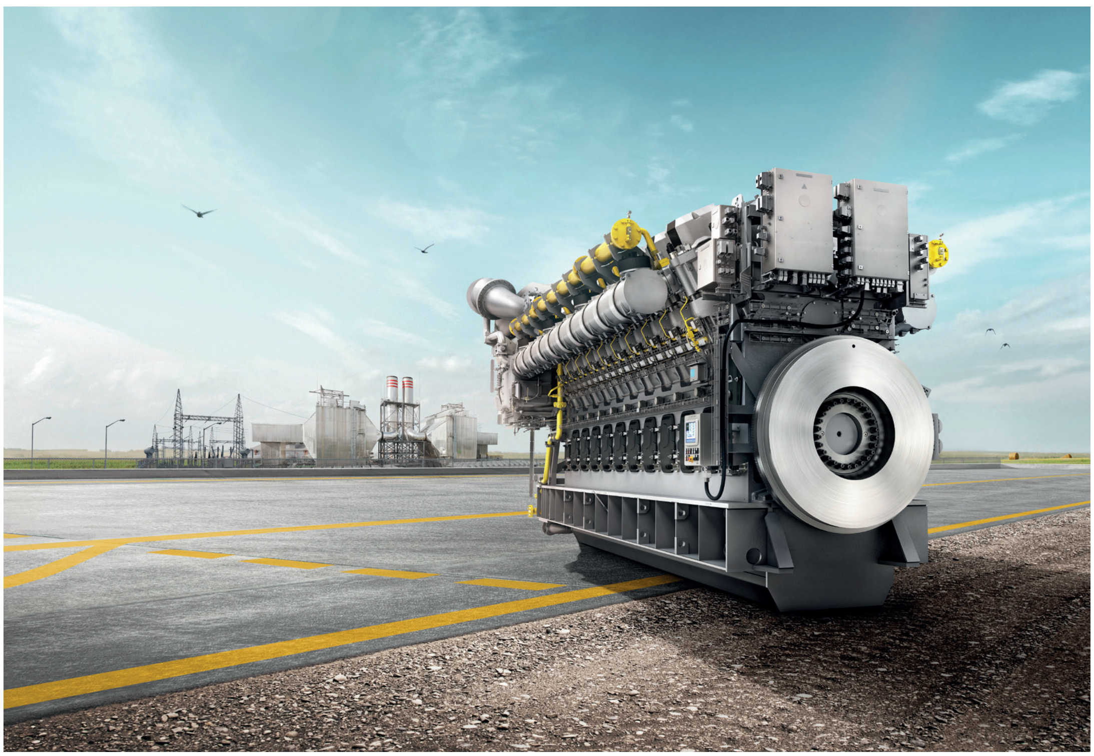
MICROGRID KNOWLEDGE

Reciprocating Engine Generators and Microgrids:

The Last Defense Against a Power Outage



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About this guide

Reciprocating engine generators are becoming increasingly important to help solve three contemporary energy problems.

The first problem occurs in developed areas like North America, where electric reliability is crucial as the economy grows ever more Internet-based.

The second problem can be found in remote regions of the world, where no central grid exists, or its service is spotty, hampering basic health, well-being and commerce.

The third problem arises as we attempt to green our electric supply with solar and wind energy. Intermittent by nature — dependent on the sun shining and the wind blowing — renewables often need reliable and sustainable companion technology to keep the electricity flowing.

"The Guide to Reciprocating Engine Generators and Microgrids: The Last Defense Against a Power Outage," explores the growing role that reciprocating engine generators play in solving these three problems.

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Chapter 1

Reciprocating Engine Generators: The Unsung Heroes of the Electric Grid

Superstorm Sandy knocked out power to more than 2.6 million households and businesses in New Jersey, making it the hardest hit of 20 states swept by the 2012 storm.

So it was somewhat astonishing that a small barrier island in New Jersey kept its power flowing.

It's life line? Three diesel-fueled generators with reciprocating engines.

Seaside Heights Borough had originally purchased the generators for economic reasons—to save the community money. They were meant for use at times when grid electricity became costly.

But when Sandy devastated the town's electrical infrastructure, the community quickly saw another benefit from its $4 million investment. Emergency workers were able to rely on electricity from the three, 2 MW generators as they located and rescued endangered residents. The generators powered the water supply, kept accommodations running for rescue workers and provided electricity to community residents.

The Seaside Heights story is replicated throughout communities large and small worldwide. When all else fails during storms, with power outages everywhere, reciprocating engine generators are the last line of defense.

Their importance has heightened with today's increasingly severe weather, threats from cyber-terrorism, and equipment failures on aging electrical grids.

Yet, the story of reciprocating engines, this mainstay, is seldom told. Newer, flashier technologies capture the public imagination, such as smart grid, advanced analytics and energy storage.

"You may not hear a lot about them in the popular press, but reciprocating engine generators can be found almost everywhere—as backup to sophisticated electrical grids in places like North America and Europe and as primary sources of electricity in remote areas of India, Africa and South America," said Jeffrey Powell, Product Manager at Fairbanks Morse Engine.

Use of reciprocating engines

The widespread use of reciprocating engines stems from the fact that they:

- Are modular and easy to site
- Use a range of liquid fuels, including low-sulfur diesel, which is readily available and easy to transport
- Start quickly

Times you wish you had a reciprocating engine generator…

Reciprocating engine generators provide needed services in a range of settings, many of them emergency-oriented. Consider the following:

- During the 2014 weather emergency known as the Polar Vortex, temperatures plunged to record-breaking lows in large swaths of the U.S. Demand for natural gas heightened as homes and power plants vied for the resource. Energy prices skyrocketed. But one forward-thinking Michigan utility was able to avoid the market volatility through a combination of intelligently timed fuel purchases and use of reciprocating engine generators that could switch from natural gas to diesel fuel. *(See page 12.)*

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- Sometimes power outages are all about location. Communities situated at the end of a utility distribution system tend to be more prone to the last-in-the-dinner-line syndrome: With larger populations served ahead of them, they are vulnerable to energy shortfalls that can lead to reliability problems. Consider the Florida community of Homestead, which faces the double-whammy of being both in a hurricane zone and south of Miami at the end of Florida Power & Light's service area. Homestead maintains reliability with the help of one of the nation's largest diesel generators, an important asset when natural gas supplies become limited, and Homestead must wait in line behind Miami.
- About 17 percent of the world's population lacks access to electric power, according to the International Energy Agency. Most of the energy poor live in sub-Saharan Africa or Asia, and many have no access to an electric grid. Often reciprocating engines serve as their only dependable source of power.

What's ahead for the technology

Perhaps most interesting are the fuel pairings that involve reciprocating engine generators. These include dual-fuel generators, typically natural gas and diesel, and the emerging hybrid plants that match renewable energy with fossil fuel generators. Natural gas or renewable bring lower emissions to the partnership. Diesel bring an ability to start up generators quickly, which is important when a sudden outage occurs on the grid. Diesel also brings consistency and longevity of supply not always available with wind, solar and energy storage.

Given today's need for reliable power, it's little surprise that use of reciprocating engine generators is expected to increase. In fact, diesel reciprocating engine generators represent the fastest-selling, least expensive form of distributed generation technology in the world, says Navigant Research in its report, 'Diesel Generator Sets'.

Globally, the diesel reciprocating engine generator market is expected to increase from 62.5 GW in 2015 to 103.7 GW in 2024. This represents a $538 billion market over the time period.

The research firm sees natural gas reciprocating engine generators capturing increasing market share due to emissions regulations and lower fuel costs. But Navigant adds that the low capital cost and fast-start capabilities of diesel units make them well-suited for back-up power, oil and gas, facilities, and critical infrastructure applications.

"The price of a gas generator can be three to four times that of a diesel generator with the same specification. Although in the long term gas generators are more economical, they lose out to diesel generators due to their high start-up cost."

– Prabhanjan Kumar Singh, GlobalData

At the same time, the market is evolving for natural gas and hybrid reciprocating engine generators, according to Dexter Gauntlett, senior research analyst with Navigant Research. For example, leading manufacturers have formed strategic partnerships with renewable energy companies to provide integrated hybrid and microgrid solutions targeting large customers concerned with diesel costs.

Another research firm, GlobalData forecasts that the global market for diesel generators will grow from $14.7 billion in 2016 to $17.6 billion in 2020.

"The price of a gas generator can be three to four times that of a diesel generator with the same specification," said Prabhanjan Kumar Singh, GlobalData's analyst covering power. "Although in the long term gas generators are more economical, they lose out to diesel generators due to their high start-up cost."

Singh added that many developing countries around the world still lack adequate grid infrastructure for electricity transportation and some lack natural gas reserves.

"The absence of trans-national or domestic gas pipelines means the price of gas increases, making it a less preferred fuel option. In this way, power back-up units such as diesel generators play an important part in meeting electricity needs," Singh said.

So the market is strong for diesel reciprocating engine generators, and it is growing for natural gas and renewable pairings. Contemporary society requires reliable electricity; reciprocating engine generators ensure it.

But what exactly is a reciprocating engine generator? Read on for a look at how the technology works.

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Chapter 2

The Basics: What is a Reciprocating Engine?

A fixture of the U.S. and international power generation sectors, reciprocating internal combustion engines provide incremental energy almost instantaneously at a relatively low capital cost. This makes them an instrumental part of ensuring reliable and safe flow of power to the grid.

Their dependable responsiveness and ability to run on a variety of fuels makes reciprocating engines mainstays for:

- Providing incremental peaking power to the electric grid during high-demand periods
- Mitigating the ups and downs of solar, wind and other variable-output generating sources
- Ensuring quick-start backup generation in the event of regional or local grid outages

Poplar Bluff, MO, 3 x 18 Cylinder, FM-MAN 32/40 Dual Fuel Engine Genset, 6720 kWe @ 720 RPM, Courtesy Fairbanks Morse

Improve grid efficiency

Reciprocating engines also play a role in improving efficiency on the central power grid.

In particular, they can reduce peak demand on the grid by temporarily generating power for an individual electric customer—or group of customers. This allows the customers to reduce or eliminate their dependence on the grid when it is under strain, often a hot summer day, a period when grid power is apt to be less reliable and very costly.

Reciprocating engines also can be used in combined heat and power (CHP) plants. Highly efficient, CHP channels the engine's exhaust heat byproduct to useful purposes, such as heating and cooling buildings. The heat would otherwise waft into the atmosphere wasted. Because CHP uses one fuel for two purposes—generating both electricity and heat—it is considered not only an energy efficiency play, but also a way to reduce carbon dioxide emissions.

Ensure reliability and safety

Further, reciprocating engines can provide 'black-start' capability—a feature of the technology that plays a vital role in keeping the electric grid safe and reliable. Black start is required when a power plant shuts down during a malfunction or crisis and needs an external power source to help it get started again. During a power outage, the plant cannot rely on the central grid to provide the electricity. So instead the power plant operators turn to on-site diesel reciprocating engines, which can be quickly started to provide the needed electricity.

Reciprocating engines also play another important safety role on the grid, particularly emergency diesel generators. They are often used at nuclear power plants to provide the power needed to safely shut down and maintain the reactor in the event of a loss of normal offsite power, a coolant accident or other operational anomaly.

How reciprocating engines work

A reciprocating engine uses the expansion of gases to drive a piston within a cylinder, and converts the piston's linear movement to a circular (or rotating) movement of a crankshaft to generate power.

There are several types of reciprocating engines, categorized not only by the number of piston 'strokes' it takes to complete one combustion cycle (two or four) but by the type of combustion (spark-ignited or compression-ignited) and the fuel—or fuels—the engine consumes.

The four-stroke or four-cycle reciprocating engine is the kind typically used in power generation. The four strokes involved in their operation are intake, compression, power and exhaust.

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The intake stroke expands the combustion chamber within the cylinder and draws in an air/fuel mixture, and the compression stroke compresses the mixture, thereby increasing its energy potential.

With spark-ignited combustion, the air/fuel mixture is ignited by a spark plug, and the burning of the mixture drives the piston through the power stroke. Then, an exhaust value opens and the piston forces out the exhaust gases. With compression-ignited (or diesel) combustion, a higher compression ratio creates extra heat during the compression stroke that ignites the air/diesel mix on its own, without the need of a spark plug.

As noted above, reciprocating engines can be designed to burn a variety of fuels; some burn only diesel and some are fired only by natural gas. But many are dual-fuel in design, meaning that they can burn either gaseous or liquid fuels.

The capacity of individual reciprocating engines typically ranges from less than 1 MW to as much as 20 MW, and often groups or sets of engines are installed side-by-side so they can be switched on or off as the precise needs of the grid vary. So they can as a group provide 50, 100 or even 200 MW of power.

Reciprocating engines installed to provide backup power or to ensure grid reliability generally are switched on automatically when a transfer switch senses a temporary power loss or sudden change in voltage. The engines also can be turned on and managed manually.

Before closing, it's important to highlight several characteristics that make the reciprocating engine an especially effective 'last defense' to keep the power flowing during a grid outage. These include:

- Ability to power up quickly (typically reaching full load in five minutes or less)
- Short run-cycle requirements (they can go on and offline multiple times daily with minimal wear and tear)
- Ability to operate at high altitudes and in areas with high ambient temperatures
- Ease in siting because of their relatively small size compared to a gas-fired combustion turbine.

In the next, chapter we will look at the pros and cons of different fuels and types of reciprocating engines.

Chapter 3

Common Fuels Used in Reciprocating Engines: Pros and Cons

Electricity costs are determined largely by the price and availability of fuels used in power production. As a result, the power industry values generation technologies that offer fuel diversity and flexibility.

In western Kansas, the City of Goodland owns and operates its own utility to supply residents with electricity. Their production facility relies on eight Fairbanks Morse generator sets, including two Opposed-Piston and two Colt-Pielstick PC2.5 dual fuel engines which run on natural gas with diesel pilot for ignition.

This is part of the reason reciprocating engines are in widespread use in the power sector, and dual-fuel units are becoming increasingly popular.

Reciprocating engines can be designed to consume a wide variety of individual fuels or—in the case of dual-fuel units—to be capable of using gaseous fuels (such as natural gas or propane) as well as liquid fuels such as diesel.

A dual-fuel reciprocating engine generally runs primarily on natural gas (or propane when pipeline gas is not available). It also needs at least a small amount of diesel fuel to ignite the mixture. A dual-fuel engine can also run entirely on diesel, and typically this is done when limited or no natural gas is available.

Generally, reciprocating engines fueled either entirely by natural gas or—in dual-fuel units—by a mix of mostly natural gas and small amounts of diesel create lower overall levels of harmful emissions than engines that are fueled entirely by liquid fuels such as diesel, gasoline or jet fuel.

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Significant emission reductions

It is important to note, however, that tightening federal requirements and technological improvements in recent years have resulted in significant reductions in emissions from newer diesel and other liquid-fueled reciprocating engines.

EPA allowed emergency engines to operate up to 100 hours a year for non-emergency purposes while maintaining their emergency status, but a federal appellate court later overturned that part of the agency's rules.

The U.S. Environmental Protection Agency's rules for regulating reciprocation engines exempt 'existing emergency' engines from compliance with emissions limits, with 'existing' referring to engines manufactured or ordered before 2002, or up through 2009 for certain categories.

EPA also allowed emergency engines to operate up to 100 hours a year for non-emergency purposes while maintaining their emergency status, but a federal appellate court later overturned that part of the agency's rules. Now, emergency engines can only operate during emergency situations or for a limited number of hours annually for testing and maintenance purposes.

Fuel availability and cost, of course, are important considerations in determining which fuel would be best for reciprocating engines used in the power sector.

Natural gas prices are considerably lower as a result of hydraulic fracturing—and generally less volatile than they had been, though price spikes still are possible during periods of high demand, pipeline constraints and/or gas-supply disruptions caused by hurricanes or other events.

Advantages of natural gas

The availability and use of natural gas for power generation in the U.S. has increased considerably in recent years due primarily to the success of gas producers in extracting vast quantities of gas from shale deposits through the use of hydraulic fracturing. Natural gas prices are considerably lower as a result—and generally less volatile than they had been, though price spikes still are possible during periods of high demand, pipeline constraints and/or gas-supply disruptions caused by hurricanes or other events.

Also, natural gas pipelines do not extend into all parts of the U.S., and in some regions such as New England existing pipeline infrastructure cannot always ensure delivery of all the gas that may be needed, especially during winter peak demand periods when gas demand for space heating is very high.

Advantages of diesel fuel

As a result, it is common for utilities, industrials, hospitals, government facilities and others to turn to either dual-fuel or diesel-only reciprocating engines—and for owners of dual-fuel units to stockpile diesel for use in the event that natural gas is not available when emergency back-up generation is needed. (Diesel can be stored for a year or more without any significant degradation with proper treatment.)

Because diesel is readily transportable, additional supplies of the fuel can be delivered by truck if reciprocating engines need to be used for extended periods, such as in the days after a devastating ice or wind storm.

Two more points should be made regarding fuel price.

1. While natural gas prices are currently near historic lows and projected to rise only gradually over the next several years, the prices for diesel, gasoline and jet fuel also are lower than they have been in some time.
2. Since most reciprocating engines in the power sector are operated for only limited periods, the fuel costs associated with their operation generally are not as important a factor as the cost of fuels used in larger plants that operate most hours of the year.

In the next chapter, we will look at the important role that reciprocating engines are playing in the emerging microgrid market.

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Chapter 4

Microgrids and Reciprocating Engines: A Natural Fit

Microgrids are not a new idea; in fact, there are microgrids that have been operating for decades. But it wasn't until after Superstorm Sandy crippled major U.S. population centers in 2012, including New York City, that North America began a concerted effort to install the technology. About the same time, efforts accelerated to electrify rural Africa, India and other remote areas without access to the grid.

What is a microgrid?

A microgrid is a group of interconnected loads and distributed energy resources in a defined geographic area that can connect and disconnect from the grid. Advanced microgrids often derive their energy from multiple sources of on-site generation, as well as the central grid. They also serve the central grid, providing power and ancillary services. An advanced microgrid controller optimizes all of these resources, as well as load served by the microgrid, to achieve maximum cost efficiencies and reliability at any given time. For more details see: Microgrids 101.

Together these two trends are spurring a microgrid boom, which Navigant Research expects to grow into a $20 billion market by 2020.

In North America and other developed regions, reliability is a key value proposition for microgrids. When the central grid fails, the microgrid's generators begin serving electricity customers. They tend to be deployed at facilities where reliable power is crucial, such as hospitals, data centers, research facilities, storm shelters, and telecommunications facilities. Given that microgrids are the backup when the central grid fails, their generators *must* work or else the result is a blackout.

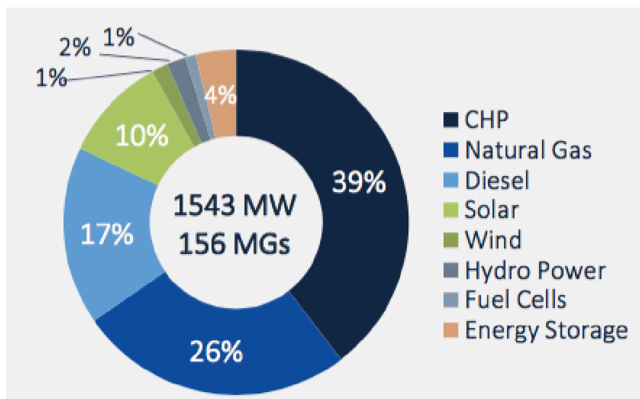
Microgrids achieve their high reliability through redundancy—by having more than one form of generation and sometimes energy storage. In this line-up of resources, reciprocating engine generators often stand as the last defense, participating as emergency, quick-start generators that are fueled by diesel or dual-fuel configurations of diesel and natural gas.

By the numbers

In reviewing 237 microgrids in the United States, GTM Research found indicators of extensive use of reciprocating engines in microgrids. The fuels used by the microgrids signal the likely presence of reciprocating engines. About 43 percent of the projects employed diesel or natural gas for at least some of their generating capacity.

"While we don't have the exact details here as they aren't always disclosed, it would be safe to assume that most North American natural gas and diesel gensets are based on reciprocating generator technology," said Omar Saadeh, GTM Research, Senior Analyst.

Reciprocating engines also can be found in a number of microgrids that include CHP units. GTM Research found CHP technology in 39 percent of the microgrids analyzed. *(See below.)*



Value to microgrids

Because reciprocating engine generators take up little space, they work well within a microgrid, especially one located in a densely built urban or campus setting, as many of today's U.S. microgrids are. Batteries take up far more real estate than a reciprocating engine generator handling the same job.

Reciprocating engine generators also are valued in a microgrid for their ability to ramp up quickly. This speed-to-service not only minimizes or negates power outages, but also assists in microgrid optimization.

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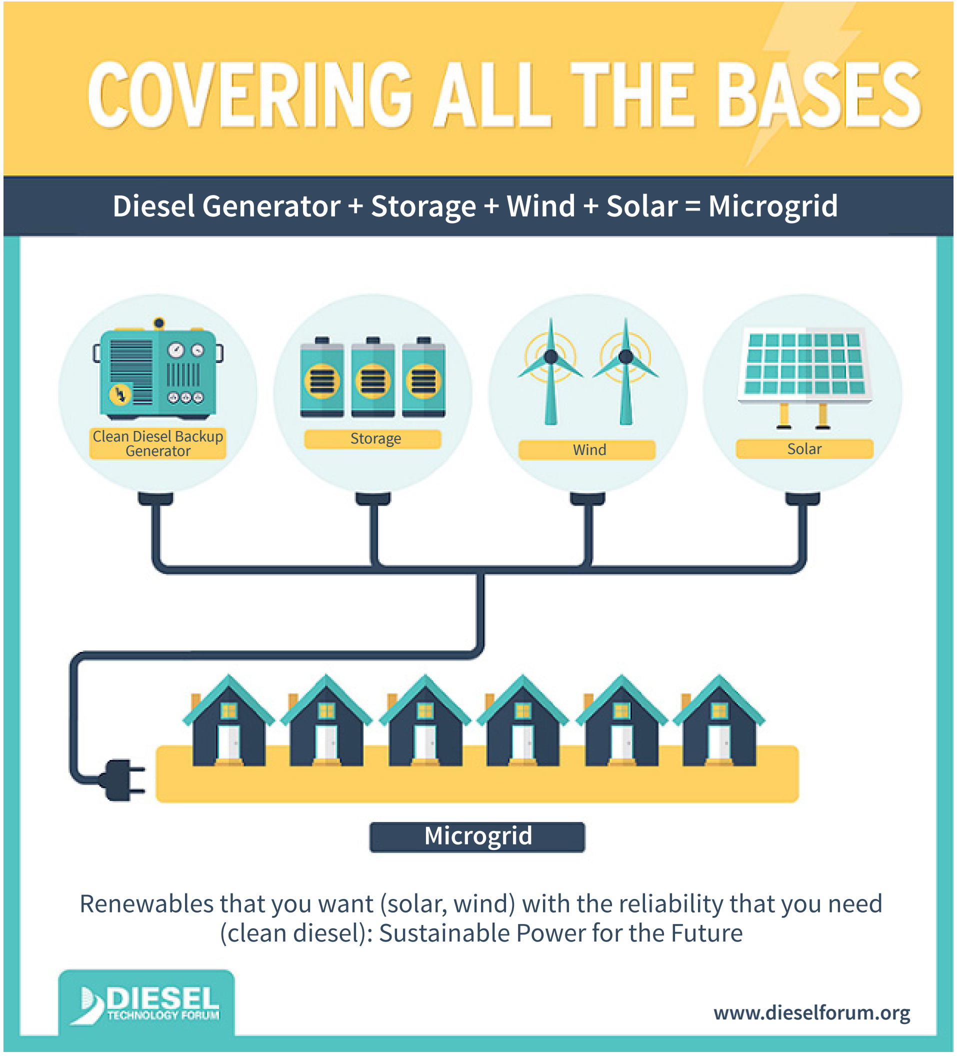

Optimization refers to the ability of an advanced microgrid controller to leverage the microgrid's various resources for best economics. Sometimes referred to as the "brain" of the microgrid, the advanced microgrid controller is the software that orchestrates all of the microgrid's resources and enables it to disconnect and re-connect to the central power grid.

The controller constantly calculates the best or optimal mix of resources for the microgrid to use based on energy prices, fuel availability, weather and other factors. Because the reciprocating engine can start and stop quickly—and typically has a ready source of fuel—it's a flexible tool the controller can leverage. For example, the reciprocating engine generator might be quickly called into action if there is a sudden drop in solar or wind generation. It also may serve as a tool for peak shaving or other forms of demand management.

Three examples of reciprocating engines in microgrids

- ABB operates a solar-diesel microgrid at its 314,961 square-foot Longmeadow business park in Johannesburg, South Africa. The facility, which includes a factory and offices, had been using diesel generators for back-up power. ABB integrated solar and microgrid control technology with the back-up generation to green the facility and increase its electric reliability.
- Alcatraz, a former prison and now 22-acre tourist attraction in San Francisco Bay, is powered by a microgrid that includes solar, batteries and two diesel reciprocating engine generators.
- Enchanted Rock (ERock) has secured financing to install 50-MW of reliability microgrids for grocery stores and other commercial and industrial customers in Texas. All of the microgrids will use reciprocating engine, natural gas generators, as the primary source of power.

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The value of CHP in a microgrid

Reciprocating engines can sometimes be found within microgrids as part of a CHP unit. CHP plants offer value to the microgrid in several different ways.

First, they produce not only electricity, but also thermal energy for the microgrid customer. The thermal energy may be used to create steam, heat and cooling for buildings, data centers, hospitals, manufacturers and other customers within the microgrid.

Second, CHP plants bring high levels of efficiency to the microgrid, since from one fuel (often natural gas) they are able to produce two forms of energy—power and heat. The heat is a byproduct of the generation process. Conventional power plants waste the heat, letting it waft into the air or a nearby body of water. CHP plants instead reuse it.

Third, CHP plants can play an important energy market role. Advanced microgrids constantly leverage their energy assets against electricity and fuel prices as they change within the market. The microgrid's controller, its software intelligence, gauges grid electric pricing, weather, fuel efficiencies and other factors to determine the best mix of power plants to run at any given time—and how much power if any to buy from the electric grid. Given their ability to produce both power and heat, the CHP plant adds an additional level of play within markets for the microgrid.

Chapter 5

A Global View: Why Reciprocating Engines Remain Vital for Remote Communities

In a land where winter can bring only a few hours of sunlight daily—or none at all for 67 days in Barrow, Alaska the northern most inhabited place in the United States—solar energy is not a practical resource.

Such Alaskan communities rely instead on reciprocating engine generators to keep the dark at bay.

In fact, according to the Alaska Energy Authority, 94 percent of electrical generation in rural Alaska comes from diesel generators, and this is not likely to change significantly in the immediate future.

Of course, Alaska is not the only place where generation options are limited. About 1.2 billion people worldwide currently lack access to electricity. And if the pace of new connections made during 2000–2010 continues for the next 15 years, and population growth is taken into account, the number will rise by an additional 40 percent by 2030.

Like Alaska, most remote areas of the world use reciprocating engines powered primarily by diesel fuel. Reciprocating engines have many advantages for these communities, whether they are used in a home or for a village. They are simple in design and easy to install, are low maintenance, have a long engine lifespan, and can be combined with other systems.

Increasingly, diesel generators are paired with renewable energy sources, particularly solar where practical. Called hybrids, or hybrid gensets, these systems often are made up of a conventional fuel (diesel) generator, a renewable energy resource (often solar), and sometimes with energy storage, such as batteries.

Such pairing increases system efficiency because:

- When the sun is shining and the solar panels are producing electricity, the fossil fuel generators do not need to run. This reduces fuel costs, emissions, and generator maintenance needs.
- When the sun is not shining, the customer has an alternative source of energy to ensure reliability. The reciprocating engines are flexible; can run anytime on fuel and are not limited to daylight hours when the sun shines.

However, hybrids are significantly more complex than simple gensets, especially when paired with cycling rechargeable batteries. So, often the hybrid still needs to be subsidized for rural electrification.

Campaigns are now underway to bring electrification to remote areas of the world, particularly in Africa and India. Reciprocating engines are expected to become increasingly important to this effort, given the difficulty and expense of connecting many remote regions to a central grid.

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In fact, the 2011 World Energy Outlook, produced by the International Energy Association (IEA), found that in 70 percent of rural areas distributed generation was a more efficient option to achieve universal energy access than the expansion of centralized electric grids.

Below is a look at distributed generation, in the form of reciprocating engines, in the less developed areas of sub-Saharan Africa, India and South America, where the central grid tends to be unreliable—if one exists at all. It shows why these reciprocating generators are in strong demand in these regions—and are likely to continue to be so.

Sub-Saharan Africa

Sub-Saharan Africa has seen rapid economic growth and energy use has risen by 45 percent since 2000. Efforts to promote electrification in the region are gaining momentum, according to the IEA, but only 290 million out of 915 million people have access to electricity. And the total number without access is rising due to population growth.

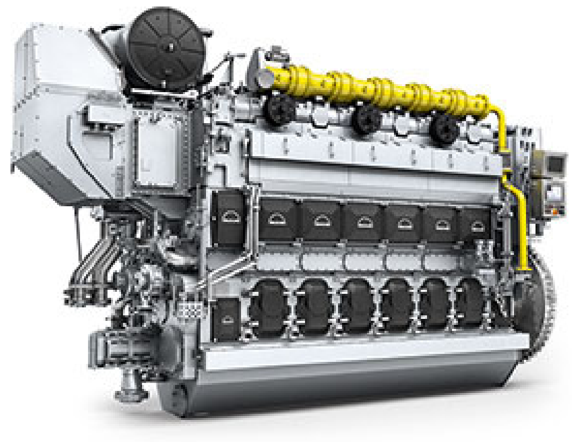
Demand for diesel fuel is expected to grow by 2.7 percent by year 2040, a rate greater than kerosene and gasoline in African countries such as Nigeria and Ethiopia. Overall, the demand for reciprocating engines in rural and peri-urban areas of sub-Saharan Africa is expected to grow in the next few decades. Also, diesel hybrid systems may provide the largest share of electricity in both microgrids and off-grid systems in these areas by 2040, according to the IEA.

India

India is the world's second most populous country, but it is fifth in regional electricity consumed, barely coming ahead of Japan which has about 1 billion fewer people.

Energy use in India has almost doubled since 2000, but energy consumption per capita is still only around one-third of the global average and some 240 million out of 1.3 billion people have no access to electricity.

Millions of diesel generator sets—or about 90,000 MW—meet the shortfall in industrial and commercial energy production, with capacity growing at a rate of 5,000 MW to 8,000 MW annually. This annual capacity is higher than the cumulative nuclear and solar capacities being added each year. Genset capacity is also increasing annually at the consumer level—most commercial businesses, mid-to-large sized factories, and apartment complexes are equipped with diesel back-up power.



Latin America

Of the top five electricity-generating countries in Central and South America, three—Brazil, Venezuela and Paraguay—generate more than 70 percent of their total electricity from hydropower.

Still, about 75 million people overall in Latin America live without access to electricity and about 31 million people—seven percent of the regional population—live without grid-connected electricity. In Nicaragua, for example, only about 52 percent of the population has access to electricity, one of the lowest rates of electricity coverage in Latin America. Peru, which fares better, still has around six million people without access. While Brazilians have the highest overall levels of access to electricity, in poor rural areas 30 percent of households have no electricity.

Expansion of the electric grid may take decades to reach areas such as the Amazon jungles of Brazil and Columbia, and the mountainous Andes area in Venezuela and Chile—if it comes at all. While hydropower has long been the workhorse of the region's energy sector, recurring droughts have forced countries such as Chile to change their energy focus from hydropower to natural gas and other fuel sources.

Rural communities, then, tend to rely on simple reciprocating engines to provide power to their households. For example, many of the 12,000 communities located on the banks of the Amazon meet their energy needs through small diesel generators. Higher income families in these areas tend to consume more energy and usually supplement their diesel gensets with one or two solar arrays.

In the final chapter of this report, we profile real world uses of reciprocating engines.

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Chapter 6

Bay City Electric Light & Power: Powering the World Forward

The polar vortex of 2014 enveloped much of North America in bone-chilling cold and strained power generation facilities. It also gave Bay City (Mich.) municipal Electric Light & Power (BCEL&P) the opportunity to use its Fairbanks Morse gensets to assist in meeting regional power needs and purchase power savings for its customers.

If the BCEL&P team had not engaged in some thoughtful, long-range planning and made some wise decisions, the story could have been quite different.

Like other utilities, Bay City maintains a diverse portfolio of power generation facilities. Two of its power plants are each equipped with two Colt Pielstick dual fuel (diesel fuel and natural gas) gensets from Fairbanks Morse. The four gensets are rated at 27 MW in total; they are normally used for peak shaving in summer when electrical demand spikes and it is most cost effective to operate the units.

Not too many years ago, Bay City seriously considered shutting down the plants, both of which had been in service for more than two decades. An Environmental Protection Agency ruling (RICE-NESHAP) in 2010 called for reduction of toxic air pollutant emissions and imposed strict operating limits on existing stationary compression ignition and spark ignition engines.

To meet the new emissions standards, both Bay City plants required modernization. In addition, the gensets were scheduled for a periodic top-end overhaul. The utility's managers had to make a choice — make a substantial investment to bring the plants into compliance and complete the necessary maintenance, or shut them down.

The utility decided to modernize the plants after assessing the power generation market. The anticipated shutdown of coal plants would remove generating capacity from the market, making the generating capacity of the Bay City units — and other plants like them — more valuable. Also, power needs were expected to increase as the economy improved and factories ramped up production.

Bay City selected Fairbanks Morse for a turnkey overhaul and modernization program. Fairbanks Morse tailored a cross-functional approach that included engine maintenance, installation of all-new engine controls to optimize engine performance, and specification and installation of 'combo' catalyst/silencer units.

When the winter of 2013-2014 arrived, the BCEL&P team was prepared, although no one anticipated the extent to which utilities would be tested. A common practice, taking advantage of lower electrical demand in winter to take plants offline for routine maintenance, would compound the challenge.

As the winter wore on, utilities began to feel the strain. The carrier ships that supply coal to power plants around the Great Lakes had to wait for ice breakers to clear a path, delaying deliveries and causing utilities to shift loads to alternate power generation facilities — many of them fueled by natural gas, such as BCEL&P's engine-driven power plants.

Because Bay City had bought storage natural gas early at under $5 per mcf, it was able to operate the gensets at a considerably lower cost than if it had bought gas on the spot market during the prolonged cold snap, when prices shot up to as much as $50 per mcf.

"There were no outright power emergencies in Michigan that winter," said Lee Techlin, Bay City's generation and maintenance supervisor. "But our units were cleared to run for more hours in January, February and March of 2014 than they run for peak shaving in a typical summer. We were able to maintain stable power costs for our customers and we helped ensure that the lights stayed on through one of the toughest winters in recent memory."

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Special thanks to Fairbanks Morse for making this guide possible.

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For more information:

Fairbanks Morse
701 White Avenue
Beloit, WI, U.S.A. 53111
800.356.6955
www.fairbanksmorse.com
marketing@fairbanksmorse.com

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