Executive **Summary**

WATER ENVIRONMENT & REUSE FOUNDATION

Anaerobic digestion of food waste can be environmentally and economically advantageous when used to produce renewable energy from biogas

Renewable Energy Production from DoD Installation Solid Wastes by Anaerobic Digestion (ENER14R14)

The Central Issue

The Department of Defense Environmental Security Training Certification Program (ESTCP) sought to investigate how well an organic waste anaerobic digestion system could reduce solid waste disposal and provide a renewable energy source to offset energy purchases from fossil fuel technologies.

Context and Background

Worldwide, food waste is generated at a rate of about 0.3 kg person per day. In 2011, the U.S. discarded 164 million tons of municipal solid waste, which contained 34.44 million tons of highly biodegradable food waste. Its energy content is estimated to be 130 trillion BTU. Much of this food waste is disposed in landfills where it is anaerobically converted into the greenhouse gases (GHG) methane and carbon dioxide. The methane produced in landfills is substantial, yet only a fraction of it is recovered. The production of methane-rich biogas through the digestion of food waste in anaerobic digesters offers a sustainable alternative to current practices and a source of energy, including biogas purified to produce vehicle fuel and to provide electric power and heat.

If recovered, Department of Defense (DoD) installations worldwide could supply 60% of their energy requirements from the energy in food waste, which would also help meet DoD sustainability goals. The DoD's ESTCP collaborated with WE&RF on a demonstration project at the U.S. Air Force Academy (USAFA) in Colorado Springs, Colorado. The performance objectives of the demonstration included various aspects of renewable energy conversion efficiency; digester capacity and stability; biogas purification, solids destruction, and minimization of process residuals; operational reliability; and accounting of greenhouse gas emissions. Both quantitative and qualitative performance objectives were evaluated during the demonstration.

Findings and Conclusions

The researchers found that use of standard wastewater engineering metrics and observations was not necessarily applicable to food waste digestion. For example, digester feeding was better monitored and controlled using the Specific Energy Loading Rate (SELR) rather than a volumetric organic loading rate. Furthermore, when the energy loading rate (measured in terms of chemical oxygen demand) was limited to the protein and fat content, a better prediction of methane production rates was observed when compared to the total chemical oxygen demand (COD).

Food waste at USAFA Mitchell Hall is sent through a system that grinds and partially dewaters it.

On military bases, especially ones with 40,000 people, food waste digestion and biogas purification showed an economic advantage combined with the minimized GHG emissions and dependence of petroleum-based fuels. For example, the estimated biomethane production from food waste generation alone at USAFA is 6,000-10,000 gasoline gallon equivalents (GGE)/year. Biogas purification was demonstrated to be capable of producing biomethane that was sufficiently pure to be compressed and used as vehicle fuel.

Management and Policy Implications

When food waste digestion with biogas capture and use are considered together, they provide a solid waste reduction technology that recovers energy, creates a greenhouse gas offset, and produces an end product. The process provides distinct advantages over landfilling and composting with respect to energy recovery and greenhouse gas offsets. Collaboration between WE&RF researchers and the DoD to support this research, and the transformation of the nation's military to a sustainable energy paradigm, has great implications for renewable energy utilization nationwide.

Related WE&RF Research

Project Title and Number	Research Focus
Cost and Performance Report – Renewable Energy Production from DoD Installation Solid Waste by Anaerobic Digestion (ENER14R14a)	Determines the capital and operations and maintenance costs (O&M) of a green field food waste digester and gas purification system for three installation sizes (10,000, 20,000, and 40,000 personnel). The net present cost ranged from $1.28 million to $280,000. The costs for food waste digestion and vehicle fueling were as low as $4/wet ton. These costs compare favorably to average landfilling costs of $50/wet ton and composting costs ranging from $29 to $52/wet ton. This economic advantage combined with the minimized GHG emissions and dependence of petroleum-based fuels suggests that food waste digestion and biogas purification is advantageous.
Engineering Guidance Report – Renewable Energy Production from DoD Installation Solid Waste by Anaerobic Digestion (ENER14R14b)	Provides engineering guidance for DoD installations considering implementing the technology.
Developing Solutions to Operational Side Effects Associated with Co-Digestion of High-Strength Organic Wastes (ENER8R13)	Part of a three-study collaboration on operational side effects of co-digestion evaluates survey responses from a set of utility partners practicing co-digestion to collect data on various aspects of the practice and the utility experience. Includes case studies and an economic tool to aid co-digestion decision making.
Co-Digestion of Organic Waste – Addressing Operational Side (ENER9C13)	Supports the goal of increasing energy recovery at municipal treatment facilities through co-digestion of treatment plant sludges and supplemental organic waste by compiling and summarizing performance, operations, and maintenance experience of several full-scale co-digestion facilities. The first phase focuses on analysis of available operations and maintenance data and identification of operations and maintenance issues at participating treatment facilities. The second phase focuses on sampling at select treatment facilities and bench-scale testing to identify variability in as-received supplemental organic waste characteristics. The focus will be on the nitrogen balance from supplemental organic wastes.
Co-Digestion of Organic Waste – Addressing Operational Side Effects (ENER12R13)	Provides tools to utilities performing co-digestion to enable them to better understand the implications of co-digestion and reduce roadblocks and uncertainty associated with the process. Develops an analytical approach to understand and predict the broad array of impacts of co-digestion, as well as a model for estimating the side effects of co-digestion.

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