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NATURAL GAS TASK FORCE

NATURAL GAS BRIEFING DOCUMENT #1:

Natural Gas Liquids

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PREFACE AND ACKNOWLEDGEMENTS

In May 2011, The Brookings Institution Energy Security Initiative (ESI) assembled a Task Force of independent natural gas experts, whose expertise and insights provided inform its research on various issues regarding the U.S. natural gas sector. In May 2012, Brookings released its first report, analyzing the case and prospects for exports of liquefied natural gas (LNG) from the United States. The Task Force now continues to meet periodically to discuss important issues facing the sector. With input from the Task Force, Brookings will release periodic issue briefs for policymakers.

The conclusions and recommendations of this report are those of the authors and do not necessarily reflect the views of the members of the task force. The Energy Security Initiative would like to thank the members of the task force for their time and input.

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KEY TAKEAWAYS

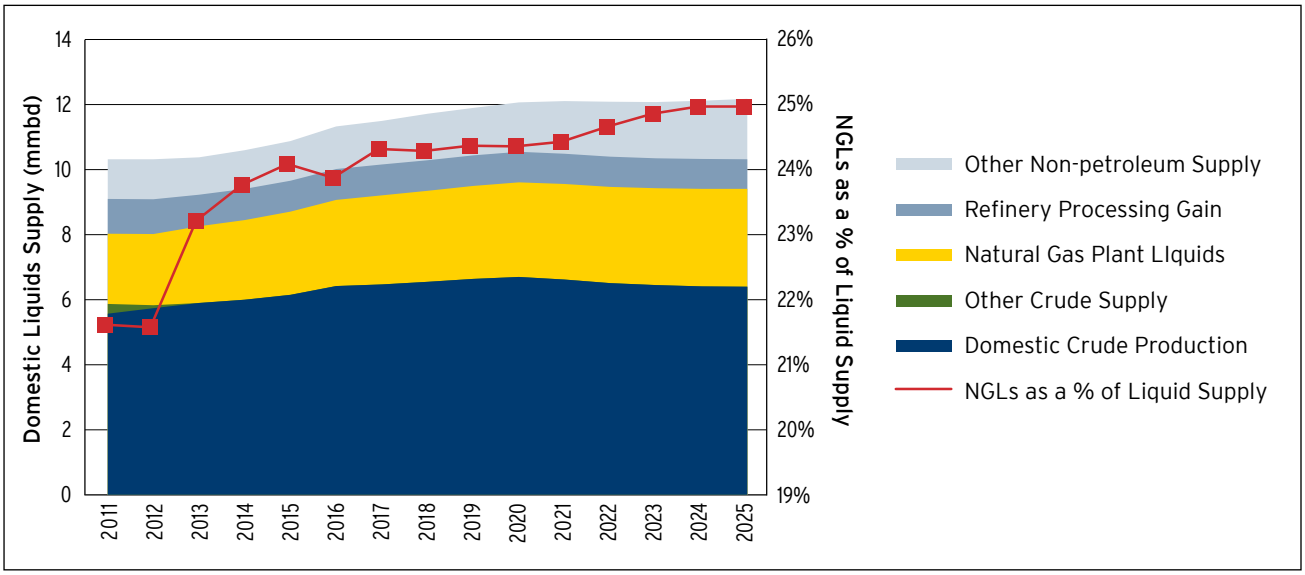
- **NGLs are a significant portion of what many international organizations refer to as U.S. "oil production." It is important to recognize that roughly 2.5 mmbd of U.S. "oil" production is from NGLs, the majority of which are not substitutable for crude oil.**
- **NGLs will be essential for the revenues of gas producers during prolonged periods of low natural gas prices.**
- **Maintaining domestic oil and gas production is critical for U.S. NGL production and for the U.S. industrial sector.**
- **Domestic infrastructure is currently ill-situated to harness new production: investments in new pipelines and petrochemical facilities are often delayed by the regulatory and permitting process.**
- **U.S. NGL exports are important for reducing price volatility and incentivizing further production.**

INTRODUCTION

The fundamental changes in the U.S. hydrocarbon production landscape are now widely acknowledged. Advances in exploration and drilling technology have led to a surge in domestic oil and gas production in recent years with profound economic and geopolitical implications. However, one important aspect of the U.S. unconventional oil and gas "revolution," has gone relatively unnoticed: the rapid increase in the production of natural gas liquids (NGLs). NGLs comprise a number of hydrocarbon products that are produced in conjunction with methane (also known as "dry" natural gas), or as a byproduct of crude oil refining, and which are liquid at room temperature. NGLs include ethane, propane, butane, isobutane, and natural gasoline. While such commodities do not attract the attention that is shown to crude oil, gasoline, or natural gas, they are a critical component of the industrial sector's ability to take advantage of the U.S. hydrocarbon resurgence, and will play a large role in the country's ambitions for energy "self-sufficiency."

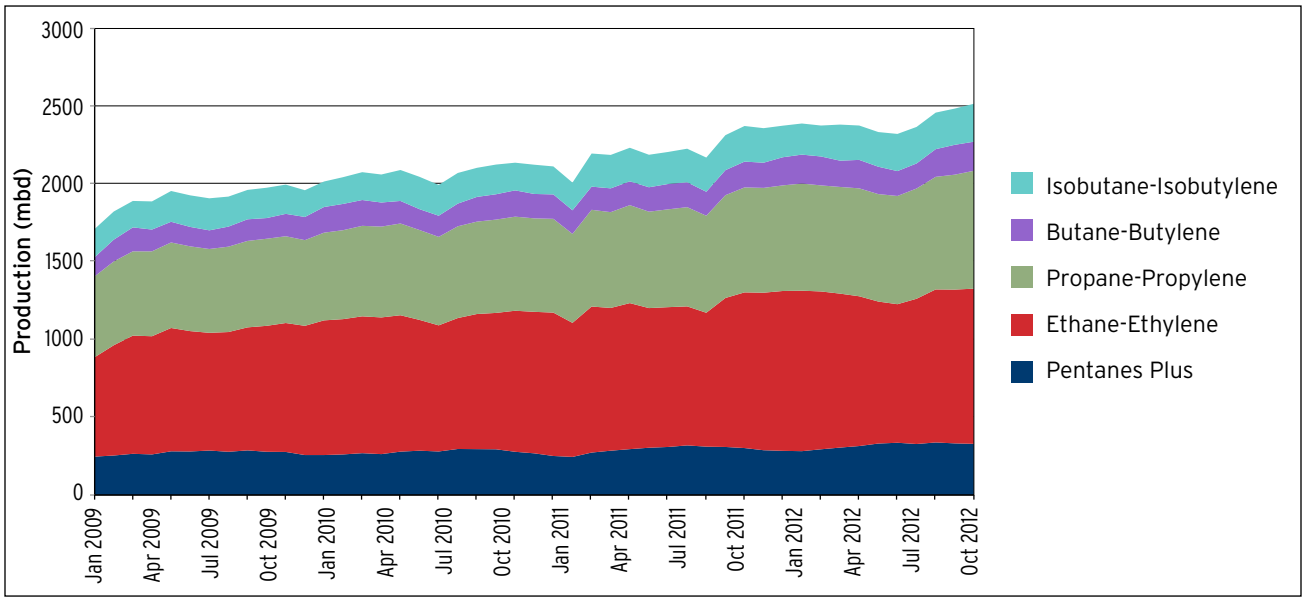
NGL production has increased significantly in recent years. According to the Energy Information Administration (EIA), total domestic NGL production increased from just over 1.7 million barrels per day (mmbd) in 2005 to nearly 2.5 mmbd in October 2012, and now accounts for around 20 percent of the global market. As **Figure 1** demonstrates, NGLs are projected to account for roughly one-quarter (nearly 3 million barrels per day) of U.S. liquids supply by 2025. **Figure 2** illustrates the absolute and year-on-year growth in NGL production.

Figure 1: U.S. Liquids Supply by Source, 2011-2025



Source: EIA, Brookings

Figure 2: U.S. NGL Production, 2009-2012



Source: EIA, Brookings

NGL Basics

What is a natural gas liquid? Not all natural gas is created equal. "Dry" natural gas is comprised mostly of methane. "Wet" natural gas, which has a higher energy content than dry gas, generally has a number of other gases that make up the gas stream including ethane, propane, butane, isobutane, and natural gasoline (sometimes known as "pentanes plus"). These gases, known as natural gas liquids, are separated from the dry gas at gas processing facilities. Such processing of natural gas accounts for roughly 74 percent of U.S. NGLs. NGLs are also produced as a byproduct of the crude oil refining process, which currently accounts for around 20 percent of U.S. NGLs. (The remaining 6 percent of liquids is imported.)[1]

A standard unit of measurement for the NGL content of natural gas is gallons per thousand cubic feet of gas (GPM). Typically, dry gas contains about 1 GPM, while the NGL content of wet gas can vary widely. For example, gas produced from the Barnett shale formation in Texas produces about 2.5 to 3.5 GPM while that from the Bakken formation in North Dakota can produce up to 12 GPM. See **Table 1** for the liquids-content of gas from selected shale plays.

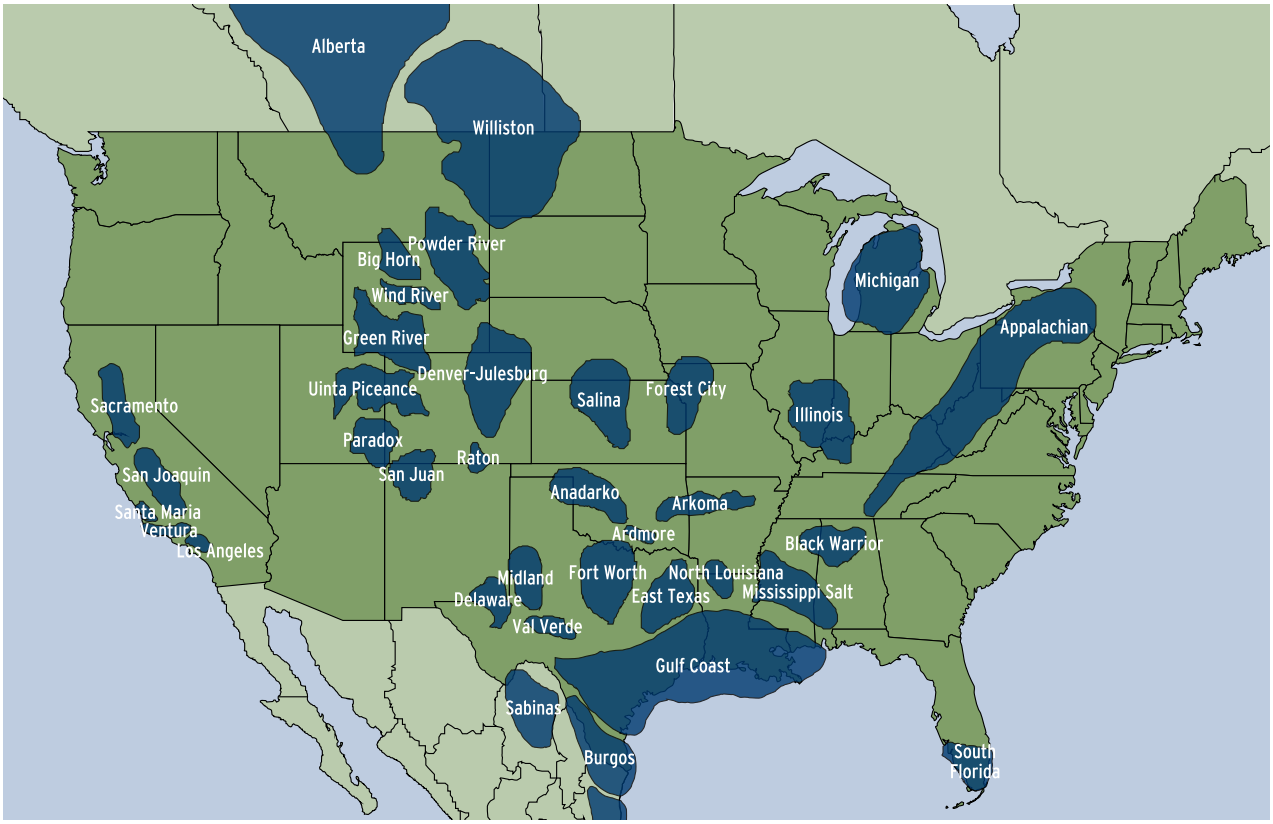
Table 1: Gallons of NGL per Thousand Cubic Feet (Mcf) of natural gas, selected shale plays

Rich Gas Shale Play	Gallons of NGL per Mcf (GPM)
Bakken (shale oil)	6 to 12
Barnett	2.5 to 3.5
Eagle Ford (oil and gas)	4 to 9
Green River (shale oil)	4 to 6
Niobrara (shale oil)	4 to 9
Marcellus/Utica (oil and gas)	4 to 9

Source: Veresen, EPRINC

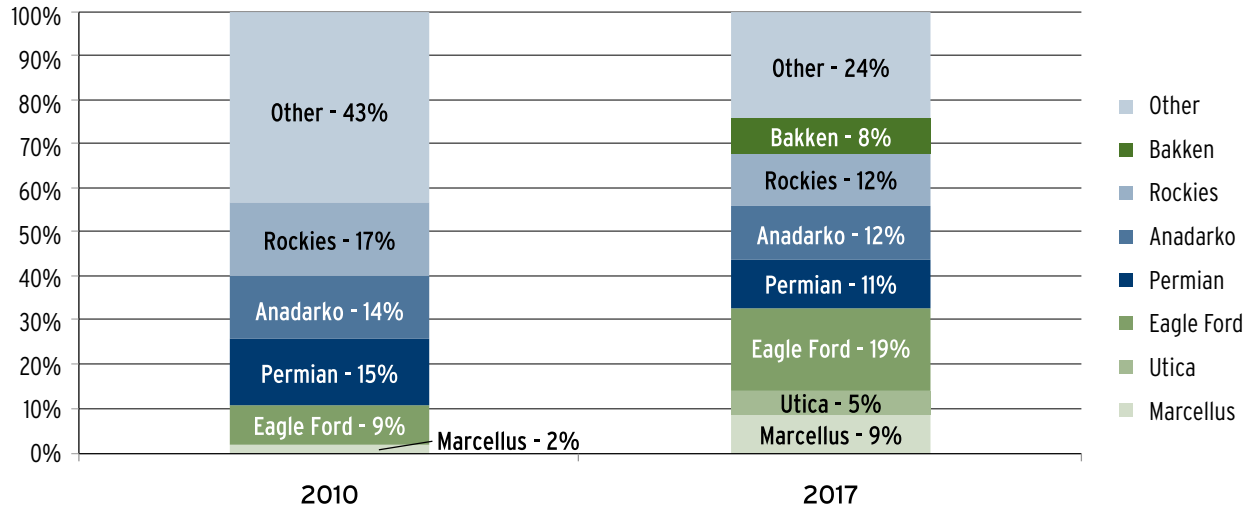
1 Presentation by Anne Keller, "NGL 101 – the Basics," Midstream Energy Group, June 6, 2012.

Figure 3: Map of Various North American Shale Gas and Oil Plays



Source: EPRINC

Figure 4: New Sources of Supply: U.S. NGL supply by Formation, 2017



Source: EPRINC, Bentek

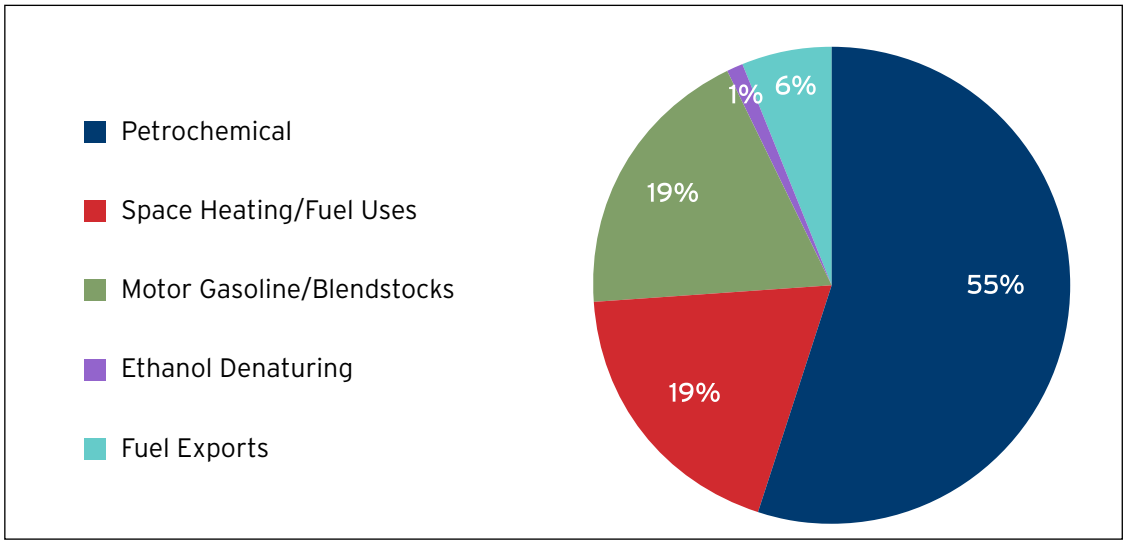
Where are NGLs found? As demonstrated in **Figure 4**, the regional diversity of shale oil and gas production is changing the map of the source of NGLs. Historically, the majority of NGL production has occurred in the Gulf Coast region, mostly in Texas, with additional NGLs being produced offshore Texas and Louisiana, and in the Mountain West. However, increased significant volumes of NGLs are expected to come from newer formations like the Bakken and the Marcellus and Utica formations in Pennsylvania, West Virginia, and Ohio, all of which are experiencing increased unconventional oil and gas production.

How are NGLs made? NGLs produced by gas processing are separated from the overall gas stream at a processing plant, which separates the raw NGL mix from dry gas. The dry gas is then sent through pipeline to consumers, while the raw mix is sent to a fractionation facility, which processes and separates the mix into different NGLs (ethane, propane, butane, iso-butane, and natural gasoline), also known as "purity products."

An important component of the NGL production and marketing process is storage. Since NGLs are not always consumed when and where they are produced, appropriate storage locations are important. In the United States, NGLs are usually stored in salt-dome formations, most of which are found in East Texas, near Mont Belvieu. Not surprisingly, much of the petrochemical production capacity and refiners, two major NGL consumers, are also located in this region.

Who uses NGLs? After being processed, or "fractionated", NGL products are piped to various consumers. Different industries consume different NGLs. Almost all ethane and around one third of all propane is consumed by the petrochemical sector to make olefins such as ethylene and propylene.[2] These compounds are then turned into plastics and a variety of other products. Heating and other fuel uses account for 52 percent of propane consumption. NGLs such as butane, isobutane, and natural gasoline are often used as blending agents in the refinery process.[3] **Figures 5 and 6** break down NGL consumption by sector and source.

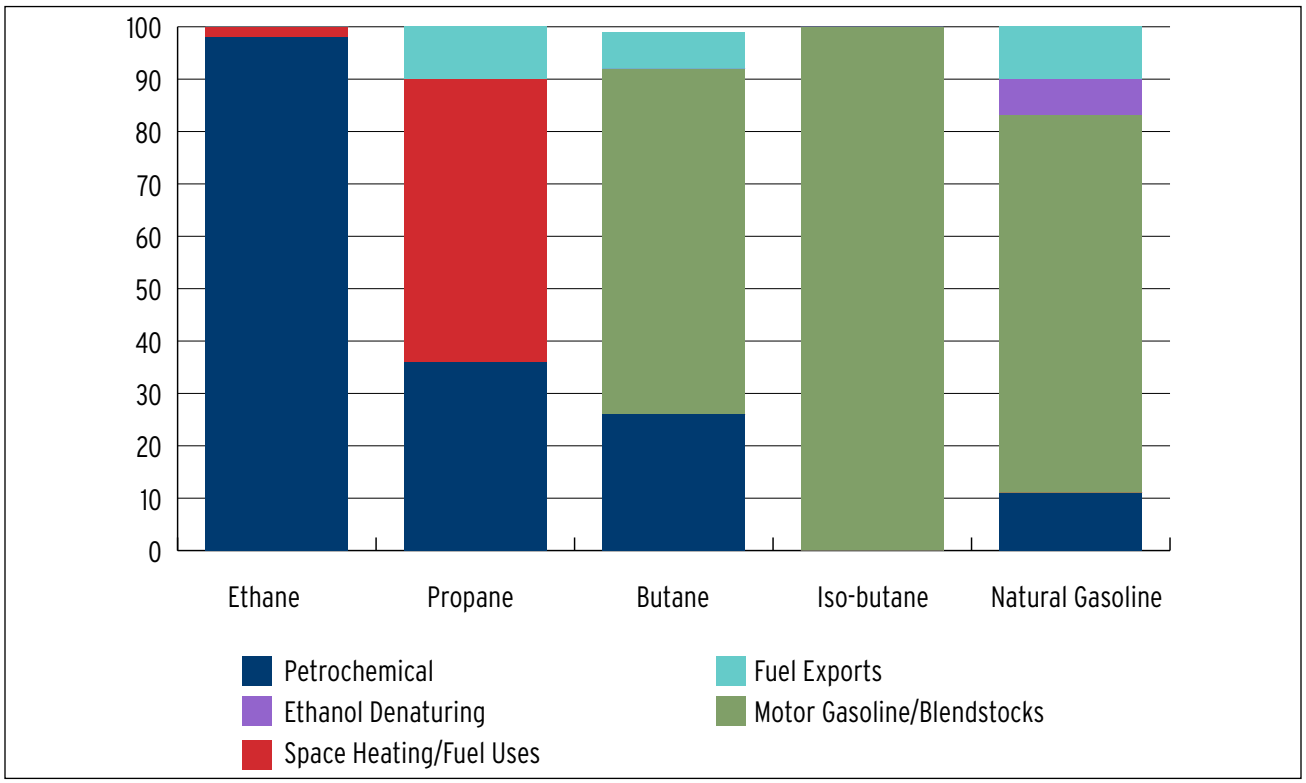
Figure 5: NGL Consumption by Sector



*Source: En*Vantage*

[2] Presentation by Peter Fasullo, "Outlook for U.S. Propane Supplies," En*Vantage, January 30, 2012.
[3] Ibid.

Figure 6: Who Consumes What? NGL Consumption by Sector and Source



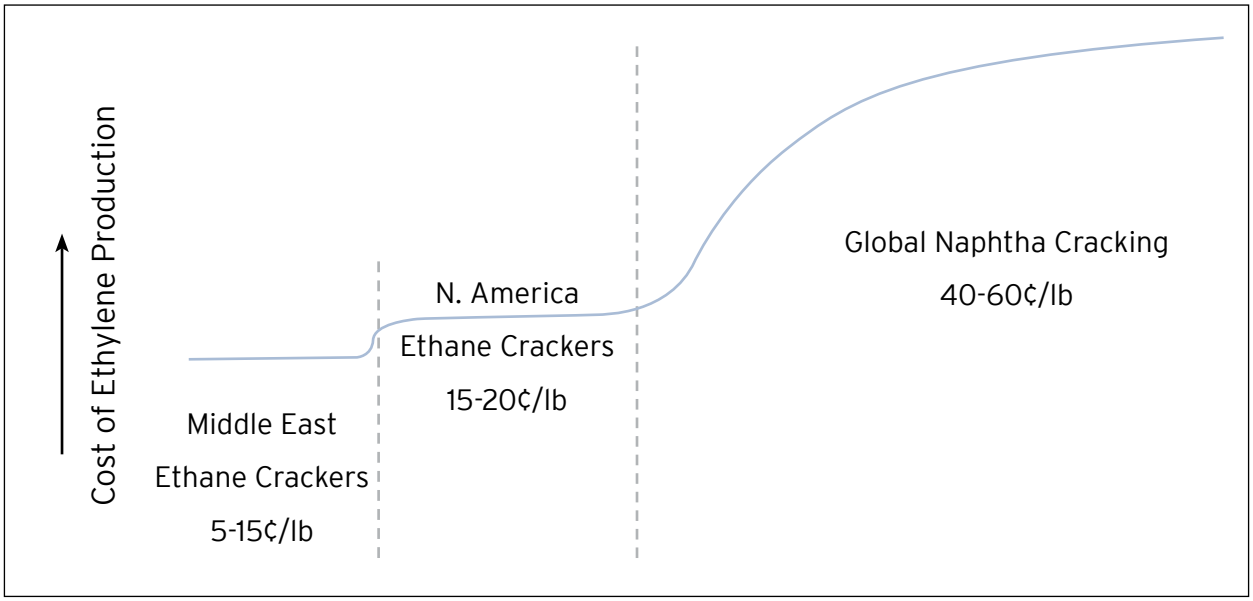
*Source: En*Vantage*

Why are NGLs important? The increase in NGL production is a boon for the U.S. economy. As **Figure 5** demonstrates, the petrochemical industry is a major consumer of NGLs. Liquids such as ethane are central ingredients in many industrial processes, such as the production of ethylene, which is a critical component in the production of plastics and other goods. Owing to a surge in domestic NGL production, petrochemical producers are now benefitting from the availability of cheap NGLs. The latter give U.S.-based petrochemical producers a significant competitive advantage relative to many European and Asian producers, which mostly use more expensive oil-based products, such as naphtha and fuel oil as a feedstock. The American Chemistry Council, an industry trade body, estimates that for U.S. petrochemical producers to be internationally competitive, the absolute ratio of the price of Brent crude, an international crude oil benchmark, to the price of natural gas traded on the New York Mercantile Exchange priced at Henry Hub, must be at least 7:1.[4] As of March 2013, this ratio stands at more than 25:1. According to a May 2011 ACC study, a 25 percent increase in ethane production will yield a $32.8 billion increase in U.S. chemical production. **Figure 7** illustrates the impact of abundant NGLs (specifically, ethane) on the cost-competitiveness of U.S. petrochemical producers.[5]

[4] "Shale Gas and New Petrochemicals Investment: Benefits for the Economy, Jobs, and U.S. Manufacturing," American Chemistry Council, March 2011.

[5] It is important to note that this competitive advantage has its limits. While fractionating ethane produces ethylene, it doesn't produce much else in the form of by-products. When petrochemical producers crack naphtha to create ethylene, however, there are often valuable by-products such as propylene and butadiene. This suggests that there will always be a demand for naphtha-based petrochemical production.

Figure 7: Typical Petrochemical Cost Curve by Country/Region



Source: LyondellBasell Investor Presentation, November 2012

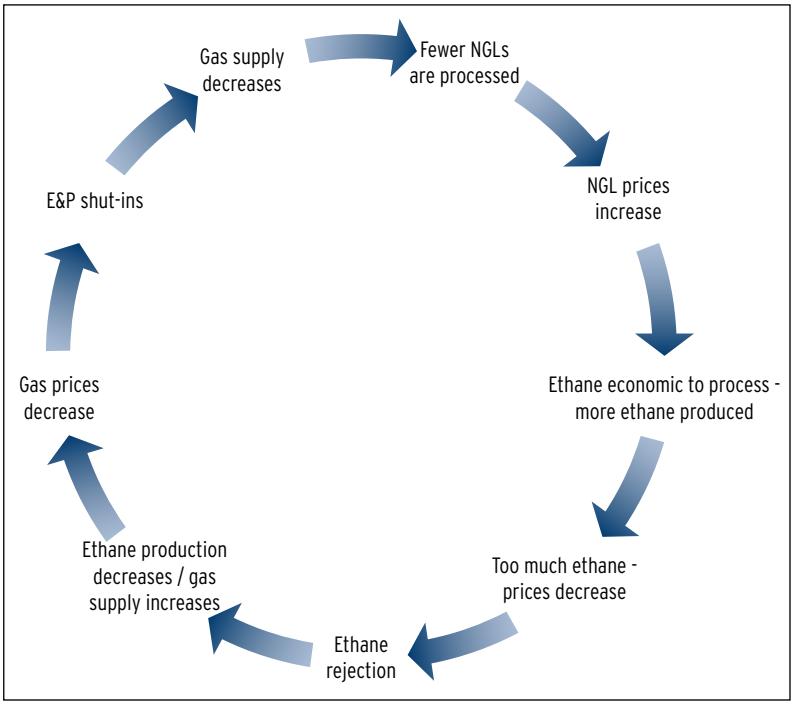
THE U.S. NGL MARKET

The Market Players While some of the major integrated oil companies have NGL operations, the NGL market is dominated by a number of less-familiar companies, which own much of the processing, fractionation, pipeline, and storage capacity. These companies include Enterprise Product Partners, DCP Midstream, Targa Resources, Williams Company, and OneOK.

Fundamentals of the NGL Market NGL pricing is cyclical. As the primary consumer of NGLs, the petrochemical industry is an integral factor in determining prices, particularly in the case of ethane, which represents roughly 40 percent of the NGL stream. Industrial consumers bid for NGLs depending on the difference between the price of NGLs and the price of gas, also known as the "spread." During periods of strong industrial-sector demand, the spread increases and gas processors continue to pull ethane out of the natural gas stream. As NGL production increases, prices for NGLs come down and it is more economic for gas processors to leave ethane in the gas stream, a process known as "ethane rejection." Leaving ethane in the gas stream increases the physical volume of natural gas, putting downward pressure on prices and reducing gas—and NGL—production. Declines in NGL production lead to an increase in prices, and the trend repeats itself (see **Figure 8**).

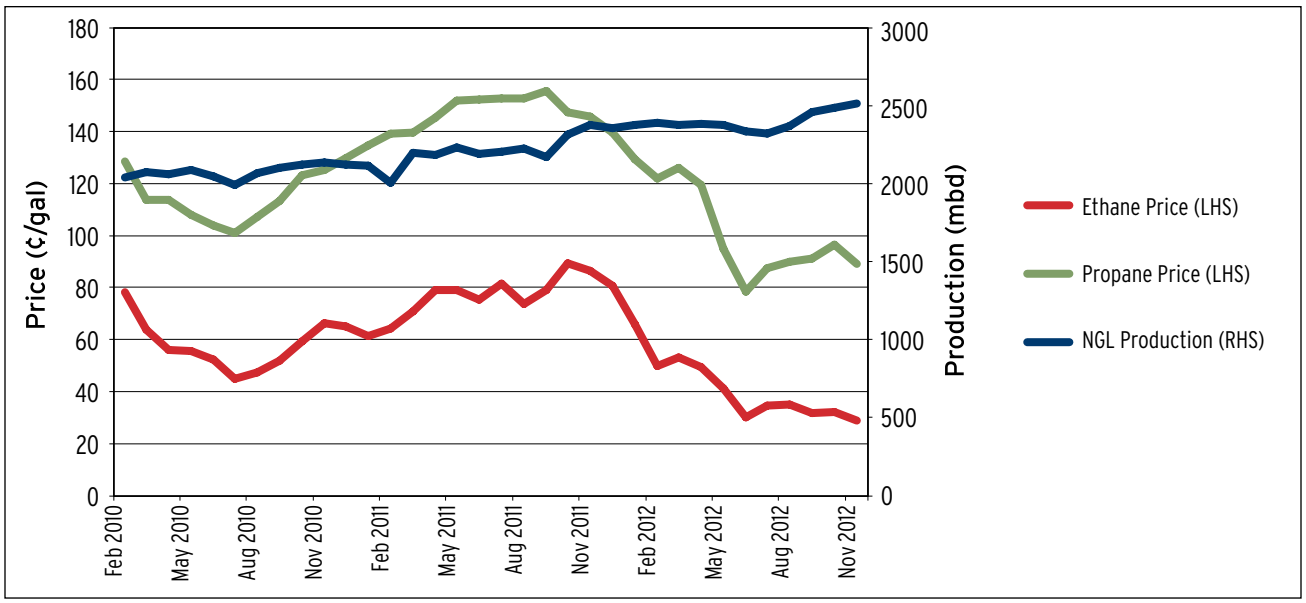
Over the past two years, NGLs have played a particularly important role in driving the economics of natural gas production. With prices for dry gas hovering above $3/MMBtu—and, at one point in 2012, even dropping below $2/MMBtu—producers have moved rigs to wetter plays, where they can produce higher-value NGLs as well as dry gas. Traditionally, NGL prices track oil prices because the primary consumers of NGLs—petrochemical producers, home and commercial heating, and gasoline mixing—are able to use refined petroleum products (such as naphtha and fuel oil) as substitutes. By maintaining demand for ethane and propane, consumers have helped maintain domestic gas production.

Figure 8: Economics of NGL production



Source: Tudor Pickering Holt, Brookings

Figure 9: NGL Production and Ethane and Propane Prices, Feb 2010-November 2012



Source: EIA, Bloomberg

As **Figure 9**, illustrates, NGL prices have come under downward pressure since the increase in NGL production. Declining NGL prices have encouraged drillers to divert rigs away from NGLs to crude oil plays instead. Owing to this shift, it is likely that NGL supply will be driven by oil production as opposed to just gas production.

As ethane prices remain low, more gas processors are leaving ethane in the gas stream and remove only the heavier liquids, such as propane. Some industrial consumers are responding to this by consuming propane instead of ethane in their facilities. (This is only an option for petrochemical producers that have made upfront investments in flexible facilities that can process either feedstock.) However, unlike ethane, which is consumed almost exclusively by the petrochemical sector, propane is a major source of heating fuel, which accounts for over half of propane consumption. As a result, propane demand peaks in the winter and troughs in the summer, leaving the petrochemical sector dependent on a far more variable market.

The NGL market is facing a glut of supply in the coming years. Although traditional NGL economics would suggest that a prolonged period of low NGL prices would result in a shortage of ethane, improvements in the efficiency of shale gas production have maintained gas and liquids production despite a diversion of rigs to crude oil plays. With large NGL volumes expected to enter the market in the coming years, it is more likely that demand will not be able to keep pace with supply rather than the other way around.

CHALLENGES FACING THE SECTOR AND CONSIDERATIONS FOR POLICYMAKERS

If the United States is to realize the full potential in its resurgence as a major hydrocarbon producer, NGLs will play a major role. NGLs production will have a direct impact on the competitiveness of U.S. manufacturers and petrochemical producers and play a significant role in any scenario of domestic self-sufficiency in hydrocarbon liquids.

As the flow diagram above demonstrates, the NGL sector is highly responsive to market signals. Much of the success of the NGL (and overall unconventional) production is owing to the market-driven nature of investments in production, transportation, and consumption. However, while the market is generally efficient at allocating resources in the NGL sector, politicians and government officials should understand what factors could slow down future investments in domestic industry and the resultant prospects for a U.S. petrochemical "renaissance."

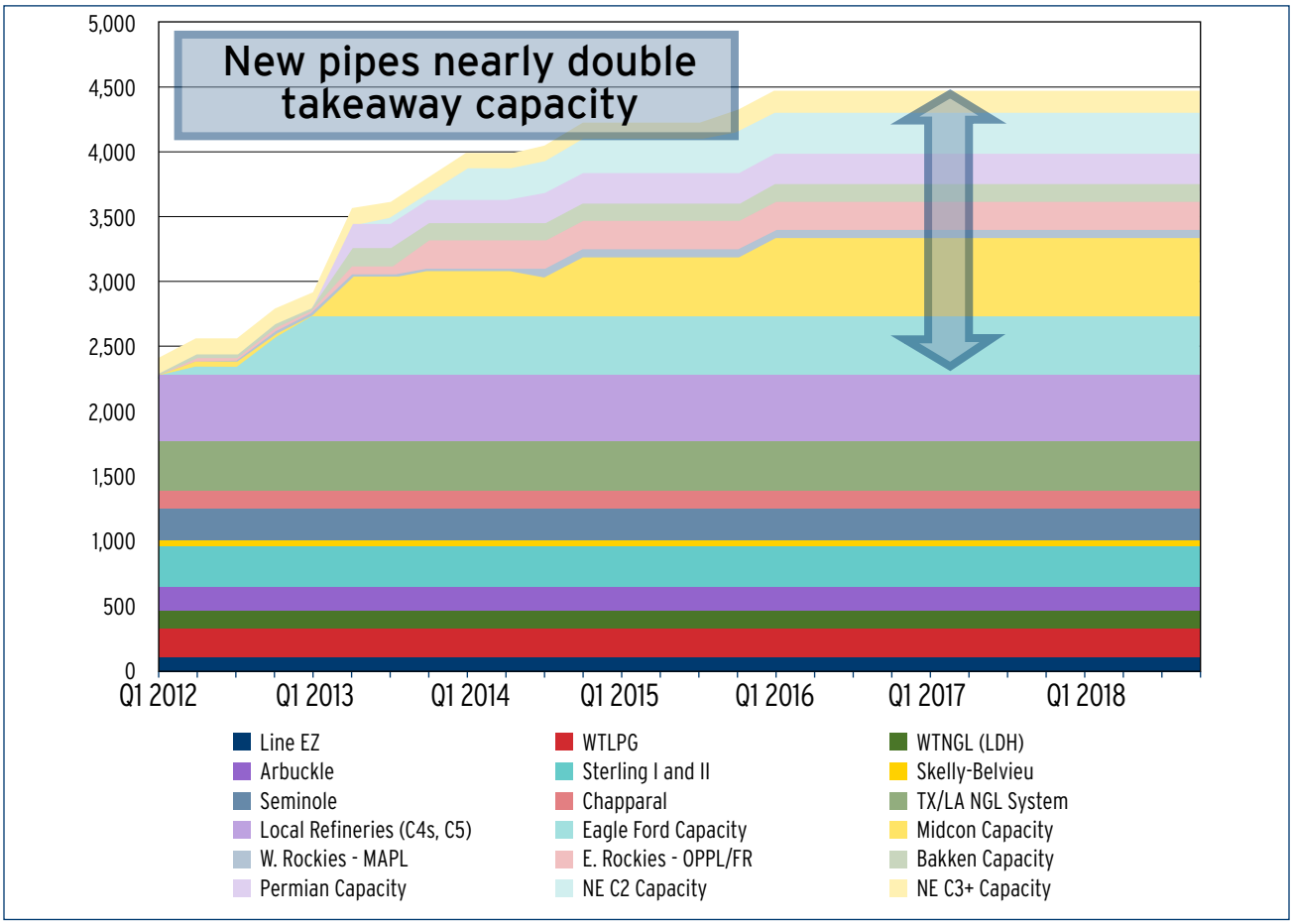
Infrastructure Bottlenecks and Permitting

NGL infrastructure—both midstream and downstream—has struggled to keep up with the increase in supply. The Interstate Natural Gas Association of America, a midstream trade association, estimates that companies need to spend at least $7.8 billion in pipeline investments by 2016.[6] Companies in the midstream sector are responding to market signals of low prices and supply bottlenecks: they are investing in the construction of a host of pipelines that will transport NGLs to market. Tudor Pickering Holt, an investment bank, forecasts that by 2018 NGL pipeline capacity will nearly double from 2012 levels (see **Figure 10**).

Developing new pipeline capacity, however, will not be without difficulties. Right-of-way issues and landowner rights pose potential obstacles that can slow down the construction process. Nowhere is this clearer than in the northeast. Pipeline investments are particularly important for the projected surge in NGL production from the Marcellus and Utica. With enough investment in pipelines and petrochemical production capacity, the Northeast states will no longer have to send their NGLs to the Gulf Coast for consumption or export. While some companies have expressed interest in developing new petrochemical facilities in the Marcellus, getting permits and approval has proven to be a daunting task. To construct pipelines in the state of Pennsylvania, a company has to work with any affected individual townships. By one estimate, there are over 2,500 townships in the state of Pennsylvania alone, many of which have their own regulations.

[6] "A feast of NGL riches from shale," *NGL Shale Gas Special Report,* Argus Media, 2012.

Figure 10: Forecasted NGL Pipeline Projects



Source: Tudor, Pickering, and Holt

The downstream sector—comprising consumers of NGLs—is unlikely to build the capacity to keep pace with the increase in supply. Despite a surge in new planned petrochemical capacity, contributing as much as 550,000 barrels/day of new ethane demand, NGL supply will likely outweigh demand for much of the remainder of this decade, owing to the long lead times and high capital expenditure required to build petrochemical facilities.[7]

One consideration for policymakers would be the streamlining of the permitting process for new facilities. While permitting delays are often mentioned with respect to new pipelines, some analysts suggest that regulatory bottlenecks surrounding issues such as ozone permits for new facilities are also contributing to a delay in new capacity development.

Export Policy

Just as the U.S. has become a net exporter of refined petroleum products and is a potential exporter of liquefied natural gas (LNG), it has also become a net exporter of NGLs and petrochemical products, such as propane and propylene (see **Figure 11**). NGL exports, which are occurring as a result of an excess

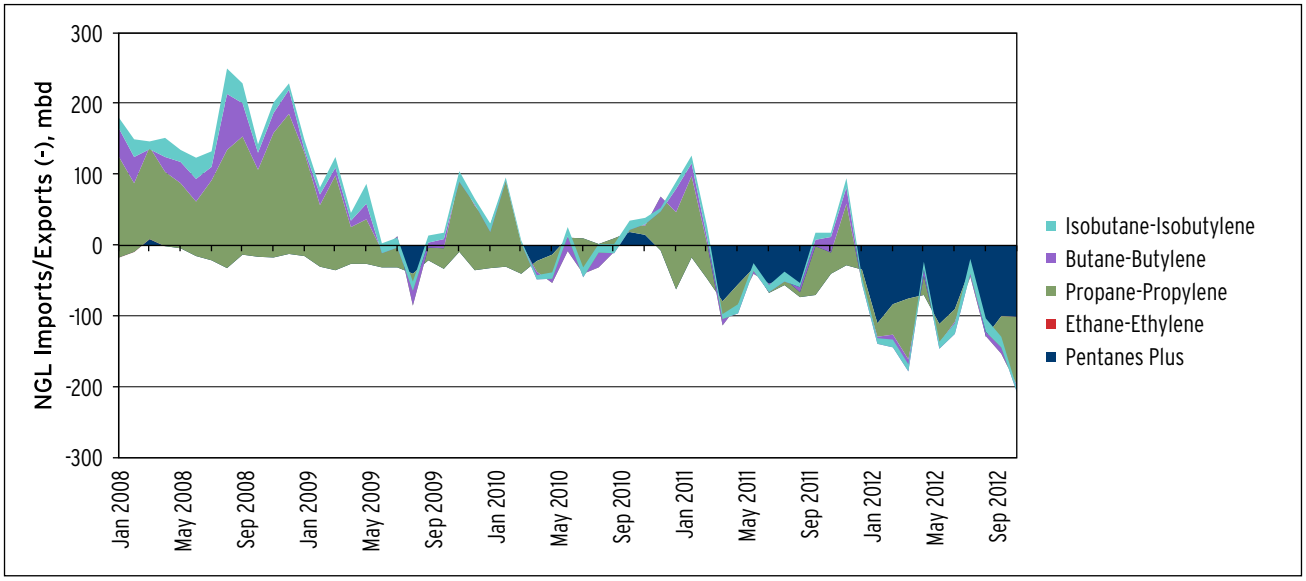
[7] Brad Olsen, "The NGL Report Summary," Tudor Pickering Holt, April 27, 2012.

in domestic supply and weak demand from the petrochemical sector, are growing increasingly important for sustaining domestic NGL—and dry natural gas—production. Further, the need for an outlet for NGL supplies is met with growing demand for propane and other liquids, which are critical for heating and cooking in a number of emerging economies, including India and Central and South America.

Yet although exports have been increasing, according to RBN Energy, a consultancy, export capacity is still constrained by a "lack of suitably equipped terminals."[8] A number of companies are looking to expand or build new export capacity including Enterprise and Targa, both in Mont Belvieu, Texas, and Sunoco Logistics, which is building an export terminal at Marcus Hook, in Philadelphia. The latter project, which is connected to Sunoco's Mariner East pipeline evacuating NGLs from the Marcellus shale, is viewed by some analysts as critical for the development of the Northeast's NGL infrastructure.

Exporting NGLs will provide producers an incentive to maintain production of both NGLs and, in turn, dry natural gas. Further, many investors see exports as a critical component to smoothing the price volatility that characterizes the NGL market. More important than the current surge in investments in U.S. manufacturing is the assurance of a predictable supply of NGLs, something provided by increasing NGL exports.

Figure 11: U.S. NGL Imports/Exports (-), 2008-2012



Source: EIA, Brookings

[8] "Exports Prescribed for Propane Relief," RBN Energy Network, November 1, 2012.

ABOUT THE AUTHORS

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Charles Ebinger is a senior fellow and director of the Energy Security Initiative at Brookings. He has more than 35 years of experience specializing in international and domestic energy markets (oil, gas, coal, and nuclear) and the geopolitics of energy, and has served as an energy policy advisor to over 50 governments. He has served as an adjunct professor in energy economics at the Johns Hopkins School of Advanced International Studies and Georgetown University's Walsh School of Foreign Service.

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