UNDERSTANDING NATURAL GAS

HISTORY OF NATURAL GAS

Centuries ago, man noticed that lightning ignited natural gas seeping from the ground and creating a "burning spring." The most famous legend about natural gas originated on Mount Parnassus in Greece approximately 1,000 B.C. A goat herdsman discovered a burning spring on the mountain. A temple was built on that spot and the priestess, Oracle of Delphi, spoke of prophecies inspired by the burning spring.

Burning springs of natural gas were prominent in religious practices of ancient Persia and India, where temples were constructed around these "eternal flames." The Greeks, Persians, and Indians did not recognize the energy value or potential usefulness of natural gas. Ancient Chinese realized that natural gas could work for them. About 500 B.C., they used natural gas to make portable water by piping it from shallow wells through bamboo poles to evaporate salt from sea water.

Britain commercialized the natural gas industry around 1785. This was gas manufactured from coal, not from naturally occurring natural gas. A Scotsman, William Murdock, improved upon a method of manufacturing natural gas and used it to light his home. Shortly afterwards, the first natural gas company illuminated London streets with gaslights.

Manufactured natural gas arrived in the United States in 1816, when the city of Baltimore, Maryland installed gaslights. Baltimore's gas was also manufactured from coal. This gas had a much lower energy content and more impurities than today's natural gas.

Other sources of natural gas were discovered, which were superior in performance and price. Early explorers noticed natural gas seeping up from the ground in the eastern United States and along the California coast. As early as 1626, French missionaries had recorded that Indians ignited gases in the shallows of Lake Erie and in streams flowing into the lake. The American natural gas industry began in this area, known as New York. The birthplace of underground natural gas in America is Fredonia, New York, a small village on the Candaway Creek near Lake Erie.

In 1821, Fredonia residents observed gas bubbles rising to the surface from a creek. William Hart dug the first natural gas well in America along a creek outside Fredonia. The well was approximately 27 feet deep. (By contrast, today's wells are over 30,000 feet deep). As the first person to put natural gas to work in America, he is considered America's "father of natural gas." Other individuals expanded upon his work and a group of entrepreneurs formed the Fredonia Gas Light Company, our nation's first natural gas company. Natural gas drilling continued throughout western New York, Pennsylvania, northern Ohio, and northern Indiana. By 1900, natural gas was discovered in 17 states.

Natural gas continued to aggressively compete with manufactured gas into the 1920's. Plants that manufactured gas from coal were usually located in prominent cities, where there was a large and steady demand. During this time manufactured gas had a competitive advantage over coal's established distribution system.

In the 1950's, interstate pipelines reached across the entire continent to provide competitive, naturally occurring natural gas, and manufactured gas' dominance declined. America's interstate pipeline system now contains over one million miles of pipe that deliver large quantities of clean, efficient and cost-effective natural gas to different regions.

From heating to power generation to transportation—Natural Gas does it all.

Production has taken a gigantic step from open pit wells to deep sea drilling.

Clean-burning Natural Gas

Origins of Natural Gas

Origins of methane (CH_4) include conversion of organic material by micro-organisms (biogenesis), thermal decomposition of buried organic matter (thermogenesis), and deep crustal processes (abiogenesis). Buoyant methane migrates upward through rock pores and fractures and either accumulates under impermeable layers or eventually reaches the surface and dissipates into the atmosphere.

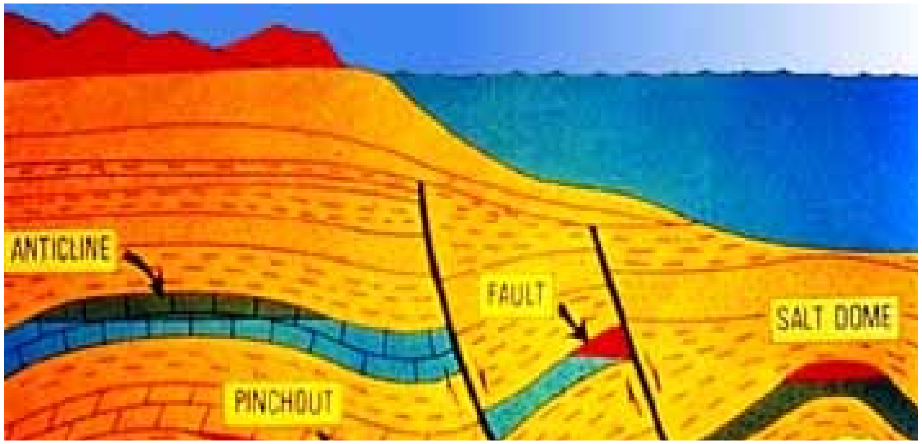
Biogenic methane results from the decomposition of organic matter by methanogens, which are methane-producing micro-organisms and which pervade the near surface of the Earth's crust in regions devoid of oxygen, where temperatures do not exceed 97 degrees Celsius (207 degrees Fahrenheit). Methanogens also live inside the intestines of most animals (people included) and in the cud of ruminants such as cows and sheep, where they aid in the digestion of vegetable matter. Because the methane generated in the subsurface is less dense than the rocks in which it is produced, it diffuses slowly upward through tiny, interconnected pore spaces and fractures, and it can eventually reach the Earth's surface and dissipate into the atmosphere. In places, however, the diffusion of methane is impeded by impermeable rock layers and gas can become trapped in structures. If enough gas accumulates under these impermeable layers, the structures can be drilled and gas can be extracted for use as an energy source.

Thermogenic methane is formed in a manner similar to oil. As organic particles deposited in mud and other sediment become deeply buried and compressed, higher temperatures cause carbon bonds in organic compounds to break down and form oil with minor amounts of gas. At increased temperatures (caused by increased burial depth), methane becomes the dominant product until it eventually replaces oil altogether. The simultaneous formation of both oil and gas in the early stage of the thermal decomposition process is the principal reason for the association of oil and gas in accumulations present in the upper 2 to 3 km of the Earth's crust. In deep parts of basins and possibly even in subduction zones methane may be the only hydrocarbon formed.

At greater burial depths, metamorphism may drive off all hydrogen atoms from organic compounds and leave a residue of carbon, often in the form of graphite. Under certain conditions in the deep crust, graphite may react with water; this reaction results in the recombining of carbon and hydrogen into methane. Recent studies on quartzvein systems indicate the presence of large fluxes of deep crustal gases and fluids; the volume of methane transported can be as large as 50 to 500 trillion cubic feet for a single giant vein system.

Abiongenic methane is formed by another process that involves nonorganic carbon- and hydrogen-rich gases, which exist deep within the Earth. They form as either primordial gases that seep from our planet's interior or as gases liberated from crustal rocks during metamorphism. As these gases migrate upward and interact with crustal minerals, they react to form the elements and compounds present in the atmosphere (nitrogen, oxygen, carbon dioxide, argon and water). In volcanic regions today, there is a continual outgassing of carbon dioxide and water, which originated deep in the Earth. If these same gases were to migrate through rocks at high pressures, and in the absence of oxygen, methane would be the dominant stable compound. Perhaps methane is forming in this matter deep beneath the Earth's large continental regions where high pressure and low oxygen conditions prevail.

Natural gas can be converted into motive or electrical power.



Onshore Drilling

People, for one reason or another, have been digging into the earth's surface since the beginning of recorded history. The first wells were mainly used for drinking water or irrigation. These hand dug wells were usually shallow (relative to today's oil and gas wells), only scratching the surface of the Earth. At first, tools of stone and wood were used to dig these primitive wells, eventually, these tools were replaced by metal tools that were more efficient. Debris from the well was often hauled out of the hole in buckets. As early as 600 B. C. the Chinese were using percussion tools to dig wells through brine formations.

These wells used bamboo shafts with a metal bit to pound through the layers of brine. Percussion, or cable-tool drilling, is characterized by repeatedly raising and dropping a heavy metal bit into the Earth's surface- eventually pounding a hole downwards into the ground. This process is still widely used today for drilling water wells. Periodically, bailers, or containers that remove debris, must be lowered into the shaft to clear out loose soil and rock chips so that the bit will have a clear shot at the bottom of the well.

David and Joseph Ruffner are credited with an important development in well drilling: the first well that used a casing for the sides to prevent collapse. They were drilling through brine near Charleston, West Virginia where their holes kept collapsing in and ruining their well. To remedy the situation, they used hollow tree trunks to reenforce the sidewalls of the well. Today, steel pipe serves the same purpose.

Egyptians are credited with another first in drilling technology: they used rotary drilling mechanisms to drill into the Earth as early as 3000 B.C.. Much later, in 1500 Leonardo DaVinci developed a design for a drilling rig that is similar to many of today's rigs. Today, about 85% of the wells drilled use conventional rotary drilling rigs to dig their deep wells.

Natural gas can help reduce environmental pollution concerns around the globe.

Dependence on foreign oil is our nation's greatest energy concern. The United States imports nearly one-half of the oil we consume for a variety of uses, like space heating, process heating and drying, and electric power generation. Each year we pay other nations approximately $80 billion for their oil. This is greater than the combined net worth of our nation's three largest corporations.

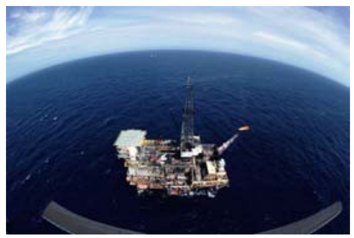
The massive monetary exodus directly contributes to our nation's trade deficit and encourages our reliance on other nations for this vital energy source. Over 95% of our natural gas energy is produces within the United States, while virtually all of the remaining 5% is imported from neighboring Canada and Mexico. When we choose natural gas as our main energy choice, we help to create a financially stronger and more stable America.

Natural gas is sometimes found along with crude oil production.

Workers lower a new rotary bit into the wellbore. Notice the sharp teeth that will break up rock formations.

OFFSHORE DRILLING

One of the earliest offshore drilling rigs was owned by T.F. Rowland in 1869. It was used in shallow water, but its anchored, four legged tower was the grandfather of today's modern platforms. Offshore technology surged shortly after World War II, when technology was sufficient to make such operations profitable. The biggest difference between onshore and offshore drilling is that the base where the rig is placed is man-made for offshore wells, while the land provides this base on land. The first step in drilling an offshore well is to establish a mechanism for attaching the floating drilling platform to the base of the ocean, but at the same time allow for pitching and rolling caused by the ocean's surface. In order to provide such a base, an underwater guided base is moved into precise position using LORAN and satellite technology. Next, a wide, relatively shallow hole (about 100ft deep) is drilled into the ocean floor. This hole is filled with a casting, which serves as a permanent base for the drilling template. The drilling template looks a bit like a cookie cutter: a box with several large, round holes cut into it. This template will eventually serve as the guide for multiple wells. Several other pieces of equipment are also attached to the drilling template, including a blowout preventer, which prevents oil or other pollutants from flowing out into open water. Several kinds of platforms can be attached to the drilling base, once it is in place. The type of platform varies with regard to the depth of water, distance from shore, and the turbidity of the waters over the well. For inland drilling, a drilling barge can serve as a suitable platform, while other, larger rigs are needed for open water drilling. Near shore, submersible or semisubmersible rigs are generally used. These rigs can be moved from site to site by pushing air into a lower hull, which causes them to float high on the water. However, when they are in place, the lower hull is flooded, which causes the platform to sink partially into the sea, thus becoming more stable. These platforms are also held in place by heavy weights, and anchor cables which anchor them to the sea floor. Drill ships can also be used to drill in deeper waters. They appear similar to ordinary ships, but they have a drilling rig located in the center of their hull. While drilling, these ships are kept in position by dynamic positioning, where the ship uses satellite navigation and multi-directional propulsion to remain directly above the well site. Permanent platforms are the largest, and most complex offshore structures. These massive platforms are placed in areas where multiple wells will be drilled, and production is high. Offshore permanent platforms built for use in the North Sea are some of the largest structures ever built. They can be constructed in over 500ft of water because of their massive size. They must be durable, able to withstand waves over 60ft high, and winds in excess of 90 knots. Often, these giants are constructed in part while they are being towed to the well site. Some of the larger platforms are 455ft in diameter at their base, weigh over 550,000 tons, and rise some 770ft from the seabed to the tip of the derrick (200ft taller than the Washington Monument). The cost of these platforms routinely exceeds 1 billion dollars. Permanent rigs are held in place by concrete, steel, or tension legs. Tension legs are hollow steel tendons that allow no vertical platform movement, but some minor horizontal movement. They can be less expensive than other forms of support.



Offshore rig workers lower a large drilling template into the ocean. It will guide the platform's drilling by providing an anchor to the ocean floor.

Offshore drilling technology has improved to a point where rigs can drill in extremely deep waters—beyond 3,000 feet.

DRILLING TECHNOLOGY

Advances in the latter part of the century have allowed drilling companies to cut costs, gather more information about well holes, and increase the value of wells through a variety of technologies. In the past, all information about the depth and conditions at any point below the surface in a well had to be obtained from the surface analysis of materials that were brought up by the drilling rig.

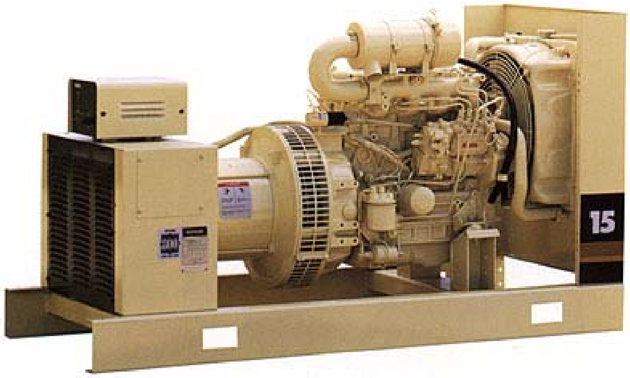
This was unsatisfactory because in deeper wells there was often a considerable delay between the time when a bit contacted a new layer of rock, or new conditions, and when evidence of this contact came to the surface. A new class of technology, known as measurement while drilling (MWD, includes all devices that help drilling crews by providing information about downhole conditions. They often constantly provide information to crews at the surface, thus eliminating the need to cease drilling operations in order to take measurements, and they also eliminate the amount of lag time between contact with new conditions and the surface crew's awareness of the change in drilling environment. These technologies have increased drilling safety, as well as efficiency.

One of the most exciting and productive new technologies is horizontal drilling. It is heralded today as, "...causing the greatest change in the industry since the invention of the rotary bit." The first patent for horizontal drilling tools was issued in 1891 to Robert E. Lee (the Civil War general). Lee drilled a horizontal drain for a vertical oil well.

The notion of drilling wells that are not aligned vertically with the surface is not new. For years, companies have been employing slant drilling to drill wells at an angle in order to reach areas where rigs could not feasibly be placed. Slant or deviation drilling has also been traditionally utilized in offshore sites where the expense of platforms prohibits the construction of multiple platforms. In order to reduce costs, several slanted wells are drilled from a single platform, reaching several different traps or oil fields. In some cases 20 or more slanted wells can be drilled from a single platform. The difference between slant wells and today's horizontal wells is that slant wells would take as much as 2000ft or more to bend from vertical to horizontal.

Drilling technology of today allows a drill head to turn nearly 90^0 in only a few feet. This allows greater control and targeting to locate natural gas pockets.

Millions of miles of pipe have been used as well casings in the exploration of natural gas.



On some drill platforms, all electricity used to work the rig is generated onsite using a natural gas power generator. Many generators use IMPCO products and technologies to run reliably.

MEASURING ENERGY GASES

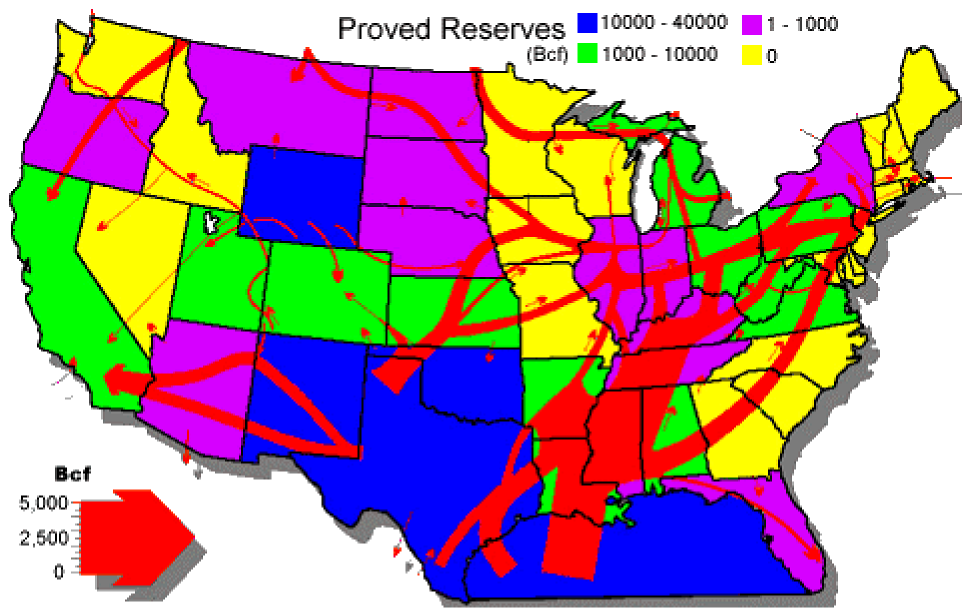
Quantities of natural gas are measured in volume units. A cubic foot of natural gas at a temperature of 60 degrees Fahrenheit and an atmospheric pressure of 14.7 pounds per square inch is the common unit of measure. Gas production from wells and supplies to power plants are measured in thousands or millions of cubic feet (Mcf and MMcf). Resources and reserves are calculated in trillions of cubic feet (Tcf). How much is a trillion feet? Enough to fill a cube with sides two miles long!

The amount of energy that is obtained from the burning of a unit volume of natural gas is measured in British thermal units (Btu). One Btu is the amount of heat required to raise the temperature of one pound of water from 60 to 61 degrees Fahrenheit at normal atmospheric pressure (14.7 pounds per square inch). At sea level, it takes about 75 Btu to make a cup of tea. A cubic foot of natural gas on the average gives off 1,000 Btu, but the range of values is 500 to 1,500 Btu. Therefore, one cubic foot of some natural gas may make only 7 cups of tea, while another makes as many as 20 cups of tea.

Energy content of natural gas varies because natural gas accumulations vary in the amount and types of energy gases they contain: the more non-combustible gases in a natural gas, the lower the Btu value. In addition, how much of any energy gas that is present in a natural gas accumulation-the mix of combustible gases-also influences the Btu value of natural gas. The more carbon atoms in a hydrocarbon gas, the higher its Btu value. To illustrate: methane typically represents more than 80 percent of energy gases. Methane contains one carbon atom per molecule; burning one cubic foot of methane gives off 1,012 Btu. Butane, possessing four carbon atoms, has a Btu value more than three times larger than that of methane.

Molecular hydrogen, on the other hand, though combustible, contains no carbon atoms; its Btu value is three times smaller than that of methane.

During crude oil production some wells burn off well gases as a safety precaution. Other rigs use the natural gas to power generators.



This map shows the prinipal flow of natural gas in the lower 48 states. It also shows the areas that hold most of the nation's proved reserves. The flow of natural gas from the Gulf region is nearly 5,000 Bcf annually.

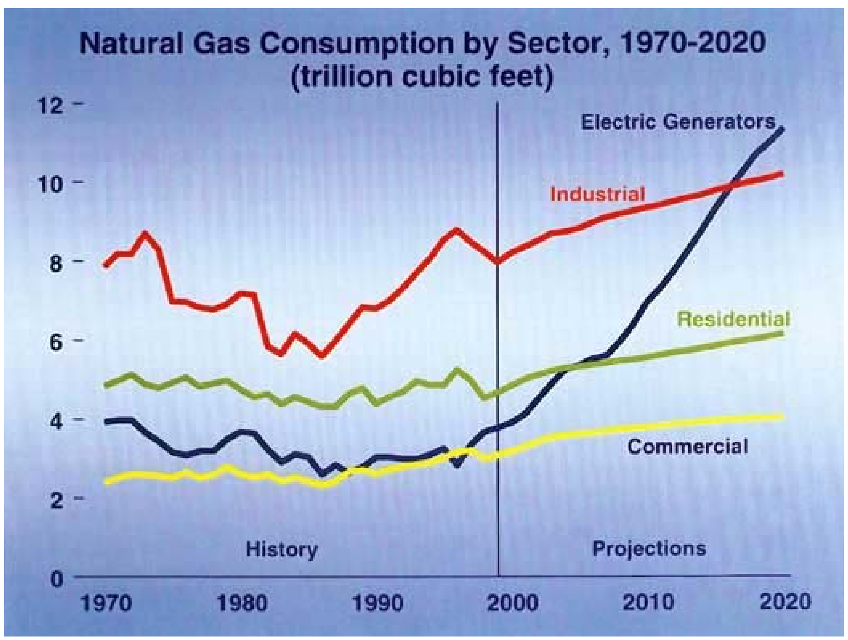
Natural gas is used to heat homes, water and for cooking.

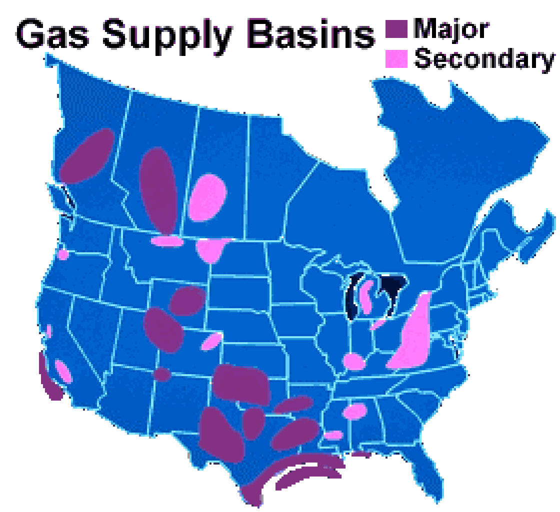
GLOBAL ABUNDANCE

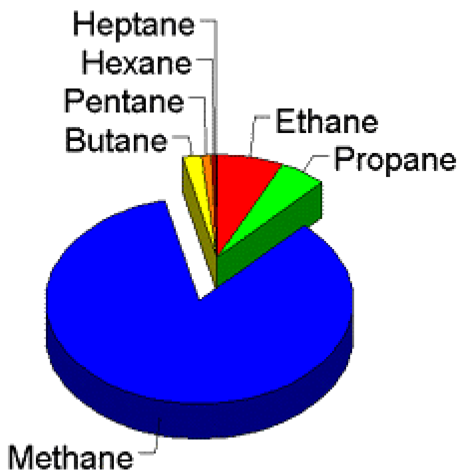
Natural gas resources are widely and plentifully distributed throughout the world. At current consumption rates, many countries have several decades, if not centuries, of estimated natural-gas resources.

A recent U.S. Department of Energy study reports that recoverable reserves and resources of natural gas in the lower 48 states total 1.295 trillion cubic feet, more than a 70-year supply at current production levels. Most of these reserves are recoverable at prices below $3.50, so the country is in no danger of running out of natural gas any time soon. Most U.S. gas demand is met by domestic production. In 1992, 9.2% of U.S. natural gas consumption was met by imports, virtually all arriving by pipeline from Canada. The low level of U.S. imports is typical of the natural gas markets worldwide. While nearly 50% of world oil production crosses a country's borders, only 16% of the world's gas production does so.

Natural gas is sometimes cooled and stored as Liquid Natural Gas or LNG.







An approximate breakdown of raw natural gas by component. Many other hydrocarbon gases are removed from the methane mixture and sold separately from natural gas.

As a method of transport, natural gas is cooled and shipped in bulk as LNG.

NATURAL GAS PRODUCTION

Once drilling has come into contact with a productive petroleum formation, it is important to test the formation in order to determine whether or not a company will be able to profit from extracting gas and oil from the formation, as well as the proper rate of extraction and other production issues. Information that needs to be obtained includes the depth and type of formation, the gas to oil ratio, the viscosity of the oil, and the overall economic outlook for the project.

In the past, oil and gas producers were intent on extracting the most oil and gas in the least possible time from a given well. Today, the climate is much different. Much more emphasis is placed on the most efficient recovery performance of a well. Efficient recovery takes planning and the right kind of equipment. Excessive production rates can cause a well to be damaged, leading to less oil and gas in the long run.

When a new well begins production, a potential test is run on it to determine the most oil and gas that it can produce in a 24 hour period. The MER, or most efficient recovery rate, is based on the most oil and gas that can be extracted for a sustained period of time without harming the formation. Other tests are also performed to measure pressure, heat and other variables at the bottom of the well.

Some wells are under enough pressure that the oil and gas will flow freely from them without any need for a pump or lifting system. There are only a small number of these formations, and even these usually require a lifting system at some point in their active lives. Flowing wells only require a 'Christmas tree' or a series of valves and pipes at the surface in order to produce gas and oil.Most wells, however, require some sort of lifting method to extract the oil and gas present in their formations. The lifting method depends on the depth of the well and whether or not the well has multiple completions. The most common lifting method is rod pumping. Rod pumping involves a surface pump that is run by a cable and rod that move up and down, pumping oil and gas out of a well. The most common engine for a rod pump is the horse head, or conventional beam, pump. This pump uses weights to help the motor lift and drop the rod in the rod pumping mechanism. They are aptly nicknamed horse head pumps because the fixture which feeds cable into the well is shaped like a horse head. Other lifting mechanisms are also in use that lie under the surface of the Earth. These subsurface units sit nearer to the petroleum deposit, and pump the oil and gas to the surface. Some formations also require some sort of treatment to improve the flow of gas or oil.

NATURAL GAS PROCESSING

The gas processing industry is a major segment of the oil and gas industry, distinct from either crude oil or natural gas production, separate from oil refining or gas distribution, yet indispensable to all. As a separate and identifiable function, it is probably the least known and least understood part of the petroleum industry.

Whether or not the gas processing function is understood, even in the petroleum industry, gas plant production provides about 20% of total U. S. petroleum liquids production. Including liquefied refinery gases, natural gas liquids (NGLs) account for about 24% of total U.S. production of liquid petroleum. Given the inevitable trend to increased natural gas consumption, coupled with a continuing decline in crude oil production, NGL's will, by the end of the decade of the 1990's, account for 25-35% of total U.S. production of liquid hydrocarbons. In addition, the gas processing function gathers, treats, conditions and delivers over 18 trillion cubic feet of natural gas per year into the U.S. energy economy the equivalent of about 3 billion barrels of crude oil.

In simple terms, the gas processing industry gathers, conditions and refines raw natural gas from the earth into saleable, useful energy forms for use in a wide variety of applications. Through the gas processing industry's plants flows approximately 61% of U.S. petroleum energy production, which emerges in the form of merchantable natural gas, liquefied petroleum gases, motor fuel components, and raw materials for a myriad of basic petrochemicals.

Natural gas may also contain water, hydrogen sulfide, carbon dioxide, nitrogen, helium, or other components that may be diluents and/or contaminants. In any case, natural gas as produced rarely is suitable for pipe line transportation or commercial use. Natural gas in commercial distribution systems is composed almost entirely of methane and ethane, with moisture and other contaminants removed to very low concentrations. Although there are no industry specifications for pipeline quality gas, Table 3 is a summary of typical requirements; each pipeline may impose other specification parameters, depending on its system requirements.

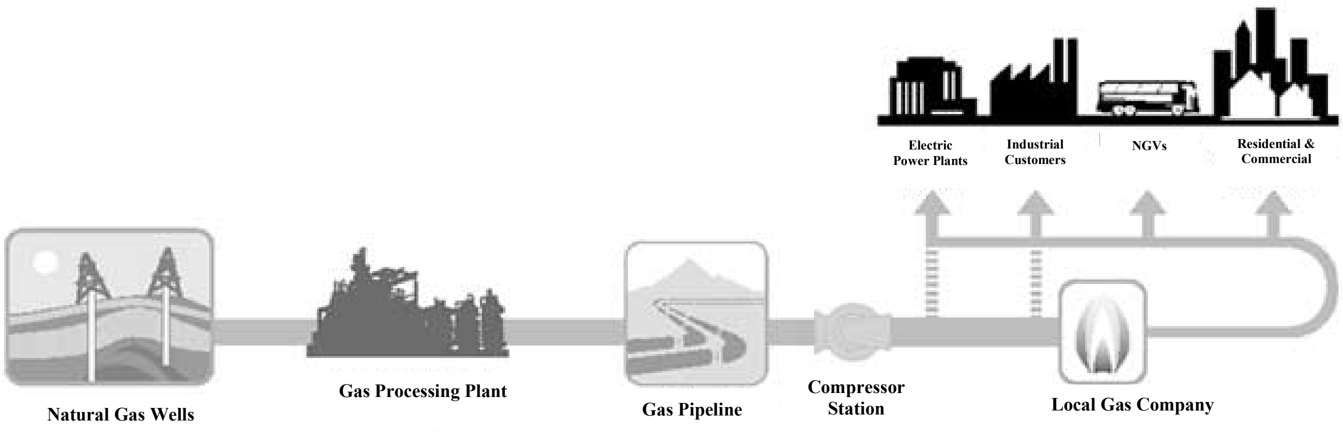
Therefore, all natural gas is processed in some manner to remove unwanted water vapor, solids and/or other contaminants that would interfere with pipe line transportation or marketing of the gas. In addition, and equally important, most natural gas is processed to separate from the gas those hydrocarbon liquids that have higher value as separate products.

These natural gas liquids (NGLs) are part of a family of saturated hydrocarbons called paraffins. Each compound has a chemical formula C_nH_{2n+2}, and each has distinctive physical properties. The principal natural gas liquids include:

- **Ethane:** Exists as a liquid only under very high pressures (800 psi) or at extremely low temperatures(-135°F). It is recovered and transported in either the liquid or gaseous state principally for use as feedstock for ethylene, the most important basic petrochemical produced today.
- **Propane:** Recovered and handled as a liquid at pressures over 200 pounds, or at temperatures below -44 F. Its principal uses are as feedstock for production of ethylene and propylene, and as LP-gas for heating fuel, engine fuel, and industrial fuel.
- **Butane:** Recovered and handled as a liquid under moderate pressure. Its principal uses are to provide needed volatility to gasoline motor fuel; as LP-gas fuel, either alone or in mixtures with propane; and as a feedstock for the manufacture of ethylene and butadiene,a key ingredient of synthetic rubber. It is also isomerized to produce iso-butane.
- **Iso-butane:** The chemical isomer of butane, it is fractionated from "field grade" butanes or derived by isomerization of normal butane and produced as a separate product, principally for the manufacture of alkylate, a vital ingredient of high-octane motor gasoline. It has become an increasingly important product for production of methyl tertiary butyl ether (MTBE) for use as a high octane oxygenate ingredient of reformulated motor gasoline.
- **Natural Gasoline:** A mixture of pentanes and heavier hydrocarbons, with small amounts of butane and iso-butane. Industry specifications define its physical properties in terms of vapor pressure at 100°F (10 to 34 psi), and percentage evaporated at 140°F (25 to 85%). It is recovered as a liquid, principally for use as a motor fuel component.

Natural gas processing plants operate all around the world.

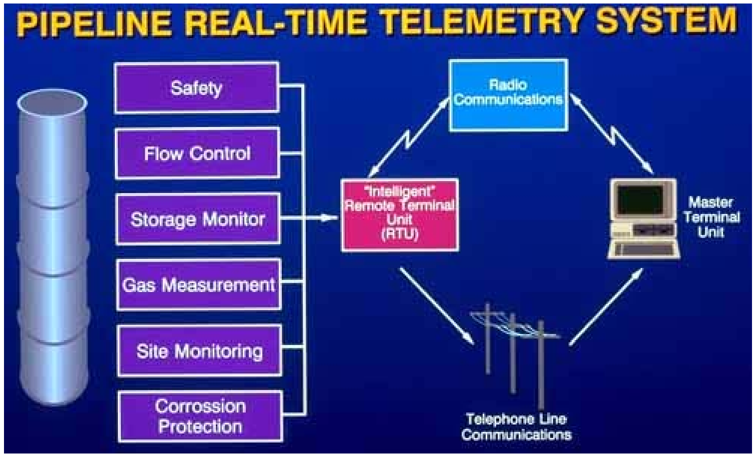
NATURAL GAS TRANSPORTATION



After raw gas from the wellhead is processed, it is moved into a pipeline system for transportation to an area where it will be sold. A pipeline company is a very separate company from a producer or a distributor, although sometimes pipelines sell gas directly to large customers. The interstate pipeline system is massive, reliable, and efficient. Major investments in the pipeline system during the 1980's and early 1990's improved the system's capacity to areas in the Northeast, West Coast and Florida. However, the pipeline industry is still making improvements in capacity, efficiency and cost effectiveness, since transportation costs still make up a large portion of the consumer's price for natural gas.

Most sections of pipeline are made of steel piping, measuring anywhere from 20 to 42 inches in diameter. When natural gas is moved through a pipeline, it is transmitted at higher pressures (from 200 to 1500 psi) to reduce the volume of the gas, and provide a pushing force to propel the gas through the pipe. In order to maintain the level of pressure required to move the large volumes of gas through a pipeline, the gas needs to be compressed periodically as it moves through the pipeline. This requires pipelines to install compressor stations every about every 100 miles along the pipeline. Most of these compressors are classified as reciprocating compressors, which means that they are powered by a very small portion of the natural gas that flows through the pipeline. These compressors are efficient and safe, their only drawback being that they tend to be quite large. There are over 8,000 gas compressing stations along gas pipelines, with a combined output capability of over 20 million horsepower.

The U.S. gas transmission system is composed of over 300,000 miles of piping, not including local distribution lines. These pipelines need to be monitored 24 hours a day and 365 days a year. In order to keep accurate, constant information on sections of pipeline, pipeline companies use 'supervisory control and data acquisition systems' . These are computerized systems that allow pipeline operators to acquire information from remote sections of pipeline, and also control the flow of gas at remote locations by using computers that are linked to satellite communication and telephone communication systems. SCADA systems allow not only the pipeline operators to obtain timely information, but they also allow producers to have access to some of the same information so that they can purchase distribution services according to the current volume of gas in a pipeline.



NATURAL GAS DISTRIBUTION

Distribution is the delivery of natural gas from an interstate pipeline to local consumers. It is performed by local distribution companies (LDCs).

Types of Distributors

LDCs are of two types:

- Investor-owned, which are owned by shareholders.
- Municipally owned (sometimes called public gas systems), which are owned by local governments, such as cities, counties and special utility districts.

For most of the 20th century, LDCs have been awarded exclusive rights (or franchises) to distribute gas in a specified geographic areas. In return, investor-owned LDCs are regulated by state public utility commissions to assure adequate gas supply, dependable service, and reasonable prices for consumers, and to assure reasonable rates of return on investment for the shareholders. Municipally operated LDCs are owned by the local community and governed by agencies of local government to assure compliance with local needs and preferences.

LDC Customers

While many large gas users today buy gas from marketers, LDCs continue to serve residential, commercial, and industrial customers. Usually, LDCs have different rates for different customer classifications based considerations such as the amount of gas used or daily and seasonal fluctuations in use.

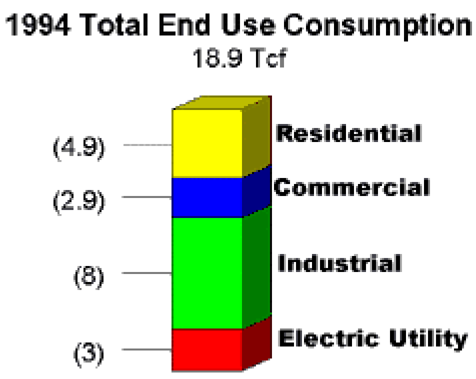
Today, it is primarily larger users who purchase gas separately from transmission services; smaller users still tend toward the "bundled" gas product-and-service offered by most LDCs. In the future, however, residential and commercial end users may be offered new ways to buy natural gas. A number of states are experimenting with pilot programs permitting smaller users, including residences, to buy gas from a party other than the local LDC.

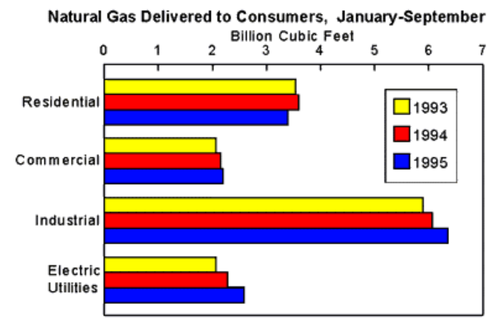
New Distribution Technologies

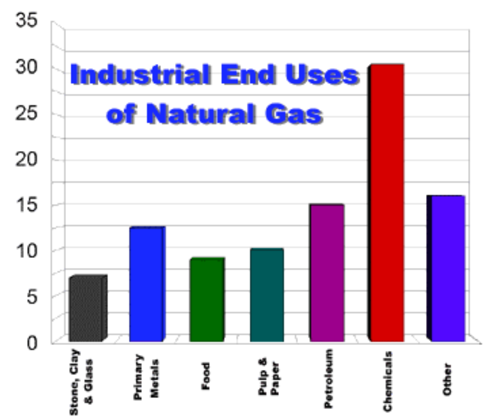
Distributors have been very active in developing both new gas applications (such as the gas fireplace and cooling systems) and new technologies that help cut costs and improve service. Some of the most important of these latter are:

- Flexible distribution tubing, which replaces the traditional rigid steel pipe used to get gas from the house meter to the appliance with corrugated stainless-steel tubing, which can save up to 50 percent on installation costs.
- Plastic distribution pipe, which today replaces traditional steel mains and service lines in 90 percent of new installations.
- Electronic meter-reading systems that reduce the costs of deploying human meter-readers.
- Computer mapping systems that help locate underground pipe.
- New trenching techniques that reduce excavation and site restoration costs when mains are extended or when pipes are replaced or repaired. Some of these techniques involve guided boring systems that can install pipe without extensive disturbance of land surfaces.

In addition, like interstate pipelines, distributors make extensive use of computer-based transportation technologies such as valve regulation via satellite telemetry and "supervisory control and data acquisition" (SCADA) systems that control gas flow while also providing accounting information, contract data, and electronic gas measurement.







WHAT'S AN NGV?

NGV stands for natural gas powered vehicle. A dedicated NGV is designed to run exclusively on natural gas. A bi-fuel NGV operates on gasoline or natural gas and can change fuels with the flip of a switch. A dual-fuel NGV runs on a combination of natural gas and diesel. In most NGVs, the natural gas is compressed, up to 3600 psi. For heavy-duty NGVs, such as transit buses, long-haul delivery trucks, or even locomotives, natural gas can be liquefied, using a cryogenic process.

Who uses NGVs?

The U.S. Postal Service has the largest fleet of NGVs in the nation, with 3,000 natural gas delivery trucks, and plans to convert thousands more. United Parcel Service (UPS) operates nearly 400 package delivery vehicles on natural gas and expects to add hundreds more. Transit authorities and taxi fleets throughout the U.S. have also discovered the benefits of using natural gas. Even Disneyland uses natural gas to fuel many of its boat rides.

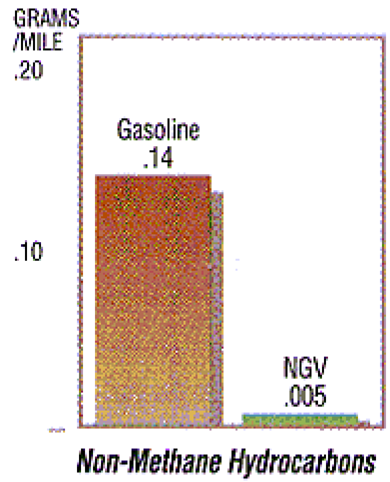
Buses around the world operate exclusively on natural gas with IMPCO providing the fuelling technology.

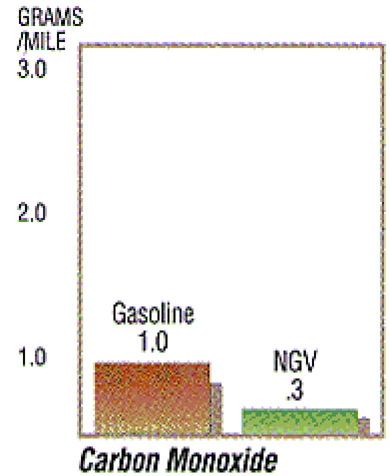
Ford offers bi-fuel pickup trucks through its Qualified Vehicle Modifier (QVM) program.

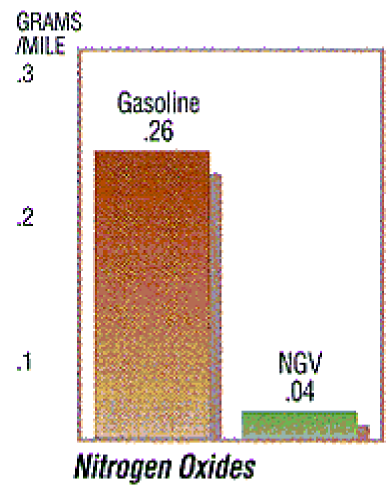
NATURAL GAS IS ALSO USED IN MEDIUM- AND HEAVY-DUTY TRUCKS, SCHOOL BUSES, TRANSIT BUSES, SHUTTLE BUSES AND TROLLEYS. IT IS AN EXCELLENT FUEL FOR NON-ROAD VEHICLES, SUCH AS FORKLIFTS, BACKHOES, STREET SWEEPERS, AIRPORT GROUND SUPPORT EQUIPMENT, AND EVEN BOATS.

HOW CLEAN IS NATURAL GAS?

Natural gas emits less carbon monoxide, nitrogen oxides and non-methane hydrocarbons than gasoline, as shown in the graphs below.







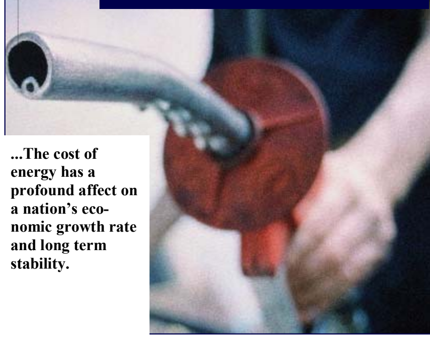
Is natural gas safe?

- Natural gas is lighter than air. In the event of a leak, it would disperse upward, rather than pooling on the ground.
- The ignition temperature of natural gas is over 1200°F, compared with about 600°F for gasoline.
- Natural gas is only flammable within a narrow range of about 5-14% volume in air.
- Natural gas tanks are made of steel, aluminum, and/or composite materials, and are much stronger than gasoline tanks.

Air Pollution & Global Warming

...Global warming is an issue we all must be concerned with. Yet countries looking to grow in the world economy must place a higher level of action in improving their nation's air quality. They must also create policies that make economic incentive a parallel factor to reduction in pollution.

Rising Fuel & Power Costs



...The cost of energy has a profound affect on a nation's economic growth rate and long term stability.

Unreliable Fuel & Power Supply

...Countries that do not have reliable sources of clean energy have slower domestic growth and greater health issues for its population.

...EVERY YEAR OVER 5.7 BILLION POUNDS OF POLLUTANTS ENTER OUR ATMOSPHERE...MAKING THE AIR WE BREATHE DANGEROUS TO OUR CHILDREN AND OURSELVES.

CHANGING TO GASEOUS FUELS IS ONE WAY TO COMBAT THIS PROBLEM. THE OTHER IS TO IMPLEMENT POLICIES THAT ATTRACT THE USE OF CLEAN FUELS, THEN ENFORCE THE RULES THROUGH THOUGHTFUL ENTERPRISE.

MARKET DRIVERS

Drivers for each country may change in their level of importance, yet on a global scale each of the three key market drivers will be found: air quality; fuel and energy costs; and energy source reliability. When two or more of these drivers are found, the likelihood of success in clean-fuel policy making increases tenfold.

Most every country in the world has its own indigenous supply of clean gaseous fuels. Countries which make advantage of this help to reduce dependency on foreign oil supply, reduced air pollution and stabilization of national fuel costs.

...Successful markets are where the government has implemented and controls the use of clean fuels for the benefit of the environment, its resources and the economy.

	Government Regulations	Lower Fuel Costs	Energy Self-Reliance
Australia	●	●	●
Canada	●	●	●
China	●	●	●
Holland	●	●	●
India	●	●	●
Indonesia	●	●	●
Malaysia	●	●	●
Mexico	●	●	●
Pakistan	●	●	●
Turkey	●	●	●
United Kingdom	●	●	●
United States	●	●	●
Argentina	●	●	●
Egypt	●	●	●
France	●	●	
Germany	●	●	
Hong Kong	●	●	
Italy	●	●	
Japan	●	●	
S. Korea	●	●	
Taiwan	●	●	
Thailand	●	●	
Chile	●	●	
Venezuela		●	●
Brazil		●	●
Poland		●	●
Russia		●	●

WHY PROMOTE NATURAL GAS AT THE GOVERNMENTAL LEVEL?

- Clean efficient combustion.
- Among the lowest life-cycle greenhouse gas emissions of all commercially available fuels.
- Insignificant emission levels of sulphur, the main cause of acid rain.
- Extremely low particulates produced during combustion.
- Absence of damage to soil and water in case of spills, due to rapid evaporation of Automotive Natural Gas.

ADVANTAGES FOR COUNTRIES AROUND THE GLOBE.

- Natural Gas is a very suitable fuel for vehicles that have to comply with stringent emission requirements.
- The emissions of carbon monoxide (CO), nitrogen oxide (NOx), hydrocarbons (HC) non-burned hydrocarbons and particles are very limited.
- Natural Gas produces the lowest amount of greenhouse gases of all the fossil fuel options for automotive use in total fuel cycle emission analysis.

IMPCO's Eclipse system passes the 4 million kilometer mark during tests in the UK.

GOVERNMENTS FINANCIALLY MAKE THE MARKET SUCCESSFUL.

Clear and concise long-term government policies are required to allow commercially interested parties to justify the funding of infrastructure projects. This also allows potential vehicle users to gain a good understanding of the benefits to both the environment and to themselves when determining the purchase of Natural Gas vehicles.

GENERAL RULES & POLICIES.

An even-handed approach to alternative fuels, whereby market forces will result in the adoption of the alternative energy source most commercially suited to the country.

INDUSTRY LEVEL ACTIONS.

Development of alternative taxation strategies, to offer lower capital taxation rates on items supporting Natural Gas.

Participation in joint venture agreements to foster and develop Natural Gas and/or subsidize trials in the market place.

CONSUMER LEVEL ACTIONS.

Favorable excise duties for Natural Gas, to encourage its use.

Conversion pay-backs, through taxation benefits or direct cash grants for conversions actually performed.

Unrestricted access and parking of Natural Gas vehicles within cities, even on days of high pollution.

Reduced road registration fees for Natural Gas fuelled vehicles.

Mandate approach, specifying how much of the country's fleet is to be powered by Natural Gas and when.

OUR MISSION

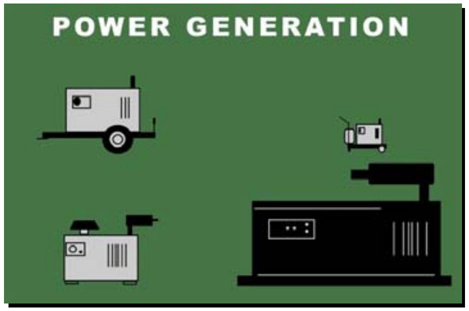
Our business is the technology development, manufacturing, and worldwide marketing of products that support the use of alternative fuels in propulsion systems. We are committed to providing quality, reliable, and cost effective products that provide customer value and a better environment. We strive to maintain our leadership position in the markets we serve through effective supplier and employee teamwork in response to customer needs. We dedicate ourselves to a better world through cleaner air.

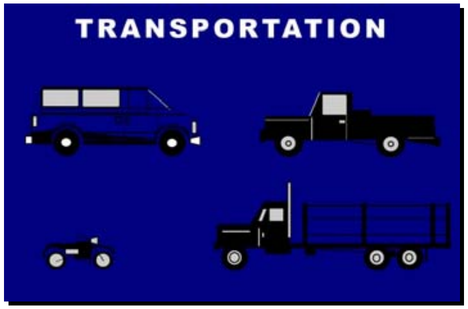
IMPCO IS THE WORLD'S LEADING SOURCE OF ADVANCED ALTERNATIVE FUEL SYSTEMS TECHNOLOGY AND COMPONENTS FOR INTERNAL COMBUSTION ENGINES. IMPCO PRODUCTS ENABLE THESE ENGINES TO FUNCTION USING ENVIRONMENTALLY FRIENDLY GASEOUS FUELS SUCH AS PROPANE, NATURAL GAS AND BIOGAS. IMPCO PRODUCTS OPTIMIZE EFFICIENCY AND PERFORMANCE WHILE REDUCING EMISSIONS TO THE LOWEST-LEVELS. IMPCO IS A MAJOR SUPPLIER TO TRANSPORTATION, INDUSTRIAL AND POWER GENERATION MARKET SEGMENTS.

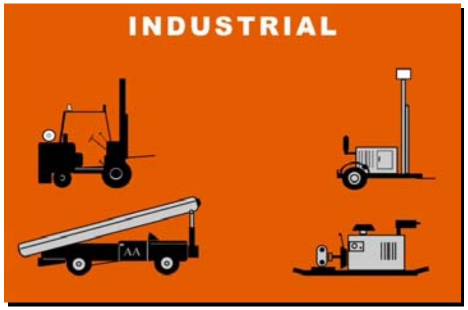
One company has taken the challenge of improving the air we all breathe - IMPCO Technologies. IMPCO is a company dedicated to a better world through cleaner air. IMPCO's promise to the environment is demonstrated by our continued expansion of services and products around the world.

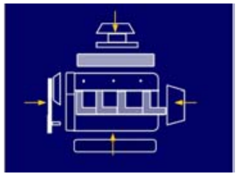
IMPCO does business in three, key growth market segments: Transportation; Industrial; and Power Generation. We design, manufacturer and market components, complete fuel systems, engine management controls, electronic control products, engine dress services, integrated and certified emission packages, powertrain systems, service part programs and technical training. Our market segments contain diverse applications, from: small one-cylinder scooters and low displacement automobiles to forklifts, wood chippers and welders to large portable and stationary power generators used to keep the lights and power flowing.

IMPCO has shipped more than 4.5 million systems worldwide. We have the broadest application coverage in the industry.

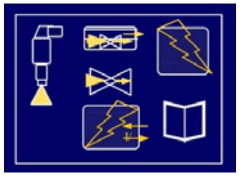






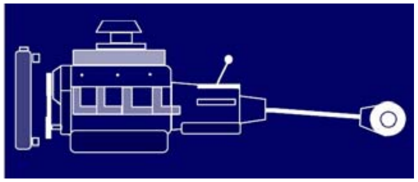


Engine Dressing Services

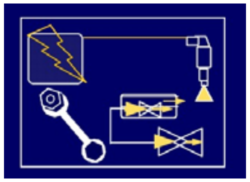


Fuel System Components

Technical Training



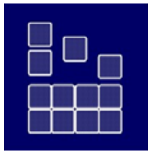
Integrated Powertrain Systems



Complete Fuel Systems

Service Part Programs

Electronic Control Products



Systems Integration

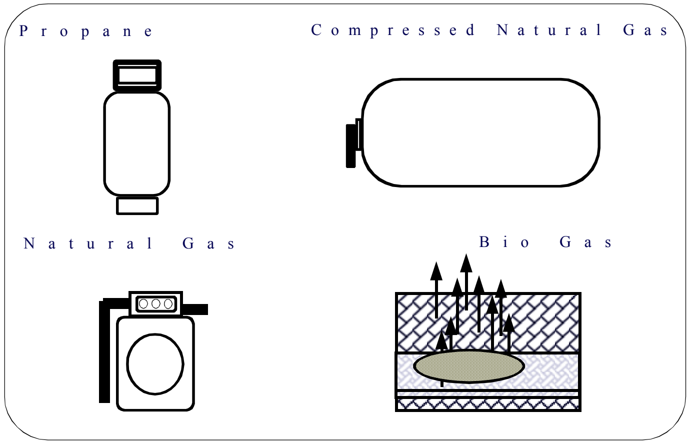
Engine Management Systems

For Internal Combustion Engines Ranging From:

1.5HP (1.1kW)

5,000HP (3,728kW)

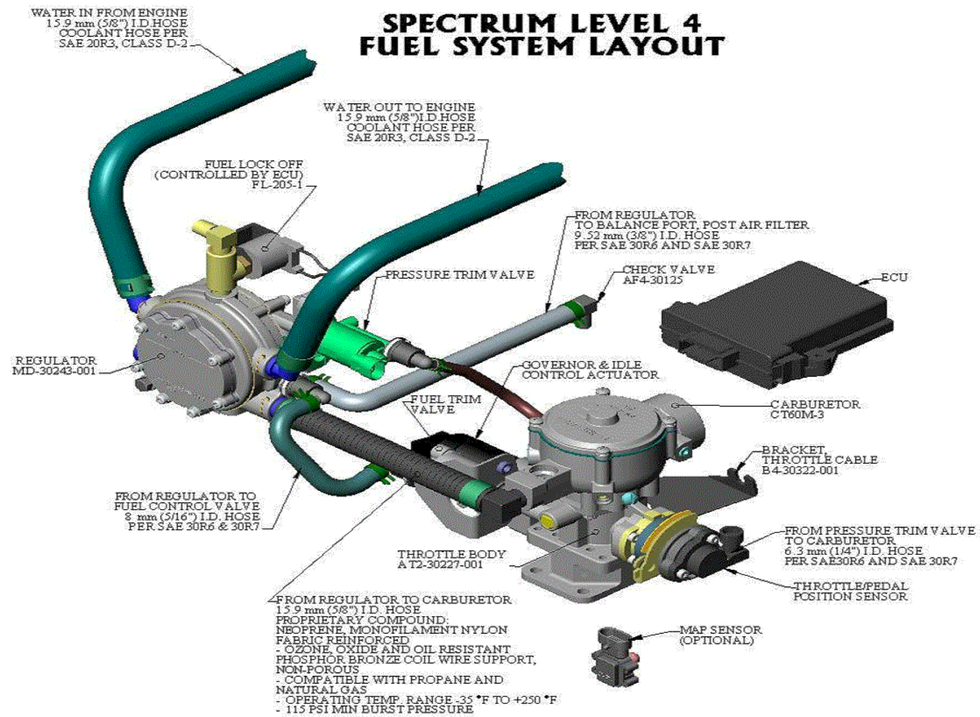
The only alternative fuel company that has products for engines ranging from 1.5 to 5,000 horsepower.



IMPCO products make use of all of the most popular and clean gaseous fuels.

Spectrum's next-generation natural gas control and metering systems ensure the lowest possible exhaust emissions by including computer controls. This provides the best overall performance and reduced levels of pollutants.

Much like advanced automobiles, IMPCO natural gas systems can match vehicle performance, driving range and Euro emission levels to that of gasoline (petrol) . With the unique induction and metering design of the IMPCO system, durability and reliability are assured, not matter what the fuel blend quality may be. This ensures long lasting emission level reduction: a key government objective.



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Japan
China
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Russia*
New Zealand*
Canada
United States
Mexico
Mexico City
Latin America
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South Africa*
Egypt
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