Commercial Scale Demonstration of Hydrothermal Process (HTP) on Guam

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Hydrothermal Processing (HTP) accepts wet feedstock, generally 15 to 30% solids, compresses and heats it to 200-bar and 350°C. Early in the heating and compressing, phosphate and sulfur precipitate out and are recovered. After less than an hour, approximately 60% of the carbon becomes low-sulfur fuel oil #6. Most of the remaining carbon contacts a catalyst developed at Pacific Northwest National Laboratory (PNNL) and converts to biogas (60% CH_4: 40% CO_2). Alternatively, HTP can skip the oil production and make only biogas. The feedstock can be any carbon source, including: seaweed, microalgae, municipal wastewater sludge, municipal solid waste, grass, leaves, woodchips, plastics, paper, cardboard, food processing waste such as fish waste, etc.

HTP converts nearly all the nitrogen in the feedstock to ammonia. The ammonia and any metals from the feedstock are dissolved in the clear effluent water. Processes are available to recover/concentrate the ammonia into a commercial grade 19% aqua ammonia, ammonium chloride, ammonium sulfate, ammonium bicarbonate. The production of ammonium bicarbonate would scrub the CO_2 from the biogas. Processes also exist to recover metals from the clear water.

HTP's ability to transform any wet carbon source to energy efficiently in relatively small tanks allows for robust seaweed grow-harvest options. There are no concerns for what species or when to feed or harvest the plants. No finicky biologic transformations. Random plastics and other contaminants are not a problem with the proper grinding/cutting equipment.

Genifuel-PNNL performance using HTP to date includes recovering 75-85% of the carbon with parasitic energy loss of 15% of the fuel energy produced while using common materials (mostly stainless steel). The Pacific Islands plan to reduce parasitic energy loss to 12% of the fuel energy produced and reduce equipment capital costs at least 30%. Efficiency will be improved by improving the pumpability of higher carbon-fraction materials (higher % solids). The team will address rheology (the science of matter flow) and tribology (the science of relative motion between interacting surfaces) using concepts from other industries. Capital costs will be reduced by substituting a lining on high-strength steel for solid stainless steel components.

As an example of the yields that can be achieved, a spreadsheet analysis was performed using HTP to produce electricity from Guam Waterworks Authority's wastewater sludge. Using the sludge as a feedstock for HTP, and using the HTP oil and gas as fuel for an engine-generator, over 10,000 MWh/y of electricity could be produced. Guam's other waste feedstocks include waste lubricating oils, foodwaste mixed with plastics, landfill leachate, paint, etc. They may be processed with HTP to produce over 100,000 MWh/y.

HTP is relatively insensitive to the type of feedstock and the feedstock is not dried. As long as it can be pumped through the heat exchanger, all the carbon will become biofuel and some CO_2. And nearly all the nutrients can be recovered. PNNL and Genifuel have run many feedstocks through their HTP process at laboratory scale. Genifuel has completed a demonstration with the Water Research Environment Foundation intermittently processing digested dewatered sewage sludge at rates up to 30 liters/day as of September 2015. Genifuel is ready for first commercial use near 50 wet tons/day. (aka, venturing into the Valley of Death.) Also in September 2015, Genifuel proof tested a 1-ton/day pilot unit for their customer, Reliance Industries Limited, India. Representatives of a Japanese consortium came to check out the same pilot. They want to grow algae for energy on what used to be rice paddies near the failed nuclear power plant.

While HTP's temperature and pressure are high, the product transformations are not strongly exo-or endothermic. This makes it less expensive to safely increase scale, unlike supercritical water processes which

have similar pressure and temperature, but a strongly exothermic reaction. HTP is also quick and simple, compared to the drying equipment for pyrolysis or the fermentation processes of ethanol and bacterial biogas production.

Guam's HTP unit can discover unit can address ways to improve the maximum % solids input. As long as it can be pumped, higher % solids increases the biofuel and product output per volume and output per surface area of the components. That means more energy out with less energy and lower capital cost. Most locations, including Guam, will have a host of candidate feedstocks which can be blended: used fats, oil, and grease sludge to both increase % solids and improve pumpability, but plastics can affect the feedstock while they are melting in the heat exchanger. The issues are similar to the issues of pumping concrete, but the material properties are changing as they increase in temperature.

This commercial demonstration will dramatically affect the economy of many islands, and introduce similar integrated waste-to-energy+water+food operations throughout the United States. For example, data shows that wastewater sludge is only about 8% of the total wastes available in many locations. Therefore the power generation described above could potentially be increased by an order of magnitude. Since the wastes have a significant cost for disposal, the combination of biofuel-generated power and avoided cost for waste disposal would dramatically improve the economy and environment on Guam and many other locations.

Like many islands, Guam has exceedingly high fuel and fertilizer costs, while struggling to reduce damage to coral reefs from nitrogen in wastewater effluent. These issues are compounded by limited land space for living, agriculture, and fresh water storage. Existing agriculture-based biofuel, solar, and wind energy options do not address the waste and water issues and are vulnerable to typhoons.

The United States Military is putting stress on Guam's resources by moving military bases from Okinawa to Guam. Meanwhile, tipping fees at Guam Solid Waste Authority's (GSWA) new landfill at $170/ton are among the highest in the world. The Guam Water Authority pays over a $1 million per year to landfill wastewater sludge. The U.S. EPA requires additional cleaning of Guam's wastewater prior to ocean discharge, which will increase sludge production and expense. The Guam Power Authority GWA imports oil and is planning to import liquefied natural gas for electricity production. The majority of the wastes produced and electricity consumed is from and to U.S. military bases, service members, and employees.

All the above plus the Genifuel Corporation, PRD Tech, the University of Guam, and Ocean Forests have established communications with a previous grant proposal. ARPA-E could trial an incentive for performance relatively quickly by informing the agency managers of the incentive. An appropriate incentive to open the discussion is $50/barrel for the first 100,000 barrels produced and $0.50 per therm for the first 2,000,000 therms. ARPA-E would need to have about $5 million in escrow over ten years to make the payments with this incentive level and project size.