Developments in the Asia-Pacific LNG Trade

By Iain Esau

Next year will mark the 40th anniversary of the arrival of Asia-Pacific's first LNG cargo under an initial contract quantity of less than 1 million tonnes per annum (mtpa). Today, the region accounts for two-thirds of the worldwide LNG trade, equivalent to some 110 mtpa.

In the last few years in particular, regional LNG imports have increased dramatically due to strong demand in the long-established markets of Japan, South Korea and Taiwan, and new demand from the rapidly expanding economies of China and India. They may soon be joined by Hong Kong, Singapore and Thailand. Even Indonesia, which for years was the world's number one LNG exporter, is considering imports to its highly populated island of Java. This strong demand has driven up gas prices which have in turn made stranded gas fields, notably in Australia but also other Asia-Pacific areas, more economic to develop as LNG export schemes.

Tokyo Gas Company and Tokyo Electric Power Company started the region's LNG imports from Kenai in Alaska under a contract with Phillips and Marathon, and the first cargo arrived at the Negishi terminal in Yokohama on November 4, 1969 onboard the *Polar Alaska*. From that beginning, Japan has grown to dominate the global import business and accounted for 39% (65 mtpa) of LNG demand in 2007, followed by South Korea (15% or 25 mtpa) and Taiwan (4.8% or 8 mtpa).

India became the region's fourth LNG importer in 2004 with 2 mtpa and this rose to 7.3 mtpa in 2007. Future growth of LNG into India will depend on the product's competitiveness relative to other energy sources including oil, coal and piped gas, from both domestic and overseas sources.

China began using LNG in 2006 and imports are currently running at about 3 mtpa with expansion relying, like India, on the competitiveness of other fuels, particularly coal, piped gas and nuclear energy.

As to when Hong Kong, Singapore and Thailand will join the region's group of LNG importers will depend on demand and when current piped gas supplies are deemed insufficient to meet domestic needs based on price, remaining reserves and geopolitical risk. Singapore and Hong Kong each have plans to start taking in 3 mtpa in 2012 at the earliest while Thailand may need LNG five years later.

Most of the region's imports are based on long-term contracts although spot cargoes are becoming increasingly common, certainly in India.

Imports

China

The role of gas in meeting Chinese energy demand is fast-growing but still small compared to the importance of coal. In fact, gas use is some way below the Asia-Pacific average.

China's first LNG cargo, from Woodside Petroleum's North West Shelf (NWS) project, arrived in May 2006 at the 5 mtpa Guangdong Dapeng terminal, still the country's only operating import facility.

While a plethora of other import terminals have been proposed very few are progressing on a solid footing because much of domestic demand is still being met locally by coal, oil and piped gas. In addition, competition to secure supplies is tough and LNG prices are high so striking a deal is far from easy.

The Dapeng facility is operated by a joint venture led by China National Offshore Oil Corporation (CNOOC) and is the first of a number of terminals the corporation has planned. It has two terminals under construction, one at Fujian, designed to handle 2.6 mtpa and another in Shanghai (3 mtpa). The Fujian facility is due to start receiving gas later this year from BP's Tangguh project in eastern Indonesia under a long-term deal. The Shanghai terminal is set to start importing gas in 2009 from the Malaysia LNG consortium at initial rates of 1.1 mtpa, rising to 3 mtpa by 2012.

Asia-Pacific's first LNG cargo was delivered by the 71,500 m^3 *Polar Alaska*, which operated a shuttle service between Kenai and Yokohama with its sister ship *Arctic Tokyo*.

Another CNOOC-operated terminal, rated at 3.5 mtpa, will be sited at Zhuhai and is due online in 2010, possibly importing LNG from Iran. Other CNOOC facilities may be built at Zhejiang and Hainan with both rated at 3 mtpa.

Meanwhile, PetroChina has lined up six or so potential terminals with a combined annual capacity of at least 20 mtpa. However, so far only three have secured government approval. One project on the move is at Dalian where QatarGas is due to begin supplying 3 mtpa in 2012. PetroChina has also agreed to buy 2-3 mtpa from Woodside Petroleum for 15 to 20 years for a terminal at Rudong City, while in Tangshan City the company

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China's Guangdong Dapeng LNG terminal started operations in 2006.

is constructing a terminal that may receive 4 mtpa from Iran's Pars LNG project. PetroChina is also considering building terminals at Shenzen, Zhuhai and Beihai.

None of Sinopec's three facilities has so far secured gas feedstock, so the start of construction is some way off. One of its sites, at Zhuhai, could be online in 2012 while others have been proposed at Qingdao – a 3 mtpa facility which may be operational in 2010 – and at Tianjin. Such is Sinopec's frustration at failing to secure LNG feedstock, it has proposed taking a stake in a mooted LNG export plant in Alaska fed by gas from the North Slope.

If all projects planned to come online by 2010 do materialise then China could be importing some 35 mtpa of LNG at 12 terminals under long-term deals, supplemented by an increasing number of spot cargoes. However, due to the competitive environment in securing long-term LNG deals, the likelihood is that by 2010 only six or seven terminals will be operational, importing about 18 mtpa.

Hong Kong

Currently supplied by gas from Chinese fields and via a pipeline from CNOOC's Dapeng LNG terminal, Hong Kong expects to begin receiving LNG directly in 2012. A 3 mtpa terminal is being built by local utility CLP Holdings.

India

India's imports of LNG currently arrive at terminals in Dahej, operated by Petronet, and Hazira, which is controlled by Shell.

Dahej in Gujarat began receiving cargoes in January 2004 under a long term 5 mtpa contract with Qatar's RasGas. This terminal can handle up to 6.5 mtpa and Petronet has plans in hand to expand its capacity to 10 mtpa. Some of this

The Hazira LNG terminal in India.

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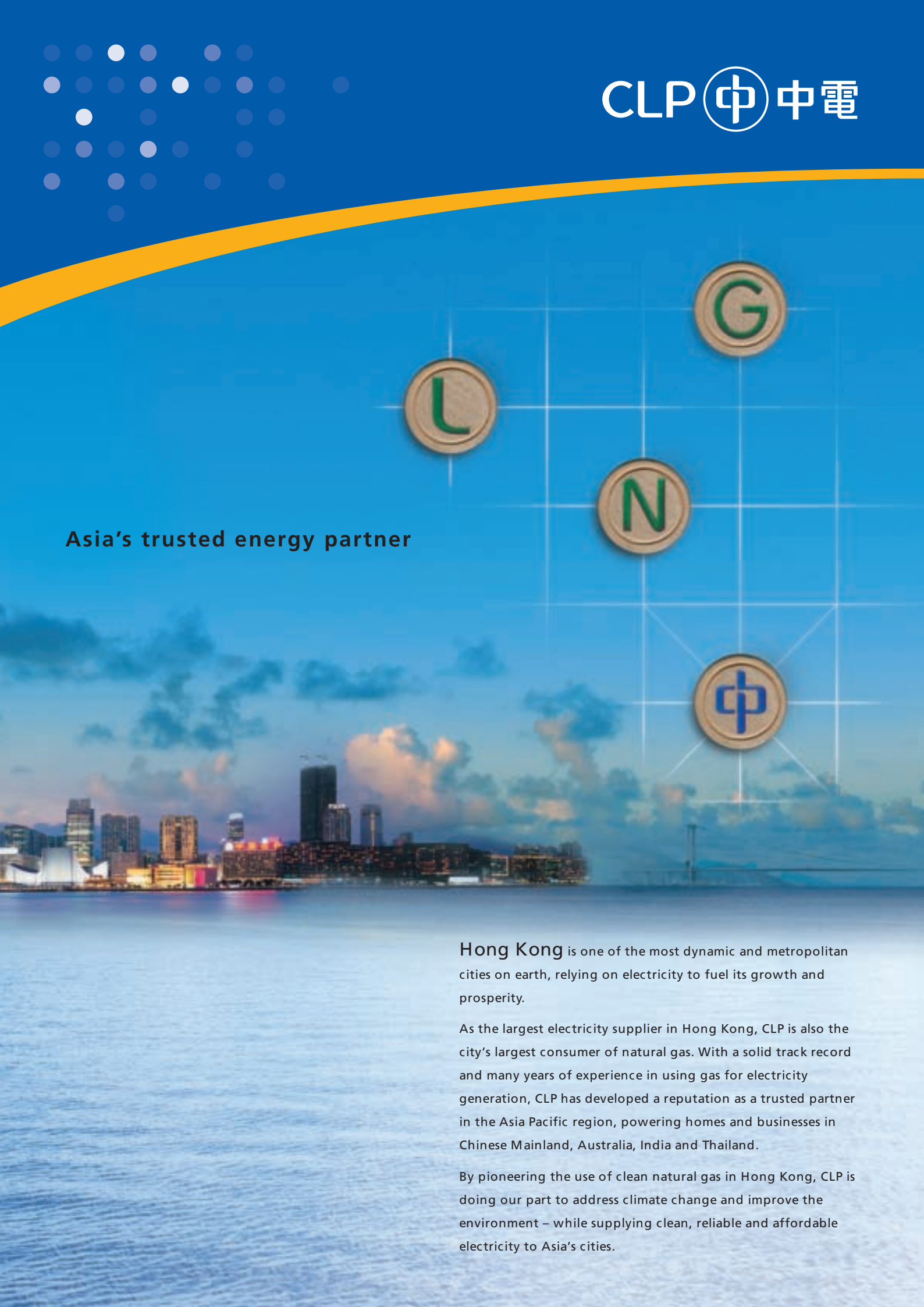

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increase will be met by boosting purchases from RasGas to 7.5 mtpa in 2009.

In 2011, Petronet aims to bring online a new terminal at Kochi in Kerala in southwest India. This facility is initially designed to handle 2.5 mtpa but its capacity could be doubled. LNG may be sourced from Australia or Papua New Guinea, among others. A 2.5 mtpa terminal is also proposed at Ennore in Tamil Nadu for which Petronet and Oil India Limited have signed a memorandum of understanding.

Petronet is a consortium of the Oil & Natural Gas Corporation (ONGC), Indian Oil Corporation, Bharat Petroleum Corporation, the Gas Authority of India Ltd (GAIL), Gaz de France, the Asian Development Bank and public shareholders.

Hazira, also in Gujarat, began operations in 2005 and to date has only accepted spot cargoes. It is currently designed to handle 3 mtpa but this may be increased to 5 mtpa if Shell can secure a long-term contract.

GAIL and the National Thermal Power Corporation are reviving the Ratnagiri terminal (formerly known as Dhabol), which could be importing up to 5 mtpa by 2010, up from its current capacity of 1.2 mtpa.

Two other potential terminals may also spring up in Gujarat, which is a good location for this type of industrial complex because it lies close to large industrial and residential consumers in Mumbai. Gujarat-based Adani Group is in talks with Gujarat State Petroleum Corporation (GSPC) about a 5 mtpa facility at Mundra, while GSPC itself is considering a terminal at Pipavav.

At Mangalore in Karnataka state, ONGC is working on plans for a 5 mtpa terminal with reports that Russia's Rosneft is interested in taking a stake. This terminal could be on line in 2011, perhaps sourced by LNG from Iran.

How much market penetration LNG achieves in India will depend on the continued success of offshore exploration (which has so far resulted in the discovery of more than 1 tcm of gas), commercialisation of India's abundant coal-bed methane (CBM) resources and the revival of the country's coal sector. Piped gas imports from Iran and Central Asia are on the agenda but these pose significant technical and geopolitical risks.

Indonesia

Once the world's largest LNG exporter, burgeoning demand in Java has led state-owned utility PLN and state-owned upstream company Pertamina to consider a 3 mtpa import terminal at Cilegon, perhaps fed by domestically produced LNG.

Japan

Japan has 28 import terminals with further facilities being considered. Its key LNG suppliers are Australia, Indonesia and Malaysia although it has a diverse array of sources including Brunei, Egypt, Oman, Qatar, Trinidad, the UAE and the US, and will soon start imports from Sakhalin Island off Russia's east coast.

Of the existing terminals, most are located on Honshu Island near the major centres of demand while the others are on Kyushu Island in the south-west. The plant owners are electric utilities (accounting for two-thirds of capacity) and gas utilities such as Tokyo Electric, involved in four facilities, Chubu Electric (three), Toho Gas (three), Osaka Gas (three) and Tokyo Gas (three). Tokyo Gas and Tokyo Electric control some 30 mtpa of capacity with Osaka Gas handling about 10 mtpa and Chubu owning about 7.5 mtpa.

New sites, some of which will be on line in 2010, include Joetsu (Chubu Electric and Tohoku Electric), Wakayama (Kansai Electric), Sakaide (Shikoku Electric), Omaezaki (Chubu Gas, Tokai Gas and Suzuyo), Kumamoto (Saibu Gas) and Nakagusuku (Okinawa Electric).

New Zealand

A proposal for a small import facility has been made by Contact Energy and Genesis Energy with Port Taranaki identified as the best location for the 0.9-1.1 mtpa terminal.

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Korea's KOGAS is boosting LNG capacity.

Philippines

Proposals have been mooted for LNG import terminals at Batangas, controlled by Philippine National Oil Company, and Mariveles, both sited on Luzon Island. However, it is not clear at this stage whether they will be firmed up.

Singapore

Singapore currently receives all its gas via pipeline from Indonesia and Malaysia but has identified a need for an LNG terminal which is due online by 2012. The project, which will initially receive about 1 mtpa, reaching 3 mtpa by 2018, will be operated by Singapore Power with BG Group supplying the gas.

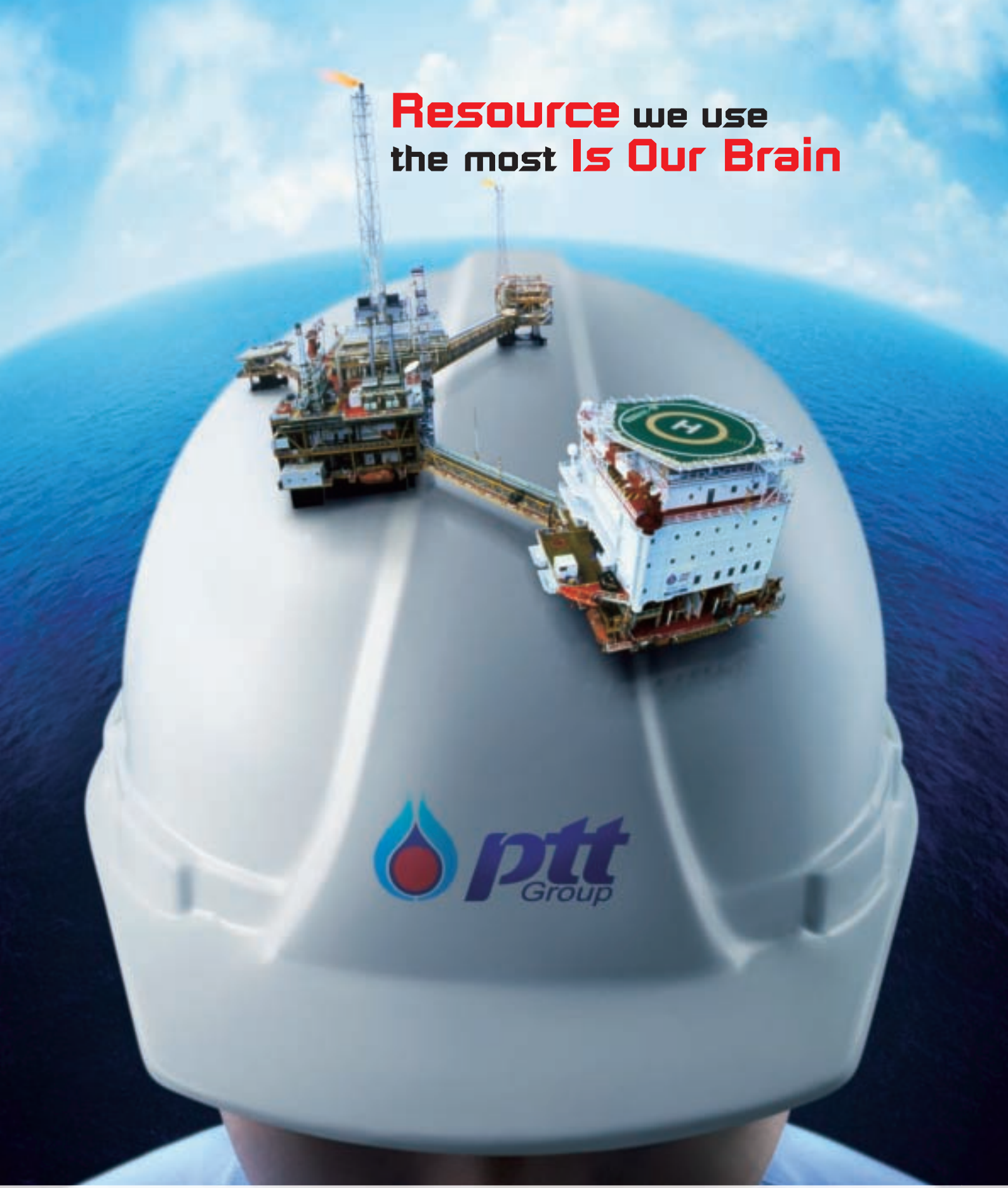
South Korea

South Korea started LNG imports in 1986 and the country's regasification facilities are found at Incheon (7.2 mtpa), Pyeongtaek (7.2 mtpa), Tongyeong (3 mtpa) and Gwangyang (1.7 mtpa), the first three operated by Korea Gas Corporation (KOGAS) and the last by POSCO.

KOGAS recently unveiled plans to increase its LNG storage capacity by 72% in the next five years to meet South Korea's growing demand for gas and to accommodate seasonal fluctuations in consumption. It plans to expand storage at Incheon, Pyeongtaek and Tongyeong and is evaluating sites for the construction of a new LNG terminal. Meanwhile, GS Caltex is considering a 1.5 mtpa unit at Gunsan.

Taiwan

Taiwan has one terminal at Yungan (7.9 mtpa) on the west coast with another under construction just to the north at Taichung (3 mtpa). Indonesia and Malaysia are the island's key LNG suppliers with both terminals owned by Chinese Petroleum Corporation.



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Sri Lanka

One terminal has been put forward and could be built at Kerawalapitaya on the west coast. The fast-track 1-3 mtpa facility could be online in 2009 or 2010, possibly fed by gas from Iran and would be partly funded by Japan.

Thailand

Thailand, which has relied heavily on its offshore domestic gas resources, has such an increasing demand for energy that PTT aims to have a 5 mtpa terminal up and running at Map Ta Phut in Rayong province by 2011. It may import LNG from Iran's Pars LNG scheme.

● Exports

Australia

Australia is becoming increasingly important as an LNG supplier in the Asia-Pacific region, driven by a plethora of major gas finds off its north and north-west coasts and its emerging CBM resources in Queensland.

The country's available export capacity could potentially hit about 50 mtpa in 2014, a huge scaling up of output from the current 15.4 mtpa, with the possibility of further increases later in the next decade. However, the timing of many projects is likely to slip due to human resource constraints and a lengthy approval process for new developments.

To date, the country's key project is Woodside Petroleum's NWS scheme, currently rated at 11.9 mtpa and which is due to add a fifth, 4.4 mtpa train in late 2008. The only other operating plant is ConocoPhillips' 3.5 mtpa Darwin facility which is fed by gas from the Bayu-Undan field.

By the end of 2010, Woodside's $12 billion Pluto project could be up and running, supplying 4.3 mtpa to the market from one train. A year later, it is likely to be joined by Chevron's 15 mtpa, three-train Gorgon scheme.

As regards the remaining projects, there is less clarity on how they will be developed and when they could come online. These include Woodside's Greater Sunrise scheme which has been held up

Australia is becoming increasingly important as an LNG supplier – the onshore processing plant at Karratha serving the NWS project.

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due to long-running negotiations between Canberra and the East Timor government over resource ownership. If approved, the plant could be producing 5 mtpa. Woodside's other major proposal is a further 15 mtpa facility called Browse which may be up and running in 2014.

Inpex's Icthys project, meanwhile, coud be online in 2013 feeding some 8 mtpa to Asian buyers. ExxonMobil's Scarborough project is currently rated at 6 mtpa while Methanol Australia's Tassie Shoal development has been earmarked to supply 3.5 mtpa. A multitude of other schemes based on offshore gas discoveries are being considered including Chevron's Wheatstone (5 mtpa), Shell's Prelude (3.5 mtpa) and BHP Billiton's Thebe. Prelude could host the world's first floating LNG project.

Four chunky LNG export schemes have also recently sprung up on Australia's east coast based on Queensland's substantial CBM resources. Santos Energy's 3 mtpa Gladstone project is furthest down the development line targeting first output in 2014, while BG Group and Queensland Gas plan a 4 mtpa development. Two other projects, of around 1 mtpa, are also being evaluated by Arrow Energy and Shell.

Bangladesh

Cairn Energy is considering development of a mini-LNG scheme if further exploration in offshore Block 16 proves successful in the coming year or so. This proposal would circumvent Dhaka's ban on piping gas to India.

Brunei

The five-train, 7.2 mtpa plant operated by the government, Shell and Mitsubishi has been up and running since 1972 with product exported to Japan and South Korea. There are no firm plans for expansion.

Burma

The military government was until recently evaluating an LNG scheme based on gas reserves in offshore blocks A1 and A3 operated by South Korea's Daewoo. However, in the end it was decided to pipe this gas to China instead.

Indonesia

Indonesia lost its position as the world's biggest LNG exporter to Qatar in 2006 due to declining production from gas fields feeding its plant in Aceh, Sumatra (Arun) and upstream delays to projects that will supply gas to its Kalimantan (Bontang) facility. Both plants are operated by state oil and gas player Pertamina. However, new production from Irian Jaya (Tangguh), the Timor Sea (Abadi), Sulawesi (Sengkang and Senoro) and possibly the Natuna Sea (Natuna-D Alpha) could all help to stem the decline.

An extra train at Bontang is also being considered although this will have to wait until Jakarta approves a major new Chevron-operated offshore gas project in the Kutei Basin. Bontang currently has eight trains with a capacity of 21.8 mtpa, but has had problems meeting its contractual gas sales to Japan and South Korea in recent years so desperately needs gas from the Kutei Basin fields to improve reliability.

At Arun, designed to handle 6.5 mtpa, output is currently about 2.5 mtpa and is likely to decline further unless major new gas discoveries are made in its vicinity.

In eastern Indonesia, BP's $6.5 billion Tangguh plant is due on stream in late 2008 or early 2009 and will be able to supply 7.6 mtpa from two trains with room to add a further six. A third train is already under serious discussion.

At Abadi, Japanese operator Inpex has filed a development plan with Jakarta targeting first production in 2015-2016. A 5 mtpa facility is being considered and it may be sited offshore or onshore.

Of the two projects being assessed in Sulawesi, the Sengkang scheme proposed by Hong Kong-based Energy World Corporation could be the first to start up: late 2009, compared to 2012 for Medco Energi's Senoro project. Sengkang would

be a phased project starting out with a capacity of 0.5 mtpa and potentially hitting 5 mtpa by about 2015. Senoro is a planned 2 mtpa scheme with output to be sold to Japan.

ExxonMobil's and Pertamina's huge but long-untapped Natuna D-Alpha field has often been touted as forming the foundation for an LNG scheme. However, the gas has a high CO_2 content and the cost implications mean that a development decision is some way off.

Malaysia

Malaysia is the world's second largest LNG producer with Petronas's Malaysia LNG project in Bintulu supplying up to 22.7 mtpa to Japanese and South Korean buyers from eight trains.

While the country has enough gas to feed further trains, Kuala Lumpur's oil and gas depletion policy is designed to prolong the benefits the country receives from its oil and gas resources instead of bringing gas discoveries onstream as quickly as possible.

Papua New Guinea

In Papua New Guinea, ExxonMobil is planning to build a 10 mtpa plant and has targeted an onstream date of 2014 based on reserves in the country's highland areas.

Outlook

These developments on the production and consumption fronts have been driven by sustained economic growth in the Asia-Pacific region. Indeed, the figures for 2007 show that the rate of growth in the Asia-Pacific LNG trade at 9.5% surpassed the global average of 7.3%. While continued high energy prices are likely to impact on economic growth in the immediate future, Asia-Pacific is clearly set to reinforce its leading position in the global LNG market.

Iain Esau is the London correspondent of the international oil and gas newspaper Upstream.

Malaysia is Asia-Pacific's largest LNG producer and number two in the world.

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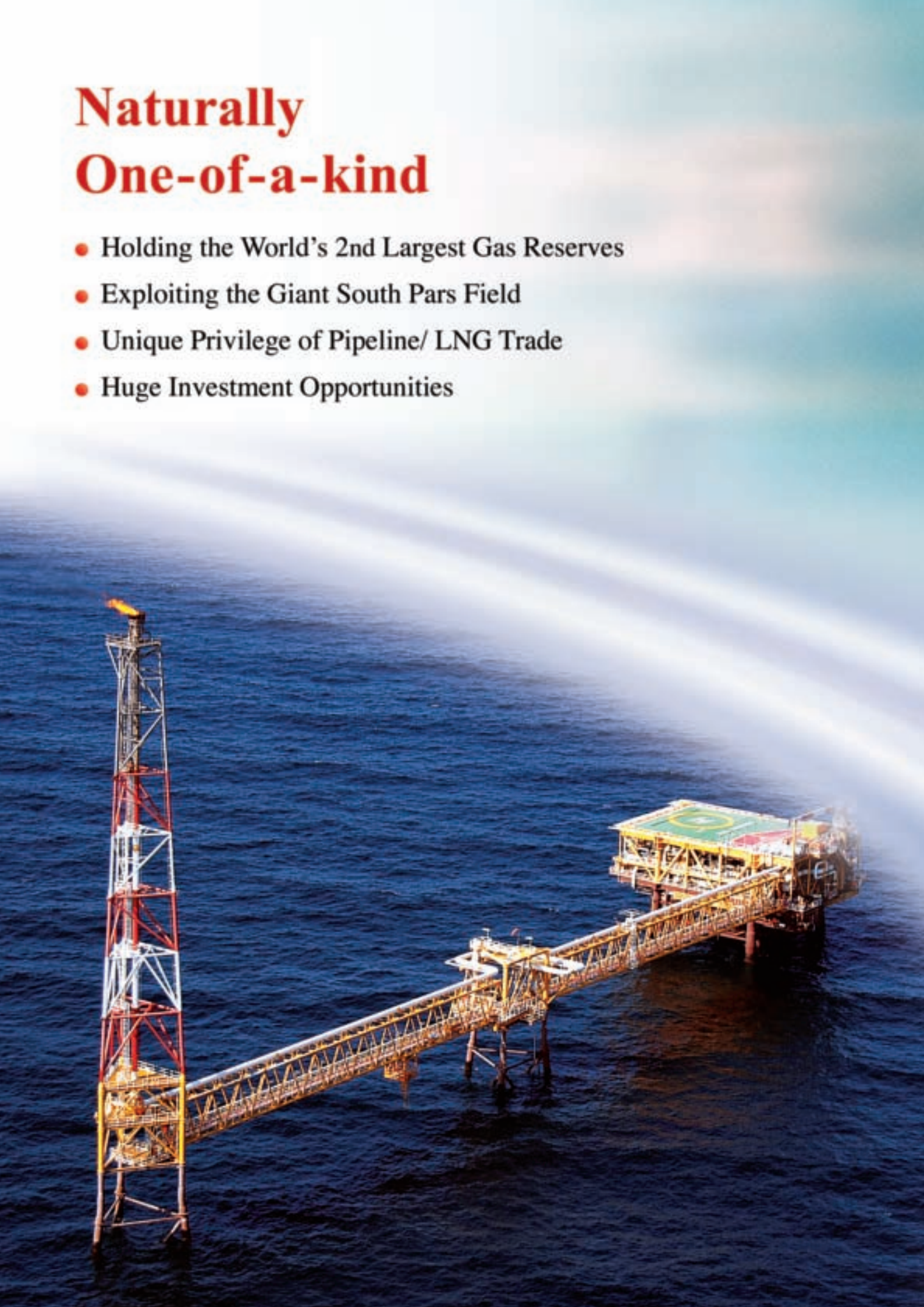

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South Pars Gas Field

South Pars gas field

South Pars/ North Dome gas field is one of the largest independent gas reservoirs in the world lying on the territorial border between Iran and the State of Qatar in the Persian Gulf. It is one of the country's main energy resources.

This gas field covers an area of 9700 square kilometers, of which 3700 square kilometers belongs to Iran. The Iranian portion is estimated to contain some 14 TCM of gas reserves and some 18 bn bl of gas condensates. This amounts to roughly 8% of the world gas reserves and approximately half of the Iran's gas reserves.

Presently, some precise and sophisticated projects have been designed for development of 24 phases to produce 800 million cubic meters of gas per day. South Pars gas field development shall meet the growing demands of natural gas, injection into oil fields, gas and condensate export as feedstock for petrochemical industries.

As a result, Assaluyeh and Tombak ports, some 270 and 220 kilometers south east of Bushehr respectively, have been selected as onshore locations for the construction of onshore installations of the phased development of this field.

Phase 1

South Pars Development Plan Phase1, developed by Petropars, came onstream in November 2004.Phase 1 involves production of 28 MMscm/d of natural gas for the domestic grid,plus 40,000-45,000 bbl/d of condensate.

Objectives :

- Producing 25 MCM /d of marketed natural gas;
- Producing 40,000bl/d of gas condensate for export;
- Producing 200,000 tons/d of Sulfur for export;
- The contract lump sum was $1 billion;
- In line with strengthening the domestic industries and in implementation of this project, the share of local players has been materialized by 65%.

Phases 2 & 3

Phases 2 and 3 of South Pars development were officially inaugurated in February 2003 and began to come onstream in March 2002. A consortium led by Total developed the project at a cost of approximately $2 billion. Currently, phases 2 and 3 are producing around 56MMscm/d of natural gas, plus 80,000 bbl/d of condensates. Twin undersea pipelines carry gas from South Pars to onshore facilities at Assaluyeh.

Objectives :

- Daily production of 50 million cubic meters of marketed natural gas;
- Daily production of 80,000 bl of gas condensate;
- Daily production of 400 tons of Sulfur;
- The lump sum of the contract is $ 2012 million; and
- The share of local players amounting to 32% has been materialized.

Gas and gas condensate are transferred from the offshore platforms to onshore refinery through a three phased flow method.

Phases 4 & 5

Phases 4 and 5, estimated to cost $2 billion, are being handled by Eni and Petropars, and involve construction of onshore treatment facilities at the port of Assaluyeh.These two phases began coming online in October 2004 and are ultimately expected to produce around 56 MMscf/d,of natural gas, 80,000-90,000 bbl/d of condensates, plus ethane, sulfur, liquefied petroleum gas (LPG).

Objectives:

- Daily production of 50 million cubic meters of marketed natural gas;
- Daily production of 80,000 bl of gas condensate;
- Annual production of 1 million tons of ethane as petrochemical plants feedstock;
- Annual production of 105,000 tons of "LPG" (propane and butane) for export;
- Daily production of 400 tons of sulfur;and
- The share of local players amounting to 42%has been materialized.

The development operation of the above mentioned phases was awarded to a consortium comprising of Eni of Italy (60%), Petropars (20%) and NICO (20%) of Iran in July 2000.The refinery came onto stream officially on April 17, 2005.

Phases 6 , 7 & 8

Phases 6 ,7 and 8, are being handled by Petropars and Norway's Statoil, which signed an agreement in October 2002. The development project for these phases has been designed to produce 104 MMscm/d of gas from the reservoir which is going through its final construction steps.

Objectives:

- Daily production of 104 MMscm of sour and dry gas;
- Daily production of 158,000 bl of gas condensate; and
- Annual production of 1.6 million tons of "LPG" (propane and butane) for export.

The sour gas produced in these phases is transferred to Aghajari oil field in Khuzestan province via a 512 kilometer pipeline to be injected into the oil wells to enhance the recovery coefficient of the field.

Phases 9 & 10

Phases 9 and 10, being developed by a consortium of OEIC and IOEC of Iran and South Korea's LG Engineering and Construction Corp are expected to supply 56 MMscm/d from the reservoir.

Objectives:

- Daily production of 50 MMscm of marketed natural gas;
- Daily production of 80,000 bl of gas condensate;
- Annual production of 1 million tons of ethane; and
- Annual production of 1.05 million tons of "LPG" (butane and propane); and
- Daily production of 400tons of sulfur.

Phase 11

In 2004, Phase 11 was awarded to Total.

Technical Specifications of the Project:

- Gas production amounting to 2000 MMscf/d from South Pars Gas Field;
- Extraction of 1900 MMscf/d sour gas to feed the LNG units; and
- Extraction of 70,000 bl/d of condensate.

Phase 12

Phase 12 was awarded to Petropars in 2006. The allotted structure comprises 3 Bcf/d of total production, with 1Bcf/d for domestic use and 2 Bcf/d for a potential LNG project, with 110k bbl/d of condensate. Phase 12 is slated to come onstream in 2012 or 2013.

Objectives:

- Daily production of 78 MMcmd natural gas for transportation by the sixth Iranian Gas Trunk Line (IGAT6) or alternatively to be partly delivered as rich sour gas to the nearby gas liquefaction units (Iran LNG).
- Daily production of 110.000 barrels condensates
- Daily production of 750 tons granulated sulfur

Phases 13 & 14

In December 2005, Iran signed a contract with the Royal Dutch Shell Company and Spanish company Repsolon developing the downstream section of Phases 13 & 14, which are slated for LNG export (3 Bcf/d) starting in 2010.

The Project Technical Specifications:

- Production of 3000 MMscfd gas from South Pars field;
- Production of 2800 MMscfd sour gas to feed the LNG units; and
- Extraction of 105,000 bl/d of condensate.

Phases 15 & 16

In 2006, Phases 15-16 of the South Pars project were awarded to a consortium led by Ghorb, a domestic engineering company. The two phases are expected to cost $2 billion to develop.

Objectives:

- Producing 50 million cubic meters of natural gas per day;
- Producing 75,000 barrels of gas condensate per day;
- Annual production of 1.05 million tons of "LPG" (propane and butane);
- Annual production of 1 million tons of ethane as feedstock for the petrochemical industry; and
- Daily production of 400 tons of sulfur.

Phases 17 & 18

The development of phases 17 & 18 of South Pars gas field is to be implemented to produce 50 million cubic meters of natural gas, 80,000 barrels of gas condensate, 400 tons of sulfur per day, and also 1 million ton of ethane and 1.05 million tons of liquid propane and butane (LPG) per annum.

The onshore facilities of this project will be constructed in Assaluyeh region, some 100 kilometers from South Pars gas field. The offshore facilities of this project include four drilling platforms with 44 wells, two submarine 32" pipelines for transferring the gas, and two 4 " pipelines for transferring MEG.

The onshore refinery of this project is to be constructed adjacent to phases 9-10 in Assaluyeh. The Contract for this project has been awarded to a Consortium of IDRO, IOEC and OIEC.

The executive operation of these phases started in July 2007.

Phases 19, 20 & 21

The buy-back contract, for South Pars gas field phases 19, 20 and 21 development is under tendering.

Objectives:

- Production of 80 MMscm/d treated gas for domestic consumption network;
- Recovery of at least 1.6 MMTPA ethane, as feedstock of petrochemical industries;
- Recovery of at least 1.6 MMTPA premium grade LPG for export;
- Daily production of 120,000 barrels stabilized and de-sulfurized condensate for export; and
- Daily production of 750 tons sulfur for export.

Phases 22, 23 & 24

The EPSCC (Engineering, Procurement, Supply, Construction and Commissioning) buy-back contract, for South Pars gas field phases 22, 23 and 24 development project, will be executed with Iranian contractors and manufacturer's participation- at least 51 percent of the contract lump sum.

Objectives:

- Daily Production of 38 MMscm treated gas for domestic consumption network;
- Recovery of at least 0.75 MMTPA ethane, as the feedstock of the petrochemical industry;
- Recovery of at least 0.80 MMTPA premium grade LPG for export;
- Daily production of 55,000 barrels stabilized and de-sulfurized condensate for export; and
- Daily recovery of 350 tons sulfur for export.

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Gas Pipelines: Strong Growth, Old Problems and New Technologies

By John Tiratsoo

The recently-published *World Onshore Pipelines Report*[1] forecasts strong growth in the onshore gas pipeline market, with annual expenditure on all pipelines reaching $38.8 billion by 2012. After a period of declining capital expenditure (Capex), the market is set for a period of substantial growth as many large transcontinental, international and national projects come to fruition. For the global pipeline industry, this outlook makes welcome reading, and we begin by summarising the key drivers for this growth, with a brief look at some of the main projects expected to be constructed in the next five years.

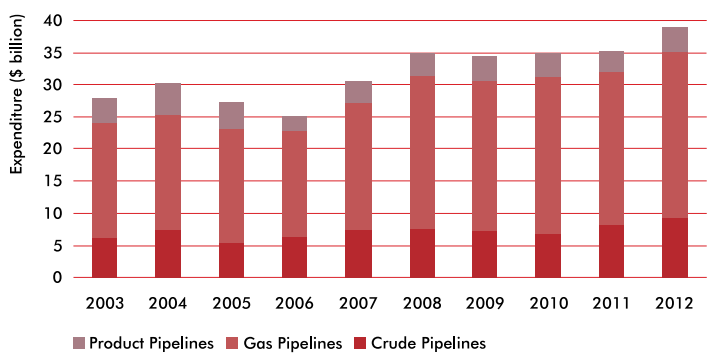
There are currently more than two million kilometres of onshore trunk pipelines used to transport gas (72% of the network by length), oil (18%) and refined products (10%) worldwide. Around 45% of these pipelines (again by length) are located in North America, and a further 20% in Eastern Europe and the former Soviet Union (FSU). However, much of this network, particularly in North America, Eastern Europe and the FSU, is old and in need of substantial investment to either replace or upgrade it to meet increasingly-demanding integrity standards. In addition to the country-specific factors that are driving investment in the onshore pipeline infrastructure, there are some key macro-economic drivers that have an impact on the entire global onshore pipelines market. These include:

- The growth in global energy demand, particularly in the developing economies, such as China and India;
- The attractiveness of natural gas as a fuel for power generation;
- As new regions are developed for hydrocarbon production, new pipelines are becoming necessary in order to link with, or expand, the existing infrastructure;
- A previous lack of investment – there are increasing concerns over the integrity of the global pipeline network, some of which is in excess of 40 years old and in dire need of replacement; and
- Supply/demand security – both exporting and importing nations are seeking to ensure long-term supply/demand security through diversification of supply/demand sources. Transcontinental and international pipeline projects are central to achieving this.

1 *The World Onshore Pipelines Report 2008-2012*, Douglas-Westwood, Canterbury, UK, 2008.

BELOW
Figure 1.

GLOBAL ONSHORE PIPELINE CAPEX BY PRODUCT 2003-2012



Source: The World Onshore Pipelines Report 2008-2012.

The market

The levels of Capex that are forecast to be required to install new onshore gas, oil, and product pipelines between 2008 and 2012 are shown in *Figure 1*. Construction of gas pipelines is driving the growth of the onshore pipeline market, and is expected to account for 68% of global onshore pipeline Capex up to 2012: gas pipeline Capex is set to increase from just over $90 billion between 2003 and 2007 to in excess of $121 billion for 2008 to 2012 – an

increase of 35%. This growth is supported by a 22% increase in the total length of gas pipeline installed – increasing from 77,955km to 95,341km for the respective periods. Growing demand for gas, particularly for power generation, and a desire for energy security through a diversification of supply, are the main global drivers for this increasing investment in gas pipeline infrastructure, although in North America, for example, there are other drivers central to growth in gas pipelines expenditure. Shifting natural gas production concentrations, with traditional production locations in Canada and the USA either becoming very mature or already in decline, are leading to strong investment in LNG and development of unconventional sources of gas (such as shale gas). This, along with the ageing pipeline infrastructure – 60% of all pipelines were installed before 1970 – is driving the need for pipeline investment in North America.

Some of the major gas export pipelines supporting this global growth include the 7,000-km Turkmenistan to China pipeline, the 2,800-km Altai gas pipeline connecting Russia to China, and the 3,400-km Nabucco pipeline between Turkey and Austria.

Key regional projects

Asia, Eastern Europe and the FSU, and North America are expected to account for 74% of the forecast global pipeline Capex, and it is therefore of no surprise that many key projects will be constructed in these regions. Gas-export pipelines from Eastern Europe and the FSU to Asia, in particular, will make up a significant proportion of Capex in both of these regions.

The $8-10 billion, 7,000-km long, Turkmenistan to China gas pipeline, which started construction in August 2007 and is expected to be completed by the end of 2009, is by far the longest pipeline expected to be installed in the world between 2008-2012 and is likely to account for as much as 20% of the total Asian Capex over the period. The project had been under consideration for over a decade with little progress; however, driven by a growth in energy demand and a desire for diversification of energy supply among other strategic benefits, China pushed the project forward in spite of poor project economics. Similarly, Russia's Kovykta gasfield "international development scheme", with 1,943km of pipelines to be installed in Russia, 1,427km in China, and a 649-km onshore section in South Korea, has also been under consideration for a decade and is now set to be installed by 2012. The project is part of a wider desire from Russia to develop its East Siberian resources, which includes a variety of tax incentives to stimulate development.

Though there is much talk in Western Europe about developing supply security, this has not translated into much investment in new gas pipelines in the region, owing largely to the fact that the current pipeline network is already well integrated. Having said that, the major planned gas-export pipelines to the region from Russia, the Middle East, and Africa – Nord Stream, Nabucco, and Medgaz – will certainly require significant investment in their offshore sections in order to link with the current onshore infrastructure. Nord Stream, the most recent of these projects to be launched, is profiled later in this article.

North America is also set for some key pipeline developments over the next five years. The region's oil pipeline network is being expanded by the $5.2-billion, 3,500-km Keystone oil pipeline from Alberta to Oklahoma, and the 1,158-km Gateway oil pipeline from Alberta to British Columbia. The 800-km Midcontinent Express gas pipeline, the 1,220-km long Mackenzie Valley gas pipeline, and the proposed Alaska Highway gas pipeline, will be crucial in bringing Arctic gas to US markets. All three projects are expected to start construction before 2012, although they are unlikely to be operational before 2013-14.

Industry issues

The security of supply and demand is probably the most significant driver for growth within the gas-pipeline industry, underpinning many of the

projects that are being planned. Interestingly, however, the security of the pipelines themselves is also becoming an increasingly-important issue for the industry: pipelines represent a significant and obvious target for insurgents, both military and terrorist. The remoteness and length of many overland pipelines means that they can be easily approached and potentially damaged, and there are many instances of pipelines being deliberately targeted in Africa, Eastern Europe and the FSU, the Middle East and Latin America. Consequently, investment in security for the protection of pipelines is becoming increasing common. For example, the Russian government has allowed Gazprom to set up what is effectively an independent armed force to protect its pipelines, and over $170 million has been invested in safeguarding the Baku-Tbilisi-Ceyhan (BTC) pipeline with measures including setting up a 700-person strategic pipeline protection department in Georgia to help support BP's field security teams.

Another significant issue that the gas (and oil) pipeline industry is likely to have to address is the capacity of the pipeline industry itself to meet the strong growth in demand. As the market moves to a higher level of activity, concerns are being raised over the capacity of the industry supply chain, from linepipe mills to construction companies, to meet demand, together with the effect this will have on pipeline costs.

● A secure gas supply for Europe: the Nord Stream pipeline

Of the planned projects to increase the security of the gas supply to Europe, the €7.4-billion Nord Stream subsea pipeline across the Baltic Sea represents one of the most important. The project, which has been designated a "Project of European Interest" by the EU under its Trans-European Energy Network Guidelines (TEN-E), comprises two 48-in diameter lines, each totalling 1,210km in length, and offering a combined capacity of 55 bcm/year. With European gas import needs projected to grow by about 200 bcm/year by 2015, Nord Stream will meet about 25% of this additional requirement and, after its completion in 2012, the twin pipelines will connect the world's largest gas reserves, in Russia, with the European gas pipeline network, securing natural gas supplies for the continent over the coming decades.

The new pipeline's owner, Switzerland-based Nord Stream AG, plans to have the first of the two parallel pipelines operational in early 2011. The company, an international joint venture, has four shareholders: Gazprom holds 51%, BASF/Wintershall and E.ON Ruhrgas each hold 20% and Nederlandse Gasunie holds the balance of 9%.

While the technical aspects of the pipeline design and construction are not unusual – with the exception of the comprehensive efforts made by the planners to survey in great detail and avoid munitions dumps on the seabed which the pipeline route crosses – of particular significance have been the tremendous efforts made to ensure that the environmental and political requirements of the nine countries involved in the pipeline route have been fully satisfied.

As a cross-border project, running from Vyborg in Russia to Greifswald in Germany, Nord Stream is subject to international conventions and national legislation in each of the countries through whose territorial waters it passes. Before construction starts in 2009, a highly-detailed trans-boundary environmental-impact assessment governed by international law (the 1997 Espoo Convention) has required completion along the whole pipeline route. Under the requirements of this Convention, Nord Stream submitted the Project Information Document to the states through whose territorial waters the pipeline route passes in November 2006. This effectively launched the first phase of the consultation process, during which the company participated in over 20 public hearings and a large number of meetings with the relevant authorities in the countries involved. These consultations resulted in the receipt of 129 statements from

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private and public bodies in the Baltic Sea countries, all of the concerns arising from which have now been resolved in great detail.

According to the current programme, pipelaying using Saipem's *Castoro Sei* laybarge and other vessels will take place in 2009-2010, and the concrete-coated and fusion-bonded epoxy-lined pipes are already being delivered to the main stockpiling yards in countries along the route.

Early designs for the pipeline incorporated a central platform which was essentially being planned as a pig launch and receive station. However, following the example of other long-distance subsea gas pipelines in the region, Nord Stream found that the currently-available inspection pigging technology was capable of inspecting the complete line in a single run, and no intermediate station would therefore be required. Removal of the requirement for the platform has naturally had a beneficial effect on the overall project cost, and has further been welcomed by those who feared its environmental impact would be of concern.

New technology for integrity

As has been mentioned – and, indeed, always seems to be mentioned when the state of the global pipeline network is the focus of discussion – gas (and other) pipelines are generally growing older, while at the same time the legislative regimes under which they are operated are imposing increasingly-stringent integrity assessment requirements. One of the effects of this apparent conundrum is that the pipeline-inspection industry is having to come up with solutions to problems which, in the past, have classified a pipeline as "unpiggable".

Today, it is generally-accepted that there is almost no pipeline-inspection problem that cannot be solved, provided an unlimited amount of investment is available. Despite this, however, pipeline operators are very much driven by the goals of minimising operational costs while maximising their pipelines' operational lifetimes, and there are few – if any – operators who are able to follow the example of British Gas in the 1970s with its huge investment in the development of magnetic-flux leakage technology for metal-loss inspections.

Solutions to an increasing number of inspection problems do exist, however, and three current examples are profiled below, each of which solves a problem hitherto thought insoluble. Interestingly, two out of the three developments are the product of cross-industry cooperation, highlighting the satisfactory way in which investment by the developer and the client can be combined to mutual advantage.

High-resolution EMAT technology for crack detection and coating disbondment[2]

The complex cracking processes that can occur on a pipeline have made accurate and reliable crack detection a great challenge. Different conditions give rise to different cracking mechanisms, which result in different crack types; in many cases, coating disbondment occurs as a precursor to cracking, as with stress-corrosion cracking (SCC).

An in-line inspection tool for the detection of cracks, in particular SCC, and coating disbondment has now been developed by Rosen Engineering, in cooperation with Saudi Aramco. The system is equipped with electromagnetic acoustic transducers (EMATs) and, after successfully testing this 16-in crack-detection tool through sample pipes containing real SCC and various types of artificial defect, the first operational runs – one in a gas pipeline and the other in an oil pipeline – were performed which have proved the performance of the system under operational conditions.

Saudi Aramco is one of the world's major pipeline operators, and owns and operates a large and diverse hydrocarbon transportation network in Saudi Arabia. The network comprises over

2 Hamad Al-Qahtani, Thomas Beuker and Dr Joerg Damaschke, 2008. *In-line inspection with high-resolution EMAT technology: crack detection and coating disbondment*. 20th International Pipeline Pigging & Integrity Management Conference, February, Houston, organised by Global Pipeline Monthly and Clarion Technical Conferences.

The pipeline of Camisea in Peru is a project that seeks to bring development to the population respecting the nature.
After 730 kilometers of immeasurable efforts displayed in the jungle, peaks and deserts, our aim has been achieved in the construction of the pipeline as well as in its maintenance. That was the idea, wasn't it?

TgP Transportadora de Gas del Perú

The new 16-in diameter inspection tool from Rosen Engineering designed for crack and coating disbondment detection.

17,000km of pipelines ranging from 3-in to 56-in diameter, and the company is constantly researching and testing emerging technologies to overcome the challenges it faces in maintaining its network's integrity. Some of the most recent of these include the detection of cracking and coating disbondment. Non-destructive in-line inspection tools generally use magnetic-flux leakage (MFL), ultrasonic testing (UT), or eddy current, although none of these techniques will detect SCC, especially in gas pipelines. Rosen's new type of ultrasonic sensor is based on an electromagnetic acoustic transducer (EMAT) which, by using physical effects such as the Lorentz force and magnetostriction, allows contact-free generation and observation of ultrasonic signals. The new technology is thus independent of a coupling medium between the sensors and the pipeline to be inspected, a major advantage for gas pipelines.

For this project, a 16-in tool was manufactured and equipped with EMAT sensors. The first inspection surveys in Saudi Aramco's gas and oil pipelines showed that both pipeline and coating-related features could be accurately found and evaluated, and the high-resolution approach produced accurate results and offers further potential for improvement.

A new pipeline cleaning technology: the hydraulically-activated power pig[3]

The validity of any pipeline inspection process is very much based on the cleanliness of the pipeline that is being inspected. While there is no widely-accepted answer to the question of "how clean is clean?", there is no question that the cleaner the pipeline can be before running an inspection tool, the better will be the results.

The development of the new "hydraulically-activated power pig" – HAPP (*see Figure 2 over*) is seen as providing a cleaning alternative where other processes may have failed. The new tool works essentially by making a powerful jet of the

3 Björn Stoltze, 2007. *A new pipeline cleaning technology: the hydraulically-activated power pig*. Pigging Products & Services Association annual seminar, November, Aberdeen.

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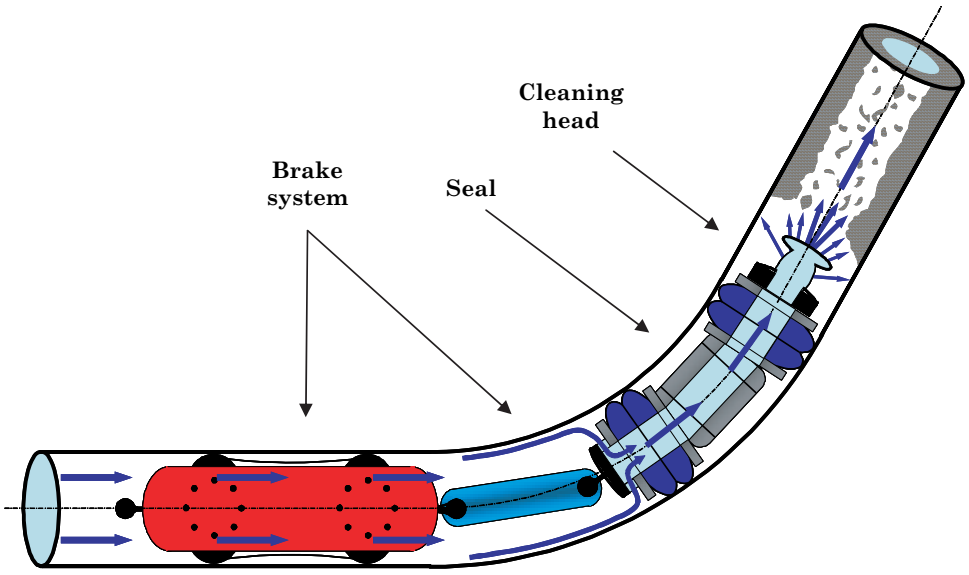
HAPP TECHNOLOGY'S HYDRAULICALLY-ACTIVATED POWER PIG



RIGHT
Figure 2.

fluid or gas in the pipeline, which is projected ahead of the tool, and which scours the pipe wall of debris and accumulated deposits. The tool is equipped with a braking system enabling its speed to be carefully controlled, and the flow restriction provided by the cleaning head is designed to provide powerful forward-facing jets of the transported medium.

The feeler-snake pig: a simple idea to detect and size internal corrosion[4]

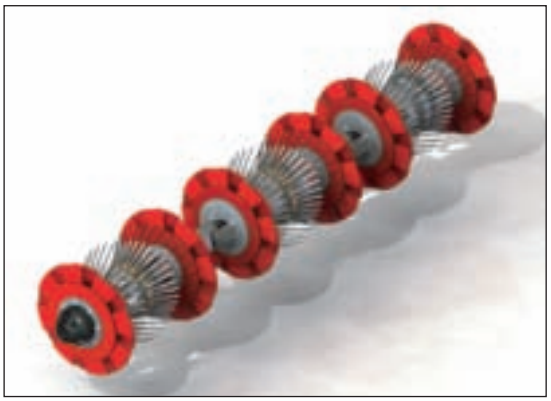
The pipeline pigging and inspection industry achieved a higher public status recently when a technical advance in pigging won the prestigious Global Pipeline Award. The Award is made by the American Society of Mechanical Engineers (ASME) each year, and presented at either the Rio de Janeiro pipeline conference, or the Calgary pipeline conference (which are held in alternating years). The 2007 Award, presented in Rio de Janeiro, was given to the "feeler-snake" pig, a project jointly developed by Petrobras and the PUC-Rio University to detect and size internal corrosion in what have been up to now classified as "unpiggable" pipelines.

The project has been aimed specifically at subsea pipeline inspection, where it can be very common to find pipelines with the awkward geometric characteristics (such as varying diameters and small-radius bends), that can prevent the use of conventional instrumented pigs. A further factor that can make inspection of such lines difficult is increased pipeline wall thicknesses, which significantly limit the use of magnetic instrumented pigs. The use of ultrasonic pigs is similarly inhibited by their need for a homogeneous liquid, with good acoustic properties, to serve as couplant (i.e. a material to facilitate the transmission of the ultrasonic energy). Even in crude oil pipelines this couplant is not always available, as these lines may carry multi-phase fluids.

The new pig has been developed to detect and size the loss of wall thickness associated with

4 Claudio Camerini, Jean Pierre von der Weid, Miguel Freitas and Thiago Salcedo, 2007. *The feeler-snake pig: a simple way to detect and size internal corrosion*. Rio Pipeline Conference, Rio de Janeiro, October, organised by IBP.

A 22-in diameter feeler pig with 250 sensors.

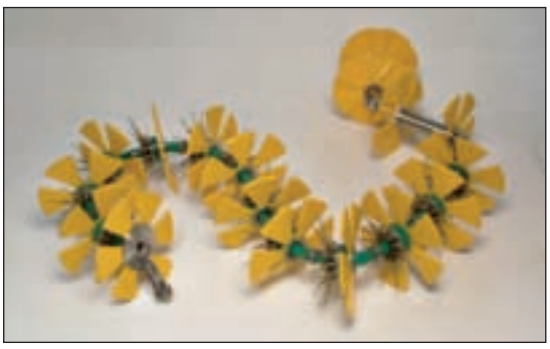


A 12-16-in diameter feeler pig with 180 sensors.

internal corrosion, and has been designed to be able to negotiate large variations in diameter, with no practical limit on the wall thickness to be inspected, as well as being able to pass through small-radius bends. The first prototype was called a "feeler" pig, as it consisted of a collection of feeler-type sensors that measured internal corrosion. The system was tested in the field and its performance compared to that of a standard ultrasonic instrumented pig: excellent defect correlation was observed between the two types of inspection tool, both in terms of geometry and depth of internal corrosion. An extension of the design was then developed named the "feeler-snake" pig, in which the feeler sensors are mounted on a flexible support, giving a tool with high tolerance to geometric restrictions. The excellent results from the prototype, and its robustness against in-line geometric restrictions, are seen as opening a wide range of opportunities for the feeler-snake pig technology in field applications.

As a result of this development, Petrobras has changed its offshore pipeline inspection system, prioritising this technology for internal corrosion control. The use of other pigs, such as MFL and ultrasonic, will still be required wherever external corrosion is suspected, but with the new system, Petrobras intends to inspect the majority of its subsea pipelines, and almost eliminate the expression "non-piggable line" from its offshore production vocabulary.

John Tiratsoo is the Editor of Global Pipeline Monthly *(www.globalpipelines.com)*.



The feeler-snake pig: (ABOVE) a general view of electronics and sensor modules; (RIGHT) the pig being received from an offshore pipeline.

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With rapidly increasing production from Brazilian oil and gas fields, the Company recently attained self-sufficiency in oil supplies in Brazil and has boosted local production of natural gas in order to meet the rising domestic demand. In 2007, the Company set a new record in terms of production topping 2 million barrels of oil per day – a feat achieved by few companies around the world.

Also in 2007, Petrobras won the Corporate University Best in Class (CUBIC) award for 2007 for the best Corporate University in the World from the specialist US-based International Quality & Productivity Center (IQPC).

Petrobras is responsible for supplying Brazil's internal demand for natural gas and also controls the extensive network of gas pipelines in the country, which spanned 18,176 thousands kilometers in 2007. This includes the 3,150 thousands km-long Bolivia-Brazil gas pipeline, which is the largest integration undertaking ever implemented in the whole of South America, with total costs of approximately $2 billion. In addition to this, it has a thermoelectric generation park with installed capacity of 4,126 thousands MW and 15,414 thousands km of electricity transmission lines.

In order to strengthen its domestic natural gas production, Petrobras has strongly invested in hydrocarbons prospecting in "ultra-deep" waters of

Campos and Santos Basins. The program of wildcat drillings has proved the existence of large natural gas, oil and condensate fields in the Santos Basin's sub-salt beds. The recent finds of Tupi, Jupiter, Carioca and Sugar Loaf fields indicate a further evidence of strong geological sub-salt potential for all regional marginal basins.

Furthermore, to improve the domestic natural gas supply, the Company will feature as a permanent player in the international liquefied natural gas (LNG) market with two new terminals coming on-stream and with the arrival of the first regasification vessel during this year. By 2009, Brazil's capacity for processing LNG will be in the order of 21 million cubic meters per day.

In line with its social and environmental commitments, Petrobras has scaled up its biodiesel program by starting work on the construction of three plants slated to produce 171 million liters per year, thus meeting 20% of Brazil's demand in 2008.

Toward New Technologies for the Gas Market

By Jean Schweitzer and Thorsten Formanski

Micro cogeneration (μCHP) is an important technology for the gas industry as it allows natural gas to remain a competitive energy source for the home of tomorrow. Traditional gas-fired heating boilers will play a declining role in the residential sector as new energy saving regulations demand greater efficiency, and improved insulation standards reduce the demand for heat.

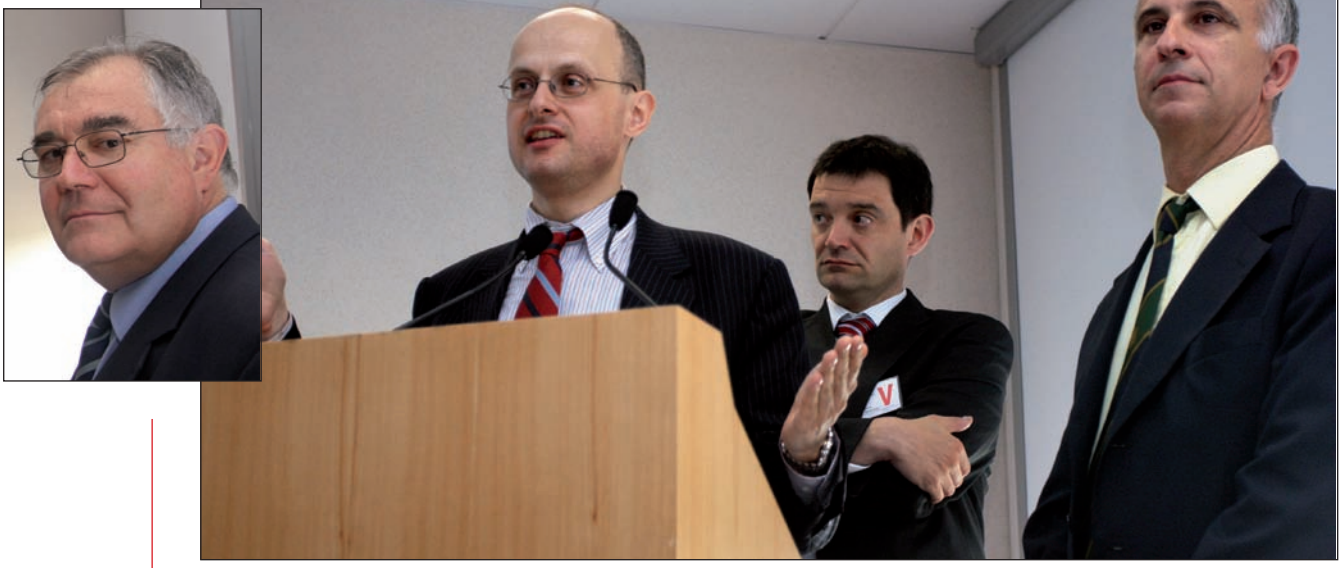
With this in mind and on the initiative of IGU's Working Committee 5, Marcogaz and GERG, organisations that are committed to the development of new gas technologies, a workshop was organised on May 29 and 30 in the premises of Gaz de France R&D in Paris, France. The goal of the workshop was to gather together the main actors from the gas industry, manufacturers and European authorities in order to define a gas industry strategy to facilitate the development and integration of μCHP technology.

The workshop was organised by a steering group (*see Table 1*) led by Daniel Hec, Secretary General of Marcogaz, and Jean Schweitzer, Manager for International Projects at the Danish Gas Technology Centre (DGC), who are both active in IGU work: Jean Schweitzer as Chairman of WOC 5 and Daniel Hec as a member of several committees.

Special thanks are due to Marcogaz for taking on the administration of invitations and registra-

WHAT IS MICRO CHP?

CHP is combined heat and power generation through appliances that can be based on different technologies. Micro CHP designates applications targeting the domestic residential sector. More information can be found at: www.gerg.info/publications/brochure_asue.pdf.



The first session was addressed by Guido de Wilt of DG TREN (LEFT), Stephan Ramesohl of E.ON Ruhrgas (CENTRE) and Marc Florette of Gaz de France (RIGHT). Daniel Hec of Marcogaz was the workshop moderator (INSET).

RIGHT, BELOW RIGHT AND BOTTOM RIGHT
The workshop was attended by 80 invited participants (RIGHT) and a showroom was open throughout the two-day event (BELOW RIGHT AND BOTTOM RIGHT).

BELOW LEFT
Table 1.

tions as well as the chairing of the workshop, and to Gaz de France for the practical organisation of the event. The sponsors were Gaz de France, GasTerra and GERG.

The workshop was restricted to 80 invited participants and was a great success as evidenced by the wide-ranging and animated debates. Real appliances were presented in the showrooms during the duration of the two-day event. From the initial feedback received from the participants it seems that they were unanimously impressed by:

- The high quality attendance (including representatives of the European Commission, Japanese and US experts, the European Association for

STEERING GROUP MEMBERS

Daniel Hec (Marcogaz)
Jean Schweitzer and Jan de Wit (Danish Gas Technology Centre/IGU)
Henk Ensing and Hans Overdiep (GasTerra)
Thorsten Formanski (ASUE/IGU)
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D. Pinchbeck (GERG)
P. Mela and P. Canal (Gaz de France)