Executive **Summary**

A highly disruptive technology for converting all water resource recovery facility organics into resources

Genifuel Hydrothermal Processing Bench-Scale Technology Evaluation Project (LIFT6T14)

The Central Issue

In recent years, there has been a concerted effort to develop processes that convert organic biomass to usable fuels. The reasons are many and range from decreasing reliance on imported fossil fuels, to providing new markets for domestic farmers, to improving clean up and extracting value from materials previously viewed as wastes. Most of the processes are either biological or thermochemical in nature. Hydrothermal processing (HTP) is a thermochemical process where water is used as the medium for breakdown of organic matter into relatively simpler chemicals at elevated temperatures and pressures. This study sought to determine whether HTP technology has potential for treating wastewater solids.

Context and Background

Wastewater treatment sludge is a feed type that should be particularly suited for HTP processing due to its high water content and rich organic matter. HTP has the potential advantages of not only reducing the amount of solids for disposal, but also of being able to convert organic matter in the sludge to fuel that can be used or sold. The fuel produced has further potential value with respect to carbon/greenhouse gas (GHG) emission offsets due to its displacement of fossil fuel equivalents. When used for primary or secondary sludge, HTP has an additional advantage of augmenting or potentially replacing biological digestion, such as anaerobic digestion.

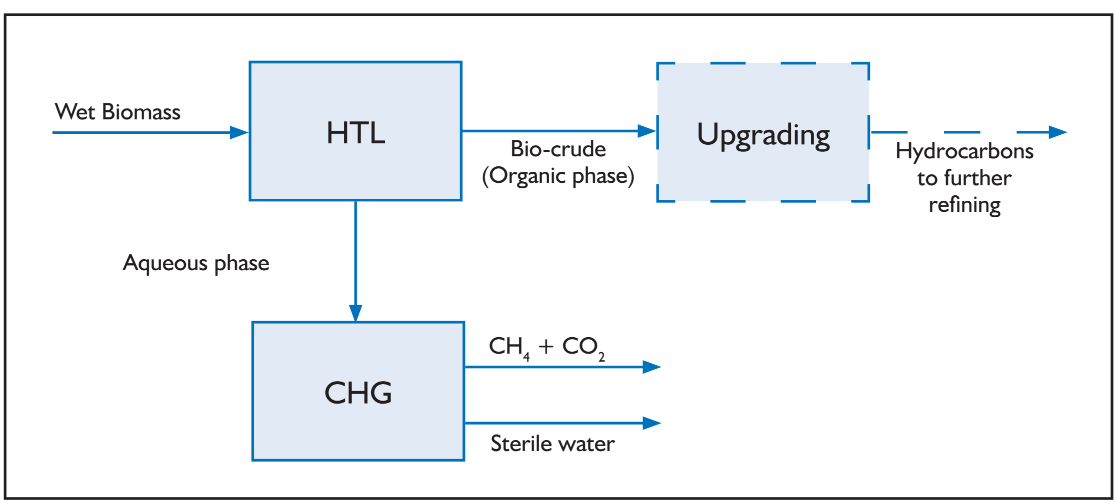
HTP eliminates the need (and significant expense) for drying the feed as required in other thermochemical processes such as pyrolysis and gasification. Hydrothermal liquefaction (HTL) and catalytic hydrothermal gasification (CHG) are two separate and specific forms of HTP that operate at intermediate temperatures and pressures just below the thermodynamic critical point of water (i.e., subcritical). HTL produces a liquid organic phase product referred to as biocrude and CHG produces a methane-rich product gas. Both the biocrude and gas mixture can be used as fuels. The Genifuel HTP technology includes versions of both HTL and CHG processes that were developed at the U.S. Department of Energy's (DOE) Pacific Northwest National Laboratory (PNNL) over the past 30 years.

This report describes the results of HTL and CHG bench-scale tests performed at PNNL on three different types of wastewater solids: primary sludge, secondary sludge, and post-digester sludge. In these bench-scale tests, the specific configuration of the equipment used and certain other aspects (e.g., energy requirements) do not necessarily reflect that which would be installed at a water resource recovery facility (WRRF) at full-scale. However, the chemistry, product yields, and feed behavior characteristics, which are critical to assessing whether the technology can be successfully applied to wastewater solids, is expected to be representative.

Findings and Conclusions

After performing several proof-of-concept bench-scale tests documented in this report, the research team believes that the technology has potential for treating wastewater solids. Accordingly, further evaluation of the Genifuel hydrothermal processing system at a larger scale is recommended. This recommendation is made both to address certain issues that arose in the bench-scale testing and also to obtain further data on economics, energy consumption, and long-term operating behavior in a system more representative of what could be installed at an operating utility.

This research quantified the amount of biocrude oil and methane gas produced from representative sludge feeds by HTP, determined a wastewater sludge concentration that can be successfully pumped without



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interruption during normal operation, conducted a mass balance closure for the process, and assessed areas of future work based on test observations and results. The project included collaboration and participation from 10 utilities, U.S. EPA, DOE, and subject matter experts.

Management and Policy Implications

HTP could deliver new income from resources recovered from solids and provide a new approach for solids management, in particular for areas where regulations and restrictions on land application or disposal are tightening.

HTP converts organic material into biocrude oil, natural gas, or both, with potentially more than 99% conversion of organics. HTP uses the same processes which form fossil fuels, (heat, pressure, time, and water), but amplifies these conditions so the conversion occurs in a much shorter timeframe. This technology is specifically designed for wet feed stocks. The byproduct is clear, sterile water. The process has been successfully tested at small scale with a large variety of feed stocks, but has only been minimally tested with sewage sludge or biosolids.

Biocrude from the HTL test with primary sludge feed.

Related WE&RF Research

Project Title	Research Focus
A Guide to Net-Zero Energy Solutions for Water Resource Recovery Facilities (ENER1C12)	Aids WRRFs in moving toward "net-zero" energy use through near-at-hand practices and technologies in the areas of energy conservation, demand reduction, and enhanced production.
Triple Bottom Line Evaluation of Biosolids Management Options (ENER1C12a)	Uses a TBL approach to evaluate common wastewater solids management technologies and processes relative to their potential for long-term sustainability, including energy neutrality.
Guidelines for Utilities Wishing to Conduct Pilot-Scale Demonstrations (ENER11R13)	Synthesizes sector knowledge to simplify demonstration project processes so that WRRF decision makers are better able to consider new technologies and feel confident in their decision making.
State of Knowledge and Workshop Report: Intensification of Resource Recovery (IR2) Forum (TIRR1R15)	Presents the possibilities for process intensification of resource recovery that are available through new technologies including biosolids to energy, and identifies critical research or demonstration needs.

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