ENE•FARM Fuel Cell Systems for Residential Use

By Shunichi Eguchi

In a world first, gas companies in Japan started selling fuel cell systems for residential use in May 2009. These fuel cell systems generate electricity and hot water through a chemical reaction between oxygen in the atmosphere and hydrogen extracted from city gas[1], LPG or kerosene, and are expected to play a key role in combating global warming by reducing CO_2 emissions from the residential sector.

The systems were developed through demonstration research projects conducted by the government, manufacturers and energy utilities starting in fiscal 2002, and underwent government-sponsored major demonstration projects from fiscal 2005. The fuel cell systems for residential use are expected to greatly reduce CO_2 emissions from energy consumption in the residential sector, and thus become a major countermeasure against global warming. In this article, I will describe these fuel cell systems, and the process from development to marketing.

Fuel cells as national policy

Installation of commercial units in the Prime Minister's official residence

Fuel cells are expected to play a dominant role in the new energy policies of the Japanese government as urgent countermeasures for global warming. In particular, fuel cell systems for residential use, which substantially reduce CO_2, have attracted the attention of various sectors who would like the systems to be put into practical use as soon as possible. The Japanese government was ahead of other countries in introducing fuel cell cars, and the then Prime Minister Junichiro

1 City gas is the gas supplied by gas utilities through reticulated pipeline networks.

Shunichi Eguchi: fuel cell systems for residential use are expected to greatly reduce CO_2 emissions.

Koizumi actively promoted the commercialisation and deployment of fuel cells. Demonstration research projects of stationary fuel cell systems were performed at 55 sites between 2002 and 2004 under a national policy, and the first two commercial units manufactured by Matsushita Electric Industrial Co., Ltd (presently Panasonic) and Ebara Ballard Corporation (a joint venture of Ebara and Ballard that has since been dissolved), respectively, were installed in the Prime Minister's official residence in March 2005. Subsequently, field tests prior to commercialising the systems were started in households under actual operating conditions to evaluate their performance.

Fuel cell cars and hydrogen stations

In 2002, the first hydrogen refuelling station was built on the site of Tokyo Gas Senju Techno Station as part of the government-sponsored "Major Demonstration Projects for Hydrogen Fuel Cell Systems". This hydrogen station was jointly constructed by Tokyo Gas and Nippon Sanso Corporation for verifying hydrogen purification, supply technology, operational know-how, and so forth through actual operations and supply to fuel

cell cars, and attracted much interest from delegates at the 22nd World Gas Conference in 2003. Meanwhile, Tokyo Gas has been working on developing and commercialising hydrogen energy and fuel cell systems, such as high-efficiency technology for purifying hydrogen by reforming city gas methane, in order to spread hydrogen-based infrastructure and pave the way for the hydrogen society of the future. If the infrastructure for delivering hydrogen to ordinary households can be established, then stationary fuel cell systems will be simplified considerably.

Major demonstration projects

A total of 3307 fuel cell systems for residential use were installed in ordinary households all over Japan in 2008 to conduct field tests under the "Large-Scale Stationary Fuel Cell Demonstration Project" which started in 2005. These systems were installed from Hokkaido in the north to Kyushu in the south, in both urban and suburban districts, as well as in diverse types of housing such as condominiums and detached houses (*see Figure 1*). The systems have been proved to work efficiently, meeting the electricity and thermal demands of residential consumers.

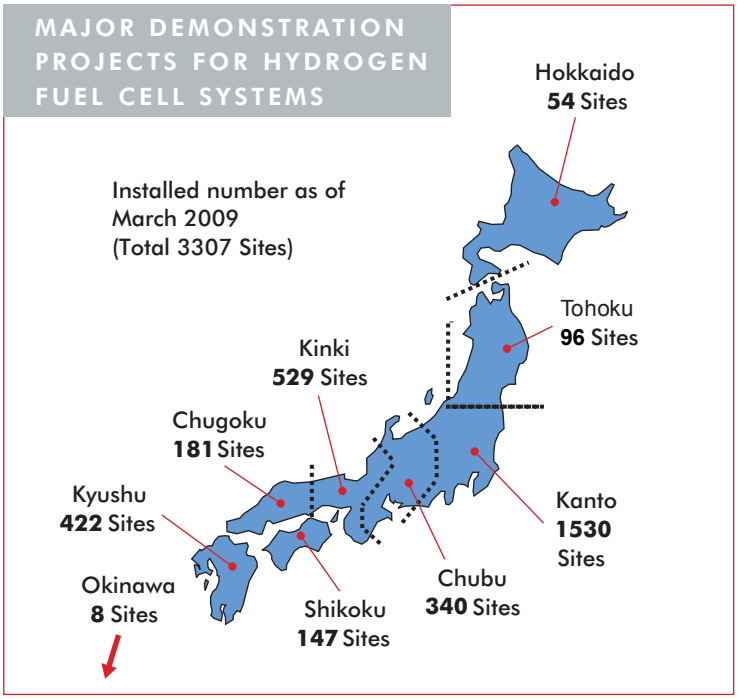
This project has confirmed the excellent environmental protection performance of fuel cell systems. Specifically, the efficiency of primary energy utilisation was improved by 70 to 80% and primary energy consumption was cut by about 30%, while CO_2 emissions were reduced by about 45% in comparison to the conventional parallel use of electricity and city gas. Thus, these fuel cell systems greatly help curb global warming. In addition, various technological issues have been fed back to manufacturers and used to significantly improve performance, durability and reliability.

The fuel cells installed in this project were polymer electrolyte fuel cells (PEFC) and were produced by five domestic manufacturers (Panasonic, Ebara Corporation, ENEOS Celltech, Toyota Motor Corporation, Toshiba Fuel Cell Power Systems),

One of the hydrogen refuelling stations in Tokyo.

and used various fuels such as city gas, LPG and kerosene (*see Table 1 over*). Of 16 energy supply companies, the five city gas utilities of Tokyo Gas, Osaka Gas, Toho Gas, Saibu Gas and Hokkaido Gas participated in this project. Japan is the only

BELOW
Figure 1.



BREAKDOWN OF RESIDENTIAL FUEL CELLS IN JAPAN BY MANUFACTURER AND FUEL

Manufacturer	*Number of fuel cells*	*Fuel type*	*Number of fuel cells*
ENEOS Celltech	1253	LPG (propane)	1614
Toshiba Fuel Cell Power Systems	748	City gas	1379
Ebara Corporation	710	Kerosene	314
Panasonic	520		
Toyota	76		
TOTAL	3307	TOTAL	3307

RIGHT
Table 1.

country where fuel cell systems for residential use are being used on such a scale.

● Activities at the Hokkaido Toyako Summit – zero-emission house and fuel cell systems

In July 2008, the G8 Summit – dubbed the Environmental Summit – was held in Toyako in Hokkaido. On the sidelines of this summit, the Japan Gas Association (JGA) organised various activities to showcase Japan's energy policy for cogeneration and other technologies including residential fuel cells with the cooperation of the International Energy Agency, as well as to help increase awareness and knowledge of the latest city gas technologies among many visitors from abroad.

The zero-emission house was a futuristic house constructed by the Japanese Ministry of Economy, Trade and Industry near the International Media Centre, which was used by journalists from all over the world. The JGA built a footbath in the house, which was powered by a fuel cell unit for residential use which included other types of fuel, in partnership with the New Energy Foundation. This footbath was particularly popular with visitors, including the leaders of the summit countries, the first ladies, aides and journalists. The footbath, which enabled visitors to warm their feet in hot water, was an excellent way of increasing their understanding of fuel cell systems for residential use.

● Start of general sales of fuel cell systems for residential use

Unified name of "ENE•FARM"

The Fuel Cell Commercialisation Conference of Japan (FCCJ), which comprises firms and organisations including fuel cell manufacturers and gas utilities, decided to unify the names of fuel cell systems under the "ENE•FARM" brand, and held a press conference in June 2008, which was attended by representatives from various companies, ministries and agencies, as well as journalists representing more than 40 companies including three TV broadcasting stations. The term "ENE•FARM" comes from "energy" and "farm". Generating electricity and heat from hydrogen and oxygen is similar to growing crops from water and soil, so the word conveys the futuristic concept of creating our own energy. The logo (see *Figure* 2) expresses the environmental friendliness of fuel cell systems for residential use and symbolises a tree providing new energy and benefits to people and the earth. The fruits of the tree represent various values including electricity, hot water, comfort and environmental protection, provided by fuel cell systems for residential use.

Figure 2.

Full-scale marketing of "ENE•FARM" fuel cell systems for residential use

The six companies of Tokyo Gas, Osaka Gas, Toho Gas, Saibu Gas, Nippon Oil (ENEOS) and Astomos Energy held a ceremony in January 2009 to mark the start of marketing ENE•FARM fuel cell systems for residential use, and signed a joint declaration in which they declared they would totally commit themselves to widespread marketing of ENE•FARM under the joint slogan "ENE•FARM – Helping to Establish an Environmentally Advanced Nation". The joint declaration also expressed the companies' expectations that ENE•FARM will be widely used as an important means for achieving a low-carbon society, and will help establish Japan as the world's leading environmentally advanced nation.

Currently, three of the companies, Panasonic, ENEOS Celltech and Toshiba Fuel Cell Power Systems, are mass-producing fuel cell systems, and they launched full-scale general sales in May 2009. The ENE•FARM systems sold by the six companies cost from ¥3.2 million ($33,000) to ¥3.465 million ($35,800); the rated output of the Panasonic unit is 1 kW and the ENEOS Celltech unit is 750 W.

The Ministry of Economy, Trade and Industry started a support programme which subsidises half the cost of equipment and installation, up to ¥1.4 million ($14,460) per unit in fiscal 2009. The project's budget for the first year is more than ¥10 billion ($103 million).

The six companies are now engaged in extensive marketing with the aim of selling 2.5 million units[2] by 2030, which is the government's forecast, thus making ENE•FARM a standard feature of Japanese homes in the future.

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2 The number of residential CHP systems, including residential fuel cells, in 2030, as forecasted by the Long-Term Energy Supply and Demand Outlook.

Presidents of the six companies and Director-General Ishida of the Agency for Natural Resources and Energy, shaking hands following the signing of the joint declaration

Ultrasound technology from SICK: ... reliable even in CO_2-rich gases

SICK
Sensor Intelligence.

Until now ultrasonic gas flow meters only worked to a limited extent in gases with a high carbon dioxide content. In order to tackle the high acoustic attenuation of such gases, SICK – leader in ultrasound technology – developed innovative sensors, path concepts and signal processing methods. The result: the FLOWSIC600 ultrasonic gas flow meters can be used reliably and with long-term stability in practically any gas composition – including gases rich in CO_2. And they are less costly and more reliable, as they require less maintenance and offer many diverse diagnostic possibilities.

The use of unconventional gas reserves brings with it increasingly complicated metering situations. One particular challenge here is the increasing levels – up to 100% – of CO_2 content in the gas, as, for example is usual when storing or reinjecting CO_2 into underground reservoirs or declining oilfields. The storage of gas involves huge flow volumes that have to be reliably recorded. In order to make ultrasound technology usable for CO_2 applications as well, SICK not only systematically developed the stacked sensor design but also optimized it for this measurement.

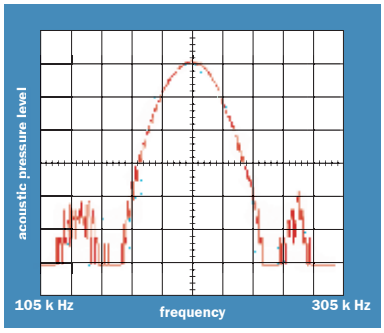


Chart 1: Frequency range of a ultrasonic sensor with resonance converter

Longitudinal oscillators inject signals better

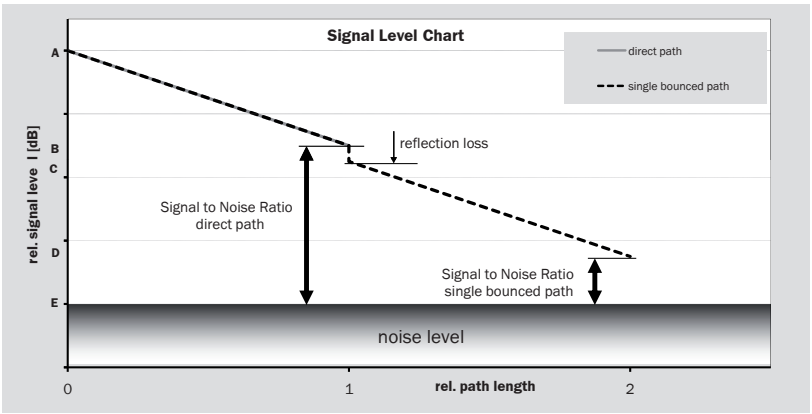
Modern sensor technology has moved away from bimorph wide-band sensors, which always had to battle with overlaying frequencies that impaired the quality of the measurement as a whole. By contrast, sensors with resonance converters – so-called 'stacked ultrasonic transducers' – work within a well-defined frequency range (*see chart 1*) and do not transmit any unwanted signals. Even with signals of short duration, it is possible to achieve the greatest possible amplitude. They permit relatively short acoustic pulses with high spectral purity. Furthermore, SICK is able to manufacture miniaturised sensors for very small pipe diameters, e.g. probes with an 8mm diameter, as used in 2" DN50 gas flow pipes.

The measurement path in gases with a high CO_2 content has to be as short as possible. The measured signal strength reduces over the path length. Where the signal to noise ratio for a direct path measurement is still good (*see chart 2*), the ratio could be too low for a reliable measurement with an increased path length. In a highly attenuating gas, the only path-layout that comes into question is therefore a direct layout with no reflection of the signal on the pipe wall (*see chart 2*).

Disturbances caused by pressure regulator noises are minimized through the use of electric amplifiers with minimal inherent noise and optimized signal processing methods. They reliably rule out any corruption of the measurement results even when used in carbon dioxide.

Outstanding results even without calibration

Through optimal path layout, coupling of the ultrasonic signal via stacked ultrasonic transducers and the use of electronic equipment with minimal inherent noise, SICK has been able to take measurements reliably in CO_2 despite its attenuating effect. Test installations in a CO_2 re-injection project (8", CO_2 content of 62%) show that ultrasonic meters are extremely well suited for applications in high CO_2 concentrations.



◀ *Chart 2:* Signal level chart

Typical gas composition in %				
CO_2	CH_4	C_2H_6	C_3H_8	N_2
62,1	37	0.3	0.1	0.5

▲ *Chart 3:* Typical gas composition at the reinjection of natural gas with a high CO_2-rate

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North America Gas Market Integration: Status and Steps

Gas market integration is the focus of Strategic Guideline 3 of the 2006-2009 Triennium and work in this area has been coordinated by a special Task Force. Past issues of the IGU Magazine have included papers on the energy relationship between Russia and Germany, cooperation between Qatar Petroleum and ExxonMobil, South America's Southern Cone and the Iran-Pakistan-India pipeline project. In this issue we have three more case studies and the first looks at North America.

BELOW
Table 1.
Table 2.

The main objective of this paper is to compare the integration of the US-Canadian market with the US-Mexican market and identify benefits of further collaboration in US-Mexican market development.

The Canadian, US and Mexican natural gas markets have evolved differently over the years with a much higher degree of interaction between the US and Canadian markets. That interaction is generally seen as having a favourable impact on all segments of the markets. There are several factors that have contributed to this success and which, if replicated in US-Mexican interactions, could further Mexico's contribution to the North American gas marketplace.

Background

It is useful to first examine some demographic and natural gas facts concerning each of the three countries in 2008 (see *Table 1*).

Additionally, there are wide differences in the natural gas supply/demand balance as shown in *Table 2*.

In Canada, supply is greater than demand, whereas in Mexico and the US it is reversed. As a result, both the US and Mexico are dependent on imports of natural gas to augment domestic production, Mexico somewhat more so at 20% versus the US at 15%. These could be either supplies from one of the other three countries or imported LNG.

There are almost twice as many physical interconnections between the US and Canada than between the US and Mexico: 31 physical interconnections along the US-Canadian border compared to 16 along the US-Mexican border (see *Figure 1*).

This leads to the fact that more gas flows between the US and Canada than between the US and Mexico. In 2008, the relationship was over 10 times greater between the United States and Canada (see *Table 3*).

Reinforcing the ability to move gas between the US and Canada, the US-Canadian interconnects have a combined capacity of nearly 19 bcf/d spread across four major access routes, spaced almost evenly across the length of the US-Canadian

BACKGROUND FACTS

Country	*Population (millions)*[1]	*GDP (US$ billions)*[1]	*Land Mass (million square kilometres)*	*Proven Gas Reserves (tcf)*[2]
USA	307	14,330	9	238
Mexico	111	1,143	2	18
Canada	33	1,564	10	58

1 **Source:** CIA World Factbook 2008.
2 **Source:** BP Statistical Review of World Energy, June 2009.

NATURAL GAS SUPPLY/DEMAND BALANCE

	2007		*2008*	
Country	*Supply (bcf/d)*	*Demand (bcf/d)*	*Supply (bcf/d)*	*Demand (bcf/d)*
US	52.3	63.1	56.2	63.4
Mexico	5.2	6.1	5.3	6.5
Canada	17.8	9.4	16.9	9.7

Source: BP Statistical Review of World Energy, June 2009.

GAS FLOWS

Flows in million cubic feet per day (2008)	*Mexico*	*Canada*
US imports from:	117	9,953
US exports to:	991	1,534
Total flows to/from	1,108	11,487

Source: BP Statistical Review of World Energy, June 2009.

LEFT
Table 3.

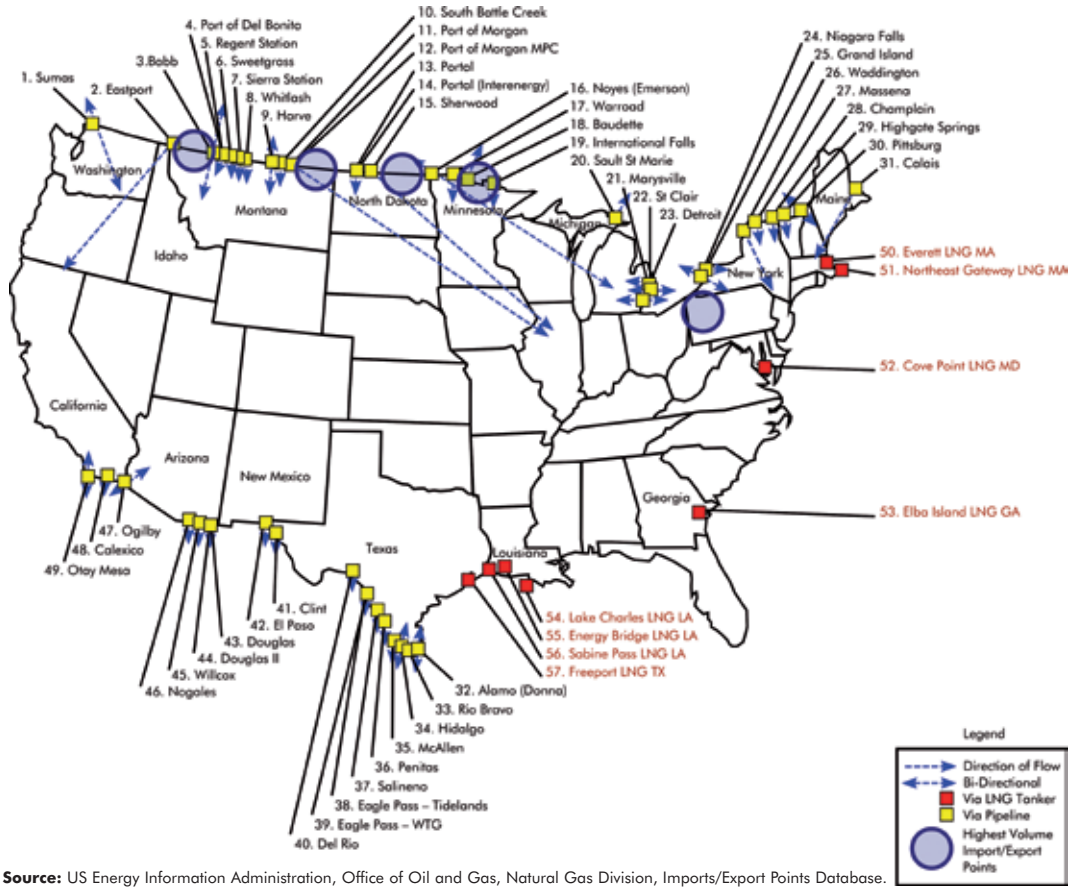
border. By contrast, US-Mexican capability is more constrained with only one major interconnect, at about 0.5 bcf/d, along with a variety of pipeline laterals that provide some additional capacity.

● Sector development in the three countries

A number of factors have influenced the development and utilisation of natural gas in the three countries. Among the most important factors are contract and market structure, governmental regulation, infrastructure and exploration and development.

Historically, the US and Canadian experience with natural gas has been similar, and different than Mexico's. These different evolutionary paths help explain why the US and Canadian markets are highly integrated today. In recognising the benefits of the US and Canadian markets, there is incentive for Mexico to consider similar

PIPELINE INTEGRATION



Source: US Energy Information Administration, Office of Oil and Gas, Natural Gas Division, Imports/Export Points Database.

LEFT
Figure 1.

parameters in order to potentially enjoy similar benefits.

United States

The US market structure has evolved to what could be characterised as a liberal or decentralised level. In the gas value chain, exploration and production (E&P) is open to all interested parties, a function of the private monetary capital parties are willing to commit. Market share among producers is widely distributed. Producers access end-use customers via a vast array of large diameter, high pressure interstate pipelines. These pipelines are generally owned and operated as stand-alone pipeline companies. The pipeline owners sell transportation rights (capacity) and transport gas from receipt points to downstream delivery points. Some pipeline companies also operate associated storage fields and provide storage capacity as well. Interstate pipeline rates and terms of service are regulated by the Federal Energy Regulatory Commission (FERC). As to the physical contract structure between parties, many parties prefer to use a standard form contract developed by NAESB (North American Energy Standards Board). By contrast, the structure of financial contracts is often governed by the ISDA (International Swaps and Derivatives Association) standard structure.

Besides approving a pipeline's rates and services, FERC also has jurisdiction over requests to build interstate pipelines. Pipelines that do not cross state boundaries (i.e., are intrastate in nature) generally fall under the jurisdiction of the local state public utilities commission. As a result, FERC's decisions have more influence on the development of a national gas market.

Any customer may purchase pipeline capacity, subject to being creditworthy. The delivery points might be to a local gas distribution company (LDC) for redelivery to LDC customers such as residences and commercial businesses, industrial customers or natural gas burning electric gener-

In the US, gas producers access end-use customers via a vast network – a pipeline control centre in Houston.

ation power plants. Generally, industrial and natural gas electric generation customers purchase their own natural gas supplies, while LDCs obtain supplies for commercial and residential customers and are regulated at the state level. By rule, pipeline companies are not directly involved in the commodity segment of the natural gas business, just transportation and storage.

Another factor affecting natural gas development is the natural gas liquids market. To some extent, producers can assess the relative economic value of treating and removing for sale the heavier hydrocarbons instead of leaving them in the natural gas stream. This affects the quantity of energy contained in the natural gas delivered downstream to end use customers and can affect the gas quality. Generally, pipelines and their customers have found ways to address changing gas quality but some issues remain, often dependent on local circumstances and the historical gas quality of the particular geographic area.

LNG is playing a growing role in the US although recent reductions in natural gas prices have resulted in lower imports in 2008 and 2009. There are currently nine operational receiving terminals with plans for several more (*see Table 4*) as well as one export facility (Kenai, Alaska). LNG comprised about 2% of total US consumption in 2008 and about 9% of total imports. Two different federal agencies have permitting authority over terminals (FERC and the US Coast Guard), depending on whether the project is located onshore or offshore.

The price of natural gas is not controlled by regulation but is determined in the open market place, with physical and financial alternatives available. The market is characterised by high liquidity, that is, a number of trading points where buyers and sellers can ascertain market prices in a transparent manner, with publishers issuing reports on pricing activity within 24 hours. Terms of sales can be anywhere from a day or less to a year or more.

US LNG RECEIVING TERMINALS

Name	*Location*	*Capacity (bcf/d)*
Everett	Boston, Massachusetts	1.0
Cove Point	Cove Point, Maryland	1.8
Elba Island	Elba Island, Georgia	1.2
Lake Charles	Lake Charles, Louisiana	2.1
Gulf Gateway Energy Bridge	Offshore, Louisiana	0.5
Northeast Gateway	Offshore, Massachusetts	0.8
Sabine Pass	Cameron Parish, Louisiana	2.6
Freeport	Freeport, Texas	1.5
Cameron	Hackberry, Louisiana	1.5

Source: Federal Energy Regulatory Commission.

ABOVE
Table 4.

Canada

The Canadian market, similar to the US market, has also evolved to what could be termed a liberalised or decentralised level.

As with the US, exploration and production is open to all interested parties with numerous producers active in both the US and Canadian E&P business. Pipelines are operated as open access transportation companies, separate from the E&P business. Canada has fewer large diameter pipelines than the US, but sufficient capacity to move gas from the production basins, largely in western Canada, to eastern Canada and to the US. In Canada, the government controls much of the land on which drilling can occur, and receives royalty payments tied to production.

LDCs in Canada function similarly to those in the US, with emphasis on procurement and delivery of supply for commercial and residential customers. They may also serve industrial and natural gas-fired electric generation load.

Canada's first LNG import terminal at St John received its first cargo in June 2009 and another is planned (*see Table 5*).

The best of both worlds.

By ROSEN Europe Inspection Technologies

highly accurate detection of metal loss and pipeline wall features with a single inspection tool combining Magnetic Flux Leakage (MFL) and Ultrasonic Testing (UT)

Introduction

Though an important technology used to detect many different types of defects in pipelines, Magnetic Flux Leakage (MFL) is not the ideal method for identifying certain geometries, notably large uniformly corroded areas and two-dimensional mid-wall discontinuities such as laminations. Similarly, Ultrasonic Testing (UT) tends not to reveal small corrosion pits and internal defects covered by wax and other deposits. In response to these limitations, ROSEN Inspection Technologies has developed RoCorr·UT (*see Figure 1*), a new Combo tool in which the two inspection methods ideally complement each other.

Integrating different inspection methods

In the presence of internal or external metal loss, the magnetic flux created as part of the MFL method "leaks" out of the pipeline. Since this leakage is recorded by hall-effect sensors, the location of defects as well as the depth, length and width of the recorded metal loss can be accurately inferred. MFL technology is especially suitable for detecting even very small pitting defects. This strength of MFL technology is at the same time the weakness of the UT inspection method which cannot, as a general rule, detect anomalies smaller than 10-20mm.

The strength of the UT method is direct measurement of two-dimensional features, notably pipe wall thickness. Taking into account relevant factors such as the velocity of ultrasound in the coupling fluid and in the pipe wall, UT inspections measure the time of flight of ultrasonic signals reflected from the internal and external surfaces of the pipe wall as a basis for determining both metal loss and wall thickness.

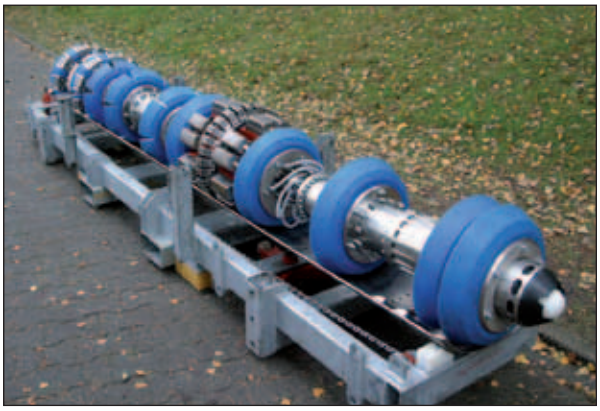


Figure 1: The new RoCorr·UT tool consists of an MFL and a UT unit and is available in sizes ranging from 6 to 40".

Capable of compensating for the weaknesses of each technology used on its own, the combination of MFL and UT provides highest accuracy in length, depth and width measurements for exact defect shapes and precise information on general wall thinning. The detailed defect shapes provided not only result in improved defect classification which in turn translates into fewer false alarms, but they also enable sophisticated asset profiles for RSTRENG (Remaining Strength of Corroded Pipe) and other assessment methods. Inspection tools combining both methods furthermore show excellent detection performance for numerous metal loss flaws (e.g. pitting, axial grooving, circumferential grooving), mid-wall features (e.g. lamination, inclusions, blisters), weld features (e.g. girth welds, longitudinal welds, spiral welds), geometry features (e.g. dents, ovalities, misalignments), and other features (e.g. valves, fittings, bends). Last but not least, the RoCorr·UT tool combining MFL and UT can be used in both liquid and gas pipelines and achieves exceptionally high probability of detection (POD) and probability of identification (POI) rates.

Conclusion

Amalgamating the advantages of the two non-destructive testing methods Magnetic Flux Leakage and Ultrasonic Testing, ROSEN's new RoCorr·UT combo tool is capable of traversing pipelines between 6 and 56", negotiating a minimum bend radius of 1.5 D, and conducting uninterrupted inspections of up to 300 km. As shown during numerous runs, the integrated tool detects common defects such as corrosion pitting and irregular general corrosion, accurately sizes large uniformly corroded areas and laminations, and even measures pipeline wall thickness to an accuracy of ± 1mm. RoCorr·UT therefore not only makes an invaluable contribution to integrity management, but also significantly reduces both inspection costs and operational risk, since all data is gathered in a single run.

INNOVATION.

In its quest for ideal solutions for the oil and gas industry, ROSEN designs, develops and manufactures its inspection instruments in-house.

www.roseninspection.net

EMPOWERED BY TECHNOLOGY ROSEN

RIGHT
Table 5.

CANADIAN LNG RECEIVING TERMINALS

Name	*Location*	*Capacity (bcf/d)*	*Consortium*
Canaport (operational)	St John, New Brunswick	1	Irving Oil/Repsol
CacounaEnergy (planned)	Rivière-du-Loup, Québec	0.5	TransCanada/PetroCanada

Source: Federal Energy Regulatory Commission.

The liquids market plays a large role in the Canadian natural gas business with liquids projects often as important, if not more important, to developers than a single focus on extraction of natural gas.

At the federal level, the National Energy Board (NEB) serves as the FERC equivalent and regulates the inter-provincial pipelines. What characterises both the US and Canadian market is a stable regulatory environment in which governmental and regulatory policy promotes transparent, non-discriminatory market participation and environmental protection. Infrastructure investment is encouraged and market forces drive development. There are numerous market participants, with commercial relationships developed over years.

The commodity market, like the US, is deregulated, with natural gas commodity prices a function of an open market. Canadian suppliers also tend to utilise similar contractual arrangements as in the US.

Mexico

The Mexican natural gas industry has evolved much differently than in the US and Canada. Until 1995, virtually the entire Mexican natural gas industry was exclusively controlled by the federal government, including pricing. Today, exploration, production and processing remains closed to

Canaport, Canada's first LNG receiving terminal, started up in June 2009.

Nature invented skin

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A smart, flexible and economical solution

In natural gas transport and liquified gas transmission systems certain pipes require special protection. In order to fulfil these requirements in an economically effective and durable way, a new and flexible protection system has been introduced on the gas market by Dutch specialists.

Over 30 years of experience in research, engineering and development of glass fibre reinforced products laid the foundation of *Blue Jetty*, a unique system of top quality pipe protection.
The system protects pipes:

- for *insulation* of hot or cryogenic transmission systems (LNG),
- *mechanically* for horizontal directional drilling (HDD),
- or for the *prevention* of *corrosion* (CP).

Mill applied GRP and GRE

The principle of this new pipe protection system, named *Blue Jetty*, is smart.
A spray winding machine moves gradually alongside a rotating pipe to apply one or more layers of glass reinforced composites homogeneously on to the pipe.
The various combinations of glass fibre, resins and special fillers determine, together with the thickness of the applied layers, the technical properties of the mechanical, insulation or anti corrosion protection.

The *Blue Jetty* GRP/GRE system guarantees a constantly superb quality of the required protection properties.

Cryogenic applications demand a high fire retardancy and thermal performance. The GRP protection layers applied by the *Blue Jetty* are highly recommended for temperatures down to –165°C (–265°F).

Mobility

The *Blue Jetty* is a mobile unit, i.e. the machine is transported by container and can easily be installed on locations around the world, where skilled specialists operate the machine.

The unit can protect pipes with a diameter up to 56", a length of 20 meter and a weight of 20 ton.

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private investment, in accordance with the federal constitution, with the federal agency, PEMEX, the only entity allowed to own the resources. Revenues received by PEMEX are mainly used to support the federal government budget.

Pricing policy varies. Natural gas is generally priced in the US open market using a few Texas indices such as Houston Ship Channel, Texas Eastern STX or Tennessee Zone 0, while prices for other hydrocarbons such as gasoline, diesel and LPG and electricity are under government control. This variation in pricing policy creates a distortion in customer consumption behaviour and imposes an obstacle to a higher degree of integration with Mexico's neighbours.

The primary focus of service has been self consumption in PEMEX for the oil industry accounting for more than 40% of the total volume. Second in importance is power generation with around 35% followed by the industrial sector, with these last two sectors being the primary driver for developing the transmission and distribution network.

LDCs mainly serve the residential and commercial sectors, and LDCs are usually owned by multinational European and US corporations. However, service to the residential and commercial sectors is not as widespread as it could be, as local municipalities have sometimes opposed the expansion of natural gas due to pre-existing support for LPG. As a result, competition between natural gas and other hydrocarbon products is not fully developed.

Natural gas transportation and storage are open to private investment but do not provide a clear open access schema, as US and Canadian pipelines do. Both activities are regulated by the Comisión Reguladora de Energía (CRE), the Mexican federal equivalent of the US FERC and the Canadian NEB. A large diameter, high pressure pipeline system is partially developed on a localised basis with a combination of both privately sponsored projects and government sponsored projects, but there is not a long-term planned national transmission system.

LNG has been encouraged in Mexico, particularly by the Comisión Federal de Electricidad (CFE) to support natural gas-fired electric power generation, with two operational projects (Altamira and Costa Azul), one approved project under construction (Manzanillo) and other projects under study, such as Puerto Libertad and Lazaro Cardenas (see *Table 6*). Several other sites have been identified for potential development. The main reason for this development for a producer country such as Mexico is the lack of supply and transportation capacity, a reflection of constitutional restrictions permitting only PEMEX, and no private companies, to invest in E&P.

The liquids market is only marginally developed but has the potential to grow substantially.

BELOW
Table 6.

MEXICAN LNG RECEIVING TERMINALS

Name	*Location*	*Capacity (bcf/d)*
Terminal de LNG de Altamira	Altamira	0.75
Energía Costa Azul	Ensenada	1
Terminal KMS de GNL (due for 2011 completion)	Manzanillo	1
Puerto Libertad	Under study	NA
Lazaro Cardenas	Under study	NA

Source: Natural Gas Market Outlook 2008-2017, SENER (Ministry of Energy, Mexico).

Conclusions

The US and Canada enjoy the benefits of virtually full integration between the two countries with positive effects on flexibility, availability and network development. There are numerous physical interconnections that allow the movement of natural gas in either direction between the countries. Governmental regulation is similar in both countries with the general goal being the prudent development of the natural resource for the benefit of all consumer segments: residential, commercial, industrial and power generation. Further, natural gas prices are established in the marketplace; they are not government regulated. A national trans-

cleaner-burning natural gas goes a long way. our technology makes it go even further.

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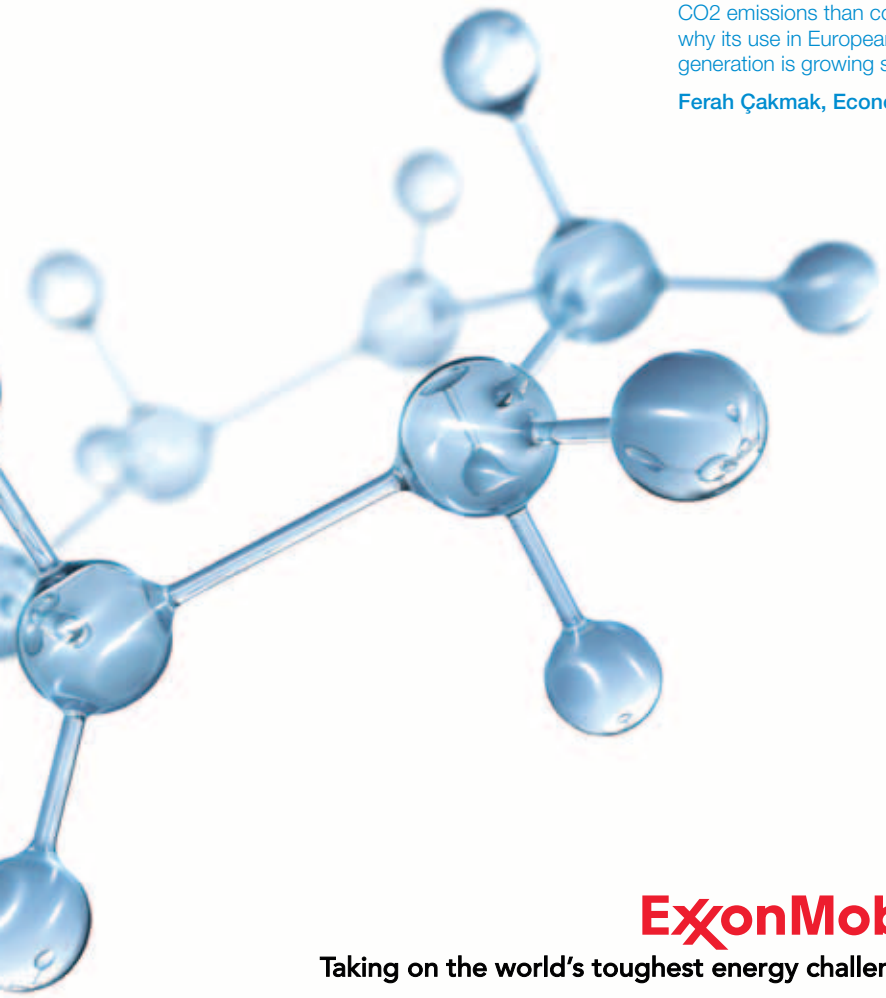

"Natural gas produces a lot less CO_2 emissions than coal. That's why its use in European power generation is growing so rapidly."

Ferah Çakmak, Economist

ExxonMobil

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portation grid exists, with transportation companies moving natural gas from producing areas to areas of consumption.

Mexican consumers could benefit from further evolution along the lines of the US and Canadian experiences. Currently, one of the strongest limiting factors in the growth of the Mexican market is the restriction on development, with E&P controlled by the government and indirectly by PEMEX's restrictions.

A related obstacle is that natural gas production is seen as a tool to support other objectives of the federal government, not as a natural resource that is evaluated and managed on its own merits in the context of a North American market place.

If the Mexican government were to follow the US and Canadian models, the government would place more emphasis on infrastructure development, both domestically and cross border, welcome privately funded E&P and free PEMEX of the obligation to support the budget; instead it would invest. Such investment could lead to more opportunities to serve customers currently without access to natural gas. Moreover, the government would remove itself from setting natural gas prices and instead recognise the efficiency of the existing open market in the US and Canada.

Mexico can also look to Europe for additional guidance as to how central governments can gradually move to embrace and support open markets. European governments endorse the concept of multiple suppliers, and while many purchasers still desire long-term contracts for supply security, there is growing latitude in contractual terms concerning prices and delivery/purchase obligations. Often, prices paid for natural gas are linked in some manner to the price of oil. By contrast, Asian markets, and in particular Japan, have evolved somewhat differently. Asia imports most of its natural gas as LNG, and without its own domestic production or physical pipeline access to other countries with domestic production, places great emphasis on supply security, tending to favour long-term contracts with less ability to accept flexible contractual delivery terms.

Mexico is in the enviable position of having substantial undeveloped natural gas resources. It can choose to more efficiently further develop these resources in an environmentally responsible manner for the ultimate betterment of all its citizens. To achieve the maximum benefit, the Mexican government needs to substantially reduce its control over natural gas and allow private investment. By recognising the benefits of partnering with private enterprise, the Mexican government can become a far more significant and effective participant in the North American natural gas market place, and at the same time, better meet the needs of its citizens.

In closing, here are key action steps Mexico needs to take now, in order to more fully integrate itself into the North American market:

- For contracting purposes, indicate support for use of the NAESB and ISDA contract structures;
- Reduce PEMEX's obligation to support the federal budget;
- Open E&P to all interested parties; and
- Improve coordination between regulators to develop joint energy policies.

If Mexico follows the steps mentioned above, the North American natural gas market would be strengthened by integrating all three countries instead of just two. Accomplishing such integration will require a major effort of coordination between Mexican energy authorities, the Secretaría de Energía (SENER) and CRE, and their counterparts in the US and Canada.

Fortunately, Mexico has begun to take steps to further open its gas industry. President Felipe Calderón approved new energy reforms in April 2008 which focused on greater autonomy for PEMEX. Although the reforms do not achieve full autonomy for PEMEX, it is a first step and could help other institutions (CRE, PEMEX, CFE and SENER) increase the degree of integration. This would allow Mexico to enjoy more of the benefits of a multinational integrated market, including greater market flexibility and security of supply.

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The Trans-ASEAN Gas Pipeline – Accelerating Gas Market Integration within the ASEAN Region

This is the second of the case studies by the Task Force looking at Gas Market Integration to be presented in this issue of the IGU Magazine.

To formalise the spirit of cooperation among the countries within South East Asia, the Association of South East Asian Nations (ASEAN) was established on August 8, 1967 in Bangkok by the five original Member Countries, namely, Indonesia, Malaysia, Philippines, Singapore and Thailand. Brunei Darussalam joined on January 8, 1984, Vietnam on July 28, 1995, Lao PDR and Myanmar on July 23, 1997, and Cambodia on April 30, 1999.

The objectives of ASEAN, as per the ASEAN Declaration, state the aims and purposes of the Association as being to:

- Accelerate economic growth, social progress and cultural development in the region; and
- Promote regional peace and stability through abiding respect for justice and the rule of law in the relationship among countries in the region and adherence to the principles of the United Nations Charter.

On December 15, 1997, at the 2nd ASEAN Informal Summit held in Kuala Lumpur, Malaysia, the ASEAN Heads of State adopted the ASEAN Vision, which amongst other issues, called for cooperation to "establish inter-connecting arrangements for electricity and natural gas within ASEAN through the ASEAN Power Grid and Trans-ASEAN Gas Pipeline". The objective was to enhance security of energy supply for ASEAN while forging greater economic cooperation amongst Member Countries.

The Heads of ASEAN Power Utilities and Authorities (HAPUA) were entrusted to lead the ASEAN Power Grid while the ASEAN Council on Petroleum (ASCOPE) was entrusted to spearhead the Trans-ASEAN Gas Pipeline (TAGP). These two major initiatives constitute the Trans-ASEAN Energy Network.

The ASEAN Vision 2020, adopted by the ASEAN leaders on the Association's 30th anniversary, also agreed on a shared vision of ASEAN as an assembly of South East Asian nations, outward looking, living in peace, stability and prosperity, bonded together in partnership in dynamic development and in a community of caring societies.

ASEAN Member Countries have adopted the following fundamental principles in their relations

An ASCOPE delegation visited the ASCOPE Gas Centre in Bangi, Malaysia, in November 2008.

with one another, as contained in the Treaty of Amity and Cooperation in South East Asia (TAC):

- Mutual respect for the independence, sovereignty, equality, territorial integrity and national identity of all nations;
- The right of every state to lead its national existence free from external interference, subversion or coercion;
- Non-interference in the internal affairs of one another;
- Settlement of differences or disputes by peaceful manner;

Renunciation of the threat or use of force; and
Effective cooperation among themselves.

As of 2008, the ASEAN region has a population of about 580 million, a total area of 4.44 million square kilometres, a combined GDP of approximately $1500 billion and a total trade of about $1700 billion.

ASEAN Council on Petroleum

The ASEAN Council on Petroleum (ASCOPE) was established on October 15, 1975, as an "instrument for regional cooperation among Member Countries of ASEAN". Member Countries are represented in ASCOPE by their respective National Oil Companies (NOCs) or, in cases where the country does not have an NOC, by the authority in charge of petroleum matters (*see Table 1 and Figure 1*).

In 1999, ASCOPE's Vision, based on its initial objectives of establishment was agreed upon as follows: "ASCOPE shall be globally competitive in an open international market by creating and facilitating synergistic business opportunities while actively engaging in the petroleum and petroleum related business."

As stipulated in the ASCOPE Declaration, the Council's Objectives shall be to:

- Promote active collaboration and mutual assistance in the development of the petroleum resources in the region through joint endeavours in the spirit of equality and partnership;
- Collaborate in the efficient utilisation of petroleum;
- Provide assistance to each other in the form of training, the use of research facilities and services in all phases of the petroleum industry;
- Facilitate the exchange of information which will promote methodologies leading to successful achievements in the petroleum industry and which may help in formulating policies within the industry;
- Conduct petroleum conferences on a periodical basis; and
- Maintain close and beneficial cooperation with existing international and regional organisations with similar aims and purposes.

MEMBERS OF ASCOPE

Founding members
Pertamina for Indonesia
Petronas for Malaysia
Philippine National Oil Company (PNOC)
Singapore (later Singapore Petroleum Co. Ltd)
Thailand (later Petroleum Authority of Thailand)
Other members
For Brunei Darussalam, the Petroleum Unit of the Prime Minister's Department joined in 1985. It was later replaced by PetroleumBrunei
PetroVietnam joined on November 5, 1996
Myanmar Oil and Gas Enterprise (MOGE) joined on February 14, 2001
The Cambodian National Petroleum Authority (CNPA) also joined on February 14, 2001
The Ministry of Energy and Mines for Lao PDR became the 10th member in 2006

LEFT
Table 1.

Trans-ASEAN Gas Pipeline

The Trans-ASEAN Gas Pipeline (TAGP) project is an ASEAN project based on the ASEAN Vision 2020.

The 17th ASEAN Ministers of Energy meeting in Bangkok, Thailand in 1999 requested ASCOPE

to undertake the TAGP project. The conceptual TAGP masterplan was completed in 2000 and the ASEAN Memorandum of Understanding (MoU) on the TAGP project was signed by all the ASEAN Ministers of Energy on July 5, 2002 in Bali, Indonesia. In June 2004, the MoU came into force.

Various bilateral agreements have been signed between Petronas of Malaysia and Pertamina of Indonesia, between Singapore and Malaysia and between Singapore and Indonesia on the sale and purchase of gas. New initiatives to implement the MoU, such as the ASCOPE Gas Centre in Malaysia and the establishment of the ASEAN Gas Consultative Council, have been put in place.

With strong political will and support from the ASEAN Ministers of Energy and the cooperation of the ASEAN senior energy officials, the TAGP project is being pursued collectively.

Activities undertaken by TAGP Task Force

Since its formation in 1999, the TAGP Task Force has completed various activities to facilitate the realisation of the TAGP.

To ensure smooth implementation of the above activities, several Expert Working Groups (EWGs) were established under the TAGP Task Force. The EWGs were assigned to cover the main issues and challenges in implementing the TAGP and their activities include the following:

- Formulating a conceptual masterplan for the TAGP infrastructure project;
- Facilitating the completion of a conceptual project feasibility study;
- Identifying and addressing issues relating to institutional, legal, financial/commercial, health, safety and environmental, technical and management matters; and
- Facilitating the execution and realisation of the TAGP infrastructure project.

Key achievements of the TAGP Task Force

The key activities undertaken and completed by the TAGP Task Force are as follows:

- Completion of the conceptual masterplan study for the TAGP project in 2000, which was approved by the ASCOPE Council in 2001. The masterplan identified seven new possible gas pipeline inter-connections in ASEAN and it served as a useful guide in the long-term development of the Trans-ASEAN Energy Network;
- Formation of the ASEAN Gas Consultative Council (AGCC) in July 2003. AGCC was created comprising representatives from the ASEAN governments/authorities and ASCOPE to address cross-border issues relating to gas market integration and to facilitate the implementation of the TAGP project;
- Formulation and finalisation of the ASEAN MoU on the TAGP in June 2004. The MoU provides a broad framework for the ASEAN Member Countries to cooperate towards the realisation of the TAGP project to help ensure greater regional energy security;
- Establishment of the ASCOPE Gas Centre (AGC) in Malaysia that serves as the strategic, technical and commercial information resource and capacity building centre in facilitating the implementation of the TAGP project; and
- Completion of the model TAGP Gas Sale and Purchase Agreement and the Gas Transportation Agreement.

The TAGP Task Force's on-going activities include the following:

- Creation of the Joint Venture Company (JVC); and
- Conducting discussions on "Unaccounted-for Gas Guideline", "Emergency Pipeline Repair" and "Corrosion Management".

Progress of the TAGP infrastructure

The existing and planned cross-border gas pipeline inter-connections in ASEAN are shown in *Figure 2*.

The first cross-border gas pipeline inter-connection was built in 1991 between Malaysia and Singapore. Achievements from 1999-2006 were:

- 1999 – a 470-kilometre cross-border pipeline

ORGANISATIONAL STRUCTURE OF ASCOPE

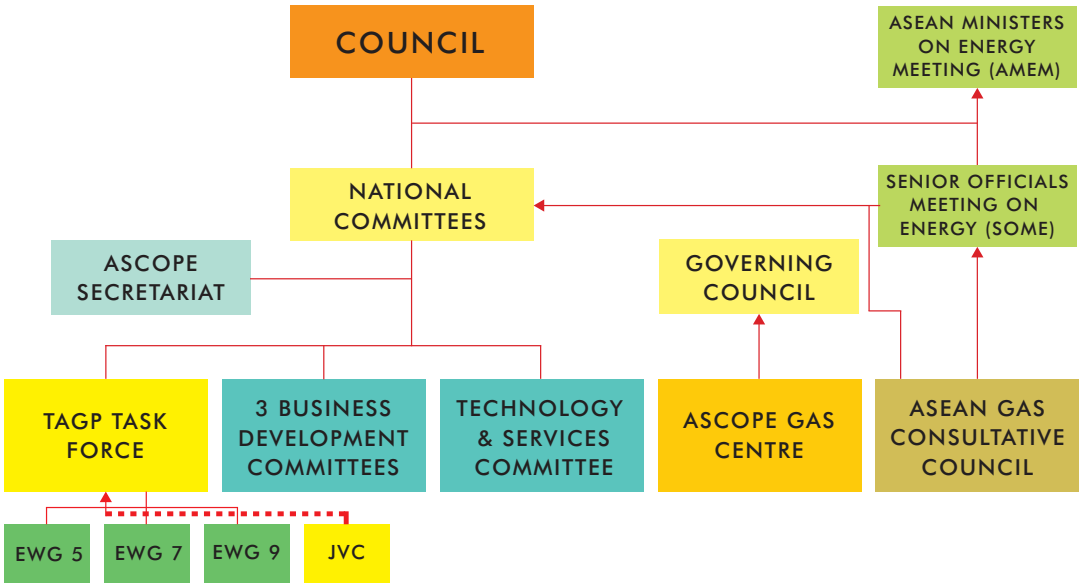

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Figure 1.

CROSS-BORDER GAS PIPELINE INTER-CONNECTIONS IN ASEAN

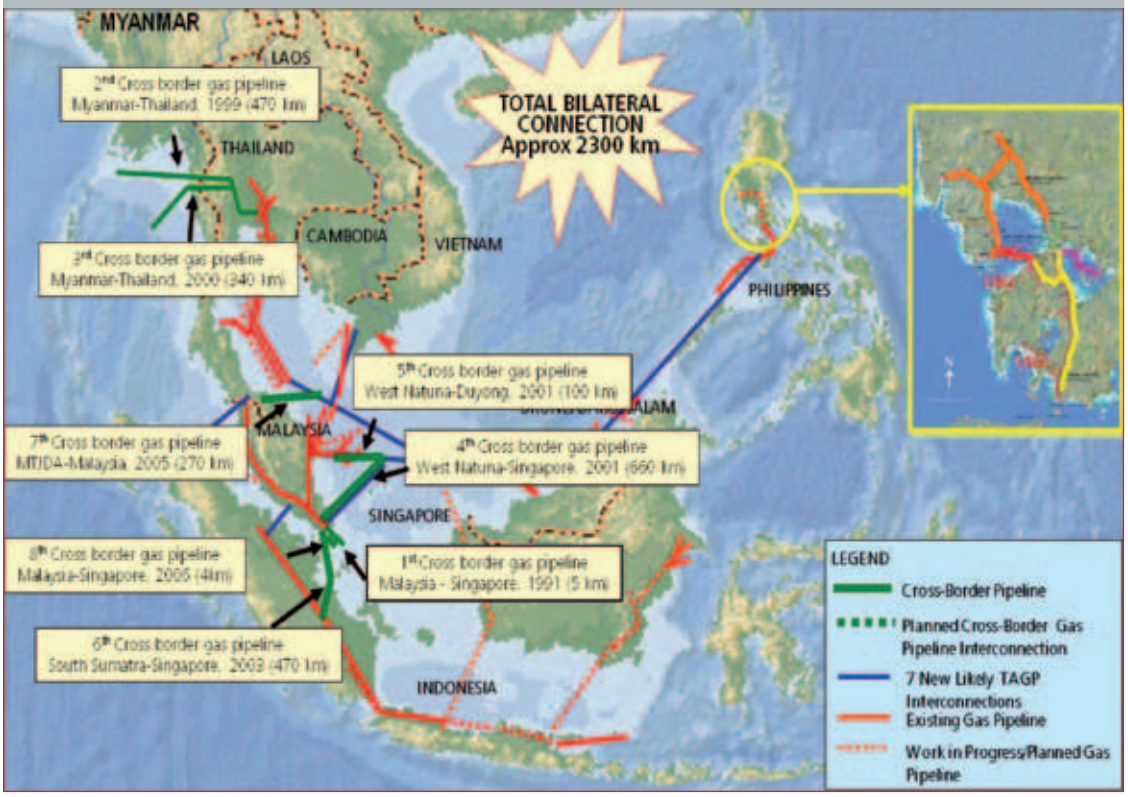

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Figure 2.

Indonesia is ASEAN's biggest producer and consumer of gas – its West Natuna gas field supplies Singapore via a pipeline opened in 2001.

from Yadana, Myanmar to Ratchaburi, Thailand;

- 2000 – a 340-kilometre cross-border pipeline from Yetagun, Myanmar to Ratchaburi, Thailand;
- 2001 – a 660-kilometre cross-border pipeline from West Natuna, Indonesia to Singapore;
- 2001 – a 100-kilometre cross-border pipeline from West Natuna, Indonesia to the Duyong field of Peninsular Malaysia;
- 2003 – a 470-kilometre cross-border pipeline from South Sumatera, Indonesia to Singapore;
- 2005 – a 270-kilometre cross-border pipeline from the Malaysia-Thailand Joint Development Area to Peninsular Malaysia via Songkla; and
- 2006 – a 4-kilometre cross-border pipeline from Malaysia to Singapore.

In addition to the above, several domestic gas pipelines were completed in Vietnam and Myanmar in 2007 and 2008. New projects underway or proposed are shown in *Table 2*.

Some of the additional initiatives planned to be undertaken in the near future towards fully implementing and realising the TAGP project are updating the TAGP masterplan as well as formulating harmonised principles for gas transit, tariffs, technical specifications and taxation.

Impact of the TAGP on gas market integration in ASEAN

Currently, the TAGP is not fully integrated; but it is being undertaken on a step-by-step approach based on bilateral inter-connections, evolving towards more integrated cross-border gas pipeline inter-connections.

The TAGP infrastructures are being planned to partly address the emerging and growing supply-demand gas gaps in the region, in addition to the

planned LNG imports by countries such as Thailand and Singapore.

The impact of the TAGP on the regional gas market

The TAGP has significant impact on the gas market integration efforts in ASEAN. Generally, the TAGP has helped to enhance the overall integration between the various gas markets within the region. There are numerous benefits derived from gas market integration, as summarised below:

- Augment energy supply security and promote energy diversification to reduce dependence on oil;
- Monetise and maximise value of excess indigenous natural gas resources in the region (e.g. Myanmar and Indonesia);
- Enhance foreign income earnings for gas exporting countries (e.g. for Myanmar and Indonesia);
- Create local gas infrastructure/market and other spin-off to industrialise the economies in the region;
- Promote the use of natural gas which is a more environmental friendly fuel; and
- Promote regional cooperation to enhance energy security and reduce reliance on energy/gas import from outside ASEAN, dampening the external effect relating to energy/gas supply uncertainties and gas price volatilities.

Nevertheless, the extent of the benefits depends on the state of the economy of each country (whether it is a net gas exporter or importer) and it varies from one country to another due to country specific factors such as the energy mix, energy diversity, availability of domestic gas production, contribution of gas revenue to the nation's GDP and others.

Security of energy supply and diversity

The issue on security of energy/gas supply and diversity are more pronounced for gas importing countries. In ASEAN, the major net gas importers are Singapore and Thailand. For net gas importing countries, gas importation diversifies their energy mix. Instead of relying on one energy source such as oil or coal, these countries have access to gas as an alternative source of energy. Gas market integration via the TAGP allows gas to be imported from different supply sources that may emerge as the gas market develops.

In the case of Singapore, gas is imported from both Malaysia and Indonesia. Previously, Singapore relied on oil for its energy needs. Singapore

NEW PROJECTS

Country	*Pipelines and LNG Terminals*
Thailand	Proposed fourth Arthit to Rayong pipeline in Thailand Proposed 5 mtpa LNG terminal
Indonesia	Proposed Cirebon to Semarang pipeline and Semarang to Gresik pipeline Proposed Kalimantan to Java pipeline Proposed LNG terminal
Singapore	Proposed 3 mtpa LNG terminal
Malaysia	Proposed Sabah to Sarawak gas pipeline
Philippines	Proposed Batman 1 pipeline Proposed 1.5 mtpa LNG terminal
Vietnam	Proposed Block B to O Mon pipeline

LEFT
Table 2.

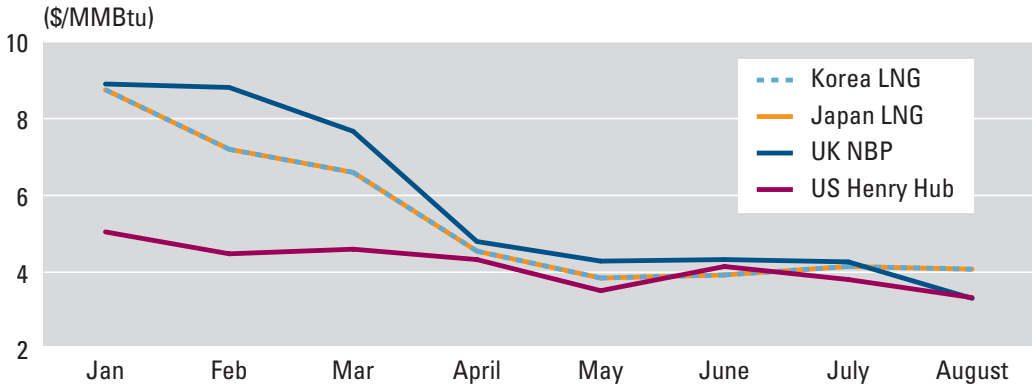
Platts has international gas markets covered

The link between geopolitics and gas has always been close: the long-term nature of the business, the distance the gas travels, and the need for transit countries all distinguish it from oil, whose ease of transport makes it a relatively short-term business. However, this year has been marked by quite extraordinary developments: starting with the January gas crisis between Ukraine and Russia – which saw some countries in southern and eastern Europe almost completely cut off from imports for a fortnight and forced to rely on limited storage or some contractual reverse flows – and followed by the signing of the intergovernmental agreement for the European Union's Nabucco pipeline project, in mid-July.

The European Union has been seeking to reduce its reliance on Russian gas for some years – Nabucco took over seven years to reach even this preliminary stage – but finding alternative sources in any serious volume has always been difficult. The Caspian region, historically and physically tied to Moscow, is torn between the desire to find other markets and the knowledge that Russia could outbid European companies trying to market gas so far away from central Asia.

Liquefied natural gas is an obvious solution, but Iran's pursuit of nuclear energy has so far ruled out this giant gas reserve holder from joining the gas exporters' community. Qatar has imposed a moratorium on further developments at its North Field. Nigeria remains riven by internal conflict, and the new big producer, Australia, is the other side of the world from the EU, and is cultivating buyers in Asia, in particular the huge growth markets of India and China.

Keeping an eye on all these developments is a full-time job. Platts, by its robust coverage of prices for gas in Asia, the US and Europe, and its authoritative market commentaries, shows the global pattern of trade, and the underlying politics, as never before.



Source: International Gas Report

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diversified its energy sources and improved energy supply security when it started to import gas from Malaysia in 1991. Singapore subsequently enhanced its energy diversity and security of supply when it imported gas from West Natuna, Indonesia, in 2001. This situation was further improved when Singapore imported gas from another source in Indonesia i.e. South Sumatra in 2003. Moving forward, Singapore is in the process of developing an LNG terminal to augment its energy security. The LNG terminal is expected to be completed in 2012 and it will definitely increase Singapore's integration with the regional and global gas markets while at the same time boosting its supply security.

For Thailand, domestic oil and gas production was insufficient to meet its fast growing demand. Hence, Thailand decided to import gas from Myanmar in 1999 to ensure availability of sufficient energy, diversifying supply sources and enhancing security of gas supply. To enhance its gas source diversity and security of gas supply, Thailand imported gas from the Malaysia Thailand Joint Development Area (MTJDA) in 2005. Moving ahead, Thailand is developing an LNG terminal with the hope of integrating its local gas market with both the regional and global gas markets and at the same time further improving its gas supply diversity and gas supply security.

Thailand is one of the biggest gas consumers in ASEAN – a gas-fired power station in Khanom.

Malaysia is the only country in the region that enjoys the benefits of both exporting and importing gas. Malaysia has been a major LNG exporter to Japan, South Korea and Taiwan and gas is also exported to Singapore via pipeline. By importing gas via pipeline from Indonesia, Malaysia is able to supplement its indigenous gas production, prolonging its indigenous gas reserve life.

Monetise excess gas resources and augment local gas infrastructure/market

For exporting countries such as Myanmar and Indonesia, one of the benefits of cross-border pipelines is to monetise the excess gas (beyond domestic requirements) and to earn foreign exchange from the exports of excess gas. The export contracts provide some level of certainty on the volumes (via an annual or monthly contract quantity) and prices (fixed, formula based or a combination of the two) for the gas being supplied to the buyer countries. This is important to ensure the long-term viability of gas production value chain, which includes upstream development and production as well as the supporting downstream infrastructure – particularly the cross-border gas pipelines. The foreign earnings received from gas exportation can be used in many ways to enhance the local economies. This is particularly true for both Myanmar and Indonesia.

In the case of Malaysia, exporting gas helped to enhance gas transmission and related infrastructure while at the same time augment the local gas market. Malaysia also enjoys foreign earnings from gas exportation and channels a substantial portion of the earnings to strengthen its gas-related infrastructure and operations.

In addition to the above, the development of a gas transmission system would encourage the development of stranded gas fields whose smaller

size may not be commercially attractive without such infrastructure. This is particularly true for gas exporting countries such as Indonesia and Malaysia.

Promote usage of cleaner fuel and regional cooperation

Through cross-border pipelines, more environmental friendly fuel is made available to the end customers within the region. Hence, over the years, gas demand within the region has been increasing steadily. To a certain extent, the availability of gas provides the ability for end customers to switch to a cleaner source of fuel. The power sector has been very responsive in capitalising on the availability of a more efficient and cleaner fuel and has emerged as the main gas user in the region.

The development of the TAGP is an initiative that requires extensive cooperation between relevant parties at all levels. Due to its strategic importance, it has been collectively recognised as a regional initiative. Hence, the implementation of the TAGP has assisted in enhancing regional cooperation particularly on regional energy security (in terms of energy availability and price) and sustainability.

In addition to the country specific benefits, the ASEAN region as a whole has benefited in terms of enhanced regional cooperation, creation of jobs, capability development and the associated economic spill-over benefits arising from the cross-border pipeline projects.

● Challenges in implementing gas market integration in ASEAN

The challenges facing efforts such as the TAGP

The main challenge in integrating the ASEAN gas markets relates to the different stages of market development within the region. Some countries are quite advanced in terms of market structure, regulation and operation, whereas some countries are lagging behind. The situation calls for the harmonisation of rules and regulatory frameworks, standards and procedures etc.

Singapore probably has the most advanced gas market in the region with a fully market-based approach. Gas markets in some countries in the region such as Cambodia and Laos are non-existent whereas other countries are between the two extremes. This situation, at times, makes market access challenging.

The different economic conditions amongst ASEAN countries results in varying levels of purchasing power and hence, gas prices and subsidies. The diversity in gas pricing structures, formulae and commercial terms affects, to a certain extent, the pace of gas market integration within the region.

One of the pre-requisites for gas market integration is the development of supporting infrastructure such as gas pipelines. The infrastructure requires substantial upfront investment which needs to be financially viable. Unlike the gas markets in Europe which are more developed and with greater economies of scale, the developing gas markets in South East Asia are relatively small and will take time to be developed into more integrated and matured gas markets. This affects the ability to secure an attractive financing package for the TAGP implementation. Additionally, the recent banking crisis and global economic slowdown make the task of securing attractive financing package even more challenging.

Availability of substantial gas reserves within the region is critical to ensure the long-term sustainability of the TAGP. In ASEAN, most of the prospective blocks in gas exporting countries such as Indonesia, Malaysia and Myanmar have been explored. Generally, recent gas discoveries within the region have been relatively remote in terms of location and smaller in size. Nonetheless, the general outlook for gas reserve addition within the region is still positive. Deep water exploration activities have just started and recent gas discoveries

In the ASEAN residential sector gas is primarily used for cooking although space heating is needed in parts of the region such as Hanoi in winter.

in deep water blocks in Malaysia and Myanmar are very encouraging. The main gas reserve in the region is the East Natuna field which is located in Indonesia. The gas field contains about 220 tcf (6.16 tcm) but it has an exceptionally high percentage of CO_2. Despite the technological challenges in handling the high percentage of CO_2, efforts to develop the East Natuna field at a gas price that is affordable and competitive to the alternative fuels such as coal or fuel oil have been initiated.

Unlike countries in temperate climates where gas usage is almost evenly distributed between the power, industrial (as feedstock or for industrial processes) and residential sectors (for space heating), in the tropical countries of ASEAN, gas is used primarily for power generation. Usage of gas by industrial users is growing but growth is quite limited for the residential sector where gas is mainly use for cooking. Within the region, space heating is generally not necessary except for cooler parts of countries in Lao PDR, Myanmar, Thailand and Vietnam. The uneven distribution of the gas customer mix to a certain extent hinders the gas demand growth, which in turn, affect the pace of gas infrastructure development.

Thus, some of the key challenges faced in implementing gas market integration efforts with ASEAN can be summarised as follows:

- Different states of the economy and gas market development within the region;
- Different levels of purchasing power and varying gas prices and subsidies in some of the countries in ASEAN;
- Project funding/financing, particularly the need to incur substantial upfront investment and to secure an attractive financing package;
- Rather limited sources of regional gas supply except for in Indonesia and Myanmar. The major gas supply source in Indonesia's East Natuna field has a high CO_2 content. The gas supply needs to be developed at a gas price that is affordable and competitive to the alternative fuels such as coal or fuel oil. Future alternatives may include coal-bed methane gas and renewables; and
- Uneven distribution of the gas customer mix affects overall gas demand growth and, hence, the pace of gas infrastructure development.

The future challenges in making the TAGP a reality

In ASEAN, most of the existing cross-border pipelines were undertaken on a bilateral basis. Hence, the next challenge would be to connect all these cross-border pipelines into an integrated system. In doing so, there are numerous issues relating to harmonisation that need to be resolved. In particular, harmonisation in terms of:

- Technical specifications on the inter-connection of gas pipelines that include gas quality;
- Specifications and standards during the development, construction and operation phases, and for maintenance procedures; and

- Cross-border issues relating to more harmonised regulations on health, safety, the environment, company formation, transit principles, open access or third party access, taxes and tariff setting.

The above issues are mainly related to integration and harmonisation efforts that require extensive cooperation of all the industry players including gas buyers and sellers, regulators, authorities and statutory bodies.

Policy options to enhance gas market integration in ASEAN

To address some of those challenges highlighted, energy policymakers and relevant authorities in ASEAN will have to examine the issues and challenges carefully with high-level energy policy responses to minimise the barriers that hinder regional gas market integration in ASEAN. Some of these policy options are highlighted below as a possible way forward to enhance gas market integration:

- Liberalising the gas market in stages to attract more gas players to compete in the market;
- Gas pricing that is market-oriented, with gradual elimination of subsidies;
- Open access or third party access to gas pipelines for common gas carriers, supporting the "gas highway concept" to attract more upstream players to explore new gas resources and utilise these infrastructure to monetise the discovered gas;
- Gas transit principles or protocol have to be put in place to enable cross-border gas pipelines to be built and to ensure smooth transportation of gas through transit countries; and
- Tax incentives and fair tariff structures that promote gas market integration.

Extensive study needs to be carried out to determine the most suitable policies as well as the potential impact of adopting them. Regardless of the eventual policies adopted, it is important to maintain a stable business environment to attract investment, maintain predictable and consistent application of policies and, at the same time, create healthy competition amongst the players to attain industry-wide operational efficiency and cost effectiveness.

Lessons learned from gas market integration efforts in ASEAN

Although the gas market in ASEAN is yet to be fully integrated, there are some lessons that can be learned from gas market integration efforts in ASEAN that can be adopted and customised in developing gas markets in other regions of the world. These include the rather unique model and positive roles performed by the governments, the NOCs or the authorities in charge of petroleum and the industry gas players and pipeline operators in ASEAN towards fully realising the aspiration to enhance regional cooperation and energy security as follows.

Role of governments

The 10 ASEAN governments have provided a very clear message and demonstrated strong political will towards establishing regional economic and energy cooperation, amongst others, recognising the importance of energy security and the need to enhance regional energy security collectively through the Trans-ASEAN Energy Network, comprising both the TAGP infrastructure and the ASEAN Power Grid.

Role of NOCs and authorities in charge of petroleum

At the industry level, the NOCs or, in cases where the country does not have an NOC, by the authority in charge of petroleum matters, were instrumental in spearheading and facilitating the aspiration of the ASEAN governments towards implementing and realising the TAGP infrastructures.

Several building blocks have been put in place besides the eight cross-border gas pipeline inter-

connections. These include obtaining the governments' support and approval to ratify the ASEAN MoU on the TAGP, and the setting up of AGC and AGCC as the appropriate institutional instruments to facilitate the implementation and realisation of the TAGP project.

Currently, both AGC and AGCC are developing appropriate guidelines to address cross-border issues relating to amongst others, the following:

- Technical specifications on the inter-connection of gas pipelines that include gas quality;
- Specification and standards during the development, construction and operation phases, and for maintenance procedures;
- Cross-border issues relating to more harmonised regulations on health, safety, the environment, company formation, transit principles, open access or third party access, taxes and tariff setting; and
- Unbundling of costs, etc.

Role of other gas industry players and pipeline operators

Pipelines are an essential part of the gas delivery system, and within the ASEAN region there are several companies that own and/or operate natural gas pipelines. Additionally, there are companies involved in the transport of oil and petroleum products that face many of the same operational issues as natural gas pipeline companies.

AGC has taken the initiative to facilitate the creation of the South East Asia Pipeline Operators Group (SEAPOG) to, amongst other factors:

- Enable participants to gain a comprehensive understanding of operational best practices employed around the region and to benchmark their practices accordingly;
- Promote discussion on pipeline incidents and safety alerts with their peers, enabling participants to exchange views and lessons learned from one another;
- Educate pipeline operators on the operational aspects of other pipelines through the sharing of experiences and knowledge; and
- Develop a database of key owners/operators in the region to enable companies to seek information (non confidential) in a timely manner and benefit from the experiences from their industry peers.

Coordination, diligence and resolve

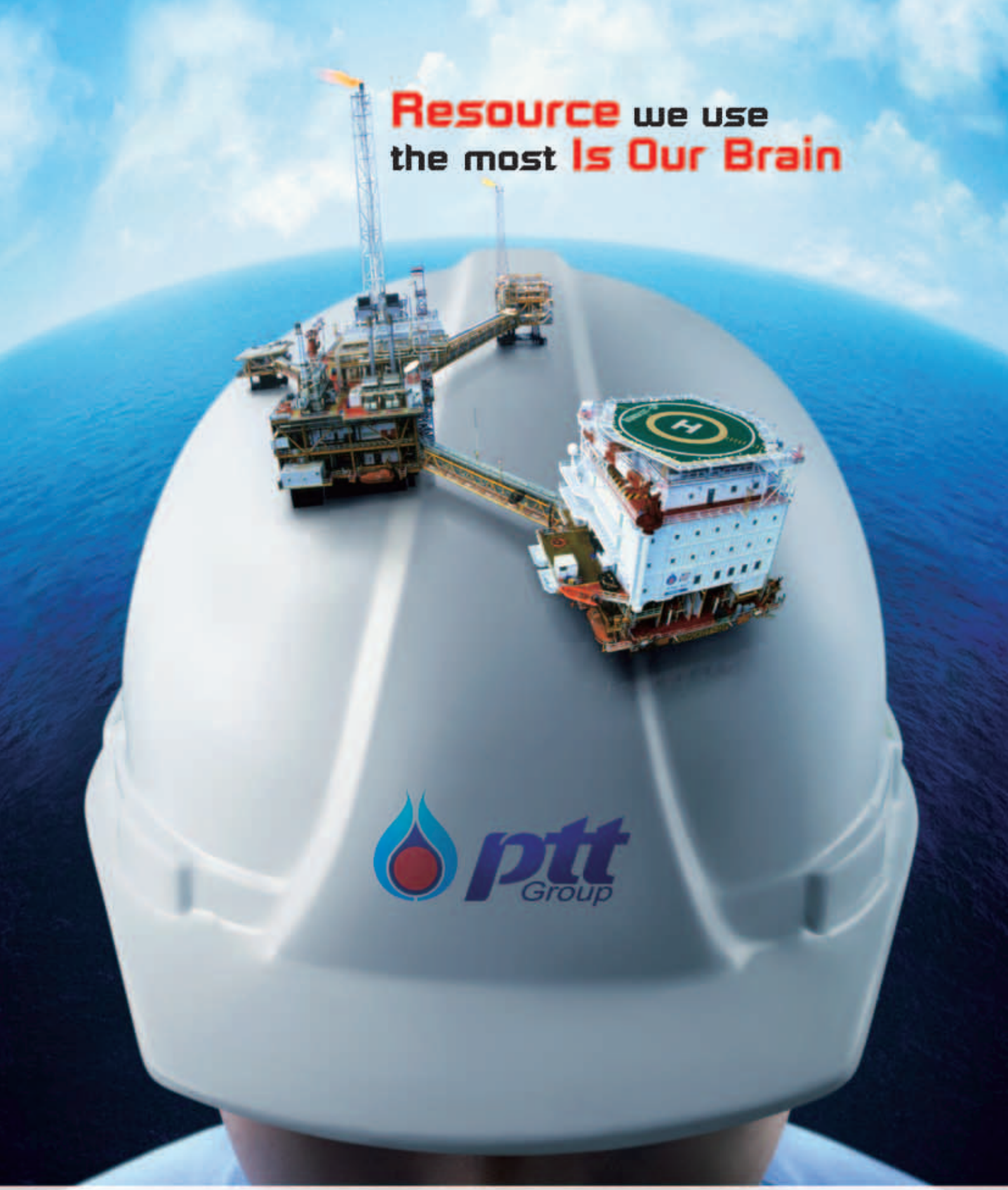
It is an accepted fact that any integration efforts require extensive communication between the relevant parties at all levels and excellent coordination. In implementing the TAGP, structured communication channels were established to ensure uninterrupted flow of clear messages so that actions are well coordinated. This is essential to minimise confusion and disruption.

Additionally, relevant industry players, regulators and authorities were engaged from the early stages of the TAGP and they continue to be extensively involved not only in formulating implementation strategies and plans but also in the actual execution of the strategies and plans.

In selecting the policies and formulating the implementation plans for the TAGP, due consideration is given to options available as well as to the potential impact of adopting such policies or plans. Once the policies and implementation plans for the TAGP have been collectively agreed upon, there is a conscious effort to ensure consistent and predictable application of policies as well as the execution of implementation plans.

Due to its strategic importance, the TAGP has been collectively recognised as a high priority regional initiative. From its inception, ASEAN Member Countries have displayed the political will and resolve not only to initiate but also to execute the TAGP implementation plans.

In summary, all the above are key ingredients that allow the TAGP to progress smoothly and can be used as guidance in integrating gas markets in other regions.



PTT Group synergizes our business operations for top class performance, ensuring minimum cost and maximum value added. Our competitiveness in the international arena is indisputably rooted in our high operational efficiency. Ultimately, our efficiency lies in our strength in directing the infinite human intelligence to best manage the bounded natural resources.

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