Gas Turbine World

Bright ideas in small packages
page 12

Controlling compressor costs
page 18

A new upgrade ethos
page 23

Flexible engines down Mexico way
page 28

July-August 2015
www.gasturbineworld.com

Subscriptions
Peggy Walker
Facsimile +1 203 254 3431
orders@gasturbineworld.com

Executive Office
Gas Turbine World
654 Hillside Road
Fairfield, CT 06824, USA
Telephone +1 203 259 1812

Website
www.gasturbineworld.com

Advertising Sales
US & Canada – James Janson
Telephone +1 203 226 0003
Facsimile +1 203 226 0061
publications.grp@snet.net

Europe – Peter Gilmore
Telephone +44 (0)207 834 5559
pgilmores@aol.com

Japan – Victor deBiasi
Telephone +1 203 259 1812
Facsimile +1 203 254 3431
vdebiasi@gasturbineworld.com

Postmaster, please send Form 3579 to PO Box 447, Southport, CT 06890

On the Cover Centrifugal and axial compressors can incorporate comprehensive and integrated software packages to improve operation and efficiency.

Gas Turbine World (USPS 944760, ISSN 0746-4134) is published bi-monthly in addition to the GTW Handbook annual by Pequot Publishing Inc. 654 Hillside Rd., Fairfield, CT 06824. Canada Post International Mail Product (Canadian Distribution) Sales Agreement No. 0747165. Printed in U.S.A.
www.gasturbineworld.com

United Kingdom

Sutton Bridge upgrade will boost competitiveness

Calon Energy has selected GE to upgrade its Sutton Bridge Power Station in Lincolnshire, United Kingdom, in a move to increase power production, improve efficiency and flexibility and reduce its operating costs. The 800 MW natural gas-fired combined cycle power plant provides electricity to the East Anglian region of the United Kingdom, and the upgrades will help increase the competitiveness of the plant in the country's challenging power industry.

Sutton Bridge's two existing GE 9FA gas turbines and a D-11 steam turbine will be upgraded with multiple applications from the OpFlex controls software suite, a Dry Low NOx 2.6+ combustor and Advanced Gas Path (AGP) technology solutions. The project represents the first 9FA AGP upgrade in the UK.

These enhancements will help the power station become a far more flexible, reliable and efficient plant, able to meet today's UK market requirement while being able to respond to the needs of the future with the introduction of the UK Power Market Balancing Mechanism.

Sutton Bridge will also benefit from additional availability to generate power with extended periods between planned outages with these upgrade solutions. The project is expected to begin in mid-2016 and be completed some months later.

"This is a significant investment by Calon Energy, particularly in the current economic [climate]," said Kevin McCullough, chief executive, Calon Energy. "We play an important role by providing energy at peak times and cover renewable generation intermittencies."

The 800 MW Sutton Bridge power station is located approximately two miles from the village of Sutton Bridge in Lincolnshire.

USA

NY school to showcase novel microturbines

Four FlexEnergy GT250S microturbines will soon become an integral part of a comprehensive energy savings project for the Longwood Central School District in Long Island, New York.

FlexEnergy is the manufacturer of the world's only synchronous generator-based microturbines.

The Flex turbines will include an integrated hot water cogeneration module to allow for a simple mechanical connection to multiple-facility hot water systems, as well as absorption chilling, thus reducing equipment footprint and facilitating reliable operations for combined heat and power (CHP) systems.

Michael Passantino, President of MDP Energy, FlexEnergy's channel partner, said: "Long Island has the second highest energy rates in the country; Longwood's blended rate is $0.198 per kWh.

The Flex microturbines will bring the High School and Middle School costs down to nine cents per kWh, reducing energy costs by over 50%."

FlexEnergy expects to deliver the units by mid-August to help minimize disruption during the school year. Commissioning is expected to occur in the 4th quarter of 2015.

USA

Duke sees falling cost for combined cycle plants

Duke Energy has seen the construction costs for combined cycle gas facilities coming in below budget. According to *Platts*, the company's 625 MW Sutton facility in North Carolina cost 8% below initial estimates.

In a detailed look at the cost of several plants completed recently, *Platts* reports that the cost to construct and operate combined cycle gas facilities is falling. Facilities are now regularly costing less than $1000/kW, it said.

Duke Energy Progress said the final cost of its Sutton facility in North Carolina was $551 million, compared with the initial estimates of more than $670 million.

This means Duke paid only $882/kW at Sutton, compared to initial estimates of $1073/kW. Cosntruction costs under $1000 per installed kW are increasingly becoming the norm, *Platts* notes. Florida Power & Light expects its 1277 MW combined cycle project at Port Everglades to cost around $670/kW.

The findings support recent forecasts from The US Energy Information Administration (EIA), which expects combined cycle plants coming online in 2020 to have a levelized cost of electricity about $14/MWh, compared with $60/MWh for conventional coal resources.

In its 2015 Annual Energy Outlook, EIA predicts that from a levelized cost of capital standpoint combined cycle facilities coming online in 2020 will return the cheapest power. Conventional combined cycle plants are projected to have a cost of about $14.4/MWh, compared with about $60/MWh for conventional coal and almost $100/MWh for coal with carbon capture and sequestration technology.

However, the EIA cautioned that its estimates do not account for fluctuations in fuel price, which can vary widely. "Although levelized cost calculations are generally made using an assumed set of capital and operating costs, the inherent uncertainty about future fuel prices and future policies may cause plant owners or investors who finance plants to place a value on portfolio diversification," it said.

Egypt

Ansaldo Energia MoU to convert '6th of October' power plant

Ansaldo Energia has signed a memorandum of understanding with the Egyptian Electricity Holding Company (EEHC) to convert the 6th of October power plant from simple to combined cycle.

The Italian company's scope of supply covers the design and turnkey construction of the plant conversion, through the addition of four heat recovery steam generators and a steam turbine rated at 340 MW and associated air condenser. The conversion will be completed in 24 months from the signing of the contract.

The 6th of October power plant, located on the industrial outskirts of Cairo, is owned by the Cairo Electricity Production Company, which is in turn owned by the government's electric power agency, the Egyptian Electricity Holding Company.

Under the framework of the project, SACE has already provided funding of €210 million ($233.5 million) in relation to the previous order awarded to Ansaldo Energia. SACE has also expressed its availability to examine the possibility of providing support for the next stage of work.

USA

Micro-turbines will power oil field project in Alaska

Capstone Turbine Corporation has received an order for two C600 dual mode micro-turbines to power a facility and onsite equipment at an oil field project in Alaska.

Horizon Power Systems and Chenega Energy, two of Capstone's North American distributors, worked together to secure the order.

Two natural gas fired C600 dual mode micro-turbines, designed specifically for high humidity environments, will be installed at an onshore oil and gas production site in Alaska to provide primary power for operating the oil facility and on-site equipment. The plant is expected to be commissioned in September 2015.

Capstone microturbines were chosen in lieu of traditional diesel engine generator sets for their high reliability, low emissions, low maintenance and low noise.

"The conversion to natural gas is a much cleaner and more efficient solution than traditional diesel engines," said Sam Henry, President of Horizon Power Systems. "Combined with the scalability of micro-turbines, this allows for the facility's power plant to expand incrementally, as the volume of production is expected to increase over time."

According to the US Energy Information Administration (EIA), natural gas accounts for over half of Alaska's electricity generation. Though with natural gas production volumes exceeding local demand, about three-quarters of the natural gas withdrawn is used at production sites.

USA

West Medway II gets Limited Notice to Proceed

Gemma Power Systems, LLC (GPS) has received a Limited Notice to Proceed (LNTP) to commence activities under a turnkey engineering, procurement and construction (EPC) contract with Exelon West Medway II, LLC for a 200 MW dual-fuel simple cycle power plant in Medway, Massachusetts. The Full Notice to Proceed (FNTP) is contingent upon Exelon receiving all Massachusetts regulatory approvals for the project.

The new facility will be constructed on a 70-acre site adjacent to Exelon's existing 173 MW Medway Generating Station and will feature two 100 MW GE LMS100 combustion turbines. Construction and commissioning is planned to be complete in the second quarter of 2018.

Mexico

Operations start at San Luis de la Paz power plant

Dutch power generation company InterGen has commenced operations at the 205 MW gas fired combined cycle power plant near the municipality of San Luis de la Paz, Guanajuato, Mexico.

Located approximately 160 miles from Mexico City, the $217 million San Luis de la Paz facility is built adjacent to the company's majority-owned 600 MW Bajio plant.

Under a 20-year deal, the majority of the power generated from the San Luis de la Paz plant will be sold to a mining company with the remaining supplied to industries in the region.

Jointly owned by the Ontario Teachers' Pension Plan and China Huaneng / Guangdong Yudean, InterGen operates power plants in the UK, the Netherlands, Mexico and Australia with a combined capacity of 7892 MW. InterGen President and CEO Neil Smith said: "We are committed to expanding our business in Mexico and providing energy solutions to a variety of customers in the country."

Samsung Engineering managed the construction of the power plant.

Russia

Hoerbiger Russia becomes Waukesha gas engines distributor

GE has appointed Hoerbiger (Russia) Ltd as an authorized Waukesha gas engines distributor for sales and services.

The move builds on GE's ongoing commitment to provide Russian oil and gas, power generation and other industrial customers with reliable, more efficient power at or near the point of use.

With a large inventory of genuine products and service parts, GE says Hoerbiger Russia is well-positioned to partner with Waukesha end users active in any power application in Russia, which includes hundreds of engines installed in the country.

As an authorized distributor, Hoerbiger Russia can improve a Waukesha end user's operations with a complete life cycle of engine coverage, including installation and startup, upgrades and overhauls with genuine parts and factory warranties.

Hoerbiger Russia was founded in 1992 and is a subsidiary of Switzerland-based Hoerbiger Holding AG, a leader in compression, automation and drive technology. The company is headquartered in Moscow, with a team of engine technicians located throughout the country.

"With our new GE distributor agreement, we will be able to greatly enhance the customer experience for companies that need power in Russia, ranging from oil and gas power to industrial on-site power production," said Denis Pestov, managing director of Hoerbiger Russia. "Our growing team of skilled Waukesha-certified engine technicians around the country and stock of genuine parts inventory help ensure immediate, local customer support – both on-site and in our shops."

Iraq

Mapna to build 3000 MW Rumaila CCGT plant

Following the successful implementation of the Najaf and Baghdad Al-Sadr gas fired power plants, Mapna has won the contract for construction of the 3000 MW Rumaila combined cycle power plant.

The power plant will be constructed in a Basra suburb by a consortium of Mapna and Jordanian-Iraqi company Shamara Holding Co. Notably, for the first time in the history of the country the Iraqi government is supporting the contract with a sovereign guarantee. The total value of the Rumaila contract will exceed $2.5 billion.

The plant, which will be constructed in four phases, will incorporate 12 gas turbines, and associated heat recovery steam generators (HRSGs) and six steam turbines. Mapna Group will be responsible for engineering, procurement, and installation of the MAP2B 180 MW gas turbines, E-Type 160 MW steam turbines and HRSGs.

Rumaila is one of a series of projects launched by the Iraqi Ministry of Electricity with the objective of increasing current installed capacity from 8500 MW to 20 000 MW by 2016.

Electricity shortages have hampered Iraq's development in recent years, as large parts of the country continue to suffer from blackouts. The situation is costing the economy an estimated $40 billion per annum.

Australia

Engine distribution agreement will allow oil and gas expansion

In a move to further expand its Waukesha gas engine sales presence in Australia's mineral and oil and gas sectors, Clarke Energy has been appointed as a new authorized distributor and service provider for GE's Waukesha gas engines and genuine parts in Australia.

The new agreement will enable both Clarke Energy and GE to support an even wider range of oil and gas production projects throughout Australia as Waukesha gas engines are ideally suited for a variety of on-site mechanical drive, gas compression and power generation applications.

Clarke Energy is a well-known multinational specialist in distributed power and reciprocating engine technology. The company is the existing distributor in Australia for GE's Jenbacher and diesel-fuelled power generation technologies. The company's services range from the supply of an engine through to the turnkey delivery of a multi-engine power plant, as well as aftersales product support.

"Our new distribution and services agreement with GE gives Clarke Energy an expanded portfolio of GE products to supply in Australia. GE's Waukesha gas engines complement our existing diesel and gas-fuelled GE products, and we will now deliver an enhanced level of Waukesha products and services support for the gas compression and power generation industry in Australia," said Greg Columbus, managing director of Clarke Energy's Australian and New Zealand operations.

"This agreement will bring quality service delivery to both existing and new Waukesha gas engine customers in Australia," said Geoff Culbert, President & CEO, GE Australia and New Zealand.

Turkmenistan

GT installations to increase electricity export

Turkmenistan plans to build 14 gas turbine power plants in order to increase electricity exports to 6.9 TWh by 2020. Electricity from the new plants, with a total capacity of 3854 MW, will be exported to Iran, Afghanistan, and Turkey.

Turkmenistan plans to increase electricity production to 27.4 TWh by 2020, rising to 35.5 TWh by 2030, in accordance with the 'Concept of Electric Power Industry Development of Turkmenistan for 2013-2020'. The Concept, approved by Turkmen President Gurbanguly Berdimuhamedov on April 12, promises to invest $5 billion into the sector to boost electricity exports by a factor of five.

The new power industry development plan will be implemented in two phases, 2013-2016 and 2017-2020. As part of the first phase of the plan, the country put into operation gas turbine power plants in Akhal, Mary, and Lebap regions with capacity of about 149 MW each in 2014. A gas turbine power plant in the Ak Bugday region, with a capacity of 252.2 MW, was also installed last year. Meanwhile, a gas turbine power plant in the Dervezin region with capacity of 504.4 MW is in its final stage of construction.

The construction of the gas turbine power plant in the Lebap region with a capacity of 252.2 MW is ongoing, and another power plant with a capacity of 400 MW is planned for construction in the same region in the coming years.

The second phase, covering 2017-2020, envisions the conversion of six simple cycle gas turbine plants to combined cycle. This will increase electricity production in Turkmenistan to 26.38 billion kWh by 2020.

Turkmenistan has 11 operational power plants with a total of 40 turbines, including 14 steam and 26 gas turbines.

USA

GE LM2500s to power Arleigh Burke destroyers

GE Marine will provide eight LM2500 marine gas turbines to power the US Navy's DDG 121 and DDG 122 Arleigh Burke-class destroyers. GE also received a five-year extension on its requirements contract for the DDG 51 program.

Brien Bolsinger, Vice President, Marine Operations, GE Marine said: "Once operational, these Arleigh Burke-class destroyers will be in service for some 30 years. GE Marine will be there alongside the US Navy for the life of this program, providing support of the LM2500 gas turbines through continual infusion of advanced technologies."

For example, each LM2500 gas turbine for these new destroyers will feature common engine improvements including parts upgrade of the compressor rotor, the turbine mid-frame, the compressor rear frame and the power turbine. Through the common engine program, the US Navy can leverage the LM2500 industrial volume to control cost, and to improve manufacturing, durability and spare parts lead times.

Common engine changes are contained within the gas turbine, so as to not impact ship interfaces or on-ship maintenance activities; this configuration has been recertified to US Navy Mil 901D shock requirements. GE's common engine program also is available to international naval customers.

Thailand

Alstom signs new Kaeng Khoi II service agreements

Alstom has been awarded a new Long Term Service Agreement (LTSA) as well as an extension of a Long Term Parts Agreement (LTPA) by Gulf Power Generation Company Limited (Gulf Power) for its Kaeng Khoi II power plant in Thailand.

With a combined value of over €160 million ($178 million), the new extension agreements will see Alstom providing technical expertise to oversee the service and maintenance of the Kaeng Khoi II power plant. Under the scope of these two agreements, Alstom will also provide new parts, reconditioning services and field service for planned outages for the plant's existing gas turbines, steam turbines and generators until 2033.

Contributing around 1500 MW of power to Thailand's energy mix, the Kaeng Khoi II combined cycle natural gas plant, located in Saraburi Province at the north of Bangkok, was built by Alstom and has been in operation since 2008. The original LTPA only covered the gas turbines. The new LTSA and LTPA extension increases Alstom's scope to cover the steam turbine and generators as well.

Germany

Stadtwerke Kiel orders 190 MW cogeneration plant

German municipal utility Stadtwerke Kiel has selected GE and general contractor Alpiq, a subsidiary of Kraftanlagen München (KAM), to build a combined heat and power (CHP) plant in the city of Kiel.

The project will feature 20 GE Jenbacher J920 FleXtra gas engines – the largest order for the engines in the company's history. The new multi-engine gas fired installation will replace a coal fired plant to supply a total output of 190 MW of electricity to the grid and 192 MW of thermal energy to the district heating network. The plant will have an overall efficiency of more than 90% and an electrical efficiency is 45%.

The marketing of balancing energy and the integration of an electrode boiler (power-to-heat) during periods of low electricity prices provide an extremely flexible and economical solution. According to GE this arrangement not only ensures regional supply, but also guarantees operational cost-effectiveness. Compared with the previous coal fired power plant, CO_2 emissions are reduced from 1.8 million tons to approx. 540 000 tons.

Operational flexibility was a primary requirement of the new Stadtwerke Kiel plant. Due to the high proportion of wind-generated electricity in the regional grid, the power plant has to be able to feed full power into the local electrical grid within a short period in order to offset the volatility of the wind level, thus ensuring stability of the grid.

The Jenbacher J920 FleXtra gas engines by GE can optimally compensate for these fluctuations. Their full capacity can be called up in just a few minutes. According to GE, the solution represents the ideal bridge technology and application to implement the energy transition plan in Germany. The country has a goal of generating 80% of electricity from renewables, which are variable energy sources, by 2050.

The order from Stadtwerke Kiel is divided into two phases. The initial project involves the planning and construction of the pump house to connect to the district heating system, the electrode boiler and heat storage as well as scheduling and obtaining operating approval for the entire system, including gas engines. The second phase of the project, including construction of the gas engine power plant, is scheduled to start in May 2016.

Qatar

Samsung C&T to build 2500 MW power and desalination project

Samsung C&T has clinched a contract for major construction work on the largest Independent Water and Power Project (IWPP) in Qatar.

The Korean company has been awarded the $1.8 billion EPC deal for the 2500 MW power generation component of Facility D, which is being developed by Japanese companies Mitsubishi Corp and Tokyo Electric Power Company (Tepco).

Qatar General Electricity & Water Corporation (Kahramaa) ordered the combined cycle power plant and 130 million imperial gallons per day (590 000 m^3/d) desalination plant in May. The facility, to be constructed 15 km south of Doha, is due to be completed in June, 2018.

Kahramaa will purchase the power and water off-take under a 25-year contract with K1 Energy, a consortium formed by the Japanese pair. K1 will own a 30% stake in Umm Al Houl Power, a special purpose company (SPC) set up to own the IWPP, while Qatar Electricity and Water Company (QEWC) will hold 60%, with Qatar Petroleum and Qatar Foundations each holding 5%.

Samsung C&T said it will take on $1.8 billion worth of EPC work out of a total EPC contract of $2.46 billion. Spanish firm Acciona Agua previously announced it would develop the desalination component of the project.

Korea

GE 7HA.02 turbines will help Anyang achieve 61% efficiency

General Electric (GE) is to supply GS Power, one of Korea's largest private electricity and heating generators, with its high efficiency 7HA.02 gas turbine and associated clutched steam turbine for a new combined cycle power plant in Anyang, Gyeonggi Province.

According to GE, the 7HA.02 gas turbine is the world's largest and most efficient 60 Hz gas turbine – in power-only mode it will achieve more than 61% electrical efficiency, and deliver an overall efficiency of more than 91% in district heating mode.

The Anyang plant will be able to generate 935 MW of power in combined cycle mode, enough to power 900 000 Korean homes. GS Power Vice President Kim Eung-hwan added that GE's 7HA technology has the largest steam exhaust energy output in the world, which will help it maximize its district heating output in Anyang.

Anyang, a suburb outside of Seoul, experiences temperatures as low as -18°C (0°F) in the winter months. The district heating network distributes centralized heat to a concentrated population and is GS Power's primary application for the HA technology in Korea. One hundred per cent of the steam generated by the new plant has the potential to be used for district heating in winter months.

Thailand

RWG secures maintenance contracts for Avon and RB211 units

Thailand's multi-national energy company PTT has awarded UK company RWG (Repair & Overhauls) Ltd multiple contracts for maintenance of Siemens aero-derivative gas turbines. The contracts cover major overhaul of three Industrial RB211 DLE units and three Industrial Avon 200 gas turbines in service at PTT's five gas separation plants in Rayong Province, Thailand.

The contracts, valued at approximately £8 million ($12.5 million), will be undertaken at RWG's Aberdeen, UK, service centre. The scope of work includes engine disassembly, detailed inspection, component repair, re-assembly and performance test of each gas generator prior to return to the customer. Overhaul of both Industrial RB211 and Industrial Avon engines has already commenced and is scheduled for completion during 2015.

PTT operates the latest technology Siemens aero-derivative gas turbines for mechanical drive and power generation duty at its gas separation plants. RWG has a long association with the company, having supported the Siemens equipment since first commissioning.

RWG provides maintenance support for an additional gas separation plant (GSP) located at Amphur Khanom in Nakhon Sri Thammarat Province. PTT's GSP Unit 4 operates Siemens Industrial 501 gas generators and recently contracted with RWG for overhaul of a single Industrial 501KC5 machine, complete with Dresser-Rand GT22 power turbine. This work scope was completed at RWG's Texas, USA, facility, enabling PTT to consolidate support for Siemens equipment with a single service provider.

Africa

APR Energy extends and expands mobile power plants in Africa

APR Energy plc, a supplier of fast-track mobile power plants, has been awarded contracts to extend and expand power plants in Sengal and Angola.

The first contract with Société Nationale d'Éléctricité du Sénégal (Senelec), Senegal's national electric utility, covers the installation and operation of an additional 48 MW of mobile diesel-powered generation, including assets being redeployed from Libya. This will supplement an existing 20 MW block of power at APR Energy's Kounoune site. The contract term for the combined 68 MW plant extends into the fourth quarter of 2015.

APR Energy also announced that it has extended its 40 MW mobile gas turbine project in Rocha Pinto, Angola, through to late in the fourth quarter of 2015. Located near the capital city of Luanda, the project is one of two the company has in Angola. APR Energy provides an additional 40 MW of power generation at its plant in Morro Bento, which was extended through the first quarter of 2016 earlier this year.

United Kingdom

Watt Power's first gas fired projects secure planning consent

UK-based independent power company Watt Power has secured consent from the Department of Energy & Climate Change for its first gas-fired power projects in the UK: the Hirwaun Power project, near Aberdare in south Wales, and the Progress Power project located near Eye in Suffolk. The two open-cycle gas fired power generation plants will be entered into the UK's Capacity Market Auction, scheduled for December 2015.

Subject to the outcome of the auction and the projects' financing, Watt Power would expect both plants to commence construction within 18 months of the auction, with commercial operation scheduled for 2019.

Each open-cycle gas turbine project has a capacity of 299 MW and will operate as "peaking plant", providing back-up to intermittent renewable generation and at times of high system demand. Amber Rudd, the Secretary of State for Energy & Climate Change granted Development Consent Orders (DCOs) to both after a two-and-a-half year consultation and examination process for each project.

George Grant, a Director of Watt Power, said: "This is great news for the Watt Power team and the UK government… However, despite the widespread acceptance that new generation plant is required and the considerable investment we have made to date, we don't have any guarantees of success in the Capacity Market Auction given the current market arrangements. We recognise that there is still much to do even though we have the DCOs for two projects – it is an important point that government and market commentators should not overlook."

The projects are designed to meet the UK government's energy policy objectives of security of supply and affordability and support the country's transition to a low-carbon economy.

Turkey

GE Oil & Gas to provide turbo-compressor trains for TANAP

GE Oil & Gas will provide turbomachinery for Phase 1 of the landmark Trans-Anatolian Natural Gas Pipeline (TANAP) – a partnership between the State Oil Company of Azerbaijan (SOCAR), Turkey's state-owned BOTAŞ (Petroleum Pipeline Corporation), and BP – that will transport gas from Azerbaijan via Turkey to European energy markets. The pipeline is being built to provide the benefits of uninterrupted gas flow as well as security and diversification of energy resources for Europe.

GE's scope of supply under the multi-million dollar contract includes aeroderivative gas turbine driven centrifugal compressor packages manufactured, packaged and tested by GE Oil & Gas in Florence (Italy) for shipment in 2017.

The deal supports the commissioning of Phase 1 of TANAP scheduled to come online in 2018. According to GE Oil & Gas, its equipment was chosen because of its high operational efficiency, lower emissions and lower maintenance.

Rami Qasem, President & CEO, GE Oil & Gas MENAT, said: "We are pleased to be providing technologically advanced GE O&G solutions for the prestigious TANAP project."

"The contract reiterates our commitment and proven track-record to support game-changer projects, such as TANAP that will not only support local economies through job creation and economic value but also strengthen the energy security of markets across Europe."

USA

Panda Power Funds breaks ground on Stonewall power plant

Panda Power Funds was joined by elected state officials to break ground on its newest power plant, the Stonewall Energy Center, on August 6, 2015.

Located four miles southeast of Leesburg, Virginia, the new power plant will be one of the most advanced natural gas fired generating facilities in the country and will supply power to Va. and D.C. The plant is expected to begin commercial operation in 2017.

Generating 778 MW of energy, the plant will provide enough power for 750 000 homes, create about $20 million per year in spending, increase the tax base, and provide revenue for Leesburg.

It will also utilize the most advanced emission control technologies, making it one of the cleanest natural gas fired power plants in the country. Additionally, the plant will be cooled using treated wastewater instead of potable water, thereby conserving Va.'s natural resources and preventing pollution of the nearby Potomac River and Chesapeake Bay watersheds

Construction of the facility will create approximately 600 jobs and once complete, will require 30 permanent employees to operate the station.

Bangladesh

Ghorashal refurbishment to add 400 MW to grid

The Power Development Board (PDB) is inviting international tenders to re-power Unit 4 of the Ghorashal power plant. The project will see the construction on a turnkey basis of a 400 MW gas fired combined cycle power plant.

The existing power plant, built some 25 years ago, has a generating capacity of 170 MW.

"Given the perennial gas crisis, repowering technology gives a very cost effective solution to the country. The gas efficiency of the plant is now 33%; it will exceed 54% after the conversion," said project director Md Shah Nawaz.

"Once a contract is signed, the construction period for the project is 900 days, including a simple cycle completion time of 540 days," Shah Nawaz added.

The new plant will be built in Ghorashal on five acres of land owned by the PDB. The estimated cost of the project is $400 million, he said.

The PDB, under the Ministry of Power, Energy and Mineral Resources, has already invited international tenders for the project. The last date for tender submissions is September 30.

The re-powering of the 4th unit of the Ghorashal plant is expected to be completed by December 2017.

Eligible bidders must provide $3 million in the form of an irrevocable and unconditional bank guarantee issued by a scheduled bank of Bangladesh or a foreign bank duly endorsed by a scheduled bank.

Saudi Arabia

GAMA Power Systems to build 1800 MW CCPP PP13

GAMA Power Systems has signed the contract with Saudi Electricity Company (SEC) for mechanical, instrumentation and control (I&C) and electrical installation of the complete power generation equipment and balance-of-plant at the 1800 MW Power Plant PP13 Project.

The plant will be located next to PP12 (under construction) about 140 km west of Riyadh near Durma.

The plant will consist of two blocks with each block being a three-on-one combined cycle power block. Each power block will include three GE F-Class combustion turbines, three-pressure heat recovery steam generators (HRSGs), one steam turbine generator and one air cooled condenser.

In a statement, GAMA said its main goal is to "perform an outstanding execution in a very short period of time", so the plant can start operating no later than September 2016.

Korea

HHI, GE next-gen LNG carrier powered by gas turbines

South Korean shipbuilder Hyundai Heavy Industries (HHI) has received Approval in Principle (AIP) from Lloyd's Register for the world's first gas turbine-powered LNG carrier, developed jointly with GE Aviation and Marine (GE).

The IMO Tier III-compliant 174 000 m^3 LNG carrier is equipped with GE's gas turbine-based Combined Gas turbine Electric and Steam system (COGES 2.0).

The vessel is expected to save ship owners or operators an estimated $17.83 million over a ship's 20-year lifetime, since it does not need additional equipment to handle exhaust emissions.

The gas turbine-powered engine is 60% lighter than conventional engines and will lower operating and maintenance costs accordingly, HHI said.

USA

FPL plans to add new 1600 MW combined cycle power plant

NextEra Energy utility Florida Power & Light (FPL) plans to add a new 1600 MW combined cycle natural gas plant, known as FPL Okeechobee, to its fleet in 2019.

If approved by regulators, the new plant would be built on company-owned property in northeastern Okeechobee County, Fla., and enter service by mid-2019.

The new facility would complement other major system improvements, including the three new large-scale solar power plants that FPL is building before the end of 2016. The plant would be built on a large site that could eventually accommodate utility-scale solar energy generation, FPL said.

FPL intends to file for regulatory approval in the coming months. If the planned facility receives all needed approvals on the anticipated schedule, construction would start in 2017, and the plant would begin powering customers in mid-2019.

FPL issued a Request for Proposals (RFP) during the first quarter of 2015 to invite prospective bids from interested power providers for firm generation. Despite substantial early interest from more than 20 companies, none chose to compete with FPL's Okeechobee Clean Energy Center proposal. The company received only one partial bid that did not conform to the terms of the RFP and fell far short of meeting the required energy need.

FPL expects to build the proposed new facility for a cost of about $670/kW, which it claims is lower in cost than any comparable plant being built in the world today.

The plant represents an estimated $1.2 billion investment and would create an average of 300 jobs during construction.


Gas Turbine World
2015 Performance Specs
31st Edition

Bright prospects for micro-turbines

By Junior Isles

A team of researchers at City University London has started testing a micro-turbine for a solar dish system project. The power system could provide and demonstrate a technical solution for the use of a state-of-the-art concentrated solar power system coupled to a micro-gas turbine to produce electricity.

Solar power is playing a significant role in the drive towards increasing the deployment of renewables in many parts of the world.

While much of the general media focus has been on solar photovoltaics (PV), development is also taking place in the field of solar thermal, or concentrated solar power (CSP).

CSP plants use a field of mirrors to concentrate energy from the sun to a single focal point known as a solar receiver. This is typically used to heat-up a working fluid such as molten salt. The heat generated is typically used to produce steam to drive traditional steam turbines that drive an electricity generator. It is also possible to store the thermal energy in a CSP plant so electricity can be produced day or night.

One type of CSP technology uses a parabolic dish to collect the solar energy, which is combined with a Stirling engine to generate power. These are smaller units, typically in the range of 1-30 kWe. The technology has been around for some time but has failed to really get off the ground. Stirling engines, which are piston-type engines, have proven unreliable. However, a new micro-gas

Dish/engine system. Each unit uses a parabolic dish of mirrors to direct and concentrate sunlight onto a central engine that produces electricity.

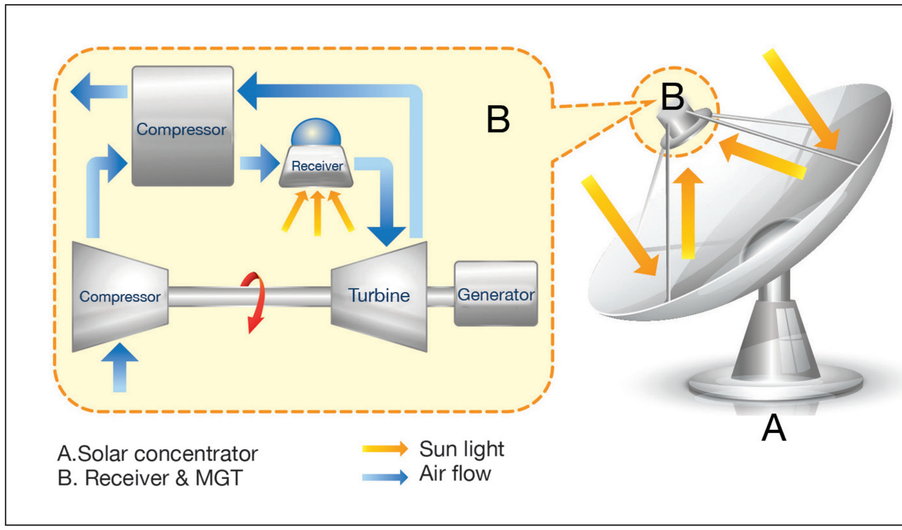
turbine (MGT) being developed by City University London researchers, could be a game changer.

Professor Abdulnaser Sayma, Professor of Energy Engineering at City University London explained: “Attempts are still being made to use Stirling engines. They have a good design point efficiency but there are serious reliability issues. A Stirling engine uses a gas, typically hydrogen or helium, stored inside but after a period of time the piston rings tend to leak and you have to keep recharging with the gas.”

Still seeing the potential in the technology, a few years ago the European Commission, under its 7th Framework Programme for Research and Technical Development, identified dish/engine CSP as an important technology and therefore began looking to address the reliability issue as well as improvements of the actual dish itself.

It was at this point that Professor Sayma decided to set-up a project to look at possible solutions.

“I thought: we could replace the Stirling engine with a micro-turbine. So we then looked around for partners that could handle other aspects such as the receiver, solar dish and tried to progress the technology. We started working on a proposal to the Commission in 2011, which was submitted in 2012. We got the award [for EU funding] in 2013.



CSP-MGT hybrid. Flow schematic of a dish/MGT system

Project set-up

The concept of a micro-turbine operated by a solar dish is not totally new. Similar projects have been undertaken in the past but at a larger scale. Being a first at this size, Professor Sayma and his team decided the project should have two goals: a demonstration that the basic technology works and an Optimised Micro-turbine Solar Power (OMPoP) system based on the data collected from the demo unit would be suitable for future market deployment.

The technical challenges addressed by the OMSoP project are split into three Work Packages (WPs): System Component Development (WP1); System Design and Integration (WP2) and Techno-economic Analysis (WP3).

In addition to taking the overall lead for the project, City is also designing, developing, building and testing the micro-turbine, with the help of Sweden-based company, Compower. The project partners for the other main components are KTH Royal Institute of Technology of Sweden (solar receiver) and Italy’s Innova (dish concentrator).

Other partners are Roma TRE University, Universidad of Seville and the European Turbine Network, which will help with publicity and dissemination of results.

The whole demonstration will take place in Casaccia, just outside Rome, Italy, at a Research centre owned by ENEA – the Italian National Agency for New Technologies, Energy and Sustainable Economic Development. ENAE is City’s partner in the project and responsible for system integration and demonstration.

The total project will cost €5.8 million ($6.4 million), of which €4.42 million will come from EU funding.

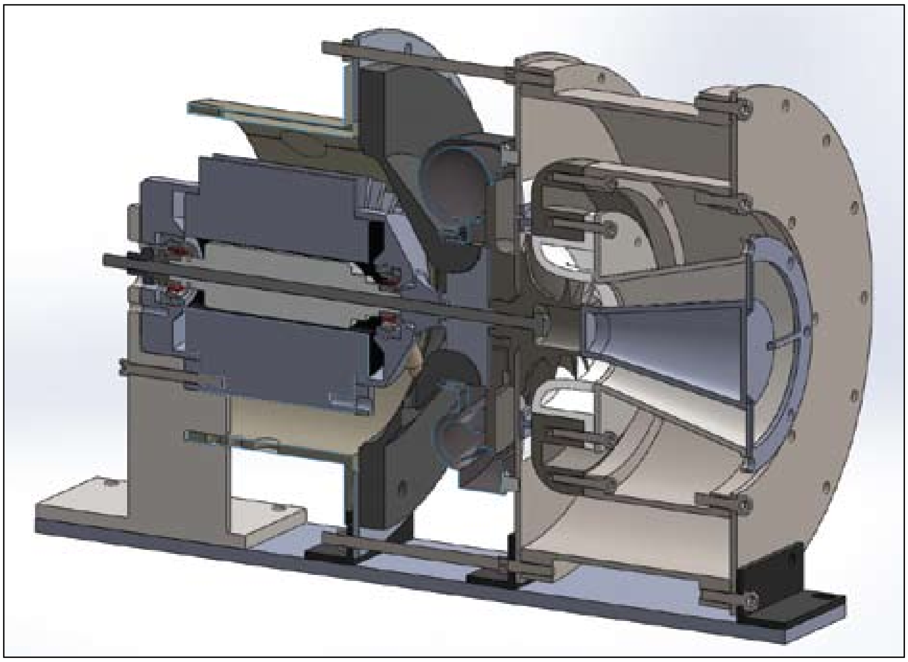
Demonstration system

The demonstration system will have a power output of 3-10 kW. If larger amounts of power are needed, a number of units can be “stacked”, says Professor Sayma. “It’s a modular system. If you want just a small amount of electricity in a remote area for a school or a house, you could have just one module. To generate a large amount of electricity you could have lots of units, like a solar park.”

Each unit has its own MGT, which sits on an arm attached to the solar dish. Unlike a typical MGT, which burns a fuel to increase the temperature of the working fluid, air, essentially the combustion chamber is replaced with a receiver to heat the air directly by the sun.

“Rather than having the air compressed and heated by a fuel, we just heat it by the sun. We are looking to reach a turbine inlet temperature of 800-900°C (1472-1652°F); this is one of the

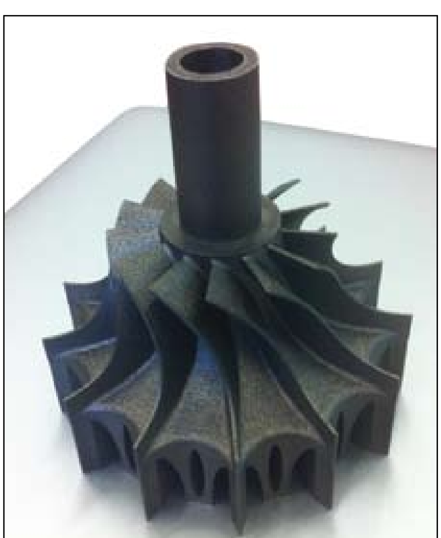
Each unit has its own MGT, which sits on an arm attached to the solar dish.



CAD cross-section of the MGT. It uses one radial turbine stage and one centrifugal compressor stage – it is similar to a turbocharger design.

technological advances we are aiming for," said Professor Sayma.

This temperature is low compared to a large gas turbine, where turbine inlet temperature is typically around 1400-1500°C (2550-2730°F). "Microturbines don't have blade cooling technology, so you are limited by the materials," explained Professor Sayma. "With a microturbine, you can go up to about 1100°C but here we are limited by the receiver material. KTH uses ceramic foam which cannot withstand more than 900°C."



The new MGT uses a single-stage design. The turbine was produced using Selective Laser Melting, a technique similar to 3D printing.

Due to its size, it was not possible to modify an off-the-shelf MGT for the demonstration. MGTs made by the two main manufacturers, Capstone and Turbec, are too large. Capstone turbines start at 30 kWe, while Turbec units are 100 kWe. "That's one reason why we have to build a bespoke unit," noted Professor Sayma.

Another key reason new technology is required, is to link it with the solar receiver. "There is no combustion chamber and the control system are different," he explained.

"Putting it simply, if you want to take less power from a turbine, if demand is lower, there is an automatic switch on the fuel. It's like in a car where you press the accelerator to go faster. But when you have the sun we do not have direct control on the solar insolation, so you need to control the electricity going into the grid in a different way. Therefore the control system cannot be bought off the shelf either. One solution is to use a controllable inverter, or rectifier, that can take a specified amount of electricity from the generator to the grid as dictated by the control system."

The starting point for the new MGT is a unit previously developed by Compower. The MGT comprises a compressor, turbine, heat exchanger for heat recuperation, the shaft and high-speed generator. The recuperator utilises hot exhaust from MGT and uses this to preheat air going into the receiver and thus increase the efficiency of the cycle.

City's objective is to improve the aerodynamic design of compressor and turbine in the first instance. "The original design by Compower uses modified turbocharger components that are usually designed for high specific power, which compromises efficiency," said Professor Sayma.

City therefore developed a new turbine and compressor with high efficiency as the main design parameter. It also designed a new shaft arrangement that was more resilient to the variation of power output due to variable heat from the sun.

Professor Sayma added: "A typical MGT usually runs at a given design point. This one will experience [temperature] variations throughout the day. So we need a shaft arrangement that does not have critical modes of vibration within the running range. For a typical MGT, there might be a critical mode of vibration but you pass through it quickly as you accelerate to maximum speed. We have a new arrangement where we put all the vibration modes out of the operating range."

He added: "There are a lot of detailed technical aspects we need to look at. For example, we also need to look at the bearing system and a robust oil system because it will be moving up and down as the dish moves to track the sun."

The new MGT has a single-stage design, i.e. it uses one radial turbine stage and one centrifugal compressor stage – in some ways it is similar to a turbocharger design. The turbine was produced using Selective Laser Melting, a technique similar to 3D printing. Techniques such as Computational Fluid Dynamics (CFD) and Finite Element Modelling (FEM) for structural and thermal analysis were used to optimise the new turbine and compressor.

Status

A milestone was reached in late April with the installation of the MGT in City's lab and the start of testing of the

MGT testing. Professor Sayma and members of the research team are testing the MGT at City's lab in London

new turbine and compressor designs. Another milestone was also reached that month with the installation of the solar dish in Cassacia and the start of characterising the solar power at the focus.

At this point, a mid-term review of the project also took place. The micro-turbine will be integrated with the receiver and dish which is expected to generate 6 kW of electricity in early 2016 when testing starts. The team is currently about two-thirds of the way through the planned activities.

With regards to the MGT, the design is complete and parts have been ordered. Professor Sayma commented: "Making a micro-turbine is not easy and we cannot make it all in-house. We make a lot of parts, such as the casing and frame, but many have to be ordered. For example we have ordered the high-speed generator from a company in Switzerland. They will send us a magnet and the windings, which is the core of the generator, and this will be delivered in early November. A company in London has been commissioned to assemble the generator, i.e. putting the core together with the electric drives, shaft and bearings."

City has also designed other components such as the recuperator, which will be built by another company in London. Once built, it will be delivered to the University for testing.

Once the compressor and turbine designs have been tested and finalised, they will be combined with components being bought in.

Professor Sayma noted: "We are operating like an OEM: we design, we have suppliers and a supply chain. We have to manage the whole thing, so we have to know the lead-time for each component, where it can be sourced and at what price etc."

Commercialisation

According to Professor Sayma, the target Technology Readiness Level (TRL) of the demonstration will be about 5 or 6. He says that another level will be required to move it closer to commercialisation level, which will require further funding.

"We are already talking to the European Commission. They have in fact identified this as a key technology for collaboration between the UK and China, as a major market for this technology. So part of the funding that we have received is to hold workshops coordinated by the European Commission and the Ministry of Science in China

Phase	Activities	2013	2014	2015	> 2016
Phase 1	Research and development				
Phase 2	Proof of principle component level				
Phase 3	Proof of concept demonstration				
Phase 4	Life cycle assessment, market study, market and academic exploitation				

Timeline. The demonstration is scheduled for completion in 2016

and include partners from research and industry from EU and China. During the workshops, there has been a big interest in China for solar dish micro turbine technology."

While exploring industry interest in taking the technology to the next stage, it is hoped that the project will be included in the updated call for further Commission funding in 2016. This would be timely, as the demonstration will be entering the one-year test phase.

In the meantime the commercial prospects are being assessed under the third Work Package. WP3 will provide a cost and market analysis, as well as a lifecycle analysis.

Professor Sayma said: "We have a team looking at potential markets, what would be the cost of the final product if manufactured in certain numbers and what would be the lifecycle of the product. From this we would determine the optimum size for the market and identify the target markets – will it be individual units or solar parks, what size solar parks, etc.

"In the next stage we will define the manufacturing requirements such as the materials, supply chains things that will take it from TRL 5 or 6 to TRL9. This will happen maybe two or three years after the conclusion of the current project."

Although the cost of electricity from a commercial system is not expected to compete with solar PV directly, the technology does have other selling points argues Professor Sayma. Firstly, it is dispatchable due to the systems inherent ability to store thermal energy or hybridisation with conventional biofuels. Secondly it is better suited to hot climates than solar PV, which have a reduced performance and degrade over time at high ambient temperatures.

Therefore, Professor Sayma expects key markets to include southern Europe, North Africa and China.

Professor Sayma concluded: "China sees a big market for the technology as they diversify their resources. So we are talking to companies as well as developers who are interested in buying the technology or know-how from us." ■

How solar dish technology works

CSP technology is based on optical systems that collect direct solar radiation, concentrate it, and send it to a receiver, where it is converted into high temperature heat. This heat is transferred by means of a heat carrier fluid such as molten salt, which can store the energy for use in a thermodynamic power cycle to generate electricity.

There are various arrangements that differ in the shape of the concentration device.

The dish/engine system produces relatively small amounts of electricity compared to other CSP technologies – typically in the range of 3 to 25 kW. Dish/engine systems use a parabolic dish of mirrors to direct and concentrate sunlight onto a central engine that produces electricity. The two major parts of the system are the solar concentrator and the power conversion unit.

The solar concentrator, or dish, gathers the solar energy coming directly from the sun. The resulting beam of concentrated sunlight is reflected onto a thermal receiver that collects the solar heat. The dish is mounted on a structure that tracks the sun continuously throughout the day to reflect the highest percentage of sunlight possible onto the thermal receiver.

The power conversion unit includes the thermal receiver and the engine/generator. The thermal receiver is the interface between the dish and the engine/generator. It absorbs the concentrated beams of solar energy, converts them to heat, and transfers the heat to the engine/generator. A thermal receiver can be a bank of tubes with a cooling fluid – usually hydrogen or helium – that typically is the heat-transfer medium and also the working fluid for an engine. Alternate thermal receivers are heat pipes, where the boiling and condensing of an intermediate fluid transfers the heat to the engine.

The engine/generator system is the subsystem that takes the heat from the thermal receiver and uses it to produce electricity. The most common type of heat engine used in dish/engine systems is the Stirling engine. A Stirling engine uses the heated fluid to move pistons and create mechanical power. The mechanical work, in the form of the rotation of the engine's crankshaft, drives a generator and produces electrical power.

Path to advanced gas turbine driven compressor control systems

Staff Report

With fluctuating oil prices, oil and gas executives are looking to invest in technology to increase efficiencies. Gas Turbine World looks at how technological advances in the era of the Industrial Internet are creating opportunities to increase gas turbine and compressor operational efficiency and drive predictive maintenance schedules.

While executive leadership wants to optimize costs and plan for the future, industrial operators responsible for maintaining reliability of their gas turbines and increasing productivity rely on software to manage alarms and asset health on a daily basis. Emerging technology must meet the goals of each organizational level, because data from connected assets – including everything from the turbine to the compressor control – is now a critical component for business success.

Homero Endara, Product Line Manager for control solutions at GE Measurement & Control noted: “Original equipment manufacturers (OEMs), such as GE, provide this software to oil and gas organizations, enabling them to customize software modules to meet their unique needs and improve the efficiency of existing turbine equipment.”

When assessing new technology needs for gas turbine and compressor control operation, there are a number of software, hardware and lifecycle management concerns to take into consideration. Based on the number of operating units and environment, each upgrade needs to be specifically tailored to the facility requirements. Unit control systems that take advantage of the latest advances in software and analytics have an opportunity to improve gas turbine and compressor operation significantly and protect against unplanned outage.

Life cycle management

The primary concern for oil and gas, refining and petrochemical applications (the largest market for compressor controls) is to determine how organizations can maintain and enhance the performance of their most critical, long-life assets. These assets interact and rely on digital electronic components that continue to advance and require regular updates. The rapid growth and capacity of information technology (IT), which was initially forecasted in Moore’s law, continues to double nearly every two years. Both the control system and human machine interfaces (HMIs) that the operators interact with through software are advancing at a rapid rate. They require

An integrated turbine and compressor control solution can provide improved equipment protection through effective prevention and detection of surge events.

frequent patches, upgrades and even full replacement of compressor control systems. Maintaining and upgrading systems is critical not only for the performance of the gas turbine, but also to protect computing systems against increasing security risks.

Despite the speed at which computing components and sensors that monitor and drive the gas turbine are evolving, the turbine itself can remain in operation for years. The cost to take a turbine offline in the oil and gas industry, particularly if the system downtime is unplanned, can be millions of dollars each day. As a result, operators must weigh the existing limitations and challenges with their available budget to determine the optimal path forward.

Nate Martin, also Product Line Manager for control solutions at GE Measurement & Control, explained: "Operators can select to replace existing hardware and software, upgrade software systems or maintain legacy systems through specialized programs designed to help organizations maintain out-dated systems with spare and refurbished parts. Each path has its own set of unique considerations. It is important that both the immediate constraints and future objectives are taken into account when evaluating how to move forward."

Maintaining legacy systems

Organizations that want to maintain a legacy system due to budgetary limitations can select various sustainment programs with the OEM or third-party vendor to ensure the system maintains its current functionality and does not create any risk to operations.

As a minimum, oil and gas organizations should have spare parts at each facility to respond to issues as quickly as possible. If a part fails or a chronic issue arises, field technicians can perform a site analysis and recommend spare part actions based on the specific control system and turbine serial number. Often, a team of field engineers will produce a site survey report to show what software patches have or have not yet been done on a unit to avoid trips or unplanned downtime in the future.

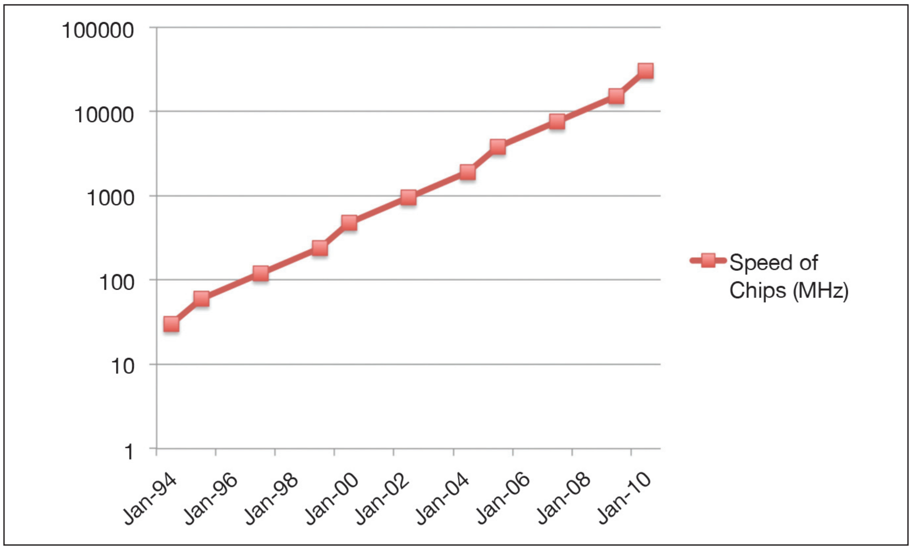
There are also facilities, like GE's Parts and Services Facility in Louisville, Kentucky, that produce refurbished parts for existing systems that are no longer in production.

"An oil and gas facility may be unsure of whether an outdated compressor control system part has failed or if something else is wrong with the unit," said Endara. "If they send it to a facility, like the one in Louisville, technicians will assess the problems, refurbish and recertify it or exchange it for another refurbished part immediately. Organizations can even pay an annual fee to hold a set of refurbished parts as a physical insurance policy on their existing equipment."

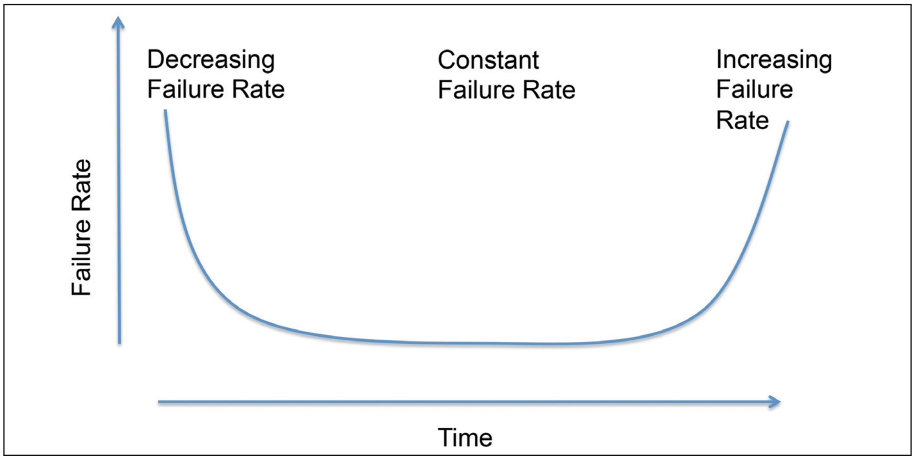
Older control systems can also undergo a revitalization program where the primary controller boards, including the central processing unit (CPU) boards, or the "brains" of the system, are replaced with refurbished cards. The terminal boards remain in place.

As demonstrated by the standard Bathtub Curve, over an extended period of time, the cost of operating these systems increases as internal parts begin to wear out. Most legacy units in need of refurbished parts or revitalization have achieved a normal life expectancy and undergone such standard failure modes. By being proactive about replacing components with limited lifespans, operators can reset the Bathtub Curve and extend the life of their control system.

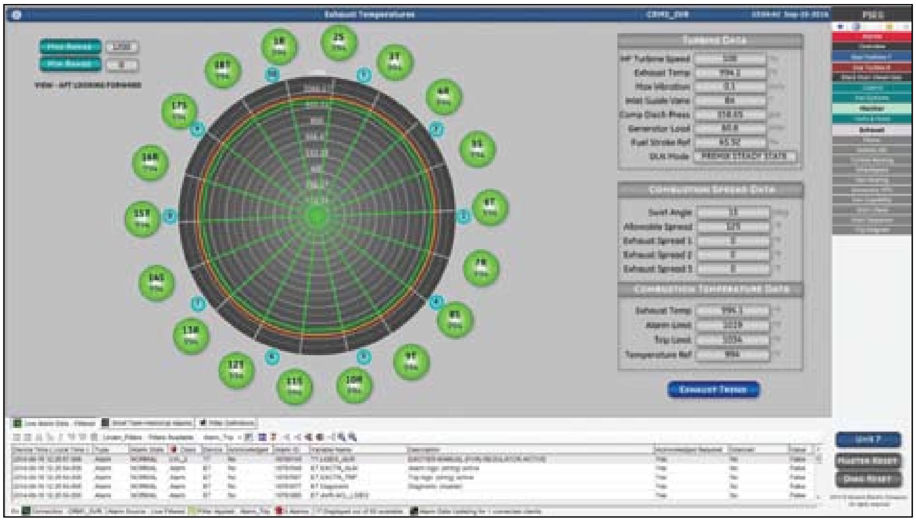
For newer compressor control systems, many organizations choose to build lifecycle management into their standard operating processes. A subscription-based program ensures routine maintenance and security upgrades. It can include full-time technical support



Moore's Law. Processor speed will double every couple of years



Bathtub Curve. The standard Bathtub Curve describes how the cost of operating systems increases as internal parts begin to wear out.



Swirl chart displays. These help operators identify the location of malfunctioning combustion hardware in gas turbines.

by phone, software updates and regularly scheduled visits from a controls field engineer.

The subscription-based model reduces financial uncertainty resulting from possible future Technical Information Letters (TILs) and parts failures. Life cycle management programs can range in features and length, but they provide plant operators with the support and tools necessary to avoid unnecessary equipment failures and downtime.

Regardless of age and anticipated lifetime intervals, regular testing and field data analysis help operators assess how the compressor control system is performing. If performance continues to decline after parts replacement, the costs to continue maintenance for an underperforming unit can become more than the cost to upgrade or replace it with a new unit. Once the organization determines if an upgrade is necessary, there are various technological capabilities to consider for the next system.

Hardware considerations

Today's centrifugal and axial compressors can benefit from comprehensive and integrated software and hardware control solutions. Operations can rely on state-of the-art unit controls, supervisory control and data acquisition (SCADA) and HMI systems integrated with process control.

When flow reverses and flows backward though a centrifugal or axial compressor, surge protection is instrumental in the compressor control algorithm to prevent serious damage to the equipment. Elements of a robust compressor control system consist of anti-surge control and protection algorithms. These are used in the industry to effectively and safely match compressor performance to process demand within the operational constraints of the compressor, its driver and the process.

The ability of compressor control systems to anticipate surge conditions in real-time and respond to protect equipment is critical. Effective surge protection control can be applied in a wide range of applications including single-stage compressors to complex multi-stage compression trains with series and parallel configurations installed in refining, petrochemical, LNG, NGL and pipeline operations.

Once an avoidable trip event occurs in an operation, industry experience has shown that the cost of lost production can be $500 000 per hour or several millions each day while waiting to get machinery back up and running – and that assumes there was no significant damage caused by the trip or unplanned equipment shutdown. Avoiding unnecessary trip events through effective compressor control systems, with robust machine protection, has thus become an operational imperative across the industry.

Ideally, the unit control system is fully integrated so there is continuous and effective communication between the compressor and the gas turbine driving it. An integrated compressor control system can even extend control and protective functions for equipment beyond the basic machine train, such as associated auxiliaries up to and including the entire compressor station.

When the control processing hardware has a reliable and integrated software suite running on top of it, operators can have greater immunity to sudden avoidable trips or equipment damage. Additionally, with a single common user interface for monitoring and control, operators are able to increase their productivity.

GE decsribed one case, where a Middle East natural gas liquids plant with three GE Frame 5 gas turbines driving two-stage Nuovo Pignone centrifugal-type booster compressors required an upgrade because of aging control systems and chronic failures.

"The facility chose GE's Mark IV to VIe migration solution, rather than complete full panel replacement, to maximize their original control system investment by reusing hardware and wiring," said Martin. "This upgrade allowed the plant to integrate control and protection while maintaining segregated functionality. In addition to the Mark VIe hardware, the organization chose to integrate GE's OptiComp compressor control suite.

"With an integrated platform and software compressor control unit in place, the plant noticed immediate improvements in regards to operability, smoother startup and shutdown and steady-state operation – while minimizing compressor surges and consequent production losses."

According to GE, the integrated system led to an 80 per cent reduction in start-up man-hours. The plant has also lowered its total life cycle costs through energy and production savings. It reduced downtime by approximately 150 hours per month and decreased associated maintenance costs. As a result of the time savings, operations specialists are now able to focus more on process optimization tasks.

Oil and gas organizations face some of the most demanding production requirements, and compressor performance and anti-surge controls have a direct and immediate impact on production processes and profitability. The hardware platform is as significant as software in the long run because it determines what software can ultimately run in the system. An integrated unit helps optimize process efficiency while controlling and enhancing protection for compressors.

Software considerations

Compressor control issues are unique for each type of oil and gas facility and cannot always be resolved using "off-the-shelf" solutions. Organizations require both a strategic approach along with system flexibility in order to address their specific problems. Advanced software has the capability to scale from a single compressor anti-surge and process control to managing the performance of multiple turbine and compressor trains including all auxiliaries and overall process control.

OEMs are increasingly using advanced equipment and process knowledge and embedding them in the control systems to provide model based controls and diagnostics solutions to improve overall performance and availability of the system. Physics-based first principle models, as well as data driven input–output models, are generally used for this purpose.

These models are personalized using unit specific data to tune the model parameters. These unit specific models are also being used for 'what-if' scenario simulations to predict and understand system behavior to presumed input and operating conditions.

Gas turbines and compressors are designed to operate optimally and safely in a certain operational envelope defined by, for example, temperature, pressure, flow, etc. Many of these parameters are not readily, reliably or economically available. In the absence of real-time information about these parameters, the machines are normally operated conservatively. Using a site-specific model, the model-based controls can operate the machine close to the operational and safety boundaries, thus enhancing the efficiency and throughput of the system.

Site-specific models are also used to help reduce the downtime required for equipment maintenance. For example, a swirl chart display can help operators to identify high temperature spread in a combustion chamber in a gas turbine. In the past, technicians had to remove all of the cans and operators endured a lengthy outage.

Now with site-specific models and built-in process and operational knowledge of turbine speed and flow pattern, the algorithms can calculate accurate temperature profile at the exhaust plane, thus narrowing down the problematic can within one to two cans in the machine.

Operators interact with equipment and control systems through an HMI. Site customized models and diagnostics can be embedded in these HMIs that run like applications on a smartphone to test the health, temperature and output, among other metrics. A systems diagnostics package, for example, improves operator capability to more quickly and efficiently diagnose system issues. Some of its features could include a system reset function, which enables auxiliary systems that have gone offline to be reset separately from a complete turbine master reset. Similarly, an expanded alarm help function enhances troubleshooting information for an operator in an onscreen format.

While operators strive to maintain operations and avoid a trip, advanced controls and diagnostic algorithms and advanced control hardware platforms allow operators a wider range of functionality and control over gas turbine processes to ultimately keep the most critical assets in operation longer and safer.

Centrifugal and axial compressors can incorporate comprehensive and integrated software packages to improve upon anti-surge control and protection.

Strategic path

Gas turbine driven compressor control technology is essential in oil and gas operations. Today's oil and gas plant owners are faced with more unknowns and more opportunities than ever. While working under constrained budgets and facing an increasing safety and security risk, plant floor operators and industry executives must determine how advanced technology can improve daily performance and their competitive position in the market.

Martin concluded: "Identifying the most strategic path forward begins with life cycle management and ends with selecting the best technology to keep the organization running efficiently." ■

By David Flin

Keeping mature units competitive

EthosEnergy aims to increase the full life cycle value of its customers' assets, and has a class of units that should, by all rights, be at the end of their life. However, the company has been innovative in attempts to increase the life and the life cycle value with further development of the TG20 and TG50 turbines through improved cooling technologies and new materials.

The TG20 and TG50 date back to the 1970s, when they were designed and manufactured by Fiat TTG (later Fiat Avio, GTT, TurboCare, and now EthosEnergy), under the licence of Westinghouse, and then in cooperation with Westinghouse and Mitsubishi. The TG20 is the same frame design as the W251 and M251, while the TG50, the 50 Hz version of the W501, is also known as the W701D and M701D. EthosEnergy also has the capability to provide the same level of improvement and services to the W251 and W701 fleets.

As an example of the long-running nature of some of these machines, there are eight units among the fleet of TG50D5 gas turbines in the Middle East that were commissioned in 1994-1998. These units have in excess of 100 000 hours of operation, and are still operational. The units are running at an average site power of 100 MW with gas fuel, and a few thousand hours of operation with residual oil. The rotors have been recently overhauled by EthosEnergy, and have been reinstalled in the gas turbines to enable them to continue to produce energy for another 100 000 hours.

Turbine overview

The fleet of TG20 gas turbines operating in the Middle East commissioned in the 1980s has significant running experience on various fuels: #2 distillate fuel oil in Libya, crude oil in Saudi Arabia, and natural gas operation in Iraq. There are at least 20 gas turbines still running, which have accumulated over 100 000

TG50D5U assembled in factory. There are eight units among the fleet of TG50D5 gas turbines in the Middle East that were commissioned in 1994-1998. These units have in excess of 100 000 hours of operation, and are still operational.

TG50 rotor. The rotors of the Middle East units were recently overhauled by EthosEnergy, and have been reinstalled in the gas turbines to enable them to continue to produce energy for another 100 000 hours.

hours of operation each. Many of the units have been completely refurbished in recent years.

The TG20 gas turbine is a single-shaft, axial-flow heavy duty industrial gas turbine, with a cold-end power drive, in the 40-50 MW range. Designed in the 1970s, TG20 gas turbines have undergone continuous development from the original TG20A to the current TG20B7/8. Specific performance improvements include cooling system modifications, hot parts designs, compressor redesigns, and enhanced DLN combustion system and coatings.

New materials and cooling technologies allow the unit to operate with an increased firing temperature – up from the original 900°C (1652°F) to the present which is in the range of 1130°C (2066°F). Compared to the first design of the engine, power output has been increased by nearly 70 per cent, and heat rate has been reduced by 17 per cent.

The TG50 is a single-shaft unit operating at 3000 rpm, driving a two-pole generator. Thermal efficiency is now 35 per cent in simple-cycle use. This can be increased to around 50 per cent in combined cycle operation. The TG50 has an electronic control adjustment system to provide good automation, reliability and operational safety. Special attention has been paid to the design and development of cooling systems for the hot-section components during both transient conditions and normal operation. In addition, combustion system upgrades to Dry Low NOx (DLN) technologies are available to reduce pollutant emissions.

The first TG20s, called the TG20A, had a rating of around 27 MW, with an efficiency of about 27 per cent. The first TG50s, called the TG50B, had a rating of around 70 MW, with an efficiency of about 28 per cent.

Since the very start of design, the Centre for Engineering and Manufacturing of these specific EthosEnergy gas turbines has been at the 60 000 m^2 (645 834 ft^2) Torino factory in Italy.

Historically, all the gas turbine units of the frames manufactured in Torino were dedicated to the power generation market, either in open cycle, cogeneration or combined cycle. The TG20 is a geared unit suitable for both 50 Hz and 60 Hz operation, while the TG50 is an ungeared unit designed for the 50 Hz grid. The main geographical markets for the two frames have been the Middle East, South and Central America, and, within Europe, predominantly Italy.

Driving change

Over the years, many improvements have been made involving all the engine components. The compressor has been redesigned, delivering more mass flow, with consequent benefits in power output. New materials, new coating technologies, improved cooling, and improved sealing design enable the units to have higher firing temperatures, with a consequent improvement in both power and efficiency. These changes have resulted in a large increase in power output and efficiency.

Frank Avery, President of Power Plant Services for EthosEnergy, said: "Most customers evaluate gas turbine requirements on a life cycle basis. Our customers need to be able to maximise their investment in gas turbine technology by developing the longest possible economic benefit when compared against alternative or replacement investments."

Key factors that are often considered in this evaluation include: a reduction in \$/kW in installed costs, a reduction in operating and maintenance costs in \$/kWh, reduction in fuel consumption and increased power output, often coupled with a need for a reduction in NOx emissions as a result of the increase in environmental regulations in many countries. In addition, users also demand greater fuel flexibility along with simpler and faster maintenance.

"In short, customers need to generate greater value for the investment that they have made, to avoid the need to make large replacement investments. In this way their capital can be applied to other areas of their business allowing them to grow more effectively," said Avery

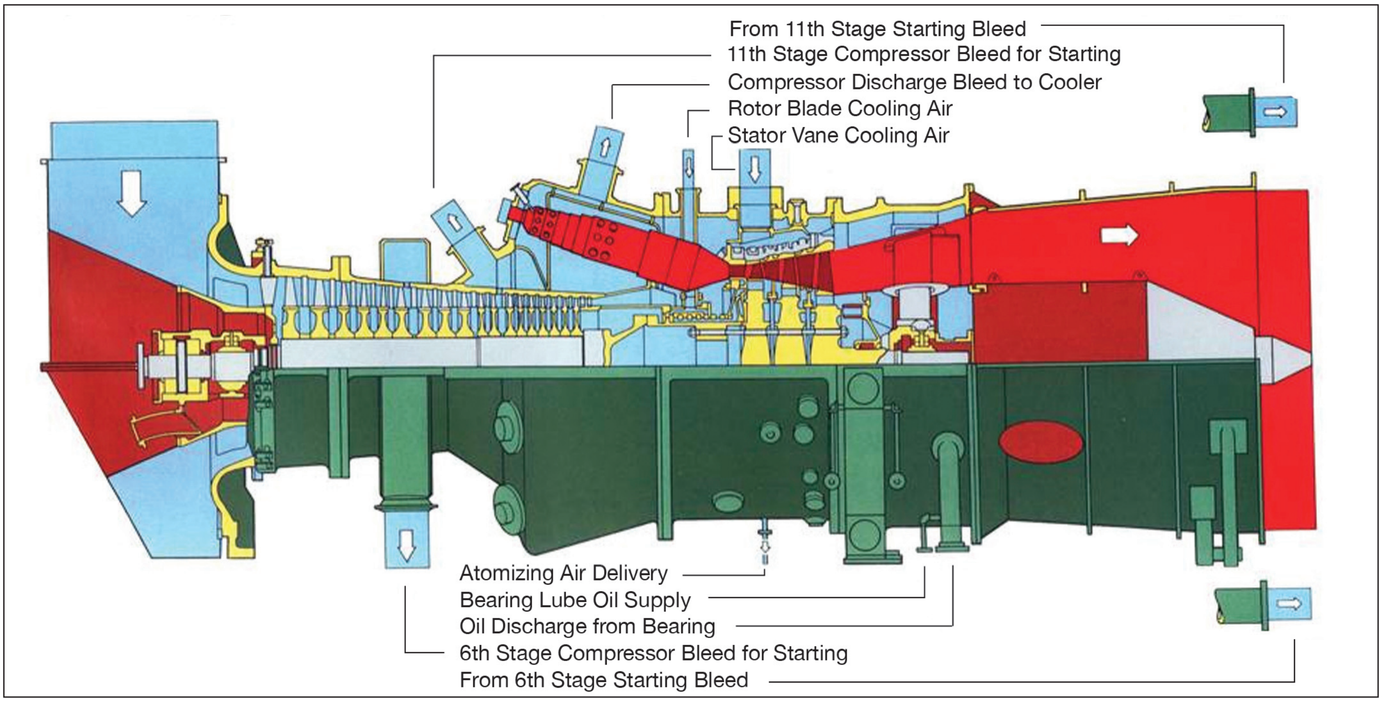
Manufacturers, therefore, tend to focus on improvements in specific areas. EthosEnergy explains that these units are very reliable and robust, leading to low maintenance costs and fewer and shorter outages. They also have good fuel flexibility, and low installation and maintenance costs.

The increasing demand for emission compliance has required the development of 25 ppm Dry Low NOx natural gas combustion systems, in addition to water/steam injection systems.

Historically, many TG20 customers are industrial users who have installed

Comparison of first and current turbines

	Power output	Efficiency	Firing temperature
TG20A (first version, early 1970s)	27.1 MW	27 %	900°C
TG20B78UG (latest version, 2015)	45.4 MW	31.5 %	1130°C
TG50B (first version, late 1970s)	70 MW	28 %	900°C
TG50D5U (latest version, 2015)	144.5 MW	35 %	1130°C



TG20 cross-section. The TG20 gas turbine is a single-shaft, axial-flow industrial gas turbine, with a cold-end power drive.

these units in their manufacturing, or oil and gas facilities. They often regard the power plant as a utility. As a result, they tend to demand high availability and reliability, ease of maintenance and fast support from the OEM, and these tend to be the strongest driving forces for improvements to this frame.

By contrast, many of the owners of the TG50 are national public power producers, who tend to demand higher outputs and upgraded packages in addition to availability, reliability and ease of maintenance.

Recent developments

The latest developments in the TG20 have been to enable an increase in the turbine inlet temperature in order keep the engine performance at the industry standard, while at the same time reducing the environmental footprint through an upgrade of the DLN combustion system, and reducing life cycle costs through improved availability resulting from an improved maintenance schedule.

The latest developments for the TG50 has been a further upgrade of the DLN combustion system to reduce NOx emissions and improve the reliability of the engine.

The TG20, being an early design, was conceived to operate without any particular attention to NOx emissions, and these units were originally equipped with standard diffusion flame combustion systems. As environmental regulations have tightened, users have become more concerned with exhaust pollutants and required the installation of NOx reduction systems. Water/steam injection were the first solutions employed and installed, operating at NOx limits of approximately 120 ppm at 15 per cent O_2.

Around 2004-2005, regulations started to be imposed, especially in Europe, to reduce NOx limits below 25 ppm, and DLN technology introduction was mandatory to achieve this. The TG20 DLN design was scaled from D/F class engine technology, and incorporates four combustion stages to control the premix fuel/air ratio through an accurate fuel and IGV schedule.

Torino nozzle manufacturing centre. Since the very start of design, the centre for engineering and manufacturing of these specific EthosEnergy gas turbines has been at the 60 000 m^2 Torino factory in Italy.

In the TG20 DLN design, there is no bypass air regulation through the transition pieces. The bypass valve on the transition piece is sometimes an unreliable device: the original TG50D5 DLN system was designed with only three combustion stages, gaining a fourth level of flexibility through the addition of a bypass valve, completely immersed in the combustor shell, on each of the 18 transition elbow pieces.

The operating experience of the fleet equipped with this combustion system configuration showed its weakness; the risk of failure of a mechanical device immersed in a hot environment such as the combustor shell due to oxidation phenomena is very high. Therefore, the latest developments introduced on the TG50D5 have been aimed at eliminating the bypass valve by introducing a fourth combustor stage, and moving the regulation from the air to the fuel side.

NOx and CO emissions were improved from 35 ppm to less than 25 ppm by changing the combustor basket geometry using different swirler angles, improved flow distribution in the

Torino blade coating center. To permit the hot parts to operate at even higher temperatures, ceramic coating was introduced on the first two rotating and stationary stages in both the TG50D5 and TG20B7/8 engines.

combustion chambers, and additional splash plates at the combustor exit. In addition, combustion dynamics have been kept under control through dedicated active control system modules. Flashback margin has been improved by increasing the flow velocity downstream of the premix section.

Improving performance

These developments have allowed these mature frames to remain competitive in their technology classes on the market, and remain up-to-date in regards to the market and emissions laws. The recent upgrades have been released to the existing fleet to allow owners to benefit from the improved capabilities developed for the new models.

Avery said: "The evolution of gas turbine performance has been driven primarily by increasing the gas temperature at the turbine inlet, and, as a consequence, the capability of the turbine materials to operate safely and reliably. The operating conditions (stress, temperature, and aggressive environment), the service demand (duty cycle and expected safe life), and the alloy characteristics, including aspects related to parts manufacturing, are the criteria used for alloy selection.

"In industrial gas turbine design, it is standard practice to adopt new material solutions based on well-consolidated experience. New solutions from the alloy suppliers are screened to select the material with the best potential to satisfy the gas turbine design goals. Extensive testing follows to ensure that the materials will perform satisfactorily in the specific application, with actual machine operating experience being the best and final test of the new material. The positive experience with new materials is then extended to other previously designed frames."

This procedure can be shown using the example of rotating blades. Initially, blades were wrought made, showing better mechanical characteristics with respect to the castings.

In the FIAT-Westinghouse-MHI family of engines, the multi-purpose Inconel X-750 was initially adopted, and later replaced by Udimet 520, a nickel-based alloy specially designed to forge the blades. Nickel-based super-alloys are used for the rotating parts that are most stressed by the applied loads, because of their capability to be strengthened by heat treatment.

Investment cast blades have been introduced since the mid-1960s, followed by adoption of hipping – the hot iso-static pressure process – useful for reducing internal porosity.

Udimet 500 and Inconel 713 were the first nickel-base cast alloys extensively used for years until the 1970s, when Inconel 738 (IN738) appeared in industrial applications on TG50D5 engines. Because of excellent operating experience, IN738 was then extended to F-class engine designs in the early 1990s to meet higher performance goals. Over 30 years of experience with IN738 became available from hundreds of units. The positive results suggested an extension of its application to units/parts of mature frames such as TG20 and W251.

To permit the hot parts to operate at even higher temperatures, the material change was followed by the introduction of ceramic coating on the first two rotating and stationary stages in both the TG50D5 and TG20B7/8 engines. The coating application process, consolidated on millions of new and repaired parts, includes a double layer (metallic and ceramic).

The metallic layer, applied through HVOF (high-velocity oxygen-fuel) or LPPS (low-pressure plasma spray) techniques, has the double function of working as an anchor for the ceramic and protection from hot corrosion phenomena. The ceramic layer, applied through the APS (air-plasma spray) process, works as a thermal barrier, lowering the base metal temperature. The coating process has undergone a long tuning and qualification process over the years, achieving very high quality and improving the bond strength level to above 10 000 psi for the metallic and 1500 psi for the ceramic layers.

When applying ceramic coatings, the cooling system plays a very important role: ceramic coatings have no effect on parts that are not internally cooled. On many older design turbines, such as the TG20, when a considerable turbine inlet temperature increase was desired, it was absolutely mandatory to redesign the cooling system and install Row 1 and 2 cooled blades and vanes.

This change required a complete redesign of the parts and of the internal and external cooling circuits, involving modifying the cooling flow distribution on the stationary vanes, changing the external calibrating features (orifices and/or valves), and adding cooling holes on the blades through stem drilling.

Modification of the cooling systems allowed the improvement of the thermodynamic cycle of the gas turbine by allowing an increase in gas inlet temperature, and it was also important to prevent turbine disc cracking. Keeping metal temperatures lower also extends the creep life of the turbine discs.

Future developments

One of the crucial fields of interest is in the area of OEM aftermarket service. Ever improved reliability, in terms of reductions in the number of outages, the length of outage, and the cost of repair, is a key factor in future demands, and hence in future developments. As a result, EthosEnergy is looking to focus on developing upgrades to deliver better, faster and value-added services.

In the near term, the company is focusing on reducing repair cost, monitoring and diagnostics, environmental compliance, exchange parts solutions for those items that can be repeatedly restored in order to reduce capital costs, and applying current technology to achieve material performance improvements. ■

Huinalá will showcase the benefits of gas engines

By Junior Isles

A combined cycle project being built near Monterrey, Mexico, will offer an interesting solution for a project that essentially straddles three countries.

Construction has started on a new gas engine-based combined cycle plant in northern Mexico. As a 'tri-national' project, it is somewhat unique – natural gas from the United States will be imported to the power plant near the city of Monterrey, and the electricity will be transmitted from Mexico to Guatemala.

When complete, the project will have a capacity of 139 MW generated by a Wärtsilä Flexicycle combined power plant, which has several features that are important to its owner. The plant offers:

- High availability and reliability
- Guaranteed heat rate at high ambient temperature
- Minimum of 120 MW of power all year round.

The reform of Mexico's energy laws is creating new opportunities for private investment. Following reforms signed into law in August last year, the government is predicting over $50 billion in new investments by 2018.

One piece of Mexico's energy reform is a new electricity law that will create a competitive power market managed by an independent system operator. Essentially it is designed to break up the electricity generation and distribution monopoly of Comisión Federal de Electricidad (CFE), and thereby reduce costs.

Natural gas is seen as the linchpin of the energy reform. The government wants to build more natural gas-fired plants, which will also help to reduce costs. Mexico says it expects to put out for bid $4.9 billion in electrical generation and natural gas pipeline projects as part of the opening of the energy sector. Some of the pipelines would be built in Texas, to take advantage of cheaper US gas.

This reform has paved way for independent power producer (IPP) projects that will help the Mexican energy sector to not only cover national demand, but also export electricity to its neighbouring countries.

This is exactly what IPP company Energía del Caribe, S.A. plans to do with the new power plant it is building in Huinalá in the state of Nuevo León, near the city of Monterrey.

Raúl Carral, Wärtsilä Business Development Manager, Mexico, Central America and the Spanish-speaking Caribbean, said: "This is a very innovative project in terms of the possibilities they looked at. Obviously they wanted to win the bid and thought that if they could get cheap gas from the US and then wheel the power to Guatemala, the cost of electricity could still be competitive.

"Compared to an inside-the-fence power plant, this is a complicated project in that it involves three countries. But it's a win, win, win situation," said

3D CAD drawing of Huinalá. The project will have an installed capacity of 139 MW generated by a Wärtsilä Flexicycle combined cycle power plant comprising seven gas engines and a single steam turbine.

Carral. “The US has so much shale gas and has to send it somewhere. This is one of the reasons for the rapid growth of new gas pipelines in Mexico. For Mexico, the project attracts investment in the country and creates jobs. And when you wheel the power, it creates revenue for the transmission network owner, CFE. For Guatemala, they get clean electricity from a clean source. Most of the thermal generation in Central Americas comes from heavy fuel oil (HFO). Gas is cleaner than HFO and cheaper. The cost of gas coming from Mexico will be around $3-4 per million Btu, whereas HFO would be about $7-9 per million Btu depending on the country. Even with the cost of transmission it is still interesting.”

Recip engines vs GTs

According to Wärtsilä, gas turbines are often used for such projects “almost by default” without considering many aspects that might affect the business case.

In addition to the performance, the location of the plant, the ambient conditions and how the plant will be run should all be considered when choosing the technology, says the company.

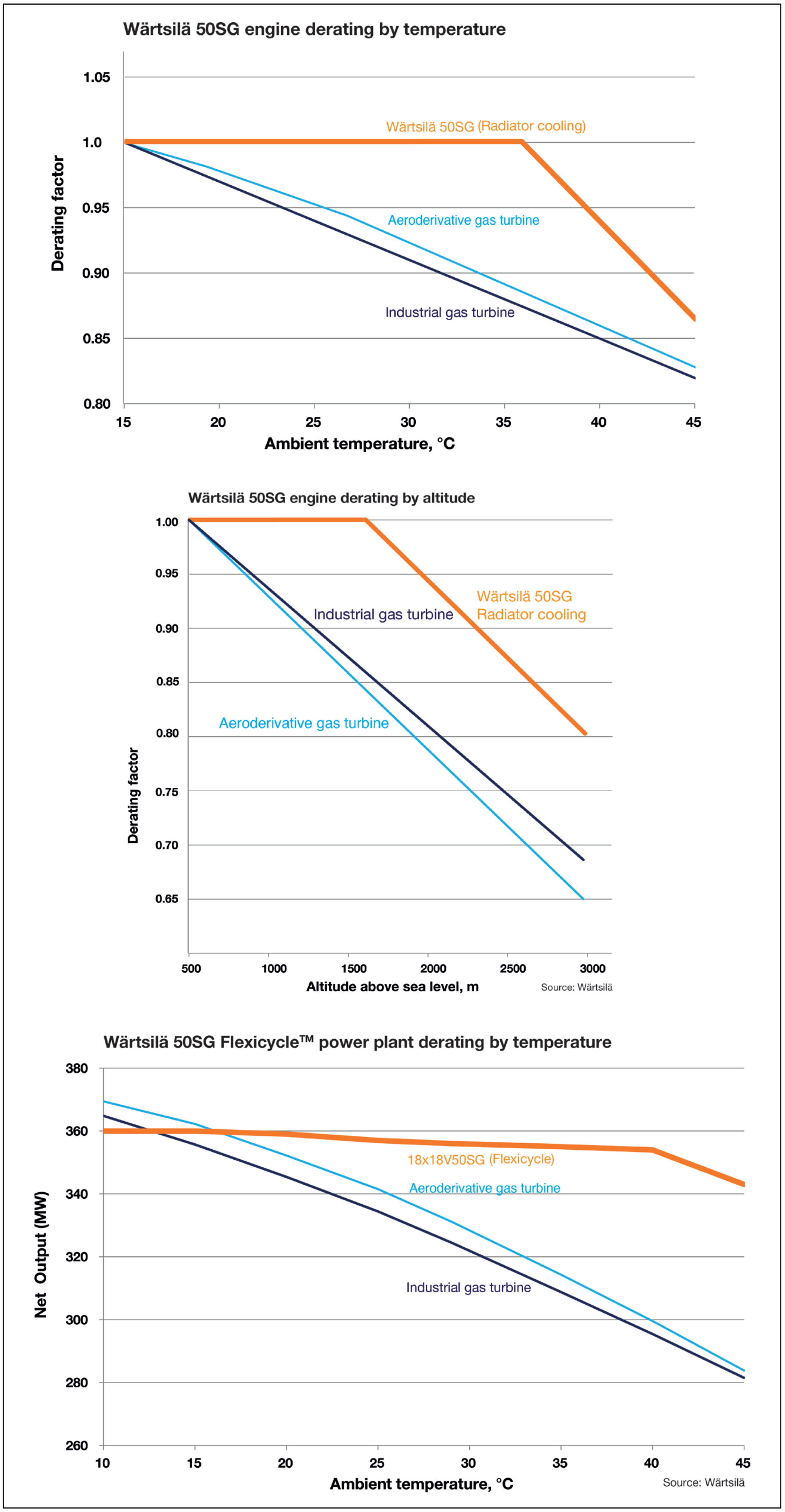
“If you look beyond the traditional solution when developing a new power plant there are lots of possibilities and a combined cycle using recips [reciprocating or internal combustion engines] is one of them,” said Carral.

Under the terms of the contract, the plant supplier had to deliver 120 MW of power and therefore had to guarantee a heat rate and price accordingly.

“It is important that the 120 MW of power is available continuously. So we looked at a configuration of ‘n+1’, with a combined cycle of reciprocating engines, which offers pretty good efficiency under various conditions,” said Carral.

This is particularly important at the site where average highs in ambient temperature range between 21°C and 36°C (70°F-97°F) all year round. The project is therefore designed to operate at an ambient temperature of 35°C – a level at which gas turbines derate significantly.

Mikko Piekkala, Project Manager Wärtsilä Energy Solutions added: “In Monterrey temperatures can get up to



Performance curves. Reciprocating engines show a smaller drop-off in efficiency at high ambient temperature and altitude compared to gas turbines.

Port Westward engine hall. In a similar arrangement, all seven engines at Huinalá will be in a single engine hall.

40°C in summer time, which affects turbines much more than engines. So with the engines they know they can achieve the guaranteed heat rate under any expected ambient conditions."

Under conditions where ambient temperature is not too high and where the plant is of a certain size, gas turbines are generally a more economic option. But the plant size and conditions at Huinalá called for a closer comparison of the two technologies.

"When we move higher in ambient temperature or altitude and start to consider flexibility, [reciprocating] engines can compete or be even better," said Piekkala. He points out that the altitude of about 400 m is another challenge to efficiency. "Engines show less derating at high altitudes than gas turbines."

Wärtsilä's gas engine option was compared with gas turbines in terms of performance, reliability and availability as well as capex and opex.

According to Carral, in terms of efficiency gas engine and gas turbine solutions are "comparable". He says the two are also comparable on capex and opex but engines can be even better on capex and also notes that water consumption is much lower. This can be an issue in many parts of the world, including Mexico, where water resources are scarce.

While performance, availability and cost were all overriding factors in the choice of technology, Wärtsilä says it was its "one-stop shop philosophy" – the ability to act as EPC contractor, and operate and maintain the plant – that helped it to secure the contract.

"They didn't want to split the deal among several players and found it attractive that we could provide the guarantees and execute the project in a short time," commented Piekkala.

Carral added: "We can do projects of this size very fast, which is another advantage."

Plant configuration

Plant efficiency and availability were of vital importance in meeting the contract terms for guaranteed power output.

At Huinalá, high efficiency will be achieved in a very flexible plant. The plant will consist of a single engine hall housing seven Wärtsilä 18V50SG gas engines, each with an associated heat recovery steam generator (HRSG).

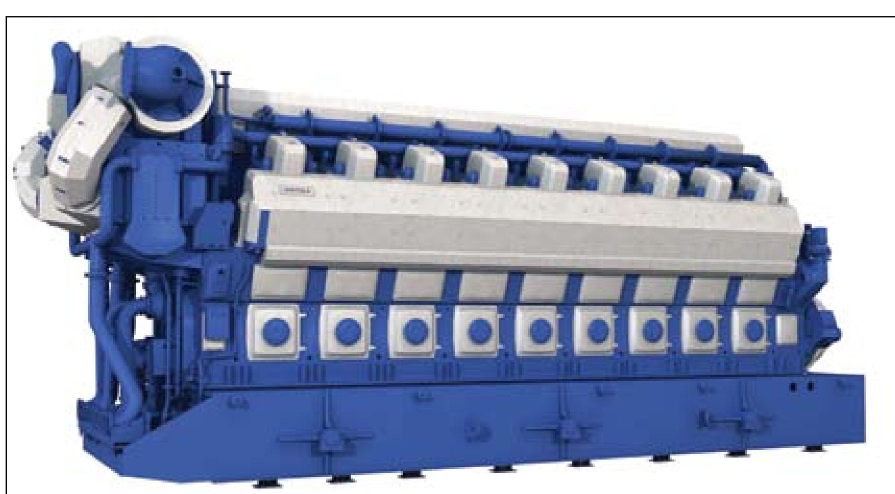
Although it will be a baseload plant, the engines are capable of very fast start-up – in of 5-10 minutes, so that 120 MW can be available in minutes. Start-up time for the total combined cycle plant is less than 60 minutes, or less than 45 minutes from a hot standby condition.

Wärtsilä points out that its Flexicycle plants can maintain maximum performance across a wide load range by shutting down individual engines as necessary. The multi-engine approach also helps maintain plant availability and reliability, ensuring power production at all times. The plant's modular arrangement allows one boiler or engine to be taken offline for maintenance without having to shut down the entire plant.

This arrangement also has benefits in terms of construction logistics, as boilers and engines can be transported as pre-assembled, tested units. This reduces work on site and consequently installation time.

When configured the boilers consist of three sections from exhaust inlet to exhaust outlet – superheater, evaporator, economizer – delivering superheated steam at a pressure of 345°C and temperature of 16 bar. The combined steam from the HRSGs is used to drive an 11 MW steam turbine supplied by Shin Nippon Machinery.

The 18V50SG engines already have



Wärtsilä 18V50SG. The engine has an output of about 19 MW and its efficiency is among the highest on the market for an engine of this size.

a fairly high simple cycle efficiency, 49 per cent at the generator under ISO conditions. Adding a bottoming steam cycle boosts plant efficiency by another 8-9 per cent. After own plant consumption and parasitic losses etc., the net plant efficiency of the combined cycle plant (LHV) is about 50%, taking into account the high temperatures and altitude.

Engine design

The efficiency of the 18V50SG is among the highest on the market for an engine of its size.

The 60 Hz version to be installed at Huinalá runs at 514 rpm to produce a maximum electrical power output of 18.76 MW.

The Wärtsilä 50SG is a four-stroke, spark-ignited gas engine with pre-chamber, (also known as SG technology) that works according to the Otto principle and the lean-burn process.

The pre-chamber is the ignition source for the main fuel charge and is one of the essential components of a lean-burn spark-ignited gas engine. It is designed as small as possible to deliver low NOx values, but big enough for rapid and reliable combustion.

The engines will be built in Italy. First they will be stripped down, removing the common base frame, the exhaust gas and charge air module from the top of the engine, and the turbocharger module from the front.

Under the contract (at 5% O_2), Wärtsilä guarantees a maximum NOx level of 375 ppm and CO level of 350 ppm. The CO level is achieved with the help of a device called an IOXI (or Oxi-Cat), which is a circular element installed directly on the exhaust gas duct after a flexible bellow and the exhaust gases react with the catalyst elements as they flow through it. In addition to CO emissions, its purpose is to reduce formaldehyde emissions.

The engines use a ported gas admission system whereby gas is admitted to the pre-chamber through a mechanical, hydraulic-driven valve. The gas admission valves are located immediately upstream and are electronically actuated and controlled to feed the correct amount of gas to each cylinder. Since the gas valve is timed independently of the inlet valve, the cylinder can be scavenged without risk of the gas escaping directly from the inlet to the exhaust.

Various parameters such as engine load, speed and cylinder exhaust temperatures are monitored and used as inputs to the Engine Control System (ECS). This solution has proved to be extremely reliable and results in an excellent mixture in the pre-chamber.

The Wärtsilä 50SG ignition system is closely integrated with the ECS. The ignition module communicates with the main control module, which determines the global ignition timing. The ignition module controls the cylinder-specific ignition timing based on the combustion quality. The cylinder-specific control ensures optimum combustion in every cylinder with respect to reliability and efficiency.

The ignition coil is located in the cylinder cover and is integrated in the spark plug extension. The coil-on-plug design minimises the number of joints between the spark plug and the ignition coil and thus increases reliability.

The spark plug has been specially developed for long lifetime and to withstand the high cylinder pressure and temperature related to the high engine output.

The engine has a bore size of 500 mm. The engine block is made from nodular cast iron. Optimum use is made of modern foundry technology to integrate most oil and water channels, resulting in a virtually pipe-free engine. It has an underslung crankshaft, which imparts high stiffness to the engine block and provides excellent conditions for maintenance. The engine block has large crankcase doors to enable easy maintenance.

The Wärtsilä 50SG is designed with a Wärtsilä open interface cooling system for optimal cooling and heat recovery. The system has four cooling circuits: the cylinder cooling circuit (jacket), the charge air low temperature (LTCA) and high temperature (HTCA) cooling circuits, and the circuit for the lube oil cooler (LO) built on the auxiliary module.

Quisqeya Flexicycle plant in the Dominican Republic. Such installations show the possibilities in the region with the availability of cheap gas.

The engine has an engine-driven oil pump and is provided with a wet sump oil system. Before entering the engine, the oil passes through a full-flow automatic filter unit and a safety filter for final protection. Lubricating oil is filtered through a full-flow paper cartridge filter. A separate centrifugal filter acts as an indicator of excessive dirt in the lubricating oil. A separate pre-lubricating system is used before the engine is started to avoid engine wear.

Pistons are of the low-friction, composite type with forged steel top and aluminium skirt. Long lifetime is ensured through the use of Wärtsilä's patented skirt-lubrication system, a piston crown cooled by "cocktail-shaker" cooling, induction hardened piston ring grooves and the low-friction piston ring.

The piston ring set features two compression rings and the oil control ring are located in the piston crown. This three-ring concept has proved its efficiency in all Wärtsilä engines. Most of the frictional loss in a reciprocating combustion engine originates from the piston rings. A three-ring pack is thus optimal with respect to both function and efficiency.

The engine uses four-screw cylinder head technology, well-suited to high cylinder pressure. In addition to easier maintenance and reliability, it provides the freedom to employ the most efficient air inlet and exhaust outlet channel port configuration.

A distributed water flow pattern is used for proper cooling of the exhaust valves, cylinder head flame plate and the pre-chamber. This minimises thermal stress and guarantees a sufficiently low exhaust valve temperature. Both inlet and exhaust valves are fitted with rotators for even thermal and mechanical loading.

The engine's connecting rod is designed for optimum bearing performance. It is a three-piece design, in which combustion forces are distributed over a maximum bearing area and relative movements between mating surfaces are minimised. The design also allows variation of the compression ratio to suit gases with different knocking resistance.

The three-piece design reduces the height required for piston overhauling. Piston overhaul is possible without touching the big-end bearing and the big-end bearing can be inspected without removing the piston. The big-end bearing housing is hydraulically tightened, resulting in a distortion-free bore for the corrosion-resistant precision bearing.

Crankshaft and bearings are designed so that the crank gear is able to operate reliably at high cylinder pressures. The crankshaft is therefore robust and the specific bearing loads maintained at acceptable levels.

The Wärtsilä 50SG is equipped with a single pipe exhaust turbocharging system designed for minimum flow losses on both the exhaust and air sides. The interface between the engine and turbocharger is streamlined to avoid all the adaptation pieces and piping.

The engines will be built in Italy and shipped to Corpus Christi, Texas, where they will be dismantled and transported roughly 500 km to site by train.

"There are some width, height and weight limitations for transporting by train," said Piekkala, "so they will be stripped down in Italy, where we remove the common base frame, the exhaust gas and charge air module from the top of the engine, and the turbocharger module from the front of the engine. The engines, along with these modules, are then shipped and transported by train and bolted back together at site."

Re-assembly is expected to take just a couple of days per engine.

Construction schedule

The Huinalá project is already under way. Wärtsilä received the Notice to Proceed (NTP) in February this year and construction started in early May, with site preparation and foundations.

The plan is for the first four engines to produce power by late April/early May next year and the remaining engines by around late May. The installation and commissioning of the combined cycle will then be undertaken so that the entire plant is handed over by the end of August 2016.

As an EPC turnkey project of the type that is fairly standard for Wärtsilä, no unusual challenges are anticipated during plant construction. However, the whole project is a venture between three countries, which could present different challenges.

Gas will come from an existing pipeline in Texas to Monterrey. Energía del Caribe will handle connecting the plant to the pipeline, as well as the grid connections for transmitting the power down to Guatemala.

Piekkala commented: "This all brings a level of complexity to the project and means we have to coordinate very closely with the customer. While it's quite a standard project for us, its nature makes it quite interesting."

When the project starts up next year, it will not only show the possibilities in the region with the availability of cheap gas but also that gas engines are a viable option under certain site conditions. ■