The "Nuts and Bolts" of New Mexico's Oil and Gas Industry

Brian S. Brister, *New Mexico Bureau of Geology and Mineral Resources*

Since the early 1920s New Mexicans have enjoyed the benefits of a thriving petroleum (oil and natural gas) industry that today provides thousands of jobs and hundreds of millions of dollars in state revenues. However, relatively few citizens of the state have a basic understanding of, or appreciation for, the basic elements of petroleum production, processing, transportation, and distribution systems required for a viable industry. The "nuts and bolts" referred to here are the infrastructure and processes required for the industry to accomplish its job of delivering an end product to the consumer market. It is important to understand that all of the components of the production-through-distribution cycle are necessary in order for the industry to function and provide the fuels and products upon which we rely.

Petroleum industry infrastructure varies significantly depending upon the raw materials produced and the needs of the end user. Production in the San Juan Basin is dominated by natural gas, although crude oil is also produced. Production in the Permian Basin of southeastern New Mexico is dominated by crude oil, but natural gas production is also significant (see paper by Laird Graeser in this volume). End consumers are found all over the Southwest, with California being an important market, particularly for natural gas. This article will focus on infrastructure in the San Juan Basin, but common to the "oil patch" in general.

WHAT ARE OIL AND NATURAL GAS?

Natural gas and crude oil naturally reside in underground reservoirs. Crude oil, typically liquid at surface temperature and pressure, is a complex mix of hydrocarbon molecules (molecules that contain hydrogen and carbon) and non-hydrocarbon molecules. Crude oil in the reservoir often contains light hydrocarbons in solution that bubble out of the oil as natural gas at the surface (sometimes called "casinghead gas"). San Juan Basin oil reservoirs tend to have a significant amount of associated gas. In fact, today the gas from these wells is more volumetrically and economically significant than the oil. Oil-producing reservoirs in the San Juan Basin are limited to the flanks of the basin, whereas basin-center reservoirs are gas productive. Both crude oil and natural gas must be refined to yield the varied fuels and petrochemicals that we consume.

Gas in its natural state is somewhat different from the natural gas we consume, and it may or may not be associated with oil. As produced at the wellhead, natural gas is a mixture of light hydrocarbons including methane, ethane, propane, and butane. It also may contain variable amounts of nitrogen, carbon dioxide, hydrogen sulfide, and perhaps traces of other gases like helium. Condensate (a.k.a. "drip gas") is a light oil byproduct of cooling natural gas as it rises to the surface in the well. More than half of the natural gas produced in the San Juan Basin is from coalbed methane (CBM). CBM is a simpler mix of methane and carbon dioxide. Gas that is transported in major interstate pipelines and sold as burner-tip fuel for heating is almost all methane, with a heating value of 1,000 BTU per mmcf, where BTU stands for British Thermal Units and mmcf stands for million cubic feet of gas. This "standard" gas is what we rely upon as consumers. In order to produce standard gas, non-methane hydrocarbons (that increase BTU value), and non-hydrocarbons (that decrease BTU value) must be removed from the gas stream.

UPSTREAM AND DOWNSTREAM

The terms "upstream" and "downstream" are often heard, but what do they mean? Upstream operations are those that involve extracting crude oil or natural gas from a natural underground reservoir and delivering it to a point near the well site, such as an oil tank or gas meter. From here it is sold by independent producers to refiners or pipeline companies who may or may not be the ultimate marketers of the product. Downstream operations are those that include gathering, transporting, and processing of the oil or natural gas and distributing the final products, including standard natural gas and refined products like gasoline. A variety of processes and equipment are required in the upstream and downstream industries. Each step of the production-to-distribution cycle tends to create added value and employs skilled workers in well-paying New Mexico-based jobs.

UPSTREAM INFRASTRUCTURE

Although many companies continue to explore for new reservoirs, New Mexico is generally considered to be a "mature" petroleum province, in that a large number of reservoirs have been found and developed to full production potential. For this reason, there is extensive upstream infrastructure in the producing New Mexico counties. At one time these producing fields were the assets of major integrated oil companies, but today these fields have been largely divested to smaller independent producers, many of whom are headquartered here in New Mexico. Associated with these fields are the easily recognized pumpjacks and tank batteries (row of tanks) that dot our landscape. But there is more there than meets the eye. Figure 1 illustrates typical upstream equipment associated with individual or small clusters of wells.

Below the surface of the ground at each well, there are miles of steel alloy well casing designed to withstand the heat and pressure encountered in the underground environment, carefully treated to withstand a corrosive environment and remain functional through the predicted life of the field. Two or more casing strings are installed in each well, cemented into the drill hole in order to prevent contamination of fresh water and mixing of fluids between porous formations. Within the production casing is a string of production tubing, which conveys reservoir fluids to the surface. Where gas is produced, the gas flows under its own pressure up the tubing. In wells where liquids are produced, a downhole pump, driven by the pumpjack at the surface alternately raising and lowering a single string of interconnected solid rods, acts as a plunger to lift the liquid to the surface.

At the surface the wellhead caps the casing and tubing and directs the produced fluids toward temporary storage. Wellheads on gas wells, commonly called "Christmas trees," typically stand tall in order to provide

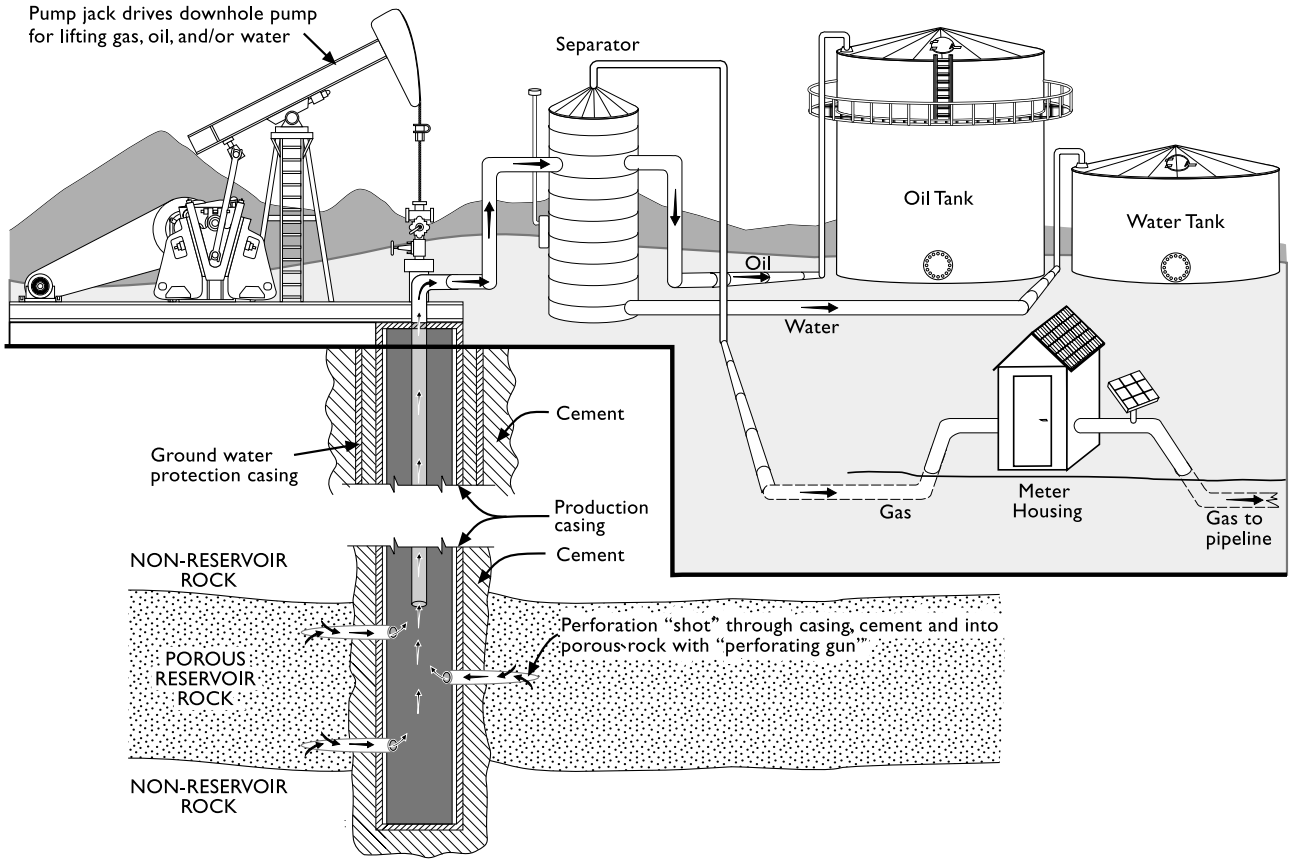

FIGURE 1 Upstream infrastructure of oil and natural gas production.

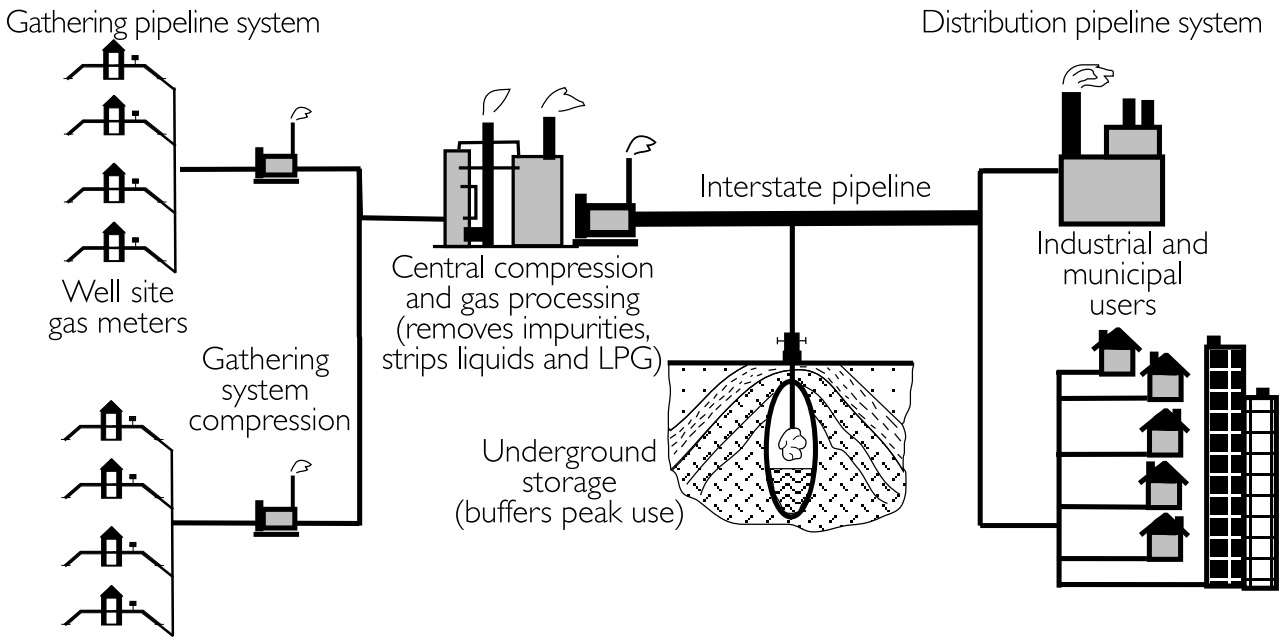

FIGURE 2 Downstream natural gas infrastructure.

working room for servicing the high-pressured well. After leaving the wellhead, the fluids will go to a separator in order to separate gas from oil and/or water that is sometimes produced from the well with the gas. Once separated, the oil flows to an above-ground storage tank, the water flows to a water tank, and gas flows through a meter and into a pipeline. If water is produced, there may be equipment nearby to pump it back into the reservoir to maintain reservoir pressure or the water may be trucked or piped to an approved subsurface-disposal facility.

DOWNSTREAM INFRASTRUCTURE

Downstream infrastructure includes a complex network of transportation, processing and refining, storage, delivery, and sales networks that span the continent.

In the San Juan Basin, oil is typically collected at or near the well site from the tank battery and trucked to a pipeline terminal, although some 20% is trucked directly to the refinery. Some larger fields may deliver oil directly to a pipeline. Either way, much of the crude oil arrives at a refinery (for example, the Giant Industries, Inc. Bloomfield refinery) via pipeline where it is then temporarily stored in above-ground tanks in a tank farm. The largest tanks may hold several million gallons.

The refinery processes the oil to create familiar end products such as gasoline, diesel, jet fuel, kerosene, lubricating oil, asphalt, and petrochemical feedstocks. Processes such as distillation and catalysis essentially "crack" the complex and heavy hydrocarbon molecules in the oil to create the various products. The reforming process creates desirable molecules following cracking, generally to increase octane of the gasoline fraction. Unwanted parts of the crude oil, such as sulfur, are removed in the scrubbing process.

The primary product of most refineries is transportation fuel, which is stored at the refinery tank farm awaiting shipment via product pipeline or truck transport to tank farms at distribution terminals near larger cities. These terminals are the hub for truck transportation to retail outlets.

Due to the low dollar value per volume of natural gas, trucking is not a viable option for transporting it; it must therefore be transported by pipeline. The processes and related infrastructure for gas production can be summarized in key components shown in Figure 2. Gas is compressible; as it is stuffed into a smaller space, its pressure rises. On the other hand, as pressure is reduced, it expands. This useful property

provides the mechanism for gas to flow from one point to another (from high to low pressure) through the pipeline system. San Juan Basin gas wells produce relatively low-pressure gas that must undergo several stages of compression (pressure increase) upon leaving the well site gas meter. A gathering system of pipelines transports the gas to a central hub, where the gas is compressed before entering the next pipeline stage.

At strategic points along the pipeline system, but generally before it enters an interstate pipeline, the gas is processed at a gas plant (such as the Williams Field Services gas plant at Lybrook, New Mexico) to separate certain natural components from the standard quality "residue" gas desirable for interstate transport and distribution. The chemical characteristics of the gas produced at the well determine the processing that will take place. For example, if the natural gas is relatively high in carbon dioxide, as is typical for coalbed methane, an extraction facility uses an exothermic (heating) chemical reaction to extract the offending component. In this example, not only is the BTU value of the gas upgraded, but a corrosive component is removed, thus protecting the integrity of the interstate pipeline. Natural gas produced from conventional (non-coalbed methane) reservoirs tends to be rich in ethane, butane, and propane. These hydrocarbons are extracted through a cryogenic (cooling) process. Butane and propane are the components of LPG or liquefied petroleum gas (which stays liquid while pressurized) used as a natural gas substitute in areas not served by the natural gas pipeline system.

Once standard natural gas enters the interstate transportation pipeline system, it may move through several hubs. Along the way, gas may be temporarily stored at strategic places in underground salt caverns or old gas fields in order to meet seasons of peak demand. Gas is eventually delivered to a utility, which then delivers the gas through a distribution pipeline network to the consumer. Typically, natural gas changes ownership multiple times along the gathering, transportation, and distribution system.

WHAT DOES THE FUTURE HOLD?

The role of new and evolving technologies should never be discounted. We are ever more creative in improving the efficiency of our fossil fuel energy infrastructure. Such efficiencies are designed to extract more value from the raw material. Automation, safety improvements, and improved environmental compliance are on the forefront of engineering research. In the future the uses of oil and natural gas will likely change. A new trend is the increasing use of low-emission natural gas turbines to generate electricity during peak demand. Natural gas-based fuel cells powering portable electric motors may one day replace the gasoline-fueled internal combustion engine as the transportation engine of choice. Future improvements in processes and minimization of environmental impacts will ensure that New Mexico's home-grown oil and gas industry will continue to provide responsibly for the needs of New Mexico and the Southwest for many decades to come.