Cogeneration for Industrial Wastewater Evaporation Has Rapid Payback

Mark Macaulay and Casey Cammann

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. Today, there are over 4,400 cogeneration systems in the United States in a variety of applications.

Cogeneration projects have been an environmentally friendly way to save money and improve process reliability for many years. The US government and many individual states offer compelling incentives for cogeneration projects that can significantly offset installation costs—at times reducing the required investment by as much as 50 percent.

The vast majority of cogeneration projects fall into one of four application areas, where thermal energy from a turbine or engine is used for the following:

1. To make more electricity
2. To make steam for industrial processes
3. To make hot water
4. As part of the refrigeration cycle.

Today, an innovative wastewater treatment technology (**Figure 1**) is enabling an entirely new category of cogeneration application, called *CoVAP*, which stands for *cogeneration for industrial wastewater evaporation*. CoVAP uses the waste heat from turbines and engines to evaporate challenging wastewaters. In many cases, the evaporation results in only solids remaining (this is called *zero liquid discharge*).

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COGENERATION OVERVIEW

Reciprocating (piston) engines and turbines convert hydrocarbon fuels, such as natural gas, into useful energy.

However, when making electricity, turbines and engines fall far short of using 100 percent of a fuel's potential energy. Modern engines and turbines convert less than half of a fuel's energy potential to usable electricity.[1] 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. Capturing and using this otherwise wasted heat energy is what cogeneration solutions are all about. Users get more value out of a fuel when wasted heat is used for an economically useful purpose. In fact, some cogeneration applications can use nearly 90 percent of the energy potential of a fuel.

Cogeneration projects typically have strong economic benefits. This idea makes sense given that the heat produced from the power-generation process is used beneficially rather than

[1] Gas turbines breaking the 60% efficiency barrier. (2010, January 5). *Decentralized Energy*.

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Figure 1. Heartland Concentrator Using Waste Heat From a Gas Turbine in a Landfill

being wasted. It further stands to reason that more valuable uses of thermal energy create greater economic benefit.

Adding to the value of cogeneration are *cogeneration incentives*, which are offered at both the federal and state levels, which can significantly offset installation costs and at times reduce the required investment by as much as 50 percent. Governments incent cogeneration for the simple but important reason that cogeneration is good for the environment. With the heightened focus on climate change and greenhouse gas (GHG) reduction, and until such a time when we do not need to combust hydrocarbon fuels for energy, we should be motivated to use hydrocarbon fuels as efficiently as possible.

Four cogeneration applications make up the vast majority of all cogeneration projects.

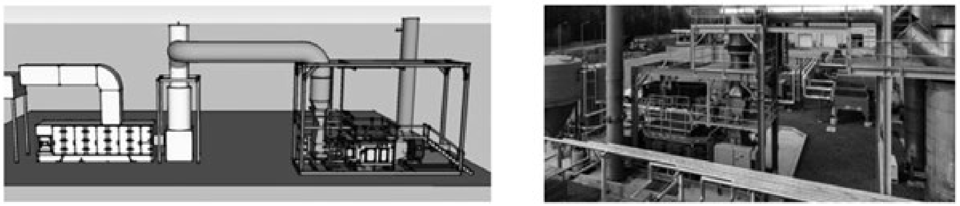
- *Combined-cycle power plants* use waste heat from combustion to make steam, which is then used to power a steam generator to make additional electricity.
- *Utility heating solutions* use waste heat to make hot water that is then circulated for building heat and process applications.
- *Utility steam 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.

These four applications are well-understood and have been successfully delivered for decades. Unfortunately, the markets for these applications are now quite developed. What is needed is a new, pervasive cogeneration application that can open new and substantial market opportunities for cogeneration projects.

COGENERATION FOR INDUSTRIAL WASTEWATER EVAPORATION

For nearly a decade, Heartland Water Technology has developed and delivered an *entirely new* category of cogeneration application, CoVAP. The Heartland CoVAP solution uses heat from

Figure 2. Heartland Concentrator in a CoVAP Configuration



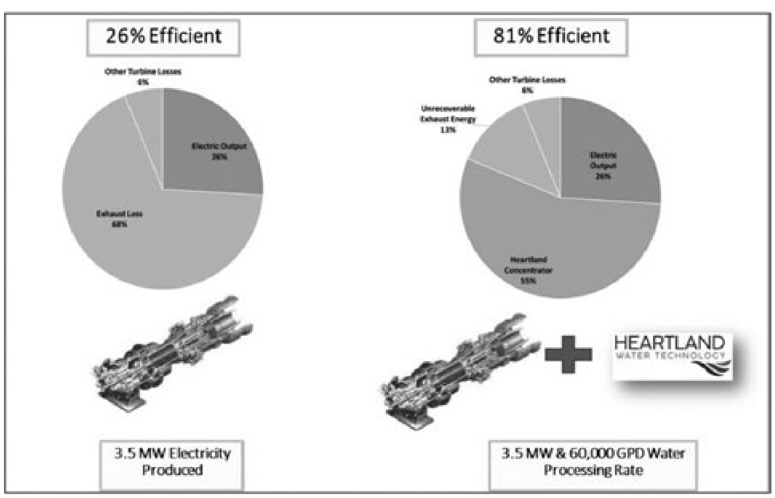
turbines and engines to evaporate challenging industrial wastewaters like landfill leachate, produced water from oil and gas operations, power plant scrubber water, cooling tower blow-down, and mine water, among many others.

For nearly a decade, Heartland Water Technology has developed and delivered an *entirely new* category of cogeneration application,

The key element of the CoVAP solution is the Heartland Concentrator. **Figure 2** shows 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 80 percent or more (**Figure 3**). In some states, this efficiency is critical in order to qualify for cogeneration incentives that can significantly decrease the capital cost of the project. Furthermore, in applications where wastewater disposal costs are high, wastewater treatment

Figure 3. CoVAP Thermal Efficiency Comparison



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can significantly improve the overall economics of a project.

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The Heartland Concentrator is designed to treat the world's most-challenging industrial wastewaters. It 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.

Traditional technologies, such as thermal brine concentrators, use heat exchangers to drive evaporation (**Figure 4**). When operated on difficult waters, significant problems with fouling and rapid corrosion often occur. In order to avoid these issues, designers are forced to use expensive high-alloy components and significant pretreatment. Significant skill and training are required for operation.

Because of its proprietary, direct-contact approach, Heartland eliminates the need for heat exchange surfaces and drastically reduces the skill and maintenance required to operate the system. With little to no pretreatment required, the Heartland Concentrator is uniquely positioned to treat such difficult wastewaters.

REAL-WORLD CASE STUDIES DEMONSTRATING COVAP'S EFFECTIVENESS

A couple of examples demonstrate how Heartland deployed its CoVAP solution to successfully treat difficult wastewater using exhaust from engines or turbines as the heat source. Payback achieved in these projects was under three years based on wastewater disposal savings alone.

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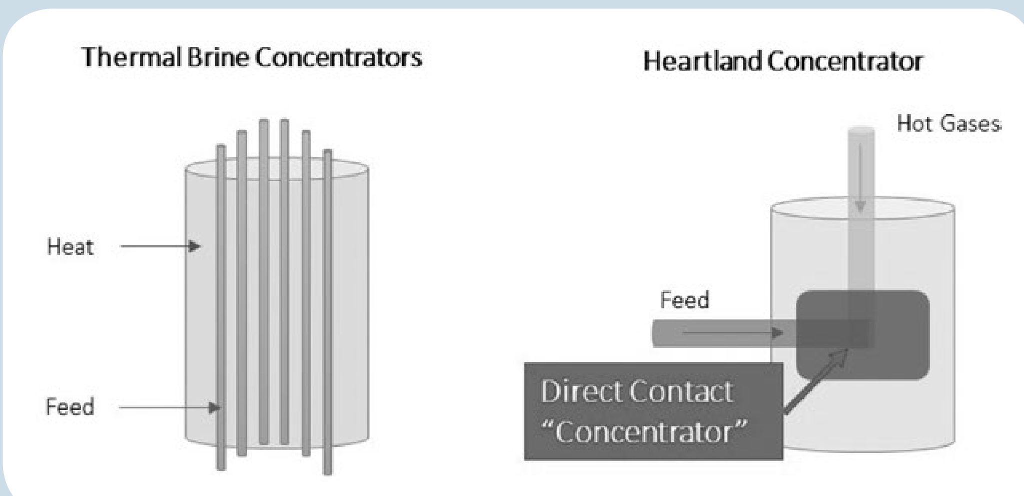
CoVAP Case Study #1—Municipal Solid Waste Facility, Eastern United States

A large municipal solid waste (MSW) landfill in the Eastern United States generates over 80,000 gallons per day (GPD) of landfill leachate requiring appropriate treatment and/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,

Figure 4. Heartland Concentrator Using Waste Heat From a Gas Turbine in a Landfill



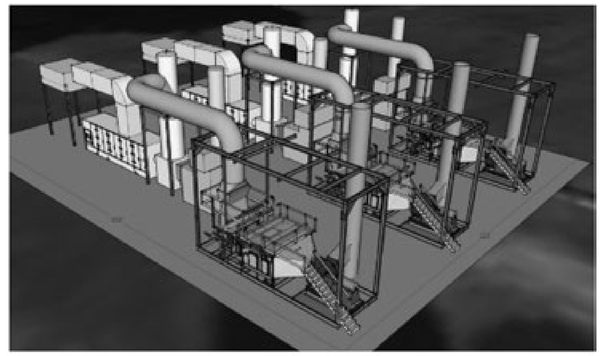
using that biogas to generate electricity from gas turbines.[2]

Given how challenging landfill leachate is to treat, over 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.[3] Trucking costs, as well as municipal operators' growing reluctance to accept leachate due to the challenges it brings to their treatment processes, are driving up costs of leachate disposal.

This landfill now treats its leachate onsite using three Heartland Concentrators in a cogeneration configuration with its existing turbines (**Figure 5**). This solution allows the landfill to have maximum 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 important, use of the Heartland Concentrator in this cogeneration configuration has dramatically lowered the landfill's cost and other economic risks related to leachate management. The Heartland Concentrator has virtually eliminated high trucking disposal costs and significantly reduced the operator's dependency on municipal wastewater treatment plants.

Figure 5. Three Heartland Concentrators in a Multiunit CoVAP Configuration



CoVAP Case Study #2—Natural Gas Compressor Station, Eastern United States

A major operator of natural gas compressor stations in the Northeast was seeking a cost-effective treatment solution for the produced water resulting from their natural gas drilling operations. Heartland's solution offered this customer a way to use the captured waste heat from six compressors to treat 30,000 GPD of produced water to zero liquid discharge (**Figure 6**).

Because the Heartland Concentrator could be configured to run on waste heat, Heartland was able to capture sufficient thermal energy

Figure 6. Heartland Concentrator in a CoVAP Configuration Treating Produced Water

[2] EPA. (2017, October). Landfill methane outreach program. Retrieved from www.epa.gov/lmop/landfill-gas-energy-project-data.

[3] Bolyard, S. (2017, May). State of practice landfill leachate management and treatment in the U.S. Presented at the Environmental Research & Education Foundation WasteExpo.

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Table 1. CoVAP Economics

Incentives (State and Federal)	Up to 50% of total capital costs
Annual Savings	• Revenue from electricity generation • Operational savings from cogeneration • CoVAP water treatment savings
Operating Costs	• Natural gas • Maintenance
Simple Payback	2.5–2.75 years

from the six compressors on the customer's site to treat the entire produced water stream, eliminating the need for additional energy. Each connection included automated safety isolation valves, and supply header pressure was continuously monitored to optimize operating conditions and ensure no backpressure was placed on the engines driving the compressors.

Heartland also implemented an innovative energy efficiency strategy at this customer's site, involving a spray condenser to achieve the dual benefit of preheating the produced-water-feed material and condensing the clean water vapor exiting the process for beneficial reuse.

ECONOMICS

When an industrial customer is considering a greenfield cogeneration project, CoVAP can provide the additional savings necessary to provide a positive return for the project. Challenges and expenses associated with wastewater treatment become the justification for implementation of a CoVAP solution. First, the customer will be able to beneficially use the power generated from engines or turbines either to support its existing operations (realizing energy cost savings) or make money from selling excess electricity.

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Second, the customer will be able to take advantage of incentives available today that can reduce the capital investment required by as much as 50 percent and further shrink the payback period. Incentives are generally available at both the federal and state levels. In order to achieve these gains, companies combine federal tax credits with state incentive programs.

Finally, implementation of an on-site wastewater treatment solution can dramatically reduce current treatment costs while reducing risk associated with off-site disposal. In addition, in certain situations, alternative uses of thermal energy do not qualify for energy credits, and CoVAP can provide justification necessary to qualify for incentives that dramatically improve economics.

Table 1 outlines the summary economics for a hypothetical CoVAP project generating 2 megawatts of on-site natural gas–powered electricity for an industrial operation using available state and federal incentives. In this illustrative example, waste heat from a turbine engine is used to treat 10,000 GPD of wastewater.

MORE EFFICIENT AND HAS FINANCIAL INCENTIVES

When seeking to improve the efficiency and cost-effectiveness of new or existing distributed generation operations, consider the significant benefits attainable from deploying a CoVAP solution. While there are numerous alternatives if cogeneration is the only goal, when wastewater disposal is also a requirement and comes at a very high cost. Using water treatment as the cogeneration integration provides a very strong financial alternative that can also reduce the operational and environmental risks typically associated with wastewater treatment.

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