FINANCIAL FEASIBILITY ASSESSMENT:

Poultry Litter Anaerobic Digestion and Nutrient Capture at Millennium Farm, Worcester County

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Background

The Maryland Department of Agriculture's Animal Waste Technology Fund (AWTF) provides grants for on-farm demonstration projects of innovative technologies for managing animal manure. These technologies are expected to manage on-farm waste, improve water quality, and create new revenue streams for farmers in the form of cost savings and marketable byproducts.

Figure 1. Planet Found Energy Development's anaerobic digestion and nutrient capture system at Millennium Farm. Credit: PFED.

Millennium Farm is a four-house poultry operation and grain producer located on Maryland's Eastern Shore in Worcester County. In 2014, Millennium Farm partnered with Planet Found Energy Development (PFED), a startup manure management technology company, to install a pilot-scale anaerobic digestion and nutrient capture system (AD + NCS) at the farm. Funded in part by an AWTF grant, this system uses a combined heat and power generator to convert poultry litter into methane gas that can generate heat and/or electricity. The system is designed to process 1,200 tons of poultry litter per year, and it became operational in spring 2017.

Expected Benefits

The AD + NCS system at Millennium Farm is a pilot facility, with primary purposes of testing and refining the technology, building the market for nutrient-adjusted byproducts, and exploring future models for scaling-up the system. Other expected benefits of the pilot and/or future facilities include the production of heat and electricity to accommodate system parasitic demand, the generation of excess electricity that can be net metered back to the farm to offset costs, and the production of excess heat to offset propane costs for poultry house heating.

Additionally, the nutrient capture portion of the system separates out the major nutrients found in poultry litter (nitrogen, phosphorous, and potassium) after the litter has been processed by anaerobic digestion and partitions these nutrients into three by-products: a soil amendment, a potting soil, and a high-phosphorous fertilizer that can be sold out of the region. All of these byproducts represent either a revenue stream or source of value for their on-farm use. Other potential benefits for the farmer or vendor include revenue from the sale of renewable energy credits and/or nutrient trading credits.

In addition, poultry litter AD + NCS systems like the one installed at Millennium Farm are expected to have broader regional benefits on Maryland's Eastern Shore. Chief among these is reduced agricultural pollution to local streams and the Chesapeake Bay, due to avoidance of direct land application of unprocessed poultry litter as well as the stabilization and partitioning for formulation of nutrients in the finished byproducts. With the high-phosphorous byproduct able to be sold out of the region and the remaining soil amendment lower in phosphorous, the technology enables the region's farmers to continue deriving value from poultry litter despite new Maryland state regulations that limit the application of phosphorous on certain cropland with high risk of phosphorus movement, as discussed in greater detail in the Transferability and Policy Considerations section, below.

Results: Financial Feasibility Assessment

The Environmental Finance Center developed a full cost balance model for the pilot scale anaerobic digestion and nutrient capture system at Millennium Farm. This assessment contrasts pre- and post-technology expenses and revenues across various modules including labor, operations and maintenance, materials and services, energy, capital costs, and byproducts. EFC developed this assessment through desktop research and interviews with the vendor and other specialists familiar with the technology and with Millennium Farm.

Table 1. *Cost assessment results for base scenario (see inputs and assumptions below)*

	Pre-Technology	**Post-Technology**	**Balance *(positive indicates cost savings or revenue)***
Labor costs ($)	5,648	48,000	-42,352
O&M, materials, and services costs ($)	-1,825*	96,000	-97,825
Energy costs ($)	58,000	58,000	0
Byproduct revenue ($)	0	16,800	16,800
Sub-total	*$61,823*	*$185,200*	*-$123,377*
			Summary
Capital costs			$1,832,137
Annual cost savings + revenue			-$123,377
Simple payback on investment			Infinite
Return on investment			N/A

* Includes value of poultry litter as on-farm fertilizer ($9,125) minus O$M, materials and services costs.

Key finding: Based on available information, the pilot scale AD + NCS system as applied on Millennium Farm will result in approximately $123,377 annual losses for the farm and/or Planet Found Energy Development (see Table 1). O&M, materials and services is the most significant line item, with a post-technology increase of $97,825. Labor costs are also significantly higher post-technology ($42,352). Favorable to the project's bottom line is the value from use or sale of three byproducts, estimated to be worth a total of $16,800. Not included in this result is any benefit from the use or sale of excess energy, as discussed below, or environmental impacts associated with the technology (monetized or otherwise).

An important note is that due to mechanical delays, the facility is not yet operating at full capacity, processing only about 1 ton per day, compared to the 3.3 tons it is designed to process. The vendor anticipates that at full capacity, the system will generate energy in excess of its own operational needs.[1] However, even if operating at full capacity, the pilot AD + NCS system at Millennium Farm is not expected to be financially viable at a farm scale, nor was it intended to be. Rather, the system was designed and installed with the purpose of testing and refining the technology in order to support future installations. The real anticipated value of this technology – both to operators and to the region more broadly – will be in its scale-up to a significantly larger system that is designed to process poultry litter on a regional basis.

Table 2. *Critical inputs, value, and corresponding notes*

Input Name	Value	Note
Poultry litter input (tons/year)	365	System is designed to process 1,200 tons/year but is not operating at full capacity.
Pre-technology litter allocation ration (stored / field applied : sale)	1:0	Pre-technology, 100% of litter was applied as crop fertilizer and/or stored in a standard poultry litter manure shed and 0% was sold to other farmers. Per farmer/vendor.
Pre-technology labor costs ($/year)	5,648	Labor to clean poultry houses and to load and transport litter from houses to field for application.
Post-technology labor costs ($/year)	48,000	Salary for one full-time skilled facility operator employed to run the pilot AD + NCS facility.
Pre-technology revenue from sale of litter ($/year)	0	Pre-technology, Millennium Farm did not sell litter but rather used it on-farm to fertilize its grain crops.
Pre-technology value of litter as on-farm fertilizer ($/year)	9,125	365 tons/year at an average market price of $25/ton, the amount Millennium would have to pay if purchasing litter as fertilizer.
Post-technology operations and maintenance costs ($/year)	22,054	Maintenance costs estimated at 2.5% of capital costs annually (construction, engineering, site prep, equipment), plus $29,000 operations costs, which include chemicals and product transport.
Total capital costs ($)	1.83 million	Represents direct costs for surveying, site prep, engineering, equipment and construction but excludes some early project costs (such as R&D, staff time to seek funding, etc). Accounts for $1,221,470 from MDA, MEA and other grants, with remaining capital investment from PFED.
Purchased electricity costs pre-and post-technology ($/year)	20,000	Per vendor/farmer. Equates to 152,672 kWh total usage at 4 houses at .131 $/kWh average commercial electricity rate on Maryland's Lower Eastern Shore. System is not producing excess energy.
Purchased propane costs pre- and post-technology ($/year)	28,500	Per vendor/farmer. Equates to 47,500 gallons of propane use per year at EIA estimated wholesale prices of $0.6/gallon. No change post-technology.
Net electricity export per year (kWh)	0	Pilot system is currently not meeting its own energy demands.

Soil amendment byproduct produced per year (tons)	161	Based on 50 percent conversion rate from dry litter input to soil amendment output. Conversion rates per vendor.
Post-technology revenue from sale or on-farm use of soil amendment ($/year)	8,050	Based on mid-range estimated market value of $50/ton. Per vendor. May be either sold or used on-farm as fertilizer to offset poultry litter
Potting soil produced (tons/year)	193	Based on 40 percent conversion rate from dry litter input to potting soil output. Conversion rates per vendor.
Post-technology revenue from sale of potting soil ($/year)	6,755	Based on minimum estimated market value of $35/ton. Per vendor.
High-phosphorous fertilizer produced (tons/year)	57	Based on 10 percent conversion rate from dry litter input to fertilizer output. Conversion rates per vendor.
Post-technology revenue from sale of fertilizer ($/year)	1,995	Based on minimum estimated market value of $35/ton. Per vendor.
Useful life of the technology (years)	20	Per vendor.

Critical model inputs and assumptions: The results for the base (pilot-scale) scenario are sensitive to inputs. In order of relative importance, the most important inputs include: (1) the capacity of the system, with higher amounts of litter loaded per year yielding greater cost savings and revenue, (2) the cost of labor, operations, maintenance and service, relative to pre-technology conditions, and how costs are shared between the vendor and host farmer, and (3) the amount of revenue generated from the sale of byproducts, renewable energy credits and nutrient trading credits.

Scenario analysis findings: The base scenario outlined above employs inputs for the Millennium Farm pilot scale system that would not apply to future applications of this technology, as PFED does not anticipate offering the system at the individual farm scale but rather at a significantly larger community or regional scale. However, the pilot scale financial model can be used to demonstrate that changes to a few key inputs and assumptions can impact project feasibility, as illustrated in the scenario analysis findings (see Table 3, below).

For example, higher input of poultry litter to pilot system, so that it is processing its full capacity of 1,200 tons/year (**Scenario A**) yields roughly $54,000 in annual byproduct revenue, as well as annual energy savings of $46,190 above the base scenario, due to the ability to realize revenue from net metering and REC sales. However, this scenario still results in annual losses ($19,655). Financial feasibility improves slightly if the farm or vendor is able to tap into the nutrient credit trading market, which in effect monetizes avoided environmental costs (**Scenario B**). This scenario – which also assumes the system operates at its full 1,200 ton/year input capacity – yields a theoretical revenue of about $12,000/year from the sale of nutrient credits. However, the project would still result in net annual losses, as additional revenue is not enough to outweigh project costs. Greater improvements in farm-scale financial feasibility are realized if labor costs for operating the system are externalized to the project (e.g. borne by the vendor rather than the farmer), as shown in **Scenario C**. This scenario yields annual cost *savings* of $88,509. However, the simple payback on the initial $1.8 million investment would be 32 years, longer than the technology's anticipated useful life.

The system's real potential for profitability, however, depends on system being sized significantly larger than the pilot farm-scale model. PFED has completed projections for various iterations of this larger system, including a public-private partnership model that is portrayed in **Scenario D**. In this scenario, PFED contracts with a public entity such as a college or university to construct and operate a 1.5 MWh facility capable of processing 50,000 tons of poultry litter per year. Capital costs are $8.58 million, and annual costs for materials, services and operations are $4.5 million. In this scenario, PFED does not pays poultry farmers for litter but does assume the cost of cleaning out poultry houses and transporting litter to the facility. The model generates $5.4 million in annual revenue, including not only proceeds from the sale of byproducts and nutrient trading credits but also as much as $220,000 in state subsidies including incentives eligible from the Manure Transport Program. Additionally, the model incorporates revenue from the host entity via an operations contract. With annual profits of $427,323, this scenario yields a simple payback period of 20 years.[2]

In addition to demonstrating financial feasibility, this public-private model offers benefits for both parties: PFED would receive stability and risk reduction, which is important given the evolving political and financial landscape in which the technology is being deployed. The public entity would realize revenue from REC sales, as well as potentially significant cost savings due to net metering; government-owned facilities are good candidates for such a partnership as they are among the largest electricity consumers on Maryland's Eastern Shore. Additionally, this system has the potential to benefit the State and the public, by removing an estimated 305,262 pounds of phosphorous from previously-land applied poultry litter and generating a marketable byproduct.

Table 3. *Base scenario financial results plus four alternative scenarios with modified inputs*

	Scenario A Revised litter input rate of 1,200 tons/yr	**Scenario B** 1,200 tons/yr; sale of nutrient credits	**Base Scenario** See inputs above	**Scenario C** 1,200 tons/yr input; $0 labor*	**Scenario D** Community-scale system ($8.6M, 50,000 tons/yr facility)
Annual cost savings + revenue ($)	-19,655	-7,491	-123,377	40,509	427,323
Simple payback (years)	Infinite	Infinite	Infinite	45 > 20 year useful life	20 = 20 year useful life

* Assumes externalization to the project of labor costs to operate the system.

Discussion: Transferability and Policy Considerations

A number of factors affect whether poultry litter anaerobic digestion and nutrient capture systems have the potential to be profitable in Maryland.

<u>Scale of the system:</u> The greatest determinant of whether an AD + NCS system is financially feasible is the scale at which it is employed. As discussed above, PFED has several models for replicating this system throughout Maryland's Eastern Shore, all of which include sizing the facility significantly larger than the pilot (in the case presented above, the system would receive more than forty times the poultry litter input as does the pilot). In these scaled-up models, litter is received from multiple poultry farmers (various models for compensating contributing farmers are still being explored), and finished byproducts are sold to regional grain farmers and to other buyers outside the Chesapeake region. While these larger systems require greater levels of capital investment, they would also

achieve efficiencies in labor and operations and generate greater amounts of electricity and revenue from the sale of byproducts, excess electricity, RECs and potentially nutrient trading credits.

The value of such a community-scale system to individual poultry and grain farmers depends on how costs and revenue are shared between the vendor, the host entity, and other contributing farmers – e.g. who bears capital and operations costs; how revenue from the sale of byproducts and RECs is shared; who benefits from net metering, etc. However, at a minimum, poultry and grain farmers would benefit from the ability to continue to sell or use poultry litter after Maryland's new Phosphorous Management Tool (PMT) regulations come into effect, which as discussed in greater detail below, will limit the amount of phosphorous that can be applied to land with high environmental risk posed by soil phosphorous levels. The technology separates out phosphorous into a byproduct that can be sold outside the region, while also producing a low-phosphorous soil amendment that can be used within the region including as a cropland nutrient source. Because of this product's improved nitrogen to phosphorous ratios, the vendor anticipates that farms will be able to apply more finished byproduct per acre (to supply nitrogen demand) than they could previously apply raw litter in the absence of PMT regulations.[3]

Capital costs and other sources of revenue: Construction costs for Millennium Farm's pilot scale system was $987,081. Engineering, permitting, site prep and equipment were an additional $845,056. These costs can be expected to vary in future installations, depending on siting conditions, infrastructure needs, and the size of the facility. Design, engineering, and programming costs are also likely to vary, and could reasonably be expected to be decline in future applications, as some of these costs relate to technology start-up and would not need to be replicated. Capital costs may not increase linearly as the system is scaled up, because the pilot system needed to incorporate some major components that are oversized for its needs (but were the smallest units available that would still enable the system to function). Over time, as additional systems are installed and the technology is refined, capital expenditures may be expected to gradually decrease. Further, the profitability of future facilities would improve based on their ability to take advantage of any existing or future state subsidies or incentive programs (such as the Manure Transport Program, which provides cost share assistance to eligible entities to ship excess manure).[4]

Value of byproducts: The AD + NCS system at Millennium Farm is producing three novel byproducts, the markets for which are still being developed. To the degree that strong markets emerge for these products – and that values increase – financial feasibility will improve. The technology also enables the distinct byproducts to be blended into custom nutrient mixes, tailored to the needs of individual markets or buyers (horticulture, specialized agriculture, etc.) These possibilities are still being explored and could bring added value.

Regulatory drivers: As discussed above, under Maryland's nutrient management regulations, farms with high soil phosphorous levels may be more strictly limited in applying manure to their land after using the new **Phosphorus Management Tool** (PMT), and thus will have a stronger impetus to find alternative uses for the manure they produce. Farms most impacted by this regulation are located in the Lower Eastern Shore counties of Somerset, Wicomico, and Worcester, where only an estimated 28% of the land area is not required to use the PMT to manage phosphorous, compared to 79% for the state as a whole.[5] Poultry farmers on the Eastern Shore have historically applied poultry litter as fertilizer on their own grain fields, or they have sold litter to other grain farmers in the region. Because PMT may make these manure management practices less feasible, it has potential to encourage alternative uses for poultry litter.

Another policy driver affecting the financial feasibility of AD + NCS systems is Maryland's **Nutrient Trading Program** and accompanying markets. If this technology were to be designated an eligible generator of nutrient credits – and if the market were to start to see stepped-up trading activity – nutrient credit trading would represent a potential source of revenue for the system's host farmer and/or vendor. According to analysis by Planet Found Energy Development, the nutrient capture system installed at Millennium Farm removes approximately 80% of phosphorous from the original poultry litter waste stream, converting it into a product that can be sold outside the Chesapeake Bay region. This suggests that the technology would be a strong candidate to generate nutrient trading credits. A Manure Treatment Technologies Expert Panel convened by the US EPA Chesapeake Bay Program recommends that nutrient reductions from compost systems, thermochemical systems, and other technologies with verifiable nutrient reductions be approved for trading within the watershed.[6] However, each state must determine eligibility requirements for its own trading program, and Maryland has not yet specified eligibility for this technology.

While the sale of nutrient credits is still only a theoretical revenue source, the technology *is* able to benefit from the sale of renewable energy credits. Maryland's **Renewable Energy Portfolio Standard** specifies that methane generation from anaerobic digestion and poultry waste-to-energy renewable energy technologies qualify as eligible fuel sources under the standard,[7] meaning that AD + NCS systems like the one installed at Millennium Farm are eligible to generate RECs.

A final significant regulatory driver is US EPA's 2010 **Chesapeake Bay Total Maximum Daily Load** (TMDL), which mandates levels of nutrient and sediment pollution reductions that must be achieved in each Bay state by 2025 in order to meet water quality standards.[8] The TMDL provides strong impetus for the State of Maryland to invest in cost-effective pollution reduction measures in order to meet targets.

Conclusions

The pilot scale anaerobic digestion and nutrient capture system as applied at Millennium Farm is not financially feasible as a farm scale project – nor was it intended to be. Rather, it enabled the testing and refinement of a novel technology that has strong potential to benefit poultry and grain farmers in Maryland as well as cost-effectively reduce nutrient pollution to the Chesapeake Bay. Based on available data from the pilot as well as financial modeling by Planet Found Energy Development, it appears the AD + NCS technology would be more feasible in other applications throughout Maryland if: (1) the system is sized to process poultry litter from multiple farms and thus realize efficiencies and economies of scale including production of excess heat and/or electricity; (2) the system is used in areas with a high percentage of farms subject to PMT requirements, which can be expected to be a significant driver for the pursuit of alternative uses for poultry litter; and (3) additional revenue can be realized via state incentives or subsidies, a well-developed byproduct market, proceeds from net metering, and the sale of nutrient credits and/or renewable energy credits.

References

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