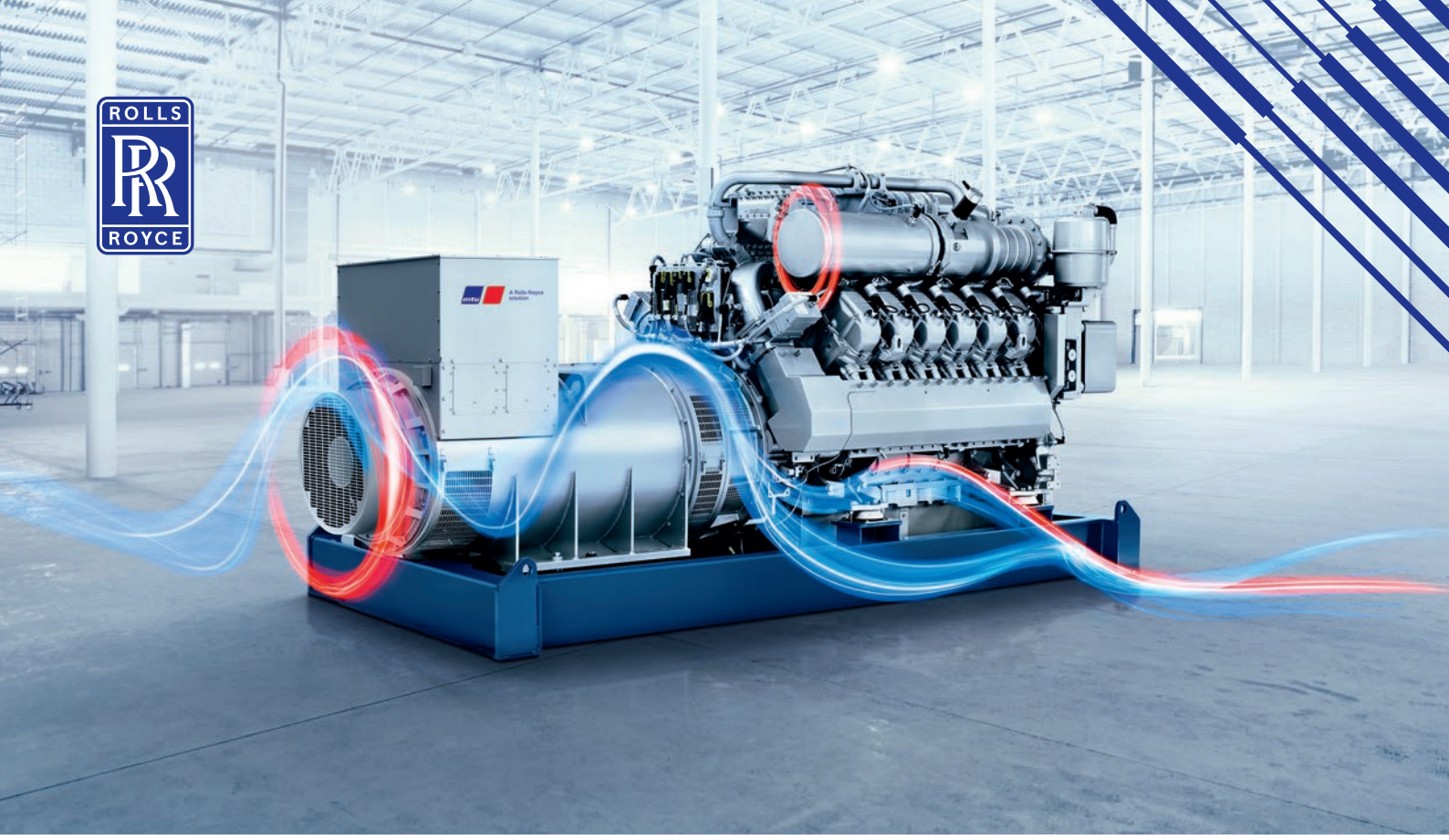

Power Generation

CHP LOOKS BETTER THAN EVER TO A GROWING LIST OF ENERGY CONSUMERS

As a wide range of companies and organizations realize the cost and environmental benefits of combined heat and power (CHP) systems, installations around the world continue to expand.

By **Alan Prosser**
Director of Latin and North American Sales
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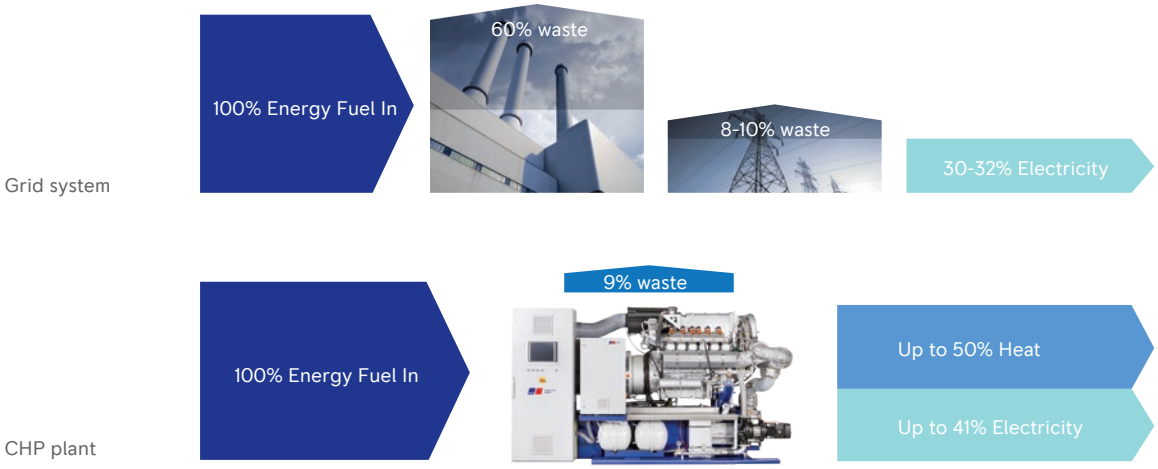
Thomas Edison could have rested on his laurels after inventing the electric light bulb. But to no one's surprise at the time, the irrepressible Mr. Edison kept innovating. One of his next creations was the Pearl Street power station—the world's first economically viable application of cogeneration principles. Edison's innovative "dynamo" generators and underground network of wires and pipes distributed electricity to those nifty new incandescent bulbs and provided steam heat to hundreds of delighted customers in lower Manhattan.

One can't help but wonder if Edison wouldn't be just a little disappointed with the lack of progress that's been made in the commercialization of systems similar to the one he built at Pearl Street to produce heat and power from a single fuel source. Alternative energy sources like solar, wind and geothermal technologies capture

Energy efficiency comparison



the imagination, but have had little impact on energy markets. America's utility grid is overburdened, but still has the kind of commercial inertia that only a regulated, centralized, century-plus-old system could have. But cogeneration—combined heat and power—although proven to be remarkably cost-effective and efficient when properly applied, has yet to enjoy the kind of widespread understanding and acceptance it deserves in North America.

History shows that going green is a lot more appealing when consumers realize they'll be saving green.

Thanks to the recent emergence of compact, powerful, modularized combined heat and power (CHP) systems, along with substantial shifts in the external factors that influence energy choices, that may be about to change.

Energy alchemy?

Less than 8 percent of all the energy consumed in the U.S. is supplied by cogeneration applications, which means that very, very few prospective CHP customers and suppliers are more than vaguely familiar with its potential. CHP's capacity for turning one fuel source into up to three forms of usable energy can seem to cogeneration novices to be a kind of power generation alchemy—it defies the conventional wisdom about how electricity, heat and air conditioning have been generated and distributed for decades. Since its introduction in North America by Edison more than 130 years ago, the lingering mystery surrounding how CHP works has obscured how well it works.

The latter question, of course, is the more pressing one for a nation whose energy demands have been skyrocketing, even as the conventional methods of generating and distributing energy are being tested now like no time in history. But the mystique about the "how" must nonetheless be erased before modern CHP systems can gain the traction in North American energy markets that they deserve. That customer education process has already begun—after all, there's a great, new story to tell—and it will become much easier as the number of CHP installations increases.

Historically, CHP applications have been reserved for very large commercial facilities. One recent example is the cogeneration operation of Arcelor Mittal Steel and Sun Coke in East Chicago, IN, where a 95 MW CHP system recovers heat from coke furnaces to provide electricity and process steam to the steel plant, reportedly saving 500,000 tons of carbon dioxide emissions annually compared to plants using separate heat and electricity sources. In another example, silicon producer West Virginia Alloys (Fayette County, WV) utilizes CHP to capture exhaust heat from its manufacturing processes and uses it to drive turbine generators to generate over 400 MW of power for the plant.

Although the benefits of cogeneration are easy to grasp in this kind of large-scale use, the real advances and opportunities in CHP now are in much smaller installations. These new markets have emerged recently because the "prime movers" in cogeneration—the machines that drive the process converting the fuel source into electricity, heat and (with an absorption chiller), air conditioning—have become more compact, affordable and efficient. As a result, they have much faster payback periods for customers who invest in them.

Most people assume cogeneration only makes sense in large-scale applications, when the prime mover is a coal-fired plant, a massive steam turbine or a combustion turbine burning oil or natural gas. That simply isn't the case anymore, thanks to recent, significant developments in compact cost-effective natural gas- or biogas-fueled reciprocating engine generators that can produce electricity and heat at more than 90 percent efficiency, compared to the 30-32 percent rate averaged by utilities. As a result, many North American facilities, including hospitals, hotels, commercial buildings, and smaller factories can reap the benefits of CHP.

Those benefits are substantial, particularly in the context of our continent's ever-growing need for more energy and increasing scrutiny of how that energy is produced and distributed. For facilities with the characteristics necessary for a successful CHP system installation, the technology can deliver major bottom-line cost savings, a reduced carbon footprint and reliable power in the event of a utility outage—all while offering radically decreased dependency on the public grid, if not outright energy independence.

Moreover, there's plenty of evidence that CHP systems are a practical alternative to relying on conventional power delivery, although for now we need to look across the Atlantic to find it. Denmark, for example derives 55 percent of its power from CHP applications. The European Union gets about 11 percent.

As you might guess then, case studies featuring the most modern CHP systems are more easily found at businesses like Nordfrost, a 40-location provider of temporary storage of fresh fruit, vegetables, meat and dairy products based in northern Germany. In its newest seaport terminal in Schorten, Germany, Nordfrost relies on two natural gas-fueled CHP modules driven by one 12-cylinder and one 20-cylinder diesel engine. The resulting 3.1 MW of electricity and 3.5 MW of thermal output supplies all of the electricity needed to power lighting, cold store doors, offices and information technology equipment. Surplus power is fed into the public utility grid. The heat that is recovered from Nordfrost's CHP modules is used for heating in the winter, and is also used in combination with absorption chillers for the warehouse's refrigerated storage areas.

It's no longer necessary to have a coke furnace, coal-fired electricity plant or a natural gas turbine half a city block long to power an effective cogeneration facility. Today, a high efficiency, plug-and-play, low-emissions diesel engine-powered 128kW CHP unit could fit in your family garage.

Knowledge gaps and spark spreads

There's no doubt that the comparatively low number of CHP installations in North America has created an information gap between suppliers and prospective customers, and as one would expect, a knowledge gap among CHP suppliers themselves. It also must be acknowledged that the market for smaller-scale cogeneration that new CHP modules provide is really just entering its growth curve. Prior to this, customers interested in purchasing a small-scale CHP system more than likely had to rely on multiple suppliers to cobble together an array of equipment to build a cogeneration operation. Unfortunately, the end result may not have offered the kind of efficiency and reliable performance that a CHP module that is engineered, manufactured, sold and supported by a single source offers today. This mismatch between equipment, supplier and

What is cogeneration or CHP?

CHP is the simultaneous production of electricity, heat and sometimes air conditioning from a single fuel source. In the process of generating electricity a "prime mover" such as a gas-fueled engine will generate large quantities of heat that is captured and put to use in industrial processes and space heating.

Is CHP new?

No. CHP has been in use in industry for more than 130 years. And even back in 1882, Thomas Edison's Pearl Street station in New York City achieved overall operating efficiency of 50 percent—considerably better than the average 30 to 32 percent delivered by the public utility grid today. Modern CHP modules operate at 90 percent or more efficiency.

What types of engines are used in modern, compact CHP systems?

Most packaged CHP systems today are based on gas turbines or gaseous–fueled reciprocating engines. Natural gas or biogas reciprocating engines have enough flexibility to power applications from 400 kW to 5 MW at lowest overall cost.

How much heat can be obtained from a CHP package unit?

A large gas-powered CHP module can produce up to 2,145 kW of electrical power and 2,260 kW of thermal energy operating on natural gas.

after-sale support led to the kind of "it's the software, not the hardware" type of intra-vendor conflicts that marked the early days of personal computers.

That's a pretty stark contrast to the approach applied today by the handful of major manufacturers of CHP systems in North America who have recognized and seized the sales opportunity offered by the latest natural gas and biogas fuel engine technology. Packaged CHP units are engineered, built, installed and supported by single-source companies. The larger players in this arena have a global presence and offer worldwide service for their units. And today's CHP system sales cycle reflects a thorough, methodical and highly scientific approach to a prospective installation, with calculations to measure the projected ROI of the proposed CHP facility.

For example, measuring and determining "spark spread" is just the starting point for that discernment. That spread— the differential between the local utility's electricity price that the proposed CHP system will displace and the cost of natural gas or biogas fuel— needs to be sufficient to justify the investment in cogeneration. But once sufficient spark spread has been established, there are many other factors that have to be carefully weighed and calculated before committing to CHP.

It's not unusual for a CHP installation to take 12 months from initial consideration to installation, and major suppliers recognize the importance of a successful outcome. Every happy new customer represents a potential advocate for another prospect who's considering this "new" technology that's really not new at all, but tested, proven and more efficient than any other commercially viable, modular power generator.

Success begets success

In North America, there have been relatively few companies interested in supporting CHP installations, and fewer still qualified to produce the sophisticated, neatly-packaged, gas-powered units that are now driving the future of the business.

That will surely change in coming years as political and cultural pressure continues to demand greenhouse gas emission reductions, federal and state governments continue to offer incentives encouraging alternative energy sources, and high state tariffs on electricity purchases persist.

Can CHP also provide cooling?

Yes, using the lower temperature heat from the prime mover's cooling system, which is well suited for powering an absorption chiller that uses heat energy to produce cooling. When a CHP system produces electricity, heat and cooling, it's called trigeneration.

Is CHP good for the environment?

CHP systems offer benefits compared to conventionally purchased electricity and heat that is generated onsite. For starters, CHP systems require less fuel than separate heat and power systems. Less fuel consumption means fewer greenhouse gas emissions. CHP modules can also operate on biogas or landfill gas that would otherwise be released into the atmosphere. And heat generation by CHP modules creates virtually no additional CO_2 emissions.

Should I consider CHP for my facility?

Prospective CHP users should, at a minimum, have a simultaneous need for electricity and heating/cooling for at least 4,000 hours a year. A detailed analysis by a qualified supplier is a must to calculate "spark spread"— a term that means the difference between the market price of electricity and its cost of production. When natural gas prices are low and electricity costs are high as they are now in North America, the spark spread is positive and it's more economical to generate power onsite with a CHP module than to produce it from a local utility.

There is also a growing school of thought that views cogeneration very favorably as part of the solution to what's viewed as an overburdened centralized utility grid. Advocates of the so-called "smart grid" approach to decentralizing power believe that a kind of peer-to-peer electrical power infrastructure would be a far more efficient way to distribute and manage electricity use, and that CHP should play a part in that new decentralized infrastructure.

According to the white paper, "U.S. Smart Grid: Finding New Ways to Cut Carbon and Create Jobs" (April 19, 2011, Marcy Lowe, Hua Fan and Gary Gereffi), "The highly centralized, one-way system wastes energy and increasingly struggles to keep up with demand. Since 1982, growth in peak power demand—such as on summer days when countless air conditioners are running—has outpaced growth in transmission by nearly 25 percent per year. Too often, the result is power outages and even blackouts. The U.S. Department of Energy (DOE) reports that such interruptions cost the nation at least $150 billion annually (U.S. DOE, 2008)."

External factors like these are paving the way for a greater receptivity to the idea of incorporating more CHP systems into everyday energy applications. But for that idea to convert to actual purchases, there is no more effective motivator than basic economics. The biggest increase in CHP demand will arise simply as a result of more and more power consumers discovering how, under the right circumstances, CHP might just be the biggest bargain in energy today.

Prime prospects

So who will be the most likely early adopters of the new modular CHP systems? It will be the power customers who will most immediately benefit from the cost savings this recently updated technology delivers. Whether getting North American drivers to consider hybrid cars or motivating citizens to recycle newspapers and containers in our households, history shows that going green is a lot more appealing to consumers who realize that by doing so they'll be saving green. Applying that admittedly capitalistic rule, there are certain specific facility types and locations that could benefit substantially from the newest CHP modules.

- **Hotels, hospitals, condominium/commercial buildings**
  Large facilities like these have a high possibility of more efficient and less costly thermal utilization because they have significant demand for electricity, hot water, space heating and cooling.
- **Corporate and university campuses**
  A large corporate headquarters could use a CHP module for electricity and heat and for space heating and cooling. University campuses are often already set up for district heating and cooling; a CHP module would be a natural fit here as well.
- **Wastewater treatment plants**
  Here, a CHP module could be used to produce the electricity needed to run pumps and blowers, while the waste heat from the gas engine could be used to warm effluent tanks to speed up bacterial digestion or to dry sludge for disposal.
- **Industrial facilities**
  Plants, warehouses, and other industrial facilities with simultaneous need for power, heating, and cooling represent an excellent opportunity for a CHP application. Facilities that manufacture or process food (especially milk, chocolate and similar products with processes that consume large amounts of hot water for sanitizing), bottle beverages, produce ethanol, or make pulp and paper are particularly good candidates for cogeneration.
- **Commercial complexes**
  Large resorts, hotel complexes, athletic clubs, gyms, indoor swimming pools, shopping malls and greenhouses can all benefit from CHP.
- **Locations generally favorable for CHP systems**
  States and territories with high average electricity tariffs—say, 12 cents per kW-Hour and up—offer strong opportunities for CHP applications. This includes New York, Connecticut and Massachusetts. Some states offer favorable CHP incentives, including NYSERDA (New York), Clean Energy Fund (Connecticut), Maryland CHP Incentive Program, and Massachusetts CHP Incentive Program. Like any milestone business opportunity, a convergence of economic, political and cultural circumstances has paved the way for widespread understanding and acceptance of cogeneration—and the new modularized CHP systems that now make it practical for thousands of future commercial applications.

As hundreds of New York City citizens discovered when they happily tossed their smelly gas lanterns in favor of Mr. Edison's amazing electric light bulb, the future is already here.

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