SUMMARY:
BENEFICIAL REUSE SOLUTIONS FOR LANDFILL OPERATIONS AND MANAGEMENT

Daniel E. Meeroff (PI)[1]
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In 2016, the Bill Hinkley Center for Solid and Hazardous Waste Management funded FAU Lab.EES to investigate organic waste diversion from landfills to anaerobic digestion to capitalize on existing anaerobic digester capacity in the wastewater sector. The project will explore the impact of organic waste diversion on landfill gas recovery and landfill economics.

Biogas is produced by wet organic waste decomposing under anaerobic conditions. First the microorganisms break open the cellular substrate in a process known as hydrolysis. Then microorganisms turn those molecules into organic acids, which become the food for the methanogens that produce methane, the energy component of biogas. In a landfill, this biogas builds up and is slowly released into the atmosphere if the site has not been engineered to capture the gas or flared to carbon dioxide from a series of landfill gas (LFG) collection wells. Landfill gas released in an uncontrolled way can be hazardous since it can become explosive when it escapes from the landfill and mixes with oxygen from the air.

In Florida, organic wastes make up 6-20% of the municipal solid waste (MSW) stream, but only 2-5% is diverted from landfills meaning that about 2 million tons per year end up in the landfill. This material has a high moisture content (>70%) and a low heating value (<2500 BTU/lb) compared to MSW without organic waste (~5000 BTU/lb). Therefore, organics are not as desirable for waste-to-energy operations either, but they are ideal for anaerobic digestion. In 2015, there were 1497 anaerobic digesters in the US, of which 83% were being used strictly for wastewater applications.

Recent innovations in co-digestion have unlocked the potential for cleaner biogas (65-75% methane) with only 10% of the digester feed being diverted food waste, tripling the digester biogas output in some cases. Using the total amount of food waste reported for the State of Florida and estimates from Dung et al. (2014), this represents a potential to generate 1829 – 4043 GWh per year, which is equivalent to the energy required to power 321,000 – 710,000 homes (USEPA 2013) or 8% of all of the energy requirements for the State.

However, since food waste is rich in carbon, if a fraction of this material is diverted from the landfill or waste-to-energy stream, it may ultimately impact LFG production and methane content at the solid waste facility. Therefore, we propose to quantify these effects by calibrating the USEPA LFG Emissions Model (LandGEM, Alexander et al. 2005) based on experimental measurements of methane production potential and first order decay rate at different food waste diversion ratios. Using the new data, this study will investigate if we can take advantage of unused anaerobic digester capacity in the wastewater sector to generate more clean biogas from diverted food waste and determine the life cycle cost impact of organic waste diversion programs from the perspective of the solid waste industry and also holistically from the entire waste sector if implemented.

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PROGRESS REPORT
(May 2017)

Project Title: BENEFICIAL REUSE SOLUTIONS FOR LANDFILL OPERATIONS AND MANAGEMENT

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Methodology/Scientific Approach

TASK 1. Compilation of information and updated literature review. The research team is updating its comprehensive preliminary literature review for the characteristics, potential uses and processes for the organic waste types identified in profiling, with respect to following:

1) Identification of the types of organic waste prior to secondary use
2) Identification of process modifications and expected performance efficiency with different feedstock
3) Identification of the key operating parameters for anaerobic digestion, the potential legal, policy, or social barriers to implementation, and associated costs.

TASK 2. Assemble stakeholder task force. The proposed task force will be comprised of key stakeholders such as solid waste facility managers, waste facility managers, waste/septage haulers, wastewater utilities, and Florida department of environmental protection (FDEP), CNG/LFG users. To date, several members of the TAG have been contacted to be members of this task force, and candidates from the key stakeholder groups are still being identified and contacted.

TASK 3. Collect representative food waste samples. Publix Greenwise Store #1159 Recycling and Solid Waste Manager Kim Brunson has been contacted to obtain samples of organic waste for preliminary testing. The quality control manager for the Boca Raton utility services department, Donald M. Kree, has agreed to provide digester biosolids to seed the laboratory digester. FAU is in the process of collecting these samples for waste characterization studies of quantity, variability, composition, and contamination (e.g. organics, recyclables, FOG, trash) in preparation for our preliminary experiments in May 2017. A trial was already conducted for detection of any leaks on April 15, 2017 (see Figure 1).

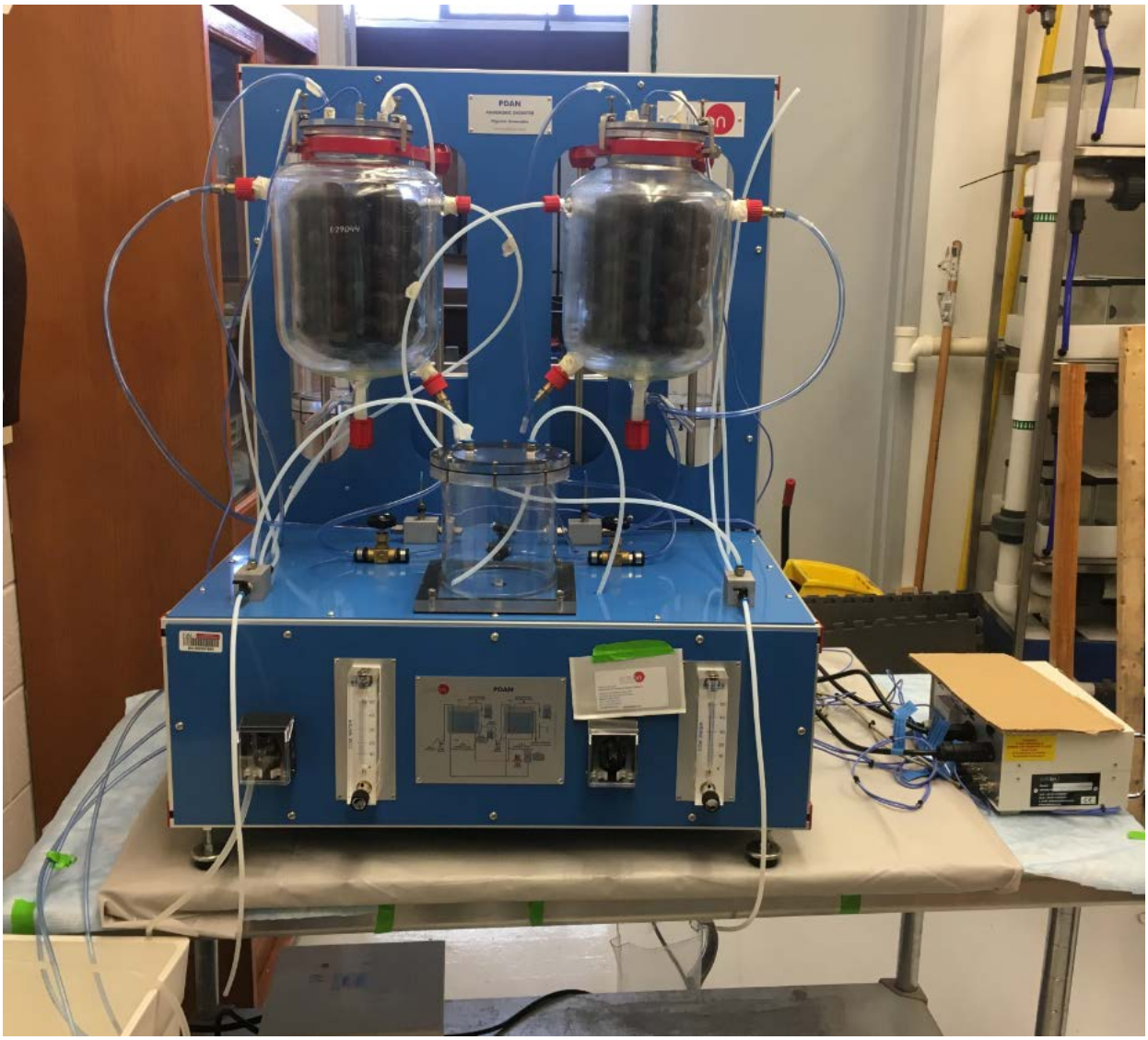

Figure 1 Setup for PDAN Anaerobic Digester

TASK 4. Food waste separation impacts to LFG recovery. Some of the technical issues regarding the fuel use of landfill gas include gas composition, the effects of corrosives and particulates on equipment, potential energy losses, and gas extraction and cleanup. FAU will conduct experiments to model and quantify the changes to landfill gas composition and flowrate with reduced organic content in the mix. The parameters that will be monitored include pH, temperature, slurry ratio, C/N ratio, potential inhibitory substances like ammonia and hydrogen sulfide, VFAs and biogas quantity and quality. The amount of biogas generated and its composition for different mixtures will be measured and compared to determine the methane production. The gases obtained will be measured and assessed by using GEM5000 which is specifically designed for use on landfills to monitor landfill gas (LFG) collection and control systems. Bertrand King, Joao de Almeida, and Ghulam Quddus received an FAU Undergraduate Research Grant for $1200 to purchase a column and supplies for the HPLC detection of organic acids. They are currently working on method development. All students working on this project are completing their training to use the HPLC for VFA detection and the GEM5000 for biogas composition.

TASK 5. Assess life cycle cost. Using the data developed from literature and stakeholder interviews, a preliminary assessment has been conducted to evaluate the associated costs and environmental consequences of food waste diversion to existing anaerobic digesters in West Palm Beach, FL. Ghulam Quddus also conducted a carbon footprint evaluation using the Co-digestion economic analysis tool (CO-EAT) as part of a directed independent study for his Innovation Leadership Honors Program curriculum. He used a simulation of nine scenarios with varying operating capacity ranging from 20% to 60% in 5% increments to come up with a breakeven point.

TASK 6. Develop final recommendation and prepare publication materials. Interim and final report will be developed and submitted. A strategy will be established for looking into the work and experiments being conducted based on the comments from reviews. A TAG meeting was conducted in December 2, 2016 and a presentation was made to the Air and Waste Management Association Southeast Florida Chapter meeting in January 17, 2017.

Future Work:

We plan to complete work on the following:

- Collect samples of food waste and digester seed from the respective authorities to start our first preliminary experiments with the digester in May 2017
- Update literature review and database
- Meet with representatives from waste management and FDEP for collecting and analyzing the data
- Complete the stakeholder group and organize a virtual meeting
- Complete training for GEM5000 and HPLC
- Gather missing information for preliminary assessment of associated costs and environmental effects

Project Metrics

1. List graduate student or postdoctoral researchers **funded** by this Hinkley Center project

Last name, first name	Rank	Department	Professor	Institution
Sethi, Rohan	MSCE candidate	CEGE	Meeroff	FAU

2. List undergraduate student/researchers working on this Hinkley Center project

Last name, first name	Department	Professor	Institution
Quddus, Ghulam	CEGE	Meeroff	FAU
Almeida, Joao	CEGE	Meeroff	FAU
King, Bertrand	CEGE	Meeroff	FAU

3. List research publications resulting from this Hinkley Center project (use format for publications as indicated in the Hinkley Center Investigators Guide).
   None yet

4. List research presentations resulting from this Hinkley Center project (use format for listing presentations as indicated in the Hinkley Center Investigators Guide).
   Technical Advisory Group Meeting held on December 2, 2016
   FAU Undergraduate Research Symposium Poster Presentation April 2017

5. List research papers that have cited any publications (or the final report) resulting from this Hinkley Center project (use format for publications as indicated in the Hinkley Center Investigators Guide).
   None yet

6. List additional research funding that has been secured due to leveraging the research results from this Hinkley Center project (give project title, funding agency, amount of funding, award date, and award period)
   $1200 Undergraduate Research Grant

7. List submitted proposals which leverage the research results from this Hinkley Center project (give the proposal title, funding agency, requested funding, date submitted)
   None yet

8. List new collaborations initiated based on this Hinkley Center project
Rhonda Moll (Test America), Marc A. Lefebvre and Mark Aument (Mas Environmental, LLC), Manuel Hernandez and Mike Fisher (SCS Engineers), Kim Brunson (Publix)

9. How have the results from this Hinkley Center funded project been used (***not will be used***) by the FDEP or other stakeholders in the solid waste field? Please note that the term "other stakeholders" is meant to broadly include any party or practitioner in the solid waste field. This includes county solid waste directors and their staff, municipal solid waste directors and their staff, solid waste facility design engineers, local/county/city solid waste management regulatory staff, federal solid waste regulatory staff, landfill owners and operators, waste haulers, waste to energy plant owners and operators, recyclers, composting plant owners and operators, yard waste operators, construction and demolition debris companies and organizations, county recycling coordinators, citizens and members of the academic community, etc. (1 paragraph maximum)

None yet to our knowledge

TAG Members:
Mark Eyeington, Mark Maclean, Mark Bruner, Owrang Kashef, D.V. Reddy, Craig Ash, Ravi Kadambala, Ron Schultz, Jeff Roccapriore, André McBarnette, Dan Schauer, Damaris Lugo, Amanda Krupa, Richard Meyers, Amede Dimonnay, Art Torvela, Ted Batkin, Roshan Jachuk, Fred Bloetscher