FINANCIAL FEASIBILITY ASSESSMENT:

Fluidized Bed Combustion at Double Trouble Farm, Dorchester County

Prepared for the Maryland Department of Agriculture by the University of Maryland Environmental Finance Center, January 2018

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 better 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. Fluidized bed combustion system at Double Trouble Farm. Credit: BHSL. Figure 2. Chicks raised in poultry houses heated by the new FBC system. Credit: Edwin Remsburg.

Double Trouble Farm, located in Dorchester County, Maryland, is a poultry operation that raises chickens for the integrator Mountaire. Double Trouble has partnered with Biomass Heating Solutions Inc., a corporation that specializes in manure-to-energy technologies, to install a fluidized bed combustion system (FBC) at the farm.

The technology converts poultry litter into heat and electricity, by suspending litter above upward-blowing streams of air during a combustion process. This creates a turbulent mixing of gas and solids and improves the efficiency of chemical reactions and heat transfer.[1] The technology has been used in power plants for decades, and BHSL's Irish arm has successfully used FBC in poultry operations in Europe. However, the system at Double Trouble Farm is the first such application in the United States.

Expected Benefits

The FBC system at Double Trouble Farm processes about 1,000 tons of poultry litter per year (with capacity for up to 3,300 tons/year), generating energy to heat four poultry houses and offsetting the need for purchased propane. The system also produces a high-phosphorous and high-potassium ash byproduct. While the market for this product is still being developed, initial sales indicate a market value of $65/ton and this value is expected to rise. In addition to introducing a new revenue stream for the farmer, production of this byproduct benefits regional water quality by enabling the majority of the phosphorous found in poultry litter to be captured and either sent out of the Chesapeake Bay region or recycled on farmland where the nutrient management plan calls for additional phosphorous inputs.

Another expected benefit of the FBC system is the production of additional energy (beyond what is needed for poultry house heating) that can be converted to electricity and sent to the grid to offset the farm's electricity costs. The output of Double Trouble's system has proven insufficient to capture this benefit, but future systems may be sized to take advantage of net metering. Another initial expected benefit of the technology was improved growth rates and improved feed conversion efficiencies for poultry raised in houses heated by the FBC system (which produces a dryer, healthier heat compared to propane and allows for increased ventilation which reduces ammonia levels in the houses). This benefit has been achieved in European applications of the technology, but flocks raised via Double Trouble's system to date have not demonstrated statistically significant altered growth rates or feed conversion rates.

Results: Financial Feasibility Assessment

The Environmental Finance Center developed a full cost balance model for the FBC system at Double Trouble Farm. This assessment contrasts pre- and post-technology expenses and revenue 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.

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 ($)	2,773	3,057	-284
O&M, materials, and services costs ($)	2,000	24,343	-22,343
Energy costs ($)	30,727	1,703*	29,024
Byproduct revenue ($)	18,000**	9,100	-8,900
Sub-total	*$17,500*	*$20,003*	*-$2,503*
			Summary
Capital costs			$2.73 M
Annual cost savings + revenue			-$2,503
Simple payback on investment			Infinite
Return on investment			N/A

* Includes revenue from the sale of renewable energy credits. ** Includes revenue from the sale of unprocessed poultry litter.

<u>Key finding</u>: Based on available information, the fluidized bed combustion system at Double Trouble Farm appears to result in approximately $2,503 in annual losses for the farmer and/or vendor (see Table 1). The project benefits from a $29,024 net decrease in the energy line, due to avoided energy expenses and the sale of renewable energy credits. Also beneficial to the project's bottom line is the sale of the ash byproduct at a value of $65/ton. However, these benefits are offset by an $22,343 increase in operations and maintenance, materials, and services costs, as well as by substantial lost

income from the sale of unprocessed litter (estimated to be worth a total of $18,000 at the price of $18/ton).

This result does not account for any environmental impacts from operating the system, such as reduced water quality degradation from land application of untreated poultry litter. Further, it does not include revenue from net metering or accelerated poultry growth rates, since initial performance has not borne out these anticipated benefits as discussed above. For the project to be considered cost effective, defined here as having a simple payback less than the useful life of the technology, or 25 years, the system would need to yield cost savings and/or revenue totaling approximately $110,000 per year through enhanced bird production, byproduct sales, net metering, nutrient trading credit sales, and/or monetized environmental benefits.

Table 2. *Critical inputs, value, and corresponding notes for* ***non-energy factors***

Input Name	**Value**	**Note**
Poultry litter input (tons/year)	1,000	Average of 1.88 tons per day for 275 days per year (average number of days poultry is on farm), doubled to reflect heating all four houses instead of two.
Additional labor post-technology (hours/year)	284	22 hours to move/raise fans to facilitate cleaning; 61 hours to clean ash bag every 1.5 days at 15 minutes per cleaning; 70 hours to market and package ash or .5 hours per ton produced. Labor cost set at $20/hour.
Pre-technology revenue from sale of litter ($/year)	18,000	1,000 tons sold at a rate of $18/ton. Subsidized via the Maryland Manure Transport Program.
Post-technology operations and maintenance costs ($/year)	21,943	Based on $25K median from $20K-$30K BHSL estimate, less labor costs explained above.
Total capital costs ($)	2.73 million	Sum of $960,000 from MDA AWTF state award and $1,768,000 remaining capital investment from BHSL.
Quantity of ash produced (tons/year)	140	Based on 14 percent conversion rate from input litter to output ash, as provided by BHSL.
Post-technology revenue from the sale of ash ($/year)	9,100	Based on initial market value of $65/ton (BHSL anticipates higher values, up to $150/ton once market is developed).
Useful life of the technology (years)	25	Mid-range estimate; vendor anticipates 20-30 years.

Table 3. *Critical inputs, value, and corresponding notes for* ***energy factors***

Input Name	**Value**	**Note**
Pre-technology purchased electricity costs ($/year)	17,879	248,172 kWh combined usage at 4 houses
Pre-technology purchased propane costs ($/year)	12,848	Total of 21,414 gallons of propane consumed per year to heat four poultry houses.
Post-technology electricity output (kWh)	99,645	Based on 65 kW x 8,400 hours/year x 25% efficiency* minus 2,200 hours/year when heating/steam delivery takes priority over electricity output. *Monitored efficiency during first year was closer to 10% due to mechanical issues but 25% is used as a reasonable expectation w/ continual operation.

Post-technology electricity usage (kWh/year)	273,172	25,000 kWh annual usage from heater-fans plus baseline 248,172 kWh (see above).
Post-technology net electricity export per year (kWh)	0	The FBC system is currently using more electricity than it is producing.
Revenue from the sale of Tier 1 renewable energy credits ($/year)	2,048	Based on 137 MWh/year production and an annual Tier 1 REC price of $15/MWh, or the average price in Maryland in 2016 for a Tier 1 REC plus another 115 MWh of equivalent thermal RECs sold at the same price.
Post-technology diesel costs ($/year)	1,000	Based on back-up/auxiliary power for combined heat and power generator at the assumption of 667 gallons per year at $1.5/gallon.
Post-technology net energy costs ($/year)	1,703	Based on renewable energy credit revenue less diesel and other energy costs.

Critical model inputs and assumptions: The results for the base scenario are sensitive to inputs. In order of relative importance, the most important inputs include: (1) sale of raw poultry litter at a rate of $18/ton (the market value for litter may reasonably be expected to decrease as Phosphorous Management Tool regulations come into full effect, as is discussed in the Transferability and Policy Considerations section below); (2) Double Trouble Farm's lower-than-anticipated electricity output and inability to realize revenue from net metering; and (3) the market value for system's high-phosphorous ash byproduct at $65/ton (value is expected to rise).

Scenario analysis findings: Table 4, below, depicts four alternatives to the base scenario described above. These demonstrate the impact that changes to key inputs can have on the project's payback period and overall financial feasibility. Altered inputs represent reasonable but theoretical assumptions, not necessarily realistic expectations based on the pilot project's initial performance.

Scenario A assumes greater energy output of the FBC system's generator, with an efficiency rate of 77.5% (as originally modeled) compared to the lower rate based on the system's initial performance. With the generator operating more continually and efficiently, Double Trouble could see a net electricity export of ~36,000 kWh/year, which at the retail electric rate of $.12/kWh would produce $4,287 in revenue from net metering per year. The resulting overall annual net revenue of $6,085 would put Double Trouble's FBC system in the black, but it would not be sufficient to produce a positive payback period for the project.

Profitability would improve slightly if the farmer were able to earn revenue from the sale of nutrient trading credits, as shown in **Scenario B**. Because a nutrient credit market has not emerged in Maryland, this scenario uses Virginia credit values as proxies and is fairly theoretical. It yields $10,137 in annual revenue from credit sales, for a total net annual revenue for the project of $7,634. The payback period on the $2.73 million investment is still significantly higher than the technology's useful life.

Scenario C depicts a situation that is somewhat likely over the long-term (i.e. within the coming fifteen years), in which the market value for poultry litter is reduced. This scenario assumes a sale value of $5/ton, compared to $18/ton in the base scenario. By dampening the farmer's pre-technology revenue potential, this scenario improves the FBC system's financial picture, with annual net cost savings plus revenue rising to $10,498. While an improvement over the base scenario, this result is not enough to demonstrate financial feasibility when considering the payback period.

A situation much closer to achieving feasibility is modeled in **Scenario D**, which accounts for improved health of chickens raised in houses heated by the FBC system. As discussed above, improved bird health was an expected benefit of the system, as European applications of the technology have shown that poultry raised on the FBC system's relatively dry heat experience accelerated growth compared to birds raised in control houses. This scenario assumes an additional half pound per bird by production time, for four poultry houses and four flocks per year. At an average price per pound of $2.8,[2] this scenario generates $89,600 per year in additional revenue, and $87,098 in total annual net revenue. The simple payback period is 31.3 years – just above the vendor's upper-range estimate of the technology's useful life.

Incorporating the revised inputs from *all* the above scenarios portrays a best-case scenario in terms of project feasibility. This would yield $118,821 annual net revenue and a simple payback period of 22.9 years relative to the initial investment.

Table 4. *Base scenario financial results plus four alternative scenarios with modified inputs*

	Scenario A 36K kWh/year export	**Scenario B** Sale of nutrient credits	**Base Scenario** See inputs above	**Scenario C** Pre-technology litter sales at $5/ton	**Scenario D** Accelerated poultry growth rate
Annual cost savings + revenue ($)	6,085	7,634	-2,503	10,498	87,098
Simple payback (years)	448 > 25 year useful life	357 > 25 year useful life	Infinite > 25 year useful life	260 > 25 year useful life	31.3 > 25 year useful life

Discussion: Transferability and Policy Considerations

The analysis above pertains specifically to Double Trouble Farm. As discussed below, a number of factors affect whether investment in this technology will be feasible on other farms in the state.

<u>Capital costs and additional sources of revenue</u>: The total cost for engineering, permitting, and constructing Double Trouble Farm's FBC system was $2.73 million. These capital costs can be expected to vary in future installations due to differing siting conditions, infrastructure needs, local sourcing of materials, and other factors. Further, as the FBC technology is tested and refined over time, capital expenditures for future systems may reasonably be expected to decrease.

The profitability of future applications of this technology would also improve if the project could take advantage of revenue opportunities such as nutrient credit trading and/or augmented revenue from net metering. Appropriate sizing of the generator to farm size and output potential are important for future systems to benefit from connection to the regional electricity grid.

The profitability of future FBC systems will also be affected by their ability to tap into existing or new sources of state or federal support via subsidy or incentive programs. For example, access to cost-share assistance offered through the Maryland Agricultural Water Quality Cost Share Program would reduce farmers' out-of-pocked expenses for installing the system.[3] Such assistance may be necessary to help bridge the gap until the technology is able to become financially self-sustaining.

Byproduct value: The high-phosphorous ash produced via the FBC process is a fertilizer source with various potential applications and markets. From a regional water quality perspective, a major benefit of this product is that it captures the majority of phosphorous found in poultry litter into a form that can be marketed and sold outside the Chesapeake Bay region, where phosphorous input is in demand. However, the ash is a novel product and its market is still being explored and developed. BHSL estimates a market value ranging from $65 (actual price for initial sales) to $150 per ton. To the degree that robust demand and a good market price for this product develop, revenue opportunities for future FBC implementers will increase.

Regulatory drivers: As with other advanced manure management practices, multiple state and federal regulatory drivers have the potential to affect the profitability of poultry litter FBC systems. Chief among these is Maryland's **Phosphorus Management Tool** (PMT) requirements, which begin to go into effect in 2018 and will more strictly limit phosphorous application on Maryland farms with high soil phosphorous levels. PMT is likely to have the greatest impact on Maryland's Eastern Shore (Somerset, Wicomico, and Worcester counties), 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.[4] 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. By making these manure management practices less feasible, PMT is likely to have the effect of encouraging alternative uses for poultry litter.

Maryland's **Renewable Energy Portfolio Standard** provides further impetus for future FBC applications, by specifying poultry waste-to-energy technologies as eligible generators of renewable energy credits and thereby introducing a valuable revenue stream for project operators.[5] Additional revenue for systems like this one could also come in the form of nutrient credit sales, if Maryland's dormant **Nutrient Trading Program** were to see trading activity. This technology would need to be designated an eligible generator of nutrient credits under Maryland's program, as recommended by a Manure Treatment Technologies Expert Panel convened by the US EPA Chesapeake Bay Program.[6]

Some federal regulations may increase the operational cost of FBC systems, namely, Clean Air Act rules (administered by the state) that limit emissions from incineration facilities in nonattainment areas according to National Ambient Air Quality Standards. However, another federal regulatory driver may have the opposite – positive – effect on FBC and other advanced manure management technologies. The US EPA's **Chesapeake Bay Total Maximum Daily Load** (TMDL) mandates pollution reductions for all Bay states, incentivizing them to find cost-effective means of reducing agricultural and other nonpoint sources of pollution.[7] Because technologies like FBC have innate profit-generating potential and thereby the potential to engage private sector capacity (financial and otherwise), they represent a worthwhile target for investment of state funds for water quality restoration.

Conclusions

Based on available information from the initial performance period, the pilot fluidized bed combustion system at Double Trouble Farm does not appear to generate sufficient cost savings and revenue to overcome project costs, which suggests that this technology may not be a viable investment for other farmers in similar situations. However, these results are highly sensitive to inputs that could reasonably be expected to change as the project's performance period lengthens. While initial flocks have not demonstrated expected accelerated growth rates, it is possible that this benefit may be realized as the system's operations become more streamlined and efficient over time. Additionally, the farm-scale financial scenario for this and future installations of the FBC technology is likely to change in light of PMT requirements, which have long-term potential to depress the market value of raw poultry litter, as discussed above.

Considering the transferability of this technology to other farms in Maryland, it appears that it will be more feasible if (1) PMT regulations have the expected effect on the market value of poultry litter and consequently on the demand for alternative uses; (2) the system is sized appropriately to realize revenue from net metering when connected to the regional electricity grid; and (3) the project is able to capture most or all of the technology's revenue-generating opportunities, including robust byproduct sales, REC sales, and increased value from higher-weight birds.

References

[1] Maryland Department of Agriculture. "Biomass Heating Solutions, Inc." Accessed 12/15/17: http://mda.maryland.gov/resource_conservation/Pages/biomass_heating_solutions.aspx

[2] University of Wisconsin Center for Integrated Agricultural Systems. 2003. *Research Brief #63: Large-scale pastured poultry farming in the US.* Available: https://www.cias.wisc.edu/large-scale-pastured-poultry-farming-in-the-us/

[4] Maryland Department of Agriculture. Maryland Agricultural Water Quality Cost-Share Program website. Accessed 1/25/18: http://mda.maryland.gov/resource_conservation/Pages/macs.aspx.

[4] Maryland Department of Agriculture. March 2016. "Preliminary Phosphorous Soil Test Results." Available: http://www.mda.maryland.gov/documents/Preliminary-P-Data_03.2016.pdf. State figure updated per Louise Lawrence, 2/15/17.

[7] Jeremy Hanson, Virginia Tech / Chesapeake Bay Program. Interview with EFC, 11/7/16.

[9] US Environmental Protection Agency. December 2010. "Chesapeake Bay Total Maximum Daily Load for Nitrogen, Phosphorous and Sediment."

[8] Maryland Public Service Commission. Renewable Energy Portfolio Standard Program website. Accessed 11/27/17: http://www.psc.state.md.us/electricity/maryland-renewable-energy-portfolio-standard-program-frequently-asked-questions/