Operational Energy

By: HDIAC Scientific and Technical Analysis Team

Energy security and forward operating base self-sufficiency are not solely logistics issues; they also affect the safety of the warfighter. Self-sufficient FOBs require fewer resupply convoys, which are vulnerable to insurgent attacks and put warfighters in harm's way. [1] To mitigate these dangers, the Department of Defense's 2025 energy security goals include reducing energy consumption at military instillations, while also increasing on-site energy generation and utilizing alternative energy sources. [2]

The Homeland Defense and Security Information Analysis Center received a request to analyze emerging technologies capable of assisting in meeting operational energy requirements.

Many alternative energy systems, such as solar panels and wind turbines, rely on consistent weather conditions, which may hinder their use in military installations. All FOBs, however, generate waste during day-to-day operations, which provides an untapped opportunity for on-site energy generation as 90 pounds of mixed waste possesses the same energy content as five gallons of JP-8 jet fuel. [3] Using waste to create energy can improve FOB self-sufficiency and energy security by diversifying energy generation options while reducing the amount of waste requiring removal, including food and animal waste, grass, and waste paper. [4,5]

The DoD previously tested waste-to-energy systems, employing the Tactical Garbage to Energy Refinery to reduce the need for fuel and waste convoys during operations in Iraq. [6] TGER employs a biocatalytic system to break down organic materials and a thermochemical system to process "solid wastes such as paper, plastic and Styrofoam." [7]

TGER decomposes the waste, creating a slurry, and ferments it to create a 5 percent hydrous ethanol. [7,8] The system converts the remaining material into fuel pellets, [7] and heats the pellets within a gasifier to break them down into a synthetic gas. [8]

After adding a diesel drip to the synthetic gas and ethanol blend, the mixture powers a standard diesel generator. [7,8] Byproducts from this procedure include ash, carbon dioxide and heat usable for "field sanitation, shower, laundry, or cooling devices." [7] During TGER's use at Camp Victory, the unit processed an average of 54 pounds of solid waste and 13 pounds of liquid waste per hour, while saving 2.6 gallons of diesel fuel each hour. [7]

Wastewater treatment offers another process for waste-to-energy generation for FOBs. Transitioning military installations to anaerobic wastewater treatment systems allows processing wastewater while producing biogas, all at a lower energy cost than aerobic wastewater treatment. [4,9] During anaerobic wastewater treatment, matter is broken down through chemical reactions. The process creates compounds used to fuel subsequent reactions, culminating in the creation of biofuel. [10,11]

In the first step, hydrolysis reactions convert large and complex molecules into smaller, more easily metabolized molecules. [10] Hydrolysis is especially important when large amounts of suspended solids and large molecules are present. [10] Using the products created at the end of hydrolysis, acidogenesis uses microorganisms to further break down organic matter while creating additional compounds, most notably

hydrogen and carbon dioxide. [11]

In the next step, acetogenesis, bacteria transforms the products resulting from acidogenesis into acetic acid and additional hydrogen and carbon dioxide. [11]

The final step, methanogenesis, converts hydrogen and carbon dioxide formed during acidogenesis and acetogenesis into methane and water through a chemical reaction. [11] The final biogas product following methanogenesis possesses an energy content of 22-26 MJ/m^3 and consists of 60 to 70 percent methane and 30 to 40 percent carbon dioxide with traces of other compounds and gases. [10]

Further modification of waste-to-energy systems to use non-organic materials not currently supported, such as metal and glass, [8] would increase usability by offering additional fuel sources otherwise discarded.

Recent research may prove beneficial toward incorporating metal wastes by utilizing metal particles such as iron, which possesses high energy densities and low emissions, heated in a metal-fueled combustor. [12] This process creates thermal energy used to power heat and steam engines as well as provide heating. [12]

In an ideal system, alternative energy sources such as waste-to-energy systems deliver on-site power generation to run energy efficient technologies. While many commercial off-the-shelf products offer the DoD technology needed to meet its energy security mission, the technology requires additional research and development to ensure the products meet military standards of ruggedness, portability and cost.

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