cogen

GE Energy gas engines

Issue 06
2012

Lean-burn or rich-burn?
It depends on what meets your application needs

Powering up in Africa
GE technology helps Africa secure its energy future

Proactive spare parts management
Providing top plant availability in Africa

GE imagination at work

Dear Reader,

In this issue, we take a close look at the types of energy challenges that developing nations face and the ways GE is helping to solve them. With more than 30 countries and an average annual growth rate of 5.5 percent, Africa is a focal point of those challenges, and so we zero in on the gap between energy supply and demand on the continent, and what can be done to bridge it.
We also look at the three powerful product lines that comprise GE's Gas Engines business and how they meet our customers' energy needs.
Highlights of this issue include a comparison between the lean-burn and rich-burn engine concepts. With GE's advanced technology solutions in this area, we can help determine the best choice for your application. We also report on the revamped APG1000 Waukesha gas engine and its use at a Philippines pig farm, where it supplies all the electricity and heat by burning methane digester gas from the farm's animal waste. And, GE has commissioned Germany's first biogas plant with a Jenbacher gas engine, a Clean Cycle* power generator, and a CL.AIR* exhaust aftertreatment. New German feed-in tariff rules make it beneficial to install Organic Rankine Cycle (ORC) technology in biogas plants. Finally, the Jenbacher gas engines production center won GE's Global Star Award for environmental protection, health and safety measures in the workplace. On behalf of the entire editorial team, I wish you exciting and instructive reading and look forward once again to receiving your feedback.

Yours sincerely,
Martina Streiter
Communications

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PS: Also in this issue, you can experience augmented reality, e.g., how ORC works, with Cogen 2.0. To learn more, go to the inside back cover. _

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Focus on leadership, innovation, execution

Distributed power: Solutions for all of our customers

Distributed power solutions – which grow the grid in developing countries – are part of a GE's versatile gas engines portfolio for all types of customers, from industrial clients to developing communities to governments. That portfolio, spanning Jenbacher and Waukesha gas engines and heat recovery products in the 0.12-to-9.5 MW range, makes reliable, efficient, low-emission, and affordable power available everywhere in the world.In 2012, we will continue to provide gas engines leadership, creating customer value through innovative solutions for distributed power and natural gas.

AN EXCITING MEGA-TREND. Distributed power is one of the biggest trends in worldwide energy generation today, and it's a flexible solution, too; though it's considered "growth off the grid," distributed power also can be sent to the grid. It's one of several major influences shaping the way the world is meeting its energy needs, along with a greater reliance on natural gas, a shift to renewables generation (with 15 percent of the world's power coming from that source by 2014), an emphasis on energy efficiency, and the scarcity of water.

"Distributed power is becoming increasingly important in light of the growing role renewables are assuming in the power generation mix and the ability of advanced technologies to provide that power."

Distributed power is becoming increasingly important in light of the growing role renewables are assuming in the power generation mix and the ability of advanced technologies to provide that power. More renewable power plants that use wind, solar energy, and biogas are being installed to meet the demand for power that has a low impact on the environment. Also, smaller-scale natural gas power generation units are becoming a more popular combined heat-and-power solution and are more appealing to customers in remote locations with a weak or unreliable grid connection.

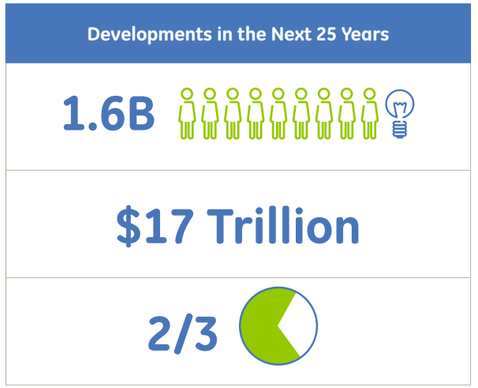
CRITICAL ENERGY CHALLENGES. The world faces a number of critical energy challenges – and distributed power is well positioned to solve all of them. For instance, holes in the grid are everywhere, particularly in many parts of China, India, Latin America, and Africa, where 50 percent of Nigeria's 167 million people have no access to power. In addition, those areas that have a public grid often must deal with instability, along with the needs for energy efficiency, emergency power, and onsite power sources.

"GE's Gas Engines business has the flexibility and power to provide reliable, high-efficiency distributed power technology."

FLEXIBLE AND POWERFUL CHOICES. GE's Gas Engines business has the flexibility and power to provide reliable, high-efficiency distributed power technology. Our gas engines can operate on a broad range of fuels – natural gas, certainly, but also biogas and landfill, sewage, coal mine and flare gases. Waukesha gas engines also can run on hot gases without fuel treatment, and they are considered a pacesetter in the compression and mechanical drive segment. Our Waukesha and Jenbacher gas engines put GE in a good position to serve the global demand for natural gas and develop technologies to solve natural gas extraction problems. With the Clean Cycle* power generator the third pillar of GE's Gas Engines business, GE offers a technology that allows reciprocating engines, biomass boilers and microturbine customers with renewable power projects to generate electricity from heat without additional fuel or emissions.

Rafael Santana,
president of gas engines, GE Energy

Developments in the Next 25 Years



PEOPLE RECEIVING POWER FOR THE FIRST TIME:	1.6 BILLION
POWER INFRASTRUCTURE SPENDING:	$17 TRILLION
SPENDING SHARE - DEVELOPING REGIONS:	2/3, UP FROM < 1/3

"Cultivating and exercising leadership, innovating with new products, and flawlessly executing to achieve operational excellence are the strategic imperatives GE's Gas Engines business is pursuing in 2012."

CURRENT IMPERATIVES. Cultivating and exercising leadership, innovating with new products, and flawlessly executing to achieve operational excellence are the strategic imperatives GE's Gas Engines business is pursuing in 2012. Fulfilling those objectives will let us take maximum advantage of the push for distributed power, and meet customer demands for cleaner-burning, natural gas technologies that cut fuel usage, assure reliable power generation, and compensate for the uncertain availability of the renewables coming onto the grid. _

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It depends on what meets the customer's application needs

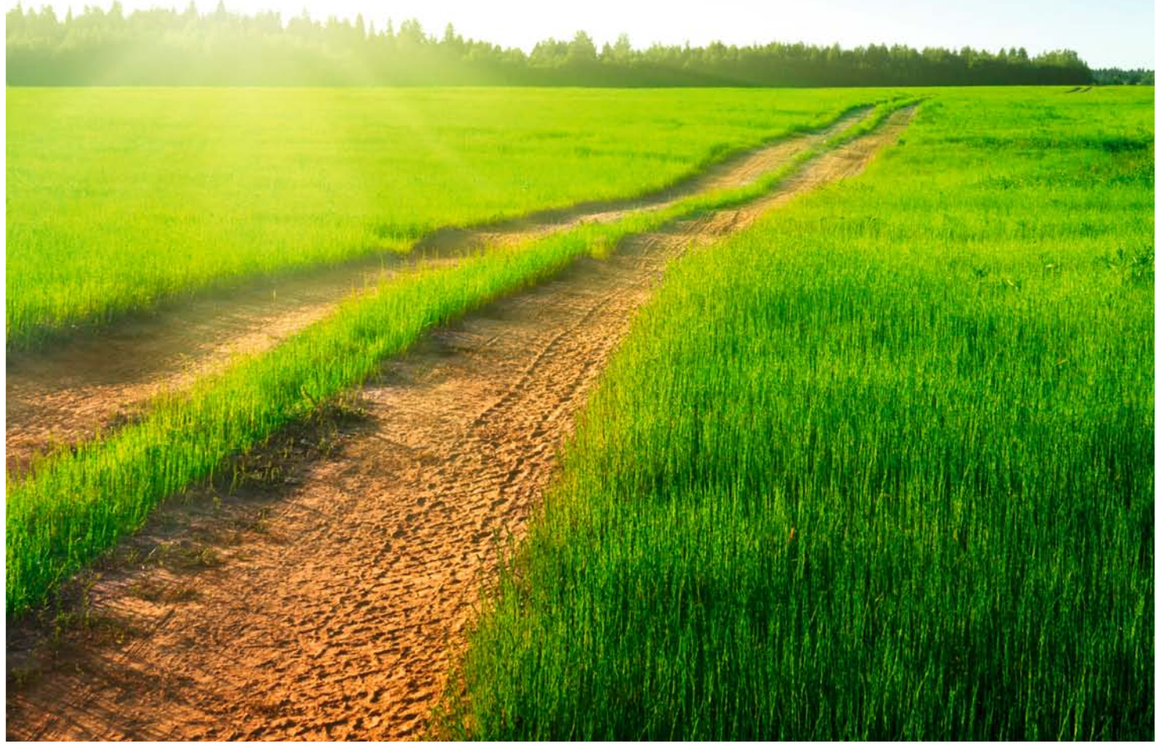
Lean-burn or rich-burn?

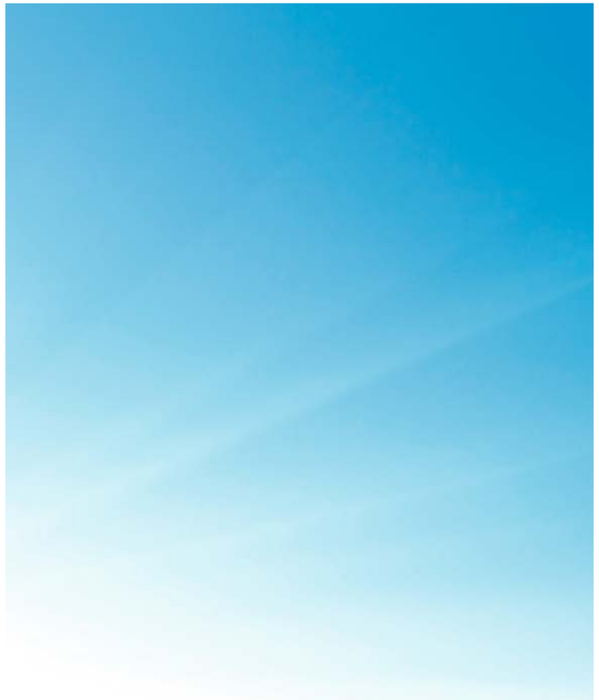
GE's Gas Engines business develops lean-burn and rich-burn technologies that have proven themselves in minimizing emissions and delivering strong operational performance. The basic differences between lean-burn and rich-burn engines, and how to decide which is best for you, are neatly summarized by Christian Trapp, head of performance engineering for Jenbacher gas engines.

"While lean-burn gas engines are more economical at certain emissions calibration levels and can operate at higher loads, rich-burn engines can achieve lower emission levels with a single aftertreatment, are more tolerant of broad fuel ranges and ambient conditions, and generally have better transient load capability," says Trapp. "Neither technology is inherently superior: Choosing the right one depends on requirements for fuel flexibility, reliability, power density, gas costs, and compliance with local emissions standards."

BASIC DIFFERENCES AND ADVANTAGES. Essentially, rich-burn engines operate at an almost stoichiometric air/fuel ratio (AFR), which is exactly enough air to burn all of the fuel. This allows a simple three-way (NSCR or Non-Selective Catalytic Reduction) catalyst (TWC) like in a gasoline passenger car to be applied to reduce nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and HAPS (Hazardous Air Pollutants), all in one aftertreatment system. Lean-burn engines use a lot of excess air, usually up to twice the amount needed for complete fuel combustion. This air dilution effectively cools down the peak combustion temperatures in the cylinder; that reduces the NOx production and allows low engine-out emissions without the need for an aftertreatment system in many applications. This lean combustion process has the additional advantage of reducing the knock (detonation) probability and, therefore, allowing higher BMEP (Brake Mean Effective Pressure) levels (loads) and an optimized combustion phasing. This results in higher power density and usually produces better fuel efficiency.

CUTTTING DOWN EMISSIONS. Rich-burn engines operate at engine-out emissions of 12-16 g/bhph-hr (5,000 – 6,500 mg/Nm^3 @ 5 percent O_2 in the exhaust gas) NOx, but the almost stoichiometric exhaust gas composition and the increased exhaust gas temperatures allow the use of a three-way catalyst. The resulting high conversation rates (for NOx above 99 percent) significantly reduce all three major types of engine-out emissions – NOx, CO and HC – and destroy inferior but hazardous pollutants like formaldehyde (CH_2O). In this way, rich-burn engines can reach a system-out emission limit below 50 mg/Nm³ (@ 5 percent O_2 in the exhaust gas < 0,1 g/bhph) NOx and ultra-low total hydrocarbon emissions, leaving a decreased overall greenhouse gas footprint. When it comes to meeting high power-density needs or achieving the highest possible efficiency at moderate emission limits of 500 or 250 mg/Nm³ NOx (@ 5 percent O_2 in the exhaust gas) – such as those stipulated in the German TA Air or the Gothenburg Protocols – lean burn engines can leverage this advantage: At an adequate gas quality they deliver BMEP levels of up to 24 bar with electrical efficiencies up to 46.5 percent (type 6 engine) without the need for a NOx or THC aftertreatment system. To lower the NOx emissions toward levels reached by rich-burn engines with a three-way-catalyst, lean-burn engines require selective catalytic converters with urea injection to maintain engine efficiency.





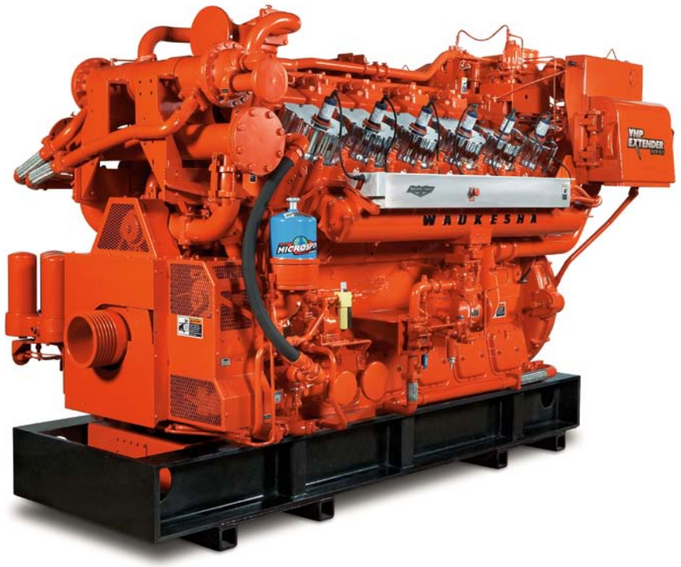
"While lean-burn gas engines are usually more economical and powerful and operate at higher loads, rich-burn engines can achieve lower emission levels with a single aftertreatment and show a higher flexibility regarding transient loads and ambient conditions"

– Christian Trapp, head of performance engineering for Jenbacher gas engines

Oxidation catalysts perform most of the CO reduction in lean-burn engines but, as with other catalytic systems, the fuel gas must be very pure. These catalysts also can reduce CH_2O emissions – again, if the gas is pure – but their low exhaust temperature limits hydrocarbon conversion efficiency.

OPERATIONAL FLEXIBILITY. While rich-burn engines can operate on a broad variety of natural gas fuels, alternative gases like biogas, sewage gas, or landfill gases cannot be used because they could poison the three-way catalyst. The potential for "poisoning" the catalyst makes the TWC solution suitable only for clean fuels such as natural gas, and not for sewage gas, biogas, or landfill gas. High combustion temperatures restrict specific output and the BMEP, so there is lower efficiency than with lean-burn engines operating at typical air/fuel ratios. If lean burn engines are calibrated to operate at extremely low NOx levels (ultra-lean), their efficiency begins to degrade so that the difference between rich-burn and lean-burn fuel consumption is minimized. Since lean-burn engines have a much higher AFR – with about 10 percent excess oxygen in the exhaust – their engine-out NOx emissions are only 5 percent to 10 percent of the amount discharged by a rich-burn engine. Lean-burn engines require selective catalytic reduction (SCR) treatment to obtain the lowest possible NOx emissions levels in the exhaust gas. SCR injects a controlled amount of urea into the catalyst to convert NOx to nitrogen. Being able to operate at a more optimal AFR with an SCR system makes the lean-burn engine very efficient and allows high break mean effective pressures.

Oxidation catalysts are used to provide most of the CO and NMHC reduction in lean-burn engines but, as with other catalytic systems, the fuel gas has to be very pure. These catalysts also can reduce CH_2O emissions – again, if the gas is pure – but their low exhaust temperature limits hydrocarbon conversion efficiency. >

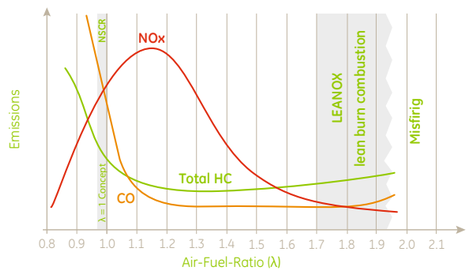


--> GE'S GAS ENGINES BUSINESS HAS THE TECHNOLOGY SOLUTIONS TO MAKE THE BEST USE OF THE LEAN-BURN AND RICH-BURN CONCEPTS

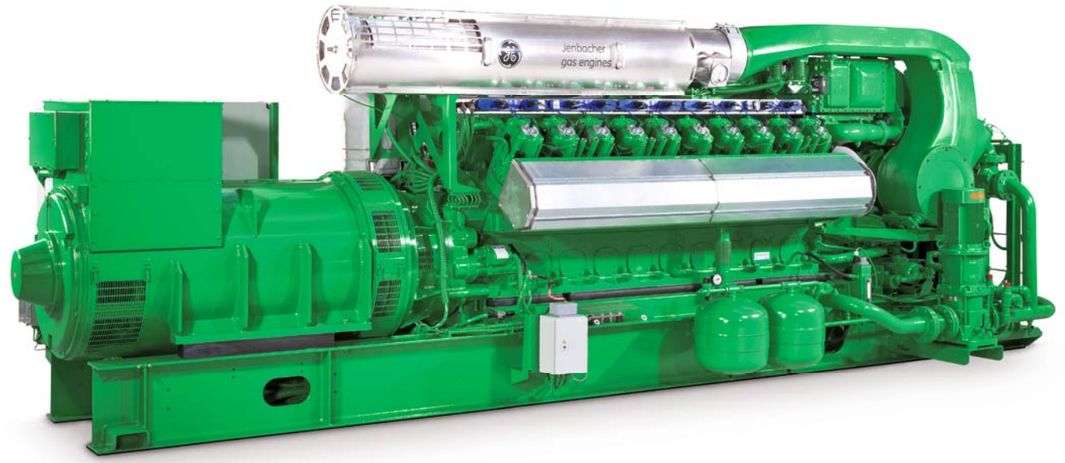
> CONTRASTING LEAN-BURN COMBUSTION CONTROLS.

Controlling the AFR is essential for controlling the combustion and, therefore, NOx emissions. One technology for controlling lean-burn combustion applies Lambda sensors to detect exhaust gas oxygen, but readings can be distorted by sensor exposure to comparatively high temperatures and acid-producing components in the exhaust gas. Other methods use sensors mounted in the combustion chamber to measure combustion temperature, but their exposure to high temperatures, peak pressures, and fouling by oil ash and trace component deposits from the fuel gas can throw off the temperature signals, leading to an offset in the AFR measurement. LEANOX*, the GE lean-burn concept, is a vastly different approach from Lambda sensors. Without resorting to costly exhaust-gas aftertreatment systems, LEANOX controls NOx emissions to @ 5 percent O_2-dry, which equals ~0.55 g/BHP-hr, by measuring engine output, intake pressure, and air-fuel mix temperature after the intercooler, and feeding these values into a controller that adjusts the gas mixer to produce the appropriate AFR. This combustion and control system keeps the thermal and mechanical stresses on related engine parts at low levels. With no sensors located in critical areas, LEANOX reliably complies with exhaust emission limits under volatile operating conditions.

CRITICAL CONSIDERATIONS. As emissions standards become more exacting the natural gas industry must develop technologies that reduce the levels of these substances as much as possible. Those rules require low NOx and CO emissions on a national level, but some states are getting even tougher than that and mandating NOx levels of 0.5 g/BHP-hr or less. That especially impacts businesses with large fleets of engines that require mobility and application flexibility. In these cases, their fuel and application flexibility and very low emissions levels make rich-burn engines a good choice. Rich-burn engines with TWC technology are preferable when lowest emissions with highest operating flexibility are the requirements. The NOx levels can be easily pushed below 0.4 g/BHP-hr, which is lower than lean-burn engines without exhaust gas aftertreatment systems. However strict the clean air requirements become, GE is keeping pace with or even exceeding them. Rich-burn engines from GE's Waukesha product line are reliable performers in a variety of circumstances, such as hot or fluctuating fuel conditions; when



--> LEANOX LOWERS NOx EMISSIONS BY CONTROLLING THE AFR



there are loading capabilities with more than 50 percent load steps; when service intervals are extended; or when the same continuous operation for gas compression has proven to be reliable. Also, while lean-burn engines can have altitude limitations on their performance and require derating above 1,500 feet, the flexible rich-burn technology of engines such as the Waukesha L5794GSI allows full power at up to 8,000 feet.

GE's Gas Engines team has the technology solutions to make the best use of the lean-burn and rich-burn concepts, and we can help you determine which engine is the best choice for your application.

Finally, rich-burn engines operate with a wide margin for knock and misfire. TWC-equipped rich-burn engines featuring the Waukesha Engine System Manager* control system can work with higher loads and lower fuel quality – up to 1,700 BTU/ft^3 with 99 percent ethane – so customers don't have to store, transport, flare, or sell the ethane.

MEETING YOUR GAS ENGINE NEEDS. "GE's Gas Engines team has the technology solutions to make the best use of the lean-burn and rich-burn concepts, and we can help you determine which engine is the best choice for your application," sums up Trapp. The GE portfolio includes Waukesha rich-burn gas engines, which perform reliably in remote and harsh applications, and highly efficient, economical Waukesha and Jenbacher lean-burn engines. All have proven themselves in tackling combustion control challenges.Rich-burn and lean-burn engines from GE provide the innovative technologies that meet specific customer needs. Their reliability, flexibility, and precise combustion control make them suitable for a wide variety of operating conditions. _

*Trademark of General Electric Company

Comparing Lean-burn and rich-burn			
		J420 B305	VHP 9500 GSI
Combustion concept		Lean	Rich
Pel	[kWe]	1,487	1,175
eta-el	[%]	43.0 / 41.7	31.6
BMEP	[bar]	20	9.6
Emissions			
NOx	[mg/Nm³]	500 / 250	<50[2)]
CO	[mg/Nm³]	300[1)]	<50[2)]
HCHO	[mg/Nm³]	25[1)]	<2[2)]

[1)] depending on oxidation catalyst design [2)] depending on TWC design

Choosing the right engine depends on application needs		
Typical applications		
CHP	+++	+/-
Biogas/LFG	++	-
Oilfield PG	+	+++
load steps to full load	5+	2

The latest GE biogas engine has expanded fuel flexibility

The newest addition to GE's global waste-to-energy portfolio is the Waukesha APG1000, a 1 MW engine redesigned for biogas to serve customers with smaller onsite power projects. This adaptation combines the proven high levels of efficiency of the original APG1000 with the expanded flexibility to run on fuels that come from a variety of sources - including landfills, digesters and wastewater treatment plants - and span a substantial range of low-BTU heating values.

CONFRONTING OPERATIONAL CHALLENGES. The reconfigured APG1000 emerged from an 18-month redesign and testing initiative targeting engines that run on biofuels, whose different sources create widely varying and highly volatile heating values. Depending on where the gas is formed, it could contain from 400 to 650 BTU/ft^3. Changes in ambient conditions at the gas site – including barometric pressure, temperature and humidity – can trigger short-term fluctuations in heating values and supply pressures, which can hurt engine performance. As a result, the operator needs to make manual adjustments to make the engine run smoothly. Smaller digesters and landfills especially are prone to inconsistent fuel quality.

THE TECHNOLOGY SOLUTION. Improvements to the engine include modifications to the combustion chamber, a new spark plug design and a new fuel system whose electronic control value operates in tandem with an enhanced version of the proven Waukesha Engine System Manager* (ESM). The upgrades boost the engine's fuel flexibility and load stability, make it easier to operate, and give it high availability. With an automated response to fuel gas fluctuations, the engine's new system enables faster, more reliable starts and a more consistent engine output with less manual intervention. Its efficiency rating of 42.1 percent makes the APG1000 one of the most efficient 1 MW gas engines in the world, and its availability with GE's factory-designed, combined heat-and-power (CHP) technology optimizes productivity by achieving up to 90 percent system efficiency.

> The efficiency rating of 42.1 percent makes the APG1000 one of the most efficient 1 MW gas engines in the world.

"The APG1000's new biogas fuel system has made a significant improvement to the engine's load stability, despite fluctuations in the heating value of the fuel gas," says Bob Weston, managing director, Entec Services Ltd.

> The APG1000 complements GE's biogas portfolio and responds to the growing customer demand for waste-to-energy solutions.

"This is particularly beneficial for smaller digester and landfill sites, which by their nature are prone to varying fuel quality. The new system provides an automated response to fuel gas fluctuations that results in faster, more reliable engine starts as well as more consistent engine output with less manual intervention. These benefits can lead to decreased operating costs and increased revenues for operators."

PORTFOLIO AND CUSTOMER VALUE. The APG1000 complements GE's biogas portfolio and responds to the growing customer demand for waste-to-energy solutions. "We feel this engine provides a nice operating range for the biogas industry," says Scott Nolen, power generation product line leader for GE's Gas Engines business. "It fits in nicely between the Jenbacher J320 and J416 gas engines models within our biogas waste-to-energy product line-up. With the addition of the APG1000, our biogas engine portfolio now has 11 different engine types that cover the 0.25 to 4 MW power range for both 50 and 60 Hz installations." _

*Trademark of General Electric Company

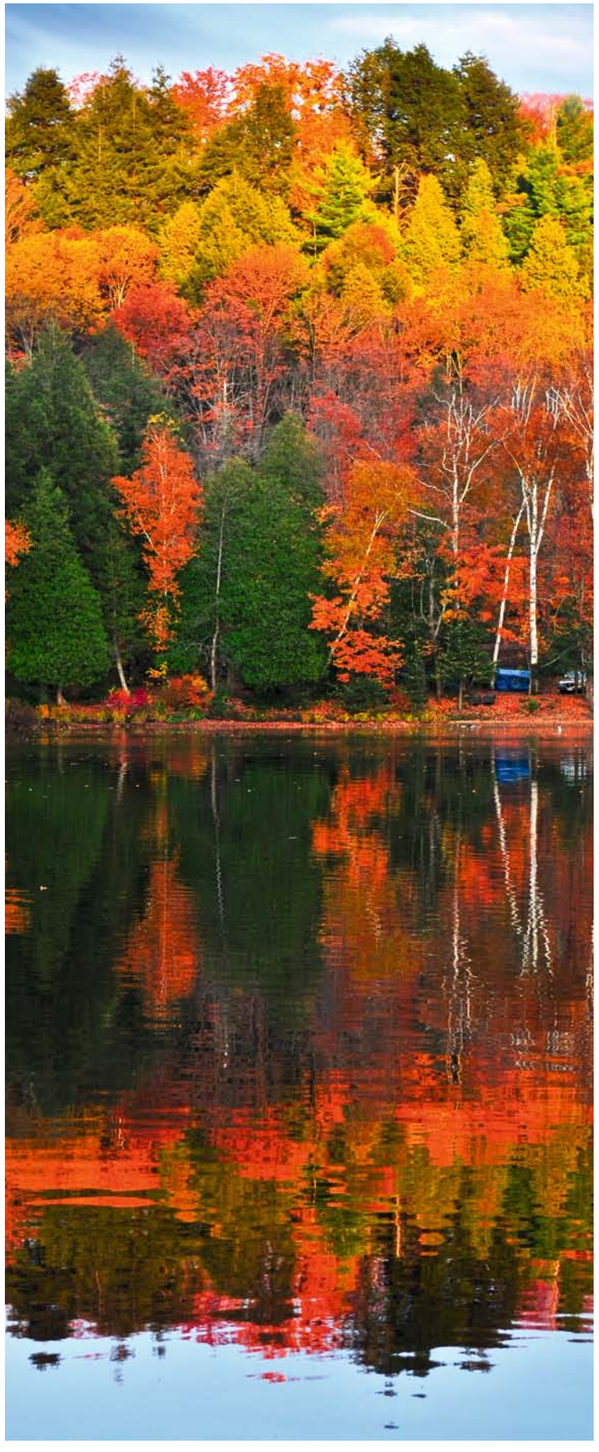
APG1000 facts and figures:

- Available for natural gas and biogas applications
- APG1000 Enginator genset rated at 1,014 kWe at 50 Hz (1,500 rpm)
- APG1000 Enginator genset rated at 1,117 kWe at 60Hz (1,800 rpm)
- Up to 42.1 percent electrical efficiency
- Up to 90 percent total efficiency with factory-designed CHP system

The world has noticed.

More than a dozen of the redesigned Waukesha APG1000 units are on order for waste-to-energy projects in the U.S. and Asia. Nine of them will generate electricity at a new landfill in Asia for sale to the local grid. Two engines, in Asia and the U.S., will power wastewater treatment plants. Two more engines in the U.S. will burn gas from a digester plant that uses food processing wastes. Here, too, electricity will be sold to the local grid, and the engine heat will provide heat and hot water to an entertainment venue.

Clearly, GE is finding a niche with the APG1000. "Supplying these units to local communities as they develop renewable energy projects using biogases has been especially rewarding," agrees Aaron Trexler, power generation product line manager for GE's Gas Engines business.



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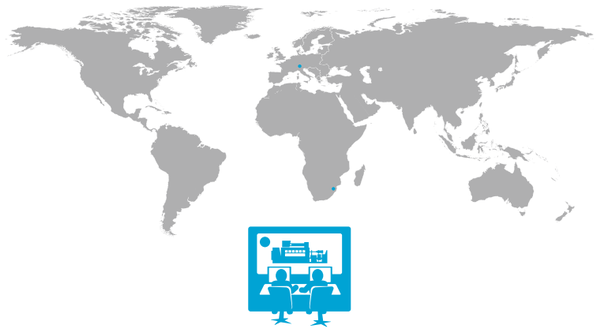
Remote services are always ready, always there – even in the hinterlands

Saturday, June 11, 2011. Shortly before midday, there is an unscheduled shutdown of the plant at the Bisasar Road landfill, a site operated by eThekwini Municipality. Shortly afterward, an employee of the local operating company contacts the 24/7 service hotline of GE's Gas Engines business and describes the problem. Fortunately, the plant has integrated remote maintenance access, so the problem can be remedied quickly and easily.



11:15
Using remote access to access the plant in Durban from Jenbach.

12:15
Establish the fault, upload the latest parameters, and start up the engines again.

12:45
The downtime: just 1.5 hours.

With 3.1 million inhabitants, the South African city of Durban is the country's second largest city after Johannesburg. eThekwini Municipality, the local administrative authority, set up the Bisasar Road landfill project several years ago to improve the public power supply. The company has been operating four Jenbacher J320 gas engines ever since 2007 on the 108.7 acre (44 hectare) waste dump in Durban, and added another two J320 gas engines and one J312 engine 2009. These are fueled entirely by landfill gas, which is released during the decomposition of the organic substances contained in ordinary household garbage.

ATTRACTIVE SOURCE OF ENERGY. Landfill gas is a high-grade fuel for gas engines and can be utilized efficiently. A ton of household garbage contains between 330 and 551 lbs. (150 and 250 kg) of organic material. The methane gas released during the decomposition process can be extracted from the landfill and fed directly to the engines. About 60.0 to 88.3 million ft³ (1.7 to 2.5 million m³) of methane can be extracted from 1 ton of household garbage. The Jenbacher gas engines installed at the Bisasar Road landfill produce a total electrical output of 7 MW. The energy generated in this way is fed into the grid network, which enhances the regional electricity supply. Under ideal conditions, the seven engines have a total annual output of 52,500 MWh, provided that they operate continually at full load with low downtimes. Marc Wright, CDM project manager with eThekwini Municipality, sums up the importance of having fast reaction times in the operation of this Durban plant: "In view of the critical energy situation in South Africa, plant downtime is always a challenge for us, as it means that we can supply less energy to the public grid network. This disrupts the power supply to both local people and industry." To ensure optimal service, the Bisasar Road landfill commissioned the firm of Peters Plant Hire as the operator responsible for technical management of the plant onsite. The plant also has worldwide remote monitoring access.

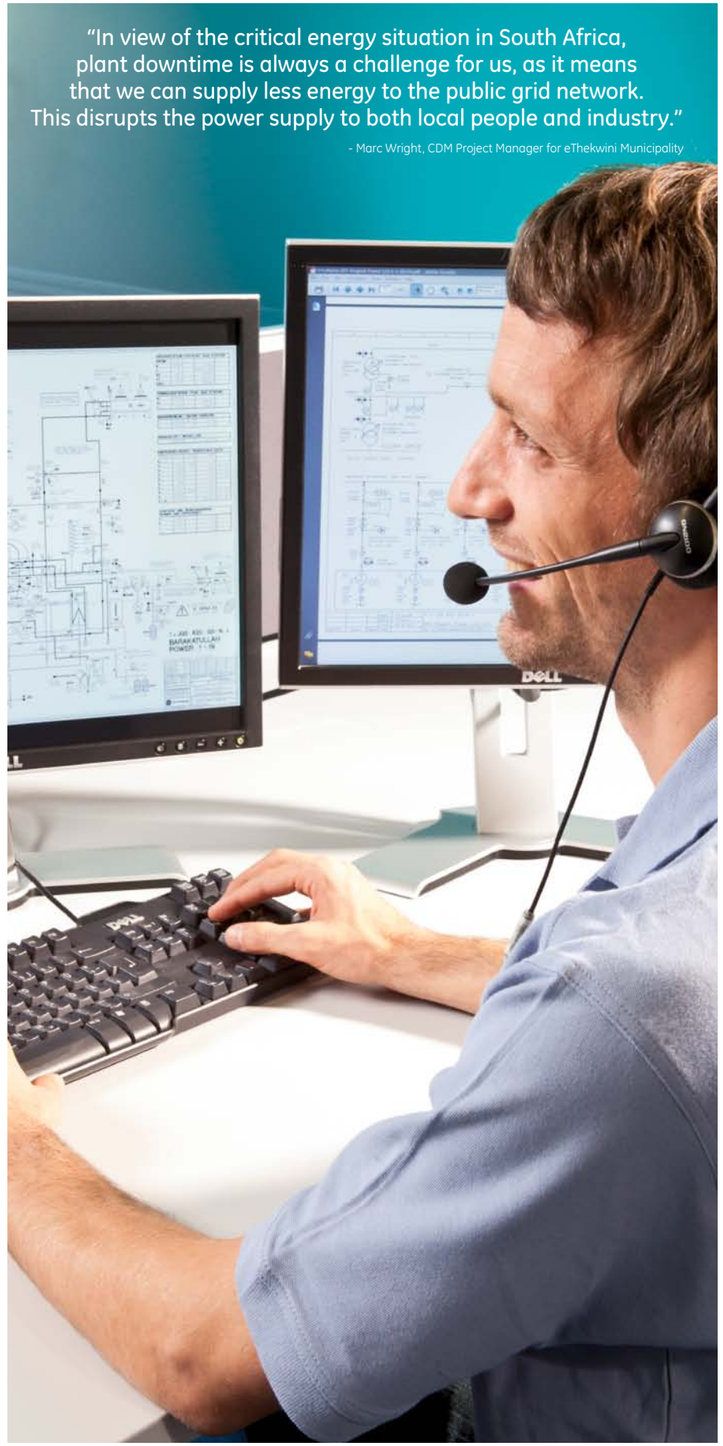
→ BISASAR ROAD LANDFILL, A SITE OPERATED BY ETHEKWINI MUNICIPALITY

CONNECTED WORLD-WIDE. The 24/7 service hotline was notified about the June 11 plant stoppage by a Peters Plant Hire employee onsite. Fleet management indicated a parameter loss, which immediately and automatically shut down the affected plant. Using remote access, a service hotline agent in Jenbach, Austria, was able to access the plant in Durban, establish the fault, upload the latest parameters, and start up the engines again. The downtime: just 1.5 hours.

"Without remote access, a Jenbacher service engineer would have had to travel from Johannesburg 600 kilometers away. The downtime would certainly have been much longer."

- Peter Seagreen, CEO of Peters Plant Hire

For Peter Seagreen, CEO of Peters Plant Hire, the possibilities of global remote access are worth their weight in gold: "The cause of the stoppage on June 11 was a defective backup battery, which resulted in a parameter loss – actually a trivial fault that can quickly be remedied. Without remote access, a Jenbacher service engineer would have had to travel from Johannesburg 600 kilometers away to upload the new parameters. The downtime would certainly have been much longer. Ninety percent of all Jenbacher gas engines in South Africa have long-term service agreements, and are therefore remotely accessible worldwide. Short reaction times in the event of a breakdown coupled with individual customer support from the 24/7 service hotline have decisive advantages for the customer. This is particularly true of regions like South Africa, where the installed plant is distributed over a huge area. _



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DELTA Energy & Environment

Current problems are creating new opportunities:

Electricity in Africa

The following simple comparison highlights Africa's electricity challenge. Africa's population is just over 1 billion, and its total installed electric capacity is about 140 GWe. The European Union, by comparison, has half the population and almost six times the installed electric capacity. Hence, per capita capacity in Africa is less than 9 percent of per capita capacity in Europe. Can this situation change, and if so, how?

Here is a perspective from Michael Brown, director at Delta Energy & Environment, a research consultancy providing marketplace intelligence on decentralized energy products and technologies for utilities, investors, policy makers, equipment manufacturers and technology developers.

BADLY NEGLECTED ELECTRICITY SYSTEMS: A MULTI-NATIONAL PROBLEM. It is hard to generalize about Africa because of the huge diversity in energy-generating capabilities among its 50-plus countries. Many African economies are buoyant and their electricity demand is surging. Yet most countries have not invested enough in generation and network infrastructure to keep up with this demand, so their power supplies can be highly unreliable and plagued by brownouts and blackouts. One of Africa's biggest economies is Nigeria. The country is a big oil exporter, but its people get only a few hours of electricity a day. The entire population – around 167 million – uses the same amount of electricity as a large international airport. The reason is lack of investment. During the 1990s, there was little investment in generation. While that has recently changed, there has not been enough corresponding investment in network infrastructure, so overall electricity supply is flat.

At the other end of the continent, in South Africa, under-investment in generating capacity and rapid growth in energy demand resulted in severe electricity shortages in 2007 and 2008.

At the other end of the continent, in South Africa, under-investment in generating capacity and rapid growth in energy demand resulted in severe electricity shortages in 2007 and 2008. Since then, there has been investment in new plants, but demand is surging ahead of this as the economy rebounds after the recent recession. The story is just as bad, or even worse, in many other countries.

A SOLUTION BY AND FOR END USERS. Africa clearly needs lots of new electric capacity, but what are the implications of this challenge for onsite generation based on gas engine systems? One indication comes from Nigeria, where almost all wealthy Nigerians and businesses cope with the supply problems by having their own diesel power plants. Over 60 percent of all Nigerian electricity is produced in this way, so the diesel genset will be the default solution where diesel is more readily available than other fuels.

THE GROWING ROLE FOR NATURAL GAS AND BIOGAS. What about the prospects for gas engines that use natural gas or other gases such as biogas? Actually, they look attractive in several countries. According to the International Energy Agency (IEA), natural gas, by far, will be the fastest-growing fuel in use for power generation in Africa. (Gas-fired combined heat and power (CHP) has an added benefit, since it can be used to drive chillers to meet the continent's accelerating demand for cooling.) Growth in gas use will likely be even faster than the IEA projects given the rate at which new discoveries are being made around the continent. For example, at the end of 2011, gas producer Andarko upped its estimates for a field off the east coast of Africa and confirmed that it was one of the most important fields discovered globally in the last 10 years.

-> STREET LIFE IN SAINT LOUIS, SENEGAL

Growth in gas use will likely be even faster, given the rate at which new discoveries are being made around the continent.

Further south, in South Africa, vast quantities of shale gas are now believed to exist. If they can be extracted safely, and used for high-efficiency CHP generation, that could result in a large reduction in carbon emissions from the electricity sector, which is dominated by coal. Biogas prospects depend on fuel availability from sources such as water treatment plants, farms, and landfills, and on the introduction of new renewable energy incentives. On both counts, Africa is still in its infancy. But the growth potential is there: As Africa urbanizes, waste water treatment facilities will need to be developed, and that will create new opportunities for gas engine-based CHP.

Perhaps the greatest challenge to gas engine adoption in many countries is marketplace awareness. Many policymakers and energy users understand the benefit of switching to natural gas use in large combined cycle gas turbine (CCGT) power plants, but few see the much greater energy and environmental benefits of locating high-efficiency CHP in industrial facilities and other buildings. _

Author

MICHAEL BROWN
Director at Delta
Energy & Environment

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GE sets a waste heat-to-power precedent in Germany

Technology mesh boosts biogas plant efficiency

In January 2012, GE commissioned Germany's first biogas plant with a Jenbacher gas engine, a Clean Cycle* power generator, and a CL.AIR* exhaust aftertreatment. The installation demonstrates the benefits of implementing Clean Cycle technology, using Organic Rankine Cycle (ORC), in biogas plants in the wake of recently adopted legislation requiring biogas plants to use their heat in order to qualify for the German feed-in tariff. The mesh of GE's technologies makes the power generation system greater than 3 percent more efficient than a gas engine on its own.

DOUBLE SHOT: TURNING BIOGAS AND WASTE HEAT INTO POWER. Located in Jedesheim near Illertissen, in the south of Germany, the plant is owned by the Bioenergie Iller-Roth GmbH & Co. KG, an association of 25 farmers. The plant's original power source is agro-industrial biomass from the farmers' harvest – specifically, crop clippings and grass. Anaerobic digestion technology changes this material into the biogas that the Jenbacher J416 gas engine burns for power, and the Clean Cycle generator recovers the resulting waste heat and turns it into additional electricity.

Combined with a Clean Cycle generator, the gas engine plant produces 7.5 percent more electricity from the same amount of biogas.

Ecogas GmbH, which built the facility, developed a unique design for the plant and fermenter, maximizing the plant's efficiency and functional economy by minimizing construction and operating costs as well as power consumption. The configuration with the Organic Rankine Cycle boosts the Jenbacher gas engine plant efficiency by more than 3 percent – i.e., the plant produces 7.5 percent more electricity from the same amount of biogas. Moreover, the Clean Cycle solution produces a 90 kW increase in electrical output, all of which is being fed into the local grid. The engine's electrical efficiency is 42.2 percent and the total plant combined electrical efficiency is 45.5 percent.

-> THE J416 ELECTRICAL EFFICIENCY IS 42.2 PERCENT

-> VIEW OF THE BIOGAS PLANT IN JEDESHEIM NEAR ILLERTISSEN, GERMANY

By converting engine heat into electricity, the Clean Cycle generator, using the Organic Rankine Cycle, enables the biogas plant to qualify for feed-in tariffs under Germany's Renewable Energy Initiative 2012.

"By applying GE's Clean Cycle generator we have been able to increase the efficiency of the biogas plant by more than 3 percent," says Hubert Atenried, managing director, Ecogas GmbH. "That means our customer – the farmers' association - gets more output from the same amount of biomass. At the same time, we increased the electrical output by 90 kWel (gross) and can feed more electricity into the grid. This makes the plant highly efficient for our customer."

A CL.AIR REDUCTION IN EMISSIONS. Using GE's CL.AIR exhaust aftertreatment system with the Jenbacher gas engine lowers the carbon monoxide (CO) emissions to 300 mg/Nm³ and formaldehyde emissions to 15 mg/Nm³ - both well below Germany's air pollution limits. Created to work with Jenbacher gas engines, CL.AIR is a system of thermal regenerative post-combustion of engine exhaust gases. Since CL.AIR doesn't react to fuel gas impurities, and there are no catalytic reactions involved in heat treatment of the exhaust, the CL.AIR system works well with biogas and other critical gases where catalytic converters have limited or no effectiveness. CL.AIR also decomposes all unburned methane in the exhaust gas and converts it to additional exhaust heat.

UPBEAT BIOGAS OUTLOOK IN GERMANY. The biogas boom in Germany, dating back to 2007, bodes well for the development of more ORC and CHP projects. Germany's biogas sector, the largest in Europe, posted a record-breaking year in 2010, with 1,200 new plants constructed to bring the country's biogas plant total to about 6,000. Most of those sites are in Bavaria and the eastern federal states. By the end of 2012, the country is projected to have 7,000 biogas plants. _

The biogas boom in Germany bodes well for the development of more ORC and CHP projects.

*Trademark of General Electric Company

Germany's renewable energy initiative 2012

- Requires biogas plants to use 60 percent of their heat in a district heating loop, or install an Organic Rankine Cycle generator to convert the biogas engine heat into additional electricity
- Qualifies biogas plants for a feed-in tariff of up to 20 cents Euro per kilowatt hour
- Aligns with Germany's goal of doubling the biogas contribution to its total energy needs between 2010 and 2020

Steel and ferro alloy production also pays off with electricity production

Rising energy prices and electricity shortages are putting pressure on heavy industry the world over. Therefore, as a major consumer, industry must produce as efficiently and as ecologically as possible. This is no easy task, but with the aid of the latest gas engine technology, it can be achieved. The large quantities of special gases occurring during steel and ferro alloy production can either be flared off unused or transformed into valuable electricity by using Jenbacher gas engines.

SPECIAL GASES AS AN ENERGY SOURCE. Today steelworks in all parts of the world are on the lookout for energy supplies that are not only reliable and low-cost, but also reduce greenhouse gas emissions to a minimum. The solution the industry seeks is close at hand. The special gases known collectively as 'steel gas' occur in large quantities as a by-product of steel and ferro alloy production and offer an attractive source of energy for electricity generation. The conversion of special gases into electricity is based on highly advanced gas engine technology. Once again, the innovative pioneer in this field has been Jenbacher gas engines from GE's Gas Engines business. The business has been carrying out intensive research into, and successfully commercializing, the use of steel gas for electricity generation since the mid-1980s. Throughout the world, more than 50 Jenbacher gas engines are currently fueling all types of steel and ferro alloy processes, like coke gas, blast furnace gas, and converter gas. The ferro alloy gases are a part of the converter gas group as they exhibit similar characteristics as converter gas. All told, these engines have successfully logged well in excess of million operating hours. The low flammability of blast furnace gas that results from its low calorific value is absolutely no problem for a Jenbacher gas engine. Hence, GE is the world's first gas engine manufacturer capable of utilizing all three of the steel and furnace industry's process gases as a valuable source of energy.

CHALLENGE FOR SOUTH AFRICA. Although creating an efficient and ecological energy supply is high on the agendas of steel mills worldwide, this is particularly true for steel mills and for the ferro alloy industry in the Republic of South Africa. Because of a shortage of electricity and the need to stabilize the grid network, ESKOM, Africa's largest electric utility, has had to reduce electricity supplies to industry by 10 percent. Generating electricity independently from steel gas is an advantage that not only provides a reliable source of supply but also has environmental benefits.

+8 MW FOR SACC. With its huge metal and mining industries, South Africa has a valuable resource that – thanks to the latest gas engine technology – also offers a remedy for the problem of unstable electricity supplies from an overloaded and unpredictable public network. Yet another example of the fuel flexibility of Jenbacher gas engines is the use of the arc furnace waste off gas that occurs in the production of calcium carbide (a steel gas in the widest sense of the term). In the autumn of 2012, with the aid of four Jenbacher J620 gas engines, South African Calcium Carbide (SACC) of Newcastle (the second largest town in the South African province of KwaZulu-Natal after Durban) will begin to generate a total of 8 MW of electricity from its own waste gas production.

> "We have opted for an independent electricity supply using Jenbacher gas engines from GE because this technology is innovative and time-tested, and because GE simply knows what is important in our industry."
>
> Juan Sabio, general manager of South African Calcium Carbide

This will enable the company to meet its additional demand for electricity independently of the grid network so that it can concentrate on further growth. _

Steel and ferro alloy gas characteristic

	Coke gas	Blast furnace gas	Converter gas	Ferro Alloy
... occurs as a by-product ...	in the industrial production of coke from hard coal	in the production of pig iron from iron ore	during the production of steel from pig iron	during production of ferro chrome, ferro manganese, ferrosilicon, titanium slag, calcium carbide
... is composed mainly of ...	50–70% hydrogen ~5% carbon monoxide 25–30% methane	~3% hydrogen ~20% carbon monoxide	~1-50% hydrogen ~25-80% carbon monoxide	~5–35% hydrogen ~50-80% carbon monoxide
... has a calorific value of ...	~5 kWh/Nm³	~0.9 kWh/Nm³	~2.5-3 kWh/Nm^3	~2-3kW/Nm³

-> THE PRODUCTION FACILITY OF SOUTH AFRICAN CALCIUM CARBIDE (SACC) IN NEWCASTLE, SOUTH AFRICA

Generator set turns pig farm waste into renewable energy

A large pig farm in the Philippines is using one of GE's Waukesha gas engines generator sets to supply all of its electricity and heat by burning methane digester gas from the farm's animal waste. The project's conversion of the waste resource into renewable energy is generating energy cost savings and reducing greenhouse gas (GHG) emissions.

THE CHALLENGE: HOW TO HANDLE ALL THAT WASTE. With 100,000 pigs on its farmland and a commitment to producing energy that has a minimal environmental impact, Cavite Pig City Inc. (CPC), south of Manila, had to determine the most responsible way to manage its animal waste. CPC decided to install a high-efficiency, Waukesha APG1000 as an onsite, combined heat-and-power (CHP) plant to meet its needs. The 1.1 MW generator set – the largest single biogas power plant in the Philippines – generates electricity and captures the engine's waste heat for other essential farm operations. It was supplied by Entec Services Ltd., an authorized sales and service provider for Waukesha gas engines based in Auckland, New Zealand.

HOW THE TECHNOLOGY WORKS. CPC replaced the lagoons that had been decomposing, processing and treating the farm's pig waste with a new, two-stage biogas digester that improves the quality of the treated waste. The digester produces gas whose composition is about 60 percent methane and 40 percent carbon dioxide (CO_2), and since the methane is a potent greenhouse gas with 25 times the global warming impact of the CO_2, the gas engine keeps it from being released into the air by burning it as fuel.

> "CPC has invested in a technology that converts a waste product into a valuable resource. It reduces the farm's energy costs and avoids emitting methane into the atmosphere."
>
> - Bob Weston, managing director, Entec Services, Ltd.

Currently, 40 percent of the electricity generated by the power plant meets the farm's total electrical demand. This includes power for a mill that processes pelletized feed for the animals and a cool cell ventilation system for the barn.
In the future, CPC hopes to sell the excess electricity it produces to the public grid. The engine's efficiency also provides the farm with heat from hot water recovered from the engine jacket and high-temperature intercooler circuits. About 30 percent of the hot water circulates through plates in the floor of the building housing the newborn piglets to keep them consistently warm, improve their health and reduce their mortality. CPC's choice of the Waukesha solution reflects the farm's dedication to producing energy in advanced and humane ways that protect the environment. "With this project CPC demonstrates further leadership in the Philippine pig farming industry by investing in technology that converts a waste product into a valuable resource," proclaims Bob Weston, managing director of Entec. "The project reduces the farm's energy costs and avoids emitting methane into the atmosphere."

CONVENIENCE AND OPERATIONAL CONTROLS. Entec, which has extensive experience in biogas engine projects, pre-packaged the generator set with a dump heat radiator, PLC controls, switchgear panel and heat recovery equipment in a modified 40-foot shipping container for easy installation onsite. Once in place, the plant only required a fuel gas source, and electrical and power connections. Entec also supplied an operator panel for onsite and remote control monitoring of system operating parameters such as exhaust temperatures and fuel pressure. Both CPC technicians and Entec provide ongoing service, with Entec also giving remote support. _

-> AN AERIAL VIEW OF CAVITE PIG CITY INC. IN THE PHILIPPINES, WHICH TYPICALLY HOUSES 100,000 PIGS

Full speed ahead for the future...

With approximately 167 million inhabitants, the Federal Republic of Nigeria is Africa's most populous nation, and it also has the world's seventh-largest population. In a survey published by Goldman Sachs in 2003, Nigeria was added to the Next Eleven (N11) list, which names the 11 most promising economies in the 21st century. The region offers interesting growth opportunities for gas engines, according to Clarke Energy, authorized sales and service provider for Jenbacher gas engines in Nigeria.

Clarke Energy and the Jenbacher gas engines team have enjoyed a close and successful association for more than 17 years now. With more than 700 highly qualified employees and a worldwide distribution network, Clarke Energy is one of the largest authorized sales and service providers for Jenbacher gas engines. The company established an office and service center in Lagos in 1999, its first on the African continent. Clarke Energy's Nigerian operations are served from the seaport of Apapa, which is west of the capital city of Lagos. The first Jenbacher gas engine in Nigeria was commissioned in 2002. Over the last decade, 75 plants with a total electrical output of over 150 MW further increased the gas engine fleet. Rising diesel costs and an unstable and unreliable electricity grid helped spur this rapid growth in sales. As a result, natural gas has established itself as the fuel of choice for power generation for many companies.

A key element behind Clarke Energy's success in Nigeria has been the company's attention to understanding both the customer and the customer's actual project requirements.

THE PHILOSOPHY IN ACTION. In line with the company's corporate philosophy, Clarke Energy employees are closely involved in customer projects right from the planning and design phases. The primary objective of such intensive engineering and project management is to develop comprehensive solutions for each customer's requirements that make economic and ecological sense. The company's extensive Jenbacher project portfolio is supported by its customer service department. This encompasses highly trained employees, the latest tooling, and a large stock of original spare parts to ensure the engines achieve maximum availability.

REGION SUCCESS FACTORS: PRODUCT SUPPORT. A critical factor for Clarke Energy's success in Nigeria has been the company's dedication to the customer and support of the Jenbacher product. Over the years, the company has established an excellent reputation in its core countries as a reliable and highly capable service provider. This is particularly noticeable in regions where the electricity grid is unreliable and operations depend upon a distributed power concept. Here the efficiency, reliability and durability of a company's own plant are essential to its survival.

AN ENHANCED DISTRIBUTED POWER SOLUTION. One such example is Apapa-based Honeywell Flour Mills plc., which commissioned Clarke Energy to extend its existing Jenbacher power plant by another 3 MW. The company specializes in the production of high-quality flour grades for the food industry, with a daily processing capacity of 1,600 tons that makes this one of Nigeria's largest flour mills. In 2008 four Jenbacher J620 gas engines went into operation. Growing demand for the company's product translated to higher energy demand, and that, in turn, made it necessary to install an additional J620 engine in 2011. Today the natural gas-fueled facility has a total electrical output of 15 MW operating in island mode (isolated from the electricity grid network). This allows Honeywell Flour Mills to operate its mills completely independently from the Nigerian electricity grid. _

facts and figures:

Clarke Energy Nigeria Ltd.

Established:	1999
Jenbacher plants installed:	74
Total electrical output:	> 150 MW

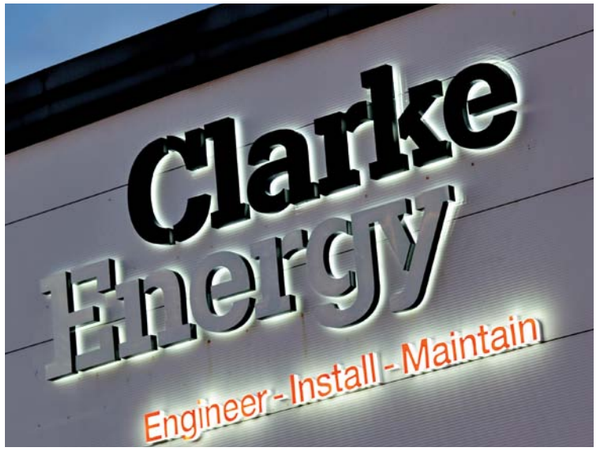
Customer orientation the key to success in Nigeria

cogen spoke with **ALAN FLETCHER,** main board member of the Clarke Group, one of the largest authorized sales and service providers worldwide for Jenbacher gas engines.

cogen: ***You have had a branch office in Nigeria since 1999. How has business in this region developed over the last 12 years?***
Alan Fletcher: Clarke Energy has actually been operating in Nigeria since 1988. However, prior to our association with GE, we were mainly active as service and spare part providers for diesel engines. We established an office in 1999. Initially the gas engine business was slow to take off. This was due to the lack of a gas infrastructure in Nigeria and the low cost of diesel fuel.
What has changed since that time?
The development of a low pressure gas infrastructure network and an increase in the cost of diesel are key drivers for businesses to look at switching from diesel to gas-fueled power generation. A key milestone was the installation of a 1 MW Jenbacher J320 gas engine for Dunlop Tyres.

> "The reliability and performance of a power generation plant depends on the quality of the gas engine, facility engineering, design, and level of service that we as a company can deliver."

After many years of reliable performance it became the technology choice for many other businesses including Flour Mills of Nigeria plc., which placed a significant order in 2005 for 21 MW for its facility in Apapa, west of Lagos. This was the first of many projects for the Flour Mills Group. The continued reliable and economical performance of the engines has seen the group increase the fleet to more than 50 MW over three sites.



-> GLOBAL HEADQUARTERS OF CLARKE ENERGY IN LIVERPOOL, UNITED KINGDOM

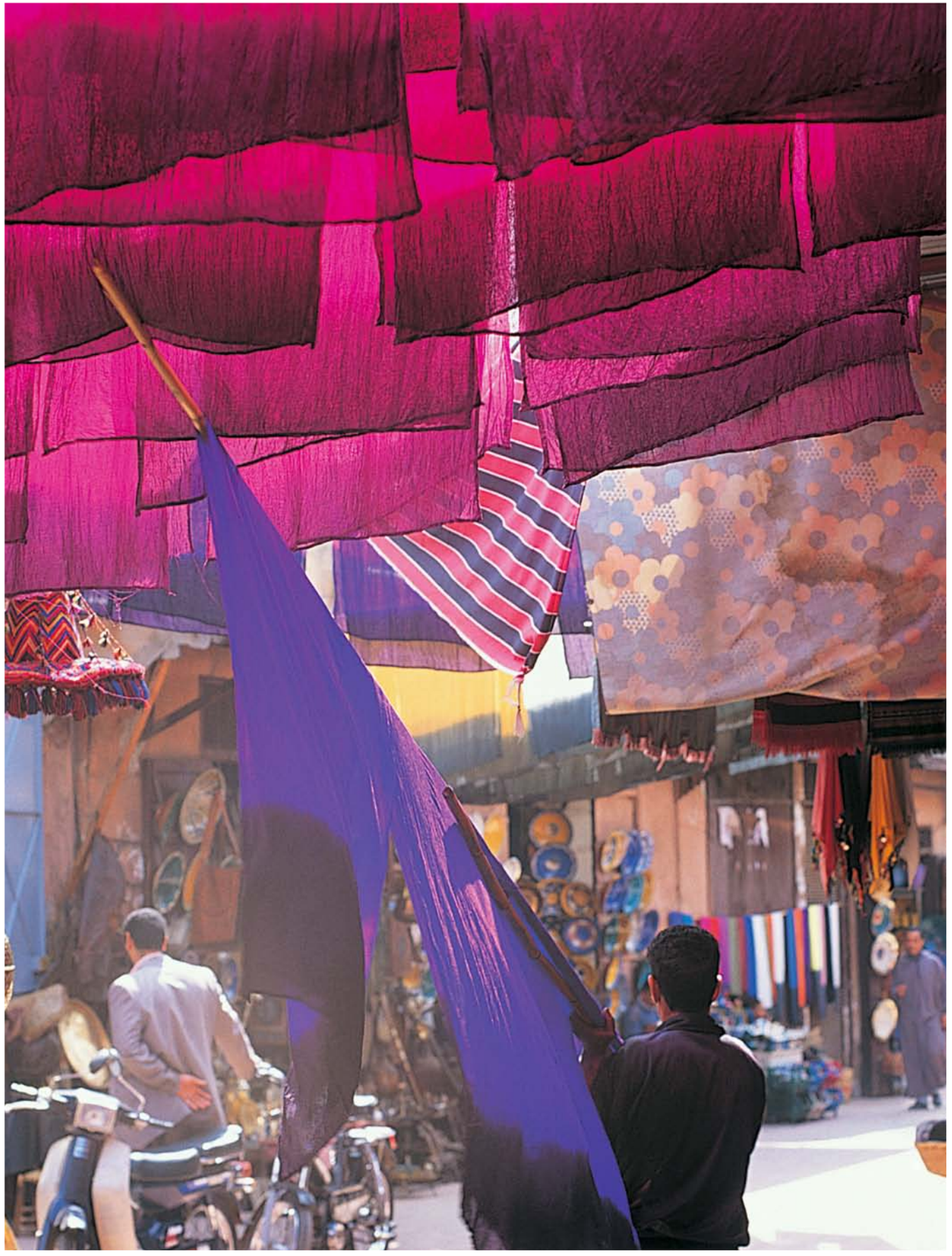
-> INSIDE THE POWER GENERATION PLANT OF FLOUR MILLS OF NIGERIA PLC. IN APAPA, NIGERIA

Clarke Energy's success strategy is to a large extent based on first-rate customer service. Why does service play such a big role for you?
The reliability and performance of a power generation plant depends on the quality of gas engine, facility engineering, design, and level of service that we as a company can deliver. This process begins by consulting with our customers to develop an understanding of their operational philosophy. This, coupled with our well-qualified and trained local support personnel and our ability to react quickly to rectify problems, ensures that the highest levels of availability are maintained year on year. Our service organization in Nigeria is a carbon copy of the model that we have successfully developed across Clarke Energy's global operations. In addition we also have a worldwide pool of service engineers at our disposal who can be deployed in Nigeria if needed. Continuity of the highest levels of availability and performance are our best long-term sales tools.

> "Continuously high plant availability is our biggest sales argument for new customers."

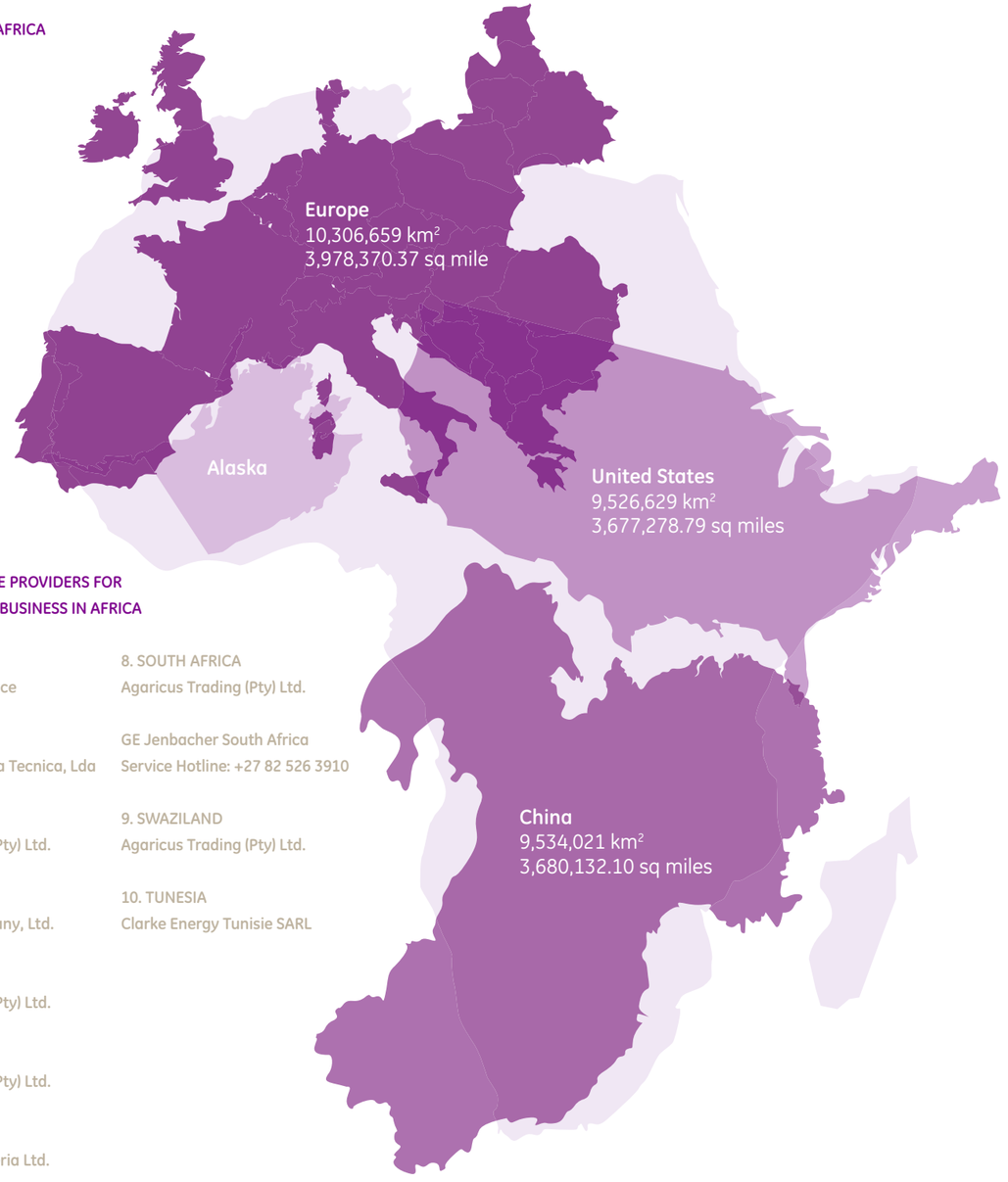
The government in Nigeria recently reduced the subsidy for diesel. What effect has this had on the demand for GE's gas engines? The requirement for gas-fueled generation products will continue to grow due to the reduction of these subsidies. The price offset between diesel and gas, coupled with the lower maintenance costs and longer service intervals associated with gas engines, will only continue to make gas the fuel of choice.
How would you assess the general energy situation in Nigeria?
Population growth, increased political stability, and prosperity are translating to a rising demand for energy. The development of major infrastructure projects, including the 4,100 km long West African gas pipeline (2015) and the discovery of gas reserves in nearby Ghana, will be the drivers for the development and further expansion of the low pressure gas distribution network. In turn, this will bring new business opportunities for Clarke Energy and Jenbacher gas engines. We see power generation from natural gas as one of the most important growth areas in Nigeria over the next five years. _

Thank you for talking to us.



-> COLORFUL TEXTILES HANGING IN A BAZAAR IN MARRAKECH, MOROCCO

THE TRUE SIZE OF AFRICA



SALES AND SERVICE PROVIDERS FOR
GE'S GAS ENGINES BUSINESS IN AFRICA

1 . ALGERIA
Clarke Energy France

2. ANGOLA
Jembas Assistencia Tecnica, Lda

3. BOTSWANA
Agaricus Trading (Pty) Ltd.

4. EGYPT
HCH Supply Company, Ltd.

5. LESOTHO
Agaricus Trading (Pty) Ltd.

6. MOSAMBIQUE
Agaricus Trading (Pty) Ltd.

7. NIGERIA
Clarke Energy Nigeria Ltd.

8. SOUTH AFRICA
Agaricus Trading (Pty) Ltd.

GE Jenbacher South Africa
Service Hotline: +27 82 526 3910

9. SWAZILAND
Agaricus Trading (Pty) Ltd.

10. TUNESIA
Clarke Energy Tunisie SARL

Powering up in

Africa

GE technology helps Africa secure its energy future

Energy generation in Africa is being caught between two opposing pressures – power demand, particularly from industry, and chronic power shortages and service interruptions. As part of its heavy investment in Africa's energy future, GE offers gas engine technologies and renewables solutions to help bridge the supply-and-demand gap, create more energy self-sufficiency for African companies, and reduce the industrial carbon footprint.

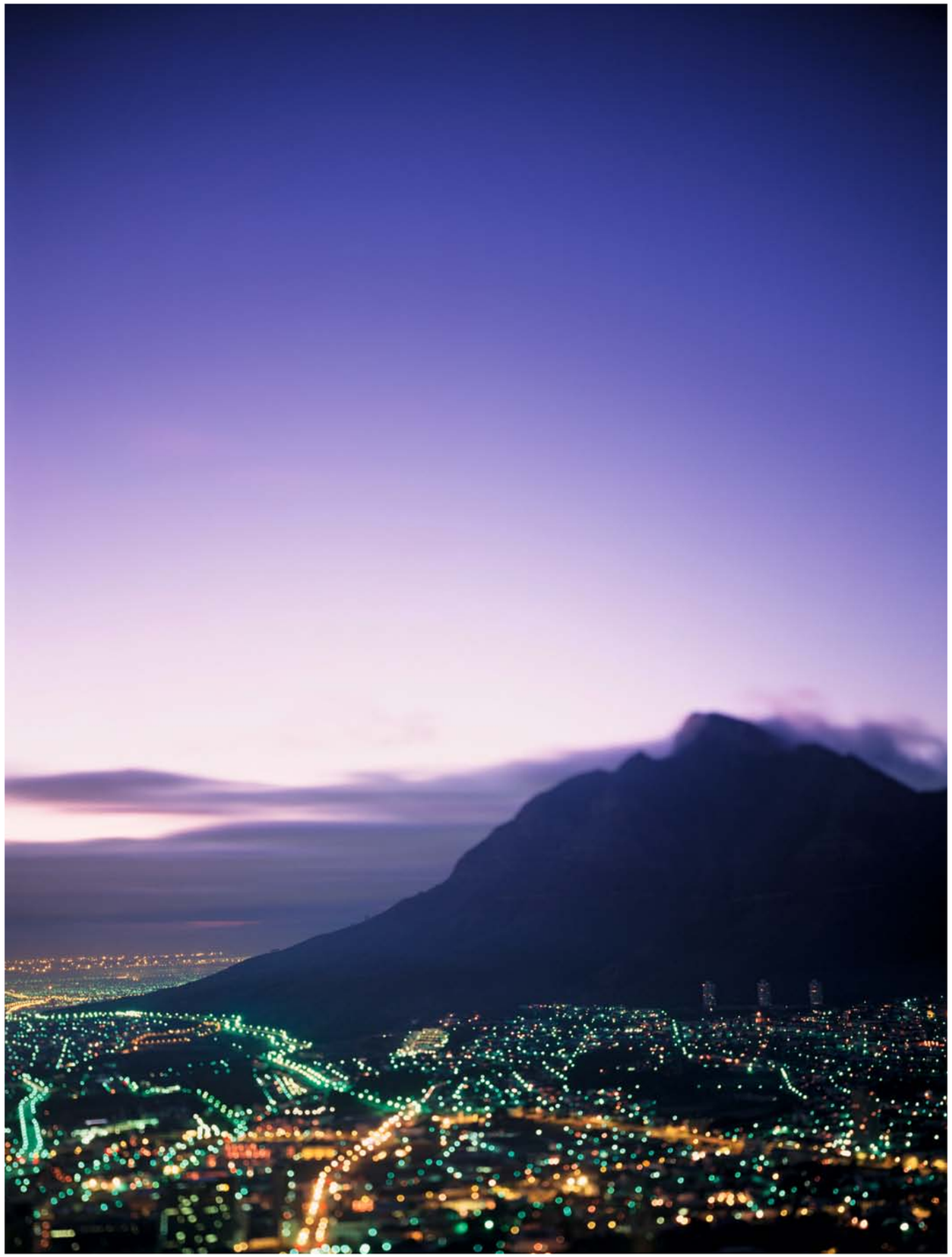
GRID CAN'T SATISFY ENERGY DEMAND. The continent of Africa is made up of more than 50 countries, and their average growth is about 5.3 percent a year. Particularly in South Africa, the public grid can't keep pace with that greater demand, and in peak hours there is a critical shortage of reserve capacity. The imbalance – which has prompted national utilities to enforce load shedding (i.e. rationing) by implementing planned outages – is so big that a World Bank report estimates that about 40 percent of the $93 billion needed to improve Africa's infrastructure must be devoted to boosting power supply alone.

> Industry in Africa will have to relieve demand on the grid's strained resources.

Industry in Africa will have to relieve demand on the grid's strained resources by providing as much of its own energy as possible. And, to compensate for grid inadequacies, African nations may need to look at different strategies from those adopted in Europe and America. For instance, since bigger, long-term projects aren't satisfying capacity needs, some governments and industrial consumers are looking more readily at short-term emergency power solutions. In addition, smaller, simpler projects may better suit Africa than large-scale, independent power producer (IPP) facilities that supply hundreds of megawatts. Indeed, governments – which traditionally have kept energy generation to themselves in Africa – are partnering with private entities on smaller (less than 100 MW) distributed power plants to avoid the high infrastructure costs of generation, transmission and distribution.

INCENTIVES FOR EFFICIENCY. Businesses and utilities in Africa are looking for cleaner, more efficient ways to make industrial production less energy-intensive. Cost is one motivator for this. ESKOM, South Africa's national utility that produces 95 percent of the electricity for its host nation and 45 percent for all of Africa, is demanding that industry reduce its energy consumption by 10 percent. That's because ESKOM has to pay for a major power infrastructure overhaul over the next several years that will leave many areas within South Africa without power.

THE PUSH FOR RENEWABLES. Africa as a whole lacks renewable generation projects – except for hydropower. By far the single biggest source of electricity in many African countries, hydropower is affected by recent droughts and other uncertain weather patterns. The government of South Africa, where GE Energy's regional headquarters is located, is looking at other renewable options and has mobilized against the energy supply shortage by setting the goal of putting 10,000 GWh >



-> CITY LIGHTS OF CAPE TOWN, SOUTH AFRICA

> of renewable energy into its grid by 2013 – much of it coming from solar water heating.

Financial donors are emerging, and more governments are voicing commitments to wind, solar and other sustainable technologies.

In addition, financial donors are emerging, more governments are voicing commitments to wind, solar and other sustainable technologies, some new ventures are being launched, and climate change is motivating countries like Morocco and South Africa to explore carbon credits. Most renewables activity is small-scale – as with photovoltaic solutions that furnish off-grid electricity in places like Mali (where Africa's largest PV power plant, at 50 MW, will come online this year) and Senegal. And showing how renewables can replace carbon-fueled power will require the kind of bigger projects that are happening in just a few countries, such as Egypt and Morocco.

GAS ENGINES: THE OPPORTUNITY AND THE CHALLENGE. In response to Africa's energy dilemma, some South African companies are installing advanced natural gas- and steel gas-fueled Jenbacher gas engines to provide dependable onsite power. Two of those businesses, the Thos Begbie & Company copper foundry and the ABSA Bank Tower West office building, each have four Jenbacher J620 natural gas-fired engines to generate power, while MTN Group, a multinational telecom, has two Jenbacher J320 gas-powered generating sets working at its self-sustaining trigeneration plant.

South African companies are installing advanced natural gas- and steel gas-fueled Jenbacher gas engines to provide dependable onsite power.

Jay Wileman, sub-Saharan Africa region executive for GE Energy, sees this kind of collaboration dynamic as a template for securing South Africa's energy future. "More and more South African companies are looking to GE to supply them with alternative energy solutions," he says. "By expanding the use of cleaner, distributed-energy technologies to enhance local energy reliability, we're helping South Africa make great strides in addressing its ongoing energy supply issues."

"By expanding the use of cleaner, distributed-energy technologies to enhance local energy reliability, we're helping South Africa make great strides in addressing its ongoing energy supply issues."

- Jay Wileman, sub-Saharan Africa region executive for GE Energy

Moreover, the growing diversification of the African energy sector – beyond big power generation plants and hydropower – has created a space for smaller gas-fired power plants in such countries as Tanzania, Mozambique, Angola and Nigeria. Conditions in Africa also are ripe for alternatives such as waste gas-, waste heat-, biogas- and landfill gas-to-power. Even so, demographics pose a formidable challenge to the gas engines business. Industries that are the focus of much new economic activity in Africa tend to grow up around mineral discoveries in isolated areas where there is little or no grid coverage or basic energy infrastructure. Companies working in this sector are prime candidates for advanced GE technologies such as waste gas-to-power and smaller-scale Organic Rankine Cycle (ORC).

-> THE BUSY STREETS OF LUSAKA`S CITY MARKET, ZAMBIA

A MAJOR PRESENCE. Given its expertise, its 112-year history in Africa and its network of key facilities in South Africa, Angola and Nigeria, GE Energy is well positioned to help this continent meet its energy challenges. _

GE Energy in Africa	
Nations where we operate	Algeria, Angola, Congo, Egypt, Ghana, Kenya, Nigeria, Senegal, South Africa, Tanzania
Total population	>1 billion (as of 2010)
Annual per capita electricity consumption (Sub-Saharan Africa)	124 kWh
GE Energy employees	>800
Total Jenbacher/Waukesha capacity	392 MW

The future energy for Tanzania:

Natural gas

"Freedom and Unity" is the motto of the East African state of Tanzania. In a figurative sense, this motto also applies to efforts to achieve the urgently needed expansion of the country's energy supplies. There is general consensus that the best way to achieve independence from the unreliable and expensive national grid and to meet the growing demand for electricity is to use the country's rich natural gas resources in combination with advanced gas engine technology.

RETAINING COLORFUL DIVERSITY. Jamhuri ya Muungano wa Tanzania – the name of the United Republic of Tanzania in Swahili – dates back to the year 1964, when the newly independent states of Tanganyika and Zanzibar were united. Tanzania is a land of colorful diversity; the country's 43 million inhabitants belong to 130 different ethnic groups and speak almost the same number of different languages. However, one question concerns them all: How can the country find urgently needed, new, low-cost, and reliable sources of energy to meet the growing demand for electricity?

WATER AND DIESEL ARE NOT THE SOLUTION... At present, electricity is generated in Tanzania mainly by water power.

> Natural gas can be efficiently converted into energy using advanced gas engine technology – especially the combined production of electricity and warmth in combined heat and power plants.

However, apart from its very limited capacity, water has the major disadvantage of producing large fluctuations in energy output. Diesel engines also generate a small quantity of electricity, but they are very expensive to run, and industry can't afford expensive public power supplies. An 18.5 percent increase in the price of electricity in January 2011, followed by a 40.3 percent tariff hike at the beginning of 2012, has given the country's growing industrial base another reason to take a keen interest in alternative energy solutions.

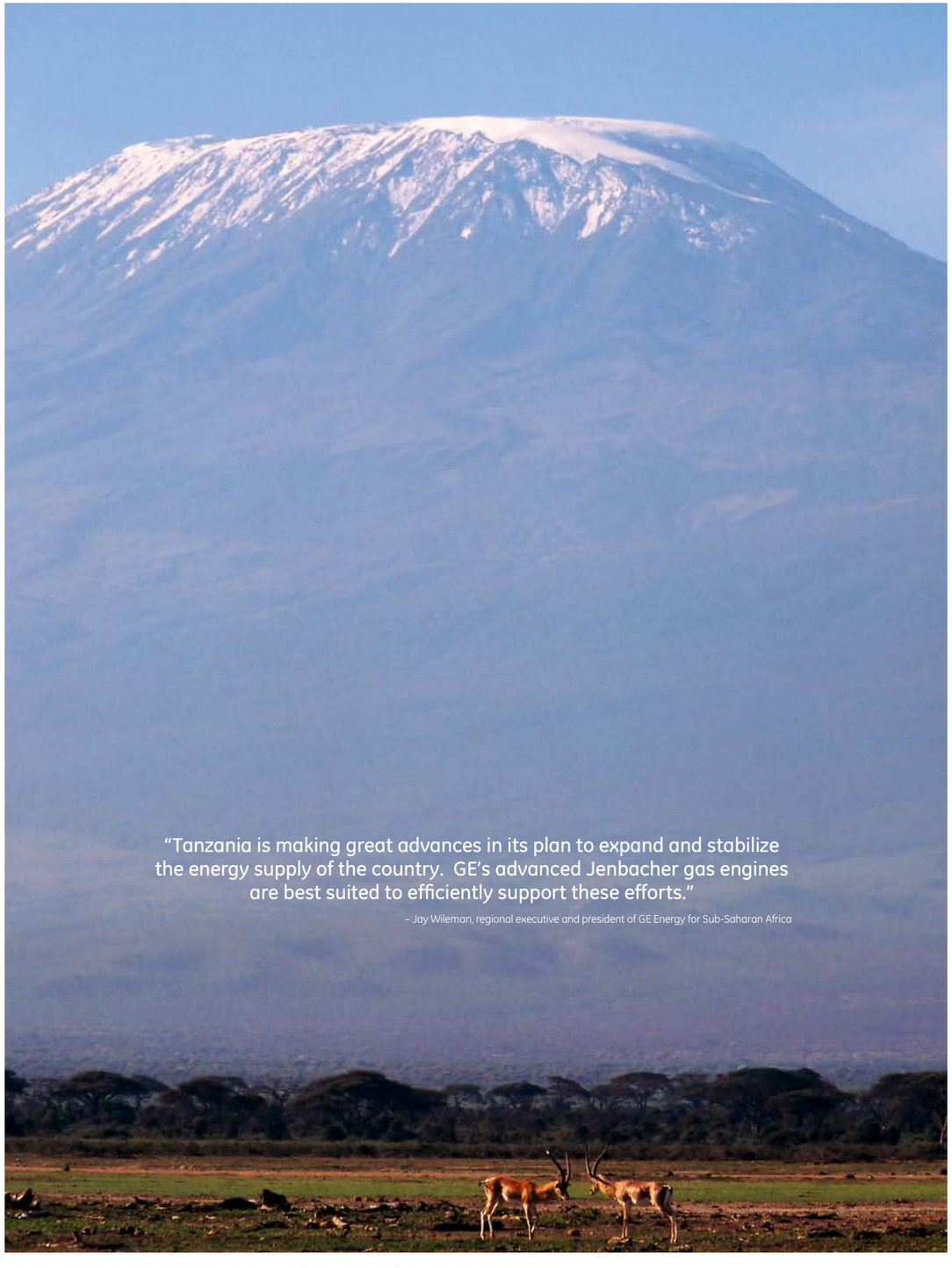
...BUT DECENTRALIZED ENERGY SUPPLIES FROM NATURAL GAS ARE! Although Tanzania has an inadequate energy supply infrastructure, it has rich reserves of natural gas, estimated at 6.5 billion cubic feet (184 million cubic meters). Natural gas can be efficiently converted into energy using advanced gas engine technology – especially the combined production of electricity and warmth in combined heat and power plants. And, this can be done locally, where the demand arises, eliminating the need for additional investment in grid infrastructure.

HERE IS THE PLAN... Tanzania currently generates about 1,003 MW of electricity, of which 342 MW are produced by natural gas. However, peak demand is around 1,219 MW, a figure that is expected to grow by 6.7 percent annually. In order to get its energy problems under control, the Tanzanian government drew up a Power System Master Plan (PSMP) in 2009. This plan calls for about 56 percent of energy requirements to be met using natural gas by the year 2025. With a total demand of 3,800 MW forecast for the year 2025, this would mean 2,128 MW of electricity from natural gas. This ambitious plan even foresees the export of future electricity surpluses to neighboring countries, and the relevant infrastructure measures are already being taken to implement the plan.
Because Tanzania should be able to generate an additional 1,003 MW as soon as 2019 by using natural gas, the gas engines industry will provide an important opportunity to help the country implement economical and ecological energy plans. _

facts and figures:

Tanzania

Natural gas reserves:	approx. 6.5 billion cubic feet (184 million cubic meters).
Population:	approx. 43 million
Households:	approx. 7 million



-> GAZELLES GRAZING IN FRONT OF THE 19,340-FOOT-HIGH (5,895-METER-HIGH) KILIMANJARO IN TANZANIA

Providing top plant availability in Africa

Proactive spare parts management

For more than two years now, the Johannesburg service office of GE's Gas Engines business has been working with customers in South Africa and Tanzania, and in the near future Mozambique will be added to the list. Creating a service office in Johannesburg was an important step toward anticipating our customers' growing requirements for rapid and individual maintenance services. The office offers customers first-rate spare parts service to ensure maximum plant availability coupled with short reaction times.

Customers in the region welcomed the establishment of a service office in Johannesburg and saw it as a clear sign of GE's long-term commitment to South Africa, Mozambique and Tanzania. In the past, Agaricus Trading acted as GE's authorized sales and service provider for our local Jenbacher customers. With the establishment of our own service organization, GE assumed responsibility for the service business for Agaricus Trading's 15 installed Jenbacher gas engines, although the company continues as a sales provider in the region.
Today, the Jenbacher team services 37 plants with a total electrical output of more than 65 MW. The factors behind this rapid growth have been the high flexibility, reliability and efficiency of Jenbacher gas engines along with the company's intelligent maintenance services.

INTELLIGENT SERVICE. Nine out of 10 plants installed in South Africa, Tanzania and Mozambique have long-term service agreements, also referred to as Contractual Service Agreements (CSA). This all-inclusive care-free package gives Jenbacher customers maximum service quality, enabling them to focus entirely on their own core business. One element of every long-term service agreement is world-wide remote access, which transfers all essential engine data to the service office or the engineer's PC in "real time." In combination with the 24/7 service hotline, 50 percent of all plant defaults can be remedied remotely – without an engineer onsite. In addition, orders for original spare parts for scheduled service work can be placed proactively, and the parts required can be quickly dispatched to the customer from the central warehouse in Johannesburg. Many of the plants installed in South Africa alone are more than 1,000 km from the service office. In view of these large distances, proactive spare parts management is an essential precondition in minimizing downtime during maintenance.

Due to the fluctuating public power supply, plant availability is the top priority for customers in South Africa, Tanzania and Mozambique. A dependable original spare parts service is an essential precondition.

SUCCESS WITH MAINTENANCE CONTRACTS. The example of the Tanzanian Cigarette Company, a manufacturer of quality cigarettes based in Dar es Salaam, Tanzania, illustrates the impact that a Jenbacher gas engine with a long-term maintenance contract can have on the profitability of a company. Installed in 2009, a Jenbacher J612 gas engine with an output of 1.6 MW supplies all of the company's office buildings and production lines with energy. Switching to a distributed power supply has enabled the company to become completely independent of the fluctuations in the public grid network.

-> DISTRIBUTED POWER PLANT AT ...

-> ... TANZANIAN CIGARETTE COMPANY

"The proactive planning of maintenance work is a decisive factor behind the economic success of our plant."

- Bony Ralf Scheerschmidt, manufacturing director of Tanzanian Cigarette Company

Bony Ralf Scheerschmidt, manufacturing director of Tanzanian Cigarette Company, regards GE's intelligent service as an important factor in the success of his plant: "Since we commissioned our Jenbacher gas engine, we have been able to increase the productivity of our company significantly. Worldwide access to the plant in combination with the 24/7 hotline and proactive planning of maintenance work have also played a decisive role." The fluctuating public power supply, plant availability and reliable original spare parts service are top priorities for businesses in South Africa, Tanzania and Mozambique. Proactive maintenance planning, global remote monitoring and sound customer relations are essential for providing optimal service to customers in this growth region. _

facts and figures:

Jenbacher gas engines in South Africa

- Established: 2009
- Installed plants: 37
- Total electrical output: > 65 MW
- Plants with remote access: > 90 percent

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Jenbacher gas engines wins Global Star Award

Environmental protection, health, and safety in the workplace play key roles in the working lives of GE employees. To ensure that quality standards are maintained in those areas, GE has set up a worldwide certification program whose supreme accolade is the Global Star Award. In 2011 the production center of GE's Gas Engines business in Jenbach, Austria, won this distinction for the first time.

For many customers, it is a given that their business partners engage in sustainable business activities and 100 percent compliance with labor regulations. To consistently operate in that manner on a global level, GE has developed a certification program in the areas of environmental protection, health, and industrial safety. This group-wide EHS certification (Environment, Health, and Safety) meets and exceeds the basic requirements of the international ISO 14001 environment management standard and the OHSAS 18001 health and safety program developed by the American Occupational Health & Safety Group. In drawing up its EHS criteria, GE took the world's most stringent regulation as its starting point in all three areas. Achieving the highest certification level – the Global Star Award – ensures that the sites receiving that honor comply with, and frequently far surpass, national legal requirements.

LONG-TERM PROJECT FOCUS. The EHS certifications that have been carried out at the production center in Jenbach are more than just a snapshot of a situation. "The EHS team in Jenbach was founded over eight years ago. Over the last two years we have worked very intensively on our Global Star certification," recalls Martin Fiedler, global supply chain leader for Jenbacher gas engines. "During this time we were able to steadily improve our processes. Then in 2011 we were finally able to harvest the fruits of our labors." The Jenbacher production center has 21 EHS programs with a variety of themes that are continually subject to evaluation by external auditors. They include programs for the timely detection of safety hazards in the workplace and a comprehensive health service in the company. There even are programs stipulating conditions for suppliers and contracting parties. The international ISO 14001 environment management standard and the OHSAS 18001 health and safety program developed by the American Occupational Health & Safety Group were taken as a starting point.

INCENTIVE FOR THE FUTURE. For the production center of GE's Gas Engines business, the Global Star Award is more than just evidence of successful process implementation. It demonstrates the attitude that our employees actively display every day in the workplace, and it is the result of an extended and continuous development process within the company. However, the Global Star Award is by no means the end of these efforts. "For the future, our aim is to maintain our standards at a high level, and even to exceed them on occasion. To this end, we hold regular follow-up activities at the factory, and in five years' time we shall have complete recertification," explains Fiedler.
As long as people maintain that dedication, the Jenbacher production center will be a model of EHS quality. Incidentally, the Global Star Program in Jenbach even has a mascot: Roger the Eagle. A larger-than-life replica of Roger now stands on the wall at the entrance to welcome visitors and customers to the Jenbacher production center. _

cogen2.0

P.S. You can see how EHS has improved industrial safety in Jenbach in cogen 2.0. Simply go to www.ge-energy.com/cogen20en/ and point your webcam at this double-page spread.

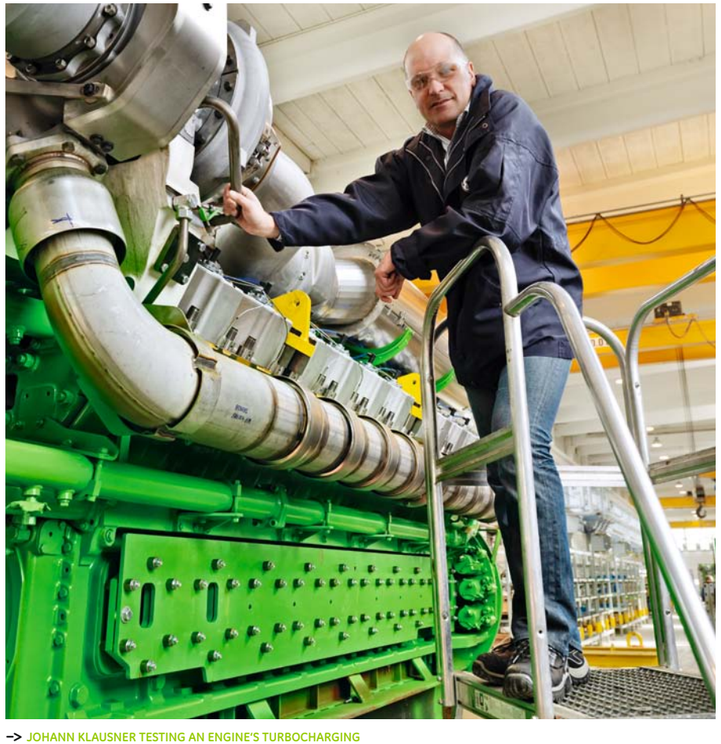
WHO IS ROGER, THE BLUE EAGLE?
The mascot for the Global Star Program in Jenbach needed to be closely associated with the province of Tyrol, and since the eagle is a central element of the Tyrolean coat of arms, Roger the Eagle was born.

"The Global Star Award will further enhance our competitiveness."
– Martin Fiedler, global supply chain leader for Jenbacher gas engines

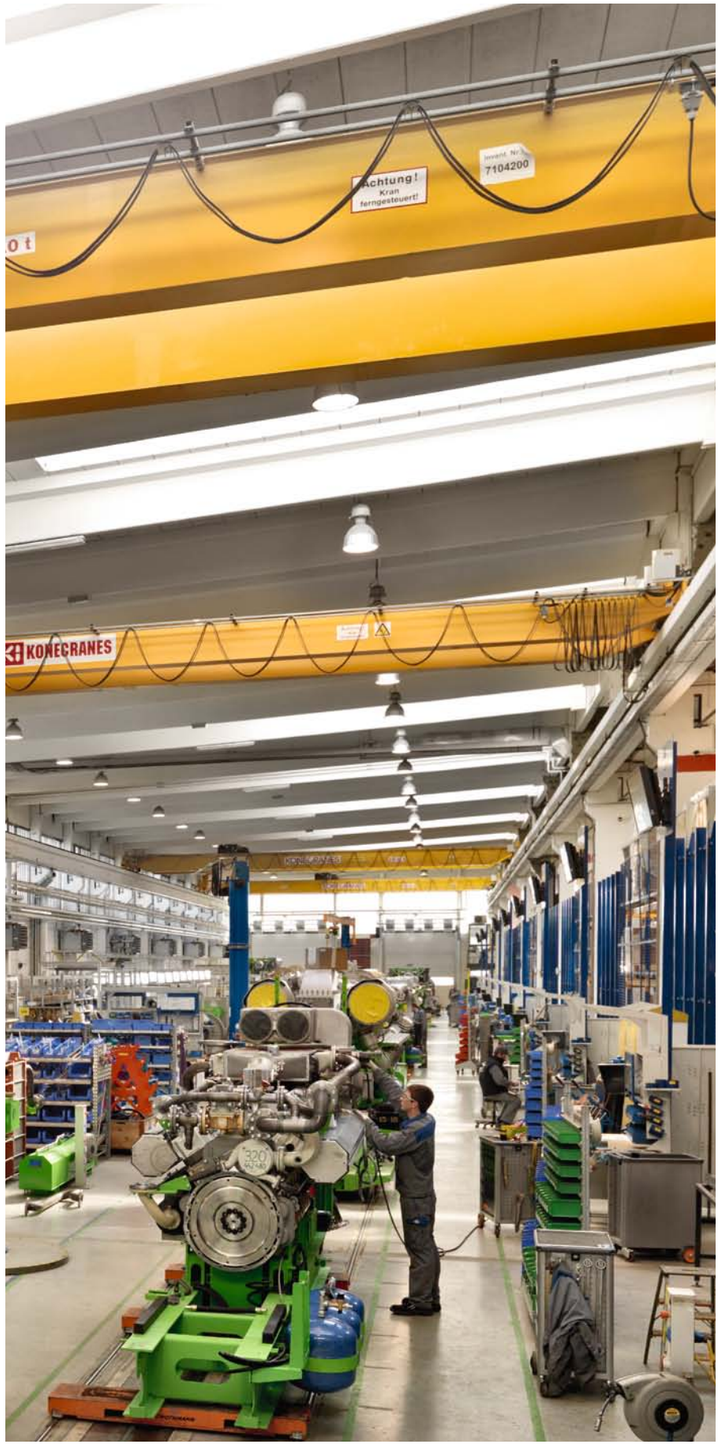
Passing the test!

The appeal of his job is knowing that, day in and day out, he plays a hand in shaping gas engines technology leadership. The most important thing for him is that every new development should have a clear benefit for our customers. In fact, he regularly visits their plants to gain an insight into their needs and wishes. He also stays in close touch with suppliers to ensure they are providing their best. His name is Johann Klausner, senior engineer/technologist for Jenbacher gas engines, and he cannot imagine a more exciting job.

ONLY THE BEST STAND THE TEST OF TIME...
Two different types of test benches are available at the factory in Jenbach, Austria. There are the test benches on which all series products undergo trial operation prior to delivery to the customer. And there are the development test benches, which are deployed long before that. A Jenbacher gas engine is subjected to a tedious process before it is ready for series production – though sometimes this process is amazingly fast. The whole process begins with calculations and simulations using the latest simulation software. As soon as the desired results are obtained, a prototype is built that then must withstand testing on the development test bench. The requirements made here are the most exacting demands that could be made on the engine. They involve rigorous testing, both in continuous operation and under overload conditions. After all, the goal is to provide another new, reliable gas engine with top ratings for overall efficiency. GE is aware of its role as technology leader and knows exactly what the customer expects of the newly introduced engine: a mature product that – if possible – exceeds all previous top specifications. This is no simple task, but for all that it is an exciting challenge and an obligation for the development team.



-> JOHANN KLAUSNER TESTING AN ENGINE'S TURBOCHARGING



THE MAN BEHIND THE MACHINE. For 13 years now, Johann Klausner has been helping to improve the reliability and longevity of Jenbacher gas engines. As the engineer responsible for the engines' turbocharging, gas exchange and thermal management, he is quick to enthuse when asked about his job in Jenbach.

"Thanks to my close contact with customers and suppliers, I always get direct feedback on our daily work that I can implement immediately – an exciting cycle of continual improvement!"
- Johann Klausner, senior engineer/technologist for Jenbacher gas engines

"We are continually writing the history of technology with the development of our new products and the optimization of our existing portfolio. Besides, thanks to my close contact with customers and suppliers, I always get direct feedback on our daily work that I can implement immediately – an exciting cycle of continual improvement!" enthuses Klausner.
Thanks to his many years of experience, he also knows the limits of Jenbacher gas engines. At the same time, however, he has often played an active role in extending these limits. He describes increasing the efficiency of these engines as working at the cutting edge, a task that requires not only technological expertise, but also extreme vigilance.

Increasing the efficiency of gas engines is working at the cutting edge, a task that requires not only technological expertise, but also extreme vigilance.

ON THE ROAD... TO EXCELLENCE. The path to the ideal engine takes Klausner not only to a wide variety of test facilities on the test bench, but also to suppliers who must comply with the high standards of Jenbacher gas engines in their own products. And it also takes him to the pilot customers for whom he is responsible, most of them operating in Europe. This close contact with both customers and suppliers is an important prerequisite for being able to contribute to GE's technology leadership every day, and for the flexibility, reliability and high efficiency that make a Jenbacher gas engine stand out. _

Brian White, president
of GE's Waukesha gas engines division

The mission: to become the global leader in advanced gas engines technologies

Now that the Waukesha compression portfolio is well integrated into GE's Gas Engines business, Brian White, the Waukesha business leader, is focused on driving innovation, customer service and team development. His aim: for the Waukesha segment to become a major contributor globally as part of GE's advanced gas engines technology leadership. Given his athletic endeavors – which include rappelling down a 165-foot (50-meter) waterfall – Brian has the vigor to handle that challenge, which he discussed with cogen.

cogen: ***What's the most exciting part about your job?***
Brian White: Building a team and working with people. I'm a people person and like seeing people grow and develop. Externally, I like interacting with customers. It's a great way to keep a pulse on what's happening in the segment and on the front lines of the industry.
It's also great to hear their direct feedback on what we're doing well and where we need to improve. You can learn so much by simply listening to customers and understanding their challenges.

The mission for GE Energy's Gas Engines business is to become the global leader in customer value for advanced gas engines technologies. What does that mean to you?
To become the global leader, Waukesha gas engines must be recognized as providing an advanced technology suited to meet customer challenges everywhere, not just the ones in North America. And, we must be the first technology and engine that the customer thinks of when looking for solutions in gas compression. In short, we must be the leader – not a close-behind follower – in the advanced gas technologies we offer.

In your role with GE and Waukesha gas engines, what is your most important objective? Building the gas engine technology to solve our environmental challenges in the future is the top priority. To do this, we must use all of the great resources at GE as well as the legacy of innovation and expertise that has made Waukesha gas engines an industry leader for over 100 years. That's how we can take our game to the next level.

> "Building the gas engine technology to solve our environmental challenges in the future is the top priority."

What do you see as a big opportunity for GE's Waukesha gas engines division?
We can greatly enhance our customer value through our service business. One of our biggest service opportunities is in remote monitoring, which yields a 50 percent return-to-service rate, according to our experience data. Once a product goes out the door, it's important to monitor performance in a way that benefits our customers. That means having the ability to pull data from engines and turn it into knowledge that adds value to the customers by improving their productivity, uptime, and reliability; optimizing engine performance; and ultimately increasing their profitability. Remote monitoring will enable us to solve customer problems very quickly, even in remote locations.

GE recently introduced new messaging called GE Works, which highlights how GE powers, builds, cures and moves the world. How does GE's Gas Engines business play into that?
1.3 billion people in the world live without electricity, a basic resource that's so vital to economic development and personal well-being. Our Gas Engines product lines – which include power generation, gas compression and heat recovery – provide reliable, efficient and flexible power solutions to improve peoples' lives anywhere in the world.

What trends do you see in the energy sector over the next couple of years?
I believe that because it's a greener-energy option, natural gas is going to experience substantial growth and play a much bigger role in gas compression and power generation, whether it's distributed power or replacing coal-fired power plants. _

Thank you for talking to us.

profile:

Age: 52 years
Education: B.S. in electrical and electronics engineering from Northumbria University, Newcastle, United Kingdom
Married to Sandra, two sons – Andrew (22) and Chris (26)
Leisure activities: water and snow skiing, snowshoeing, soccer, fishing, and walking.

The most daring thing he ever did was rappelling 165-feet (50-meter) down a waterfall in Costa Rica. "The most daring thing I want to do is skydive from an airplane, which I almost did. My sons bought me a skydiving adventure for my 40th birthday, but I never went. The company I was going to jump with had two people die in the span of six weeks because their parachutes didn't open."

If he couldn't be what he is now at GE, Brian would be a high school soccer coach "because I like building, developing and leading teams. I get a lot of enjoyment out of teaching and leading both in my personal life and professionally. Starting with a group of people who have never played together before and uniting them to work together and be successful is an absolute rush."

Previous position: Corporate vice president of reengineering for the former Dresser business.

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Please take a few minutes to respond to the questions above and the bullet points below and send your suggestions to us by fax at +43 5244 600-527 or by email to **gasengines.cogen@ge.com.**

Happy reading, and good luck in the drawing!

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