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Food waste: a new fuel for CHP in the US

Anaerobic digester facility
Source: Harvest Power

Increasing volumes of food waste are being converted, via digestion, into biogases to fuel CHP schemes across North America, reports Ed Ritchie, who finds that food waste can be an important fuel source, both when used alone and when mixed with other waste streams.

Is food waste on a fast track as a prime resource for on-site CHP power in North America? Indeed, the trend is gaining momentum, thanks to the growing popularity of anaerobic digestion and market drivers that include government support, investor confidence and, of course, the overriding race to produce energy in the most sustainable manner possible. Then too, it doesn't hurt that food waste, typically lumped into the term municipal solid waste (MSW) by the professionals, and garbage by the rest of us, is in abundance throughout the continental US and Canada.

In the US, for example, the latest figures from the Environmental Protection Agency (EPA) estimate that, in 2009, Americans generated about 221 tonnes of trash, or 1.97 kg per person per day. In Canada, it is a lower overall volume, but the daily stats are close to the same. Food waste typically accounts for about 13–30% of MSW content, depending on the locale.

But no matter the composition, historically, the vast majority of MSW is disposed of by hauling it off to a landfill site. Not surprisingly, the transportation and associated costs of landfills are rising, and so too are the number of communities voicing opposition to them. When landfills are approved, they typically get sited far away from the cities they serve, and that raises fuel and transportation costs.

WASTE-TO-ENERGY ON THE RISE

The rise of MSW costs and a nationwide anti-landfill sentiment have spurred rapid growth of large-scale

waste-to-energy plants across the US and Canada. In fact, according to Pike Research of Boulder, Colorado, worldwide revenues from waste-to-energy systems are expected to grow from US$3.7 billion to $13.6 billion, by 2016. But these use some form of incineration, and have drawbacks such as centralized locations that bring high truck traffic, and ash that must be disposed of. They also lack the efficiency benefits of cogeneration for on-site power because of their energy is fed into the utility grid.

That kind of scenario does not offer much appeal to sustainability-minded constituencies such as universities, food related industries and, in general, most businesses concerned with running an environmentally responsible operation. However, we have just described the ideal customer base for CHP and anaerobic digester system manufacturers. Especially if those manufacturers have a track record of success in Europe, and view North America as a territory for substantial growth –as does the CHP system manufacturer 2G-Cenergy.

'We will see fast development of organic waste for on-site combined heat and power projects,' says Michael Turwitt, president and CEO of 2G-Cenergy Power Systems Technologies of Orange Park, Florida. 2G-Cenergy refined its CHP systems in more than 1500 projects across Europe, and now has six projects in the US. All but two use anaerobic digestion of food waste and other organic waste to supply biogas.

'Waste needs to be deposited in landfills and municipalities and politicians don't like to see more landfills,' adds Turwitt. 'Instead of taking tonnes and tonnes of food waste or other organic waste and just dumping it in the landfill it can be used for anaerobic digestion and it makes a lot of sense.' Turwitt points out two projects, a brewery and a university that illustrate his case.

First is the Matt Brewing Company, Utica, New York. Brewing takes plenty of process heat and uses hops and other food related products to make beer. Matt Brewing contracted with 2G-Cenergy to supply a high efficiency biogas CHP unit for the company's wastewater treatment project. The 400 kW biogas CHP module has an electrical efficiency of 39% and delivers 556.5 kW/h of thermal energy. 2G-Cenergy also supplied a complete gas treatment system, including cooler, dryer/dehumidification, and the H2S removal system, plus controls and switchgear, and utility interconnection.

BIOGAS WITH CLASS

The second example is a unique project that lifts the sustainability profile of a university and the surrounding community. It is at the University of Wisconsin (UW), Oshkosh, where the ultimate goal is for a carbon neutral campus.

The new CHP system has a 370 kW generator designed to produce 4200 MWh of thermal energy and 3100 MWh of electricity annually. The system relies on a 2G Optimus 370BG unit, built by MAN Engine, Nuremberg, Germany. 'This type of power plant has been proven in Europe for many years,' says Turwitt. 'We are actually cleaning up the gas before it goes into the combustion process but of course the cleaning process is by no means a necessary purification because our engines can take a much higher level of the corrosive elements in biogas.'

The 2G systems are 'turnkey' modular units, and customers can scale up with additional modules to boost power. In the university's case it is a convenient option because a city wastewater treatment plant is a neighbour and currently flares excess biogas from its digester during the summer months. A simple pipeline could bring the gas to the CHP system to boost heat and electricity output, with the possibility of excess electricity to sell to the grid. Even without a contribution from the wastewater plant, the project is expected to pay for itself in about six to seven years.

The Oshkosh site marks the debut of North America's first dry anaerobic bio-digester. It is supplied by

BIOFerm Energy Systems of Madison, Wisconsin. The company has 28 operating installations worldwide, with more under construction.

2G-Cenergy 'Aginator' CHP unit at VanDyk Dairy Farm
Source: 2G-Cenergy

According to Caroline Chappell, an application engineer at BIOFerm, it is the same biological fermentation as wet anaerobic, but the difference is that the feedstock has less moisture content and that eliminates the need for a slurry, which is mechanically intensive. Instead, once the biomass is delivered the chamber doors are sealed and a percolate solution sprinkles down from above, then it is recycled and sprinkled on top again. In previous projects, BIOFerm has found that wood waste and yard waste combinations can also yield good results as a feedstock, but woody biomass with a lignin structure does not break down as well.

Chappell notes that most of BIOFerm's digesters provide fuel for CHP installations, and that is a benefit because the process requires a temperature in the chambers of about 40°C, throughout a cycle that takes 28 days. Negative pressure is maintained in the chambers, with air treated by a biofilter. The Oshkosh system has four digester chambers, each with a processing capacity of 1814.4 tonnes/year.

According to Dr Gregory Kleinheinz, director of Environmental and Public Health Microbiology at the university, food waste is the primary feedstock for the digester. 'Food makes up the majority of our feedstock and we've taken the approach that we want a good diversity of feedstock but we want to take all the food waste and use that first,' says Kleinheinz. 'But we aren't taking any meat products because our facility is located in the middle of a city and whether or not it happens we don't want to be perceived as a source of odour or vermin.'

CITIES AND RESTAURANTS PITCH IN

The digester will consume more food waste than is created on campus, so additional feedstock from the city's MSW and local businesses has been tapped, plus biomass such as yard waste. Beyond the benefits of a renewable fuel source and the efficiency of CHP, Kleinheinz sees a distinct role for the bio-digester and CHP system as a new resource in providing education about sustainable technologies. The university will do biomass testing on materials to determine their potential to generate methane, and provide an operational laboratory for other universities and organizations interested in the process.

The project supports the university's goal of using only renewable energy by 2025, as part of its Clinton Climate Commitment. Tom Sonnleitner, UW Oshkosh vice chancellor for Administrative Services, adds that sustainability is one of the four legs of the plan for the school, and that students are making a choice for schools where sustainability is a driving force. Oshkosh has a sustainability director, and the operations plan has more than 125 sustainability related goals.

Universities in both the US and Canada have played a major role in the growth of the sustainability movement in North America. And they are key players in the field of anaerobic digestion. For example, Professor Ruihong Zhang began researching anaerobic digestion in the late 1990s at the University of California at Davis (UC Davis). In 2006, Zhang and UC Davis launched the Biogas Energy Project, a campus facility designed to digest 7.26 tonnes of food waste per week.

TAKING THE STING OUT OF ONION WASTE

Zhang's system proved successful and quickly found a customer in Gills Onions of Oxnard, California. Gills grows and processes onions, and in a typical week delivers millions of pounds of cut onions to restaurants, grocery stores, and specialty food producers. Food waste was a major problem. Leftover tops, tails and skins, make up about 40% of the onion waste, and Gills had 680,388.6 kg per week that they paid to truck to open fields for ploughing back into the soil.

2G-Cenergy CHP unit outside BioFERM digester building
Source: 2G-Cenergy

With the help of Zhang, in 2009 Gills launched its 'Advanced Energy Recovery System', a waste-to-energy process that converts 100% (about 136,077.7 kg per day) of onion waste into renewable energy and cattle feed, while reducing greenhouse gas emissions. The system extracts juice from the waste for treatment in a high-rate anaerobic reactor. Biogas from the digester fuels two 300 kW fuel cells that power the onion processing plant, and save about $700,000 in annual electrical costs. Gills sells the leftover onion pulp as cattle feed cake and saves about $400,000 per year on the cost of hauling the onion waste to farm fields.

Cost savings from on-site energy and other savings are expected to return a full payback of the $10.8 million investment in less than six years.

Six years would be considered as a commendable timetable for most projects in the energy industry, but there is still an initial investment in all the projects described so far. However, it is possible to forego upfront

investing and set up the same kind of power purchase agreements that have advanced the growth of large-scale photovoltaic projects, according to Paul Sellew, CEO, Harvest Power. 'We provide the capital and own and operate the system,' Sellew explains. 'When you look at everything such as tipping fees, the transportation costs and energy and fertilizer, they add up. Harvest saves money on those things and gives customers a whole series of benefits from the sustainability standpoint as well.'

The organic cycle Source: Harvest Power

Sellew describes Harvest Power as the largest manager of organic waste in Canada, and its Richmond, British Columbia facility manages a majority of the biomass such as grass and brush, along with food waste, in the lower mainland of British Columbia. The territory includes the Vancouver region, serving about 2.5 million people, while creating 3 MW of CHP sold to the grid and, finally, there is a large-scale composting operation.

The next project for Harvest Power is a commercial-scale, high solids and anaerobic digestion facility in London, Ontario. It will produce biogas for a 6 MW CHP system, under a long-term contract with BC Hydro to provide renewable energy. Thermal energy is used on-site and after the 14-day anaerobic process finishes, the company sells the residual material to its composting lawn and garden and agricultural customer base.

'We want to extract the maximum value out of these organic feedstocks and that includes the renewable energy potential,' says Sellew. 'Biogas is a very good fuel and in a CHP unit you can operate at close to 80% efficiency, with 40% electric and 40% thermal capture. Hook that up to the grid and you have a distributed form of renewable energy.'

INVESTORS JOIN THE PARTY

Investor confidence was mentioned as one of the drivers in this sector, and Harvest Power provides a good example. In May 2011, the company announced that it had received $6 million from SAM Private Equity (a division of the Rabobank Group, focused on sustainability investing, based in Zurich, Switzerland). The sum added to a previous round of $51.7 million of investment from backers that include Waste Management, Kleiner Perkins and Munich Venture Partners.

The capital resources provide a foundation for carrying out projects at a wide variety of industries and institutions. Says Sellew, 'On-site CHP at a university or a brewery makes a lot of sense because one of the great things about anaerobic digestion is that it's a free biological process. You don't need enzymes or catalyst and less than 5% of the energy is used for the process so it's a very productive high energy yielding technology. We clearly are very focused on on-site opportunities where there is an organic waste generator that's also a consumer of power.'

Harvest Power is not the only commercial scale anaerobic digestion operator in Ontario. Organic Resource Management Inc (ORMI) of Woodbridge, Ontario, is an organics recycling company that has provided liquid residuals collection services to the food industry sector for more than 20 years. But 2010 was a watershed year for the company. At the beginning of fiscal 2010, approximately 25% of ORMI's residuals were being used by anaerobic digester partners as feedstock to produce renewable energy. By the end of the year, the tally grew to about 80%.

For example, ORMI's first digester partner, Fepro Farms, Cobden, Ontario, saw its system operate at full capacity throughout 2010, allowing for the sale of electricity to the grid in excess of 90% of the time. Fepro has about 300 animals plus 140 milking cows. The cost of their project was about $250,000 and the owners estimate a 10-year payback, while saving between $1000 and $2000 in monthly power bills. Though the numbers are not staggering, the project demonstrates that the technology is available to both large and small operations. In fact, the success motivated Fepro to take further advantage of Ontario's feed-in tariff programme by adding a 196 kW photovoltaic solar system to complement the 500 kW bio-digester.

DISTRIBUTION NETWORKS ADD VALUE

A widespread fuel or feedstock distribution network can be a benefit to on-site energy production, and the same holds for anaerobic digestion. In July 2010, ORMI bought property in Woodstock, Ontario, to develop its first combined liquid and solid food waste-to-renewable energy transfer station. The station adds the ability to receive solid food waste from collected industrial, commercial and institutional sources, plus separated green bin organics. And it could be a boost to on-site CHP, but there is one caveat, according to Charles Buehler, chairman and CEO, ORMI.

'There has been a lot of work going on with on-site CHP but biogas and digesters need big pieces of real estate or they need to be attached to either a very large food processing operation or farm,' says Buehler. 'But there is an opportunity to have them stand alone in an urban area and a couple of those are planned in Ontario.'

In the meantime, Buehler believes that the industry can look to another revenue source to boost its staying power – upgrading biogas to liquefied (LNG) or compressed (CNG) natural gas. 'Though we do see biogas used in a generator it can be upgraded to natural gas and there are opportunities to take CNG and operate a vehicle fleet,' he said.

Those opportunities could provide a substantial boost to an already highly efficient biogas-fed CHP system. According to Edgar and Associates, Chattanooga, Tennessee, financial and engineering consultants in mining, transportation and fossil fuel industries, developing an anaerobic digestion facility using food and green waste to generate biomethane for CNG could achieve an 84% reduction in the cost of fleet operations.

Using biogas to create LNG is also possible. In fact, one of North America's largest MSW treatment and haulers, Waste Management, recently commissioned its 1000th natural gas truck. The company is the largest owner and operator of natural gas burning heavy duty trucks in North America, and one third of its fleet runs on LNG derived from organic waste delivered and processed at the Altamont Landfill located in Livermore, California. The company also has 17 CNG and LNG fuelling stations at its facilities, and more under development. Waste Management has many landfill biogas energy projects that sell electricity back to the grid.

SATISFYING RENEWABLE PORTFOLIO STANDARDS

These projects can help to satisfy a state's Renewable Portfolio Standards, as is the case with a new project in Moncks Corner, South Carolina. The South Carolina Public Service Authority, an electric and water utility,

recently agreed to a 20-year power purchase agreement with W2E-Organic Power, Columbia, South Carolina, to construct a 1.6 MW generation plant fuelled by biogas from food waste, grease, food processing waste and wastewater sludge.

Ultimately, these examples demonstrate a broad base of support for biogas as a fuel for electricity generation – and that provides multiple markets for companies like 2G-Cenergy, which, not surprisingly, has a landfill biogas project in the state of Mississippi that is designed to feed electricity to the grid.

As the projects and markets continue to grow, the industry's profile as a provider of renewable energy grows with it. And so the potential is high for locations such as Oshkosh, where CHP projects fuelled by food waste are sited downtown, and regarded as beneficial contributors to sustainable communities.

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Food waste, lost energy, lost money

Food waste is a costly problem in the US, according to Dr Timothy Jones, a professor at the Bureau of Applied Research in Anthropology, University of Arizona, Tucson. Jones says that 14% of food purchases end up as garbage. About 14% of the tossed food never left the package and wasn't even out of date. The cost to the economy in 2006 was $43 billion.

Jones headed the Food Loss Study for the US Department of Agriculture and also found that Americans are unaware of their habits when wasting food. Nor are they aware of the wasted energy in lost food, adds mechanical engineering professor Dr Michael Webber, Cockrell School of Engineering, University of Texas at Austin. In a recent study Webber found that the US could save 2% of its total energy consumption by ending food waste. The equivalent in oil savings amounts to a staggering 350 million barrels.

But the US is not alone. The United Nations Food and Agriculture Organization published a study that says about 1.3 billion tonnes of the entire world's food production goes to waste. Not surprisingly, it is the industrialized nations that account for the majority of the waste. The study suggests that good uses should be found for food that would otherwise be thrown away. Does energy recovery through anaerobic digestion and CHP qualify?

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