

NO LONGER ADRIFT: NAVIGATING A TIGHTER ETHANE MARKET

MARCH 2016

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INTRODUCTION

The JS INEOS Intrepid arrived at Sunoco's Marcus Hook terminal in Pennsylvania in mid-February and is slated to carry the first shipment of waterborne ethane exports to leave US shores by March. This cargo marks the beginning of large-scale waterborne ethane exports, a groundbreaking event in the natural gas liquids (NGL) market. Ethane export projects were initially proposed starting in 2012, as the growth of US shale gas production made ethane widely available and inexpensive as a petrochemical feedstock. Shale producers sought new markets for their ethane production and global petrochemical companies looked to take advantage of wider margins from ethane compared to oil-linked naphtha. When Bentek published *Adrift in a Sea of Ethane* in November 2014, the economics for ethane exports appeared attractive and a wave of new projects had recently been announced. Further developments appeared imminent and Bentek projected waterborne ethane exports to reach 260 Mb/d by 2020.

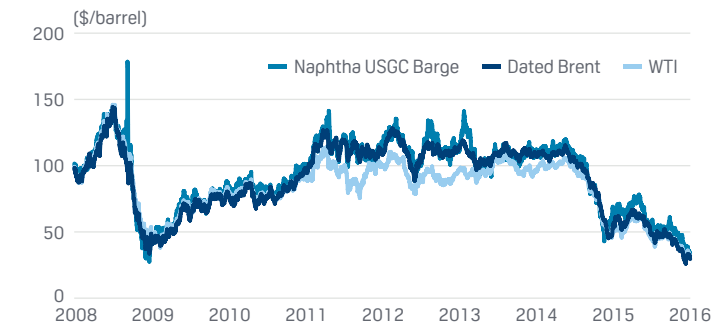
Since that time, market conditions have shifted dramatically and the economics of ethane export projects for petrochemical consumers have deteriorated. The high crude-to-gas price ratio of the early 2010s, which made US ethane a more competitive petrochemical feedstock than oil-linked naphtha, collapsed due mainly to falling crude prices since late 2014. Low commodity prices have decreased drilling activity and have resulted in a less aggressive ethane production forecast. In the original publication of *Adrift in a Sea of Ethane*, Bentek expected ethane supply from gas plants to reach 2,264 Mb/d in 2020. In the latest edition of Bentek's *Market Call: North American NGLs*, published January 2016, ethane supply reaches only 1,960 Mb/d in 2020, a 13% decline and the equivalent of demand from about 3.5 world-scale steam crackers.

At the same time, previously announced projects that will generate ethane demand both domestically and for export continue to move forward. Seven ethane crackers are currently under construction along the US Gulf Coast and expected to begin service starting in 2017. Export volumes are expected to ramp up at Sunoco's Marcus Hook terminal and Enterprise's Morgan's Point terminal is due to begin service later this year. As a result, domestic and export demand will increase simultaneously, tightening a market that has been structurally long since mid-2012 and pushing ethane prices above the gas-equivalent floor. High feedstock prices will further erode ethylene production margins and reduce the competitiveness of ethane steam crackers compared to other feedstocks.

PRICES AND MARGINS HAVE COLLAPSED

Since autumn 2014 commodity prices have collapsed. Brent crude oil dropped from an average of \$79/bbl in November 2014 to \$31/bbl in January 2016. Naphtha has fallen similarly, decreasing 49% from \$77/bbl to \$39/bbl (Figure 1). Natural gas and ethane prices were already depressed in November 2014 and have since fallen to near all-time lows, although the decline is less than oil on a percentage basis (Figure 2).

FIGURE 1: CRUDE AND NAPHTHA PRICES



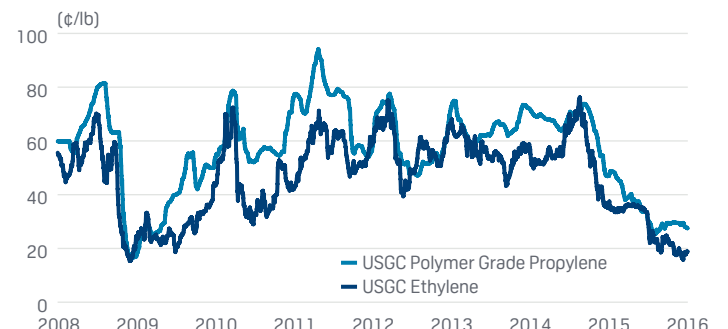
Source: Platts

FIGURE 2: HENRY HUB GAS VS. MONT BELVIEU ETHANE PRICES



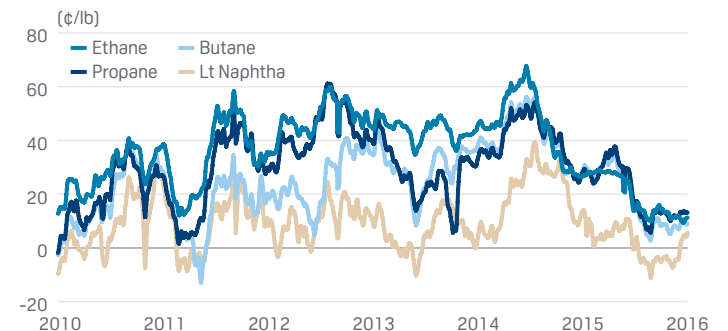
Source: Platts

FIGURE 3: ETHYLENE AND PROPYLENE PRICES



Source: Platts

FIGURE 4: ETHYLENE PRODUCTION MARGINS



Source: Bentek's NGL Daily Market Monitor

Petrochemical prices have also suffered, resulting in depressed ethylene margins across feedstocks. Ethylene prices averaged 53 cents/lb in November 2014 while polymer-grade propylene

prices averaged 65 cents/lb. In January 2016, prices for these products had dropped to 18 cents/lb and 29 cents/lb, respectively (Figure 3).

The drop in petrochemical prices has negated gains from lower feedstock costs, and ethylene production margins have fallen year over year for all feedstocks. The relatively steeper drop in oil prices compared to natural gas has also eliminated the competitive advantage of cracking ethane over heavier feeds. Margins from propane, butane, and even naphtha have been competitive with ethane throughout 2015 and into 2016 (Figure 4). A daily calculation of ethylene production margins by feedstock is available in Bentek's *NGL Daily Market Monitor*.

DOMESTIC DEMAND AND EXPORT PROJECTS ARE STILL MOVING FORWARD

Domestic Demand

Despite the change in economics, previously announced domestic and export ethane demand projects continue to move forward. Eight greenfield steam crackers are under construction on the US Gulf Coast including projects by ChevronPhillips Chemical, ExxonMobil, Dow Chemical, Oxychem/Mexichem, Formosa Plastics, Sasol, Axiall/Lotte and Shintech (Table 1). Many other potential facilities are in various stages of planning and permitting, including facilities in the Northeast and North Dakota. It is important to note that all of the under construction and proposed greenfield crackers are designed to take 100% ethane, with the exception of Dow Chemical which can use up to 30% propane. Bentek's forecast assumes that new steam crackers currently under construction

TABLE 1: GREENFIELD PROJECTS UNDER CONSTRUCTION

Company	Plant Name/ Location	State	Capacity (million lbs/yr)	Ethane Demand ('000 b/d)
ChevronPhillips Chemical	Cedar Bayou	TX	3,300	86
Dow Chemical	Freeport	TX	3,300	86
ExxonMobil	Baytown	TX	3,300	86
Formosa Plastics	Point Comfort	TX	2,640	69
OxyChem/Mexichem	Ingleside	TX	1,200	36
Axiall & Lotte Chemical	Lake Charles	LA	2,200	57
Sasol	Lake Charles	LA	3,300	86
Shintech	Plaquemine	LA	1,100	29
Total			20,340	535

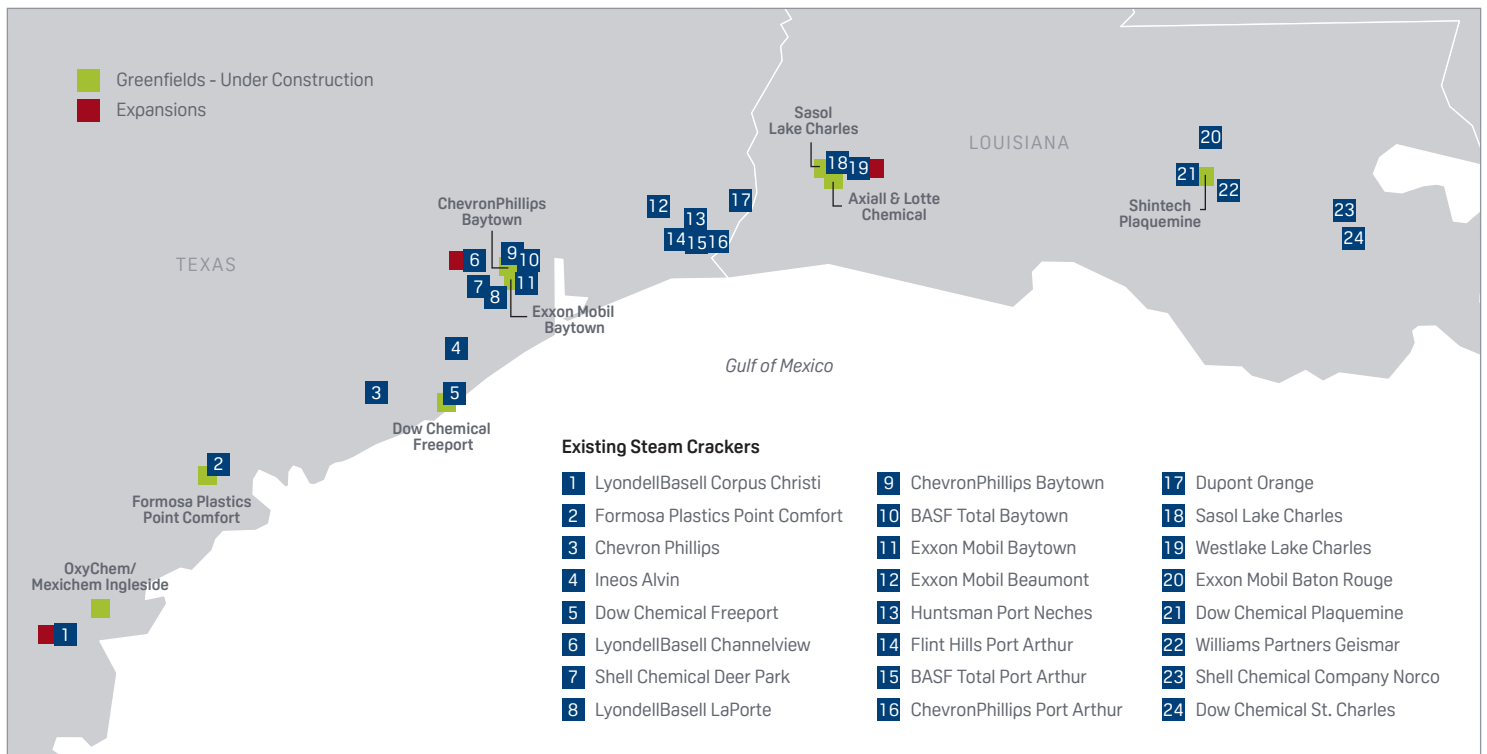
Source: Bentek's NGL Facilities Databank

will add 535 Mb/d of incremental ethane demand by 2021, an increase of approximately 50% from current demand levels. If other proposed projects move forward, demand will continue to increase further into the forecast period. Completion of all the potential projects being tracked by Bentek would represent at least 430 Mb/d of incremental demand above the volume from projects under construction. For a complete list of proposed steam crackers and expansions, please refer to Bentek's *NGL Facilities Databank*.

Export Terminals

As the new steam crackers continue to make progress, infrastructure for ethane exports is also moving forward. Unlike other NGLs such as propane and butane (sold as liquid petroleum gases, LPG), ethane has never been exported via ship from the US, so new terminals were necessary to facilitate waterborne exports. Bentek is tracking two ethane export terminals in the US: Sunoco's 70 Mb/d Marcus Hook terminal and Enterprise's 200 Mb/d Morgan's Point terminal.

STEAM CRACKERS



Source: Bentek

The first terminal with plans to export waterborne ethane from the United States was Sunoco Logistics' Marcus Hook terminal in Delaware County, PA. According to Platts reports, ethane exports from Marcus Hook have been delayed until March 2016, after an anticipated loading in February was postponed. The terminal was initially set to load its first cargo in December 2015, but technical challenges delayed the start of shipments.

Enterprise Products Partners plans to commence service at the company's 200 Mb/d export terminal on the Houston Ship Channel in mid-2016. On November 9, Enterprise Products announced a new long-term contract from the Morgan's Point terminal. According to the press release, the new contract puts around 90% of the 200 Mb/d facility under long-term agreements. However, the company has not announced an estimated timeline as to when it will reach this utilization. Enterprise stated that they expect the full capacity at Morgan's Point to be sold by early 2016 and they plan to commence exports in the third quarter of 2016.

Outside of Enterprise and Sunoco Logistics, Bentek does not expect additional ethane export terminals to move forward in the near term.

Ethane Ships

One of the major challenges to large-scale, waterborne ethane exports is ship capacity. Unlike LPG or liquefied natural gas (LNG), ethane has never been shipped overseas in large quantities, and thus new ships needed to be designed and built to serve ethane projects. Individual recipients of ethane have arranged charter agreements for the newly constructed ships to correspond with their projected export volumes.

As of the November 2014 report, Bentek was tracking orders to build 24 new ships designed specifically to support US ethane exports with in-service dates between 2015 and 2017. Currently, the construction of most of these vessels appears to be progressing on schedule and Bentek expects exports to ramp up as new ships come online. Additionally, four ships have been completed and delivered and plans to build four to six more vessels have been announced (Table 2).

The first-ever ships designed to transport ethane were commissioned in mid-2015 by INEOS and Evergas. The JS INEOS

Insight and JS INEOS Ingenuity were received from Sinopacific Offshore Engineering on July 14, 2015. The two Dragon class vessels were joined by a third, the JS INEOS Intrepid, in October and a fourth, the JS INEOS Inspiration, in January 2016. Evergas is expecting to receive four more Dragon class ships in 2016. While awaiting full commissioning of the Marcus Hook terminal, INEOS has used the delivered ships to handle LPG cargoes.

Before taking receipt of the full fleet of Dragon class ships, Evergas has signed a new contract for at least four and up to six new 32,000 cubic meters (200 Mb) ships. The new "INEOS Max" class ships are over 10% larger than the Dragon class ships, and will be optimized to the capacity of INEOS ethane terminal and storage facility at Grangemouth, UK. Upon receipt, Evergas intends to put at least two of the Dragon class vessels into LPG or LNG transport service.

Additionally, according to TradeWinds News, United Ethane Carriers, the joint venture between Jaccar Holdings and Hartmann Group, has disclosed further details about their order of five VLECs (Very Large Ethane Carriers). The order for the 85,000 cubic meter (530 Mb) ships will be fulfilled by Dalian Shipbuilding Industry Offshore (DSIC Offshore). TradeWinds reported that the contract included a precondition of approval from the Chinese government to construct an ethane cracker and a confirmed ethane source. The ships will reportedly operate on a ten-year charter with Oriental Energy, a Chinese LPG trader.

Global Ethane End Users

Bentek is tracking four overseas petrochemical customers that have confirmed plans for waterborne US ethane imports: INEOS, Borealis, SABIC, and Reliance (Table 3). Bentek is also monitoring several other companies that are considering ethane imports, but have not announced a final decision on their projects.

INEOS is the first mover in the ethane export market and has announced plans to supply US ethane to multiple locations in Europe. Ethane for the Rafnes, Norway facility will be sourced from Sunoco's Marcus Hook Terminal and supply for Grangemouth will come from Enterprise's Morgan's Point terminal. INEOS new storage tank at Grangemouth was

TABLE 2: ETHANE SHIP ORDERBOOK

Ship owner	End User	Number of ships	Unit capacity (cu m)	Est. Unit Capacity ('000 barrels)	In-Service Date	Status
Orders						
Evergas	INEOS	4	27,500	260	2015-2016	Under Construction
Evergas	INEOS	4 (2)	32,000	301	2018	Ordered
Reliance/ Mitsui	Reliance	6	87,000	835	2016-2017	Ordered
Navigator Gas	Borealis	1	35,000	325	2016	Under Construction
Navigator Gas	TBD	3	35,000	301	2016	Ordered
Ocean Yield	SABIC	3	36,000	310	2016	Ordered
Hartmann Schifffahrts	Oriental Energy	5	85,000	802	2017	Ordered
Delivered						
Evergas	JS INEOS Insight		27,500	260	2015	In Service
Evergas	JS INEOS Intrepid		27,500	260	2015	In Service
Evergas	JS INEOS Ingenuity		27,500	260	2015	In Service
Evergas	JS INEOS Inspiration		27,500	260	2016	In Service

Source: Bentek

completed in July 2015 and is designed to hold over 60,000 cubic meters (438 Mb) of ethane.

In November 2015, INEOS announced an agreement with ExxonMobil Chemical and Royal Dutch Shell to ship ethane by pipeline from storage facilities at Grangemouth to the Fife ethylene plant in Mossmorran, Scotland beginning in 2017. The Fife plant is operated by ExxonMobil, with Shell holding a 50% interest in the capacity. The Mossmorran Fife cracker has a nameplate capacity of 1,830 MMlbs/yr of ethylene and previously received its NGL feedstock from North Sea production.

SABIC signed a deal to import US ethane to support its project to take gas-based feedstock at the 1,900 MMlbs/year Wilton cracker in Teesside, UK, according to a BBC News report. Details of the deal have not been disclosed. SABIC has already begun constructing a new ethane import terminal and a cryogenic gas storage tank at the site, which would start taking ethane by H2 2016. SABIC UK expects the cracker upgrade to be complete in 2016.

Borealis announced plans to upgrade four steam crackers starting in late 2016 at its Stenungsund, Sweden site as part of its plans to consume US ethane. Two crackers will be decommissioned as part of the project. Work will extend through 2020. Borealis has a long term contract in place with Antero Resources for 11.5 Mb/d of ethane supplied from Sunoco's Marcus Hook terminal. The company is anticipating their first delivery of ethane in 2017.

Among the European firms included in the earlier report, Versalis appears to be backing away from plans to import ethane. Versalis stated that the conversion of their 838 MMlbs/yr naphtha cracker at Dunkirk, France to consume 50% ethane from US imports is on hold because of lower oil prices. This project is no longer included in Bentek's base case export forecast.

Reliance will consume imported ethane at three crackers on the west coast of India: Dahej and Hazira in Gujarat and Nagothane in Maharashtra. Reliance has a contract to purchase approximately 72.5 Mb/d of ethane from Enterprise and is building a world-scale shipping terminal and storage facility at its Dahej site. A dedicated ethane pipeline was recently approved to deliver ethane between the Dahej and Nagothane facilities and a lateral is being constructed to reach Hazira. Reliance is in the process of upgrading its crackers to

maximize ethane as a feedstock. This work is expected to be finished by December 2016 to coordinate with the start-up of ethane shipments.

Two additional Indian companies have shown interest in importing US ethane. Bharat Petroleum Corporation (BPCL), a state-owned oil and gas company in India, is exploring ethane imports as a fuel for its refinery operations. BPCL directly operates two refineries, with a combined capacity of 500 Mb/d expanding to 635 Mb/d, and holds interests in two others, with a combined capacity of 200 Mb/d. BPCL has not disclosed further details about the project.

Indian gas utility GAIL announced plans in February 2016 to import ethane for a greenfield \$5 billion petrochemical plant in Andhra Pradesh on the East Coast of India, according to the Economic Times. Imports of ethane for the plant could reach as high as 1.3 MMt/yr (about 63 Mb/d), beginning in 2022. It was not reported whether GAIL has secured shipping or supply commitments for the required volume of ethane. BPCL and GAIL are currently not included in Bentek's current base case export forecast, but are being closely watched for further developments.

Finally, as reported in TradeWinds News, the German shipper Gaschem will transport US ethane on behalf of Brazilian petrochemical company Braskem to use as feedstock in the company's ethane cracker in Brazil. Braskem currently operates eight steam crackers in Brazil, but only one facility is currently configured to use an ethane feedslate. The ethane cracker is located in the city of Duque de Caxias, Brazil with a nameplate capacity of 1,147 MMlbs/yr of ethylene. Braskem will be using two to four of Gaschem's semi-refrigerated LPG/ethylene carriers with a capacity of about 8,500 cubic meters (62 Mb) each. Gaschem currently owns four semi-refrigerated vessels around this size. These ships will undergo modifications that involve the addition of a regasification kit that would regasify ethane prior to delivery. This would enable Braskem to receive the product without building an onshore regasification facility. The ships are expected to transport ethane from the US Gulf Coast.

Although it is possible to use ethane for power generation, Bentek has not heard of any confirmed projects to import US ethane for this purpose. Rusal proposed a 140 MW ethane-fueled power plant to supply power to its bauxite/aluminum refinery operations in Jamaica, but Rusal has not been able

TABLE 3: CONFIRMED GLOBAL ETHANE END USERS

Company	Location	Country	Ethylene Capacity (million lbs/yr)	Max Ethane Demand ('000 b/d)*
INEOS	Rafnes	Norway	1,213	32
INEOS	Grangemouth	UK	1,610	42
Borealis	Stenungsund	Sweden	1,378	36
ExxonMobil	Mossmorran	UK	1,830	48
SABIC	Wilton	UK	1,900	50
Reliance Industries	Dahej	India	882	23
Reliance Industries	Nagothane	India	882	23
Reliance Industries	Hazira	India	1,985	52

*Assumes a 95% utilization rate and 100% ethane feedslate.

Source: Bentek

to reach a contractual agreement with proposed US supplier American Ethane.

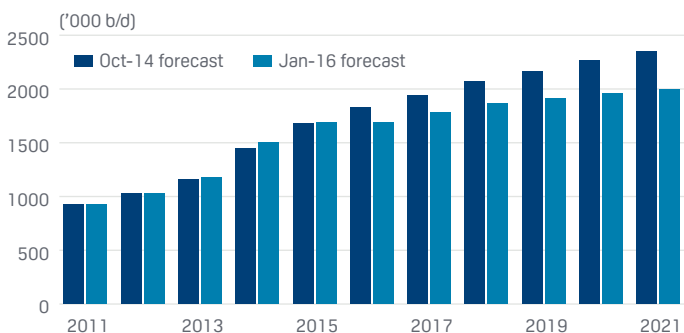
In total, Bentek's base case forecast for waterborne exports estimates that volumes will reach a total of 170 Mb/d by 2018. Of this amount, 60 Mb/d will come from the Marcus Hook terminal while 110 Mb/d will be exported from Morgan's Point. These volumes represent about 63% of the 270 Mb/d total nameplate capacity from both terminals, a relatively low utilization rate. Enterprise has publicly announced that the Morgan's Point terminal is 90% contracted, but additional volumes have not been added to Bentek's forecast pending more information on end users and the time frame of new contracts. It would also be possible for Sunoco to expand ethane export capacity from Marcus Hook as new pipelines come online to supply the terminal, including Mariner East 2 and the potential Mariner East 2X, which is currently in open season.

ETHANE PRODUCTION GROWTH IS LESS AGGRESSIVE AND THE ETHANE MARKET WILL TIGHTEN

While demand projects appear to be materializing, ethane supply growth is less certain. Bentek's forecast of ethane production from gas plants has been revised down over the past several quarters due primarily to decreased drilling activity caused by low commodity prices. Negative NGL fractionation spreads have also reduced the outlook for raw mix production as producers move from wet to dry areas to avoid the costs associated with liquids production, especially in the Northeast. In the original publication of *Adrift in a Sea of Ethane*, Bentek expected ethane supply from gas plants to reach 2,264 Mb/d in 2020. In the latest edition of Bentek's *Market Call: North American NGLs*, ethane supply reaches only 1,960 Mb/d in 2020, a 13% decline (Figure 5).

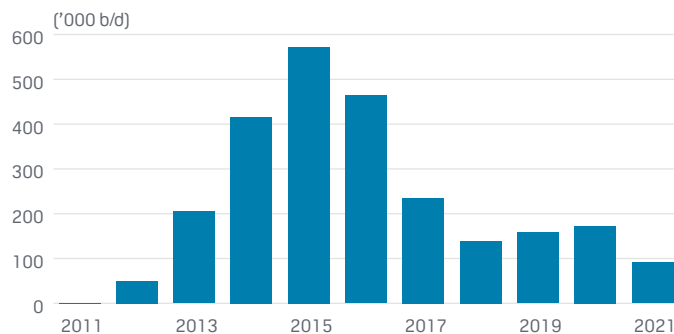
Despite the lower ethane supply curve, domestic and export demand are expected ramp up simultaneously starting around 2017. This will tighten a market that has been structurally long since mid-2012 and push ethane prices above the gas-equivalent floor. In order to incentivize ethane recovery versus rejection into the natural gas stream, prices have to rise to cover transportation, fractionation, and ethane recovery fees. Bentek expects this increase in prices to come as the new cohort of steam crackers enter service. The primary driver for this tighter market is the US domestic petrochemical

FIGURE 5: ETHANE SUPPLY FROM GAS PLANTS



Source: Bentek's Market Call: North American NGLs

FIGURE 6: TOTAL US ETHANE REJECTION



Source: Bentek's Market Call: North American NGLs

market, not the ethane export market. Bentek expects almost complete ethane recovery in the Gulf Coast and the Mid-Continent by 2018 to meet incremental demand. However, producers farther from the Gulf Coast petrochemical complex may continue to experience lower fractionation spreads due to higher costs of transportation and ethane recovery and therefore not recover all the available ethane. Total US ethane rejection is projected to decrease from a high of 572 Mb/d in 2015 to only 173 Mb/d in 2020 (Figure 6). Bentek provides a regional breakout of ethane rejection and recovery in the *Market Call: North American NGLs* report.

FUTURE ETHANE EXPORTS DEPEND ON CRUDE/GAS RATIO

Since *Adrift in a Sea of Ethane* was initially released, Bentek believes that the upside potential for additional ethane exports is reduced, as prices for all petroleum products have come down in the past year. The economics of ethane export projects depends on whether the up-front infrastructure costs are offset by the savings in cracking ethane instead of another feedstock, typically naphtha, over the life of the project. This is largely determined by the future crude-to-gas ratio and the relationship between natural gas and ethane.

As noted previously, ethane prices in the US have been trading at or near their gas-equivalent floor since mid-2012 while naphtha has trended with crude. Sustained low crude and LPG prices would keep feedstock costs for heavier-feed units low and make them more competitive with ethane crackers. On the other hand, higher crude prices would improve the economics of ethane crackers by making naphtha crackers less competitive. Rising crude prices also have an indirect effect by improving producer economics in liquids-rich areas, resulting in increased ethane supply from associated gas.

If companies believe that the large spread between feedstocks that existed in 2011-2012 will return, pursuing an ethane export project may appear economic. However, Bentek believes that there is significant upward risk for Mont Belvieu ethane prices due to higher demand from new steam crackers and a flattening production forecast. Greater ethane recovery will be necessary in areas far from the Mont Belvieu market, including the Northeast and Rockies. As a result, ethane prices could rise as much as 25 cents/gallon over the gas-equivalent floor to cover fractionation and transportation costs from production

areas to the Gulf Coast. Some ethane exports are subject to pricing based on an index to natural gas, rather than the price of ethane at Mont Belvieu, mitigating the price risk for their exports to changes in the domestic ethane market. These projects will be relatively more economic if the ethane price rises above the gas floor, but they will still face competition from the heavier-feed units.

Despite the risk to ethane prices and margins, Bentek expects that the previously announced committed projects will move forward, due to several key factors. First, investment in infrastructure and long-term take-or-pay commitments become sunk costs after the assets come online and the contract period begins. Thus, ethane importers who have made such commitments will consider only the marginal cost of imports going forward. Second, companies also face fees for ethane cargo cancellations, which will encourage them to take the contracted volumes. Third, the relatively low rate of ethane cracking internationally and limited fleet of ethane-capable ships reduces the liquidity of the global ethane market. Unlike

LPG or LNG, producers will have limited options to resell ethane cargos on the spot market. Fourth, several of the users detailed here, particularly those in Europe, are facing declining ethane availability from other oil and gas production. Their ethane cracking infrastructure was tied to local ethane production and will now largely depend on ethane exports from the US, limiting their other options for feedstock sourcing. Finally, the option to take other feedstocks is limited by the design specifications of the crackers themselves. Generally, lighter-feed crackers have less flexibility than units designed to take heavier feeds.

Overall, given the current price environment and Bentek's ethane, LPG, and crude price forecasts published in the latest *Market Call: North Americans NGLs* report, the economics appear challenging for new entrants to the ethane export market. Export volumes for previously announced projects have long-term, take-or-pay contracts and extensive infrastructure already under development. As a result, Bentek anticipates that committed volumes with announced end users will likely be exported, but the potential for new entrants is limited.

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