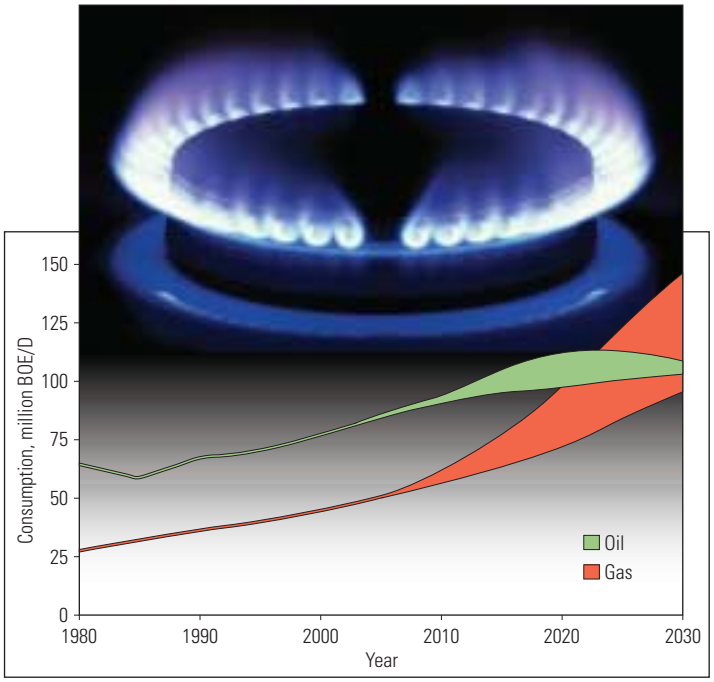
A Dynamic Global Gas Market

Natural gas has come a long way from the days when it was just a by-product of the search for oil, a nuisance that was removed by flaring. Within a generation, it could become the world's most important fuel because of its abundance, cleanliness and diverse uses.



^ Expected oil and natural gas consumption. Some experts believe gas consumption will exceed that of oil by about 2025, when put in consistent units of barrels of oil equivalent per day (BOE/D). Future estimates indicate prediction ranges. (Adapted from Watts, reference 1.)

The overall demand for energy from oil, gas and other sources is expected to more than double over the next 50 years, and there will be massive shifts in the pattern of demand. At present, the United States, Canada and Europe consume about half the world's energy, while the Asia-Pacific region uses a quarter. In the next half-century, those consumption positions are likely to be reversed.[1] The composition of energy supplies is also changing and observers now expect the world to consume more gas than oil by 2025 (above right). The gas industry may have to provide two to three times more gas over the next 30 years than it has since 1970.[2]

The world has around 156 trillion cubic meters (trillion m^3) [5500 trillion cubic feet (Tcf)] of proven reserves of natural gas, according to a BP study.[3] Of this worldwide resource, approximately 31% is in Russia, 36% is in the Middle East, and 8% is in the Asia-Pacific region (next page, top). Present consumption is about 2.5 trillion m^3 [88 Tcf] a year, and demand is growing rapidly, especially in the Asia-Pacific region where many countries are pressing ahead with energy-intensive industrialization programs.[4]

A key reason for the rising demand for gas is that it burns more cleanly than other fossil fuels. A gas-fired thermal power plant typically emits far less carbon dioxide and nitrogen oxides than either a coal-fired or an oil-fired plant. The cleanliness of gas makes it particularly attractive to those who are trying to minimize the environmental impact of energy use. The Chinese economy, for example, is predicted to grow at around 6 to 8% a year, suggesting that China will need much more energy in the future. While committed to rapid growth, the Chinese also are aware of environmental problems in their country. They are determined to reduce their dependence on coal. As such, gas consumption in China could increase sevenfold over the next 20 years.[5]

Making Gas Even Greener

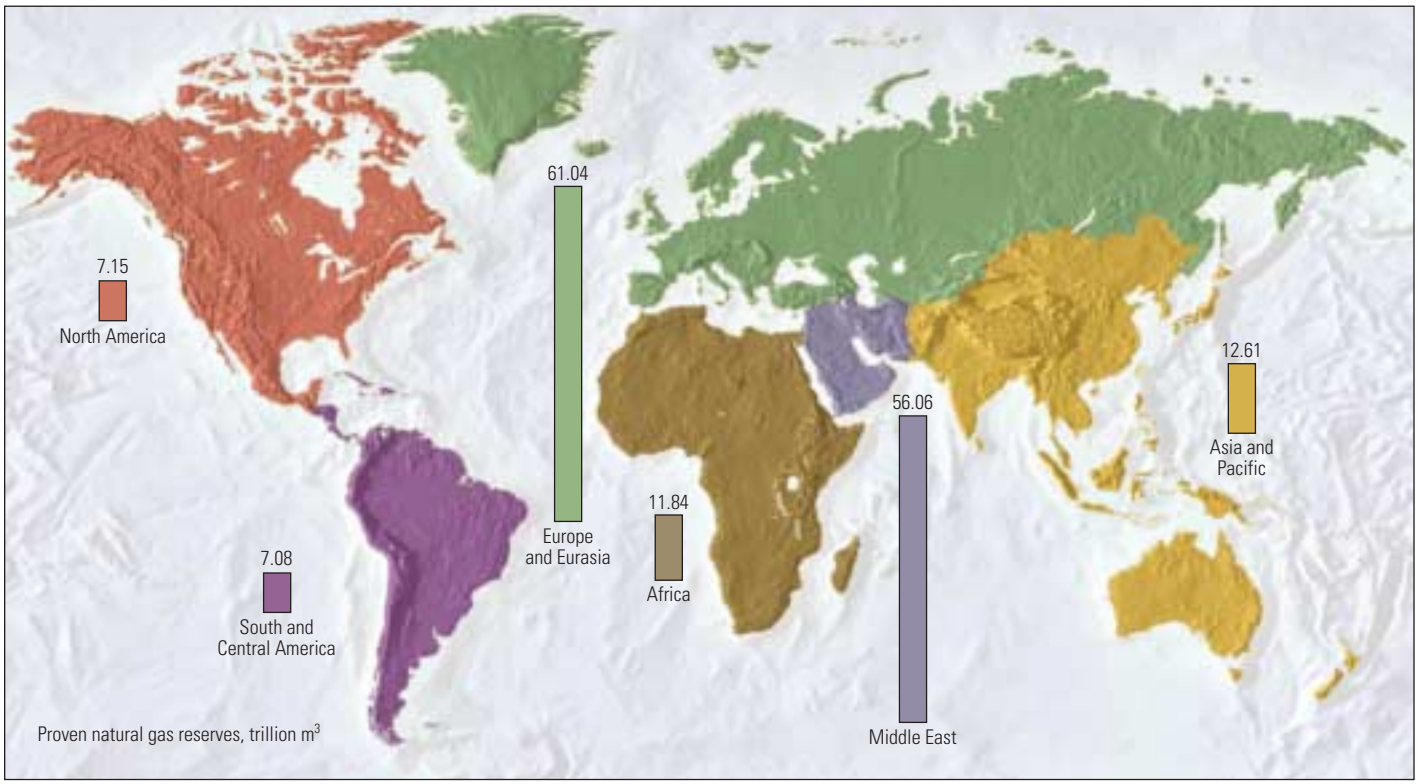
Gas is already greener—more environmentally friendly—than the other main fossil fuels, oil and coal, but technology is helping it to become even more friendly to the environment. Gas-to-liquids (GTL) technology is being developed to convert natural gas into ultraclean liquid fuels (see "Turning Natural Gas to Liquid," *page 32*). When GTL-converted fuels are used in conventional engines, they produce only a fraction of the emissions generated with normal gasoline or diesel fuels.

The GTL process uses a modern version of the Fischer-Tropsch process, which was developed in the 1920s, and consists of three steps:

1. By partial oxidation of carbon-bearing material, convert natural gas into synthesis gas, a mixture of hydrogen and carbon monoxide.
2. Produce synthetic oil from the synthesis gas in a Fischer-Tropsch reactor.
3. Upgrade the synthetic oil to produce a final product, such as low-sulfur diesel fuel or gasoline.[6]

At present the only two commercial GTL plants are a Shell facility at Bintulu, Malaysia, and a PetroSA South Africa plant. They have a combined capacity of 6760 m^3/d [42,500 barrels per day (B/D)] from conventional gas sources. Two other South African plants provide an additional 25,400 m^3/d [160,000 B/D] from coal-derived gas (for more on coalbed gas, see "Producing Natural Gas from Coal," *page 8*). Some estimates suggest that within five years there could be at least 14 plants in 10 countries, with a combined capacity of nearly 111,300 m^3/d [700,000 B/D].[7] The hydrocarbon liquid output could be used directly in vehicles or blended with other fuels.

Although natural gas is now an energy resource in its own right, much of the gas associated with oil production is still flared. Flaring natural gas is harmful to the environment. The industry collectively burns off or vents about 93 billion m^3 [3.25 Tcf] of gas annually, gas that could be put to better use.[8] For example, if the gas currently flared in Africa were used as an energy source, it could meet nearly half the



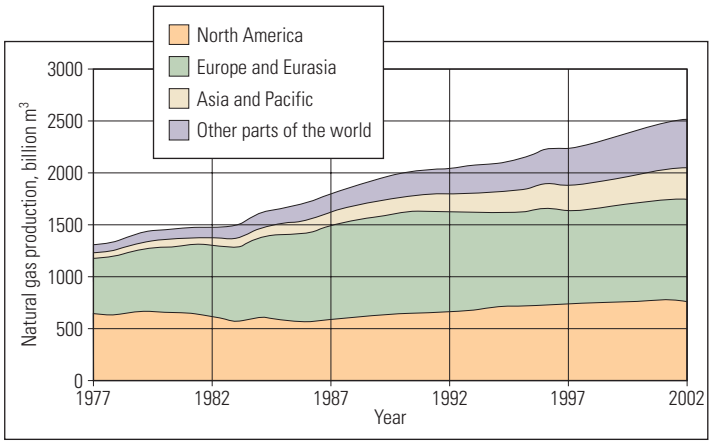
^ Proven natural gas reserves at the end of 2002, by region. Russia holds about 78% of the reserves of Europe and Eurasia. The Middle East is the other region containing large reserves of natural gas. (Adapted from *BP Statistical Review of World Energy 2003*, reference 3.)

power needs of the entire continent.[9] To try and solve this worldwide problem, the World Bank in collaboration with a number of governments and oil companies has launched the Global Gas Flaring Reduction Partnership. The aim of this initiative is to limit flaring and use the gas in other ways. Companies that have joined the partnership include BP, Shell, ChevronTexaco, Total and Sonatrach. Member governments include Angola, Cameroon, Ecuador, Nigeria, Norway and the USA.[10]

From Regional to Global Market?

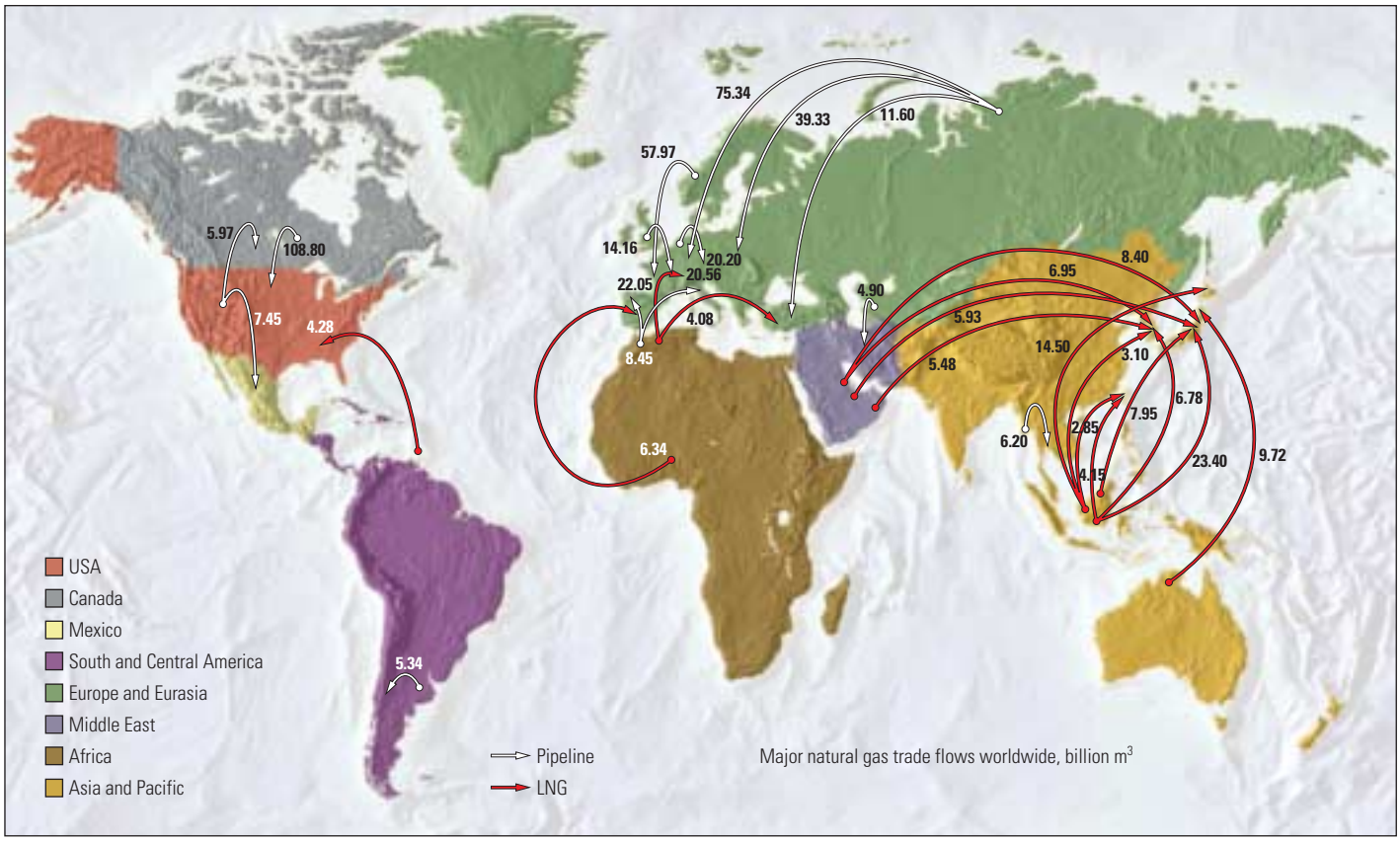
Because gas is difficult to transport, nearly 80% of current gas demand is met by supplies from wells within the end-user's own country, but if demand continues to grow rapidly that will change (right). Gas will have to be transported over much longer distances and across borders. By 2030, according to one estimate, less than 50% of demand will be met by indigenous supplies.[11] Pipeline imports could double. Imports of liquefied natural gas (LNG), a liquid obtained by cooling the gas to –162°C [–259°F] so that it occupies only 1/600th of the volume of the original gas, might grow by a factor of five.[12]

More countries are becoming significant LNG producers, including Egypt and Norway, and there



^ Distribution of natural gas production by region. During this period, natural gas consumption showed a similar trend, because most gas was consumed near where it was produced. However, trade between regions is expected to increase in the future. (Adapted from *BP Statistical Review of World Energy 2003*, reference 3.)

1. Watts P: "Building Bridges—Fulfilling the Potential for Gas in the 21st Century," speech delivered at the World Gas Conference, Tokyo, Japan, June 3, 2003, www.shell.com/static/mediaen/downloads/speeches/PBWwgc03062003.pdf
2. Watts, reference 1.
3. *BP Statistical Review of World Energy 2003*. London, England: BP (June 2003): 20. BP conversion factor used for this statistic.
4. BP study, reference 3: 25.
5. Watts, reference 1.
6. Cottrill A: "GTL Seeking Its Big Break into Stardom," *Upstream* (March 8, 2002): 24–25.
7. Thackeray F: "Gas-to-Liquids Prospects: GTL in 2007," *Petroleum Review* (January 2003): 18–19.
8. US Energy Information Agency, "World Natural Gas Production, 2000," www.eia.doe.gov/pub/international/ieapdf/t04_01.pdf
9. World Bank press release, August 30, 2002, www.ifc.org/ogmc/pdfs/PartnershipPressRelease.pdf
10. World Bank, reference 9.
11. Watts, reference 1.
12. Watts, reference 1.



^ Major trade movements for natural gas in 2002. Gas is traveling ever greater distances, both by pipeline and as cargoes of liquefied natural gas (LNG). Most of the current shipments, shown here in units of billions of cubic meters, remain within two or three large regions. (Adapted from *BP Statistical Review of World Energy 2003,* reference 3.)

is a possibility of new LNG supply projects in Angola, Iran and Venezuela. Supply diversification will increase the attraction of natural gas to customers. They will feel more secure because they will not depend on a single supplier.[13] LNG supplies can be distant from the customer (above). In 2002, for example, Japan imported cargoes of LNG from Abu Dhabi, Oman and Qatar, in addition to obtaining LNG supplies from the Asia and Pacific areas. The major supply of LNG for the USA came from Trinidad and Tobago, but the USA also took deliveries from Algeria, Brunei, Malaysia, Nigeria, Oman and Qatar.[14]

There has been much debate about whether gas could eventually become a globally traded commodity like oil. Most of the world's oil is traded internationally and prices are more or less the same everywhere. Natural gas, by contrast, is traded regionally or even locally, and prices vary significantly from place to place. The debate on globalization has been spurred by a number of factors, including an increase in the number of LNG cargoes transported over long distances and the rapid expansion in the fleet of LNG carriers. Recent maintenance problems at a nuclear power plant owned by Tokyo Electric Power Company led to suggestions that the company might seek additional LNG supplies as a temporary replacement source of energy.[15] Any such transactions could impact supplies to other major consumers, like the USA.

Analysts tend to think of the world as comprising two principal gas-trading blocs—Asia-Pacific and the Atlantic Basin, which includes everything from the United States to Europe and Africa. Some experts consider Europe as a separate, third, bloc, but the specific groupings are not important. More significant is some analysts' belief that although most past LNG trade has been within regional blocs, substantial future trading could be between blocs. If that happens, they argue, prices around the world will converge and, ultimately, LNG and natural gas generally could become global commodities.

Whether such a revolution is just around the corner or 20 years away, analysts agree about the limiting factors. First, LNG trade is dominated by long-term contracts, meaning that most LNG is spoken for and cannot simply be diverted in response to price without significantly restructuring contracts. It should be remembered, however, that in the 1960s and 1970s most natural gas in the USA was also sold using long-term contracts. That

13. Cook L: "Liquefied Natural Gas—Realising the Potential," speech delivered at the World Gas Conference, Tokyo, Japan, June 5, 2003, www.shell.com/home/html/iwgen/downloads/lindacook-wgc3.pdf
14. Poten and Partners: "2002: Global LNG Imports Reach Nearly 111 MMt," Market Opinion, March 21, 2003, www.poten.com
15. Tokyo Electric Power Company Press Release: "Investigation of Maintenance Work at TEPCO's Nuclear Power Plants," August 29, 2002, "Conclusion of a Heads of Agreement on LNG Purchase under the Sakhalin II Project," May 19, 2003, and "Official Participation in Darwin LNG Project," June 30, 2003, www.tepco.co.jp/corp-com/press/index-e.html
16. Thackeray F and Leckie G: "Stranded Gas: A Vital Resource," *Petroleum Economist* 69, no. 5 (May 2002): 10.
17. DeLuca M: "Thinking Big, Delving Deeper," *Offshore Engineer* (April 2002): 24.
    Carré G, Pradié E, Raymondeau M, Christie A, Delabroy L, Greeson B, Watson G, Fett D, Piedras J, Jenkins R, Schmidt D, Kolstad E, Stimatz G and Taylor G: "High Expectations from Deepwater Wells," *Oilfield Review* 14, no. 4 (Winter 2002/2003): 36–51.
18. Collett TS, Lewis R and Uchida T: "Growing Interest in Gas Hydrates," *Oilfield Review* 12, no. 2 (Summer 2000): 42–57.
19. Kvenvolden K: "Gas Hydrates—Geological Perspective and Global Change," *Reviews of Geophysics* 31, no.2 (May 1993): 173–187.

practice quickly changed in the 1980s when demand and gas prices increased substantially.

Second, pricing is not transparent, largely because of the contractual nature of the business. A potential customer cannot simply log on to a commodity exchange to see the latest prices around the world. Services such as natural gas transportation, storage and distribution also were bundled in the US gas market in the 1960s and 1970s. Once the US government separated these businesses, competition took over and the costs of each part of the business were soon evident.

The third and most important factor: substantial infrastructure investment would be required to make interregional trade feasible. Liquefaction plants would have to be built to convert gas to a low-temperature liquid, and regasification equipment would be necessary at ports of entry to convert the LNG back into gas.

Stranded Gas

Natural gas may be abundant, but more than a third of global gas reserves are classified as *stranded*.[16] Stranded reserves are those that have been discovered but are undeveloped because they are too remote or too small to justify production. Until recently, that would have been the end of the story. Now, however, companies with stranded reserves are looking for ways to bring the gas to market. There are two ways of doing so: by mounting LNG facilities on a barge or by using floating GTL units.

Shell is among the leaders in the development of floating LNG (FLNG) facilities. An FLNG operation is one option being discussed by Shell and its partners to exploit the large Sunrise gas fields in the Timor Sea, the stretch of water lying between north Australia and the island of Timor. There is no agreement yet between Shell and its partners on whether an FLNG vessel is the best option for developing the field of greater than 230 billion m^3 [8 Tcf] reserves. However, if the FLNG option were selected, a barge would remain on station at Sunrise for at least 20 years. Once gas had been liquefied on the barge, it would be offloaded to dedicated carriers.

In the future, new technologies may help turn stranded gas from a liability—gas that would have to be flared or reinjected—into a saleable asset. However, the product still has all of the constraints of LNG, not least the fact that its site of production may be distant from intended markets. Costly and time-consuming supply chains have to be developed to make LNG trade a viable global market. An alternative is to convert gas not into LNG, but directly into premium-grade liquid products through GTL technology aboard a vessel. Such GTL products would have ready local and regional markets.

Deep Gas

The physical difficulties involved in finding deepwater gas are the same as those for finding deepwater oil. However, developing the gas field and getting the gas to market at a reasonable price present special problems. A project that may prove to be a blueprint for the exploitation of a group of small fields is the Canyon Express project in the Gulf of Mexico. Canyon Express, which came on stream earlier this year, uses a common gathering system to take gas from fields owned by three different companies—Total, BP and Marathon.[17] The shared infrastructure means lower costs for each company.

Exploration teams are not only drilling in deeper water, they are also revisiting acreage in the shallower waters of the Gulf of Mexico continental shelf and drilling there to much greater depths. The shallow-water section of the Gulf of Mexico, less than 300 m [1000 ft] deep, is peppered with wells and is generally thought of as an area in decline. But the US Department of the Interior's Minerals Management Service (MMS) believes that there may be about 300 billion m^3 [10.5 Tcf] of natural gas at much greater depths in the same area.

The US government proposed financial incentives to companies to drill at depth in the region. Under the proposal, the MMS would provide royalty suspension when companies take the risk of exploring and developing deep gas deposits in shallow-water areas that they have already leased. Around 60% of the estimated 300 billion m^3 of new gas is thought to be below existing leases, with the rest in blocks that are not currently leased. El Paso Production, which has experience in deepgas drilling onshore, has already drilled deep wells in the Gulf and by last year was producing 9.7 million m^3/d [340 million scf/D] from five wells in sands at depths of 5360 m to 5790 m [17,600 ft to 19,000 ft]. An advantage for companies working in the area is that the infrastructure built for shallow-water finds over the years is still there. The new deep wells can also use these facilities, keeping costs down.

Gas Hydrates

No matter how carefully operators minimize their costs, eventually traditional sources of hydrocarbons may no longer be enough to satisfy the world's demand for energy. With that in mind, several research groups in the USA and elsewhere are examining the possibility of extracting gas from naturally occurring hydrates.[18] Hydrates are hollow cage-like crystals of water molecules that enclose a single gas molecule, but do so without chemical bonding. The exploration and production industry has long been aware of hydrates as a problem rather than as a resource. The ice-like hydrates form in and block pipelines in deep water or Arctic regions. Chemical inhibitors are used to stop them from forming.

Scientists and engineers now believe that naturally occurring hydrates, which are found in oceanic sediments and in sediments underlying the Arctic permafrost zone, could become a major source of hydrocarbons. If these hydrates can be developed economically, the world would have an enormous new source of energy. Deposits of methane hydrate have been located in almost every area of the world where water depths are greater than 1000 ft, the temperature of the seabed is below 10ºC [50ºF] and the area is gas-prone. Large deposits of naturally occurring gas hydrates have also been discovered in the Arctic regions of Alaska, USA, Canada and Russia.

An estimate of world reserves suggests that there may be as much as 20 thousand trillion m^3 [700,000 Tcf] of gas locked up in hydrates.[19] If only a small proportion of the gas in hydrates were recoverable, it would be enough to supply world energy needs for hundreds of years. A substance now regarded as a problem could end up being the energy source that sustains society.

Fuel of the Future

Energy supply will continue to be dominated by hydrocarbons for the foreseeable future. Within the mix of energy sources, natural gas is likely to play an increasing part. Sometime in the next 25 years, the world could begin to consume more gas than oil. But realizing the full potential of gas will require considerable technological ingenuity and a constant effort to find ways of cutting the costs of production and transportation. —MB

Gas Volume Units

In this issue, units of gas volume are presented in standard cubic feet (scf) at 60°F and 14.696 psia and standard cubic meters at 15°C and 100 kPa, following the SPE standard, except where otherwise noted. The conversion factor used is 0.0286364 m^3/scf.