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HANDBOOK 2019

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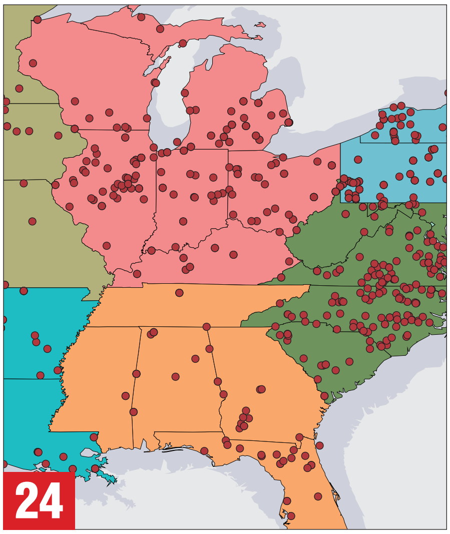

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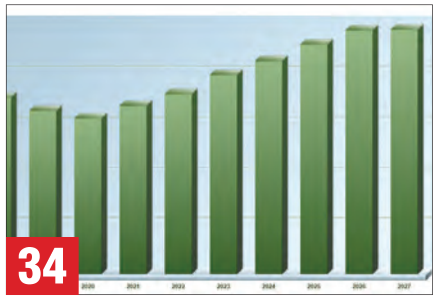

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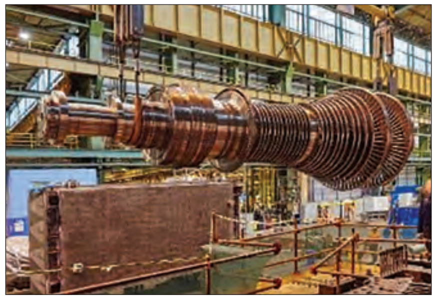

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SPECIFICATIONS

HOW TO USE THIS HANDBOOK

Here is your 2019 edition of the *Turbomachinery International Handbook*.

The **Features** section provides the U.S. power industry outlook on p. 24 and the worldwide gas turbine market on p. 34.

The alphabetical **Company Directory**, beginning on p. 46, provides complete contact information on every company listed in the handbook. The text of each listing is provided by the company itself.

The **Category Index** on p. 8 lists the categories within each segment of the industry, and on which page to find them.

The **Categories** section provides a list of specific segments of the turbomachinery market and begins on p. 70. Refer back to the Company Directory for more detailed information about each company.

Equipment Specifications for gas turbines, steam turbines, compressors and expanders begins on p. 82.

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FUTURE PREDICTIONS

Each year, we receive in-depth analyses from two of the premier market intelligence companies in the power generation and gas turbine (GT) fields. Industrial Information Resources (IIR) provides an overview of the U.S. power generation sector. Forecast International supplies global insight into GT sales. Both reports are included in this year's handbook.

Taking a look at the numbers, it is apparent that there are some tough times ahead for GTs. Forecast International noted overcapacity among GT OEMs and a turndown that will result in a few lean years.

The market is expected to bottom out by 2020 and then slowly revert. But it won't be until 2023 that we exceed 2018 GT sales levels. That's why Forecast is citing a drop of more than 7% in GT sales over the next ten years compared to last year's report.

Strong points include large-scale combined cycle facilities, especially in Europe and Asia, modernization of facilities built in the 60s and 70s, and a market sweet spot for turbines of 250 MW and larger. Those in the 20 MW to 100 MW range, though, appear to be in trouble. The exception is likely to aeroderivatives which will dominate GT sales in that range.

The IIR study puts those numbers in perspective. Despite tough times, natural gas generation is still likely to account for around 40% of the overall U.S. market over the next five years. That number has remained stable for the last few years. But it is under threat in California and other western states.

With coal and nuclear now beaten into submission, the environmental lobby has gas turbines in its sights as the next fossil fuel to eliminate. While some may see this as an extreme stance, these guys are serious.

California has already enacted legislation to be 100% fossil fee by 2040. Some other states will follow suit. They believe battery energy storage can replace natural gas to fill the availability gap that plagues renewables. Realistic or not, that is the plan.

Clearly, the gas turbine industry needs to up its game. Propaganda abounds about the evils of power plant emissions. The environmental lobby is painting GTs with the same brush it used on coal generation.

That has already led several utilities on the West Coast to cancel plans to modernize GT plants. The City of Glendale in California, for example, has shelved the modernization of its aging gas-fired plant in favor of cleaner, non-emitting electric options. If this wave of anti-gas sentiment grows, IIR's estimate of almost 90,000 MW of new gas generation over the next five years could drop markedly.

Battery storage is seen as the panacea for any energy shortfall in an emission-free future. But the technology is immature and is struggling to scale adequately.

Taking tens of thousands of fossil megawatts off the grid to replace them with renewables and batteries may be overly optimistic. But time will tell. IIR knows of 30 utility-scale battery storage projects that will go into construction in the next five years.

At that rate, it could be ten years or more before we know if battery storage has a significant role to play in the future energy mix. Yet utilities seem to be rushing in this direction, much in the same way they rushed to nuclear and IGCC. Both proved to be foolhardy gambles.

It may be possible to eventually reach an emissions-free future. But let's arrive there smartly. That requires fossil-based and renewable proponents to adopt a less adversarial stance. There has to be a middle ground that considers lowered emissions, a workable power infrastructure, grid security and technological maturity.

Perhaps even coal has a small role to play. Here is why. Imagine that the natural gas pipeline network fails. That wind and solar aren't adequate to power the grid. A large stockpile of coal can act as an emergency backup source to ensure power availability.

It could even represent energy storage on a grand scale. What about the emissions? If there is no power, anywhere, people will be happy to temporarily fire up the coal plants to get the heating and cooling back on. It might be a last resort, but taking it completely off the table may not be the wisest course. ■

Drew Robb

DREW ROBB
Editor-in-Chief

CATEGORY INDEX

MECHANICAL VARIABLE SPEED DRIVES

COMPARING A MECHANICAL TO AN ELECTRICAL VSD FOR USE IN TURBOMACHINERY

BY AMIN ALMASI

Mechanical variable speed drives (mVSD), particularly a hydrodynamic torque converter or fluid coupling, can soften the transmitted load and damp the load peaks and load pulsations generated by connected devices, such as electric motors. An mVSD can also soften large dynamic torques in transient situations, such as a start-up or short circuits.

There have been many designs for mVSDs in industrial applications over the years. Before the advances in electrical VSDs (eVSD) systems, a wide range of mVSD systems were designed and used for various services and applications. Some have left the market; others were modified for use in specific applications.

In addition, new mVSD designs have been introduced as not all applications can be served by eVSDs. Examples of available mechanical drive options are:

1. MVSD speed control and speed increase for high-speed output; this is used for medium and large machinery
2. Geared variable-speed coupling: Cheaper than option 1, but lower efficiency at part-loads might be expected
3. Variable-speed coupling: Speed control with no speed increase; relatively cheap, but less efficient.

For example, in a medium-sized, electric-motor-driven machinery train, transient torques are reduced from around 210% of the nominal torque for an electric-motor-driven shaft down to around 105% of the nominal torque with a driven machinery-to-mVSD coupling. A short-circuit (transient) torque is also damped through the mVSD from an excitation above 380% down to around 155% of the nominal torque on the driven machinery shaft.

mVSD vs eVSD

There can sometimes be design, commercial, and operational advantages for an mVSD compared to other options, such as an eVSD in specific applications. A smaller footprint is usually required for an mVSD.

An mVSD does not generate harmonic pulsations, which can be a problem in some Variable Frequency Drive systems. An mVSD also offers vital mechanical damping and softening effects to counter disturbances.

For an mVSD, though, some unknowns are expected: special commissioning and alignment procedures are required; and there are limited options available to the user. But based on experience, the reliability and availability of properly designed and applied mVSDs has been satisfactory.

There can sometimes be design, commercial, and operational advantages for a mechanical VSD compared to an electrical VSD

Like any complex mechanical system there are limits. The reliability of an mVSD cannot be higher than a certain level, in spite some manufacturer claims. As a rough indication, the run time before an unexpected shutdown could be around one or two years for some mVSDs. Unexpected shutdowns are mainly related to bearings and oil systems.

A reference check is important for mVSDs. Make sure the same model of mVSD has already been used in the intended type of turbomachinery and that it is operating successfully over the long term in similar applications.

The best range for mVSD applications is in medium-sized applications of 500 kW to 4 MW. For small power ratings and low-voltage electric motors an electrical VFD is almost always preferred as it is cheaper than an mVSD.

The use of mVSDs as hydraulic torque converters is not recommended for large turbomachinery above 8 MW. There may be a handful of successful applications of that size, but this range is dominated by other technologies such as large eVSDs. Therefore, the limit of mVSDs, depending on the application, might lie somewhere between 5 MW and 8 MW.

Overall, mVSDs are special variable speed systems which should only be used in certain applications. They should provide definite technical, commercial, or footprint benefits. In those systems where there are constrains on space, weight, or budget, as well as in some special revamp or renovation projects, mVSDs may provide obvious value.

As mentioned earlier, they are cheaper, though the exact percentage varies depending on how the mVSD is being used. There are also differences between the rates charged by manufacturers. But generally speaking, an mVSD will be anywhere from 5% to 25% cheaper than an electrical VSD.

Any comparison between an mVSD and an eVSD should always consider the details of the application. The speed, power, operating characteristics, footprint, and other factors have to be carefully considered. Any final decision concerning the appropriate variable speed technology should always be based on purchase costs plus estimates operational costs. ■

Amin Almasi is a Chartered Professional Engineer in Australia and U.K. (M.Sc. and B.Sc. in mechanical engineering). He is a senior consultant specializing in rotating equipment, condition monitoring and reliability.

ROADMAP FOR MHPS "NEXT GEN" LARGE GAS TURBINE

The MHPS T-point gas turbine combined cycle demonstration facility in Japan is being used to develop a machine capable of running at firing temperatures of 1,700°C.

Mitsubishi Hitachi Power Systems (MHPS) has rolled out the roadmap for the next large gas turbine. Part of the Japanese National Project to develop gas turbines with firing temperatures of 1,700 °C, the company is building a new power plant at its Takasago Works, Hyogo, Japan to validate it. This plant and the new gas turbine are expected to become operational in 2020. The company has set goals of 67% combined cycle efficiency and a firing temperature of 1,700°C, according to MHPS engineers.

While emphasizing that the present J-class gas turbine design has enough potential for further development, they outlined three strategies to achieve their efficiency goal in the new model. During a recent visit to the company's Takasago Works gas turbine manufacturing facility by *Turbomachinery International*, cooling was highlighted as a critical issue. Engineers pointed at the complex cooling holes produced by 3D printing of components. They added that 3D printing has the potential to increase cooling efficiency, thereby helping to achieve higher efficiency and an improved turbine inlet temperature (TIT). They also discussed the use of advanced materials such as ceramic composites that require no cooling until they reach temperatures of 1,300°C. Lightweight turbine parts such as compressor blades will also play a key role in the attainment of these ambitious efficiency goals.

But the company is not waiting until 2020 to put some of these breakthroughs into action, MHPS has designed a 1700°C technology-based retrofittable upgrade for the G-class machine. It is said to provide a 10% power boost and 5% efficiency increase to existing G-class turbines.

Presently, J-class gas turbines operate at a TIT of 1,600°C. M501JAC Series gas turbines adopt air cooling for combustors instead of steam cooling. With a performance equivalent to the M501J Series gas turbines, the air cooling features are said to enhance operability and offer shorter start-up times.

MHPS first introduced the air-cooled JAC gas turbine in 2016. One year later, MHPS announced that customers in Asia, the U.S., Mexico, and South America had technically selected the M501JAC for projects representing over 14 GW. The JAC has a 64% efficiency, 99.5% reliability and a combined cycle output of 614 MW.

J-class technology at the Grand River Dam Authority's power plant in Oklahoma recently surpassed 8,000 hours of commercial operation. This power plant is the American fleet-leader for the MHPS J-class and is the 25th to surpass 8,000 hours of operation globally.

These technology innovations are showing up in increased orders. MHPS received 40% of global orders for gas-fueled turbines in the first half of 2018. Siemens had 29% and GE had 18%.

MHPS J-class gas turbine

Finish LNG

A ground-breaking ceremony has been held for the new Hamina LNG terminal that is to be engineered, procured and constructed by Wärtsilä. The 30,000 m3 capacity terminal will provide storage of liquefied natural gas (LNG). It will also have re-gasification capability for sending the gas to the existing distribution network serving both regional and national markets.

In addition, the terminal will have a truck-loading area for LNG, as well as the possibility to supply bunkering barges and small-scale carriers. The tank foundation for the terminal has already been cast, and the facility is scheduled to become fully operational in 2020.

Caterpillar Integrates OSIsoft

Caterpillar has integrated OSIsoft's Connected Services into its Cat Asset Intelligence platform, a suite of subscription-based AI services for analyzing fuel consumption, equipment health and critical operations in real time.

Connected Services from OSIsoft are a selected set of cloud-based services that enable hardware manufacturers, software developers and service providers to integrate PI System technology into their offerings. It transforms data streams from sensors and other devices into real-time insights.

Cat Asset Intelligence services can be used to optimize the performance of diesel generators and other equipment from multiple brands, not just Cat equipment. Caterpillar also integrates OSIsoft's Connected Services into Cat Asset Intelligence services for many land-based equipment lines as well.

Turboden order

Turboden has signed an agreement with Centrale del Latte di Brescia, the municipal dairy in Brescia, for installation of the first high-temperature cogeneration ORC plant in the world. The company began developing its Steam & Power ORC System (ST&P ORC System) two years ago, taking advantage of a Research and Development project supported by the Italian Ministry of Economic Development.

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The ORC system is designed to satisfy the energy requirements of manufacturing companies requiring maximum overall efficiency (>90%) with high steam content (about 75%), and no hot water. It will be used to co-generate about 700 kW electric power and 5 ton/hour of steam at 15 bar needed to pasteurize long-life milk.

Turboden provides a turn-key solution, supplying the complete system, from the natural gas fired boiler (in partnership with boiler manufacturer Bono Sistemi) to the high-temperature Organic Rankine Cycle turbogenerator.

Iraqi air intakes

CTM Ambiente has designed and implemented the supply of six complete air intakes for the Rumaila combined cycle power plant in Iraq. Each gas turbine has a power output of 180 MW. The first unit was synchronized with the Iraqi national network on 9 June 2018.

Rumaila power station is located near Basra, in southern Iraq, in one of the most exposed areas to sandstorms of the planet. The air intake is a self-cleaning type with a pulse jet system with a pre-filtration section of accumulation type, to maximize the lifetime of high efficiency filters. The air flow rate is about 1,600,000 Nm^3/h for each unit.

The system includes: two pre-filtration stages of accumulation with efficiency G3 and M6 according to ISO EN 779; one stage of self-cleaning filters with efficiency F9 according to ISO EN 779; and minimal pressure loss as the filtration speed is kept low.

Shipping emissions

As the shipping industry is the biggest culprit of sulfur emissions, the International Marine Organization (IMO) will be launching Regulation 2020, set to cut sulfur emission, a by-product of the fuels used, by 80%. This will have a marked impact as the marine industry accounts for half of the global fuel oil demand.

Last year, the marine industry consumed 3.8 billion fuel/oil barrels per day. The regulation will see sulfur limits for bunker fuels cut from 3.5% to 0.5%. According to one study, the shipping industry's annual bunker costs could rise by up to $60 billion in 2020 with full compliance with the IMO's sulfur cap.

AVEVA's InTouch SCADA system will be integrated with Canon cameras

Aveva adds imaging

AVEVA has signed a technology partnership agreement with Canon to enable the development of new visualization solutions for factory automation. By combining AVEVA's industrial automation and information management capabilities with Canon's imaging technology, the two companies can develop new solutions to facilitate Smart Manufacturing operations.

U.S. LNG dominance

The U.S. is expected to become the world's leading LNG supplier by 2028 and still be the largest natural gas producer by 2040,

ABB digest

ABB is set to deliver what it believes to be the world's fastest start-up when Equinor's Aasta Hansteen gas field begins operating and produces its first gas later this year. ABB will provide a suite of ABB Ability digital technologies for Aasta Hansteen, which is located in 1,300 meters of water in the Vøring area of the Norwegian Sea, 300 kilometers from land.

Part of the challenge was to make the first gas start-up process as quick and efficient as possible. For this, ABB needed to reduce a sequence of over 1,000 manual interventions to as few as possible. The outcome is a series of simple buttons. The ABB Ability System 800xA simulator was used to do a virtual start-up of the plant. The company estimates it saved about 40 days in the commissioning phase of the project.

ABB has won an order from SACS Construção e Montagem and Niplan Engenharia to supply an E-house to support the modernization of the São Paulo pipeline network in Brazil. E-houses are prefabricated, modular outdoor enclosures designed to house a range of electrical and automation equipment.

Requiring less time to install, commission, deliver and start up, they offer a faster alternative to traditional on-site concrete or brick-built constructions. Costing typically 20% less than permanent structures and offering up to 60% reduced footprint, they are "drop and deliver" electrical housing solution.

ABB will provide E-houses for the 47 pumping stations along the pipeline, spread across 47 kilometers, connecting a station being built in São Bernardo do Campo to the Capuava Refinery (RECAP) in Mauá in São Paulo. The E-house is 112 square meters, uses anti-corrosion paint and has ISO9001 certification.

ABB's security, monitoring and communications technology has been installed on the 1,850 km Trans-Anatolian Natural Gas Pipeline (TANAP). The first phase, "Gas to Eskisehir" officially opened in early summer 2018, ahead of schedule.

ABB provided the security, telecommunications, SCADA main control room, containerized equipment rooms and has installed the fiber optic cable along the pipeline to contribute to this achievement. As part of the project, ABB has installed a fiber optic leak detection and subsea pipeline monitoring system detecting events such as anchor drag. Over 4,000 km of fiber optic cable has been installed the length of the pipeline.

ABB has installed an integrated security system, which monitors the external and internal CCTV cameras and the perimeter intruder detection system of every site along the pipeline. This pipeline intrusion detection system covers every meter of pipeline, incorporating over 1,300 cameras and 650 access control points.

Gas field using ABB software

according to consultancy Wood Mackenzie. Kristy Kramer, Wood Mackenzie's Head of Americas Gas Research, said the shale gas revolution had resulted in the U.S. becoming the largest gas producer in the world, comprising 23% of total global production.

At the start of 2014, more than 50% of U.S. gas production was from shale and today it has reached 65%. Wood Mackenzie forecasts continued production growth of 47% by 2035. By 2040, U.S. natural gas production should increase to almost 130 bcfd, more than 50% over today's level.

Optimism has also returned to the global LNG market. Wood Mackenzie believes that by 2035, U.S. LNG exports will exceed 140 mmtpa, far above that of Qatar (100 mmtpa) and Australia (80 mmtpa).

Japanese combined cycle

Japan's Kawasaki Heavy Industries has received an order for 100 MW combined cycle power plant (CCPP) from Kashima South Joint Power Corporation (KSJPC). The Kashima South Joint Power Station will feature the Kawasaki L30A model 30 MW GT.

Kawasaki will perform the overall design of the plant, supply and installation of GTs, an ST and heat recovery steam generators (HRSGs), as well as civil engineering construction. The 107 MW output CCPP will be constructed in Kamisu City, Ibaraki in Japan. The facility will feature three L30As, three HRSGs and one ST. Operations are expected to commence in 2020.

RWG contract

Metragaz has awarded RWG a long-term contract to provide exchange, overhaul, installation and recommissioning services to maintain their fleet of Siemens SGT-A35 (Industrial RB211) aero-derivative gas generators. Metragaz operates from two locations in Morocco, providing gas compression services for the Maghreb-Europe Gas Pipeline transporting gas from Algeria via Morocco on to Spain and Portugal.

This contract has an initial term of three years, requiring RWG to build, configure and ship exchange gas generators to Metragaz in advance of each scheduled overhaul, resulting in reduced operational downtime. In addition, RWG will provide field service support to install and recommission each unit, returning time expired equipment to RWG's OEM authorized SGT-A35 service center in Aberdeen, Scotland for major overhaul.

Chinese Voith order

Voith and Guangzhou China Resources Thermal Power signed an order for two VECO-Drive speed control products for the NanSha thermal power plant located in Guangzhou City, part of the Guangdong province. The VECO-Drive is an electric superimposing gear and combines a mechanical planetary gear with frequency-controlled servo motors.

The order covers two separate units, which will replace the existing speed control components for the boiler water feed pumps. With the integration of the VECO-Drives, Guangzhou China Resources Thermal Power can decrease energy consumption and greenhouse gas emissions.

U.S. energy outlook

The Energy Information Administration (EIA) estimated in their latest Short-Term Energy Outlook that the U.S. is now the largest global crude oil producer, likely surpassing Russia and Saudi Arabia. In February, U.S. crude oil

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Siemens digest

The Egyptian Electricity Holding Co. chose Siemens to provide operation and maintenance services for the Beni Suef, New Capital and Burullus power plants, for the next eight years. The agreement includes the implementation of the company's Omnivise digital service solutions.

Egypt's Burullus is one of three new power plants to be operated and maintained by Siemens

The three 4.8 GW power plants represent about 40% of Egypt's power capacity, at the time of signing contracts, generating 14.4 GW — enough to supply 40 million Egyptians with electricity. The multi-year agreement covers all on-site equipment including 24 gas turbines, twelve steam turbines, 36 generators, 24 heat recovery steam generators and three 500 kV gas-insulated switchgear systems.

Siemens will also improve asset visibility, reliability and availability of the three power plants. Data from the plant operation will be collected, analyzed and transformed via diagnostics, troubleshooting and condition forecasting.

The 3-D printed burner for an SGT-700 gas turbine has been in operation for one year at E.ON's CCPP in Philippsthal in the German state of Hessen. The burner has been operating for over 8,000 hours with no reported issues.

In 2017, Siemens began printing gas turbine burners using selective laser melting technology in Finspång, Sweden. Each burner head is manufactured in one piece compared to traditional methods that required 13 individual parts and 18 welds.

Design improvements, such as the pilot-gas feed being part of the burner head instead of the outside fuel pipe, allow the operating temperature to be kept lower, thus contributing to a longer operational lifespan of the components.

Siemens has received an order for the first 50-Hz unit of the SGT-9000HL GT, which will be delivered to the Scottish energy company SSE for the new gas-fired power station Keadby 2 in Lincolnshire, UK.

Siemens has issued increased performance for the machine: 481 MW for the 50-Hz SGT5-8000HL (and 708 MW for combined cycle 1×1 operation); 567 MW for the SGT-9000HL in the 50-Hz version and 388 MW for the 60-Hz version (841 and 577 MW for combined cycle 1×1 operation respectively). The 63% efficiency mark in combined cycle operation is confirmed but Siemens also maintained that this threshold is going to increase further for these air-cooled four stage turbine models.

GE digest

GE's Power Services business has launched a repowering solution for the 6B GT. GE also announced it has signed its first agreement for the solution with a chemical company to repower three 6Bs.

Part of GE's Fleet360 platform of total plant services solution, the new 6B Repowering Solution incorporates F and H class technology to elevate the machine's performance. It consists of a flange-to-flange upgrade of all major components, including the combustion system, hot gas path and compressor. The 6B unit becomes a GE 6F.01 GT, which is also available as a new unit. The upgrade is capable of:

- Increasing turbine output up to 35% simple-cycle/25% combined-cycle
- Improving efficiency up to 5%
- Achieving up to $3 million in fuel savings per unit annually
- Achieving NOx emissions as low as 15 ppm.
- Extending the hot gas path inspection interval to 32,000 hours (from 24,000 hours) and major inspection interval to 64,000 hours (from 48,000 hours)

Since its first installation in 1978 at Montana-Dakota Utilities' Glendive Power Plant in U.S., GE's 6B fleet has accumulated more than 65 million operating hours. GE's fleet spans more than 1,150 6B turbines.

Meanwhile, power project developer Advanced Power and GE Power announced that South Field Energy, a 1,182 MW CCPP to be built in Columbiana County, OH, will be powered by two of GE's 7HA.02 GTs. South Field Energy will also use GE ST and HRSG technologies, as well as services on the equipment through a contractual service agreement (CSA).

GE Power received an order to supply a GT and generator for a captive power unit planned at Hindustan Petroleum (HPCL) refinery at Visakhapatnam, India. GE will supply a 6F.03 GT to state-owned Bharat Heavy Electricals Ltd (BHEL), the principal contractor for the project.

National Power Parks Management Company Limited (NPPMCL), Harbin Electric International Company Limited (HEI) and GE announced the completion of the Balloki power plant in Pakistan, following the conclusion of all commissioning works and performance-related tests. Balloki can supply up to 1,223 MW as part of a regasified liquefied natural gas (RLNG) power project. It uses GE HA gas turbines.

GE's Power Services announced the results from a cross-fleet GT upgrade project at the Fuerza y Energía de Tuxpan facility in Veracruz, Mexico. It achieved an output increase of 9.2% and a 2.9% efficiency improvement on one of Tuxpan's GT, while extending maintenance intervals to 32,000 hours for the 450 MW power plant.

GE applied its cross-fleet technologies to two MHPS M501F GTs and two STs. GE completed the work as part of a 12-year agreement, showcasing its Fleet360 platform. The upgrades at Tuxpan include new GT hardware infused with GE materials technology and improved engine component architecture. GE also serviced Tuxpan's STs, uprated its generator systems, and installed a combustion-dynamics monitoring system to help the site identify combustion issues.

GE 6B.03 gas turbine

Russell Stokes, President and CEO of GE Power, has referred to oxidation problems that have cropped up on the blade of the air-cooled HA Turbine. "Teething problems inevitably occur," said Stokes. "We have identified a fix and have been working proactively with HA operators to address impacted turbines."

This turbine blade oxidation forced Exelon Corp to idle four electric power units in Texas. GE said it could affect some 75 9FB machines in addition to the HA. The 9FB belongs to the F class gas turbines.

The first HA turbine gas turbine started working inside a new French combined cycle power plant in June 2016. It has since been recognized as the world's most efficient combined cycle power station in the 50 Hertz configuration used in Europe, delivering 62.22% net efficiency.

production exceeded that of Saudi Arabia for the first time in more than two decades. In June and August, the U.S. surpassed Russia in crude oil production for the first time since February 1999.

The U.S. Department of Energy (DOE) also announced that on September 6, 2018, a short-term order was issued to the Freeport LNG project to export up to 2.14 billion cubic feet per day (Bcf/d) of natural gas as LNG over a two-year period to both free-trade and non-free trade agreement countries.

This order authorizes Freeport's initial commissioning volumes and other exports pursuant to short-term contracts. Freeport LNG will be exporting the LNG from the Freeport LNG Liquefaction Project, which is currently under construction on Quintana Island, TX. The two-year export term will become effective on the date of the commencement of the facility's first export of LNG, currently projected to be in the third quarter of 2019.

Since exports of U.S. LNG began in 2016, over 1.3 trillion cubic feet of U.S. natural gas have been exported. U.S. LNG has now landed in 30 different destinations in Europe, Asia, Africa, the Middle East, South America, North America and the Caribbean. EIA expects natural gas exports to average 9.9 Bcf/d in 2018, up 15% from 2017 levels. EIA also expects natural gas exports to rise by an additional 38% in 2019 to 13.7 Bcf/d.

To date, the U.S. Department of Energy has approved 21.35 Bcf/d of long-term exports of natural gas to any country in the world not prohibited by U.S. law or policy. There are currently two large-scale LNG export projects in operation, Sabine Pass and Dominion Cove Point, which have a combined export capacity of approximately 3.5 Bcf/d.

Freeport is one of four additional large-scale LNG export projects expected to be completed over the next two years. Once these four projects are completed, U.S. LNG export capacity is expected to reach about 11 Bcf/d. There are over a dozen large-scale export projects under review that would provide over 20 billion cubic feet per day of additional export capacity if approved.

Ethos contract

EthosEnergy has been awarded a six-year contract to provide maintenance and engineering services for work at seven production facilities plants across the U.S. The scope includes over 10 GE STs, three Dresser Rand STs, two SDDT STs, and three Westinghouse 251B12 GTs across Mid-West and Eastern U.S. sites.

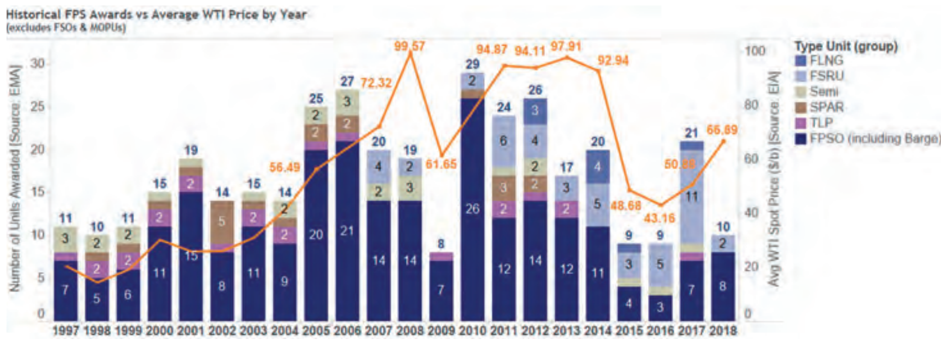
Floating production report

The Q4 2018 Floating Production Systems Report from Energy Maritime Associates (EMA) reviewed the market for Floating Production Systems: Key trends include:

- Floating Production, Storage, and Offloading (FPSO) vessel orders were highest in four years: Eight FPSOs have been awarded so far in 2018, including six new-built units (five in china one in Singapore) and two redeployed idle units. This is the most FPSO orders since oil price crashed in 2014.
- More awards on the way: 31 projects are likely to be sanctioned in the next 12 months. A few will be awarded by year end, with most being approved in 2019.

EMA analysts noted that oil prices have rebounded over 100% from their lowest levels, while offshore costs have hardly moved. As a result, many offshore developments are now competitive, if not more attractive, than onshore shale fields, with break-evens as low as $30/bbl.

This is seen as the start of a new cycle for the industry, with re-set pricing and a growing oil price similar to the period from 2004/5. If oil prices remain stable, there is opportunity for new floating production projects over at least the next two years.



Croatian CHP

The Elektrana-Toplana Zagreb power plant (EL-TO Zagreb power plant) located in Zagreb, Croatia, is being modernized by replacing unit A with a new CHP system. Hrvatska elektroprivreda (HEP) is undertaking the project.

With an electrical output of 150 MW and heat output of 114 MW, construction of the unit is expected to begin in 2018, with completion anticipated by the end of 2021. The combined cycle power unit will be equipped with two GTs, two HRSGs, and one extraction back-pressure ST.

Each GT will have an output of 50.5 MW. The HRSGs will generate superheated steam by using hot flue gases at the gas turbine exit. The cooling system of the plant will comprise air-cooled heat exchangers, divided into two sections.

The first section will be used for cooling the steam from the ST, especially during the hottest time of the year, while the other will be used for cooling certain systems of the plant such as electric generators, lubricating oil system, and feed pumps. Process steam will be used for industrial needs, while generated heat will be used in the district heating system (DHS) of Zagreb city.

Continued 22

Wind tunnel

A wind tunnel at The University of Alabama in Huntsville (UAH) Johnson Research Center (JRC) will be used to provide data to research GT hot section components at engine conditions. Known as the SuperSonic/TranSonic/WindTunnel or SS/TS/WT, the facility will be used during a two-year grant from Solar Turbines to study cooling configurations and develop a new physical understanding of surface heat transfer characteristics, including cooling technologies.

The principal investigator is Dr. Phillip Ligrani, a scholar in propulsion and professor of mechanical and aerospace engineering. The aim is to reduce cooling air requirements and thermal loading, with equivalent improvements in thermal protection and structural integrity.

As data are acquired, the SS/TS/WT will be employed in a blow-down mode to create the transonic flows under investigation. During each test, a variety of flow characteristics will be measured, including surface static pressures, flow stagnation pressures, mass flow rates and Mach numbers. infrared thermography techniques will also be employed to acquire the associated spatially resolved surface heat transfer characteristics.

The wind tunnel's test sections reside in the Air Breathing Test Cell at the JRC. Test sections of the facility reach speeds and air velocities ranging from Mach 1.6 at an airspeed of some 1,230 miles per hour to Mach 3 at an airspeed of about 2,300 mph. Five air storage tanks provide 50 cubic meters of compressed air storage at supply pressures up to 2,500 pounds per square inch.

MHPS digest

Mitsubishi Hitachi Power Systems (MHPS) has signed a memorandum of understanding (MOU) with China's Dongfang Electric and Sichuan Provincial Investment Group pursuant to plans for a project adopting the latest J-Series GT at a thermal power plant for a new CCPP. MHPS will provide technical support for the manufacturing process. Dongfang Electric is a state-owned company, and a licensee of MHPS.

MHPS has completed construction of its Unit 2 CCPP System at the Tanjung Priok Power Plant, a natural-gas-fired facility being built on Java Island in Indonesia. PLN (Persero), Indonesia's state-owned electricity provider, plans to build an 880 MW plant comprising of two GTs.

Unit 1 initially went into operation as a simple system this June with output nearing 300 MW. Unit 2 has joined to produce equivalent wattage. MHPS is responsible for providing two M701F GTs as well as two exhaust heat recovery boilers, one ST, and auxiliary equipment. Mitsubishi Electric Corporation supplied the generators. The launch of operations as a GTCC system is slated for 2019.

MHPS) has received an order for two sets of STs for Nghi Son-2 thermal power project in Thanh Hoa province, Northern Vietnam, led by Marubeni Corporation and Korea Electric Power Company (KEPCO). The new plant will have a capacity of 1,330 MW. It is due to be commence operations in 2022. For Nghi Son-2 project, MHPS will also provide two generators and ancillary equipment in addition to two STs.

MHPS announced a successful first fire for the Dominion Energy Greensville County Power Station located in Emporia, VA. Designed to generate 1,558 MW, the plant operates three M501J STs supplied.

"With the third successful first fire in a row at Greensville, MHPS has successfully met key milestones to keep the project on target to meet commercial operation by the end of 2018," said MHPS Project Manager, Matt Herbst. "Each engine start validated our commitment to Dominion Energy to provide reliable units on time and on budget."

NTE Energy's has cut the ribbon on the Kings Mountain Energy Center (KMEC), located in Cleveland County, NC. The 475 MW CCPP will uses MHPS G-Series gas turbines. MHPS manufactured the GT for KMEC at Savannah Machinery Works (SMW) in Georgia. KMEC also uses MHPS's TOMONI artificial intelligence.

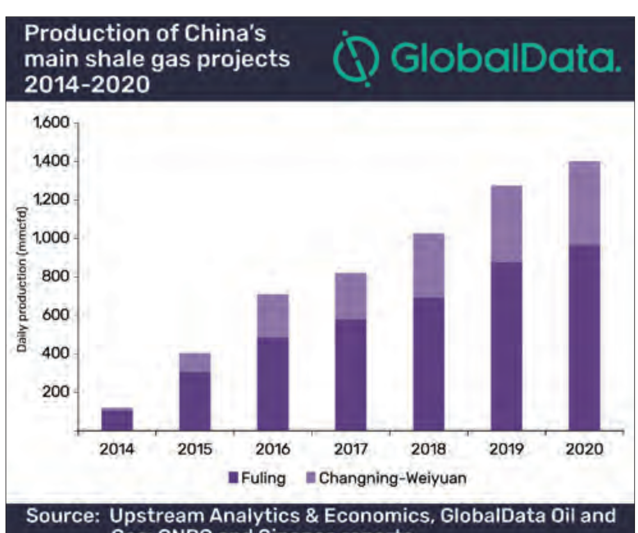
Chinese shale problems

China's upstream industry is turning to natural gas as a way to reduce air pollution created by the consumption of coal. However, despite the progress made in the shale gas industry since 2011, China has been facing challenges to develop efficient shale gas extraction, observes leading data and analytics company GlobalData.

With 27 trillion cubic feet (tcf) of proved shale gas reserves, China has emerged as the world's largest shale gas producer outside the U.S. and Canada. State-owned China Petroleum & Chemical Corporation (Sinopec) accelerated its Phase II development in the Fuling shale gas project in Chongqing, which has become the largest shale gas field outside North America with an annual production capacity of 350 billion cubic feet (bcf) in 2017.

Changing-Weiyuan national shale gas demonstration zone, China National Petroleum Corporation (CNPC)'s pilot shale project, produced 239 million cubic feet per day (mmcfd) in 2017 and is under further development to lift the output capacity to 350 bcf by 2020.

Despite big tax incentives, though, production is expected to fall short of the government targets since exploration of shale gas remains difficult in China. The available area is relatively fragmented and mountainous. The complex geological structures challenge the commercialization of shale gas plays.



Source: Upstream Analytics & Economics, GlobalData Oil and Gas; CNPC and Sinopec reports

BHGE contract

Baker Hughes GE (BHGE) has been awarded a contract by the South Gas Company of Iraq (SGC) to help the recovery of flare gas for the Nassiriya and Al Gharraf oilfields. It will use gas processing technology developed in the U.S. and Italy to build a plant capable of producing 200 million standard cubic feet per day (MMSCCFD) of dry gas, liquefied petroleum gas (LPG) and condensate. It is due to be completed by 2021. It will also contribute to curtailing the amount of gas flared in the fields of Nassiriya and Gharraf that otherwise goes to waste.

GTL facility

Energy Security Partners (ESP), a developer of gas-to-liquids (GTL) projects, has secured funding to complete engineering & design activities for the GTL Americas (GTLA) Project near Pine Bluff, Arkansas. The facility is expected to produce 33,000 barrels per day of transportation fuels from natural gas.

Over the next 24 months, ESP will complete the detailed engineering, site preparation, natural gas purchase and supply, product sales, and raising the equity and construction financing necessary for development of the project in Jefferson County. Construction and completion of the plant is estimated to take 39 months; the plant start-up is anticipated to commence in late 2023.

Waste heat recovery

ElectraTherm has partnered with the Office of Naval Research (ONR), Creare, and the U.S. Naval Academy (USNA) to demonstrate GT waste heat recovery as part of a Small Business Innovation Research project. The demonstration was commissioned at the USNA in Annapolis, MD to prove the potential for waste heat recovery onboard ships.

ElectraTherm's Power+ Generator captures low temperature waste heat to generate power. Power+ captures waste heat from an existing helicopter GT used to train the USNA Midshipmen, using a custom designed exhaust gas heat exchanger provided by Creare. The 390 HP helicopter turbine's exhaust heat is converted to hot water, the fuel for the Power+ Generator. It converts that exhaust heat into power.

ElectraTherm's Power+

ElectraTherm uses Organic Rankine Cycle (ORC) to generate power from low temperature heat ranging from 170–252°F/77–122°C. Hot water is the only fuel consumed by the Power+. The waste heat is used to produce a high-pressure vapor that expands through ElectraTherm's twin screw power block, spinning an electric generator to produce power. After spinning the expander, the vapor is condensed back into liquid using cold water from a liquid loop radiator.


MAN's new Australian facility

MAN office

MAN Energy Solutions has opened a new site in Yennora, part of Sydney. Sydney is MAN Energy Solutions Australia's main location. Together with the workshops in Auckland, Melbourne and Perth, it provides the support network for MAN's customers in Australia, New Zealand and the Pacific Islands. The new facility features a revamped 2 MW engine test cell with an improved acoustic attenuation and an increased crane capacity (25 t, 35 m span). ■

U.S. POWER INDUSTRY OUTLOOK 2019

YEAR TWO OF THE TRUMP ADMINISTRATION SAW WIDESPREAD INTERVENTION IN ENERGY MARKETS

BY BRITT BURT & BROCK RAMEY

President Donald Trump's plan to transform the domestic energy market took several steps forward in 2018, most notably the releasing of the Affordable Clean Energy rule in August. The Trump administration's initiative largely delegated to the states decisions about regulating carbon dioxide emissions from coal-fired power plants.

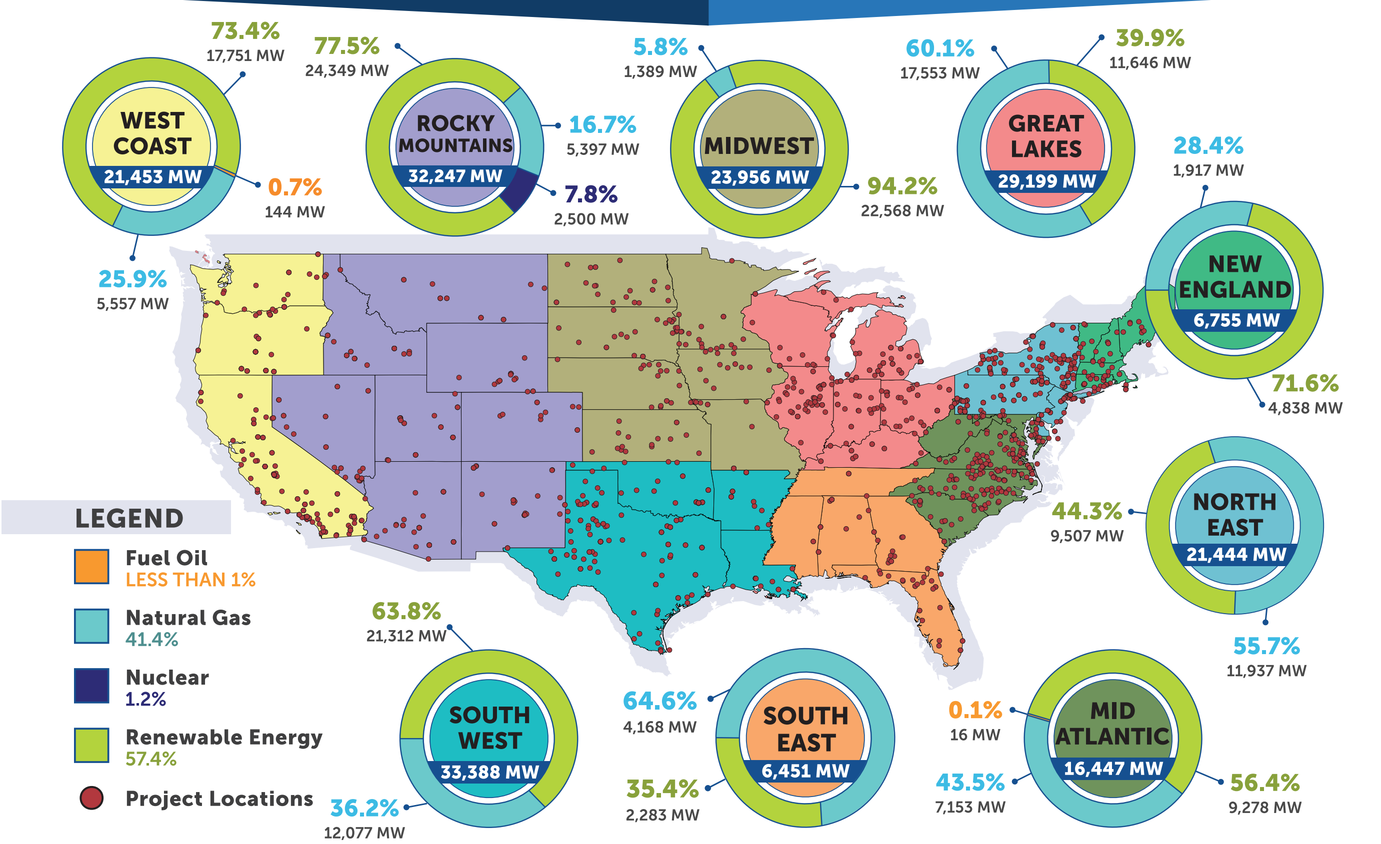
Andrew Wheeler, a former coal-industry lobbyist, took over as the U.S. Environmental Protection Agency's (EPA) acting administrator last July.

The intended beneficiaries of the administration's regulatory rollback are oil & gas companies, coal firms, coal-burning electric utilities, and electric utilities that own nuclear power plants.

The administration's efforts drew support from the nuclear and coal industries but criticism from state, regional and federal regulators, along with sectors of the energy market that could lose if the subsidies go through, including renewable energy companies, oil & gas producers, merchant generators, gas power interests, and industrial energy users.

U.S. POWER GENERATION CAPACITY

UNDER DEVELOPMENT WITH CONSTRUCTION KICK-OFF SCHEDULED DURING 2019-2023



Industrial Info Resources

All data derived from Industrial Info's Database (August 2018)

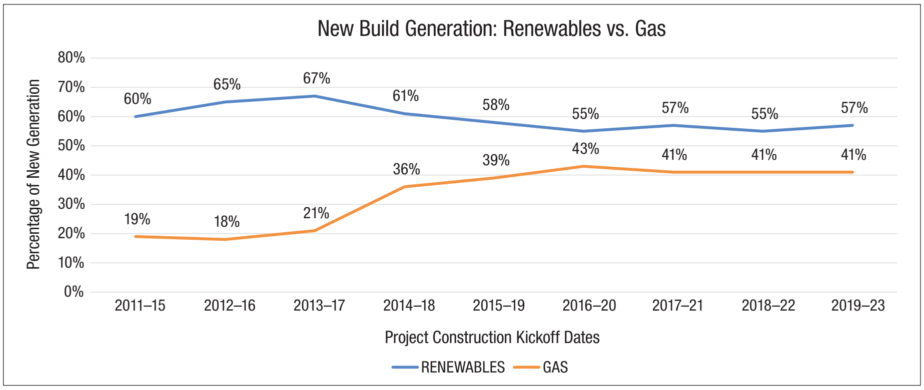


Figure 1: Renewables' and gas' share of the new-build generation market over the last nine five-year periods. *Source: IIR*

By and large, coal-burning utilities have not changed their plans to continue reducing their reliance on coal-fired generation in favor of gas or renewable generation. As of the time of writing, no company had announced plans to develop a new coal-fired power plant in the U.S. during 2018. Many analysts doubt a coal-fired generator will be built in the U.S. over the next five years.

Some measures enacted this year, including the imposition of stiff import tariffs on steel, aluminum and solar cells and panels, were not welcomed by power generators or other segments of the energy industry. They may drive up costs and disrupt the economics of near-term projects.

The President and his aides said the tariffs amounted to "short-term pain for long-term gain." There was some early indication that was true, at least for steelmakers. Profitability returned to the steel industry. Several steelmakers expanded output, capital expenditures, and employment in response to the president's moves.

But those measures also triggered a tit-for-tat, dollar-for-dollar retaliation from countries that export goods to the U.S. A potentially devastating game of "tariff chicken" has begun with each side vowing to protect their interests via successive rounds of tariffs and restrictions. Aside from increasing input costs to electricity companies, which use steel in constructing new assets, it is not clear how all of this could end.

Outside of Washington, D.C., the U.S. power generation market continued to be a two-fuel game: renewable energy and natural gas. According to data tracked by Industrial Info Resources (IIR), renewable energy will account for about 57.4% of all power generation projects scheduled to begin construction between January 2019 and December 2023. That amounts to about 121,532 MW of new generation capacity.

Natural gas, by contrast, is expected to account for approximately 87,647 MW of new generation to be built in the U.S. over the next five years, about 41.4% of all new-build generation.

Renewables' share of the new-build market has slipped a bit from its pinnacle of 67% during the 2013–2017 period (Figure 1). Some of that lost market share was captured by natural gas, as the "dash to gas" mantra helped to more than double gas' share of the new-build market over the last decade. But most of gas' gains came at the expense of coal-fired and nuclear power, which had brighter five-year outlooks a decade ago.

During the height of the "nuclear renaissance," nuclear power was scheduled to account for about 13% of all new generation built over the 2011–2015 and 2012–2016 periods, according to IIR. Today, cost overruns and construction delays have soured utilities, investors, regulators and customers on new-build nuclear power.

Only one grassroot nuclear generation project is scheduled to kick off over the next five years: the long-delayed Blue Castle Nuclear Plant in Green River, Utah. New-build nuclear is expected to account for slightly more than 1% of all generation capacity to be built over the 2019–2023 period.

Coal outlook

Despite proclamations that the war on coal is over, there is little evidence to date that coal mining or coal-fired power has turned a corner or will do so in the near future. Indeed, the U.S. Energy Information Administration reported that the amount of coal used by power generators in the U.S. fell to three-decade lows, about 661 million short tons in 2017, down about 36% from its 1983 peak.

In the U.S., the percentage of electricity generated from coal is expected to fall to 28% in 2018 and 27% in 2019, down from 30% in 2017. An expected uptick in exports will not be enough to overcome continued reduction in domestic thermal coal use.

Overall coal production will decline about 1% in 2018 and 2% in 2019, the Energy Information Administration (EIA) projected in its August 2018 Short-Term Energy Outlook.

Coal-mining companies employ about 53,000 people, according to an August 2018 estimate from the Federal Reserve Bank of St. Louis (Figure 2). That figure, which represents all job classifications in the industry (not just coal miners), was up slightly from 2016, but down dramatically from previous years. Coal interests have said recent coal initiatives have slowed the

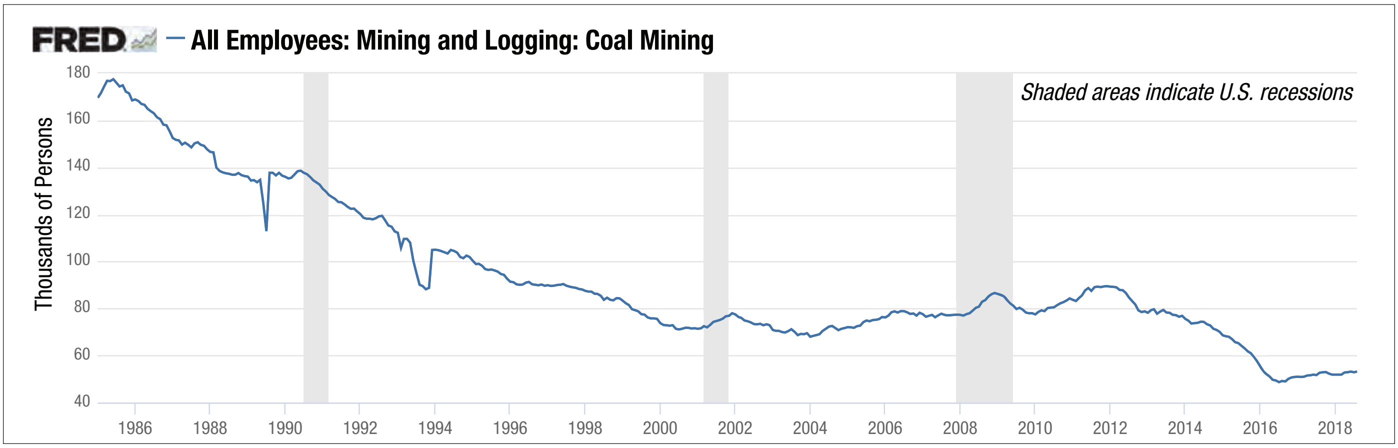


Figure 2: U.S. coal company employment since 1986. *Source: Federal Reserve Bank of St. Louis (FRED)*

Construction work for environmental remediation at some coal plants may be pushed back

bleeding and provided an opportunity to rebuild.

Power generators closed more than 12,000 MW of coal-fired capacity in 2018. Closures are expected to continue over the next five years. Although asset owners closed less coal generation in 2018 than in past years, that shuttered capacity is not being replaced by new coal-fired generation. Typically, some combination of gas-fired generation, renewables, storage and customer-facing energy efficiency programs is being used to replace the lost coal generation.

No new coal-fired generation is scheduled to be built between 2019 and 2023. In fact, asset owners have cancelled or postponed the start of construction for 40 coal-power projects valued at about $11 billion that were scheduled to begin construction during that five-year period.

New generation accounts for about $7 billion of cancelled or delayed projects, while pollution-control and carbon-recovery projects account for more than $2 billion of planned projects that have been abandoned or pushed back.

Navajo Generating Station (NGS), the largest coal-fired plant west of the Mississippi River in northern Arizona, plans to close its three-unit, 2,250-MW coal-fired plant by the end of 2019.

In Ohio, Dayton Power & Light Company (DP&L) closed two coal-fired plants with a combined generating capacity of 2,373 MW during the summer of 2018. The affected plants are the J.M. Stuart Station (1,755 MW) and the Killen Station (618 MW).

Evergy, the Kansas utility holding company formed by the merger of Great Plains Energy and Westar Energy, announced plans to close about 805 MW of coal-fired generation by yearend 2018.

At the end of last summer, FirstEnergy's merchant unit announced plans to close three coal-fired plants totaling over 4,000 MW of generating capacity. The plants were units 1–3 of the Bruce Mansfield plant in Pennsylvania, and units 5-7 of the W.H. Sammis plant in Ohio. The plants would close in 2021 and 2022.

"As with (our) nuclear (plants), our fossil-fueled plants face the insurmountable challenge of a market that does not sufficiently value their contribution to the security and flexibility of our power system," said Don Moul, president of FirstEnergy Solutions Generation. "The market fails to recognize, for example, the on-site fuel storage capability of coal, which increases the resilience of the grid."

Aside from those closures, owners of coal-fired generators in Maryland, Mississippi, Florida, Iowa, Michigan, Wisconsin and Texas all announced plant closures in 2018.

IIR tracks about 70 capital projects valued at about $3.4 billion scheduled to begin construction at U.S. coal-burning power plants between January 2019 and December 2023. Most are for environmental remediation, including installing equipment to limit NOx emissions and complying with regulations like Coal Combustion Residuals (CCR) and Effluent Limitations Guidelines (ELG).

But there is a chance that some of that scheduled work will be pushed back following a mid-2018 revision to the CCR regulation from the EPA delaying the

effective date of some coal-ash pond closures and granting more flexibility to states and utilities in how they treat those sites.

That first set of revisions to the CCR rule will affect an estimated 400 coal-fired power plants across the country. The EPA estimates the new rules will save power plant owners $28 million to $31 million annually on compliance costs.

The first set of revisions to the CCR rule was the first major policy decision of Acting Administrator Andrew Wheeler. A second set of revisions to the CCR regulation, expected to be issued in early 2019, is likely to address how to recycle coal ash to make concrete, gypsum wallboard and pavement. IIR is tracking two dozen CCR-related projects valued at about $1.75 billion.

The EPA is expected to make changes to another regulation affecting coal-fired generators, the Effluent Limitations Guideline (ELG) rule. Five ELG projects valued at about $282 million are scheduled to kick off at coal-fired power plants over the 2019-2023 period.

Another type of construction activity at coal-fired generators — plant decommissioning and demolition — is expected to generate about $343 million of work over the next five years. Additionally, in-plant capital outlays to refurbish boilers and rewind, replace or upgrade turbines is expected to account for about $151 million of work over the next five years.

Natural gas outlook

Gas is great
Gas is good
What could stop it?
Regulators could!

Though that ditty was not heard at recent industry conferences, it became increasingly apparent in 2018 that state regulators could do what geology or economics could not: slow the rise of new-build, gas-fired generation.

As is often the case, it appears California started the trend. Under separate mandates from the state legislature to reduce carbon emissions and increase the use of renewables, the state's utility regulators began turning against gas-fired generation in 2018.

One data point in this trend was the decision by the California Public Utilities Commission (CPUC) in January 2018 to deny Pacific Gas & Electric (PG&E) the opportunity to use power from three existing gas-fired units to meet customer demand and system voltage requirements. Those three Northern California plants, totaling about 700 MW of generation capacity, are operated by Calpine Corporation.

Another data point is a 564 MW, out-of-market gas-fired power plant in San Jose. Also owned by Calpine, it had been awarded a "reliability must run" designation by the California Independent System Operator (ISO).

However, the CPUC challenged that action, arguing that energy storage projects could be more economic than classifying the Metcalf Energy Center as a must-run power plant. Separately, another merchant plant owner, NRG Energy Incorporated, asked the CPUC for a delay in considering its application to build a 262 MW Puente Power Plant for Southern California Edison (SCE).

In yet another development, in April 2018, the Glendale, California, City Council placed a hold on plans to repower the 80-year-old Grayson Power Plant, a 500 MW gas-fired generator. Instead, the city council instructed the local utility, Glendale Water & Power, to more fully investigate cleaner, non-emitting electric options.

Finally, on one of its last legislative days in the 2018 session, California lawmakers adopted a plan to require all retail electricity to be carbon free by 2045.

Even before the state legislature acted, the trend against gas-fired generation was becoming apparent in regional projections for fuel types in new-build generation in various regions.

States on the west coast plan to build only about 5,557 MW of gas-fired generation over the next five years, down 72% from their plans only one year ago when natural gas was scheduled to account for about 49% of new generation built between 2018 and 2022. Given California's 100% carbon free mandate, the region's number of new-build gas plants may drop further.

Other states in the West, including Oregon and Washington, have upped their renewable portfolio standard (RPS) in recent years or adopted mandates to lower carbon emissions. These are critical factors that may cause regulators, utilities, and developers to rethink gas power in those states.

But there is a different picture in other parts of the country. Several regions, including the Great Lakes, the Northeast, the Mid-Atlantic, and the Southwest, plan to dramatically increase their fleet of gas-fired generators over the next five years.

Renewables outlook

Renewable generation is expected to account for about 57.4% of all new-build power projects over the next five years. On a percentage basis, the areas that have turned most sharply to sun and wind are the Midwest, Rocky Mountains, West Coast and New England regions.

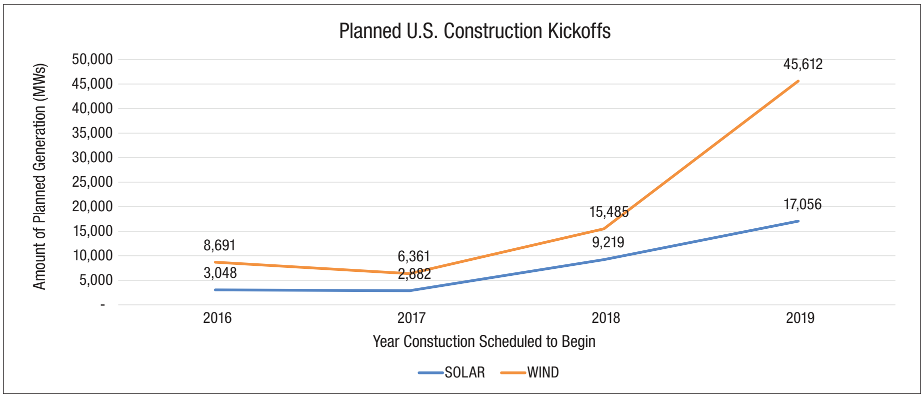


Figure 3: Planned construction kickoff dates for U.S. Wind and Solar projects. *Source: Industrial Info Resources*

In terms of raw numbers, the Rocky Mountains, with plans to build 24,339 MW of renewables over the next five years, edges out the Midwest (22,568 MW), the Southwest (17,751 MW) and the West Coast (15,571 MW) as the region most enthusiastically going for renewable energy.

Within the renewables segment, measured by "fuel," there is far more installed wind generation than solar generation in the U.S. Near-term plans to build more wind turbines continue to outnumber plans to build solar generation (Figure 3).

But wind power developers are battling something that solar power developers are not: financial incentives that decline by the year. Boom and bust cycles created by tax incentives play a large role in what amount of renewable generation moves forward in a given year. The federal production tax credits (PTCs), which benefit wind, continue to decline.

When Congress last extended those PTCs in late 2015, it wanted to incent developers to get steel in the ground sooner rather than later. For each year between 2016 and 2020, tax credits are lowered 20%.

Companies that broke ground on a wind project in 2016 were eligible to receive 100% of the 2.3 cents per kilowatt-hour PTC. Companies that broke ground on a project in 2019, by contrast, will only be eligible for 40% of the credit less than $0.01/kWh. By yearend 2020, the credits sunset.

Not surprisingly, developers responded as incented: 52 projects valued at about $14.7 billion were completed in 2016 compared to 44 projects worth $12.7 billion finished in 2017. Preliminary estimates show that seven projects with total generating capacity of about 1,200 MW and valued at $2 billion are scheduled to start operating in 2018.

In mid-2018, a Nebraska utility reportedly signed a power purchase agreement for wind at $11/MWh. That number, if confirmed, would represent a historic low price for wind power.

Meanwhile, the sun continues to rise for solar power. The solar industry's Investment Tax Credits (ITCs) were extended for five years in late 2015. Projects that begin construction before yearend 2020 are eligible for the full 30% tax credit. Projects breaking ground after 2020 would be eligible for less federal largesse.

Predictably, 2016 saw a surge of U.S. solar power development: 76 projects worth about $13.4 billion were completed that year. The next year, 77 projects worth $5.9 billion began operating. Preliminary estimates were that 32 solar projects valued at about $2.75 billion would come online in 2018.

Over the next few years, there is no shortage of work for renewable power developers, whatever their fuel. But developers are expected to keep a close eye on the calendar, as additional extensions of the PTC or ITC seem unlikely at this time.

Renewable energy may be the ultimate bipartisan energy issue, with broad and strong support from Republicans and Democrats across numerous states. But predicting what could happen in two years' time, when the PTC sunsets and the ITC starts declining, seems like a fool's errand.

The Trump administration's decision to levy a 25% tariff on imported steel, plus tariffs on imported solar cells and panels, enacted in early 2018, scrambled the economics of several thousand MWs of proposed renewable energy projects.

Nuclear outlook

The U.S. nuclear renaissance has officially receded in the rear-view mirror. The owner of Iowa's Duane Arnold Nuclear Power Station in mid-2018 joined the owners of nuclear plants in Nebraska, Vermont, Massachusetts, New York, New Jersey, California, and Wisconsin in deciding to prematurely retire operating nuclear plants.

The reason: cheap, abundant natural gas and, in some areas, high-quality wind or solar resources, that make gas, wind and solar power a more competitive alternative to nuclear (or coal).

In recent years, some states, including Illinois, New York and New Jersey, have enacted financial aid packages to keep uneconomic nuclear plants in their states open. But other states, including Connecticut, Ohio and Pennsylvania, have resisted financially propping up uneconomic nuclear plants.

Rebuffed by lawmakers in Ohio and Pennsylvania, FirstEnergy Solutions, the merchant-power unit of FirstEnergy Corporation, filed for Chapter 11 bankruptcy in early 2018 and began notifying regulators of plans to deactivate its three nuclear units: Davis-Besse (planned deactivation date, May 2020), Perry (May 2021) and Beaver Valley (Unit 1: May 2021; Unit 2: October 2021).

Those three plants have combined generating capacity of 4,048 MW. The two Ohio plants, Perry and Davis-Besse, generated nearly 90% of the Buckeye State's carbon-free generating capacity.

During the summer of 2017, after investing an estimated $9 billion to build two new units at the V.C. Summer Nuclear Power Station in South Carolina, the owners terminated that project. Following that decision, investigators, litigators, lawmakers and customer advocates swarmed over owners South Carolina Electric & Gas and Santee Cooper. Several executives departed, and the new leaders confronted the prospect of forced sales and dramatic electricity price reductions to refund some of the billions collected from customers for nuclear generation that will never operate.

Meanwhile, in Waynesboro, Georgia, where Georgia Power Company is adding two new units to its Alvin W. Vogtle Nuclear Power Station, costs continued to escalate. In late 2017, the Georgia Public Service Commission accepted Georgia Power's recommendation that construction continue. The project as originally budgeted in 2001 was projected to cost about $7.5 billion, but by late 2017 new cost estimates put the capital cost at about $25 billion.

At the end of 2017, regulators unanimously agreed to let construction at Vogtle to continue. Nine months later, in August 2018, Georgia Power said costs to complete the project jumped again, by about $2.3 billion, to over $27 billion, not including financing costs. The in-service dates remained November 2021 for Unit 3 and November 2022 for Unit 4.

The main reason for the cost escalation, Southern Company Chief Executive Officer Tom Fanning told investors, was scarcity of skilled craft labor. There were about 7,000 workers at the Vogtle site, 1,100 of which were electricians and pipefitters. But in an early August earnings call with analysts, he estimated an additional 600 electricians were urgently needed.

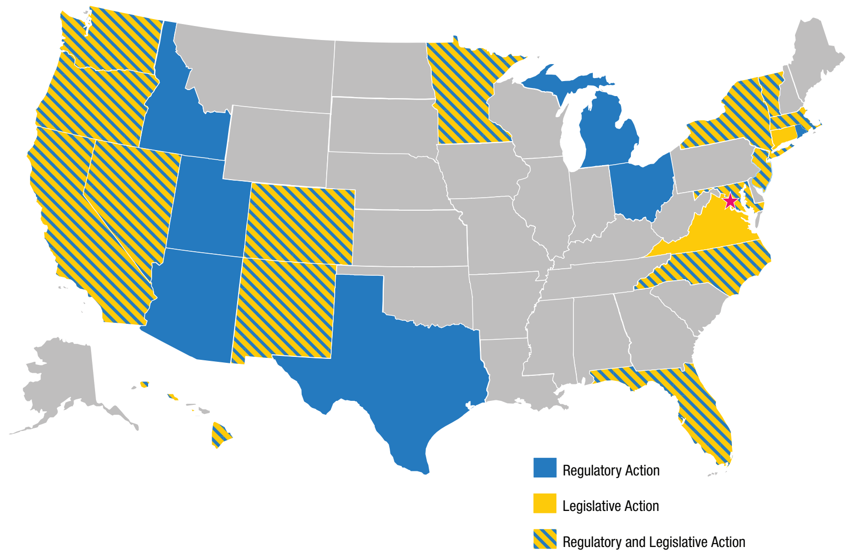


Figure 4: Map of energy storage regulatory and legislative activity.
Source: Energy Storage Association

With the cancellation of the Summer project and the continuation of the Vogtle project, no other nuclear generators were under construction in 2017. And, with the exception of Utah's Blue Castle project, no other nuclear projects are scheduled to begin construction for the next five years.

A big part of the reason for nuclear power's recent troubles was Westinghouse Electric Corporation's decision in March 2017 to declare Chapter 11 bankruptcy and exit the new-build nuclear construction business. But that was not the first sign that all was not well in the nuclear world.

In recent years, one utility after another deferred, then cancelled, plans to build new nuclear units. Nuclear turned out to be a bet-the-company proposition where the rewards for success were modest, but the cost of failure was catastrophic.

Aside from new-build, project activity in the nuclear area over the 2019-2023 period is limited to small modular reactors (SMRs), dismantlement and demolition of shuttered plants and in-plant capital projects like steam generator replacements and controls upgrades. No nuclear uprate projects are on the horizon for the next five years.

Battery energy storage systems

In recent years, utility-scale battery energy storage systems (BESS) have gone through an intense phase of research & development, pilot demonstrations, and full-scale commercial deployments, all aided by supportive regulatory decisions. Early successes have moved this category of technology closer to the center of the electricity business from its former position at the industry's periphery. Indeed, BESS now is the belle of the electricity ball.

Even its staunchest advocates do not claim BESS will fix all that bedevils wholesale and retail electric markets. But battery storage is seen by a growing number of decision makers as a valuable, flexible and multi-purpose resource. Over the next five years, we anticipate utility-scale BESS will become a multibillion-dollar business. We expect to see at least 1,300 MW of BESS projects operating by year-end 2020. The number could be considerably higher.

BESS got a lot more attractive following a favorable ruling from Federal Energy Regulatory Commission (FERC) in early 2018. That opened wholesale markets to energy storage on an equal footing with generators and other resources. The industry spent a lot of time and effort in 2018 trying to figure out how that could work and what it might look like.

In that order, FERC instructed each of the nine organized regional transmission organizations (RTOs) and ISOs where it has jurisdiction to return to the agency by year-end 2018 with a plan to remove obstacles to considering storage on a level playing field with other resources. According to news reports, the nation's largest organized market, PJM, has deployed over 250 MW of battery energy storage projects since 2013.

A few years ago, California utility regulators got the BESS ball rolling in a big way when they issued specific mandates for energy storage projects, triggering an avalanche of bids for utilities in the Golden State. Battery energy storage projects helped utilities in California keep the lights on through the retirement of the San Onofre

Nuclear Generating Station, the loss of the Aliso Canyon natural gas storage facility and the scorching summer of 2017.

Across the nation, battery storage projects of various sizes and purposes were being procured and deployed. Assuming they perform as planned, we expect the pace of procurements and deployments to accelerate over the next five years.

BESS projects are being used to defer capital outlays on a utility's transmission & distribution (T&D) system, provide voltage support, reshape customer electric demand, get around distribution transformer bottlenecks, and help electric utilities keep the lights on during emergencies or operational challenges.

Some executives have termed storage "the Swiss Army knife of energy." Costs have declined rapidly — about 70% over the last three years, by one estimate, helping drive more pilots and full-scale commercial deployments.

Storage could create more optionality for utilities, which means it can have a lot of value. Rather than investing heavily to build costly new generation or T&D infrastructure, utilities increasingly are warming to storage as a smaller-scale resource with lower costs, faster installation times and more targeted deployments compared with traditional generation or T&D projects. Utility-scale BESS could reshuffle the economics of the electricity business.

If storage projects can help utilities burnish their environmental credentials, so much the better. BESS could help California attack its so-called "duck curve" problem, where renewable generation produces far more electricity than is needed during peak demand hours, forcing the cycling of other plants that are not designated as "reliability must run."

And in Texas, the Great Plains and the Midwest, when winds gust at 3 a.m. but no one is using electricity, storage could play a huge role in making more efficient use of those area's abundant wind resource and large installed base of wind generation.

BESS projects were an important part of responses to a request for proposals (RFP) issued by Xcel Energy subsidiary Public Service Company of Colorado (PSCo) at the end of 2016. In mid-2018, after weighing all the bids, the utility approached state utility regulators with a long-term energy plan that included 275 MW of electricity-storage projects.

In disclosing the details of the bids, PSCo said the median price of bids for wind + battery storage was $21 per MWh. The median price of bids for solar + battery storage $36 per MWh. Unlike average prices, median prices reflect an equal number of price points above and below the median number. So, there is reason to assume battery storage will soon be making a large splash across Colorado.

A growing number of other states are looking at BESS in a more favorable light. The list of states exploring, or committing to, some level of storage is long and getting longer every day. Besides California and Colorado, others include New York, New Jersey, Massachusetts, Florida, North Carolina, Illinois, Hawaii, Oregon, Arizona, and Nevada (Figure 4). As the technology proves itself to be reliable and cost-effective, that list is expected to grow over the next five years.

In mid-2018, Arizona Public Service Company issued an RFP to add up to 106 MW of battery storage to its solar plants. The utility said that bid was part of its 15-year plan to add up to 500 MW of battery storage.

IIR is tracking 30 utility-scale battery storage projects valued at about $2 billion that are scheduled to begin construction over the next five years. That number should grow over the next five years, depending on regulatory mandates and the outcome of early deployments.

One market research firm predicted lithium-ion battery-storage projects will fall below $200/kWh in 2019. Regardless of the exact price point, all sides agree the price trajectory is moving down, making storage an increasingly viable product that could provide value to utilities in a wide range of settings.

Microgrids and distributed generation

Like utility-scale BESS, microgrids now are being viewed more favorably both by utilities as well as non-utility organizations. The U.S. market for microgrids continues to build, driven by utility efforts to make their T&D networks more resilient, particularly after natural disasters like Superstorm Sandy in 2012 and hurricanes Harvey and Irma in 2017.

Aside from utilities, large power-sensitive customers, such as hospitals, data centers, distribution centers and local governments, are spending more time investigating how microgrids could make them less susceptible to the vicissitudes of severe weather and utility operations. Currently, microgrids capable of distributing more than 1,500 MW of electricity are operating in the U.S. Another 3,000 MW could be added by the end of 2020.

Engineering and consulting firms are doing a brisk business assessing microgrids. The U.S. Department of Energy has a robust grant program issuing funding for several ongoing and future studies.

Like BESS and microgrids, distributed energy resources (DERs) continue to grow in importance, a trend that should continue for the next five years. Right now, there are an estimated 3,000 MW of distributed solar and wind, fuel cells, small-scale combined heat and power (CHP) and internal combustion projects in operation in the U.S. DER deployment is being driven by corporate clean-energy pledges and rooftop solar power.

But microgrids do have their challenges, including regulations, costs, and a rapidly evolving base of knowledge. Regulatory challenges include how to craft net metering 2.0 regulations that will not disadvantage those customers who cannot or choose not to install DERs. But the DER market has grown rapidly, to an estimated base of about $150 billion by 2016, and we expect nearly another $170 billion will be invested by 2020.

Looking ahead

Advanced technology, dynamic regulatory mandates, and shifting fuel and capital costs continue to roil the power generation business. Consumer preferences increasingly are playing a role in the industry's tumult, as residential and commercial customers in one state after another tell their regulators and power providers they do not mind paying slightly more, if they have to, for electricity with beneficial environmental attributes. In some cases, there is no longer a "green premium" for purchasing renewable or carbon-free electricity.

Consumer preferences appear to be something some industry veterans have trouble accepting and internalizing. For an industry long based on scale and cost/kWh, factoring the diverse needs and wants of customers into capital budgets and operating plans produces a bit of a deer-in-the-headlights look. But for those that are uncomfortable with the pace of industry transformation, there is no sign it will slow down any time over the next five years. ■

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IMPROVING COMPRESSOR AFTERMARKET SERVICE

Ryan Canter, Vice President Sales and Marketing, Centrifugal at Epic International, discusses the centrifugal compressor aftermarket, the skills shortage, and how to improve compressor maintenance.

Tell our readers briefly about Epic.

Headquartered in Houston, TX, Epic International was founded in 2015 and serves the global energy and industrial engine-compressor market with parts, repair services, and field service. Our entire business is focused on the engine-compressor aftermarket without the distraction of a new equipment business. Epic Air, a division that focuses on centrifugal equipment, became a resource for the centrifugal compression aftermarket with the 2016 acquisition of Air Relief of Mayfield, KY. We have two established domestic repair facilities (Houston and Mayfield, Kentucky), a team of OEM factory-trained technicians, and the new Air Relief and TurboLogix brands. This allows us to serve the world's 50-60 Hz market and comply with major quality requirements.

What new services have you recently added?

In the spring of 2018, we became a full supplier of parts, repairs, field service, and technical support for Atlas Copco HP, ZH, ZT and ZR rotary screw compressors.

What trends have you observed?

The demand for high-quality manufactured parts, and the maintenance cycles that consume such components, have not changed much over the years. What has changed is the availability of key components as equipment owners and suppliers have cut inventories to reduce long-term costs and improve cash flow. This trend has opened up an opportunity for those compressor component suppliers with a customer-service mindset and that are willing to stock inventories in multiple locations globally.

What trends have you observed with centrifugal compressor repair?

As the cost of impellers, diffusers, and inlets has risen, demand for repair services has increased. This has been a trend in the North American market for some time. But we are starting to see much higher demand for creative and quality repair services in Europe and the Far East. Epic has repaired rotors from 37 nations in the last 24 months, which is an increase of 15 nations during the previous 12 months.

There has been a huge loss of experience in the field which drives organizations like Epic to focus on technical training and continuous education of employees and customer personnel.

What new services have you recently added?

In the fall of 2017, we opened a 10,000 sq. ft. facility in Milan, Italy for Europe, Middle East, and Africa. In the spring of 2018, we became a full supplier of parts, repairs, field service, and technical support for Atlas Copco HP, ZH, ZT and ZR rotary screw compressors.

We recently added a full-service aftermarket program called EpicCare that allows the equipment owner to turn the entire compressor maintenance program over to Epic Air. This "contract maintenance" program combines planned maintenance, parts discounts, extended warranties, and our new TurboLogic controls system to provide a maintenance program that improves compressor performance and reduces maintenance costs.

What trends have you observed in field service?

The most impactful trend is retirement of skilled field service professionals. As workforces diminished, companies have not replaced these workers quickly. This fosters the need for full-service turnkey suppliers with senior field service staffs and mechanics. It is expensive and difficult to find skilled people for this kind of work. Customers are turning to aftermarket suppliers to supplement their own maintenance efforts.

How has the experience level of operations and maintenance personnel changed over time?

There has been a huge loss of experience in the field which drives organizations like Epic to focus on technical training and continuous education of employees and customer personnel. We conduct centrifugal compressor seminars in the U.S., Europe, and Asia. We cover theory, operations and maintenance.

What would you recommend plants do when they are experiencing heavy personnel losses?

Reach out to technical schools, create internship or apprentice-type programs, and invest in internal training. These are long-term commitments that must be planned and funded carefully, or the results will be less than inspiring.

In lieu of these efforts, there are many contract-type services offered by compressor repair suppliers. Turning your maintenance program over to a repair expert can reap many benefits if the program is jointly planned and executed.

Is there any company news you wish to communicate?

We recently hired Mike Pelezo as our Vice President of Service and Operations, and John Sargent as our Chief Executive Officer. Both are compressor industry veterans with a combined 50+ years of experience at companies like Cameron, Schlumberger, Spitzer and El Paso Corp. ■

WORLDWIDE GAS TURBINE FORECAST

DECLINES ARE APPARENT FOR THE NEXT FEW YEARS, BUT A MARKET RECOVERY IS IN SIGHT

BY STUART SLADE AND CARTER PALMER

Overcapacity of power generation equipment and the resulting softness of prices is impacting the gas turbine-powered electrical generation market. In short, companies are selling significantly fewer gas turbines than predicted and are receiving a lower unit price on each sale.

The direness of the situation is exemplified in a recent statement from Siemens AG about the restructuring of its power generation activities to accommodate the world situation:

> *"Global demand for large gas turbines (generating more than 100 megawatts) has fallen drastically and is expected to level out at around 110 turbines a year. By contrast, the technical manufacturing capacity of all producers worldwide is estimated at around 400 turbines."*

These figures confirm independent estimates by Forecast International that showed power generation gas turbine sales over the period 2018–2027 will total $107.433 billion, a decrease of 7.35% over sales during the 2017–2026 period. This equates to a significant reduction in income and greater pressure on profit margins.

As a result, all three of the leading companies in the power generation equipment sector, GE, Siemens and MHPS, have undertaken major restructuring initiatives to reduce costs and rationalize production.

For the near term, there appears to be little relief in sight from the current market depression. Indeed, as projections

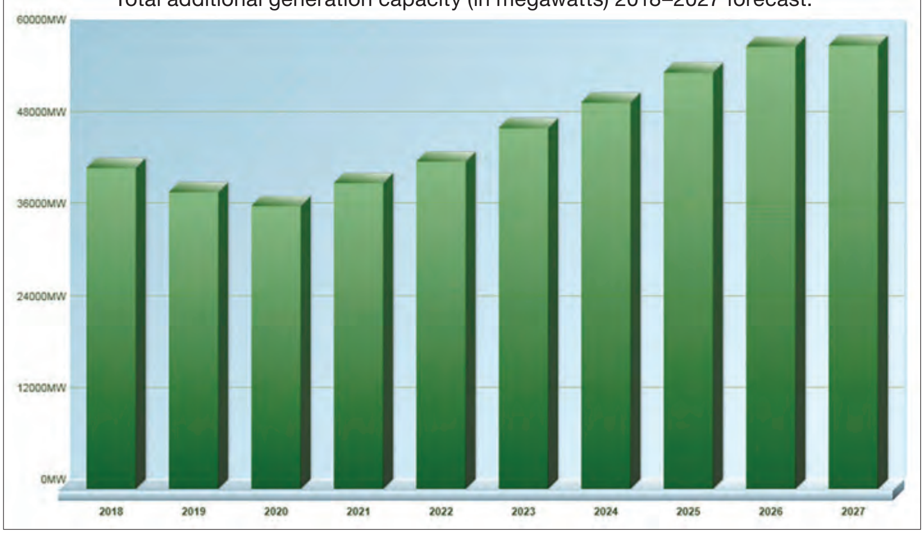


Figure 1: Gas turbine electrical power generation.
Total additional generation capacity (in megawatts) 2018–2027 forecast.

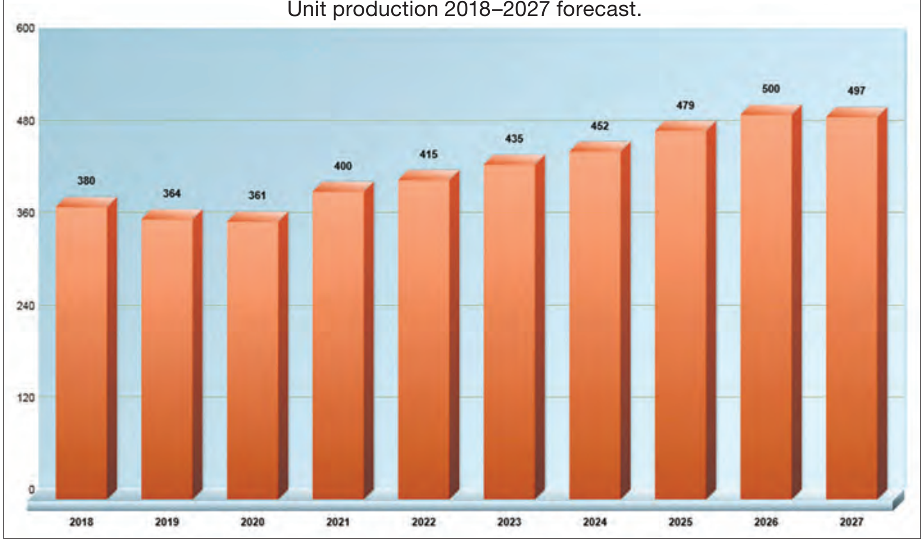


Figure 2: Gas turbine electrical power generation.
Unit production 2018–2027 forecast.

have been refined, the market recession has grown deeper and is extending further into the future.

In 2018, Forecast International undertook a modernization of its industrial and marine databases. Power brackets have been refined to accommodate steady increases in gas turbine output and calculations of added power production capacity supplementing the existing unit and value forecasts. These changes turned out to be revealing (Figure 1).

Based on this information, it appears certain that the current situation of reduced demand, overcapacity, and soft prices is set to continue until at least the early 2020s. It will probably be 2022 before annual increases in installed capacity equal those of 2018, which represented a substantial reduction over previous years. However, the recovery of installed capacity from this low point is quite marked and increases rapidly until around 2026.

The primary driver for this recovery is the development of large combined cycle facilities in industrialized nations, notably Japan, Europe and Asia. The replacement of highly polluting plants will be a significant factor during this period.

It will be supplemented by the modernization of older facilities to meet efficiency standards. Gas turbines built in the 1960s and early 1970s are going to be replaced with modern turbines. The significance of this trend in added capacity can be illustrated by comparing Figure 1 to Figure 2 on unit sales.

Comparing these charts, it can be seen that the average output of a power generation gas turbine in 2018 is 110 MW. By 2027, this increases to 116.5 MW. A close examination of the data shows that this trend is accelerating. Note that this figure does not take into the account the major increase in output and efficiency resulting from the widespread introduction of larger-scale combined cycle plants.

The recovery of waste heat from gas turbines and its use to drive a steam turbine has resulted in efficiencies in excess of 60% for plants with outputs in the 800 MW to 1,000 MW range.

This highlights another profound change in the financial picture. Gas turbine procurement is no longer directly related to increasing power demands. Instead, the option of procuring additional gas turbines is but one of many that are available to both generation and distribution companies.

Another way of looking at this is to compare the costs of generating a megawatt of power in 2018 with those likely to be applicable in 2027. In 2018, it cost a total of $4.2 million to add a megawatt of generating capacity. By 2027, this figure will rise to $4.4 million. There is, of course, considerable regional variation.

Figure 3: Gas turbine electrical power generation.
Value statistics 2018–2027 forecast.

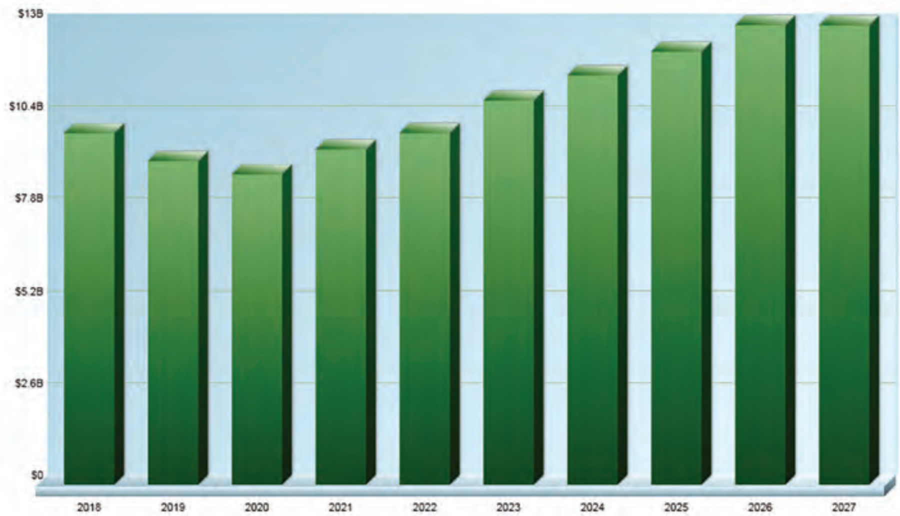
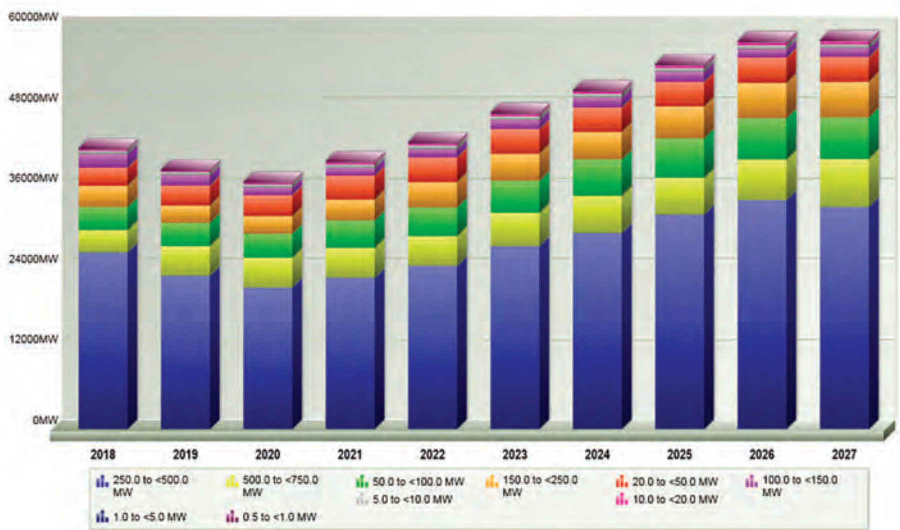


Figure 4: Gas turbine electrical power generation.
Additional projected installed capacity % market share by power class (in megawatts) 2018–2027.



Comparing the projected graphs for the 2018–2027 period in terms of total power output, number of units and value (Figures 1, 2, and 3), shows that the two most closely aligned are value of production and total power output. The post-recession increases are significantly lower when expressed in units than they are when displayed in value and power output.

This suggests that the largest turbines represent the major area of industry growth, those in the 250–500 MW and 500–750 MW brackets. At the same time, we are also seeing significant growth in the microturbine area.

Putting these factors together suggests that the smaller gas turbine power output class in the 20–100 MW brackets is being squeezed. This is also area the area where aeroderivative turbines are making their greatest impact. This does not bode well for established non-aeroderivative products in this bracket.

Figure 4 highlights total installed power output for the 2018–2027 period by power class. It is apparent that the 250–500 MW class is the backbone of the power generation industry and looks set to hold this position for at least the next decade.

This category has been a less badly hit by the current recession than most other sectors. The 500–750 MW segment is also gaining steadily in importance as is the 50–150

Figure 5: 1MW–10MW ten year 2018–2027.
Unit production 2018–2027.

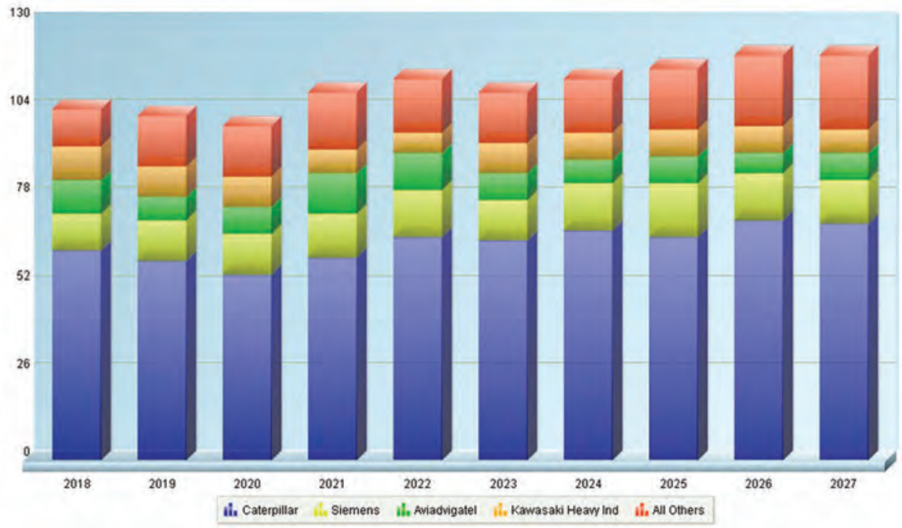
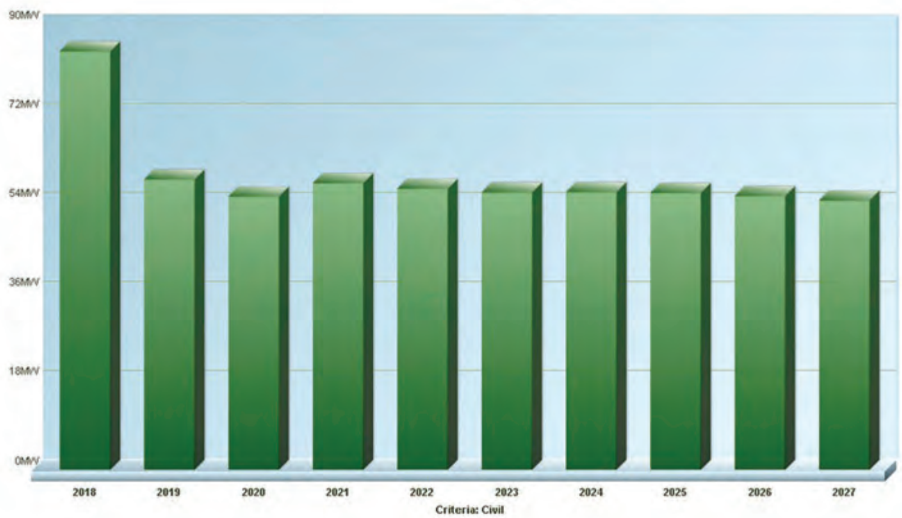


Figure 6: Microturbine electrical power generation.
Total additional generation capacity (in megawatts) 2018–2027 forecast.



MW segment. The latter sector appears to be largely due to aeroderivative gas turbines.

Small turbines and microturbines make a tiny contribution to overall power capacity. But they account for the majority of unit sales. The modularity and flexibility of smaller turbines as well as low emissions levels are some of the advantages promoting their adoption.

Small turbines and microturbines

The outlook is largely positive for small gas turbines in the 1 MW to 10 MW range. Market analysis reveals a slight decrease in value and unit production over the near-term with overall positive growth out to 2027 (Figure 5). Gas turbines in this power class, though, face stiff competition. Reciprocating engines are gaining ground due to relatively high efficiency in this power range.

Mircroturbines have a slightly different outlook. Power generation capacity is predicted to level off in the forecast period. There was a significant increase in the market in 2018 due to a huge Russian order for FlexEnergy turbines (Figure 6).

Unit production, though, may be in for a shake-up. Two new European companies are coming to market with unconventional products. Micro Turbine Technologies and Bladon Jets have both developed small machines. MTT's EnerTwin produces 3.2 kW and is optimized for heat production in smaller buildings.

Bladon Jets' MTG12 is 12 kW and geared for powering remote mobile phone towers. These new microturbines are just hitting the market. Their overall share will be minor in terms of power production and value. But both are likely to have a significant impact on unit totals (Figure 7). While Capstone Turbine will remain the top unit producer, Bladon and MTT are predicted to occupy second and third place over the forecast period.

Regional trends

Changing user consumption profiles has become a worldwide phenomenon, although the motivation may differ from region to region. In Europe and the U.S., the primary driver is to reduce electricity demand and thus reduce pollution and eliminate potentially harmful emissions.

In other areas, the economic benefits of new, power-efficient technologies are the leading driver, placing electrical equipment within the reach of people who otherwise could not afford to run it.

Some factors, though, are common on a worldwide basis. Natural gas has become the go-to fuel for power generation, feeding at least 75% of gas turbines used for generation duty. Yet even here, there are exceptions. Coal- and oil-powered plants are still ordered in the Asia-Pacific region, while coal is preferred in Eastern Europe.

The forecast for the next ten years has North America continuing as the largest market in terms of added capacity and value of gas turbines (Figures 8 and 9), with Europe second. Both markets, however, can be considered mature. There is plenty of unrealized potential for gas turbine additions in other regions.

United States of America

According to the U.S. Energy Information Administration, coal currently accounts for about 41% of the nation's power versus 27% from natural gas. This situation is changing fast. By 2035, the agency anticipates natural gas will be the primary fuel for power generation.

Natural gas-fired generation is projected to grow 3.1% a year through 2038, meaning that more than 340,000 MW of gas-fired capacity will be added to the U.S. grid in that time frame.

The primary factors driving the shift to gas-powered generation are the favorable economics of building gas plants, confidence in the long-term fuel supply, and environmental regulations that are making the continued use of coal-fired generation more arduous.

However, there has been a push by the current administration to roll back the phase-out of coal and to find ways of enabling its use in environmentally responsible power plants.

Continued on 38

The impact of improved distribution and grid control in the U.S. is continuing to blur the distinction between baseload capacity and the rest. Now, only nuclear-powered generation capacity is unequivocally considered to be baseload due to its long run times at steady-state load. In this climate, sales of G-, H- and J-class machines are increasing as utilities place more importance on efficiency.

Western Europe

According to Eurostat, the primary source of energy data on countries within the European Union, total net electricity generation in the EU was 2.78 million gigawatt hours (GWh) in 2016. This represented an increase of 1.1% from the year before, reversing a long-standing fall in output dating back to 2011. In aggregate, however, the level of net electricity generation in 2016 was still 14% lower than its peak level of 3.22 million GWh in 2008.

Germany had the highest level of net electricity generation in 2014 among the EU member states, accounting for 18.6% of the EU total, just ahead of France at 15.8%. The United Kingdom was the only other member state with a double-digit share, at 10.9%.

The drive to reduce emissions, conserve resources, and increase energy efficiency has affected European generation by bringing about the elimination of older plants and slashing the use of coal. In Britain, this has resulted in the virtual elimination of coal as a power generation fuel.

Figure 7: Microturbine electrical power generation—civil.
Unit production % market share by manufacturer 2018–2027.

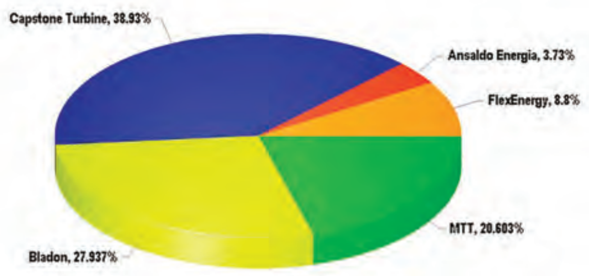


Figure 8: Gas turbine electrical power generation.
Ten year additional projected installed capacity % market share by end user region (in megawatts) 2018–2027.
(User-selected date range no applicable.)

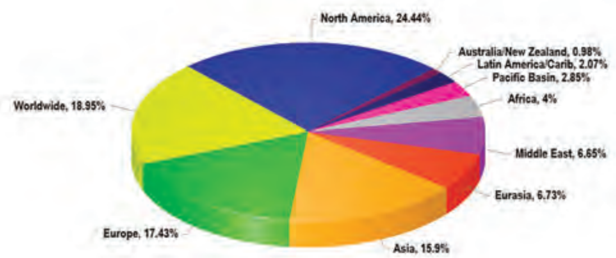
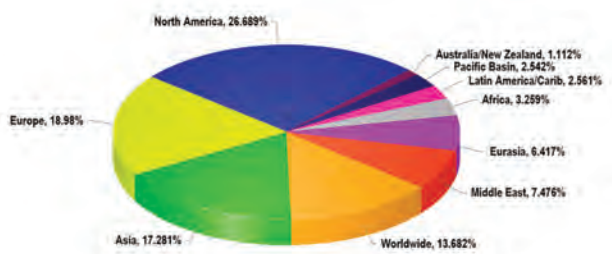


Figure 9: Gas turbine electrical power generation.
Ten year value statistics % market share by end user region 2018–2027. (User-selected date range no applicable.)



A declining energy market does not appear to be good news for turbine suppliers, but the situation is not completely negative. Older, less efficient plants are being replaced by new technology. Gas is replacing coal, and cogeneration is becoming more commonplace. Thus, Western Europe will continue to be a marketplace for power generation turbines, although major growth will be found elsewhere.

Eastern Europe

The fall in electricity generation over the period 2010–2014 may have been reproduced across Western Europe. But net electricity generation rose in Eastern Europe, including Romania, Poland, Slovenia, Bulgaria and the Czech Republic.

The primary driver here has been the long, slow recovery of these countries from the decades of stagnation under communism. They have emerged with legacy power generation systems comprised of old, inefficient, and poorly maintained equipment.

At the moment, natural gas only accounts for 9% of generation capacity in this region. Doubts over the stability of supplies from Russia count against further expansion of gas-fired capacity.

Gas turbines, though, retain a strong position in Poland, Croatia, Macedonia and Hungary. Poland has plans to build up to 8,000 MW of gas-fired generating capacity over the next decade.

Overall, market opportunities in Eastern Europe are good. Constraining factors are economic rather than technical or environmental. This suggests that companies selling successfully to this market sector will do so by aiding customers in finding financing.

Southeast Asia

Southeast Asia's energy demand is projected to grow by 80% by 2040 as the regional economy triples in size and the population rises by almost a quarter to 760 million. Oil demand is predicted to rise from 4.7 million barrels per day in 2014 to 6.8 million b/d in 2040, and natural gas use will grow by almost two-thirds to around 265 billion cubic meters.

In sharp contrast to the regions above, coal demand will expand at an unprecedented rate. By the end of the projection period, coal will overtake oil to become the largest fuel in the energy mix.

Meeting Southeast Asia's hunger for electrical power will require the installation of 400 GW of power generation capacity, of which 40% will be coal fired. The rise in coal use is underpinned by economic factors, abundant supplies, and the need for rapid electrification.

But it also highlights the need to accelerate the deployment of more efficient technologies to address the rise in local pollution and CO_2 emissions. There remains significant potential for deploying more efficient coal-fired power plants.

The average efficiency of Southeast Asia's coal-fired power plants has increased by about 5% in recent years, but more than 50% of total coal-fired installed capacity in the region is still below world standard efficiency levels.

Another aspect of the energy situation in Southeast Asia is limited power generation grids and regional interconnectivity. In some areas, they are almost non-existent. These conditions run against investment in power generation since a glut of power in one area cannot easily be transferred to cover deficits in another.

This, more than a lack of total generating capacity, explains the prevalence of brownouts and gasouts in many parts of the region. Major increases in power generation capacity and enhanced grid interconnections could stimulate economic development by providing more efficient, reliable and resilient electricity service across the region.

Therefore, investment in these sectors is a high priority, and a stable and lucrative market for both gas and steam turbine producers appears to be inevitable.

India and China

India and China, the two most populous countries in the world by a wide margin, share many of the same power generation issues as Southeast Asia. The sheer size of their populations presents grave problems for those seeking to spread economic development.

Both are short of electrical power. The generation capacity is inefficient and a major cause of pollution. Power distribution grids are incomplete and lack proper coordination and administration.

Under Prime Minister Modi, India has eliminated much of the centralized bureaucracy that hampered previous energy generation investment. But the country remains wedded to the concept of set development plans.

The country needs to commission 20 to 40 GW per year to meet its targets, which is more than five times the power addition rate achieved over the last decade.

According to the National Bureau of Statistics of China, power generation in China declined slightly in 2015, by 0.2%, the first decrease since 1968. This decline was linked to an economic slowdown in China that accelerated in 2016, making a further drop in power demand more likely.

This may well serve as a brake on future investment in power generation capacity in the short term, and possibly longer. The sheer size of China and the scale of its power generation plans are such that even a relatively small scale-back equates to a lot of lost turbines orders.

Chinese energy policy favors nuclear power. By 2013, power generation investment was already being directed away from thermal and wind power toward nuclear and hydropower projects. Currently, investment planned for these sectors totals $114.4 billion, of which $58.7 billion will be devoted to enhancing the power grid.

OEM overview

The three leading companies in this market sector have been ranked by value of sales (ranking by power output gives the same answer). They account for just over 90% of the world's projected capacity increase over the next ten years. Note that subsidiaries and licensees are included in the overall total.

GE

2018–2027 Production	% of Total
1,608 units	37.27
2018–2027 Production Value	**% of Total**
$49.88 billion	46.43
2018–2027 Power Capacity (GW)	**% of Total**
232.26	49.66

General Electric is one of the most diversified gas turbine engine and machine manufacturers in the world. In the gas turbine-powered electrical generation marketplace, its product line spans the power range of 2–750 MW in simple-cycle mode.

GE is enhancing its product range to exploit developing technology. The LM6000 has been continually improved in efficiency and emissions levels, especially with use of the steam injection process. GE's Frame series are also being improved, through technology injection from the CF6 and GE90 airline turbofan programs.

Yet for all its market strength, GE has been hit hard by the economic forces. It has been forced into major restructuring, reductions in staffing levels, and the divestiture of subsidiaries. But the company's established business, licensee, and packaging agreements with more than 30 firms worldwide, have broadened the geographic appeal of GE units.

And the harsh market conditions facing its traditional large-frame gas turbines are being offset by the manufacture of GE LM500, LM2500, LM6000 and LM9000 gas turbines. Almost half of the world's projected increase in energy production will be supplied by GE gas turbines.

Siemens

2018–2027 Production	% of Total
1,034	24.00
2018–2027 Production Value	**% of Total**
$29.21 billion	27.19
2018–2027 Power Capacity (GW)	**% of Total**
122.2	26.13

Despite the company's acquisition of the Rolls Royce industrial turbine range, Siemen's sales and market share have both declined. Siemens has been restructuring its operations aggressively. It shrunk from 18 divisions in 2013 to five. It raised more than 9 billion euros in merging, selling, or spinning off businesses. It is now investing a substantial proportion of this money in new technologies. Aeroderivatives acquired from Rolls-Royce offer Siemens an opportunity to compete more broadly in power generation.

MHI

2018–2027 Production	% of Total
443	10.30
2018–2027 Production Value	**% of Total**
$16.65 billion	15.49
2018–2027 Power Capacity (GW)	**% of Total**
69.4	14.84

Mitsubishi Hitachi Power Systems (MHPS) holds third place and has also been hit by declining sales, excess capacity and unsold inventory. It also announced restructuring. It is predicted to account for 10% of unit production, 15% of production value, and 15% of capacity for the forecast period.

Despite the vicissitudes of the last year, the top three companies in the electrical generation gas turbines hold 90.63% by value of the market. In both critical market projection parameters, total unit numbers, and total capacity, it is clear that the market is highly concentrated and becoming more so. Other participants in the sector are limited to niche applications.

Subdivision of the market shows the dominance of the 250 to 500 MW turbine capacity segment. The 500 to 750 MW segment is growing slowly but has a long way to go before it challenges the 250 to 500 MW segment in capacity terms. It is hard to avoid the impression that the 250 to 500 MW sector represents a sweet spot in electricity generation terms, one where considerations of capital cost, efficiency, environmental protection, and return on investment coincide. ■

Stuart Slade is the Senior I&M Gas Turbines Analyst at Forecast International. This article provides data compiled from Forecast International's Platinum 4.0 information and analysis service.

Carter Palmer is an Industrial & Marine Gas Turbine Analyst at Forecast International with a focus on smaller gas turbines and microturbines.

For more information, visit: www.forecastinternational.com

CENTRIFUGAL BLOWERS

VARIABLE SPEED DRIVE CENTRIFUGAL BLOWERS CAN SAVE ENERGY AND INCREASE RELIABILITY

BY DEEPAK VETAL

Atlas Copco variable speed drive centrifugal blowers

There are various blower technologies available for low-pressure applications, including lobe, screw, multistage, integrally geared, direct drive turbo and claw. With each technology comes benefits depending upon the application and process where these blowers are used.

To choose the right technology, users should consider energy consumption, performance, process requirements, and life cycle cost. Variable speed drive (VSD) centrifugal blowers, for example, are relevant in applications, such as wastewater treatment, flue gas desulfurization and lead recycling.

The VSD centrifugal air blower is an approach to low-pressure compressed air applications. These blowers require non-contact bearings, either air bearings or magnetic bearings. The bearings are driven by a permanent magnet motor and raise efficiency by eliminating bearing losses in motors and blowers.

Air bearings have limited starts and stops due to bearing contact upon startup, shut down and under surge conditions. They are not protected against surge conditions. Magnetic bearings, on the other hand, are protected by their ability to have unlimited stops by way of electromagnets. Therefore, magnetic bearings are preferred in VSD centrifugal blowers due to reliability.

VSD centrifugal blowers use an internal closed loop air circuit to cool the motor housing and the integrated VSD converter. By using a direct drive system, there is no need for speed-increaser gears and the accompanying oiling system. Vibration, noise, required floor space and weight are reduced. A high-speed permanent magnet synchronous motor (PMSM) with VSD offers greater energy efficiency at full and part load compared to conventional motors.

Wastewater treatment

Water treatment is one of the most important industrial segments for blowers and low-pressure compressors. Industrial wastewater generally contains higher concentrations of contaminants, such as biochemical oxygen demand (BOD), suspended solids, as well as fats, oil and grease, and in some cases, contains heavy metals and toxic materials that make disposal difficult.

Selecting an adequate treatment process is a function of load, speed, contaminant type and discharge standards. Treatment can vary from a simple single stage to a complex multistage with many steps and processes in which the optimal objective is to meet government and environmental regulatory compliance.

To gain efficiency and reliability in the process, a wastewater treatment plant installed low-pressure VSD centrifugal compressors. Due to oxygen requirements, four machines were installed, of which two or three operate around the clock depending on contamination levels. The fourth compressor serves as a contingency reserve.

The facility runs 365 days a year in 24-hour operation. The water depth and the membrane pipe system at the bottom of the basin required high pressure. Normal rotary lobe blowers could only provide 14.5 psi. Therefore, centrifugal technology was required.

The turbo compressors are single-stage, speed-controlled VSD machines. The motors have a contactless electromagnetic bearing system. The impeller is mounted on the motor shaft itself. This drive design does not require any extra lubricant so there is no risk of oil getting into the blower. Compared with rotary lobe blowers, this type of drive achieved energy savings of 30% to 40% and saved on space.

Flue gas desulfurization

Flue gas desulfurization (FGD) involves the removal of sulfur dioxide contained in gases produced by the combustion of fossil fuels, such as coal, oil, bitumen-based fuels, municipal solid waste, automobile tires, and for the processing of petroleum, cement, paper, glass, steel, iron and copper.

A power plant burning anthracite, for example, had to add a precisely defined amount of oxidation air to desulfurize the flue gas in two-circuit absorbers. Otherwise, the sulfur would stick together and could cause the reaction to take place either too early or start at the wrong location in the installation.

The process is currently under proper control using three VSD centrifugal blowers, which allow them to produce the exact amount of oxidation at any given moment. The blowers are speed controlled to allow volume flow to be adjusted to meet demand. This has saved 18.1% on energy costs compared to earlier installed blowers. The power plant also uses less coal per kilowatt hour produced.

Lead recycling

Another user recycles lead from battery scrap and battery paste using VSD centrifugal blowers in a compressed air station. With a total of six blowers in operation, the facility uses flow-controlled blowers instead of pressure-controlled blowers.

Air from the blowers is needed for three shifts, around the clock, for process and after-burning air. The process air is blown together with natural gas and oxygen through a lance immersed in the molten slag, which has a variable consistency. The colder it is, the stiffer it is. The lance will also deteriorate, resulting in immersion depth variation. This and other effects cause the counter pressure to fluctuate at the tip of the lance.

To keep the metallurgic process securely under control, it was necessary to provide a constant flow volume at any time despite rapidly changing operating conditions. VSD centrifugal blowers with flow control were able to maintain the metallurgic process in the immersion melting furnace. In addition, after-burning air was fed into the furnace through the molten bath to ensure no reactive components, such as non-combusted natural gas ended up in the exhaust.

Implementing VSD centrifugal blowers with proper controls can save energy and make processes work more reliably in a variety of industries. ■

Deepak Vetal is National Sales Manager for industrial blowers and low pressure compressors at Atlas Copco. He can be reached at deepak.vetal@us.atlascopco.com.

MHI TARGETS LEADERSHIP OF GLOBAL GT MARKET

Kenji Ando is Senior Executive Vice President of Mitsubishi Heavy Industries (MHI), President and CEO of MHI Power Systems, and President and CEO of Mitsubishi-Hitachi Power Systems (MHPS). MHPS is an energy joint-venture established in 2014 by MHI and Hitachi. Ando is a 40-year veteran of MHI. Turbomachinery International recently visited him in Japan and enjoyed a tour of several MHI facilities. He discussed the state of the gas turbine market, the extent of the current downturn, new technology, and alternative technologies.

What is your take on the gas turbine market now. Do you think the downward trend in gas turbine orders is temporary?

I think that the gas turbine market is shrinking temporarily, but it should recover after two or three years.

Most observers see a historical shift away from the large gas turbine in power generation due to renewables. Do you think we will stop making bigger gas turbines? Is a temperature of 1,700°C and 65% efficiency the limit?

We view the global energy sector as a continuously changing one. We see both the need for large 600 MW to 700 MW gas turbines which will address increases in renewables, as well as the requirement for flexibility to have more efficient generators. At the same time, it is vital to reduce CO_2 emissions. The focus of MHPS will be to continue improving efficiency to 65% and beyond. Where needed, we can adjust output to reflect market needs.

What prospects do you see for alternative technologies to the gas turbine, such as the fuel cell hybrid?

We naturally think a hydrogen gas turbine is the most feasible technology for a renewable energy society. It offers high performance and quick response for renewable energy with no CO_2. We expect significant improvements in the coming years in battery technology that will enable more renewables.

As a leader in the energy sector, we foresee greater global opportunities for geothermal power. Finally, small fuel cells are another technology that are coming into their own as a very clean source of power. Energy companies are looking at ways to make hydrogen more easily accessible.

GE and Siemens' gas turbine businesses are downsizing. How can Mitsubishi avoid a similar situation?

Our manufacturing capacity is smaller than GE or Siemens. Additionally, we can develop reliable GTs utilizing long-term verification at our T-point facility in Japan. We feel that we understand the power market and the direction it is taking. We also look at history as a guide and use that to determine our growth structure and demand. We think this approach has been essential in our setting of production capacity and avoidance of overshooting the market.

What are you considering for your 30 MW gas turbine?

We are now looking into all possibilities. This includes the scaling down of a larger MHPS machine, the uprating of a Hitachi GT, MHPS JAC technology, PWPS technology, or a combination of these.

Do you see aeroderivative technologies from PWPS flowing into other models?

That remains a possibility we are exploring.

You talked about becoming the leading gas turbine OEM, surpassing GE. How will you achieve this?

MHPS was already the global industry leader for F-class and above for the first half of 2018. There is a reason why customers chose MHPS over the others. Our gas turbines are acknowledged as having unmatched reliability and efficiency. The industry has been clear; it trusts MHPS and it wants our technology. ■

Ares Active Magnetic Bearing

AMB turboexpander

L.A. Turbine (LAT) has released the first Ares Active Magnetic Bearing (AMB) turboexpander-compressor designed for a 200MMSCFD gas processing plant. It features a skid-mounted AMB control system and programmable logic control (PLC) panel, made possible through a partnership between L.A. Turbine and Waukesha Magnetic Bearings.

Until now, AMB controllers needed to be installed in a building away from the skid installation site. With the new Ares AMB design, the control system is installed directly on the turboexpander skid and is ready for operation upon delivery to the site.

Gas processors benefit from lower capex, faster commissioning, decreased maintenance, greater site layout, temperature and performance flexibility, a smaller footprint, and a more environmentally friendly machine. Operators benefit from the ability to perform remote commissioning, monitoring and tuning of machine performance due to the digital signal processors and control algorithms of the Waukesha Magnetic Bearings Zephyr 5-Axis Controller.

Laturbine.com

High load bearing repair

Stronghold Coatings has introduced MM1018, a polymeric metal material that provides 100% force fit gap compensation for the repair of deck machinery on drilling rigs, windfarms and oil & gas platforms. When applied to the baseplates of deck machinery, MM1018 allows equipment to be repaired and re-positioned without having to re-align, saving time and money.

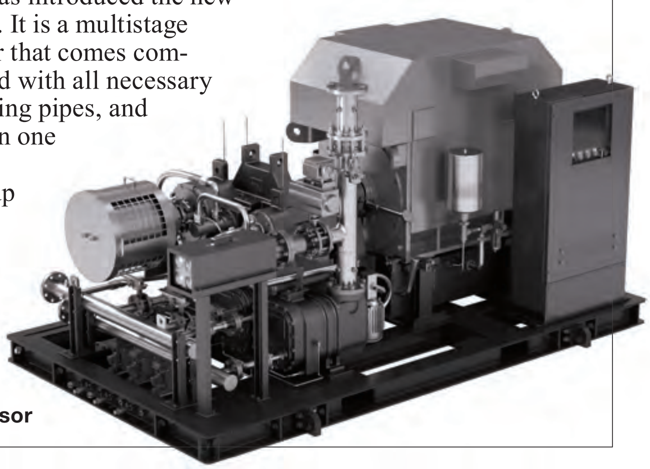
It provides volume restoration inside the gap between bearing and construction without machining of back plate and face plate. MM1018 combines compressive and shear strength, vibration damping, and corrosion protection in extreme service conditions. It is resistant to weathering and aging, as well as gasoline, oils, coolants, acids, lye, and more.

StrongholdOne.com

Air compressor

Hanwha Power Systems has introduced the new SM2100 turbocompressor. It is a multistage centrifugal air compressor that comes completely wired and equipped with all necessary components, interconnecting pipes, and instrument control lines on one skid. It extends Hanwha's compressor product line-up into the smaller HP (200 hp to 400 hp) range.

Hanwha.com



Hanwha air compressor

New pump valve

ThermOmegaTech is designed to save water, wear and expense for industrial companies that use pumps with mechanical seals. The EcoFlow is a self-actuated, thermostatic valve that manages and controls the water flow that mechanical seals use to keep cool, lubricated and clean. Current practice often does not monitor or control this water flow, potentially wasting hundreds of thousands of gallons of water a year.

EcoFlow valves attach to a seal water outlet to thermostatically monitor water temperature at the pump seal face. When water gets too hot, the valve opens and permits cooler water to flow in. It works without the use of external power. Temperature response is unaffected by pressure variations. The water supply can be kept turned on even when the pump is off, preventing dry starts due to operator error. Installing these valves can extend the lives of mechanical seals by maintaining the optimal seal head environment.

ThermOmegaTech.com

Tensioning pump

Enerpac has introduced an electric tensioning pump. The ZUTP1500-S Series with a pendant-operated solenoid valve is ideal for multiple bolt tensioning applications and allows for single-person operation. The operator can pressurize and retract the tensioner directly from the pendant.

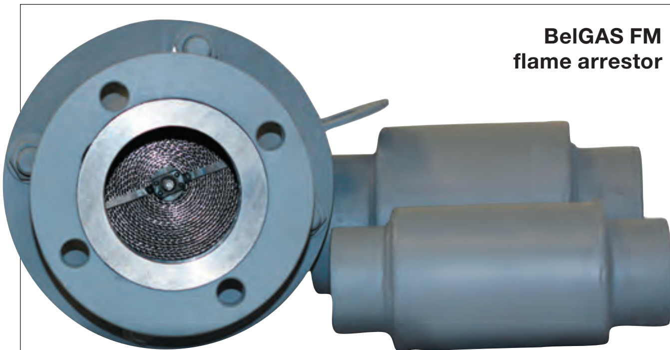
The pump achieves high pressure without the need for an intensifier. This allows for low-maintenance and less cost for the end user. Its two-stage pump design provides high-flow at low-pressure for fast system fills and controlled flow at high pressure.

Key features include:

- 7 hp heavy-duty universal motor
- Easy access manual override valve quickly releases pressure if power is lost
- Replaceable 10-micron reservoir breather and inline high-pressure filter helps maintain oil cleanliness.

Enerpac.com

Enerpac tensioning pump



BelGAS FM flame arrestor

Flame arrestor

BelGAS FM has introduced a line of flame arrestors for the oil and gas industry. They stop ignited vapors from traveling backward into the vent line or tank, preventing explosions, burns and other hazards. The suite of flame arrestors includes burner arrestors, inline arrestors, stack arrestors and vent arrestors.

The company's in-house engineering team assists with custom orders as well, often performing calculations based on customer-supplied data to reverse engineer a product that will perform as needed. The face plate has a pressed and sealed sight glass to eliminate seams and gaps, reduces the chance of leaks, and better withstands equipment vibration.

marshbellofram.com

Density meters

Mettler Toledo has launched an Excellence line of benchtop density meters and refractometers. The Density Excellence models D4, D5 and D6, along with the Refractometry Excellence models R4 and R5, combine performance with simplicity. These instruments permit the measurement of the density or refractive index of liquids as well as their derivatives, such as Brix, % alcohol and many more. Measurements are possible with up to six decimal places in density and up to five in refractive index. Automatic bubble detection and live video view and playback of the density measurement process ensure trustworthy results. LabX PC software ensures traceability and compliance with 21 CFR Part 11.

MT.com

MHPS Energy Cloud Factory

Mitsubishi Heavy Industries, Ltd. (MHI) has launched Energy Cloud Factory, a new service package that uses Artificial Intelligence (AI) and Internet of Things (IoT) technologies. Energy Cloud Factory is a package specifically for factories within Energy Cloud, MHI's energy solution service.

Using data acquired from Netmation eFinder, this system for collecting data on equipment operations, enables visual monitoring of production equipment operating ratios and energy consumption. A factory's overall performance can be evaluated in parameters.

AI technology enables forecasting of future factory performance. The MHPS Takasago Works is employing Energy Cloud Factory to establish a state-of-the-art factory capable of achieving low costs and energy savings in all aspects of designing, manufacturing and operating power generation facilities.

amer.mhps.com

Pruftechnik Optalign

Laser alignment

Pruftechnik has launched the Optalign touch system for simple, fast and precise daily alignment jobs. The package consists of the touch handheld device and the Pruftechnik sensALIGN 5 sensor/laser heads for every day alignment jobs. This includes continuous Sweep measurement mode, simultaneous real-time machine corrections in horizontal and vertical directions, automatic evaluation of alignment condition, and soft-foot detection. It provides wireless connectivity and cloud-based file transfer.

pruftechnik.com

Pipeline compressor

The Siemens SGT-400 pipeline compressor package is an integrated gas turbine and centrifugal compressor that offers a single-lift, one-baseplate configuration for fast deployment. It also has Dry Low Emissions (DLE) combustion technology for emissions compliance even at low loads, and 24×7 support.

Siemens.com

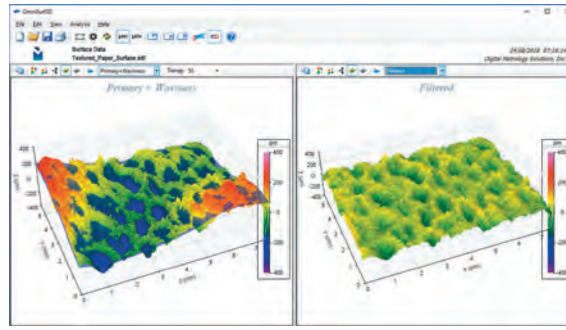
3D surface analysis

Digital Metrology Solutions has released OmniSurf3D for 3D surface texture visualization and analysis. The new software can be quickly mastered by non-metrology experts to explore their measured surfaces and better understand the effect on part functionality. It provides machinists, line engineers, and managers with a toolset to visualize surfaces quickly in 3D.

A streamlined interface puts all basic settings in one place: preprocessing to account for missing pixels, outliers; common reference geometries for removing overall shape to reveal the surface texture; filtering to highlight large-scale waviness or fine-scale roughness; and dozens of ISO and custom parameters to describe the most critical aspects of the surface.

Advanced users can zoom on a particular region of interest, rotate, apply and position cross-sectioning tools in real-time, and alter filter parameters. It can import datasets from virtually all common metrology systems and software.

Digitalmetrology.com



OmniSurf3D screenshot

Accelerometer

PCB Piezotronics has announced a USB digital accelerometer designed for use in predictive maintenance and condition monitoring applications. Model 633A01 is a high-resolution, broad-frequency piezoelectric accelerometer with integrated internal digital data processing for USB plug-and-play capability as well as easy data collection and sharing. It features a wide frequency range (1.5–11,000 Hz with a ±10% tolerance) packaged in a stainless steel, hermetically sealed housing with integral cable.

pcb.com

New bushing design

Flexible couplings for critical equipment must accommodate angular and axial movement due to thermal growth. In steam and gas turbine applications, machinery shafts, casings and piping expand as their temperature increases. When axial deflection is significant, spacers are purposely made short to stretch the coupling statically.

As the machines grow toward each other, the coupling is designed to grow into its neutral, relaxed position. In many cases, however, couplings must operate in a compressed mode to handle this movement. FEA testing has shown that when approaching the axial limit of a disc coupling, while accommodating for angular mis-alignment, the disc packs become highly stressed in the area around the traditional round bushings.

Accordingly, Ameridrives and Bibby Turboflex, two Altra brands, have developed the Tri-Bushing, a flex element/blade triangular bushing design that increases the axial capability of high performance flexible disc couplings used in turbomachinery applications.

Altra's design features two straight profiles that reduce and redistribute the stresses that occur around the disc pack bushings. This can increase a coupling's axial capability by more than 33%. Coupling designers no longer need to upsize their coupling to accommodate this growth. It is available for use in all new Ameridrives, Bibby Turboflex, TB Wood's and Lamiflex disc couplings. Disc packs with can also be retrofitted into existing couplings as part of repair or rebuild services performed at various Altra coupling facilities around the world.

Altramotion.com

Altra Tri-Bushing

Actuator test stand

Voith actuator test stand

Voith Digital Solutions and Turbine Technology Services (TTS) have joined forces to add an actuator, governor and turbomachinery test stand at the TTS facility in Houston. A certified team of trained actuator technicians provides fast service for Voith actuators that are often embedded in products created by other companies. More than an OEM repair shop, it offers diagnostic and testing equipment to optimize actuators for field use. The test stand is also available for training.
Voith.com

Mann+Hummel air filters for gas turbines

GT air filters

New air filters from Mann+Hummel known as the Aircube Pro Power S and Nanoclass Cube Pro Power S, have been developed for gas turbines. Using a synthetic filter medium, they can meet the requirements for extreme operating conditions found on oil platforms at sea. The filters are robust, ensure a reliable process, reduce the total cost of ownership for operators and help to protect the turbines. The filters are available in different versions: with an installation depth of 300 mm or 420 mm as an XL Version, in the filter efficiency classes ePM1 80% acc. to ISO 16980 and E10 acc. to EN 1822.

Typical media are made from microglass fibers, which are sensitive to mechanical stress and water. Under the extreme operating conditions found at sea, they are prone to failure. Synthetic media achieve high performance, and independent studies show superior values for burst pressure, long-term resistance to saltwater, efficiency, and stability compared to conventional technology. The XL variant with its large dust holding capacity performs well according to the ISO 16890 standard. It offers long filter service life, high energy efficiency and lower overall running costs with maximum operational reliability.
Mann-Hummel.com

New DCS

Schneider Electric has released EcoStruxure Foxboro DCS Control Software 7.1 to improve real-time efficiency, cybersecurity, reliability and profitability of assets and operations. With expanded capabilities and an enhanced HMI, the software simplifies engineering and drives operational profitability improvements, safely. EcoStruxure Foxboro DCS runs on Windows 10 and Windows Server 2016. Users can upgrade individual sections of the plant as desired.
schneider-electric.us ■

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<100kW-1MW Waste2Energy at point of need Electricity, Cogen/Trigen Solutions.
Energy Systems

ZOLLERN BHW PLAIN BEARING TECHNLOLOGY
Rolandsweg 16-20
Osterode, 37520 Germany
Contact: Florian Schreyer, Director
Sales and Product Management
Bearings
Tel: +49 5522 3127 86
Fax: +49 5522 312799
Florian.Schreyer@Zollern.com
www.zollern.com
Global supplier of engineered hydrodynamic bearings for all turbomachinery application.
Bearings

AFTERMARKET

ACCESSORIES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Young & Franklin Inc.
Liverpool NY

ALIGNMENT

Acoem AB (formerly Fixturlaser AB)
Moelndal Sweden

Acquip, Inc. - Rotating Equipment Solutions
Miami Beach FL

Di Vita Engineering, LLC
Salt Lake City UT

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Universal Plant Services, Inc.
Deer Park TX

ANALYTICAL LABORATORIES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

BALANCING EQUIPMENT

Hines Industries
Ann Arbor MI

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Schenck Balancing and Diagnostic Systems
Deer Park NY

BALANCING EQUIPMENT - AT- OR HIGH-SPEED

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Sulzer Management Ltd
Winterthur ZH Switzerland

BALANCING EQUIPMENT - LOW-SPEED

Elliott Group
Jeannette PA

IRD Balancing
Louisville KY

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

BLADES

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

Engineered Turbine Components
Ithaca NY

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Siemens AG, Power and Gas Division
Erlangen Germany

BLADES - COMPRESSORS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Sulzer Management Ltd
Winterthur ZH Switzerland

BLADES - DIAPHRAGM NOZZLE

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

BLADES - GRINDING

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

BLADES - TESTING

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Schenck Balancing and Diagnostic Systems
Deer Park NY

BLADES - TURBINES

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Stork H&E Turbo Blading
Ithaca NY

Sulzer Management Ltd
Winterthur ZH Switzerland

Turbine Resources, Inc.
Euless TX

BORESCOPES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PAL Turbine Services, LLC
Amsterdam NY

COATINGS

Baker Hughes, a GE company
London UK

Bodycote
Dallas TX

Elliott Group
Jeannette PA

Heresite Protective Coatings
Manitowoc WI

Master Bond, Inc.
Hackensack NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Sifco ASC
Independence OH

Turbine Resources, Inc.
Euless TX

COMBUSTOR PARTS

Baker Hughes, a GE company
London UK

EthosEnergy
Houston TX

DEMAGNETIZING PRODUCTS & SERVICES

Turbo Non-Destructive Testing, Inc.
Houston TX

MAINTENANCE - BOILERS

Agis, LLC
Ambler PA

MAINTENANCE - COMPRESSOR SPECIALIST

Atlas Copco Gas and Process Division
Cologne NRW Germany

Cook Compression
Houston TX

Cook Compression Ltd.
Ellesmere Port UK

Elliott Group
Jeannette PA

MAN Energy Solutions SE
Augsburg Bavaria Germany

Rotating Machinery Services, Inc.
Bethlehem PA

Siemens AG, Power and Gas Division
Erlangen Germany

Sulzer Management Ltd
Winterthur ZH Switzerland

Universal Plant Services, Inc.
Deer Park TX

MAINTENANCE - GAS TURBINE SPECIALIST

Eta Technologies. LLC
Coventry CT

MAN Energy Solutions SE
Augsburg Bavaria Germany

PAL Turbine Services, LLC
Amsterdam NY

PW Power Systems LLC
Glastonbury CT

Sulzer Management Ltd
Winterthur ZH Switzerland

Turbine Resources, Inc.
Euless TX

Universal Plant Services, Inc.
Deer Park TX

MAINTENANCE - GENERAL

Baker Hughes, a GE company
London UK

Doosan Škoda Power
Plzen Czech Republic

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

National Electric Coil
Columbus OH

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

Universal Plant Services, Inc.
Deer Park TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

MAINTENANCE - STEAM TURBINE SPECIALIST

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

MAN Energy Solutions SE
Augsburg Bavaria Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PAL Turbine Services, LLC
Amsterdam NY

Revak Keene Turbomachinery, LP
La Porte TX

Rotating Machinery Services, Inc.
Bethlehem PA

Steam Turbine Engineering, India Pvt. Ltd.
Ahmedabad Gujarat India

Sulzer Management Ltd
Winterthur ZH Switzerland

Universal Plant Services, Inc.
Deer Park TX

MAINTENANCE PROGRAMS

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

L.A. Turbine
Valencia CA

NRG Energy Services
Houston TX

PW Power Systems LLC
Glastonbury CT

Sulzer Management Ltd
Winterthur ZH Switzerland

Universal Plant Services, Inc.
Deer Park TX

MATERIALS SUPPLIER

Air Liquide America Specialty Gases, LLC
Houston TX

Fabreeka International, Inc.
Stoughton MA

PW Power Systems LLC
Glastonbury CT

NOZZLES - FUEL

EthosEnergy
Houston TX

Turbine Resources, Inc.
Euless TX

NOZZLES - TURBINE

Elliott Group
Jeannette PA

OPERATIONS & MAINT. - COGENERATION/ RENEWABLE ENERGY

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

PW Power Systems LLC
Glastonbury CT

OPERATIONS & MAINT. - GAS TURBINES

Ansaldo Energia S.p.A.
Genoa Italy

EthosEnergy
Houston TX

MTU Maintenance Berlin-Brandenburg GmbH
Ludwigsfelde Brandenburg Germany

PW Power Systems LLC
Glastonbury CT

Roblicorp
Boynton Beach FL

OPERATIONS & MAINT. - STEAM TURBINES

Ansaldo Energia S.p.A.
Genoa Italy

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

HRST, Inc.
Eden Prairie MN

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

OPERATIONS & MAINTENANCE

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PT. Imeco Inter Sarana
Jakarta Indonesia

Voith GmbH & Co. KGaA
Heidenheim BW Germany

PARTS - GAS TURBINES

AeroGen Turbine Services, LLC
Palm Beach Gardens FL

Allied Dynamics
Commack NY

ap+m
Boynton Beach FL

APG
Houston TX

Baker Hughes, a GE company
London UK

EthosEnergy
Houston TX

MAN Energy Solutions SE
Augsburg Bavaria Germany

Maximum Turbine Support
San Bernardino CA

Nevsky Industrial Corp.
St.Petersburg Russia

Rotating Machinery Services, Inc.
Bethlehem PA

Siemens AG, Power and Gas Division
Erlangen Germany

Sulzer Management Ltd
Winterthur ZH Switzerland

Turbine Resources, Inc.
Euless TX

Universal Plant Services, Inc.
Deer Park TX

PARTS - MANUFACTURERS

Atlas Copco Gas and Process Division
Cologne NRW Germany

EthosEnergy
Houston TX

Howden Roots, LLC
Connersville IN

L.A. Turbine
Valencia CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PARTS - STEAM TURBINES

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

MAN Energy Solutions SE
Augsburg Bavaria Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

Rotating Machinery Services, Inc.
Bethlehem PA

Star & Star Field Fit, Inc.
Marion OH

Sulzer Management Ltd
Winterthur ZH Switzerland

PARTS - SUPPLIERS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Universal Plant Services, Inc.
Deer Park TX

REAPPLICATION SERVICES

Elliott Group
Jeannette PA

REPAIR - ACCESSORIES

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Gard Specialists Co., Inc.
Eagle River WI

REPAIR - BEARINGS

Atlas Copco Gas and Process Division
Cologne NRW Germany

Bearings Plus, Inc.
Houston TX

Elliott Group
Jeannette PA

Fusion Babbitting Co., Inc.
Milwaukee WI

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Pioneer Motor Bearing
Kings Mountain NC

Revak Keene Turbomachinery, LP
La Porte TX

Turbine Resources, Inc.
Euless TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

REPAIR - BLADES

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PAS Technologies Ireland Ltd.
Carrigtwohill County Cork Ireland

Revak Keene Turbomachinery, LP
La Porte TX

Siemens AG, Power and Gas Division
Erlangen Germany

Turbine Resources, Inc.
Euless TX

REPAIR - CASINGS

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

Turbine Resources, Inc.
Euless TX

Universal Plant Services, Inc.
Deer Park TX

REPAIR - COUPLINGS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Riverhawk Company
New Hartford NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

REPAIR - GEARBOXES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

The Gear Works
Seattle WA

Universal Plant Services, Inc.
Deer Park TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

REPAIR - PUMPS

Elliott Group
Jeannette PA

PAL Turbine Services, LLC
Amsterdam NY

Revak Keene Turbomachinery, LP
La Porte TX

Universal Plant Services, Inc.
Deer Park TX

REPAIR - ROTORS

Atlas Copco Gas and Process Division
Cologne NRW Germany

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

REPAIR - VANES

Elliott Group
Jeannette PA

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

Turbine Resources, Inc.
Euless TX

REPAIR & OVERHAUL

Air Products CryoMachinery
Allentown PA

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

Doosan Škoda Power
Plzen Czech Republic

Drake Controls, LLC
Houston TX

Elca Engineering Co. (Pty) Ltd
Vanderbijlpark Gauteng South Africa

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Howden Roots, LLC
Connersville IN

L.A. Turbine
Valencia CA

Laservorm GmbH
Altmittweida Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

National Electric Coil
Columbus OH

PT Nuscaco Hasteloy Turbine Services
Jakarta Timur Jakarta Indonesia

Rotating Machinery Services, Inc.
Bethlehem PA

Turbine Resources, Inc.
Euless TX

Universal Plant Services, Inc.
Deer Park TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

Young & Franklin Inc.
Liverpool NY

REPAIR & OVERHAUL - GAS TURBINES

Ansaldo Energia S.p.A.
Genoa Italy

APG
Houston TX

EthosEnergy
Houston TX

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

MAN Energy Solutions SE
Augsburg Bavaria Germany

PAL Turbine Services, LLC
Amsterdam NY

Sulzer Management Ltd
Winterthur ZH Switzerland

RERATES

Atlas Copco Gas and Process Division
Cologne NRW Germany

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

RINGS - COMPRESSOR STATOR

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SEALING PRODUCTS

Bearings Plus, Inc.
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SHROUDS - TURBINE

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SKIDS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SPIN TESTING EQUIPMENT

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

STUD REMOVAL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Universal Plant Services, Inc.
Deer Park TX

TOOLS

LINK Tools International (USA), Inc.
Chicago IL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TOOLS FOR ALIGNMENT

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TOTAL PLANT SERVICE

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TUBES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TURBINE MAINTENANCE TOOLS

Kipper Tool Company
Gainesville GA

Machida, Inc.
Orangeburg NY

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Power House Tool, Inc.
Joliet IL

UPGRADES

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

L.A. Turbine
Valencia CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PerAero Turbine Designs
Bonita Springs Florida

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

VANES - STATORS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

ANALYSIS & SOFTWARE

DESIGN & ANALYSIS

Baker Hughes, a GE company
London UK

CD-adapco
Melville NY

CFturbo, Inc.
Brooklyn NY

KISSsoft AG
Bubikon Switzerland

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Notre Dame Turbomachinery Laboratory
South Bend IN

PW Power Systems LLC
Glastonbury CT

Simulia
Providence RI

DESIGN AUDITS

Mechanical Solutions, Inc.
Whippany NJ

FAILURE ANALYSIS

Elliott Group
Jeannette PA

L.A. Turbine
Valencia CA

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

LPI, Inc.
Los Angeles CA

Lucideon
Schenectady NY

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PW Power Systems LLC
Glastonbury CT

Rotating Machinery Services, Inc.
Bethlehem PA

Voith GmbH & Co. KGaA
Heidenheim BW Germany

FINITE ELEMENTS ANALYSIS

Apex Turbine Testing Technologies
Spring Hill TN

Elliott Group
Jeannette PA

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PLANT DESIGN

Baker Hughes, a GE company
London UK

PROGNOSTICS

Baker Hughes, a GE company
London UK

Mechanical Solutions, Inc.
Whippany NJ

SOFTWARE & ENGINEERING PROGRAMS

Advanced Design Technology Ltd.
London UK

Apex Turbine Testing Technologies
Spring Hill TN

Baker Hughes, a GE company
London UK

Concepts NREC
White River Junction VT

Engineered Software, Inc.
Lacey WA

Open Mind Technologies USA, Inc.
Needham MA

Siemens Product Lifecycle Management Software, Inc.
London UK

SoftInWay, Inc.
Burlington MA

STRESS ANALYSIS

American Stress Technologies, Inc.
Pittsburgh PA

Apex Turbine Testing Technologies
Spring Hill TN

Elliott Group
Jeannette PA

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Notre Dame Turbomachinery Laboratory
South Bend IN

TESTING

Apex Turbine Testing Technologies
Spring Hill TN

Baker Hughes, a GE company
London UK

E.T. Balancing Inc.
Los Angeles CA

Laboratory Testing, Inc.
Hatfield PA

Mechanical Solutions, Inc.
Whippany NJ

TESTING - LUBRICATION

Analysts, Inc.
Hawthorne CA

R&G Laboratories, Inc.
Tampa FL

SGS Herguth Laboratories
Vallejo CA

Under My Hood
Queen Creek AZ

WearCheck USA
Cary NC

TESTING - TELEMETRY

Apex Turbine Testing Technologies
Spring Hill TN

Mechanical Solutions, Inc.
Whippany NJ

TURBINE BLADE STRESS ANALYSIS

Apex Turbine Testing Technologies
Spring Hill TN

Elliott Group
Jeannette PA

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

VIBRATION ANALYSIS

Apex Turbine Testing Technologies
Spring Hill TN

Baker Hughes, a GE company
London UK

Benstone Instruments
St. Paul MN

Beta Machinery Analysis
Katy TX

Data Physics Corporation
San Jose CA

Diagen Laboratory
Plzen Czech Republic

Elliott Group
Jeannette PA

Emerson
Knoxville TN

Inertance
Seoul Korea South

Laschet Consulting GmbH
Bergisch Gladbach Germany

Mechanical Solutions, Inc.
Whippany NJ

Mid-America Dynamics, Inc.
Lisle IL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Notre Dame Turbomachinery Laboratory
South Bend IN

Oros, Inc.
Dulles VA

Schenck Balancing and Diagnostic Systems
Deer Park NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

AUXILIARY EQUIPMENT

ACOUSTIC ENCLOSURES

AAF International
Cramlington Northumberland UK

BBM-CPG Technology Inc.
Laurens SC

SAI
Massy France

AIR DRYERS

La-Man Corporation
Mazeppa MN

Sullair, A Hitachi Group Company
Michigan City IN

AIR FILTERS

Boll Filter Corporation
Novi MI

Defitec
Waterloo Brabant Belgium

Eagle Filters Ltd.
Kotka Finland

Nordic Air Filtration A/S
Nakskov Denmark

Sullair, A Hitachi Group Company
Michigan City IN

BEARINGS

Baker Hughes, a GE company
London UK

Bently Bearings
Aston PA

Cerobear GmbH
Herzogenrath Germany

Elliott Group
Jeannette PA

Gleitlagertechnik Weissbacher GmbH
Alpen Nordrhein-Westfalen Germany

GMN Bearing USA Ltd.
Houston TX

Graphite Metallizing Corporation
Yonkers NY

John Crane Engineered Bearings
Grafton WI

K C Engineering
Consett UK

Kinematics Manufacturing
Phoenix AZ

Kingsbury, Inc.
Philadelphia PA

Mohawk Innovative Technology, Inc.
Albany NY

New Way Air Bearings
Aston PA

New-Seal
Aston PA

RENK AG
Rheine Germany

Revak Keene Turbomachinery, LP
La Porte TX

Schaeffler Technologies GmbH & Co. KG
Herzogenaurach Germany

Texas Bearing Services
Houston TX

TRI Transmission & Bearing Corp., Div of Turbo Research, Inc.
Lionville PA

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Waukesha Bearings
Pewaukee WI

Waukesha Bearings - Suzhou
Suzhou China

Waukesha Bearings Ltd.
Rickmansworth Hertfordshire UK

Zollern BHW Plain Bearing Technlology
Osterode Germany

BEARINGS - MAGNETIC

Calnetix Technologies, LLC
Cerritos CA

Cerobear GmbH
Herzogenrath Germany

L.A. Turbine
Valencia CA

Mecos AG
Winterthur ZH Switzerland

Waukesha Bearings - Suzhou
Suzhou China

Waukesha Magnetic Bearings
Worthing West Sussex UK

CLUTCHES

Ameridrives, Bibby Transmissions, Marland Clutch
Erie PA

COMBUSTION MONITORING

AMETEK Power Instruments
Rochester NY

EthosEnergy
Houston TX

COMPRESSOR WASHING SYSTEMS

ECT, Inc.
Bridgeport PA

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Mitten Manufacturing
Syracuse NY

Rochem Technical Services
Winchester Hampshire UK

Turbo-K Ltd.
Emmendingen Germany

CONDENSERS

Ambassador Heat Transfer Co.
Cincinnati OH

COOLING SYSTEMS

Ecodyne Heat Exchangers
Houston TX

Mitten Manufacturing
Syracuse NY

Moffitt Corporation
Jacksonville Beach FL

York Process Systems (by Johnson Controls)
Waynesboro PA

COUPLINGS

Ameridrives, Bibby Transmissions, Marland Clutch
Erie PA

Goodrich-A UTC Company
Rome NY

Kile Industries, Inc.
Houston TX

KTR Corporation
Michigan City IN

KWD Kupplungswerk Dresden GmbH
Dresden Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PSC Couplings
Menomonee Falls WI

Regal Beloit America, Inc.
Florence KY

Rexnord NV
Mechelen Belgium

Riverhawk Company
New Hartford NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Voith Turbo SafeSet AB
Hudiksvall Sweden

Wuxi TRUMY Transmission Engineering Co. Ltd.
Wuxi Jiangsu China

DAMPERS

AAF International
Cramlington Northumberland UK

Riverhawk Company
New Hartford NY

WES GmbH
Nordkirchen Germany

DEAERATORS

Sterling Deaerator Company
Cumming GA

DISCS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

EXHAUST SYSTEMS

BBM-CPG Technology Inc.
Laurens SC

STF SpA
Magenta (MI) Italy

EXPANSION JOINTS

EagleBurgmann Expansion Joint Solutions
Lakeside CA

Isolated Systems Ltd
Heanor Derbyshire UK

FANS & BLOWERS

Daltec Canadian Buffalo Fan Mfg. Ltd.
Guelph ON Canada

New York Blower Company
Willowbrook IL

Piller-TSC Blower Corporation
Schenectady NY

Ventilatorenfabrik Oelde GmbH
Oelde Germany

FASTENERS (STUDS, NUTS, BOLTS, ETC.)

Belleville International
Butler PA

Boltight Ltd.
Walsall West Midlands UK

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Nord-Lock, Inc.
Carnegie PA

Pilgrim International Ltd
Oldham UK

Riverhawk Company
New Hartford NY

FILTERS

Air Filters, Inc.
Houston TX

Baldwin Filters
Kearney NE

Boll Filter Corporation
Novi MI

Contec GmbH Industrieausrüstungen
Bad Honnef Germany

Defitec
Waterloo Brabant Belgium

Freudenberg Filtration Technologies SE & Co. KG
Weinheim Germany

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

Hy-Pro Filtration
Fishers IN

Hydac Corporation
Bethlehem PA

One Eye Industries, Inc.
Calgary AB Canada

FLUID DRIVES

Voith GmbH & Co. KGaA
Heidenheim BW Germany

FUEL SYSTEMS, TREATMENT, FILTERS, & PUMPS

Boll Filter Corporation
Novi MI

EthosEnergy
Houston TX

Mitten Manufacturing
Syracuse NY

Roper Pump Company
Commerce GA

GAS TURBINE EXHAUST SYSTEMS

AAF International
Cramlington Northumberland UK

BBM-CPG Technology Inc.
Laurens SC

Innova Global (Formerly ATCO Emissions Management)
Cambridge Ontario Canada

Sound Technologies
Michigan City IN

GAS TURBINES - STARTERS

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

GEARBOXES

Artec Machine Systems
North Branford CT

Baker Hughes, a GE company
London UK

Brevini Power Transmission
Reggio Emilia Italy

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Philadelphia Gear, A Timken Brand
King of Prussia PA

RENK-MAAG GmbH
Winterthur Zurich Switzerland

Turbo Non-Destructive Testing, Inc.
Houston TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

GEARS

Excel Gear, Inc.
Roscoe IL

IGW (Power)
Oostkamp Belgium

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

AUXILIARY EQUIPMENT

HEAT EXCHANGERS

AMSEnergy Corp.
Columbia TN

Baker Hughes, a GE company
London UK

Doosan Škoda Power
Plzen Czech Republic

Echogen Power Systems
Akron OH

Enerfin, Inc.
St. Hubert QC Canada

GEA Heat Exchangers GmbH
Bochum Germany

Hubei Defon Heat Exchanger Co. Ltd.
Daye City Hubei China

Kelvion Holding GmbH
BOCHUM Germany

Lytron
Woburn MA

Oeltechnik
Waghaeusel Baden-Württemberg Germany

Tech Solutions International Group, LLC
Chicago IL

TMEC - Thermal & Mechanical Equipment Co.
Houston TX

HEATERS

Power House Tool, Inc.
Joliet IL

HYDRAULIC SYSTEMS

Mitten Manufacturing
Syracuse NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

IGNITION SYSTEMS & IGNITORS

Forney Corporation
Addison TX

INTAKE FILTERS

AAF International
Cramlington Northumberland UK

Advanced Filtration Concepts, Inc.
Norwalk/Los Angeles CA

Clarcor Industrial Air
Overland Park KS

Donaldson Company, Inc.
Bloomington MN

Pneumafil Nederman
Charlotte NC

LUBE OIL SYSTEM ACCUMULATORS (LOSA)

Fluid Energy Controls, Inc.
Los Angeles CA

LUBRICANT PURIFICATION

C.C.JENSEN, Oil Maintenance
Newnan GA

LUBRICANTS

American Chemical Technologies
Fowlerville MI

Lubrication Engineers, Inc.
Fort Worth TX

PetroCanada
Mississauga ON Canada

Shell International Oil Products Limited
London UK

Sullair, A Hitachi Group Company
Michigan City IN

LUBRICATION SYSTEMS

Cobey, Inc.
Buffalo NY

Elliott Group
Jeannette PA

G.J. Oliver,Inc.
Phillipsburg NJ

Lube-Power, Inc.
Shelby Township MI

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Mitten Manufacturing
Syracuse NY

Sicelub Lubritech
Mexico Distrito Federal Mexico

Worcester Fluids Technology
Auburn MA

LUBRICATION SYSTEMS - COOLERS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

LUBRICATION SYSTEMS - FILTERS

Boll Filter Corporation
Novi MI

Donaldson Company, Inc.
Bloomington MN

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

OilKleen, LLC
Anthem AZ

LUBRICATION SYSTEMS - PUMPS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

NOISE & VIBRATION SUPPRESSION EQUIP.

Acoustiblok, Inc.
Tampa FL

BBM-CPG Technology Inc.
Laurens SC

Kinetics Noise Control - Heavy Industrial Division
Cambridge ON Canada

OIL PURIFICATION EQUIPMENT

General Atomics Electromagnetic Systems
San Diego CA

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

Isopur Fluid Technologies, Inc.
North Stonington CT

Kleentek, a division of United Air Specialists, Inc.
Cincinnati OH

Meiji Corporation
Itasca IL

PACKING RINGS

Cook Compression
Houston TX

Cook Compression - Suzhou
Suzhou China

Cook Compression Ltd.
Ellesmere Port UK

PIPES

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Permanent Steel Manufacturing Co. Ltd.
Changsha Yuelu China

Ritinox Overseas
Mumbai Maharashtra India

Yaang Pipe Industry Co.
Wenzhou Zhejiang China

SEALS

Bal Seal Engineering, Inc.
Foothill Ranch CA

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Houston Dynamic Service, Inc.
Houston TX

Inpro/Seal
Rock Island IL

JetSeal, Inc.
Spokane WA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Planet Asia Pte. Ltd.
#07-108 Singapore

Waukesha Bearings
Pewaukee WI

Waukesha Bearings Ltd.
Rickmansworth Hertfordshire UK

SEALS - GAS

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SEALS - MECHANICAL

Elliott Group
Jeannette PA

Erie Bronze & Aluminum Co.
Erie PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Sichuan Sunny Seal Co., Ltd.
Chengdu Sichuan China

SEALS - OIL

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SHIMS

Accushim, Inc.
Lyons IL

Machinery Mounting Solutions, Inc.
The Woodlands AL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

SILENCERS

AAF International
Cramlington Northumberland UK

BBM-CPG Technology Inc.
Laurens SC

G+H Schallschutz GmbH
Ludwigshafen Rhine Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Stoddard Silencers, Inc.
Grayslake IL

SKIDS

CP International, Inc.
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Mitten Manufacturing
Syracuse NY

Starr Manufacturing, Inc.
Vienna OH

STARTERS

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

Voith GmbH & Co. KGaA
Heidenheim BW Germany

TANKS

Caldwell Energy Company
Louisville KY

TORQUE CONVERTERS

Voith GmbH & Co. KGaA
Heidenheim BW Germany

TRANSMISSIONS

Baker Hughes, a GE company
London UK

Voith GmbH & Co. KGaA
Heidenheim BW Germany

TURBINE COOLING - CHILLING SYSTEMS

AAF International
Cramlington Northumberland UK

Donaldson Company, Inc.
Bloomington MN

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TURBINE COOLING - FOGGING

ECT, Inc.
Bridgeport PA

EthosEnergy
Houston TX

Mee Industries, Inc.
Irwindale CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

TURBINE COOLING - INLET COOLING

AAF International
Cramlington Northumberland UK

DRS Technologies - Marlo Coil
High Ridge MO

EthosEnergy
Houston TX

Everest Sciences
Tulsa OK

TURBINE COOLING - MEDIA BASED

Donaldson Company, Inc.
Bloomington MN

Munters Corporation
Selma TX

TURBINE COOLING - OVERSPRAY

ECT, Inc.
Bridgeport PA

VACUUM EQUIPMENT

High Tech Services
Richardson TX

Oerlikon Leybold Vacuum GmbH
Köln Germany

VALVES

Baker Hughes, a GE company
London UK

Checkfluid
London Ontario Canada

Conval, Inc.
Enfield CT

Cook Compression
Houston TX

Cook Compression - Suzhou
Suzhou China

Cook Compression Ltd.
Ellesmere Port UK

Copes-Vulcan
McKean PA

Drake Controls, LLC
Houston TX

HILCO Filtration Division of the Hilliard Corporation
Elmira NY

JASC-Controls
Tempe AZ

Jonloo Valve Manufacturing Co.
Shanghai China

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

MSA, a.s.
Dolni Benesov Czech Republic

Schutte & Koerting
Trevose PA

ThermOmegaTech
Warminster AL

Voith Digital Solutions GmbH
Crailsheim Germany

Woodward, Inc.
Fort Collins CO

Young & Franklin Inc.
Liverpool NY

WIND GEARBOXES

Voith GmbH & Co. KGaA
Heidenheim BW Germany

BOILERS - SUPPLIERS

BOILERS

Rentech Boiler Systems, Inc.
Abilene TX

Siemens AG, Power and Gas Division
Erlangen Germany

COGENERATION & COMBINED CYCLE

COGENERATION ENG. & CONSULTING SERVICES

Delve Energy Group
Minneapolis MN

HCS Group, Inc.
Humble TX

Sargent & Lundy
Chicago IL

COGENERATION SYSTEMS

Baker Hughes, a GE company
London UK

Belyea Company, Inc.
Easton PA

Centrax Gas Turbines
Devon England UK

PW Power Systems LLC
Glastonbury CT

Sterling Energy Assets, Inc.
Alpharetta GA

COMBINED CYCLE PLANTS

Ansaldo Energia S.p.A.
Genoa Italy

B-Tech Valve, LLC
Palmyra NJ

Cheng Power Systems, Inc.
Mountain View CA

Doosan Škoda Power
Plzen Czech Republic

GE Power & Water
Schenectady NY

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

HRSG

HRST, Inc.
Eden Prairie MN

Rentech Boiler Systems, Inc.
Abilene TX

Siemens AG, Power and Gas Division
Erlangen Germany

MACHINERY FOR COGENERATION

Baker Hughes, a GE company
London UK

Beltservice Corporation
St. Louis MO

Schutte & Koerting
Trevose PA

Universal Plant Services, Inc.
Deer Park TX

COMPRESSORS & EXPANDERS

COMPRESSORS

Air Products CryoMachinery
Allentown PA

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

BORSIG ZM Compression GmbH
Meerane Saxony Germany

CompMaster, LLC
Houston TX

Cryostar SAS
Hesingue France

Elliott Group
Jeannette PA

Enerproject SA
Mezzovico Ticino Switzerland

FLSmidth, Inc.
Bethlehem PA

Graco Air
Pinehurst TX

Howden Centrifugal & Reciprocating Compressors
Rheden Netherlands

IHI Corporation
Tokyo Japan

Louisiana Chemical Equipment Co., LLC
LaPorte TX

Mitsubishi Heavy Industries Compressor Corporation
Hiroshima Japan

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Mohawk Innovative Technology, Inc.
Albany NY

Siemens AG, Power and Gas Division
Erlangen Germany

Turbo Non-Destructive Testing, Inc.
Houston TX

Universal Turbomachinery Equipment
Lodz , Poland

York Process Systems (by Johnson Controls)
Waynesboro PA

COMPRESSORS - AXIAL

Elliott Group
Jeannette PA

MAN Energy Solutions SE
Augsburg Bavaria Germany

Rotating Machinery Services, Inc.
Bethlehem PA

COMPRESSORS - CENTRIFUGAL

Atlas Copco Gas and Process Division
Cologne NRW Germany

Bharat Forge Ltd.
Pune Maharashtra India

Elliott Group
Jeannette PA

FIMA Maschinenbau GmbH
Obersontheim Germany

Hanwha Power Systems Co. Ltd.
Seoul Korea South

Hitachi America Ltd.
Tarrytown NY

Howden Roots, LLC
Connersville IN

Ingersoll-Rand Company
Davidson NC

Kawasaki Heavy Industries, KCC
Kobe Hyogo Japan

MAN Energy Solutions SE
Augsburg Bavaria Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PillAerator GmbH
Moringen Lower Saxony Germany

Revak Keene Turbomachinery, LP
La Porte TX

Rotating Machinery Services, Inc.
Bethlehem PA

Siemens AG, Power and Gas Division
Erlangen Germany

Sullair, A Hitachi Group Company
Michigan City IN

Turbine Services Ltd.
Saratoga Springs NY

York Process Systems (by Johnson Controls)
Waynesboro PA

COMPRESSORS - ISOTHERM

MAN Energy Solutions SE
Augsburg Bavaria Germany

COMPRESSORS - PACKAGERS

ABB sp. z o.o.
Warsaw Poland

Cobey, Inc.
Buffalo NY

Eltacon Engineering B.V.
Waddinxveen Netherlands

GEA
York PA

Graco Air
Pinehurst TX

York Process Systems (by Johnson Controls)
Waynesboro PA

COMPRESSORS - RECIPROCATING

Atlas Copco Gas and Process Division
Cologne NRW Germany

CPI - Worldwide Headquarters
Stafford TX

Gas & Air Systems, Inc.
Hellertown PA

Howden Roots, LLC
Connersville IN

Ingersoll-Rand Company
Davidson NC

Neuman & Esser Gulf FZE
Dubai United Arab Emirates

Siemens AG, Power and Gas Division
Erlangen Germany

COMPRESSORS - SCREW

Aerzen USA
Coatesville PA

Atlas Copco Gas and Process Division
Cologne NRW Germany

Howden Roots, LLC
Connersville IN

Ingersoll-Rand Company
Davidson NC

MAN Energy Solutions SE
Augsburg Bavaria Germany

Rotating Machinery Services, Inc.
Bethlehem PA

Sullair, A Hitachi Group Company
Michigan City IN

York Process Systems (by Johnson Controls)
Waynesboro PA

EXPANDERS

Air Products CryoMachinery
Allentown PA

Atlas Copco Gas and Process Division
Cologne NRW Germany

Baker Hughes, a GE company
London UK

Cryostar USA
Bethlehem PA

Elliott Group
Jeannette PA

L.A. Turbine
Valencia CA

MAN Energy Solutions SE
Augsburg Bavaria Germany

Rotating Machinery Services, Inc.
Bethlehem PA

Siemens AG, Power and Gas Division
Erlangen Germany

ELECTRIC EQUIPMENT

ELECTRICAL SYSTEMS

PEMCO
Bluefield VA

Schneider Electric - Square D
Knightdale NC

GENERATORS & ALTERNATORS

Brush Group
Loughborough Leicestershire UK

Calnetix Technologies, LLC
Cerritos CA

EthosEnergy
Houston TX

IDEAL Electric Company (formerly Hyundai Ideal Electric Co.)
Mansfield AL

Mega-Watt Consulting, LLC
Klein TX

National Electric Coil
Columbus OH

Siemens AG, Power and Gas Division
Erlangen Germany

MOTORS - ELECTRIC

ATB Laurence Scott
Norwich UK

ATB Motors
The Woodlands TX

Baker Hughes, a GE company
London UK

Brook Crompton USA, Inc.
Cleveland OH

Calnetix Technologies, LLC
Cerritos CA

General Atomics Electromagnetic Systems
San Diego CA

Wolong Americas, LLC
Chicago IL

VARIABLE FREQUENCY DRIVES

Calnetix Technologies, LLC
Cerritos CA

General Atomics Electromagnetic Systems
San Diego CA

Schneider Electric - Square D
Knightdale NC

Siemens AG, Power and Gas Division
Erlangen Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

ENERGY RESOURCES

COMBINED HEAT & POWER PLANT (CHP)

Baker Hughes, a GE company
London UK

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

POWER PLANTS

Baker Hughes, a GE company
London UK

Combustion Associates, Inc.
Corona CA

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

Turboden s.r.l.
Brescia Italy

POWER SERVICES

Baker Hughes, a GE company
London UK

Power Generation Consulting, LLC
Madison NJ

ENVIRONMENTAL SERVICES

CATALYSTS

Catalytic Combustion Corporation
Bloomer WI

EmeraChem
Knoxville TN

CONTINUOUS EMISSION MONITORING SYSTEMS

Loccioni
Angeli di Rosora Ancona Italy

EMISSIONS REDUCTIONS

Cook Compression
Houston TX

Cook Compression Ltd.
Ellesmere Port UK

Cormetech, Inc.
Durham NC

Sargent & Lundy
Chicago IL

UT 99 AG Oil Mist Eliminators
Andelfingen Switzerland

POLLUTION CONTROLS

Miratech
Tulsa OK

WASTEWATER TREATMENT

Allen Filters, Inc.
Springfield MI

Boll Filter Corporation
Novi MI

WATER TREATMENT

Boll Filter Corporation
Novi MI

DEWA (Dubai electricity and water authority)
Dubai United Arab Emirates

GAS TURBINES

GAS TURBINES

AddQual
Derby DS UK

Ansaldo Energia S.p.A.
Genoa Italy

APG
Houston TX

Baker Hughes, a GE company
London UK

Great River Energy
Elk River AL

Kawasaki Heavy Industries Ltd.
Hyogo Pref. Japan

MAN Energy Solutions SE
Augsburg Bavaria Germany

Meggitt Control Systems
North Hollywood CA

Mitsubishi Hitachi Power Systems Americas, Inc.
Lake Mary FL

Mitsubishi Hitachi Power Systems, Ltd.
Yokohama Japan

Natole Turbine Enterprises, Inc.
Spring TX

PW Power Systems LLC
Glastonbury CT

Shin Nippon Machinery Co., Ltd.
Osaki 2-Chome Shinagawa-Ku, Tokyo Japan

Siemens AG, Power and Gas Division
Erlangen Germany

Southwest Research Institute
San Antonio TX

TechnipFMC
Zoetermeer Netherlands

Turbine Consulting & Spare Parts Supplier
Balsorano AQ Italy

Turbine Technology Services Corporation
Orlando FL

Turbo Non-Destructive Testing, Inc.
Houston TX

U.S. Bolt Manufacturing, Inc.
Houston TX

GAS TURBINES - AERODERIVATIVES

Air New Zealand - Gas Turbines
Manukau Auckland New Zealand

PW Power Systems LLC
Glastonbury CT

GAS TURBINES - AUXILIARY POWER UNITS

Braden Manufacturing, LLC
Tulsa OK

GAS TURBINES - COMBINED CYCLE

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

Tecnicas Reunidas
Madrid Spain

GAS TURBINES - ELECTRICAL GENERATION

Centrax Gas Turbines
Devon England UK

Ener-Core, Inc
Irvine CA

PW Power Systems LLC
Glastonbury CT

GAS TURBINES - INDUSTRIAL

Centrax Gas Turbines
Devon England UK

Kraft Power Corp., USA
Pompton Plains NJ

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

Reintjes GmbH
Hamelin Germany

GAS TURBINES - MECHANICAL DRIVE

MAN Energy Solutions SE
Augsburg Bavaria Germany

MUC Oil & Gas Engineering Consultancy
Sharjah United Arab Emirates

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

GAS TURBINES - PACKAGERS

Alturair
El Cajon CA

Centrax Gas Turbines
Devon England UK

Greengold Energy Ltd.
Kuala Lumpur WP Malaysia

MAN Energy Solutions SE
Augsburg Bavaria Germany

PW Power Systems LLC
Glastonbury CT

GAS TURBINES - POWER GENERATION

Axford Turbine Consultants, LLC
Burnet TX

Brayton Energy
Hampton NH

Centrax Gas Turbines
Devon England UK

Cincinnati Gearing Systems Inc.
Cincinnati OH

Industrial Motor Power Corporation
Los Angeles CA

Major Tool & Machine, Inc.
Indianapolis IN

MAN Energy Solutions SE
Augsburg Bavaria Germany

Precision Air & Liquid Solutions, LLC
Hammond LA

PSM
Jupiter FL

PW Power Systems LLC
Glastonbury CT

Siemens AG, Power and Gas Division
Erlangen Germany

GAS TURBINES - POWER TURBINES

PW Power Systems LLC
Glastonbury CT

Rotating Machinery Services, Inc.
Bethlehem PA

GAS TURBINES - REFURBISHED

EthosEnergy
Houston TX

PW Power Systems LLC
Glastonbury CT

GENERATOR SETS - GAS TURBINES

Centrax Gas Turbines
Devon England UK

EthosEnergy
Houston TX

Kawasaki Gas Turbine Europe GmbH
Bad Homburg Hessen Germany

MAN Energy Solutions SE
Augsburg Bavaria Germany

Opra Turbines BV
Hengelo Netherlands

PW Power Systems LLC
Glastonbury CT

MICROTURBINES

Ansaldo Energia S.p.A.
Genoa Italy

Capstone Turbine Corporation
Chatsworth CA

INSTRUMENTATION & CONTROL

ACTUATORS

Drake Controls, LLC
Houston TX

REXA, Inc.
West Bridgewater MA

Voith Digital Solutions GmbH
Crailsheim Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

Young & Franklin Inc.
Liverpool NY

ANALYZERS

OROS
Meylan Cedex France

AUTOMATION

HIMA Americas, Inc.
Houston TX

TMEIC
Houston TX

CONDITION MONITORING

Baker Hughes, a GE company
London UK

Drake Controls, LLC
Houston TX

Emerson
Knoxville TN

EthosEnergy
Houston TX

Lenox Instrument Co., Inc.
Trevose PA

Mechanical Solutions, Inc.
Whippany NJ

Pruftechnik Dieter Busch AG
Ismaning Germany

Schenck Balancing and Diagnostic Systems
Deer Park NY

Shinkawa Electric Co. Ltd.
Chiyoda-ku Tokyo Japan

Veros Systems, Inc.
Austin TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

CONTROL SYSTEMS - OPTIMIZATION

Baker Hughes, a GE company
London UK

Energy Control Tecchnologies
Urbandale IA

EthosEnergy
Houston TX

Mauell GmbH
Velbert NRW Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

REXA, Inc.
West Bridgewater MA

Turbine Technology Services Corporation
Orlando FL

Voith GmbH & Co. KGaA
Heidenheim BW Germany

CONTROL SYSTEMS - RETROFIT

Baker Hughes, a GE company
London UK

Drake Controls, LLC
Houston TX

Elliott Group
Jeannette PA

HPI, LLC
Houston TX

L.A. Turbine
Valencia CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

REXA, Inc.
West Bridgewater MA

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

Young & Franklin Inc.
Liverpool NY

CONTROL SYSTEMS & GOVERNORS

Baker Hughes, a GE company
London UK

Basler Electric
Highland IL

Drake Controls, LLC
Houston TX

Governor Control Systems, Inc.
Fort Lauderdale FL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

REXA, Inc.
West Bridgewater MA

SSE - Sirio Sistemi Elettronici S.p.A.
Prato Italy

Veinfurt s.r.o.
Plzen Czech Republic

Voith Digital Solutions GmbH
Crailsheim Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

DATA LOGGERS & RECORDERS

Apex Turbine Testing Technologies
Spring Hill TN

DETECTION SYSTEMS

Environment One Corporation
Niskayuna NY

General Atomics Electromagnetic Systems
San Diego CA

Spectronics Corporation
Westbury NY

FLOW METERS

Hoffer Flow Controls
Elizabeth City NC

Universal Flow Monitors, Inc.
Hazel Park MI

Wyatt Engineering, LLC
Lincoln RI

GAS ANALYZERS

Control Instruments Corporation
Fairfield NJ

Enerac
Holbrook NY

MKS Instruments, Inc.
Andover MA

GAUGES & INDICATORS

Clark-Reliance
Strongsville OH

Moore Industries-International, Inc.
North Hills CA

Palmer Wahl Temperature Instruments
Asheville NC

INSTRUMENTATION - TELEMETRY

Accumetrics
Schenectady NY

Apex Turbine Testing Technologies
Spring Hill TN

INSTRUMENTATION & CONTROLS

4D Technology Corporation
Tucson AZ

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

GE Oil & Gas - Measurement & Control
Billerica MA

Kytola Instruments
Alpharetta GA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Moore Industries-International, Inc.
North Hills CA

Petrotech, Inc.
New Orleans LA

REXA, Inc.
West Bridgewater MA

Siemens AG, Power and Gas Division
Erlangen Germany

Spectro Scientific
Chelmsford MA

Weschler Instruments
Cleveland OH

MONITORS

Alber
Pompano Beach FL

Emerson
Knoxville TN

Moore Industries-International, Inc.
North Hills CA

REMOTE MONITORING & DIAGNOSTICS

Baker Hughes, a GE company
London UK

Emerson
Knoxville TN

EthosEnergy
Houston TX

Schenck Balancing and Diagnostic Systems
Deer Park NY

Siemens AG, Power and Gas Division
Erlangen Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Windrock, Inc.
Knoxville TN

SENSORS

Baker Hughes, a GE company
London UK

Emerson
Knoxville TN

SENSORS - PRESSURE

Kistler Instrument Corp.
Amherst NY

SENSORS - TEMPERATURE

Moore Industries-International, Inc.
North Hills CA

Pyromation, Inc.
Fort Wayne IN

Temp-Pro, Inc.
Northampton MA

The Sensor Connection
Troy MI

SHAFT GROUNDING & CONDITION MONITORING

Sohre Turbomachinery Inc.
Florence MA

TESTING EQUIPMENT

Apex Turbine Testing Technologies
Spring Hill TN

Baker Hughes, a GE company
London UK

Capture 3D, Inc.
Costa Mesa CA

Durlmark Industrial, Inc.
Jinagsu China

Fischer Technology, Inc.
Windsor CT

Gradient Lens Corporation
Rochester NY

UE Systems, Inc.
Elmsford NY

TORQUEMETERS

Riverhawk Company
New Hartford NY

S. Himmelstein and Company
Hoffman Estates IL

TRANSDUCERS

Moore Industries-International, Inc.
North Hills CA

TURBINE CONTROL SYSTEMS

Baker Hughes, a GE company
London UK

Drake Controls, LLC
Houston TX

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Gas Turbine Controls Corporation
Hawthorne NY

Holland-Controls
Hengelo Overeijssel Netherlands

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Voith Digital Solutions GmbH
Crailsheim Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

VIBRATION MONITORING EQUIPMENT

Apex Turbine Testing Technologies
Spring Hill TN

Baker Hughes, a GE company
London UK

Balmac, Inc.
Plain City OH

Brüel & Kjær Vibro - SETPOINT Operations
Minden NV

DeWal Industries
Narragansett RI

Drake Controls, LLC
Houston TX

Emerson
Knoxville TN

IfTA GmbH
Groebenzell Germany

Mechanical Solutions, Inc.
Whippany NJ

Meggitt Sensing Systems
Fribourg Switzerland

Metrix Instrument Co.
Houston TX

R.STAHL, Inc.
Stafford TX

Riverhawk Company
New Hartford NY

SEC of America, Inc.
Durham NC

Sensonics Ltd.
Berkhamsted Hertfordshire UK

Tern Technologies, Inc.
Anchorage AK

MANUFACTURING

3D PRINTING

Baker Hughes, a GE company
London UK

C-Mac 3D Printing Service Sydney
Girraween New South Wales Australia

Hoosier Pattern, Inc.
Decatur IN

Siemens AG, Power and Gas Division
Erlangen Germany

Sintavia, LLC
Fort Lauderdale FL

The ExOne Company
North Huntington PA

CASTINGS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

FABRICATORS

LAI International, Inc.
Tempe AZ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Penn Iron Works, Inc.
Wyomissing PA

SAS Global Corporation
Warren MI

FORGINGS

Ellwood City Forge
Ellwood City PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

GRINDING

Abrasive-Form, Inc.
Bloomingdale IL

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Niche Tools & Abrasives
Orlando FL

Voith GmbH & Co. KGaA
Heidenheim BW Germany

IMPELLERS

Baker Hughes, a GE company
London UK

Champion Aviation Dynamic Technology (Xi'an) Co. Ltd.
Xi'an Shaanxi China

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

MACHINE TOOLS

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Prima Power Laserdyne
Champlin MN

Weingartner Maschinenbau GmbH
Kirchham Austria

MACHINING

Ace Wire Spring & Form Co., Inc.
McKees Rocks PA

Adron EDM Specialists
Menomonee Falls WI

Alexander Comley Ltd.
Wolverhampton West Midlands UK

EDM Department, Inc.
Bartlett IL

General Atomics Electromagnetic Systems
San Diego CA

GOIMEK
Itziar-Deba Guipuzcoa Spain

Just In Time CNC Machining
Rochester NY

Leistritz Turbomaschinen Technik GmbH
Nuremberg Bavaria Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Mitsubishi Hitachi Power Systems Canada, Ltd.
Saskatoon Saskatchewan Canada

Praewest Praezisionswerkstaetten Dr-Ing Heinz-Rudolf Jung GmbH & Co KG
Bremen Germany

Ushers Machine & Tool
Greenville SC

Voith GmbH & Co. KGaA
Heidenheim BW Germany

MANUFACTURERS

Lucifer Furnaces, Inc.
Warrington PA

Thermal Structures, Inc.
Corona CA

MILLING

Emuge Corp.
West Boylston MA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Voith GmbH & Co. KGaA
Heidenheim BW Germany

WELDING

Arc Products
San Diego CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PTR-Precision Technologies, Inc.
Enfield CT

MATERIALS

ALLOYS

United Performance Metals
Hamilton OH

CARBON & CARBON PRODUCTS

Edgen Murray Corporation
Baton Rouge LA

St. Marys Carbon
St. Marys PA

HIGH TEMPERATURE METALS

Gloria Material Technology Corp.
Tainan Taiwan

United Performance Metals
Hamilton OH

INSULATION

AB Thermal Technologies
Ogdensburg NY

PLASTICS

R. Blaine Industries (RBI)
Reading PA

PUMPS

PUMPS

Air Products CryoMachinery
Allentown PA

Baker Hughes, a GE company
London UK

Blackmer- part of PSG, A Dover Company
Grand Rapids MI

FMC Technologies/ Direct Drive Systems
Fullerton CA

Gorman-Rupp Company
Mansfield OH

Hammelmann Corporation
Dayton OH

SPX Flow Technology
Delavan WI

Tri-Rotor Pump
Torrington CT

Turbo Non-Destructive Testing, Inc.
Houston TX

PUMPS - CENTRIFUGAL

Carver Pump Company
Muscatine IA

Gorman-Rupp Company
Mansfield OH

PUMPS - SCREW

KRAL-USA, Inc.
Matthews NC

Leistritz Corporation
Allendale NJ

RENEWABLE ENERGY

ENERGY SYSTEMS

BASF
Shakopee MN

General Atomics Electromagnetic Systems
San Diego CA

Iren SpA
Torino Switzerland

LPP Combustion, LLC
Columbia MD

ZE Europe Ltd.
Salisbury Wilts UK

GEOTHERMAL POWER

L.A. Turbine
Valencia CA

HYDRO TURBINES

Voith GmbH & Co. KGaA
Heidenheim BW Germany

SOLAR ENERGY

MAN Energy Solutions SE
Augsburg Bavaria Germany

SAFETY EQUIPMENT

EMERGENCY SHUTDOWN

Emerson
Knoxville TN

Voith Digital Solutions GmbH
Crailsheim Germany

Voith GmbH & Co. KGaA
Heidenheim BW Germany

Woodward, Inc.
Fort Collins CO

FIRE DETECTION EQUIPMENT

Allestec Corporation
Kingwood TX

FIRE PROTECTION & SUPPRESSION

Victaulic
Easton PA

SERVICES

ASSET MANAGEMENT SERVICES

Baker Hughes, a GE company
London UK

Emerson
Knoxville TN

EthosEnergy
Houston TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Sargent & Lundy
Chicago IL

ASSOCIATIONS

ASME International Gas Turbine Institute
Houston TX

CLEANING SERVICES

Rico Industrial Services Ltd.
Tenbruy Wells Worcestershire UK

COATING SERVICES

Bodycote S3P
London OH

Fusion, Inc.
Houston TX

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

PW Power Systems LLC
Glastonbury CT

CONSTRUCTION CONTRACTORS

BBM-CPG Technology Inc.
Laurens SC

Petrochem Insulation, Inc.
Vallejo CA

CONSULTING SERVICES

Axford Turbine Consultants, LLC
Burnet TX

Baker Hughes, a GE company
London UK

BWD Turbines Ltd.
Hamilton ON Canada

DyRoMa, LLC
Cincinnati OH

Emerson
Knoxville TN

Foster Cove Engineering, Inc.
Davenport FL

Global Turbomachinery Consulting Group
League City TX

Heat Transfer Technologies
Saint Lizier France

Jonas, Inc.
Pomfret MD

Kotra Zurich
Zurich Switzerland

Lahmeyer International GmbH
Bad Vilbel Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Natole Turbine Enterprises, Inc.
Spring TX

PCA Engineers Ltd.
Lincoln Lincs UK

Peter Baldwin Consulting Services
Winchester MA

Rotating Machinery Services, Inc.
Bethlehem PA

Sargent & Lundy
Chicago IL

Steven B. Kushnick, P.E., Inc.
Marietta GA

Voith GmbH & Co. KGaA
Heidenheim BW Germany

DIMENSIONAL INSPECTION & RE-ENGINEERING

BBM-CPG Technology Inc.
Laurens SC

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

ENGINEERING SERVICES

Alden
Holden MA

B&B-AGEMA
Aachen DE Germany

Baker Hughes, a GE company
London UK

BBM-CPG Technology Inc.
Laurens SC

DyRoMa, LLC
Cincinnati OH

ENPPI
Cairo Egypt

Flexware, Inc.
Grapeville PA

GTAnalysis, Inc.
Bradenton FL

Hoerbiger Service - Middle East
Dubai United Arab Emirates

KnightHawk Engineering, Inc.
Houston TX

Liburdi Turbine Services, Inc.
Dundas Ontario Canada

Macek Power & Turbomachinery Engineering
Friendswood TX

Mechanical Solutions, Inc.
Whippany NJ

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

MTU Aero Engines North America
Rocky Hill CT

Omara Engineering, PC
Williamsville NY

PAL Turbine Services, LLC
Amsterdam NY

Petra Resources Sdn Bhd
Petaling Jaya Selangor Malaysia

Reinhart & Associates, Inc.
Austin TX

Rotor Bearing Technology & Software (RBTS)
Phoenixville PA

Sargent & Lundy
Chicago IL

Turbine Technology Services Corporation
Orlando FL

Voith GmbH & Co. KGaA
Heidenheim BW Germany

ENVIRONMENTAL SERVICES

Sargent & Lundy
Chicago IL

EPC

Ansaldo Energia S.p.A.
Genoa Italy

KBR Power and Industrial
Birmingham AL

PW Power Systems LLC
Glastonbury CT

Sargent & Lundy
Chicago IL

EQUIPMENT - LEASING

Graco Air
Pinehurst TX

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

PW Power Systems LLC
Glastonbury CT

Rental Power Solutions
Miami FL

EQUIPMENT - USED

EthosEnergy
Houston TX

FIELD SERVICE

Air Products CryoMachinery
Allentown PA

AST Turbo AG
Altendorf Switzerland

Baker Hughes, a GE company
London UK

BBM-CPG Technology Inc.
Laurens SC

Donaldson Company, Inc.
Bloomington MN

Drake Controls, LLC
Houston TX

DyRoMa, LLC
Cincinnati OH

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

L.A. Turbine
Valencia CA

Maintenance Technologies International, LLC
Milford CT

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Mitten Manufacturing
Syracuse NY

PEC Ltd. (Machinery Service)
Singapore

PW Power Systems LLC
Glastonbury CT

Rotating Machinery Services, Inc.
Bethlehem PA

Roteq Switzerland Ltd.
Langnau am Albis Zuerich Switzerland

Siemens AG, Power and Gas Division
Erlangen Germany

Universal Plant Services, Inc.
Deer Park TX

Woodward, Inc.
Fort Collins CO

GROUTING

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Universal Plant Services, Inc.
Deer Park TX

HEAT TREATING - FURNACES

EFD Induction
Madison Heights MI

Vac Aero International, Inc.
Oakville ON Canada

IGCC

Sargent & Lundy
Chicago IL

Young & Franklin Inc.
Liverpool NY

INSPECTION

American Efficiency Services
Woodbine MD

Baker Hughes, a GE company
London UK

Donaldson Company, Inc.
Bloomington MN

Turbo Non-Destructive Testing, Inc.
Houston TX

INSTALLATION

Baker Hughes, a GE company
London UK

BBM-CPG Technology Inc.
Laurens SC

Elliott Group
Jeannette PA

Universal Plant Services, Inc.
Deer Park TX

MARKET RESEARCH

Business Exploration
Dubai United Arab Emirates

Essential Resources, LLC
Morristown NJ

Forecast International, Inc.
Newtown CT

Global Market Insights, Inc.
Selbyville DE

Industrial Info Resources, Inc.
Sugar Land TX

PLANT OPERATION & MANAGEMENT

Baker Hughes, a GE company
London UK

EthosEnergy
Houston TX

PROJECT ENGINEERING

Sargent & Lundy
Chicago IL

Scansonic GSM GmbH
Berlin Germany

RECRUITERS & EMPLOYMENT AGENCIES

As We Dream, LLC
Lilburn GA

DB Consulting
Virginia Beach VA

System One
Pittsburgh PA

RESEARCH & DEVELOPMENT

Baker Hughes, a GE company
London UK

Creare, LLC
Hanover NH

Mechanical Solutions, Inc.
Whippany NJ

Mohawk Innovative Technology, Inc.
Albany NY

Notre Dame Turbomachinery Laboratory
South Bend IN

SERVICE FOR TURBINES & GENERATORS

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

National Electric Coil
Columbus OH

The Balancing Company
Vandalia OH

TST-Turbo Service & Trading GmbH
Moers NRW Germany

Universal Plant Services, Inc.
Deer Park TX

TURBOMACHINERY SHIPPING & STORAGE CONTAINERS

Crowley Logistics Inc.
Houston TX

Dixie Cullen Interests, Inc.
Houston TX

TURNKEY POWER PLANT DEVELOPMENT

PW Power Systems LLC
Glastonbury CT

STEAM TURBINES

GENERATOR SETS - STEAM TURBINES

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

MAN Energy Solutions SE
Augsburg Bavaria Germany

Skinner Power Systems, A Division of Time Machine, Inc
Erie PA

STEAM TURBINES

Ansaldo Energia S.p.A.
Genoa Italy

APG
Houston TX

Baker Hughes, a GE company
London UK

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

Fincantieri SPA
Genova Liguria Italy

Franco Tosi Meccanica S.p.A.
Legnano Milano Italy

G-Team a.s. - Steamturbo
Plzen Czech Republic

Howden Roots, LLC
Connersville IN

Jasa Aman Engineering Sdn Bhd
Puchong Selangor Malaysia

M+M Turbinen-Technik GmbH
Bielefeld Germany

MAN Energy Solutions SE
Augsburg Bavaria Germany

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Precision Profiles, Inc.
Titusville PA

Prime Steam Turbine (Jasa Aman)
Puchong Selangor Malaysia

Revak Keene Turbomachinery, LP
La Porte TX

Rotating Machinery Services, Inc.
Bethlehem PA

Siemens AG, Power and Gas Division
Erlangen Germany

Skinner Power Systems, A Division of Time Machine, Inc
Erie PA

Steam Turbine Generators, LLC
Woodstock GA

TGM Steam Turbines
Sertaozinho - SP Sao Paulo Brazil

Turbo Non-Destructive Testing, Inc.
Houston TX

STEAM TURBINES - ELECTRICAL, INDUSTRIAL

Elliott Group
Jeannette PA

STEAM TURBINES - MECHANICAL

Elliott Group
Jeannette PA

Frontken (Singapore) Pte. Ltd.
Singapore

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Rotating Machinery Services, Inc.
Bethlehem PA

STEAM TURBINES - MECHANICAL, PROCESS

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

STEAM TURBINES - PACKAGERS

Cobey, Inc.
Buffalo NY

Elliott Group
Jeannette PA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

STEAM TURBINES - REFURBISHED

Doosan Škoda Power
Plzen Czech Republic

Elliott Group
Jeannette PA

Integrated TurboMachinery, Inc.
Montebello CA

Mitsubishi Heavy Industries Compressor International (MCO-I)
Houston TX

Revak Keene Turbomachinery, LP
La Porte TX

Rotating Machinery Services, Inc.
Bethlehem PA

TRAINING & EDUCATION

BOOKS & MAGAZINES

TURBOMACHINERY INTERNATIONAL
Norwalk CT

EDUCATION

International Generator Technical Community
Columbus OH

TurboMachinery Laboratory
College Station TX

TRAINING

Baker Hughes, a GE company
London UK

Elliott Group
Jeannette PA

EthosEnergy
Houston TX

Vibration Institute
Oakbrook IL

TRADEMARKS

Addax Composite Cooling Tower Coupling. Corrosion resistance, highmisalignment and low weight • Rexnord NV, Mechelen, Belgium

AeroBlock Standardized integrally-geared main air compressor for industrial gas applications • Atlas Copco, Cologne, Germany

Camseal High-performance, in-line serviceable metal-seated, zero leakage forged ball valves • Conval, Inc., Somers,CT

Clampseal High-performance, in-line serviceable forged globe, gate, check, stop, bellows, throttling, fire-safe, cryogenic and urea valves • Conval, Inc., Somers, CT

ECOMAX Fully customizable solution for automated combustion tuning • EthosEnergy, Alpharetta GA

Euroflex High Performance Disc Coupling customized for your application. Gas and steam turbine-driven, high-speed motor driven, gas compression • Rexnord NV, Mechelen, Belgium

FSR Full Solution Rejuvenation Proprietary Heat Treatments to restore turbine blades/buckets to as-new strength • Liburdi Turbine Services, Inc., Dundas Ontario Canada

Icon Control Systems Proven solution replaces legacy GE controls for Mark I to Mark VI • EthosEnergy, Alpharetta GA

Machinery Health Applies to technology developed by Emerson for rotating equipment. • Emerson Process Management, Knoxville TN

Modulflex Torsionally Stiff Disc Coupling with modular design for your application • Rexnord NV, Mechelen, Belgium

MSG Centac Multi-stage geared (MSG) centrifugal air compressors • Ingersoll-Rand Co., Davidson, NC

MSG Turbo-Air Multi-stage geared (MSG) centrifugal Air & Gas Compressors • Ingersoll-Rand Co., Davidson, NC

PeakVue Unique approach for earliest identification of developing faults in bearings. • Emerson Process Management, Knoxville TN

Plantweb Digital ecosystem • Emerson Process Management, Knoxville, TN

PolyBlock Standardized direct-driven centrifugal compressor for PP/PE applications • Atlas Copco, Cologne, Germany

Thomas Flexible Disc Coupling designed for critical applications including API applications • Rexnord NV, Mechelen, Belgium

TurboBlock Standardized, integrally-geared centrifugal compressor for the power generation market • Atlas Copco, Cologne, Germany

Combined Cycle Plant Specifications

ANSALDO ENERGIA, Genoa, Italy

MODEL	POWER RATING Net plant power output (MW)	EFFICIENCY Net plant efficiency %	GAS TURBINES Number	Model	Frequency (Hz)
1AE64.3-CC1S	120.0	55.7	1	AE64.3A	50/60
1AE94.2-CC1M	287.0	55.8	1	AE94.2	50
1AE94.3-CC1S	495.0	60.0	1	AE94.3A	50
1GT26-CC1S	540.0	61.0	1	GT26	50
1GT36-S5-CC1M	760.0	62.6	1	GT36-S5	50
1GT36-S6-CC1M	520.0	62.3	1	GT36-S6	60
2AE64.3-CC1M	243.0	56.4	2	AE64.3A	50/60
2AE94.2-CC1M	578.0	56.2	2	AE94.2	50
2AE94.3-CC1M	992.0	60.3	2	AE94.3A	50
2GT26-CC1M	1083.0	61.2	2	GT26	50
2GT36-S5-CC1M	1525.0	62.8	2	GT36-S5	50
2GT36-S6-CC1M	1046.0	62.6	2	GT36-S6	60

Note: Reference Conditions: ISO conditions (Amb. temp. = 15°C, amb. press.= 1.013 bar, amb. R.H. = 60%; natural gas methane), direct cooling, 3RH cycles, 100% CH_4 natural gas fuel

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW)		HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	GAS TURBINES		Frequency (Hz)	COMMENTS
	Gas Turbines	Steam Turbine		Number	Model		
THM 1304-10N	20.16	9.4	7,755	2	THM 1304-10N	50/60	(1)
THM 1304-12N	23.04	11.0	7,718	2	THM 1304-12N	50/60	(1)

1 One steam turbine, dual-pressure HRSG, and 1.0 psia condenser pressure.

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW)		GROSS HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	GAS TURBINES		Frequency (Hz)	Efficiency (%)
	Gas Turbines	Steam Turbine		Number	Model		
MPCP1 (M501DA)	112.1	55.3	6,635	1	M501DA	60	51.4
MPCP2 (M501DA)	224.2	112.0	6,610	2	M501DA	60	51.6
MPCP3 (M501DA)	336.3	169.9	6,585	3	M501DA	60	51.8
MPCP1 (M501F)	182.7	102.4	5,976	1	M501F	60	57.1
MPCP2 (M501F)	365.4	206.8	5,955	2	M501F	60	57.3
MPCP1 (M501G)	264.4	134.5	5,843	1	M501G	60	58.4
MPCP2 (M501G)	528.8	271.7	5,823	2	M501G	60	58.6
MPCP1 (M501GAC)	280.8	146.2	5,640	1	M501GAC	60	60.5
MPCP2 (M501GAC)	561.6	294.4	5,622	2	M501GAC	60	60.7
MPCP3 (M501GAC)	842.4	442.6	5,622	3	M501GAC	60	60.7
MPCP1 (M501J)	326.2	157.8	5,504	1	M501J	60	62.0
MPCP2 (M501J)	652.4	318.6	5,486	2	M501J	60	62.2
MPCP1 (M501JAC)	420.3	193.7	5,332	1	M501JAC	60	64.0
MPCP2 (M501JAC)	840.6	390.4	5,315	2	M501JAC	60	64.2
MPCP1 (M701DA)	142.1	70.4	6,635	1	M701DA	50	51.4
MPCP2 (M701DA)	284.2	142.4	6,610	2	M701DA	50	51.6
MPCP3 (M701DA)	426.3	218.7	6,585	3	M701DA	50	51.8
MPCP1 (M701G)	325.7	172.3	5,755	1	M701G	50	59.3
MPCP2 (M701G)	651.4	348.0	5,735	2	M701G	50	59.5

Combined Cycle Plant Specifications

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW) Gas Turbines	Steam Turbine	GROSS HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	GAS TURBINES Number	Model	Frequency (Hz)	Efficiency (%)
MPCP1(M701F)	379.3	186.7	5,504	1	M701F	50	62.0
MPCP2 (M701F)	758.6	376.4	5,486	2	M701F	50	62.2
MPCP1 (M701J)	472.3	228.7	5,477	1	M701J	50	62.3
MPCP1 (M701JAC)	557.5	260.5	5,332	1	M701JAC	50	64.0
MPCP1 (M701JAC)	441.7	208.3	5,332	1	M701JAC	50	64.0
MPCP1 (H-25)	39.6	20.5	6,319	1	H-25	50/60	54.0
MPCP2 (H-25)	79.2	42.2	6,261	2	H-25	50/60	54.5
MPCP1 (H-100)	112.7	58.3	5,945	1	H-100	50	57.4
MPCP2 (H-100)	225.4	120.6	5,884	2	H-100	50	58.0
MPCP1 (H-100)	102.5	47.5	6,193	1	H-100	60	55.1
MPCP2 (H-100)	205.0	100.7	6,083	2	H-100	60	56.1

Note: All ratings on natural gas fuel, with inlet and exhaust losses (LHV base).

PW POWER SYSTEMS, Glastonbury, Connecticut, U.S.A. www.pwps.com

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW) Gas Turbines	Steam Turbines	HEAT RATE Lower Heating Value (LHV) (kJ/kWh)	GAS TURBINES Number	Model	Frequency (Hz)	COMMENTS
FT8 SWIFTPAC 30	42.1	12.0	7333	1	FT8-3	50/60	
FT8 SWIFTPAC 60	85.1	24.6	7257	2	FT8-3	50/60	
FT4000 SWIFTPAC 60	88.0	17.7	7190	1	FT4000	50/60	2P, non reheat, unfired
FT4000 SWIFTPAC 120	177.2	36.4	7135	2	FT4000	50/60	2P, non reheat, unfired

SIEMENS

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW) Gas Turbines Total power	HEAT RATE Lower Heating Value (LHV) (kJ/kWh)	GAS TURBINES Number	Model	Frequency (Hz)	COMMENTS
SCC5-9000HL Single Shaft	841	5,714	1	SGT5-9000HL	50	(2)
SCC5-9000HL 2x1	1,682	5,714	2	SGT5-9000HL	50	(2)
SCC6-9000HL Single Shaft	577	5,714	1	SGT6-9000HL	60	(2)
SCC6-9000HL 2x1	1,154	5,714	2	SGT6-9000HL	60	(2)
SCC5-8000HL Single Shaft	708	5,714	1	SGT5-8000HL	50	(2)
SCC5-8000HL 2x1	1,416	5,714	2	SGT5-8000HL	50	(2)
SCC6-8000H Single Shaft	460	5,920	1	SGT6-8000H	60	(2)
SCC6-8000H 2x1	930	5,910	2	SGT6-8000H	60	(2)
SCC6-5000F 1x1	375	6,071	1	SGT6-5000F	60	(2)
SCC6-5000F 2x1	750	6,071	2	SGT6-5000F	60	(2)
SCC5-8000H Single Shaft	665	5,890	1	SGT5-8000H	50	(2)
SCC5-8000H 2x1	1,335	5,880	2	SGT5-8000H	50	(2)
SCC5-4000F Single Shaft	475	6,030	1	SGT5-4000F	50	(2)
SCC5-4000F 2x1	950	6,030	2	SGT5-4000F	50	(2)
SCC5-2000E 1x1	275	6,755	1	SGT5-2000E	50	(1)
SCC5-2000E 2x1	551	6,755	2	SGT5-2000E	50	(1)
SCC6-2000E 1x1	174	6,893	1	SGT6-2000E	60	(1)
SCC6-2000E 2x1	347	6,901	2	SGT6-2000E	60	(1)

Site conditions = 59°F, 14.7 psia, 60% RH (15°C, 1.013 bar).
1 dual pressure, no reheat
2 triple pressure, reheat
Net plant performance shown above includes auxiliary power consumption. All ratings on natural gas with LHV

Combined Cycle Plant Specifications

SIEMENS

MODEL	POWER RATING ISO Base Load At Generator Terminals (MW) Gas Turbines	Total power	HEAT RATE Lower Heating Value (LHV) (kJ/kWh)	GAS TURBINES Number	Model	Frequency (Hz)	COMMENTS
INDUSTRIAL APPLICATIONS							
SCC-600 1x1	35.9		7,220	1	SGT-600	50/60	(1)
SCC-600 2x1	73.3		7,071	2	SGT-600	50/60	(1)
SCC-700 1x1	45.2		6,876	1	SGT-700	50/60	(1)
SCC-700 2x1	91.6		6,788	2	SGT-700	50/60	(1)
SCC-750 1x1	51.6		6,760	1	SGT-750	50/60	(1)
SCC-750 2x1	103.7		6,718	2	SGT-750	50/60	(1)
SCC-800 (47.5 MW) 1x1	66.6		6,693	1	SGT-800	50/60	(1)
SCC-800 (47.5 MW) 2x1	135.4		6,583	2	SGT-800	50/60	(1)
SCC-800 (47.5 MW) 3x1	203.5		6,569	3	SGT-800	50/60	(1)
SCC-800 (50.5 MW) 1x1	71.4		6,530	1	SGT-800	50/60	(1)
SCC-800 (50.5 MW) 2x1	143.6		6,494	2	SGT-800	50/60	(1)
SCC-800 (50.5 MW) 3x1	215.7		6,485	3	SGT-800	50/60	(1)
SCC-800 (54.0 MW) 1x1	75.9		6,427	1	SGT-800	50/60	(1)
SCC-800 (54.0 MW) 2x1	153.7		6,349	2	SGT-800	50/60	(1)
SCC-800 (54.0 MW) 3x1	229.9		6,365	3	SGT-800	50/60	(1)
SCC-800 (57.0 MW) 1x1	80.7		6,207	1	SGT-800	50/60	(2)
SCC-800 (57.0 MW) 2x1	163.1		6,143	2	SGT-800	50/60	(2)
SCC-800 (57.0 MW) 3x1	245.0		6,143	3	SGT-800	50/60	(2)
SGT-A35 DLE 1x1 (Ind. RB211-G62 DLE)	37.7		7,175	1	SGT-A35	50/60	(1)
SGT-A35 DLE 1x1 (Ind. RB211-GT62 DLE)	39.8		7,005	1	SGT-A35	50/60	(1)
SGT-A35 DLE 1x1 (Ind. RB211-GT61 DLE)	42.6		6,820	1	SGT-A35	50/60	(1)
SGT-A65 DLE 1x1 (Ind. Trent 60 DLE)	73.0		6,593	1	SGT-A65	50/60	(1)
SGT-A65 DLE ISI 1x1 (Ind. Trent 60 DLE ISI)	83.0		6,648	1	SGT-A65	50/60	(1)
SGT-A65 DLE 2x1 (Ind. Trent 60 DLE)	147.0		6,546	2	SGT-A65	50/60	(1)
SGT-A65 DLE ISI 2x1 (Ind. Trent 60 DLE ISI)	166.8		6,617	2	SGT-A65	50/60	(1)

Site conditions = 59 °F, 14.7 psia, 60% RH (15C, 1.013 bar). Footnotes: (1) dual pressure, no reheat; (2) 3P, no reheat
Net Plant performance show above includes auxiliary power consumption
All ratings on natural gas with LHV.

Electrical Generation Specifications

ANSALDO ENERGIA, Genoa, Italy

MODEL	POWER RATING ISO Base Load (MW)	EFFICIENCY %	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Grid Frequency	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
AE64.3A	80	36.4	*3,000/3,600	18.3	1 (annular)	*50/60 Hz	215	580
AE94.2	190	36.3	3,000	12.0	2 (silo)	50 Hz	555	550
AE94.2K	170	36.5	3,000	12.0	2 (silo)	50 Hz	540	545
AE94.3A	340	40.3	3,000	19.5	1 (annular)	50 Hz	755	593
GT26	370	41.0	3,000	35.0	2 (annular)	50 Hz	741	625
GT36-S5	538	42.8	3,000	26.0	1 (annular)	50 Hz	1,020	621
GT36-S6	369	42.3	3,600	24.0	1 (annular)	60 Hz	710	630
AE-T100	0.1	30.0	70,000	4.5	1 (silo)	50/60 Hz	1	270

Notes: Reference conditions: ISO, i.e., Amb. temp. = 15°C, amb. press.= 1.013 bar, amb. R.H. = 60%;
Natural gas methane, except low heating value gas for AE94.2K
GT Inlet pressure loss = 0 mbar, GT Exhaust pressure loss = 0 mbar
*with gear (gas turbine 90 Hz)

BAKER HUGHES, a GE company

MODEL	POWER RATING ISO Base Load (MWe)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
OIL & GAS								
NovaLT5-1	5,644	11,146	16,630	15.0	1 annular	—	20.2	574
GE10-1	11,250	10,882	11,000	15.5	1 can	—	46.7	485
NovaLT16	16,300	9,425	7,800	19.0	1 annular	—	54.1	490
PGT25	22,562	9,392	6,500	17.9	1 annular	—	68.9	524
MS5001 DLN	26,716	11,934	5,100	10.6	10 cans	—	124.1	485
MS5002E	33,092	9,561	5,714	17.8	6 cans	—	104.9	515
PGT25+	30,162	8,685	6,100	21.5	1 annular	—	84.3	500
PGT25+G4	32,663	8,683	6,100	23.2	1 annular	—	89.7	510
PGT25+G5	35,178	8,592	6,100	25.1	1 annular	—	92.5	550
LM6000PC (60Hz)	43,574	8,168	3,600	28.8	1 annular	—	126.5	452
LM6000PF (60Hz)	43,139	8,160	3,600	29.1	1 annular	—	124.6	455
LM6000PF+ (60Hz)	52,740	8,233	3,930	32.3	1 annular	—	144.6	476
LM6000PG (60Hz)	51,703	8,146	3,930	32.3	1 annular	—	141.3	471
LM9000	64,025	7,937	3,600	33.0	1 annular	—	179.0	454
Nova LT12	12,200	9,639	8,904	19.0	1 annular	—	42.3	485

CAPSTONE TURBINE CORPORATION, Van Nuys, California

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (kJ/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
C30	0.030	13,800	96,000	4:1	1 Annular	15	0.31	275
C65 and C65 ICHP	0.065	12,400	96,000	4:1	1 Annular	15	0.49	309
C65 CARB	0.065	12,900	96,000	4:1	1 Annular	15	0.51	311
C200	0.200	10,900	61,000	4:1	1 Annular	15	1.33	280
C1000 Signature Series	1.000	10,900	61,000	4:1	1 Annular	15	6.65	280

Electrical Generation Specifications

CENTRAX GAS TURBINES, Newton Abbot, England, UK

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating (kJ/kWh)	POWER SHAFT Value (LHV) (RPM)	SPEED RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
CX501-KB5	3.9	12,391	14,571	10.3:1	6 (can)	—	15.8	555
CX501-KB7	5.6	11,130	14,571	13.9:1	6 (can)	—	21.3	521
CX 300	7.9	11,773	14,010	13.7:1	6 (can)	—	30.2	542
CX 300	8.5	10,399	11,500	13.8:1	6 (can)	—	29.9	511
CX 400	11.9	10,374	9,500	16.8:1	6 (can)	—	38.9	544
CX 400	12.9	10,355	9,500	16.8:1	6 (can)	—	39.4	555
CX 400	14.4	10,178	9,500	18.9:1	6 (can)	—	44.0	540

Note: Specifications are for natural gas fuel, sea level, 15°C, no intake-exhaust losses.

KAWASAKI HEAVY INDUSTRIES, LTD., Akashi, Japan

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
M1A-13A	1.49	14,104	1,500/1,800	9.4	1	—	8.1	521
M1A-13D	1.49	14,246	1,500/1,800	9.6	1	—	8.0	531
M1T-13A	2.93	14,312	1,500/1,800	9.4	1×2	—	16.2	521
M1A-17D	1.81	12,160	1,500/1,800	10.5	1	—	8.1	522
M1T-13D	2.93	14,445	1,500/1,800	9.6	1×2	—	16.0	531
M5A-01D	4.71	11,030	1,500/1,800	15.4	6	—	17.4	511
M7A-01	5.53	11,510	1,500/1,800	13.1	6	—	21.7	545
M7A-01D	5.47	11,550	1,500/1,800	13.1	6	—	21.7	542
M7A-02	6.80	11,250	1,500/1,800	16.0	6	—	27.0	516
M7A-02D	6.74	11,270	1,500/1,800	16.0	6	—	27.0	513
M7A-03D	7.80	10,190	1,500/1,800	15.8	6	—	27.2	523
L20A	18.52	9,948	1,500/1,800	18.6	8	—	59.8	541
L30A	34.38	8,460	1,500/1,800	25.8	8	—	92.6	502

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
MGT6000	6.63–7.80	10,270–10,610	1,500/1,800	14–16	6	—	26.1–29.4	490–505
THM1304-10N	10.08	11,690	9,000	10	2	—	46.5	490
THM1304-12N	11.52	11,460	9,000	11	2	—	48.1	525

Electrical Generation Specifications

MITSUBISHI HITACHI POWER SYSTEMS, LTD

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)	Efficiency (%)
M501DA	114.0	9,780	3,600	14	14	—	354	543	34.9
M501F	185.4	9,230	3,600	16	16	—	468	613	37.0
M501G	267.5	8,730	3,600	20	16	—	612	601	39.1
M501GAC	283.0	8,531	3,600	20	16	—	618	617	40.0
M501J	330.0	8,105	3,600	23	16	—	620	635	42.1
M501JAC	425.0	7,755	3,600	25	16	—	738	649	44.0
M701DA	144.1	9,810	3,000	14	18	—	453	542	34.8
M701G	334.0	8,630	3,000	21	20	—	755	587	39.5
M701F	385.0	8,144	3,000	21	20	—	748	630	41.9
M701J	478.0	8,067	3,000	23	22	—	896	630	42.3
M701JAC	563.0	7,826	3,000	25	22	—	989	649	43.6
M701JAC	448.0	7,755	3,000	25	22	—	765	663	44.0
H-25	41.0	9,432	7,280	17.9	10	—	114	569*	36.2
H-100	116.5	8,909	3,000	18	10	—	296	586*+	38.3
H-100	105.8	8,930	3,600	18.4	10	—	293	534*++	38.2

Notes: All other specifications are for natural gas fuel with inlet and exhaust losses. * without inlet and exhaust losses. +50Hz, ++60Hz

OPRA GAS TURBINES, The Netherlands

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kW-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp (°C)	Exhaust Flow (lb/sec)	Exhaust Temp. (°C)
OP16-3A	1.88	13,585	26,000	6.7	4 combustor cans	—	19.8	573
OP16-3B (DLE)	1.88	13,585	26,000	6.7	4 combustor cans	—	19.8	573
OP16-3C	1.88	13,585	26,000	6.7	4 combustor cans	—	19.8	573

PW POWER SYSTEMS, Glastonbury, Connecticut, U.S.A. www.pwps.com

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD TURBINE INLET TEMP (°F)	EXHAUST FLOW (lbs/sec)	EXHAUST TEMP (°F)
PW POWER SYSTEMS (50 HZ)								
FT8 SWIFTPAC 60 *	61.6	9,366	3000	21.3	18		405	922
FT8 SWIFTPAC 30 *	30.7	9,383	3000	21.3	9		202	922
FT8 SWIFTPAC 50 DLN	50.9	8,970	3000	19.5	2		373	863
FT8 SWIFTPAC 25 DLN	25.3	9,016	3000	19.5	1		186	863
FT8 MOBILEPAC **	28.5	9,834	3000	21.3	9		203	924
FT4000 SWIFTPAC 120 ***	140.4	8,348	3000	37.6	2		803	793
FT4000 SWIFTPAC 60 ***	70.2	8,352	3000	37.6	1		401	793
PW POWER SYSTEMS (60 HZ)								
FT8 SWIFTPAC 60 *	62.1	9,281	3600	21.3	18		404	916
FT8 SWIFTPAC 30 *	30.9	9,327	3600	21.3	9		202	916
FT8 SWIFTPAC 50 DLN	51.1	8,938	3600	19.5	2		372	861
FT8 SWIFTPAC 25 DLN	25.4	8,993	3600	19.5	1		186	861
FT8 MOBILEPAC **	30.9	9,312	3600	21.3	9		202	916
FT4000 SWIFTPAC 120 ***	141.6	8,248	3600	37.6	2		802	784
FT4000 SWIFTPAC 60 ***	70.8	8,269	3600	37.6	1		401	785

Estimates are for natural gas fuel. Zero installation losses.
*combustor water injection, **combustor water injection, transportable, ***combustor water injection, wet compression, inlet fogging

Electrical Generation Specifications

SIEMENS (50/60 HZ)

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWh)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD		
						Turbine Inlet Temp. (°F)	Exhaust Flow (lbs/sec)	Exhaust Temp (°F)
SGT5-9000HL	567	8,019	3,000	24.0	16	—	2,205	1,256
SGT6-9000HL	388	8,074	3,600	24.0	12	—	1,543	1,256
SGT5-8000HL	481	8,006	3,000	24.0	16	—	1,874	1,256
SGT5-8000H	450	< 8,322	3,000	21.0	16	—	2,061	1,166
SGT6-8000H	310	< 8,530	3,600	21.0	12	—	1,433	1,193
SGT5-4000F	329	8,322	3,000	20.1	1 (annular)	—	1,596	1,110
SGT6-5000F	250	8,682	3,600	18.9	16	—	1,296	1,108
SGT5-2000E	187	9,349	3,000	12.8	2 (silo)	—	1,230	997
SGT6-2000E	117	9,639	3,600	12.0	2 (silo)	—	811.0	990
SGT-800 (57.0 MW)	57.0	8,502	6,608	21.8	—	—	301.2	1,049
SGT-800 (54.0 MW)	54.0	8,725	6,608	21.4	—	—	298.7	1,045
SGT-800 (50.5 MW)	50.5	8,899	6,608	21.0	—	—	295.8	1,027
SGT-800 (47.5 MW)	47.5	9,048	6,608	20.1	—	—	292.8	1,007
SGT-750	39.8	8,456	6,100	24.3	—	—	253.3	875
SGT-700	32.8	9,170	6,500	18.7	—	—	209.0	991
SGT-600	24.5	10,161	7,700	14.0	—	—	179.2	1,009
SGT-400 (15 MW)	14.3	9,647	9,500	18.9	—	—	97.7	1,004
SGT-400 (13 MW)	12.9	9,815	9,500	16.8	—	—	86.8	1,031
SGT-300	7.9	11,158	14,010	13.7	—	—	66.6	1,008
SGT-100 (5.4 MW)	5.4	11,007	17,384	15.6	—	—	45.4	988
SGT-100 (5.1 MW)	5.1	11,292	17,384	14.0	—	—	43.1	1,013
SGT-A65 50 Hz DLE	61.9	7,874	3,000	38.1	—	—	377.0	826
SGT-A65 50 Hz DLE with ISI	65.9	7,799	3,000	39.6	—	—	392.4	808
SGT-A65 60 Hz DLE	59.6	7,895	3,600	36.6	—	—	363.8	829
SGT-A65 60 Hz DLE with ISI	64.9	7,877	3,600	38.0	—	—	377.0	819
SGT-A65 50 Hz WLE with ISI	67.4	8,269	3,000	39.9	—	—	392.4	808
SGT-A65 60 Hz WLE with ISI	70.8	8,242	3,600	39.3	—	—	388.0	837
SGT-A45 50 Hz (at 15 °C ambient)	41.0	8,777	3,000	27.7	—	—	279.9	891
SGT-A45 50 Hz (at 30 °C ambient)	39.3	8,914	3,000	26.7	—	—	264.5	934
SGT-A45 60 Hz (at 15 °C ambient)	44.0	8,477	3,600	27.9	—	—	277.7	901
SGT-A45 60 Hz (at 30 °C ambient)	39.6	8,660	3,600	25.8	—	—	255.7	928
SGT-A35 (GT30 38 MW) 50 Hz	36.6	8,813	3,000	25.4	—	—	244.7	912
SGT-A35 (GT30 34 MW) 50 Hz	32.2	9,109	3,000	22.9	—	—	220.0	937
SGT-A35 (GT30 34 MW) DLE 50 Hz	31.9	9,140	3,000	22.6	—	—	218.7	939
SGT-A35 (GT30 38 MW) 60 Hz	37.4	8,600	3,600	25.0	—	—	240.5	909
SGT-A35 (GT30 34 MW) 60 Hz	33.2	8,873	3,600	22.7	—	—	218.0	934
SGT-A35 (GT30 34 MW) DLE 60 Hz	32.5	8,906	3,600	22.3	—	—	215.8	932
SGT-A35 (GT61) DLE	32.1	8,681	4,850	21.6	—	—	207.0	950
SGT-A35 (GT62) DLE	29.9	9,089	4,800	21.7	—	—	209.0	937
SGT-A35 (G62) DLE	27.2	9,387	4,800	20.6	—	—	201.0	934
SGT-A05 (KB7HE)	5.8	10,281	14,600	14.0		—	47.1	972
SGT-A05 (KB7S)	5.4	10,570	14,600	13.9	—	—	47.0	921
SGT-A05 (KB5S)	4.0	11,504	14,200	10.3	—	—	34.0	1,040
KG2-3E	1.9	18,956	1500/1800	4.0	—	—	33.1	1,210
KG2-3G	2	13,124	1500/1800	7.0	—	—	20.9	1,279

Note: EG ratings at generator terminals. Specifications are for natural gas fuel.

Electrical Generation Specifications

SOLAR TURBINES, San Diego, California, U.S.A.

MODEL	POWER RATING ISO Base Load (MW)	HEAT RATE Lower Heating Value (LHV) (Btu/kWhe)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO BASE LOAD Turbine Inlet Temp. (°C)	AT ISO BASE LOAD Exhaust Flow (kg/sec)	AT ISO BASE LOAD Exhaust Temp (°C)
Saturn 20	1.2	10,405	1,500/1,800	6.7	1 (annular)	—	6.5	505
Centaur 40	3.5	12,240	1,500/1,800	10.1	1 (annular)	—	19.0	445
Centaur 50	4.6	11,630	1,500/1,800	10.6	1 (annular)	—	19.1	510
Mercury 50	4.6	8,865	1,500/1,800	9.9	1 (annular)	—	17.8	365
Taurus 60	5.7	10,830	1,500/1,800	12.4	1 (annular)	—	21.8	510
Taurus 65	6.5	10,375	1,500/1,800	15.1	1 (annular)	—	21.1	550
Taurus 70	8.2	9,955	1,500/1,800	17.6	1 (annular)	—	26.9	510
Mars 100	11.4	10,365	1,500/1,800	17.7	1 (annular)	—	42.6	485
Titan 130	16.5	9,695	1,500/1,800	17.1	1 (annular)	—	54.7	490
Titan 250	23.1	8,775	1,500/1,800	24.1	1 (annular)	—	68.2	465
MOBILE POWER UNIT								
Taurus 60 MPU	5.7	10,830	1,500/1,800	12.4	1 (annular)	—	21.8	510
Titan 130 MPU	16.5	9,695	1,500/1,800	17.1	1 (annular)	—	54.7	490
MODULAR POWER PLANT								
Taurus 60 MPP	5.7	10,830	1,500/1,800	12.4	1 (annular)	—	21.8	510
Taurus 130 MPP	16.5	9,695	1,500/1,800	17.1	1 (annular)	—	54.7	490

Note: Specifications are for natural gas fuel. MPP stands for Modular Power Plant

Mechanical Drive Specifications

BAKER HUGHES, a GE company

MODEL	POWER RATING Base Load (HP)	HEAT RATE Lower Heating Value (Btu/hp-h)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER of COMBUSTORS	Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
NovalT5-2	7,510	10,835	12,500	15.0	1 annular	—	20.2	555
GE 10-2	16,068	7,649	7,900	15.5	1 can	—	46.7	480
NovaLT16	22,491	6,829	7,800	19.0	1 (annular)	—	54.1	490
PGT25	31,660	6,992	6,500	17.9	1 (annular)	—	68.9	524
MS5002C	39,520	8,714	4,670	9.1	12 cans	—	124.3	517
MS5002D	45,569	8,413	4,670	10.4	12 cans	—	141.4	509
MS5002E	45,300	6,884	5,714	17.8	6 cans	—	104.9	515
PGT25+	42,962	6,348	6,100	21.5	1 (annular)	—	84.3	500
PGT25+G4	46,385	6,343	6,100	23.2	1 (annular)	—	89.7	510
PGT25+G5	49,960	6,280	6,100	25.1	1 (annular)	—	92.5	550
LM6000PC	59,560	5,957	3,600	28.8	1 (annular)	—	126.5	452
LM6000PF	58,809	5,917	3,600	29.1	1 (annular)	—	124.6	455
LM6000PF+	72,812	5,960	3,930	32.3	1 (annular)	—	144.6	476
LM6000PG	70,787	5,890	3,930	32.3	1 (annular)	—	141.3	471
MS6001B	58,380	7,647	5,111	12.2	10 cans	—	140.0	544
MS7001EA	115,630	7,718	3,600	12.7	14 cans	—	296.0	535
LM9000	87,165	5,921	3,429	33.0	1 (annular)	—	179.0	454
MS9001E	174,520	7,348	3,000	12.7	14 cans	—	410	540

KAWASAKI HEAVY INDUSTRIES, LTD., Akashi, Japan

				AT ISO BASE LOAD				
Model	POWER RATING ISO Base Load (hp)	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
L30A	47,660	6,100	5,600	25.8:1	8	—	92.6	502

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany

					AT ISO BASE CONTINUOUS			
MODEL	POWER RATING ISO Base Load (hp)	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
MGT6000	9,250–11,130	7,270–7,480	12,000	15–16	6	—	28.1–30.0	460–480
THM1304-10N	14,080	8,370	9,000	10	2	—	46.5	490
THM1304-12N	16,090	8,210	9,000	11	2	—	48.1	525

MITSUBISHI HITACHI POWER SYSTEMS, LTD.

						AT ISO RATING CONTINUOUS		
MODEL	POWER RATING ISO Base Load (hp)	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
H-100	144,350	6,542	3,600	18.4	10	—	293	534
H-100	160,780	6,549	3,000	20.1	10	—	315	552

Note: All ratings are at the gas turbine shaft end and based on the natural gas fuel.

Mechanical Drive Specifications

PW POWER SYSTEMS, Glastonbury, Connecticut, U.S.A.

MODEL	POWER RATING ISO Base Load (hp[1])	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	AT ISO RATING CONTINUOUS: NUMBER OF COMBUSTORS	Turbine Inlet Temp. (°F)	Exhaust Flow (lbs/sec)	Exhaust Temp (°F)
FT8	37,940	6,580	5,500	20.2	9	—	193.4	857

1 shp base.
Note: Estimates are for natural gas fuel.

SIEMENS

MODEL	POWER RATING ISO Base Load (hp)	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	AT ISO BASE CONTINUOUS: NUMBER OF COMBUSTORS	Turbine Inlet Temp. (°C)	Exhaust Flow (lbs/sec)	Exhaust Temp (°F)
SGT-750 (41 MW)	54,994	6,121	3,050–6,100–6,405	24.3	—	—	253.3	875
SGT-750 (34 MW)	45,595	6,299	3,050–6,100–6,405	21.9	—	—	236.9	822
SGT-700	45,151	6,661	3,250–6,500–6,825	18.7	—	—	209	991
SGT-600	33,847	7,344	3,850–7,700–8,085	14.0	—	—	179.2	1,009
SGT-400 (15 MW)	20,006	6,908	4,750–9,500–9,975	18.9	—	—	97	1,004
SGT-400 (13 MW)	18,000	7,028	4,750–9,500–9,975	16.8	—	—	86.8	1,031
SGT-300 (9 MW)	12,388	7,141	5,750–11,500–12,075	14.5	—	—	67.2	954
SGT-300 (8 MW)	11,216	7,255	5,750–11,500–12,075	13.8	—	—	65.5	916
SGT-100	7,640	7,738	6,500–13,000–13,650	14.9	—	—	43.4	1,009
SGT-A65 DLE	77,645	5,831	2,380–3,430–3,570	34.3	—	—	347.7	837
SGT-A65 DLE with ISI	83,545	5,859	2,380–3,430–3,570	34.3	—	—	358.9	825
SGT-A35 (GT30 38 MW)	51,092	6,317	2,400–3,429–3,600	25.2	—	—	241.4	910
SGT-A35 (GT30 34 MW)	45,195	6,516	2,400–3,429–3,600	22.8	—	—	218.9	934
SGT-A35 (GT30 34 MW) DLE	44,387	6,541	2,400–3,429–3,600	22.3	—	—	216.5	932
SGT-A35 (GT61)	45,316	6,299	3,153–4,850–5,093	22.1	—	—	209	950
SGT-A35 (GT61) DLE	44,230	6,307	3,153–4,850–5,093	21.6	—	—	207	950
SGT-A35 (GT62)	41,495	6,599	3,120–4,800–5,040	22.0	—	—	211.9	937
SGT-A35 (GT62) DLE	41,084	6,602	3,120–4,800–5,040	21.7	—	—	209	937
SGT-A35 (G62)	39,075	6,743	3,120–4,800–5,040	21.3	—	—	205.9	934
SGT-A35 (G62) DLE	37,465	6,819	3,120–4,800–5,040	20.6	—	—	201	934

SOLAR TURBINES, San Diego, California, U.S.A.

MODEL	POWER RATING ISO Base Load (hp)	HEAT RATE Lower Heating Value (LHV) (Btu/hp-hr)	POWER SHAFT SPEED (RPM)	PRESSURE RATIO	NUMBER OF COMBUSTORS	AT ISO RATING CONTINUOUS: Turbine Inlet Temp. (°C)	Exhaust Flow (kg/sec)	Exhaust Temp (°C)
Saturn 20	1,590	10,360	22,300	6.7	1 (annular)	—	6.5	520
Centaur 40	4,890	9,100	15,500	10.3	1 (annular)	—	18.2	450
Centaur 50	6,130	8,485	16,500	10.3	1 (annular)	—	18.9	515
Taurus 60	7,700	7,950	14,300	12.2	1 (annular)	—	21.7	510
Taurus 70	11,110	7,190	11,605	16.5	1 (annular)	—	27.2	500
Mars 90	13,220	7,655	9,500	16.3	1 (annular)	—	40.2	465
Mars 100	15,900	7,395	9,500	17.1	1 (annular)	—	42.6	485
Titan 130	23,470	7,020	8,855	16.1	1 (annular)	—	56.1	495
Titan 250	31,900	6,360	7,000	24.1	1 (annular)	—	68.2	465

Steam Turbine Specifications

ANSALDO ENERGIA, Genoa, Italy

MODEL	Power Rating (MW)	Thermal Cycle Type	Application	Configuration	Grid Freq. (Hz)	Inlet Temp. (°C)	Inlet Pressure (bar)
GT series	15–150		Geothermal	1 to 2 cylinder	50/60	Up to 240	Up to 20
MT10	40–250	Non-Reheat	Combined Cycle, Fossil, Solar	1-cylinder	50/60	Up to 565	Up to 140
MT20	100–350	Non-Reheat	Combined Cycle, Fossil, Cogeneration	2 to 3 cylinder	50/60	Up to 565	Up to 140
MT15	100–300	Reheat	Combined Cycle, Fossil, Solar	2-cylinder	50/60	Up to 600/585	Up to 170
RT30	150–1000	Reheat	Combined Cycle, Fossil, Cogeneration	3 to 5 cylinder	50/60	Up to 600/620	Up to 280

BAKER HUGHES, a GE company, Steam Turbine—Reaction Technology (Florence, Italy; Elblag, Poland)

MODEL	POWER RATING (MW)	SPEED RANGE (RPM)	RATED INLET PRESSURE (BAR A)	RATED INLET TEMPERATURE (°C)	INLET CONTROL TYPE	CONTROLLED EXTRACTIONS (#)	EXHAUST
SC/SAC	2–100	3,000–15,000	140	565	Sliding/Fixed Pressure	0–2	Radial/Axial
SNC/SANC	2–100	3,000–15,000	140	565	Sliding/Fixed Pressure	0–2	Radial, Max 60 BARA
A5/A9	20–100	3,000–3,600	140	565	Sliding/Fixed Pressure	—	Axial
SG	5–40	3,000–3,600	30	300	Sliding/Fixed Pressure	—	Radial/Axial
SDF	10–80	3,000–3,600	30	300	Sliding/Fixed Pressure	—	Double Flow
GRT/HRT	15–100+	4,300–7,000	140	565	Sliding/Fixed Pressure	0–1	Axial
MT	50–135+	3,000–3,600	175	585	Sliding/Fixed Pressure	0–2	Radial/Axial
MP	2–30	3,000–13,000	150	530	Sliding/Fixed Pressure	0–1	Radial
MC	2–45	3,000–13,000	150	530	Sliding/Fixed Pressure	0–1	Radial/Axial
BFPT	5–45	4,000–15,000	170–280	565–575	Sliding/Fixed Pressure	—	Radial
SINGLE OR DOUBLE ADMISSION							
P	1–6	5,000–13,000	90	480	Sliding/Fixed Pressure	0–1	Radial, Max 20 BARA
C	1–6	5,000–13,000	90	480	Sliding/Fixed Pressure	0–1	Radial
GST	20–55	3,000–3,600	10	300	Sliding Pressure	N/A	Radial/Axial

SC = Condensing Type, SAC = Condensing Type with Controlled Extractions, SNC = Backpressure Type, SNC = Backpressure Type with Controlled Extractions, A5/A9 = Single Casing Reheat, SG = Geothermal Applications, SDF = Double Flow, MP = Multivalves—Backpressure Type, MC = Multivalves—Condensing Type, BFPT = Boiler Feed Pump Turbine, P = Single valve—Backpressure Type, C = Single valve—Condensing Type

DOOSAN ŠKODA POWER, Czech Republic

ELECTRIC POWER GENERATION			MECHANICAL DRIVE		
ELECTRIC UTILITY MW RANGE Fossil Fueled	ELECTRIC UTILITY MW RANGE Nuclear	INDUSTRIAL MW Range	COMBINED CYCLE MW Range	MARINE hp Range	OTHER hp Range
up to 800	up to 1,200	up to 250	up to 400	—	—

Important worldwide producer and supplier with more than 100 years of experience in the production of steam turbines. Doosan Škoda Power is part of a strong group of companies united under the Doosan Group that supplies its customers worldwide with cutting-edge technology and services. Modular design lines of ŠKODA turbines from DST-G10 to DST-S30 cover the power range from 3 MW up to 1,200 MW (more on www.doosanskodapower.com). Design configurations include reheat, non-reheat, condensing, back-pressure, arranged with and without extractions, working in 50 and 60 Hz. Doosan Škoda Power services cover complete delivery of turbine machine halls for fossil power plants including supercritical, industry, combined cycles, renewables power plants and nuclear power plants. Non OEM retrofit and modernization. Cooperation with premier global EPC contractors.

Steam Turbine Specifications

ELLIOTT GROUP, Jeannette, Pennsylvania, U.S.A. and Sodegaura, Chiba, Japan

ELECTRIC POWER GENERATION			MECHANICAL DRIVE		
ELECTRIC UTILITY MW RANGE		INDUSTRIAL MW Range	PROCESS hp Range	MARINE hp Range	OTHER hp Range
Fossil Fueled	Nuclear				
0.05–50	—	0–130	1–175,000 hp	—	1–175,000 hp

Elliott designs, manufactures, tests, installs, services and repairs steam turbines for industrial power generation and mechanical drive service. Dependable, versatile turbomachinery is essential for today's refinery and chemical processes, industrial applications, and power generation use. Elliott steam turbines yield proven reliability and high efficiency which make them a key element of successful mechanical drive or power genera- tion services. Elliott offers a complete line of steam turbines ranging up to 175,000 HP (130,000 kW) capable of inlet steam conditions up to 2,200 PSIG 151 BarG) and 1050°F (565°C). Elliott's steam turbines are available in multiple configurations including condensing and back pressure designs, single and multiple valve designs, and multiple controlled and uncontrolled extractions or inductions. Elliott steam turbines can operate at speeds up to 16,000 RPM making them suitable as drivers for equipment such as pumps, fans, compressors, and generators. With manufacturing headquarters in Sodegaura, Japan and Jeannette, Pennsylvania along with an extensive network of service shops strategically located worldwide Elliott is exclusively situated to provide design, manufacturing, testing, installation, and service to steam turbines for global industrial power.

FUJI ELECTRIC CORPORATION OF AMERICA, Edison, New Jersey, U.S.A.

ELECTRIC POWER GENERATION				MECHANICAL DRIVE
ELECTRIC UTILITY Fossil Fueled	BINARY GEORTHERMAL Organic Rankine Cycle	INDUSTRIAL MW Range	CONVENTIONAL GEORTHERMAL MW Range	MARINE hp Range
50–350 MW Per Unit	2–10 MW Per Unit	50–350 Per Unit	10–150 Per Unit	

As a leading manufacturer of steam turbines and generators since 1957, Fuji Electric offers a wide range of steam turbine and generator models for various applications, including combined cycle, cogeneration, fossil-fueled, biomass, geothermal, and geothermal binary, ranging from 10 MW to 1,000 MW. In addition to engineered power generation systems, Fuji Electric offers field service and maintenance through its wholly-owned subsidiary, Reliable Turbine Services.

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany
MAN ENERGY SOLUTIONS SE, Hamburg, Germany

ELECTRIC POWER GENERATION			MECHANICAL DRIVE		
ELECTRIC UTILITY MW RANGE		INDUSTRIAL MW Range	PROCESS hp Range	MARINE hp Range	OTHER hp Range
Fossil Fueled	Nuclear				
1–180	—	1–180	1,400–240,000	—	—

Steam turbines as mechanical drive. Generator steam turbines.
Multi-stage back-pressure steam turbines. Multi-stage condensing steam turbines.
MAN Diesel & Turbo SE manufactured its first steam turbine in 1904. The rigid design of these machines ensures a long life and optimum service intervals. Various models and sizes are available: condensing turbines, back pressure turbines, extraction and admission turbines. A modular sys- tem guarantees the extensive flexibility of the design without sacrificing the persistent value of the standardized components. Steam turbines are delivered for mechanical drive applications, driving compressors, as well as for generator drive applications (including refineries, biomass, waste- to-energy, concentrated solar power, WHRS, pulp & paper, CHP and Combined Cycle) for industrial power generation.

SIEMENS POWER AND GAS

ELECTRIC POWER GENERATION			MECHANICAL DRIVE		
ELECTRIC UTILITY MW RANGE		INDUSTRIAL MW RANGE	PROCESS rpm	MARINE rpm	OTHER rpm
Fossil Fueled	Nuclear				
up to 1,200	up to 1,900	0.045–250	up to 18,000	up to 17,000	up to 18,000

Siemens offers a full range of steam turbine generator products and services for both utility and industrial applications. Technologically advanced 50 and 60 Hz units are available for applications ranging from large utility fossil or nuclear plants to a broad range of combined cycle units including backpressure or extraction machines for cogeneration and industrial use. Steam turbines for inlet steam pressures and temperatures up to 330 bar (4,786 psig) and 610°C (1,130°F), and back pressures up to 80 bar (1,160 psig) are provided. Turbine arrangements with controlled extractions or bleeds are also available.

Turbocompressor Specifications

ATLAS COPCO GAS AND PROCESS (www.atlascopco-gap.com)
ATLAS COPCO ENERGAS GMBH, Cologne, Germany
ATLAS COPCO COMPTEC LLC, Voorheesville, New York, U.S.A.
ATLAS COPCO PROCESS EQUIPMENT CO., LTD., Shanghai, China
ATLAS COPCO GAS AND PROCESS APPLICATION, Pune, India

CENTRIFUGAL COMPRESSORS

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
GT	250–500,000	up to 205	50,000	1 to 8	52,000	V	all	all	C,I
RT	320,000–650,000	up to 7	60,000	3	6,500	H	C	Air	C,R
T	15,000–65,000	up to 43	16,000	1	3,600	V	D	PP, PE	C

Note: The T-Series is a direct-driven compressor

POSITIVE DISPLACEMENT COMPRESSORS

MODEL	NUMBER OF THROWS	MAXIMUM POWER (kW)	MAXIMUM DISCHARGE PRESSURE (bar)	MAXIMUM FLOW (Nm^3/h)	APPLICATIONS	TYPE OF DESIGN
DM	4	37	447	140	H, CNG/NGV	Oil-free, piston
CU/CT	up to 6	190	480	1.6	air, N, He, H, CNG/NGV	Oil-lube, piston
BBR/FBR/VIP	2	450	312	6	CNG/NGV	Oil-lube, piston
GB	NA	560	35	2400	LNG—BOG, FGB, Refrigeration, Biomethane	Oil-injected, screw
GZ	NA	1000	27	9000	LNG—BOG, CO_2 liquefaction, Refrigeration	Oil-free screw

BAKER HUGHES, a GE company, Florence, Italy

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
BCL, 2BCL	125,000	900	—	2–10	20,000	V	D,L,O	2	C
MCL, 2MCL	400,000	60	—	2–10	20,000	H	D,L,O	3	C
DMCL	700,000	25	—	2–8	10,000	H	D,L,O	3	C
3MCL	400,000	60	—	2–10	15,000	H	D,L,O	3	C
SRL	450,000	200	—	1–10	40,000	V	D,L,O	2	C
DBCL	250,000	100	—	2–8	18,000	V	D,L,O	3	C
PCL	100,000	130	—	1–4	18,000	V	D,L,O	natural gas	C
ANR	600,000	25	—	up to 20	10,000	H	D,L,O	3	A+C
AN	600,000	15	—	up to 20	10,000	H	D,L,O	3	A
BlueC 400	180,000	205	16,763	3–5	10,670	V	—	natural gas	C
RA	4,500	220	10,700	1–7	20,000	V	D,L,O,	process gas	C
ICL	35,000	250	20,000	1–9	18,000	V	Sealless	non-acid gas	C
D/DH	375,000	50	—	1	20,000	V	D,L,O	2	C
Oil-Free Screw	1,000–70,000	21	—	—	—	V	D,C,L,O	All excluding O_2 S	

2 Air, steam and process gases. 3 Air and process gasses. S - API 619
GE Energy manufactures a complete range of compressors for all major compression services. Key locations include: Florence, Italy; Houston, Texas, U.S.A.; Le Creusot, France

Turbocompressor Specifications

BAKER HUGHES, a GE company, Florence, Italy

RECIPROCATING COMPRESSORS

Model	Maximum Number of Throws	Stroke (inches)	Discharge Pressure P_2 (Bar)	Maximum Power (Hp)	Number of Stages	Maximum RPM	Rod Load (lbs)***	Field Replaceable Liners	Compressor Can Handle
M	2	3	415	120	4	1,800	12,000	No	Sweet Natural gas
H	4	3	415	400	6	1,800	20,000	No	Sweet/Sour Natural gas
A	4	3.5	415	800	6	1,800	27,000	No	Sweet/Sour Natural gas
DS	4	5, 6	325	2,400	6	1,500	70,000	Yes	Sweet/Sour Natural gas
ES	6	5, 6, 7	325	7,200	6	1,500	97,500	Yes	Sweet/Sour Natural gas
FS	6	5, 6, 7	450	7,200	6	1,500	117,000	Yes	Sweet/Sour Natural gas
AJAX DPC 2804	3	11	379	845	5	440	40,000	*	Sweet/Sour Natural gas
AJAX DPC 2803	2	11	379	633	3	440	40,000	*	Sweet/Sour Natural gas
AJAX DPC 2802	2	11	379	422	3	440	33,000	*	Sweet/Sour Natural gas
AJAX DPC 2801	1	11	379	192	2	440	30,000	*	Sweet/Sour Natural gas
AJAX DPC 2202	2	11	379	295	3	440	33,000	*	Sweet/Sour Natural gas
AJAX DPC 2201	1	11	379	147	2	440	30,000	*	Sweet/Sour Natural gas
AJAX C-302	2	11	379	300	3	455	30,000	*	**
Superior CFA 4	4	3	400	580	4	1,800	13,000	—	**
Superior RAM 4	4	5	152	2,375	4	1,500	40,000	—	**
Superior MH	6	6	568	5,400	6	1,200	52,000	—	**
Superior WH	6	6,7	568	5,400	6	1,200	65,000	—	**
Superior WG	6	6,7	568	9,000	6	1,200	75,000	—	**
GMV #	12	14	1,034	2,700	6	330	85,000	—	Sweet/Sour Natural gas
W330 #	16	20	1,034	8,000	8	330	150,000	—	Sweet/Sour Natural gas
KM #	10	10.5, 14	1,034	8,250	10	600	85,000	—	Sweet/Sour Natural gas
LM #	10	14, 20	1,034	12,000	10	450	150,000	—	Sweet/Sour Natural gas

* Varies by cylinder ** Sweet/Sour Natural Gas/Process *** Peak to Peak # Cooper-Bessemer

BAKER HUGHES, a GE company, Florence, Italy

AP618 RECIPROCATING COMPRESSORS

MODEL	NUMBER OF THROWS	MAX POWER (@max speed) (KW)	ROD LOAD (lbs)	Maximum RPM	Application	Type of Design
OA	1	435	26,325	800	Process (1)	Horizontal
HA	2 TO 4	2,120	32,557	1,000	Process (1)	Horizontal
HB	2 TO 4	3,680	53,055	800	Process (1)	Horizontal
HD	2 TO 6	7,800	72,562	700	Process(1)	Horizontal
HE	2 TO 6	15,300	150,750	800	Process (1)	Horizontal
HF	2 TO 10	34,600	256,500	514	Process (1)	Horizontal
HG	2 TO 10	42,000	445,500	400	Process (1)	Horizontal
SHM	2 TO 6	7,980	80,565	1,200	Natural Gas	Horizontal
SHM-8	2 TO 4	5,320	80,565	1,200	Natural Gas	Horizontal
PK	4 TO 24*	60,000	652,500	310	LDPE	Horizontal

* # of cylinders
1 Refinery & Petrochemical

Turbocompressor Specifications

ELLIOTT GROUP, Jeannette, Pennsylvania, U.S.A. and Sodegaura, Chiba, Japan

MODEL	INLET VOLUME (M³/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
SINGLE STAGE									
PH	1,200–125,000	55	—	1	13,500	V	L,C,G,O,W,D	all	C
TC	600–150,000	50	—	1	10,000	V	L,C,G,O,W,D	all	C
MULTISTAGE									
M-Line	1,700–900,000	69	—	10	20,000	H	L,C,G,O,D	all	C
MB-Line	1,700–430,000	690	—	12	20,000	V	L,C,G,O,D	all	C
AXIAL									
A	705,000	6	—	18	8,025	H	L	air	A

Notes: Elliott Group designs, manufactures, tests, installs, services and repairs centrifugal and axial compressors for the petrochemical, refining, oil & gas as well as general industrial markets. Features and stand alone products include:
• Proprietary EDGE centrifugal designs • High efficiency and exceptional reliability • Advanced impellers • Low maintenance
• Wide range of inlet volume and pressure capability • Elliott control systems • Superior casing design • Lubrication oil systems
• Auxiliary systems are available ON and OFF skid. • Full load testing • Wide complement of coatings are available to extend unit life
• High speed balancing • Elliott-designed bearings are included for optimum running • Dry gas seal and buffer gas systems
• Integrated bundle, end-walls and housings for quick turn around of barrel centrifugal
* Inquire with Elliott Group for volume flows greater than 680K m³/hr.

FS-ELLIOTT CO. LLC (www.fs-elliott.com)

MODEL	INLET VOLUME (M³/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
PAP PLUS ENGINEERED AIR COMPRESSORS									
S1	3,600	10.5	250–450	1–3	70,000	H	C	air, N	C,I
A1	6,000	10.5	350–700	1–3	52,000	H	C	air, N	C,I
BH	11,700	10.5	800–1,250	1–3	40,000	H	C	air, N	C,I
CH	18,600	10.5	1,000–2,000	1–3	30,000	H	C	air, N	C,I
DH	31,500	31.0	2,000–5,000	1–4	53,000	H	C,L	air, N	C,I
EH	41,700	24.0	1,595–6,000	1–4	47,000	H	H	air, N	C,I
POLARIS + INDUSTRIAL AIR COMPRESSORS									
P300 +	3,600	10.5	250–450	2–3	68,320	H	C	air, N	C,I
P400 +	6,000	10.5	400–700	2–3	51,930	H	C	air, N	C,I
P500 +	7,800	10.5	700–1,000	2–3	43,450	H	C	air, N	C,I
P600 +	10,800	10.5	900–1,500	2–3	39,140	H	C	air, N	C,I
P700 +	19,800	10.5	1500–2250	2–3	29,770	H	C	air, N	C,I

FS-Elliott designs, manufactures, tests, installs, services and repairs intergrally geared centrifugal compressors. Design benefits and features follow:
• High base-load and part-load efficiency • Optimized operational efficiency throughout the year • Professional Service
• Minimum number of moving parts • Superior package design • Lowest life-cycle cost
• Robust and reliable design • Simple and low-cost installation •Ease of maintenance
• Industrial to API 672 applications • Ease of operation •Genuine OEM parts

Turbocompressor Specifications

HITACHI AMERICA, LTD., HITACHI, LTD., Toyo, Japan

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
2BCH	150–100,000	750	—	11	3,000–18,000	V	D,L,O	12	C
MCH	500–350,000	45	—	11	2,500–18,000	H	D,L,O	1	C
2MCH	500–350,000	45	—	11	3,500–18,000	H	D,L,O	1	C
3MCH	500–350,000	45	—	11	3,500–18,000	H	D,L,O	1	C
BCH	150–100,000	750	—	11	3,000–18,000	V	D,L,O	12	C
PCH	500–100,000	120	—	4	3,000–14,000	V	D,L,O	12	C

1 Process industrial gases. 2 Process gas, natural gas

INDUCTION MOTORS

TYPE	FRAME SIZE	OUTPUT (kW)	VOLTAGE (V)	POLES (Hz)	FREQUENCY
TEFC	250S - 500J	55–2,250	380–13,800	2–12	50/60
TEACC	355L - 1120	630–13,000	2,300–13,800	2–22	50/60
WP-II (TEWAC)	355L - 1120	750–15,000	2,300–13,800	2–22	50/60

Applicable standard: NEMA, IEEE, API-541, IEC-60034/60079
Explosive protection: Exn, Exe, Exp, Exd

SYNCHRONOUS MOTORS

TEWAC	1,000	7,000–25,000	6,000–13,800	4–6	50/60

VFD

MODEL	TYPE	CAPACITY (KVA)	VOLTAGE (V)	COOLING SYSTEM	FREQUENCY (Hz)
HIVECTOL-HVI	Multi-Level IGBT Drive	360–28,000	2,400–11,000	Forced Air	0–120

Turbocompressor Specifications

INGERSOLL RAND

MODEL	INLET VOLUME (M3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
INTEGRALLY GEARED CENTRIFUGAL COMPRESSORS									
MSG PRODUCT LINE: Applications engineered with many configurations to efficiently provide oil-free air and gas									
MSGLMAC-20	20,000–35,000	9	up to 4,000	1 to 3	26,000	V	L	Air & Nitrogen	C,I
MSGLMAC-30	35,000–50,000	9	up to 6,000	1 to 3	21,000	V	L	Air & Nitrogen	C,I
MSGLMAC-50	50,000–90,000	9	up to 15,000	1 to 3	12,000	V	L	Air & Nitrogen	C,I
MSG-2/3	4,250–17,000	100	up to 5,500	1 to 6	50,000	V	D,C,L	all except O_2	C,I
MSG-4/5	12,000–30,000	100	up to 9,500	1 to 6	40,000	V	D,C,L	all except O_2	C,I
MSG-8/9	28,000–60,000	100	up to 10,000	1 to 6	35,000	V	D,C,L	all except O_2	C,I
MSG-12/14/16	51,000–100,000	100	up to 19,000	1 to 6	35,000	V	D,C,L	all except O_2	C,I
MSG-18	77,000–136,000	41	up to 20,000	1 to 6	23,000	V	D,C,L	all except O_2	C,I
MSG-25	85,000–230,000	20	up to 22,000	1 to 4	13,000	V	D,C,L	all except O_2	C,I
TURBO-AIR PRODUCT LINE: Packaged on a common base for easy installation and available in many configurations to efficiently provide oil-free oil and gas									
TA-2000	900–2,900	10	up to 350	1 to 3	75,000	V	L	Air & Nitrogen	C,I
TA-2040	2,500–3,100	42	up to 800	1 to 4	75,000	V	L	all except O_2	C,I
TA-3000	3,400–6,800	10	up to 800	1 to 3	60,000	V	L	Air & Nitrogen	C,I
TA-6000	6,800–13,600	10	up to 1,750	1 to 3	44,000	V	L	Air & Nitrogen	C,I
TA-6040	7,600–10,000	42	up to 2,250	1 to 4	67,000	V	L	all except O_2	C,I
TA-NX 8000	8,500–17,000	15	up to 2,250	1 to 3	45,000	V	L	Air & Nitrogen	C,I
TA-NX 12000	12,700–31,500	40	up to 5,650	1 to 5	33,000	V	L	Air & Nitrogen	C,I
TA-11000	14,000–25,000	10	up to 3,700	1 to 4	40,000	V	L	Air & Nitrogen	C,I
TA-20000	31,000–42,000	80	up to 5,500	1 to 6	50,000	V	L	Air & Nitrogen	C,I
CENTAC PRODUCT LINE: Packaged on a common base for easy installation and available in many configurations to efficiently provide oil-free oil air									
CV1	1,400–2,500	8.6	up to 400	2	64,700	V	C	Air & Nitrogen	C,I
C400	2,700–4,000	8.6	up to 500	2	64,700	V	C	Air & Nitrogen	C,I
C700	3,200–7,100	10	up to 800	2 to 3	52,300	V	C	Air & Nitrogen	C,I
C800	3,500–7,600	13	up to 1,100	2 to 3	40,100	V	C	Air & Nitrogen	C,I
C1000	7,600–12,800	10	up to 1,500	2 to 3	31,300	V	C	Air & Nitrogen	C,I
C950	7,300–11,200	10	up to 1,350	2 to 3	43,000	V	C	Air & Nitrogen	C,I
3CII	11,000–16,750	10	up to 2,000	2 to 3	38,100	V	C	Air & Nitrogen	C,I
C3000	16,000–25,700	10	up to 3,200	2 to 3	35,000	V	C	Air & Nitrogen	C,I
5CII	27,000–51,400	10	up to 6,000	2 to 3	25,000	V	C	Air & Nitrogen	C,I
C750	3,400–4,000	40	up to 900	3 to 4	65,500	V	C	Air & Nitrogen	C,I
C1050	6,450	40	up to 1,250	4	55,500	V	C	Air & Nitrogen	C,I
3C	7,500–16,800	25	up to 3,000	2 to 5	37,300	V	C	Air & Nitrogen	C,I
4C	15,000–26,500	25	up to 4,500	3 to 5	29,200	V	C	Air & Nitrogen	C,I
CH5	2,200–5,200	2.2	up to 350	1	43,800	V	C	Air & Nitrogen	C,I
CH6	5,700–10,000	2.2	up to 600	1	34,000	V	C	Air & Nitrogen	C,I
2ACII	7,100–8,900	22	up to 1,750	3	55,600	V	C	Air & Nitrogen	C,I

Turbocompressor Specifications

KAWASAKI HEAVY INDUSTRIES, LTD., Akashi, Japan

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
CENTRIFUGAL COMPRESSORS: HORIZONTALLY SPLIT									
RBS	10,200	50	—	1–10	19,000	H	D, L, O	all	C
RCS	23,000	45	—	1–10	12,000	H	D, L, O	all	C
RDS	39,000	35	—	1–10	9,000	H	D, L, O	all	C
RES	68,000	30	—	1–10	7,000	H	D, L, O	all	C
RFS	119,000	25	—	1–10	5,500	H	D, L, O	all	C
VERTICALLY SPLIT									
RBB	10,200	450	—	1–10	19,000	V	D, L, O	all	C
RCB	23,000	230	—	1–10	12,000	V	D, L, O	all	C
RDB	37,400	140	—	1–10	9,000	V	D, L, O	all	C
REB	60,300	90	—	1–10	7,000	V	D, L, O	all	C
RFB	106,000	50	—	1–10	5,500	V	D, L, O	all	C

D = Dry gas, C = Centrifugal, L = Labyrinth, A = Axial, O = Oil, I = Integral gear, W = Water, R = Radial inflow, C = Carbon ring, S = Screw, G = Gas

KOBELCO / KOBE STEEL LTD.
KOBELCO COMPRESSORS AMERICA, INC.

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (PSI)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF API DESIGN
API CENTRIFUGAL COMPRESSORS									
VH Series	500–100,200	5,000	28,000	Multi	18,000	V	D, L, O	all	617 Chap2
VGS/VGSP/VGS7	800–450,000	3620	67,000	1 to 8	40,000	V	D, C, L, O	all	617 Chap3
Process gas VG/ VGP/VG7 Air/N2	800–450,000	1,500	67,000	1 to 8	60,000	V	D, C, L	air, N_2	617 Chap3, 672
DH series	800–150,000	1,300	33,500	single	18,000	V	D, C, L, O	all	617 Chap2
V-VS-VSS Series	800–340,000	700	21,000	multi	18,000	H	D, C, L, O	all	617 Chap2
API RECIPROCATING COMPRESSORS									
	150–30,000	15,000	30,000	1 to 6		V	various	all gases & cold LNG	618
API 100% OIL-FREE SCREW COMPRESSORS									
100% oil-free design	400–145,000	650		1 to 3	~16,000	H/V	D, C, L, O	all	619
API OIL-INJECTED SCREW COMPRESSORS									
< 0.5 ppm/ wt. oil carryover	150–35,000	1,500		1 & 2	~5,200	V	O,D	all	619

API 617 = Centrifugal
API 618 = Reciprocating
API 619 = Rotary Screw
Seals: D = Dry gas, L = Labyrinth, O = Oil/Mech, C = Carbon Ring

Turbocompressor Specifications

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany
MAN ENERGY SOLUTIONS SE, Berlin, Germany
MAN ENERGY SOLUTIONS SCHWEIZ AG, Zurich, Switzerland

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
CENTRIFUGAL COMPRESSORS									
Horizontally split	780–708,000	80	107	1–10	24,000	H	D, L, O	all	C
Vertically split	240–320,000	1,000	—	1–10	24,000	V	D, L, O	all	C
ISOTHERM COMPRESSORS									
Radial	70,000–760,000	20	—	3–6	8,000	H	L	air + nitrogen	C
Axial Radial	250000–1,000,000	13	—	9A+3C	5,400	H	L	air + nitrogen	A + C
Radial Isotherm for Oxygen	10,000–124,000	20	—	4–5	16,000	H	L	O_2	C
GEAR TYPE COMPRESSORS									
	1,000–660,000	250	—	1–10	50,000	V	D, C, L, O	all (exc. O_2)	C
AIR AXIAL COMPRESSORS									
Axial	50,000–1,527,000	1.5–20	—	5-20	12,000	H	L	air	A
Axial Radial	50,000–1,527,000	1.5–25	—	10A+3C	12,000	H	L	air	A+C
GAS AXIAL COMPRESSORS									
Axial	50,000–830,000	2–20	—	5–20	8,800	H	D, L, O	hydrocarbon	A
INTEGRAL SEALED COMPRESSORS									
Tandem HOFIM	240–30,000	300	max. 24,000	1–17	12,600	V	Sealless	hydrocarbon	C
MOPICO	1,700–30,000	150	max. 24,000	1–2	12,600	V	Sealless	hydrocarbon	C
Subsea HOFIM	240–30,000	300	max. 15,500	1–8	8,000	V	Sealless	well stream gas	C
SCREW COMPRESSORS									
CP	180–20,400	50	13410	—	25,000	V	D, C, L, O	all (exc. O_2)	S
SKUEL	3,960–102,000	16	13410		8,900	H	D, C, L, O	all (exc. O_2)	S
CPO	480–17,100	40	12096	—	3,600	V	O	all (exc. O_2)	oil flooded

Turbocompressor Specifications

PART OF SIEMENS POWER AND GAS (PG) DIVISION

MODEL	INLET VOLUME (M³/hr)	DISCHARGE PRESSURE P_2 (BAR)	POWER REQUIREMENT (hp)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
SINGLE SHAFT AXIAL									
STC-SX	50,000–1,300,000	up to 7	as required	up to 19	9,000	H	L	air & clean gases	A
AXIAL-RADIAL									
STC-SR	50,000–1,300,000	up to 16	as required	up to 13	9,000	H	L, G	air	A-R
RADIAL									
STC-SH	250–600,000	up to 50	as required	up to 10	20,000	H	L, G	all	C
STC-SV	250–480,000	up to 1,000	as required	up to 10	20,000	V	L, G	all	C
PIPELINE CENTRIFUGAL COMPRESSORS									
RFA24/36	43,000–102,800	up to 103	20,000–50,000	1	9,500–13,800	V	D	natural gas	C
RFBB20/30/36/42	21,600–106,500	up to 155	25,000–75,000	1–5	6,667–13,800	V	D	natural gas	C
INTEGRALLY GEARED									
STC-GV	1,500–1,000,000	up to 200	as required	up to 8	45,000	H	L, G, C	all	I-C
STC-GC	10,000–400,000	up to 20	as required	up to 4	44,000	H	L	air & N_2	I-C
STC-GVT	1,500–480,000	up to 60	400–15,000	up to 6	45,000	H	L,D,C	process gas, air	C
DATUM									
Axial split	800,000	62	as required	12	26,500	H	L,O,C,G	all	C
Radial split	800,000	1,000	as required	12	26,500	V	L,O,C,G	all	C
AXIAL									
1000/1500/3000/4000/5000/6000/7000	127,426–1,140,000	5.2	as required	6–15	up to 8,000	H	L	air	A
LNTERCOOLED									
CVM	187,000	12	as required	4	10,400	H	L	air	C
INTEGRAL SEALED									
DATUM C	59,000	207	< 20 MW	6	20,000	V	not applicable	all	C

Note: figures acc. US spelling

SOLAR TURBINES, San Diego, California, U.S.A.

MODEL	INLET VOLUME (M³/hr)	DISCHARGE PRESSURE P_2 (BAR)	DISCHARGE PRESSURE P_2 (kPag)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
C16	3,600	310	24,130	10	23,800	V	D	natural gas	C
C33	16,200	186	19,000	12	19,000	V	D	natural gas	C
C40M	15,300	172	17,235	6	14,300	V	D	natural gas	C
C40P	18,000	186	11,030	2	15,500	V	D	natural gas	C
C41 (1)	30,600	259	25,855	10	14,300	V	D	natural gas	C
C45	31,500	124	15,513	3	12,000	V	D	natural gas	C
C50	33,900	103	10,350	5	14,000	V	D	natural gas	C
C51 (1)	42,600	207	20,685	10	12,000	V	D	natural gas	C
C61	59,400	207	20,685	10	10,200	V	D	natural gas	C
C65	40,800	110	11,030	2	10,500	V	D	natural gas	C
C75	51,000	155	15,510	3	8,860	V	D	natural gas	C
C85	76,500	110	11,030	2	7,000	V	D	natural gas	C

1 Pressure Ratios are higher for the C41/C51/C61. Dual Compartment compressors depending on cooling capability.

Turbocompressor Specifications

YORK (BY JOHNSON CONTROLS), Waynesboro, Pennsylvania, U.S.A.

MODEL	INLET VOLUME	DISCHARGE PRESSURE	POWER REQUIREMENT	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
CENTRIFUAL COMPRESSORS									
M 25 & 26 Series	600–9,000	up to 41.3	5,000	1–8	22,000	H	O	(1)	C
M 38 Series	7,000–20,000	up to 41.3	7500	1–8	9,000	H	O	(1)	C
M 55 Series	15,000–40,000	up to 31.7	15000	1–8	5,000	H	O	(1)	C
SCREW COMPRESSORS									
RXF (XJS) Series	120–1,000	up to 24.1	300	1	3,600	V	O	(1)	S
RWFII (SGC) Series	1,000–14,000	up to 48.3	5,000	1	4,500	V	O	(1)	S
HPSH 1510	100–600	up to 50	550	1	6,000	V	O	(1)	S
HPSH 270	350–2200	up to 68	1750	1	4,500	V	O	(1)	S

1 Hydrocarbons, mixed gases, sour gas, CO_2
Note: Applications include refrigeration and gas compression. Steel or cast iron casings.

Turboexpander Specifications

ATLAS COPCO GAS AND PROCESS (www.atlascopco-gap.com)
ATLAS COPCO COMPTEC LLC, Voorheesville, New York, U.S.A.
ATLAS COPCO MAFI-TRENCH COMPANY LLC, Santa Maria, California, U.S.A.
ATLAS COPCO ENERGAS GMBH, Cologne, Germany
ATLAS COPCO (SHANGHAI) PROCESS EQUIPMENT CO.,
ATLAS COPCO GAS AND PROCESS APPLICATION, Pune, India

MODEL	INLET PRESSURE (BAR A)	INLET TEMPERATURE (°C)	NUMBER OF STAGES	RPM	POWER (kW)	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS EXPANDER CAN HANDLE	TYPE OF DESIGN
EC/ECM	up to 200	–220 to +200	1	up to 100,000	up to 23,000	V	L	(1)	R, 2
EG/EGI	up to 200	–220 to +300	1 to 4	up to 50,000	up to 25,000	V	L/D/O	(1)	R, 3
EHB	up to 200	–220 to +120	1	up to 90,000	below 250	V	L	(1)	R, 5
ETB	up to 80	–220 to +100	1	up to 81,000	up to 5,000	V	L/C/D	(1)	R, 2
ETG	up to 160	–220 to +510	1 to 4	up to 44,000	up to 15,000	V	L/C/D	(1)	R, 4
ETF	up to 64	–220 to +100	1	up to 105,000	below 120	V	L	(1)	R, 5

1 All industrial gases and hydrocarbon gas mixtures, including condensing streams.
2 EC and ETB have compressor load with oil bearings. ECM has Compressor load with active magnetic bearings.
3 EG has electric generator load with external gearbox. EGI has electric generator load with integral gearbox.
4 ETG has electric generator load with gearbox
5 EHB and ETF have oil brake load.

BAKER HUGHES, a GE company, Radial Expanders (Florence, Italy).

MODEL	FRAME (1)	INLET PRESSURE (Bar A)	INLET TEMP. (°C)	INLET FLOW (m³/h)	NUMBER OF STAGES	RPM	TYPE OF CASING SPLIT (2)	TYPE OF SEALS (3)	TYPE OF GAS EXPANDER CAN HANDLE (4)	TYPE OF DESIGN (5)	TYPE OF BEARING (6)
HIPER	25	15 to 85	0 to 100	40,000	1	30,000	V	NA	HC	IN	M
EC/EG/ED	10	2 to 230	–270 to 315	300	1–4	120,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG/ED	15	2 to 230	–270 to 315	500	1–4	90,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG/ED	20	2 to 230	–270 to 315	2,000	1–4	80,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG/ED	25	2 to 230	–270 to 315	3,000	1–4	45,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG/ED	30	2 to 230	–270 to 315	5,000	1–4	35,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG	40	2 to 230	–270 to 315	7,000	1–4	27,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG	50	2 to 140	–270 to 315	11,000	1–4	22,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG	60	2 to 140	–270 to 315	15,000	1–4	16,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG	80	2 to 90	–270 to 315	20,000	1–4	12,000	V	D,L,O	HC,S,I	R,C,I	M,P,0
EC/EG	100	2 to 90	–110 to 315	35,000	1–4	10,000	V	D,L,O	HC,S,I	R,C,I	P,0
EC/EG	130	2 to 50	–110 to 315	50,000	1–4	7,500	V	D,L,O	HC,S,I	R,C,I	P,0
EC/EG	160	2 to 50	–110 to 315	80,000	1–4	6,500	V	D,L,O	HC,S,I	R,C,I	P,0
EC/EG	180	2 to 20	–110 to 315	110,000	1–4	5,000	V	D,L,O	HC,S,I	R,C,I	P,0

1 Model: EC = Expander Compressor, EG = Expander Generator, ED = Expander Dyno
2 Type of Casting Split: H = Horizontal, V = Vertical
3 Type of Seals: C = Carbon ring, D = Dry gas, L = Labyrinth, O = Oil, W = Water
4 Type of Gas: HC = Hydrocarbons, S = Steam, I = Industrial gasses, incl. Air, Nitrogen, CO, CO_2, Waste, NH_3, etc., F = Flue Gas
5 Type of Design: A = Axial, R = Radial, C = Centrifugal / Centripetal, I = Integral gear, S = Screw
6 Type of Bearings: M = Magnetic, P = Pressurized oil bearings, O = Oil bearings

Turboexpander Specifications

BAKER HUGHES, a GE company, Hot Gas Expanders (Florence, Italy)

MODEL	INLET PRESSURE (Bar A)	INLET TEMPERATURE (°C)	INLET FLOW (kg/hr)	NUMBER OF STAGES	RPM	TYPE OF CASING SPLIT (2)	TYPE OF SEALS (3)	TYPE OF GAS EXPANDER CAN HANDLE (4)	TYPE OF DESIGN (5)
FEX-81	4.4	760	170,000	1	7,500	V	L	F	A
FEX-81	4.4	760	170,000	1	7,500	V	L	F	A
FEX-97	4.4	760	305,000	1	6,500	V	L	F	A
FEX-107	4.4	760	365,000	1	5,100	V	L	F	A
FEX-125	4.4	760	480,000	1	4,000	V	L	F	A
FEX-142	4.4	760	750,000	1	3,600	V	L	F	A
NAE	11	500	300,000	7	4,500	H	L	I	A

1 Model: EC = Expander Compressor, EG = Expander Generator, ED = Expander Dyno
2 Type of Casting Split: H = Horizontal, V = Vertical
3 Type of Seals: C = Carbon ring, D = Dry gas, L = Labyrinth, O = Oil, W = Water
4 Type of Gas: HC = Hydrocarbons, S = Steam, I = Industrial gasses, incl. Air, Nitrogen, CO, CO_2, Waste, NH^3, etc., F = Flue Gas
5 Type of Design: A = Axial, R = Radial, C = Centrifugal/Centripetal, I = Integral gear, S = Screw
6 Type of Bearings: M = Magnetic, P = Pressurized oil bearings, O = Oil bearings

CRYOSTAR SAS, Hesingue, France (www.cryostar.com)
CRYOSTAR USA LLC, Bethlehem, PA

MODEL	PRESSURE BAR	INLET TEMPERATURE (°C)	NUMBER OF STAGES	RPM (UP TO)	FLOW (UP TO) kg/s	CASING SPLIT	TYPE OF SEAL	TYPE OF GAS	TYPE OF BEARINGS
ECO	up to 16	–196 to 100	1	65,000	—	V	L	IG (gas only)	OLB
TC/TFC	up to 150	–196 to 160	1	65,000	—	V	L	HC, IG, Ref.*	OLB
MTC	up to 150	–196 to 160	1	50,000	—	V	L	HC, IG, Ref.*	AMB
TG/LTG	up to 150	–196 to 200	1 to 4	50,000	—	V	L, D, O	HC, IG, Ref.*	OLB
TP	up to 150	–196 to 100	1	65,000	—	V	L	HC, IG, Ref.*	OLB

MTC = Compressor loaded Turbo-expander using Active Magnetic Bearings (AMB); TC = Compressor loaded Turbo-expander using Oil Lubricated Bearings (OLB); TP = oil brake loaded Turbo-expander; TG = Generator loaded Turbo-expander; LTG = Generator loaded liquid Turbo-expander; TFC = compressor loaded turbo-expander equipped with an oil brake using OLB; ECO = compact oil brake turbo-expander dedicated to Industrial gases. HC: Hydrocarbon gases (including H2): IG Industrial gases; Ref = refrigerant; OLB = Oil Lubricated Bearings; AMB = Active Magnetic Bearings

All expanders use centrifugal radial inflow technology (API617). Generator loaded Turbo-expander can use either external gearbox, integrally geared design or direct coupling.

Key to Symbols Used for Compressor and Expander Specifications
Type of Casting Split: H = horizontal, V = vertical
Type of Seals: C = carbon ring, D = dry gas, G = gas, L = labyrinth, O = oil, W = water
Type of Design: A = axial, C = centrifugal, I = integral gear, R = radial inflow, S = screw

ELLIOTT GROUP, Jeannette, Pennsylvania, U.S.A. and Sodegaura, Chiba, Japan

MODEL	INLET PRESSURE (BAR A)	INLET TEMPERATURE (°C)	INLET FLOW (kg/hr)	NUMBER OF STAGES	RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS EXPANDER CAN HANDLE	TYPE OF DESIGN
TH-85	4.5	760	220,000	1–2	7,500	V	L	(1)	A
TH-100	4.5	760	330,000	1–2	5,800	V	L	(1)	A
TH-120	4.5	760	505,000	1–2	4,700	V	L	(1)	A
TH-140	4.5	760	772,000	1–2	3,960	V	L	(1)	A

Notes: Elliott designs, manufactures, tests, installs, services and repairs FCC flue gas power recovery expanders. Our proven designs and technology result in rugged, reliable machines with millions of hours of operation in the field and up to 10 years of blade life from a single row of blades. Product features include:
• Aerodynamic design to eliminate secondary erosion • Integral expansion joint • Superior materials technology • Overspeed protection • After burn protection

1 FCC, blast furnace, coal gas

Turboexpander Specifications

L.A. TURBINE, Valencia, California, U.S.A.

MODEL	INLET PRESSURE (BAR G MAX.)	INLET TEMPERATURE (°C)	NUMBER OF STAGES (2)	RPM (MAX.)	TYPE OF BEARINGS (6)	TYPE OF CASING SPLIT (3)	TYPE OF SEALS (4)	TYPE OF GAS EXPANDER CAN HANDLE	TYPE OF DESIGN (1)
L1000	up to 206	–195 to 260	1	105,000	Oil	V	L	(5)	EC/EG/ED (7)
L2000	up to 206	–195 to 260	1 to 2	52,000	Oil/AMB	V	L	(5)	EC/EG/ED
L3000	up to 206	–195 to 260	1 to 2	31,000	Oil/AMB	V	L/D	(5)	EC/EG/ED
L4000	up to 206	–195 to 260	1 to 2	29,000	Oil/AMB	V	L/D	(5)	EC/EG
L5000	up to 206	–195 to 260	1 to 2	18,000	Oil/AMB	V	L/D	(5)	EC/EG
L6000	up to 206	–195 to 260	1 to 2	15,000	Oil/AMB	V	L/D	(5)	EC/EG

1 Model EC = Expander-Compressor, EG = Expander-Generator, ED = Expander-Dyno (Oil Brake)
2 Number of Stages: Multi-Stage is only applicable to the EC model
3 Type of Casting Split: V = Vertical
4 Type of Seals: L = Labyrinth Seal, D = Dry Gas Seal
5 Type of Gas: Hydrocarbons, Industrial Gases, Refrigerant, Steam
6 Type of Bearings: AMB = Active Magnetic Bearing, Oil = Oil Bearing. AMB is only applicable for EC model.
Skid-Mounted AMB Control Panel is available for NEC area classifications or non-hazardous areas.
7 High Pressure/High Power does not apply on ED equipment. A maximum of 105,000 RPM is only applicable to the ED model.

MAN ENERGY SOLUTIONS SE, Oberhausen, Germany

MODEL	INLET PRESSURE (BAR A)	INLET TEMPERATURE (°C)	INLET FLOW (kg/hr)	NUMBER OF STAGES	RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS EXPANDER CAN HANDLE	TYPE OF DESIGN
EN/E	16	540	360,000	multi	to 20,000	H/V	L+O,G	(1)	A
EH	12	760	250,000	single or multi	24,000	H/V	L,O	(1)	A
ER	15	500	450,000	½ or multi	48,000	V	L+O,G	(1)	R

1 all industrial gases.

SIEMENS

MODEL	INLET PRESSURE (BAR A)	INLET TEMPERATURE (°C)	INLET FLOW (kg/hr)	NUMBER OF STAGES	RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS EXPANDER CAN HANDLE	TYPE OF DESIGN
STC-GT	15	up to 550	9,000–600,000	up to 3	25,000	V	L	all	I-C
E-516/520/522/526	15	760	45,000–165,000	5	7,100–10,930	H	L	(1)	A
E-132/232	3.3–5	760	165,000–200,000	1–2	7,500–8,400	V	L	(1)	A
E-138/238	3.3–5	760	345,000–350,000	1–2	6,000	V	L	(1)	A
E-148/248	3.3–5	760	450,000–555,000	1–2	4,000	V	L	(1)	A
E-156	3.3	760	730,000	1	3,600	V	L	(1)	A

1 Nitric acid, ethylene oxide, FCC, coal gas, blast furnace gas

Turboexpander Specifications

SOLAR TURBINES, San Diego, California, U.S.A.

MODEL	INLET VOLUME (M^3/hr)	DISCHARGE PRESSURE P_2 (BAR)	DISCHARGE PRESSURE P_2 (kPag)	NUMBER OF STAGES	MAXIMUM RPM	TYPE OF CASING SPLIT	TYPE OF SEALS	TYPE OF GAS COMPRESSOR CAN HANDLE	TYPE OF DESIGN
C16	3,600	310	24,130	10	23,800	V	D	natural gas	C
C33	16,200	186	19,000	12	19,000	V	D	natural gas	C
C40M	15,300	172	17,235	6	14,300	V	D	natural gas	C
C40P	18,000	186	11,030	2	15,500	V	D	natural gas	C
C41 (1)	30,600	259	25,855	10	14,300	V	D	natural gas	C
C45	31,500	124	15,513	3	12,000	V	D	natural gas	C
C50	33,900	103	10,350	5	14,000	V	D	natural gas	C
C51 (1)	42,600	207	20,685	10	12,000	V	D	natural gas	C
C61	59,400	207	20,685	10	10,200	V	D	natural gas	C
C65	40,800	110	11,030	2	10,500	V	D	natural gas	C
C75	51,000	155	15,510	3	8,860	V	D	natural gas	C
C85	76,500	110	11,030	2	7,000	V	D	natural gas	C

1 Pressure ratios are higher for the C41/C51/C61. Dual compartment compressors depending on cooling capability.

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POWER PLANTS ARE SUFFERING UNNECESSARY LOSSES

I recently visited a newly commissioned 500 MW natural gas combined cycle plant in Europe to perform a total plant efficiency audit. Such an audit usually reviews the total plant performance, including all ancillary, auxiliary equipment and other parasitic losses. The plant operator proudly explained to me that this, the almost latest generation of gas turbine combined cycle plants, was operating at a thermal efficiency exceeding 60%.

Readers familiar with the newest generations of combined cycles built around G, J, and H frame gas turbines will have seen the beauty and complexity of a modern natural gas combined cycle plant running at peak firing temperatures, high operating pressures, using state-of-the-art aerodynamics and advanced super-alloy materials.

But this column is not about modern power plant efficiencies, heat rates, and what can be optimistic performance claims based on faulty definitions. This is about often ignored, but relevant incremental efficiency gains and power losses in these plants.

I had the opportunity to closely inspect the equipment and operation of the facility. It used ultra High Efficiency Particle Air (UHEPA) inlet filters with inlet silencers and an inlet ducting system that was far from aerodynamically optimized.

The result was a pressure drop of nearly seven inches of water across the inlet system. A quick calculation showed that this pressure drop led to a gas turbine heat rate increase of 1.3% and a gas turbine output power loss of almost 3%.

Similarly, an exhaust pressure drop of nearly 16 inches of water was observed from the gas turbine through the silencer, the heat recovery steam generator (HRSG), and to the stack outlet. This resulted in another performance loss of approximately 2.5% in efficiency and 3.5% in power.

The same plant used oversized boiler feed water pumps operating at a part load with a fairly low pump efficiency, and two fuel gas compressors with the gas recycle valves 50% open during normal operation. The parasitic losses of these inefficiently run pieces of plant equipment added approximately 0.3–0.5% efficiency loss.

There were a number of other inefficient balance of plant design choices, such as using undersized lube oil filters, continuously running redundant lube oil cooler and enclosure ventilation motors, and incorrectly set fuel gas heaters. These added losses of nearly 0.3%.

A performance calculation showed that by optimizing the gas turbine's inlet and exhaust system, shutting down needlessly running motors, and reducing other parasitic losses, the plant total efficiency could be raised by approximately 5%. Real plant efficiency was not greater than 60% as advertised, but closer to 56% due to unnecessary power losses.

Real plant efficiency was not greater than 60% as advertised, but closer to 56% due to unnecessary power losses.

It is important to note that the plant operating company paid a premium to acquire modern gas turbines and steam turbines with very high efficiencies. Yet the overall plant design was so poor that significant performance gains were thrown away.

From a thermodynamic perspective, inlet and exhaust pressure drop directly takes away from the compression ratio that the gas turbine's compressor produces, moves the compressor off its best design point, and results in a disproportional gas turbine power and efficiency loss.

In extreme cases, a poorly designed inlet duct can lead to a non-uniform gas turbine inlet flow distribution at the bellmouth, which impacts the loading, surge margin, and the life of the gas turbine's compressor.

A good inlet filtration system is necessary to keep the gas turbine compressor clean and avoids fouling, erosion, and corrosion. It is also important to recognize that the pressure drop across the inlet filtration system has a direct performance impact on the gas turbine.

The selection of the inlet filtration system, the inlet and outlet silencers, and the ducting and stack design are all design decisions that should be balanced between gas turbine performance, degradation, parts life and capital costs. Similarly, the balance of plant design should consider cost, safety and optimized plant operation for minimal losses.

When designing power plants, it should be considered that the plant may not always run at full load. With the onset of large quantities of highly fluctuating and unpredictable alternative energy electricity sources, primarily wind and sun, many natural gas power plants operate in cyclic or load following modes.

The impact on efficiency at part load operation for the gas turbine and steam turbine cycle is commonly understood, but the impact on ancillary, auxiliary, and parasitic loads is less discussed and often more complex. These losses often increase non-linearly at part load plant operation.

If an operator is willing to invest in the most efficient gas turbine power plant, it is also worthwhile for the operator to invest in properly designed inlet/exhaust systems and the balance of plant to minimize parasitic and ancillary losses. This will maximize dollars per kilowatt produced. ■

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