, regulations, policies, related programs, and initiatives.

The cost of an anaerobic digestion waste-to-energy project can be off-putting to a farmer considering undertaking this type of project. Federal funding through various USDA grants offer the most opportunities for financial assistance, however, budget cuts have continued to reduce the amount of funding available through these programs. President Obama's renewed commitment to renewable energy in his 2012 State of the Union address may prove to be

[9] See http://www.epa.gov/agstar/index.html.
[10] See http://www.dsireusa.org/incentives/index.cfm?getRE=1?re=undefined&ee=1&spv=0&st=0&srp=1&state=NC.

beneficial for farm waste-to-energy projects, but this will go up against continued calls for budget cuts in Congress. Although grants are an important piece of the funding model we have established, in the end, they are uncertain and should not be relied on for success of the project. Our funding model has been adapted to include situations in which the farmer receives grant funding and those in which he does not. The results serve to demonstrate that the financial viability and success of a waste-to-energy anaerobic digestion project is more dependent on the offsets, renewable energy certificates, electricity payments, and tipping fees[11] than successful grant funding.

[11] "Tipping fees" are the charges levied upon a given quantity of waste received at a waste processing facility.

CARBON OFFSETS

Carbon offsets represent one of the potential revenue streams for a farmer with an anaerobic digester. However, in order for a carbon offset to be sold on the market, it must meet certain basic criteria. There are a number of accepted carbon offset standards available with some variation in definitions, but all include basic components such as project eligibility, baseline assessment, additionality, monitoring and verification, ownership, crediting period, and permanence. Certification, project registration, credit issuance and tracking prepare the offset for the market. For the purposes of this project, we are following the standards of the Climate Action Reserve's (CAR) Organic Waste Digester Protocol, version 2. CAR is "a national offsets program working to ensure integrity, transparency and financial value in the US carbon market."[12] It has established standards for the development, quantification and verification of GHG emissions reduction projects in North America. CAR issues carbon offset credits known as Climate Reserve Tonnes (CRT) and tracks the transaction of credits over time in a publicly-accessible system.

Additionality is key to the Barham Farms project. Additionality addresses the question of whether the benefit provided by the project would have happened anyway, even in the absence of possible revenue from carbon offset credits. Only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market are eligible. Thus, Barham Farms' swine waste emissions reductions are ineligible to be registered with CAR because he was already capturing the methane released from the waste in a covered lagoon. The only waste stream that is eligible in the Barham Farms project is the food waste stream.

As discussed previously, the value of a combined swine and food waste stream is that the food waste combined with the animal waste greatly increases the energy content or BTU-value of the entire waste stream, thereby allowing for increased electricity production and greater displacement of fossil fuels. The food waste further decreases emissions of greenhouse gases because the food waste is turned into energy-producing biogas rather than unchecked methane emissions from landfills. At 33 million tons per year, food waste is the largest component of the municipal solid waste entering landfills, and methane from landfills accounts for more than 20%

[12] Climate Action Reserve. "About Us," http://www.climateactionreserve.org/about-us/.

of US methane emissions each year at 179.7 million metric tons carbon dioxide equivalent ($mTCO_2e$) in 2009 alone[13].

The digester installed on the farm has the potential to divert 145 tons of food waste per day (52,925 tons of food waste per year) from landfills, resulting in approximately 49,745 $mTCO_2e$/year of avoided methane emissions. This figure is based on the Organic Waste Digester (OWD) tool we created derived from CAR's OWD protocol.[14] The figure is the difference between baseline emissions and project emissions. Total baseline emissions are the lessor of either calculated baseline emissions or methane destroyed by the biogas control system during the reporting period. At this time, it is not possible to accurately estimate the methane that will be destroyed by the biogas control system because the farmer does not know the monthly standard cubic feet of gas that the food will create. Thus, the 49,745 $mTCO_2e$/year of avoided methane emissions represents the maximum offsets this project could generate, but the actual amount may be less depending on the biogas control flow measured during the reporting period.

The digester also addresses the significant methane emissions from the swine waste already produced on the farm, (the swine industry as a whole accounted for 19.9 million $mTCO_2e$ in 2010).[15] Swine waste lagoons can result in up to 0.6 $mTCO_2e$ of methane per pig per year, meaning that Barham Farms' 4,000 hogs will release approximately 2,500 $mTCO_2e$/year in methane emissions that will now be captured in the digester.[16] The combined emissions reductions from food and swine waste will amount to 52,245 $mTCO_2e$ of waste-related methane emissions avoided every year. However, as stated previously, Barham Farms' swine waste is ineligible for carbon offset credits due to the additionality criteria. For the funding model, we estimated an offset price of \$8/$mTCO_2e$. This price is based on sale prices of CRTs in the California market for delivery in 2013,[17] which is when the California Carbon Market compliance period starts per the California climate legislation AB32. The 2013 delivery prices are approximately \$14/$mTCO_2e$. However, OWD is not currently allowed in this market, which

[13] EPA, "Basic Information about Food Waste," http://www.epa.gov/osw/conserve/materials/organics/food/fd-basic.htm.
[14] See Duke Carbon Offsets Initiative website for OWD tool, http://sustainability.duke.edu/carbon_offsets/index.php.
[15] Environmental Protection Agency, 2012 Draft U.S. Greenhouse Gas Inventory Report http://epa.gov/climatechange/emissions/downloads12/6.%20Agriculture.pdf.
[16] Calculated from Climate Action Reserve, U.S. Livestock Project Protocol, http://www.climateactionreserve.org/how/protocols/us-livestock/.
[17] California Market Prices, Thomson Reuters, PointCarbon.com, March 16, 2012 (subscription website).

is why we chose a conservatively low price of $8/m$TCO_2$e. At a market price of $8/m$TCO_2$e, the food waste has the potential to raise annual revenue of $422,000.[18]

An additional benefit to using food waste is that it provides potential tipping fee revenues to farmers. Tipping fees are fees levied on a particular quantity of waste at a waste processing facility. Landfills in Wake County charge between $30/ton and $36/ton,[19] while landfills in Johnston County charge $33/ton.[20] Since Barham Farms is only charging $20/ton, it is providing a cost saving to organizations that decide to divert their waste to Barham Farms. In our funding model, tipping fees account for approximately 30% of the revenue, making them an essential part of the financial success of the project.

Barham Farms has already contracted for 20 tons per day of food waste from Walmart, however, we discovered that this waste is ineligible to be registered on CAR since it does not meet the additionality requirement discussed earlier. The carbon offsets generated from food waste in an OWD project must be the result of waste diverted from landfill, thus, any food waste streams from grocery stores and/or supermarkets that have historically avoided directing their waste streams to landfills are ineligible. Since Walmart's food waste stream was being composted before they agreed to send it to Barham Farms, it cannot be registered for carbon offsets under CAR.[21] In fact, OWD projects must demonstrate the eligibility of each new grocery store waste stream digested by the project by documenting that the waste of the grocery store waste was being disposed of in a landfill for a period of at least 36 months prior to the date that the grocery store waste was first delivered to the digester.

As a result of this information, Mr. Barham is searching for additional waste sources in order to facilitate registration of the offsets on CAR and make them available for sale. Mr. Barham has identified local restaurants and supermarkets whose food waste would be good candidates for his project and has begun to organize pick-up services for these waste streams. In order to further facilitate Mr. Barham's search for CAR-eligible food waste, we contacted local public school systems to gauge their interest, ability, and willingness to participate in this innovative project. Involving schools would provide benefits not only for Mr. Barham but for the school system itself as a new avenue for teaching environmental science.

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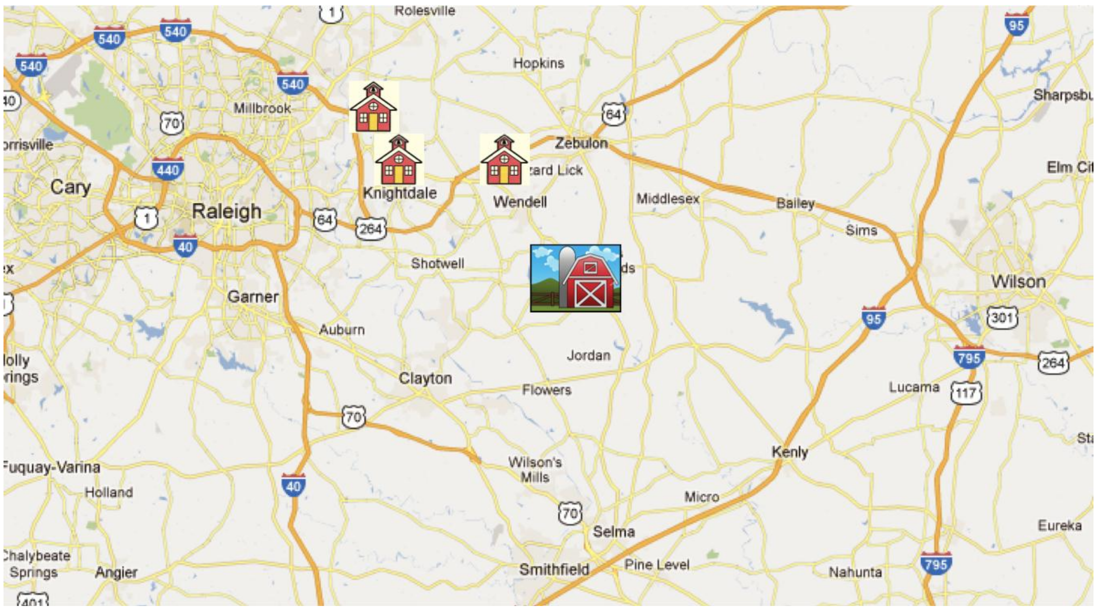
[18] See the Funding Model.
[19] Wake County, Disposal Locations and Fees, http://www.wakegov.com/recycling/business/disposalfees.htm.
[20] Johnston County. Landfill Tipping Fees.
http://www.johnstonnc.com/mainpage.cfm?category_level_id=571&content_id=3920
[21] Climate Action Reserve, Organic Waste Digestion Project Protocol, Version 2, Los Angeles, June 29, 2011.

Barham Farms is located in Zebulon, North Carolina. This is in Johnston County but also proximate to Wake County. Thus, these two counties were identified as the two school systems to survey interest. Ultimately, we have identified three schools in Wake County that are interested in working with Barham Farms. These schools are Knightsdale Elementary, Knightsdale High School, and Wendell Creative Arts and Science Magnet Elementary School, identified on the map below.

Map of Barham Farms and the Three Interested Schools

Figure 1 – Map of Barham Farms and the Three Interested Schools



The process of locating these willing schools is as follows:

The first step was to contact the superintendents of both Johnston and Wake County about the project and ask if they would be willing to participate. The Wake County superintendent forwarded us to the Director of Child Nutrition, who gave her consent and provided the contact information of 20 principals located near Barham Farms. Based on our conversation with the director, we ascertained that the schools' waste pickup was under an annual contract; therefore, diversion of some of the waste would not result in cost savings to the schools unless the waste management company would be willing to deliver to Barham and avoid the current tipping fees. It is also unlikely that the schools would be willing to pay additional tipping fees to Barham. At this time we have not made contact with Johnston County Schools since none of the superintendents have returned our contact requests. We recommend that Barham contact the Johnston County Director of Child Nutrition if he is still interested in additional food sources.

A letter was sent to the 20 Wake County principals to gauge interest in the project.[22] Of the 20 schools, three schools are interested in participating. Those that responded and were not willing to participate cited school academics as a higher priority at this time and noted that they simply do not have time to deal with this type of a project. The three schools listed above responded favorably to the opportunity.

We worked with the principals and various other stakeholders of these schools, however, recently the Wake County School district hired someone to implement such a food waste system countywide. Barham Farms has been in contact with the new hire to secure the schools' waste stream for their digester. At this time, the new hire is investigating sanitary procedures for the food waste recycling system.

[22] See Appendix II.

RENEWABLE ENERGY

In August 2007, the North Carolina General Assembly signed into law Senate Bill 3, establishing a statewide Renewable Energy and Energy Efficiency Portfolio Standard (REPS). [23] To comply with this law, investor-owned utilities must generate 12.5% of their energy needs from renewable sources or energy efficiency measures by 2021.[24] Rural electric cooperatives and municipal electric suppliers must meet a 10% REPS threshold to be in compliance by 2018. North Carolina is one of twenty-four states with a binding renewable portfolio standard, and currently is the only state in the Southeast to have committed to such a measure.[25]

Numerous renewable energy sources are eligible to fulfill the REPS requirements. These include, but are not limited to, solar-electric, solar thermal, wind, hydropower up to 10 megawatts, ocean current or wave energy, biomass (if it includes best available control technology [BACT] for air emissions), landfill gas, combined heat and power (CHP), and hydrogen derived from renewables.[26] Energy efficiency measures can be utilized to meet up to 25% of each utility's REPS requirement; this percentage increases to 40% after 2021. Senate Bill 75, passed during the 2011 legislative session, allows electricity demand reduction to count towards the standard as well.[27]

In addition to these general renewable source measures, the North Carolina portfolio standard also includes technology-specific targets known as "set-asides." These targets mandate that 0.2% of the state's energy must be derived from solar-based sources by 2018, 0.2% must come from swine waste by 2018, and 900,000 MWh must come from poultry waste by 2014.[28] These set-asides put a premium on projects that can supply these resources, which result in swine farmers like Barham Farms potentially benefitting greatly from participation in the North Carolina Renewable Energy Tracking System (NC-RETS). As a way of measuring utility compliance with the North Carolina REPS, the state created a system of renewable energy

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[23] Session Law 2007-397 (Senate Bill 3), available at http://www.ncleg.net/sessions/2007/bills/senate/pdf/s3v6.pdf
[24] North Carolina Utilities Commission, http://www.ncuc.commerce.state.nc.us/reps/reps.htm.
[25] US Department of Energy, http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm.
[26] North Carolina General Assembly, Senate Bill 3, http://www.ncga.state.nc.us/Sessions/2007/Bills/Senate/HTML/S3v6.html.
[27] North Carolina General Assembly, Senate Bill 75, http://www.ncga.state.nc.us/Sessions/2011/Bills/Senate/PDF/S75v4.pdf.
[28] US Department of Energy, Database of State Incentives for Renewables & Efficiency, http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NC09R&state=NC&CurrentPageID=1&RE=1&EE=1.

certificates (RECs). One megawatt of renewable energy generation corresponds with one REC, which a renewable energy producer can sell to any utility, not just the owner of the grid where the producer is located. These RECs, discussed further on page 21, constitute a significant additional source of revenue beyond renewable electricity sales.

ELECTRICITY SALES

Another important piece of the funding puzzle for North Carolina swine farmers who install waste-to-energy anaerobic digestion projects on their farms is electricity sales. The system generates electricity by converting the waste into biogas, which is used to power a generator. The electricity is then sold back into the grid. As stated above, investor-owned utilities must collectively demonstrate by 2018 that 0.2% of the electricity sold to retail customers in North Carolina comes from swine waste.[29] This swine waste set-aside obligates utilities in the state to pursue electricity generated from swine waste—good news for Barham Farms and other swine farmers looking to take on these types of projects. Because any electricity sales go directly into the grid, however, farmers can only sell to the utility that manages the grid at their particular location. This limitation means that farmers have little bargaining power against the utility regarding the price for the electricity they produce.

In addition to this diminished bargaining power, swine farmers are also limited by the fact that swine waste generates a relatively low amount of energy due to the amount of methane per volume of waste.[30] This is where Barham Farms' addition of the food waste into the digester is particularly important and innovative—the food waste has a higher energy content, therefore boosting the overall electricity generation. Even swine farms smaller than Barham Farms could produce substantial amounts of electricity by augmenting their swine waste feedstock with another waste stream, meaning that these types of projects are not necessarily restricted to only large swine farms. The question remains, however, whether such a mixed feedstock would still qualify for the swine waste set-aside for purposes of the North Carolina REPS, or whether there must be some minimum ratio of inputs (say 51% swine by volume) to qualify.

North Carolina utilities periodically issue request for proposals (RFPs) in search of specific renewable energy sources. For example, on September 22, 2011, Duke Energy Carolinas issued an RFP for electricity from wind energy sources.[31] When a utility issues an RFP, it includes a timeline for when the proposals are due and when the utility will make a decision. Outside of these formal requests, renewable energy sellers can submit unsolicited RFPs at any time. Progress Energy and Duke Energy have forms available online that sellers can complete in

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[29] §62.133.7(e).

[30] http://www.face-online.org.uk/resources/factsheets/discovering/anerobic%20digestion%20and%20biogas.pdf.

[31] http://www.duke-energy.com/news/releases/37022.asp.

an attempt to negotiate an agreement for electricity sales. Both utilities indicate that the main factor for consideration in the ultimate price the utility will offer is the cost of the renewable energy project to the potential seller.[32] However, both utilities rely on a set schedule for the amount they are willing to pay for renewable energy.[33] As a result, the bulk of the negotiation with a utility over price surrounds the amount it is willing to pay for the Renewable Energy Certificates.

In our work with Barham Farms, we filed an unsolicited RFP with Progress Energy. Barham Farms is located on the Progress Energy power grid, making Progress our only potential buyer of the electricity produced. Progress divides its RFPs into "Solar" and Non-Solar" projects and requires different information for each type of project. Using the Non-Solar forms and instructions, we provided Progress with estimates of potential electricity generation from the Barham Farms project and compiled the project's costs. Using this information, we were able to determine a price per megawatt hour that would allow Barham Farms to recover the cost of its investment.

However, after submitting our proposal, Progress directed us to its rate schedule for renewable energy, contained in CSP-27.[34] Thus, the electricity price would be based on a few characteristics of the project, and not negotiated based on the cost of the project. With this information in hand, we proceeded to negotiate a price for the RECs that Progress would be willing to pay. As of the time of the completion of this paper, those negotiations were still ongoing. Also as of that time, Progress had indicated an unwillingness to view all of the electricity generated from the project as originating from swine, since half of the feedstock would be from food waste. This is a position which will significantly reduce the potential returns to Barham Farms from REC sales. So, we also sent the RFP to Duke Energy in hopes that they would take a different view.

Although the details of the Barham Farms RFP are contained in Appendix III, a few points warrant explanation. First, the high capacity factor associated with anaerobic digesters (around 90%), consistent throughout the year in insulated digesters like Mr. Barham's, means

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[32] See http://www.duke-energy.com/suppliers/carolinas-rfp.asp and https://www.progress-energy.com/carolinas/business/renewable-energy/renewable-rfp.page.

[33] See, e.g., Progress Energy, Cogeneration and Small Power Producer Schedule CSP-27, available at https://www.progress-energy.com/assets/www/docs/company/NC-CSP.pdf.

[34] Progress Energy, Cogeneration and Small Power Producer Schedule CSP-27, https://www.progress-energy.com/assets/www/docs/company/NC-CSP.pdf.

that swine farmers can apply to provide base-load energy to the utility. The digester, if operated at full capacity for twenty-four hours per day, 365 days per year, can consistently meet electricity demand. In this way, biomass differs significantly from solar or wind sources, whose generation profiles are much more variable. Barham Farms is able to offer a consistent generation profile across the seasons because the digester is insulated. This insulation allows it to run the 1 MW generator consistently over the life of the project, without fluctuations. Any swine farm with a digester that is not insulated would need to take into account the impact of seasonal temperature changes on its estimated generation profile. The capacity to produce constant, base-load electricity makes these anaerobic digestion waste-to-energy projects much more attractive to energy utilities.

Another important point is that the purpose of the RFP is to bid on a price from the utility. Therefore, the RFP reflects a price that would recover the project's cost, not a price that is competitive with cheaper forms of energy generation. The price that Barham Farms requires to recover its costs over a ten year timeline is $66 per megawatt hour, while the national average cost of coal per megawatt hour to utilities is $40.[35] Were it not for the REPs, it would be nearly impossible for Mr. Barham to recover his costs in this period. If Progress did decide to offer a lower rate for Mr. Barham's electricity than that needed to recover the cost of the project, more pressure would be on the other aspects of the funding model to make up the difference. For example, Mr. Barham would need to ask for a higher payment for the renewable energy credits (discussed in detail below) to compensate for the low electricity price.

Overall, electricity sales offer an important source of revenue to swine farms. These sales, when combined with renewable energy credits, could be enough for farmers to recover their costs, even without considering other revenue streams.

[35] http://nuclearfissionary.com/2010/04/02/comparing-energy-costs-of-nuclear-coal-gas-wind-and-solar/.

RENEWABLE ENERGY CERTIFICATES

To facilitate the production and purchase of renewable energy, the North Carolina Utilities Commission (NCUC) established the Renewable Energy Tracking System (NC-RETS). NC-RETS issues renewable energy certificates (RECs) and energy efficiency certificates (EECs) that are then tracked by their system.[36] Energy producers who register with the NCUC are entered into the NC-RETS in order to create RECs, and utilities use this system to demonstrate compliance. Using verifiable energy production data, NC-RETS creates a digital certificate for each megawatt hour or thermal equivalent generated by a registered renewable energy facility; one REC represents one MWh. Each utility determines the price they will pay per REC, which varies depending upon the source. However, unlike electricity sales, renewable energy producers can sell the RECs they create to any utility or interested purchaser, regardless of who is purchasing the underlying electricity.

If Barham Farms receives the Conservation Innovation Grant mentioned earlier, they will begin installation of the 1 MW electricity generator in the fall of 2012. The generator is expected to produce 7,884,000 kilowatt-hours (or 7,884 MWh), which will be sold into the grid, (see discussion of electricity sales in previous section). This project could effectively create 7,884 RECs for Barham Farms. Duke Energy's standard offer for 2012 is $5.00 for non-solar RECs, and $20.00 for solar RECs.[37] It is expected that utilities will establish a separate price for poultry and swine RECs that would be closer to the price for the solar certificates, but that information has not yet been released. Mr. Barham could choose to pursue RECs based on the size and capabilities of the smaller generators he runs currently from the digester, however if he's planning to install the larger generator, that project represents a significantly larger opportunity for RECs.

One challenge that Barham Farms will face with RECs is whether all of the MWh produced by the generator will be considered to be derived from swine waste. Barham Farms' digester is permitted as a waste management system by the NC Department of Water Quality (DWQ). Their DWQ permit mandates that the input of waste into the digester must be 51:49 swine to food waste. However, approximately 90% of the resulting biogas can be attributed to

[36] North Carolina Renewable Energy Tracking System: http://www.ncrets.org/.
[37] Duke Energy REC Purchase Offer, http://www.duke-energy.com/pdfs/REC-Purchase-Offer-Info.pdf.

the food waste due to the volatile solids available in the food and the amount of water that gets added to the swine waste. The best-case scenario for the Farm would be that all RECs are considered to be derived from swine waste, which would result in a higher price because they would fulfill the swine set-aside. A more realistic scenario would be that 51% or 10% of the RECs would be categorized as from swine waste, while the remainder would be considered standard RECs.

The decision about the RECs will be made by the NCUC after Barham Farms files the application to be registered as a certified renewable energy facility. The application has been completed, and currently awaits submission to the NCUC by Mr. Barham. A proposal for construction of the electricity generator will also be filed at that time. If the Commission determines that Barham Farms qualifies as a certified facility, the next step will be registering with NC-RETS. This will likely happen once construction on the generator nears completion. Upon registration with the tracking system, the facility and application are once again reviewed and if approved, RECs are issued. Utilities are then able to purchase those RECs to fulfill their obligation under the REPS.

RECs appear to be a promising source of revenue for Barham Farms, though many steps must be taken before this money can be accessed. In addition to the application process, we are assuming that the generator will be built in the fall, will come online within a reasonable timeframe, and will produce the amount of electricity mentioned above. Any changes could alter the outlook for RECs. Assuming, however, that things go as planned, RECs should be a viable source of cost-recovery and eventually profit for Barham Farms and for other farmers who take on a waste-to-energy project in the future.

FUNDING MODEL

As discussed previously, DCOI is interested in offset projects related to the utilization of swine waste to generate energy due to the prevalence of swine farms in the area and the massive amount of waste and disposal problems they generate. Projects that turn this waste stream into energy have the dual benefits of reducing the amount of methane released into the atmosphere and reducing the amount of non-renewable energy needed. With one of these projects already in place, DCOI knows the value in supporting these types of projects. Additionally, they are interested in the learning opportunities they present for assisting future farmers in such endeavors. The Initiative desires to understand the various funding opportunities available to Barham Farms so that it can apply this understanding to future projects and provide this information to other farmers in North Carolina.

The revenue sources explained above are incorporated into an Excel-based funding model, which can be modified for different scenarios based on grant acquisition, eligibility for offsets, REC classifications, and electricity sales. All revenue listed in the tables below, except that from grants, is estimated annual revenue to the farmer while the grant funding is a one-time payment from the government. The revenue from RECs and offsets are based on the amount of food and swine waste the digester receives and the market price for the swine and food portions. The current market price estimated for food RECs is \$6 and for swine RECs is \$40, (we have been told that swine RECs can range anywhere from \$20 to \$80 per REC). The price estimated for carbon offsets is \$8 $mTCO_2e$, based on a conservative estimate.[38]

Using the funding model for Barham Farms, the potential funding options consist of the following:

[38] See Carbon Offsets section above for explanation of \$8 $mTCO_2e$ offset price.

Figure 2 – Funding Scenario for Barham Farms

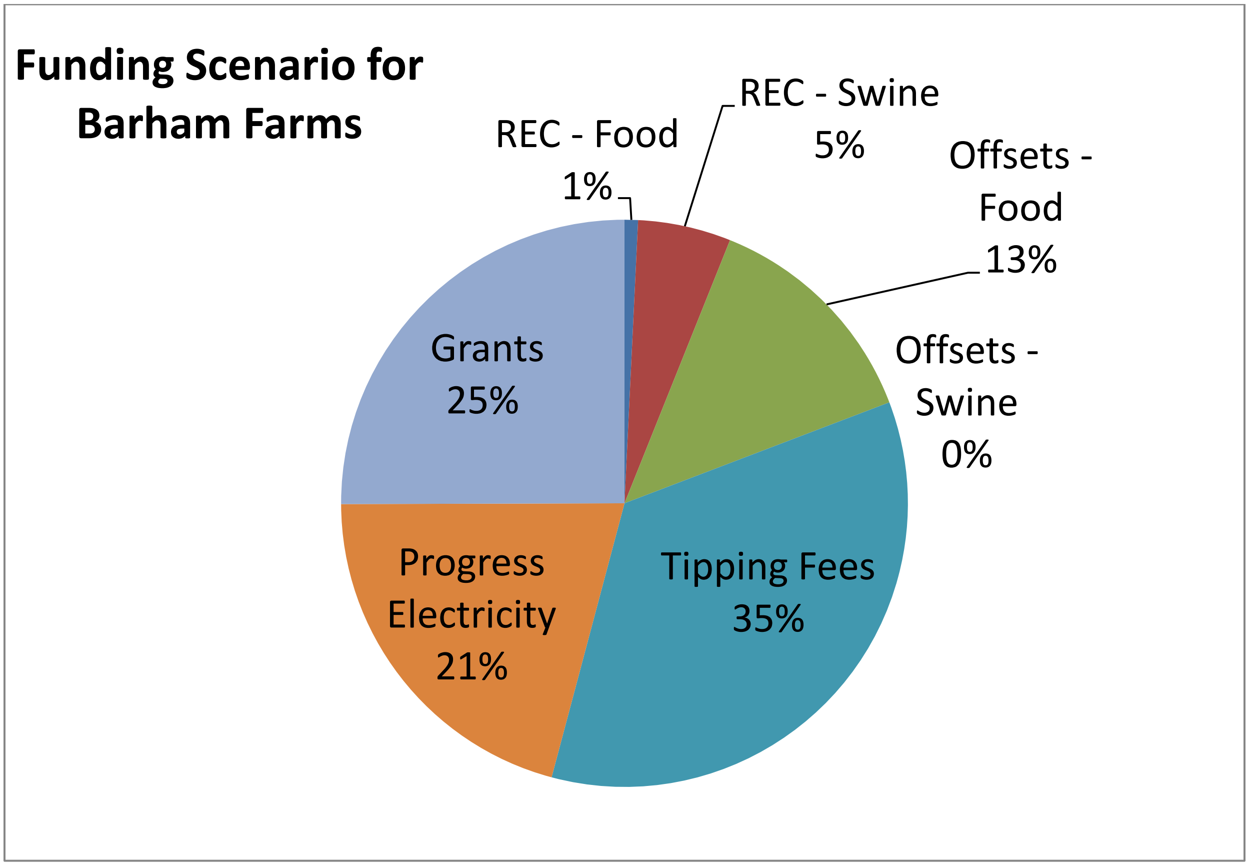


Table 1 – Funding Available for Barham Farms

Funding Available for Barham Farms	Amount
REC- Food	$23,179
REC- Swine	$160,834
Offset- Food	$397,962
Offsets- Swine	$0
Tipping Fees	$1,058,500
Progress Electricity	$630,720
Annual Revenue	$2,271,195
Grant (one year payment)	$758,840

Table 2 – Expenses for Barham Farms

Expenses	Amount
Annual O&M	$80,000
Other Expenses	$150,000
Offset Registration	$500
Offset Issuance	$9,400
Offset Verification	$10,000
Annual Costs	$249,900
Initial Investment	
Digester & Construction	$1,750,000
Generator &Construction	$1,517,680
Total	$3,267,680

For the Barham Farms funding scenario, we used the maximum permitted amount of food, which is 145 tons per day. The tipping fees are estimated at $20 per ton, which is based on Barham Farms' current agreement with one of its food waste suppliers. We assume a 51:49 swine to food ratio for the RECs and REC prices. Finally, the revenue from Progress Energy is based on an estimate that electricity sales from Barham Farms' project would yield $0.08 per kilowatt hour based on the rate schedule, (still in negotiation). Note that Barham Farms is not eligible for swine offsets, (see Carbon Offsets section above). If it were, these offsets would add an additonal revenue stream of approximately $21,000 per year. See the respective sections above for more details on each funding opportunity. The above tables also provide a summary of the costs associated with both purchasing and running the digester and generator, including the costs of registering and issuing the carbon offsets with the Climate Action Reserve as well as the costs for annual operation and maintanence.

The revenues and expenses described in tables 1 and 2 were used to determine various net present value scenarios to project any general farmer's potential profit for the life of the project. Table 3 below contains a summary of the NPV analysis, followed by an explanation of the scenarios in Figure 3. For additional details and the sensitivity analysis, see Appendix VI, and for the complete funding model, visit our website: *http://sites.duke.edu/mpdcoi2012/*.

Table 3 – NPV Analysis

	NPV	NPV with CIG
Scenario 1	N/A	$17,372,472
Scenario 2	$62,074	$759,823
Scenario 3	$5,758,087	$6,455,835
Scenario 4	$15,317,367	$16,015,116
Scenario 5	($219,433)	N/A
Scenario 6	$9,339,847	N/A
Scenario 7	($3,632,798)	N/A
Scenario 8	($3,531,909)	($2,834,161)
Scenario 9	($4,766,520)	($4,068,772)

Figure 3 – Funding Model Scenarios Descriptions

	Carbon Offsets - Food	Carbon Offsets - Swine	Electricity Sales	RECs - Food	RECs - Swine	Tipping Fees
Scenario 1	X	X	X		X[1]	X
Scenario 2	X			X	X	
Scenario 3	X		X	X	X	
Scenario 4	X		X	X	X	X
Scenario 5	X					
Scenario 6	X					X
Scenario 7		X				
Scenario 8				X	X	
Scenario 9				X[2]		

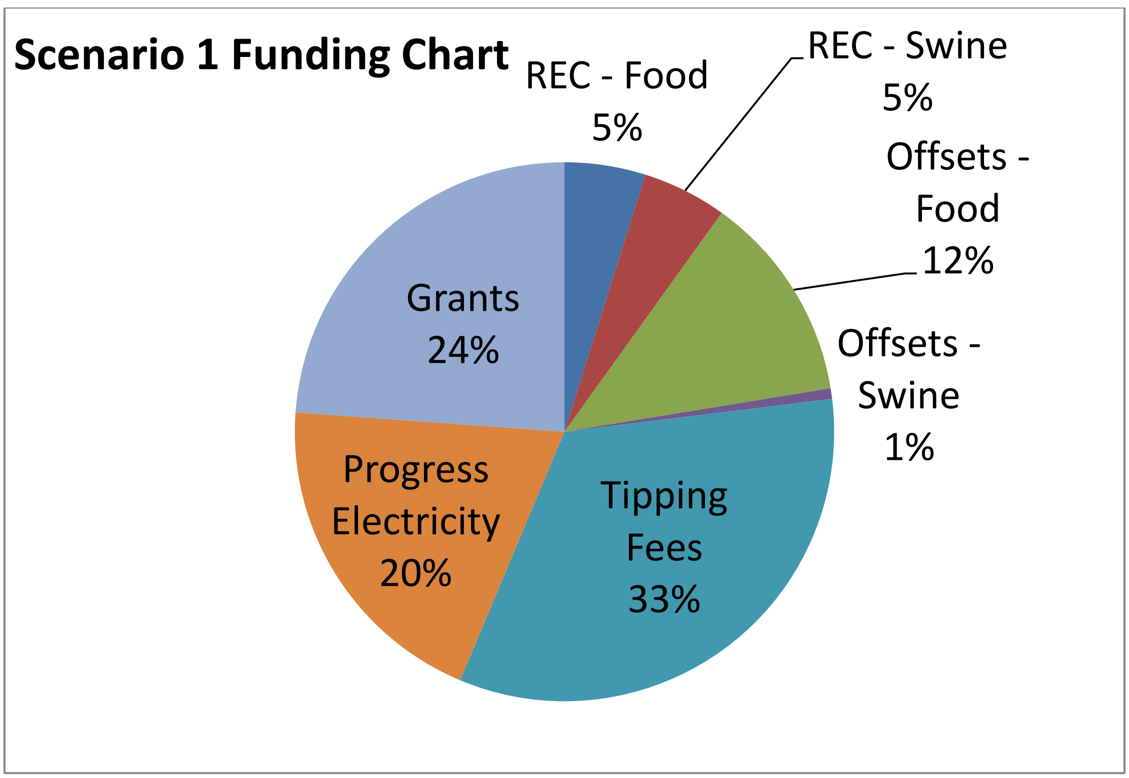
[1] All RECs are considered swine RECs in this scenario.
[2] All RECs are considered food RECs in this scenario.

The following is an example of the interpretation of Scenario 1 based on the above chart. In Scenario 1, the farmer receives all payments including tipping fees, electricity payments from Progress Energy, offsets for both swine and food waste, and all the RECs are declared swine RECs, warranting a higher price. This scenario also includes successful application for $758,840 in government grants. It should be noted that Barham Farms will not be able to get offsets for its swine waste, which is the main difference between the two scenarios, (see Carbon Offsets above section for details). However, Scenario 1 represents a farmer and prospective project of similar size to that of Barham Farms, and represents the most revenue a farmer with the same characteristics as Barham Farms could hope to make by installing the project.

Table 4 – Funding Available for Scenario 1

Funding Available, Scenario 1	Amount
REC - Food	$154,526
REC - Swine	$160,834
Offsets - Food	$397,962
Offsets - Swine	$20,000
Tipping Fees	$1,058,500
Progress Electricity	$630,720
Annual Revenue	$2,422,542
Grants (one year payment)	$758,840

Figure 4 – Funding Model Results for Scenario 1



We conducted a NPV sensitivity analysis based on the volume of methane emissions avoided and the price of carbon offsets to see at what volume and price the project would generate revenue from carbon offset payments alone (see Appendix V).[39] Based on this NPV scenario analyses, we determined that the farmer cannot break even with carbon offset payments alone under the conditions described above, ($8/m$TCO_2$e). Assuming, however, a 100% conversion of the captured emissions into offsets in the OWD tool, an increase of $0.50 in the carbon offset price will allow the farmer to breakeven. However, if the metric tons of CO_2e avoided decrease by 10% from the estimated 49,745, the price of carbon offsets would have to increase by almost $1.50 before the farmer would breakeven.

When reviewing the other revenue streams, the addition of tipping fees of $20/ton for 145 tons/day of food waste would provide the project with a positive NPV no matter the price of offsets. In this case, it would not be necessary to acquire the generator to obtain additional sources of revenue to breakeven. Though, if the farmer is able to obtain government grants, it is definitely within the farmer's interest to install the generator to capture the additional revenue streams as this will increase his potential profit for the life of the project substantially. In this case, the farmer would move from scenario 6 to scenario 4 or 1. Even without the grant, however, we have found that it is still worthwhile for the farmer to obtain the generator assuming he can fund the project through other means and is willing to undertake the additional investment.

[39] Carbon offset payments discussed here are from food waste, which at $397,962/year is higher than the $20,000.year from swine waste. In the scenario with swine waste offsets only, the farmer will never break even on costs.

CONCLUSION

Our results indicate that the financial investment for these waste-to-energy anaerobic digestion projects is high, but that there are many possible revenue streams available that would make the projects financially viable for North Carolinian swine farmers. Grant funding, although limited, is available through federal agencies, particularly the USDA, which would reduce the financial burden posed by the installation of these projects and would remove a major barrier to their proliferation across the state and nation. The possibility of selling electricity back into the grid is another significant source of revenue, and when combined with revenue from Renewable Energy Certificates, could cover the entire cost of the project without any other revenue streams. Additionally, tipping fees acquired by accepting food waste can provide enough revenue to make the project financially viable should a farmer decide not to install an electricity generator. Surprisingly, carbon offset payments play a much smaller role in the financial success of the project, and using the conservative estimate of \$8/mTCO_2e, a farmer would be unable to recoup his investment in the project. This demonstrates that carbon offset credits alone are not a significant incentive for farmers to install these waste-to-energy projects on their farm, thus, if DCOI wants to support these projects in the future, it will be important that the project provides other revenue streams upon which to rely.

The case study of Barham Farms demonstrated the fact that overall, offset payments are not a significant source of revenue, (only \$397,962 annually) in light of the costs of the project, (initial investment of 2.75 million and \$249,900 annually). However, the project at Barham Farms demonstrates that co-digestion systems that utilize both swine waste and other organic matter, like food waste, have many potential revenue streams that would allow farmers to make a profit. These are outlined in our Excel-based funding model that can be modified and used for other farmers looking to take on these waste-to-energy projects in the future. By facilitating such projects going forward, DCOI can offset a significant portion of Duke's greenhouse gas emissions. If Barham Farms' anaerobic digester produces the amount of offsets we've estimated, 49,745 mTCO_2e/year, Duke University could cover 27% of the 183,000 tons of offsets per year it needs to purchase to achieve its carbon neutrality goal. Ultimately, our project has demonstrated that these waste-to-energy anaerobic digestion projects are financially viable, provide valuable new sources of revenue for farmers, create credible carbon offsets for DCOI, and contribute to DCOI's larger goals of facilitating environmentally progressive projects in North Carolina

APPENDICES

APPENDIX I- GRANT APPLICATIONS

Due to confidential information, grant applications have been removed.

APPENDIX II- LETTER TO POTENTIAL FOOD SOURCES

Dear ,

I am a dual Master of Environmental Management (MEM) and Master of Business Administration (MBA) student at Duke University. I am currently working on my Masters Project as part of my graduation requirement. For this project my team (there are four of us) will evaluate a local farmer's new way of recycling waste. Specifically, he has installed an anaerobic digester, which treats swine and food waste. This system has the potential to create energy and carbon offsets, which can be purchased by third parties. Overall, our goal is to help make the farmer's project economically successful, so that innovative systems that address waste issues and reduce greenhouse gases can become viable.

The farmer is located in Zebulon and manages a swine farm. He is looking for new sources of food waste to combine with the swine waste that his farm produces. This process reduces the amount of methane released into the atmosphere by burning the methane and then pumping the resulting carbon dioxide into his greenhouses. This allows the farmer to grow his vegetables without having to purchase outside gas.

As a part of this project, I am assisting this farmer in attaining additional food waste streams. We have identified your school/grocery store as a potential food waste source. I would like the opportunity to discuss this opportunity further with you. Please respond to my email so that we can arrange a convenient time for a call. Should I not hear from you within a week, I shall try to contact you again. Thank you for your time.

Sincerely,

Karina

APPENDIX III- BARHAM FARMS REQUEST FOR PROPOSAL TO PROGRESS ENERGY

Due to confidential information, the Request for Proposal has been removed.

APPENDIX IV- RENEWABLE ENERGY CERTIFICATES APPLICATION

Due to confidential information,
the Renewable Energy Certificates application has been removed.

APPENDIX V- FUNDING MODEL

Funding Model Inputs

Offset Inputs			
Farm size	4,000	Pigs	
Food Waste	52,925	tons/yr (permit is for 145 tons/day)	
Conversion Factor Food	0.94		Based on OWD
Percent biogas from Food	0.49		
Percent biogas from Swine	0.51		
Project Offset Generation from Food[1]	49,745	mtCO2e (annually)	
Project Offset Generation from Swine[2]	2,500	mtCO2e (annually)	Livestock protocol
Offset price - Food[3]	$8.00	mtCO2e	
Offset price - Swine	$8.00	mtCO2e	

REC Inputs			
Project Electricity Generation	7884	MWh (annually)	
Percent biogas from Food	0.49		
Percent biogas from Swine	0.51		
Project Electricity Generation from Foc	3863	MWh (annually)	1 MW generator with 90% capacity (source: Progress RFP)
Project Electricity Generation from Swi	4021	MWh (annually)	
REC price food	$6.00	MWh	
REC price swine	$40.00	MWh	

Revenues	
REC - Food	$23,179
REC - Swine	$160,834
Offsets - Food	$397,962
Offsets - Swine	$20,000
Tipping Fees	$1,058,500
Progress Electricity	$630,720

Expenses		
Digester & Construction	$1,750,000	(CIG)
Generator & Construction	$1,517,680	
Annual O&M	$80,000	(Farmer)
Other expenses[5]	$150,000	
Inflation (Electricity/RECs/Offsets)	3% [6]	
Discount Rate	5%	

Grants/Payments

Total Grants	$758,840	
Progress Electricity	$0.08	/kwh
Tipping Fees	$20.00	/ton

ASSUMPTIONS - Project Registration, Validation, & Verification

Offset Project Registration[4]	$500	per offset project
Offset Issuance Fee[4]	$0.20	per offset (CRT) issued
Offset Verification	$10,000	annual (under CAR)

[1] Per Organic Waste Digester calculator

[2] Per the livestock calculator

[3] Offset prices derived from California Market Prices. Thomson Reuters.

[4] Quote on offset project registration fees from Carbon Action Reserve (CAR), http://www.climateactionreserve.org/how/program/program-fees/

5 Other expenses consist of potential unexpected expenses throughout the year.

[6] Unadjusted 12-month ended April 2011 CPI Index 3.2% http://www.bls.gov/news.release/cpi.nr0.htm

10-year government bond rate is 3.125% as of 6/13/11 per http://www.bloomberg.com/markets/rates-bonds/government-bonds/us/. Thus the risk premium is 1.875%.

Sensitivity Analysis for Scenario 5- Carbon Offsets from Food Only

Base=	$8.00
Increment=	$0.50
Total Project Offsets Generated from food	49,745 $mTCO_2e$/year

Date table of NPV as a function of Carbon Offsets from food

Percentage of MtCO2e

	($219,433)	$8.00	$8.50	$9.00	$9.50	$10.00	$10.50	$11.00	$11.50	$12.00	$12.50	$13.00	$13.50	$14.00	$14.50	$15.00	$15.50	$16.00
10%	**4,975**	($3,387,337)	($3,364,875)	($3,342,412)	($3,319,950)	($3,297,487)	($3,275,025)	($3,252,563)	($3,230,100)	($3,207,638)	($3,185,175)	($3,162,713)	($3,140,251)	($3,117,788)	($3,095,326)	($3,072,864)	($3,050,401)	($3,027,939)
20%	**9,949**	($3,035,348)	($2,990,423)	($2,945,498)	($2,900,573)	($2,855,649)	($2,810,724)	($2,765,799)	($2,720,874)	($2,675,949)	($2,631,025)	($2,586,100)	($2,541,175)	($2,496,250)	($2,451,325)	($2,406,401)	($2,361,476)	($2,316,551)
30%	**14,924**	($2,683,358)	($2,615,971)	($2,548,584)	($2,481,197)	($2,413,810)	($2,346,423)	($2,279,035)	($2,211,648)	($2,144,261)	($2,076,874)	($2,009,487)	($1,942,099)	($1,874,712)	($1,807,325)	($1,739,938)	($1,672,551)	($1,605,163)
40%	**19,898**	($2,331,369)	($2,241,520)	($2,151,670)	($2,061,820)	($1,971,971)	($1,882,121)	($1,792,272)	($1,702,422)	($1,612,572)	($1,522,723)	($1,432,873)	($1,343,024)	($1,253,174)	($1,163,325)	($1,073,475)	($983,625)	($893,776)
50%	**24,873**	($1,979,380)	($1,867,068)	($1,754,756)	($1,642,444)	($1,530,132)	($1,417,820)	($1,305,508)	($1,193,196)	($1,080,884)	($968,572)	($856,260)	($743,948)	($631,636)	($519,324)	($407,012)	($294,700)	($182,388)
60%	**29,847**	($1,627,391)	($1,492,616)	($1,357,842)	($1,223,067)	($1,088,293)	($953,519)	($818,744)	($683,970)	($549,196)	($414,421)	($279,647)	($144,872)	($10,098)	$124,676	$259,451	$394,225	$529,000
70%	**34,822**	($1,275,401)	($1,118,165)	($960,928)	($803,691)	($646,454)	($489,217)	($331,981)	($174,744)	($17,507)	$139,730	$296,966	$454,203	$611,440	$768,677	$925,914	$1,083,150	$1,240,387
80%	**39,796**	($923,412)	($743,713)	($564,014)	($384,314)	($204,615)	($24,916)	$154,783	$334,482	$514,181	$693,881	$873,580	$1,053,279	$1,232,978	$1,412,677	$1,592,376	$1,772,076	$1,951,775
90%	**44,771**	($571,423)	($369,261)	($167,100)	$35,062	$237,224	$439,385	$641,547	$843,708	$1,045,870	$1,248,031	$1,450,193	$1,652,355	$1,854,516	$2,056,678	$2,258,839	$2,461,001	$2,663,162
100%	**49,745**	($219,433)	$5,191	$229,814	$454,438	$679,062	$903,686	$1,128,310	$1,352,934	$1,577,558	$1,802,182	$2,026,806	$2,251,430	$2,476,054	$2,700,678	$2,925,302	$3,149,926	$3,374,550

Barham Farms Funding Model Sensitivity Analysis (Scenario 4)

Scenario 4 without CIG Grant (See Figure 3 for Scenario Description)

	Year	1	2	3	4	5	6	7	8	9	10	11
Initial Capital Cost		($3,267,680)										
Revenue:												
RECs			$195,219	$201,075	$207,108	$213,321	$219,721	$226,312	$233,102	$240,095	$247,297	$254,716
Offsets			$422,198	$434,864	$447,910	$461,347	$475,188	$489,443	$504,127	$519,250	$534,828	$550,873
Electricity Sold to Progress			$669,131	$689,205	$709,881	$731,177	$753,113	$775,706	$798,977	$822,947	$847,635	$873,064
Tipping Fees			$1,122,963	$1,156,652	$1,191,351	$1,227,092	$1,263,904	$1,301,821	$1,340,876	$1,381,102	$1,422,535	$1,465,212
Expenses:												
Other Expenses			($159,135)	($163,909)	($168,826)	($173,891)	($179,108)	($184,481)	($190,016)	($195,716)	($201,587)	($207,635)
Annual O&M			($84,872)	($87,418)	($90,041)	($92,742)	($95,524)	($98,390)	($101,342)	($104,382)	($107,513)	($110,739)
Offset Registration			($10,949)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)
Offset Verification			($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)
Total Cash Flow		($3,267,680)	$2,144,554	$2,210,019	$2,276,934	$2,345,855	$2,416,844	$2,489,963	$2,565,275	$2,642,847	$2,722,746	$2,805,042
Discounted Cash Flow		($2,963,882)	$1,852,547	$1,818,189	$1,784,037	$1,750,513	$1,717,606	$1,685,305	$1,653,599	$1,622,479	$1,591,933	$2,805,042
NPV	**$15,317,367**											

Scenario 4 with CIG Grant (See Figure 3 for Scenario Description)

	Year	1	2	3	4	5	6	7	8	9	10	11
Initial Capital Cost		($2,508,840)										
Revenue:												
RECs			$195,219	$201,075	$207,108	$213,321	$219,721	$226,312	$233,102	$240,095	$247,297	$254,716
Offsets			$422,198	$434,864	$447,910	$461,347	$475,188	$489,443	$504,127	$519,250	$534,828	$550,873
Electricity Sold to Progress			$669,131	$689,205	$709,881	$731,177	$753,113	$775,706	$798,977	$822,947	$847,635	$873,064
Tipping Fees			$1,122,963	$1,156,652	$1,191,351	$1,227,092	$1,263,904	$1,301,821	$1,340,876	$1,381,102	$1,422,535	$1,465,212
Expenses:												
Other Expenses			($159,135)	($163,909)	($168,826)	($173,891)	($179,108)	($184,481)	($190,016)	($195,716)	($201,587)	($207,635)
Annual O&M			($84,872)	($87,418)	($90,041)	($92,742)	($95,524)	($98,390)	($101,342)	($104,382)	($107,513)	($110,739)
Offset Registration			$0	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)
Offset Verification			($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)
Total Cash Flow		($2,508,840)	$2,155,503	$2,210,019	$2,276,934	$2,345,855	$2,416,844	$2,489,963	$2,565,275	$2,642,847	$2,722,746	$2,805,042
Discounted Cash Flow		($2,275,592)	$1,862,005	$1,818,189	$1,784,037	$1,750,513	$1,717,606	$1,685,305	$1,653,599	$1,622,479	$1,591,933	$2,805,042
NPV	**$16,015,116**											

Scenario 1 Funding Model Sensitivity Analysis

Scenario 1 (See Figure 3 for Scenario Description)

	Year	1	2	3	4	5	6	7	8	9	10	11
Initial Capital Cost		($2,508,840)										
Revenue:												
RECs			$334,565	$344,602	$354,940	$365,589	$376,556	$387,853	$399,489	$411,473	$423,817	$436,532
Offsets			$443,416	$456,719	$470,420	$484,533	$499,069	$514,041	$529,462	$545,346	$561,706	$578,557
Electricity Sold to Progress			$669,131	$689,205	$709,881	$731,177	$753,113	$775,706	$798,977	$822,947	$847,635	$873,064
Tipping Fees			$1,122,963	$1,156,652	$1,191,351	$1,227,092	$1,263,904	$1,301,821	$1,340,876	$1,381,102	$1,422,535	$1,465,212
Expenses:												
Other Expenses			($159,135)	($163,909)	($168,826)	($173,891)	($179,108)	($184,481)	($190,016)	($195,716)	($201,587)	($207,635)
Annual O&M			($84,872)	($87,418)	($90,041)	($92,742)	($95,524)	($98,390)	($101,342)	($104,382)	($107,513)	($110,739)
Offset Registration			($10,949)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)	($10,449)
Offset Verification			($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)	($10,000)
Total Cash Flow		($2,508,840)	$2,305,119	$2,375,401	$2,447,276	$2,521,308	$2,597,561	$2,676,101	$2,756,998	$2,840,321	$2,926,144	$3,014,542
Discounted Cash Flow		($2,275,592)	$1,991,248	$1,954,248	$1,917,505	$1,881,439	$1,846,038	$1,811,291	$1,777,185	$1,743,711	$1,710,856	$3,014,542
NPV	**$17,372,472**											

APPENDIX VI- NEXT STEPS, BARHAM FARMS

The following outlines the next steps for Barham Farms to continue to move forward on their waste-to-energy anaerobic digestion project:

Grant Funding

If awarded the Conservation Innovation Grant, Barham Farms cannot purchase the 1 MW electricity generator until September 1, 2012. In the meantime, however, Barham Farms can continue to negotiate electricity and/or Renewable Energy Certificates contracts with Progress Energy.

Carbon Offsets

As stated in the report, the Duke Carbon Offsets Initiative would be interested in purchasing the food offsets created by Barham Farms' project. Barham Farms needs to register their anaerobic digestion project within 6 months of operation, which in this case would be by June 2012 since the digester came online in December 2011. Below are the specific steps that need to be completed:

1. Open account with the Climate Action Reserve (CAR) at http://www.climateactionreserve.org/open-an-account/
2. Register project with the Climate Action Reserve within 6 months of the digester coming online. Forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/
3. CAR staff pre-screen projects for eligibility. Eligible projects are posted on the Reserve site with a status of "listed."
4. Complete project verification by an independent, accredited verification body. For a list of verification bodies visit: http://www.climateactionreserve.org/how/verification/connect-with-a-verification-body/
5. Once verification is completed, CAR staff review the verification documentation, and if the project passes this final review process, it is labeled "registered" and Climate Reserve Tonnes (CRTs) are issued.

Renewable Energy Certificates

We found that the swine set-aside from the NC Renewable Energy and Energy Efficiency Portfolio Standard makes it financially beneficial for Mr. Barham to become a source of RECs. Next steps for this include:

1. Register with the NC Utilities Commission as a certified renewable energy facility. A proposal for construction of the electricity generator will need to be filed at that time as well.
    a. The application is complete, and can be submitted by Mr. Barham at any time. The application was written with a proposal for construction of the larger 1 MW generator, and the RECs application is based on the capacity of that generator.
    b. Although Barham Farms can pursue RECs based on the production of the smaller generators that the farm is currently running, it would net a much smaller number of RECs for the farm. We suggest that Barham Farms invest in the 1 MW electricity generator and register that under the NC-RETS since the financial opportunities from the project are more substantial.
2. After getting approval from the NCUC, Barham Farms must register with the NC-Renewable Energy Tracking System. This can most likely be done when the generator is under construction.
3. After being approved by both of those entities, Barham Farms will be issued the RECs, which can then be sold to any utility.

Electricity Generation

The next step for Barham Farms in negotiating electricity sales is to continue the discussion with Progress Energy over interpreting its rate schedule. There is little room for movement once the schedule has been set, so it is important that Mr. Barham be sure that the peak and off-peak prices, as well as its relationship to the Progress transmission system, is accurately understood by the employees of Progress Energy. And, of course, Barham Farms would need to purchase the generator in order to actually generate the electricity for sale.