BCWWA
BC WATER & WASTE ASSOCIATION

FALL 2015

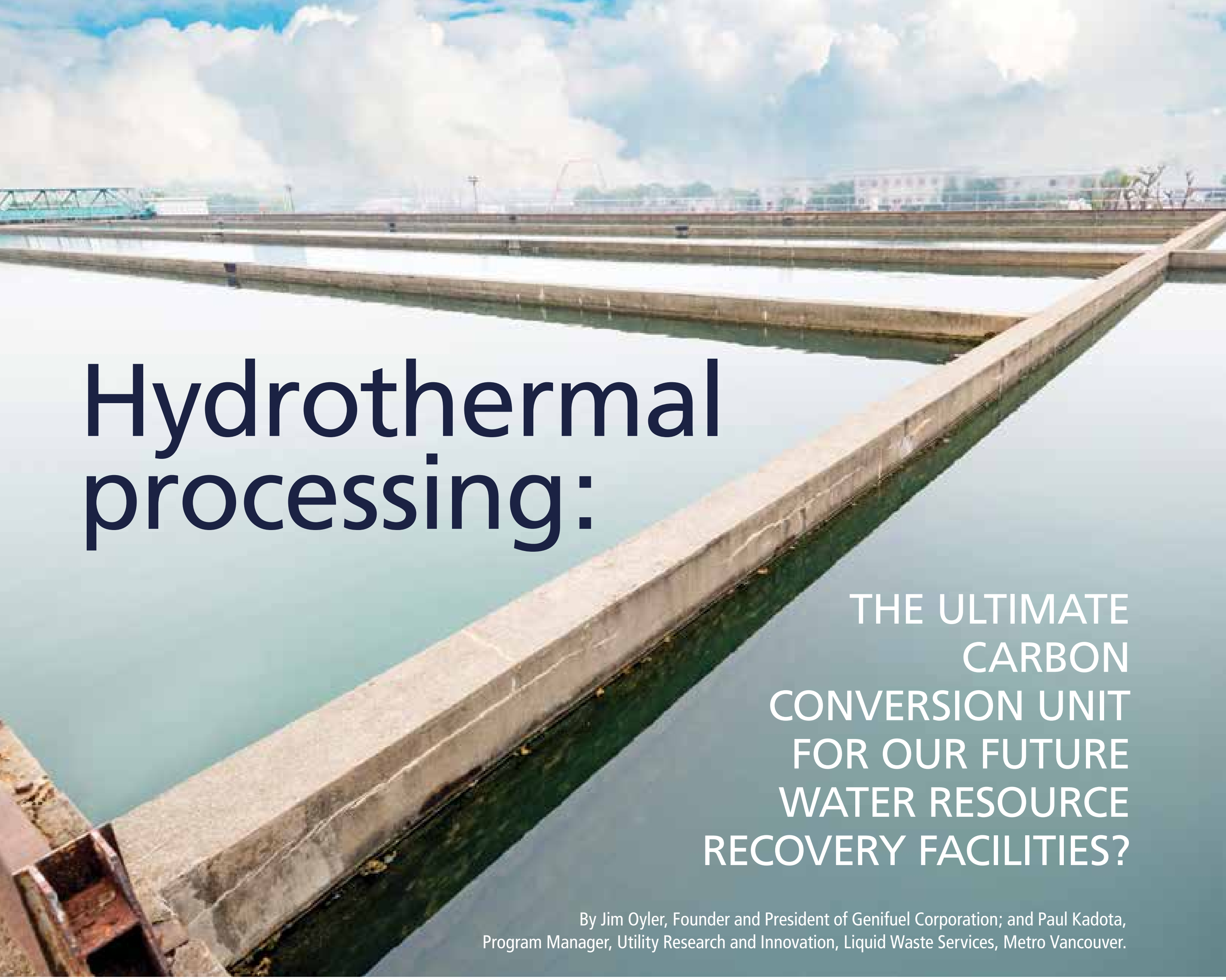
VOLUME 24 NUMBER 3

watermark

Emerging Technology

Mia Edbrooke and Sarah Partanen (Metro Vancouver) undertaking preliminary dewatering of wastewater sludge at Metro Vancouver's Annacis Research Centre in preparation for hydrothermal processing tests.

PM# 40065075
Return undeliverable Canadian addresses to lauren@kelman.ca



Hydrothermal processing:

THE ULTIMATE CARBON CONVERSION UNIT FOR OUR FUTURE WATER RESOURCE RECOVERY FACILITIES?

By Jim Oyler, Founder and President of Genifuel Corporation; and Paul Kadota, Program Manager, Utility Research and Innovation, Liquid Waste Services, Metro Vancouver.

There's never been a more exciting time to be in the wastewater industry than now, because of the high level of activity occurring in terms of caring for our waterways, being more efficient, reducing our carbon footprint, and recovering more resources than ever from our waste streams. The application of emerging technologies is an essential strategy to reaching goals of providing a more sustainable liquid waste service. For technology developers, the road from conceptualization, to proof-of-concept, to full-scale installation can be a long one, but the right technology that addresses key issues could result in a game-changing shift for the entire industry. Current examples of how instrumental technology can be for the wastewater treatment industry include:

1. adding thermal hydrolysis to anaerobic digestion for better solids reduction; and
2. capitalizing on the anammox bacteria's ability to efficiently neutralize ammonia toxicity.

Another technology that has the potential to provide a quantum leap in value for the wastewater industry is hydrothermal processing (HTP). Over the last several decades, the US Department of Energy (DoE) has been developing HTP as a means to convert wet biomass into biocrude oil and biogas. The DoE has several patents on the technology and their bench-scale process established at their Pacific Northwest National Laboratory has achieved nearly 100% organic carbon conversion of algal biomass to biofuels. Attention is now turning to HTP research using wastewater sludges as the feedstock. Under the Leaders Innovation Forum for Technology (LIFT) Program, jointly run by the Water Environment Federation (WEF) and Water Environment Research Foundation (WERF), testing of HTP using wastewater sludges as input is currently underway. If wastewater sludges can yield results similar to that of algal biomass, HTP may develop into the technology that displaces anaerobic digestion (AD) as the process of choice for solids reduction and biofuel production. In comparison, AD typically achieves organic carbon conversion rates of 50% to 60% with wastewater sludges, leaving 40% to 50% behind as biosolids.

TECHNOLOGY

Unlike AD, which is a biological process, HTP is a thermo-chemical process operating under high pressures and temperatures, but does not involve combustion or drying. HTP mimics the geological processes that produce conventional oil and gas where organic materials are held under pressure and heat for millions of years, eventually converting the organics to hydrocarbons.

Click here to return to Table of Contents

The DoE has developed HTP as a two-stage process:

1. hydrothermal liquefaction (HTL); and
2. catalytic hydrothermal gasification (CHG).

Stage 1 takes as input wet biomass feedstocks at between 15% and 35% solids and applies pressure and heat (about 200 bar and 350°C) to produce a mix of biocrude oil and water with a small amount (less than 1%) of precipitate. The precipitate is a clay-like material consisting of phosphates and sulfates. The liquid mix undergoes an oil and water separation process to produce biocrude and HTL effluent water. The biocrude can be refined using conventional methods into liquid fuel products or used as a bunker oil alternative. The HTL effluent water, still containing the remaining organic fractions, is passed to Stage 2, which involves a gasification process (also at 200 bar and 350°C) using a catalyst. The output stream of CHG undergoes a gas and water separation process to produce a CHG gas and sterile water. CHG gas composition is about 65% methane and 35% carbon dioxide with low sulphur and siloxane content. The sterile water can be clear with sufficient nutrients for use as a liquid fertilizer containing ammonia, silica, sulphur, and other inorganic metallic or alkali salts with a chemical oxygen demand (COD) of about 200 mg/L.

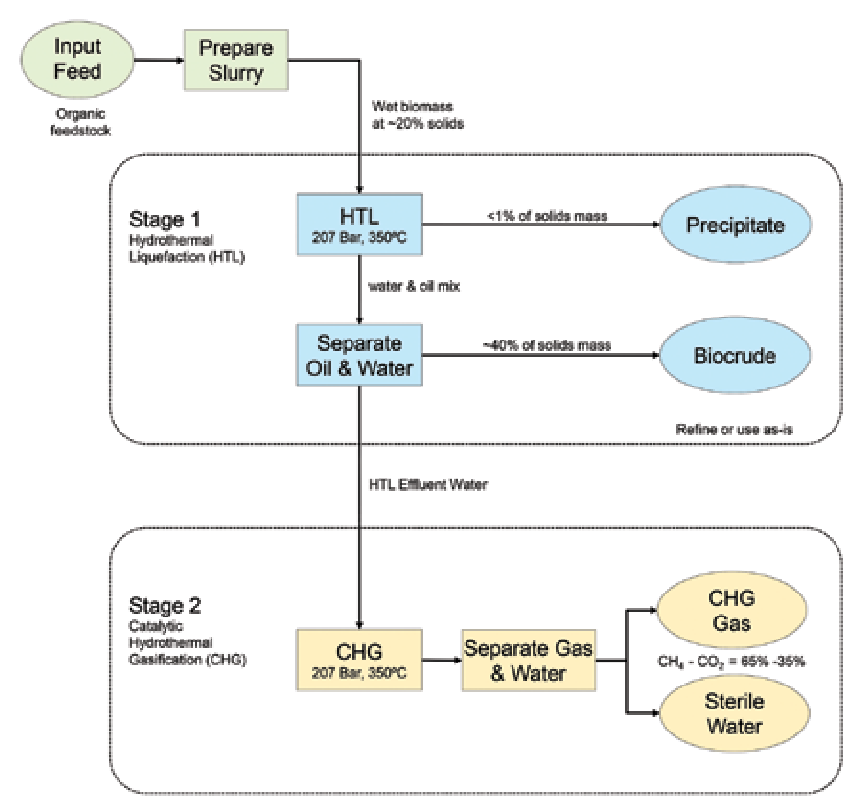
From the two-stage HTP process, the produced fuels in the form of biocrude and methane account for about 80% of the incoming carbon, which is a major advantage over AD that converts about 35% of the carbon to fuel. The energy efficiency goal for a full scale HTP system is for its consumption equivalent of less than one-quarter of the energy it produces. The likelihood of achieving this goal is deemed high, given that comparatively HTP does not expend any energy drying solids or involve combustion of the feedstock from which the biofuel is being produced. Figure 1 shows the complete HTP concept.

RELEVANCE TO RESOURCE RECOVERY FACILITIES

The application of HTP for wastewater treatment has tremendous potential and numerous benefits, including:

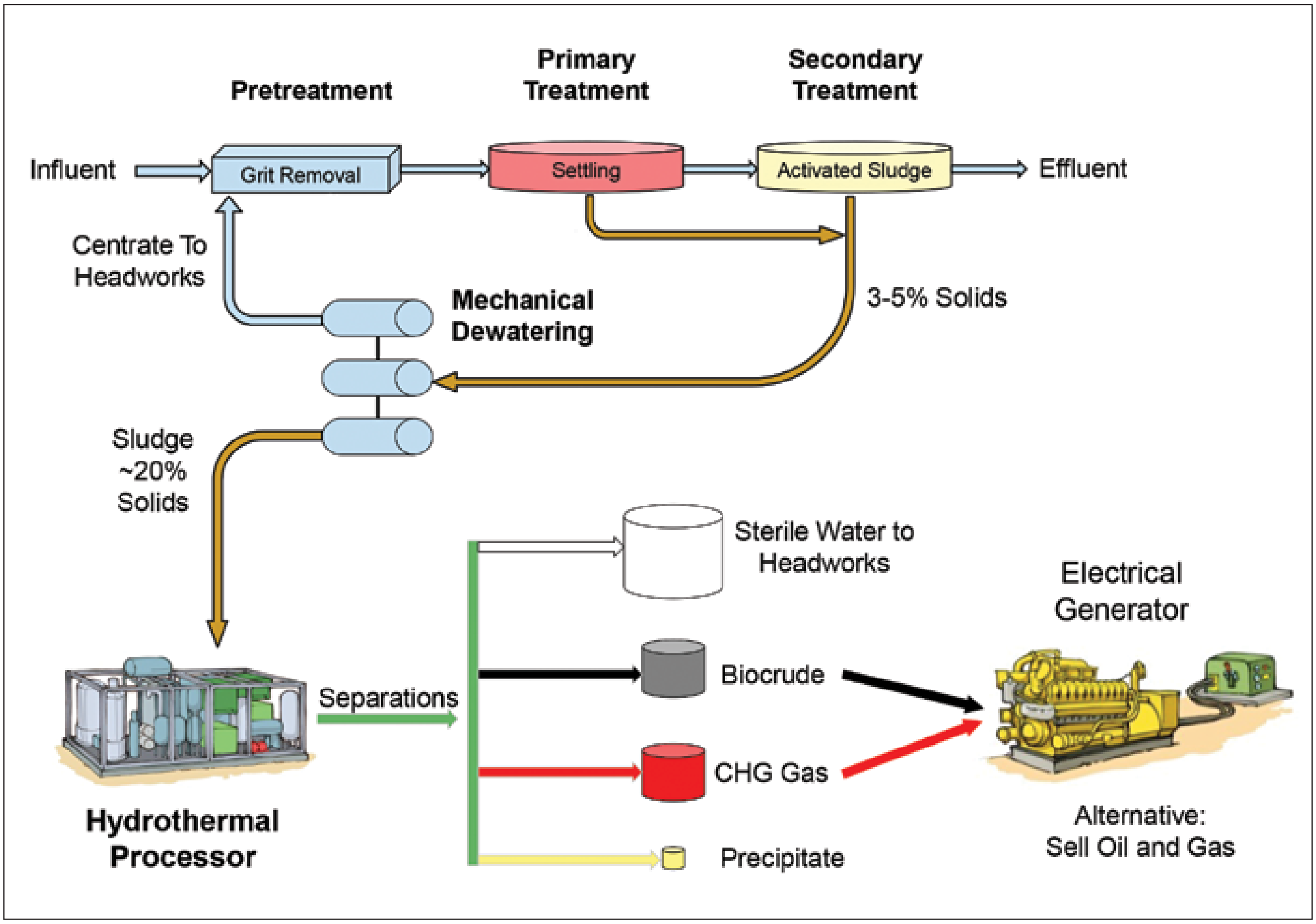
- HTP offers near complete organic carbon conversion, which could be the foundation for the lofty goal of producing zero biosolids from a wastewater treatment facility, with associated cost savings. Many utilities are challenged to find good alternative use for biosolids and HTP could become a strong candidate for future facilities.
- Compared to 15 – 30 days for solids reduction with AD, HTL works in less than one hour, meaning a much smaller vessel can be used, resulting in a smaller footprint and presumably lower capital costs.

FIGURE 1: Two-stage hydrothermal processing



Click here to return to Table of Contents

FIGURE 2: HTP configuration at a wastewater treatment facility of the future



- Apart from the sterile water, the liquid and gas biofuels from HTP represent the biggest outputs of the process and displaces fossil fuels. The biofuels can be used on-site or sold to the open market.
- Energy balance for HTP using algal feedstock has been excellent, with numbers that outperform AD, incineration and drying technologies. HTP is a significant energy production proposition and could be the strategic cornerstone for achieving energy neutrality or becoming net energy positive at a water resource recovery facility.
- Many emerging substances of concern are organic contaminants and these are likely to be broken-down during HTP's high pressure and temperature processes, which should minimize concerns.

HTP processes organics in a wet state, as does AD. While wastewater sludges are typically thickened to 3-5% solids for AD, HTP runs more efficiently when the input feedstock is closer to 20% solids. This means thickened wastewater sludge would need to be mechanically dewatered ahead of the HTP process. Compared to an AD configuration, an HTP configuration will require more dewatering capacity. As well, the high operating pressures and temperatures of HTP will require a steamfitter/pipefitter holding a Certificate of Qualification with Red Seal Endorsement be on hand. But HTP's high barometric and thermal operation gives it the competitive advantage over many other technologies as heat energy is not expended to vapourize water[1] and the superheated water becomes a highly-effective solvent and reactant for a number of processes involved in transforming feedstock carbon to a biofuel. Figure 2 illustrates how HTP could be implemented at a water resource recovery facility.

RESEARCH ACTIVITIES

Over the many years of development, the DoE has tested HTP with a wide range of organic feedstocks from manures to pulp sludge, grasses to sawdust, as well as food and chemical wastes. Each level of success has led to allocation of additional resources to scale the HTP system several times from a small micro-reactor to most recently a 1,000 L/d pilot-scale system for the fledgling algal biofuel industry. All of these systems have been configured for continuous operation, not batch operation, to enable a better path towards a full-scale system. In 2010, Genifuel Corporation licensed the HTP technology and has been further developing the process with DoE to realize its commercial potential.

The current research and development initiative focuses on wastewater sludge as the feedstock, for which there has been limited HTP testing. WERF, through its LIFT Program is sponsoring the bench testing of HTP using wastewater sludges as input. The LIFT HTP project involves the collaboration of several parties including:

1. WERF – sponsor and owner of research valued at nearly $300,000.
2. Leidos – retained by WERF as lead researcher and project manager.
3. US Department of Energy – monetary contributor, HTP patent holder and developer, host to bench tests at their Pacific Northwest National Laboratory.
4. Genifuel – licensee of DoE's patented HTP technology and co-developer.
5. Metro Vancouver – selected to supply wastewater sludge feedstocks.
6. Other participants – monetary contributors by US EPA and several WERF-member wastewater utilities.

Click here to return to Table of Contents

The LIFT research project involves testing of three different wastewater feedstocks:

1. thickened screened primary sludge (TSPS);
2. thickened waste secondary sludge (TWSS); and
3. post-digester sludge (biosolids).

For each feedstock, the research objectives are:

- Determine the solids concentration (% solids and viscosity) that can be pumped through the HTP system;
- Quantify the yields of biocrude oil and methane gas produced;
- Characterize the composition of all inlet and outlet streams; and
- Verify the mass balance on carbon and other relevant elements.

The research plan was set in the spring and physical activities began in May. The sludges were prepared at Metro Vancouver's Annacis Research Centre (Figure 3), then delivered to DoE's Pacific Northwest National Laboratory in Washington State, where the bench scale tests were performed. Data from the project will be assessed and performance summarized in a WERF report later in 2015 or early 2016.

If good results are achieved, this will indicate the viability of using HTP for wastewater sludges and builds a case for subsequent development for this application. The development road from bench scale to pilot scale, to full-scale operation is still years away, but each successful milestone achieved brings this concept closer to reality.

Not all facilities can capitalize on the most recent thermal hydrolysis or nitrogen removal schemes, but all treatment facilities must deal with solids, which HTP promises to completely address. Compared to the large pool of emerging wastewater technologies, HTP could be the game-changer that actuates the vision of all water resource recovery facilities to readily become net energy positive and output zero biosolids.

FIGURE 3: Mia Edbrooke and Sarah Partanen (Metro Vancouver) undertaking initial wastewater sludge dewatering at the Annacis Research Centre

ABOUT THE AUTHORS

James R. Oyler is the Founder and President of Genifuel Corporation. Formed in 2006, Genifuel develops and manufactures hydrothermal processing systems to produce biofuels from wet organic materials, especially wet wastes. Mr. Oyler holds more than twenty patents issued or pending, as well as exclusive licenses to other patents for hydrothermal processing. Earlier, he held senior positions in energy consulting and corporate management leading to twelve years as CEO of a publicly-traded company.

Paul Kadota, M.A.Sc., M.P.A., P.Eng., is the Program Manager of Utility Research and Innovation, Liquid Waste Services at Metro Vancouver.

Paul has over 25 years of experience in municipal engineering including the set-up of water and sewer network models, developing liquid waste management plans, collection and treatment engineering, undertaking infrastructure lifecycle evaluations, laying-out annual and long-range capital plans, managing biosolids recycling activities, as well as identifying energy and materials recovery opportunities, and researching emerging technologies.

REFERENCES:

1 The energy needed to vapourize water is more than six times greater than the energy to raise its temperature from ambient to just below the boiling point.

Click here to return to Table of Contents