Gastech

The Official **2015 Conference Newspaper**

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DAY ONE

Tuesday, 27 October 2015

Welcoming the global gas industry to Asia's business epicentre

GAVIN SUTCLIFFE, Head of Conference & Governing Body, Gastech

Welcome to Gastech Singapore 2015! We are continuing the event's Asian roadshow following the huge success of Gastech Korea in 2014, and this year we will again reflect the dynamism and new business opportunities in the global gas and LNG supply chain.

Singapore, now celebrating 50 years as an independent nation, has proved one of Asia's (if not the world's) great commercial success stories. It is acknowledged as the hub of Southeast Asia and a centre of technical and commercial excellence in the fastest growing market for LNG. The World Bank has ranked the country at the top of its list for ease of doing business for the last nine years, and opportunities for new partnerships between international gas and LNG players are only just emerging.

Singapore's potential is vast, with many key emerging markets from Southeast Asia now seeking more natural gas and LNG infrastructure and capacity. As North Asia continues to dominate global gas and LNG demand, emerging domestic markets, including Indonesia, Malaysia, Vietnam, Thailand, the Philippines, Myanmar and—at the epicentre—Singapore, are creating new opportunities for those seeking to gain a market foothold.

Domestic gas and LNG fuel continue to offer more flexible, cost-effective and scalable solutions, underpinned with existing and emerging technologies. With its world-class financial and legal institutions, Singapore has the capacity and competency to generate major new business in gas and LNG, catalysing regional investors and stakeholders to drive the uptake in gas use across Southeast Asian domestic markets.

This year's conference agenda was again advised, and then meticulously shaped, by a Governing Body that welcomed an increasing number of key regional stakeholders. New faces and organisations representing Asia-Pacific include CNOOC, JERA (Chubu-TEPCO partnership), SINOPEC, Santos, Pavilion Energy, IE Singapore, Singapore LNG, Bank of Tokyo Mitsubishi, Badak LNG and the EMA.

With its capacity to generate major new business in gas and LNG, Singapore is a natural choice for this year's Gastech Conference.

The Gastech conference has never before been so widely endorsed by so many companies, reaffirming our robust approach to selecting and delivering the finest presentations, papers and speakers. Across four days of content, our conference commences with an afternoon of high-profile keynote and panel speakers before launching into 12 dedicated streams with careful consideration of Asia-Pacific stakeholder needs, but with critical appeal to our international community.

Fresh topics and themes reflect the continually-evolving industry, with sessions tailored to health, safety, security and environment; the future use for gas in the Asian fuel mix; emerging gas markets; and contracting, pricing and trading. Gastech also remains dedicated to delivering the strongest original presentations in shipping; gas as a transport fuel; innovative technologies; floating LNG and containment; and the global market outlook for gas.

Another innovative feature for Gastech Singapore is our Global Meetings Programme, which enables you to plan specific meetings with relevant delegates throughout the event. This is managed using our tailor-made approach and our team onsite, allowing you to maximise your time to drive new relationships.

On behalf of the organisers and our hardworking, dedicated Governing Body, enjoy the conference and make the most of the outstanding presentations, speakers and networking opportunities. ■

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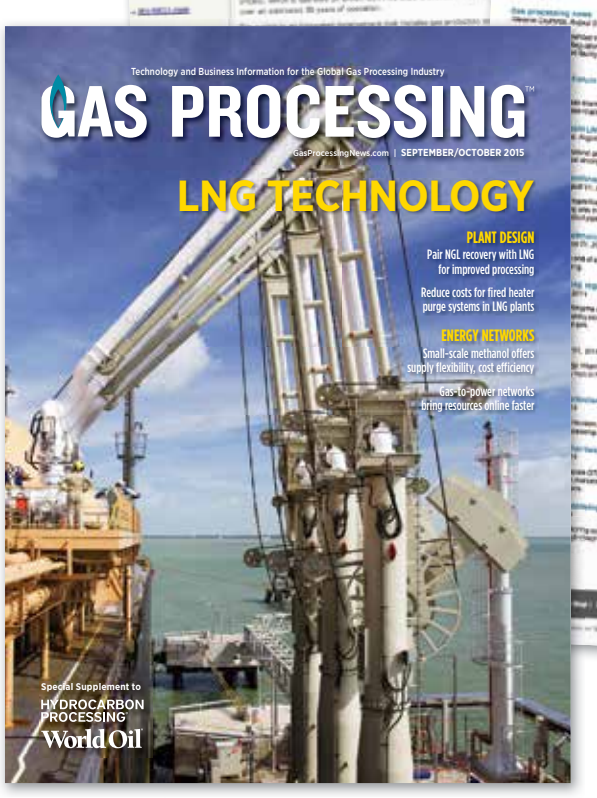


Conference Programme

TUESDAY, 27 OCTOBER

AFTERNOON

12:15–13:30 **Delegate Lunch**

13:50–14:00 **Organizer and Gastech Governing Body Chairmen's Welcome**
- **Chris Clucas,** Group Fleet Director, Bernhard Schulte Shipmanagement Ltd.
- **Paul Sullivan,** Senior Vice President—Global LNG and FLNG, WorleyParsons Group

14:00–14:15 **Government Host Welcome Address**
- **Teo Eng Cheong,** Chief Executive Officer, International Enterprise Singapore

14:15–14:40 **Host Keynote Address—Building a Sustainable Energy Business**
- **Helge Lund,** Chief Executive Officer, BG Group

14:45–15:00 **Singapore Keynote Address**
- **Seah Moon Ming,** Executive Director & Chief Executive Officer, Pavilion Energy Pte Ltd.

15:00–15:15 **Global NOC Keynote Address**
- **Alexander Medvedev,** Deputy Chairman of the Management Committee, Gazprom

15:15–15:45 **Networking Break**
Sponsored by Pavilion Energy

15:45–16:45 **Suppliers Panel Debate: "What will be the Impact of Lower Oil and LNG Prices on LNG Buyers and Sellers Over the Next 5 Years?"**
- (Moderator) **Joseph A. Bevash,** Partner—Tokyo, Hong Kong, Singapore, Latham & Watkin LLP
- **Pierre Breber,** Executive Vice President, Chevron
- **Hamad Mubarak Al-Muhannadi,** Chief Executive Officer, RasGas Co. Ltd.
- **Steve Hill,** Executive Vice President, Global Energy Marketing and Shipping, BG Group
- **Philip Olivier,** Chief Executive Officer, ENGIE GLOBAL LNG
- **William M. Walker,** Governor, The State of Alaska, US

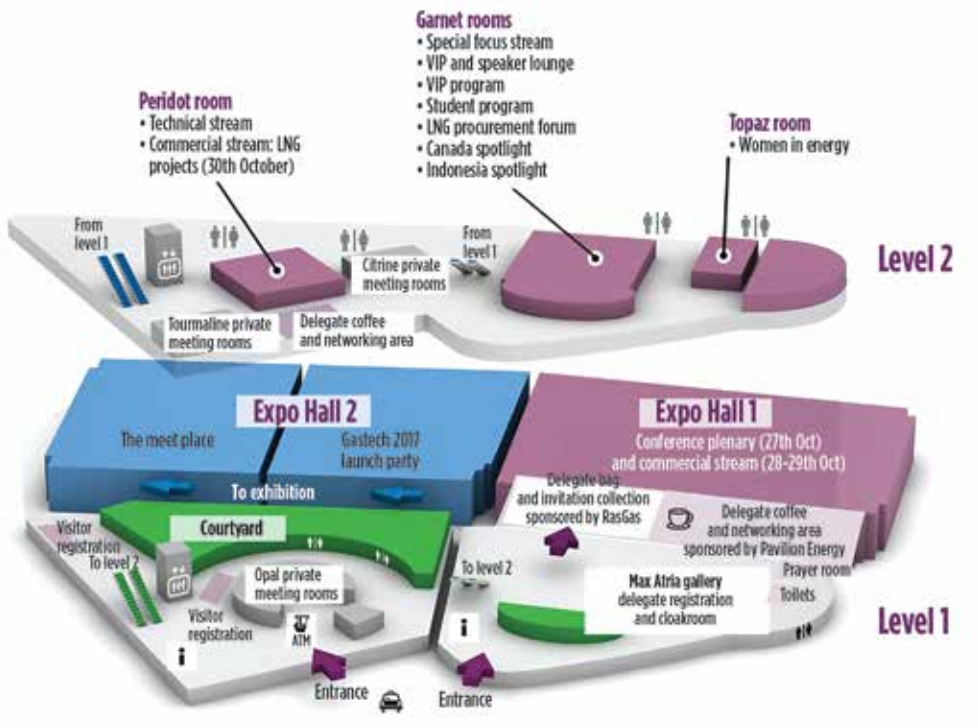
16:50–17:50 **Importers Panel Debate: "What will be the Impact of Lower Oil and LNG Prices on LNG Buyers and Sellers Over the Next 5 Years?"**
- (Moderator) **Ian Catterall,** Managing Director, Head of Natural Resources Project Finance, Bank of Tokyo-Mitsubishi UFJ Ltd.
- **Shigeru Muraki,** Executive Advisor, Tokyo Gas Co. Ltd.
- **Jong-Ho Lee,** Senior Executive Vice President, Korea Gas Corporation (KOGAS)
- **Hiroki Sato,** Vice President, Fuel Procurement Department, JERA Co. Inc.
- **Huang-Chang Lee,** Deputy Chief Executive Officer–Natural Gas Business, CPC Corporation Taiwan
- **Satpal P. Garg,** Director of Finance, ONGC Videsh Ltd.
- **Weiguo Shan,** Head of Gas Market Research, ETRI, China National Petroleum Corporation (CNPC)

18:30–21:00 **The Gastech Industry Party, Gardens by the Bay**
Hosted by Chevron

CONFERENCE AND EXHIBITION OPENING TIMES

	Conference	Exhibition
Tuesday 27 October 2015	14:00–17:50	10:00–18:00
Wednesday 28 October 2015	09:00–18:00	10:00–19:00
Thursday 29 October 2015	09:00–18:00	10:00–18:00
Friday 30 October 2015	09:00–13:00	10:00–16:00

Gastech Expo Map



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CoTEs showcases the latest developments and applications in gas technology

The Centres of Technical Excellence (CoTEs) programme is open to all Gastech Exhibition visitors. This popular seminar series—80 cutting-edge sessions conducted over four days by leading industry experts—delivers awareness of technological developments and applications in the gas and LNG industries.

Moving LNG bunkering beyond "chicken and egg" problem. A full day has been dedicated to the latest developments in LNG bunkering technology, which is becoming more relevant as industry shows its determination to overcome its "chicken and egg" problem. Carnival Corp. is the latest to support LNG bunkering by signing a multi-billion dollar contract to build four "next-generation" LNG-powered cruise ships with the world's largest guest capacities in the world. On the infrastructure side, South Korea has announced plans to construct LNG bunkering terminals at a number of its ports.

Gastech's CoTEs, in association with DNV GL, will welcome the Maritime and Port Authority of Singapore and top engine maker, Rolls-Royce, to specifically outline what is needed to realise LNG bunkering in Southeast Asia. These seminars will feature industry experts from Shell, TGE Marine Gas Engineering and FMC Technologies.

DNV GL to unveil latest FLNG technology. The company will also discuss how its latest technology will help overcome current challenges in unlocking previously inaccessible offshore gas fields as part of the Floating LNG stream. The new FLNG concept offers some 20% reduction in annual OPEX, adds only a small increase in CAPEX and increases overall safety.

Capitalising on potential of small- and mid-scale LNG. A full-day stream will highlight the potential and challenges of small- and mid-scale LNG in Southeast Asia. These projects are offering economical solutions to develop Asia's energy and maritime landscapes.

GTT, the leading expert in cargo containment systems, LNG carriers and land storage of LNG, will share its industry expertise. "We see good potential in this market because there is a real need for a supply chain adapted to smaller quantities, coastal transportation, river transportation, and the supply of LNG to islands in the Caribbean or in Southeast Asia," explains Philippe Berterottière, GTT Chairman and CEO.

Other presentations will include an array of LNG technology issues in process, design, infrastructure, power and LNG carrier technology. The programme will also address: Gas Processing, LNG as a Marine Fuel, Natural Gas Vehicles, LNG & Gas Carrier Shipbuilding, Offshore Technology, LNG Facilities & Infrastructure, Information & Communication Technology in Gas, and Pipeline Infrastructure.

The CoTEs seminars have been a regular draw at the Gastech Exhibition since 2011, and they provide technology firms, research institutes and other technical experts an interactive platform to showcase and discuss developments in gas technology. ■

CoTEs—TUESDAY 27 OCTOBER 2015

	GAS PROCESSING (Exhibition Theatre A)	LNG AS A MARINE FUEL (Exhibition Theatre B)	FLOATING LNG (Exhibition Theatre C)
Introduction 10:15–10:30	**Moderator Introductory Remarks** **John Sheffield,** Consultant Instructor, PetroSkills | John M. Campbell & Co.	**Moderator Introductory Remarks** **Leo Karistios,** Global Gas Technology Market Manager, Lloyd's Register	**Moderator Introductory Remarks** **Conn Fagan,** Vice President, Business Development, DNV GL Offshore Gas Projects
Session 1 10:30–10:55	**Why Do We Need to Have Gas Processing?** **John Sheffield,** Consultant Instructor, PetroSkills | John M. Campbell & Co.	**LNG as a Marine Fuel—Where Technology Meets Logistics** **James Forsdyke,** Asia Marine Sales and Marketing Manager, Lloyd's Register	**An Economic Shallow Water LNG Concept** **Augusto Bulte,** Project Development Manager, Amec Foster Wheeler
Session 2 11:00–11:25	**Sour Gas Treatment Technology Selection—Pushing Boundaries Using Novel Hybrid Processes** **Ankur Jariwala,** Senior Product Manager, Cameron Intl.	**Trends and Adoptive Concepts in Marine Maintenance** **Sören Karlsson,** Business Development Manager, Fuel Gas Handling, Wärtsilä Corp.	**Combining Shipping and Offshore Experience in an Innovative Terminal Design for Different LNG Applications** **Tore Røysheim,** CEO, GraviFloat AS
Session 3 11:30–11:55	**Combination Filtration For Removing Divalent Salts and Contaminants From Monoethylene Glycol (MEG) Reclamation Units** **Barry A. Perlmutter,** President & Managing Director, BHS-Sonthofen Inc.	**High Manganese Steel for LNG Storage Applications** **Kihwan Kim,** Senior Principal Researcher, POSCO	**Innovation: A Safer, Smarter, Greener FLNG for the Future** **Richard Whitehead,** Vice President, Global LNG Segment, DNV GL
Session 4 12:00–12:25	**Desulphurization of Lean Gas with Thiopaq O&G** **Colin Choong,** Licensing Technical Manager, Shell Global Solutions (Malaysia) Sdn. Bhd	**"LNG Ready" Solutions Using GTT Membrane Fuel Tank Solutions** **Arthur Barret,** Program Director LNG Bunkering, GTT	**Process Cycle Options for FLNG** **Annemarie Weist,** LNG Process Engineer Manager, Air Products
12:25–13:45	**Break**		
Moderator Recap 13:45–14:00	**Moderator Recap** **John Sheffield,** Consultant Instructor, PetroSkills | John M. Campbell & Co.	**Moderator Recap** **Leo Karistios,** Global Gas Technology Market Manager, Lloyd's Register	**Moderator Recap** **Conn Fagan,** Vice President, Business Development, DNV GL Offshore Gas Projects
Session 5 14:00–14:25	**Process Technology for Rich Natural Gas, NGL and Condensate Applications** **Zaheer Malik,** Manager of Process Technology, Global Midstream & Gas Processing, Wood Group Mustang	**LNG Bunkering Procedures—Process and the Human Element** **Douglas Raitt,** Regional Consultancy Manager, Lloyd's Register Asia	**Panel Discussion: Choosing a FLNG Pre-Treatment Technology** **Laurent Normand,** Business Development Manager, Prosernat; **Fedrik Vancraeynest,** Lead Process Engineer, Honeywell, UOP LLC; **Ralf Notz,** Senior Technology Manager—OASE Gas Treating Excellence, BASF SE
Session 6 14:30–14:55	**Commercializing SE Asia Sour Gas Resources** **Robert Denton,** Senior Process Consultant, ExxonMobil Upstream Research Co.	**A Scalable, Prismatic Pressure Vessel with Applications for the LNG Infrastructure** **Daejun Chang,** CEO, LATTICE Technology	
Session 7 15:00–15:25	**Pre-Engineered Modular Natural Gas Pretreatment** **William Shimer,** Strategic Marketing Director—Gas Processing and Hydrogen, Honeywell, UOP LLC	**Innovative Fuel Handling Technology for Medium Size LNG-Fuelled Merchant Vessels** **Mathias Jansson,** General Manager, Innovation & Product Support, Wärtsilä Marine Solutions	**Compact Equipment Technology Applications for Floating LNG** **Jason Manning,** Principal Process Engineer, Black & Veatch
Session 8 15:30–15:55	**1100 MMSCFD Single Train AGRU & TGTU for the Giant QatarGas LNG Plant: Optimized Design and Successful Operation** **Laurent Normand,** Business Development Manager, Prosernat	**Integrated LNG Propulsion Systems for Efficiency: Case Studies Analysis** **Oscar Kallerdahl,** Sales Manager—LNG Systems, Rolls-Royce	**How to Select the Optimum Liquefaction Technology for FLNG Projects** **Francesco Criminisi,** FLNG & FPSO Proposal Manager, SBM Offshore
Closing Remarks 15:55–16:00	**Moderator Closing Remarks** **John Sheffield,** Consultant Instructor, PetroSkills | John M. Campbell & Co.	**Moderator Closing Remarks** **Leo Karistios,** Global Gas Technology Market Manager, Lloyd's Register	**Moderator Closing Remarks** **Conn Fagan,** Vice President, Business Development, DNV GL Offshore Gas Projects
16:00–18:00	**Prosernat Special Workshop**		

Triple offset valves in molecular sieve processes

SERGIO CASAROLI and **MARCO FERRARA,** Pentair Valves & Controls

The oil and gas industry often uses molecular sieves to dehydrate or separate contaminants from natural gas. Such a process involves several operational challenges that put valves under severe strain, potentially causing damage and service disruptions. Triple offset valves (TOVs) represent an innovative solution for molecular sieving due to their design and ability to handle extreme conditions. Using TOVs minimizes the need for, and cost of, maintenance, while offering significant footprint reduction compared to conventional ball valves.

Natural gas molecular sieving processes. A large number of dehydration and purification processes in the oil and gas industry rely on the adsorption principles of solid bed molecular sieves. Made from a micro-porous material, their ability to selectively adsorb gases and liquids makes them widely used across various applications. Smaller diameter fluid molecules separate from the main feedstock via electrostatic attraction or micro-porosity adsorption and remain trapped inside the adsorbent structure.

After use, molecular sieves are regenerated with temperature swings and regenerating gases, which allow full recovery of the trapped molecules while restoring the sieve adsorption capacity. Adsorption dryers are typically equipped with two to four molecular sieve beds, each dedicated to the adsorption of a single molecular type (water, CO_2, mercury, lead, etc.). Water adsorption is a common application in natural gas treatment plants, refineries and petrochemical complexes. It utilizes hard, granular adsorbents manufactured in several types of materials, including aluminosilicates, such as Zeolite, ceramic materials, activated carbon and silica gels. They usually have a spherical or cylindrical shape and their internal pores allow access to free volumes within their microcrystalline structure (**FIG. 1**).

FIG. 1. Internal pores allow access to free volumes within their microcrystalline structure.

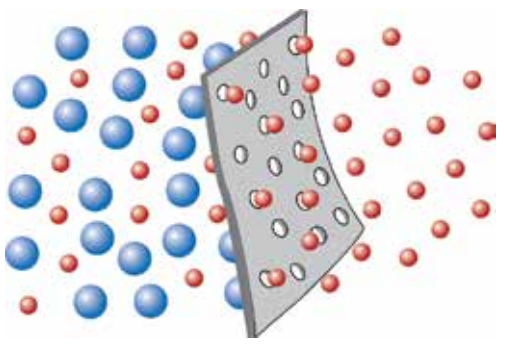

FIG. 2. Membrane molecular sieve. Regeneration processes are undertaken via temperature swings achieved by gas flushed in the opposite direction.

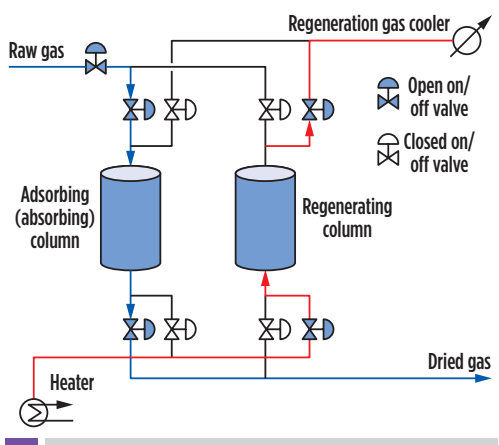

FIG. 3. Molecular sieve process schematics. High-frequency open/close cycles and frequent thermal cycles are two challenges faced during molecular sieve processes.

Conversely, carbon dioxide (CO_2) removal from natural gas (typically not pre-treated) is a process often handled by using thin membranes to perform a solution-diffusion separation (absorption principle). These membranes, typically made with polymers in spiral shapes, allow fluids to dissolve over their surface and diffuse through their structure, leaving molecules with specific permeation rates trapped inside. With natural gas, the feed gas is separated into a methane (CH_4)-rich stream on the exterior of the membrane and a CO_2-rich stream on its interior. Pressure is the force driving the membrane diffusion, while regeneration processes are undertaken via temperature swings achieved by gas flushed in the opposite direction, seen in **FIG. 2.**

Solid bed and membrane molecular sieve processes are extremely challenging for valve equipment. Both processes use valves to perform frequent ON-OFF functions to switch one or more vessels from gas purification to regeneration modes. Operating failure can lead to significant plant downtime, product loss, potential environmental pollution and other safety issues.

Critical issues with existing valve solutions. Gas purification valves currently face a number of challenges during both molecular sieve processes (**FIG. 3**):

- High frequency open/close cycles—typically one every four hours, with a maximum of eight each day
- Frequent thermal cycles—during regeneration mode, the molecular sieve is flushed with hot gas, typically at 350°C. During purification mode, it is brought down to ambient temperature.

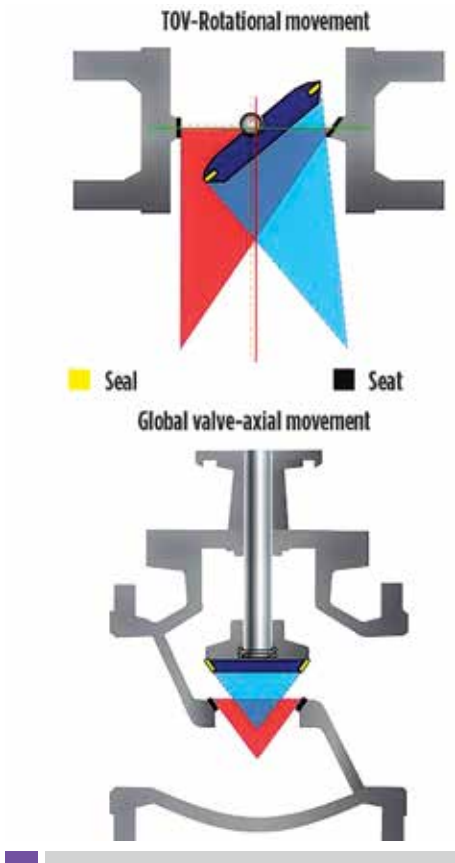

FIG. 4. Triple offset valve vs. glove valve seating mechanism comparison.

Gas purification residuals (crushed adsorbents) are often present in outlet gases and can pass through screens and flow through the valves towards downstream lines, causing abrasion of sealing components and jeopardizing valve integrity. Conversely, whenever membranes are used for CO_2 removal without pre-treatment, corrosive gases (sour/acid) are present, especially in offshore installations.

Historically, non-rubbing rising stem (tilting) ball valves have been the standard used in natural gas molecular sieves. The basic design of a ball valve—a ball rotating on soft sealing surfaces with systematic rubbing—is enhanced by introducing an additional mechanical device that allows for a tilt/turn operation and a mechanical camming action of seating surfaces nearing closure. So far, this been the most effective response from the industry to tackle the issue related to cycle-intensive applications, such as frequent switching, which would otherwise require recurrent valve maintenance or replacement.

However, rising stem ball valves of larger sizes and pressure classes are extremely heavy and have a large footprint, generating a number of direct (material use) and indirect (installation) costs that engineers must account for during front-end engineering design (FEED) project phases. The tilting mechanism itself, a variant on a standard quarter-turn ball valve, is subject to wear and can degenerate over time. Although the valve sealing elements may not involve rubbing capabilities, friction is transferred to both the shaft cam (towards core pins) and the S-shaped pin slot. This valve design requires specialized maintenance, including the use of costly spare parts, significant time and effort.

Long-term reliability of non-rubbing, metal-to-metal TOVs. Process designers and plant operators looking for a reliable and cost-effective option should consider using a different type of valve in molecular sieve applications, such as TOVs. They share the same cone-to-cone principle as globe valves (**FIG. 4**), with one key difference: sealing is performed by applying a quarter-turn rotation.

Three offsets against the symmetrical axes of the pipe/valve eliminate any possibility of rubbing:

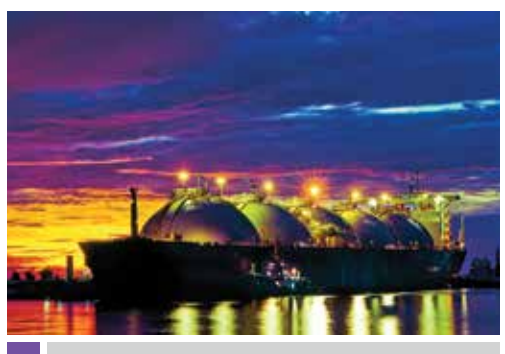

FIG. 5. A MOSS-type LNG tanker at berth.

1. The shaft is placed behind the plane of the sealing surface to ensure a continuous seat path.
2. The shaft is placed to one side of the pipe/valve centerline to allow the displacement of the seal from the seat during the 90° opening.
3. The seat and seal cone centerlines are inclined with respect to the pipe/valve centerline. This third offset completely eliminates rubbing.

Pentair Valves & Controls' Vanessa TOV design with a flexible metal seal ring represents an innovative solution to withstand high-frequency open/close cycles. Due to the non-rubbing design, wear between sealing components is completely eliminated. The whole trim, including bearings and thrust bearing, is designed for heavy-duty services. To protect equipment from frequent thermal and pressure cycles, Vanessa TOVs' metal-to-metal sealing, a resilient seal ring and torque seating compensate different thermal expansion rates between trim and body, while ensuring outstanding tightness and removing the risk of valve jamming. Vanessa Series 30,000 TOVs feature Stellite 21 seat overlays, which offer high resistance to wear generated by the fluid (which may include particulates released from the sieve vessel). The valves also include an easily replaceable one-piece metal solid seal ring, proven across several molecular sieve processes.

The material selection of each component offers the best compromise among necessary mechanical properties, corrosion resistance and equivalent expansion coefficient, making Vanessa TOVs suitable across a wide range of corrosive gases. The cost-effective solution enables the use of a carbon steel body in a corrosive environment by protecting all surfaces in contact with the fluid with corrosion resistant alloy (CRA)-quality weld overlay.

An ongoing trend: replacing rising stem ball valves with TOVs. Rising stem ball valves can be safely substituted by TOVs. Footprint and weight savings can be achieved, especially on larger diameters (> 6 in.) and pressure classes (ASME class 300 and 600), due to lower material use and a more compact body. Vanessa Series 30,000 TOVs require minimum maintenance, which can be easily performed onsite, and their non-rubbing rotation and full metal construction significantly extend the valve life.

Pentair's first experience in molecular sieve applications dates back to 1999, when the company provided its Vanessa Series 30,000 TOVs to a major end user of offshore operations in Malaysia. Some of the valves replaced rising stem ball valves for a CO_2 membrane system that featured a two to four-hour open/close cycle; those valves are still in operation. Hundreds of rising stem ball valves have also been replaced in gas plants in Mexico in solid bed molecular sieve applications, and there are many more cases of TOV valve evaluation and adoption in response to the recommendations by major molecular sieve process licensors. ■

Visit booth #D450 to experience Pentair Valves & Controls' capabilities, products and latest innovations for the natural gas and LNG industries.

Dresser-Rand eliminates high vibration levels in gas compressor

A charge gas compressor train at an ethylene plant was exhibiting high vibration levels in the low-pressure casing before crossing first critical speed. These vibration levels prevented the train from reaching its design operating speed of 5,800 rpm. With only a 45-day window to identify the cause of the vibration and fix it, Petroquimica Mexicana de Vinilo (PMV) asked Dresser-Rand engineers to have a look.

PMV, a flagship joint venture (JV) between Pemex and Mexican petrochemical firm, Mexichem, represents the first JV between Pemex and a private company. The merger joined Mexichem's salt, chlorine and caustic soda operations with Pemex's ethylene and vinyl chloride monomer (VCM) operations.

PMV revamped an old Pemex plant in the Pajaritos petrochemical complex to produce an expected 120 tons of VCM, the key material used to manufacture polyvinyl chloride (PVC), commonly used for electrical insulation, films and pipes.

"Initially, PMV representatives asked us to perform a vibration analysis on the compressor train—consisting of a 3 MX compressor, a 3M compressor and a 4M compressor—to determine possible causes," said Francisco Moncayo, Dresser-Rand Services director for Mexico. "The fact that there was no historical data on maintenance or vibration levels compounded the problem because, in the past, Pemex had sourced third-party, non-Dresser-Rand parts and service."

Vibrations affected operations, production and revenue. At the outset, the compressor (**FIG. 1**) was operating at 5,150 rpm. However, increasing the speed to 5,220 rpm significantly increased vibration levels, causing the protection systems to trip the compressor train and shut it down. Data analysis during the machine trip showed high vibration (6.85 mils peak-to-peak) at the 5,220 rpm level, so the machine could not operate at speeds above 5,150 rpm. Such interruptions affected plant operation and resulted in lost production and revenue.

Internal friction in the low-pressure casing, lack of rigidity in the system, train misalignment and process piping were found to be the main causes for vibration. Dresser-Rand engineers also found corrosion in the compressor casing and in the suction and discharge flanges, a 0.5-in crack on one of the shaft journals, impeller pitting, and coupling gear teeth and spacer flange pitting. Several of the components (installed over the years by third-party parts manufacturers) were found unsuitable and not within Dresser-Rand original equipment manufacturer (OEM) dimensions.

PMV accepted Dresser-Rand's proposed solutions to repair the train that included shutting down the train to inspect and repair internal compressor components; measuring bearing clearances and compressor shaft run-out; inspecting labyrinth seals; aligning the compressor and turbine, and aligning the suction and discharge piping to the compressor flanges; and stiffening the compressor supports and discharge lines. Upon inspecting the proximity vibrations system and bearing clearances on the 3M compressor, Dresser-Rand recommended replacing it and supplied its OEM parts for the overhaul, capital spare parts and 3MX shafts.

When completed, Dresser-Rand finished the agreed-upon scope, aligned the train, commissioned it and started it within the 45-day deadline. The Houston, Texas service center was able to accommodate other major repairs to the 3M and 3MX rotors in a short time period to avoid longer delays to the shutdown.

"Meeting the project's extraordinary time constraints was a result of many different functions working together within Dresser-Rand, including our services team in Mexico (sales, proposals, field services, reliability and predictive maintenance teams); the Houston service center; Dresser-Rand turbine technology services in Olean, New York; the operations upgrades and parts team; and our technical support team in Venezuela," Moncayo said, adding that the vibrations on the compressor train are now well below 1 mil. ■

FIG. 1. The failure to operate at speeds above 5,150 rpm affected plant operation and resulted in lost production and revenue.

Pipeline operator upgrades control for critical compressor operations

Electricity and natural-gas delivery company CenterPoint Energy—Mississippi River Transmission LLC (CNP-MRT) owns and operates 8,200 mi of US transmission pipeline that carries an average of 1.6 Tcfy of gas throughout a nine-state, mid-continent region.

Competing for utility customers against other transmission companies and alternate forms of energy requires CNP-MRT to leverage technology that minimizes operating, maintenance and downtime costs. Transmission profitability is further complicated because the throughput-dependent segment must also accommodate variables such as demand-reducing mild weather, fluctuating gas prices and regulatory-compliance overhead.

Efficiently, reliably and intelligently controlling, automating and monitoring the performance of reciprocating engine compressors represents one of the most significant challenges in moving the highest quantity of natural gas at the lowest cost. The school bus-sized engines (**FIG. 1**) maintain a pressurized flow (up to 1,500 psi) to reduce gas volume up to 600 times and propel it through a pipeline.

Control and automation opportunities to reduce infrastructure maintenance costs, minimize downtime and leverage real-time diagnostics are significant. The potential capital investment and resource allocation attached to deploying upgraded control technology across almost 70 transmission-line compressor units are also vital.

Upgrading pipeline compression station control systems.

Each compression station, located at 40 mi to 100-mi intervals along a pipeline route, utilizes two to 10 compressors in the 2,000-hp (1.5-MW) range. The aging systems typically found in the energy-delivery space were built to last: even equipment that went online in the 1960s can have another 20 years of life. However, the decades-old machines are not as efficient as current technologies.

Upgrading control systems across the sizeable Midwest compressor fleet represents an enormous capital undertaking, particularly under a traditional outsourcing model that contracts control design and implementation to multiple engineering firms and system integrators. Over time, that approach created a mix of control products and solutions at CNP-MRT, often based on black-box proprietary logic.

The CNP-MRT control and automation group saw the company's Horseshoe Lake compressor station as a test case for designing and deploying an internally executed station upgrade. The company inherited Horseshoe Lake from another entity that specified and built the facility before turning it over to CNP-MRT to operate. The seven-year-old station was relatively new, but at the time of construction the original, economically minded systems integrator opted for proprietary architecture and PLCs already nearing the end of their lifespan.

"Relative to the potential of today's open architecture, the result was an antiquated control system," says Steve Starkey, the CNP-MRT instrumentation and electronics specialist overseeing the company's Northern pipelines. "In addition, CNP-MRT uses Rockwell Automation exclusively and does not support the platform that was in use at that facility. So, we could not work on the control system ourselves without investing a significant amount of time and money in training."

Simply adding another step in an engine startup sequence, for example, required a control vendor to reprogram it at an additional cost for each improvement. Troubleshooting a problem or obstacle, particularly in the middle of the night or on a weekend, opens compressor operations to downtime risk. Finally, CNP-MRT needed significant improvement in the information solution, from data access, collection and sharing, to real-time remote monitoring and alarming. An engine that fails means that the energy company loses revenue. With contracts based on high standards for delivery reliability, including fines for not moving gas as promised, a lack of data-driven visibility prevents being proactive on maintenance, reacting quickly with adjustments, and efficiently expanding or scaling up.

Designing a standard upgrade solution.

CNP-MRT used the Horseshoe Lake station to create and prove a potential model to cost-efficiently develop, manage and implement a major control upgrade (**FIG. 2**). Partnering with oil and gas specialists from the global solutions team at Rockwell Automation, CNP-MRT set out to design a solution that was specific to Horseshoe Lake, but that could also serve as the standard for upgrading the rest of its Midwest region's compressor fleet.

CNP-MRT selected Rockwell Automation's PlantPAx process automation system to integrate control and information. The system provides vastly improved asset visibility and production information that gives station operators the data necessary to respond faster on maintenance, operation and flow-control issues.

"The trend in compressor operations is collecting, integrating and using higher amounts of data," Starkey says. "We are trying to optimize every operational aspect, in real-time, that contributes to improved uptime, efficiency and profitability, including monitoring for unit performance, emissions and even the safety of engines that pump gas and run on gas."

The Horseshoe Lake upgrade enables station operators to more easily manage speed and load control. The control system also determines which compressor units should start based on engine hours and the number of engines the system controls.

The visualization capabilities within the PlantPAx system provide a window on compression by incorporating performance metrics and the situational display of production information at engine, station and pipeline system levels. Accurate reporting of real-time engine events, along with analysis tools and management dashboards, deliver contextual, localized, role-based information for better decision making.

Categorizing the results.

CNP-MRT has summarized the upgrade returns in four key areas.

1. Cost of ownership—Design through installation and delivery of the new system at Horseshoe Lake came in well below previous systems. Based on experience with previous systems, Mr. Starkey estimates the capital investment at approximately 20% of the total for control projects equal in scale.
2. Simplified HMI configuration—Eliminating the need to learn every HMI application from scratch cuts training time considerably. With a baseline to work from, even if a station is different, the in-house control group can make modifications to fit nearly every type of engine, significantly reducing integration time.
3. Reduced downtime—The PlantPAx system has reduced station downtime and the capital outlay for repairs. Previously, there were no alarms other than shutdown. With alarms now programmed to catch engine issues before failure, operators initiate repairs ahead of engine failure. By watching the data remotely, staff can make an engine the least available until they resolve an issue.
4. Improved operability—The Horseshoe Lake experience indicates that operators who are responsible for their respective stations can be confident in most anything they will be asked to do. "Previously, there were too many instances where operators did not have control or the necessary insight," Mr. Starkey says. "The approach is different now. It is the operator's control system."

The PlantPAx solution is the consensus control and automation model for the entire compressor fleet. From the faceplates to the look and feel of how the control system operates, the design and implementation is the CNP-MRT standard for upgrading other compressor stations in the future. "The PlantPAx system has outperformed on every metric, from reliability to scalability and integration of most anything we can think of," Mr. Starkey says. The results mentioned here are specific to CenterPoint Energy-Mississippi River Transmission LLC's use of Rockwell Automation products and services in conjunction with other products. Specific results may vary. ■

FIG. 1. Each compression station, located at 40-mi to 100-mi intervals along the pipeline route, utilizes two to 10 compressors in the 2,000-hp (1.5-MW) range.

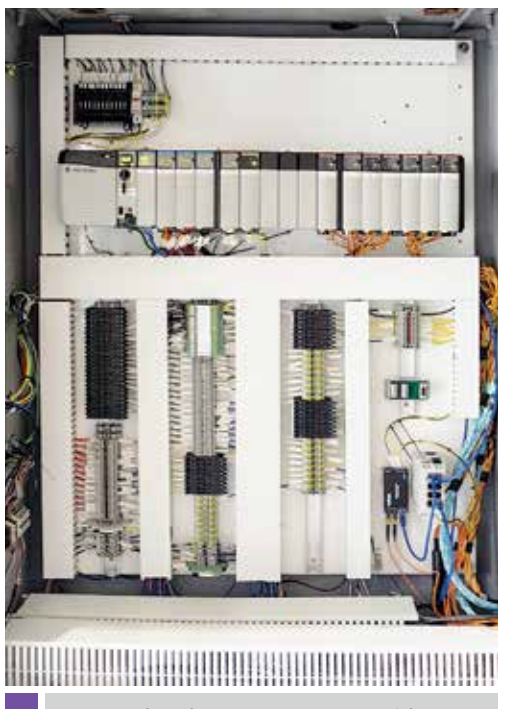

FIG. 2. The PlantPAx system provides a window on compression by incorporating performance metrics and the situational display of production information at engine, station and pipeline system levels.

For more information on the company's latest extraction, production, processing, regasification, transmission, distribution, power generation and information technologies, visit D210 to meet the Rockwell Automation Southeast Asia team.

Production underway at Air Products' new manufacturing facility

The production of LNG entails the cooling of natural gas from ambient temperatures to –160°C. This is accomplished in specially designed heat exchange equipment, which is the heart of the LNG facility. Much of the worldwide LNG production incorporates proprietary natural gas liquefaction process technology and large coil-wound heat exchangers manufactured by Air Products.

To meet customer demand for LNG technology, Air Products recently began production of its LNG heat exchangers (**FIG. 1**) at a second manufacturing facility in Port Manatee, Florida, in the US. The new facility supplements existing production at Air Products' facility in Wilkes-Barre, Pennsylvania, where the company has designed, manufactured and exported more than 100 coil-wound heat exchangers for LNG projects in 15 countries over the past 45 years.

At Port Manatee, the company will be able to supply the additional capacity required to meet market demand, as well as manufacture the even larger LNG heat exchangers that are being demanded by the market.

A typical Air Products LNG heat exchanger can be as large as 5 m in diameter, 55 m long, and weigh as much as 500 tons. Air Products' heat exchangers fabricated at the Wilkes-Barre facility are typically transported by rail to the company's manufacturing annex at the Port of Bucks County in Pennsylvania, where final fitting and assembly work are performed. The heat exchangers are then loaded aboard ships and transported.

Expanded seaport access and streamlined delivery. One key advantage to the new LNG equipment production facility in Port Manatee is ready access to port services, which will facilitate global shipping of the extremely large equipment. When production of one of the units is complete, it will head straight out of the finishing building and travel approximately 1 km along surface roads to the deepwater Port of Manatee, where it will be loaded onto a ship for delivery. There are currently multiple large coil-wound heat exchangers in various stages of manufacture at the Port Manatee facility, with the first expected to be completed and ready to ship by autumn of 2016.

FIG. 2 shows the 30,000-m^2 facility, which is built on 13 hectares (32 acres) of land and will employ a workforce of approximately 250 when at full production. The Port Manatee facility consists of five buildings, including one administration and four manufacturing, each designed for a specific step in the heat exchanger production process—fabrication, winding, assembly and finishing. The qualified workforce consists of craftsmen, including a team of skilled welders and fitters, and manufacturing support personnel.

Air Products has been involved in the LNG market since its beginning, providing highly efficient, cost-effective process cycles and main cryogenic heat exchange equipment. It provides technology solutions to meet a wide range of requirements, whether for an onshore or offshore plant, a small plant or mega train, and for all locations and environments. ■

Air Products LNG experts will be available for discussions at booth D40 throughout the conference.

FIG. 1. A large coil-wound heat exchanger in production at Air Products' new manufacturing facility.

FIG. 2. The 32-acre Port Manatee, Florida facility will allow expanded production and easier access to a deepwater seaport for transportation to global customers.

Updated practice for LNG bunkering facilities metering

MARTIN LAYFIELD, DNV GL

As the international market for small-scale LNG and bunkering expands globally, the need for safety and enhanced commercial practices are increasingly important and are being addressed by DNV GL through an updated recommended practice (RP).

LNG has proven to be a viable option as a bunkering fuel for ships, and its use is set to soar over the next decade. LNG bunkering is currently available as a bunker fuel for maritime and inland shipping at a number of ports across Europe, the US and especially in Southeast Asia, and infrastructure development is being planned in several ports globally.

LNG is odorless, colorless, non-toxic and non-corrosive. Its atmospheric boiling point is –163°C, hence its cryogenic properties. Management of the risks associated with LNG continues to be developed, especially as the fuel supply is not yet widely carried out on a routine basis. Key differences to traditional marine fuels include the low flashpoint and cryogenic temperature.

As energy demand grows and the industry looks to monetize the use of gas globally, another aspect that requires attention is the fact that LNG is produced at different locations around the world. This results in LNG compositions that may vary substantially with the geographical origin due to differences in natural gas sources, production technologies and the target market for LNG. These various compositions of LNG need to be addressed in terms of equipment requirements and operating procedures to accommodate appropriate billing (trading) and fuel quality demands—based on the energy that the gas quality actually provides, not just the quantity by volume and mass—to ensure fair and robust commercial value.

Composition is also of great importance from a safety perspective. The maximum filling limits in fuel tanks need to reflect the LNG properties for potential expansion to avoid liquid-full tanks and to determine the performance of engines and turbines.

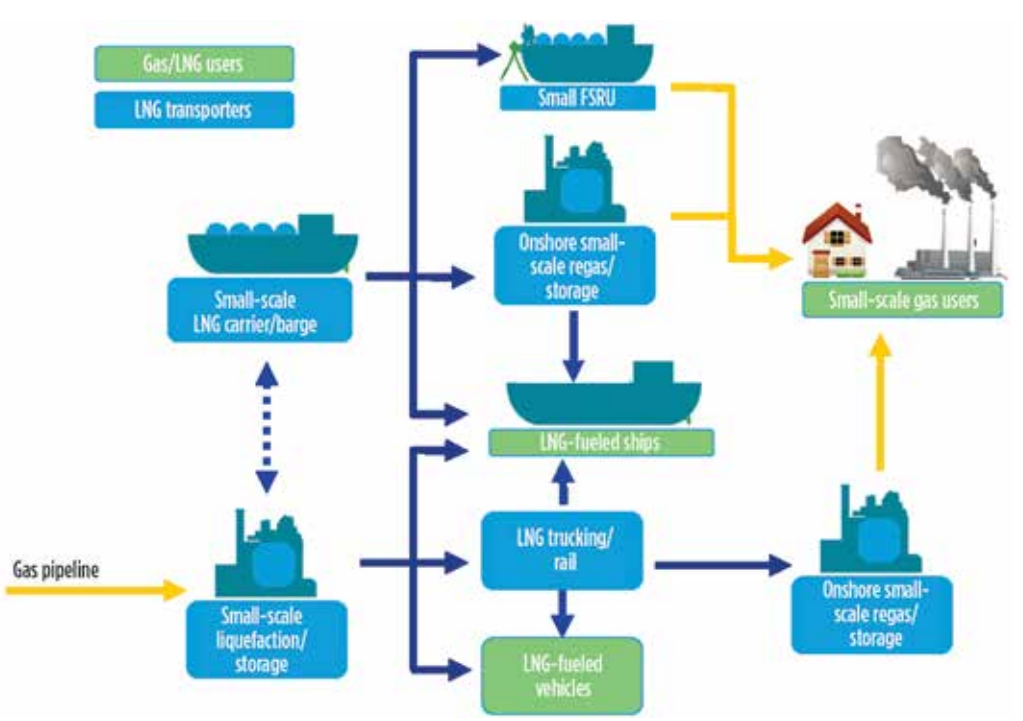

FIG. 1. Small-scale LNG value chain.

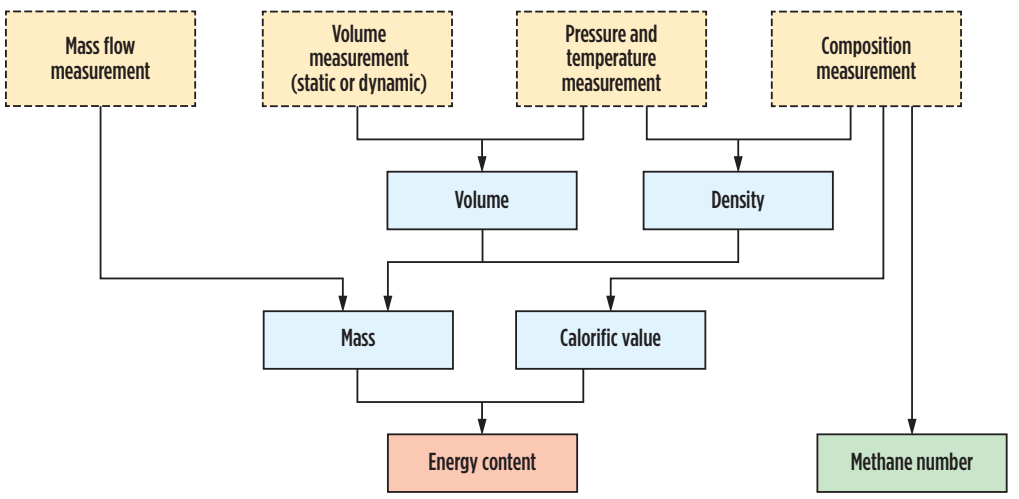

FIG. 2. Parameters and characteristics for determining energy content (DNVGL-RP-0006).

Updated RP with guidance on metering.

To tackle the challenges that varying LNG compositions present, DNV GL is now launching an update of the RP on "Development and operation of liquefied natural gas bunkering facilities (DNVGL-RP-0006)" to help the industry maximize the commercial value for fuel suppliers by de-risking fuel use for the customer. There is no international standard that determines classification and specification for LNG as a marine fuel, nor is there any required metering methodology.

The RP has been established with the aim of supporting the industry in the development and operation of safe LNG bunkering facilities, achieving compliance with regulatory targets, and ensuring the safety of personnel and protection of the environment. It focuses on four main elements: safe design and operation; safety management systems; risk assessment; and, for the first time, coverage on gas quality and metering. The RP bridges the gap between the ISO/TS 18683—which, by its very nature, is generic—and site-specific regulations like port regulations, terminal procedures and operating procedures (OP) for LNG bunkering.

The scope of the guideline covers all activities and stakeholders involved in the development and operation of such facilities (FIG. 1). It also addresses the risk evaluations that may be used for strategic considerations in the planning phase of an LNG bunkering facility project. The RP is applicable to truck-to-ship, terminal-to-ship and ship-to-ship bunkering scenarios, as well as vessels covered by the International Maritime Organization (IMO) regulations, including inland shipping.

Gas quality and quantity metering.

Through this update of the RP, DNV GL is the first regulatory body to provide guidance on how to perform quality and quantity metering of LNG fuel from bunkering.

The most elementary billing methods that can be applied are based on the volume or mass of bunkered LNG. Given the large spread in the density and in the calorific value among the available LNG sources, these methods could result in a substantial variation in energy content of the bunkered LNG. If the energy content is not determined, this variation leads to an uncertainty in the bunkered energy, illustrated in FIG. 2. This uncertainty not only affects billing and taxation, but also impacts the expected voyage distance.

In addition to transparency regarding the amount of bunkered energy, it is essential to ensure that the engines to be used in LNG-fueled ships are matched with the expected variations in fuel composition (fitness for purpose). Consequently, variations in composition can cause variations in engine performance. Specifically, the engine knock resistance of the fuel must be determined unambiguously. An engine failure at sea will have significant financial ramifications. The occurrence of engine knock leads to significant loss of performance (power reduction), engine damage and shutdown. Loss of propulsion and maneuverability can also cause catastrophic consequences, such as collision, grounding and foundering. Furthermore, the "boil-off" of the volatile components in the stored LNG leads to a change in composition, which decreases the knock resistance of the stored LNG over time.

Risk management.

As LNG is a hazardous substance—by its nature it has different risk properties than traditional fuel—the RP also provides in-depth guidance on risk management during development and operation of LNG bunkering facilities, such as safety management systems and the use of risk assessment techniques. The updated RP elaborates further on how to establish proper safety zones, including RPs on techniques and risk methodologies

More broadly, there is also a need to enhance the understanding of the risks and hazards in small-scale LNG. As such, DNV GL has also launched a joint industry project (JIP) to assess the capabilities of hazard tools and to demonstrate the consequences of credible failure scenarios at small-scale LNG bunkering stations. The aim of the JIP is to fill the gaps in knowledge by providing experimental data to validate and improve physical models, and to answer the still-open safety related questions. This will result in rigorous standards for safe design, siting, construction and operation of small-scale LNG bunkering stations. ■

For more information on this updated recommended practice, and to speak with the members of the DNV GL team, visit us at #B510b.

PETRONAS TO EXPORT CANADIAN GAS VIA PACIFIC NORTHWEST LNG

Malaysian energy company Petroliam Nasional Bhd. (Petronas) has renewed its pledge to proceed with its $28-B Canadian natural gas export project. The company is developing the LNG shipping terminal on the nation's Pacific Coast—pending approval from Canadian Environmental Assessment Agency regulators—despite the current market volatility for oil and gas. As of early October, this is the only Canadian proposal to issue an investment decision. Other owners of the venture are Indian Oil Corp., Japan Petroleum Exploration Co., China Petroleum & Chemical Corp., and Brunei National Petroleum Co.

Analysts have expressed doubts about Canada's ability to deliver LNG export projects. With new ventures beginning in Australia and the US, the global market is entering a period of oversupply. Demand in Asia is slowing just as the oil slump has taken down prices for LNG. There are 20 projects now under consideration for export from the Pacific Coast in British Columbia, and none have begun construction.

Canada and East Africa are lagging behind the rest of the world's LNG producing regions. The dramatic drop in oil prices means that only approximately 170 MMcmd (6 Bcfd) of LNG exports will be developed in North America by 2022, according to CIBC World Markets—about half the amount forecast last year. ■

Modeling logistics operations before committing significant capital

JAVIER VAZQUEZ-ESPARRAGOZA and **CHRIS CASWELL,** KBR

Logistics simulation provides users with the opportunity to quantify and visualize how their logistics intensive projects will be executed prior to actual project capital commitment. A discrete simulation-based approach tackles storage, loading, transportation and critical delivery operations to balance the capacity for material movements against risk, unforeseen events and the overall project schedule.

Generally, discrete simulation models are powerful tools, supporting decision making in both strategic and operational levels during logistics planning and execution. For example, **FIGS. 1** and **2** show a screen capture of a simulation model animation to determine the construction sequence for a modular designed project, detailing the delivery and execution sequence for the construction modules and large equipment installation. The installation sequence needs to be as flexible as possible to allow the release of productive work at the jobsite, while maintaining the highest safety standards (i.e. incident and injury free). Logistics models can be used to:

- Obtain a realistic understanding of the operating characteristics of a system
- Evaluate performance of supply chain under a series of plans (material delivery, construction and inventory policy) by considering various complex and uncertain factors
- Supplement schedule risk management of EPC projects
- Proactively identify potential bottlenecks and opportunities
- Effectively suggest optimal solutions for achieving best business interests.

Logistics operations can be simulated from the project level down to the detail of material handling activities at a single hub. "What-if analysis" is performed to examine the logistics plan against the project schedule. More specific scope includes:

- Matching freight delivery plans with the construction schedule, considering constraints of ports, vessel, barge, rail and trucks
- Ensuring the civil infrastructure in place can handle the labor and freight traffic loads
- Predicting laydown space requirements
- Identifying risks and contingency plans during the planning process.

Four examples of applications for KBR's logistics simulation experience are listed here.

FIG. 1. A KBR construction module sequence simulation.

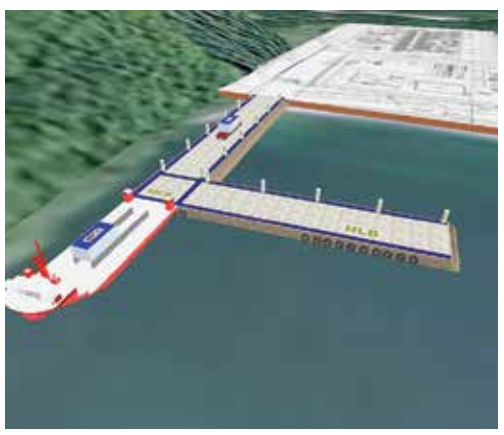

FIG. 2. A screen capture of a simulation model animation.

Construction logistics: Timing is everything. A freight profile and model are developed to examine the supply chain capacity of civil infrastructure, ensuring that the planned freight arrivals can be accommodated in different construction phases. A simulation-based module and heavy-lift sequencer are also built to test the module delivery feasibility. The feasibility of the freight delivery profile and schedule are analyzed and verified. A logistics simulation of the project's supply chain accompanies each major EPC effort. **FIG. 2** shows a picture of a 3D model used to demonstrate the results of a module sequence construction study.

LNG shipping and storage: Don't overinvest in marine infrastructure. Simulation models are built to determine the number of tanks, optimal tank size and marine berth occupancies to ensure these facilities do not restrict the continuous liquefaction process. The LNG vessel fleet size is also optimized, taking trip times, destinations, ship maintenance, currents and weather into account. **FIG. 3** shows a screen capture for an LNG storage and shipping study; the animated model includes the liquefaction terminal, multiple receiving terminals, tanks and vessels. By optimizing the shipping and storage logistics of LNG facilities, KBR can reduce capital costs by not overinvesting in marine and logistics infrastructure.

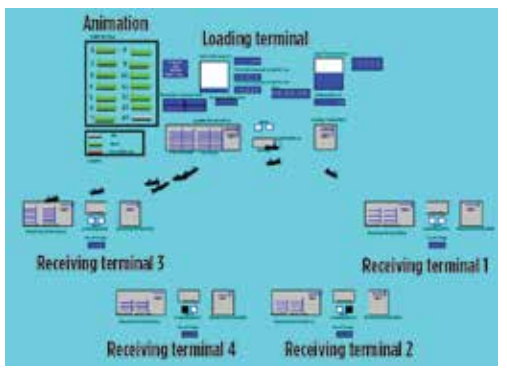

FIG. 3. Sizing tanks and loading vessels fleet, including the liquefaction terminal, multiple receiving terminals, tanks and vessels.

FIG. 4. A refinery model can estimate the number of receiving crude tanks and product tanks, and the storage capacity needed for solids and other products from the refinery.

Oil movement and tankage: Study the transportation of any product. Simulation models test the size of tank farms and the shipping schedule under various uncertain constraints. The study also evaluates production performance of the blends and verifies the material movements through tanks against the schedule of different shipment modes and the utilization of critical facilities. A refinery model developed to estimate the number of receiving crude tanks; the number of product tanks; the storage capacity needed for solids and other products from the refinery; and the size and number of vessels needed to run the refinery import and export under normal operations is illustrated in **FIG. 4.** The number of berths and berth utilization is also estimated. These studies include modeling of constraint situations like weather delays, tidal conditions and waves, marine traffic, loading and unloading capacity, unplanned shutdown time and maintenance.

Solids handling: If you move it, you should model it. Discrete models can accurately simulate product conveyance and storage; and the loading of pelletized materials and other solids products, including sulfur/coke handling facilities from sulfur pastillators/coke drums to truck or conveyor systems. These models detail and analyze operations to ensure these facilities are adequately sized and will not interrupt day-to-day operations.

KBR's Logistics Simulation allows clients to visualize detailed elements of their projects using a discrete simulation-based approach that analyzes critical delivery operations such as storage, loading and transportation. These models allow clients to review EPC risk, consequences from unforeseen events, and test the overall project schedule in the areas of supply chain management and traffic management. ■

For more information, please visit the KBR Gastech exhibition at #C160 to discuss your engineering needs with our team.

Höegh LNG perspectives on the market for floating LNG solutions

Höegh LNG has been involved in the LNG industry for more than 40 years, and since the mid-2000s has possessed a strategic focus on floating LNG infrastructure. The company has a fleet of twelve LNG vessels: eight floating storage and regasification units (FSRUs), three of which are under construction, and four LNG carriers.

Sveinung J.S. Støhle is the president and chief executive officer (CEO) of Höegh LNG, and has been with Höegh LNG since 2005. Mr. Støhle, who also holds the position as chairman of Höegh LNG Partners LP, has more than 25 years of experience in the LNG industry with both shipping and oil and gas companies. Prior to Höegh LNG, he held positions as president of Total LNG USA Inc.; executive vice president and chief operating officer (COO) of Golar LNG Ltd.; general manager, commercial, of Nigeria LNG Ltd.; and various positions with Elf Aquitaine. He earned a BS degree in finance from California State University and an MBA from the University of San Francisco.

Gas Processing caught up with Mr. Støhle to discuss his perspectives on the market for floating LNG solutions in the years to come.

GP: Höegh LNG was among the first to enter the market for FSRU solutions. What are some of the major developments you have experienced in the past years, and how are they reflected in the market today?

Støhle: Over the last five to six years, FSRUs (**FIG. 1**) have increasingly become accepted as the preferred alternative to onshore LNG import terminals. The number of units has increased rapidly since the first FSRU commenced operations in 2009, and today there are a total of 21 FSRUs operated by four suppliers. An additional eight units are on order and expected to be delivered within the next three years; four of these orders have already been awarded long-term contracts.

The majority of the FSRUs are employed in emerging markets in South America, Southeast Asia and the Middle East to cover an increased demand for natural gas to fuel electricity production, replace depleting gas reserves or to cover seasonal gas demand. Traditional onshore LNG receiving terminals require large areas of land, large investments and frequently a time period of 6 to 10 years to design and build.

Comparatively, FSRUs take half the time and half the cost to construct. Additionally, during periods where the regasification service may not be required, the FSRU can be re-used elsewhere, either by relocating it to a new terminal location or utilizing it as a traditional LNG carrier.

Recently, two factors in particular have had a positive influence on the FSRU market. First, as natural gas prices have decreased and become more affordable, we have experienced a spike in interest for FSRUs. Secondly, an increase in new LNG liquefaction capacity makes LNG available to new importers, which creates demand for additional FSRUs since new markets generally do not have available LNG import capacity.

GP: How do these recent trends affect your perspective on the FSRU market in the years to come?

Støhle: At Höegh LNG, we are very confident about the future of the FSRU market. We have identified approximately 35 potential new projects—against four uncommitted FSRUs in the current order book—and, although some of the discovered projects might not materialize, we anticipate that the demand for FSRUs will remain very strong for the foreseeable future, with a rising number of contract awards in the coming years.

GP: Floating LNG liquefaction (FLNG) is a new and emerging segment in LNG that has recently been attracting an increasing amount of attention. What are your thoughts on this developing market?

Støhle: Planned land-based LNG liquefaction projects that have not yet reached a final investment decision will have to compete in the market based on much lower gas prices than was previously the case. This will likely lead to a number of planned LNG liquefaction projects being either delayed, scaled down or put permanently on hold, unless their costs can be reduced to meet the new lower price of natural gas. This should create opportunities for FLNG, which represents a more flexible and significantly less capital intensive solution than large land-based liquefaction projects, which require double digit billion-dollar investments. FLNG projects also have a significantly shorter construction schedule.

Although FLNG projects have been discussed for years, the development of a commercially viable solution has not been available until recently. As a result, the market is increasing both in terms of investments and activity, with eight units currently under construction: three are large offshore units with full onboard processing plants; three are conversions of old Moss-type LNG carriers; and two are barge FLNGs designed to liquefy pipeline specification gas. Beyond these projects, more than 20 proposals for FLNGs have been announced. Although the market for FLNG is less mature compared to FSRUs, it is developing quickly. However, it is important for me to underline that Höegh LNG will only be involved in the low-cost, technically less complex segment of the market, with our barge-based FLNG, and not the high-cost, high complexity segment, such as Shell's Prelude FLNG. ■

Visit the Höegh LNG booth at #B520 to meet the company's senior management and experience the latest promotional features within FSRU and FLNG. Höegh LNG is also showcasing a special feature of the green recycling process of the LNG carrier, the *Norman Lady.*

SVEINUNG J.S. STØHLE, president and CEO of Höegh LNG

FIG. 1. Höegh LNG conducts a ship-to-ship (STS) operation.

A HISTORY OF GASTECH

The very first Gastech was known as the S&SR LNG & LPG Meeting, and, like all the events until 1994, was organised by its creator, Brian Singleton. In 1974, the first event to bear the Gastech title was held under the umbrella of the Europort show in the Netherlands. The rest, as they say, is history!

1972—London, UK
1973—London, UK
1974—Amsterdam, the Netherlands
1975—Paris, France
1976—New York, USA
1978—Monaco, Principality of Monaco
1979—Houston, USA
1981—Hamburg, Germany
1982—Paris, France
1984—Amsterdam, the Netherlands
1985—Nice, France
1986—Hamburg, Germany
1988—Kuala Lumpur, Malaysia
1990—Amsterdam, the Netherlands
1993—Paris, France
1994—Kuala Lumpur, Malaysia
1996—Vienna, Austria
1998—Dubai, UAE
2000—Houston, USA
2002—Doha, Qatar
2005—Bilbao, Spain
2006—Abu Dhabi, UAE
2008—Bangkok, Thailand
2009—Abu Dhabi, UAE
2011—Amsterdam, the Netherlands
2012—London, UK
2014—Seoul, South Korea
2015—Singapore

Expanding the envelope of liquefaction technology

BILL HOWE, Gasconsult Ltd.

The fall in the oil price and the resulting impact on LNG prices, together with the upcoming availability of new LNG supplies from projects under construction, have cast doubts over the viability of many planned LNG facilities. Current levels of LNG plant complexity, the high production capacities and the associated high capital costs may not be sustainable in an era of lower energy prices.

Floating liquefied natural gas (FLNG) schemes, as a means of maximizing high-quality low-cost shop fabrication, avoiding pipeline costs to a land-based facility and eluding delays from regulatory authorities, are under more active review. However, even with these benefits, investment returns on FLNG at current oil prices are reported as single-digit as measured by internal rate of return (IRR), which is not especially enticing given the high costs and commercial risks of these ventures. Certainly, new projects will require innovative thinking if they are to proceed in the current pricing environment.

The development of the ZR-LNG process. Gasconsult commenced its development of new liquefaction technology in the early 2000s, when oil prices ranged from $30/bbl to $50/bbl. During development, Gasconsult was seeking a simple, low-cost, safe and high-efficiency design. This culminated in late 2012 with the award of a patent for its ZR-LNG process, a dual methane expander technology (FIG. 1). Studies conducted jointly with GE Oil & Gas indicate single train capacities exceeding 2 MMtpy are feasible with all equipment sized and configured within windows of proven operating experience.

Potentially, ZR-LNG is well suited to today's energy price environment, and the objective of simplicity has been achieved. A 2 MMtpy-train requires only two compressor packages and nine major pieces of equipment. Specifically, ZR-LNG requires no external gaseous or liquid refrigerants, as it uses natural gas feed as the refrigerant medium. This eliminates refrigerant extraction/production equipment and refrigerant storage/blending facilities, saving costs and, importantly for FLNG schemes, minimizing deck area. The absence of liquid hydrocarbon refrigerants improves safety, also particularly relevant to FLNG where exit opportunities are limited in the event of fire or explosion.

The process requires no ongoing refrigerant makeup other than the natural gas feed—a significant annual cost saving—and also avoids the logistical problems of importing refrigerant components to remote locations. This is particularly relevant to lean feed gases. ZR-LNG is also simple to operate. Unlike mixed refrigerant schemes, adjustments to the refrigerant composition to maintain liquefaction cycle efficiency are not required.

Energy efficiency is high, very close to dual-mixed refrigerant processes and a 30% lower power demand than dual-nitrogen (N_2) expander schemes. This high energy efficiency is achieved without feed-gas pre-cooling, reinforcing ZR-LNG's intrinsic simplicity.

Validating the technology. BP and two large engineering and construction (E&C) companies under non-disclosure agreements have undertaken due diligence and design verification work on the technology, all with positive outcomes. The process steps are all conventional and can be seen in numerous cryogenic gas processing plants. All equipment is proven in equivalent service and can be purchased from multiple vendors. There is no equipment purchase tied to the technology, providing competitive bidding leverage on schedules and over the total project cost.

Gasconsult offers the technology on a licensed basis through the provision of a front-end design package of flexible scope to suit the client's requirements. Licenses are available to LNG producers directly, which may then arrange for plant design and installation by an engineering company of their choice. Licenses are also available to E&Cs that may wish to offer the technology on a case-by-case project basis or secure a specific geography for the exclusive marketing of the technology.

Bill Howe, CEO of Gasconsult, will be presenting a paper titled, "Capital cost and efficiency data for the ZR-LNG dual methane expander zero refrigerant liquefaction technology," at the Application of Innovative Technology Session 1 at 12:15 pm on Wednesday, October 28th. The session will cover industry feedback on the ZR-LNG technology and provide a wide range of power demand data from 20–80 bar at two selected temperature points. The paper will also provide details of a range of single train plant capacities in the 0.9 MMtpy to 2.2 MMtpy range with matched gas turbine/compressor/expander configurations.

In keeping with the "Innovative" slant of the session, the paper will also provide details of two new variants of the ZR process:

- Integrated pressure liquefaction—an adaptation to reduce power demand when processing low-pressure feed gas
- Integrated heavies removal—an adaptation improving C_5^+ and aromatics removal efficiency when processing higher-pressure feed gas.

Both these adaptations involve innovative but simple modifications to the basic ZR flow scheme and achieve their objectives without additional equipment. ■

Gasconsult Ltd CEO Bill Howe will be presenting in the morning session of the Technical Stream on Wednesday from 12:15–12:40 p.m. The company is exhibiting at #D438, where Mr. Howe and Geoff Skinner, Gasconsult's technical director, will be available for discussion.

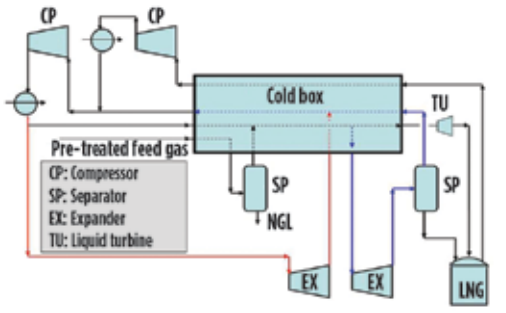

FIG. 1. The ZR-LNG process schematic.

ANZAI AWARD PRESENTED TO BG GROUP

BG Group has been presented with the Gastech Anzai Award in recognition of the Queensland Curtis LNG (QCLNG) project and the company's long-term championing of the LNG business. BG Group CEO Helge Lund accepted the award during Monday night's VIP dinner.

The Anzai Award is a rarely-given trophy, first presented to Dr. Hiroshi Anzai, former Chairman of Tokyo Gas during the 1960s in the pioneering days of LNG. Dr. Anzai committed his company to the first major LNG import project in the Pacific region, which was considered a great risk at the time. Before this Kenai-Japan project, the global LNG business was in a fairly static state; many planned LNG import projects to Europe became uneconomic once natural gas was found in the North Sea. Dr. Anzai's decision provided significant momentum to the international LNG trade, and he was consequently honored with an award in his name at the first Asian edition of Gastech, held in Kuala Lumpur in 1988. Previous Anzai Award recipients include Woodside Petroleum, Shell Australia, Pertamina, Qatargas and Exmar.

QCLNG is the world's first project to turn gas from coal seams into LNG, and is one of Australia's largest capital infrastructure projects ever conceived, involving more than $20 B in investment since 2010.

The project was completed ahead of schedule and is now delivering LNG cargoes to customers in North Asia. At plateau production, expected mid-2016, both trains at QCLNG will be producing enough LNG to load ten vessels per month combined, exporting around 8 MMtpy. ■

Successful startup of Qatar JBOG project

By successfully launching its new Jetty Boil-Off Gas (JBOG) Recovery Project, the State of Qatar has reaffirmed its commitment to the safest, most sustainable and technologically innovative LNG in the world.

A brief history of the JBOG project. Producing 77 MMtpy, Qatar is the largest provider of LNG in the world. During the loading of LNG, a portion of the –160°C liquid boils off as it comes in contact with the warmer ship tank. Previously, this boiled-off gas would be flared at the berth because there was no other outlet for the low-pressure gas.

Consequently, in line with Qatar's National Vision to produce and supply clean energy to the world, Qatar Petroleum (QP) and the Ministry of Environment introduced the JBOG project, which was inaugurated earlier this year, to recover the flared gas at the country's LNG berths.

Initiated by QP in 2004 under the auspices of HH, the Emir, Sheikh Tamim bin Hamad Al Thani, as well as HE, Dr. Mohamed bin Saleh Al Sada, Minister of Energy and Industry, the JBOG project's front-end engineering design (FEED) was awarded to the US-based company Fluor in October 2007.

Thereafter, Qatargas was permitted to lead the undertaking on behalf of the project's stakeholders—QP, the Ministry of Environment, RasGas and Qatargas itself—playing a pivotal role in its safe and successful delivery, thanks to the leadership of Qatargas Chief Executive Officer Sheikh Khalid bin Khalifa Al Thani.

The project was led by Qatargas' operations development department, while the care, custody and control were transferred to the onshore operations department, with the ready for startup (RFSU) certificate signed on September 17th, 2014.

Because of Qatargas' vision to be the premier LNG company, and its incident and injury-free culture, the project's construction was completed with an excellent safety record of 22 MM worker-hours without any loss-time incidents (LTI). That record continued during red-blinds removal, the critical gas-in phase and the most important milestone, the first ship recovery, with central compression area (CCA) compressor trains in operation and the distribution of compressed gas to vendors.

The JBOG project officially began with the recovery of jetty boil-off gases on October 6th, 2014 from the Q-Max ship *Zarga* at Berth-6.

Design and construction. RasGas' initial design for the JBOG project in 2004 was based on using liquefied nitrogen gas as a cooling medium to liquefy the boil-off gas into LNG at the berths. The LNG would then be sent to the storage tanks and eventually exported with the bulk LNG.

The conceptual design undertaken by RasGas at the FEED stage showed that the volume of nitrogen (N_2) required to liquefy the boil-off gas generated from six berths (**FIG. 1**) would be too great. The N_2 gas vented into the atmosphere could prove harmful to the environment, and the power consumption required to liquefy air to produce liquid nitrogen was too prohibitive.

In June 2007, RasGas handed over the JBOG Project to Qatargas, which initiated a detailed review of the design. The results indicated that the location of the compressors at the berths might lead to safety, constructability, cost and scheduling issues. The subsequent awarding of the FEED contract to the US-based Fluor included a location study, leading to an eventual change of plant design and a relocation of all compressors to a central location.

Located in Qatar's Ras Laffan port area, the JBOG project is now part of the Common LNG Storage and Loading (CLNG S&L) Asset, and consists of a CCA that is connected to all six LNG berths in the area through a 60-in. collection header.

Boil-off gas generated at low pressure during the process of LNG loading is collected via the collection header and routed to the CCA, where it is compressed to 47.5 barg. The compressed gas from the CCA is then sent through distribution headers fitted with custody transfer meters to each LNG producer's viz, where it is consumed as fuel gas.

The CCA is comprised of two trains of low-pressure (LP), medium-pressure (MP) and high-pressure (HP) compressors with a design capacity of 163 tonnes per hour, equivalent to the maximum amount of boil-off gases generated by three ship loadings simultaneously, illustrated in **FIG. 2.** With this installed capacity, the CCA can recover 90% of the total flared gases at LNG berths.

Technical innovations: From challenge to opportunity. Conceptually, the overall design of the JBOG project had one overarching challenge: space. The Ras Laffan City LNG terminal had not been designed with sufficient space to install a compressor, driver and associated equipment. This eventually led to a decision by the JBOG project management team to change the design of the plant and relocate all the compressors to a central location.

This new concept relied heavily on the ships' high-duty boil-off gas (BOG) compressors to deliver the gas at a pressure high enough to allow for the gas to be transported from the ships to the CCA, approximately 5 km away.

The JBOG project team worked with the Fluor FEED team to combat these challenges, and in the process they introduced several technical design innovations, which included: the implementation of ultra-low differential pressure check valves; the design and use of the largest BOG compressor in the world, which was designed by GE Nuovo Pignone; and the use of ultra-low temperature buckling pins that were designed with special seals and mechanisms to ensure reliability during operation.

Another challenge was the JBOG project's location in brownfield areas, making construction itself difficult. During 2009, the Qatargas JBOG project team worked with Fluor to commission a laser scan survey of all the brownfield areas through which the JBOG facilities would be installed. This scan produced high-resolution digital images, which were later incorporated into the 3D computer design model, effectively saving millions of dollars by eliminating possible clashes and reducing the project's scheduled development time.

Safety and sustainability. Maintaining the safety of personnel and property was another great challenge, and the highest priority of the Qatargas JBOG project. To date, the project has kept all of its 3,000 workers safe from serious injury. An incident and injury-free safety behavioral program was fully implemented on the JBOG project, with many initiatives in place to enhance safe working practices (**FIG. 3**).

As one of the largest environment projects in the world, JBOG's largest environmental boon is the reduction of 1.6 MMtpy of carbon dioxide (CO_2) emissions, which is in line with Qatar's National Vision and National Development Strategy.

In accordance with strict international standards, the JBOG project also recovers the loss of approximately 0.6 MMtpd of flared gas, producing 750 MW and generating enough energy to power roughly 300,000 homes. That savings translates to a cumulative windfall of 1 Tcf of gas over 30 years.

The landmark JBOG project also achieves the stipulated flaring standard of 0.3 wt% in the total annual production of sweet gas, effectively decreasing the carbon footprint of Qatar's 77 MMtpy LNG industry to a minimum. ■

FIG. 1. Qatar's Ras Laffan port area features a CCA that is connected to all six LNG berths in the area through a 60-in. collection header.

FIG. 2. With a design capacity of 163 tonnes per hour, equivalent to the maximum amount of boil-off gases generated by three ship loadings simultaneously, the CCA can recover 90% of the total flared gases.

FIG. 3. Maintaining the safety of personnel and property was the highest priority of the Qatargas JBOG project.

Gastech showcases VIP Programme

The Gastech VIP Programme is an exclusive part of the Gastech Conference & Exhibition and specifically designed for the global gas industry's leadership, collectively representing over $4.2 T in annual revenue, with 25 governments and over 40 countries represented. This short but valuable forum provides busy gas executives and government officials an opportunity to:

- Meet with fellow C-level leaders (over 250 top-leaders) representing the largest players across the global gas value chain
- Tackle the most pressing industry challenges in a closed-door setting
- Engage in private discussions during bilateral meetings through the Gastech Global Meetings Programme.

Confirmed VIP Delegates include:

- President & Chief Executive Officer, **Angola LNG Marketing** (Angola)
- Chief Executive Officer, **BG Group** (UK)
- President, **Chevron Gas and Midstream** (USA)
- Chairman, **CPC Corporation** (Taiwan)
- Chief Executive Officer, **Delfin LNG** (USA)
- President, **ENGIE** (France)
- Chief Executive Officer, **E.ON Global Commodities** (Germany)
- President, **ExxonMobil Gas & Power Marketing Company** (USA)
- Chairman & Managing Director, **GAIL** (India)
- Director General, **Gazprom Export** (Russia)
- Chairman & Chief Executive Officer, **GTT** (France)
- Executive Chairman, **GSPC LNG** (India)
- Chief Executive Officer, **Hanas LNG Investment** (China)
- Chief Executive Officer, **Höegh LNG** (Norway)
- Executive Director (elect), **International Energy Agency** (France)
- President & Chief Executive Officer, **Jordan Cove LNG** (USA)
- President, **MI LNG** (Japan)
- Chairman, **Parallax Energy** (USA)
- Chief Executive Officer, **Rasgas** (Qatar)
- Executive Vice President, Integrated Gas, **Shell** (Netherlands)
- Chief Executive Officer, **Singapore LNG** (Singapore)
- President, Oil and Gas, **SNC-Lavalin** (Canada)
- Vice Chairman, **Tokyo Gas Co. Ltd.** (Japan)
- President–Gas, **Total** (France) ■

Tuesday 27 October 2015—Singapore Expo (MAX ATRIA)

Registration and Coffee 08:00–09:00	**Registration and Coffee** Hosted by Mozambique LNG
09:00–09:10	**Introduction and Welcome Address** **Christopher Hudson,** President—Energy, dmg::events **Helge Lund,** Chief Executive Officer, BG Group
09:10–09:30	**Keynote Address—Towards More Efficient, Competitive and Secure Gas Markets** **Fatih Birol,** Executive Director, International Energy Agency
09:30–09:40	**Address—Growing LNG Demand and the Challenges of its Potential** **Robert S. Franklin,** President, ExxonMobil Natural Gas and Power Marketing
VIP Session 1 09:40–10:40	**Strategic Executive Debate—How Will the Gas and LNG Industry Realign Itself to Capitalise on Future Opportunity?** **Nobuo Tanaka,** Former Executive Director, International Energy Agency **Klaus Schäfer,** Member of the Board of Management, E.ON SE **BC Tripathi,** Chairman and Managing Director, GAIL India **Maarten Wetselaar,** Executive Vice President, Integrated Gas, Shell **Laurent Vivier,** President—Gas, Total **Robert S. Franklin,** President, ExxonMobil Natural Gas and Power Marketing
Networking Break 10:40–11:10	**Hosted by Mozambique LNG**
VIP Session 2 11:10–11:30	**Industry Outlook—Global Gas and LNG Market Outlook—From a Black Swan's Eyes** **Stephen Thompson,** Manager, LNG and Gas, Asia Pacific, Poten & Partners
VIP Session 3 11:30–12:30	**Executive Leadership Panel - What Impact Will Lower Prices Have on Investment in Global Gas & LNG Infrastructure Projects?** **Steven Miles,** Partner, Baker Botts **Frederick Jones,** Founder and CEO, Delfin LNG **Elena Burmistrova,** Director General, Gazprom Export **Hon. Rich Coleman,** Deputy Premier and the Minister of Natural Gas Development and Minister Responsible for Housing, Government of British Columbia **Tush Doshi,** President, Projects, Oil and Gas, SNC-Lavalin/ Kentz **Hiroshi Matano,** Executive Officer and General Manager, The Bank of Tokyo-Mitsubishi UFJ, Ltd. (BTMU)
VIP Private Luncheon 12:30–13:45	

News in brief

India considers gas price deregulation to lure foreign investment

Natural gas producers in India have petitioned that the current tariff is too low to support exploration and production costs, prompting the government to study the possibility of allowing producers to set the price in consultation with customers. Market rates can be set for gas extracted from 69 small fields due for auction by the end of the year.

Explorers in India, including Reliance Industries and its international partner BP, state-run Oil and Natural Gas Corp. (ONGC) and Gujarat State Petroleum Corp., have been seeking independent pricing, arguing that current prices make new investments unviable. Raising local gas output is key to reviving industries, such as fertilizer and power, which have cut capacity use for lack of the fuel.

On 30 September, the government cut the price of natural gas by 18% to $3.82/MMbtu. The price, based on the gross heat value, is effective from 01 October for six months. (The country sets prices every six months, based on a combination of global prices.) The reduction will squeeze profit margins at major producers, including ONGC, while benefiting consumers.

State control on fuel pricing has been a key factor in keeping oil majors such as ExxonMobil, Chevron and Royal Dutch Shell away from India's exploration-block auctions. BP is the only overseas company with any significant presence in India's exploration sector. Now, Prime Minister Narendra Modi has made energy security his priority, and he is lifting restrictions to attract foreign investments.

In 2007, Reliance was allowed to set the price of gas it produced from the fields in the Bay of Bengal on India's eastern coast. In 2013, the government decided to set a formula-based pricing for natural gas, subtly ending the freedom given to the producers.

The government's decision to cut natural gas prices has prevented energy explorers and producers from undertaking new capital expenditure. India's gas output from local fields has fallen 36% over five years to 33.7 Bscm, from data provided by the oil ministry's Petroleum Planning & Analysis Cell. Production is predicted to increase to 140 MMscmd in the next 10 years, while demand is forecast to reach 330 MMscmd, according to New Delhi-based rating company ICRA.

Putin touts Nord Stream-2 expansion to Germany

Russia's plan to expand a natural gas pipeline directly to Germany, bypassing Ukraine, is not intended to reduce the importance of existing supply routes, according to President Vladimir Putin.

The new Baltic Sea link, known as Nord Stream-2, "is not designed to strip anybody of transit opportunities," and will help Europe offset declining domestic gas production, Putin said at a recent forum in Moscow. The project has faced some criticism since Gazprom signed an agreement in September to build the link with five European energy companies, including Royal Dutch Shell and EON.

The pipeline risks concentrating 80% of the bloc's Russian gas imports on one route, and eastern European leaders warn that it could isolate Ukraine, which currently carries about a third of Russia's gas exports through its pipelines.

Russia, which supplies a third of Europe's gas, has plans for at least two new routes to the region, one via Turkey in the south and one through Germany in the north. Russia has said it may cut supplies through Ukraine when the current transit deal expires in 2019, which could cost Ukraine an estimated $2 B/yr in lost fees.

Cheniere commissioning Sabine Pass gas terminal

Cheniere Energy's Sabine Pass terminal, the first complex designed to liquefy and export natural gas from the continental US, is being commissioned and is on track to start producing by the end of the year, said Bechtel, the engineering and construction (E&C) company behind the project. Bechtel is performing the commissioning work alongside Cheniere.

Cheniere is planning six liquefaction plants at the terminal in Louisiana, and the company says that five have been contracted and are under construction. The export terminal is being built as gas supplies surge out of shale formations. Drillers are using hydraulic fracturing and horizontal drilling in the fields to reach long-trapped deposits of the heating and power-plant fuel, and US domestic gas stockpiles may reach record levels by the end of October, according to the Energy Information Administration (EIA).

The liquefaction process is consistent across the plants where Bechtel is working. The San Francisco, California-based contractor is also building Cheniere's Corpus Christi LNG facility in Texas and three projects in Australia, the third of which will begin liquefying gas by the end of the year.

Queensland's QIC to acquire Iona gas storage plant

QIC, the fund manager owned by the government of Australia's Queensland state, has agreed to buy the Iona gas storage plant in Australia for $1.28 B in cash from Hong Kong's CLP Holdings. The Iona plant, located in Victoria State, has storage capacity to supply as much as 500 terajoules/day of gas, according to EnergyAustralia. The facility is used by energy companies to store gas during periods of low usage, which can then be distributed by pipeline to supply markets around Melbourne and Adelaide when demand is high.

QIC says that Iona is a strategic infrastructure asset in the Australian east-coast gas market, plays an essential role in energy supply and has long-term contracts with its customers, all of which present a platform for further growth and expansion opportunities.

AGL Energy, Australia's biggest power producer, has obtained long-term gas storage rights, subject to conditions, to utilize the Iona facility. ■

Optimizing the propane refrigeration system in an NGL extraction plant

MAHDI NOURI and **EBERHARD LUCKE,** CH2M Oil, Gas and Chemicals

Natural gas liquids (NGL) are liquid hydrocarbons generally recovered from natural gas in gas processing plants. NGLs include ethane, propane, butane, pentanes and heavier hydrocarbon components. Increased demand for natural gas in the 1960s, and the requirement to correct the hydrocarbon dew point for natural gas transportation, have encouraged the development of the mechanical refrigeration process using propane as refrigerant. Refrigeration system optimization is a key in the natural gas processing industries for NGL recovery and hydrocarbon dew point control purposes.

Many factors, all of which can be analyzed and optimized, affect investment and operating costs. These can include the influence of the number of trains; the levels of refrigeration; the impact of the propane system configuration, the operating pressures at the propane collector, the propane sub-cooling on compression power and the operating pressures on compression power; plant layout; and construction materials.

The major goals of propane refrigeration system optimization are to provide the necessary amount of propane to the prechiller/chiller, and minimize the total propane circulation in the closed system and the total compression power.

A case study. The rich gas is cooled through a hot gas/gas exchanger and then routed to a water separator, where a significant portion of the water is condensed and separated. The gas is further cooled, with a combination of prechiller/chiller using the propane refrigerant, to the desired temperature of –24°F (–31°C) due to maximum NGL recovery. Glycol (MEG) is injected at proper locations to prevent any hydrate formation through the hot gas/gas exchanger, prechiller and chiller. The NGL, glycol and lean gas are separated, and then the NGL is stabilized in the demethanizer to achieve a specified vapor pressure. The lean gas is compressed and delivered to the pipeline, and the stabilized NGL is pumped to the pipeline (**FIG. 1**).

The cooling duties required for chilling the inlet gas are provided by the propane refrigeration system, shown in **FIG. 2.** The propane refrigeration system consists of a closed loop in which the propane is expanded, vaporized, recompressed and condensed. The plant operating costs are significantly increased by further compression power, so various alternative schemes are analyzed to minimize that compression power.

The propane vapors are compressed by a three-stage propane compressor that is driven by a fixed-speed electric motor. The propane from the compressor discharge enters the propane condenser, where it is condensed via the air cooler. The condensed liquid propane is collected in the propane collector at approximately 315 Psia (21.7 Bara) as slightly sub-cooled liquid propane. The warm refrigerant liquid is routed from the propane collector to propane coolers, where warm liquid propane exchanges heat with low-temperature streams from the top of the stabilizer, stabilizer reboiler and product NGL. The sub-cooled propane then enters the suction drums by pressure letdown. The self-refrigerated propane from the suction drums is routed to the prechiller/chiller. The chilling load required by the process is provided by the latent heat of propane vaporization in the exchangers. The vapors generated in the pressure letdown are combined with other propane vapors generated in the prechiller/chiller, due to the latent heat impact that can be optimized due to the compressor power reduction.

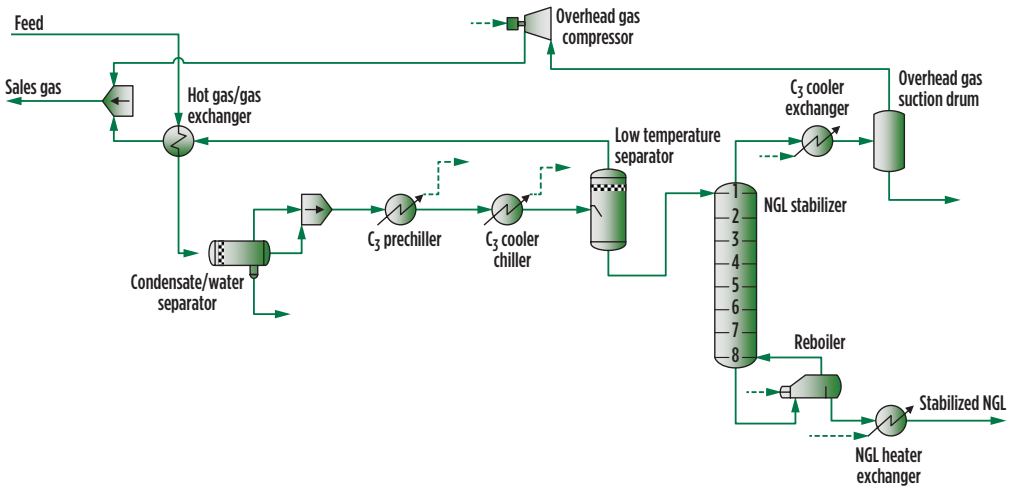

FIG. 1. A typical process flow diagram for an NGL extraction plant.

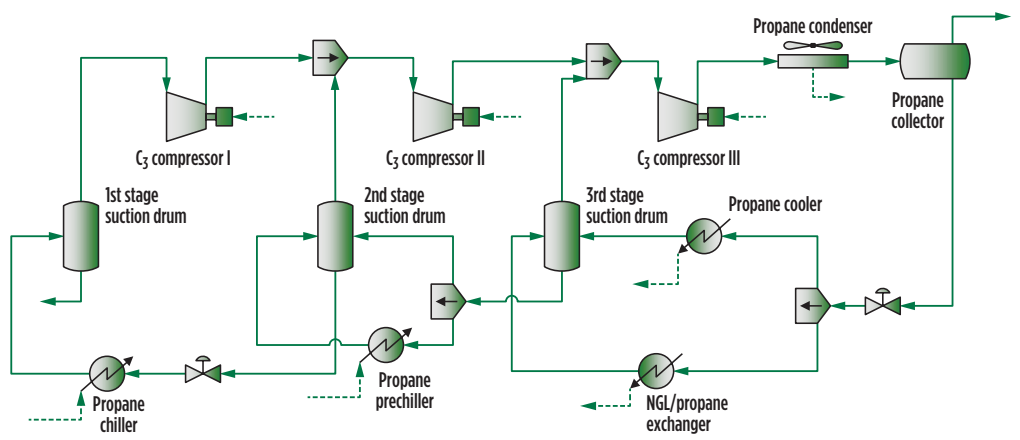

FIG. 2. A typical process flow diagram for a propane refrigeration system.

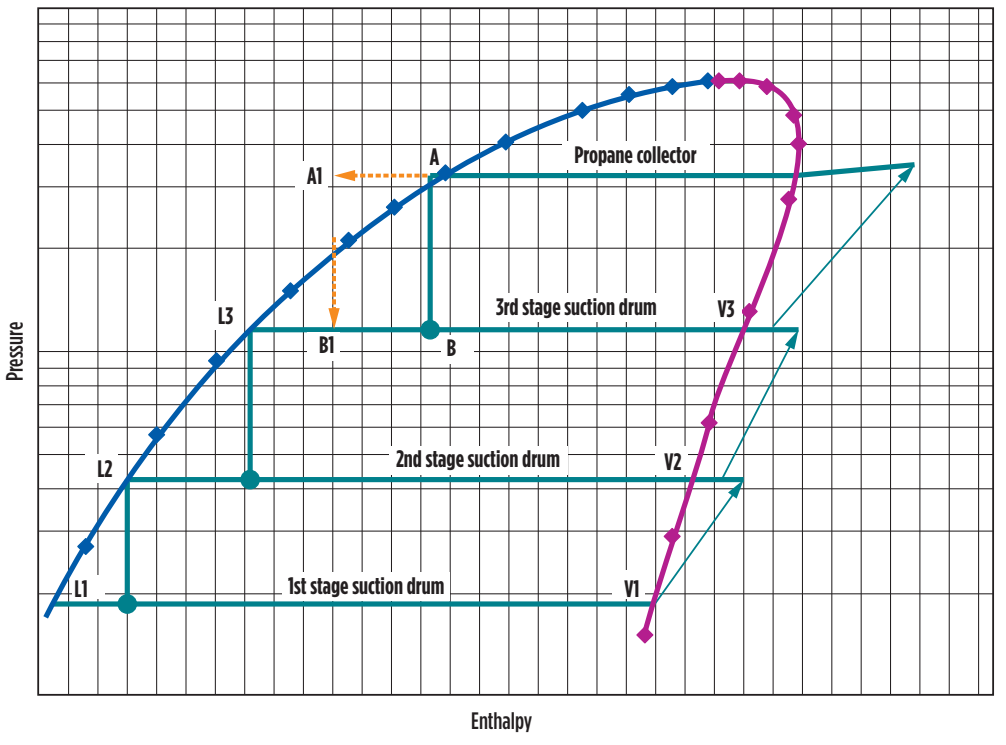

FIG. 3. A PH diagram of a propane refrigeration system.

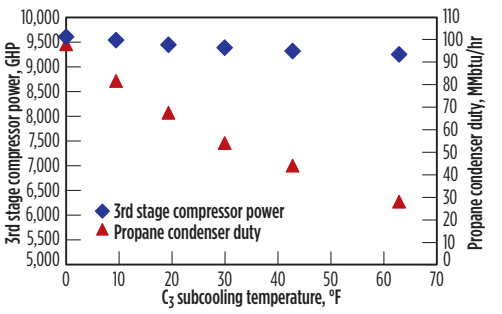

FIG. 4. Impact of subcooling on compression power and condenser duty.

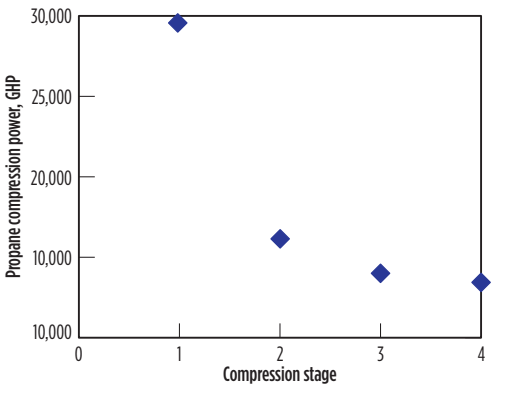

FIG. 5. Impact of compression stages on compression power for two refrigeration levels.

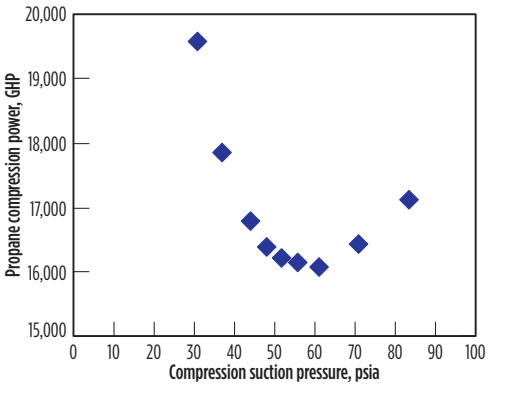

FIG. 6. Impact of 2nd-stage suction drums pressure on propane compression power for two levels of refrigeration and two-stage compression.

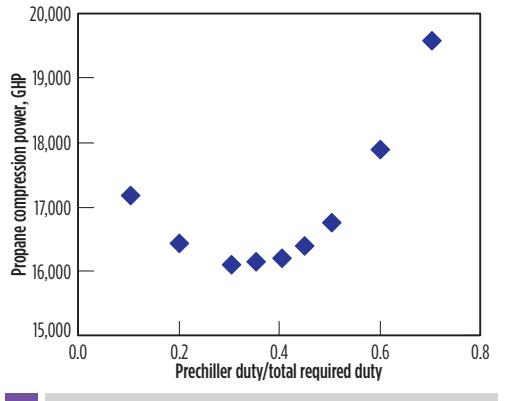

FIG. 7. Impact of chilling load distribution on propane compression power for two-stage compression.

Results. By sub-cooling the warm propane from the propane collector, the third-stage propane compression power and condenser duty are reduced (**FIGS. 3** and **4**); however, there is a limitation for the level of sub-cooling. **FIG. 3** illustrates the typical thermodynamic path of a three-stage propane refrigeration cycle, indicated in the PH diagram.

The following major process streams can be utilized to sub-cool saturated liquid propane: outlet treated gas from the stabilizer column (–42°F or –41°C); stabilized NGL (81°F or 27.2°C); the stabilizer column reboiler (22°F or –5.5°C); and outlet gas from the NGL/glycol separator (–24°F or –31°C).

Increasing refrigeration stages will diminish the compressor power, and additional costs can potentially be required without gain from three to four compression stages (**FIG. 5**). **FIG. 6** illustrates the impact of an inter-stage economizer on the total required compression power. One-level refrigeration will obviously result in the highest compression power.

One-level chilling is defined as when all required chilling duty is provided by one exchanger with the proper approach temperature. The purpose of increasing the level of refrigeration is to reduce the

See NGL, page 18

Egypt's natural gas: Ancient treasure for the modern world

L. NICHOLS, *Hydrocarbon Processing*

On the west bank of the Nile River, just on the outskirts of Cairo, sit the Great Pyramids of Giza. Built during the fourth dynasty, the pyramids mark the tombs of the Pharaohs Khufu, Khafre and Menkaure. Their construction marked the height of Egyptian power, economic prosperity and stability. Construction took over 100 years, tens of thousands of laborers and millions of blocks of stone.

Today, the pyramids at Giza are still some of the most magnificent human-made structures ever to be built. The Pyramid of Khufu, the oldest and largest of the three pyramids, is the only wonder of the ancient world still intact.

More than 4,000 years from the time these structures were built, Egypt is embarking on a new, massive construction project—energy infrastructure. Metal and steel have replaced giant stones, and natural gas has become a treasured commodity. This build-out is imperative to feed a growing demand for power generation, alleviate rolling blackouts and mitigate an escalating energy crisis (**FIG. 1**).

FIG. 1. The populous, energy-hungry city of Cairo, Egypt rises up behind the ancient pyramids 6 km away in Giza. Photo by A. Blume.

Supply and demand. At 77 Tcf, Egypt holds the fourth-largest natural gas reserves in Africa, after Nigeria, Algeria and Mozambique. Domestic natural gas fields are located primarily in the deepwater Mediterranean Sea, the Nile Delta and the Western Desert. Nearly all of Egypt's natural gas production has been diverted to the domestic market to satisfy surging demand.

Egypt is the largest consumer of oil and natural gas on the continent. The country of over 86 MM people relies on natural gas to generate nearly 70% of power for households and the industrial sector. Increasing consumption and decreasing production has reversed Egypt's role as an energy exporter to that of an importer.

Due to surging natural gas demand, the country has emerged as a prime destination for both LNG and natural gas pipeline imports. However, the high consumption level has also renewed the country's outlook on upstream exploration and production (E&P) activities. Imports are vital to Egypt's power industry in the short term, but new E&P contracts could satisfy consumption and decrease (or even halt) natural gas imports by the end of the decade.

E&P efforts. The start of 2015 marked a new shift in Egypt's upstream activities. Egypt's government awarded six of 20 new contracts for oil and gas exploration in the Gulf of Suez and the Western Desert. This new round of exploration awards followed 36 petroleum agreements the Egyptian government has signed with foreign firms since November 2013. These contracts represent an infusion of billions of dollars in new upstream investment, as well as the resurgence of an industry that has seen minimal activity in recent years.

After the 2011 uprising that toppled the Hosni Mubarak regime, natural gas exploration activities nearly ceased due to lack of funds. Foreign firms argued that the Egyptian government was not paying enough for new gas supplies to justify capital-intensive E&P activities.

Coupled with the claims of insufficient reimbursement, new fuel subsidies took a toll on Egypt's pocketbook. Money destined for oil and gas producers was diverted to pay for fuel subsidies. This led not only to oil companies suspending operations, but it also resulted in the country accumulating $8 B in debt to foreign firms.

With an increasing population accustomed to low-priced gasoline, diesel and electricity, in a country in political turmoil, decreasing fuel subsidies was a political non-starter. Oil and gas developers slowed production and ceased investment in new developments. From 2011–2013, no new exploration contracts were signed. Egypt, the largest non-OPEC oil producer in Africa and the second-largest natural gas producer on the continent, was witnessing a sharp demise of its oil and gas sector.

Fortunes can change quickly, however. In mid-2013, Egyptian Defense Minister Abdel Fattah el-Sisi assumed power through a military coup. Within the next year and a half, the economy began to stabilize, the Gulf Arab countries of Kuwait, Saudi Arabia and the UAE pledged $12 B in aid, new oil and gas exploration contracts were signed, plans were announced to cut fuel subsidies and Egypt began paying off its debt. At the time of this publication, Egypt has reduced its debt from $8 B to $3 B, with the possibility of eliminating its debt by the end of next year.

Also, six new contracts were signed with major oil companies in January. These contracts went to BP, Eni, General Petroleum Co., Shell, Tharwa and Trans Globe. Eni is investing $5 B for oil and gas exploration in the region, which includes the development of 200 MMbbl of oil and 1.3 Tcf of gas over the next four years.

Eni is also partnering with BP on the $12-B Denise-Karawan (DEKA) project. The DEKA project, located in the East Nile Delta, consists of five subsea wells and the installation of subsea production systems, together with subsea pipelines and onshore gas processing facilities at the El Gamil gas plant. BP expects peak production to reach 230 MMcfd.

With all capital-intensive exploration efforts, production takes time. Activity is starting in certain fields, but increasing consumption has outpaced petroleum and liquid fuels production and is quickly gaining on natural gas (**FIG. 2**).

Egypt has become a new market for natural gas imports over the short term, as demand for the fuel is at an all-time high. Whether it is through LNG or pipelines, imports are a new dynamic in Egypt's growing energy sector.

LNG, pipelines and FSRUs. Egypt has only two LNG terminals, both designed for export. Total domestic LNG export capacity is 12.7 MMtpy, but actual liquefaction activity is nearly nonexistent. With the decrease in domestic production, the LNG terminals at Damietta and Idku have been starved of gas feedstock. Supplies are so low that the 5.5-MMtpy Damietta LNG terminal has ceased operations. The two-train, 7.2-MMtpy Idku terminal is still operational, but exporting cargoes have dwindled from 50 in 2013 to only five cargoes in 2014.

LNG exports have decreased substantially over the past six years as the government has diverted gas from the export market to satisfy increasing domestic demand. The country needs more natural gas and is taking the necessary steps to secure additional supplies. However, without a functioning import pipeline or a regasification terminal to import LNG, the country is forced to lease a vessel to receive LNG imports.

In 2Q 2015, Egypt installed the country's first LNG receiving terminal. The *Höegh Gallant* floating storage and regasification unit (FSRU) (**FIG. 3**) arrived at Ain Sokhna in April 2015. The FSRU, built by South Korea's Hyundai Heavy Industries, has a regasification capacity of 550 MMcfd, as well as a cargo capacity of approximately 170 Mcm. The *Höegh Gallant* will receive and gasify LNG, and then pump the supplies to Egypt's national natural gas network. Egyptian Natural Gas Holding Co. (EGAS) has chartered the vessel from Höegh LNG for five years.

Just as the *Höegh Gallant* vessel docked in Ain Sokhna, EGAS announced plans to invest in a second LNG import terminal in Adabiya. The Adabiya LNG receiving terminal was originally planned for Ain Sokhna, but it was moved to Adabiya due to security concerns. Adabiya will also utilize an FSRU vessel with the same regasification capacity as the *Höegh Gallant.* Infrastructure preparations are underway at the Adabiya port to begin additional gas flow operations by the end of 2015.

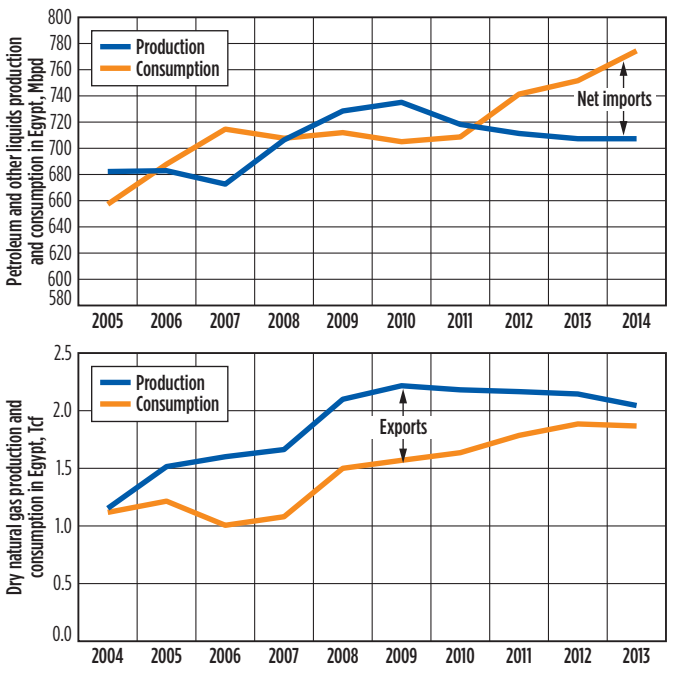

FIG. 2. Egypt's oil and natural gas production and consumption. Source: US EIA.

FIG. 3. The *Höegh Gallant* FSRU vessel. Photo courtesy of Höegh LNG.

Egypt has already secured more than $3.5 B of LNG cargoes through its 2015–2016 fiscal years. These LNG shipments will help satisfy demand until the country can restore its natural gas production.

Additional natural gas supplies could be imported from Israel. Discussions are taking place to pump Israeli natural gas, discovered at major offshore fields in the Eastern Mediterranean, to Egypt via an undersea pipeline. The natural gas supplies would travel to the Damietta LNG terminal. From there, the gas would be liquefied and exported to European markets.

Additionally, some of the gas would make its way to Egypt's gas grid to help supply the domestic market. If approved, a full ramp-up of supplies may not begin until late 2016. Until that time, Egypt will need to rely on imported LNG and domestic production to satisfy natural gas demand and help mitigate rolling blackouts.

Whether it is through additional upstream production or natural gas imports via pipeline, more gas supplies are imperative to restart the idled Idku and Damietta LNG terminals. This would bring much-needed revenue to the country and enable it to pay off its debt.

Return to the Old Kingdom. Egypt's third and fourth dynasties marked a time of great stability and economic prosperity. In the present age, new oil and gas production, increased trade and the construction of more energy infrastructure could mark a return to economic prosperity and stability, as well as the ability to supply energy needs for future generations. ■

News in brief

L.A. Turbine AMB turboexpander-compressor headed to Africa

L.A. Turbine has completed another active magnetic bearing (AMB) turboexpander-compressor unit (LAT 562EC) that was designed and built in the company's California-based headquarters and manufacturing facility. The skid-mounted L3000 AMB turboexpander-compressor (**FIG. 1**) is designed to handle a flow range of 200 MMscfd and includes a seal gas system, a PLC-based remote control panel and a magnetic bearing remote control cabinet.

Shipment of the LAT 562EC unit to a gas processing plant in North Africa is scheduled for the first quarter of 2016. L.A. Turbine will also be responsible for the installation supervision and commissioning of the unit during the first quarter of 2017.

L.A. Turbine designs and manufactures application-specific, highly engineered turboexpanders used in hydrocarbon processing, geothermal power generation and other industrial power recovery or refrigeration applications. The company is also a recognized leader in aftermarket repair, redesign, maintenance and production of spare parts for all brands and configurations of turboexpanders worldwide. A global field service team provides diagnostics, maintenance and emergency response 24/7/365. The company's global headquarters is located in Valencia, California, with sales and service support in California, Texas and Belgium. US operations address the needs of Canada, South America, Asia, Australia and the US, while its European headquarters in Belgium serves Europe, the Middle East and Africa.

FIG. 1. L.A. Turbine's newest L3000 AMB turboexpander-compressor is scheduled for a 2017 delivery to an African gas processing plant.

FIG. 2. The Gazprom Sosnogorsk GPP.

LUKOIL gas flowing to Gazprom-owned Sosnogorsk GPP

Associated petroleum gas (APG) produced from the northern group of fields owned by LUKOIL-Komi, a wholly-owned subsidiary of LUKOIL, has begun flowing to the Gazprom-owned Sosnogorsk gas processing plant (GPP).

APG supplies will enable the loading of available capacities of the Sosnogorsk GPP (**FIG. 2**), making it possible to efficiently utilize the growing APG production from the LUKOIL fields in the Republic of Komi. Total gas supplies will make up 3.9 Bcm between 2015 and 2021. APG supplies were preceded by the implementation of Gazprom and LUKOIL's joint project on rearranging the gas supply circuit for consumers within the Pechora industrial cluster.

The 2014–2024 General Agreement on Strategic Partnership is effective between Gazprom and LUKOIL, which signed an agreement to supply natural gas from the LUKOIL fields in the Northern Caspian Sea; the cooperation initiatives provide, inter alia, that Gazprom purchases natural gas from the LUKOIL fields in the Bolshekhetskaya Depression. With their Kazakh partners, both companies are engaged in geological exploration and development of the Tsentralnoye oil, gas and condensate field in the Caspian Sea.

Wärtsilä to optimise the performance of GasLog's LNG carriers

Wärtsilä, has signed a three to five-year extensive maintenance agreement with GasLog LNG Services Ltd. to ensure the operational reliability of GasLog's seven LNG carriers, which have a cargo capacity of 155 Mcbm each.

FIG. 3. GasLog's *Santiago* vessel in operation.

The demand for predictive analytics and advisory services is increasing. By analyzing the data collected from GasLog's vessels (**FIG. 3**), Wärtsilä is able to provide valuable information regarding the condition of the equipment, enabling GasLog to optimize maintenance and asset performance.

Utilization of the data collected via satellite allows GasLog to maximize intervals between maintenance periods, streamline logistics for spare part deliveries and ensure that main generating engines are operating optimally, which lowers operating costs, minimizes fuel consumption, ensures minimal emissions and lowers the environmental impact.

The broad range of services offered to GasLog under this agreement includes proactive condition-based maintenance, maintenance management services, performance monitoring and remote online support, enhancing the safe and reliable operation of GasLog's vessels. Workshop services for all 28 Wärtsilä 50DF dual-fuel engines are covered by the agreement as well.

Sinopec approved for $20-B coal-to-gas pipeline

An 8,400-km (5,200-mi) pipeline to transport synethic gas from coal-to-gas (CTG) projects in the Xinjiang region to the manufacturing hub of Guangdong province on the southern coast of China has been approved.

The pipeline, which will carry up to 30 Bcmy of gas and cost an estimated $20.5 B, could eventually also transport conventional gas, shale gas and coal-bed methane, Sinopec said.

China, the world's largest energy consumer, has made largely untested CTG technology a key part of its strategy to boost the use of cleaner fuels as it battles increasing pollution in its large cities.

Environmental groups have warned that CTG and coal-to-liquid (CTL) projects will do little to cut carbon emissions or reduce pollution. CTG technology uses vast volumes of water and produces a large amount of carbon dioxide (CO_2), but proponents argue that any carbon emissions would typically be concentrated in sparsely populated regions.

In a bid to allay concerns about the environmental risks of the process, projects will only be permitted in regions with sufficient water resources, China's National Energy Administration (NEA) said in July.

A year ago, energy giant Sinopec said it would proceed with plans to build an 8-Bcmy capacity CTG plant—the country's largest—in Xinjiang, ignoring worries that the $10-B undertaking could potentially face prohibitive costs that have plagued similar projects.

The NEA has again warned operators that are developing projects that turn coal into synthetic fuel of the underlying requirements needed for regulatory approval, as companies rush into investments that are costly and might harm the environment. ■

NGL, continued from page 16

refrigerant circulation by proper division of the required cooling load between prechiller and chiller. The impact of compression power for a two-level operation is shown in **FIG. 7.**

The case study shows that three-stage refrigeration compression with two levels of refrigeration (prechiller/chiller arrangement) significantly decreases the required compression power by about 2010 hp (1.5 MW) when compared to two-stage compression with same levels of refrigeration. Operating costs are optimized by the reduction in annual electricity consumption.

The following parameters are optimized to achieve the lowest power consumption:

- Pre-chiller duty to total required chilling duty ratio (R)—0.45
- 1st stage suction drum—18 Psia (1.24 Bara)
- 2nd stage suction drum—48 Psia (3.31 Bara)
- 3rd stage suction drum—117 Psia (8.07 Bara).

The chiller outlet temperature of –24°F (–31°C) is determined after economic analysis, as is its impact on demethanizer material selection changes from killed carbon steel (KCS) to low-temperature alloy steel. The required gas power of the propane compressor is approximately 14,600 hp (10.9 MW) in the case of an electrical motor driver. Considering the safety margins in the API standard and over design factors, the required power from the electrical drive is approximately 16,500 hp (12.3 MW). Due to the limitations of electrical overhead lines and the consequent surges in the electrical power supply during the startup of the compressor, the size of the electrical motors has been limited to approximately 5,400 hp (4.03 MW). Therefore, three 5,500 hp (4.1 MW) electric motor-driven centrifugal compressors are employed in this propane refrigeration system instead of the originally proposed two operating and one spare configuration, without consideration for any spare. ■

The "Lion City" welcomes visitors with open arms

MIKE RHODES, *Hydrocarbon Processing*

Modern Singapore (FIG. 1) was founded in the 19th century as the British sought an ideal base for its merchant fleet and to forestall any Dutch advances along the Malacca Strait. A treaty with the local rulers established the city as a trading station, quickly attracting immigrants from China, India, the Malay Archipelago and beyond. Development continued with the establishment of key banks, commercial associations and chambers of commerce. In 1924, a causeway opened linking the northern part of Singapore to Johor Bahru.

The Japanese invasion in December 1941, and the ensuing Allied surrender, dealt a major blow to Singapore's prosperity. After the war, Singapore became a British Crown Colony until the growth of nationalism led to self-government and the country's first general election in 1959. Singapore became part of Malaysia when it was formed in 1963, but moved away two years later to become an independent and sovereign democratic nation.

Oh, the places you'll see! With thrilling attractions, golden beaches, luxe retreats and the country's first integrated resort, **Sentosa Island** is Singapore's favourite leisure destination.

Sentosa used to be called Pulau Belakang Mati, or "island of death from behind" in Malay, because of the tales of piracy and bloodshed surrounding it. Due to its strategic location, it served as a British military fortress until World War 2, when it became a prisoner-of-war camp during the Japanese Occupation.

In the 1970s, a dramatic makeover and a new name transformed the island. There is something for everyone: renowned golf courses, a yachting marina, luxurious residences, nature trails, spas and 3.2 km of pristine, sandy beaches: Siloso, Palawan and Tanjong. Foodies can indulge in hawker fare or world-class dining at Resorts World Sentosa, Saint Pierre, Blue Lotus and Sabio By The Sea.

A 15-min. drive or a short ride on the Sentosa Express from VivoCity make getting there a breeze; or just take the cable car from HarbourFront, a vibrant neighbourhood across the water, and enjoy spectacular views of Sentosa and the city.

If you are interested to know more about the country's history and art, the **Civic District Art Trail** dives into the heart of the city's past, from prominent historical figures such as Sir Stamford Raffles, the man who founded Singapore, to up-and-coming architectural icons of the 21st century. You can admire the works of some of Singapore's pioneering sculptors, tour restored homes, see the **Arts House** (formerly the Parliament House, built in 1827) (FIG. 2), and follow the sounds of music to the **Victoria Theatre and Concert Hall.** If you are asked to visit **"The Chopsticks",** you will not find food, but instead will experience the **Civilian War Memorial,** honouring civilians killed during the Japanese Occupation.

A short walk takes you to **Esplanade Park,** with historical landmarks such as the **Lim Bo Seng Memorial** and the **Cenotaph.** Just across the road is the **Esplanade—Theatres on the Bay,** known for top-notch arts performances. Locals call it "the durian" for its unique architecture that seems to resemble the prickly fruit. Speaking of architecture, Singapore boasts some of the most interesting and forward-thinking designs in the world. These are just a few of the many attractions the city offers.

Local flavours that you should not miss. Singapore's multi-ethnic culture and heritage have served up a multitude of colourful cuisines, each with its own unique flavour and aroma. The delicious mixture of cultures that is Singaporean cuisine will delight you. **Chili crab,** shown in FIG. 3, is one of the most popular dishes, with a tangy gravy that seeps into the flesh of the stir-fried crab. When translated from Malay to English, **nasi lemak** means "rich rice," which refers not to wealth but to the coconut cream that makes this dish irresistible. This flavourful dish mixes aromatic rice infused with coconut milk and pandan leaves, and it is eaten with deep-fried fish or chicken wings, "otah" (grilled fish paste), fried "ikan bilis" (local anchovies), peanuts, eggs, cucumber slices and "sambal" (spicy chili paste). **Kaya toast** is the ultimate comfort food for those of us with a sweet tooth, with the perfect mix of crunch and sugar rush. **Roti prata** is a south-Indian flat bread made by frying stretched dough and flavouring it with ghee (Indian clarified butter). This delicious dish is normally served with fish or mutton curry. Try some **rojak** (which means "eclectic mix" in colloquial Malay), a local salad of mixed vegetables, fruits and dough fritters covered in a dark and sticky sauce and garnished with chopped peanuts and finely-cut fragrant ginger flowers for a piquant taste. Head to the Maxwell Food Centre in the heart of Chinatown for authentic local fare, such as **Hainanese chicken rice.** Don't forget, you won't have to go far to get a taste of Singapore's famous street food.

Festivals and events happening now. There is always a party going on somewhere on the island, whether it is a celebration of the Chinese New Year, the excitement of Formula 1 races, or the thrill of watching world-class athletes at the **BNP Paribas WTA Finals Singapore,** happening now from 23 October—01 November at the Singapore Indoor Stadium. On select nights from 02–31 October, check out **Universal Studios Singapore,** which has one of the most intense and immersive Halloween events anywhere, with four horrifying haunted houses, three terrifying scare zones and thrilling rides. The **Singapore Wine Fiesta 2015** in Clifford Square from 22–25 October features acclaimed winemakers from around the world for four days of tastings, complimentary masterclasses and live performances.

The **Singapore River Festival,** 23–25 October, is a three-day celebration of the diverse offerings, history and heritage of the Singapore River area, featuring aerial theatrical performances, art installations and a market with homegrown music and crafts. Under the big top next to the Marina Bay Sands, **Cirque Du Soleil—Totem** performs a show that explores human evolution, from 28 October–22 November.

Up-and-coming fashion designers from Singapore and the world parade their latest creations at the annual **Digital Fashion Week Singapore,** held in the Capitol Theatre from 29 October–01 November.

Shop 'till you drop. Whether you are looking to indulge, scout for uncommon threads, or simply add that stylish piece to your wardrobe, you can find it all in fashion-forward Singapore. From luxury boutiques to streetside flea markets, the city is a shopping paradise.

The shoppes at **Marina Bay Sands,** with its nautical-inspired glass and crystal pavilion, include the Louis Vuitton Island Maison store, the first Maison concept store in Southeast Asia, and a broad selection of current collections, curated books and artworks. New York-based Proenza Schouler has set up shop here, its first international outpost outside the US, to entice us with a full collection of highly covetable clothes and bags.

The prime shopping district (FIG. 4) is the 2.2-km (1.4-mi) **Orchard Road,** yet another area that supplies innumerable spending opportunities and home to famous flagships such as H&M, Forever 21 and Abercrombie & Fitch. Front Row at **Raffles Hotel** is the place to go for hard-to-find cult brands from across the region, including fashions from Singapore, Thailand, Japan and Korea. These areas represent only a small portion of the shopping opportunities.

We welcome you to our city and hope you enjoy every moment of your stay. ■

Information courtesy of www.yoursingapore.com

FIG. 1. A bird's eye view of Singapore's fantastic skyline (Source: Beboy Photographies).

FIG. 2. The city's history is reflected in some of its architecture. The former Parliament House was built in 1827.

FIG. 3. Chili crab is a local favourite, and a must have during your stay.

FIG. 4. The bright lights will welcome you to the 2.2-km shopping paradise of Orchard Road.

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