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Microgrids are energizing universities

CHP improves efficiency and reduces emissions

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on the cover

Site construction of the CHP plant at Cornell University in Ithaca, N.Y. The plant houses two 15 MWe Solar Titan 130 gas turbines. Image courtesy: Solar Turbines

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inside

CHP, DG, AND MICROGRIDS ENERGIZE UNIVERSITIES

Combined heat and power (CHP), distributed generation (DG), and microgrids keep university campuses energized—fueled by natural gas.

COMBINED HEAT AND POWER (CHP) SYSTEMS GENERATE ELECTRICITY AND USABLE THERMAL ENERGY FROM ONSITE GENERATOR SETS. Typically, CHP systems are used at facilities with high heat load requirements, such as universities/colleges, hospitals, and industrial campuses.

A microgrid is a localized electrical network that allows campuses and other similar-sized districts to generate and store power from various distributed energy resources including renewables. Microgrid usually refers to a collection of two or more distributed generation assets working together to serve a common load center, such as critical facilities, hospitals, colleges, or small communities, and can be isolated from the larger grid and still provide electricity.

Distributed generation (DG) typically refers to a category of equipment used to generate electricity, such as CHP, solar panels, battery or energy storage, generator sets, or fuel cells at or near the end user. DG equipment is distributed either on the user's side of the meter or located near utility distribution lines.

Site construction of the CHP plant at Cornell University in Ithaca, N.Y. The plant houses two 15 MWe Solar Titan 130 gas turbines. Image courtesy: Solar Turbines

CHP, DG, and microgrids are related

"CHP is a central component to most microgrids," said Doug Edgar, vice president of operations at White Harvest Energy, a distributor for 2G Energy. "For example, if the microgrid consists of only solar panels and battery storage, it could become useless at night or a cloudy day when the battery has been exhausted. CHP provides on-call, reliable energy, and is typically a work-horse ensuring the supply and demand of electricity is equal."

"CHP is an effective resource that should be part of the local microgrid," said Chris Lyons, manager, power generation at Solar Turbines. "In most cases, this would be an ideal anchor for the microgrid because it can use a host of fuel supplies with the most reliable, and easiest to use being natural gas. CHP plants also can use the energy outputs to provide thermal storage of chilled water and even heat to provide better overall security of energy supply to the microgrid."

The case for natural gas

Microgrids almost always include one or more gas turbines, reciprocating engines, or steam turbines that can produce a controlled amount of power. The energy source for these is usually natural gas.

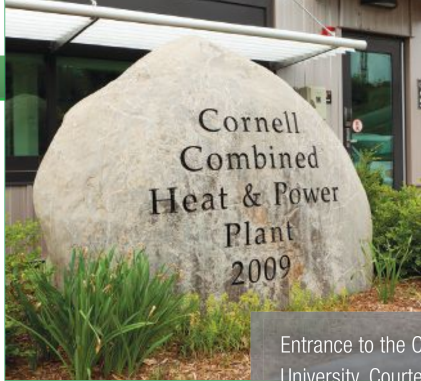
Traditionally, diesel engine-generator sets have been installed as standby generation in health care centers, universities, government facilities, and other mission critical campuses because they are able to pick up critical elements of the electrical load if the utility power goes down. In addition, diesel engines start quickly and, if properly maintained and periodically tested, provide reliable backup power. However, they require onsite fuel storage for two or more days of operation, and that fuel has to be kept in good condition. Because of emission restrictions, unless they have significant upgrades for pollution control, they cannot be operated other than in emergency service.

While there are increasing limitations on diesel, natural gas is becoming a viable alternative fuel. "In the U.S., natural gas is a very cost effective and reliable source of fuel supply for microgrids and/or DG," Lyons said. "However, this is not the same across the globe where there are still places without natural gas distribution and in some cases due to limited or constrained supplies, can be very expensive. In these cases, alternative fuel supplies would be a better choice."

"Natural gas is very reliable in terms of infrastructure and availability, which makes it a great choice for microgrids and/or DG," Edgar agreed. "However, in some areas of the country—the Northeast in particular—natural gas supply may become scarce or costly during really cold snaps or winter storms and may be subject to curtailments."

Generator sets versus gas turbines

Using generator sets or gas turbines for CHP, DG, and microgrids does not have to be mutually exclusive. When asking the question, "Which technology is ideal for CHP, DG, and microgrids?"



Entrance to the CHP plant at Cornell University. Courtesy: Solar Turbines

The answer is, "It depends on the specific application."

Both natural-gas powered generator sets—such as the CHP microgrid system installed at Texas Wesleyan University—and gas turbines—such as the ones installed in the CHP plant at Cornell University—have their applications. "Gas turbines have high grade exhaust heat that can be used to make steam, chilled water, or for various drying applications including processes, such as tissue production and ceramic tile," Lyons said. "Gas turbines have very fast response times and provide excellent localized VAR (reactive power) support. Internal combustion engines use lower gas supply pressures and are more electrically efficient in open cycle than gas turbines. Each technology has its applications, but in many cases, work well in combination."

"Gas turbines supply more thermal energy than reciprocating internal combustion engines," Edgar said. "However, they require natural gas compression equipment if the NG pressure is not adequate. This adds more capital cost and another maintenance item. Internal combustion engines have better turndown than gas turbines, meaning, they can run at 40% or 50% fairly easily and without excessive efficiency loss. Gas turbines will take a larger hit to efficiency or will not even run at low loads. Gas turbines also are more susceptible to ambient conditions than internal combustion engines. At high ambient temperatures or high altitude (both create lower air density), gas turbines have a larger reduction in efficiency and output than internal combustion engines."

Why universities are choosing CHP, DG, and microgrids

Microgrids are owned and operated by college and university campuses, military bases, hospitals, housing complexes, research facilities, and some municipalities and businesses. Typically, these are organizations that place a high value on energy reliability, efficiency, security, power quality, or minimized environmental impact.

"Having one large distribution network of various buildings, living spaces, and research facilities all located on a contiguous property make universities and military bases ideal candidates," said Lyons. "Municipalities that can control the integration and distribution of energy supply to various buildings and users also is an excellent application."

According to Lyons, there are two main drivers to implementing a microgrid. "The first is reliability of the energy supply to avoid issues if the main grid is out for a host of supply issues including cybersecurity, weather related reasons, or even grid congestion causing potential supply interruptions. The second is the ability to integrate the variety of potential generation assets, both for cost and for environmental improvements," he said.

"Microgrids place the generation of electricity locally and decreases the amount of risk associated with a faulty, failing, or disrupted grid," said Edgar. "The typical example is a severe storm that knocks out a main transmission line, which affects several neighborhoods or an area of downtown. With a microgrid, power is local (there are little to no transmission lines) or power is re-allocated to serve the critical loads as needed."

The central control room for Cornell University's CHP plant. Image courtesy: Solar Turbines

Microgrids could reduce utility costs, according to Edgar. "CHP is a more efficient means of producing energy, which equates directly to utility savings. Solar and wind offer tax credits and other benefits," he said.

Lyons suggests that CHP, DG, and microgrids are not a panacea. "CHP only makes sense when you have the proper balance of power and thermal demands," he said. "It is not a solution for areas that do not have critical loads that do not need to operate independently of the grid or where various generation assets cannot be economically controlled."

Cornell University launches CHP

To improve efficiency and reduce emissions, Cornell University replaced coal-fired boilers in 2009 with two Solar 15 MWe Titan 130 gas turbine generator sets for its CHP plant. Previously, the Ithaca, N.Y. campus purchased 80% of its electricity from the local utility. The turbines now fulfill 80% of the campus power and steam needs to 150 buildings covering more than 14 million sq ft. By early 2011, the university discontinued use of coal as a fuel source. Cornell's district energy systems produce hot water, steam, or chilled water at a central plant and then distributes them through underground pipes to buildings connected to the system. Cornell students, faculty and staff use hot or chilled water to meet their space heating, water heating, processing, and air-conditioning needs. After water is used, it is returned to the central plant to be reheated and rechilled before recirculating through the closed-loop piping system.

"The natural gas fired project at Cornell University was installed to meet growing steam de-

Located inside Cornell University's CHP plant are two 15 MWe Solar Titan 130 gas turbine generator sets. Image courtesy: Solar Turbines

mands, provide onsite distributed generation after concerns over the August 2003 Northeast blackout, and to replace older coal fired boilers that would have been subject to new environmental regulations such as Boiler MACT," said Lyons. "This allowed Cornell to significantly reduce its greenhouse gas (GHG) emissions and upgrade its district energy plant with more reliable and lower-polluting natural gas-fired combustion turbines. The plant uses duct firing of the turbine's exhaust heat to meet peak winter steam demands for heating and when this demand is lower in the summer, can use the steam in combined cycle with the steam turbine for good overall efficiency. A load management system was developed to include import/export control, main-tie-main automation of the secondary bus at the primary substation, load shedding and bump-less transfer to island mode operation, and synchronization across the mains and ties at the primary substation."

Texas Wesleyan University chooses CHP

Texas Wesleyan University in Fort Worth, Texas, launched an energy-saving project in 2015. The centerpiece of the project is 2G Energy's avus 800, a natural gas-powered CHP plant that supplies 80% of the power to the 83-acre campus, while reducing the university's dependency on the public power grid. The power plant also includes a 250-ton absorption chiller, new cooling tower, new heating boilers, pumping systems and central plant optimization controls. The system has been in operation since 2016.

According to Edgar, the CHP system generates electrical energy used directly by the university's multiple facilities. "Hot water is generated from the combustion exhaust gases as well as engine cooling circuit. This hot water is sent next door to the university's energy plant where it is either delivered to facilities as hot water for heating in the winter or sent to an absorption chiller where it is turned into chilled water for cooling in the summer," he said.

The 2G Energy avus 800 CHP system is equipped with exhaust gas heat recovery heat exchangers and fan coolers (i.e., radiators) to reject heat to the atmosphere when the CHP system generates too much heat during shoulder months. The first priority is to use the heat in the university, but it must go somewhere to keep the engine-generators cool and running smoothly, according to Edgar.

Many projects have their challenges and this one is no exception. "The CHP is not allowed to export power and must import a minimum amount of electricity," said Edgar. "Therefore, it is critical that the CHP system and grid communicate via controls and relays to ensure good power quality for the university and the surrounding neighborhoods. This required close coordination and communication with the local utility."

DG, CHP, and microgrid perks

CHP systems can reduce operating costs, increase electrical reliability, and reduce greenhouse gases. A microgrid can operate as an "island" or independently from the larger utility grid as required. Advantages include lower heat and power costs (using CHP) compared to a centralized utility company, lower carbon footprint, minimized impact of weather emergencies, higher security, and higher power quality. Having electrical power generation capability on the user site of the meter (DG) definitely has its perks. **GT**

MORE info

2G ENERGY
www.2g-energy.com

ENERGY SOLUTIONS CENTER
http://understandingchp.com/installations/case-studies/

SOLAR TURBINES
www.solarturbines.com

The avus 800, a natural gas-powered CHP plant from 2G Energy, supplies 80% of the power to the 83-acre campus of Texas Wesleyan University in Fort Worth, Texas. Image courtesy: 2G Energy

Steam traps keep an eye on energy efficiency

Steam traps may not always be top of mind. However, a little bit of attention can go a long way toward efficient steam plant operation.

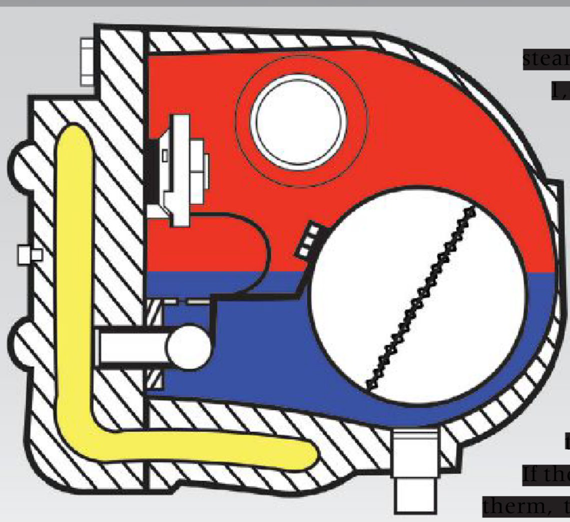
ACCORDING TO THE U.S. DEPARTMENT OF ENERGY, MANY FACILITIES CAN RECAPTURE ENERGY BY INSTALLING MORE EFFICIENT STEAM EQUIPMENT AND PROCESSES. A typical industrial facility can achieve up to 20% steam savings by improving its steam system. While most components of a typical steam system can contribute to energy efficiency, taking a closer look at proper steam trap operation can be the energy-efficiency low-hanging fruit for your plant.

Eye on energy efficiency

"Whether trapping from distribution lines or at a given point of use, the main function of a steam trap is to impede steam loss while effectively removing insulators, such as condensate and noncondensable gasses from a steam system," said Matt Nowak, director of North American sales, steam and condensate, at Armstrong International. "This allows the steam user to get the most efficient use of the available latent heat energy within a given volume of steam. Also, the condensate that is removed by the steam traps can be returned to and reused by the boiler. The preheated condensate requires less heat energy for the boiler to bring its feed water up to saturation temperature, consequently, conserving energy and saving the facility on steam generation costs."

Jarek Berezowski, senior product specialist, Xylem Bell & Gossett sheds light on the economics: "When a trap fails open, it will discharge steam to the return pipes. This can be very costly in terms of energy use. The relatively small cost of a regular maintenance program can save thousands of dollars, and an initial investment can be recovered in a very short period of time. For example, a single trap with 3/8-inch orifice discharging 100 psig of steam into the atmosphere will cause a steam loss of 652 lb/hr. Because each pound of [redacted]s equivalent to about [redacted]0 Btu/h, the loss will [redacted] 652,000 Btu/h. A gas-[redacted]red boiler, operating [redacted]t 70% efficiency will produce about 70,000 Btu for each therm of natural gas. The gas required to replace the loss of steam will then become 652,000 Btu/h divided by 70,000 Btu/[redacted]rm or 9.31 therms/hr. [redacted]atural gas cost is $0.60/[redacted] money wasted due to the faulty trap becomes 9.31 therm of gas/hr. If a therm of gas cost $0.60, the cost is $5.59/hr. If the boiler operates 10 hours/day, 241 days/year, Oct. 1 through May 1, the cost is $13,462/year. The significance of these savings becomes considerably higher when you realize even a small steam system has several traps. A larger system can have more than 1,000 traps," he said.

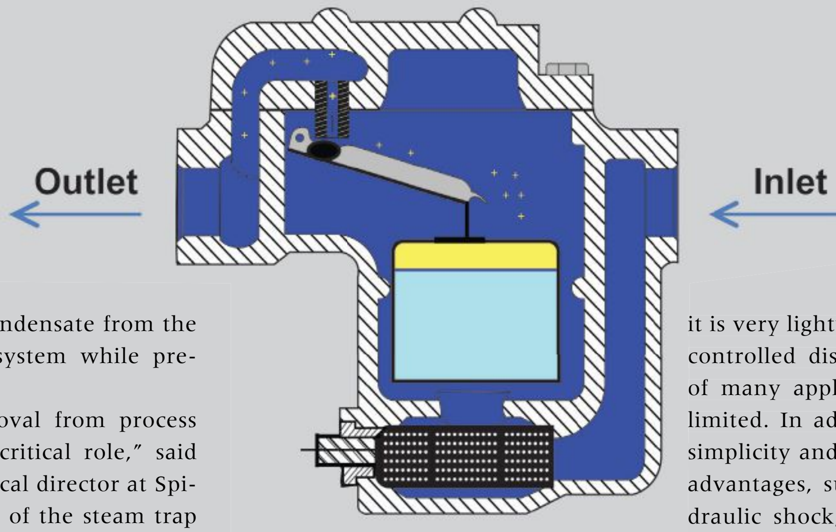
Float and thermostatic traps have two elements. One is a thermostatic element to vent air from the system during startup. The second is a float assembly that opens



Steam system anatomy

Most steam systems, regardless of the application have the following functions in common: generation, distribution, process applications/heat transfer, and condensate return. Steam generation occurs in a boiler, which applies heat to water to raise its temperature. After the water has vaporized, the resulting steam moves into the distribution lines, which supply pressurized steam to various locations via steam mains and headers. The steam pressure causes the movement of the steam within the closed system to its point of use. Point-of-use equipment, such as heat exchangers, sterilizers, heating coils, and jacketed kettles are the process applications. Regardless of the application, the use of steam by such equipment is called "heat transfer," where the heat energy within the steam is put to work.

As the steam gives up its heat through heat transfer, it condenses back into water, which is called "condensate." Draining condensate from a steam system quickly is very important. Condensate removal is done by steam traps. In other words, the purpose of a steam trap is to keep steam in the system while removing condensate and



Inverted bucket traps have an open bucket installed in the inverted position. The top of the bucket has a small bleed hole to allow air to vent from the bucket. The trap body is filled with condensate. As air or steam enters the bottom of the bucket it collects in the top, the buoyancy lifts the bucket to close the trap. When the bucket is filled with condensate it sinks and opens the trap to drain condensate. Image courtesy: Xylem Bell & Gossett

air. Drip legs are condensate collection points at the bottom of which steam traps are installed to remove condensate from the steam distribution system while preventing steam loss.

“Condensate removal from process equipment plays a critical role,” said Shaibaal Roy, technical director at Spirax Sarco. “The role of the steam trap is to trap steam, ensure condensation takes place inside of the heat transfer equipment, and then remove condensate from the space efficiently and quickly. The quality of steam that reaches the process equipment through the distribution network also is affected by the efficient removal of condensate from the steam pipes.”

Condensate can contain up to 20% of the energy required to make the steam in the boiler. It is important to maximize the amount of condensate returned to the boiler to save energy and water treatment chemicals. The condensate-return component of a steam system does what the name implies; it returns the condensate back to the boiler where the process starts over. Condensate is collected at each point of steam use or heat transfer and in long steam pipe runs. It is then pumped back to the boiler using steam pressure or electric-operated pumps. Equipment associated with condensate return includes condensate pumps, flash tanks, deaerators, and boiler feed units.

Steam trap types and operation

According to Roy, steam traps can be classified as mechanical, thermostatic, and thermodynamic. However, steam trap types can be in more than one category. For example, while the inverted bucket and the float/thermostatic steam traps are both considered to be mechanical, the float and thermostatic trap operates on thermal principles as well.

The inverted bucket operates on the difference in density between steam and water, according to Nowak. “Steam entering the submerged inverted bucket causes the bucket to float and close the discharge valve. Condensate entering the trap changes the bucket’s buoyancy allowing it to sink and open the trap valve to discharge the condensate, which can be piped to a drain, or in most cases, collected and transported back to the boiler feed system to be reused,” he said.

“Float and thermostatic traps have two elements,” said Berezowski. “One is a thermostatic element to vent air from the system during startup. The second is a float assembly that opens in the presence of condensate. Float and thermostatic traps modulate to continuously drain condensate at a fixed rate depending on the system load. They completely drain the condensate at saturation temperature.”

Thermodisc and controlled disc are thermodynamic type steam traps. “The controlled disc steam trap is a time-delayed device that operates on the velocity principle,” said Nowak. “It contains only one moving part—the disc itself. Because it is very lightweight and compact, the controlled disc trap meets the needs of many applications where space is limited. In addition to the disc trap’s simplicity and small size, it also offers advantages, such as resistance to hydraulic shock, and the complete discharge of all condensate when open, and intermittent operation for a steady purging action.”

Thermostatic steam traps operate on the difference in temperature between steam and cooled condensate and air. Steam increases the pressure inside the thermostatic element, causing the trap to close, according to Nowak. “As condensate and noncondensable gases back up in the cooling leg, the temperature begins to drop and the thermostatic element contracts and opens the valve. The amount of condensate backed up ahead of the trap depends on the load conditions, steam pressure, and size of the piping.”

Bimetallic steam traps also fall into the thermostatic category. “They have the ability to handle large startup loads. As the trap increases in temperature, its stacked nickel-chrome bimetallic elements start to expand, allowing for tight shutoff as steam reaches the trap, thus preventing steam loss,” Nowak said. “In addition to its light weight and compact size, it offers resistance to water hammer.”

Knowing when to repair and when to replace

According to Roy, most steam traps are expected to provide service for a minimum of 1,000 working days and if either repair or replacement comes into question, it should raise a red flag.

The photo shows various Inverted Bucket and Thermostatic steam Traps. Image courtesy: Armstrong International

Generally, the cost of repair for very small steam traps does not compare favorably with replacement.

But how does one know if steam traps require attention? Nowak offers some troubleshooting tips. "There are three ways to check if a steam trap is functioning properly: visually, auditorily, and thermally. The most effective method of determining whether a trap is operating effectively is visually. With a test port, an operator can observe a trap's cycle to see if the trap is operating as expected, if it is blowing through, or possibly locked up. Another effective method of determining if a trap is functioning properly is listening to hear if the trap is cycling. Pared with a visual inspection, the two methods are ideal for manually monitoring a trap's functionality. Although, the temperature of a trap may indicate an operational issue, it is the least reliable method of evaluating trap performance. For example, in a blow-through condition, the trap may register the same temperature as one that is functioning properly."

Routine maintenance is important as well. Steam traps should be monitored on a regular basis. According to Berezowski, steam trap testing should be performed on a weekly basis for high-pressure systems above 150 psi, monthly for systems between 30 and 150 psi, and annually for systems less than 30 psi. Repair or replacement should be done based on cost analysis, delivery time replacement parts versus the whole trap, and age of steam traps. A system that has not been properly maintained for 5 years might have up to 30% failed traps.

According to Berezowski, typical symptoms of failed traps include:

- Condensate temperature raise. This will cause pump seals to fail.
- Flooded heat exchangers.
- Steam coming from receiver vent pipes.
- Parts of the building not getting hot.
- Return lines getting pressurized.

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ENERGY SOLUTIONS CENTER
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XYLEM BELL & GOSSETT
http://bellgossett.com/steam-specialties/traps/

Survey says...

"Steam trap performance needs to be monitored regularly and in case of critical applications, one may want to consider continuous monitoring using wireless technology," Roy said. "Depending on the type of steam traps, they can fail either open or closed. Steam trap surveys need to be conducted for reasons more than the obvious one—to establish if the trap is functioning. It needs to take into account the selection, location, orientation, and if it is established that a particular trap is seeing chronic failures, then those need to be identified as part of the steam trap surveys."

According to Nowak, the advantages to conducting a steam-trap survey include:

- Identification of malfunctioning traps.
- Ability to evaluate if the degree of malfunction justifies the cost of repair or replacement.
- Increase system efficiency and steam equipment longevity.
- Avoid unnecessary process downtime.
- Decrease steam loss.
- Decrease safety risk (water-hammer).
- Identification of problem areas as they occur versus discovering issues.

Although there are many advantages to conducting a steam-trap survey, there could be issues with scheduling cost of initial implementation, and manpower.

Nowak explains how to get started with a steam trap survey and monitoring. "The first point of contact should be a local steam and condensate equipment vendor representative who can coordinate and schedule a steam system survey with the manufacturer. After an accurate survey has been performed, individual traps can be identified for monitoring systems installation. After a monitoring plan has been developed, a follow-up radio frequency or wireless survey is performed where a field technician can help determine infrastructure requirements for the monitoring system," he said. **GT**

Finding Help with Energy Projects

Hundreds of Assistance Programs

"WHERE CAN I GO FOR HELP WITH THIS ENERGY PROJECT?" THIS QUESTION IS ASKED MANY TIMES BY BUSINESS MANAGERS AND PROJECT ENGINEERS. Because of the federated-type governments of the U.S. and Canada, answers can be complicated and will vary from state to state, province to province. Further, most natural gas distribution companies have customer assistance programs, specialized rates, and sometimes even project grants, but these vary from state to state, or even within certain economic incentive zones. The key is finding the opportunities, and then asking for help.

Project payback often critical

Typically, owners of commercial, institutional, and industrial facilities decide whether to proceed with energy improvement projects based on simple payback—how many months or years it will take for the improvement to pay for itself. A payback in six months is relatively easy to sell: One taking eight or ten years is tougher unless the owner is quite sure the facility will still be in use at that time, and investment dollars are available. Even if the dollars are there, the energy project has to compete with other potential uses like process efficiency improvements or facility expansion plans.

Shortening the payback

Here's where government, utility consulting, and incentive programs can help shorten the payback. One example is interruptible gas rates. Many gas suppliers—both regulated distribution companies and third-party suppliers—offer attractive rates for gas users who will agree to tolerate periodic interruptions of service. An example might be replacing an electric or oil-fired piece of equipment with a natural gas device on an attractive interruptible rate. Ask your gas supplier about interruptible rates and get details on exactly what your commitment would be. Some suppliers use the service interruption very infrequently but offer a significant discount. This could further shorten the energy improvement project payback.

Another possibility is actual incentive payments from federal or state energy or environmental agencies, or from your utilities themselves. These incentive programs are intended to encourage owners to take energy improvement steps now rather than waiting. Programs include direct grants, tax credits, financing assistance, and project engineering assistance.

Major energy-related facility improvements, such as installing a boiler economizer, can often receive grant, engineering or loan assistance from government or utilities. Image courtesy: Resource Recovery Company.

Finding current incentives

Programs are numerous but are constantly changing so it's important to know you are acting on current program requirements. Often your project engineer or your utility customer representative can help you find these.

Another great resource for U.S. owners searching for help is this website:

http://energy.gov/eere/femp/energy-incentive-programs

Canadian owners can similarly benefit from this website:

www.nrcan.gc.ca/energy/funding/efficiency/4947

These resources summarize federal, state, provincial, and utility incentive programs for improving facility energy efficiency. Payback should not be the only criterion for embarking on a facility energy efficiency project. Such projects may also improve your compliance with present or future environmental regulation and may increase your energy supply security status. If you are considering embarking on such a program and are looking for a partner, your own gas utility, along with the website tools shown above, may be the right place to put in your shovel. **GT**

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SMALL BUSINESS ADMINISTRATION ENERGY AND ENVIRONMENTAL GRANTS AND LOANS
www.sba.gov/content/environmental-grants-loans

U.S. ENVIRONMENTAL PROTECTION AGENCY GREEN BUILDING REQUIREMENTS
www.epa.gov/oaintrnt/projects/requirements.htm

Using gas catalytic infrared curing for powder coating

Powder coatings have many advantages over liquid paint; gas catalytic infrared (IR) has benefits beyond convection curing.

ACCORDING TO THE POWDER COATING INSTITUTE, POWDER COATING IS A DRY FINISHING PROCESS USED ON A WIDE ARRAY OF PRODUCTS. Increasingly more companies specify powder coatings for a high quality durable finish, allowing for maximized production, improved efficiency, and simplified environmental compliance. Used as functional (protective) and decorative finishes, powder coatings are available in an almost limitless range of colors and textures, and technological advances have resulted in excellent performance properties.

Powder coatings are easy to use, environmentally friendly, cost effective, and tough. Advantages of powder coating include thicker coatings without running or sagging, faster production cycles, and much lower emissions of volatile organic compounds (VOC). They are based on polymer resin systems, combined with curatives, pigments, leveling agents, flow modifiers, and other additives. These ingredients are melt mixed, cooled, and ground into a uniform powder similar to baking flour. A process called electrostatic spray deposition (ESD) typically is used to achieve the application of the powder coating to a metal substrate. This application method uses a spray gun, which applies an electrostatic charge to the powder particles, which are then attracted to the grounded part. After application of the powder coating, the parts enter a curing oven where, with the addition of heat, the coating chemically reacts to produce long molecular chains, resulting in high cross-link density. These molecular chains are very resistant to breakdown. An alternative to convection curing is gas catalytic infrared (IR) curing.

MDF must be dense with a strong internal bond so it can withstand the rapid heating and cooling it will undergo in the powder coating process. Poor quality MDF will split and crack on the edges where there are cut surfaces when it is powder coated. Image courtesy: Heraeus Noblelight America

Gas catalytic IR versus convection ovens

In most cases, key elements of powder paint systems are natural gas-fired convection ovens or gas-fired catalytic IR systems. Convection ovens heat objects via the conduction of heat from hot, high-velocity air to the substrate, and IR heats the surface by radiation.

By comparison, convection ovens are less efficient than catalytic IR ovens. According to Mike Chapman, catalytic product manager at Heraeus Noblelight America, a conventional [convection] oven must be heated to fill its interior cavity as well as to bring interior surfaces of the oven to the desired temperature, a costly expenditure of energy. "IR ovens, on the other hand, target heating the coated part surface and affecting a cure without the mass of the part reaching the curing temperature. IR systems offer design flexibility, allowing a thermal treatment area to be adapted for various coatings and product types," he said. Chapman also notes the short cure times for IR versus convection oven systems.

Powder coating using gas catalytic IR

Gas catalytic IR emitters convert natural gas or propane into medium- to long-wave IR by using a special platinum catalyst. The only byproducts are water and carbon dioxide. The flameless catalytic reaction produces controllable surface temperatures of the emitters between 175°C and 480°C without the release of NO_x gases or CO. The radiation intensity can be infinitely varied between 20% and 100% of the available output.

Gas catalytic technology has high efficient direct radiant energy transfer to the powder coating resin component at a wavelength that is very receptive to absorbing that IR energy wavelength. "The radiant energy heats the entire thickness of coating on the part substrate," said Allan McKellar, design services for Blasdel Enterprises. "For metallic substrates, the radiant energy transferred to the substrate is less than the rate that the resin component of the coating absorbs. So, conduction from the coating to the substrate is a significant component of energy transferred to the substrate, and the entire mass of the substrate does not need to be entirely heated to reach the process temperature—as required for convection processing—for the powder to be cured. Direct radiant en-

The photo shows a gas catalytic IR oven designed for powder coating road construction equipment. Image courtesy: Blasdel Enterprises

ergy is transferred to the coating, which elevates the coating temperature much faster than can be done with convection transfer. Every incremental degree of coating temperature elevation results in the curing process being at the upper end of the coating manufacturer's bandwidth of forced curing. Consequently, the chemical polymerization of the coating occurs at a much faster rate than at a lower temperature. It is typical for gas catalytic IR curing of powder to process in 25% of the time required to do the same curing process in a convection oven."

"The reason why this catalytic technology works so well with powder is because the powder coating—epoxy, polyester, acrylic—is the ideal wavelength of energy that is easily absorbed by these powdered surfaces is 3 to 4 microns of wavelength," Chapman said. "It so happens that a catalytic heater that operates at a max temperature of 850°F, emits its IR energy at a peak of 3.4 microns. This wavelength also is considered "color blind." It does not recognize colors. Shorter wavelengths that are emitted from electrical medium or short-wave IR are dependent on the color for maximum absorption.

More than metal

Powder coatings also can be applied to non-metallic substrates, such as plastics and medium-density fiberboard (MDF). Chapman stresses that powder coatings for MDF products is an important trend. "The first part of the process is to heat the MDF to around 50°C to draw moisture to the surface. This makes it conductive. It is important to use MDF that has a moisture content between 5% and 8%. The other issue with powder coating MDF is the need for quality. It must be dense with a strong internal bond so it can withstand the rapid heating and cooling it will undergo in the powder coating process. Poor quality MDF will split and crack on the edges where there are cut surfaces when it is powder coated," he said.

According to Chapman, it is important to seal off the edge to any outgassing that tends to happen along the edges of the board. By concentrating the IR toward these edges, the face of the board easily absorbs the required IR to flow and cure the flat areas. "MDF has a natural tendency to expand when the relative humidity increases, especially at low ambient temperatures. Some MDF expands more than others. That's why the powder on the edges has to be well cured to reach the full physical properties of the coating," he said.

Gas catalytic IR design optimization

How important is optimizing gas catalytic IR designs for powder coating processes? McKellar said that optimization of equipment configuration can be adjusted or determined during the initial product testing phase of any project prior to equipment being proposed, so it is important that a potential oven supplier have an adequate test facility. "Optimization depends on patterning of the radiant energy onto the overall part profile. The energy density (radiant energy Btu/h/ft^3) of the emitters for the oven must be high enough for the desired curing process of powder efficiently at high speed, which typically requires 1,800 Btu/h/ft^3 or greater. Recirculated air can be used to optimize the heat load on a part, in general, as it steals heat from the portion of the parts that are receiving energy faster, while the areas of the part that are behaving as a bigger heatsink can come up to temperature," he said. GT

Optimization depends on patterning the radiant energy onto the overall part profile. Image courtesy: Heraeus Noblelight America

MORE info

BLASDEL ENTERPRISES
www.blasdel.net

ENERGY SOLUTIONS CENTER
www.energysolutionscenter.org

HERAEUS NOBLELIGHT AMERICA LLC
www.heraeus-thermal-solutions.com

POWDER COATING INSTITUTE
www.powdercoating.org

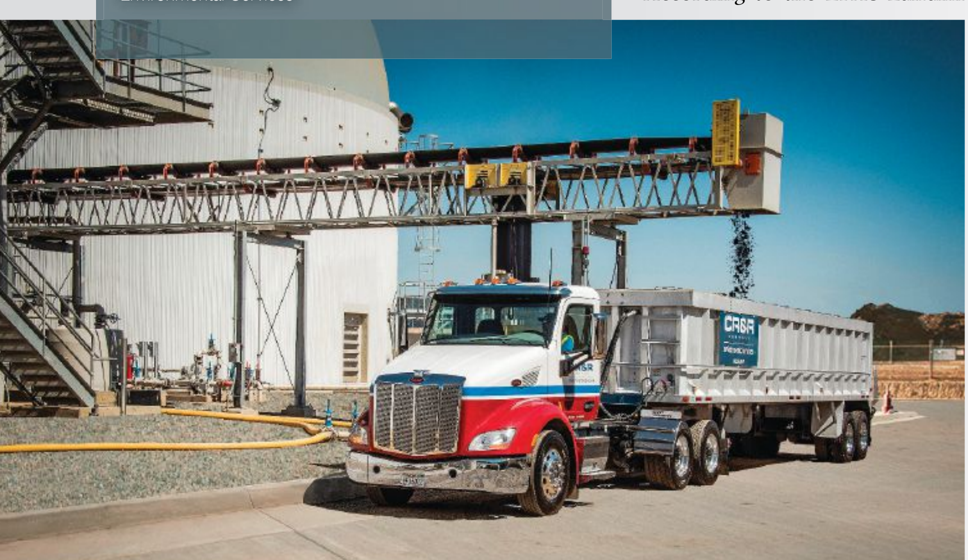
LANDFILL GAS LEADING THE CHARGE FOR RENEWABLES

Renewable natural gas (RNG) is lending fossil fuel a hand.

THERE IS INCREASING POTENTIAL FOR SUPPLEMENTING FOSSIL FUEL NATURAL GAS with gas produced in digesters by anaerobic decomposition of organic wastes, and by thermal processing of other organic material. These renewable fuels not only have the potential to replace some fossil natural gas, but also help solve waste disposal issues and reduce emissions of greenhouse gases.

Pipeline quality renewable gas could originate from either anaerobic digestion (AD) or thermal gasification of biomass. Sources of biomass include waste water treatment plants, landfills, wood waste, livestock manure, municipal solid waste, agricultural residues, and energy crops. Regardless of the source of the gas, it needs to be treated to remove water vapor, carbon dioxide, sulfur oxides, or other contaminants. After treatment, the renewable gas is essentially interchangeable and compatible with pipeline natural gas.

The truck in the photo is fueled by RNG and is being loaded with anaerobically-produced compost. Image courtesy: CR&R Environmental Services



Renewable natural gas (RNG) sources—landfill gas (LFG)

Landfill gas (LFG) is generally considered a renewable energy resource, whereas natural gas is a fossil fuel-based energy resource. Natural gas is usually slightly more than 95% methane after extraction and treatment.

According to the U.S. Environmental Protection Agency, the root energy component of LFG and natural gas are the same—methane. LFG is a natural byproduct of the decomposition of organic material in landfills. LFG is comprised of roughly 50% methane (the primary component of natural gas), 50% carbon dioxide, and a small amount of non-methane organic compounds.

LFG can be captured, converted, and used as a renewable energy resource. Using LFG helps to reduce odors and other hazards associated with LFG emissions, and prevents methane from migrating into the atmosphere and contributing to local smog and global climate change.

LFG is a prevalent renewable energy resource in the U.S. According to the EPA's Landfill Methane Outreach Program (LMOP), as of February 2018, there are 632 LFG energy projects operating at about 575 landfills and more than 470 candidate landfills in the U.S. (www.epa.gov/lmop). With minimal treatment, LFG can be used to offset traditional fossil fuels for electricity and other energy (e.g., boilers, kilns, and heaters) production. With more extensive treatment and upgrading, LFG can produce the equivalent of pipeline quality gas (natural gas), compressed natural gas (CNG), or liquefied natural gas (LNG).

LFG and other biogas sources are the most flexible renewable energy fuels as they can be used for almost any energy need. LFG constituents must be monitored and treated as appropriate to protect human health and the environment, and to assure proper operation and maintenance of energy generation equipment.

Other RNG sources

Whenever organic waste streams are managed in an anaerobic environment (absence of oxygen), methane (or biogas) is generated. This can happen in a landfill or a more controlled management system, such as an anaerobic digester (AD). RNG is produced when the biogas is treated and upgraded by increasing the methane content and, conversely, reducing the CO_2, nitrogen, and oxygen contents.

AD systems are used widely to manage animal manure, municipal wastewater biosolids (sludge), and source-separated organics (e.g., food production and post-consumer food waste, agriculture residuals). When these waste streams are managed in an AD system, methane-rich biogas (50% to 75%) will be produced. AD systems also can co-digest multiple organic waste streams, such as manure/agriculture residuals in an on-farm AD system, or biosolids/food wastes at a wastewater treatment facility AD.

Regardless of the source of the gas, it needs to be treated to remove water vapor, carbon dioxide, sulfur oxides, or other contaminants. After treatment, the renewable gas is essentially interchangeable and compatible with pipeline natural gas. Image courtesy: U.S. Environmental Protection Agency

Making use of RNG

For RNG to be produced from any biogas source, the gas must be treated to remove moisture, trace impurities, and carbon dioxide. After RNG is generated, it can be used to replace natural gas and other fossil fuels for most energy purposes. RNG can be injected into the natural gas pipeline for fueling stationary combustion equipment or creating vehicle fuel. In the case of vehicle fuel, RNG is used to produce the equivalent of CNG or LNG for use in natural gas vehicles. Vehicles can be fueled at or near the source of the RNG (e.g., a landfill) or the upgraded gas can be injected into the pipeline and then compressed or liquefied at an alternate location.

Because of the expense of upgrading biogas to RNG, the best way to maximize return on investment is to realize the renewable value of this flexible resource. An example is the use of RNG as a replacement for gasoline and diesel in heavy duty vehicles for which there are federal and state incentives.

Most RNG produced today comes from landfills and is injected into the natural gas pipeline to take advantage of national markets for environmental attributes associated with renewable transportation fuel. Out of the 46 currently operational LFG RNG projects in the U.S., the majority are injecting the RNG into the pipeline for vehicle fuel use at the end of the pipeline.

RNG in action

CR&R Environmental Services in Perris, Calif. has invested in an advanced AD organics processing technology, which has enabled the company to produce a clean RNG that can be used to power its large fleet of refuse and recycling collection vehicles. This 100% RNG is created from the organic waste captured throughout CR&R's collection network.

CR&R's state-of-the-art processing facility can accept the region's organic waste and divert the material from the local landfills where it would naturally degrade into environmentally-damaging methane gas. The process moves waste and its associated methane emissions away from the landfill and into the company's vehicles in the form of RNG. In addition, CR&R also creates a high-grade organic compost material for farms, gardens, and other agricultural facilities.

A digester "digests" organic waste, producing a biogas. The process cleans up the biogas and converts it into RNG to be used in compressed natural gas collection trucks servicing Southern California. This proprietary process is unique to CR&R and is fully enclosed with zero untreated emissions. It has the highest energy conversion rate in the industry due to its state-of-art design and digital controls. CR&R also has the only renewable natural gas interconnect in California. This unique interconnect, in partnership with the Southern California Gas Company, allows the company to distribute RNG anywhere in the state. **GT**

The truck in the photo is fueled by compressed natural gas (CNG) from landfill gas (LFG). Image courtesy: U.S. Environmental Protection Agency

MORE info

CR&R ENVIRONMENTAL SERVICES
http://crrwasteservices.com/sustainability/anaerobic-digestion/

ENERGY SOLUTIONS CENTER
www.energysolutionscenter.org

LANDFILL METHANE OUTREACH PROGRAM
www.epa.gov/lmop

U.S. ENVIRONMENTAL PROTECTION AGENCY
www.epa.gov

Editor's note: The U.S. Environmental Protection Agency is the primary source of information for this article.

Virtual pipelines to the rescue

Virtual pipelines go where no pipes have gone before.

THE MERRIAM-WEBSTER DICTIONARY DEFINES PIPELINE AS "A LINE OF CONNECTED PIPES WITH PUMPS, VALVES, AND CONTROL DEVICES FOR CONVEYING LIQUIDS, GASES, FINELY-DIVIDED SOLIDS."

Underground Construction's 2016 survey figures of oil & gas pipeline construction indicate 34,027 miles of pipelines are currently planned and under construction in North America. Of these, 21,412 miles represent projects in the engineering and design phase while 12,615 miles are in various stages of construction. However, pipelines don't go everywhere. Plans for pipelines depend on population density and allocation of funds.

How do those in areas not served by a pipeline obtain the natural gas they need? When pipelines are constrained, additional pipeline product transportation options include transporting product via truck or rail. The "virtual pipeline" is a clean energy infrastructure that connects industrial facilities, institutions, and municipalities to the natural gas pipeline through a network of pipeline terminals, trucks, and onsite decompression stations.

Virtual pipeline basics

In effect, a virtual pipeline serves as a temporary solution where a pipeline is not yet available. According to Rico Biasetti, CEO of NG Advantage, a virtual pipeline is a natural gas supply process in which natural gas is sourced from a transmission pipeline, dried, chilled, and compressed to 3,600 psi. "The compressed gas is then loaded into high-tech, carbon fiber tubes housed within a trailer. The CNG is then transported to a customer site where it is offloaded from the trailer, warmed, and decompressed, thus reducing the psi to accommodate a customer's specific requirements," he said.

Examples of virtual pipeline customers include large manufacturers and institutions that do not have access to pipeline natural gas or utilities that do not have ample supply during peak periods of usage (e.g., winter and summer). In fact, Colchester, Vt.-based NG Advantage served National Grid, one of the largest investor-owned utilities in the U.S., with a three-month winter peaking project at a facility in New York State. During this winter's extremely low temperatures, NG Advantage offered the utility a CNG solution capable of delivering 15,000 M cu ft/day to support spikes in demand.

Benefits include greatly reduced capital expenditure and investment risk, quicker implementation versus pipeline extension, increased flexibility, decreased maintenance costs for those switching from coal or heavy fuel oils, enhanced control over supply chain, and the solution is readily scalable, according to Biasetti.

The photo shows a typical virtual pipeline customer site. All images courtesy: NG Advantage

Virtual pipeline applications—asphalt plants

To maintain the temperature and consistency of finished products, asphalt plants typically are located close to the paving project site. In many cases, these plants are not located near a natural gas pipeline, which means reliance on other sources of fuel that may be more expensive, demand greater amounts of equipment maintenance, or emit greater CO_2 emissions. A competitor that is located on a pipeline may be able to underbid a facility that is not on a pipeline.

NG Advantage offers a solution for asphalt plants that burn more than 30,000 MMBtu a year and are located in proximity to one of the company's existing compressor stations. NG Advantage delivers CNG to asphalt facilities with no access to a pipeline via a virtual pipeline that consists of 40 ft. carbon-fiber trailers that are hauled to the customer site. The gas is drawn directly from the trailer, decompressed, heated, and passed to the customer's regulator, eliminating the need for onsite storage.

The asphalt plant is responsible for the site work required to make its yard able to accept two or three trailers, bring communications, electricity, and a new low-pressure gas pipe to the decompression station. A second burner is recommended to attain dual-fuel capability. Dual-fuel capability facilitates redundancy of supply and protects against price swings.

Advantages of a virtual pipeline for asphalt plants include

- **Cost savings**—By replacing oil-based fuels with natural gas, customers can realize considerable savings. Some customers say they could not have been competitive with plants located on pipelines without a CNG supply.
- **Reduced emissions**—Customers can reduce their carbon footprint by nearly 30% based on their original fuel source.
- **Reduced maintenance**—Customers can reduce their downtime caused by scheduled baghouse and burner maintenance.

Virtual pipeline applications—biomethane transportation

Transportation of biomethane for injection into a pipeline is another virtual pipeline application. A biomethane virtual pipeline is an alternative mode of distribution for remote biomethane projects with no natural gas pipeline access. It uses lightweight, carbon fiber tube trailers to safely transport biomethane. Trucks haul the trailers from landfill gas projects and anaerobic digesters to pipelines or other offsite locations, thereby replacing in-the-ground natural gas distribution pipes.

The U.S. biomethane industry is poised for significant expansion. A challenge faced by agricultural, municipal, and landfill gas sites is the ability to deliver their biomethane to market, according to Biasetti. Despite the challenges encountered by producers to harness the power of biomethane, the economic and environmental benefits are significant. As a provider of trucked CNG service in the country, NG Advantage operates a virtual pipeline service that can transport biomethane by truck from anaerobic digesters, landfills, and wastewater treatment plants to pipelines or other remote locations not directly served by the natural gas distribution system.

According to NG Advantage, those who can benefit from virtual pipeline biomethane transportation include:

- Projects too remote for reinjection directly into a natural gas pipeline.
- Projects generating electricity that face expiring power purchase agreements (PPAs) and diminished revenues in wholesale electric markets.
- Projects flaring gas because alternatives are not economical.
- Projects seeking to access diverse markets and increase revenue stream.
- Projects looking to participate in renewable identification number (RIN) markets.

In most virtual pipeline applications, compressed natural gas (CNG) is transported to a customer site, typically by truck.

Virtual pipeline applications—peaking CNG supply

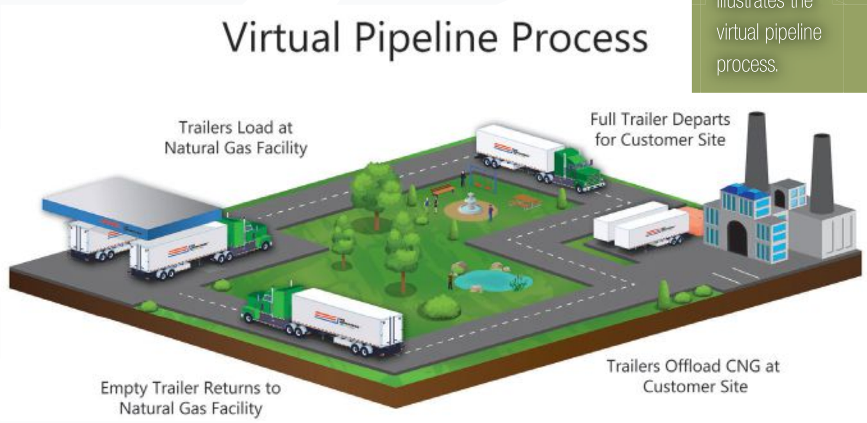
CNG is a flexible, low-cost, and clean-burning fuel used to complement pipeline natural gas to provide dynamic supplies of heat and electricity that respond to erratic temperatures and uncertain flows. During peak summer and winter months, when heating and electricity demands are highest, the supply of natural gas can be constrained. NG Advantage offers peaking services to ensure that CNG supplies exceed demand. Gas and electricity providers can deliver consistent service to their customers and avoid volatile price spikes.

Peaking supply to electrical power generation facilities include:

- **Continuous operation**—Switching to a backup fuel can be costly and cause lost revenue when the price of electricity is high. By staying on natural gas, generators can be operated when it is most profitable without the burden of switching to oil.
- **Load-following**—Seasonal weather can be unpredictable causing fuel demand to fluctuate. By using peaking supply, power producers can receive supplemental supply only when it is most economical.
- **Environmental compliance**—Generators receive the environmental benefits of natural gas by avoiding the need to switch to dirtier alternative fuel sources for electricity generation. In addition, the intermittent supply of renewable power can be balanced with hourly supplies of trucked CNG.
- **Load sculpting**—Power generators with temperature-sensitive loads can plan for and respond to erratic demand by sculpting their gas supply with hourly nominations.

Peaking supply to gas distribution companies include:

- **Outage protection**—Unplanned pipeline outages can pose a significant challenge for local distribution companies. CNG can be injected into the distribution piping during repairs to guarantee uninterrupted flow.
- **Pressure support**—Gas can be injected into the local distribution network to increase pipeline pressure and provide incremental volume to ensure all end users receive reliable gas supply.
- **Peak shaving**—Mobile natural gas supply can be delivered precisely where it is needed and when it is needed with a mobile fleet of high-volume CNG trailers. **GT**



This image illustrates the virtual pipeline process.

Editor's note: NG Advantage is the primary source of information for this article.

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