Chapter 4

Natural Gas

Natural gas trails coal as the fastest growing primary energy source in IEO2006. The natural gas share of total world energy consumption increases from 24 percent in 2003 to 26 percent in 2030.

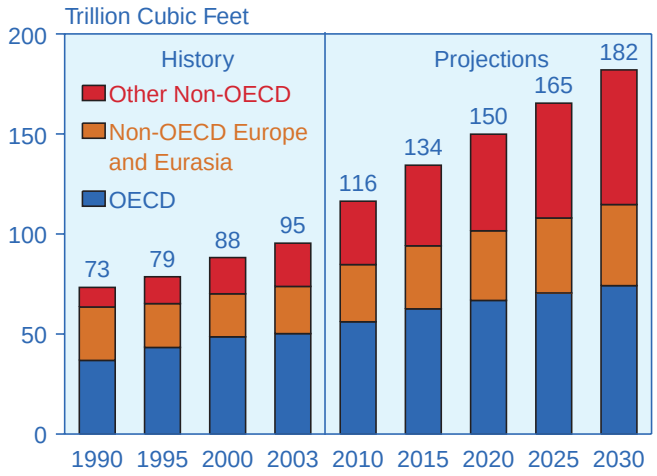
Consumption of natural gas worldwide increases from 95 trillion cubic feet in 2003 to 182 trillion cubic feet in 2030 in the *IEO2006* reference case (Figure 34). Although natural gas is expected to be an important fuel source in the electric power and industrial sectors, the annual growth rate for natural gas consumption in the projections is slightly lower than the growth rate for coal consumption—in contrast to past editions of the *IEO*. Higher world oil prices in *IEO2006* increase the demand for and price of natural gas, making coal a more economical fuel source in the projections.

Natural gas consumption worldwide increases at an average rate of 2.4 percent annually from 2003 to 2030, as compared with 2.5 percent per year for coal and 1.4 percent per year for oil. Nevertheless, natural gas remains a more environmentally attractive energy source and burns more efficiently than coal, and it still is expected to be the fuel of choice in many regions of the world. As a result, the natural gas share of total world energy consumption (on a Btu basis) grows from 24 percent in 2003 to 26 percent in 2030.

Worldwide, the industrial and electric power sectors are the largest consumers of natural gas (Figure 35). In 2003, the industrial sector accounted for 44 percent and the electric power sector 31 percent of the world's total natural gas consumption. In the projections, natural gas use grows by 2.8 percent per year in the industrial sector and 2.9 percent per year in the electric power sector from 2003 to 2030. In both sectors, the share of total energy demand met by natural gas grows over the projection period. In the industrial sector, natural gas overtakes oil as the dominant fuel by 2030. In the electric power sector, however, despite its rapid growth, natural gas remains a distant second to coal in terms of share of total energy use for electricity generation.

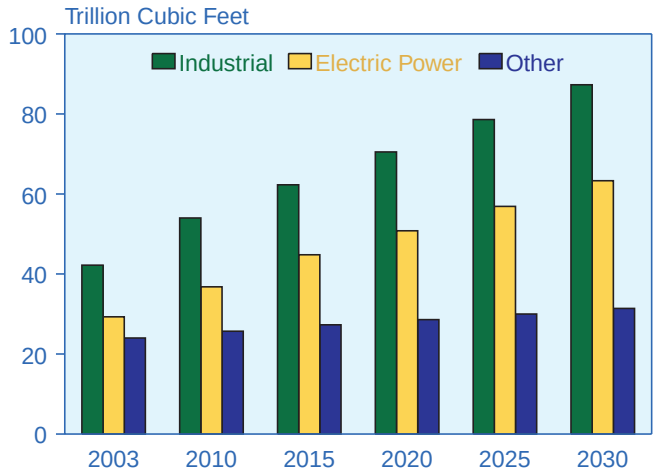
In 2003, OECD member countries accounted for just over one-half of the world's total natural gas use, non-OECD Europe and Eurasia accounted for one-quarter, and the other non-OECD countries accounted for the remainder. The OECD countries are, by and large, mature consumers of natural gas with well-established infrastructure and consuming patterns. In contrast, natural gas infrastructure in the non-OECD countries, outside of non-OECD Europe and Eurasia, is largely in its infancy, and natural gas demand is fairly small. The *IEO2006* reference case projects fast-paced growth in

Figure 34. World Natural Gas Consumption by Region, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

Figure 35. World Natural Gas Consumption by End-Use Sector, 2003-2030



Sources: **2003:** Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

demand for natural gas among those non-OECD countries, as their natural gas infrastructures expand.

In the reference case, natural gas consumption in the non-OECD countries grows more than twice as fast as consumption in the OECD countries, with 3.3 percent average annual growth from 2003 to 2030 for non-OECD countries, compared with an average of 1.5 percent for the OECD countries. Natural gas demand in the non-OECD countries accounts for 73 percent of the total world increment in natural gas consumption over the projection horizon. In the non-OECD countries (excluding non-OECD Europe and Eurasia) natural gas use increases from less than one-quarter of the world total in 2003 to 38 percent in 2030.

Reserves and Resources

Historically, world natural gas reserves have, for the most part, trended upward (Figure 36). As of January 1, 2006, proved world natural gas reserves, as reported by *Oil & Gas Journal*,[5] were estimated at 6,112 trillion cubic feet—70 trillion cubic feet (about 1 percent) higher than the estimate for 2005 [***1***].

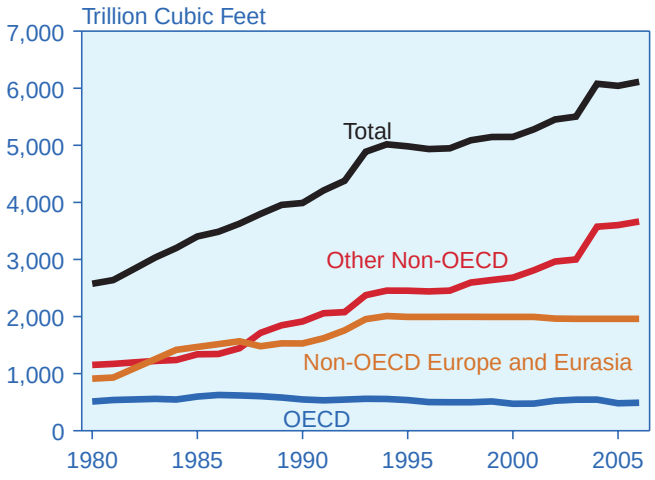
The largest revision to natural gas reserve estimates was made in Iran. Iran's natural gas reserves increased by 31 trillion cubic feet (3 percent) between 2005 and 2006, from 940 trillion cubic feet to 971 trillion cubic feet. Also in the Middle East, higher reserve estimates were reported by Saudi Arabia, with an increase of 7 trillion cubic feet (3 percent). Other countries with substantial increases in reserves include Norway with a gain of 11 trillion cubic feet (14 percent), Nigeria with an increase of 9 trillion cubic feet (5 percent), and Indonesia with an increase of 7 trillion cubic feet (8 percent). Declining natural gas reserves were reported for Bangladesh (a decrease of 6 trillion cubic feet), and smaller losses were reported for Argentina (3 trillion cubic feet), Taiwan (2 trillion cubic feet), Germany (1 trillion cubic feet), and the United Kingdom (1 trillion cubic feet).

Almost three-quarters of the world's natural gas reserves are located in the Middle East and Eurasia (Figure 37). Russia, Iran, and Qatar combined accounted for about 58 percent of the world's natural gas reserves as of January 1, 2006 (Table 8). Reserves in the rest of the world are fairly evenly distributed on a regional basis.

Despite high rates of increase in natural gas consumption, particularly over the past decade, most regional reserves-to-production ratios have remained high. Worldwide, the reserves-to-production ratio is estimated at 66.7 years [**2**]. Central and South America has a reserves-to-production ratio of 55.0 years, Russia 81.5 years, and Africa 96.9 years. The Middle East's reserves-to-production ratio exceeds 100 years.

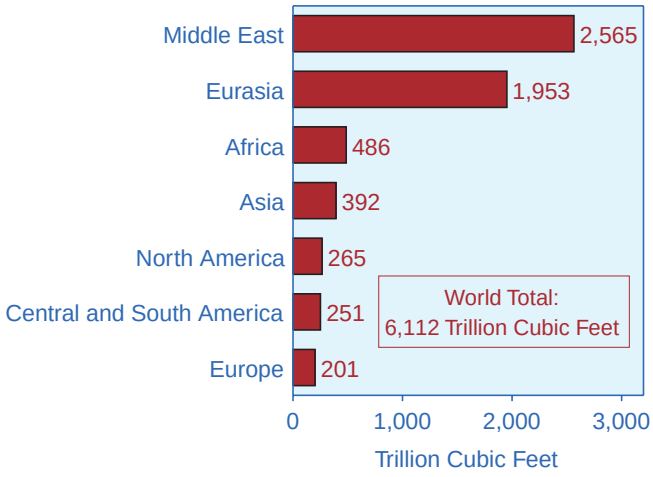
The U.S. Geological Survey (USGS) periodically assesses the long-term production potential of worldwide petroleum resources (oil, natural gas, and natural gas liquids). According to the most recent USGS estimates, released in the *World Petroleum Assessment 2000* and adjusted to reflect current proved reserves, a significant volume of natural gas remains to be discovered. Worldwide undiscovered natural gas is estimated at 4,221 trillion

Figure 36. World Natural Gas Reserves by Region, 1980-2006



Sources: **1980-1993:** "Worldwide Oil and Gas at a Glance," *International Petroleum Encyclopedia* (Tulsa, OK: PennWell Publishing, various issues). **1994-2006:** *Oil & Gas Journal* (various issues).

Figure 37. World Natural Gas Reserves by Geographic Region as of January 1, 2006



Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25.

[5]Proved reserves, as reported by the *Oil & Gas Journal*, are estimated quantities that can be recovered under present technology and prices. Natural gas reserves reported by the *Oil & Gas Journal* are compiled from voluntary survey responses and do not always reflect the most recent changes. Significant natural gas discoveries made during 2005 are not likely to be reflected in the reported reserves.

cubic feet (Figure 38), slightly larger than the *IEO2006* projection for cumulative worldwide natural gas consumption from 2003 to 2030.

Of the total natural gas resource base, an estimated 3,000 trillion cubic feet is in "stranded" reserves, usually located too far away from pipeline infrastructure or population centers for its transportation to be economical. Of the new natural gas resources expected to be added through 2025, reserve growth accounts for 2,347 trillion cubic feet. More than one-half of the mean undiscovered natural gas estimate is expected to come from Eurasia, the Middle East, and North Africa; and about one-fourth (1,065 trillion cubic feet) is expected to come from a combination of North, Central, and South America.

World Natural Gas Supply

Non-OECD Europe and Eurasia and the Middle East account for almost three-quarters of the world's natural gas reserves, but in 2003 they accounted for only 39 percent of world production. Together, these two regions account for 47 percent of the projected increase in global natural gas production from 2003 to 2030 (Table 9), much of it for export to OECD countries.

Russia is already the world's single largest exporter of natural gas, with net exports of 6.3 trillion cubic feet in 2003, all of it by pipeline. There are also some plans to export natural gas from the Middle East, but much of the region's increase in production is projected to be used domestically—particularly in the electric power sector, where shifts from petroleum to natural gas allow the producing countries to monetize more of their oil assets through export.

Other non-OECD regions are also expected to increase their natural gas production strongly. Africa, with its rich and underdeveloped natural gas resources, has the fastest growth rate in natural gas production worldwide, with supply rising by 4.9 percent per year from 2003 to 2030. A considerable amount of the incremental production in Africa—from Algeria, Nigeria, Libya, and Egypt—is slated for export, both by pipeline and in the form of liquefied natural gas (LNG).

Natural gas production in non-OECD Asia also grows substantially over the projection period, but all the growth in supply is required for consumption within the region, and imports are needed to fill the shortfall. In Central and South America, natural gas production outpaces regional demand. As a result, Trinidad and Tobago continues to export LNG outside the region. Peru, and possibly Venezuela, may also begin to export LNG outside the region over the course of the projection.

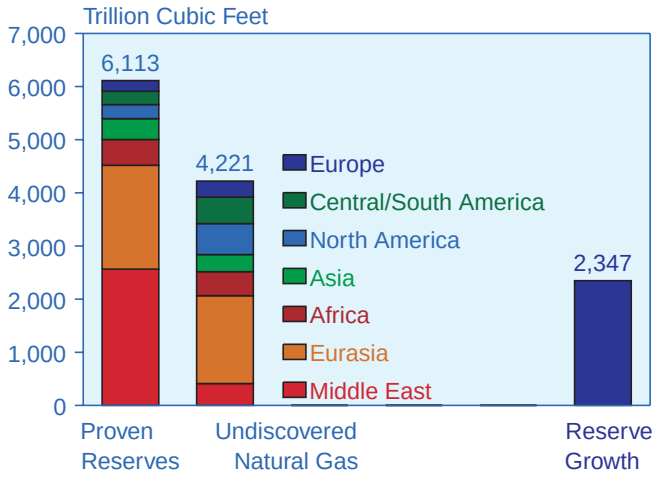
In 2003, the OECD countries accounted for 41 percent of the world's total natural gas production and 52 percent

Table 8. World Natural Gas Reserves by Country as of January 1, 2006

Country	Reserves (Trillion Cubic Feet)	Percent of World Total
World	**6,112**	**100.0**
Top 20 Countries	**5,510**	**90.2**
Russia	1,680	27.5
Iran	971	15.9
Qatar	911	14.9
Saudi Arabia	241	3.9
United Arab Emirates	214	3.5
United States	193	3.1
Nigeria	185	3.0
Algeria	161	2.6
Venezuela	151	2.5
Iraq	112	1.8
Indonesia	98	1.6
Norway	84	1.4
Malaysia	75	1.2
Turkmenistan	71	1.2
Uzbekistan	66	1.1
Kazakhstan	65	1.1
Netherlands	62	1.0
Egypt	59	1.0
Canada	57	0.9
Kuwait	56	0.9
Rest of World	**602**	**9.8**

Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25.

Figure 38. World Natural Gas Resources by Geographic Region, 2006-2025



Source: U.S. Geological Survey, *World Petroleum Assessment 2000*, web site http://greenwood.cr.usgs.gov/energy/WorldEnergy/DDS-60; "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 103, No. 47 (December 19, 2005), pp. 24-25; and Energy Information Administration estimates.

of total natural gas consumption; in 2030, they are projected to account for only 25 percent of production and 40 percent of consumption. Natural gas supply from the OECD nations increases by an average of only 0.5 percent per year in the *IEO2006* reference case, whereas demand increases by 1.5 percent per year. As a result, the OECD countries rely increasingly on imports to meet natural gas demand (Figure 39), with a growing percentage of traded natural gas coming in the form of LNG. OECD countries rely on natural gas produced in other parts of the world to meet more than one-third of their natural gas consumption in 2030, up from 22 percent in 2003.

LNG is expected to become an increasingly important source of supply to meet the world's demand for natural gas. Although there were only 12 LNG-exporting countries in 2004,[6] the number is increasing. In 2005, Egypt joined the ranks of LNG-producing countries with the start of two separate liquefaction projects. Russia also entered the LNG business in 2005, not with LNG it produced but with LNG for which it traded pipeline natural gas [3]. Not until 2008, when the Sakhalin liquefaction project is expected to start operations, will Russia become an LNG-producing country. Norway and Equatorial Guinea also have their first liquefaction terminals under construction, and construction on the first liquefaction terminal in South America is scheduled to begin in 2006 in Peru.

The number of countries installing the infrastructure necessary to accept LNG imports is also increasing.

Table 9. World Natural Gas Production by Region and Country, 2003-2030
(Trillion Cubic Feet)

Region/Country	2003	2010	2015	2020	2025	2030	Average Annual Percent Change, 2003-2030
OECD North America	**27.1**	**26.4**	**28.1**	**29.3**	**29.9**	**30.4**	**0.4**
United States	19.0	18.6	20.4	21.6	21.4	21.2	0.4
Canada	6.5	6.1	5.8	5.5	5.8	6.2	-0.2
Mexico	1.5	1.7	1.9	2.2	2.6	3.0	2.6
OECD Europe	**10.7**	**10.9**	**11.0**	**10.7**	**10.7**	**10.3**	**-0.2**
OECD Asia	**1.5**	**2.4**	**3.2**	**3.9**	**4.4**	**4.8**	**4.3**
Japan	0.1	0.1	0.1	0.1	0.1	0.1	0.6
South Korea	0.0	0.0	0.0	0.0	0.0	0.0	—
Australia/New Zealand	1.4	2.3	3.1	3.8	4.2	4.6	4.5
Total OECD	**39.3**	**39.7**	**42.3**	**44.0**	**44.9**	**45.4**	**0.5**
Non-OECD Europe and Eurasia	**27.9**	**33.9**	**38.2**	**42.0**	**45.7**	**51.1**	**2.3**
Russia	21.8	26.8	30.4	33.5	36.6	41.5	2.4
Other	6.1	7.1	7.8	8.5	9.0	9.6	1.7
Non-OECD Asia	**9.7**	**12.9**	**16.5**	**19.9**	**23.7**	**27.4**	**3.9**
China	1.2	2.4	3.0	3.5	3.9	4.4	4.9
India	1.0	1.1	1.3	1.6	1.9	2.4	3.5
Other non-OECD Asia	7.5	9.3	12.2	14.8	17.8	20.6	3.8
Middle East	**9.1**	**14.2**	**17.1**	**19.8**	**23.1**	**26.2**	**4.0**
Africa	**5.1**	**8.7**	**11.4**	**14.3**	**16.3**	**18.5**	**4.9**
Central and South America	**4.2**	**6.7**	**8.4**	**9.6**	**11.4**	**13.0**	**4.3**
Brazil	0.3	0.6	0.7	0.8	0.9	1.1	4.8
Other Central /South America	3.9	6.2	7.7	8.8	10.5	11.9	4.2
Total Non-OECD	**55.9**	**76.4**	**91.7**	**105.6**	**120.2**	**136.2**	**3.4**
Total World	**95.2**	**116.1**	**134.0**	**149.6**	**165.1**	**181.6**	**2.4**

Note: Totals may not equal sum of components due to independent rounding.
Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2010-2030: United States:** EIA, *Annual Energy Outlook 2006*, DOE/EIA-0383 (2006) (Washington, DC, February 2006), web site www.eia.doe.gov/oiaf/aeo/. **Others:** EIA, System for the Analysis of Global Energy Markets (2006).

[6]Algeria, United States, Libya, Brunei, United Arab Emirates, Indonesia, Malaysia, Australia, Qatar, Nigeria, Trinidad and Tobago, and Oman.

More than 30 years had passed since the United Kingdom imported LNG, but in 2005 it rejoined the ranks of LNG importers, with the startup of its Isle of Grain regasification terminal. China, Canada, and Mexico all have their first LNG import terminals under construction; and Germany, Poland, Croatia, Singapore, and Chile are among the other countries considering their first regasification terminals.

World Natural Gas Demand

OECD North America

North America's natural gas consumption (Figure 40) is projected to increase at an average annual rate of 1.1 percent between 2003 and 2030. The regional growth rate for natural gas demand is somewhat slower than in past *IEO*s, largely because of the impact of higher prices and supply concerns in natural gas markets of the United States, North America's largest consumer. The United States accounted for more than 80 percent of the 27.4 trillion cubic feet of natural gas consumed in the region in 2003, and its share of the total in 2030 is 73 percent, despite robust growth in demand for natural gas in Canada and Mexico, averaging 1.9 percent per year and 3.4 percent per year, respectively.

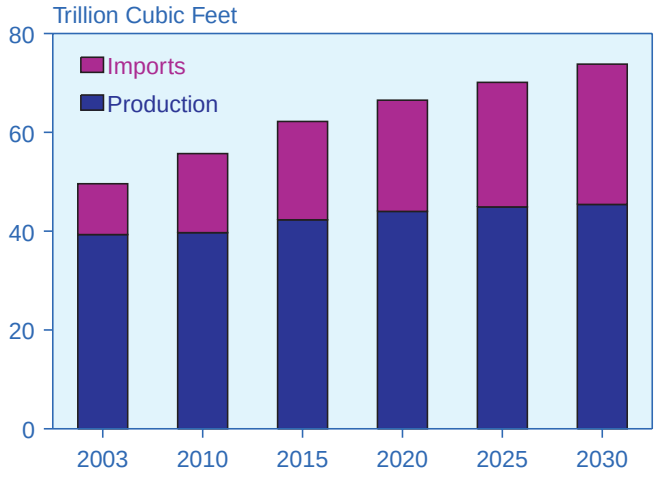
The current high levels of natural gas prices in the United States are expected to discourage the construction of new natural-gas-fired electricity generation plants in the mid-term. As a result, only 130 gigawatts of new natural-gas-fired capacity is added from 2003 through 2030 in the reference case, as compared with 154 gigawatts of new coal-fired capacity. U.S. natural gas consumption for electricity generation peaks in 2020 at 7.5 trillion cubic feet, followed by a decline to 6.4 trillion cubic feet in 2030.

Natural gas prices in the United States remain relatively high throughout the projection period; and as a result, consumption of natural gas in the U.S. industrial sector grows slowly, from 8.3 trillion cubic feet in 2003 to 10.0 trillion cubic feet in 2030. Natural gas consumption increases in all the major industrial sectors, with the exception of the refining industry. High prices also limit consumption increases in the U.S. buildings sector (residential and commercial), where natural gas use grows from 8.3 trillion cubic feet in 2003 to 9.6 trillion cubic feet in 2030. The net result of changes in energy use in the electric power, industrial, and other end-use sectors is that U.S. natural gas consumption is essentially flat between 2020 and 2030.

Canada, currently the source of almost 90 percent of U.S. net natural gas imports, remains the primary source of natural gas imported into the United States until 2010. After 2010, LNG imports replace Canadian imports as the primary source. The decline of Canada's largest producing basin, the Western Sedimentary Basin, coupled with 1.9-percent projected average annual growth in Canada's domestic consumption, leaves less Canadian natural gas available for export to the United States.

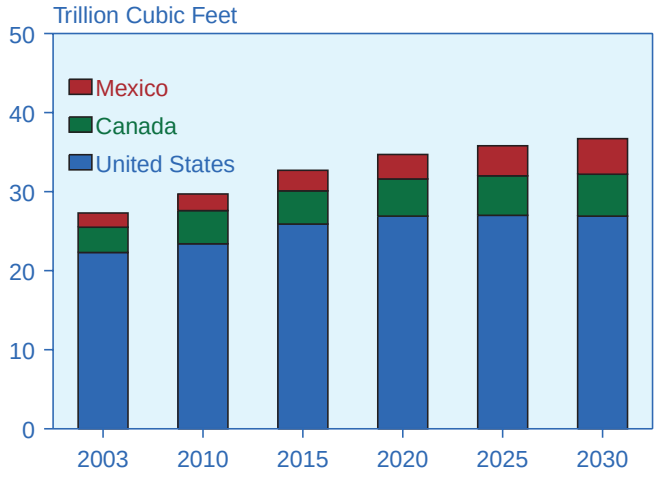
In EIA's *Annual Energy Outlook 2006* (*AEO2006*) reference case, rising natural gas prices make it economical for two major North American pipelines that have long been in the planning stages to come online. The first, a Canadian pipeline to transport natural gas from the MacKenzie Delta, is expected to become operational in 2011. The second, an Alaska pipeline, is expected to

Figure 39. OECD Natural Gas Supply by Source, 2003-2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

Figure 40. Natural Gas Consumption in North America by Country, 2003-2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

begin transporting natural gas from Alaska to the lower 48 States in 2015, contributing significantly to U.S. domestic supply. From 2003 to 2030, Alaska's natural gas production accounts for most of the growth in domestic U.S. conventional natural gas production, with flows on the pipeline exceeding 2 trillion cubic feet in 2030.

The other expected source of U.S. domestic incremental supply is unconventional natural gas production. More than one-third of the remaining U.S. technically recoverable resource base consists of unconventional sources, which include tight sands, shale, and coalbed methane. With most of the large onshore conventional fields in the United States already having been discovered, the United States, like Canada, must look to these costlier sources of supply to make up for declines in conventional production.

Currently, the United States has five LNG import facilities in operation, with a combined peak annual capacity of 1.6 trillion cubic feet. Three additional terminals under construction in the Gulf of Mexico will add a combined peak annual regasification capacity of 2.0 trillion cubic feet, more than doubling U.S. LNG import capacity. *AEO2006* projects peak annual U.S. LNG import capacity in 2030 at 5.9 trillion cubic feet, with actual imports of 4.4 trillion cubic feet (Figure 41). The growth of U.S. LNG import capacity is expected to be strong through 2015 and then to slow as high natural gas prices begin to slow the growth of domestic consumption. LNG imports into Canada are also expected to contribute to the supply of Canadian natural gas available for export to the United States. LNG is expected to be a significant contributor to supply in the United States, indicative of the country's growing dependence on imports and the increasing globalization of natural gas markets.

In Canada, most of the projected increase in natural gas consumption is for industrial uses and electricity generation, with only moderate growth in the other consuming sectors. Although natural gas use in Canada's electric power sector more than doubles from 2003 to 2030, the largest absolute increase is projected for the industrial sector, largely because significant amounts of natural gas are expected to be used in the mining of Canada's expansive oil sands deposits.

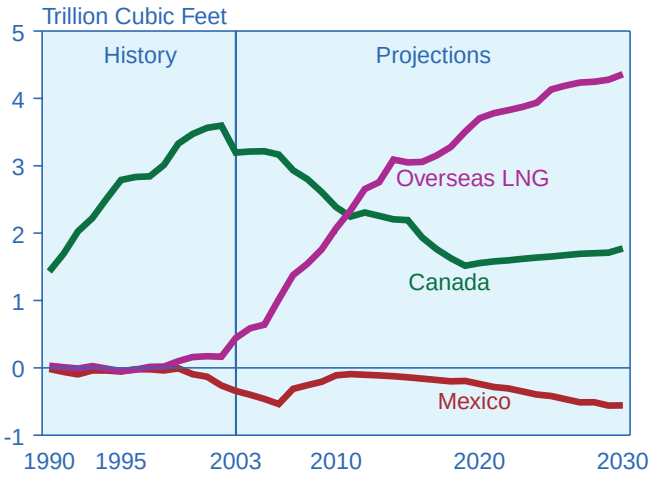
Canada produced more than twice as much natural gas as it consumed in 2003, and the balance was exported to the United States. In 2030, Canada is projected to consume 85 percent of its own production, leaving only 15 percent available for export. Increases in unconventional production in western Canada and conventional production in the MacKenzie Delta and Eastern Canada are expected to help reverse the decline in production after 2020, and net exports to the United States increase gradually from 2020 to 2030.

In Mexico, strong growth in natural gas consumption for industry and for electricity generation is expected, with industrial consumption doubling and consumption for electricity generation more than tripling between 2003 and 2030. Growth in Mexico's natural gas consumption is expected to far outpace growth in its production. Although Mexico has significant untapped natural gas reserves, the Mexican government does not have the resources needed to develop them and to date has been relatively unsuccessful in attracting foreign capital. Currently, only the state oil and natural gas company, Petroleos Mexicanos (PEMEX), is allowed to have any ownership interest in Mexico's oil and natural gas reserves. Mexico is thus expected to be dependent on pipeline imports from the United States and LNG imports to meet its growing supply deficit. In the reference case, imports grow from 17 percent of Mexico's total natural gas consumption in 2003 to 33 percent in 2030. Throughout the projections, Mexico remains a net importer of natural gas from the United States.

OECD Europe

Natural gas is expected to be the fastest growing fuel source in OECD Europe, with demand increasing at an annual average rate of 2.0 percent, from 17.8 trillion cubic feet in 2003 to 23.9 trillion cubic feet in 2015 and 30.8 trillion cubic feet in 2030. Almost 60 percent of incremental natural gas consumption in OECD Europe between 2003 and 2030 is expected to be used for electric power generation (Figure 42). Natural-gas-fired generation is less carbon-intensive than oil- or coal-fired generation and is expected to remain more cost-competitive

Figure 41. U.S. Natural Gas Supply by Source, 1990-2030



Sources: **History:** Energy Information Administration (EIA), *Annual Energy Review 2004*, DOE/EIA-0384(2004) (Washington, DC, August 2005), web site www.eia.doe.gov/emeu/aer/. **Projections:** EIA, *Annual Energy Outlook 2006*, DOE/EIA-0383(2006) (Washington, DC, February 2006), web site www.eia.doe.gov/oiaf/aeo/.

than renewable energy, making natural gas the fuel of choice for new generating capacity in OECD Europe.

Natural gas consumption for electricity generation in OECD Europe increases on average by 3.9 percent per year from 2003 to 2030, surpassing the use of renewables for electricity generation (on a Btu basis) by 2015 and the use of coal or nuclear power by 2020. The share of total electricity sector energy demand met by natural gas increases from 14 percent in 2003 to 24 percent in 2015 and 32 percent in 2030.

OECD Europe received net imports of around 7 trillion cubic feet of natural gas in 2003, accounting for more than one-third of the region's total natural gas consumption. With domestic production declining in most of the countries of OECD Europe, the region's reliance on imported natural gas grows to more than one-half of demand in 2015 and almost two-thirds in 2030. Russia, alone, currently provides around two-thirds of Europe's imports, and much of Europe was affected in January 2006 when Russia, in a dispute over contract prices, cut off natural gas supplies to Ukraine.

Security and diversity of natural gas supply are major concerns for OECD Europe now and going forward. Europe is aggressively expanding LNG receiving capacity, and several new pipelines have been proposed that would link Europe to supplies in Egypt, the Middle East, and the Caspian Basin, and would increase capacity from North Africa and add capacity from Russia via routes that bypass traditional transit states.

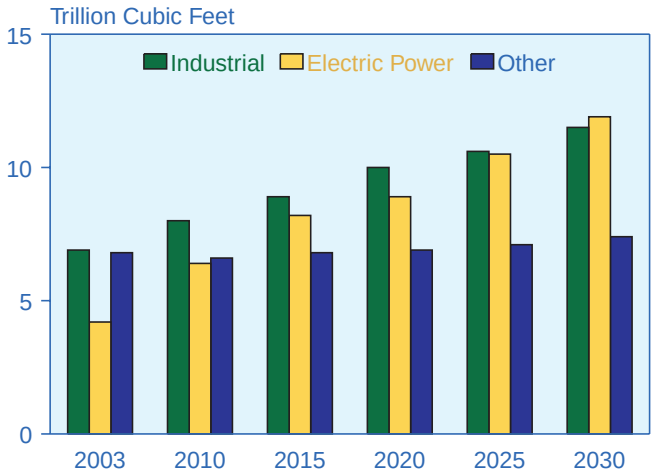
OECD Asia

In the *IEO2006* reference case, Japan has the lowest growth rate for natural gas consumption among the OECD countries outside North America (Figure 43), mainly because its population declines and its economic growth is relatively slow. Even with an average annual growth rate in consumption of only 0.8 percent, however, natural gas still is the second fastest growing primary energy source in Japan, behind nuclear power.

Total natural gas consumption in South Korea grows at an average annual rate of 1.7 percent from 2003 to 2030. In 2003, the residential sector was the country's predominant consumer of natural gas, accounting for 39 percent of the total, with the electric power sector a close second at 33 percent of total natural gas use. In the projections, natural gas use in South Korea's industrial sector increases on average by 4.9 percent per year from 2003 to 2030, compared with average annual growth of 0.7 percent in the residential sector. By 2020, natural gas consumption in the country's industrial sector surpasses that in its residential sector; and in 2030, industrial natural gas use accounts for more than 45 percent of all the natural gas consumed in South Korea.

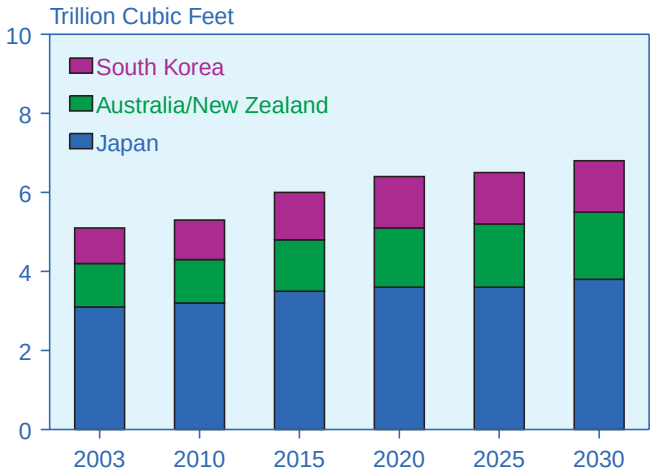
In Australia and New Zealand, the industrial sector currently is the predominant user of natural gas, and it accounts for more than one-half of all natural gas consumption in the region throughout the projection period. Natural gas is the fastest growing fuel in Australia and New Zealand in the reference case; however, with the region's abundance of coal reserves, and with

Figure 42. Natural Gas Consumption in OECD Europe by End-Use Sector, 2003-2030



Sources: **2003:** Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

Figure 43. Natural Gas Consumption in OECD Asia by Country, 2003-2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

its natural gas reserves located far from demand centers, its natural gas consumption in 2030 on a Btu basis is less than one-half of its coal consumption.

Non-OECD Europe and Eurasia

The non-OECD Europe and Eurasia region is more reliant on natural gas than any other region in the world. Russia is second only to the United States in total natural gas consumption, and it is the only country in the world where natural gas accounts for more than one-half of total primary energy consumption. In 2003, Russia consumed 15.3 trillion cubic feet of natural gas. The other countries of non-OECD Europe and Eurasia met 44 percent of their combined total energy needs with natural gas in 2003.

Growth in natural gas demand in non-OECD Europe and Eurasia remains strong throughout the projection period, with an average annual growth rate of 2.0 percent from 2003 to 2030. Natural gas consumption in both the electric power and industrial sectors increases by around 8 trillion cubic feet from 2003 to 2030 (Figure 44). Natural gas use in the electric power sector grows slightly faster, at 2.4 percent per year, from 8.4 trillion cubic feet in 2003 to 16.1 trillion cubic feet in 2030. Industrial natural gas consumption in the region grows by an average of 2.1 percent per year, from 11.0 trillion cubic feet in 2003 to 19.1 trillion cubic feet in 2030.

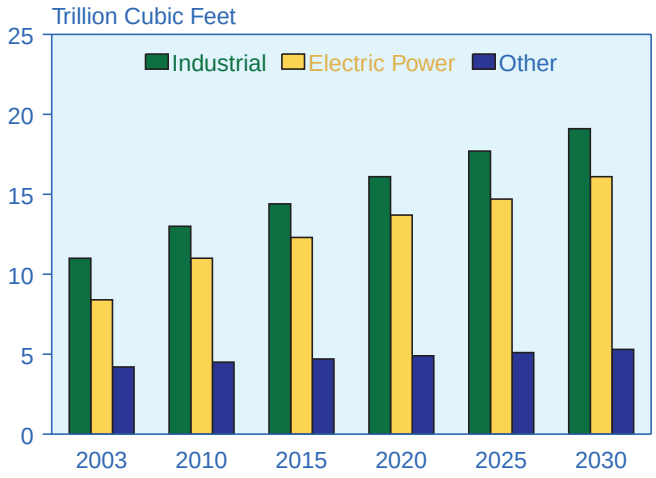
Other Non-OECD

In the rest of the non-OECD countries, significant growth in natural gas use is projected from 2003 to 2030, as strong economic growth and available resources encourage the development of natural gas infrastructure to support demand. In the other non-OECD countries (excluding non-OECD Europe and Eurasia), natural gas demand triples in the *IEO2006* reference case, from 21.7 trillion cubic feet in 2003 to 67.3 trillion cubic feet in 2030.

Non-OECD Asia accounts for much of the growth in natural gas demand projected for the non-OECD region. Led by demand in China and India, natural gas consumption in non-OECD Asia expands by 5.1 percent per year on average from 2003 to 2030. In both China and India, natural gas is currently a minor fuel in the overall energy mix, representing only 3 percent and 7 percent, respectively, of total primary energy consumption in 2003; however, both countries are rapidly expanding infrastructure to facilitate natural gas consumption, as well as natural gas imports. In the reference case, natural gas consumption grows at an average annual rate of 6.8 percent in China and 5.9 percent in India.

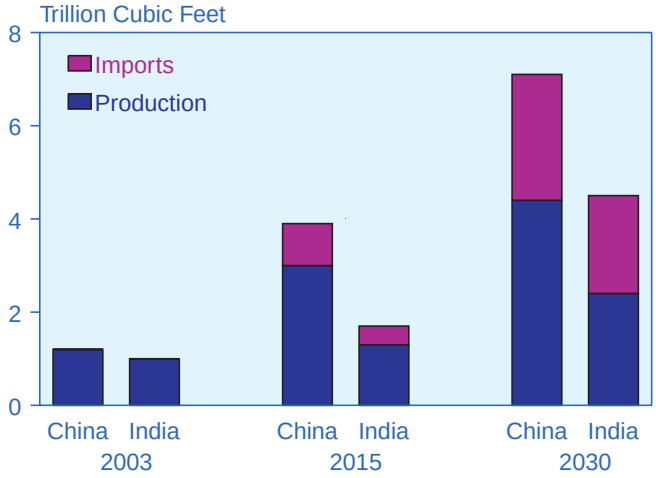
Both China and India have limited natural gas reserves and are projected to rely on imports to meet more than 40 percent of natural gas demand in 2030 (Figure 45). Both countries have been discussing possible import pipelines, but none is imminent. China and India have also been pursuing LNG imports. China has two regasification terminals under construction and a number of others approved or proposed (see box on page 45). India has two terminals operating and several more proposed. The supply contracts for China's Guandong and Fujian terminals, as well as India's Dahej terminal, were signed several years ago at historically favorable terms and prices; however, both countries are finding it difficult to secure additional long-term LNG supplies for any of their proposed regasification terminals at prices that local natural gas consumers would find acceptable [*4*].

Figure 44. Natural Gas Consumption in Non-OECD Europe and Eurasia by End-Use Sector, 2003-2030



Sources: **2003:** Derived from Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

Figure 45. Natural Gas Supply in China and India by Source, 2003, 2015, and 2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **2015 and 2030:** EIA, System for the Analysis of Global Energy Markets (2006).

Liquefied Natural Gas: Market Developments in China

Pressed by shortages of peak-load capacity and growing concern about pollution from coal burning, China has begun to turn to cleaner burning fuels—in particular, LNG—for electricity generation. There is great potential for development of LNG within China, and a number of regasification facilities are currently under construction or planned, especially in the eastern part of the country, where access to coal resources is limited (see map below). In large part, however, the growth of China's LNG market may be limited by competition with coal.

Rapid growth in China's manufacturing output increased its electric power demand by about 15 percent

(continued on page 46)

China's Natural Gas Pipelines and Major LNG Terminals Under Construction, Approved, or Proposed

Sources: **Coal:** Barlow Jonker Pty. Ltd., *Major Coalfields of China* (Sydney, Australia, 2001). **Natural Gas:** Jeffrey Logan, Senior Energy Analyst and China Program Manager, International Energy Agency, "China Oil and Gas Outlook and Implications for Energy Markets," Testimony Before the U.S. Senate, Committee on Energy and Natural Resources, Hearing on EIA's Annual Energy Outlook for 2005 (Washington, DC, February 3, 2005), web site http://energy.senate.gov/public/.

Liquefied Natural Gas: Market Developments in China (Continued)

in 2004.[a] In summer 2004, China saw a 30-gigawatt nationwide power deficit, with 24 provincial grids forced to restrict power supplies,[b] prompting a sharp increase in demand for fuel oil (estimated at 170,000 barrels per day) to generate electricity, in addition to the existing 300,000 barrels per day used for electric power generation annually.[c] The power shortage is expected to continue through 2006, but demand for fuel oil in the power sector is expected to fall in the second half of 2006, when new LNG projects come online. China's LNG imports are expected to increase from 1 million metric tons in 2006 to between 20.9 and 25.9 million metric tons in 2015.[d]

Several LNG projects are underway in China. Construction of the country's first LNG regasification terminal, in Guangdong Province, has been completed, and the facility is scheduled to receive its first cargo in June 2006 from North West Shelf Australian LNG. A second LNG terminal, in the city of Xiuyu in Fujian Province, is scheduled for completion by 2008. At present, the Chinese government is reviewing more than 10 additional LNG proposals up and down China's coastline (see table below).

Plans to build LNG terminals on China's northeast coast developed quickly in 2004, accelerating when negotiations between China and Russia over a major proposed natural gas pipeline project that would bring natural gas from Irkutsk, Russia, to northern China were stalled. Lack of progress in the negotiation resulted mainly from China's insistence that the price of natural gas from Russia be indexed to domestic coal prices in China. LNG pricing in Asian contracts traditionally has been linked to the price of oil, not coal, but China has been attempting to index LNG and pipeline natural gas imports to the price of domestic coal.

The three LNG projects most likely to be built after the Guangdong and Fujian projects are in Shanghai, Ningbao (Zhejian Province), and Qingdao (Shandong Province). Economic growth and industrial output in the two provinces are the highest in China, making it possible for their regional governments to purchase relatively expensive imported natural gas. Shanghai is both China's largest city and its largest port, and it is one of the most prosperous cities in China. The municipal government of Shanghai is planning to phase out use of coal in the city over the course of the next 10 years. At present, Shanghai consumes more than 46 million short tons of coal per year, providing 70 percent of its energy needs.[e] Shandong is rich in coal, but the provincial power companies still have coal production and deliverability problems, and there is a serious lack of available peaking capacity.[f]

Most of the areas in China targeted for LNG developments have large coal-fired power plants, and the government is carefully considering the issue of natural gas and coal prices charged to the power plants. In 2004, the cost of coal from northern China was around $1.92 per million Btu, and the average cost of natural

(continued on page 47)

China's Proposed LNG Imports, 2005-2015
(Million Metric Tons per Year)

Year	Haikou LNG (Hainan)	Shenzhen LNG (Guangdong)	Xiuyu LNG (Fujian)	Ningbao LNG (Zhejian)	Shanghai LNG	Rudong LNG (Jiangsu)	Qingdao LNG (Shandong)	Hebei/ Tianjin LNG	Dalian LNG (Liaoning)	Beihai LNG (Guangxi)
2005	—	—	—	—	—	—	—	—	—	—
2006	—	3.9	—	—	—	—	—	—	—	—
2008	—	3.9	2.6	—	—	—	3.0	—	—	—
2010	1.0	9.9	2.6	4.0	4.0	3.0	5.0	—	—	—
2012	2.0	12.9	2.6	4.0	4.0	3.0	5.0	2.0	3.0	—
2015	3.0	12.9	5.0	10.0	10.0	5.0	5.0	3.0	6.0	3.0

Sources: *International Gas Report*, No. 522 (April 22, 2005); K. Wu and F. Fesharaki, "Natural Gas Pipelines and LNG Terminals in China: An Update," *FACTS Gas Insights*, No. 46 (March 2005), web site www.factsinc.net; and FACTS Inc., *China Oil & Gas Monthly* (May 2005).

[a]Cambridge Energy Research Associates, "China Market Commentary, Spring 2005: After the Peak" (April 15, 2005), web site www.cera.com.

[b]World Market Research Centre, "China: Urban Centers in China To Face Power Crunch" (April 7, 2005), web site www.worldmarketsanalysis.com.

[c]Personal correspondence with Fatih Birol, Chief Economist, International Energy Agency (April 26, 2005), web site www.iea.org.

[d]K. Wu, L. Wang, and F. Fesharaki, "China's LNG Imports: Delayed Terminal Projects and a Less Bullish Demand Outlook," *FACTS Gas Insights*, No. 4 (January 2006), web site www.factsinc.net.

[e]C. Bergersen, "Country Profile: China Electric Power Overview" (February 16, 2005), web site www.platts.com/coal/resources.

[f]A.J. Minchener, "Coal in China" (July 2004), web site www.iea-coal.org.uk.

Liquefied Natural Gas: Market Developments in China (Continued)

gas from China's west-to-east pipeline was $4.22 per million Btu. On average, coal-fired electricity generation in China costs $34 per megawatthour and natural-gas-fired generation $44 per megawatthour.[g] Potential users of natural gas in the electric power sector estimate that prices for natural gas must be in the range of $3.30 to $3.60 per million Btu to compete economically with coal.[h] The expected price of natural gas from the Guangdong LNG terminal is $2.80 per million Btu, including freight, plus $0.40 per million Btu for regasification.[i]

All the Chinese provinces have some coal resources; however, those in the east and southeast, which account for one-half of China's total GDP, contain only 17 percent of its coal resources.[j] As a result, more than 60 percent of the coal produced in China is transported by rail over an average distance of about 340 miles, under a coal pricing scheme that used to be determined by the central government.[k] The Chinese government has gradually relaxed its pricing control on coal since 1992, and coal prices for power generation have become negotiable. Currently, coal prices are determined by a mix of negotiated contracts between state-run producers and large end users, and the price of coal imports. Domestic coal prices are typically $5 to $7 per short ton higher than the international market price of high-quality steam coal, which makes imports more attractive.[l]

Concerns about pollution from electricity generation in China have also led to higher coal prices, as the government has incorporated a number of environmental controls to limit pollution from power generation. In October 2003, the State Environmental Protection Administration (SEPA) raised the fee assessed to generators for sulfur dioxide emissions by a factor of ten and applied the same fee for the first time to nitrogen oxide emissions, in addition to banning the construction or expansion of coal-fired plants in many large cities.

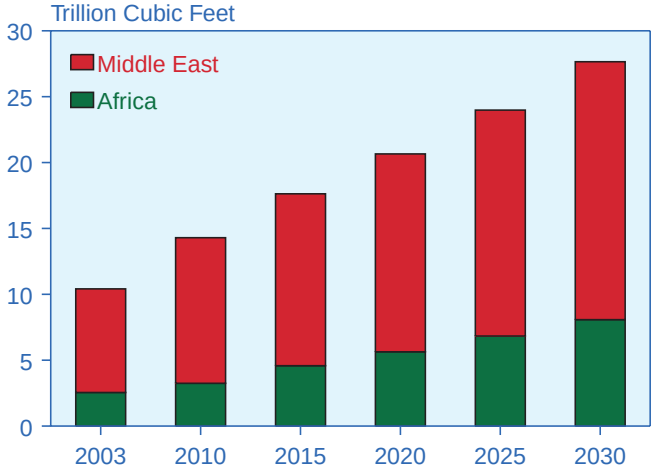
China's attempts to index its import contracts for LNG and pipeline natural gas to the price of domestically produced coal may or may not succeed. If they do, China will certainly be able to accommodate more imports of natural gas.

[g]D. Hurd, "Global LNG: Key Themes and Choices" (April 21, 2005), web site www.db.com.
[h]K. Wu and F. Fesharaki, "Natural Gas Pipelines and LNG Terminals in China: An Update," *FACTS Gas Insights*, No. 46 (March 2005), web site www.factsinc.net.
[i]*Petroleum Intelligence Weekly*, No. 5 (July 2004), web site www.EnergyIntel.com.
[j]FACTS Inc., Gas Databook I (Honolulu, HI, 2005).
[k]China National Bureau of Statistics.
[l]A.J. Minchener, "Coal in China" (July 2004), web site www.iea-coal.org.uk.

Natural gas use in the Middle East more than doubles between 2003 and 2030 (Figure 46). Oil-exporting countries in the region have deliberately sought to expand domestic natural gas use in order to make more oil available for export. In addition, natural-gas-rich countries in the region are developing projects to monetize their natural gas resources, in particular through LNG and, more recently, gas-to-liquids (GTL) projects, which have become an active area of interest (see box on page 48). As a result, the importance of natural gas as a source of supply for domestic energy demand in the Middle East grows over the projection period, with its share of regional energy use increasing from 42 percent in 2003 to 54 percent in 2030 while the oil share declines from 55 percent to 42 percent over the same period.

In Africa, natural gas consumption increases by an average of 4.4 percent per year over the projection period, making it the most rapidly growing primary energy source in the region. In comparison, Africa's oil demand increases by only 2.3 percent per year and its coal

Figure 46. Natural Gas Consumption in Africa and the Middle East, 2003-2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

demand by only 1.7 percent per year. The incremental growth in Africa's natural gas demand occurs mostly in the industrial and electric power sectors. Despite continuing instability in some countries of the region, the investment climate in Africa remains fairly attractive, with massive investments planned, mostly in West Africa.

In Central and South America, natural gas is the fastest growing fuel source, with demand increasing on average by 3.9 percent per year, from 3.8 trillion cubic feet in 2003 to 10.8 trillion cubic feet in 2030 (Figure 47). By 2010, natural gas overtakes oil as the second most prevalent fuel for electricity generation in the region, with renewables—particularly, hydropower—retaining their dominant share in the sector throughout the projection period.

South America's southern cone area is already criss-crossed by pipelines linking Bolivia, Brazil, Argentina, Chile, and Uruguay. In addition, a number of new pipelines are under discussion, which would link Peru with Ecuador and Chile, Venezuela with Colombia and Brazil, and Colombia with Panama [5]. The new lines could later be linked with each other and with existing pipelines to create a South American natural gas grid—an idea that is being promoted by Venezuela. Even some of the more modest proposed pipelines, however, face substantial political hurdles.

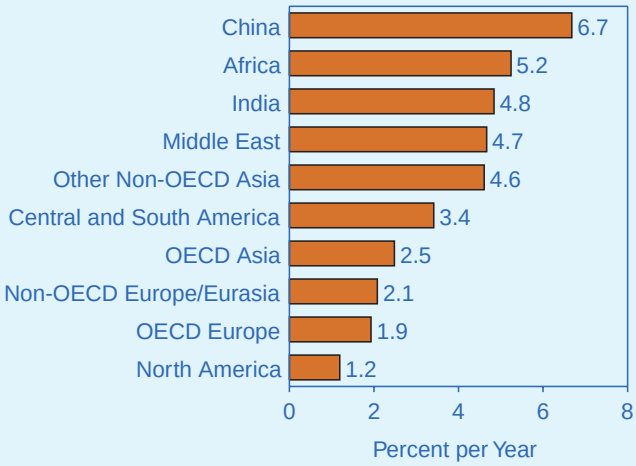
Current Developments in Gas-to-Liquids

The relatively high world oil prices of the past several years have made gas-to-liquids (GTL) a more attractive option for monetizing stranded natural gas reserves. Currently, only South Africa and Malaysia have commercial GTL operations; but new projects have been proposed for Algeria, Australia, Egypt, Iran, Nigeria, and Qatar. Proposed plant sizes range from 20 to 160 thousand barrels per day of liquids output. In addition, Russia has significant potential for GTL production because of its plentiful and often remote natural gas reserves.

Natural gas use as a feedstock for GTL operations is reflected in the *IEO2006* projections for industrial natural gas consumption. In regions where natural gas markets are less developed, GTL may represent a significant share of industrial or even total natural gas use. For example, in 2003, natural gas for the Bintulu GTL plant in Malaysia, with an original design capacity of only 12.5 thousand barrels per day, accounted for almost 2 percent of industrial sector natural gas use and 1 percent of total natural gas consumption in non-OECD Asia excluding China and India ("Other Non-OECD Asia"). In Africa, natural gas use for GTL operations in 2003 represented some 6 percent of industrial and 3 percent of total natural gas consumption.

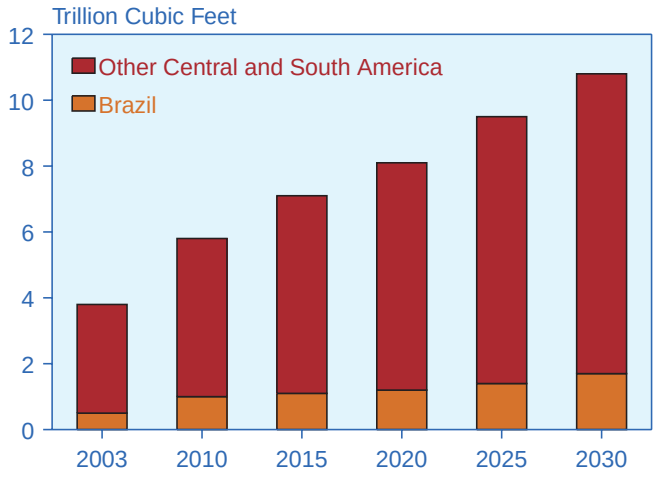
In *IEO2006*, significant quantities of GTL production by 2030 are projected only for Russia, Africa, the Middle East, and Other Non-OECD Asia. For all but Russia, which already consumes large amounts of natural gas in its industrial sector, natural gas use for GTL has potentially significant effects on industrial and total natural gas consumption. The addition of a single 140 thousand barrel per day GTL plant, consuming 0.5 trillion cubic feet of natural gas per year, would represent an increase in total natural gas consumption over 2003 levels: 3 percent in Russia, 6 percent in the Middle East, 9 percent in non-OECD Asia, and 18 percent in Africa. In all but Russia, projected GTL operations in large part drive industrial sector natural gas demand in the reference case. The projected growth rates for industrial natural gas use in the Middle East, non-OECD Asia, and Africa are among the highest in *IEO2006* (see figure below).

Average Annual Increases in Industrial Natural Gas Consumption, 2003-2030, by Region and Country



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003*, DOE/EIA-0219(2003) (Washington, DC, July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

Figure 47. Natural Gas Consumption in Brazil and Other Central and South America, 2003-2030



Sources: **2003:** Energy Information Administration (EIA), *International Energy Annual 2003* (May-July 2005), web site www.eia.doe.gov/iea/. **Projections:** EIA, System for the Analysis of Global Energy Markets (2006).

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