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Energizing wastewater

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Waste not, want not

Gasification facility enables Tennessee city to convert biomass to energy

Nancy Cooper

Photographers know that sometimes looking through a different lens can make all the difference. Last year, the City of Lebanon, Tenn., benefitted by adopting a similar strategy as it sought a cost-effective, sustainable, and environmentally friendly method to dispose of some of its municipal waste. The city's initial evaluation of a proposed gasification facility that would convert waste to energy proved less than encouraging. However, city leaders re-evaluated the project using a broader lens, so to speak, leading to the successful implementation of an innovative project that uses wastewater solids and other biomass to generate energy.

Seeing the big picture

In 2016, Lebanon conducted the first round of financial projections for a gasification project that was intended to convert various waste materials into energy. However, the first analysis determined that the status quo provided a better deal for taxpayers. Despite their high level of interest in environmental issues, city officials began to reconsider whether to proceed on the gasification project.

An interesting view emerged, though, when everyone stepped back, looked at the bigger picture, and started thinking about wastestreams without consideration of municipal and county borders. When those involved further adjusted their proverbial filters to include the participation of local industries, the pieces of a successful economic picture began to coalesce.

A thriving public–private partnership emerged, moving the city one step closer to its eventual goal of sending zero material to landfills. Aries Clean Energy LLC (Nashville, Tenn.), a developer of biomass-based downdraft and fluidized bed gasification systems, entered the picture. Finding an experienced local company that could prepare and haul several types of feedstock more cost-effectively than could the city greatly improved the financial aspects of the proposed waste-to-energy project. This partnership cast the concept in an entirely new light, one that combined positive economic and environmental benefits. Such a combination helps foster viable, long-term solutions.

◀ **Having a 58-Mg/d (64-ton/d) maximum throughput capability, the gasifier developed by Aries Clean Energy for Lebanon, Tenn., is the largest downdraft gasifier in the world today.** Aries Clean Energy

Turning the concept into reality

Ultimately, Aries Clean Energy designed and built for Lebanon the world's largest downdraft gasification facility, which uses a blend of wood waste from local industries, scrap tires from Wilson County, and solids from the city's water resource recovery facility (WRRF) to produce green electricity. Commissioned in October 2016, the gasification facility decreases the amount of waste entering local landfills, generates energy, and reduces greenhouse gas emissions.

The gasification process works by breaking down feedstock material at the molecular level at very high temperatures in an oxygen-starved, sealed vessel. Approximately 95% of the material entering the gasifier leaves in the form of synthetic fuel gas, which can be deployed like natural gas. The remaining 5% to 10% of material exiting the gasifier is a high-carbon biochar that can be recycled or sold for agricultural or industrial uses.

The project concept became reality as a result of in-depth conversations among city officials and solid waste managers in the area. Driving those talks was a sincere desire on the part of Lebanon's mayor and his department managers to find a better path forward for disposing of waste in the city.

Philip Craighead, who served as Lebanon's mayor during the project's construction, was delighted to find a local entity with a proven track record that was capable of meeting the city's needs on the project. "We have met with and talked with many people in the last few years who claimed they could take our waste and economically turn it into energy," Craighead said. "We found that what they said they could do and what they could actually deliver were far apart. Finding this solid local company to provide proven technology is going to allow us to implement a process that will make our city a leader in tackling waste disposal."

Green power and academia

Constructed at the city's WRRF, the gasification facility occupies a footprint of less than an acre. Feedstock for the downdraft gasifier comprises a blend of the city's wastewater solids, scrap tires from the county, and industrial wood waste. Currently, the facility accepts a total of 29 Mg/d (32 ton/d) of the blended waste, approximately half of the facility's total capacity. Fuel gas resulting from the process is used to power three organic Rankine cycle generators, providing enough electricity to cover the parasitic load of the gasification facility's motors, pumps, and conveyors, while also helping to offset the electrical demands of the city's WRRF.

In addition to the downdraft gasifier, on the left, the City of Lebanon's gasification facility includes a thermal oxidizer, on the right. Aries Clean Energy

Before undertaking the gasification venture, Lebanon had stabilized the wastewater solids at its WRRF by means of an auto-heated thermophilic anaerobic digester. Now that it sends the undigested solids from its WRRF to the gasification facility, the city plans to discontinue its use of the anaerobic digester. As a result, the city has eliminated the expense associated with the chemicals and the electricity needed to run the energy-hungry digester. Personnel responsible for operating the digester have been reassigned to other functions at the WRRF.

Gasification involves neither incineration nor burning, and it generates no smoke or odor. The cleanliness of this disposal method was of critical importance to the city council. Another major factor leading to the project's approval is that it benefits multiple waste producers and processors in the area, says Jeff Baines, the public works commissioner for the City of Lebanon. "We are using city sewer sludge that in the past has been transported and land applied," Baines said. "We're adding to that hundreds of tons of scrap tires that Wilson County has been paying to dispose of. Once we found that several local industries wanted to participate, in order to both reduce landfill usage and save money, the financial projections really started looking good for everyone."

Last May, educators and scientists from the University of Tennessee in Knoxville began a unique field study of the biochar produced at the facility. Forbes Walker, associate professor of biosystems engineering and soil science at UT Knoxville, is leading a 6-month study of the effects of the biochar on fescue grass. Taking place on the grounds of the UT Agriculture Extension office in Lebanon, the study involves measuring growth and assessing levels of phosphorus and potassium in the soil before, during, and after harvesting. A third-party laboratory will conduct the testing.

At the time of this writing, data are not yet complete. However, the findings of the study should enable Walker to tell farmers how much biochar to use on their fields to achieve a specific result. For example, cattle farmers will want to use the combination that produces the most protein in the fescue.

Predicted benefits

Each year, if operating at full capacity, the gasification facility will

- eliminate 2300 Mg (2500 ton) of carbon emissions by reducing the number of truck trips to the landfill,
- keep 7300 Mg (8000 ton) of waste out of the landfill used by the city,
- convert 36,000 scrap tires into energy, and
- generate 1.8 million kWh of electricity.

The carbon emissions reduction alone is the equivalent of the emissions from a line of trucks more than 6 km (4 mi) long. According to the U.S. Environmental Protection Agency, this level of emissions equates to the amount of carbon dioxide produced annually to provide electricity to 312 homes, or the annual greenhouse gas emissions from more than 450 passenger vehicles.

"We're reducing landfill use, creating clean energy, and keeping thousands of tons of carbon out of the air each year ... all with a positive cash flow" said Bernie Ash, the current mayor of Lebanon. "This is a win."

Receiving recognition

This past May, Tennessee Governor Bill Haslam and the Tennessee Department of Environment and Conservation awarded the City of Lebanon with the Governor's Environmental Stewardship Award in the category of energy and renewable resources. Now in its 31st year, the annual awards program represents the state's most prestigious conservation honor and showcases exceptional voluntary actions that improve or protect the environment. In granting the award, the state highlighted the benefits associated with the new gasification facility.

Earlier this year, Aries Clean Energy also received recognition for its involvement in Lebanon's gasification facility, garnering a 2017 Project of the Year award from *Environmental Leader*. The publication's Product & Project Awards recognize excellence in products and services that provide companies with energy and environmental benefits or in projects that improved environmental performance, sustainability, or energy management and increased the bottom line.

Third-party judges representing various national and international companies selected the winners of the Project of the Year award. The judges considered the clean-technology waste-to-energy facility in Lebanon an exemplary project. "This is such a great example of sustainability and could be a wonderful model for the rest of the world," one judge said of the gasification project. "They are using systems thinking to reduce waste, produce renewable energy, capture heat that normally would be wasted, and are also producing biochar, which has great agricultural benefits." Another judge noted that the project offers a "great example of how to increase government's productivity while also reducing" its effects on the environment.

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Lebanon paid $3.5 million for the design and construction of the gasification facility, which the city operates in partnership with Rockwood Recycling (Lebanon, Tenn.), a local provider of recycling services. For its part, Rockwood Recycling collects waste wood and tires and prepares these materials for processing in the gasification facility. To help defray the cost of the project, the city received a $250,000 grant from the Tennessee Department of Environment and Conservation (TDEC). As part of the Qualified Energy Conservation Bonds program, the TDEC also provided subsidies to Lebanon to reduce the amount of interest paid by the city to finance the project.

Lebanon views the new gasification facility as a first stage in a larger plan to convert the city's household and commercial garbage to energy in the future. "We see keeping our garbage out of the landfill and using it to make energy as major goals for Lebanon in coming years," Baines said. "[Dwindling landfill space] is a problem that is coming straight at all of us, and we are going to make sure our city is ready with answers. One of our primary criteria is that the solutions we want will have to make good financial sense along the way."

Nancy Cooper *is communications manager for Aries Clean Energy LLC (Nashville, Tenn.).*