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The IGU Vision and Mission were recently redefined to reflect changes in the global gas markets and the growth of the organisation in recent years. The new Vision and Mission – approved at the IGU Council meeting in Paris, France, June 1, 2015 – reflect IGU’s Building for the Future outreach initiative and aim at making IGU a more proactive, focused and effective advocate for the global gas industry. With the changes, focus is moved towards IGU as the Global Voice of Gas and emphasis put on the fact that natural gas is a key contributor to people’s lives and futures.

**Vision**
As the global voice of gas, IGU seeks to improve the quality of life by advancing gas as a key contributor to a sustainable energy future.

**Mission**
- IGU is the key and credible advocate of political, technical and economic progress of the global gas industry, directly and through its members and in collaboration with other multilateral organisations.
- IGU works to improve the competitiveness of gas in the world energy markets by promoting transparency, public acceptance efforts and the removal of supply and market access barriers.
- IGU seeks to collaborate with governmental agencies and multilateral organisations to demonstrate the economic, social and environmental benefits of gas in the global energy mix.
- IGU supports and facilitates the development of new technologies and best practices, while emphasising sound environmental performance, safety, reliability and efficiency across the entire value chain.
- IGU maximises the value of its services to members and other stakeholders.
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Unless otherwise stated, the dollar ($) values given in this magazine refer to the US dollar.
Dear readers,

Greetings from the USA Presidency and the Secretariat on the first anniversary of the transfer of the Secretariat from Oslo to Barcelona.

Over the past year, we have continued to increase our efforts to ensure that policymakers and key stakeholders recognise the important contribution that natural gas makes to the global energy system.

To this end, IGU tabled the report *Enabling Clean Marine Transport* at the G20 Energy and Sustainability Working Group under the German G20 Presidency. The report lays out the opportunities and challenges of LNG as a marine transport fuel. We launched *Global Natural Gas Insights*, a handy little gas facts book. We refreshed our website (www.igu.org) to make current and relevant information easily accessible. We held timely working sessions with the IEA and industry experts on global sector trends and on the issue of methane emissions, ahead of IEA’s upcoming WEO report focusing on natural gas.

In order to be more accessible and influential to global media outlets, IGU also held its first Media Day in London, UK. This event brought journalists from the global media to meet some of IGU’s most influential members.

Equally important, through our colleagues in Argentina, we are working to ensure that natural gas features prominently during Argentina’s G20 Presidency in 2018.

In May 2017, the International Gas Union Research Conference (IGRC 2017) was held in Rio de Janeiro, Brazil. This was the first time this premier forum on R&D and innovation was held in Latin America and once again it allowed for excellent discussions on recent research and innovation. IGU thanks the event organiser IBP, Jorge Delmonte, Cynthia Silveira and their teams and the IGU R&D and Innovation Committee for a successful event.

IGU events are a key part of our outreach strategy, but also an opportunity for IGU to create value for our members. As a result, we are pleased to inform you that for the LNG 2019 International Conference and Exhibition, the National Organising Committee (NOC) from Shanghai will offer a discount to IGU members for both exhibition space and delegate fee registration. IGU’s Events Director Rodney Cox can provide additional details on this exciting new feature.

A milestone event for our association this year is, of course, the election for IGU President 2021-2024 and host of the World Gas Conference (WGC 2024). The election will be held during the IGU Council meeting in Tokyo on October 26, 2017. You may already know the results of the election as you read this issue of the IGU magazine. Still, let us highlight the importance of having three excellent candidates participating in this election: Canada, China and Egypt and Oman jointly. All candidates are active IGU members and strong players in the global gas industry.

Canada has been a member of IGU since 1933 and hosted the 14th WGC in Toronto in 1979. Currently Canada has one seat on
the IGU Executive Committee, as Regional Coordinator for North America. The country is actively promoting the development of new exports of LNG and remains a critical player in North America’s integrated natural gas market.

China has been an IGU member since 1986. In 2016, it hosted a successful G20 Natural Gas Day in Beijing. In 2019, the China LNG Association will host LNG 2019 in Shanghai. Currently China holds two seats on the Executive Committee, one as elected Charter Member and one as Regional Coordinator for Asia and Asia Pacific. China is very active in promoting the development of its gas industry, through both imports and increased domestic production.

Egypt joined IGU in 1989, while Oman became a member in 2002. Both are actively supporting IGU. Oman hosted the Executive Committee meeting in Muscat, Oman, last March and Egypt will host the same meeting in Cairo in 2018. Oman also provided the IGU Secretariat with a secondee for a two-year period in 2013-15. Egypt currently holds one seat in the Executive Committee as Regional Coordinator for the Middle East and Africa. Both Egypt and Oman are very active in promoting their natural gas industries and will increase both exports and imports. It is the first time that a pair of countries present a candidacy jointly, and neither Africa nor the Middle East has hosted a WGC before.

The Tokyo Council meeting will be a place to shape IGU’s future in terms of the presidential leadership. But just as important, proposed changes in IGU governance and structure, changes aimed at strengthening both the organisation’s capabilities and finances to better serve our members well and advocate effectively for natural gas will be discussed.

A key feature of the “Building for the Future” project is moving forward with a plan to establish a permanent IGU headquarters.

Our IGU members expect and deserve value from their membership in IGU, be it from networking with each other, knowledge building or advocating for expanded gas markets. We remain committed to this mission and thank you for your ongoing support. See you in Tokyo!

Yours sincerely,

David Carroll
IGU President
Luis Bertrán Rafecas
IGU Secretary General
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Features

To mark the first LNG cargo being shipped from an offshore floating production facility on April 1 this year, we start the features section with an overview of the technology that makes it possible, the current vessels in operation and future developments in the field.

Staying with the subject of LNG, Mel Ydreos, IGU Executive Director of Public Affairs, writes on the subject of LNG as a marine fuel. While it is a cleaner alternative to marine diesel and heavy fuel oil, and a solution to environmental, economic and social challenges for the shipping industry, there are barriers to adoption that need to be surmounted. The subject is further discussed in one of IGU’s latest reports *Enabling Clean Marine Transport*.

With Charter Member the Japan Gas Association hosting IGU’s 2017 Council meeting in Tokyo, we invited Nobuo Tanaka, one of IGU’s Wise Persons Group to share his thoughts on the opportunities and challenges that face the gas industry in our current time of unpredictability. Following on from that we present a timeline of the development of Japan’s gas industry from its beginnings in 1871 with the manufacture of gas from coal to light the Imperial Mint in Osaka to its position today as the world’s largest importer of LNG.

The 27th World Gas Conference is fast approaching; as the final preparations are taking place we have an update from Jay Copan, Executive Director of WGC 2018. At the close of the conference in Washington DC next June, the IGU Presidency will pass to Korea. Work to prepare for the transition is already well underway and we close the features section with an update from Suk-Hwan Park, Secretary General of the Korea Gas Union, on the IGU Vice Presidency and the plans taking shape for the 28th World Gas Conference which will be held in Daegu in 2021.
Landmark first export cargo for floating LNG

By Mark Blacklock

Years of research and development into the marinisation of liquefaction technology bore fruit on April 1, when the first LNG cargo from an offshore floating production facility was shipped to market. The pioneering projects are set to be joined by a number of others, although the floating sector is not going to expand as rapidly as once thought due to the current low gas prices and glut of conventional capacity.

There are two main types of floating liquefaction projects: those designed to monetise otherwise stranded offshore gas resources and those, typically nearshore projects, where building a liquefaction plant in the controlled environment of a shipyard and towing it to site is a cost-effective alternative to building an onshore facility. In each case the flexibility of being able to relocate the plant is an added benefit.

While Shell’s Prelude was the first floating liquefaction project to be launched – FID was reached in May 2011 – the honours for the first operational project go to Petronas whose FLNG Satu got the go-ahead in March 2012 as part of the company’s efforts to unlock gas resources in Malaysia’s remote and stranded fields.

Petronas FLNG Satu is moored 79m above the Kanowit gas field, 180 kilometres offshore Bintulu, Sarawak. The vessel, 365m long by 60m wide, has a production capacity of 1.2 mtpa and storage for 177,000m³ of LNG. Classified by DNV GL, it was built by a consortium of Daewoo Shipbuilding and Marine Engineering (DSME) and Technip (now Technip-FMC) and uses the Air Products AP-NTM process.
and equipment. The vessel arrived at the field at the end of May 2016 and first gas was reported that November with the first export cargo being shipped to Korea on the LNG carrier Seri Camellia on April 1.

While building up operational experience with FLNG Satu, Petronas is working on a second project, although the timescale for start-up has been pushed back from 2018 to 2020. FLNG Dua is a slightly larger vessel, 381m long by 64m wide, with a production capacity of 1.5 mtpa using the AP-NTM process and storage capacity of 177,000m³. Classified by the American Bureau of Shipping (ABS), it is being built by a consortium of Samsung Heavy Industries (SHI) and JGC Corporation and is destined for the Rotan field, 240 kilometres offshore Kota Kinabalu, Sabah. Rotan is a deepwater field with depths of up to 1140m. Whereas Kanowit is operated by Petronas, Rotan is operated by Murphy Oil with Petronas holding a 20% stake.

Both vessels are designed for 20 years of service before dry-docking and have SOFEC external turret mooring systems.

### Prelude commissioning underway

Prelude FLNG is a much larger project with a total liquids production of 5.3 mtpa (3.6 LNG using Shell’s dual-mixed refrigerant process, 1.3 condensate and 0.4 LPG) and storage for 220,000m³ of LNG, 126,000m³ of condensate and 90,000m³ of LPG. INPEX (17.5%), KOGAS (10%) and CPC (5%) joined Shell as partners in 2012.

 Classified by Lloyd’s Register, Prelude is the world’s largest floating structure, 488m long by 74m wide, and was built by a consortium of SHI and Technip (now TechnipFMC) to develop the Prelude and Concerto fields 200km offshore north-western Australia in the Browse Basin at water depths of 250m. It has been designed to withstand category 5 cyclones (although production will be suspended during harsh weather conditions) and to operate for 25 years before dry-docking. The internal turret mooring system was designed by SBM Offshore and three Rolls-Royce thrusters ensure the vessel can keep its heading against the wind, current and waves to allow safe tanker berthing.

Prelude was handed over in late June and towed to its location. Commissioning is underway and the first commercial cargo is expected in 2018. But Shell’s plans for further FLNGs have been put on hold for the time being.
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Golar has lined up three of its LNG carriers for conversion at the Keppel shipyard in Singapore by adding sponson structures to the sides as integral structural sections providing space and deck area for process and utility systems. Each vessel will have a production capacity of 2.4 mtpa using four trains and a storage capacity of 125,000m³ or 126,000m³. They are suitable for sites with benign sea conditions and can be completed in about half the time of a new-build.

The first conversion was of the Golar Hilli (now renamed Hilli Episeyo) for the Cameroon FLNG project. Société Nationale des Hydrocarbures du Cameroun (SNH) and Perenco are the upstream partners developing the Sanaga Sud and Ebome fields, 10km offshore Kribi. Keppel (10%) and Black & Veatch (1%) are partners with Golar (89%) in ownership of the Hilli Episeyo. Production is due to start by the end of 2017 under an eight-year contract and will use two of the vessel’s four trains for an output of 1.2 mtpa. Gazprom Marketing & Trading will be the sole off-taker. Subject to FID, expected by the end of the year, the second conversion will be of the Golar Gandria for the Fortuna FLNG project offshore Equatorial Guinea. The Fortuna complex is in Block R, some 100km southwest of Bioko Island, in water depths up to 1,900m. Ophir Energy holds an 80% interest in Block R and GE Petrol 20%. A joint operating company of OneLNG – a joint venture of Golar and Schlumberger – (66.2%) and Ophir (33.8%) will develop, finance and operate the Fortuna project, owning Ophir’s share of the Block R licence and the Golar Gandria. First gas is targeted for 2020 and initial output will be 2.2 mtpa with Gunvor Group as the sole off-taker. Further development is proposed to double output which would see a second vessel in service by 2025.

The third candidate for conversion is the Golar Gimi and a customer is being sought. Golar is also working on longer-term tolling. Tolling
Two shipping companies, Golar and Exmar have been working on a tolling model for floating liquefaction with Golar converting LNG tankers to DNV GL classification and Exmar commissioning a purpose-built barge to Bureau Veritas classification. Both companies are using Black & Veatch Prico single mixed refrigerant technology.

Exmar’s Caribbean FLNG, 144m long by 32m wide with a capacity of 0.5 mtpa and storage of 16,100m³, was built by Wison Offshore & Marine in Nantong, China. It was originally destined for use by Pacific Exploration & Production (formerly Pacific Rubiales) in Colombia, where it would have been moored to a jetty off Tolú on the country’s Caribbean coast to process gas brought by pipeline from the onshore La Creciente field. However, changing market conditions made the project unviable and it was cancelled in March 2016. Construction of the barge was well underway so it continued and was handed over in July but an order for a second barge was cancelled. Exmar is now looking for a customer for Caribbean FLNG.
Meanwhile, three other FLNG projects are nearing FID in Mauretania and Senegal (a joint one), Congo-Brazzaville and Cameroon (a second one in addition to Cameroon FLNG).

Tortue FLNG is being developed by BP and Kosmos Energy in partnership with the NOCs of Mauritania and Senegal to exploit gas resources in the Greater Tortue area in depths of up to 2,700m. The working interests in Mauritania are BP 62%, Kosmos 28% and Société Mauritanienne des Hydrocarbures et du Patrimoine Minier 10%, while in Senegal they are BP 60%, Kosmos 30% and Petrosen 10%.

The plan is for an FPSO unit above the field and a 140km pipeline to bring the gas to two FLNG vessels, anchored behind a breakwater 8km offshore on the maritime boundary between Mauritania and Senegal. Each vessel would have a capacity of 2.3 mtpa with start-up for the first projected in 2021/2 followed by the second in 2023/4.

The Congo-Brazzaville project involves the Nkala field in Marine XII block 20km offshore in a water depth of 38m, which is operated by Eni with a 65% share. Its partners are New African Global Energy (New Age) with 25% and Société Nationale des Pétroles du Congo with 10%. New Age is driving the midstream development project with new-build vessels suitable for harsher weather conditions (see below).

**African build-up**

Mozambique is the latest country to opt for FLNG with FID for the first phase of the Coral South project being reached in June. The Coral discovery lies in the Rovuma Basin (Area 4) some 50km offshore near the border with Tanzania in depths of up to 2,000m.

Eni is the operator of Area 4 with a 50% indirect interest owned through Eni East Africa (EEA), which holds a 70% stake in Area 4. CNPC owns a 20% indirect interest in Area 4 through EEA. The other concessionaires are Galp Energia (10%), KOGAS (10%) and Empresa Nacional de Hidrocarburos (10%). In March, Eni signed an agreement to sell 50% of its shares in EEA to ExxonMobil, which is subject to regulatory clearance.

The project involves the construction of six subsea wells connected to an FLNG vessel to be built by a consortium of TechnipFMC, JGC and SHI. SOFEC will supply the turret mooring system. The vessel will be 439m long by 65m wide with a capacity of 3 mtpa of LNG and 0.48 mtpa of condensate. First gas is expected in 2022 and the entire production will be sold to BP under a 20-year contract.
Of Cameron Parish, Louisiana, linked by an existing gas pipeline to a new onshore compression plant. The pipeline was originally built to transport gas from offshore wells in the Gulf of Mexico into the US grid, and the compression plant will allow the flow of the pipeline to be reversed to supply processed gas to the port. Each vessel will have a capacity of 3.25 mtpa and would move to protected waters in the event of a hurricane.

The project is being developed by Delfin Midstream and Golar, who claim it will have the lowest liquefaction costs in North America. Delfin has completed the permitting process with the US Department of Energy, Maritime Administration and Coast Guard and received non-FTA export authorisation in June. FID for the first phase is expected in 2018 with start-up in 2021/2.

The Main Pass Energy Hub 26km offshore Louisiana was originally planned and permitted as an LNG import terminal before the impact of the US shale gas boom was felt. The import project was dropped and the project site and associated assets subsequently acquired by Global LNG Services (GLS) which is planning two FLNG vessels using its proprietary Liqui-Max process. Pre-processing of the gas would be carried out on offshore platform structures with the gas then supplied to the vessels for liquefaction. Each vessel would be 390m long by 64m wide with a capacity of 12 mtpa and storage for 300,000m³. They would be built by Sembcorp Marine in Singapore with Siemens responsible for the topside modules. FID is scheduled for early 2019 with start-up in 2023.

IGU’s World LNG Report shows there are many more FLNG projects proposed and all eyes will be on the ones that have got the go-ahead to see how their economics work out in practice.

Mark Blacklock is Editor-in-Chief of International Systems and Communications.
Sempra LNG & Midstream develops and builds natural gas liquefaction facilities, LNG receipt terminals, midstream natural gas infrastructure and is active in the sale of LNG worldwide.

Quick facts:

- Sempra LNG & Midstream developed one of the first liquefaction export facilities in the U.S., Cameron LNG in Louisiana; and the first LNG receipt terminal on the west coast of North America, Energía Costa Azul in Baja California, Mexico

- Liquefaction projects in development including Cameron LNG expansion, Port Arthur LNG in Texas and a liquefaction facility at Energía Costa Azul

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LNG – the key to unlocking cleaner marine transport?

By Mel Ydreos

Urban air pollution has become a top priority for local, national and international governments in both developed and developing countries. The World Bank estimates that one in every ten deaths worldwide is attributable to air pollution exposure, with the cost of these premature deaths to the global economy – through foregone labour income – estimated at a staggering $225 billion annually. (Source: The Cost of Air Pollution: Strengthening the Economic Case for Action – www.openknowledge.worldbank.org/handle/10986/25013). With these kind of findings, it’s clear that reduction of harmful emissions must be a priority for governments across the globe.

While many factors contribute towards the issue, marine transportation is an often overlooked contributor to negative air quality levels – with one large container ship, powered by 3% sulphur bunker fuel, emitting the same amount of sulphur oxide gases as 50 million diesel-burning cars.

Ship emissions have a detrimental impact on both human health and environmental costs. While many may think these pollutants are distributed way out at sea, the vast majority (70%) of these emissions are actually produced within 400 km of coastal population centres. This means that in the world’s top 100 ports, roughly 230 million people are directly exposed to harmful emissions. In Hong Kong, for example, ship traffic is responsible for half of the city’s total toxic pollutants – even more so than those produced by the power generation and transportation sectors.

In addition to the issues surrounding health, there is also a significant economic cost involved. The OECD estimates that the external costs of nitrous oxide, sulphur oxide and particulate matter for the world’s 50 largest ports total an incredible €12 billion per year. Table 1, pulled from IGU’s recent report Enabling Clean Marine Transport into the role of LNG in enabling cleaner marine transport, highlights some of the more heavy-hitting costs to specific areas.

Highlighted by the examples and case studies in Table 1, the global shipping sector faces a massive challenge – how to significantly reduce these dangerous levels of harmful emissions in accordance with recent legislation. Annex VI of the International Maritime

Source: China Daily Asia, Ship Emissions Choking the Region, May 20, 2016
fuels to LNG can generate reductions in sulphur oxide of over 90%; carbon dioxide of up to 29%; greenhouse gases by up to 19%; and a huge 85% reduction in particulate matter.

Economic drivers
A switch to LNG can generate significant savings in the cost of fuel to shipping operators – dependent on the vessel type and operational specifics of a fleet. Bunkering of LNG can also prove to be a lucrative business for port jurisdictions, unlocking an additional stable market and potential revenue stream. It may also benefit the local economy through creation of jobs and local infrastructure investment, with further indirect benefits including new product development and innovation spillovers, as well as creating further energy security in jurisdictions with limited domestic energy resources.

Environmental drivers
The use of LNG in marine transport delivers significant reductions in pollutions from shipping exhausts and greenhouse gas emissions. A full transition from traditional petroleum fuels to LNG as a cleaner alternative

Examples of emissions cost estimates from literature

<table>
<thead>
<tr>
<th>Port</th>
<th>Indicator</th>
<th>Estimated cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bergen (Norway)</td>
<td>Emissions of ships at berth</td>
<td>€10-22 million</td>
</tr>
<tr>
<td>13 Spanish ports</td>
<td>PM2.5, SO2, NOx</td>
<td>€206 million</td>
</tr>
<tr>
<td>Pireaus (Greece)</td>
<td>External cost per cruise passenger</td>
<td>€2.9-10.4</td>
</tr>
<tr>
<td>Kaohsiung (Taipei)</td>
<td>Emissions of ships at berth</td>
<td>€119.2 million</td>
</tr>
</tbody>
</table>

Source: OECD, 2014

The wider adoption of LNG as a marine fuel will deliver environmental, economic and social benefits.
**Social drivers**
The societal benefits from switching to cleaner LNG-fuelled shipping can, in some way, be seen as an extension of the economic benefits; however, due to a lack of price mechanisms for pollution and its negative impacts on health and mortality, they are characterised differently. It is hard to put a price on human health and wellbeing.

Air pollution from shipping contributes heavily towards respiratory, pulmonary, and oncological diseases, as well as premature deaths. Although not explicitly priced, these phenomena have real economic costs and adverse GDP impacts (as outlined earlier).

**Barriers to adoption**
While the many benefits of LNG are apparent to those who understand them, and many across the industry more generally, there are a number of barriers to the wider deployment of LNG as a marine transportation fuel.

**Regulatory barriers** stand at the forefront. Existing currently is a patchwork of regulatory bodies and regimes, all enforced regionally by different governments on international, national and sub-national levels. With LNG marine fuel as a fairly new application, some may have restrictions for LNG-fuelled ships and bunkering, effectively banning LNG shipping activities (by marking LNG as a hazardous substance, for example), while others may lack a regulatory approach to the sector entirely. The same goes in terms of emissions controls, with standards in port areas often falling behind the common international standard depending on local factors.

**Commercial barriers** also stand in the way. Many shipping operators struggle to gain access to the capital required for investment in LNG shipping, as financiers are often hesitant to commit capital due to the limited experience and knowledge around the sector. This is proving an issue, as the initial investment needed for LNG conversion and new-builds is higher than for conventionally-fuelled ships. This in turn impacts the certainty around resale value, which is regularly cited as a risk. Uncertainty surrounding future fuel prices can also be a factor, as operators and charterers are unsure as to the future price of LNG (although this uncertainty is no different to the uncertainty surrounding petroleum fuels).

**Technical barriers** also play a key role. Current bunkering capabilities for LNG are in their early stages, and not as widely available globally as conventional bunkering – as such, many operators fear the imposition of additional costs. In addition to the existing substantial bunkering capacity developing globally, ports must invest more heavily in infrastructure in order to bypass this barrier and stimulate further demand. This will also help bypass the additional barrier that always surrounds newer technologies, as operators see the process first-hand – also addressing any concerns around safety.

We at IGU are confident that the majority of the above will be addressed by the market as the industry continues to gain experience with the technology and its application.

It is essential that governments assist this process by accelerating technology demonstrations and R&D funding, to improve marine LNG technologies and enhance operational learning.

The benefits of LNG as a marine fuel are clear – policy action is urgently required, and would be most valuable in addressing the regulatory and commercial barriers, which are slowing the development and deployment of cleaner LNG marine technologies, even when the business case is strong.

*Mel Ydreos is IGU’s Executive Director of Public Affairs. The IGU report Enabling Clean Marine Transport can be downloaded from the IGU website at www.igu.org/sites/default/files/IGU_A4_CleanMarineTransport_Final%20version.pdf.*
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To mark Japan’s hosting of the 2017 Council meeting, the IGU Magazine asked the Japanese member of IGU’s Wise Persons group to look at the opportunities and challenges for natural gas. We also have a timeline of key developments in Japan’s gas market.

“Unpredictability” was a popular buzzword at the Gastech 2017 conference held in April in Tokyo.

Thanks to the US shale revolution the Henry Hub gas price has been so low that gas became the leading power generation source in the US in 2016, replacing coal and reducing CO2 emissions. This development in the world’s largest gas producer and consumer contributed to global energy-related CO2 emissions being flat for a third straight year in 2016 despite global economic growth. This is a triple win for natural gas simultaneously addressing environmental concerns and economic growth as well as energy security.

The recently announced “Energy Dominance” strategy of the US favours domestic production of fossil fuels and is likely to further encourage shale oil and gas production. Indeed, the US is the game changer of the natural gas market. According to the IEA (Gas Market Report 2017), the US will account for 40% of the world’s extra gas production to 2022, leading to the second stage of the shale gas revolution as new LNG export projects expand gas trade. Over 70 bcm of new liquefaction capacity is under construction in the US with many more projects proposed. Expanding US LNG exports will reshape the LNG market with market based pricing and flexible destination clauses. In Asia, lower prices may bring new LNG importers into the market while encouraging large users to further expand gas consumption. The Golden Age of Gas is happening in the US and elsewhere thanks to the new US LNG supplies.

And yet, President Trump’s foreign policy is fostering unprecedented unpredictability as regards the geopolitics in the Middle East. His strong support for Saudi Arabia seemed to encourage three Gulf nations and Egypt to cut off diplomatic relations with Qatar in June. In fact, Qatar has played a pivotal role in LNG security by providing more than half of global uncontracted LNG volumes in the tightened market caused by the Fukushima nuclear accident (IEA’s Global Gas Security Review 2016). President Trump has also been questioning the value of the nuclear agreement reached with Iran in 2015, which is known as the Joint Comprehensive Plan of Action (JCPOA). So far he agrees with Iran’s compliance with the JCPOA but, if the US should revoke the deal, it
would significantly destabilise the Middle East and push the Persian Gulf into crisis. This is a nightmarish scenario for the Executive Director of the IEA and a very serious energy security risk for Asian nations which need more and more oil and gas from the region.

The US’s withdrawal from the Iranian deal may increase geopolitical risks in north-east Asia. As Executive Director of the IEA, I was invited to the G8 Summit meeting in L’Aquila, Italy in 2009. This was the first summit for President Obama. At the lunch table with invited African leaders, I sat next to Colonel Qaddafi from Libya. He was outspoken in his criticism of colonialism for fostering African misery. Hosni Mubarak of Egypt, Jacob Zuma of South Africa and other African leaders agreed saying “the problem is colonialism”. Then President Obama entered the debate and said, “I understand the African situation well because I have a cousin in Kenya. He told me that to get a job in Kenya he has to bribe government officials. But bribery or corruption didn’t come from colonialism”. Angela Merkel of Germany, Nicolas Sarkozy of France and Gordon Brown of the UK echoed him by saying “the issue is corruption”. The discussion was reoriented dramatically by the eloquent President Obama. Recently I heard a story from the then Japanese Ambassador to Libya that Qaddafi started an anti-corruption campaign in early 2010 and believed that the US would never go to war with him. Qaddafi also revealed at the G8 lunch that he had abandoned his nuclear weapons programme and tried to convince North Korea to do the same but in vain. Qaddafi did comply with the US but he was eventually killed in the Libyan civil war. Unintentionally maybe, but the US sent too clear a message to North Korea; its leader, Kim Jong-un firmly committed to nuclear bomb and missile development by saying he would never repeat the mistakes of Saddam Hussein and Qaddafi. There’s no point crying over spilt milk. But if the US should revoke the Iranian nuclear deal, it would send another clear message to Kim Jong-un in favour
of continuing nuclear weapons development over diplomatic dialogue. Geopolitical risks are contagious.

Another uncertainty created by President Trump is his withdrawal from the COP 21 Paris Agreement. The leadership role for sustainability may shift from the US to the EU and China. In this respect the news about France and the UK banning sales of gasoline and diesel cars by 2040 is very important. As China commits strongly to electric vehicles, it may eventually join France and the UK to combat air pollution and maintain industrial competitiveness. The cost of batteries is coming down significantly and electrification of the transportation sector may bring peak demand for oil much earlier than expected. Is this good for natural gas? As gas is cleaner than coal and oil, it enjoys increasing demand, replacing coal power for the time being. But to achieve the Beyond 2°C Scenario (B2DS), whereby the energy sector reaches carbon neutrality by 2060 to limit the atmospheric temperature rise to well below 2°C, carbon capture and storage (CCS) technologies must be fully applied to gas and even to biomass as well as coal power. Another option for gas producers may be to separate CO₂ and export only hydrogen as “clean fuel” while injecting CO₂ for enhanced oil recovery (EOR). The former Oil Minister of Saudi Arabia, Ali Al Naimi always told me that Saudi Arabia could export “clean oil” through innovation and Saudi Aramco is studying hydrogen technology under the ambitious “Vision 2030” strategy. Another Saudi ex-Oil Minister, Zaki Yamani, once said, “The Stone Age didn’t end because we ran out of stones”.

The IEA acknowledges that the challenge of achieving net-zero emissions by 2060 is daunting. We have to prepare for an uncertain but very risky future. Possible energy scenarios help us out of “unpredictability” by identifying the costs, benefits and risks involved.

Nobuo Tanaka is the Chairman of the Sasakawa Peace Foundation (www.spf.org) and a member of IGU’s Wise Persons Group. He was Executive Director of the International Energy Agency (www.iea.org) from September 2007 to August 2011.

This graph shows the cumulative emissions reductions to net-zero in 2060 under the Beyond 2°C Scenario (B2DS), by source of savings.

RTS is the IEA’s Reference Technology Scenario, incorporating current policies and pledges including the Nationally Determined Contributions (NDCs) pledged under the Paris Agreement. These efforts would result in an average temperature increase of 2.7°C by 2100.

The 2°C Scenario (2DS) lays out an energy system pathway and a CO₂ emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100.

B2DS explores how far deployment of technologies that are already available or in the innovation pipeline could take the world beyond the 2DS, achieving net-zero emissions by 2060. The B2DS falls within the Paris Agreement range of ambition, but does not purport to define a specific temperature target for “well below 2°C”.

Source: IEA, Energy Technology Perspectives 2017.
Sustainable Future with Natural Gas

Since the first LNG import from Alaska in 1969, Japan has been leading the realization of a sustainable future with natural gas by promoting energy saving and low carbon technologies.

www.gas.or.jp/en/

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A timeline of major events for the gas industry in Japan

1871 The manufacture of gas from coal begins for lighting in the Imperial Mint in Osaka; the use of gas for lighting spreads to other cities such as Yokohama (1872) and Tokyo (1874). Cities set up Gas Boards.

1885 Tokyo Gas, today Japan’s largest gas utility, is set up from the Tokyo Gas Board.

1886 Tokyo Electric Lighting set up; the focus of gas marketing moves from lighting to cooking and heating.

1897 Osaka Gas, today Japan’s second largest gas utility, is founded; it starts supplying gas in 1905.

1912 The Imperial Gas Association is founded.

1923 On September 1, the Great Kanto earthquake causes extensive damage in Tokyo and surrounding areas but gas supplies are resumed after two months.

1945 Following World War II the Japanese gas industry rebuilds. The gas industry body goes through a number of changes until in 1947 the
Japan Gas Association is founded, becoming a Charter Member of IGU in 1952.

**1950s** The manufacture of gas from crude oil is introduced.

**1959** The Higashi-Niigata gas field on the west coast is discovered.

**1962** Natural gas from the Higashi-Niigata field is supplied to Tokyo via a 329km pipeline. Following subsequent discoveries domestic natural gas production peaks at 3.92 bcm in 2007 – 4.3% of consumption.

Tokyo Gas begins importing LPG from Saudi Arabia.

**1967** An LNG sale and purchase agreement (SPA) is signed for the sale of LNG produced by Phillips Petroleum and Marathon Oil at Kenai in Alaska to Tokyo Electric Power Company (TEPCO) and Tokyo Gas.

**1969** The import of LNG from Alaska begins through the Negishi terminal in Yokohama. In the same year, Japan makes its first upstream investment in an LNG project when Mitsubishi takes a stake in Brunei LNG.

**1970** TEPCO, Tokyo Gas and Osaka Gas sign SPAs with Brunei LNG.

**1972** The import of LNG from Brunei begins through the Senboku terminal operated by Osaka Gas. This is Japan’s second LNG regasification terminal; today there are 29.

**1973** Mitsui invests in the Abu Dhabi Gas Liquefaction Company (ADGAS) and Chubu Electric, Kansai Electric, Osaka Gas, Kyushu Electric and Nippon Steel agree to buy LNG from Indonesia’s Pertamina. At this stage

![Japan’s first LNG cargo was delivered in November 1969 by the 71,500m³ Polar Alaska, which operated a shuttle service between Kenai and Yokohama with its sister ship Arctic Tokyo.](image1)

![Japan’s first upstream investment in an LNG project was in Brunei LNG.](image2)
there is no Japanese equity in the Indonesian LNG sector but it does receive financial support from the Japanese government.

1977 The import of LNG from Abu Dhabi, UAE and Indonesia begins.

1978 Mitsubishi invests in Malaysia LNG Satu. Mitsubishi subsequently invests in Malaysia LNG Dua (production from 1995) and Tiga (production from 2003), while JX Nippon Oil & Energy and JAPEX also invest in Tiga.

1980 The sixth international LNG conference is held in Kyoto.


1983 The import of LNG from Malaysia begins. Bishu Maru in service with K Line becomes the first Japanese-built and operated LNG carrier.

1984 Mitsubishi and Mitsui agree to invest in Australia’s North West Shelf project through the jointly owned Japan Australia LNG.

1988 Tokyo Gas completes conversion to a 100% natural gas supply.

1989 The import of LNG from Australia begins. The sixth International Gas Research Conference (now the IGU Research Conference) is held in Tokyo.

1990 Osaka Gas completes conversion to a 100% natural gas supply.

1991 Mitsui invests in Sakhalin Energy and is joined by Mitsubishi the following year.

1992 The IGU Council meets in Osaka.

1994 Mitsui, Mitsui and Itochu invest in Oman LNG.
1995 On January 17, the Great Hanshin Awaji earthquake causes extensive damage in Kobe and surrounding areas and Osaka Gas temporarily suspends service to 857,400 customers.

Deregulation of the Japanese gas market begins in March with the supply to large volume users (annual consumption of 2 mcm and above).

1997 The import of LNG from Qatar begins with Marubeni and Mitsui as investors in Qatargas I. (Mitsui subsequently also invests in Qatargas III.) Itochu, LNG Japan and Nissho Iwai invest in RasGas 1.

1999 Deregulation of the Japanese gas market continues with the supply to users with annual consumption of 1 mcm and above; the top four gas companies have to allow third-party access (TPA) to their pipelines.

2000 The import of LNG from Oman begins.

In June, Japan assumes the Presidency of IGU for the 2000-2003 Triennium and in October hosts the IGU Council meeting in Kyoto.

2003 In June, Japan hosts the 22nd World Gas Conference and the IGU Council meeting in Tokyo.

INPEX, TEPCO and Tokyo Gas invest in Darwin LNG. Subsequently, JERA, a joint venture of Chubu Electric and TEPCO, takes over TEPCO’s interest (in 2016).

2004 Deregulation of the Japanese gas market for those consuming 500,000 mcm and above; TPA applies to all gas companies; accounting separation of transportation sectors mandated.

Japan drills the first offshore methane hydrate exploration wells at a single location in the Nankai Trough.
A better world

With natural gas as the world’s cleanest and most efficient fossil fuel, Oman LNG’s operations near the Omani city of Sur, is helping to make for a better world. Since starting production in 2000, we have delivered over two thousand cargoes to customers, remaining a reliable supplier of liquefied natural gas that is helping to reduce carbon emissions and preserve the earth’s natural environment for future generations to enjoy.

For centuries, this beautiful coast-bound nation of Oman was a trade centre connecting different parts of the world through vibrant and flourishing commerce relations. Trade that supported lives in far lands. At Oman LNG, we continue that tradition of seafarers and commerce through bringing energy to many corners of the world.

Oman Liquefied Natural Gas LLC (Oman LNG) is a joint venture company established by a Royal Decree in 1994 operating under the laws of the Sultanate of Oman. The company engages in the business of producing and selling liquefied natural gas (LNG), and its by-product, natural gas liquids (NGLs) and operates three liquefaction trains at its plant in Qalhat, South Sharqiyah Governorate.

Hand-in-hand with our operations comes a strong health, safety and environment performance. Our recent achievement of 20 Million man-hours without a Lost-Time Injury (LTI) is testament to our HSE excellence, and an exemplary diligence and commitment to the safety of our people, environment, and communities where we operate. Our processes meet the highest of ISO standards, which we are proud to maintain every year and our ceaseless efforts to support the environment through the sponsoring of various initiatives such as the Turtle Research and Exhibition Centre in Ras al Jinz in the eastern region of the country boasting one of the world’s largest breeding beaches for Greenback Turtles. Additionally, Oman LNG is a key sponsor of the Environmental Society of Oman’s activities that range from indigenous species protection to the championing of waste reduction, reuse and recycle programmes. As a company our responsibility to our staff, contractors and the community is to provide a safe environment so that they can come to work and return home to their families, every day.

Through our empowerment philosophy, we continue to develop talent and help remove barriers to reach success. Our aim is to develop all staff to their fullest potential. We support in-country value through focused efforts towards developing local content and stimulating local business ventures by enabling Small Medium Enterprises (SMEs), a major cornerstone of Oman’s economy, to flourish and providing equal opportunities to compete for all service contracts.

The company is a corporately and socially responsible organisation by maximising benefits to the employees, stakeholders and community and has a well-designed alignment between Corporate Social Responsibility (CSR) and business strategy, to ensure the strategic balance is maintained between
sustainable social development and the business.

From powering large industries, to keeping homes warm and the lights on, Oman LNG’s your reliable energy partner.

Perpetual sustainable investments in the society of Oman

Corporate Social Responsibility (CSR) has been an integral part of Oman LNG with a focused objective: to deliver tangible value to Oman and its people through social investment by capitalising on the country’s natural gas resource. The company allocates annually 1.5% net income after tax (NIAT) to various social investment and sustainable programmes; a commitment set when the company was founded. In addition, before the first cargoes left the LNG plant, the company invested in sustainable development projects for the community which speaks volumes about the company’s business principles; that Oman LNG’s initial investment in social development began even before the production line was fully functional.

Today, Oman LNG’s CSR programmes span the entire nation and contribute to the socio-economic development of the country. Over the past sixteen years, the company’s social investment programmes have spanned the length and breadth of the country with over 4000 projects ranging from healthcare and education to preserving the environment and road safety; reflecting its sincere interest to embed the principles of social responsibility as part of its core existence. Through strengthening the cooperation between the public and private sector, the projects and programmes aim to supplement the national economy and ambitious development plans implemented in the Sultanate.

Oman LNG Development Foundation supports Oman LNG and the company’s ambitious vision and dedication towards CSR. The Foundation champions private sector contribution to the development of Oman and its people, through CSR and citizenship, as an active contributor to social and societal welfare, and through proactively addressing community needs.
The next stage of the methane hydrate evaluation programme involves the drilling of 32 wells at 16 locations in the Nankai Trough.

2005 Marubeni and Mitsui invest in Equatorial Guinea LNG.

2006 Itochu, Mitsubishi and Osaka Gas invest in Oman's Qalhat LNG (acquired by Oman LNG in 2013).

2007 Deregulation of the Japanese gas market for those consuming 100,000 mcm and above. The import of LNG from Equatorial Guinea begins.

Kansai Electric and Tokyo Gas invest in Pluto LNG. Marubeni invests in Peru LNG.

2009 Gas companies in Japan start selling fuel cell systems for residential use under the ENE FARM programme. The import of LNG from Russia begins.

Tangguh LNG starts production with JX Nippon Oil & Energy, Mitsubishi, INPEX, KG Berau, Sojitz, Sumitomo and Mitsui as investors.

FID reached for Gorgon LNG with Chubu Electric (from 2016 JERA), Osaka Gas and Tokyo Gas as investors. FID reached for Papua New Guinea LNG with JX Nippon Oil & Energy as an investor to be joined by Marubeni in 2011.

2010 Tokyo Gas invests in Queensland Curtis LNG.

2011 On March 11, the Great East Japan earthquake and a tsunami cause devastation. The Fukushima Daiichi nuclear power station is damaged and shuts down. Other nuclear power stations are shut down in rapid succession. Gas-fired power generation takes up the burden and LNG imports increase 14% in 2011 to 107 bcm, peaking at 120.6 bcm in 2014. LNG imports from Peru begin, while FID is
reached for Donggi-Senoro LNG with Mitsubishi as an investor.

Kyushu Electric invests in Wheatstone LNG and is joined by JOGMEC, Mitsubishi, NYK and TEPCO (from 2016 JERA) the following year.

2012 FID reached for Ichthys LNG, the first majority Japanese-owned upstream LNG project led by INPEX with Chubu Electric (from 2016 JERA), Osaka Gas, Toho Gas and Tokyo Gas as co-investors, joined by Kansai Electric in 2014. INPEX also takes a stake in Prelude FLNG.

2013 Japan achieves the world’s first extraction of gas from offshore deposits of methane hydrate at Daini Atsumi Knoll in the Nankai Trough, but the tests end after six days due to problems with sand flowing into the well.

Mitsubishi, Mitsui and NYK invest in Cameron LNG.

2014 Chubu Electric (from 2016 JERA) and Osaka Gas invest in Freeport LNG.

2015 The Electricity and Gas Market Surveillance Commission is set up. The tugboat Sakigake, Japan’s first LNG-fuelled vessel (apart from LNG carriers using boil-off gas), enters service.

2017 In April, Japan opens its city gas residential market for competition.

Two wells are drilled at Daini Atsumi Knoll for further methane hydrate production tests with different types of preventive measures against sand entry. Production from the first well starts in May and ends after 12 days due to sand entering the well. Production from the second well starts in June and lasts for 24 days without sand intrusion.

In October, the IGU Council meeting is held in Tokyo.
The 27th World Gas Conference (WGC) is now less than nine months away and plans are moving along very well. The event will be held June 25-29, 2018 at the Walter E. Washington Convention Center (WEW) in Washington DC. The WEW is located in the centre of Washington DC; all hotel rooms are within an 18 minute walk of the venue. The three-year-old 1,100 room Marriott Marquis will be the headquarters hotel and it will host all of the IGU meetings associated with the WGC. The Marriott is directly across the street from the WEW.

Early bird registration for the WGC opened in late May, and the WGC team is very pleased with the strong level of registrations that has been seen to date. Early bird registration closes on January 31, 2018. To ensure access to rooms at the Marriott Marquis all IGU members are encouraged to take advantage of the early bird registration opportunity.

The response and feedback that has been received regarding the overall WGC programme has been fantastic. We are very pleased that over 40 keynote speakers, representing the leaders of the global energy industry, as well as a significant number of policymakers, have confirmed their participation in the WGC. And, thanks to the efforts of the National Organising Committee (NOC), under the direction of Dave McCurdy, President and CEO of the American Gas Association, these keynote sessions will truly set the global stage for the outlook for the natural gas industry for years to come.

Likewise, the level of interest in the Current Debate sessions has been outstanding. These 22 sessions will address, at a very senior level, the most timely and topical strategic and commercial issues facing the global gas industry. The Current Debates will cover the entire global gas value chain, and the dozens of already confirmed senior level speakers will provide invaluable insights into these topics.

Thanks to the efforts of the IGU committees and task forces, we have had an exceptional response to our Call for Abstracts, which closed on September 1, 2017. The 70 Industry Insight sessions and Technical and Innovation Center sessions being coordinated by the IGU committees and task forces have received a substantial number of abstracts, and as of this article, are currently being reviewed. These 70 sessions will focus on the most timely and topical technical, commercial and strategic issues across the global gas industry and will cover the full gas value chain from upstream to downstream.

WGC 2018 continues to engage a wide variety of constituencies as part of the pro-
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of members of the Young Professionals in Energy organisation.

Within the 40,000m² exhibition, there will be a number of special pavilions focusing on: Robotics and Automation; Gas as a Transportation Fuel; Showcase America; Sustainable Energy and others. Over 90% of the exhibition space is already allocated.

There is only ONE World Gas Conference. It is owned by the International Gas Union and 2018 will be the first year in which a significant portion of the financial proceeds are returned to IGU. All IGU members are encouraged to register early and include many colleagues in their delegations. Please take advantage of the early bird registration opportunity.

The WGC team is especially pleased to thank all of our sponsors, and our two critical partners – ETF on all sponsorship and exhibition opportunities, and the CWC Group, handling all aspects of the Conference itself, including providing one-stop shopping for all your registration and accommodation needs.

We welcome any and all suggestions regarding WGC 2018. Feel free to contact me personally at jcopan@wgc2018.com. We are under nine months out from WGC 2018 and it is full speed ahead! All of us on the WGC team look forward to welcoming you to Washington DC in June 2018.

Jay Copan is Executive Director, WGC 2018, and serves as the Special Advisor to the President of the International Gas Union.
The network respecting the future

Snam, a European leader in the construction and integrated management of natural gas infrastructure, is the owner of Europe’s largest, most accessible pipeline network (more than 40,000 km), the largest storage infrastructure (19 bcm capacity) and one of the first LNG terminals built in Europe. Snam’s investments aim to facilitate the European Energy Union network integration and to promote natural gas as a key pillar of a sustainable energy mix. With its 3,000 people, Snam is active in natural gas transportation, storage and regasification. It also operates, through associated companies, in Austria (TAG, GCA), France (TIGF), and the United Kingdom (Interconnector UK) and is a shareholder of the TAP pipeline.

www.snam.it
During the 2014 IGU Council Meeting, Korea was elected to assume the IGU Presidency for the 2018-2021 triennium and to host the 28th World Gas Conference in 2021. Next year in June, Korea will take over the IGU Presidency at the close of the 27th World Gas Conference in Washington DC and will lead the worldwide non-profit organisation for the next three years. As a country that leads the global gas industry, Korea will play a key role in handling pending issues affecting the gas sector globally.

With less than a year left before Korea takes over the leadership of IGU, preparations to fulfil the duties of the IGU Presidency and to stage the 28th World Gas Conference are well under way. The theme of the triennium leading up to the conference will be “Sustainable Future Powered by Gas”, and three strategic focuses have been identified for the Korean term: Environmental Leadership, Market Vitality, and Value Creation. Having prepared the theme and strategic focuses, Korea is now working to develop the Triennial Work Programme which will ensure that IGU continues to be the most effective voice representing the gas industry.

The incoming Korean Presidency Team held its first preparation meeting with the incoming chairs of the IGU committees for the 2018-2021 triennium in Barcelona, Spain, on February 7. The discussions started with an overview of the preliminary themes and areas of focus for the triennium and the potential areas of focus for the IGU committees for 2018-2021. A second IGU Incoming Chairs Meeting was held in Daegu, Korea, from July 3–7.

IGU membership includes 152 associations and corporations from 90 countries that are active in the gas industry, and collectively represents more than 97% of the global gas market. Established in 1931, IGU covers the entire gas value chain from upstream to downstream including exploration and production, storage, transmission, distribution, utilisation, sustainability, strategy, gas markets, LNG, marketing and communications, R&D and innovation.

In line with the work of IGU, Korea will also host the 28th World Gas Conference, scheduled for June 2021, in Daegu, Korea. Last November, the WGC2021 National Organising Committee (WGC2021 NOC) was launched to prepare all matters associated with the 28th World Gas Conference. The WGC2021 NOC is comprised of more than 60 representatives drawn from government, Daegu Metropolitan City, gas companies and organisations, associations and enterprises in Korea.
As one of the immediate tasks, the WGC2021 NOC is now fully engaged in the preparation of the hand-over ceremony which will take place at WGC2018. This ceremony will highlight the beginning of the Korean IGU Presidency as well as the 28th World Gas Conference. Moving forward, the NOC will remain committed to making every effort to ensure the success of the conference.

**Korea Gas Union**

Korea Gas Union (KGU) is a non-profit organisation that provides gas-related services to its members and is seeking ways to achieve sustainable natural gas development. KGU was founded in 1985 with the aim of building strong technical cooperation and advancement of the gas industry.

To foster international cooperation and firmly establish its global presence, KGU joined the International Gas Union (IGU) and became the Charter Member for Korea in 1986. Since then, KGU has actively sought opportunities to further promote natural gas, technological advancement and information exchange with partners around the world.

KGU has more than 60 members comprising state-run corporations, city gas companies, construction and engineering companies, marine and shipbuilding companies, research institutes and associations related to natural gas. The Union also provides quality services to its membership, holding annual ceremonies, seminars, international conferences and publishing a number of periodicals.

Alongside its membership services, KGU has greatly contributed to the development of the global gas industry by playing a major role in IGU, especially, by hosting several world-scale gas events attracting hundreds of participants. The Union successfully hosted the IGU Council Meetings on Jeju Island in 1999 and in Gyeongju in 2008, LNG13 in Seoul in 2001, IGU’s 7th Global Congress on Information and Communication Technology in Energy (ICT) in Busan in 2005, the International Gas Union Research Conference (IGRC) in Seoul in 2011, and now looks ahead to WGC2021 in Daegu.

As an organisation that represents the Korean gas industry, KGU will remain fully committed to providing excellent services for its members and will continue to pursue the advancement of the gas industry with tireless efforts.

*Suk-Hwan Park is Secretary General of the Korea Gas Union (www.kgu.or.kr).*
Focus on IGRC 2017

One of the leading events in IGU’s triennial calendar, the 15th IGU Research Conference, IGRC 2017, took place from May 24-26, in Rio de Janeiro, Brazil under the theme “Natural Gas: Catalysing the Future” bringing the spotlight on the important strides the industry is taking to push forward research, development and technological change.

This was the first of the IGRCs to be held in Latin America in the 37 years of the event series and was expertly organised and hosted by IGU Associate Member Instituto Brasileiro de Petróleo, Gás e Biocombustíveis, IBP.

Authors from more than 25 countries presented around 300 technical papers. There were also 10 presentations from invited speakers (which are available to download at www.igrc2017.com.br/presentations-download).

During the first day the main focus of discussion was the development of Brazil’s gas industry and the new rules that will be needed to ensure the growth of a competitive market in the country.

Sessions covered research across the entire natural gas value chain. On the agenda were the most important issues facing the global gas industry both now and into the future. During the three days of wide-ranging debate topics including environmental issues, energy efficiency, E&P storage techniques and the benefits of CNG were discussed.

The final day’s focus was on technology and the Brazilian market. “I think our development is not disruptive, but we need to accelerate on innovation”, affirmed Luis Bertrán, Secretary General of IGU in his closing remarks.

In this section of the magazine we share a picture gallery from the conference and three of the papers that were selected for presentation showcasing the diversity of subjects covered: shale gas exploration using geophysical data in China, an overview of the Brazilian LNG market and a paper on research undertaken on domestic condensing boilers by the Danish Gas Technology Centre which is applicable across the European market.

The proceedings from IGRC 2017 will be available to download from the IGU website (www.igu.org) after November 26, 2017.

Looking ahead, IGRC 2020 will be held in Tehran, Iran, one of the world’s major natural gas markets with a long history of research and industry innovation. For enquiries contact sepehrian@nigc.ir. Rodney Cox, IGU Events Director is also available to assist IGU Members with all of the events in IGU’s portfolio. He can be contacted at rcox1@outlook.com.au.
A picture gallery of IGRC 2017

IGU President, David Carroll, opening proceedings on the first day of the conference.

Milton Costa Filho, Secretary General of IBP, the organiser of IGRC 2017.

Poster sessions on the first two days allowed the sharing of a wealth of information.

Clarissa Lins, Director, IBP chaired the opening panel on day two on the impacts of COP 21 on the gas sector.

Raquel Coutinho from the Petrobras Research Centre speaking during the panel session on innovations in the gas value chain.

Jan Karl Karlsen, Vice President for Marketing and Origination, Statoil Brasil and Cynthia Silveira, Chair, IGRC 2017 National Organising Committee.

Milton Costa Filho, Secretary General of IBP, the organiser of IGRC 2017.

Thiago Barral, General Projects Superintendent, EPE, during his presentation entitled “Natural Gas – Renewable Energy Partnership”.

IGU’s Secretary General, Luis Bertrán, and Director, Rafael Huarte share a moment with the organisers of IGRC 2017 and the Iranian delegation.

Following the successful conclusion of IGRC 2017 we look forward to IGRC 2020 in Tehran, Iran.
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Research and application of the prediction method for sweet spots of shale gas using geophysical data

By Sheng Chen, Wenzhi Zhao, Yonglin Ouyang, Qingcai Zeng, Qing Yang Huaxing Hou, Shaohua Gai, Shihai Bao and Xinyu Li.

The W1 area in the Sichuan Basin is the first area for shale gas exploration and development in China. This is a case study carried out in the area’s Lower Silurian Longmaxi Formation, which has great resource potential. Many scholars have carried out a great deal of research work, such as the division of sedimentary facies, selection evaluation, reservoir core experiments and so on, and the core area has been preliminarily determined in the W1 area. But geophysical prospecting of sweet spots is just at its beginning and thus has not provided enough information for the deployment of horizontal well drilling.

In our study, firstly we used well log interpretation to determine key evaluation parameters of the shale reservoir at the well point, and to study the vertical distribution and variation of the shale reservoir; in this way we could determine the longitudinal distribution of sweet spots. Secondly, seismic rock physics analysis was used to find the elastic parameters that were sensitive to the key evaluation parameters, such as total organic carbon (TOC) and the gas content of the shale gas reservoir. At the same time the quantitative relationships between them were established. Finally, based on the results of seismic rock physical analysis, high quality pre-stack inversion was carried out with the combination of well and 3D seismic data, which was used to predict the plane distribution of the thickness, TOC content, brittleness, pore pressure and other key evaluation parameters of shale reservoir. Comprehensive analysis of the research results was used to determine the distribution of sweet spots.

Shale gas potential is similar in China and the US, but shale gas production is more challenging in China. Shale gas exploration and development has only recently begun in China and seismic-based prediction of sweet spots is still in its infancy.

Prediction of sweet spots is one of the most important procedures in shale gas exploration and development. A sweet spot of shale gas is defined as an area with moderate burial depth, high organic carbon content, high maturity, high gas content, high brittle mineral content, well-developed natural fractures and the easy formation of complex fracture network by fracturing. It is the preferred target for acquiring and maintaining high productivity and realising the effective production of shale gas. Gas content, which is one of the key elements of sweet spots, has great significance to the commercial development of shale gas reservoirs.

Kevin J. Dodds et al. (2007), based on core analysis results and well log data, applied a neural network method to establish a relationship between seismic attributes and gas saturation through a seismic attribute analysis and obtained some positive effects in computing the gas saturation of a shale reservoir with seismic attributes.

Daniel J.K. Ross et al. (2009), based on a detailed analysis of pore structure, TOC and pore fluid composition in the shale reservoir, suggested that the gas content was closely related to porosity and TOC, and basically established the quantitative relationship between gas content and porosity or TOC on the basis of well data.
Amanda M.M. Bustin (2012) performed a systematic study of conditions and major controlling factors for high productivity of shale gas utilising the numerical simulation method, and indirectly obtained the major controlling factors of the gas content in the shale reservoir. Her study result suggests that fracture pore, matrix pore, Young’s modulus and Poisson’s ratio are major geological factors that control shale gas productivity and the interval with high shale gas productivity exhibits evidently high Young’s modulus and low Poisson’s ratio. This study indirectly indicates that gas content is closely related to two seismic petrophysical parameters, i.e. Young’s modulus and Poisson’s ratio.

Y. Altowairqi (2014) carried out a systematic quantitative study of the influences of some parameters (e.g. TOC and gas content) on seismic elastic parameters under the formation pressure through a measurement with artificial rock samples. The study results suggest that P-wave velocity, S-wave velocity and density decrease significantly as TOC and gas content increase. Therefore, a quantitative relationship of gas content and TOC with P-wave velocity, S-wave velocity and density is established.

In recent years, many Chinese scholars have conducted feasibility studies into and put forward arguments for gas potential prediction for shale gas reservoirs using seismic data and obtained some positive effects in tests with actual data volumes.

Li Yuxi et al. (2011) discussed the required conditions for the occurrence of shale gas in reservoirs and analysed the major factors that influence the gas content; they preliminarily stated the role of gas content in the integrated evaluation of the shale gas reservoir, but did not study the prediction method of gas content.

Sun Xiaozhong (2013) applied the seismic attribute analysis method to conduct a correlation analysis of extracted seismic attributes and gas content and determined three attributes that are most sensitive to gas potential: average instantaneous frequency, arc length and average energy. In addition, she established a prediction model for gas content in the shale reservoir in the study area using the multiple stepwise regression method, allowing for prediction of gas content in the Silurian high-quality shale for a designed well. Although this method is convenient and efficient, its physical significance remains unclear and may yield multiple solutions.

Li Chao (2014) determined the lithological combination of high-quality shale interval in the Jurassic shale gas reservoir, the Jiannan region, and its seismic responses through a combination of drilling data and well log data. The waveform classification technique was used to predict the variations of lithology and lithofacies, the spectral attenuation technique was applied to predict the gas potential of high-quality shale, and the gas prospects were defined based on the results of classified waveform prediction. Although this method is highly comprehensive, it provides a qualitative prediction of gas potential instead of attempting to specifically analyse the spectral responses of the shale gas reservoir.

Guo Xusheng (2015) suggested density as the most sensitive parameter for gas content through a cross-plot analysis of core-tested gas content and geophysical elastic parameters, built a mathematical model between gas content and density, computed the gas content data volume from the density volume obtained from pre-stack inversion and obtained some positive effects in quantitative prediction of gas content. This method, however, applies the density parameter only to predict the gas content and hence is highly risky. But geophysical prospecting of sweet spots is just at its beginning and thus has not provided enough information for the deployment of horizontal well drilling.

In our study we use the method of well log interpretation to derive key evaluation parameters of a shale reservoir at the well point and
It has been 31 golden years for China’s natural gas industry since the country joined the IGU family as a Charter Member in 1986. After three decades of rapid development, China has become the third largest natural gas consumer and the sixth largest producer. In 2016, the natural gas industry in China saw 204 bcm in consumption and 134 bcm in production. China has established national trunk lines including the first, second and the third West-to-East Gas Pipelines, with a total length extending 60,000 km. There are 12 LNG receiving terminals with an annual receiving capacity exceeding 43 million tonnes.

We are closely connected with international gas markets. China has become the third largest gas importer with an annual import volume exceeding 70 bcm, equal to a 35% reliance on imports. We imported over 35 bcm of pipeline gas through the China-Central Asia Gas Pipeline and China-Myanmar Gas Pipeline, and 26 million tonnes of LNG through coastal LNG receiving terminals from over 10 countries including Australia and Qatar.

There remains great scope for further growth in demand in China. One of the primary drivers is urgency for emissions reduction and air pollution control. China consumes nearly 4 billion tonnes of coal annually, in which 20% is through the burning of loose coal. Coal accounts for 62% of primary energy consumption, while natural gas accounts for only 6.5% of the energy mix, lagging far behind the 24% world average. Converting coal to gas is the most effective and practical approach to control air pollution and reduce emissions. Another driver is urbanisation. Currently, the urbanisation rate in China is less than 60%. Accelerated urbanisation in the coming years will further promote natural gas consumption. In addition, natural gas infrastructure in China needs to be improved. The average per capita natural gas pipeline is only 0.5 metres long, half of the world average. Natural gas storage capacity is only 2.5% of annual consumption, far lower than the world average.

China has been endowed with rich natural gas resources, with 50 trillion cubic metres (tcm) of recoverable conventional gas, 22 tcm of recoverable shale gas, 12.5 tcm of coal bed methane and nearly 100 billion tonnes of gas hydrates.

The Chinese natural gas industry enjoys a favourable policy environment. The 13th Five Year Plan states that we will accelerate the development of the gas industry and increase the ratio of natural gas in the primary energy mix.

By 2020, natural gas consumption will reach 300 bcm, accounting for 8.3-10% of primary energy consumption. We are retrofitting heating supply system in northern China to replace coal with clean energy, following the guideline of “adopting natural gas or electricity depending on the actual situation”. In the next five years, heating in large areas of northern China will be powered by natural gas.

China is a successful case in point for natural gas development with Beijing enjoying particularly rapid development in natural gas use. In the past twenty years, natural gas purchase volumes increased from 130 million cubic metres to 16 bcm, ranking second in the world after Moscow. Natural gas accounts for 31.5% of the energy mix in Beijing, exceeding the world average, and is expected to reach 35% by 2020. With the significant increase of natural gas, coal consumption volumes have been reduced to less than 9.5 million tonnes.

The progress of the natural gas industry in China benefited from huge support from the global gas industry. China looks forward to strengthening cooperation with countries around the world under the IGU framework and jointly promoting the development of the gas industry worldwide. We are willing to carry forward IGU’s proud tradition and contribute our efforts and resources to serve IGU members by making IGU more influential, impactful and sustainable through innovation, cooperation and sharing.

Li Yalan is Chairperson of Beijing Gas Group Company Limited.
Longmaxi black shale and overlying Shiniulan limestone constitute a good reservoir-seal assemblage. The entire Longmaxi Formation has abundant graptolite of about 500m thick throughout the block, which is a product of deepwater shelf deposition indicating a strong reducing environment. The Longmaxi Formation comprises two distinctive sections. The upper section, the Long 2 Member, is composed of some siliceous streaks and limestone with TOC content less than 2%. The lower section, the Long1 Member, encompasses carbonaceous shale and black shale rich in lamellae, with TOC content higher than 2%. The Long 1 Member is subdivided into two sub-members as per TOC content, Long 1-1 and Long 1-2.

**Data and methods**

In this paper, shale gas sweet spots were predicted based on logging and 3D seismic data. First, using the method of well log interpretation we derive the key evaluation parameters of the shale reservoir at the well point and to study the vertical distribution and variation of the shale reservoir. Second, seismic rock physics analysis was used to define the elastic parameters that were sensitive to the key evaluation parameters, such as TOC and gas content of the shale reservoir, and the quantitative relationships between them were established. Finally, based on the results of seismic rock physical analysis, pre-stack simultaneous inversion with a combination of logging and seismic data was used to predict the plane distribution of the thickness, TOC content, brittleness and other key evaluation parameters of the shale reservoir. The research results were comprehensively analysed to determine the distribution of sweet spots and to predict the plane distribution of sweet spots. The results show that sweet spots are characterised by low density, low P-velocity, low P-wave impedance, low velocity ratio and low Poisson’s ratio. Shale gas sweet spots in this block are vertically concentrated within 30m to study the vertical distribution and variation of the shale reservoir. In this way we can determine the distribution of sweet spots in the longitudinal direction.

**Geological setting**

**Structures**

The Sichuan Basin, covering an area of 1.18 million km² is among the largest petroliferous basins in China. It is surrounded by the Daloushan, Dabashan, Micangshan and Longmenshan orogenic belts. It includes six tectonic units: the Chuandong high-steep fold belt, Chuanbei low-flat fold belt, Chuanxi low-steep fold belt, Chuanzhong flat fold belt, Chuannan low-steep fold belt and Chuandong high-steep fold belt. The Wei204 block lies in the Chuannan low-steep fold belt as shown in **Figure 1**.

**Stratigraphy and shale reservoirs**

Two suites of high-quality shale exist in the Lower Cambrian Qiongzhusi Formation and the Lower Silurian Longmaxi Formation. The latter is discussed in this paper. The Lower Silurian
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Natural gas for a safe and stable climate
We used reservoir thickness, TOC content and gas content to predict geologic sweet spots. According to the study of Caineng Zou et al. a Longmaxi shale sweet spot is defined to be a region thicker than 30m with TOC content above 3% and gas content above 2.5 m³/m³ (Zou et al., 2016). This definition was used as a standard in shale prediction in the Sichuan Basin.

Shale porosity and thickness were predicted with inverted P-velocity by the relationships derived from petrophysical analyses. The relationship between porosity and P-velocity shown in Figure 4 is formulated as follows.

Elastic parameters, including P-velocity, S-velocity and density, were derived from pre-stack simultaneous inversion on seismic gathers (Arcangelo et al., 2011; D.E. Miller, 2012). The parameters were then used to estimate shale properties.

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Elastic parameters, including P-velocity, S-velocity and density, were derived from pre-stack simultaneous inversion on seismic gathers (Arcangelo et al., 2011; D.E. Miller, 2012). The parameters were then used to estimate shale properties.
The correlation coefficient between P-velocity (Vp) and porosity (∅) is 94%.

**Equation 1:**

\[ Vp = 260952\∅^2 - 66178\∅ + 7710.5 \]

The correlation coefficient between TOC and density (DEN) is 96%. TOC content was estimated as a function of density in accordance with the linear relationship derived from petrophysical analysis.

**Equation 2:**

\[ TOC = -15.362*DEN + 42.983 \]

TOC is the TOC content of the shale reservoir and DEN is density of the reservoir. TOC content was predicted by above equation with density obtained by pre-stack inversion.

An engineering sweet spot was defined to be a region with high brittleness. Rock brittleness is generally estimated with brittle mineral content or rock mechanical parameters. The latter was used in this study. As per the study of a mass of experiments and production data by Goodway et al. in 2010 (Goodway et al., 2010; M Khandelwal, 2016) rock brittleness increases with Young’s modulus and decreases with Poisson’s ratio. Young’s modulus and Poisson’s ratio were normalised and then averaged to calculate the brittleness index. The formula is shown as follows.

**Equation 3:**

\[ BR = \left(\frac{YM - YM_{max}}{YM_{min} - YM_{max}} + \frac{PR - PR_{min}}{PR_{max} - PR_{min}}\right) \times 0.5 \]

BR is the brittleness index (a larger index indicates good brittleness); YM is Young’s modulus; PR is Poisson’s ratio. YM and PR were derived from pre-stack inversion.

Comprehensive sweet spot evaluation is based on the prediction of geologic sweet spots and engineering sweet spots. A geologic sweet spot coinciding with an engineering sweet spot is ranked to be of Grade I. A geologic or engineering sweet spot alone is ranked to be of Grade II. Other regions are excluded from sweet spots.

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**Result and discussion**

**Figure 2a** shows an inverted velocity profile, the interval of interest with low velocity is plotted in green. **Figure 2b** shows the function between the porosity and P-velocity. **Figure 2c** shows a section of seismic porosity converted from inverted velocity, the curve inserted is log interpreted porosity.

**Figure 3a** shows a density profile across Well W1; low density, which is related to high TOC content, occurs at the bottom of the Longmaxi Formation. **Figure 3b** shows the linear correlation between TOC content and density log. **Figure 3c** shows a section of TOC content converted from density data shown in **Figure 3a**. TOC content at the bottom of the Longmaxi Formation is above 3% and reaches 7% at most.

High-quality shale reservoirs exhibit high Young’s modulus and low Poisson’s ratio (Grieser and Bray, 2007). The brittleness index is more practical for the characterisation of rock brittleness (Rickman, 2008). In this study we used this method to evaluate shale brittleness. The sections of Young’s modulus, Poisson’s ratio and brittleness index calculated by **Equation 3** are shown in **Figure 4**. The high-quality shale interval at the bottom of Long 1-1 exhibits high Young’s modulus, low Poisson’s ratio and consequent high brittleness. **Figure 3** shows the average brittleness index map for Long 1-1. Brittleness index in this block ranges 25%-65% with an average of 45%.

An evaluation scheme is drafted in accordance with shale gas production in this...
Gas content was calculated by multivariate stepwise regression. A geologic sweet spot was defined by TOC content, porosity and gas content.

- The brittleness index was calculated with Young’s modulus and Poisson’s ratio derived from pre-stack inversion. The Fillippone method was used to predict formation pressure and overpressure. The attribute of curvature was used to predict natural fractures. An engineering sweet spot was defined by brittleness index, formation pressure and fracture distribution.

- As per comprehensive examination of key parameters calculated based on logging interpretation and seismic inversion, two grades of sweet spots were evaluated. Grade I sweet spots with good properties are the best candidates for production and Grade II sweet spots with moderate properties are the best successors which may be exploited in the future. It is suggested that development wells are not deployed in other regions.

**Conclusions**

- Sweet spots in Longmaxi shale are concentrated within 30m above the bottom in accordance with logging interpretation. Sweet spots are characterised by high acoustic time, high GR, high porosity, high Young’s modulus, high TOC content, high gas content, low density and low Poisson’s ratio.

- There is a negative correlation between TOC content and density. TOC content increases linearly as density decreases and was predicted with density data derived from pre-stack inversion. Shale porosity was calculated with P-velocity derived from pre-stack inversion.

**Acknowledgements**

The authors gratefully acknowledge the PetroChina Research Institute of Petroleum Exploration & Development (RIPED), Langfang for their permission to publish this paper and for their provision of software and data sets.

Dr Sheng Chen is a Petroleum Engineer from the China University of Petroleum (Beijing) and RIPED. Dr Wenzhi Zhao, Dr Yonglin Ouyang and Dr Qingcai Zeng are Professors at RIPED. Qing Yang is a Geophysics Engineer at RIPED. Huaxing Hou is a postgraduate at RIPED. Dr Shaohua Gai is a Geography Engineer at China University of Petroleum (Beijing). Shihai Bao and Xinyu Li are Geography Engineers at RIPED. The original, fully referenced version of this paper, part of the proceedings from IGRC 2017, will be available to download from the IGU website (www.igu.org) after November 26, 2017.
THE FUTURE OF GREEN ENERGY IS HERE

Natural Gas is emerging as the fuel of the 21st century, steadily replacing liquid fuels and coal due to its low ecological footprint and inherent advantages for all user segments: Industries-Transport-Households.

Indian Oil Corporation Ltd. (IndianOil), India’s downstream petroleum major, proactively took up marketing of natural gas over a decade ago through its joint venture, Petronet LNG Ltd., that has set up two LNG (Liquefied Natural Gas) import terminals at Dahej and Kochi on the west coast of India.

Over the years, the Corporation has rapidly expanded its customer base of gas-users by leveraging its proven marketing expertise in liquid fuels and its countrywide reach.

Its innovative LNG at the doorstep initiative is highly popular with bulk consumers located away from pipelines.

IndianOil is now importing more quantities of LNG directly to meet the increasing domestic demand. It is also setting up its own 5 million tonnes per annum LNG import terminal at Ennore, near Chennai on the east coast, to be operational by 2018.

The Corporation has formed two joint ventures to enter the burgeoning city gas distribution segment through Piped Natural Gas (PNG) networks that are coming up in many urban centres. IndianOil is also adding compressed natural gas (CNG) as a green auto-fuel at its 26,000+ fuel stations across India. Yet another joint venture of the Corporation is investing in cross-country natural gas pipelines.

IndianOil is committed to energising the future, naturally through Gas

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- Technology Solutions
- Petrochemicals
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Overview of the Brazilian liquefied natural gas industry

By Roberto I. da Silva, Cylon Llaw, Denis M. Fraga, Cristiano M. Borges and Edmilson M. dos Santos

As the number of people grows, so will their desire for energy. As result of this, the IEA believes demand for energy could double by 2050 from a baseline in 2010. Meeting energy demand is a massive challenge. Bringing new energy supply sources to market is critical. Gas resources are plentiful and geographically diverse. However, we will need increasing advances in technology to efficiently bring this gas to the people who need it.

This paper presents an overview of Brazilian LNG capacity and a comparison with world numbers as of December 2015, focusing on production and regasification, and also reviews the world LNG market. It is organised into six sections and a conclusion. Section 1 provides an overview of reserves. Section 2 examines demand. Section 3 examines the evolution of the reserves/production ratio and Sections 4 and 5 discuss production and regasification capacities. Section 6 presents the plans and projects of an uneven growth period.

Reserves

A review of current and future LNG capacities must first start analysing the magnitude of natural gas reserves. Global proven natural gas reserves at December 2014 were 197 tcm. Eurasia and the Middle East remain dominant with combined reserves of more than 71% of the total. In Eurasia, Russia holds about one-quarter of the world’s proven natural gas reserves. Brazil ranks 33rd in the world with proven natural gas reserves of 0.46 tcm (0.23% of global). In Latin America, Brazil’s reserves are second, far behind Venezuela with 5.6 tcm, but surpassing Peru with 0.44 tcm and Argentina with 0.38 tcm (EIA, 2016). Figure 1 breaks out the top 20 reserves by country and the total reserves by region.

Figure 2 presents global natural reserves steadily increasing from 2005 to 2014. Also, according to Schenck (2012), significant resources of natural gas remain to be found, with undis-
covered and technically recoverable mean total resources of natural gas worldwide (non-associated and associated), at about 159 tcm.

**Demand**

Annual global natural gas consumption at December 2014 was 3,393 bcm. Europe, Eurasia and North America remain dominant with combined consumption accounting for 58% of the total. In North America, the United States holds 22.4% of the world's natural gas consumption. Brazil ranks 24th in the world with natural gas consumption of 39.6 bcm (1.2% of global). In Latin America, Brazil's consumption is second only to Argentina with (1.2% of global). In Latin America, Brazil's consumption accounted for 13.5% of Brazilian primary energy consumption in 2014. Overall, 39.4% of Brazilian energy in 2014 came from renewable sources and 60.6% from non-renewables (see Figure 5).

In the Brazilian electricity matrix between 2013 and 2014, the share of coal increased from 2.6% to 3.2%, natural gas from 11.3% to 13% and biomass from 6.6% to 7.3% (EPE, 2015). Global natural gas demand is expected to grow by 1.9% per year reaching around 5,034 bcm per year by 2035. The growth is driven by the consumption in non-OECD countries that will grow twice as rapidly, 2.5% per year, as consumption in OECD countries, 1.1% per year. Electricity generation and the industrial sector account for over 80% of total demand growth with power growing 2.3% per year and industry 1.8% per year (BP, 2015). In terms of the Brazilian power matrix, the

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**Top 20 natural gas consumption by country and total by region, as of December 2014.**

Source: Prepared by the authors based on data from BP (2015).

**Natural gas consumption evolution.**

Source: Prepared by the authors based on data from BP (2015).

**Brazilian energy matrix in 2014.**

Source: Prepared by the authors based on data from BEN (2015).
For the third consecutive year, due to restrictive hydrological conditions, power supply from hydro plants fell. Hydro’s share in the energy matrix was 84.5% in 2012, 79.3% in 2013 and 65.2% in 2014, despite an increase of 3,177 MW in generation capacity.

Total consumption of electricity in 2014 increased 2.9% compared to 2013. Thermal plants played an important role in supplying the consumption increase due to the falling supply from hydro plants. This can be verified by the significant increase in production, compared to 2013, from thermal plants fuelled by coal (+24.7%), natural gas (+17.5%) and biomass (+14.1%).

According to PDE 2024, demand for natural gas in Brazil is expected to grow 2.8% per year until 2024. The daily consumption figures are 79.3 mcm/day in 2014 and 104.2 mcm/day in 2024. It is relevant that the rate of growth during the first five years is expected to be negative (-1.4%) due to lower demand by the thermal plants; on the other hand, the Compound Annual Growth Rate (CAGR) for the rest of the period is expected to be higher (+7.1%) sustained by the growth in the thermal energy sector and other sectors, as shown in Figure 7.

Adding to the expected demand the maximum thermal generation by natural gas, the figures for demand growth are 3.2% per year until 2019 and 6.1% CAGR from 2019 to 2024. The rate for the 10-year period is 4.6%. These numbers do not consider the natural gas required in energy generation for exploration and production (E&P) installations, and are relevant for natural gas infrastructure planning. Figure 8 demonstrates the share of the additional consumption required in case all thermal generation fuelled by natural gas is required to provide electricity. It also shows that a significant share of the natural gas demand, 26.98%, 41.73%, 38.92% in 2014, 2019 and 2024 respectively, is dependent on additional thermal generation. The demand to supply natural gas to power plants is dependent on the hydrological regime that has experienced severe dry seasons in the past five years. In response to the potential fluctuation and to assure the demand is supplied, the Brazilian
natural gas infrastructure has three regasification terminals with capacity to process 41 mcm/day and to store 434,000m³ (MME, 2015).

Considering the breakdown of natural gas consumption it is possible to conclude that every sector, excluding thermal, is growing in the 10-year period (see Figure 9). The energy sector is leading the growth with 6.9%. Residential, commercial and raw materials rates are fluctuating between 4.5% and 5.5% and the cogeneration, transportation and industry rates are in the 0.5% to 2.5% range. The breakdown of the consumption by sector in terms of mcm/day can be observed in the Figure 10 and illustrates the size of the thermal demand dependent on the electricity generated by the hydro plants.

LNG demand
According to IGU (2015), natural gas accounts for around one quarter of global energy demand, 10% of which is supplied in the form of LNG. This compares to just 4% in 1990. LNG supply has grown faster than any other source of gas – at an average 7% per year since 2000 – and is poised to expand its share of the gas market with a slew of new projects adding 616 mcm/day (22 bcf) per day by 2020. LNG supply grows 7.8% per year between 2013-20.

Overall, LNG supply grows by 1.3 bcm/day by 2035, with Australia (448 mcm/day) and the US (392 mcm/day) each contributing around a third of that increase. African LNG supply, led by East Africa, increases by 336 mcm/day. As a result, Qatar, which has the largest market share today, is overtaken by Australia (24% share of the market by 2035), Africa (21%) and the US (18%).

Asia is the largest destination for LNG, with its share in global LNG demand remaining above 70%. By 2035, China becomes the second largest LNG importer (336 mcm/day), just behind Japan (364 mcm/day). Europe’s share of global LNG imports rises from 16% to 19% between 2013 and 2035, with an additional 280 mcm/day of LNG demand.

According to BP (2016) from the total consumption of natural gas, approximately 30% is traded either in the form of LNG or in pipelines. The trend pointed out by BP 2016 is that LNG trade will grow faster than consumption to account for 15% of global gas supplied. Also, BP (2016) states that the US is going to be a net exporter of LNG and China and Europe will increase their dependence on LNG. Figure 11 shows the trade forms as a share of the total global gas consumption.

From 2005 to 2014 the energy production from natural gas increased 80% according to the 2014 Brazilian Energy Balance (BEN) published by the Ministry of Mines and Energy. This shows that the supply from national fields was 52.2 mcm/day (excluding the natural gas used in E&P, processing unit absorption, flaring and well reinjection), the imported natural gas from...
Bolivia was 32 mcm/day and the total maximum regasification capacity from the three terminals located in Bahia, Ceará and Rio de Janeiro was 41 mcm/day. The total supply figure from the 2014 infrastructure was 125.2 mcm/day. That number compares with the total maximum demand projected by PDE 2024 for 2019 of 127 mcm/day, requiring an additional 1.8 mcm/day by 2019. An additional 45.4 mcm/day is required in order to meet the total maximum demand by 2024. These figures are equivalent to doubling the current regasification infrastructure and adding 5.4 mcm/day from either national or imported production. Figure 12 shows the supply and demand curves.

Considering that the difference between the maximum demand expected in 2024 is 66.4 mcm/day and that the strategy of having capacity available for the maximum demand must be pursued, it is possible to expect that additional regasification terminals should be in place in order to meet that growth. This can be verified in the data published by WEBMAP EPE (2016) where three regasification terminals with total capacity of 47.5 mcm/day are being studied, located in Pernambuco, Sergipe and Rio Grande do Sul and detailed in Section 6 – Plans and Projects.

**Reserves and production ratio (R/P)**

This section looks at the relationship between reserves and production. These figures are calculated by dividing the total proved reserves by the total production for the same year, extracted from BP (2016), showing if production is increasing faster than the discovery of new reserves or if reserves discovery is increasing faster than production.

The global ratio from 2000 to 2014, as shown in Figure 13, shows a R/P ratio of 57.5 years in 2000, reaching the highest value of the time series in 2001 (61.8 years) and the lowest level in 2014 with 54 years. In terms of South and Central America the R/P ratio declines between 2000 and 2007, from 68 years to 45.4 years and maintains the 43-45 years range from 2007 to 2014, as shown in Figure 14.
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We procure gas for our customers...we are the largest physical natural gas consumer in the U.S.

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The Brazilian R/P ratio was 29.1 years in 2000 and in 2014 reached 20.5 years as shown in Figure 15. During the 14-year time period the indicator oscillates from 21.2 years to 32 years, mainly due to the increase in the production of natural gas in the pre-salt region. The depletion of mature fields either onshore or offshore also contributes to the decrease of R/P ratio.

Production

Global nominal liquefaction capacity stood at 301.2 mtpa at the end of 2014 and 19 countries held active LNG export capacity. Nearly two-thirds of the world’s capacity is held in just five countries: Qatar, Indonesia, Australia, Malaysia and Nigeria. Qatar alone holds 26% of the total (IGU, 2015). Figure 16 presents liquefaction capacity by country.

Latin American production stems mainly from Trinidad & Tobago and Peru. Combined, these countries’ capacity as at December 2014 stood at more than 19 mtpa (IGU, 2015). Table 1 presents the key characteristics of main liquefaction plants in Latin America including a small-scale Brazilian plant.

Brazilian LNG production comes from the implementation in 2005 of the Gemini Project, developed by White Martins (Praxair) and Petrobras in conjunction with GasLocal and the main responsibilities are: Petrobras supplying the natural gas, White Martins operating the liquefaction unit and GasLocal distributing and selling the LNG (ANP, 2010; GasLocal, 2016). The liquefaction plant, located in the city of Paulinía, SP, has the capacity to produce 13.2 mcm of LNG per month and the distribution and commercialisation are made in regions where gas distribution networks are poorly developed or non-existent. The annual LNG production of this plant of 0.11 mtpa makes it a small-scale one following the IGU criteria that define such plants as those with a capacity of less than 1 mtpa (GasLocal, 2016; IGU, 2015).

The liquefaction technologies shown in Table 1 prevail among most producers, combining cost-effective output and optimised mixture of refrigerants. The PRICO process is found in the small-scale Gemini project, for which CAPEX was estimated at R$50 million (2006) ($16 million) with 42% spent on equipment and technologies involved (SISEA, 2008).

Proposed by Black & Veatch Company in the 1950s, PRICO is one of the mixed refrigerants (MR) processes, widely used in small and...
Policy Council (CNPE) in 2006 which was later included in the Petrobras 2007-2011 business plan, the first two LNG import projects in Brazil were presented: Pecém, CE and Guanabara Bay, RJ. In 2011, as part of the Growth Acceleration Programme of the Brazilian government, the go-ahead was given to the third Brazilian LNG terminal in Bahia, BA (ANP, 2015; Petrobras, 2016). Brazil first began importing LNG in 2009, when two floating storage and regasification units (FSRUs) entered service, both converted LNG carriers supplied by Golar LNG. The Golar Spirit was located at the Pecém terminal and the Golar Winter was initially located at the Guanabara Bay terminal. In 2011, Petrobras executed a charter party with Excelerate Energy to provide a new advanced FSRU. Golar Winter was moved to Bahía and was replaced temporarily in Guanabara Bay.

Regasification

Global LNG receiving capacity stood at 724 mtpa at the end of 2014. The total number of active regasification terminals with capacity above 1 mtpa as of end-2014 was 101. Japan remains the world’s largest LNG import market. Nearly two-thirds of the world’s receiving capacity is held in just three countries: Japan, US and South Korea. Japan alone holds 26% of the total (IGU 2015). Figure 17 presents receiving capacity by country.

Latin American regasification accounts for just 4% of worldwide capacity with plants in Brazil, Argentina, Chile, Dominican Republic and Puerto Rico. Their combined capacity at December 2014 stood at 28 mtpa (IGU, 2015). Table 2 presents the key characteristics of regasification plants in Latin America.

The implementation of LNG import projects in Brazil has become an important option to ensure a reliable, secure and diversified supply of natural gas. After a resolution of the National Energy Council (CNPE) in 2006 which was later included in the Petrobras 2007-2011 business plan, the first two LNG import projects in Brazil were presented: Pecém, CE and Guanabara Bay, RJ. In 2011, as part of the Growth Acceleration Programme of the Brazilian government, the go-ahead was given to the third Brazilian LNG terminal in Bahia, BA (ANP, 2015; Petrobras, 2016). Brazil first began importing LNG in 2009, when two floating storage and regasification units (FSRUs) entered service, both converted LNG carriers supplied by Golar LNG. The Golar Spirit was located at the Pecém terminal and the Golar Winter was initially located at the Guanabara Bay terminal. In 2011, Petrobras executed a charter party with Excelerate Energy to provide a new advanced FSRU. Golar Winter was moved to Bahía and was replaced temporarily in Guanabara Bay.

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Overview of the Brazilian liquefied natural gas industry

**Bahia terminal** It has a regasification capacity of 14 mcm/day of natural gas and connects to the Cacimbas-Catu pipeline (GASCAC) and the Southeast-Northeast pipeline (GASENE).

Current Brazilian regasification capacity is 11.7 mtpa and LNG is imported and LNG is imported (some cargoes are re-exports) from Equatorial Guinea, Qatar, the Netherlands, Nigeria, Portugal, Spain, Norway, Trinidad and Tobago, the UK and US (MME 2016).

**Plans and projects**

Global capacity will grow significantly over the next several years, as 128 mtpa come onstream, mostly in Australia and the US. With 57.6 mtpa of liquefaction capacity under construction, Australia will be far and away the largest source of capacity growth in the near term. No plan to increase the current small Brazilian production capacity has been proposed for the coming years, either by Petrobras in its Business and Management Plan 2015-2019 or by the Brazilian Government in its Growth Acceleration Plan (PAC).

However, there are plans in Brazil for power purchase agreements (PPA) covering gas-fired power plants fuelled by LNG supplied through purpose-built FSRU import terminals. These agreements include building a regasification terminal for imported LNG, focusing on the thermal plant natural gas supply, but also looking at new markets:

**Bolognesi Group** is leading two of these import projects, both postponed to 2021 by an existing Excelerate vessel called *Exquisite*. In 2014, the FSRU *Experience*, the largest LNG regasification ship in the world at that time, started commercial operation definitively at Guanabara Bay terminal. (Gastech, 2014; Petrobras, 2014).

**Table 3** presents the key characteristics of FSRU units in Brazil.

Additional characteristics of Brazilian receiving terminals:

**Pecém terminal** The first flexible terminal for LNG regasification in Brazil has the capacity to transfer up to 7 mcm/day of natural gas to the Guamaré-Pecém (Gasfor) pipeline. Primarily serves gas-fired thermal power plants in Ceará and Fortaleza.

**Guanabara Bay terminal** This flexible LNG regasification terminal can transfer up to 20 mcm/day of natural gas to the southeast pipeline grid. Primarily serves gas-fired thermal power plants in this region.

---

**Key characteristics of main Latin America regasification plants.**

<table>
<thead>
<tr>
<th>Country</th>
<th>Terminal Name</th>
<th>Start Year</th>
<th>Capacity (MTPA)</th>
<th>Owner</th>
<th>Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Rico</td>
<td>Peñuelas (EcoElectrica)</td>
<td>2000</td>
<td>1.2</td>
<td>Gás Natural Fenosa 47.5%; Engie 35%; Mitsui 15%; GE Capital 2.5%;</td>
<td>Onshore</td>
</tr>
<tr>
<td>Domenican Rep.</td>
<td>AES Andrés</td>
<td>2003</td>
<td>1.9</td>
<td>AES 92%; Estrella-Linda 8%</td>
<td>Onshore</td>
</tr>
<tr>
<td>Argentina</td>
<td>Bahia Blanca GasPort</td>
<td>2008</td>
<td>3.8</td>
<td>YPF 50; Stream 50%</td>
<td>Floating</td>
</tr>
<tr>
<td>Brazil</td>
<td>Pecém</td>
<td>2009</td>
<td>1.9</td>
<td>Petrobras 100%</td>
<td>Floating</td>
</tr>
<tr>
<td>Chile</td>
<td>Quintero LNG</td>
<td>2009</td>
<td>4.0</td>
<td>ENAGAS 60.4%; ENAP 20%; Oman Oil 19.6%</td>
<td>Onshore</td>
</tr>
<tr>
<td>Chile</td>
<td>Mejillones LNG</td>
<td>2010</td>
<td>1.5</td>
<td>Engie 63%; Codelco 37%</td>
<td>Onshore</td>
</tr>
<tr>
<td>Argentina</td>
<td>Puerto Escobar</td>
<td>2011</td>
<td>3.8</td>
<td>Enarsa 50%; YPF 50%</td>
<td>Floating</td>
</tr>
<tr>
<td>Brazil</td>
<td>Guanabara Bay</td>
<td>2009</td>
<td>6.0</td>
<td>Petrobras 100%</td>
<td>Floating</td>
</tr>
<tr>
<td>Brazil</td>
<td>Bahia</td>
<td>2014</td>
<td>3.8</td>
<td>Petrobras 100%</td>
<td>Floating</td>
</tr>
</tbody>
</table>

**Source:** Prepared by the authors based on data from IGU (2015).

---

**Key characteristics of FSRU and LNG import terminals in Brazil.**

<table>
<thead>
<tr>
<th>Ship Name</th>
<th>Type</th>
<th>Capacity (m³)</th>
<th>Regasification (BCM/year)</th>
<th>Delivery Year</th>
<th>Propulsion Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golar Spirit</td>
<td>FSRU converted from an LNG carrier built in 1981</td>
<td>127,000</td>
<td>2.5</td>
<td>2009</td>
<td>Steam turbine</td>
</tr>
<tr>
<td>Golar Winter</td>
<td>FSRU converted from an LNG carrier built in 2004</td>
<td>136,000</td>
<td>5.1</td>
<td>2009</td>
<td>Steam turbine</td>
</tr>
<tr>
<td>Experience</td>
<td>FSRU</td>
<td>171,000</td>
<td>8.2</td>
<td>2014</td>
<td>Tri-fuel diesel-electric</td>
</tr>
</tbody>
</table>

**Source:** Prepared by the authors based on data from Gastech (2014), Petrobras (2014) and MME (2016).
though winning the A-5 bid in 2014 (ABEGÁS, 2016): near the Rio Grande port in south Brazil and the Suape port, in Pernambuco state. According to the company, the Rio Grande and the Suape projects have an estimated investment of R$3.3 billion ($1 billion) each to supply the south and northeast Brazilian regions with electricity and natural gas.

◆ The government of Ceará state has signed a memorandum of understanding (MoU) to study the viability of building an onshore terminal in Pecém, replacing the existing FSRU, with a capacity of 12 mcm/day to possibly be developed in two stages and with potential expansion to 14 mcm/day. This project aims to fuel existing and future power plants to be key for the development of a special export zone (ZPE) (GOVT. CEARÁ, 2016; KINCAID, 2016).

◆ There is a similar initiative in Pará state where an MoU aimed at the development of a new regasification terminal was signed with Norsk Hydro. The project aims to deliver natural gas to key customers such as the industrial sector and power plants (GOVT. PARÁ, 2017).

◆ Genpower Group is proposing another import terminal in Sergipe port in connection with a 1,526 MW power project, the largest thermal power station in South America, that will be fuelled by LNG supplied by ExxonMobil and delivered through a new FSRU. The project cost is estimated at $1.3 billion and is scheduled to start delivering power to off-takers for 25 years starting in 2020 (Reuters, 2016).

Conclusion

The LNG industry is developing quickly in the world energy scene. It has evolved with great speed, given the need of the countries to diversify the sources of gas supply and guarantee their domestic supply. Natural gas will be the fuel of transition from a dirty economy to a cleaner one, and although it still has a small share in the energy mix, it will reinforce government measures so that Brazil can meet the greenhouse gas emission reduction targets of 37% by 2025 and 43% by 2030, set at COP21 in December 2015 in Paris.

On the other hand, Brazil is a continental country, and, as in the case of most emerging gas markets, a lack of transportation infrastructure and pipeline deliverability has limited the outlets for natural gas production to local gas markets. The development model with state investments is no longer in force and, at the same time, there is little incentive for other players to enter this market ruled by Petrobras practices. The construction of LNG satellite stations – treatment facilities fed by major LNG import terminals through tank trucks, trains or barges in regions not connected to the gas pipeline network – is not yet part of Brazil’s natural gas diversification strategy, although efficient and lower cost routes could lead to future savings for consumers.

The original idea that recent discoveries of oil and natural gas in the Brazilian offshore pre-saltopened the prospect of the country becoming an LNG exporter will not become real in the foreseeable future. Rather, Brazil will remain a lucrative market for LNG sellers due to the dependency on gas-fired power plants as a backup to hydropower and the need to use international spot prices.

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Natural gas will continue to increase its share of the global energy mix – estimates by the International Energy Agency put growth at 1.5% per year until 2040. In Malaysia, the expanding economy coupled with improvements in the infrastructure and regulatory framework, gas price reforms and abundant supply of resources are setting the stage for natural gas to play a pivotal role in securing the country’s energy security.

In the past few years, there has been a growing interest and enthusiasm for natural gas across the globe. Its advocates point to the role of gas in enhancing global energy security and reducing the effects of climate change by acting as a complementary fuel for renewables in the transition towards a low carbon energy future.

Natural gas is commonly recognised as the most environment-friendly, affordable, reliable, efficient and secure of all the fossil fuels. From production through to use in electricity generation, natural gas produces about half the greenhouse gas emissions of coal, and in contrast to both coal and oil, natural gas results in negligible emissions of sulphur dioxide, nitrogen oxides, mercury and particulates.

Although simply replacing coal with natural gas is not a panacea in addressing climate change, there is a consensus that natural gas can play a role in a clean energy future. In addition, because natural gas generators can be ramped up and down quickly, they can help support the integration of variable renewable resources – which are characteristically intermittent – contributing to a reliable electricity supply, and be used quickly during peak electricity demand.

Natural gas has also become an integral part of the transportation choices around the world – for personal and public transportation, heavy-duty trucks and marine and rail transport. The global drive to increase energy efficiency and reduce emissions is also spurring innovation for natural gas-fuelled household installations, from hot water and heating systems to residential cogeneration systems.

Against such broad changes in the global energy landscape, natural gas is expected to continue to increase its share of the global energy mix, growing at 1.5% per year until 2040, according to the International Energy Agency (IEA). The IEA estimates that there are enough technically recoverable gas resources (both conventional and unconventional) to last at least the next 200 years at current production levels.

Meeting Malaysia’s energy needs
In Malaysia, the development of the natural gas industry is closely linked with the country’s own development. In the last 30 years, 60% of the growth in the country’s energy needs was met by natural gas, rising from 32% of total energy needs in 1990 to reach its peak of 53% in 2006.

Data from Malaysia Petroleum Management (MPM) points to strong growth in demand in the last decade or so, particularly upon the introduction of regulated gas pricing in 1997 for the power sector and in 2002 for reticulation. (The MPM, a unit within the Upstream division at Petronas, oversees the overall policy and management of domestic petroleum resources and the development of the local oil and gas industry to ensure energy security for the country).

Today, more than half (54%) of natural gas consumption in Peninsular Malaysia is accounted for by the power generation sector, followed by small (19%) and large (19%) industries. Over in Sabah and Sarawak, domestic demand is relatively small – taking up about 15% of the available supply there – but the Vice President of MPM, Muhammad Zamri Jusoh, expects the proportion to grow when the SAMUR project in Sipitang, Sabah, which uses natural gas as feedstock, and the Samalaju Industrial Park, Sarawak are fully operational.

Security of supply
According to MPM, in 2016 93% of gas supply in Peninsular Malaysia came from natural gas (from offshore Peninsular Malaysia, the Malaysia-Thailand Joint Development Area, the PM3 block located within a Commercial Arrangement Area set up between Malaysia and Vietnam, and West Natuna in Indonesia), and the remaining 7% from LNG.

An LNG regasification terminal (RGT) built in Sungai Udang, Melaka commenced operations in May 2013 – enabling LNG supplies to be fed into the Peninsular Gas Utilisation (PGU) pipeline.

The completion of the RGT in Melaka is an important development for Malaysia’s energy security, says Malaysian Gas Association Secretary General Rosman Hamzah, adding that with the RGT Pengerang project in Johor (to be commissioned in the third quarter of 2017), there is no shortage of gas in Malaysia.

Reiterating the significance of the RGT in Melaka, Petronas Vice President of LNG Marketing and
Trading. Ahmad Adly Alias, says Malaysia now has the flexibility to import from a portfolio of LNG supply. The third largest LNG exporter (after Qatar and Australia), Malaysia has traditionally sold its LNG to its customers in the Far East, and is currently eyeing opportunities in the Middle East and South Asia. Although the LNG from the Petronas LNG Complex has been fully contracted to its customers, there have been instances where Petronas was able to deliver one or two cargoes from Bintulu to Melaka.

“With the new Train 9 in Bintulu, together with the two Floating LNG (FLNG) facilities, it is possible to bring in LNG from East Malaysia into Peninsular Malaysia if there is a demand for it,” says Zamri.

Research and development and innovation are driving the natural gas and LNG industry. FLNG units for instance, play a role in gas monetisation projects, opening up opportunities to monetise gas reserves from remote, marginal and stranded gas fields, which would otherwise be uneconomical to develop. Petronas currently has two FLNG units – PFLNG Satu, which is already deployed and commissioned in the Kanowit gas field, offshore Sarawak, and PFLNG Dua currently under construction.

Investments are also going into gas processing and pretreatment facilities. The Terengganu Gas Terminal in Kertih, a joint venture between Petronas Carigali Sdn Bhd (PCSB) and Hess Exploration & Production Malaysia uses PN1, a Petronas proprietary membrane for CO₂ removal.

**Top pick for electricity generation** Thanks to the security of supply and its clean-burning attributes, natural gas has been the top choice for electricity generation. Data from the Energy Commission shows that as part of the electricity generation mix, natural gas comprised 50.4% of all fuel types in 2013, a rise from 41.7% twenty years earlier.

National power company Tenaga Nasional Bhd (TNB) Vice President (Generation) Datuk Zainuddin Ibrahim points to the benefits of gas-fired power plants. Thermal efficiency of coal plants stands at 37% and 41% for ultra supercritical coal fired plants.

“With gas, the evolution of gas-fired turbines has come a long way. The first combined cycle gas turbine (CCGT) power plant in Paka back in 1984, recorded thermal efficiency of 35% but now with the H-class CCGT in Prai it’s 60%.

“A reasonable load or power can be obtained within 30 minutes for a gas-fired plant, and the full load within an hour. With coal it’s within four hours. Gas plants are also easy to operate. There is also a consistency in the quality,” he says.

**Expanding the share of gas**

Although there are a few gas power stations that will come online in the near future such as Edra Global Energy Project in Alor Gajah, Melaka and the SIPP Energy project in Pasir Gudang, Johor (generating more than 3,000 MW of electricity), proponents of natural gas argue that it is important to grow the share of gas in other sectors.

Cogeneration is one of these. "Cogeneration is an efficient energy production system and can be used to simultaneously produce electricity, heat and/or chilled water. Co-generation is already being used in Centralised Utilities Facilities in Kertih and Gebeng, Gas District Cooling in KLIA, Putrajaya and UTP, and the Pengerang Cogeneration Plant,” says Zamri.

Due to their high thermal efficiency of up to 90%, such systems enable customers to utilise more energy from the same volume of gas, thus significantly reducing the total energy cost.

The transportation sector is another growth area. Compressed natural gas (CNG) is already being used in public transportation, mostly taxis in the Klang Valley, and a number of private vehicles. “We’re looking at [greater use of] gas for transportation, for example, the use of LNG for heavy haulage vehicles as is the case in the US and China,” adds Rosman.

Although gas demand from the industrial sector has remained relatively flat, improving prospective customers’ access to gas by expanding infrastructure such as gas pipelines to as-yet-to-be-reached locations may be a move in the right direction. The market should also target industries with the highest value-add, those that are less sensitive to the fluctuations in gas prices, suggests Adly.

There is no denying that a major driver for natural gas is its comparative advantages to other non-renewable sources of fuel. What’s more, if Malaysia is to meet its commitment to reduce 45% of its greenhouse gas emission intensity by 2030, articulated during COP 21 then natural gas has to be the fuel of choice, say its proponents.
Condensing boilers: still the most cost-effective technology for domestic space heating and hot water

By Jean Schweitzer

Sixty million gas boilers are installed in the EU and represent one of the major space heating technologies. Studies have shown that once users are confronted with a situation where they need to replace their boilers, the majority of them would prefer to invest in a gas boiler again.

Is this a good option? Knowing that “decarbonisation” of space heating is becoming part of the EU heating strategy, this question is relevant.

However, the EU electrification of space heating with electrical heat pumps is proving to be more difficult than planned: Prices of appliances are high and the extensive electrification of heating will require costly power infrastructure investments (production and distribution). In this context, the gas boiler still has an important role to play.

This paper presents in detail the performances of gas boilers so the technology can be fairly assessed in comparison with other space heating technologies.

Detailed data measured over the last 25 years by the Danish Gas Technology Centre (DGC) on about 200 boilers give a rather accurate picture of the performances of gas boilers for efficiency, emissions and electricity consumption. The data of the investigations are valid for many of the EU countries as the appliances are the same.

When combining the performances with the appliance and maintenance cost in Denmark, it appears that the condensing boiler is still the most cost-effective technology for space heating. The present low gas cost and high lifetime are making the technology even more attractive.

Is the gas boiler a technology of the past?
Not at all, on the contrary the replacement of old gas boilers by condensing boilers can bring cost-effective energy savings and CO₂ reductions. Furthermore, the gas boiler combined with a small electrical heat pump (EHP) will help a smooth “decarbonisation” of space heating for the benefit of the end user and the society.

Introduction
In the context of the energy transition discussion, gas boilers are often considered a technology of the past that should be replaced by highly-efficient new technologies. However, the condensing boiler is still the most cost-effective solution to space heating and offers a smart road to energy transition when coupled to a small EHP (hybrid technology).

Due to the high costs of competing technologies (heat pumps, micro-CHP etc.), the consumer’s first choice is still the gas boiler. At the same time, hybrid solutions and the development of green gases have contributed to making the gas boiler an interesting option for preparing the energy transition, and decision makers’ opinions on gas boilers have recently started to change.

The heating market, however, is entering into tough battles and figures used to calculate performances of heating systems are being discussed and challenged by the different stakeholders involved. This has given rise to
the need for known and reliable figures of the performance of appliances in order to ensure fair competition between technologies and reliable information for users.

In Denmark, DGC has been testing gas boilers for consumer information since 1990. The tests performed in the laboratory aim to reflect the actual performance of installed appliances and include efficiency, emissions and electricity consumption. The method used for the evaluation of annual performance has been developed over several years and validated by a consortium of partners in the EU, including laboratories, universities and manufacturers.

DGC’s boiler database – which includes results of tests on several hundred boilers – shows the positive evolution of gas boiler performance. In 2015, the boiler database was used for an extended analysis including statistics on proven and measured performance of the various boilers on the market, including the latest generation of condensing boilers. Such data are used to calculate and compare gas boilers with other space heating options.

The use of correct performance is essential for consumer information and for the setting of regulations of gas boilers. The data can also be used to calculate the performance and control strategies of hybrid solutions. The decision about when the boiler or the EHP is to be in operation needs to be based on the actual efficiency of the boiler and heat pump for the given operating conditions (load, water temperature, etc.).

The boiler database includes not only such information for heating efficiency, but also detailed results for sanitary hot water efficiency, CO and NOx emissions, electricity consumption and standby losses.

This paper gives an overview of the main results and also includes statistics on the actual lifetime of gas boilers based on records of boiler replacement by the Danish gas distribution companies.

**European domestic gas boilers, some explanations**

**Technology**

In Europe, domestic space heating with gas is dominated by gas boiler technology. A gas boiler is an appliance which burns gas to produce heat that is transferred to water used for space heating and possibly sanitary hot water. Radiators, convectors or floor heat exchangers are used to transfer the heat from the boiler to the space to be heated.

A condensing boiler is a boiler designed to recover latent heat from water vapour produced during the combustion of the gas. Condensing boilers nowadays are all equipped with full premix burners. This means that the air used for the combustion is mixed with the gas before combustion.

“Traditional boilers” do not recover latent heat from water vapour produced during the combustion of the gas. Apart from a single exception, traditional boilers have been banned from the EU market from September 26, 2015 (EU Ecodesign Directive). In many countries like Denmark, the Netherlands, etc., condensing boilers have been the “standard” boilers for the last decade or more.

**Market**

The EU market of gas boilers is dominated by “individual wet systems” (using water to transfer heat from the boiler to the space to be heated), which are mainly gas, fuel oil and solid fuel boilers. The rest of the market is district heating (about 10% – according to “The boiler and heating system markets in the EU”, BRG Consult 2006 – collective heating (about 15%) and other systems (mostly individual heaters). There are more than 60 million gas boilers in the EU. Today, the market is mainly for the replacement of existing appliances rather than for new installations.

Because of its size, there are commercial battles to gain part of the market. District heating and heat pumps are the two main
Danish boiler database
DGC has been measuring gas boilers in its accredited laboratory since 1991. During this period of time, DGC has participated in numerous inter-comparisons with other leading EU laboratories in order to ensure that measured results are comparable within the EU. The tests are carried out in agreement with the manufacturers and the Danish gas industry. The objective of these tests is to get a fair assessment of appliances on the market in order to help consumers choose appliances.

As the testing began in 1991, the database covers a large variety of boilers, from atmospheric boilers, the first condensing boilers to up-to-date condensing technology. At the present time, the database includes about 250 boilers. The earlier data are still used today, as these boilers are the boilers that are being replaced by new technologies. The knowledge of older boilers is therefore very useful to assess the energy saving of boiler replacements. Most of the boilers in the early 1990s were traditional, but the market changed rapidly to condensing only. Currently 83% of boilers in the database are condensing boilers.

DGC's test programme usually covers several test conditions in order to get a clear picture of how load and temperature influences the boilers' nominal efficiencies and how gas composition influences NOx emissions.

The extensive test programme shown in Table 1, executed on many boilers, has allowed us to gain a unique knowledge on how load and water temperature influences boiler efficiency. This has been further used to validate the BOILSIM calculation model, used for the annual efficiency.

Results, actual performances of boilers in laboratory
Nominal efficiency of gas boilers for heating (based on lower calorific value)
The nominal efficiencies are measured in the laboratory under standard conditions. Figure 1 shows among other things that most of the...
Growing with Partnership

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Condensing boilers: still the most cost-effective technology for domestic space heating and hot water

Progress for the second generation of condensing boilers is achieved via increased efficiency for part-load efficiencies.

Nominal efficiency of gas boilers for hot water (based on lower calorific value)
There has been a clear and positive evolution of nominal hot water efficiency of gas boilers since 1990. The data are for boilers with storage tanks which is the preferred option in Denmark (Figure 2).

Nominal emissions (NOx, CO) (mg/kWh input calculated with lower calorific value)
The evolution of emissions of gas boilers since 1990 shows a sudden improvement in the 2000s with the introduction in Denmark of an energy labelling requirement that has resulted in the banning of traditional boilers. The average ratio of emission at Pmax:emission at Pmin is about 3:1 (Figures 3 and 4).

For CO, a similar figure is found. The improvements at Pmin are especially important and the average ratio of emission at Pmax:emission at Pmin is about 16:1 (the very high value is due to extremely low CO for some boilers). At the same time it seems that the emission of CO at Pmax has not changed very much through the years.

If we look at only the last 15 years, the average emissions for boilers installed since 2000 are as follows:
- NOx at Pmax: 60 mg/kWh
- NOx at Pmin: 27 mg/kWh
- CO at Pmax: 66 mg/kWh
- CO at Pmin: 9 mg/kWh

Such data shows the positive impact of modulation on boiler emissions and have been used in Denmark to update the taxation system for NOx emissions.

Results, annual performances of boilers

Model
The efficiency of a boiler depends on water temperature and load. Both parameters are
related and depend on the installation. Therefore, the actual efficiency of an installed boiler may differ from the nominal efficiency measured in the laboratory and will depend on operating conditions. The design of the water distribution and emitters (radiator, convectors, floor heating, etc.), and the heat demand will particularly influence boiler performances. Therefore, in real situations, the efficiency of the same boiler can be different from one installation to another. For that reason, annual efficiency calculation methods and models have been developed and validated.

DGC was involved in the development of the model BOILSIM, which is an EU method for the calculation of the seasonal (annual) efficiency of domestic boilers. A consortium of about 15 partners (test and research laboratories, manufacturers) developed the method starting in 1994. BOILSIM’s main target is to allow a fair comparison of boilers on the basis of their annual efficiency, taking into account the installation and climate influence.

The model was validated through field tests and DGC has been using the model to calculate annual efficiencies of gas boilers under Danish climate and installation conditions for the sake of information for end users for about 25 years.

The BOILSIM method includes a detailed part-load model for the boiler and a simpler model for the installation design and operating conditions. Comparing boiler test results with the part-load model has shown that the boiler model compares very well with measurements.

The BOILSIM model requires test data as input. In Denmark, these tests have been performed by DGC since 1990. The most popular boilers on the market are tested and, through DGC data, it is possible to get a quite accurate view of the real performances of the boilers in Danish homes.

The annual efficiency calculated includes a constant sanitary hot water demand of 2,000 kWh/year which is the average in Denmark. The annual efficiency is calculated for three heating demands (10,000, 20,000 and 30,000 kWh/year) and for two types of installations (traditional and low-temperature). In doing so, we cover the majority of situations encountered in real installations and intermediate situations can be calculated by interpolation.

The method has been used since the 1990s for both oil and gas boilers and in Denmark the annual efficiency calculation was used for the national energy labelling of gas boilers.

The uncertainty in the determination of annual efficiency with background laboratory test is about 2% (accumulated uncertainty using a boiler test rig).

The importance of the distribution system

The design of a radiator installation plays an important role for the performance of appliances: The more radiators/convectors, the lower the water temperature in the distribution system, and, so, the higher the efficiency of the boiler. Since 2005 in Denmark (Building regulations BR2005), the design radiator system temperature is 55°C for all new buildings. However, installers have been educated to design distribution systems for condensing boilers and therefore such low temperatures are not unusual for houses built before the regulation entered into force in 2005.

Furthermore, existing houses subject to additional thermal insulation will see their distribution system “oversized” as a consequence of the insulation and this will lower the average water temperature in radiators as well. In the following we consider:

◆ TT = Traditional temperature, here designed with high water temperature in the radiators of 60-80°C
◆ LT = Low temperature, here designed with a high water temperature average of 55°C

Note that the above definitions originate from DGC’s early work in the 1990s. In order not to bring confusion to existing publications and calculation results we have used the
Condensing boilers: still the most cost-effective technology for domestic space heating and hot water


Traditional boilers
◆ Early: 1990-1996;
◆ Transition: 2000-2010+ (“2010+” because we have some traditional boilers after 2010).

The efficiencies are valid for boilers on the Danish market, but those are all sold on the EU market as well. This means that the figures in Table 2 would match most of the countries in the EU.

For most recent condensing boilers, Table 3 can be used to calculate more accurately the efficiency of the heating system for other installation types: MX being “mixed distribution system” with partly TT (traditional temperature definition from the 1990s, despite the fact that the current rules for designing installations have evolved, and “low temperature” is indeed lower than 55 °C, especially for floor heating systems.

Annual efficiency (based on lower calorific value)
Here we have carried out calculations over three periods and have differentiated between condensing and traditional boilers:

Condensing boilers
◆ Early: 1990-1996 (first-generation condensing);
◆ Transition: 2000-2010 (second-generation condensing);

Traditional boilers
◆ Early: 1990-1996;
◆ Transition: 2000-2010+ (“2010+” because we have some traditional boilers after 2010).

The efficiencies are valid for boilers on the Danish market, but those are all sold on the EU market as well. This means that the figures in Table 2 would match most of the countries in the EU.

For most recent condensing boilers, Table 3 can be used to calculate more accurately the efficiency of the heating system for other installation types: MX being “mixed distribution system” with partly TT (traditional temperature

<table>
<thead>
<tr>
<th>Distribution System</th>
<th>TT 10,000</th>
<th>LT 10,000</th>
<th>TT 20,000</th>
<th>LT 20,000</th>
<th>TT 30,000</th>
<th>LT 30,000</th>
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<tr>
<td>AVG</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Trad 1990-1996</td>
<td>Early</td>
<td>76.0</td>
<td>77.4</td>
<td>80.8</td>
<td>81.7</td>
<td>82.8</td>
</tr>
<tr>
<td>Trad 1997-2009+</td>
<td>Transition</td>
<td>78.3</td>
<td>79.7</td>
<td>83.0</td>
<td>83.8</td>
<td>84.9</td>
</tr>
<tr>
<td>Cond 1990-1996</td>
<td>Early</td>
<td>85.8</td>
<td>89.3</td>
<td>92.1</td>
<td>95.3</td>
<td>94.8</td>
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<tr>
<td>Cond 1997-2009+</td>
<td>Transition</td>
<td>90.7</td>
<td>94.0</td>
<td>96.1</td>
<td>99.2</td>
<td>98.2</td>
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<tr>
<td>Cond 2010-2015</td>
<td>Latest</td>
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<td>95.8</td>
<td>98.5</td>
<td>101.2</td>
<td>100.7</td>
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</table>

<table>
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<tr>
<th>Heat demand kWh/yr</th>
<th>Without HW</th>
<th>With 1,000 kWh HW</th>
<th>With 2,000 kWh HW</th>
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<tr>
<td></td>
<td>LT</td>
<td>TT</td>
<td>MX</td>
</tr>
<tr>
<td>14,000</td>
<td>104.0</td>
<td>100.0</td>
<td>102.0</td>
</tr>
<tr>
<td>15,000</td>
<td>104.3</td>
<td>100.4</td>
<td>102.3</td>
</tr>
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<td>16,000</td>
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<td>100.8</td>
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<td>105.7</td>
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<td>21,000</td>
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<td>22,000</td>
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<tr>
<td>23,000</td>
<td>106.5</td>
<td>103.7</td>
<td>105.1</td>
</tr>
</tbody>
</table>
We don’t lose sleep if the wind and the sun take a break. Natural gas is always there when you need it. It is readily available and easily stored. Its flexibility and versatility make it an ideal partner for renewable energy sources – now and in the future.
no reason to think that flue gas loss in a real situation would differ from the flue gas loss measured in the laboratory.

A large number of gas boilers in Denmark are covered by a regular service scheme, under which the boiler operation and safety are checked, and the boiler is adjusted, if necessary. The service companies performing this work must be authorised by the safety authorities.

The service reports provided can differ slightly depending on the service company, but they all include more or less the same information about boiler operation, including a number of measured combustion values. In addition, reports include various pieces of information about the installation.

We have gathered a few hundred service reports and analysed the data. The following observations can be made:

◆ There are only small variations in CO₂ before and after service and this also means between two services. The range of variation is from -1.5 to +0.5 (difference CO₂ after, CO₂ before).

◆ Furthermore, it was confirmed that there are only small differences between the CO₂ measured in the laboratory and measurements carried out by the service companies. This is not really a surprise, as the adjustment should be made according to the manufacturer’s instructions which should indicate the same CO₂.

The maximum variation (1.5%) will not impact flue gas losses very much and differences are below the range of the uncertainty in the determination of annual efficiency. As the CO₂ values in the service reports are typically very close to the value measured in the laboratory, we can thus conclude that installers are following the rules and instructions, and that there are no additional flue gas losses due to poor installation or poor service. Moreover, the difference seen for some boilers will only have a very small impact on the boiler efficiency of premix condensing boilers.

### Table 4.

<table>
<thead>
<tr>
<th>Boiler</th>
<th>Distribution System</th>
<th>Heat demand (kWh)</th>
<th>El. max</th>
<th>El. min</th>
<th>El. min</th>
<th>El. min</th>
</tr>
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<tbody>
<tr>
<td>Trad 1990-1996</td>
<td>Early</td>
<td>20,000</td>
<td>651</td>
<td>502</td>
<td>568</td>
<td>588</td>
</tr>
<tr>
<td>Trad 1997-2009+</td>
<td>Transition</td>
<td>10,000</td>
<td>790</td>
<td>515</td>
<td>557</td>
<td>592</td>
</tr>
<tr>
<td>Cond 1990-1996</td>
<td>Early</td>
<td>20,000</td>
<td>598</td>
<td>405</td>
<td>450</td>
<td>485</td>
</tr>
<tr>
<td>Cond 1997-2009+</td>
<td>Transition</td>
<td>10,000</td>
<td>576</td>
<td>351</td>
<td>380</td>
<td>401</td>
</tr>
<tr>
<td>Cond 2010-2015</td>
<td>Latest</td>
<td>30,000</td>
<td>221</td>
<td>126</td>
<td>155</td>
<td>174</td>
</tr>
</tbody>
</table>

Annual electricity consumption (including the pump)

The electrical consumption is very much dependant on the boiler control and especially if the pump is running during off periods of the burner (El. max in Table 4) or if the pump is stopping (El. min). In recent decades, manufacturers have worked energetically to decrease the electrical consumption of boilers.

Can the results obtained by calculation with models and tests from the laboratory be compared to “real efficiency”?

This question is very often asked. The answer is “Yes” for the following simple reason:

The main loss for modern boilers is the flue gas loss. If the flue gas loss for installed boilers is the same as for the boilers tested in the laboratory, the calculation of annual efficiency would fit very well. The flue gas loss depends very much on the quantity of air that is burned with the gas. For modern condensing premix boilers, the air excess is given by the boiler adjustment, and manufacturers indicate the CO₂ value in their documentation. Installers must respect the value given both at the installation phase of the boiler and at maintenance. If they do their job properly, there is...
Therefore, the results obtained by calculation with models and tests from the laboratory can be compared to real obtained efficiencies.

**Reliability of gas boilers – lifetime of boilers**

**Model**

The lifetime of boilers is defined as the time after installation where 50% of the installed population is not operational anymore. Together with HMN, a Danish gas distribution company, DGC has investigated the feasibility of a method to predict the lifetime of boilers with statistics available on boiler installations. The idea is to observe the evolution of boiler failure statistics and then extrapolate from it.

The example in Figure 5 shows the annual failures registered (blue dots) and the model (green curve). The model fits for about 18 years. There are still boilers on the market with an age below 18 years and for this reason the blue dot curve is not complete yet (we would need to wait 35/40 years to have a complete picture!). The curve and dots fit well before 18 years implying that the model is fine. The red dots and red curve show the cumulated failures recorded (dots) and the model (curve), respectively. The green dotted line shows the total number of boilers installed. The lifetime for this boiler is reached at the vertical green line (here about 21 years).

From data available we have demonstrated that a Gaussian distribution model for boiler failures would work for a majority of boilers when the “history” of the boiler is simple (no redesign of the boiler model during the period it was put on the market). This would allow us to foresee the average lifetime of boilers when, for example, about 10% of the failure rate is reached.

**Results and discussion**

The statistical calculations were made with extended data related to boiler replacement provided by HMN. The analysis of the lifetime of 26 boilers from a population of about 60,000 appliances has shown that the average lifetime of boilers is 19 to 20 years for both traditional and condensing boilers.

We have considered that in most cases replacement was due to “boiler failures”. It would be more appropriate to speak about “boiler age when replaced” as we do not know the reason for the replacement, which can also be motivated by energy savings. Therefore, a 19- to 20-year lifetime reflects the “economical lifetime” of boilers and not the “technical lifetime”, which can be better.

**What is the future for the gas boiler?**

**Overall**

The gas boiler is still a cost-effective space heating appliance that competes well against all other technologies. In Denmark, an impartial analysis by Ea Energy Analyses has shown that gas boilers are still the best space heating option for the end user and for society. High efficiency, low cost and long lifetime are the reasons for the good position of this technology. Furthermore, low gas prices are bringing its competitiveness to an even higher level!

**Evolution of the boiler population**

In Denmark, as in other EU countries, there are discussions and plans to totally decarbonise the
Concluding remarks

Any energy policy or strategy should be based on proven facts and figures. The work done in this project aims to bring real figures on gas boiler performance and lifetime to allow fair competition with other technologies. However, even if the gas boilers are still the most cost-effective space heating appliances today, the “decarbonisation” of space heating is going to influence the market towards non-fossil solutions.

Therefore, instead of playing gas boilers against other technologies, it is wise to combine them with other technologies, thus optimising the efficiency of the systems and reducing the costs for the end user and for society. At the same time, the increasing share of renewable gas in the grid will reduce the CO₂ footprint of gas technologies.

In this context, gas boilers will still play a positive role in the heating market as a reliable and cost-effective technology.

Jean Schweitzer is a Project Manager at the Danish Gas Technology Centre (www.dgc.eu). The original, fully referenced version of this paper, part of the proceedings from IGRC 2017, will be available to download from the IGU website (www.igu.org) after November 26, 2017.
Change, from the way we now produce and consume energy, to a greener mix of oil and coal-powered energy coupled with the use of natural gas as an energy source. Natural gas emits an estimated 40-70% less carbon dioxide than other fuels, reducing the growing pressure on our ecosystem. Moreover, natural gas produces less sulphur dioxide, nitrogen oxides and particulate matter.

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We begin the news section of this issue with a roundup of IGU’s work and influence over the past six months including new appointments to the Secretariat staff, a review of the ongoing work on the Building for the Future project and a look at just some of the events that the Presidential and Secretariat teams have been involved in representing IGU.

The workshops in conjunction with IGU’s Executive Committee and Council meetings are now firmly cemented in the programme. In Muscat, they provided a platform for discussion that started from an Omani perspective then broadened out to the regional and then global scale taking in both the geopolitical landscape and the place of natural gas in a post-COP 21 world.

IGU’s library of publications continues to grow, with new editions of two of its most important annual reports, a new case study on LNG as a marine fuel and a handy volume to aid those advocating for gas. We go into greater detail on their contents in the article on page 96.

The IGU Regional Coordinators for the Middle East and Africa and for Latin America and the Caribbean then provide an update on the state of the gas industry in their regions with exciting developments taking place.

With research, development and training very much in focus at IGU and in the pages of this issue, we bring you a specially extended News from organisations affiliated to IGU feature, highlighting some of the many projects being undertaken in the fields of pipelines, drilling in urban areas, methane emissions, renewable gas and NGVs. We also have news of EDI’s global executive programmes and the expansion of IPLOCA’s membership structure.

Finally we profile IGU’s newest affiliated organisation Asociación Regional de Empresas del Sector Petróleo, Gas y Biocombustibles en Latinoamérica y el Caribe (ARPEL), the Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean.
IGU Executive Committee and Coordination Committee meetings, Muscat, Oman

IGU’s Executive and Coordination Committees met from March 27-30 in Muscat, Oman hosted by IGU Charter Member Oman LNG. With the election for the IGU Presidency for the 2021-2024 triennium and World Gas Conference 2024 due to take place at the Council Meeting in Tokyo in October, the three candidates, Canada, China and, for the first time, a joint bid from Egypt and Oman were presented at the meeting.

The event provided an excellent platform for debate and discussion with topics touching the local, regional and global gas industry and the ramifications of geopolitics and environmental commitments post-COP 21. We have an article expanding on the three-session Workshop that followed the meetings on pages 92-95.

IGRC 2017

One of IGU’s three flagship events of each triennium, alongside the World Gas Conference and the LNG X Conference and Exhibition, the International Gas Union Research Conference (IGRC) was held from May 24-26, at Riocentro in Rio de Janeiro, Brazil, hosted by IGU Associate Member Instituto Brasileiro de Petróleo, Gás e Biocombustíveis, IBP.

The leading forum for R&D and innovation discussion and presentations was held for the first time in Latin America under the theme “Natural Gas Catalysing the Future”. Bringing together distinguished speakers, authors from over 25 countries and seeing the presentation of around 300 technical papers, IGU once again showed itself at the cutting edge of developments in the global gas industry.

Opening the event, David Carroll, IGU President, pointed out the importance of the IGRC, not only as a place for the exchange of ideas but also as a place where solutions can be sought and new forms of cooperation can be developed.

Closing proceedings on the final day, Luis Bertrán Rafecas, IGU Secretary General, spoke of the key role of technology in the energy
Second Coordination Committee meeting held in Daegu, Korea

To ensure the smooth continuity of IGU’s important work for the gas industry after the handover of the IGU Presidency from the USA to Korea at WGC 2018, the Coordination Committee for the 2018-2021 triennium held its second meeting from July 3-5 in Daegu, Korea, at the invitation of the Korean IGU Vice Presidential team. The Triennial Work Programme for the coming three years will be presented at WGC 2018 in Washington DC. IGU’s Committees and Task Forces are a cornerstone of the organisation’s ongoing work and participation, which grows year by year, is open to all members. Invitations to nominate representatives will be distributed after the Executive Committee meeting in Cairo in April 2018.

IGU expands the Secretariat staff

IGU welcomed two new members of staff to the Secretariat in June.

Hyunchang Kim joined as Advisor to the Secretary General on secondment from KOGAS. Mr Kim has a Bachelor’s degree in economics from Seoul National University and has completed further studies in international trade and law including the GATT and FTAs.

Emma Siobhan Paños Knowles joins the Secretariat in the role of Executive Administrative Assistant. Ms Paños Knowles gained a Diploma Degree in International Studies and has highly-qualified experience in event production, protocol and internal communications.

New and updated IGU Reports published

As part of its ongoing work to provide comprehensive and rigorous analysis of the industry, IGU has published the latest editions of its two flagship publications, the seventh edition of the World LNG Report and the latest edition of the Wholesale Gas Price Survey which has now been running for 10 years. 2016 was a dynamic year for the LNG industry with a wealth of new transition including some of the many ways that natural gas can be combined with renewable energy as part of the long-term energy solution.

To mark this important event in IGU’s calendar we have a special section of the magazine dedicated to IGRC 2017 starting on page 43, which includes three of the technical papers which were presented highlighting the diversity of topics which were covered over the three days.
supply projects coming onstream bringing greatly increased availability and also growing demand from both established and new markets. The ongoing work of IGU’s wholesale gas price surveys has brought greater understanding of the significant changes in wholesale price formation mechanisms in the global gas market during the last decade. The latest edition includes data from countries that account for 90% of gas consumption around the world.

The latest of IGU’s Case Studies series, Enabling Clean Marine Transportation, has also been published as well as the pocket-sized Global Natural Gas Insights which provides an overview of the role natural gas can play as we face global energy challenges and is designed to assist those advocating for gas.

For further information on IGU’s latest publications please see the article on pages 96-98. Also in this issue, on pages 20-22, Mel Ydreos, IGU’s Executive Director of Public Affairs, discusses the benefits of LNG as a marine fuel, a companion piece to the latest Case Study. IGU’s publications can be downloaded from the website at www.igu.org under the Resources & Data tab and are also available in print from the Secretariat.

Building for the Future
Led by the Secretary General, Luis Bertran, reporting to the President, David Carroll, the Building for the Future project is now in Phase III, reviewing IGU’s structure and governance. The progress of the project was reported at the last IGU Executive Committee meeting in Muscat in March where it was decided:
◆ To continue with the election for the IGU Presidency for the 2021-2024 triennium according to the current procedure in place;
◆ Prioritise the proposal on changes to IGU’s structure and governance, including the potential establishment of a permanent Secretariat;
◆ Prepare an implementation plan for a permanent IGU office which would begin running from 2022 when the term of the Spanish Secretariat ends;
◆ The implementation plan will be presented at the next Council meeting in Tokyo in October 2017.

Following these decisions, the Working Group (WG) has been continuing its task of preparing the implementation plan. To ensure the wider involvement of IGU’s representative members, a Reference Group has been created, which is providing feedback and advice to the WG. Also, IGU has employed the services of an international consultancy firm to give strategic guidance on the best practices for international trade associations.

At the Tokyo Council meeting IGU will be taking key decisions on continuing its relevant work representing the natural gas industry. The scope of these decisions will be the changes to our organisational structure with relation to the President, the Committees, the Management Team, the Executive Committee and the Secretariat, the structure and positions of a permanent Secretariat, its location, the financial implications and the transition plan for implementation.

To give a broad overview, the implementation of a new permanent Secretariat is planned by the end of 2021, which will allow one year of overlap with the Spanish Secretariat which will finish at the end of 2022. Meanwhile, the selection of the office is scheduled for the latter part of 2020 with staff recruitment planned for the second half of 2021.

Additionally, a reinforcement of IGU’s finances is planned with some changes to the royalty model for IGU events alongside work to grow the membership and increase the number of regional meetings and events which will contribute to the services IGU offers and add revenue. To ensure ongoing good governance, the establishment of an Ethics Committee and a Finance Committee will also be discussed.
Realising TAP. Construction facts & figures.

TAP, one of the most important energy infrastructure projects in Europe successfully began construction in 2016. As of early June 2017:

- The project has a world-class HSE performance with frequency rates well below international references. 14,500,000 man hours safely worked and 34,500,000 km safely driven.

- TAP’s contractors have cleared 53% of the project route in Greece and Albania (377km out of 765km). Also, 25% of the welded steel pipes are already in the ground.

- Approximately 70% of the total 55,000 pipes to be used for the construction of the pipeline have been received in Greece, Albania and Italy.

- More than 5,500 people have been working for the project across TAP’s host countries.

- TAP will invest over €55 million in social and environmental investment (SEI) programmes in the communities along its route.

More information:
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@tap_pipeline
and allow bilateral participation in the work of each organisation’s Technical Committees and Working Groups.

IGU and ARPEL are now reciprocally institutional members, working in cooperation for the benefit of the natural gas industry in Latin America and the Caribbean.

We present an overview of ARPEL on page 126 and look forward to bringing you news of their work and events in future issues of *International Gas*.

**Industry engagement**

Over the past six months the IGU Presidency and Secretariat teams have participated in many conferences, meetings and events and here are a selection of the highlights:

**Second meeting of the G20 Energy Sustainability Working Group**

Continuing IGU’s engagement with the German Presidency of the G20, IGU’s Relationship Manager, Pål Rasmussen, and Executive Director of Public Affairs, Mel Ydreos, attended the second meeting of the G20 Energy Sustainability Working Group in Berlin, Germany on March 23. IGU’s latest Case Study, *Enabling Clean Marine Transportation*, discussing the advantages of LNG as a marine fuel, was released at the meeting. For further information on this important topic see the article on pages 20-22.

**SE4All Forum, Going further, faster, together**

Rafael Huarte, IGU Director, met with Rachel Kyte, CEO Sustainable Energy for All (SE4ALL) and Benedikt Hoskuldsson, Lead Partnership Specialist, SE4ALL on April 4, during the third annual SE4All Forum which took place in New York, USA from April 3-5.

The event brought together over 1,000 high-level representatives from government, business, civil society and international organisations with the aim of working towards the achievement of the UN’s Sustainable Development Goal 7, ensuring access to affordable, reliable,
sustainable and modern energy for all. IGU has a longstanding relationship with SE4All through its former CEO and current IGU Wise Person, Dr Kandeh Yumkella.

**Oil and Gas Conference ARPEL 2017**

IGU Secretary General Luis Bertrán Rafecas was a speaker at the Oil and Gas Conference ARPEL 2017, held in Punta del Este, Uruguay, April 25-27, under the theme “New Energy Reality. Challenges and Opportunities”.

Chairing the keynote address on “Monetising gas in Latin America and the Caribbean. Regional Market – Optimisation possibilities and integration”, he said: “Natural gas is an energy that will facilitate decarbonisation. In addition to being an energy of transition, we see that it is also on the other side of this bridge of transition”. He discussed the anticipated imminent growth of gas via LNG and the competitive advantage on price that Latin American and Caribbean actors enjoy compared to their counterparts in Europe and Asia. He also stated the necessity for the continent’s countries to integrate their markets through the development of gas infrastructure and the opportunities to reduce production costs through the use of unconventional resources. The region also has the possibility of reaching the premium markets of Asia and Europe through LNG exports.

During the conference IGU and ARPEL (Asociación Regional de Empresas del Sector Petróleo, Gas y Biocombustibles en Latinoamérica y el Caribe) signed a memorandum of understanding to foster closer cooperation, as part of which ARPEL became an organisation affiliated to IGU.

**International Energy Agency – Workshop on natural gas**

On May 5, David Carroll, IGU President and Mel Ydreos, IGU Executive Director of Public Affairs participated in a workshop co-organised by the International Energy Agency and the Center for Strategic and International Studies in Washington DC. Mr Carroll presented the findings of the latest edition of IGU’s *World LNG Report*. The workshop provided important insights in relation to the strategic role of natural gas. IEA’s World Energy Outlook 2017 will be released on November 14 and will include an in-depth analysis of natural gas and the rapid evolution of gas markets driven by both shale gas and recent growth in LNG production capacity. The publication will also investigate the role of gas in a cleaner energy system, the opportunities it provides in mitigating local pollution and the risk of methane emissions.

**Stanford Natural Gas Initiative**

David Carroll travelled to Stanford University to take part in the Stanford Natural Gas Initiative international symposium entitled “Reducing Energy Poverty with Natural Gas: Changing Political, Business, and Technology Paradigms” from May 9-10.

The event brought together leading experts in their fields to explore the creation of opportunities to bring energy to, and reduce the poverty of, some of the most challenging places in the world.

On the second day David took part in a breakout session on the subject of “Community and the social licence to operate” looking at best practices around the development of new gas resources and later in the day moderated a session on “Natural gas beyond electricity” that discussed whether gas consumers that are not in the power generation business can drive upstream development or investment in distribution or if power generators and exports must lead.

**Africa Energy Forum**

The 19th Africa Energy Forum took place in Copenhagen, Denmark, June 7-9. The annual event is a global investment meeting for the continent’s power, energy, infrastructure and industrial sectors, bringing together senior-level representatives from all stakeholders in Africa’s energy landscape.
Rafael Huarte, IGU Director, was a panellist in the session “What is the right energy mix to achieve sustainable development goals”.

8th International Forum on Energy for Sustainable Development
Taking place from June 11-14 in Astana, Kazakhstan, the 8th International Forum on Energy for Sustainable Development combined a ministerial meeting followed by a high-level plenary session with parallel workshops.

Rafael Huarte, IGU Director, attended the event which was organised by the five UN Regional Commissions. Rafael spoke in a roundtable session jointly organised by IGU and the UN Economic Commission for Europe (UNECE) on “The Role of Gas in Achieving the Sustainable Development Goals”. The session was moderated by Torstein Indrebø, Vice Chair of the UNECE Group of Experts on Gas and former IGU Secretary General. The other panellists were Nazir Ramazanov, Chair of the UNECE Group of Experts on Renewable Energy, Dr Nikita Lomagin, Vice Rector, European University at St Petersburg and Alan Lau, Managing Director, Anglo Euro Developers Ltd.

The forum presents its conclusions to Energy Ministers and serves as advice to governments through the different regional organisations of the UN.

13th Russian Petroleum Gas Congress
The IGU Secretary General, Luis Bertrán, spoke in the opening plenary session of the Russian Petroleum Gas Conference (RPGC 2017) held jointly with the Moscow International Oil and Gas Exhibition in Moscow, Russia from June 27-28. The plenary theme was “The importance of international dialogue on energy as a key
factor in the future development of the oil and gas industry”.

Also, Mel Ydreos, Executive Director of Public Affairs, and the Secretary General attended the Gazprom AGM and met with Russian Charter Member OAO Gazprom.

**Plan a visit to the Secretariat**

Following the move from the Statoil headquarters in Oslo to Barcelona in November 2016, the IGU Secretariat is now well established in its new offices in the headquarters of Gas Natural Fenosa which is situated in the Barceloneta neighbourhood.

Several members have already taken the opportunity to visit and more are planning to do so over the months to come. Meeting with our members is important to us and we look forward to doing so when IGU travels around the world attending conferences and other meetings. However, knowing that Barcelona is a city that many of our members also visit, we encourage all members, and also others interested in IGU and its work promoting and advocating for the gas industry worldwide to visit us at the Secretariat in Barcelona. We look forward to meeting you.

**International Gas Union (IGU)**

**Att:** Gas Natural Fenosa

Plaça del Gas, 1

Building B 3rd Floor

08003 Barcelona

Spain
Building opportunities in the Peruvian Fold Thrust Belt
Peru’s Natural Gas and Liquids of Natural Gas Potential

Over the past decade, the major success of the oil and gas industry in Peru has been the development of the Camisea gas and condensate fields. The project supplies natural gas to the Lima metropolitan area, LNG for export and also light liquids production. The Camisea discoveries in the southern Ucayali Basin were made in the 1980s with the first discovery in the area by Shell in 1984 with the San Martin 1X well. This was followed by Cashiariari 3X in 1986 and Mipaya 5X in 1987.

The Camisea Gas Project consists of the development of Blocks 56, 57 and 88 along with the construction of natural gas pipelines which run for 730 km from the jungle and over the Andes mountain range to consuming areas on the Pacific coast.

As demonstrated by the Camisea and Candamo discoveries, the Fold Thrust Belt region contains an enormous potential for the hydrocarbons industry. New potential petroleum systems, with reservoirs similar to the Camisea fields, were identified in the San Matias thrust in the Pachitea area (Northern Ucayali). This basin also has two other areas under contract: Block 31C, with gas production, from which liquids are extracted and sold locally with some dry gas production, and Block 131 producing light oil for a local refinery.

Contact information:
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<th>Summaries of Potential Hydrocarbons in Ucayali and Madre de Dios Basins</th>
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<td><strong>NG Reserves (TCF)</strong></td>
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<th><strong>NG Resources (TCF)</strong></th>
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Prospective Reserves and Resources in Ucayali and Madre de Dios Basins are estimated of NG and NGL of 18.7 TCF and 975.6 MMB respectively (Source: DGH, 2016)
Andes Mountain

South Maranon basin

Huallaga basin

North Ucayali

Ene basin

Andes Mountain

Madre de Dios basin

1975: Shanusi 1X well (Deminex) - Gas shows in Jurassic reservoirs (Pucara group).

1992: Ponasillo 1X well (Mobil) - Hydrocarbon potential in Jurassic reservoirs (Sarayaquillo formation).

1998: Rashaya Sur 1X well (Pluspetrol) - Gas shows in Lower Cretaceous reservoirs (Cushabatay formation).

Block 31-C (Aguaytia Field) - 1961: Commercial discovery (Mobil) of NG and NGL in Lower Cretaceous reservoirs (Cushabatay formation), with reserves (3P) of 365 BCF of NG and 27 MMB of NGL.*

Block 107 - 1965: Oxapampa 17C-1 well (Cerro de Pasco Petroleum) - Gas shows in Permian sequences.

Block 58 - Reserves (3P) of 3.5 TCF of NG and high estimation of prospective resources of 115 MMB of NGL.*

Block 76 - High estimation of prospective resources of 6.2 TCF and 260 MMB of NGL.*

Candamo Area - 1998: Commercial discover of NG and NGL in Cretaceous and Permian reservoirs (Mobil). There is an estimated exploratory volume of OOIP of 13.5 TCF (Pmean).**

Block 76 - 1961: Commercial discovery (Mobil) of NG and NGL in Lower Cretaceous reservoirs (Cushabatay formation), with reserves (3P) of 365 BCF of NG and 27 MMB of NGL.*

- **Location:** Peru’s Sub-Andean and foreland basins cover over 24,269,100 hectares.
- **Production:** More than 3.4 TCF (NG) and 329 MMB (NGL) in southern and northern Ucayali Basin (Aguaytia, Camisea and surrounding areas).
- **Reservoirs:** Permians of Nia/Noi Fm and Lw/Up Cretaceous of Cushabatay/Vivian Fm.
- **Reserves:** Peru’s proven reserves of NG and NGL are estimated at 16.1 TCF and 789.7 MMSTB respectively.

Source

* DGH 2016 (Dirección General de Hidrocarburos-MINEM).
** PERUPETRO 2017.

Abbreviations

- BCF: Billion Cubic Feet.
- TCF: Trillion Cubic Feet.
- MMB: Million barrels.
- NG: Natural Gas.
- NGL: Natural Gas Liquids.
- OOIP: Original Oil in Place.
In the last week of March, the IGU Executive and Coordination Committees gathered in Muscat, Oman, for their first meetings of the year. A workshop on topical and informative themes was also offered to the delegates. These workshops have become a central part of the IGU Executive Committee and Council meeting weeks. Oman LNG was the host of the meetings and provided an excellent atmosphere both professionally, culturally and socially.

The Muscat workshop was divided into three parts, starting on the national level with the characteristics of the gas industry in Oman, before moving the focus first to regional issues and opportunities for the gas industry and finally to the global gas industry.

The Omani gas industry
The first session highlighted the unique geopolitical location that Oman holds with regards to energy supply, looking at the main production and economic principles and future investments.

The first speaker was the Undersecretary of the Ministry of Oil and Gas in Oman, HE Salim al Aufi. In his position as Undersecretary, HE al Aufi manages the exploration and production activities in the Sultanate of Oman and he talked about the internal and external challenges facing the country’s industry. He said being an efficient, cost effective and reliable supplier is important to the country and that so far they have been able to deliver on their promises. Oman is determined to continue doing so, in an increasingly competitive market.

Mr Salim Al Sikaiti, Gas Director at Petroleum Development Oman (PDO), gave an insight into the development of the gas industry in Oman. As Gas Director at PDO, Mr Al Sikaiti is responsible for the development and management of the company’s entire gas portfolio. He highlighted the key events that have shaped the industry and said that the Sultan of Oman’s interest in its development has been important. He concluded by elaborating further on the opportunities and challenges of the Omani gas industry.

Mr Yousuf Al-ojaili, President of BP Oman, talked about the Khazzan Gas Development. Khazzan is one of the largest natural gas deposits in Oman and the largest tight gas development in the Middle East. The field covers an area of 3,950 km² and has an estimated development cost of $16.5 billion over the lifetime of the field. BP is operator of the project, which is just about to move from development to production, with the first gas expected in the fourth quarter of 2017.

The first session concluded with a presentation by the CEO of the Oman LNG Development Foundation, Mr Khalid Al Massan, who
introduced the audience to the Foundation and the gas industry’s contribution to Oman. Corporate social responsibility is important to the company and the Foundation has a social investment programme that focuses on neighbouring communities to Oman LNG’s plants, in addition to human resources, development of national projects, sponsorships and donations.

Regional gas industry issues and opportunities

The second session, The Future of the Middle East, looked at regional gas industry issues and opportunities. Highlighted themes were gas for growth, gas as the fuel of choice in the Middle East, additional regional gas supply, LNG flexibility and small scale LNG.

Eng. Khaled AbuBakr, Chairman of TAQA Arabia, President of the Egyptian Gas Association and IGU Regional Coordinator for Africa and the Middle East moderated the session which featured another high-level guest, the Deputy Petroleum Minister of International Affairs and Trading of Iran, HE Amir Hossein Zamaninia.

HE Zamaninia talked about the development of energy in Iran during the past 40 years and the current state of the industry. Iran holds the biggest gas reserves in the world and uses all of its production domestically. The Deputy Minister was positive about the future now that international sanctions have been lifted, although the new political administration in Washington DC was seen as unsettling. He characterised the opportunities for Iran and the region as many.

The next speaker was Anna-Sophie Corbeau, Senior Fellow, KAPSARC (King Abdullah Petroleum Studies and Research Center) in Riyadh, Saudi Arabia. She said that the Middle East has an addiction to gas and that the region holds the largest share of proven gas reserves in the world with 43% of the world’s reserves. Most of this is concentrated in Iran and Qatar. The region is the only one in the world where gas represents more than half of primary energy demand.

According to Ms Corbeau, many variables will impact future gas demand growth, including the COP 21 agreement, the replacement of oil in the power and industrial sectors and the transformation plans of the region’s economies. She said current LNG producers may stop exporting in the future – except for Qatar. This...
is because the role of the Middle East as an LNG exporter is bound to decrease, while imports will increase. Governments traverse a tightrope between incentivising their own production and allowing for imports while keeping energy-intensive industries competitive.

Jassim Isa Al Shirawi, General Manager, Oil and Gas Affairs, National Oil and Gas Authority (NOGA), Bahrain spoke on the opportunities for a pan-Gulf Cooperation Council (GCC) natural gas grid. He started with an introduction to natural gas in Bahrain, a country where natural gas is the primary source of energy. The country’s gas production is being consumed locally by three sectors: oil field use, power and water, and industry. Like other states in the region, the growth in gas demand is driven primarily by the power sector.

There is a wish to establish a natural gas grid in the Gulf region and there are a number of possibilities for how to do this. He said the concept had been well received by energy ministers in the region and that hopefully the concept will be put into action by the GCC Secretariat.

Post-Paris agreement landing and the US Presidential election

In the third session, chaired by the IGU President David Carroll, the workshop moved from regional to global industry issues and opportunities. The aim of the session was to discuss the implications of the outcome of the UN climate agreement that was signed in Paris and the US Presidential election.

The COP 21 climate agreement has been a hot topic since it was signed in December 2015. Over the year that had passed since then, the gas industry had tried to better understand the agreement and its commitments. The session looked at the NDC commitments, climate policies, CO2 reductions, general climate discourses and their implications for the gas industry. How should IGU and the natural gas industry prioritise and focus its efforts in the energy transition?

Also, the outcome of the 2016 US Presidential election was expected to mark a radical change in US policies. President Donald Trump had promised changes in many spheres that will have implications for geopolitics, trade, energy policies and more. What were his promises and how could they be expected to affect the gas industry? How should the gas industry respond?

The session started with a presentation on the IEA view of the future of natural gas supply and its role in the future energy mix. Peter Fraser, Head of the Gas and Power Markets Division, gave a presentation based on the different scenarios. He made three main points. Firstly, the expected forecast of annual natural gas growth is 1.5% in both the IEA’s medium term outlook and in their World Energy Outlook. Secondly, the possibilities for a global gas market lie in LNG. This is somewhat oversupplied right now and the big question is...
when this market will re-bound. Finally, he said, the scenarios that look at further reductions of CO₂ emissions, going beyond the Paris agreement, see the growth in natural gas demand being lower than in the main scenarios.

Mariana Ortiz Laborde, Portfolio Manager, Global Gas Division, Gas Natural Fenosa, elaborated on the current developments in the LNG sector. The major shift in the LNG market is challenging for the industry due to more flexible contracts and greater competition from other fuels. She said that even more countries are expected to enter the LNG market in the years to come because of less reliance on oil, gas as a partner to renewables, the substitution of indigenous production and supply diversification. Small-scale natural gas is important and essential in the new market.

The United Nations Environmental Programme (UNEP) was invited to present their view on the Paris agreement and the gas industry. Giulia Ferrini, Associate Programme Officer, started by listing three overarching long-term goals of the agreement. The first was the temperature goal to hold global warming well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5°C. The second was the financial goal to direct global finance flows towards low-greenhouse gas and climate-resilient investment. And third, resilience. The consequences of climate change are already a reality for both companies and communities and they need to develop their resilience to these effects.

Ms Ferrini said there is a mismatch between the 2°C target and what countries have committed to do and said that UNEP is preparing an emission gap report that looks at this. She said that the policy outcome of the COP 21 agreement makes the future a little unpredictable for natural gas. Gas producers need to convince policymakers that gas has a place in the future energy mix and that it can achieve volumes that are efficient and justify infrastructure investments. She also said that gas will have a role to play in the energy future, but her message was clear, only if methane emissions are managed. Only by managing these can natural gas contribute to sustainable development and be a fuel in the future energy mix.

Mahdjouba Belaifa, Head of the Gas Market Analysis Department, Gas Exporting Countries Forum (GECF) talked about the response of the gas industry to the Paris climate agreement. More coordinated and resilient policies are needed to mitigate GHG emissions and achieve sustainable development goals. Changing the mindset that is against natural gas is key. GECF thinks one solution to changing the perception that gas as a fuel is harmful to the climate lies in technology, such as carbon capture and storage (CCS) and/or use and storage (CCUS) with regards to CO₂. Finding an appropriate way to measure and reduce methane emissions is another. She concluded by saying that cooperation is important in order to meet the challenges.

The session ended with a reflection on President Donald Trump’s promised changes and how they could affect the gas industry given by Jay Copan, Executive Director WGC 2018 and Terence Thorn, Senior Advisor to the IGU President. Mr Copan presented the Trump administration energy team and said that it holds a tremendous amount of energy industry knowledge and capability. He said that with or without the Paris agreement, US emissions have been trending downward. Mr Thorn elaborated a little further on the components of the new administration’s plans and said that there is now a wish to shift US energy policies away from combating climate and to promote fossil fuel production. At the same time he said that there are really no energy policies in the USA. The government sets the tone, but the individual states have a lot of say in the creation of their energy policies.

Anette Sørum Nordal is IGU’s Information Consultant and Secretary of the Coordination Committee.
Recently published IGU reports

Since the last edition of the IGU magazine, four new IGU reports have been published. In addition, a new Global Natural Gas Insights pocket book has been released (see box).

Flagship reports

Of the IGU reports, the most established are the World LNG and the Wholesale Gas Price reports. Both are now annual publications and two IGU committees, LNG and Strategy respectively, are responsible for their creation. Both are highly recognised. The World LNG Report serves many in the international energy business as a standard desk reference for information on the LNG industry. The first edition came out in 2010 and this year’s edition provides key insights on issues that will impact future world LNG activity, in addition to the report’s focus on recent historical data.

The 2017 edition shows that 2016 was a dynamic year for the global LNG industry, with significant growth in LNG supply projects, as well as increases in demand for LNG as a fuel from new and existing markets around the globe. The global LNG trade reached a record 258 million tonnes – an increase of 5% from 2015, and the largest ever year for LNG trade. This dramatic increase is particularly noticeable when compared with the average 0.5% growth rate of the previous four years.

IGU’s Wholesale Gas Price Survey started 10 years ago. It is a vital reference for the natural gas industry and has been undertaken for nine years. Together the studies confirm the significant changes there have been in wholesale price formation mechanisms in this period of major developments and upheaval in the global gas market.
An article by Floris Merison from the IGU Strategy Committee, in the October 2016-March 2017 edition of International Gas (pages 90-93), showed how these wholesale gas price studies prove that global gas prices, contrary to expectations, have converged since 2005.

For the latest study, survey responses were received for countries that cover 90% of total world consumption. It shows, among other findings, that average wholesale prices in 2016 were at the lowest level ever recorded by the study ($3.35 per MMBTU). Prices continued to converge in 2016, as market prices continued to decline, while regulated prices predominantly rose, outside the former Soviet Union where currency weakness reduced prices in dollar terms. The most used price formation mechanism in 2016 was gas-on-gas competition (45%) and from 2015 this share was broadly unchanged. The second most used continues to be oil price escalation, which in 2016 stood at 20%.

IGU case studies
A more recently instigated initiative, but just as valuable and requested, is the new series of IGU case study reports. In order to show how natural gas contributes to a sustainable energy future and improves the lives of people around the world, the series provides case studies on how natural gas solutions have solved issues related to air quality.

Improving urban air quality
The first edition of Case Studies in Improving Urban Air Quality was released for COP 21 in Paris in December 2015 and received attention from international media, such as the Financial Times. A second edition was published for the EU Energy Week in Strasbourg in November 2016. This latest edition highlights how the increased use of natural gas in power generation, heating and transport can significantly reduce air pollution and has done so in four European cities: Berlin, Dublin, Krakow and Rotterdam. The study examines policies, such as fuel switching initiatives, that have led, or are leading to, real progress in improving air quality without sacrificing economic development.

As one of the examples from this edition shows, in Berlin a widespread shift from coal to natural gas in power and heat generation (including residential) played a significant role in improving the city’s air quality in the decades after reunification. Since the Berlin Wall came down in 1989, air quality in Germany’s capital city has greatly improved. Berlin’s sulphur oxide (SOx) emissions have dropped by 95%, nitrogen oxide (NOx) emissions decreased 76%, and particulate matter (PM10) emissions were on track to decline by 83% between 1989 and 2015. These decreases are largely attributable to reduced use of coal and an increase in the use of gas (from 17% of the city’s energy balance in 1990, to 41% by 2012).

According to Martin Lutz, Head of Sector Air Quality Management in the Berlin Senate Department for Urban Development and Environment: “Having promoted gas for decades as a clean fuel, in particular for residential heating, we are now focusing on CNG-vehicles as a clean and mature technology alternative to diesel in order to meet road air quality standards.

While we’ve reached a decent density of CNG filling stations we still need a broader variety of gas-vehicle models to be offered by the auto industry.”
Recently published IGU reports

Recentlly published IGU reports said at the time of the release: “The case for using LNG fuel for shipping is clear. It will provide significant improvement to our quality of life by dramatically reducing air pollution. It will also support climate change goals by reducing greenhouse gases. We need effective policy change to encourage a switch to LNG. This report, and our recent reports on urban air quality, demonstrate the key role natural gas plays in tackling the issue of air pollution and improving the quality of people’s lives.”

Marine transportation is an often overlooked contributor to negative air quality levels – with one large container ship, powered by 3% sulphur bunker fuel, emitting the same amount of sulphur oxide gases, as 50 million diesel-burning cars.

Strong policy responses are needed to make this switch a reality and Enabling Clean Marine Transportation outlines a number of recommendations for governments to follow. Read LNG – the key to unlocking cleaner marine transport? by Mel Ydrees, IGU Executive Director of Public Affairs, on pages 20-22 for more information on this report.

We encourage you to download all four reports and more at www.igu.org.

Global Natural Gas Insights

Global Natural Gas Insights is a small format publication that presents a broad overview of the significant contribution natural gas can make in meeting global energy challenges – economically, environmentally, and in meeting energy security goals. The handy size allows one to easily bring it along for use when making the case for gas.

The 2017 edition contains the latest information on natural gas and its role in enhancing quality of life around the world, delivering a cleaner environment, meeting vital needs, creating economic opportunity and driving innovation.
At Itron, we believe that the way we manage energy and water will define this century. We connect people, devices and information through technology and services—and in the process, we build more insightful utilities, stronger communities and smarter cities.

As the world leader in gas metering automation connecting more than 60 million devices to the grid, we are helping gas utilities create a more resourceful world.

[Diagram showing statistics]

$24B
ELECTRICITY
Wasted in grid inefficiencies

50%
NATURAL GAS
Demand increase by 2035

34%
OF WATER
Lost in the distribution system

8B
PEOPLE
Global population by 2025

creating a more resourceful world
Reports from the Regional Coordinators

In this issue we bring you updates from IGU’s Regional Coordinators for the Middle East and Africa and for Latin America and the Caribbean following on from our spring focus on Asia and Asia-Pacific and North America.

Regional overview of the Middle East and Africa

By Khaled AbuBakr

The Middle East and Africa have always played a vital role in the global natural gas industry and trade, being in the heart of the world with proximity to the major natural gas markets in Europe and Asia. They have gained their importance as one of the world’s natural gas hubs, boasting huge proven gas reserves and in Qatar, Nigeria, Algeria, Iran, Egypt, Oman and Libya some of the largest natural gas producers in the world. Major new gas discoveries will also enhance the region’s natural gas trade either through pipelines to neighbouring countries or regions or through LNG trade.

The charts below highlight the regions’ current impact on the natural gas industry, yet these rates are projected to increase exponentially in the near future. With recent colossal gas discoveries in the East Mediterranean and East Africa, the two regions have truly become “a natural gas paradise” that will have a major impact globally.

### Natural Gas in the Middle East and Africa

- **Proven Gas Reserves**
  - Middle East: 42.5%
  - Africa: 7.6%
  - Rest of the World: 7.6%

- **Gas Production**
  - Middle East: 17.8%
  - Africa: 6%
  - Rest of the World: 6%

- **Gas Consumption**
  - Middle East: 14.4%
  - Africa: 3.9%
  - Rest of the World: 3.9%

- **Pipeline Trade**
  - Middle East: 39.4%
  - Africa: 16%
  - Rest of the World: 16%

- **LNG Trade**
  - Middle East: 39.4%
  - Africa: 16%
  - Rest of the World: 16%
Africa

East Africa is becoming an important hub for natural gas markets due to new and significant natural gas discoveries. Multinational companies and organisations plan to pour around $7 billion into floating liquefied natural gas (FLNG) projects in Africa, betting on a largely untested technology in the hope that energy markets will recover by the time they start production in the early 2020s.

Egypt’s natural gas production, expected to reach 212 Mm³/d (7.5 bcfd) in 2020 rose to around 144 Mm³/d (5.1 bcfd) in 2017 from 124 Mm³/d (4.4 bcfd) in 2016 with the start of production from the first phase of BP’s North Alexandria project. Egypt has been seeking to speed up gas production from recently discovered fields, with an eye to halting imports by 2019. Once an energy exporter, it has become an importer after domestic output failed to keep pace with rising demand. Three large projects, which include the mammoth Zohr Mediterranean gas field discovered by Italy’s Eni last year, are expected to collectively bring 130 Mm³/d (4.6 bcfd) online by the start of 2019. In July, the Egyptian parliament approved a new gas law, which will help deregulate the market. IGU, the Egyptian Gas Association and the European Community made a fundamental contribution towards this achievement and played a major part in preparations for its implementation.

The Morocco-Nigeria landmark project to lay an Atlantic gas pipeline, which will carry Nigerian gas through six West African countries up to Morocco and eventually to Europe, is heading towards realisation with the signing of new agreements related to the project. The Atlantic Gas Pipeline, to stretch over 4,000 km, will extend the existing West African Gas Pipeline that currently transports Nigerian gas to Ghana, up to the Mediterranean shore, passing through Côte d’Ivoire, Liberia, Sierra Leone, Guinea, Guinea-Bissau, Gambia, Senegal and Mauritania.

East Mediterranean

In recent years the East Mediterranean Reserve in the waters of Cyprus, Egypt and Israel has shown its potential as a source of natural gas and is starting to draw the attention of the world’s leading energy companies and countries with high energy demands.

Cyprus has decided to proceed with its first LNG import project and is preparing to tender contracts for an FSRU (floating storage and regasification unit) and LNG supplies to allow the country to switch to gas-fired power instead of using oil. Cyprus wants to start producing gas-fired power by 2020 to keep in line with EU emissions targets.

In April, Greece, Cyprus, Italy and Israel agreed to initiate discussions on an intergovernmental agreement for the EastMed gas pipeline project. The unprecedented $6-7 billion plan involves building a privately-funded 2,200 km deep-sea pipeline to bring Israeli and Cypriot gas from the Levantine Basin to the shores of Greece and possibly Italy. Potentially this pipeline could be connected to the Egyptian

BP and joint venture partner Kosmos Energy have announced a major gas discovery off Senegal, which is considered to be a new addition to the recent successful findings in the region.
the Karish and Tanin fields offshore Israel to Dalia Power Energies Ltd and Or Power Energies Ltd.

**Middle East**

In April this year Qatar lifted a self-imposed ban on development of the North Field, the world’s largest natural gas field, and announced a new project to develop its southern section, increasing output in five to seven years. This new project will raise Qatar’s total LNG production capacity by 30% to 100 million tonnes from its current 77 mtpa.

In Oman, the first gas from Phase 1 of the Khazzan field in Block 61 was expected at presstime with production reaching 28 Mm³/d (1 bcfd) by the end of 2017. Phase II of the project is expected to add an additional 14 Mm³/d (500 mcfd). BP Oman operates the block and has a 60% interest, while Oman Oil Company Exploration and Production holds the rest.

ADNOC Distribution in the UAE recently opened the Mahawi North multi-fuel service station which will be the Arabian Gulf’s largest NGV service station. The new station will be the main CNG provider to the wider service station network of ADNOC Distribution and will raise the number of NGV-enabled service stations in the Emirate of Abu Dhabi to 31 by the end of this year.

In May, Greece’s Energean Oil & Gas Group signed contracts to supply private Israeli power plants with natural gas. The company will supply as much as 23 bcm of natural gas from the Med network resulting in the most developed regional hub.

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Natural Gas
in your life, every day

- energy efficient
- environmentally friendly
- easy to use

in vehicles

in industry

in businesses

in homes

DEPA introduced natural gas into the Greek market, knowing its many advantages for all customers - and our precious environment. Our priority is to expand the natural gas network in Greece and to develop and implement CNG/LNG technology. This way, we can supply natural gas to more individual customers, remote areas, and the country’s many islands.

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Reports from the Regional Coordinators

Regional overview of Latin America and the Caribbean

By Javier Gremes Cordero

According to OPEC’s latest World Oil Outlook, total primary energy demand will increase 40% until 2040 and 63% of that demand will come from developing countries. Natural gas is expected to overtake oil as the fuel with the largest share at some point close to 2040, with consumption exceeding 100 mboe/d, representing an average annual growth rate of 2.1%. Initiatives being undertaken to mitigate the effects of climate change, with the introduction of renewable energies, will result in the gradual modification of the energy matrix. It would also be desirable that developed countries design a course of action to increase the use of gas and reduce the use of coal.

Natural gas plays a crucial role in Latin America and the Caribbean. The countries in the region are undertaking various projects related both to production and to the expansion of current LNG infrastructure, which by the end of 2016 consisted of 16 operating facilities in the region, including liquefaction plants and regasification terminals.

Given the oversupply of gas from the USA and a dependence on imports for electricity generation, countries in Latin America and the Caribbean face a scenario of growing LNG infrastructure, with some projects already being undertaken. Colombia, apart from its new regasification plant in Cartagena and the project of installing another on the Pacific coast, has had two offshore discoveries that could have significant impact in the years to come if production develops. Chile is considering some regasification projects as well.

Bolivia continues to expand its local distribution gas network, enabling access to more users and allowing for an increase in gas supplied to the domestic market. Nevertheless, it still presents a significant surplus, with supply widely exceeding local demand.

Brazil is expected to gradually reduce the industry’s vertical integration, with private companies competing in the production sector as well as in the rest of the associated infrastructure.
A GAS COMPRESSOR PLANT IS MUCH MORE THAN THAT

It is state-of-the-art technology applied by a solid team. It is more gas being transported to generate more energy for Peru. Energy that gives more opportunities to thousands of companies, which in turn employ millions of Peruvians. It is electricity that illuminates homes. It is a child with a future.

At TgP we know that, so in fulfilment of our commitments to Peru, we inaugurated the new Kámani Compression Plant in the jungle, which will allow the country to continue to grow.
To this end, concrete actions are being undertaken to progressively increase the share of renewable energies, with the aim of their meeting 20% of demand for electricity generation by the end of 2020.

Nevertheless, natural gas will continue to be the main source of primary energy in the country, and will still account for approximately 50% of the energy matrix by 2025, according to MINEM estimates. This will be possible mainly due to the development of unconventional gas: in 2013 the US Energy Information Administration (EIA) stated that Argentina, with its Vaca Muerta geological formation, ranks second among countries with technically recoverable shale gas resources.

The development of unconventional resources is essential in medium-term energy planning for two main reasons. Firstly, the need to satisfy a demand that, according to the Argentine Institute of Petroleum and Gas (IAPG), will grow approximately 50% in the next 20 years, reaching an average consumption of 230 mcm/d, with winter peaks of 290 mcm/d. Secondly, because of the magnitude of the investments related to these types of projects and the direct and indirect impacts they have on the rest of the economy.

According to MINEM estimates, the cumulative 10-year investment associated with the exploitation of unconventional gas in the region but also the diversification of the energy matrix and the encouragement of investment in infrastructure.

In Uruguay, the regasification plant project in Montevideo (GNL del Plata) is under revision, considering the fact that the expected increase in thermal demand does not yet seem sufficient to foster significant investments in gas. In fact, the strong encouragement given to development of renewable energies (wind, solar photovoltaic and biomass) has resulted in 35% of the country’s electricity demands being supplied by these sources in 2016.

In Argentina, the government, through the Ministry of Energy and Mining (MINEM), has established the assurance of energy supply as part of its medium-term goals. This implies not only good integration with countries of the
country could be between $35 billion and $55 billion, depending on the intensity of investment and the degree of productivity assumed.

At the same time, the growth in gas production will demand significant investments in transportation and distribution infrastructure. IAPG reckons that, in order to satisfy the expected demand towards 2035, over $30 billion will be needed to carry out: expansions and maintenance works to preserve the sustainability of the existing transportation system; expansions and new regulation and measurement stations on the distribution system to reach 13 million users (5 million more than today); and standardization works on clients’ internal facilities.

The development of unconventional gas in the country is growing and is increasing in productivity. Towards the end of 2016, production had grown by 32% compared to the previous year, reaching 25% of the country’s total production and 39% of production from the Neuquén Basin. This process needs to be strengthened, since it will enable not only a formidable scenario of energy supply but also substantial impacts on economic activity, with a significant increase in direct and indirect employment, the undertaking of multiple infrastructure projects and improvements in federal and state tax collection.

The exploitation of unconventional resources, and of Vaca Muerta in particular, represents perhaps the greatest opportunity, and the greatest challenge, for the energy sector and for the country’s development, and will undoubtedly have a strong impact in the region.

Natural gas will continue to prevail over other sources of energy throughout the region. The assurance of the conditions that enable the undertaking of the projects that will increase gas supply and also foster regional integration will benefit all the countries in Latin America and the Caribbean, and will be essential in terms of the environment, in the process of replacing carbon-based power generation.

Javier Gremes Cordero is IGU Regional Coordinator for Latin America and the Caribbean and Director General and CEO of Transportadora de Gas del Sur S.A.
With research and development very much at the forefront of this issue of *International Gas* we have an in-depth look at the project portfolio of Pipeline Research International (PRCI) highlighting the full range of their enquiries into all aspects of the pipeline industry. Following on from that the Gas Technology Institute (GTI) discusses a new system that will increase safety on horizontal drilling projects in urban areas. The European Gas Research Group (GERG) brings us the latest news on their work, particularly in the areas of biomethane and hydrogen in relation to their introduction to the gas grid. On the subject of training, Energy Delta Institute (EDI) provides an overview of their global executive programmes. On the transportation front, NGVA Europe presents their latest report, *Greenhouse Gas Intensity of Natural Gas*, a flagship reference study on gas as a transportation fuel in Europe. And rounding out the section, IPLOCA, the International Pipe Line and Offshore Contractors Association discusses the expansion of its membership structure to include Corresponding Members and the opportunities this will provide to broaden engagement across the industry.

As we highlighted earlier in the magazine, this year IGU welcomes ARPEL, the Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean, to its Affiliated Organisations. We have an introduction to their work on page 134 and look forward to bringing you their latest news in the spring/summer 2018 issue of *International Gas*.

**Working to enhance pipeline safety and integrity**

*By Cliff Johnson*

In an effort to continuously enhance the safety and integrity of the global pipeline infrastructure the Pipeline Research Council International (PRCI), performs research in a number of key areas: corrosion; compressor and pump stations; integrity and inspection; design, materials, and construction; measurement; underground storage; and surveillance, operations and monitoring. To support these efforts PRCI has established eight research objectives:

◆ Develop and/or validate technology and analytical processes that are capable of characterising pipeline material properties with sufficient accuracy for application in pipeline integrity assessments.

◆ Develop and enhance in-line inspection (ILI) technology to reliably detect, size and characterise indications that may be harmful to the integrity of the pipeline.

◆ Develop, evaluate and enhance non-destructive evaluation (NDE) technologies and operator and data analyst performance to define the condition and assess the integrity of pipeline, facilities and associated infrastructure from outside or above the pipeline or facility.

◆ Improve the accuracy and application of fitness for service methodologies by reducing uncertainties. Define, understand and improve the key factors, including models that are involved in design, construction or integrity assessments of any component in systems covered by PRCI.

◆ Develop, demonstrate and validate repair systems, including those that can be deployed on in-service facilities. Determine the useful
life and safe operating envelopes of such repair systems.
◆ Develop, demonstrate and validate intrusion monitoring and surveillance technologies to enhance detection of third-party activities, ground movement and interferences potentially affecting pipeline infrastructure.
◆ Reduce all releases, i.e., leaks and emissions, from all parts of hydrocarbon production, storage and transport infrastructure by developing, demonstrating and validating processes and technologies to detect, locate, measure, quantify and mitigate such releases.
◆ Enhance operational efficiency, flexibility and availability including measurement functionality, accuracy, characterisation of flows and custody transfer at all points in production and delivery infrastructure including liquid pumping and gas compressor stations and all storage systems.

PRCI members support the research portfolio with technical leadership and expertise, funding and other valued material contributions, and the time and resources required to deliver intelligence and technology that address the needs of the worldwide pipeline industry and, by extension, global energy consumers. In the last year PRCI has produced a number of key research results. The following is an overview of some of the projects that were accomplished. For additional information about these projects or the rest of the PRCI research portfolio please visit our website at www.prci.org.

**Corrosion**
◆ Studied the effect of fluctuating AC interference phenomena on the corrosion risk of pipelines. Underground transmission pipelines that share the right-of-way corridor with electricity transmission lines are susceptible to AC corrosion. Established AC criteria do not take into account the consequence of fluctuating AC voltages. The research showed that the AC-induced corrosion threat can be controlled through a two-step approach. This work provides a better understanding of how AC interference influences corrosion rates.
◆ Evaluated the effectiveness of External Corrosion Direct Assessment (ECDA) as an inspection methodology and integrity assessment process. The research evaluated the practices and procedures from a broad array of pipeline companies. The questionnaire looked for successes and failures with the ECDA process, correlation with other assessment methodologies and issues/gaps with processes and standards. Procedures were compared to industry standards and leading practices in order to help determine the overall effectiveness of the ECDA processes. The results will help operators improve the effectiveness of their ECDA programmes.
◆ Determined the kinds of pressure fluctuations that represent the greatest risk for increasing the potential for stress corrosion cracking (SCC) to form and propagate, the different types of mechanisms that are operative in the near-neutral pH (NNpH) environment and the factors that control the extent to which the mechanisms will occur. The research provides a comprehensive understanding of the effect of pressure fluctuations on the growth of NNpH SCC and will help operators design improved line pressure schemes during routine operation.
◆ Validated the long-term field performance and the failure modes and effects of fusion-
New from organisations affiliated to IGU

Compressor and pump station

- Developed chemical reaction models for non-selective catalytic reduction of emissions from rich burn engines. The work completed this year focused on evaluating the effects of dithering the air/fuel set point around the stoichiometric point. There is limited experimental data to suggest that dithering can be effective, but little is known about how dithering impacts the performance of a three-way catalyst to destroy pollutants from natural gas-powered engines.

- Evaluated the effects of variable fuel quality on a large bore two-stroke natural gas engine by varying ethane in the fuel gas from 5-25%. Multiple air/fuel control strategies were evaluated at a nominal 2 g/bhp-hr NOx emissions level as well as the potential for variable fuel composition to cause auto-ignition on conventional combustion engines. Ignition timing was found to be the most effective method to control engine auto-ignition. Fuel composition and TER were shown to have a significant effect on the severity of auto-ignition. It was noted that persistent auto-ignition lead to a steady increase in NOx production, but NOx values alone were inadequate to quantify auto-ignition. At completion of engine testing the operational parameters were analysed to create predictive models to determine if the engine would begin to auto-ignite based on fuel composition, ignition timing and TER. The generated models accurately predicted the auto-ignition level of the engine.

Assessed the outcome of the Emissions Reduction for Legacy Engines (ERLE) programme. The overall objective was to develop technical options that allow 80% of legacy engines to achieve anticipated NOx requirements (approximately 0.5 g/bhp-hr) with no increase in other emissions or fuel consumption, no decrease in operating range or stability and...
No wind?
No sun?
No problem.

We make sure you always have light and heat. We provide backup for renewables and are always there for you. With power we produce whenever it’s needed. With natural gas sourced worldwide. And with innovative solutions.

*New perspectives on energy.*
costs ranging from one-sixth to one-third of new engine replacement costs. The programme culmination consisted of field tests of two typical pipeline engines retrofitted with suites of these technologies.

**Design, materials and construction**

- **Guidance on subsea launchers and receivers.** Phase II resulted in a Guidance Document that can be used by operators to design offshore maintenance and in-service inspection programmes. The document includes definitive guidance on the design of the launcher/receivers, constructability, commissioning and ongoing pipeline operations, maintenance and inspection. Phase III performed concept-level identification and definition of potential technical solutions and/or procedures regarding specific critical subsea pig launching/receiving activities, including: lifting and handling to preclude damage to the vessel, subsea structures, reliable launch and receipt, debris handling and other potential risks. A webinar was conducted for members to review results to extract maximum immediate value from this research.

- **Guidelines for using composite systems to repair high pressure gas and liquid transmission pipelines.** Composite materials are a recognised means for repairing and reinforcing high pressure gas and liquid transmission pipelines. In spite of their widespread use and general acceptance, the pipeline industry does not have a definitive standard for providing guidance in using composite repair systems. PRCI has sponsored multiple successive research programmes aimed at evaluating composite repair technology for various applications encountered by operators. Most pipeline composite repair manufacturers utilise the design guidance provided in ASME PCC-2, Repair of Pressure Equipment and Piping (Article 4.1 Nonmetallic Composite Repair systems: High Risk Applications). This project has filled that void through the development of a composite repair guideline document. The guidelines will provide prescriptive guidance based on other published work as well as the considerable insights gained from past/ongoing PRCI studies and research performed over the past 15 years in evaluating composite repair technology. The guideline also provides essential elements for gaining regulatory acceptance of these repair methods and systems for non-temporary applications.

**Integrity and inspection**

- Assessed the current state-of-the-art for integrity management of difficult-to-inspect pipelines by proposing guidance for the application of alternate inspection approaches other than hydrostatic test, in-line inspection and ECDA/ICDA currently prescribed by United States Federal Code and regulations. The research examined technologies that can be applied to screen the condition of pipe wall for its full length, and direct inspection technologies with capability for obtaining high resolution wall thickness measurements at locations indicated from the application of
screening technologies. The research focused on external technologies that can scan through coatings, but also reports on developing internal technologies that are not currently associated with in-line inspection.

- Quantified the effects of re-rounding in pipelines in the wake of a damage event in relation to pressure cycling and crack growth for both vintage and modern steels. This research can facilitate the development of tools to screen for re-rounding severity in terms of metrics that are commonly quantified by ILI tools, such as local curvature or wall loss. In turn, this assists in prioritisation and scheduling practical response times in cases where ILI runs identify a significant number of damage-related threats. Additionally, the outcomes of this work may influence the design steels that are inherently more resistant to damage, without the need to increase wall thickness, with the long-term benefit of reduced susceptibility to this threat and its related cost reduction.

- Developed comprehensive guidance on the use of hydrostatic testing as an integrity management tool, within existing integrity and risk management processes, applicable to both mainline transmission pipe and facility piping. This document provides the necessary guidance to pipeline operators on the appropriate use of hydrostatic testing.

- With support from the US Department of Transportation – Pipeline and Hazardous Materials Safety Administration (USDOT-PHMSA), constructed an ILI pull test facility with 16-inch and 24-inch diameter test strings to provide opportunities for performance improvement. The major ILI technology providers, together with pipeline operators, designed a series of ILI performance tests to assess the performance of magnetic flux leakage (MFL) technologies against published performance specifications. These results affirmed the specifications were achieved. Additionally, this will provide a continuing resource for ILI technology developers, researchers and pipeline operators to have access to test samples with a range of characterised defects and pipe vintages.

**Measurement**

- Multiple projects to evaluate Coriolis meter technology including assessing the ability of diagnostic routines to detect the presence of liquids (in a gas application), build-up of deposits inside the flow tubes and erosion on the tubes. In addition, a field test was performed to assess the suitability of using Coriolis measurement for high pressure ethylene.

- An evaluation of the accuracy of equations of state to predict the measured physical properties (density, speed of sound and specific heat) of real natural gas compositions (including shale gas) at high pressures and a wide range of temperatures. The work shows that the models are not as accurate as expected for many gas compositions. The results of this study have been shared with international standards organisations who work to improve equation of state models.
member companies, American Aerospace Inc. and University of Dayton Vision Lab.

◆ Evaluate the effectiveness and limitations of using satellite-based interferometric synthetic aperture radar (InSAR) methods to measure the ground subsidence due to longwall coal mining, which is typically rapid and aggressive, and a threat to pipelines traversing these mines. The project provides an overview of the longwall mining process, and conventional methods of monitoring ground movement using InSAR and other means.

Cliff Johnson is President of Pipeline Research Council International (www.prci.org).

**New radar obstacle detection system could help improve safety during drilling operations**

By Diane Miller

Gas Technology Institute (GTI), in cooperation with Operations Technology Development (OTD) conducted field evaluations of real-time radar obstacle detection for horizontal directional drilling (HDD). The obstacle detection system, developed in Europe with funding support from the European Union, is designed to help utilities across the globe increase safety when digging in urban areas.

The technology is called ORFEUS, short for Optimised Radar to Find Every Utility in the Street. The objective is to help reduce damage to underground equipment from horizontal digging. It’s attached to HDD equipment and uses bore-head ground penetrating radar (GPR) technology to scan the soil and send data to the system operators in real-time.

**Looking ahead for HDD**

Horizontal digging can be faster, more efficient and cause less disruption to built-up areas than traditional excavations such as open trenches. As the use of HDD continues to grow for pipeline installations, especially in urban environments, the need to reduce the threat of...
Fluxys as a gas infrastructure company seeks to foster the integration of the European gas market through the development of a cross-border infrastructure backbone linking gas sources to markets, bridging the markets and gas trading places, and providing security of supply.

Fluxys is convinced that gas and gas infrastructure will continue to feature as core components of an affordable energy mix for tomorrow’s low-carbon economy.

- Gas is the cleanest fossil fuel with the lowest carbon footprint and the lowest emissions impacting health.
- Gas infrastructure and gas-fired power plants provide the flexibility required to complement variable power generation from renewable sources.
- Gas infrastructure is a highly versatile asset for transmission and storage of large quantities of energy at low cost. New technologies such as power-to-gas will make the gas system even more flexible in the future energy landscape.
The ORFEUS radar system was demonstrated at PG&E’s Livermore Training Center, California.

Avoiding obstacles and improving safety

The new ORFEUS technology has the potential to protect homeowners, utility companies and contractors from potential damaging cross-bore incidents. This technology can also enhance the installations of distribution gas lines in difficult areas where other utilities may intersect.

The ORFEUS radar system has been field demonstrated in Germany, France and Slovenia with successful initial results. With funding from OTD, GTI partnered with Pacific Gas and Electric (PG&E) in California to bring the pre-commercial technology to the US. A live field demonstration at PG&E’s testing facility provided a deeper understanding of how the system works, as well as its benefits and limitations. During testing, the ORFEUS technology was able to successfully detect plastic and steel gas lines, electric conduit and a sewer main.

GTI plans to continue work with the ORFEUS team to assist with further technology development to help bring the product to market.

Diane Miller is Director, Marketing Communications, Gas Technology Institute (www.gastechnology.org).

GERG – latest developments

By Robert Judd

GERG, the European Gas Research Group, continues to evolve, as focus within gas innovation increasingly addresses the place of gas in a low-carbon, more integrated energy system.

This year GERG elected a new President. Isabelle Moretti, Technology Director at Engie has replaced David Salisbury of National Grid, who spent over four years driving GERG in its new direction. We thank David for all his hard work and constant support, and welcome Isabelle, who has declared an intent to build on the progress made in the last four years.

The organisation continues to attract new members, now numbering around 24 with 10 Associate Members or Friends. We continue to look for new partnerships and are working more closely than ever with other associations and stakeholders in Brussels and beyond.

In the last year, we looked closely at our established way of doing things which was largely driven by bottom-up ideas brought into our Programme Committees, and decided to trial a new way forward. This consists of working with our members to poll their R&D and innovation priorities, and then reconstructing these ideas into an open, themed call for proposals – the first of which was in 2016. At the same time, we continue to work to construct strategic technology roadmaps in priority areas which will form the basis of future activities, calls and targeted European-level initiatives. To better manage the increasing synergies within the industry, the Programme Committees have been reduced to two. The Transmission, Distribution and Utilisation Committees have
been brought together in one, PC TDU, and LNG projects are still handled in a separate Programme Committee, PC LNG.

Questions are increasingly being asked by policymakers about the future role of gas. GERG now has activities dealing with the main challenges facing the gas industry as we move through the energy transition, and look to demonstrate the key role gas will play in the future. Broadly speaking these activities include:

**Methane emissions**

How can the industry demonstrate that it understands the extent of methane emissions and the challenges of reducing them? The MEEM project, led by DBI in Germany is working to establish an accepted Europe-wide methodology for the estimation of methane emissions, initially focusing on Europe’s gas distribution networks. After a successful Phase 1, in which methods were compared, Phase 2 is now underway to hone in on a robust and universally applicable methodology.

**Renewable gas**

Significant flagship projects are now underway in biomethane introduction to the gas grid, and in understanding how to push forward the limitations of hydrogen introduction to ensure that the energy system is meeting the flexibility and low carbon challenge. We have recently completed Phase 1 of the GERG biomethane project, in which we have aligned closely with CEN (the European Standardisation Agency). Work has focused on the need to understand what threshold values are needed for trace components to allow us to develop robust European standards and therefore remove barriers to biomethane injection in the gas network. Many European network operators have been involved, several of them providing unique and valuable data on biomethane in their countries. We are now expecting to launch Phase 2 of this project later this year, supported by the European Commission through CEN, with a planned experimental programme to begin to answer the unknowns.

In the case of hydrogen, the HIPSNET and Hyready projects are developing a deeper understanding of current knowledge of hydrogen injection into the grid, and recommended practices for network operators. GERG is also closely involved in the CEN and European Commission-led Sector Forum Energy Management (SFEM) Working Group Hydrogen. This is developing roadmaps for the standardisation needs for hydrogen in gas networks, and mapping research requirements to fill the gaps in our knowledge.

**Health of our networks and gas transport and use**

If we are rightly arguing that our networks are the ideal existing source of energy transport into the future, we also need to ensure that they are fit for that future – lifetime extension, integrity and SMART operation are key here. Asset health R&D has been a traditional strength of GERG, with system operators forming a large part of our membership. This work is as important as ever, and is being supplemented by work to understand how our networks can work.
become smarter and more flexible. Several projects developed by our member companies continue in these areas. Additionally, we are developing closer ties with Marcogaz to ensure that our work aligns technical needs with R&D outcomes. GERG has worked closely with Marcogaz and Eurogas on defining the Gas Smart Grid, and on developing position papers on the impact of the Primary Energy Factor (PEF) on gas supply and use.

**LNG and the new markets it opens**

We have seen significant growth in our LNG project portfolio. Industry standard projects on inline measurement (using Raman Spectroscopy), metrology of small-scale systems and small-scale LNG safety are underway or have been completed. Our members are hoping to develop the Raman technique to the point where it can become a standard method for direct determination of liquid composition. We are also developing models for release behaviour from small-scale facilities which are being validated against experiment at our state-of-the-art member facilities in the UK and France.

In summary, GERG continues to develop, to attract new members and to stay relevant to the evolving needs of the gas and energy community and the increasingly interconnected energy system. Innovation is increasingly important to the future of the gas industry. The GERG model for open collaboration in innovation is still giving us positive results and benefitting our members, partners and stakeholders in the wider community.

Robert Judd is Secretary General of GERG (www.gerg.eu).

**Global executive programmes at the Energy Delta Institute**

By Andrej Tibold

When Gazprom and Gasunie, together with the University of Groningen, founded the Energy Delta Institute (EDI) in 2002, it was done so as a result of the conclusion of a 20-year natural gas supply contract to Gasunie, two years earlier. After the unbundling of Gasunie, the supply contract was grandfathered to Gasterra, which automatically became a founding partner as well. Shell joined in 2006 as another founding partner.

If the first supply contract was just the occasion, the founding of EDI had a deeper underlying vision and purpose. In addition to the physical trade exchange between the two companies, the idea was to set up a mechanism for knowledge exchange and training for natural gas and energy professionals, in which employees from both companies could undergo training and study programmes together. This vision became EDI’s raison d’être. Since then a great number staff from Gazprom, Gasunie, Gasterra and many other companies have taken part in EDI’s programmes.

Each of our programmes is unique in its own way, meeting the knowledge and training needs of a particular target group, be they at an introductory, specific or executive level. Although all our programmes have an international dimension and are accessible to an international audience, our Executive Programmes are perhaps the most global ones of our portfolio. After the necessary development run-up, we recently added a new global programme to our portfolio, the Advanced Leadership Programme in Energy Management.

The focus of this joint excellence programme lies with the Indian energy transition, while attention to the role of natural gas and LNG is given as well. The programme is a joint initiative of the S.P. Jain Institute of Management and Research, Mumbai, India, the Dutch Business University Nyenrode and EDI. Collaborating partners are the International Energy Agency and the Oxford Institute of Energy Studies. The programme consists of two modules, the first of which takes place in Mumbai and the second in the Netherlands. The course aims to provide future directions for the industry by discussing...
During the past 70 years, we have succeeded in building a company that, thanks to its capacity and potential, has reached the highest European standards within the oil products trading sector. We have accomplished this success through the continuous teamwork of our professional personnel, and the trust given by our long-term partners, aspects that, now and in the future, we consider crucial for the successful accomplishment of our short- and long-term targets.

Our priority is to build the future through the devoted performance of our current business activities. We continue building a company that will overcome all challenges. Taking into account our responsibility in performing business activities, we enhance our flexibility and create long-term values in our business.

We follow the most stringent safety and environmental protection standards. International standards are our criteria, even when they exceed local requirements. We engage our best employees and we have confidence in their abilities, and, thanks to the quality of our products and services, we have gained the trust of our users.

This year, as we celebrate our jubilee, MAKPETROL continues to operate in its most significant role, that of being the leader in the oil products and natural gas supply market in the Republic of Macedonia.

The realisation of our programmes for the production of biodiesel and other renewable energy sources is also in progress. We possess a modern network of warehouses, gas stations and our own vehicle fleet that enable the best conditions for the performance of our business activities. Constant quality control provides a guarantee for achieving the highest quality of our ULTRA fuels and the other energy products that we supply.

We are always oriented towards providing high quality, safe and economical supply of oil products, gas and biofuels, enabling us a guarantee that MAKPETROL will keep the leading position in the Macedonian market and within the energy sector, always able to respond to the energy requirements of our society.
the critical strategy and transformational leadership issues that can help the energy transition in India.

The reshaped Executive Programme International Gas Business and Cooperation, which has its origins in the European Business Council as the Fellowship of Energy Programme, also has a global character while focusing on Eurasia. The maturing of global gas markets has led to an increase in the number of trade relations, while gas finds itself in the midst of political tensions and the debate about climate change. The programme helps participants to understand the goals, the ways of work and the business cultures in different parts of Eurasia. The two modules have been developed in cooperation with the Skolkovo Moscow School of Management. An important contribution about Asian gas markets, strategies and business culture is provided by the Malaysian Universiti Teknologi Petronas (UTP).

In an increasingly unstable global environment resilience requires companies to continuously understand market transformations and implement them accordingly in their strategies and processes of business development. The Natural Gas Strategy Course (NGSC) module takes participants a step further in focused strategic thinking, enabling them to put the company’s activities into a strategic context. It addresses the question of how to manage uncertainties in a rapidly changing business environment and the impact of (geo) politics, developing an understanding of the current forces shaping the international gas business.

The Executive Programmes Energy Transition and Innovation (ETI) and Mini MBA New Energy Realities (NER) are somewhat closer to our northwest European “homeland”, but also deal with the global energy transition. As their names suggest, the programmes focus, but not exclusively, on innovation and new business models respectively. Whereas the NER covers struggling companies with obsolete business models and the financing of new energy, ETI looks a bit closer at the role for gas and the business and leadership skills needed for managing the energy transition.

Besides being programmes with global dimensions, all of our executive programmes share a common two module structure. This allows participants to process the materials and skills they have acquired in between the modules and to put them into practice in a case study.

If you are interested in our Introduction Courses and Specific Programmes, please visit www.energydelta.org/mainmenu/executive-education.

Andrej Tiboldis a Senior Energy Analyst at the Energy Delta Institute (www.energydelta.org).

Gas is key to decarbonising transport: The EU should adopt a technology-neutral approach to transportation fuels
By Andrea Gerini
COP21 brought a remarkable result – a global agreement on the reduction of climate change was signed, with countries all over the world committing to reducing greenhouse gas emissions. The EU’s contribution to the deal is a firm dedication to cut emissions by at least 40% below 1990 levels by 2030. This figure is aimed to stand at 80% by 2050.

These goals are ambitious. They are also interpreted as a strong call for European industries to pay their fair share for the cleaner future for the decades to come. NGVA Europe is no exception, with our focus being on making the case for natural and renewable gas in the transportation sector as a solution to achieving the COP21 goals.

In June this year NGVA Europe issued a flagship reference study on gas as a transportation fuel – ‘Greenhouse Gas Intensity of Natural Gas’ – the first reference study of this kind (www.ngvemissionsstudy.eu). The thorough analysis assessed the whole carbon footprint of a vehicle based on the well-
With approximately 75 trillion cubic feet of recoverable natural gas, Mozambique LNG represents an extraordinary opportunity to meet increasing world demand for a sustainable, reliable and cleaner source of energy.

Learn more at www.mzlng.com
The study results are based on a full and comprehensive analysis of the current state of the natural gas supply chain and the performance of natural gas-fuelled vehicles (NGVs). Not only is this a scientific analysis, it is an industry-wide assessment of the natural gas supply to Europe and its use in the EU, as more than 50 companies from across the gas value chain provided high quality data for research.

More specifically, the study found out that natural gas reduces GHG emissions from passenger cars on the WtW basis by 23% compared with petrol and by 7% compared with diesel. In heavy-duty applications, benefits compared to diesel are of 16% for CNG and up to 15% for LNG. In the maritime sector, overall WtW benefits are up to 21% compared to conventional heavy fuel oil (HFO) fuels. Considering the overall WtW impact, the study proves there are significant benefits and reduced GHG emissions from passenger cars as well as light- and heavy-duty vehicles when switching to CNG or LNG from petrol and diesel.

In addition, the use of renewable gas provides benefits towards carbon-neutral mobility: by blending natural gas with just 20% renewable gas, GHG emissions are reduced up to 40% compared with oil-derived fuels. Biomethane can foster the circular economy, providing a clever way to produce clean and high-quality fuel from local waste. Europe has the potential to fuel more than two million vehicles with biomethane produced from waste, just by transforming its domestic disposals into renewable gas, a sustainable and locally-produced fuel.

Another important virtue of using gas as a transportation fuel is its potential to improve air quality in urban areas: in addition to low GHG emissions, natural gas is the cleanest fuel to guarantee particulate-free combustion and drastically reduce NOx and non-methane hydrocarbon (NMHC) emissions. Not only does natural gas fight climate change, it also improves air quality in a cost-efficient way.
NGVA Europe, along with our 140 members from across Europe, understands that the study cannot exist in a theoretical vacuum and needs practical implementation. What is clear from the results is that to roll out the wide use of natural gas in transport, the gas industry needs to be treated equally with other energy sources when making long-term projections.

Electricity now seems to be the silver bullet to decarbonising transport, but it would be misleading to consider electro-mobility as a solution to zero-emission vehicles. Current legislation does not take into consideration the whole lifecycle process of an electric vehicle, but rather selectively focuses on the tank-to-wheel performance of vehicles, leaving out the production phase of the fuel or the electricity respectively.

A technology-neutral approach is therefore vital to make a fair comparison of different solutions that could provide an answer to specific and realistic requirements. Introducing the WtW approach into the decision-making process is of paramount importance to tackle decarbonisation.

NGVA Europe calls on the EU institutions to maintain an open framework to decarbonising transport and adopt a technology-neutral approach, with the goal to accept natural gas and renewable methane as one of the most effective solutions in transport.

Andrea Gerini is Secretary General of NGVA Europe (www.ngva.eu).

IPLOCA deepens its relationship with key industry stakeholders

By Juan Arzuaga
Since its inception over 50 years ago, IPLOCA (the International Pipe Line and Offshore Contractors Association) has been a recognised voice of the pipeline industry and our mission continues to be to provide value to members through a forum for sharing ideas, engaging the industry and its stakeholders, facilitating business opportunities and promoting the highest standards in the pipeline industry.

IPLOCA strives to work collaboratively and to perpetuate the development of relationships across the industry, exploring how to further engage with stakeholders who are not already members of the Association, in particular clients of IPLOCA’s Regular or Associate Members.

Corresponding Members

To this end and effective from January 2016, following the work of the Client Engagement Committee, IPLOCA members agreed to open membership to those owners and operators of pipeline systems who have an interest in the work of the Association and a willingness to benefit from a range of technical guidance and briefings produced by IPLOCA. ExxonMobil, Shell and GtGaz (ENGIE) were among the first Corresponding Members confirmed by the IPLOCA Board.

There are now 14 Corresponding Members spanning the globe, including BP from the UK, Chevron from the USA, Gasunie of the Netherlands, Petronas from Malaysia, Origin Energy in Australia and Trans Adriatic Pipeline (TAP) based in Italy.

A number of these players have been closely collaborating with IPLOCA for many years, making presentations at our annual Convention and Regional Meetings or attending workshops and sponsoring the IPLOCA awards. These awards are intended to be a source for sharing new ideas while recognising those leading companies that are always in search of excellence.

Corresponding Members have access, with no annual fee, to a palette of benefits, namely networking opportunities with contractors and suppliers, promotional possibilities and sources of information, participation in and sharing of publications and initiatives to increase standards.

Access to innovation and best practices

Around the world, major pipeline owners and developers are exchanging ideas with contrac-
tors and suppliers to achieve greater certainty of results in terms of project time and cost, cheaper pipelines through better specifications and innovative technology, and high levels of safety along with low environmental impact.

**New technologies add value**
Valuable opportunities to participate in the shaping of best practices are offered via committee work in areas such as Novel Construction and New Technologies. The Association’s annual convention features technical presentations to bring technological improvements to the forefront, along with Novel Construction Initiative meetings held twice a year.

The 4th edition of the best practices, pipeline construction reference document, *The Road to Success*, has been completely revised through a highly collaborative approach, with new chapters added. It has now been issued as a mobile app available to IPLOCA members as a benefit of membership. This is a live document that continues to be expanded by multicultural work groups built up by specialists from all our members.

**Health, safety and the environment (HSE)**
Improving safety in the pipeline industry and above all, eliminating fatalities is a priority. The HSE Committee has set ambitious long-term KPI objectives for 2020, made up of leading and lagging indicators, including zero fatalities and a minimum of 15,000 training hours per million hours worked.

IPLOCA hosts Health and Safety workshops and meetings to raise awareness and to develop and encourage best practices. Submission of annual HSE statistics is a requirement of all Regular Members, and IPLOCA publishes an annual report with aggregate statistics for the industry. The H&S Shared Experiences platform carries around 150 documents on lessons learned, safety alerts and best practices, allowing experiences to be shared to benefit others.

**Networking**
Since the Association’s inception, IPLOCA members have shared ideas, networked and built business relationships with others in the industry through their membership. Corresponding Members have direct access to top executives in pipeline construction companies and their suppliers during the annual convention, regional meetings, workshops and plenary sessions.

**A voice in addressing industry challenges**
Membership in the Association provides an opportunity for members to let their voice be heard on issues such as: health and safety; environmental management and sustainability; owner-contractor relationships; risk sharing; and manpower challenges.

Visit us on [www.iploca.com](http://www.iploca.com) to keep up to date on all our initiatives.

Juan Arzuaga is IPLOCA’s Executive Secretary.

“The Road to Success” 4th edition is available as a mobile app.
PT Pertamina (Persero), a state-owned enterprise in the energy sector, continues to strengthen its position as a company that controls the integrated gas business chains in Indonesia through a number of gas infrastructures across the whole gas value chain.

Pertamina produces around 48.1 mcm/d and receives gas allocation in the form of pipeline gas from the Jambaran-Tiung Biru and Terang-Sirasun-Batur gas fields and LNG from the Bontang LNG Plant in East Kalimantan. From overseas, Pertamina procures LNG supply from Cheniere's Corpus Christi LNG in the USA, amounting to 1.52 mtpa and up to 3 mtpa from portfolio players starting from 2019 for 20 years.

In 2022, Pertamina aims to operate two additional FSRUs, including the FSRU Cilacap which will have a capacity of 1.2 mtpa while the FSRU Jawa I which will have a production capacity of 2.4 mtpa. Pertamina is also working on the Mini LNG Simenggaris project with a capacity of 0.2 mtpa, and the Land Base LNG Terminal Banten in Bojanegara, Cilegon, designed for 3 mtpa and expected on-stream in 2022.

**Pertamina’s gas portfolio**

In the upstream sector, as detailed above, Pertamina operates a number of gas fields with production of around 48.1 mcm/d. Additionally, in 2018 Pertamina will be the operator and one of the shareholders of the Mahakam Block in East Kalimantan.

In the midstream sector, Pertamina has an open access transmission pipeline operated by PT Pertamina Gas (Pertagas). The pipelines include the 350 km Arun-Belawan pipeline; the 132 km Belawan-KIM-KEK pipeline, the 30 km MuaraKarang-Muara Tawar pipeline, the 276 km Gresik-Semarang pipeline and the 56 km Porong-Grati pipeline. These pipelines are utilised to supply 16.1 mcm/d of gas to power plants, 19 mcm/d to industries and 7.1 mcm/d of gas to fertiliser plants. In addition, Pertamina has built a city gas pipeline distribution network to supply gas to 58,506 households.

Pertamina is currently developing 513 kilometres of gas transmission pipelines in three locations, the 176 km Grissik-Pusri Project (South Sumatra) with a capacity of 4.5 mcm/d, the 70 km Gresik-Petrokimia Gresik Project (East Java) with a capacity of 2.4 mcm/d and the Gresik-Semarang Project (Central Java) with a capacity of 14.2 mcm/d.

Moreover, Pertamina also supplies gas for the transportation sector through the SPBG-branded gas filling station network in Medan, Balikpapan, Palembang, Sengkang, Jabodetabek, Semarang, Cilegon and Surabaya.

In the downstream sector, Pertamina has established PT Nusantara Regas, a joint venture company with Perusahaan Gas Negara (PGN) to operate an FSRU in West Java which supplies gas to the Muara Karang and Tanjung Priok power plants. FSRU Nusantara Regas has been in operation since 2012 with regasification capacity of 14.1 mcm/d.

Pertamina established a joint venture company with Mitsubishi, KOGAS and Medco, PT Donggi Senoro LNG (DSLNG), which produces LNG with feed gas from PT Pertamina Hulu Senoro-Toili and PT Pertamina EP Donggi-Matindok which commenced its operation in August 2015 with a production capacity of 2 mtpa.

In Bontang, East Kalimantan, through its subsidiary company, PT Badak NGL, Pertamina operates eight trains with a capacity of 22.5 mtpa of LNG while in Arun, Aceh North Sumatera, through its subsidiary, PT Perta Arun Gas, operates LNG receiving and regasification facilities with a capacity of 3 mtpa.

Pertamina has been operating various LPG plants including PertaSamtan Gas in South Sumatra which produces 7.1 mcm of feed gas, 710 tons of LPG and 2,024 barrels of condensate per day; an LPG plant in Pondok Tengah, West Java which produces 0.4 mcm of feed gas, around 123 tons of LPG and 185 barrels of condensate per day; and the LPG Plant Mundu, Cirebon, West Java which produces 100 tons of LPG, 120 tons of naphtha/minasol condensate and 720,000 cubic metres of lean gas per day.

Pertamina has formed a joint venture with Marubeni and Sojitz to become an independent power producer to work on the 1,760 megawatt steam gas power plant (PLTGU) in Jawa I. The development of PLTGU Jawa I is a concrete actualisation of Pertamina's support for national energy security with environmentally clean gas fuel.

Through growing gas infrastructure, Pertamina is able to play an important role as a gas supplier for the needs of power plants, households, transportation, and industries that continue to increase every year.
During the Oil and Gas Conference ARPEL 2017 in April, IGU signed a memorandum of understanding with Asociación Regional de Empresas del Sector Petróleo, Gas y Biocombustibles en Latinoamérica y el Caribe (ARPEL), the Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean. As part of the bilateral agreement ARPEL became the 13th organisation affiliated to IGU.

ARPEL is a non-profit association which brings together oil, gas and biofuels sector companies and institutions across Latin America and the Caribbean. Founded in 1965 to foster cooperation and reciprocal assistance, its main role is to actively contribute to the integration and competitive growth of the industry it serves, and to sustainable energy development in the region.

Its membership currently represents over 90% of upstream and downstream activities in Latin America and the Caribbean including both national and international operating companies, institutions and others active throughout the entire gas value chain.

ARPEL represents the regional industry in dealings with other organisations related to the sector, from international agencies and professional associations to banks and academia. This work aims to coordinate agendas with other bodies, address emerging situations and promote the region’s vision on energy issues.

Developed by its Committees and Working Groups ARPEL boasts a library of around 300 documents from white papers and guidelines on best practices to studies and statistical databases which are freely available to its membership via the web. Through annual studies the Association provides important benchmarking information on subjects such as industrial safety, environmental performance and process safety. Through workshops, symposia and other related activities ARPEL acts as a forum for the exchange and dissemination of knowledge and best practices.

ARPEL works to build capacities and provides direct technical assistance to its membership, offering courses both in person and online on important and sensitive aspects of the work of the industry in the region including CSR, community relations, human rights and pipeline integrity management.

To provide a space for high-level dialogue, encourage networking and facilitate business development, ARPEL hosts two important events in alternate years. Its regional conference runs in odd-numbered years and provides an opportunity to analyse and the discuss the opportunities and challenges faced by industry in the region. In even-numbered years it hosts LATINVE&P (Latin American Opportunities for Investment in E&P), aiming to identify opportunities for investment and bring together hydrocarbon agencies and the business sector.

*For further information visit [www.arpel.org](http://www.arpel.org).*
Creating Exceptional Value in Energy.

The National Gas Company of Trinidad and Tobago Limited (NGC) and its subsidiaries have together, as the NGC Group of Companies, transformed Trinidad and Tobago’s energy sector.

Operating strategically in the midstream of the local natural gas value chain, with investments in the upstream and downstream sectors, the NGC Group has invested in natural gas-based development and merchandising; gas aggregation, transportation and distribution; pipeline construction, operation and maintenance; Liquefied Natural Gas (LNG) production, marketing and shipping; the development and management of industrial sites and port and marine infrastructure; fractionation, export and marketing of Natural Gas Liquids (NGLs) and the marketing of Compressed Natural Gas (CNG).

We are well positioned to internationalize our business model in emerging petroleum jurisdictions. We can be your valued partner in energy.
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IGU Secretariat Team

The staff of the IGU Secretariat (from left to right) Luisa Peris Meléndez, Executive Assistant; Emma Siobhan Paños Knowles, Executive Administrative Assistant; Hyunchang Kim, Advisor to the Secretary General; Rafael Huarte Lázaro, Director; Luis Bertrán Rafecas, Secretary General; Taek Sang Kwon, Senior Advisor; Antonia Fernández Corrales, Chief Advisor; Anette Sørum Nordal, Information Consultant and Secretary of the Coordination Committee; not pictured: Rodney Cox, Events Director.
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90 Charter Members
10 Premium Associate
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Achievements & commitments

- A recognized experience in the oil and gas industry
- A global pioneer in the LNG industry
- An internationally oriented development
- A Committed human resource
- A socially responsible company
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<td>United Arab Emirates</td>
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### Premium Associate Members

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<td>GIGNL – Groupe International des Importateurs de Gaz Naturel Liquefié/International Group of LNG Importers</td>
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<td>NGVA Europe – European Association for Bio/Natural Gas Vehicles</td>
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<td>MARCOGAZ – Technical Association of the European Natural Gas Industry</td>
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<td>World LPG Association (WLPGA)</td>
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Reports launched in 2017
IGU Wholesale Gas Price Report 2017
IGU World LNG Report 2017
Enabling Clean Marine Transport – March 2017

Reports launched in 2016
Global Gas Markets Supporting Growth and Sustainability
Case Studies in Improving Air Quality, Second edition (European cities)
Case Studies Enabling Clean Energies

Report launched at the IGU COP 21 Gas Day
Case Studies in Improving Urban Air Quality

Reports launched at WGC 2015
Biogas – from refuse to energy
Prospects for Natural Gas: Identifying the key developments that will shape the gas market in 2050

Other publications
IGU Articles of Association
IGU Annual Report
IGU General Brochure
Triennial Work Program 2015-2018

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Natural Gas as a Transportation Fuel
Global Vision for Gas – The Pathway towards a Sustainable Energy Future
IGU Natural Gas Conversion Guide
IGU Natural Gas Conversion Pocketbook
International Gas Union 1931-2016
International Gas, back issues of the bi-annual IGU Magazine

Please check the IGU website for other (older) publications which are still available from the IGU Secretariat.
IGU events and other major gas-related events 2017-2018

2017

October 24-26
IGU Council, Executive Committee and Coordination Committee meetings
Tokyo, Japan

October 27
Eurogas Annual Conference
Brussels, Belgium

November 6-17
23rd Session of the Conference of the Parties to the UNFCCC (COP 23)
Bonn, Germany

2018

January 29-31
11th Annual European Gas Conference
Vienna, Austria

May 14-17
Flame Conference
Amsterdam, The Netherlands

April 17-19
IGU Executive Committee and Coordination Committee meetings
Cairo, Egypt

June 25
IGU Council meeting
Washington DC, USA

June 25-29
27th World Gas Conference
Washington DC, USA

October 24-26
IGU Council, Executive Committee and Coordination Committee meetings
Tokyo, Japan

Acknowledgements

For the IGU Secretariat
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Information Consultant and Secretary of the Coordination Committee: Annette Serum Nordal
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Editor-in-Chief: Mark Blacklock
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Publisher: Robert Miskin
Special Projects Director for IGU: Karin Hawksley
Finance Director: Yvonne O’Donnell
Finance Assistants: Maria Picardo, Anita d’Souza
Senior Consultants: Jeffrey Fearnside, Michael Gaskell, Jonathan Unsworth
Art and Design Director: Michael Morey
Printed by: Buxton Press Ltd

IGU and ISC would like to express their thanks to all those who helped in the preparation of this publication. Thanks are also due to the following companies, people and organisations for providing pictures. The credits are listed by article. Where the pictures for an article came from a variety of sources, the appropriate page numbers are given in brackets after each source.

Cover: Oman LNG (Oman LNG plant, Qalhat, Oman), TransCanada (Pipeline welder, Northern Alberta, Canada), Egyptian LNG (LNG tanker, Puteri Zamrud Satu, Idku LNG plant, Egypt), Petromin Resources Ltd (CBM well, Xinjiang Province, China), Sonatrach (right: LNG tanker, Cheikh El Mokrani, approaching Mt Fuji, Japan).

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A timeline of major events for the gas industry in Japan: www.gasmuseum.jp (28 upper), Osaka Gas (28 left & right, 29 left, 30 left), ConocoPhillips Corporate Archives (29 upper), Brunei LNG (29 right), GTI (30 right), Woodside Energy Ltd (31 left), JGA (31 right), Air Photo Service (34 left), Tokyo Gas (34 right), INPEX Corporation (35 left), Gleam [CC BY-SA 3.0] (35 right).

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An introduction to ARPEL: ARPEL (126).

IGU Organisation: AFG (Jérôme Ferrier), GTI (David Carroll), IGU (Mel Ydreos, Luis Bertrán Rafecas, Secretariat Staff), Korea Gas Union (Jae Ho Song & Munseok Baek).
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