Cogeneration technology helps landfills reduce wastewater management costs

A cogeneration solution treats challenging landfill leachate using waste heat from a power generation facility to evaporate industrial wastewater volumes up to 97 percent. **Earl Jones** of Heartland Water Technology explains how the process works.

More than 60 percent of landfills dispose of their leachate by transporting it to municipal wastewater treatment plants. Factors driving up costs of leachate disposal and the costs of managing a landfill include trucking costs as well as municipal operators' growing reluctance to accept leachate due to the challenges leachate brings to their treatment processes.

Many landfills over the past two decades have developed valuable waste-to-energy projects, generating renewable energy from the biogas created through the decomposition of organic materials within the landfill. The vast majority of these biogas-to-energy projects are simple cycle power generation configurations, meaning that the ample energy available in the hot exhaust produced by the power generation equipment is vented to atmosphere and not used beneficially. A landfill in the eastern United States (US), however, is making use of this hot exhaust energy from its biogas-to-energy plant to evaporate leachate on site using a novel solution by Heartland Water Technology, based in Hudson, Massachusetts, US. By using this freely available energy and treating leachate onsite, the landfill is taking positive control over its leachate management, generating even more value out of its renewable biogas, lowering its total cost-to-treat, and significantly reducing its dependency on municipal wastewater treatment plants.

Figure 1a (left): Diagram of concentrator turbine. Figure 1b (above) Heartland Concentrator™ uses waste heat from a Solar® turbine as part of a landfill CHP operation. Images by Heartland Water Technology.

Cogeneration

Cogeneration, also known as combined heat and power (CHP), refers to the use of both power (electrical or mechanical) and thermal energy from a single source, such as a turbine or engine.

Reciprocating (piston) engines and turbines convert hydrocarbon fuels, such as natural gas, into useful energy. However, when making electricity, this approach falls far short of using 100 percent of a fuel's potential energy. According to the laws of thermodynamics, it is impossible to convert all of the potential energy in a fuel to electricity. However, those who are not familiar with power generation equipment might find it surprising that modern engines and turbines convert less than half of a fuel's energy potential to usable electricity. The rest of the energy – up to two-thirds of the potential energy of a fuel – is lost to the atmosphere in the form of heat. Cogeneration solutions capture and use this otherwise wasted heat energy. Users get more value out of a fuel when hot exhaust energy is used for economically useful purposes. In fact, some cogeneration applications can use nearly 90 percent of the energy potential of a fuel. With the heightened focus on climate change and greenhouse gas (GHG) reduction, and until such a time when hydrocarbon fuels are not needed for energy combustion, hydrocarbon fuels should be used as efficiently as possible. For these economic and environmental reasons, cogeneration should be a priority.

Water-energy nexus

The water-energy nexus is a term that highlights the integral relationship between water and energy, and cogeneration is a classic example. Today, there are more than 4,400 cogeneration systems in the US in a variety of applications. The vast majority recovers thermal energy by doing different versions of the same thing: heating water. The four main categories of heat recovery projects include:

- *Combined-cycle power plants:* use waste heat from combustion to make steam, which is then used to power a steam generator to make additional electricity

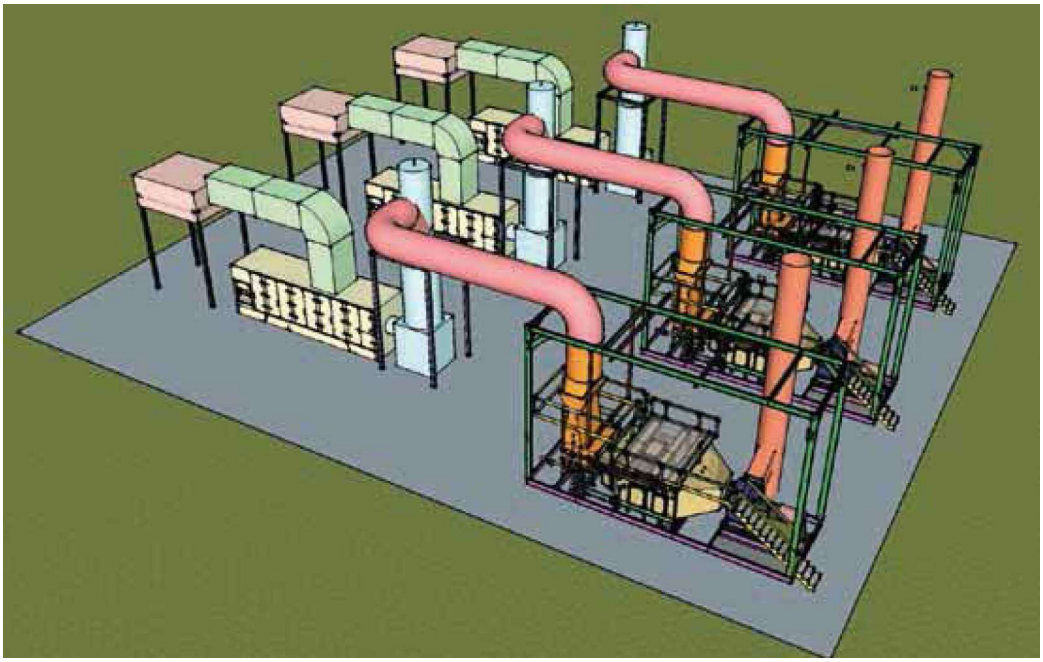

Figure 2. A landfill treats leachate onsite using three Heartland Concentrators in a cogeneration configuration with its existing turbines. Image by Heartland Water Technology

- *Utility heating solutions:* use waste heat to make hot water, which is then circulated for building heat and process applications
- *Utility steam solutions:* use waste heat to make steam that is used for steam process applications
- *Absorption chillers:* use waste heat for air conditioning, refrigeration, and process fluid cooling solutions.

Cogeneration solution treats challenging industrial wastewaters

Heartland Water Technology deploys a novel cogeneration solution that uses heat from combustion processes to evaporate challenging industrial wastewaters, such as landfill leachate, power plant scrubber water, cooling tower blowdown, mine water, and oilfield-produced water, among others.

The Heartland Concentrator™ is a proprietary direct-contact evaporator that mixes hot gases directly with wastewater, transferring heat and causing wastewater evaporation. It can reduce wastewater volumes by more than 90 percent, and in many cases the water can be completely evaporated, leaving only solids, in a process known as zero liquid discharge (ZLD), which can be accomplished in one unit operation.

Figures 1a and 1b show the Heartland Concentrator in a cogeneration configuration. This proven and safe integration with a turbine (or engine) uses a slight vacuum to redirect gases from the turbine exhaust and into the concentrator. The heat from the exhaust is then rapidly transferred into the wastewater, driving evaporation. When used as a cogeneration application, the Heartland Concentrator helps deliver combined thermal efficiencies of 85 percent or more.

Use of the Heartland Concentrator in this cogeneration configuration has dramatically lowered the landfill's cost and other economic risks related to leachate management.

Solid waste landfill

A large municipal solid waste (MSW) landfill in the eastern United States generates more than 303,000 liters per day of landfill leachate requiring appropriate treatment or disposal. The landfill also operates a significant landfill gas-to-energy facility, which collects and treats the biogas formed from the decomposition of organic material within the landfill, using that biogas to generate electricity from Solar® Centaur gas turbines.

Given how challenging landfill leachate is to treat, more than 60 percent of landfills dispose of their leachate by transporting it to municipal wastewater treatment plants, where the leachate is diluted by the larger volume of municipal wastewater. The costs of leachate disposal are being driven up by trucking costs as well as municipal operators' growing reluctance to accept leachate due to the challenges it brings to their treatment processes.

This landfill now treats its leachate onsite using three Heartland Concentrators in a cogeneration configuration with its existing turbines. This solution (see Figure 2) allows the landfill maximal control over its leachate management. Use of the Heartland Concentrator has yielded environmental benefits for the landfill by maximizing the value and productive use of its landfill gas, reducing GHG emissions by taking trucks off of the road, and decreasing the risk of an environmentally damaging leachate spill. More importantly, use of the Heartland Concentrator in this cogeneration configuration has dramatically lowered the landfill's cost and other economic risks related to leachate management. It virtually eliminates high trucking disposal costs and significantly reduces the operator's dependency on municipal wastewater treatment plants. In short, the Heartland Concentrator at this landfill displays the many benefits attainable through cogeneration at the water energy nexus.

Conclusion

When designing industrial wastewater treatment facilities, the significant benefits from cogeneration as well as opportunities to maximize energy efficiency and minimize operating costs should be considered. While there are numerous alternatives if CHP is the goal, using water treatment as the CHP integration when wastewater disposal costs are high provides a strong financial alternative that can also reduce the operational and environmental risks typically associated with wastewater treatment.

Author's Note

Earl Jones is the chief executive officer for Heartland Water Technology, based in Hudson, Massachusetts, United States.

Heartland signs contract to treat landfill leachate

Heartland Water Technology, Inc. signed a contract with the Three Rivers Solid Waste Management Authority on December 19, 2018 to install a Heartland Concentrator™ at the Three Rivers Regional Landfill near Pontotoc, Mississippi, United States, to treat landfill leachate. The seven-county region consists of Pontotoc, Itawamba, Lee, Monroe, Union, Lafayette and Calhoun Counties in northeast Mississippi.

After extensive evaluation, Three Rivers selected the Heartland Concentrator technology for its ability to use waste heat emitted from turbines and engines in a classic cogeneration (combined-heat and power) configuration. The system will capture and use the thermal energy from Three River's existing Landfill Gas-to-Energy plant.

This award comes after extensive competitive evaluations by the Three Rivers team to secure a reliable and cost-effective solution for leachate management. The Heartland Concentrator, supported by strong customer references and site visits by the Three Rivers team, provided demonstrable lifecycle cost advantages.

Heartland and Three Rivers plan for the facility to be operating in the third quarter of 2018.