by Jesse Yoder, Ph.D.

The 'Cleaner' Fossil Fuel

Considering Natural Gas as Part of the Alternative Energy Future

The energy industry has never been more in the spotlight than it is today, as the wide acceptance of global warming by the scientific community and by the general population has made the topics of clean and alternative energy of prime importance. The slow but steady warming of the atmosphere has made it critical to find non-polluting sources of energy, as well as to monitor and control carbon dioxide emissions worldwide.

When people talk about alternative energy, they typically mean "alternatives to fossil fuels." Alternative energy today takes many forms, including solar power, wind power, geothermal, hydro power, ethanol, biodiesel, hydrogen and others. And while there is a great deal of research and development going on today in all of these areas, the world is still heavily dependent on fossil fuels for its energy needs.

Fossil fuels take three main forms — oil, natural gas and coal. They are called fossil fuels because they are derived from the decayed and accumulated remains of prehistoric plants and animals, and they are used for fuel. Natural gas in particular, it is believed, was formed as a chemical reaction in the earth that required the presence of pressure and heat and took place over millions of years. The geologic phenomenon resulted in the formation of both oil and natural gas, but natural gas is typically on top, since it is lighter than oil.

Natural gas is a colorless and odorless gas that is a reliable source of energy. It is a clean-burning fuel that gives off lower levels of potentially harmful substances than other fossil fuels such as oil and coal. Natural gas is composed of between 70 and 90 percent methane, but it also typically contains a mixture of other gases. These include ethane, propane, butane, carbon dioxide, oxygen and nitrogen. The specific combination of gases varies with the particular natural gas and where it is found.

As is the case with other fossil fuels, natural gas is a non-

Natural Gas Reserves for Selected Countries, Trillion Cubic Feet

Russia	1680.0
Iran	991.6
Qatar	891.9
Saudi Arabia	258.5
United States	237.7
United Arab Emirates	214.4
Iraq	111.9
Indonesia	106.0
Norway	81.7
China	80.0
Canada	57.9
India	37.9
Japan	0.7
Other Countries	1504.2
World Total	6254.4

Source: Energy Information Administration, citing the Oil & Gas Journal

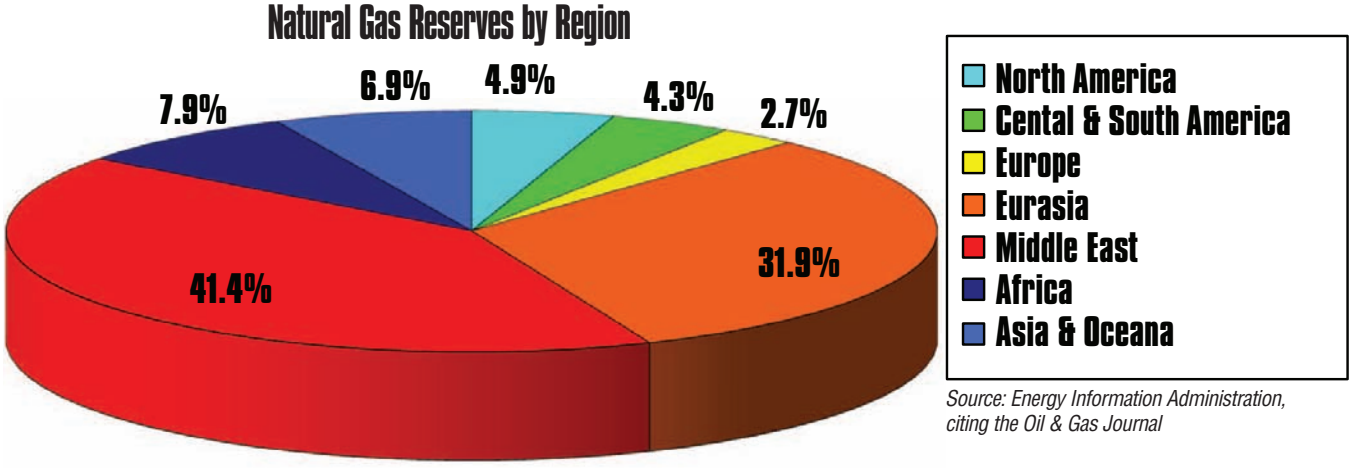


Figure 1. *Proven natural gas reserves by geographic region as of Jan. 1, 2009. Total World Reserves = 6,254.4 trillion cubic feet.*

renewable resource. Therefore, it is important how it is used, and also where it is found. Figure 1 shows proven natural gas reserves by geographic region in percentage terms as of January 1, 2009. Natural gas is measured in trillion cubic feet, and the total worldwide natural gas reserves are estimated at 6,254.4 trillion cubic feet.

Natural Gas Exploration & Production

Since natural gas exists beneath the ground, it has to be extracted from the ground in order to be used. Part of the challenge is determining where natural gas is located. Scientists use multiple methods to locate natural gas, including looking at the surface of the earth. Advanced methods such as seismic exploration, magnetometers, and gravimeters all play a role in finding natural gas deposits. Once a probable location is found, an exploratory well may be drilled to find where the natural gas is located.

A Christmas Tree on an oil well near Traverse City, Mich.

Once natural gas is located, a well is drilled down to the location of the natural gas. This may be done in conjunction with a search for oil, since oil and natural gas often are located together. Once oil or natural gas is located, the well is called a "development" or "productive" well. The point where drilling begins takes many factors into account, including the subsurface geology and the depth and size of the potential deposit. If no oil or natural gas is found, the well is called a "dry" well.

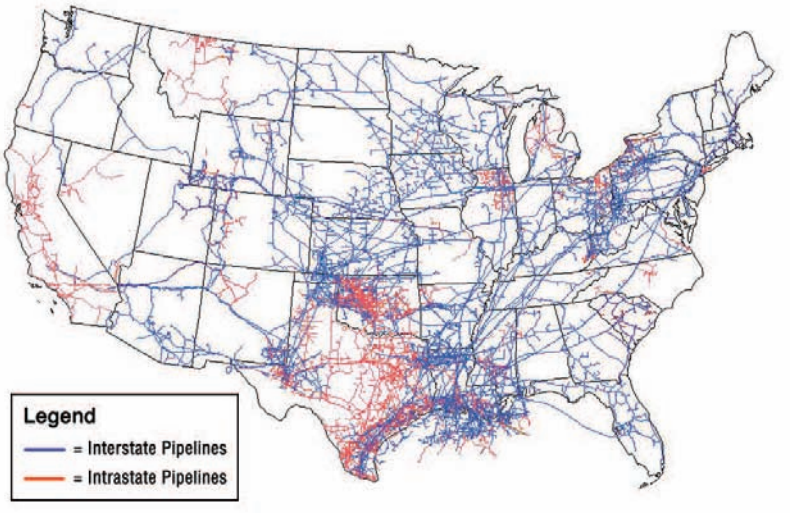
Once a well is drilled, it has to be prepared for oil and/or natural gas production. This is called "well completion," and it typically involves placing several types of casing down the well both to prevent the well from caving in and to keep the well fluids from being contaminated. A wellhead is placed at the top of the well to regulate the hydrocarbon fluids coming out of the well. A "Christmas Tree" goes on top of the casing and contains tubes and valves that control the flow of hydrocarbons and other fluids coming from the well.

Once hydrocarbon fluid leaves the well, it often goes through a separator. The separator physically separates the fluid into its oil, water, and natural gas components. This is often done by gravity. The water and oil may be sent to a storage tank for later pickup. The natural gas is often sent to a gathering area where natural gas inputs from multiple wells go into a transmission pipeline. The natural gas then is carried via pipeline to a gas processing center. At the gas processing center, all the hydrocarbons and fluids are separated from the pure natural gas, so that the natural gas can be transported to locations where it is ultimately used as fuel.

Once the natural gas leaves the gas processing plant, it travels through a network of pipelines to its ultimate destinations at industrial, commercial, and residential facilities. In the United States, a vast network of gas pipelines criss-crosses the entire country, carrying natural gas to the major population centers and to other locations as well. Natural gas is transported in these "highways" at pressures from 200 PSI to 1,500 PSI. Typical sizes of pipelines range from six inches to 48 inches in diameter.

Dolphin Energy (*www.dolphinenergy.com*) in the United Arab Emirates provides a good example of an energy company operating a natural gas production and transmission facility on a large scale. Dolphin's natural gas comes from Qatar, which has the third largest reserves of any country in the world. Dolphin operates a gas processing and compression plant at Qatar's Ras Laffan Industrial City (*www.raslaffan.com.qa*), the largest single-build plant in the world. Hydrogen sulfide and other impurities are removed at this plant. Valuable byproducts are extracted for sale, including ethane, propane, and butane. The resulting refined natural gas is then compressed and then sent through the export pipeline.

The export pipeline connects Dolphin's gas processing plant in Qatar with its receiving facilities, located in Al Taweelah, Abu Dhabi. The export pipeline is 48 inches in diameter and 226 miles long. It was designed to carry as much as two billion standard cubic feet a day (scf/day) of



A map of detailing the natural gas pipelines currently operating in the United States.
Source: Energy Information Administration, Office of Oil & Gas, Natural Gas Division

Considering the vast amount of natural gas reserves in the world, natural gas flow measurement has a bright future ahead. Even though natural gas will lose out to alternative energy for some applications, it will remain popular as a fuel for many years because it is significantly cleaner than oil or coal.

refined natural gas from Qatar to Abu Dhabi. Using this pipeline, Dolphin Energy supplies natural gas on a daily basis to Abu Dhabi, Dubai, and to the country of Oman.

Flow Measurement in Gas Pipelines

Natural gas flow is measured at many points along the way from the wellhead to the end-destination point.

Hydrocarbon fluids are often measured as they come out of the wellhead. As such, several companies have developed multiphase flowmeters for this purpose, although sometimes the measurement is done after the fluid has been separated into its component parts. Multiphase flowmeters measure fluids with two or more phases, such as oil and water. This is a difficult and expensive measurement to make.

The main types of flowmeters used to measure natural gas in pipelines are differential pressure (DP), turbine and ultrasonic. For many years, DP and turbine meters were the only types with the required industry approvals for making these pipeline measurements. However, in 1998, the American Gas Association (AGA, *www.aga.org*) published a report (AGA-9) containing a standard for the use of multipath ultrasonic flowmeters for custody transfer of natural gas. Since that time, the ultrasonic flowmeter market has been on a strong upward growth path.

Ultrasonic flowmeters have grown in popularity for several reasons. One is that inline, multipath ultrasonic flowmeters can achieve very high accuracy. Ultrasonic flowmeters also cause very little pressure drop. Unlike turbine meters, ultrasonic flowmeters do not have moving parts, and they don't require components like DP flow transmitters with orifice plates that are subject to wear over time. As a result of these advantages, ultrasonic flowmeters are displacing some existing turbine and DP flowmeters, as the technology is gaining share among end-users designing new pipeline measurement applications.

The Future of Natural Gas Flow Measurement

Considering the vast amount of natural gas reserves in the world, natural gas flow measurement has a bright future ahead. Even though natural gas will lose out to alternative energy for some applications, it will remain popular as a fuel for many years because it is significantly cleaner than oil or coal. More natural gas pipelines are being built today, and more will be built in the future. This trend will continue to provide new opportunities for natural gas pipeline flow measurement. FC

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