

# The Global Natural Gas Sector: From Norway to Qatar

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**A**lthough the world oil market still commands the lion's share of press these days, especially since prices have exceeded 100 dollars per barrel, natural gas<sup>1</sup> has been the most important fossil fuel growth story of the past quarter century. In 1980, world petroleum consumption was 131 quadrillion Btu, world coal consumption 70.3 quadrillion Btu, and world dry natural gas consumption 54 quadrillion Btu. By 2005, these figures had increased to 169.4 quadrillion Btu, 122.6 quadrillion Btu, and 107.6 quadrillion Btu, respectively. Hence, the growth in gas consumption far outpaced the other two, and just about doubled. While it is true that in the last few years much of the growth in world energy demand has come from India and China, places that are heavily reliant on coal for electricity and petroleum for rapidly growing automotive transport sectors, gas consumption is expected to continue growing rapidly as well. Its relative efficiency for electricity generation, its use in industrial sector processes, and the fact that it is relatively less polluting, especially in terms of greenhouse gas emissions, will continue to ensure growing demand despite widespread and plentiful global coal reserves.

Nevertheless, in the near to medium term, coal consumption growth rates are expected to exceed those of natural gas. According to the United States Energy Information Administration (EIA), the reference annual growth rate 2004-2015 for natural gas consumption will be 2.4 per cent; the International Energy Agency (IEA) expects a slightly higher rate, at 2.5 per cent. Likewise, longer-term (2015-2030), the IEA expects a slightly higher annual growth rate (1.7 per cent) versus the EIA (1.6 per cent). Renewables are also expected to grow faster, albeit from a much smaller base, of course. In 2010, the EIA estimates that global gas consumption will be 3.26 trillion cubic metres (Tcm), with 43 per cent of that for industrial use and 34 per cent for electricity generation.<sup>2</sup>

Before delving into regional natural gas markets and major producing countries, it is worthwhile to look at some global trends. One is the growth

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of liquefied natural gas (LNG) as a means of transporting natural gas. As it assumes an ever larger percentage of global gas consumption, this correspondingly indicates more and more of a world gas market (as LNG sales are not constrained by pipeline infrastructure) rather than regional ones. The world LNG market increased from 84.85 billion cubic metres (Bcm) in 1993 to 215.96 Bcm in 2006, and is set to continue growing strongly.<sup>3</sup> Consulting firm Wood Mackenzie forecasts 710 Bcm of consumption by 2020.<sup>4</sup> This level of increase reduces the effects of stranded gas markets and creates more of a world gas price, at least on the margins. It will be a challenge to complete the infrastructure necessary to allow for this kind of increase, for technical, environmental, and political reasons. Costs for LNG infrastructure, just as with costs for drilling rigs and offshore platforms, have risen substantially given increased demand and higher prices for basic commodities used for LNG trains. As of 2006, the three largest importers of LNG were Japan, South Korea and Spain, respectively.<sup>5</sup>

Another important trend is changes in demographics and economies that presage large increases in natural gas demand from large, rapidly-growing economies such as China, India and Brazil. In China, the limits on domestic transport of coal and ever-more polluted cities have made the increased use of natural gas important, so much so that China has recently signed large new LNG import contracts with Qatar. Brazil has hydropower as its base load, which in the past proved unreliable in dry years. In order to diversify supply, Brazil is importing as much as it can from Bolivia and developing new offshore natural gas reserves. India, and other Asian countries such as Thailand, are looking to increase natural gas imports, even at the cost of dealing with the international pariah regime of Myanmar. Economic growth rate forecasts, as well as the recent experience of high oil prices, indicate that Asia's demand will be less sensitive to higher prices, especially higher LNG prices, in the future, spurring new infrastructure development. However, there is a limit to how quickly LNG infrastructure manufacturers can respond to this increase in demand, and rises in commodity prices such as steel as well as high demand itself have led to high prices that may limit some planned future expansion of facilities, or at least delay them.

Natural gas market restructuring is another factor that is affecting some of the world's most important gas markets, and of course, could affect others in the future. Nowhere has this attracted more attention than in the world's

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1. Natural gas, in its "dry" or pure state, is usually considered to be just CH<sub>4</sub>, but so-called "wet" natural gas often contains other hydrocarbon compounds such ethane, butane, and propane, and still other compounds may be mixed with the gas.

2. The remainder is for other uses, such as heating and transport.

3. U.S. Energy Information Administration figures.

4. As cited in Allan Baker, "Global LNG Supplies Tight", *Petroleum News*, 6 May 2007.

5. EIA/IEA/CEDIGAZ data.

second-largest gas market, the European Union (EU). It is estimated that in 2005, the EU-27 represented 18.9 per cent of total world gas consumption. In the past 10 years, the EU has introduced three packages of legislative directives to open up the gas market to competition, increase efficiency, and unbundle the sector (separate gas production activities from gas transport network activities). The third package, introduced in September 2007, calls on companies to unbundle or appoint an independent system operator (ISO) to manage transport networks. Also proposed in the third package are conditions placed on non-EU companies' ownership of transmission networks, a move widely seen as an effort to protect the EU from an aggressive monopoly such as Gazprom and as an attempt to extract some reciprocity. EU companies, which face restrictions on investment in Russia's upstream gas sector, would like access to EU downstream networks, which Gazprom has shown interest in, to be commensurate with improvements in their own access to Russia. The EU differs from other large consuming regions in the OECD, such as North America or northeast Asia (Japan and South Korea), in that it is dependent for a very large share of its natural gas consumption on piped imports from neighbours that are not well integrated economically and legally with the EU.<sup>6</sup>

There has been some discussion of forming an organisation of gas exporting countries, that, if not a cartel (the so-called "Gas OPEC"), would engage in a higher level of coordination than is currently the case. In February 2007, on a trip to Qatar, Russian President Putin stated "We do not reject the idea of creating a gas cartel, but this initiative requires more study". Gas, unlike oil, still has stranded markets to a greater or lesser degree (being made lesser by the expansion of world LNG trade and more pipelines), so creating a central body that could restrict output/exports globally to influence global price (as with crude oil) is an unlikely proposition. A more likely result would be cooperation and coordination that, in the extreme, might serve to restrict competition. For example, the rising levels of LNG deliveries to Europe could mean that one day countries far away compete with Russia for European market share. A negative effect on consumers could be agreement on market share that would restrict competition. There is already an organisation of gas exporting countries, the Gas Exporting Countries Forum (GECF). So far, it has not seemed analogous to OPEC, but at the Forum's late-April 2008 meetings there was much speculation that certain members were trying to push in this direction.<sup>7</sup> Not all major gas exporting countries are members of GECF.

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6. The EU-27 imported 57.6 per cent of its gas consumption from outside of the EU in 2005. Of course, a large percentage (24 per cent) of EU gas imports come from Norway, which, although not a member of the EU, provides a very high level of security of supply. Canada's situation with the United States is similar. Japan and South Korea rely on LNG imports, a more liquid market (though both the EU and United States import LNG, for much smaller shares of consumption).

7. Though this is probably not possible, as mentioned earlier in the paragraph.

Policies to address climate change and pollution, higher on the agenda now that there is scientific consensus about the effects of global warming, while many cities in the industrialising developing world have noxious levels of airborne pollutants from the burning of coal, may also affect natural gas demand. Natural gas, being a cleaner burning fuel in conventional thermal power plants, could see increased demand resulting from policies that control carbon emissions (or put a price on carbon). Alternatively, all fossil fuels could potentially see their demand eroded by non-emitting alternatives such as nuclear and renewables. Carbon capture and storage (CCS) might be more cost-effective using pulverised coal rather than natural gas, such that if CCS became a widespread technology in the future, relative costs could affect demand.

In addition to traditional uses in electricity generation, heating and industrial processes, in recent years there has been renewed interest in natural gas as a transport fuel. This is mostly through the use of compressed natural gas (CNG).<sup>8</sup> Compared to petroleum, gas is a very small portion of the sector – for example, just 3 per cent in the US, although CNG use is already quite significant in fleet vehicles and public transport. Notably, in Asia, and South Asia particularly, CNG is becoming an important part of the sector, and some cities, such as Delhi and Ahmedabad, have converted all public transport buses to CNG exclusively. Brazil, Argentina and Pakistan are world leaders in numbers of natural-gas powered vehicles, and there are over 5 million in use worldwide.<sup>9</sup>

Finally, flaring (burning off gas at associated fields that cannot be used economically) remains an environmental and social challenge, despite some progress in reducing it in certain places. For those living near large gas flares, quality of life can be severely affected. According to an estimate using satellite observations, the total amount of gas flared in the world ranged from about 150 Bcm per year to 170 Bcm per year 1995-2006, with a peak in 2003, and just slightly less than the peak in 2006.<sup>10</sup> This is an enormous amount of gas; approximately equal to the combined production of the United Kingdom and Norway, or more than the consumption of all of Central and South America, using 2006 figures. Even more gas is released directly into the atmosphere, without being burned, by leaky infrastructure.<sup>11</sup> However, the percentage of world natural gas production that is flared has

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8. LNG is more rarely used as a transport fuel because of the additional complications of maintaining very low temperatures.

9. Source: International Association for Natural Gas Vehicles.

10. National Geographic Data Center, United States National Oceanic and Atmospheric Administration (NOAA) Satellite and Information Service.

11. This is a particularly large problem in the former Soviet Union. In Russia alone, wasted gas from leaks and other infrastructure problems amounts to about 30 Bcm per year, according to the IEA.

fallen, as gas production increases but flared gas remains fairly steady. At the heart of the flaring problem is an inability to monetise the gas that must be extracted to get at petroleum reserves. Work is being done on this by bodies such as the World Bank's Global Gas Flaring Reduction public-private partnership, but in places such as Nigeria there are understandable frustrations in affected communities at the slow pace of flaring reduction.

The remainder of this paper will look at some of the major natural gas-producing countries.<sup>12</sup>

## **Russia**

Russia is, of course, the world's largest natural gas producer (656 Bcm), the world's largest exporter (186 Bcm), and by most estimates has the world's largest natural gas reserves (47.6 Tcm). Natural gas is one of the most important sources of government revenue, and one of the largest sectors of the economy, only exceeded by oil. Subsidised gas prices are a way of life in Russia, making possible sufficient heating in far flung towns in the winter. Nearly 90 per cent of Russia's gas production is from state-monopoly Gazprom, which also has a monopoly on exports and has made a push to expand into the downstream sector in customer countries through projects such as South Stream and Nordstream. Gazprom concluded new long-term contracts with German, French, Italian and Austrian buyers in late 2006. Gazprom has also looked to become involved in the gas sectors of Algeria and Libya, prompting some in the EU to complain of "encirclement". A more concrete concern, though, is that Gazprom does not have the ability to preserve and expand Russia's output, given declines in producing fields, insufficient investment and a lack of necessary technologies. The IEA expects Russian gas exports to drop as much as 25 per cent by 2015, assuming no major changes to domestic demand. Possible changes to this could include higher domestic prices to reduce demand, or even switching to coal-fired electric power. Given that there is likely to be little growth in Russian gas supply, South Stream and Nordstream may be more about avoiding certain transit countries than providing long-term security of supply. Most of Russia's gas exports to Europe go through Ukraine and Belarus in Soviet-era pipelines, though following completion of the Blue Stream pipeline under the Black Sea in 2002, Russia exports gas directly to Turkey. China has shown some interest in importing Russian gas, but proposed projects such as

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12. Given limited space, some important gas-producing countries, such as Libya and Egypt, are not included in this paper. Countries/regions are listed in alphabetical order, with the exception of "Arab Gulf States", which follows Qatar, as this section follows naturally from the section on Qatar. EIA statistical estimates for country-level figures unless otherwise noted, and export figures are net exports calculated as production minus consumption, unless otherwise noted.

constructing a pipeline to bring gas from the Kovytkha field have not progressed from the proposal stage. Hence, Russia has no ability to export gas from its main West Siberian fields anywhere but Europe and Turkey. In the Far East, various gas (and oil) projects are being developed by mixed domestic and foreign consortia on Sakhalin Island, after some controversy that reduced the foreign share. Sakhalin I provides gas for domestic consumption in eastern Russia; Sakhalin II, phase 2, has a 2-train, 9.6 million-ton-per-year LNG export facility under construction, with exports expected to commence in 2009. Russia's other main LNG project is Shtokman, which is a field offshore in the Barents Sea that is being developed by a consortium. With several phases of development, Shtokman is expected to be Russia's largest LNG export facility in 10 to 15 years.

### **Canada**

Although Canada is more in the energy news for its oil sands, the country is the second-largest natural gas exporter after Russia. In 2006, production was 185 Bcm, net exports 92.5 Bcm, and reserves 1.59 Tcm. Most of Canada's gas is produced in western Canada, but increasingly important in the future are reserves offshore in the Atlantic, and yet-to-be developed reserves in Canada's Arctic region. Canada has a diverse private sector that develops its gas reserves, with much control retained by the provinces. All of its exports go to the United States, which has an expanding pipeline network linking the countries. Natural gas is important in Canada for use in extracting heavy oil from the oil sands, given the need to heat steam for in situ extraction. Despite Canada being a net gas exporter, it is expected to begin importing LNG in the east coast (New Brunswick – Canaport) sometime in late 2008, which could be used to offset declining production, be exported to the US, and/or allow Canada to use more gas for oil sands extraction. Canada's conventional western region production is expected to continue declining, reducing exports in the future, though two large projects will increase exports, or at least transit in the future. One is the Mackenzie gas project, which would develop and bring stranded gas reserves on the northern shore of the Northwest Territories to Canadian and American markets much further south by 2010. The other project is an Alaska pipeline that would have to pass through Canada to bring gas to the lower 48 states.

### **Norway**

Norway is the largest natural gas producer in Western Europe, and is a key source (15 per cent of OECD Europe demand) for this region of high demand and declining production. The world's third-largest gas exporter's production is exclusively offshore. Given small domestic consumption, net exports were

84 Bcm in 2006. Norway's sector is dominated by the majority-state owned StatoilHydro, but international oil companies and some independents are also important players. The state also has a direct financial interest in production through the holding company Petoro AS. Transport capacity has reached 120 Bcm with the completion of the Langeled Pipeline in October 2007. This connects the Ormen Lange field to the UK, and is the world's longest underwater pipeline. Norway has pipeline connections with the UK, France, Belgium and Germany. Norway's gas transport system is owned by the Gassled partnership and operated by GasscoAS, a state company. Most Norwegian production comes from just four fields: Troll, Sleipner, Asgard and Oseberg, but the country has been able to expand production by bringing on new fields, particularly from the Norwegian Sea and Barents Sea. The Snohvit project, which has appraised reserves of 193 Bcm, brings gas from the Barents Sea onshore at Melkoya for liquefaction and export to Europe and the US. It came online in September 2007 and is Europe's only major LNG export facility.

### **Bolivia**

Landlocked Bolivia, with South America's second-largest proven reserves, exports only to its neighbours Argentina and Brazil via the Yabog and Gasbol pipelines. Venezuela has much larger gas reserves, but exports very little, with most of its reserves in associated fields and used by the petroleum sector for power and reinjection. Bolivia's reserves are about 680 Bcm, and are mostly located in Tarija department. Net exports in 2006 were about 10.8 Bcm, small by global standards, but important for South America. Bolivia nationalised its hydrocarbons sector on May 1, 2006, forcing the foreign operators in the country, most importantly Petrobras and Repsol-YPF, to renegotiate their contracts and requiring much more state involvement, including that of the state hydrocarbons company YPFB. The issue of the use and export of Bolivia's gas has been a volatile one, leading in part to political conflicts, with many wanting to see it used for domestic economic development rather than export. In October 2006, Bolivia and Argentina reached a deal that will increase the price of gas, and also work to increase gas exports after 2010, though this will require large new investments. In February 2007, Brazil and Bolivia finally reached a deal for a higher gas price as well. There have been attempts to try to export Bolivian gas via LNG, but these have created huge political problems, and disputes with Chile have made the most cost-effective option impossible.

### **Qatar**

Qatar, one of the world's smallest countries, has the world's third-largest natural gas reserves by most estimates: 25.8 Tcm. This is mostly offshore in

the super-giant North Field, the world's largest known non-associated natural gas field. This field extends geologically into Iran's South Pars field. Qatar has experienced a dramatic rise in gas exports in the past 10 years, as exports only began in 1997 with a small amount of LNG after its first train came online. However, by 2005, Qatar had become the world's largest exporter of LNG, a position it has maintained since. In 2006, Qatar is estimated to have exported 31.4 Bcm of LNG, and its current LNG output is estimated at 31 million tons (42.8 Bcm).<sup>13</sup> Most of Qatar's exports go to Japan, South Korea, India and Spain. Qatar has two consortia, Qatargas and Rasgas, which have developed its LNG industry. Qatargas has three trains operating, and expects Train 4 to begin operating by the middle of 2008 and train 5 by mid-2009. Qatargas expects two more trains to be completed by 2010 or 2011. Rasgas has five trains operating, with two more planned by 2010. When these trains are complete, Qatar will have a capacity of about 77 million tons per year. In April, PetroChina concluded a deal to import 3 million tons per year for 25 years from 2011 onward, meaning that less exports from the new trains may reach the Atlantic basin than originally thought. Qatar has also developing piped exports through the Dolphin project, which uses an offshore pipeline to deliver gas to the UAE, and later to Oman as well. Finally, Qatar is also developing gas-to-liquids (GTL) projects. The Oryx and Pearl GTL projects together have a capacity of 174,000 bbl/d, and expansions and other projects are planned.

### **Arab Gulf States**

The other Arab states of the Persian Gulf, besides Qatar, are known for their oil exports. Yet, development of gas resources has lagged behind, and the region even faces possible shortages of gas. Booming economic growth from high petroleum prices has increased demand for gas even more than forecasters expected a few years ago, and the region already has one the world's fastest electricity demand growth rates. Saudi Arabia has the third-largest gas reserves in the Persian Gulf after Iran and Qatar, at about 6.9 Tcm, and the United Arab Emirates (UAE), near as much at 6.1 Tcm. The other three countries (Kuwait, Oman, and Bahrain), have comparatively small reserves. None of these countries export natural gas; in fact, with the Dolphin Project, mentioned in the section on Qatar, the UAE is importing gas, and is hoping to import 60 per cent more if it can reach an agreement with Qatar to increase to capacity on the pipeline. However, Qatar's moratorium on new developments on the North Field (other than for current projects) puts such an increase in doubt. The UAE has massive increases in electricity supply planned, far more than its own gas resources would be able to supply. Saudi Arabia's gas

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13. EIA and Global Insight figures.

production has increased dramatically in recent years, from 50 Bcm in 2000 to 74 Bcm in 2006, yet with the demands for industrial projects, desalination, electricity, etc., Saudi Arabia lacks sufficient gas for every desired project. Prices may have to be increased to better allocate the gas. Saudi Arabia has allowed foreign companies to explore for non-associated gas, unlike the closed oil sector, but results so far have been mostly unsuccessful. Kuwait would also like to develop its gas sector, which so far mostly uses gas from associated fields, and is less than a fifth of that of its neighbour Saudi Arabia. Oman as well has relatively small production. Given that much of the gas produced in the region is sour gas (having poisonous sulphur mixed in) and tight gas reservoirs (natural gas produced from reservoirs that have very low porosities and permeabilities, usually requiring technologically complex fracturing for gas to flow at commercial rates), attracting foreign investment and expertise is likely key to the region developing its full potential on its over 15 Tcm of reserves (not including Qatar).

### **Turkmenistan**

Central Asia's largest gas exporter is known for the uncertainty of its reserve estimates, which are 2.83 Tcm (proven) according to one well-known estimate, but there are undeveloped fields and estimates of reserves (though perhaps not proven) that are much higher. Turkmenistan exports nearly all of its gas to Russia, though much is resold to Ukraine through the less-than-transparent middleman RosUkrEnergo (50 per cent owned by Gazprom). Turkmenistan has exported six to 10 Bcm per year to Iran through a small pipeline in recent years, but a dispute halted those exports for several months at the beginning of 2008. Exports to Russia via the Central Asia Centre (CAC) pipeline in Uzbekistan and Kazakhstan are likely no more than 45 Bcm, and perhaps less, as lack of new investment in Turkmenistan's gas fields and in the CAC pipeline has prevented expansion of production despite the country's considerable reserves. These Turkmen gas exports are important to European customers, because the demand that they satisfy in Russia and Ukraine allows more Russian gas to be exported further west. The price differential between what Russian importers pay and what is sold to the EU is an important source of profit for Gazprom. Turkmenistan's current production is from reserves developed during the Soviet period, and some analysts who know the sector well believe that Turkmenistan's production will begin declining in the next few years if there is no substantial new foreign investment. But that investment is doubtful: Gazprom seems unable to invest adequately in Russia, and Western companies face large challenges in trying to monetise the gas (including lack of infrastructure connection to the EU – the recent “deal” for 10 Bcm with the EU seems lacking in specifics). Chinese company CNPC seem to have had more success in the preliminary steps of obtaining Turkmen gas, with a contract secured in

July 2007, and pipeline transit agreements with Uzbekistan and Kazakhstan. Construction of the Turkmenistan portion of the pipeline to China reportedly started in August 2007. However, sizeable investment in untapped gas reserves and faltering fields is awaited,<sup>14</sup> as currently producing reserves will be unable to supply all the exports that Turkmenistan is contemplating.

### **Australia**

Although Australia's proven gas reserves of 850 Bcm are much lower than in several other countries, the country is one of the world's largest exporters of LNG (5 in 2006). It is also important because of the Timor Sea, which it shares with Timor Leste. A joint development area (JDA) was established in 2003, and although government revenues are split 90:10 in favour of Timor Leste, Australia is the driving force behind development of the area. The Bayu Undan field there has estimated recoverable reserves of 112 Bcm (as well as 550 million barrels of condensate and LPG). In addition to offshore facilities, it has a 483 pipeline to an onshore liquefaction and export facility. The Greater Sunrise field, which is only partially in the JDA, needed a separate agreement in order for investment to proceed, but this was completed by April 2007. Australia has a diverse private sector developing its gas reserves, which are located in declining onshore basins such as the Cooper/Eromanga, declining offshore mainstay Bass/Gippsland Basin (offshore Victoria), and growth areas such as the Carnarvon Basin (Northwest Shelf). In 2006, the country exported 19.6 Bcm of LNG, entirely to east Asia, with Japan by far the largest customer. The Northwest Shelf Venture (NWSV), Australia's largest resource development project, is a consortium of six companies operated by Woodside, and consists of two platforms and an FPSO, as well as 4 LNG trains (a fifth is under construction) that export 7.5 million tons per year. A further important project is Pluto, which is due to create another LNG export facility by 2010. Australia's total gas production in 2006 was 42.8 Bcm, with consumption of 26.9 Bcm for electricity and industrial uses.

### **Iran**

Iran is noteworthy for having the world's second-largest proven gas reserves (26.85 Tcm) while not being a net gas exporter (Iran was a small net importer in 2006, but basically self-sufficient at 105 Bcm). This is more than the reserves of all of the Americas, yet production is only a small fraction, giving Iran huge growth potential. Production increased to about 130 Bcm in 2007,

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14. Such as in the Bagtyarlyk territory that is being leased by CNPC.

but this was not enough to avoid shortages in winter 2007-2008, as extreme cold temperatures boosted demand at the same time that Turkmenistan cut off exports. Power stations had to switch to liquid fuel, and some industry had its supply cut. This surge in winter demand will be a consideration in the future if Iran becomes a significant exporter, as it will be politically difficult to keep exporting piped gas during a shortage, and even LNG exporters will have a difficult time accepting seasonal outages. Iran has a very extensive consumer distribution network for a developing country, and a diversified usage profile (34 per cent domestic commercial; 26.5 per cent industry; 32 per cent power; 7.5 per cent export and oil field injection). Gas consumption is increasing rapidly, averaging 10 per cent per year, putting pressure on new projects and transport infrastructure just to keep pace, let alone export. The Iranian government has a 20-year plan to expand Iran's gas production 475 Bcm by around 2020. Key to this will be successful development of the giant South Pars field, which represents about 47 per cent of Iran's reserves.<sup>15</sup> There is a 25-phase development scheme that will take over 20 years to complete. This field is rich in condensates, making for lucrative export potential even if much of the gas is consumed domestically at subsidised prices. But South Pars has experienced difficulties progressing on schedule, and Iran will also need more gas processing plant capacity and new IGAT transmission lines to bring gas from southern fields to northern areas of consumption. Iran still flares about 8.4 Bcm per year of gas, which should be a priority utilisation goal for the country. Iran's only major gas export line is the 14-Bcm-capacity Iran-Turkey pipeline, which in recent years has been transporting about 2.8 to 4.3 Bcm per year, with shut-offs in winter. The National Iranian Gas Company (NIGC) is mostly responsible for the sector, particularly transport and distribution, but there are other Iranian companies involved, including the National Iranian Gas Export Company (Nigec), Pars Oil and Gas Company, foreign companies such as Total, Eni, and RD/Shell through buyback deals, and NIOC through associated fields and injection. Iran has had difficulty attracting foreign investment because of US sanctions, buy-back deals that are comparatively less lucrative, perceived instability surrounding international reactions to Iran's nuclear program, and structural and management problems.

## **Indonesia**

A vast archipelago of some 13,000 islands, the majority of Indonesia's proven gas reserves of 2.66 Tcm lie offshore. As the country is no longer a net oil exporter, natural gas exports have become relatively more important to the economy. The country is the second-largest exporter of LNG in the

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15. It is geologically part of the same structure as Qatar's North Field.

world, with all of its LNG going to Japan, S. Korea, and Taiwan (30.4 Bcm in 2006). However, the country is struggling to maintain export levels as growing domestic demand diverts gas, while the country's third LNG project is not yet online. Consumption rose to 43.4 Bcm in 2007, up from 34.6 Bcm in 2003, yet gas production has remained roughly constant at 74 Bcm. State-owned Pertamina is Indonesia's main natural gas company, but several foreign companies are important investors in production, including Total and ExxonMobil, which, respectively, supply the Arun and Bontang LNG plants. A BP-led consortium has invested 5 billion dollars developing the Tangguh LNG Project in West Papua. The plant, expected to be complete in October 2008, will produce 7.6 million tons per year, but has also been the subject of environmental and community-relations controversies. Indonesia has two export pipelines that connect from West Natuna and South Sumatra (places where large reserves are found) to Singapore, and also a connection to a Malaysian offshore platform. Transmission and distribution are carried out by the state-owned utility Perusahaan Gas Negara (PGN). Pertamina plans to boost production in 2008 to 12.4 Bcm, after 2007 production of 11.49 Bcm, which was 22 per cent lower than expected.

## **Nigeria**

Nigeria is sub-Saharan Africa's largest gas producer by far, producing 28.2 Bcm in 2006.<sup>16</sup> Some in industry assert that in the future Nigeria will be a "gas province with some oil in it". Proven reserves are estimated at 5.21 Tcm. The country can potentially produce much more than current levels, which would be over 100 Bcm per year if it were a normal operating environment; repairs, reopening shut-in fields, and ready markets for the gas would see Nigeria quickly ramp up to this level. However, Nigeria suffers a significant amount of shut-in acreage, sabotage, and violence that makes repairs difficult, and has difficulties marketing its gas production. Much of Nigeria's gas is in associated fields, and must be extracted and either flared or reinjected in order to recover the oil. According to the Nigerian National Petroleum Corporation (NNPC), about 40 per cent of Nigeria's production is flared, of a production level including flaring that is about 56.6 Bcm (before the most recent outages of late April 2008). Nigeria is either the largest or second-largest gas flaring country in the world, depending on the estimate. Nigeria has been able to reduce the percentage of gas flared from 70 per cent a decade ago, but because production has increased, absolute levels have not declined very much. Gas flaring is an enormously important issue in Nigeria, causing local discontent because it is unpleasant to live near, and

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16. EIA estimate, this is likely net of flaring.

offering prima facie evidence of wasted energy in a country where millions suffer from energy poverty. The oil revenues are simply too important to shut down oil production until a way to utilise the associated gas can be implemented, nullifying attempts in recent years to end gas flaring by a fixed date. Nevertheless, gas consumption has increased substantially in recent years (from 6.73 Bcm in 2000 to 10.62 Bcm in 2006), as some important utilisation and export projects have been undertaken. In particular, the most important export project has been Nigeria LNG (NNLG) on Bonny Island, which exported 17.78 Bcm in 2006. With completion of the sixth train in December 2007, NNLG now has export capacity of 22 million tons per year. Another important project is the West Africa Gas Pipeline, which will deliver Nigerian gas to Benin, Togo, and Ghana. The 678 km pipeline had been expected to start functioning in December 2007, but violence and other problems have delayed the start date. Nigeria has plans to expand electric generating capacity dramatically by using gas-fired IPPs, but many have criticised the government plans for having an unrealistic time-frame. Widespread use of expensive diesel generators does indicate much pent-up demand.

### **United States of America**

Because the United States imports large volumes of gas, mostly from Canada, though increasingly in the form of LNG, the fact that the country is the world's second-largest natural gas producer is sometimes ignored. The US has one of the highest reserves-to-production ratios in the world, indicating the mature (well-explored and well-utilised) nature of the sector, at least onshore in the lower 48 states. The country had 448,641 producing gas wells in 2006, and in 2007 produced 545.9 Bcm. Given reserves of 5.98 Tcm, this indicates only about 11 further years of production. Consumption in 2007 was 652.8 Bcm (making it the world's largest consumer, and the first increase since 2004), with net imports of 106.9 Bcm. The US exports gas in the form of LNG, almost entirely to Japan, and is a net exporter of piped gas to Mexico. After large imports of piped gas from Canada, LNG from Trinidad is the US' largest source of imports, with increasing imports from Nigeria, Egypt, and Algeria. Offshore gas production is largely restricted to the Gulf of Mexico offshore Texas and Louisiana, where production declined for the sixth straight year in 2007, but there were increases in the Barnett Shale and Rocky Mountain regions, and deepwater US Gulf of Mexico increased, notably with the Independence Hub platform coming online to produce 28 million cubic metres per day. Gross LNG imports, which reached a record high of 21.8 Bcm in 2007, are expected to reach 26.9 Bcm by 2009.

However, in the last few months of 2007 and into 2008, LNG imports into the US have declined, as growing demand outside of the US has made

for larger pricing differentials between the North American gas market and gas markets elsewhere in the world. As US customers balk at paying those higher prices and domestic supply is somewhat more plentiful than expected, short-term demand forecasts may need to be revised downward. Lower LNG imports may carry some risk of insufficient supply in the event of a spike in demand, as one effect of reduced LNG imports seems to have been lower gas storage levels of late.

Companies in the US continue to make large investments in infrastructure, with some 4.2 billion dollars in pipeline projects completed in 2007. In the future, one of the largest projects will likely be the Alaska Natural Gas Pipeline project, which would make large reserves (estimates are above 900 Bcm) on the North Slope available to the gigantic market in the lower 48 states, but many political hurdles remain in its path.

## **Algeria**

Algeria has the eighth-largest natural gas reserves in the world, at 4.5 Tcm, and its proximity to the large market that is Western Europe has helped it become the EU's third-largest external supplier. This has enabled Algeria to export most of its gas by means of pipelines rather than LNG. Much of the country's reserves are in the super-giant Hassi R'Mel field, and gas fields are far from population centres on the coast, making them relatively secure given the political turmoil that Algeria has experienced in recent years. Production in 2006 was 87 Bcm, and consumption 25.4 Bcm, making for net exports of 61.6 Bcm, of which 23.9 Bcm were exported in the form of LNG. Most went to Europe, but Algerian LNG is also exported to the United States and East Asia. State oil and gas company Sonatrach dominates the sector, but a number of foreign companies have also invested in the sector, including (but not limited to) BP, StatoilHydro, Total, BHP-Billiton, Repsol-YPF, and others. Major projects include development of the In Salah fields, which began production in 2004 and are now generating 9 Bcm per year; the Amenas wet gas project, which came onstream in 2007 and will reach peak production of 9 Bcm and 50,000 bbl/d of liquids in a few years; the Ohanet project, which came online in 2003 and produces 7.3 Bcm and 56,000 bbl/d of liquids (condensate and LPG); and the Gassi Touil exploration project. Gassi Touil was to be developed by Repsol YPF and Gas Natural of Spain, but the project has run into difficulties, and Sonatrach took it over completely from the two Spanish companies in September 2007. Algeria exports to Europe through the Transmed Pipeline via Tunisia (which takes some gas) and Sicily, which was completed in 1983 and expanded in 1994; and the Maghreb-Europe Gas Pipeline, that goes to Spain via Morocco (which takes some gas),

completed in 1996. A third pipeline, Medgaz, is under construction, and will go from Beni Saf in Algeria under the Mediterranean directly to Almería, Spain. Another pipeline, Galsi, is being planned, which would take gas to Sardinia. Combined capacity on these pipelines will be 44.6 Bcm per year, with possible further expansions. Algeria exports LNG through the Skikda (three 1.1-Bcm capacity trains remaining after an accident damaged some facilities a few years ago), and Arzew facilities (15 trains, 25.35 million tons per year).

### **Malaysia**

Malaysia has a lower profile than some other major gas producing countries, but is in fact the world's third-largest exporter of LNG. It has sizeable reserves of 2.35 Tcm, the second-largest in Asia after Indonesia (excluding the Middle East). This is a 230 Bcm increase over estimates at the beginning of 2007, following the discovery of several new deepwater fields offshore Sabah. Production in 2007 reached 60.5 Bcm, a small increase over 2006. Consumption has been steady in recent years, and was about 33 Bcm in 2006. State-owned Petronas leads the sector, and often engages in production-sharing contract consortia with international companies.

Much of Malaysia's domestic consumption is used for gas-fired power, which dominates the electricity sector. More than a dozen offshore Sarawak fields supply the massive Bintulu LNG liquefaction and export facility. Bintulu is the world's largest LNG complex, consisting of three facilities with a total of eight trains, and 23 million tons of capacity. Offshore Sabah is mostly oil-producing, but a production-sharing contract has been awarded to develop the Keabangan fields, whose gas would be brought onshore to a new terminal under construction.

Peninsular Malaysia has older producing fields in its own sector of the Malay basin, but production growth will come from the Joint Development Area with Thailand. The area is divided into three blocks, with a consortium involving a Petronas subsidiary and Thailand's PTT owning blocks B-17 and C-19, and Block A-18 allocated to Petronas and Hess subsidiary Triton. Gas is currently flowing only to Malaysia (11 million cubic metres per day), but is expected to begin supplying Thailand with an additional 11.3 million cubic metres per day summer 2008. Supplying Thailand has required the construction of a pipeline (now more or less complete) linking the field to Thailand's Arthrit field, which is already connected to other domestic infrastructure there. Onshore, the Peninsular Gas Utilization (PGU) project, completed in 1998, expanded natural gas transmission infrastructure on Peninsular Malaysia to over

1,400 km, with the capacity to transport 57 million cubic metres of natural gas per day.

### **Trinidad and Tobago**

Trinidad is known for being the largest source of LNG imports into the US. Its reserves are not among the largest in the world at 532 Bcm, and have not been fully replaced in recent years, but given the small population of the country, the completion and expansion of the Atlantic LNG facility has enabled the country to monetise additional gas production. Atlantic LNG has 4 trains with a combined capacity of 14.8 million metric tons per year – the 5.2 million-ton fourth train is the world's largest. It exported 14.8 Bcm in 2006. Trinidad is also a major producer of methanol from natural gas. Trinidad national company Petrotrin has large equity shares in nearly all projects, but it is the investment of international companies such as Chevron, BP, BG, and others in offshore fields that has increased production notably in the past 10 years. Most gas is from older fields in the east/southeast, such as Cassia, Immortelle, and Flamboyant, and from the BG-operated Dolphin field. Dolphin, which began producing in 1996, is a main supplier to Atlantic LNG, and in 2006 additional gas began flowing from the Dolphin Deep development. Another important development is the BP-led Bombax and Kapok pipeline development project, which enables gas from the Mahogany field to feed Atlantic LNG's facility. Off the north coast, BG has developed the Hibiscus, Poinsettia, and Chaconia fields, with Hibiscus already producing to supply Atlantic LNG. Development of gas reserves straddling Trinidad's maritime border with Venezuela, such as the Manatee field discovered in 2005, require agreement with Venezuela for uncontested and even joint development with nearby Venezuelan assets. An agreement between the two countries was signed in March 2007, but more details may still have to be worked out.

### **United Kingdom and the Netherlands**

The UK has gone from being a net gas exporter to a net gas importer in recent years. The country is the EU's largest gas producer, and still one of the world's largest producers despite declining production since 2001. The Netherlands is the EU's second-largest producer, and combined the two countries produce 70 per cent of the EU's internal supply (75.6 Bcm and 75.1 Bcm, respectively in 2007). If the UK continues to decline at a faster rate than the Netherlands, it is possible that the Netherlands could soon become the EU's largest producer. Because the UK is such a large consumer (95.6 Bcm), it became a net importer in 2004, and net imports

reached 19.4 Bcm in 2007. The Netherlands, with smaller domestic consumption, is still a net exporter, at 19.8 Bcm in 2007. As is well known, most of the UK's gas production comes from the North Sea, particular, associated fields in the northern part of the UK sector between Scotland and Norway, and non-associated fields in the southern part of the sector (Southern Gas Basin). There is also some production from fields in the Irish Sea. Mainstay fields in the Southern Gas Basin are declining, and independents have taken over some fields from larger companies in an effort to maintain profitable investment into declining fields. The UK and Netherlands have private/publicly traded companies mostly in their gas sectors, though the state-owned Gasunie owns the Dutch transmission network. The Netherlands draws most of its production from the giant Groningen onshore field, though it has some production in its sector of the North Sea. Both countries have pipeline networks that bring gas from offshore (including Norwegian gas), and the UK is also connected to Zeebrugge, Belgium. This was formerly for export, but the line has been reversed for import. There is also a connection between Scotland and the Republic of Ireland. Two of the most important recent pipeline projects are the Langeled Pipeline and the Balgzand-Bacton Line. The Langeled Pipeline is the longest sub-sea pipeline in the world, and connects the Nyhmana Terminal in Norway (taking gas from the nearby Ormen Lange field) with Easington, England, via the Sleipner Riser platform. The northern section, completing the project, opened in October 2007. Capacity is 70 million cubic metres per year. Balgzand-Bacton is the first gas connection between the UK and the Netherlands (for export to the UK). It began operating in December 2006, and has annual capacity of 15 Bcm.