QUARTERLY PROGRESS REPORT

02/28/18 to 05/29/18

PROJECT TITLE: Environmental and Economic Impacts of Energy Production from Municipal Solid Waste

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WEB ADDRESS: http://www.eng.usf.edu/~jnkuhn/Hinkley2017.html

Submitted to:
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Research Description

Municipalities today are faced with a variety of options on dealing with solid waste. Tools and guidance are needed to make sound decisions, regards to both environmental and economic factors, that takes into account various site specific constraints such as land and water availability, energy costs and needs, and government policies and tax incentives. The goal of this project is to quantify the benefits of various traditional and proposed Waste-to-Energy (WTE) technologies versus landfilling. The results will aid in identification of an optimal process for maximizing profitability while minimizing environmental impact given various scenarios and constraints. The proposed effort leverages previous and current efforts on the demonstration of syngas production from landfill gas and design and application of selective FTS catalysts (production of diesel and jet fuel) funded by the Hinkley Center, the Florida Energy Systems Consortium (FESC), and the Department of Energy (DOE).

The five WTE technologies selected for this comparison are gasification or anaerobic digestion to produce electricity, incineration to produce heat and power, or gasification to produce compressed natural gas or liquid hydrocarbon fuels (i.e., diesel). These five technologies will be compared to landfilling and single-stream recycling to reach a total of 7 scenarios. These processes will be evaluated at the system level, such as done by the PIs for various WTE and biomass conversion schemes already, to quantify the key parameters needed for making a sound decision taking into consideration economics and environmental impact. These parameters include CAP-EX, OP-EX, energy input requirements, GHG emissions, water input requirements, co-product generation and use/market (if any), solid waste production (if any), and profitability. The process simulations will include a sensitivity analysis, which will include a variable production scale, process lifetime, degrees of tax credits, etc. on the eight parameters identified to compare the conversion technologies.

Work Completed To-Date

In this reporting period, we performed feasibility studies using our earlier constructed MSW treatment option calculator. We compared the feasibility of several random scenarios. The process of doing a feasibility studies required that we determine the minimum discounted rate required for a project to be termed feasible. This minimum discounted rate was determined through the implementation of the discounted cash flow of Return (DCFRR) economic principle. The DCFRR was gotten through solving for the minimum attractive rate of return (i_m) of the given scenario that equates the net present worth (NPW) to zero. The solved NPW equation is shown below:

$$NPW = \sum_{t=-NI+1}^{t=NO} \frac{CF_t}{(1+i_m)^t}$$

CFt is the cash flow at year t, while t is time in years. The individual cash flows (CF) were generated by multiplying the difference between the yearly expense and revenue with the tax rate, and then adding it to the depreciation value. The application of the DCFRR method

at various capacities enabled us to generate three unique scenarios as shown in the figure below:

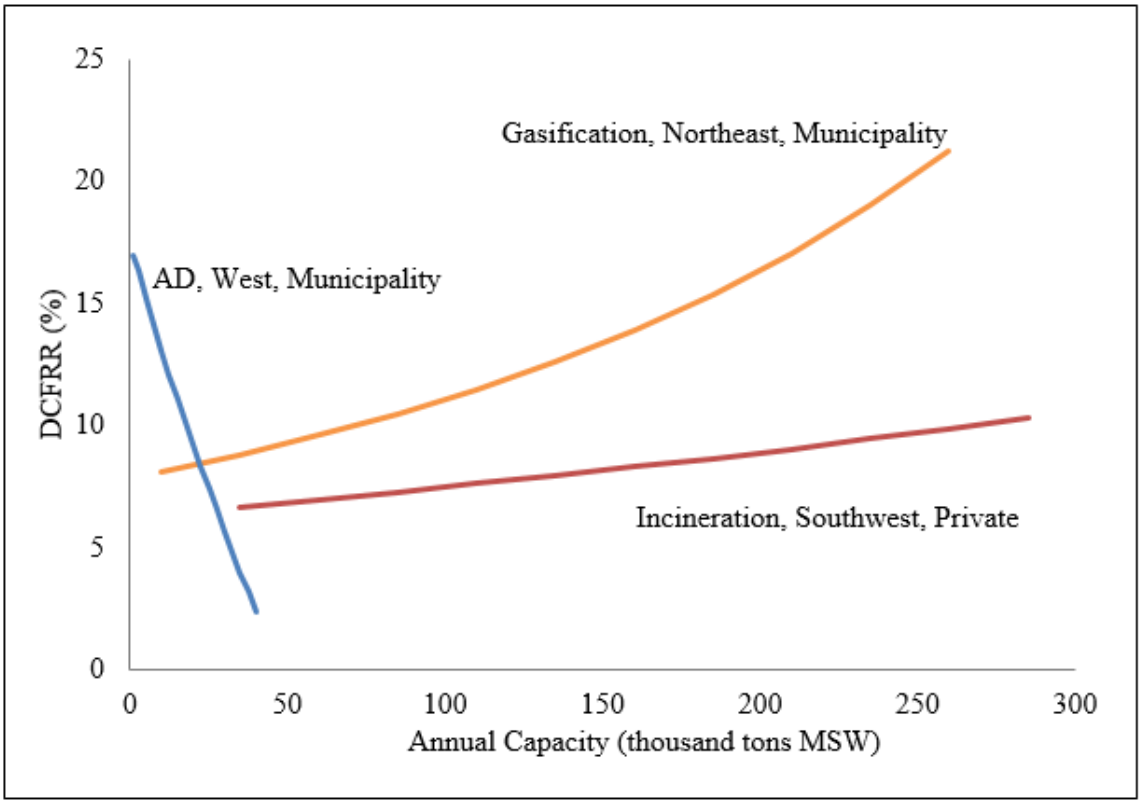

Figure 1. DCFRR as a function of operating capacity for three treatment option scenarios

We applied a 20-year life span and used the MARC depreciation method. The above graph presents information on the profitable range of the operating capacities over the stated operation period. The graph shows that at lower operating capacities, the anaerobic digestion has a relatively good rate of return. However, at larger annual capacities it becomes unprofitable. On the other hand, both the incineration and gasification scenario have steady profitability that increases with operating capacity. The higher DCFRR recorded by gasification is partly due to the fact that it is owned by a municipality.

In addition, we began considering single stream recycling scenario in comparison to the previously considered source separation. Single stream recycle involves the collection of all recyclables into the same container. The separation takes place in material recovery facilities (MRF); hence, we began studying the technical operating details for MRFs. These facilities range in operational size, which is directly related to the amount of waste that the process will receive. In general, MRF's are categorized based on the characteristic of the waste stream that they can accept and process into; single-stream MRF, dual-stream MRF, mixed stream MRF. We began collecting operational data for mixed stream MRF facilities scenario with the intention of sending organic fraction to WTE technologies. The data were obtained from the underlisted sources:

- Dubanowitz, Alexander, Design of a materials recovery facility (MRF) for

processing the recyclable materials of New York City's municipal solid waste .

- GBB Tucson, Materials Recovery Facility Feasibility Report
- Burns McDonnell, Mixed Waste Processing Economic and Policy Study
- Shaw Environmental, Mixed Waste Processing Facility Feasibility Study

Common data from these sources were organized in an excel sheet with the objective of getting the CAP-EX, OP-EX, and revenues on a PER ton basis (per ton of mixed waste diverted).These data were used form relationships in excel. We obtained equations that relates the capacity to the facility costs through curve fitting.
We then proceeded to build inputs to calculator around design questions that are most important when looking at MRFs such as:

- How much mixed waste will this facility process every year?
- How much single stream waste will this facility process every year?
- How far from an urban center will the facility be located?(i.e. transportation costs)

Future Tasks

Our future direction involves us completing the incorporation of formulas into inputs for MRF calculator. This will allow for the generation of cash flows and expense estimates. We also intend to obtain more operating data for single stream facilities, this will enable tool to take into account a facility that would receive mixed waste and single stream.

TAG Meetings Scheduled

Our first TAG meeting was held 3/6/18. It was well attended (see picture below) with nearly all TAG members able to attend in person or virtually. Here are the links to the TAG meeting.

http://www.eng.usf.edu/~jnkuhn/TAG%20Meeting%20Kuhn%20USF.mp4

https://youtu.be/dFUBl0jvNF8

TAG Members

John Schert	Director	Hinkley Center
Wester W. Henderson	Research Coordinator III	Hinkley Center
Devin Walker	Process Engineer	T2C-Energy
Matt Yung	Researcher	Nat. Renewable Energy Lab
Tim Roberge		T2C-Energy
Richard K Meyers	SWRS Program Manager	Broward County Solid Waste and Recycling Services
Lee Casey	Chief of Environ. Compliance (Retired)	Miami Dade County Dept of Solid Waste
Canan “Janan” Balaban	Asst. Director	Florida Energy Systems Consortium
Ron Beladi	Vice-president	Neel-Schaffer, Inc.
Rebecca Rodriguez	Engineer Manager II	Lee County Solid Waste Division

Linda Monroy	Project Manager Associate	Lee County Solid Waste Division
Sam Levin	President	S2LI
Charles “Peb” Hendrix	Chief Operating Officer	LocatorX
Tony Elwell	Staff Engineer I	HSW Engineering, Inc
Nada Elsayed	Scientist, PD	Catalent Pharma Solutions Inc
Yolanda Daza	Process TD Engineer	Intel Corporation
James Flynt	Chief Engineer	Orange County Utilities Department
Gita Iranipour	Engineer Associate	Hillsborough County Public Utilities Department
Luke Mulford	Water Quality Manager	Hillsborough County Public Utilities Department
Ray Oates	Solid Waste Compliance Manager	Citrus County Division of Solid Waste Management

Metrics:

1. List graduate or postdoctoral researchers funded by THIS Hinkley Center project.

Name	Rank	Dept.	Professor	Institution
Sokefun, Yetunde	2nd year PhD student	Chemical Engineering	Kuhn/Joseph	USF

*2. List undergraduate researchers working on **THIS** Hinkley Center project.*

First Name	Dept.	Institution	Professor
Daniela Chinchilla	Chemical Engineering	USF	Kuhn/Joseph

*3. List research publications resulting from **THIS** Hinkley Center projects.*

Naqi, Ahmad "Conversion of Biomass to Liquid Hydrocarbon Fuels via Anaerobic Digestion: A Feasibility Study" (2018). M.S. Thesis, Chemical and Biomedical Engineering, USF, Tampa.

*4. List research presentations resulting from **THIS** Hinkley Center project.*

Stachurski, P., Joseph, B., and Kuhn, J.N., "Waste-to-Energy Technologies: Developing a Decision Making Tool for Municipalities and Private Companies", USF UG Research Colloquium, Tampa, FL, April 2018.

Naqi, A., Joseph, B., and Kuhn, J.N. "Techno-economic Analysis of producing Liquid Fuels from Waste through a combined Biochemical and Thermochemical Route", 2018 AIChE North Central conference, West Lafayette IN, April 2018

5. List who has referenced or cited your publications from this project?

None at this time.

6. Provide an explanation of how the research results from this Hinkley Center project and previous projects have been leveraged to secure additional research funding.

We have submitted the following proposals:

Sustainable Energy, Nutrient and Water Recovery from Organic Wastes for Space Applications (in collaboration with Dr. Ergas, Professor of Civil and Environmental Engineering, USF, T2C-Energy, LLC). Submitted to Florida-Israel Innovation Partnership. This will be resubmitted in 2018.

7. List new collaborations that were initiated based on this Hinkley Center project.

A collaboration was initiated with Dr. Ergas which resulted in the above named proposal.

8. Provide an explanation of how have the results from this Hinkley Center funded project have been used (not will be used) by the FDEP or other stakeholders?

None at this time.

Student Researchers

The current student researchers on this project are Yetunde "Tosin" Sokefun and Daniella Cerna Chinchilla. Former students Ahmad Naqi graduated (MS), Matthew Kalstetic (BS) and Paul Starchurski (BS) graduated last spring semester (May 2018).

Paul Starchurski during his presentation at the USF UG Research Colloquium, Tampa, FL, April 2018.

Ahmad Naqi recently presented a poster at the 2018 AIChE North Central conference, West Lafayette IN, April 2018.