The Role of Natural Gas Liquids (NGLs) in the American Petrochemical Boom

White Paper | January 2024

KINDER MORGAN

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U.S. domestic natural gas production experienced an unprecedented increase over the past decade. This was largely due to continual advancements in drilling and producing technologies, such as hydraulic fracturing and horizontal drilling, coupled with access to prolific shale plays. In just 10 years, natural gas production in the United States has almost doubled from 18.5 trillion cubic feet in 2006, to approximately 36.4 trillion cubic feet in 2022.[1,2]

Many Americans have experienced the benefits that increased domestic oil and gas production provided consumers in recent years such as lower costs for home heating and automobile gasoline, lower electricity costs and decreased electricity-sector emissions thanks to natural gas-fired power plants, and reduced reliance on foreign countries for energy imports. What we talk about less is the fact that this shale revolution in America also resulted in an "NGL revolution."

In addition to methane, natural gas contains hydrocarbons known as natural gas liquids (NGLs), like ethane, propane, butane, isobutane and pentane. Natural gas processing plants and refineries remove (or condense) NGLs as a liquid from the vaporous natural gas stream.

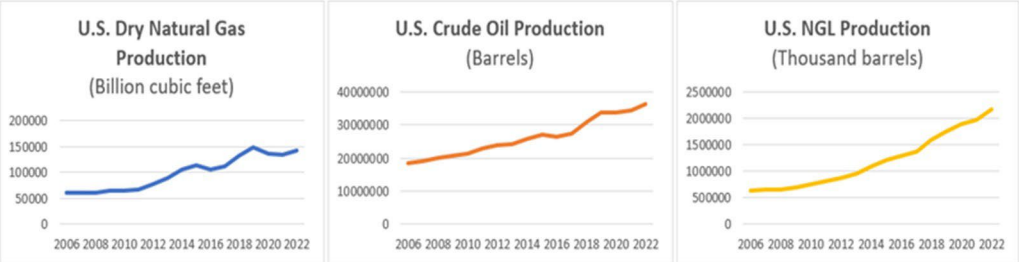

FIGURE 1: Comparison of U.S. natural gas, oil and NGL production. (Source: EIA, 2022 Data)

Given the substantial growth in natural gas production, it's no surprise that NGL production in the United States boomed — increasing 300 percent in 16 years from approximately 634 million barrels in 2006 to approximately 2.17 billion barrels in 2022.[3] The increased availability of domestic NGLs is a major boon to the U.S. petrochemical and manufacturing industries, as well as a benefit to U.S. consumers. See Figure 1 above for a comparison of the increases in U.S. domestic natural gas, crude oil and NGL production over the past 16 years.

[i] NOTE: EIA figures for NGL production do NOT include ethane rejected back into the gas stream

NGLs play an underappreciated and essential role in our lives as feedstocks for thousands of consumer goods. For example, a pair of athletic or running shoes likely contains at least three different NGL-derived petrochemicals. The outsole and midsole of the shoe is probably made from durable polyurethane foam: a derivative of the petrochemical **propylene**.

The insole cushion that your foot rests on is made of ethylene vinyl acetate (EVA): a derivative of the petrochemical **ethylene**. The exterior top and sides of the shoe is often nylon: a derivative of the petrochemical **benzene**. [4,5] NGLs aren't limited to plastics and clothing -- they are a key ingredient in almost everything in our lives including building materials, bicycles, plastic bottles, food packaging, shopping bags, car parts, heating fuels, carpeting, synthetic fabrics, medications, skis, snowboards, hiking boots, backpacks and even baby diapers, to name a few. So, what are NGLs and where do they come from?

WHAT ARE NGLs?

Natural gas is a mixture of hydrocarbon gases, and the ratio of these different components (gases) varies. Depending on the source, the vast majority of natural gas, 70-90 percent, is methane.[6] The remaining 10-30 percent is various NGLs, including ethane, propane, butane and pentane.[7] While NGLs are gaseous at underground pressure, the molecules condense at atmospheric pressure and turn into liquids.[8] The composition of natural gas can vary by geographic region, the geological age of the deposit, the depth of the gas and many other factors. Natural gas that contains a lot of NGLs and condensates is referred to as wet gas, while gas that is primarily methane, with little to no liquids in it when extracted, is referred to as dry gas.[9]

When natural gas is extracted during production, it must be processed to separate the pure natural gas (methane) from the various other hydrocarbons and fluids to produce what is known as pipeline-quality dry natural gas.

Once natural gas comes out of the wellhead, any oil and water present in the gas is removed either at the wellhead or at a nearby processing facility. Once the gas is transported to a nearby natural gas processing facility, other non-NGL liquids, such as sulfur, helium and carbon dioxide, are removed and then the NGLs are removed.[10] The process of separating the NGLs from the natural gas stream is a complicated process involving multiple steps. Once NGLs are separated from the natural gas stream, they also must be separated from one another.

FIGURE 2: A view of Kinder Morgan's Houston Central Plant, which processes NGLs.

The process of separating various NGLs is called **fractionation**. Since each molecule (ethane, propane, etc.) has a different boiling point, the hydrocarbon stream goes through multiple fractionators, each with a different temperature. This removes a different NGL at each step, starting with the lightest hydrocarbons and working up to the heaviest. Typically, ethane is removed first, followed by propane, butane and isobutane.[11] After these NGLs are removed and the natural gas meets the pipeline quality standards for the pipeline it will be transported on, it is sent to natural gas utilities, power generators and industrial customers. The NGLs are then . . . See Figure 3 below for a flowchart of the process.

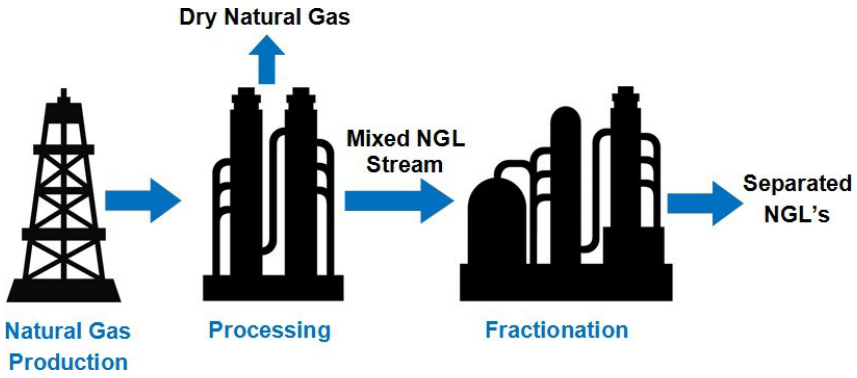

FIGURE 3: Natural gas processing steps.

WHAT ARE NGLs USED FOR?

Of the approximately 2.17 million barrels of U.S. NGLs produced in 2022, 41 percent was ethane, 32 percent propane, 11 percent was natural gasoline, 9 percent normal butane and 7 percent isobutane.[12]

NGLs are used for a variety of purposes in almost all sectors of the U.S. economy. Ethane is used almost exclusively in the production of ethylene, which is then turned into plastics. Propane is mostly used for heating and as a petrochemical feedstock. Butane and isobutane are typically blended into petroleum products to create various fuels.[13] See Figure 4 below for the various types of NGLs and how they are most commonly utilized by sector.

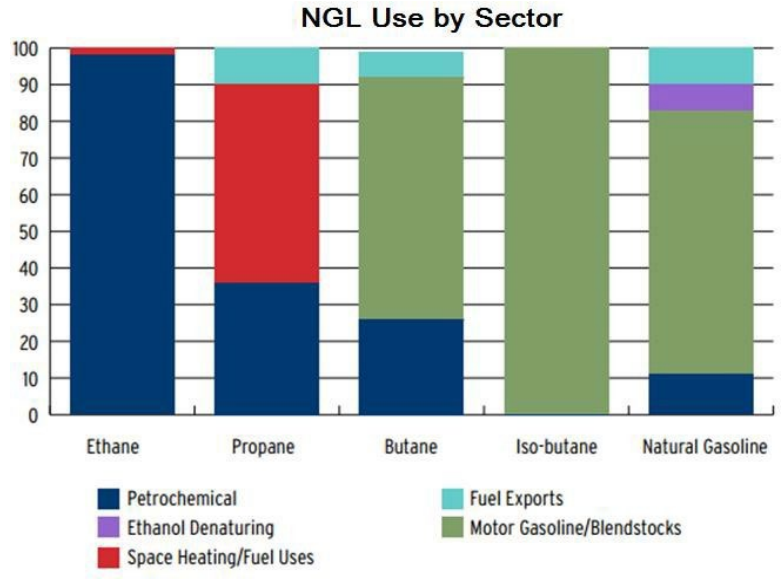

FIGURE 4: U.S. NGL use by sector. (Source: Brookings Institution, 2013).[14]

The largest customer for NGLs, particularly ethane, is the chemical industry. Ethane is valuable because the industry uses it to create ethylene, which is the raw ingredient in most types of plastics. The complex process of converting ethane into ethylene is called **cracking.** Ethane cracker facilities heat the gas to approximately 1,500 degrees Fahrenheit to change the chemical composition of the ethane molecules resulting predominantly in ethylene. The ethylene is then cooled rapidly so it can be transported via pipelines in its liquid state."[15] Other chemicals can then be added to create entirely new compounds that are made into many of the consumer products we use every day. See Figure 5 below for examples of all the products made from various forms of ethylene.

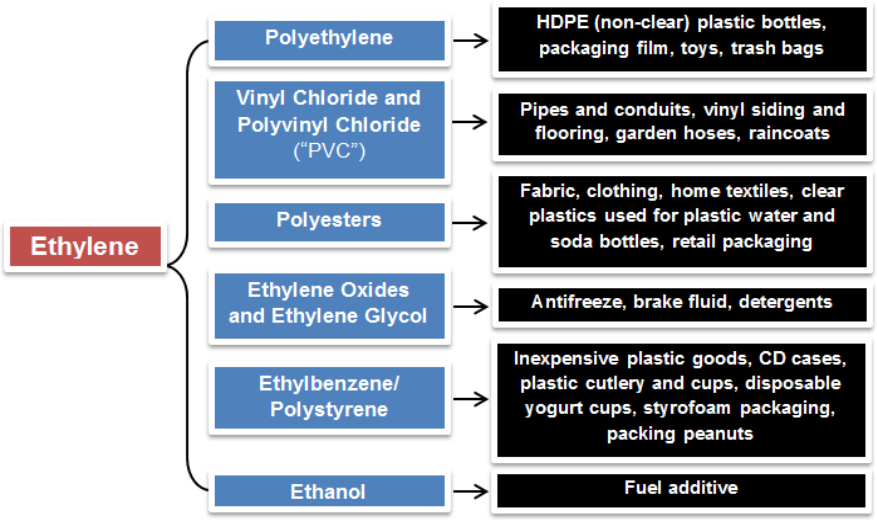

Figure 5: Products derived from ethylene and their uses.

In addition to ethylene, other chemicals derived from NGLs include propylene, benzene, methanol and butadiene. Although we may not recognize their names immediately, these products are building blocks in consumer items and applications most of us use daily.

- **Propylene and its derivatives** are often found in the form polypropylene which is used for injection-molded plastics for everything from bottle caps, to automotive plastics, toys and electronics parts. Polypropylene is also used for disposable plastic shopping bags, carpeting, luggage and backpacks. Propylene is a component in polyurethane foam, fiberglass composites and disposable diapers.[16]

- **Benzene and its derivatives** are combined with ethylene to make styrene and polystyrene plastics, and are also used to create phenol. Phenol is used in pharmaceuticals such as aspirin, detergents and pesticides. Benzene is also used to produce cyclohexane, which is a precursor to nylon, one of the most common synthetic fabrics used for textiles, parachutes, nylon stockings, toothbrush bristles, carpeting, rugs and umbrellas.[17]

- **Methanol and its derivatives**, also known as wood alcohol, are used to make gasoline additives, formaldehyde and urea for plywood, insulation and particle board, as well as to make acetic acid for latex paints, adhesives and acrylic signs.[18]

- **Butadiene and its derivatives** are used to make artificial rubbers for tires, hoses, conveyor belts and shoes.[19]

HOW NGLs GROW THE ECONOMY

U.S. petrochemical manufacturers are now benefiting from an increased supply of low-cost NGLs. This gives these producers a large competitive advantage versus manufacturers in other countries that do not have an abundant supply of NGLs. The American Fuel & Petrochemical Manufacturers association estimates that feedstocks account for 60 to 70 percent of the total cost to manufacture

petrochemicals.[20] Even a small drop in the cost of these feedstocks is a major benefit to U.S. manufacturers.

The increased availability of low-cost energy and NGLs has encouraged U.S. petrochemical manufacturers to expand their businesses. The American Chemistry Council reported that chemical industry capital spending grew 9% to $33.5 billion in 2022 with higher spending on capacity expansions, upgrades, and sustainability projects – including significant investments in lower emissions technologies and advanced recycling.[22]

CHALLENGES FOR CONTINUED DEVELOPMENT

As the United States continues to increase its supply of natural gas and NGLs, continued development of the infrastructure to move them and the facilities to process them are vital. A report produced for the Interstate Natural Gas Association of America found that NGL production growth will generally track natural gas production growth as much of the new natural gas production has a relatively high liquids' content.[25] The main challenge that the NGL and petrochemical industries must address are transportation logistics from natural gas producing areas to fractionation facilities.

In 2022, approximately 54 percent of all U.S. NGLs were fractionated in Texas and Louisiana.[26] Yet that same year, Texas and Louisiana combined accounted for only about 37 percent of U.S. natural gas production.[27] This means that in order for fractionation facilities to continue operating at full capacity, NGLs must be shipped to where those facilities are located. Yet shipping NGLs is difficult. They are expensive to handle, store and transport compared with other refined products because they require high pressure and/or low temperature to maintain their liquid state.[28] The U.S. built several large NGL pipelines in recent years, but the length of time associated with siting, permitting and constructing a pipeline makes it challenging for pipeline companies to keep transportation capacity on pace with production.

In fact, industry in America currently produces more NGLs than it is able to transport to customers.[29] If takeaway capacity or markets are not available, the ethane is rejected, meaning a small amount of it is left within the natural gas stream (within federal and pipeline operator guidelines) or flared. This is wasted product that could be very valuable if facilities were available to move and process it.

Although many companies are constructing or proposing new cracking facilities to process NGLs, they too have not been able to keep up with the boom in production.

Ethylene production plants, or ethane crackers, are very expensive facilities that take several years to develop. A Shell cracking facility that began development in 2012 went into service in Pennsylvania on November 15, 2022 and is estimated to have cost nearly $6 billion,[33] and another facility completed in 2020 by Sasol in Lake Charles, Louisiana, cost almost $13 billion.[34] In many cases, constructing a cracker near a shale-gas producing area is far more expensive than constructing an NGL pipeline to service an existing cracking facility farther away. More transportation capacity is needed to transport NGLs from the shale regions to existing and planned fractionation facilities. NOVA Chemicals chose to expand their cracker and build a new polyethylene reactor at their Corunna, Ontario facility due to the proximity to the Marcellus-Utica and the abundance of ethane being produced in that region. That expansion precipitated the need for the construction of Kinder Morgan's Utopia pipeline that began service in 2018.

AN UPSIDE OF SURPLUS

Since the United States is unable to consume all the NGLs it produces, more NGLs are available for export which helps reduce our trade deficit. Industry first started shipping NGLs by pipeline to Canada and developed facilities to ship NGLs by tanker overseas. The U.S. capacity to ship propane and butane grew from 0.2 million barrels per day in 2013 to 1.81 million barrels per day in 2022.[35] Since the United States is not able to crack and process all the ethane it produces domestically, we also began shipping ethane abroad in 2014. Ethane shipments increased from zero in 2013 to approximately 369,000 barrels per day in 2021.[36]

CONCLUSION

There are many immediate benefits of increased U.S. domestic natural gas production: lower costs for home heating and electricity, reduced emissions from power generation plants as they switch from coal and oil to natural gas, and a decreased reliance on foreign countries for energy. However, the secondary benefits of the domestic gas boom are also incredibly important to the U.S. economy. Increased domestic natural gas, oil and NGL production is strengthening the refining and petrochemical industry, restoring the manufacturing sector and making America a global energy superpower. Kinder Morgan intends to play a part in enabling this success story by moving these products safely and efficiently from production to economic use.

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