Shale Revolution Feeds Petrochemical Profits as Production Adapts

By Jesse Thompson

The marriage of advanced techniques for horizontal drilling and hydraulic fracturing has helped reverse 30 years of declining domestic production of oil, natural gas and natural gas liquids.

Booming natural gas production from shale has undeniably benefited U.S. petrochemical production and profitability. New energy supplies from shale have been so abundant that prices for natural gas and coproduced natural gas liquids, or NGLs, have rarely been lower, helping reduce overall costs.

At the same time, oil and its by-products have rarely been higher. The price differential has driven a shift wherever possible from heavier raw-material inputs—oil by-products such as naphtha—to lighter inputs, including NGLs. Since 2011, the preference for NGLs (ethane, propane and butane) has placed sectors dependent on heavy-material inputs at a competitive disadvantage.

The ability to tap directly into shale, the "source rock" from which many hydrocarbons have slowly percolated for eons, has been revolutionary. The marriage of advanced techniques for horizontal drilling and hydraulic fracturing has helped reverse 30 years of declining domestic production of oil, natural gas and natural gas liquids. Texas has played a starring role in the transformation.

The Barnett Shale in North Central Texas, the Haynesville in East Texas and Northern Louisiana, the Permian Basin in West Texas (containing several shale formations) and the Eagle Ford in South Central Texas have been leading centers of activity. The Eagle Ford—which lies within 200 miles of the Gulf Coast—is particularly important to the petrochemical industry. Most U.S. petrochemical capacity resides on the Gulf Coast, and the Eagle Ford is especially rich in industry-favored NGLs.

For every thousand cubic feet (Mcf) of natural gas extracted in the Eagle Ford, six to nine gallons of NGLs were produced in 2011.[1] That figure suggests that the Eagle Ford was likely responsible for as much as 27.7 million gallons per day of NGL production from January to August 2013—representing at least 20 percent of all NGLs produced in the U.S. The latest production rate compares with 2.9 million gallons per day in 2010.[2] The average amount of NGLs separated from the natural gas stream has likely increased since 2011 as low natural gas prices encouraged redeployment of drilling rigs to areas with higher concentrations of NGL and oil reserves (*Chart 1*).

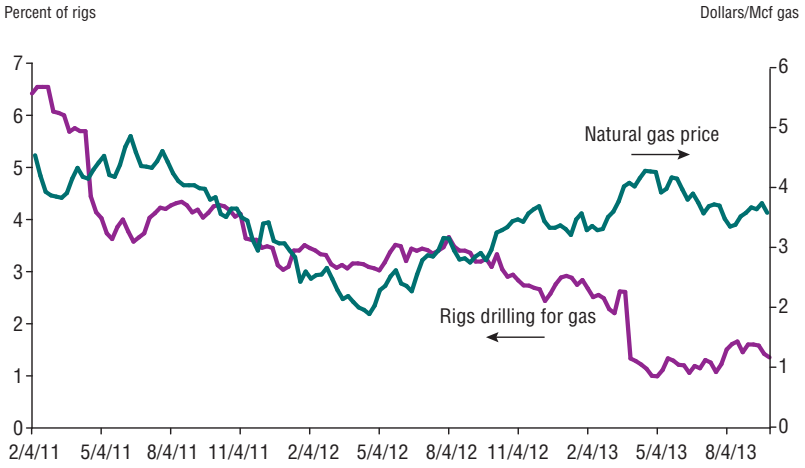
Beyond a resurgence in the petrochemical industry, the production increase and lower NGL cost are responsible for a shift that has favored some products over others. Petrochemical producers seeking to exploit this competitive advantage have begun a wave of heavy construction that is expected to last the next several years, shifting trade balances and creating jobs.

Fewer By-Products

The primary building block of the global petrochemical industry is ethylene, produced in plants called crackers—factories that break up, or crack, whatever they're fed into different substances. Ethylene, an intermediate chemical, is used to make other products as varied as plastic packaging, PVC (polyvinyl chloride) pipe for construction, and cell phones. Different inputs (feedstocks) can be sent to a cracker: lighter feedstocks such as ethane (the most common component of NGLs), or heavy feedstocks like naphtha (an oil by-product).

Ethane is a simple molecule and can only "crack" in a limited number of ways. Roughly 80 percent of ethane fed into a cracker is converted to ethylene, and most of the remainder is converted

Chart 1 Eagle Ford Drilling Shifts from Natural Gas as Prices Fall



SOURCES: Energy Information Agency; Baker Hughes.

into fuel gas, which is a mix of fuels that are gaseous at surface conditions and can include methane, hydrogen and carbon monoxide. Naphtha, however, is a soup of much more complex molecules and can, accordingly, crack in more ways. Only about 23 percent of the naphtha fed into a cracker is converted to ethylene. The majority of that naphtha is turned into a laundry list of intermediate chemical by-products (*Chart 2*).[3]

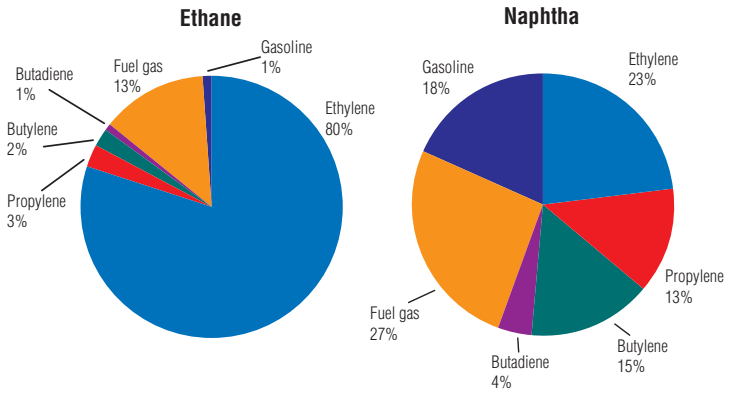
U.S. producers have reacted to the declining domestic price of NGLs—a result of booming shale production—and the rising global price of oil-tied naphtha by dramatically shifting to light NGLs in their crackers. The swing from naphtha has been remarkable for an industry that had previously anticipated rising—not falling—natural gas prices in the coming decades. From 2001 to 2005, the share of U.S. cracker capacity that was fed NGLs declined from 75.4 percent to 67.9. It remained at relatively low levels through 2007. But by the first half of 2013, 90 percent of U.S. cracker capacity was fed NGLs.[4] This move has made the U.S. industry highly profitable and globally competitive.[5] It also caused domestic shortages and record prices for the other products yielded from out-of-favor naphtha.

A wide assortment of products are affected by these domestic shortages—such as propylene (used in synthetic fibers for clothes, rigid packaging and plastic bottle caps), butadiene (used in car tires) and a group of chemicals known as BTX and often referred to as aromatics (used in Styrofoam cups, in solvents such as acetone and in gasoline formulations).[6]

Butadiene was in short supply event before the shale revolution. Inflation-adjusted U.S. butadiene prices have nearly doubled every five years over the past 15 years, averaging $1,778 per ton in 2012, as global demand for rubber grew.[7] The price of propylene, meanwhile, averaged $849 per ton from 2000 to 2010 and jumped to $1,463 per ton from 2011 through the first half of 2013.[8] The price of benzene (the "B" in BTX) reached a high late last year, averaging $1,426 per ton, a 109 percent increase from 2008 and a 97 percent rise from the 2000–10 average.[9]

Furthermore, the profits of manufacturers of many products derived from heavy by-products, such as packaging and plastic parts, have been squeezed by volatile materials costs and competition from substitutes made from shale-advantaged NGL-based ethylene.

Chart 2 Feedstock Yields



NOTE: BTX is included in gasoline totals.

SOURCE: *Petrochemicals in Nontechnical Language*, by Donald L. Burdick and William L. Leffler, Tulsa, Okla.: PennWell Publishing, 2010.

Refinery Inputs Changing

Refineries are affected as well. While they tend to keep the average characteristics of the oil they use within a narrow band—a mix of light, sweet oil and heavy, sour crude—supplies have shifted since 2008 as lighter, lower-cost shale oil came to market. Shale oil on average is 12.5 percent lower in aromatics content than the typical U.S. refinery mix had been when oil imports were greater.[10] A lighter mix can impact refinery yields, similar to how it affects cracker output. Taken together, refineries and crackers provide more than two-thirds of the nation's BTX supply. With lighter feeds for crackers and with shale oil going to refineries, the domestic supply of aromatics has dropped by

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an estimated 20 percent.[11]

The story for refinery aromatics doesn't end there. Several demand factors contributed to lower production of aromatics, specifically benzene.

First, demand for higher-octane fuels has fallen in recent years, reducing the need for high-octane blending components, some of which contain benzene. Second, environmental concerns in the U.S. and abroad have reduced the amount of allowable aromatics, benzene in particular, in gasoline. Third, the requirement that refiners blend high-octane ethanol (typically made from corn) into gasoline reduces the use of benzene-rich blending components in gasoline.[12] Finally, gasoline consumption has declined since its peak in 2007, due in part to the Great Recession, a slow recovery and more-fuel efficient cars. Gasoline exports have bolstered U.S. gasoline production. Gasoline export production peaked in 2011 at 174.8 million barrels and was 149.7 million barrels in 2012. The annual average from 2000 to 2010 was 53.9 million barrels.

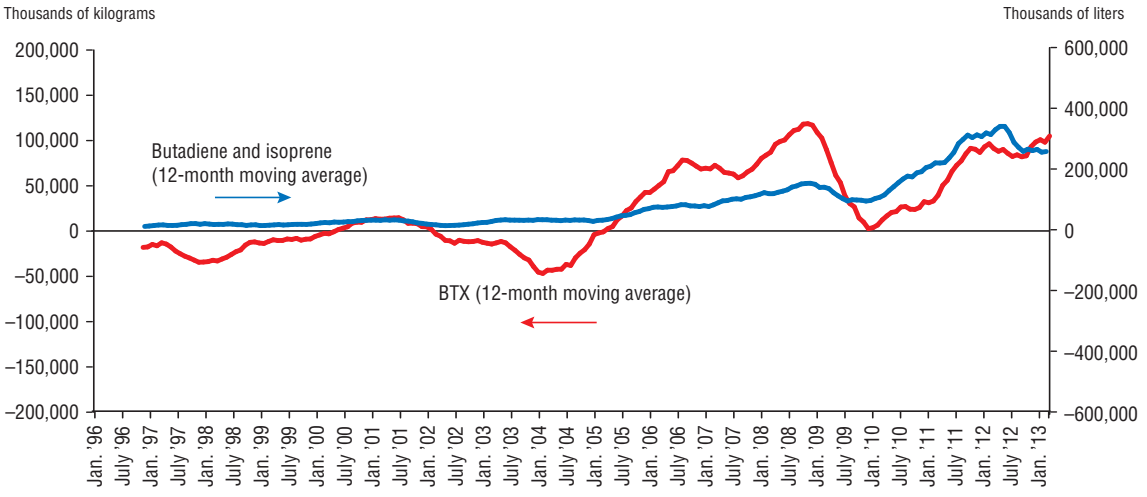
Trade Shifting

Meanwhile, imports of shale-disadvantaged chemicals into the U.S. have increased. Net imports of butadiene and isoprene have grown 167 percent since 2009, while net imports of BTXs over that same period increased 3,700 percent, albeit from a very low level (*Chart 3*).[13]

The Texas share of BTX imports into the U.S. was 43.3 percent in 2007 and 28.5 percent in 2012—15.1 percent for butadiene and 18.1 percent for isoprene. While these chemicals represent smaller markets than ethylene, they make up a vital part of the U.S. chemical industry. North American propylene, butadiene and benzene production combined was equal to 80 percent of the total tonnage of ethylene in 2007, when production peaked prior to the shale revolution.[14]

Potentially working against the overall shift are impending increases in export capacity for NGLs, particularly propane and butane, which are less expensive to ship than ethane and natural gas. A limited ability to export has driven down local NGL prices, prompting several firms to seek to significantly boost export capacity along the Texas Gulf Coast. Increased propane and butane exports would help bring regional and global prices into better balance. Producers would benefit, though the increased demand—and the higher prices it would bring—could make domestic products derived from propane and butane less competitive than they otherwise would have been.

Chart 3 Net Chemical Imports Rise on Domestic Shortages



SOURCE: International Trade Commission.

Planned Investments

The petrochemical industry's confidence in the low-price outlook for light NGLs underlies announcements of new U.S. plants and expansions that would increase capacity 33 percent by 2017 should they all be completed.[15] Faced with a longer-run prospect of high-priced imports and cheap, domestic NGLs, the economics of producing at least propylene—now in short supply—through a different process has become more attractive.

Rather than rely on propylene production as a by-product of crackers geared for ethylene, producers have announced eight construction projects dedicated to making propylene (*Table 1*).[16]

The announced capacity is expected to largely replace the output lost when naphtha became a less-profitable feed. With some construction already underway, many in the industry wonder if all the planned facilities will be built or completed on schedule. The permit process can take two years, and industry contacts are chafing at delays already encountered. Once projects start, the rule of thumb for major facilities has been four years of construction. However, there are indications that construction markets are tight—the supply of skilled trades personnel is a constant concern given the scale of demand.

Last year, construction workers with specialized skills building plants along the Gulf Coast earned as much as $40 an hour. With wage pressures mounting, substantial cost increases loom. Thus, the wave of heavy petrochemical construction starts will likely approach more slowly than the announced time frames suggest.

Long-Run Texas Benefits

While the U.S. shale revolution has provided cheap NGLs to feed petrochemical plants—making the plants the most profitable they've been in at least 10 years. Other domestic producers dependent on heavy by-products are less competitive.

Construction across the Texas Gulf Coast that includes plants specifically geared for propylene-based products will add needed new capacity, though the exact amount will depend on many factors, most notably regulatory requirements. Industries always face economic trade-offs, and producers have clearly deemed a petrochemical renaissance—driven by natural gas and NGLs from shale—to be well worth the cost of lost by-products. The Texas economy should benefit for years to come.

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Table 1 Planned North American Projects

Company	Propylene capacity (tons)*	Location	Projected startup
Enterprise Products	750,000	Texas	Q3 2015
C3 Petrochemicals	New plant	Alvin, Texas	Q3 2015
Dow Chemical	750,000	Freeport, Texas	2015
Williams Cos.	500,000	Alberta, Canada	Q1 2016
Formosa Plastics	600,000	Point Comfort, Texas	2016
Dow Chemical	New plant	n.a.	2018
Enterprise Products	New plant	Texas	n.a.
PetroLogistics	Expansion	Houston	n.a.

* Capacity figures for some planned construction projects have not been disclosed.

SOURCES: ICIS; the companies.

Notes

[1] Pricing is most frequently quoted in terms of 1 million British thermal units, MMBtu, a measure of energy content. Volumes are often given in terms of a thousand cubic feet of natural gas, Mcf. See "Flares in the Oilpatch: Understanding N.D. Infrastructure," by Trisha Curtis, Energy Policy Research Foundation Inc., Platts Rockies Fifth Annual Oil and Gas Conference, April 12, 2012.

[2] Production based on figures from the Energy Information Agency, Texas Railroad Commission and Energy Policy Research Foundation.

[3] See *Petrochemicals in Nontechnical Language*, by Donald L. Burdick and William L. Leffler, Tulsa, Okla.: PennWell Publishing, 2010.

[4] "U.S. Olefins First Half 2013: Ethylene Production Prospects Clouded by First-Half Turnarounds," by Dan Lippe, Petral Consulting, *Oil and Gas Journal*, Sept. 2, 2013.

[5] See "Booming Shale Gas Production Drives Texas Petrochemical Surge," by Jesse Thompson, Federal Reserve Bank of Dallas *Southwest Economy*, Fourth Quarter, 2012.

[6] BTX stands for benzene, toluene and xylene.

[7] Prices in Japan have been distorted by the nuclear disaster, and production in western Europe has been affected by the recession and U.S. shale boom, complicating attempts to assign a specific portion of the price increase to constraints on U.S. supply.

[8] Data are from Nexant's U.S. propylene price index.

[9] Data are from Nexant's U.S. aromatics benzene index. Bloomberg's price index (in cents per gallon) indicates a 105 percent increase in 2013 over the prior 10 years.

[10] BTXs belong to a family of substances called "aromatics," which are unsaturated naphthenes.

[11] See "Impact of Shale Plays on U.S. Aromatics Production and Pricing," Platts U.S., Jan. 10, 2013.

[12] By federal mandate, ethanol makes up 10 percent of gasoline content.

[13] Refineries are also large suppliers of BTXs. Thus, net imports of those products are also affected by their behavior.

[14] Data are from Nexant's North American production index.

[15] See note 5.

[16] See "Market Outlook: New PDH Units May Lead to U.S. Polypropylene Resurgence," by Michelle Klump, ICIS.com, April 5, 2013, www.icis.com/Articles/2013/04/05/9656095/market-outlook-new-pdh-units-may-lead-to-us-polypropylene.html.