Design Begins Here

POWER SOURCING GUIDE

2023-2024

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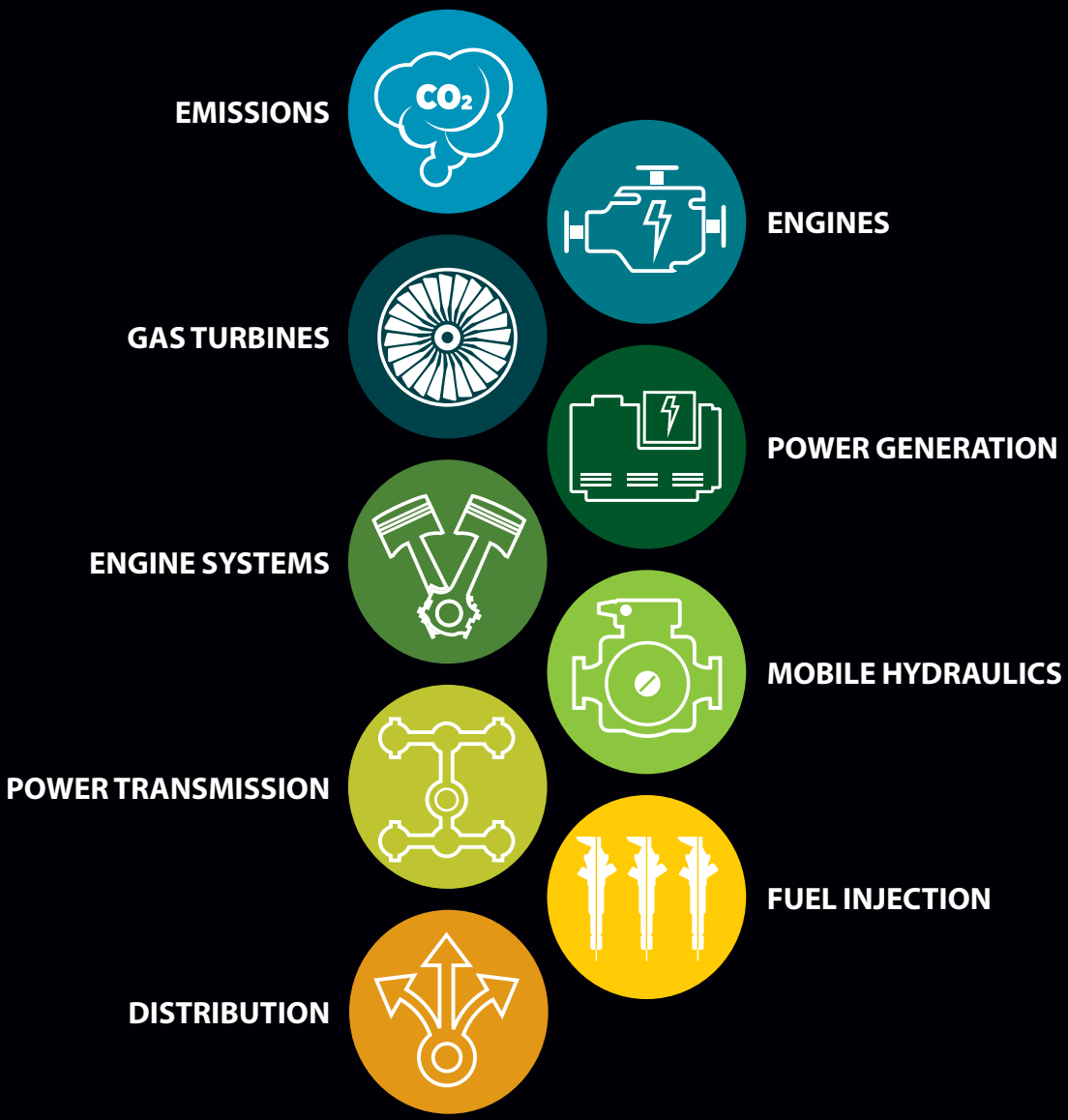


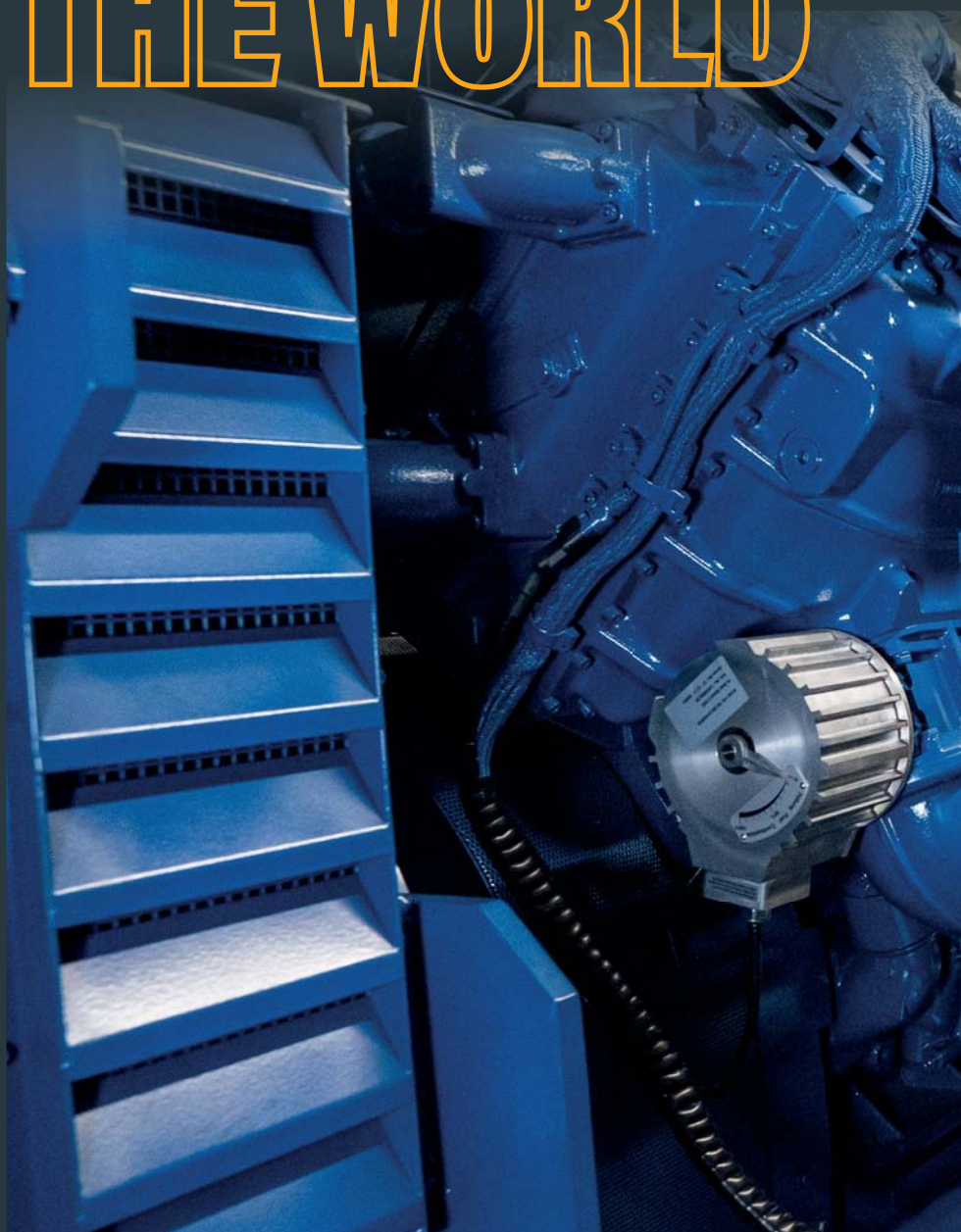
THE GUIDE FOR DESIGN ENGINEERS

DIESEL PROGRESS | DIESEL PROGRESS INTERNATIONAL | Diesel & Gas Turbine WORLDWIDE

khl

2023 POWER PLANTS OF THE WORLD

Each year, **Diesel & Gas Turbine Worldwide** invites prime-mover original equipment manufacturers to submit one specific power generation project it feels merits special attention because of advances in one or more of the following areas: efficiency increase, environmental aesthetics, operation characteristics, emissions improvements or construction principles.



GERMANY MWM

Forward-looking energy project in the Osnabrück region

A new combined heat and power plant with two MWM gas gensets has been producing electricity and heat for the residents of Alfhausen since late 2022. The heat is supplied to the connected households via a specially laid district heating network.

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Since mid-November 2022, a new combined heat and power plant with two MWM gas gensets has been producing electricity and heat for the residents of Alfhausen. The heat is supplied to the connected households via a specially laid district heating network.

Two containers, just under 20 m long and weighing around 40 tons, in a hall in the new Am Waller Esch industrial estate in Alfhausen in the Osnabrück region, do not look spectacular at first glance. And yet, behind this plant lies a forward-looking heat supply concept for rural areas. Each of the two container CHP units with MWM gas gensets has an output of 2300 kW. They form the heart of the new district heating network in Alfhausen, which the local company Rasche & Weßler is building in the town of 4,000 inhabitants. It is powered by biomethane: a renewable energy source that is in demand as never before in times of skyrocketing energy costs.

The heat generated by the two MWM TCG 3020 V20 gas gensets is supplied to households via a district heating network. In addition to the new combined heat

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and power plant with the two large gas gensets, a hot water storage tank with a volume of almost 2,500 m^3 was also built. The waste heat from the engines heats the water, which is supplied to the individual households via a district heating pipeline.

In the event of sudden cold snaps or a CHP failure, the storage unit also serves as a buffer that can continue to supply the site with heat for up to four days in winter and up to 14 days in summer. An additional gas burner also serves as a backup for emergencies. The community's new industrial park was deliberately chosen as the site for the Alfhausen CHP plant, as it is located directly opposite the local substation. This made it easy to connect to the power grid, the electricity generated in the CHP unit can be fed into the public power grid over a short distance and also has no conversion losses due to the 10kV medium-voltage generator.

Rasche & Weßler is building the 19-km district heating network itself. The

SAUDI ARABIA ROLLS-ROYCE

Dynamic UPS system has power output in total

Rolls-Royce has successfully commissioned 12 mtu Kinetic PowerPacks to secure one of the world's largest supercomputers located at King Abdullah University for Science and Technology (KAUST) in Saudi Arabia. The fully customized, turnkey secure power system is equipped with dynamically rotating kinetic energy accumulators, providing the university's Scientific Computing Data Center, which hosts the supercomputer with uninterruptible power. The fully customized, turnkey secure power system is equipped with dynamically rotating kinetic energy accumulators, providing the university's Scientific Computing Data Center, which hosts the supercomputer with uninterruptible power. The Dynamic UPS system has more than 19 MW power output in total.

"The mtu Kinetic PowerPacks are state-of-the-art, uninterruptible electrical power systems that are designed for operating in extreme environments and provide the highest reliability of back-up power for the most critical and essential systems, such as healthcare facilities, airports, data centers and in our case, our future supercomputer Shaheen III, which will be the most powerful supercomputer in the Middle East and allow KAUST to greatly enhance its ability for scientific discovery and AI Innovation," said Matthew Early, Vice President, Facilities for KAUST.

"The work completed on this complex design-and-build order for KAUST has been extremely rewarding," said Karim Hamzaoui, Operations Manager at the Rolls-Royce business unit Power Systems. "This was an opportunity for us to not only provide our world-class power generation products but also to showcase our ability to be a complete solution provider, taking on the full scope of all aspects of the project, from manufacturing and testing to delivery and installation, creating a customized solution from top to bottom."

The mtu Kinetic PowerPacks were manufactured and underwent successful factory acceptance testing in Liege, Belgium at the Rolls-Royce facility. The 12 units, along with medium-voltage switchgears, were then shipped for installation at the site. The team from Rolls-Royce managed the complete local scope including construction and electrical infrastructure to ensure the site would be ready on time.

expansion began in March 2021 and is scheduled for completion by the end of 2023. "The interest, especially from private individuals, in our supply concept, was great from the start," said Ralf Wessler, a parter in the project. But in recent months, he says, demand for connections to the district heating network has risen significantly.

Wessler and his partner Andreas Rasche have taken a unique approach to plan and building the district heating network throughout the town: they have brought Glasfaser Nordwest, a subsidiary of Telekom and EWE, on board as a partner. This means that not only will district heating connections be laid directly to customers' homes during the construction work but the town will also be equipped with fiber optic house connections in parallel. This partnership makes the expansion more economical for everyone involved – and the same construction work is avoided. The result is a modern, climate-friendly infrastructure in Alfhausen.

The network within the town center was 65% complete in December 2022. For the final expansion, approximately 10 million kWh per year will be distributed to the respective network connections. Planning has already begun for the network installation outside the town center. In December 2022, 175 network subscribers had a house connection to the district heating network, 45 of which are already receiving heat, and additional consumers are joining daily. Currently, an average of 750 kWh of heat is being extracted. The second main line also went into operation in mid-December 2022 and an average of around 1200 kWh of heat in winter conditions, Rasche said. ■

more than 19 MW

DESIGNED FOR TEMPERATURE EXTREMES

Each mtu Kinetic PowerPack has a power output of 1.6 MW, operates in medium voltage at 13.8kV, 60Hz and is powered by an mtu 16V 4000 G74S diesel engine. The systems are designed for humid ambient conditions and temperatures of up to 50 degrees Celsius. With 12 total units delivered to KAUST, the Kinetic PowerPacks were installed in two groups of 6 systems each, with one available as a back-up in each group (5 + 1 redundancy). In the event of a power outage, the constantly rotating, robust kinetic energy accumulator will both guarantee the starting of the diesel engine and instantaneously secure the critical load.

Rolls-Royce has successfully commissioned 12 mtu Kinetic PowerPacks to secure one of the world's largest supercomputers located at King Abdullah University for Science and Technology (KAUST) in Saudi Arabia.

IMAGE: ROLLS-ROYCE

"The mtu Kinetic PowerPacks securing our 16 MW Scientific Computing Data Center are not only highly efficient and robust, but also limit the Center's carbon footprint by replacing the existing uninterruptible power supply system that is based on batteries," said Mani John, Data Centers & Critical Facilities Manager, KAUST. "We are pleased to have a new solution that delivers reliable, uninterrupted power that also aligns with our sustainability goals."

"The addition of the Kinetic PowerPacks enhances the capability of the KAUST utilities system by achieving power conditioning in addition to delivering reliable power to critical computing loads," added Hesham A. Alsulaimani, Director, Utilities Services for KAUST.

KAUST is a renowned high-tech seat of learning, equipped with state-of-the-art facilities and one of the world's best supercomputing installations that is also the largest of its kind in the Middle East. The Shaheen supercomputer at KAUST Supercomputing Laboratory (KSL) is available to help KAUST users and projects, to provide training and advice, to develop and deploy applications, to provide consultation on best practices and to provide collaboration support as needed. ■ >

JAPAN JENBACHER

Jenbacher engines at the heart of Japanese-led wood power plants

A wood power plant in Shingu City serves as the first carbon-negative power plant in the APAC region, operating with SynCraft's reverse power plant technology. The combination of Syncraft's climate-positive system and INNIO's innovative Jenbacher engine technology is expected to continuously feed Japan's grid with renewable power for approximately the next 20 years.

TAPPING INTO TARIFF POWER

Japan committed to achieve carbon neutrality by 2050, reduce greenhouse gas emissions (GHG) by 46% in 2030 from its 2013 levels, and decrease dependency on nuclear power. As part of these efforts both to decarbonize and reduce the country's reliance on nuclear energy, the government of Japan established Feed-In Tariffs (FIT) to provide renewable energy projects in order to accelerate the adoption of renewable energy. Under the FIT initiative, Japanese utilities can buy electricity from renewable sources, such as, biomass, at pre-set premiums. Japan's FIT policy has stimulated the growth of two energy segments: Wood gas and biogas.

To empower the governmental plans, Shingu Forest Energy LLC – an entity of Forest Energy Corporation – moved forward with plans to construct the first biomass power generation project to operate in Shingu City, Wakayama Prefecture, Japan. The Japanese-led team turned to INNIO's Jenbacher J412 engines.

The use of biomass for decentralized power and heat generation is an increasingly important aspect of the energy transition and associated decarbonization. In contrast to wind and sun, regrowing raw materials such as wood are constantly available and can be used in the form of wood gas to generate power and heat in SynCraft's reverse power plant using Jenbacher engines. Wood gas has a hydrogen content (energy based) of over 40%. These plants achieve a fuel utilization rate of up to 92%, as well as offer another valuable advantage: in contrast to conventional plants, this new and innovative system produces biochar, rather than ash.

The overall system is capable of releasing only part of the CO_2 that originally is stored through the forest. Some of it remains as useful green carbon, thus making SynCraft's system climate-positive.

POWERING CARBON-NEGATIVE PLANTS WITH WOOD GAS

Commissioned in December 2021, the Jenbacher engines have been tailored to meet the needs of wood gas, marking the world's first 60 Hertz carbon-negative power plant delivering more than 1.7 megawatts of power. This reverse power plant uses the waste heat of four Jenbacher J412 engines as well as the heat emerging from the gasification process for a total of about 3.8 MW thermal for district heating and fuel drying. The combined heat and power configuration allows the Shingu City wood power plant to achieve an overall fuel efficiency of about 85%. Additionally, every operating hour yields around 200 kilograms of valuable biochar, which can be used for barbecues, animal feed supplementation or soil fertilization.

The use of biomass for decentralized power and heat generation is an increasingly important aspect of the energy transition and fully supports Japan's goals to decarbonize its power sector. The wood power plants, operating with Jenbacher engines, provide green and secure power because of the constant availability of wood. Additionally, the Jenbacher technology delivers a balancing power source to the grid to support the frequency stability due to the increasing higher share of intermittent renewables sources like photovoltaic. These plants are optimized with a wood gas fuel application, providing an alternative solution for decentralized power generation that is a renewable 'green energy'. The reverse power plant provides high power generation efficiency, using bark and branches as fuel well as the chipped stemwood.

The combined heat and power configuration is expected to use about 20,000 tons of unutilized wood resources annually from the Wakayama region. The material is chipped and used as fuel in the reverse power plant with the heat used to dry the woodchips. The heat from the plant makes it possible to keep drying cost low and use freshly cut wood as fuel. Additional uses for the residual heat are under exploration.

INNIO and SynCraft, an Austria-based industry leader in wood power plants, have not only delivered and commissioned this project in Japan but also in six European countries. Not only do these highly innovative power plants align with nature, but they have a real climate-positive effect as well.

IMAGE: SHINGU FOREST ENERGY LLC

A wood power plant in Shingu City serves as the first carbon-negative power plant in the APAC region, operating with SynCraft's reverse power plant technology. The combination of Syncraft's climate-positive system and INNIO's innovative Jenbacher engine technology is expected to continuously feed Japan's grid with renewable power for approximately the next 20 years.

TAIWAN SIEMENS ENERGY

Sun Ba II was designed as a multi-shaft combined cycle power plant in which two gas turbines and one steam turbine each drives its own electrical generator. Siemens Energy's scope of supply comprises the plant's power island consisting of two SGT6-9000HL gas turbines, one SST-5000 steam turbine, three SGen6-2000P generators, two heat-recovery steam generators, and the SPPA-T3000 control system.

Siemens Energy a key collaborator in Sun Ba II project

Taiwan's path to net-zero emissions by 2050 is based, among other things, on the energy transition and industrial transition strategies.

Taiwan's energy transition is rooted in promoting green energy, increasing natural gas, reducing coal-firing, and going nuclear-free – for a stable power supply with reduced carbon emissions.

In 2021, the strong global demand for semiconductors and components for the electronics industry has given Taiwan its strongest economic growth in more than a decade (GDP: 6.28%).

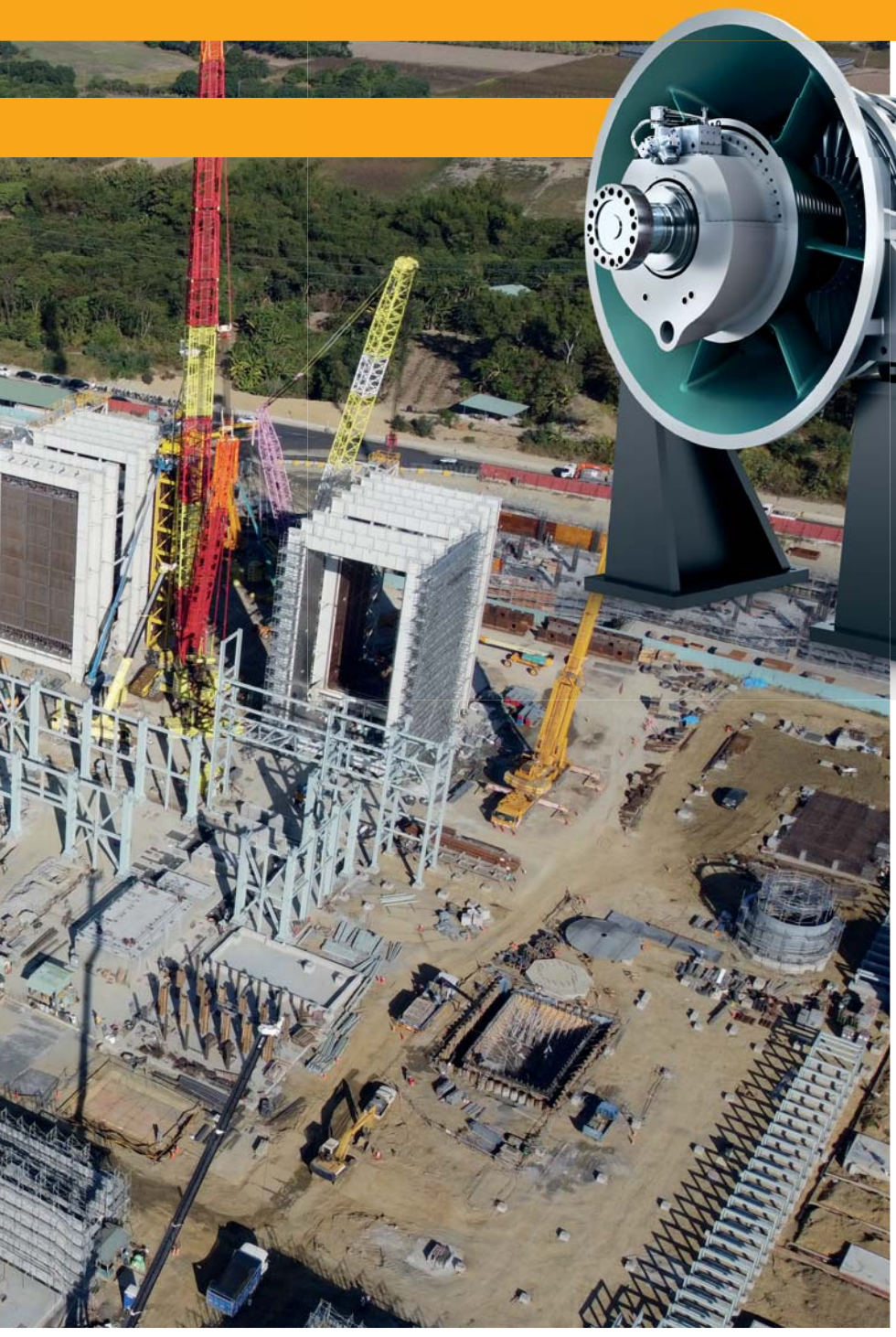
The Sun Ba II project will respond to the rising energy demand in record time to support Taiwan's economic growth and energy transition

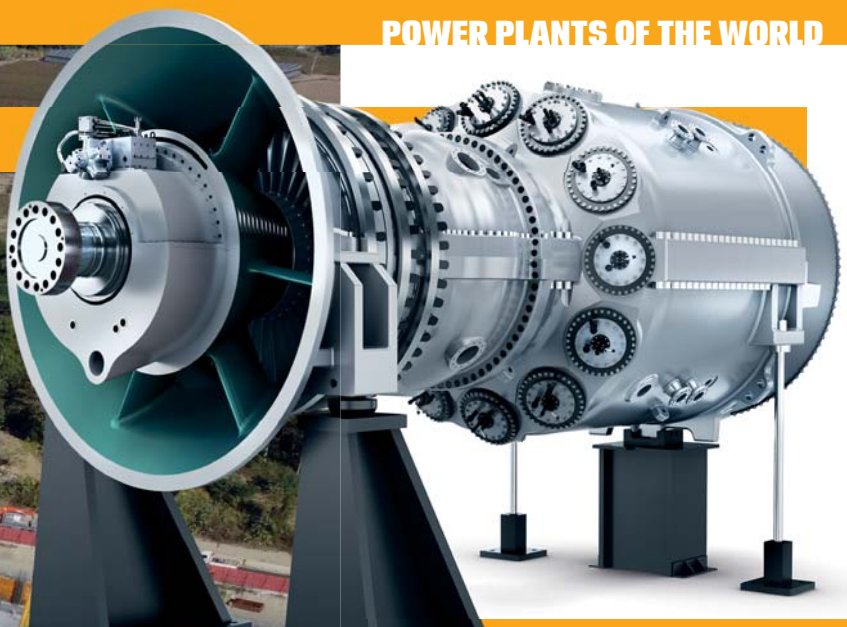
All parties involved are contributing with confidence (Siemens Energy, EPC partner CTCI Corp. and customer Sun Ba Power Corp.).

Siemens Energy collectively focused on the project goal: to produce a large amount of electricity at the lowest possible cost and at the same time drive a significant CO_2 reduction.

The project partners have conducted several CSR activities involving the community: for example, supporting local employment.

The company also worked together to resolve critical situations: for example,





The future-proof HL-class gas turbine used for Taiwan's Sun Ba II project is already capable of handling 50% hydrogen content, which will enable other operational scenarios in the future.

IMAGES: SIEMENS ENERGY

finding a solution when a key supplier experienced financial difficulties.

TAIWAN DESERVES BEST-IN-CLASS TECHNOLOGY

The plant features an optimal levelized cost of electricity (lifecycle cost) thanks to a 25-year service contract and best-in-class efficiency (to compensate for expensive LNG).

It also delivers outstanding daily start and stop cycling capability and the highest available power output.

Proof: The HL turbine offers world-class technology to Taiwan and was awarded by the Guinness World Records organization for its power output and ramp rate (100.56/min.) achieved at Duke Energy's Lincoln Combustion Turbine Station in the U.S.

The plant is also future-proof: The HL-class gas turbine is already capable of handling 50% hydrogen content today, which will enable other operational scenarios in the future.

OUTSTANDING JOINT PROJECT MANAGEMENT MASTERS ADVERSE GLOBAL MARKET CONDITIONS

The plant is on schedule to achieve COD by mid-2024, despite extremely difficult market conditions (including COVID and global supply chain issues).

Siemens Energy defied supply chain shortages: This means adjusting processes and schedules to manage the restrictions and accelerating the company's business with suppliers through targeted higher prioritization.

Siemens Energy managed logistical constraints: The forward-looking planning provided sufficient float, and the company were able to secure transportation capacities early on.

Siemens Energy mastered the energy crisis and inflation: The company ensured that the customer was the #1 priority, and so the project was finished on time in spite of adversity. The company never saw' global obstacles as an excuse but rather as an incentive to ensure that the project goals were met on schedule. ■ >

USA GE

A hydrogen pilot by GE

IMAGE: GE

GE's LM6000 aeroderivative gas turbine successfully operated on blends of up to 44% (by volume) green hydrogen in a pilot project at the New York Power Authority's Brentwood Power Station on Long Island. Tests revealed a clear reduction in CO_2 emissions with higher blends of hydrogen paving the way for a net zero carbon future and further development of green hydrogen at other sites, according to GE. The project also revealed substantial reductions in CO emissions, which could lead to additional benefits when operating on hydrogen blends, the company said.

New York has mandated, through its Climate Leadership and Community Protection Act (CLCPA), to generate 70% of the state's electricity from renewable sources by 2030 and 100% zero-emission electricity by 2040. This is expected to provide a strong incentive to explore alternatives to natural gas. While renewables, such as wind and solar, are likely to provide most of the electricity to the region, low-carbon fuels can play a significant role and be part of the solution, GE said.

The ability to retrofit GE turbines that power one-third of the world's electricity generation potentially paves the way to a decarbonization journey for the power generation industry. GE has more than 100 gas turbines globally that have or are running on between 5% and 100% hydrogen in 20 countries and one of these is installed at the New York Power Authority (NYPA)'s Brentwood Power Station. The plant, powered by a GE LM6000 aero-derivative gas turbine, was commissioned in 2001 to increase power generation capacity for Long Island and New York City in anticipation of shortages.

GE said that NYPA, the biggest public power utility in the US, has signaled the energy transition is underway in the state with its Brentwood Power Station on Long Island representing the vanguard of a green hydrogen future. In 2022, NYPA became one of the first utilities to burn green hydrogen in a retrofitted natural gas power plant in commercial operation. This required coordination between all parties involved in the project, the local grid authority, and other state agencies.

While most hydrogen is made via steam methane reforming – in which natural gas (CH_4) reacts with steam under pressure and heat to produce hydrogen (H_2), carbon monoxide (CO), and carbon monoxide (CO_2) – green hydrogen is made through electrolysis. In this process, an electric current splits water (H_2O) into its constituent elements to produce oxygen (O_2) and hydrogen (H_2). If the process uses renewable power, which by definition does not generate CO_2 emissions, this is known as green hydrogen.

DEMONSTRATION PROJECT

In the spring of 2022, NYPA conducted a green hydrogen fuel demonstration, investigating the potential of substituting hydrogen – produced using hydroelectric power – for a portion of the natural gas used to fuel NYPA's Brentwood Power Station.

GE's aeroderivative gas turbine portfolio currently has the capability to burn blends of hydrogen and natural gas; the specific limit depends on the combustion system configuration. For example, GE's LM2500 GE's aeroderivative gas turbines can run on blends of up to 85% hydrogen (by vol.) using a single annular combustor (SAC) configuration with water injection to control emissions, with a path towards a 100% hydrogen combustion in the future.

The demonstration project was part of a collaboration between NYPA, GE, the Electric Power Research Institute (EPRI), engineers Sargent and Lundy, Fresh Meadow Power and Airgas, a subsidiary of French-based Air Liquide. The team examined the impact of fuel blends from 5% to 44% (by volume) hydrogen, which represents some of the highest volumes of hydrogen blended into a commercially operating gas turbine. As the gas turbine original equipment manufacturer, GE supplied a hydrogen/natural gas blending system and supported the project's planning and execution.

During the project, the team examined the impact of water injection rates while operating on the hydrogen fuel blend and demonstrated that NOx emissions could be kept the same or even slightly reduced, but this required an increase in the water injection rate. With the Brentwood Power Station generating 47 MW, according to the Electric Power Research Institute's report carbon dioxide emission rates were reduced by about 14% with a fuel blend containing 35% hydrogen, which matched pre-test predictions. Engine control was stable throughout the duration of the test; combustion dynamic pressure (i.e., amplitudes) measured during the test indicated no change during operation on the blend. Combustion equipment was in good condition before, during and after the test; periodic borescope inspections showed no apparent damage to combustion hardware due to operation on hydrogen blends.

OTHER EMISSIONS LOWERED

In addition to demonstrating that the fuel blend could generate electricity with lower carbon emissions, the demonstration highlighted that under certain conditions, other emissions, including nitrogen oxides (NOx), carbon monoxide (CO) and ammonia (NH3), were maintained below regulatory operating permit limits using the existing selective catalytic reduction and CO catalyst post-combustion control systems. In fact, CO levels decreased as much as 88% as the hydrogen fuel fraction increased. This

finding could help allow gas turbines that run on hydrogen/natural gas blends operate across a wider load range with reduced or without CO oxidation catalysts, potentially reducing operating costs. These are critical findings, as they demonstrate the ability to reduce carbon emissions without increasing plant emissions of other pollutants, GE said.

GE said the NYPA project also highlights that gas turbines like the Brentwood LM6000 that operate as 'peakers' can simultaneously help to maintain a reliable electrical grid and provide electricity with lower carbon emissions. The lower CO emissions while operating on a blend of hydrogen and natural gas might have longer-term benefits by improving gas turbine operational flexibility, which may become more important when supporting a grid with an increasing percentage of variable renewable power.

PROVIDING VALIDATION

Efforts like the Green Hydrogen Demonstration Project are vital to validate the important role that hydrogen can play in lowering carbon emissions from power generation while also providing reliable and affordable power, according to GE.

NYPA's project is revealing new understandings impacting well beyond New York. According to GE, there were approximately 1.6 terawatts (billion MWs) of gas turbines installed globally as of YE 2020 accounting for around 21% of global power generation. The imperative is to systematically approach turning existing and future high-efficiency gas generation assets into a zero- or near-zero-carbon energy resource and sharing the results of this study with the industry and the public can help pave the way to future decarbonization efforts.

USA GUASCAR ENERGY

Guascor Energy helps Acushnet achieve its environmental goals

Titleist is a worldwide-known golf equipment brand, manufactured and distributed by Acushnet Company, headquartered in Fairhaven, Massachusetts, United States.

The first Titleist golf balls were commercialized in 1935 and it has been the best-selling golf ball brand in the United States for decades, used by many professional golfers.

Acushnet is a global organization that is fully aware of its corporate social responsibilities. As such it is always looking for ways to reduce the environmental impact of its operations.

Acushnet employs a dedicated team and engages professional consultants to ensure compliance with all applicable environmental laws and important investments have been made in equipment and processes to reduce emissions even below permitted levels and to achieve reliable and cost-effective energy supplies and to reduce overall energy usage.

One of the many initiatives undertaken to achieve this goal was the installation of cogeneration units at its United States golf ball manufacturing facilities with the target to obtain clean energy from natural gas. These are highly efficient CHP units that meet over 35% of the overall plants' energy needs, using the generated electricity and heat in its facilities and manufacturing processes.

When looking for the optimum cogeneration solution to implement in Ball Plant II, located in North Dartmouth, Massachusetts, Acushnet chose Guascor Energy's best-in-class 100EM generator set.

Natural gas-fired, the 100EM genset delivers nominal, proven engine performance of 2MWe electrical power directly at 1200 rpm, without a gearbox to achieve the necessary 60Hz generation frequency, with a 45.4% electrical efficiency, best in class in the market, and with a 92% global efficiency.

In combination with a heat recovery steam generator (HRSG) and an absorption chiller, the complete CHP facility generates also 3,300,000 Btu/hr of hot water, 2,000 lbs/hr of steam and 150 tons of chilled water (TR).

Although the Commonwealth of Massachusetts Department of Environmental Protection (MassDEP) has some of the strictest emissions standards in the country, the 100EM engine combined with its Aeri-Nox oxidation catalyst and SCR system produces half of the permitted emissions.

The facility consumes between 0.8 to 3.8 MW of electricity from the grid and has a mechanical plant to produce steam, hot and cold water, however, having the CHP system significantly reduces their utility costs. Furthermore, the manufacturing plant normally operates during the weekdays when there are additional financial incentives from the utility company to peak shave facility load during the highest demand intervals.

As a result, the necessary investment on the cogeneration facility is expected to be recovered in a few short years.

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IMAGE: GUASCOR