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Full steam ahead: Packaged boilers

Packaged boilers focus on safety,
efficiency, and modularity



on the cover

A food processing company in Bartlett, Ill. uses three 300 bhp Circulatics forced recirculation watertube boilers for their quick start/stop capabilities for intermittent production loads and compact footprint. Image courtesy: Vapor Power International



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For 115 years, National Fuel has been operating safely and responsibly in Western New York, Northwest Pennsylvania. Several of its nonresidential customers include large commercial fleets who are using natural gas vehicles (NGVs) while delivering/providing their goods or services.

FULL STEAM AHEAD: PACKAGED BOILERS

Packaged boilers focus on safety, efficiency, and modularity.

PACKAGED BOILERS ARE FACTORY-ASSEMBLED AND SKID-MOUNTED IN MOST CASES. This modularity enables quick installation and startup, which offers potential flexibility to end users as original equipment and as replacements. “Most of the steam boilers today are packaged boilers. Very few industrial boilers are field erected,” said Aqeel Zaidi, team lead, Industrial/Residential Technology at Enbridge Gas Distribution Inc. “The steam demand for some of industrial customers has been reduced due to changes in their operation. These facilities used to have large steam plants that would require various levels of full-time stationary engineers and attendants. Some of these plants are converting to smaller packaged boilers to reduce operating and maintenance costs.”

Packaged boiler types

While there are various types of small packaged equipment that produce steam, this article focuses on two primary types: watertube and traditional firetube boilers. In watertube boilers, water flows through the tubes, while combustion gases pass over the tubes. Consequently, the water volume is low, which means less startup time and quicker response to load changes compared with traditional firetube boilers.

In firetube boilers, the combustion gases flow inside the boiler tubes, while water is heated outside the tubes within the vessel, or shell side. Firetube boilers typically contain a large volume of water, and consequently take longer to produce steam than watertube boilers. However, the large water volume enables firetube boilers to respond to load changes with relatively little change in pressure or boiler cycling. “Firetube boilers often are characterized by how many times the flue gases turn inside the boiler before exiting,” Zaidi said. “Each pass sends the flue gases through the tubes in the

opposite direction. To make another pass, the gases turn 180° and pass back through the shell. The higher the number of passes, the higher the efficiency. Three and four pass boilers are most common.”

“Although there is no official requirement for any steam generating equipment to be classified as a ‘steam generator,’ a general definition is one that states a steam generator has a once-through, forced flow design. This means water is pumped into the boiler as quickly as it is boiled off into steam,” said Doug MacMaster, senior vice president, U.S. Operations, Miura America Co. “In the case of Miura, water is contained in many vertical tubes, which are surrounded by flame and/or hot combustion gases. The heat is so intense, the water in the tubes boils and converts to steam very quickly. As that water leaves the upper header as steam, more water is pumped in to the lower header to replace it. When these low content designs first appeared, traditional steam boiler manufacturers used the term ‘steam generator’ negatively in an attempt to classify a steam generator as a less robust or lower quality steam boiler. This is no longer the case. Each type of boiler design has a benefit and application that sets itself apart from other designs.”

The vertical design of the pressure vessel allows for a much smaller foot print. The EX boilers from Miura are some of the safest boilers in the world, according to MacMaster. The largest Miura watertube boiler, the EX300, holds a little more than



A food processing company in Bartlett, Ill. uses three 300 bhp Circulatics forced recirculation watertube boilers for their quick start/stop capabilities for intermittent production loads and compact footprint. Image courtesy: Vapor Power International



A safety valve manufacturer in Farmingdale, N.Y. uses two 200 bhp Modulatics once through watertube boilers because of their unique combination of low flow and high pressure, which work well for safety valve testing. Image courtesy: Vapor Power International

A. Kuhlman, Midwest regional sales at Vapor Power International, 90% of the water is converted into steam in the coils. Dry steam is then produced in the steam separator. The water remaining is removed by a steam trap.

The Circulatic, also

100 gallons of water in many small tubes, which are then surrounded by a triple-layer outer shell and casing. A pressure vessel failure in a single tube results in only a small steam leak.

Cleaver-Brooks manufactures both watertube (the FLX) and firetube (the ClearFire-H) boilers. Sean Lobdell, director of sales for Packaged Boilers at Cleaver-Brooks explains that firetube boilers typically have a larger footprint with a large effective heating surface and are capable of delivering large amounts of steam. He said that packaged watertube boilers have a smaller footprint than a firetube boiler and effective heat transfer, but lower water content. Watertube boilers have efficiency equal to that of a firetube if using an economizer. These units will provide a fast load response and can generate steam very quickly if needed.

The Modulatic from Vapor Power International is a once-through watertube boiler with a positive displacement pump that provides a constant feedwater supply. The fuel/air ratio curve changes the amount of fuel and combustion air in direct proportion to the flow of water being sent to the coils. According to Glenn

from Vapor Power International, is a forced recirculation watertube boiler that uses a drum as a steam separator and a reservoir of water to supply the coils. A recirculating pump draws the water from the drum and forces it through a set of parallel connected coils at the rate of three to four times the maximum steaming rate. The water is then pushed through a steam lance and a series of baffles in the drum where some of the water is flashed into steam and separated. The dry steam is released and the water is recirculated through the coils. The fuel and combustion air are controlled by a modulating motor that responds to steam pressure. The feedwater is controlled by a water level control system and modulating feedwater valve.

MacMaster contends that the low water volume of watertube boilers is safer than traditional pressure vessel type boilers. In a firetube (large volume) boiler, a sudden crack in the shell can cause the entire body of water to be subjected to a sudden and substantial drop in pressure. The huge volume of

flash steam that results can cause an explosion of tremendous force. "In a single-pass-through boiler, similar to Miura's technology, there are isolated tubes, which hold a certain volume of water," said MacMaster. "If one tube fails, you will have the energy release from that single tube. The chance of all the tubes failing is highly unlikely. We contain those isolated tubes within an outer shell—the pressure vessel itself. There are two layers of protection. If a tube fails, the energy would be released within the outer shell. There is much lower flash steam volume in a single-pass watertube design."

Boiler efficiency

"Generally, four-pass firetube boilers have high efficiency, however watertube boilers can achieve similar efficiencies by installing a feedwater economizer," said Zaidi. The ClearFire-H from Cleaver-Brooks is said to have efficiencies up to 85%.

MacMaster said that the efficiency of Miura boilers average in the mid-80% range. "When coupled with a condensing economizer, our overall efficiency increases to more than 90%," he said. "This is because the small heating surface reduces radiant heat losses and rapid response to fluctuating steam demand reduces energy losses."



The model FLX flexible watertube boiler for either steam or hot water is designed to minimize thermal stress and provide quick response in a compact unit. There is also a field-erectable option. Image courtesy: Cleaver-Brooks

"A steam generator [watertube boiler] can be left cold until just needed," said Kuhlman. "This results in fuel savings, compared to a firetube that typically needs to be left on low fire. The most significant savings with a steam generator may be realized in applications in which all or part of the boiler operation is in a standby mode. Because of its relatively long startup time, firetube boilers generally will be kept in a 'hot' standby condition by maintaining low fire. This results in fuel consumption without the effective use of the energy produced."

System modularity

Often plant capacity can be increased while reducing the footprint of the system if replacing an older boiler and auxiliaries with package units. Vertical package boilers are especially economical in their use of floor space.

"Due to their compact size, it is easier to build a steam system using the modular approach," MacMaster said. "This

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DOE Tools Available

The U.S. Department of Energy office of Energy Efficiency and Renewable Energy features the Steam System (www.energy.gov/eere/amo/steam-systems) and Boiler MACT (www.energy.gov/eere/amo/boiler-mact) sites. Many manufacturing facilities can recapture energy by installing more efficient steam equipment and processes and applying energy management practices.

The Steam System site lists software tools, training, case studies, and publications to optimize performance and save energy. Tools to assess your energy system include "Steam System Modeler" and the "MEASUR Tool."

DOE currently provides technical assistance on combined heat and power (CHP) technologies to commercial and industrial facilities through its seven regional CHP Technical Assistance Partnerships (CHP TAPs).

Starting in January 2013, DOE supplemented this effort by providing site-specific technical and cost assistance to the major source facilities affected by the Boiler Maximum Achievable Control Technology (Boiler MACT) rule. Through the CHP TAPs, DOE contacted more than 600 facilities with more than 1,500 affected boilers to discuss compliance strategies, as well as to provide information on potential funding and financing opportunities.

More than 50 sites are considering CHP after using DOE technical assistance resources. If all of these sites move forward with installing CHP, they would add more than 700 MW of CHP; three facilities alone are moving forward with 71 MW of CHP. More than 290 sites reported they are already in compliance with the rule. More than half of those sites reported they have switched to natural gas, while the remainder reported they have either changed their operating characteristics to avoid being a major source facility or are converting to biomass. Only 11 sites reported that they plan to install emissions controls to come into compliance and 76 sites have been permanently closed.

means the use of several smaller boilers, rather than one large boiler. When multiple units are tied into one system and controlled efficiently with a master controller, the N+1 requirement is met. For example, if a hospital requires 600 hp of steam, using a traditional firetube would require

a second 600 hp boiler to be in standby mode just in case the main unit goes offline. With a modular approach, the N+1 requirement could be met by installing just 800 hp, or four 200 hp boilers instead of 1,200 hp with two 600 hp boilers." **GT**

These model EX dual fuel boilers, installed at a health care facility, allow for a small footprint. The largest (EX300) holds a little more than 100 gallons of water in many small tubes, which are surrounded by a triple layer outer shell and casing. Image courtesy: Miura America Co.



Integrating RNG

Renewable natural gas (RNG) can be used in any existing infrastructure or process that currently uses conventional natural gas.

RENEWABLE NATURAL GAS (RNG) IS CARBON-NEUTRAL ENERGY CREATED FROM DECOMPOSING ORGANIC WASTE. Methane emissions from municipal landfills, wastewater treatment plants, farms, and industries can be captured, refined and converted into renewable energy.

RNG is not a fossil fuel and does not add carbon to the environment. Even more importantly, RNG captures and converts methane from waste treatment facilities, preventing the release of emissions that are 25 times more harmful than CO₂. This significantly reduces the carbon footprint of energy consumption while lowering greenhouse gas emissions.

RNG is fully interchangeable with conventional natural gas for transmis-

sion, distribution, and everyday use. It can be used in any existing infrastructure or process that currently uses conventional natural gas.

Integrating RNG

Since RNG is interchangeable with natural gas, that begs the question: Can RNG be integrated into a utility or natural gas system? The answer is, "Yes."

"Because we are a gas transmission utility company, we do accept RNG into the system," said Justin Egan, senior advisor RNG, Business Development at Enbridge Gas Distribution Inc. "However, before RNG can be injected into the system, it needs to meet very specific gas quality specifications. Should these specifications be met and there is capacity on the local system, the RNG

can be accepted into the system. Because biogas does not meet these specifications, we cannot accept this into our system."

"We have been accepting RNG in Stat-

en Island since the 1980s from the Fresh Kills Landfill," said Donald Chahbazpour, director, Gas Utility of the Future at National Grid. "A second RNG facility is expected to come online in Brooklyn later this year (2019) at the Newtown Creek wastewater treatment plant. That project came from a partnership between National Grid and New York City and will upgrade biogas from the wastewater treatment plant that would otherwise be flared. National Grid also is working with seven project developers who have submitted interconnection requests."

Getting connected to the utility

"Although there are many different sources of natural gas, the process of obtaining an interconnection is similar regardless of the source," said Jim Lucas, market development manager at Southern California Gas Company (SoCalGas). "The process starts with an interconnection capacity study, which determines the utility's downstream capacity to take the RNG away from the interconnection point and the associated utility facility enhancement cost."

Those who wish to integrate RNG into the SoCalGas utility are asked to review and complete the Gas Supplier Interconnection Project Fact Sheet, which SoCalGas will use to evaluate its ability to accept supplies from the potential RNG project. The fact sheet is a multipage application that asks for project profiles, flow and pressure data, and source of gas supply, such as dry gas zone, oil-associated, liquefied natural gas (LNG), or biogas. The section that asks for the anticipated gas quality is extremely detailed. It asks for as many as 20 gas constituents, such as methane, ethane, propane, CO₂, several butanes, several types of mercap-

This photo shows an anaerobic digester operation. Image courtesy: Enbridge Gas Distribution Inc.



tans, and much more. That section also asks for other constituents like arsenic, vinyl chloride, toluene, antimony, copper, and lead, as well as their biogas source. These are typically from dairy or publicly operated treatment works (POTW) landfills.

"Interconnectors (those who wish to integrate RNG into the utility) are responsible for the actual costs needed to perform the interconnection capacity study," Lucas continued. "These costs typically range from \$5,000 to \$10,000 and requires six weeks to complete. The next step is the preliminary engineering study, which develops the preliminary cost estimates for land acquisition, site development, right-of-way, metering, gas quality, permitting, regulatory, environmental, unusual construction, operating, and maintenance costs. Interconnectors are responsible for the actual costs needed to perform the preliminary engineering study. These costs typically range from \$50,000 to \$60,000 and requires four to five months to complete. The third step is the detailed engineering study. There are three elements in this study:

1. Description of all costs of construction.
2. Development of complete engineering construction drawings.
3. Preparation of all construction and environmental permit applications and right-of-way acquisition requirements.

"Interconnectors are responsible for the actual costs needed to perform the detailed engineering study as well. These costs typically range from \$145,000 to \$225,000 and four to six months to complete," Lucas said.

"If there is an interest in creating/injecting RNG, our group will certainly

assist wherever possible," Egan said. "We contain RNG market knowledge and pipeline system expertise. We will request from you several key aspects of information. We want to know the project location, RNG volume production, project timelines, and type of project (landfill, anaerobic digestion, etc.). Following our analysis, we will provide the market takeaway capacity, injection pressure and location, cost estimate, and a service/purchase agreement. All information is kept confidential."

"National Grid has developed an internal interconnection process supported by gas engineering," Chahbazpour said. "The process involves a preliminary evaluation, an engineering feasibility analysis, an interconnection agreement, and project commissioning. This process has informed the NY RNG Standard Interconnection Guide. The NY Standard Interconnection Guide is being developed through a collaborative process with all of New York's gas utilities and RNG industry groups. The guide's purpose is to maximize the acceptance of RNG into the natural gas network by clarifying the steps to connecting RNG projects and outlining the responsibilities for utilities and project developers. The document bridges both policy and technical concerns of project developers and pipeline operators. The

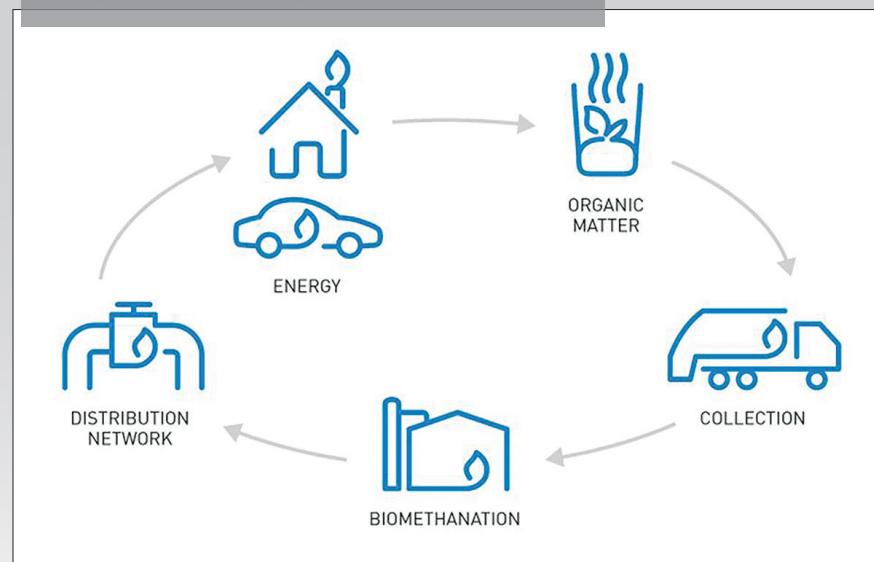
final version is expected to be public soon."

Ensuring gas quality

"We ensure that the projects that connect to our system produce pipeline-compatible gas," said Chahbazpour. "In other words, we ensure that the gas will not alter the general composition of gas flowing through the distribution system or impact our customers. We do not use a single gas quality specification because it would be too restrictive. RNG projects are unique in size and feedstock, and gas distribution systems also vary in size and seasonal gas demand. When assessing the ability to interconnect a project, we take into account the pressure and design of the surrounding gas distribution system, we identify which customers will receive the mixture of RNG and traditional natural gas, and we consider the size of the RNG project. Once we understand how the project will interact with our distribution system, we agree on gas-quality specifications with the project developer. By not setting 'one-size-fits-all' gas quality specifications, we aim to connect more RNG to our network, while ensuring that our system and our customers are not adversely impacted."

Chahbazpour also said that gas quality and flow rates must be monitored to

This drawing shows the renewable natural gas (RNG) process at a high level. The biomethanation stage includes cleaning the resulting biogas from the landfill, wastewater treatment plant, or the anaerobic digester where the organics ended up. Image courtesy: Enbridge Gas Distribution Inc.





This photo shows a wastewater treatment plant and the anaerobic digesters that exist onsite to process the treatment plant's sludge and turn it into a usable product—biogas—which can be cleaned to become RNG. Image courtesy: Enbridge Gas Distribution Inc.

ensure the gas meets the agreed-upon specifications. Monitoring is performed by online instrumentation for parameters, such as hydrocarbon composition, Wobbe Number, specific gravity and heat content, nonhydrocarbons sulfur compounds, temperature, pressure, and moisture. The Wobbe number is an indicator of the interchangeability of fuel gases such as natural gas, liquefied petroleum gas (LPG), and town gas, and is frequently defined in the specifications of gas supply and transport utilities. "This information is shared in real time with our Gas Control group. Our Gas Control group is capable of isolating the RNG project from our system remotely if gas quality falls out of the agreed-upon specifications," he said.

According to Lucas, the (SoCalGas) utility point-of-receipt facility has real-time gas monitoring equipment to ensure the gas is compliant with the Rule 30 specifications. Rule 30 provides the general terms and conditions applicable whenever the utility transports customer-owned natural gas over its system. "The supplier or interconnector is responsible for processing the natural gas or biogas as necessary to meet the Rule 30 specifications for pipeline quality natural gas so that it is then capable of being received into our natural gas transportation system for sale throughout Southern California," he said.

SoCalGas Rule 30 describes the requirements for gas to be injected into the utility pipeline. "These requirements reflect the first and foremost

priority of SoCalGas to protect its customers, employees, contractors and pipeline system, as well as the public," Lucas continued. "The standards cover two major aspects: gas constituent limits (composition-based specifications) and gas interchangeability specifications (performance-based quality specifications). Gas constituent limits restrict the concentration of gas impurities to protect pipeline integrity and ensure safe and proper combustion in end-user equipment. The interchangeability specifications address end-user combustion performance, ensuring safe and proper combustion for customers."

Gas quality standards for SoCalGas include:

- Heating value (Btu/scf): minimum = 990; maximum = 1,150

- Water content (Lb/MMscf): 7
- Various inerts: CO₂ = 3%; O₂ = 0.20%; total inerts = 4%
- Hydrogen sulfide (H₂S) (grain/100scf): 0.25

The utility also does periodic gas sampling for certain gas constituents. SoCalGas Rule 30 requires that gas quality testing on biomethane constituents of concern be done by independent certified third-party laboratories, according to Lucas.

For Enbridge, online quality monitoring is located at the injection station or is obtained via producer signals. The monitoring can be done with several different types of technology. "There are several components that are continuously monitored and measured," Egan said. "CO₂ is always monitored at the injection station. In addition, water vapor, H₂S, and O₂ also are measured. RNG also is analyzed for contaminants during commissioning of the RNG facility. After the RNG facility is commissioned, sampling will be performed at a frequency determined by an engineering assessment."

RNG integration in action

"Currently, the City of Hamilton, Ontario is injecting RNG into the gas grid," said Egan. "It creates RNG at its wastewater treatment facility. The organics used to make the RNG comes from the city's wastewater. In addition, the city of Toronto is currently developing an RNG project at its Dufferin solid waste management facility. The project will inject RNG into the natural gas grid. Once in the grid, the city will be able to use the RNG to fuel its collection trucks. **GT**

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NGV Trucking Outlook on the Rise

OVER-THE-ROAD (OTR) TRUCKING PRESENTS A MAJOR OPPORTUNITY TO REPLACE PETROLEUM FUELS WITH NATURAL GAS, ALONG WITH THE ASSOCIATED POTENTIAL FOR REDUCED EMISSIONS AND LOWER FUEL COSTS. Historically, obstacles have included a severe lack of fueling points, unavailability of heavy-duty natural-gas-powered road tractors, and long payback times for adopters of the natural gas option. However, many of those obstacles have been overcome, and the benefits continue to increase.

Natural gas versus petroleum-based fuels

Environmental issues and cost are the major problems with petroleum-based fuels. "Large truck engines running on diesel are major sources of harmful pollutants, such as ground-level ozone and particulate matter," said Brett Brown, manager of gas operations at Dominion Energy. "Natural gas is the cleanest alternative transportation fuel available and can provide particular benefits for ozone nonattainment areas. As a transportation fuel, natural gas can reduce greenhouse gas (GHG) emissions by 20% to 30% when compared with diesel and gasoline. Specifically, natural gas produces 70%

to 90% less carbon monoxide, 75% to 95% less nitrogen oxides, 50% to 75% less nonmethane organic gas, and 20% to 30% less carbon dioxide."

"With increasingly more stringent emission regulations, emission controls on diesel engines have become more complex with the addition of diesel particulate filters and selective catalytic reduction system, plus its associated diesel emission fluid," said Tom Swenson, a business development leader (California), at Cummins Westport. "Both the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) have indicated they will be considering promulgation of yet lower NO_x standards. CARB has indicated it is looking at a NO_x standard in the range of 0.02g/bhp."

"What are the problems associated with petroleum-based fuels? I think the better question is why are OTR fleets drawn to natural gas? The answer is mainly lower operating costs (fuel cost and maintenance savings) and superior emissions/sustainability benefits," said Daniel Gage, president, NGVAmerica (Natural Gas Vehicles for America). "Natural gas is traditionally cheaper and more stable in price." Current pump prices are typically \$0.75 to \$1.00 lower than diesel, according to Gage.

According to Gage, diesel has a history of volatile price swings, much of crude oil is sourced from high-conflict regions, and commodity cost makes up 60% of the sales price. However, Natural gas has decades-worth of affordable domestic reserves, it is

Increasing fueling opportunities for over-the-road (OTR) trucks and the availability of improved truck technology with larger, more efficient engines make natural gas vehicles a cost-effective, environmentally responsible choice because of lower emissions.

sourced from North America, and commodity cost makes up only 23% of the sales price.

Increasing fueling opportunities for OTR trucks

The infrastructure for refueling continues to develop. "An increasing number of truck stops and fueling stations around the country are in place to refuel large trucks including OTR freight trucks," Gage said. "These include refueling stations operated by Loves, Clean Energy, Pilot/Flying J, ampCNG, American Natural Gas, U.S. Gain, and TruStar Energy CNG. There are 907 public fast-fill compressed natural gas (CNG) fueling stations in the U.S.; 722 of these stations can fuel heavy-duty trucks. There are 66 liquefied natural gas (LNG) public fueling stations in the U.S., all of which are capable of fueling heavy-duty trucks. Natural gas fuel is a proven, commercially-ready-right-now and road-tested technology. We have an established refueling infrastructure of more than 2,000 stations with a mature network of manufacturers, servicers, and suppliers coast-to-coast. And natural gas fueling pays into the Federal Highway Trust Fund."

Dominion Energy's Brown agrees. "Over the past five years, high-speed, high-volume CNG stations along major U.S. transportation corridors have been connecting major markets," he said. Now we're start-

ing to see significant incentives to dispense renewable natural gas (RNG). On Jan. 1, 2019, the Utah, Public Service Commission approved a tariff for Dominion Energy to dispense RNG through its 24 CNG stations later this year."

Fuel providers continue to expand the natural gas fueling network with contract carrier operators, which provides more flexibility to the routes available to natural gas trucks, said Hugh Donnell, a business development leader at Cummins Westport. "The U.S. Postal Service has been particularly supportive of its contract mail carriers' use of natural gas trucks and we continue to see continually more of those routes being supported by natural gas as the network increases."

CNG and LNG advantages and disadvantages

At fueling points, natural gas may be dispensed as CNG or liquid natural gas LNG. According to Brown, CNG is pressurized up to 3,600 psi. This fuel is kept as a gas form in the vehicle. LNG involves compressing and cooling natural gas to around -260°F, which converts the gas to a liquid and cuts its volume to 1/600th of its original state.

CNG advantages include:

- Cost, because CNG is significantly less expensive than gasoline, diesel, and LNG.
- Availability, because CNG is more accessible than LNG. Dominion Energy has 24 public stations mostly along the freeway corridors in Utah and southwest Wyoming.
- CNG is very appealing for fleets that return to base each day. Trucks are connected to CNG refueling lines at the end of shift and are full for the next shift, improving fleet and employee efficiencies.

CNG disadvantages include:

- Because CNG remains in a gaseous state, it requires more frequent refueling.
- More or larger tanks are needed to increase range.
- More tank storage can create a challenge if space is limited on a given vehicle.

A UPS truck driver refuels his truck at UPS's Salt Lake City fast-fill CNG fueling dispenser. The fast-fill fueling system dispenses the equivalent of 10 to 12 gallons of CNG per minute. Image courtesy: Dominion Energy



- Refueling stations are not as available as liquid petroleum locations.

LNG advantages include:

- Increased fuel volume extends range between refueling.
- LNG is a great fit for marine use. It is quickly becoming popular in the cruise ship and freight liner markets. The volume of fuel being used offsets the cost to liquefy and greatly improves the emissions created by these otherwise large diesel engine polluters.

- Safety, because LNG is not stored under high pressure and is not explosive. Although a large amount of energy is stored in LNG, it cannot be released rapidly enough to cause an explosion.

LNG disadvantages include:

- Higher fuel cost to liquefy the gas.
- Fewer LNG stations than CNG stations.
- Access to refueling is limited.
- Trained attendants must do the refueling.

"Typically, LNG fuel can be packaged in a smaller space due to the liquification of the fuel (i.e., same energy in a condensed form) for the same effective range when compared to CNG," Donnell said. "This is an advantage for packaging for applications where space is limited. The benefit for CNG is the gas remains in one state throughout the process so no additional energy is required to change phases. Cummins Westport natural gas engines perform the same regardless of how the natural gas is stored, either as a gas or cryogenically-cooled liquid. The greatest majority of our engines purchased today operate on CNG in a wide range of applications, as this is the state in which natural gas is transported around the country through major transmission lines."

"From an operating perspective, the engine only sees methane molecules,"



UPS trucks connect to the fleet's time-fill CNG fueling system in preparation for the next delivery. The time-fill system is designed to refuel multiple trucks over time. Image courtesy: Dominion Energy

Swenson added. "Both CNG and LNG are identical as long as they meet the fuel standard requirement. The issue is how much fuel can be stored onboard and the weight of that system. Historically, LNG was viewed as necessary to achieve long range/decrease the frequency of refueling. However, as CNG tanks have become lighter and many areas are allowing vehicles' extra weight, upwards of 1,000 miles are achievable with CNG tanks."

Improved truck technology

"In June of 2017, Cummins Westport introduced its "nearly no NO_x" Classes 6, 7, and 8 large truck engines," said Brown. "This new technology for large truck engines has basically created a "net zero carbon footprint" for an internal combustion engine. According to Cummins Westport, "the new natural gas engines deliver higher torque than higher horsepower diesel engines over a wider RPM range." This engine produces zero particulate matter." Specifically, the nearly no NO_x engine operates at 0.02g/bhp.



The ISX12N Class 8 truck engine is certified to the CARB optional low NO_x standard of 0.02g/bhp, which is 90% lower than the current regulation of 0.2 g. It is capable of 400 hp, 1,450 lb-ft of torque, and operates on CNG, LNG, or RNG. When operated on RNG, the net carbon footprint emission is below zero. It also carries full on-board diagnostics certification (OBD). It is manufactured at Cummins Jamestown Engine Plant in Jamestown, N.Y. Image courtesy: Cummins Westport



The photo shows a DTE Energy Gas CNG distribution work truck and a CNG supervisor vehicle. Image courtesy: DTE Energy Gas Services

“The new technology CNG fuel engines from Cummins Westport produce emissions from a truck comparable to an electric vehicle,” said Rob Bacynski, program manager, NGV Business Development, DTE Energy Gas Services. “The improvements in the technology for adding CNG fuel storage to the trucks and reduction in costs have provided OTR trucks with more than adequate range. Examples in Michigan include a company called UBCR, which deploys a fleet of 16 OTR CNG trucks throughout the state picking up recyclable beverage containers from retailers. Another in Michigan is FCA Transport (Chrysler Transport), which deploys a fleet of 180 OTR CNG trucks based in Detroit that moves vehicle products throughout the Midwest. For example, an FCA CNG truck from Detroit will pick up an FCA transmission from Indiana and deliver it to a vehicle production facility in Canada.”

“Cummins Westport (CWI) natural gas engines operate at 0.02g/bhp NO_x emissions, which is 90% below current EPA standards of 0.2g/bhp, and when operated

with RNG, operate with a net negative (less than zero) GHG result,” said Thomas Hodek, director of sales and marketing at Cummins Westport. “This is technology available today, is certified by the EPA, and certified to the lowest of CARB’s options of low NO_x standards.”

“Advances in CNG tank technology have brought tank prices down, making the shift to CNG more cost effective,” added Brown. “In addition, advances in CNG conversion kits have enhanced the conversion of light duty, and half- and three-quarter-ton trucks. This technology allows gasoline trucks to now become bi-fuel. Technology has enhanced the performance of these bi-fuel vehicles to run on either natural gas or gasoline by flipping a switch.

Enjoying environmental and cost benefits

Donnell said that more stable and typically lower-priced fuel costs and maintenance-free exhaust treatment systems operated in a longer period of ownership more than offsets by a wide margin any cost difference RNG powered vehicles over the incumbent technology. Swenson added that natural gas engines already have emissions at the NO_x levels being contemplated by

CARB and EPA in the future, with a simple 3-way catalyst muffler system. “When we look

at well-to-wheels, these engines are comparable to, or better than, the emissions associated with charging and electric vehicles. Using certain RNG streams even results in a net negative carbon intensity impact,” he said.

Brown shared the following environmental and cost information:

- Replacing one traditional diesel-burning, heavy-

MORE info

CUMMINS WESTPORT
www.cumminswestport.com

DOMINION ENERGY
www.dominionenergy.com

DTE ENERGY GAS SERVICES
www.dteenergy.com

ENERGY SOLUTIONS CENTER
www.energysolutionscenter.org

NGVAMERICA
www.ngvamerica.org

duty truck with one new CNG heavy-duty truck is the emissions equivalent of removing 119 traditional combustion engine cars from our roads.

- New natural gas engines are 90% cleaner than the cleanest diesel engines available.
- When a new natural gas truck runs on RNG, it has a net negative carbon footprint.
- Natural gas trucks cost approximately \$20,000 more than a diesel model. Federal and state grants are available to make up for the incremental costs. Without the help of grants, differential payback from fuel costs depends on miles driven; general payback is around two years based on a \$2 difference in fuel price.

“Since the No. 1 source of urban emissions is transportation emissions, and three out of every four trucks on the road today is not EPA certified, cleaner air starts with cleaner trucks and buses, especially heavy-duty trucks and buses,” Gage said. “And purchasing new natural gas vehicles is the most cost-effective NO_x emissions reduction of any alternative. In addition, RNG, or biomethane, is furthering the natural gas transportation story.” **GT**

The number of truck stops and fueling stations in the U.S. that are in place to refuel large trucks, such as this Class 8 truck, that operate on natural gas are increasing. Image courtesy: NGVAmerica/Daimler Trucks North America



Regulations and Updates

Portland Generating RNG

RENEWABLE NATURAL GAS (RNG) PROJECTS ARE BEING DEVELOPED THROUGHOUT THE COUNTRY AND PORTLAND, ORE.

is fueling its future with the announcement of the city's first RNG-to-vehicle fueling station. On March 8, 2018, Portland City Commissioner Nick Fish and NW Natural representatives partnered to announce the opening of the station, which is located at the Columbia Boulevard wastewater treatment plant. The City's natural gas vehicles were introduced that day as well.

NW Natural is the largest independent natural gas utility in the Pacific Northwest and provides natural gas service to about 750,000 residential, commercial, and industrial customers in Oregon and Southwest Washington.

The City dubbed the RNG project "Poop to Power," because it was created to capture waste, clean it up, and then use it in heavy-duty trucks. The project was approved in April 2017 and will recover nearly 100% of the waste methane from sewage treatment, up from the current 77% recovery rate. That methane will be cleaned and used in two ways: in NW Natural's pipeline and in City vehicles.

The project fits into NW Natural's Low Carbon Pathway goals to achieve the following:

- Reduce the carbon intensity of its product by transitioning to RNG.
- Displace more carbon-intensive transportation fuels such as diesel with compressed natural gas (CNG).

"We're proud to be a part of our City's efforts to close the loop on waste," said David H. Anderson, NW Natural president and CEO. "We look forward to this being the first of many

renewable natural gas projects that move us toward a low-carbon future."

Every year, the Bureau of Environmental Services processes 28 billion gallons of wastewater. A natural by-product of sewage treatment is methane, a potent greenhouse gas. For years, Portland has been capturing a portion of this methane gas to produce electricity. The rest gets burned and released into the atmosphere. When the project is fully up and running in 2019, Portland will capture almost all of the methane from the wastewater treatment plant and convert it to RNG. That means that every year, the City will replace more than one million gallons of dirty diesel fuel with RNG, eliminate 21,000 tons of greenhouse gasses, and generate more than \$3 million each year for its ratepayers. Simultaneously.

This is the City of Portland's first CNG facility, and will provide clean fuel for the city and contractor vehicles serving the plant. For now, they run on conventional natural gas; when the city's RNG infrastructure is up and running in late 2019, they will run on RNG. Soon the second part of the project will come to fruition and RNG will be placed into NW Natural's pipeline and mixed with conventional gas.

By capturing methane from human waste and using it in new ways, Portland and NW Natural are on the road toward a clean and green future.

—Sources: *AGA, The City of Portland, Ore.*

Duke Energy issues second green bond

Duke Energy Progress, a subsidiary of Duke Energy, has completed its first issuance of \$600 million in green bonds that will finance eligible green energy projects, including the development, construction, and procurement of solar

generation in the Carolinas.

This transaction, which involved two minority-owned banks to place the bonds, marks the second green bond transaction by a Duke Energy utility. Duke Energy Carolinas issued \$1 billion of green bonds in November 2018.

"We are providing our customers and communities with ever-cleaner energy and these investments help us get there even faster as we expand renewable energy across the Carolinas," said Duke Energy executive vice president and chief financial officer Steve Young. "We saw strong interest in our first green bond last year and are excited to expand these offerings for investors."

The company is well on its way to achieving its goal of reducing carbon emissions by 40% by 2030, having already reduced carbon emissions by 31% from 2005 levels.

In the last decade, Duke Energy Progress retired 12 older coal-fired units, increased nuclear generation capacity, and added more than 2,000 MW of built or purchased solar capacity. For six straight years, the utility has been among the top 10 utilities nationwide for adding solar capacity to its system.

The green bonds, priced at 3.45% fixed-rate coupon and 10-year maturity, will ensure the company's eligible green projects continue to be financed on attractive terms to serve Carolinas customers.

"As we look ahead, we plan to invest in clean, green generation sources into the future and will continue to look for innovative options to finance these projects with diversity-owned firms," said Young. **GT**

—Source: *PRNewswire*

ESC Partnership Awards

Morton Salt, Perris Bioenergy Receive Partnership Awards

Morton Salt converted coal-fired boiler to natural gas

MORTON SALT, SILVER SPRINGS, N.Y., RECEIVED AN ENERGY SOLUTIONS CENTER PARTNERSHIP AWARD ON SEPT. 28, 2016 at the Technology and Market Assessment Forum (TMAF) in Buffalo, N.Y. Partnership Awards are given three times a year during the Center's TMAF. Morton Salt was among the companies nominated by National Fuel, Williamsville, N.Y., because of the partnership formed during a recent project.

Project description

National Fuel provides gas to Morton Salt, a large industrial customer, from a Dominion transmission feed. In 2015, Morton Salt converted its coal-fired boiler to natural gas. The boiler project included the installation of a 148 MMBtu/hr natural-gas-fired boiler and eight direct-fired gas natural gas building heating units. The new equipment replaced a 138 MMBtu/hr 1939 pulverized coal boiler and a 92 MMBtu/hr backup gas boiler along with a steam heating system. The new boiler has an 84% efficiency rating compared to 75% efficiency of the coal-fired boiler. The dedicated natural gas boiler required significantly more natural gas capacity. As a result, National Fuel needed to upgrade its existing distribution system along with numerous upgrades required by the upstream transmission provider.

It was determined that the equipment (valves, meters, and heaters) at this purchase point were undersized for the approximately 3,000 Mcf daily requirement. After calculating the cost to accomplish this upgrade, National Fuel and Morton Salt partnered on sharing the financial obligation by jointly contributing financially toward the project. Morton Salt provided direct funding, and National Fuel provided a significant system benefit credit to the project, along with a substantial capital buy-down incentive through its Partnership to Revitalize the Industrial Manufacturing Economy of Western New York (PRIME-WNY) pilot program.

In addition to an improvement in energy efficiency, the installation of the boiler had a significant positive impact on the environment by reducing greenhouse gas emissions (GHG) by approximately 40,000 tons per year. This project also resulted in an increased annual natural gas consumption of 1 Bcf. **GT**

Perris Bioenergy Facility underway

PERRIS BIOENERGY FACILITY, PERRIS, CALIF., RECEIVED AN ENERGY SOLUTIONS CENTER PARTNERSHIP AWARD ON OCT. 4, 2017 at the Technology and Market Assessment Forum (TMAF) in Los Angeles. Partnership Awards are given three times a year during the Center's TMAF. The Perris Bioenergy Facility was among the companies nominated by CR&R Environmental Services, Stanton, Calif., because of the partnership formed during a recent project.

Project description

CR&R Environmental Services has entered the construction phase of its anaerobic digestion facility that will convert organic yard and food waste into fertilizer and Renewable Natural Gas (RNG) to fuel its refuse collection fleet.

The more organic yard and food waste that is prevented from entering and decaying in landfills, the more methane, a potential greenhouse gas (GHG), can be prevented from entering the atmosphere. The Perris facility will be able to process 335,000 tons of waste per day, generating 4 million gallons of diesel gallon equivalent RNG, and almost 260,000 tons of solid amendment/compost per year. CR&R is deploying a proprietary process that has the highest energy conversion rate in the industry. **GT**

Partnership Awards at a Glance

Award:

Energy Solutions Center
Partnership Award

Award recipient:

Morton Salt, Silver Springs, N.Y.

Nominating utility:

National Fuel, Williamsville, N.Y.

Award:

Energy Solutions Center
Partnership Award

Award recipient:

Perris Bioenergy Facility, Perris, Calif.

Nominating utility:

CR&R Environmental Services, Stanton, Calif.