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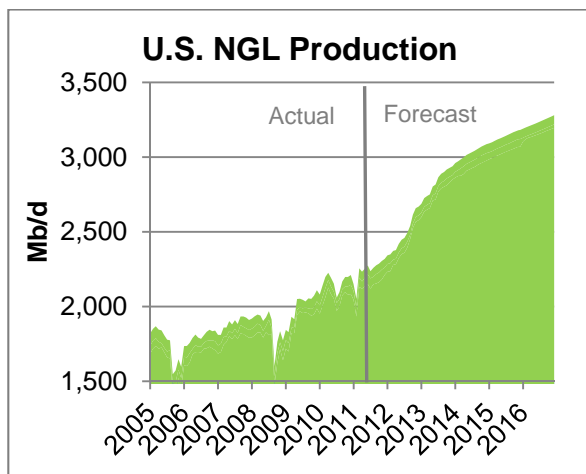


Figure 1 - U.S. Gas Plant NGL Production

- The impact of shale technologies has shifted from natural gas to NGLs and crude oil. U.S. gas plant NGL production is poised to increase by more than 950,000 b/d by the end of 2016.
- Crude production from the U.S. and Canada will grow by more than 2.8 MMb/d by 2016, adding to the NGL surplus.
- Current processing, pipeline and fractionation infrastructure is inadequate to handle the growth in NGL production.
- New quantities and qualities of crude and condensates will produce challenges and opportunities for refiners.
- For the next few years, regional basis differentials for NGLs and crude will be wide and volatile due to logistical constraints.

I. Introduction

The U.S. shale phenomenon that has reshaped the natural gas industry over the past few years is now having the same impact on natural gas liquids (NGL) and crude oil markets. Surplus natural gas supplies have depressed gas prices, driving producers to focus on high-BTU, “wet” gas plays. The result has been a surge of U.S. NGL production, with volumes from natural gas plants expected to increase more than 40% over the next five years from about 2.2 MMb/d in 2011 to over 3.1 MMb/d in 2016 (Figure 1). Traditionally thought of as byproducts of natural gas processing and petroleum refining, NGLs are now driving huge investments in gas processing, pipeline transportation, liquids fractionation and petrochemical facilities across North America.

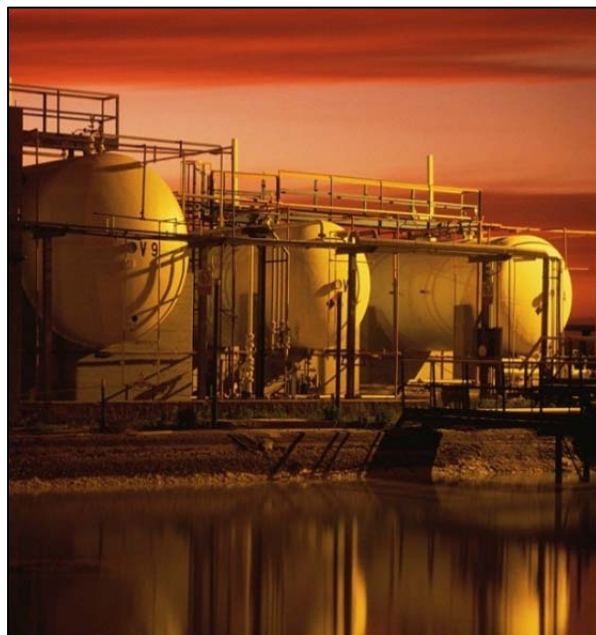
Simultaneously, the same shale technologies are increasingly being applied to crude oil production, and the results promise to be equally prolific. Based on the level of domestic crude oil drilling activity projected in this study, about 1.8 MMb/d of incremental U.S. production will be added by 2016. Over 75% of this increase will be light crude and condensates, with much of this from the shale deposits of the Williston Basin, Eagle Ford Shale and Niobrara Shale and older fields such as the Permian Basin that have been reinvigorated by advanced drilling and hydraulic fracturing techniques. The rise in domestic light production will displace most light crude imports by 2016 in all regions except the East Coast. Heavy crude imports from Canada will also increase during this period, up more than 1.0 MMb/d from current levels.

This significant growth in crude production coupled with a change in the quality of the oil will present new crude slate opportunities for the refining sector. Just a few years ago it appeared that the primary growth in crude oil supply to U.S. refineries would be from heavy Canadian oil. U.S. refineries started massive investment programs designed to run these volumes. But just as

that new refinery heavy capacity is coming online, the growth in domestic oil and condensates from shale production is unexpectedly surging – and that production is light and sweet. This new production will largely displace light crude imports into PADD 3. Both the new refinery capacity and the shift to a lighter crude slate will impact refinery production of liquefied petroleum gasses (LPG's-C2-C5) and demand for NGLs.

All of this has the potential to wreak havoc in the markets for natural gas liquids. Significant new investment is needed to process, store, transport and fractionate growing NGL production. Surplus ethane volumes need a home in the petrochemical industry. Propane demand in the residential/commercial sector is down, and dock space expansions are needed to ship surplus propane to offshore markets. Butanes will see wider summer-winter swings in supply, demand and prices and will also see increasing exports. Natural gasoline will increasingly flow into the diluent market for Canadian heavy crude, and could experience a dramatic decline in motor gasoline blending if certain EPA vapor pressure and octane regulations are implemented.

- *What does all this mean for the markets for liquid hydrocarbons?*
- *How much new investment is needed to process, store, transport and fractionate growing NGL production?*
- *Where will surplus ethane volumes find a home?*
- *With domestic propane demand in the home heating sector down, will there be enough dock space expansions to ship the volumes to offshore markets?*
- *Can current transportation and storage infrastructure handle much wider summer-winter swings in butane supply/demand?*
- *Will the diluent market for Canadian heavy crude be enough to absorb excess natural gasoline supplies if EPA vapor pressure and octane regulations are tightened?*
- *Will NGL prices significantly diverge from their traditional relationships to crude oil prices?*
- *Can refineries adjust to processing more light crudes?*



To provide insight into these questions, BENTEK Energy and Turner, Mason & Company (TM&C) have jointly prepared this comprehensive analysis of NGL markets in the U.S. and Canada titled, “The Great NGL Surge!” BENTEK contributed the analysis of natural gas production, natural gas BTU content, NGL production, transportation, storage, petrochemical demand and heating demand. TM&C contributed refinery models of NGL production and demand, an analysis of shifting crude oil slates on refinery NGL production and the analysis of other refinery sector developments on NGL demand. Together these projections provide a broad assessment of macro-level developments in NGL markets, and drill down to a product-by-product, region-by-region review of the data behind each assertion and conclusion.

Conclusions

The Drivers

- Over the past five years, huge supplies of natural gas have been unlocked throughout the U.S. and Canada. This has been christened the “shale gas revolution,” a radical shift in the economics of hydrocarbon production which has emerged out of advancements in horizontal drilling and well-completion technologies applied to low-permeability “unconventional” natural gas bearing formations – shales and tight sands.
- The shale revolution is driving huge increases in natural gas production, and that in turn has created a surge in the production of natural gas liquids. With oil priced much higher than gas, plays that are rich in liquids are providing superior returns to dry gas plays. As E&P companies continue to focus on high-BTU, liquids-rich plays, the volume of NGLs is increasing rapidly.
- As high-BTU “wet” gas increases at a more rapid rate than lean, or “dry” gas, the average liquid content (i.e. “GPM” or gallons per MCF) of the U.S. gas will increase by 14% from 1.38 today to 1.56 by 2016.
- U.S. NGL volumes will surge by more than 950 Mb/d over the next five years, up more than 40%.
- Higher crude oil prices and the same advanced drilling techniques that have reversed the downward trend in natural gas production have begun a similar shift in U.S. crude oil output, which is forecast to grow by 1.6 MMb/d by 2016. Most of this growth will be from light sweet crude and condensate production.
- During the same period, Canadian production of heavy, oil sands crude (bitumen) will increase by 750 Mb/d. Consequently, as North American crude oil volumes are increasing, U.S. oil production will become progressively lighter while Canadian production will become progressively heavier.
- Refiners had not planned for the increasing availability of domestic light crude. Until recently, most refiners assumed that essentially all growth in refinery inputs would be from heavy Canadian oil. U.S. refineries initiated massive investment programs designed to run these volumes. This new capacity is now becoming operational. Both the changes in crude slates and refinery configurations as a result of the new conversion units (cokers, catalytic cracking units, hydrocrackers) being added, will have significant impacts on the production and demand for NGLs (called LPGs in the refinery sector).

New Infrastructure

- Increasing volumes of high-BTU natural gas will require more U.S. natural gas processing capacity. In addition to 34 expansions and three restarts of existing gas processing facilities, 28 new plants are being developed throughout the shale gas plays, increasing

U.S. processing capacity by more than 9.6 Bcf/d over the next five years. All of these plants are highly efficient, cryogenic units capable of high ethane yields.

- New pipelines are planned to move raw mix (mixed NGLs or y-grade) from processing plants to central fractionation units. Twelve new pipelines and expansions will add 1.8 MMB/d of new raw mix capacity over the next three years. Two of these expansions will move Rockies NGLs into the Conway, KS hub, while the rest will move barrels into the Mont Belvieu, TX hub.
- To relieve regional bottlenecks, at least 215 Mb/d of new ethane pipeline capacity will be added during the five year period, including a route out of the Bakken into Alberta and from the Marcellus into Ontario and the U.S. Gulf Coast. Several other ethane transportation alternatives out of the Marcellus are also being considered.
- With U.S. raw mix NGL production expected to increase significantly over the next five years, total fractionation capacity will need to grow by 30% to accommodate these additional volumes. Raw mix supply in PADD III will increase about 40%, or 635 Mb/d by 2016. As a result, PADD III is expected to increase fractionation capacity by about 25% to 2.7 MMB/d over the next five years, which will be sufficient to meet demand until the end of 2016. In total, 17 new fractionators and expansions have been announced to increase U.S. fractionation capacity by 27%, or 835 Mb/d.
- Over the next five years, surpluses of propane and normal butane will develop. Excess supplies of these products will move offshore with the U.S. becoming a net exporter of both products by 2012. Currently, there is an estimated 165 Mb/d of U.S. LPG marine export capacity, the majority of which is located along the Houston Ship Channel. This capacity is fully utilized. By 2016, PADD III propane and butane exports are expected to reach about 400 Mb/d, which has prompted two expansions to existing export terminals as well as plans to build two new terminals.
- Since 2005, attractive ethane prices have driven demand from U.S. petrochemicals for the feedstock up more than 50%. As ethane production continues to increase, that demand will grow by another 27% by 2016. This is attributable to several projects to debottleneck, switch to lighter feeds, expand and to the restart of existing facilities as well as build new ethylene units in the U.S. Gulf Coast region.

The Market

- For the next two years, growth in ethane supply will be matched by growth in demand. But beginning in 2014, a surplus of ethane will develop resulting in ethane rejection (sale of ethane as natural gas, at natural gas prices) in regions with high transportation costs to market. The ethane supply imbalance will not be relieved until 2016 when new ethylene crackers come online.
- Propane supply from gas plants is expected to increase by 37% between 2011 and 2016. Refinery supply is also expected to increase as refineries retool and add units that produce additional propane including coking, fluid catalytic cracking and hydrocracking units. By 2016, propane supply from refineries is expected to be 11% higher than in 2011.

- While propane supply is increasing, demand is projected to fall. Propane demand in the residential/commercial sector will decline by 3% as lower prices for natural gas and electricity encourages fuel switching. Propane use for petrochemicals is expected to fall as additional steam crackers use more ethane, in some cases replacing propane. These declines will be partially offset by growth in propane dehydrogenation to produce propylene. The growing net surplus of propane will be exported from new terminal capacity along the U.S. Gulf Coast.
- Normal butane markets will change in a similar way to propane. Supply from natural gas plants will increase by 47%, but demand will decline primarily due to lower usage of butane in motor gasoline. This decline is being driven by decreased gasoline demand, additional ethanol in the gasoline pool and competition with natural gasoline as a blend stock. Small volumes of a growing surplus will be absorbed with the restart of “on-purpose” butadiene units. However, most of the incremental supplies will move offshore with exports increasing by more than four times over current levels.
- Between 2011 and 2016, increasing isobutane supply from gas plants will decrease the amount of isobutane required from isomerization units, especially in PADD III. However, the use of isobutane as a feedstock for production of isobutylene and other specialty chemicals is expected to grow.
- U.S. natural gasoline demand has changed substantially since 2005. Although total demand has increased only 3% over the period, the demand profile is quite different. Natural gasoline used for petrochemical production fell 50% while exports of the product to Canada for use as a “diluent” in the transportation of heavy, oil sands crude offset most of the decline. Natural gasoline demand for use as a denaturant for ethanol production has also increased. The higher demand for natural gasoline has in part been met by increasing imports from overseas sources.
- Growth in Canadian demand for natural gasoline as diluent is expected to continue, with imports from the U.S. increasing to almost 170 Mb/d by 2016. Volumes blended by refiners are expected to rise due to improvement in the overall motor gasoline octane environment resulting from increased ethanol blending and changing crude slates.

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