REPORT ON THE FEASIBILITY GASIFICATION OF MUNICIPAL SOLID WASTE FOR ENERGY PRODUCTION FOR THE DOD

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September 2019

Abstract

The following report and projects were completed as a fulfillment of funds provided to AFIT by AFCEC. Each of the projects were based on the central idea of Waste-to-Energy gasification as a method of waste diversion for the DoD. To help model the problem, computational programs such as Aspen Plus and SimaPro were used in addition to techno-economic and life-cycle analysis methods. A complete gasification system based on a deployed recipe was modeled using Aspen Plus to help determine its viability. Contacts were formed with other related agencies including DOE NETL, DLA, and Sierra Energy Inc. This opens the door for future collaborations and more extensive projects in the field. Two papers, currently in editor review, were written to help expand the field of knowledge related to WTE.

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I. Summary

This project was funded by AFCEC for $90,000 with three specific aims. The first was to establish contacts in the field of Waste-to-Energy (WTE) gasification. The second was to perform Techno-economic Analysis (TEA) on a small-scale gasification unit for potential use downrange. The final objective was to perform Life-Cycle Analysis (LCA) comparing the economic, environmental, and human health related impacts of waste disposal methods. Several different projects related to Waste-to-Energy were completed using the funding provided by AFCEC. There were several student theses completed, two papers waiting for publication, a full scale simulation and TEA was performed on a gasification system in collaboration with NETL, and a few other proposals have been created. The projects were derived all from the same perspective of diverting waste for the DoD.

AFCEC Project Log FY 17-19.pdf

II. New Contacts

The primary goal of the project was to partner and collaborate with DOE NETL on WTE-related research. As a research team, they already had experience working with small scale gasification units using coal. Half of the overall funds were sent to NETL to help with this effort (MIPR F4F5AL8005G101). They contributed by building an Aspen Plus model for use in a WTE gasification TEA. For this model, two different waste recipes were considered, one using only Municipal Solid Waste (MSW) as the feed, and the other using a combination of both MSW and coal. Collaborations were formed with a private

company, Sierra Energy, which has previously done work for the Army and DLA. A novel system, Sierra Energy's proprietary FastOx® gasifier, was the critical piece to the model. FastOx® is of special interest to the DLA and several other agencies due to Sierra's claims that its gasifier can process hazardous waste including batteries and medical waste, rendering all of the outputs an inert slag. Contacts were developed at Sierra to help better understand some features of the FastOx® system, and an ongoing partnership is still a strong possibility. Funding was also used by AFIT to purchase an Aspen license for the duration of the project and hire a research intern with Aspen experience.

III. Techno-Economic Analysis

One paper written was an article targeted for The Military Engineer Journal. It was titled "Gasification of Municipal Solid Waste: the Need for Techno-Economic Analysis" It is a short journal article that looks at the benefits and necessities of using TEA in the field of gasification and waste to energy. The article explains that TEA can help determine the long term viability of a system before large investments are made. TEAs can also give a good estimation for the success rate of novel systems that have not been thoroughly tested as of yet. TEA incorporates aspects of computational modeling, cost analysis, feasibility studies, and can used in addition with LCA to fully estimate the likelihood of success for a new project. The paper is currently under review by the editors behind The Military Engineer, but it should reach publication soon.


TEA Paper Final.pdf

The main portion of the TEA research was in collaboration with DOE NETL. The goal was to investigate whether or not a gasification system could be implemented in a deployed environment for waste disposal. For the project, a full scale Aspen Plus model was completed for two different feed scenarios. The first was performed using only MSW at a feed rate that was determined to be reasonable for a small deployed base. The second feed case was using the same amount of MSW, but also added coal up to the capacity limit of the gasifier selected. The two cases were analyzed, and compared to determine whether they were feasible, and also whether or not they could produce energy for the facility they were designed for. This project had several steps that had to be completed along the way. The Aspen Plus simulation required a proximate and ultimate analysis for the model to run accurately. An article published by ARL was used to set a baseline MSW recipe, and the proximate/ultimate analysis was based on that MSW recipe. The excel file embedded below shows the process that was completed to determine the proximate and ultimate analysis for the system. From that point, the Aspen Plus models were completed by NETL. Based on the models performed, the 5 TPD MSW case did not produce enough energy to be self-sufficient, but the energy requirement was offset by the case with the addition of coal. From that point, the interest moved to manipulating the system to determine a case where the gasification system could be powered entirely using MSW. To further constrain the model and to confirm its accuracy, it would be useful to have Sierra run the waste recipe in their own Aspen model. This opens up possibilities for future collaboration and future work.

Standard Recipe_rev1.pdf

For the AFIT portion of the Aspen plus model, sensitivity analysis was performed on the MSW-only gasification case to help understand the overall efficiency of the system. Two important values were derived, and it was determined that at the maximum gasifier capacity of 12.1 TPD, and also at a value near 8.25 TPD, the system produced a net positive amount of energy that could be used to power additional systems. There were also smaller elements that were analyzed such as the impact of gasification temperature on the energy output and composition of the outputs. It was determined that the desired components in the syngas could be tuned depending on the operating parameters at which gasification was performed. The composition of the syngas impacts the internal energy of the system and the amount of useful power that the syngas can produce. There was also another smaller portion completed that was meant to complement the Aspen model performed by NETL. The document was written to help describe the actual workings of the Aspen document. The intent was for an individual who had never used Aspen previously, to be able to understand the Aspen model on a base level.

Sensitivity Analysis.pdf

DoE FastOx File Description.pdf

IV. Life-Cycle Analysis

Simultaneously, student research has been evaluating the overall life-cycle impacts of different deployed waste treatment approaches. One student's 2018 thesis was already

provided to AFCEC. The other thesis was written with the goal of performing an LCA to make comparisons between open air burning and a full WTE gasification system. SimaPro was used to evaluate the human health, environmental quality, and climate change impacts of gasification and open air burn pits. In the end, the thesis found that not only were open air burn pits a significant human health hazard, but they were also far more economically expensive than gasifying waste.

Chester Thesis final.pdf

Another contribution of AFIT researchers was a review paper written on the topic of Waste-to-Energy technologies. It was targeted for Renewable & Sustainable Energy Reviews and was titled “An overview of the feasibility of municipal solid waste to energy options for the US landscape.” It focused on an overview of WTE technologies for use in the United States. The paper looks at recent advancements in the field of WTE and their feasibility for potential use in the US. The main tool analyzed for WTE methods was gasification. The paper looks into several different types of gasification, their fuels, their effectiveness, and ways they are modeled. It also looks into the tools used for implementing gasification systems such as LCA and TEA which help determine the feasibility and impact the systems would have. The paper concluded with the reasoning that using newly developed technologies such as plasma gasification is a promising method for both environmental and energy related reasons. Waste sent to landfills can be cut down via gasification, and with energy capture, a net positive amount of energy can be produced to help offset the use of fossil fuels. The paper is currently under review by the editor, but should reach publication shortly.

WTE Review Paper.pdf

V. Conclusion

All of the research funded was targeted toward WTE technology for the DoD. Collaborations were formed with several individuals at agencies including NETL, DLA, and Sierra Energy. Every aspect of the research seemed to come to the same conclusion that using WTE as a waste diversion method would be successful for the DoD. Not only would WTE be useful for waste diversion, but this also includes perspectives from a TEA and LCA point of view. Based on the review article written and the TEA research performed in collaboration with DOE NETL, it is a reasonable conclusion to assume that WTE gasification could be used to divert military waste, and produce a net positive amount of money and energy for the DoD. From the LCA contribution, it was found that using gasification downrange can lessen the environmental and human health impacts caused by waste disposal. There are new collaborations that can be explored, including expanding on the Aspen modeling using information from Sierra energy.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 074-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
04-09-2019	Project Deliverables	May 2018 – September 2019

TITLE AND SUBTITLE

REPORT ON THE FEASIBILITY GASIFICATION OF MUNICIPAL SOLID WASTE FOR ENERGY PRODUCTION FOR THE DOD

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER
F4ATA77208JW01

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

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10. SPONSOR/MONITOR'S ACRONYM(S)

AFCEC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

DISTRUBTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

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15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Dr. Jeremy Slagley, AFIT/ENV
U	**U**	**U**	**UU**	19	**19b. TELEPHONE NUMBER** (937) 255-6565, ext 4632 (Jeremy.slagley@afit.edu)

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18