Coupling Dairy Manure Anaerobic Digesters with Commercial Greenhouses – An assessment of Technical and Economic Feasibility

Project Description:

Through the support of a USDA Hatch and Smith Lever grant, Cornell PRO-DAIRY has undertaken a project to examine both the technical and economic feasibility of coupling Dairy Anaerobic Digesters (AD) with commercial greenhouses. The synergy of digesters and greenhouses is of particular interest as dairy digesters typically produce considerable waste heat. In addition, surplus electricity from biogas powered generators is sold to the utility at the avoided cost of production rate which is typically only on the order of $0.03 to $0.05 per kWhr, which provides little incentive to a digester operator to optimize the operation of their digester. Greenhouses are an ideal user of both the waste heat, and the surplus electricity which typically represent 30% of the cost of production in the Northeastern US.

The project essentially consists of two major efforts.

The first major effort of the project is to collect real world data from operating digesters and greenhouses so that we can characterize exactly how much waste heat and surplus power might be available from an AD project, and the demand for heat and electricity from typical commercial greenhouses in the Northeast.

We have collected (and continue to collect) data from four dairy AD projects, and two commercial greenhouses.

For the AD projects, this data is valuable quantification of exactly how much waste heat was produced, and might be available for partnering with greenhouses, or other uses such as biomass drying/pelletization. Greenhouse energy usage data provides a starting point for determining the technical feasibility of locating a greenhouse adjacent to AD projects.

The second major effort is the development of user friendly computer programs to:

1. predict the surplus heat and electricity available from digesters of user specified size, design and operational characteristics,
2. predict the required heat and electricity for a greenhouse of user specified size, design and operational characteristics,
3. use the output from the AD computer program, and determine the size of greenhouse that could be supported by the specified digester, or the portion of the energy usage of a specified greenhouse that could be digester supported.

The goal is that these user friendly computer programs will expand the project's utility beyond the farms we are directly monitoring. In addition, the programs will allow the users to identify how operational decisions such as importing food waste could affect the heat and power output of their systems. Greenhouse users can investigate different strategies for supplemental lighting, temperature set points, and other factors that impact their energy usage.

Justification:

According to the Environmental Protection Agency there are currently only about 85 intensively managed (excludes covered lagoon storages), farm-based, anaerobic digesters coupled with engine-generators, operating in the U.S. one over 60,000 dairy farms nationally suggesting the need to find solutions to the economic adoption challenges.. Anaerobic digesters alone reduce farm carbon emissions by approximately 2.5 to 3 metric tons per cow per year(Pronto and Gooch, 2010) and even more when coupled with an engine-generator set producing renewable electricity by way of displacing fossil fuel-based emissions. However, despite these and many other positive environmental benefits of AD, the economics are not sufficient to encourage widespread adoption by U.S. farmers based on selling carbon offset credits and surplus power to the grid. Often, farms are only paid the utility's avoided cost (currently 3 to 5 cents/kWh in New York State) for electricity sold to the grid, making it a better option financially to use the energy on-farm since the purchase price is two to three times higher than the price the utility obtains power for. In addition, typically in the Northeast, it is estimated that approximately 40% of the energy from a digester (in the form of excess heat) goes unused as it is wasted to the environment. Therefore, potential value-added technology/business partnerships need to be evaluated and promising ones subsequently demonstrated, such as partnering AD systems with commercial greenhouse operations. Successful business partnerships provide an opportunity for an increased number of digesters to be constructed and operated on-farm, thus reducing greenhouse gas (GHG) emissions while providing long-term, lower cost, non-fossil-fuel based renewable energy for local greenhouse growers.

In the Northeast and other similar climates, heat and electricity represent a major expense for greenhouse growers (on the order of $10 to $20 per square foot of greenhouse space annually, when supplemental lighting is installed and used). Greenhouses can make use of the excess heat from AD to provide the necessary growing conditions for year-round production. Excess electricity from biogas fueled combined heat and power (CHP) systems can be used to power supplemental lighting systems to provide light levels necessary to keep production constant throughout the year.

Present Outlook:

In a paper published by Scott et al. (2005) the energy production of an AD system on a 500-cow NY dairy farm was compared to the energy needs of two NY State commercial greenhouses. This theoretical analysis showed that the AD system could nearly (depending on greenhouse production methods used) meet all of the energy needs of both the digester and an energy-intensive greenhouse operation providing good evidence that this partnership should be further investigated.

Currently there are 4,800 dairies in NY State of which approximately 500 are of sufficient size to be viable candidates for an AD system and potentially an associated commercial greenhouse. The envisioned systems would entail greenhouse operations conducted by an entity with the requisite knowledge and operational philosophy, geared towards a centralized nursery packaging facility in conjunction with remote grow-out operations. Seedlings would be produced at a centralized location and then trucked to the farms with AD supported greenhouses. There the crop would grow to harvest size. As new seedlings are delivered to the grow-out facilities, material that is ready for harvest would be loaded onto the truck to be taken back to the centralized location for harvest and packaging. Grow-out greenhouses adjacent to digesters will not require expensive, seeding, seedling production, harvesting, packaging and materials storage space. In addition the critical production step of seedling production would be undertaken in a single location that can be overseen by an experienced grower. Production tasks at the remote grow-outs are more routine and do not require the same level of experience as for seedling production. The proposed system fits with the goal of many distributed greenhouses that can be co-located adjacent to dairy anaerobic digesters.

Deliverables:

In addition to providing the user friendly computer models, we are developing additional materials for those who may be interested in the project.

Technical Feasibility: Summary tables, based on using the AD/GH model, with ranges of digester sizes and feedstock inputs, to estimate both the size of greenhouse that can be supported (in terms of heat and electricity) entirely or in part by varying digester size, style and feedstock will be developed. Further, greenhouse crop and production strategies (supplemental lighting, CO_2 supplementation, thermal environmental control) will be examined to see how energy requirements are affected.

Economic Feasibility: We will perform economic cost-benefit analyses of the total annualized costs for the various digester/greenhouse combinations investigated for technical feasibility and others as well. This information will be used to convey the estimated ranges of potentially viable systems from heat, electricity and economic standpoints.

The computer programs and the results of the technical and economic feasibility analyses will be made available on the Cornell PRO-DAIRY Dairy Environmental Systems program web site: www.manuremangement.cornell.edu, as well as through popular press articles, technical articles/notes, and journal articles and by developing and delivering oral presentations at meetings/conferences/workshops attended by target audiences. We anticipate posting the results of the analyses in Summer 2015, with the user friendly computer programs to follow in Fall 2015.

Impact:

The immediate impact from this project will be to provide the dairy farmers with AD (or considering AD) a means of quantifying the potential usefulness of the surplus heat and surplus power. This will allow them to make informed decisions about using this by-product either through partnering with a greenhouse operator, or some other energy intensive operation such as biomass drying, pelletization, nutrient extraction from digester effluent or other treatment processes. Greenhouse operators will benefit from having a tool to quantify both the magnitude and timing of their energy requirements, which will facilitate locating their operations to take advantage of alternative sources of heat and power. In addition, this project will facilitate greenhouse operator collaboration with dairy AD operators seeking to make use of their surplus energy resources. The developed model and subsequent outcomes from applying it to real world and hypothetical scenarios will also inform greenhouse producers of potential savings of partnering with a dairy AD system.

Longer term, we believe this project will lead to several positive outcomes including reduced greenhouse gas emissions, additional revenue streams for AD owners, lower cost renewable energy supply for greenhouse owners, and contribution to sustainability of rural communities through income and employment opportunities. Optimized greenhouses provide consistent year-round production that is attractive both from a local production perspective as well as from the ability to provide long-term production contracts to wholesalers. Local diversified and distributed production is more resilient to climate change and makes more efficient use of water and nutrients.

LITERATURE CITED:

Pronto, J.P. and C.A. Gooch. 2010. Greenhouse Gas Emission Reductions for Seven On-Farm Dairy Manure-based Anaerobic Digestion Systems – Final Results. Written for presentation at the 2010 ASABE International Air Quality and Manure Management Symposium, Dallas, Texas, September 13 – 16, 2010. ASAE 2950 Niles Road, St. Joseph, MI 49085-9659.

Scott, N.R., Rutzke, C.J., and L.D. Albright. 2005. Energy Conversion Options for Energy-efficient Controlled Environment Agriculture. HortScience Vol. 40(2):287-292.