The shale revolution and its impacts on aromatics supply, pricing and trade flows

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The shale revolution in North America has had a huge impact on petrochemical production on the continent. Low-cost feedstocks associated with shale gas have altered the production landscape, as steam cracker operators scramble to capitalize on the advantage yielded by cheap natural gas liquids, particularly ethane.

Chemical majors such as Dow, ExxonMobil Chemical, Formosa Plastics Corporation USA, Sasol, Chevron Phillips Chemical and Shell are among those that have announced new steam cracker capacities. Brownfield projects encompassing expansions, debottlenecks and restarts are planned by the likes of LyondellBasell, Ineos, BASF, Westlake and Dow. Put together, said projects could increase North American ethylene capacity by more than 11 million mt/year by 2017, should all projects are realized.

Meanwhile, many producers with the flexibility to adjust feedslates at the cracker level have already increased ethane input. The ongoing shift to lighter feedslates has, however, had a significantly negative impact on heavier co-products such as propylene, butadiene and aromatics, with yields cut by as much as 55% by some estimates.

The North American aromatics market has been particularly impacted, with benzene, toluene, and xylenes (BTX) production taking a notable hit in recent years.

Despite diminished output at the cracker over the last few years, the Energy Information Administration estimates that US aromatics production at the refinery will hit a roughly seven-year high in 2013, with output expected to surpass 317,500 b/d. That level would represent an almost 15% increase from 2010, when aromatics output at the refinery level was slightly under 271,000 b/d.

On a more granular level, aromatics output form PADD 3, which encompasses the Southeast and US Gulf Coast region, hit a four-year high in 2013 with total output expected to be just north of 209,000 b/d. Conversely, aromatics production in PADD 1, which represents the Northeast, fell roughly 44% between 2011-2012, and 2013 production levels are expected to be level at 10,111 b/d.

The declines in PADD 1 have been attributed in part to the processing of lighter crudes, particularly from the Bakken shale play in the Montana/North Dakota region of the US. The average API value of crude processed by refineries in PADD 1 in 2008 was 30.95 but has since risen to 32.93 in 2012, crossing the threshold from medium to light crudes in the process. As well, a large chunk of the year-on-year decline in 2011-2012 can be attributed to refinery closures in or supplying the northeastern part of the United States.

The closure of Sunoco’s refinery at Marcus Hook in Pennsylvania in early 2012 took an estimated 19,000 b/d of aromatics out of the market. The Marcus Hook refinery accounted for 13% of operating crude capacity in the Northeast. Additionally, HOVENSA, a joint venture between Hess and Petroleos de Venezuela S.A, shut its refinery operations in St. Croix in 2011 after losses of $1.3 billion over the course of three years. The refinery had an estimated production capacity of 5,800 b/d of toluene, 4,500 b/d of benzene, and 4,000 b/d of mixed xylene at St. Croix and supplied material to the US Northeast, according to a report by the EIA and American Petroleum Institute.

Still, production of aromatics in the US is anticipated to be higher in 2013, and this has been attributed, in part, to an increase in the production of naphtha as a petrochemical feedstock.

Naphtha production for use as petrochemical feedstock averaged 7,110 kb/d for the first half of the year, up nearly 11% from the 2011 average of 6,314 kb/d. Also, higher reformer rates have supported the increase in aromatics production as the average fresh feed inputs into catalytic reformers increased by 44,000 b/d from 2011-2012.
But move away from the refinery and consider the impact of shale gas on aromatics at the cracker, and the picture is less rosy.

Prior to the move to lighter feeds, steam cracker operators were more open to using naphtha as a feedstock. Benzene yields from naphtha as a feedstock were estimated at near 7%, but a switch to ethane or an ethane/propane mix reduces benzene output to just 1%. Pygas output is reduced significantly with the use of lighter feeds. As an example, pygas yields from E/P mix are reduced to just 3%, down from 19% yields using naphtha as a feedstock.

Despite the more than 10 million mt/year of additional ethylene capacity slated for North America over the next 6-7 years, aromatics output at the cracker is expected to grow by just over 5% by 2020.

So why the interest in new cracker capacities, you ask?

The interest is rooted in the crude-to-gas ratio. In late 2010 and early 2011, natural gas prices began to decouple from crude amid increased supply. The gulf remained throughout 2011 and widened in 2012, when the ratio climbed to near 65% in March. (A higher crude-to-gas ratio suggests that operators should drill for oil in lieu of natural gas and makes NGL developments more commercially attractive and encourages operators to place rigs in liquid-rich supply basins, which contain both oil and gas, according to the EIA.)

The cost advantage associated with cheaper gas and NGLs, coupled with the ethylene yield when using ethane as a feedstock (78%), was too good to pass up, and chemical producers began to announce projects and investments.

The impact of low-cost NGL feedstocks and the lure of having a cost advantage second only to that of the Middle East, can be seen by taking a quick look at the oil and gas rig count in the past 5-6 years.

Between 2007-2013, the North American gas rig count has fallen by roughly 71.5% from 1,594 to 401, while the oil rig count has risen by over 600%, from 219 to 1,397, according to data by Baker Hughes.

The narrowing of the gulf between the two counts and the intersection in 2011 also corresponds directly to a rising crude-to-gas ratio. More specifically, the average WTI crude price in 2011 was $95/barrel, up from just under $62/barrel in 2009.

Meanwhile, gas prices averaged $3.76/MMbtu in 2011, down from an average of $4.10/MMbtu the previous year. The takeaway from this is that shale gas has proven to be extremely profitable for ethylene and ethylene derivatives but has certainly hurt the production of aromatics.

**BENZENE**

Benzene supply from the cracker improved slightly from 2012 to 2013, gaining roughly 1.7%. Going forward, growth opportunities will be limited with production expected flat in 2014 and most significant increases in production seen in 2017-2018, when the majority of new cracker capacities are expected to be completed. Despite the new cracker projects, benzene yields at the cracker could fall by an estimated 118,000 mt/year between 2011-2020 as a direct result of the shift to lighter feeds.
In regards to pricing, spot benzene values have been fairly robust in 2013 and have not fallen below $3.90/gal. The average spot price from January through November has been 437 cents/gal on an FOB USG basis, far above the 2009, 2010 and 2011 averages, which were at 243, 325.5, and 381 cents/gal, respectively. The average for 2012 was slightly higher at 444 cents/gal, supported by record high benzene prices to close out the year.

While the benzene price may seem high, its value relative to crude suggests otherwise. The historical average of the benzene-to-Brent and -WTI ratios is 1.97 and 1.98, respectively. Thus far in 2013, those ratios have been 1.72 and 1.91, respectively.

The same can be seen in May, with 2013 and 2012 import levels at 35,900 and 69,400 mt, respectively. Imports in July 2013 were less than half of the previous year at 30,400 mt, while 2012 levels were at 75,600 mt.

So with benzene prices higher and near-term production slated to decline, one might ask “What is the best play in this situation?” In the near term, say this year, the answer might very well be styrene. Styrene margins in the US have flipped into positive territory following benzene’s correction from record-high levels in late 2012. Feedstock benzene fell from $5.25/gal in mid-December 2012 to as low as $4/gal in mid-July of this year. As well, spot ethylene values fell from as high as 66 cents/lb on March 14 of this year to under 50 cents/lb to start October.

Supporting the allegation that styrene is a safe bet are supply-side limitations, not only in the US but in Asia and the Middle East. Styrene supplies in the US are expected to remain snug throughout the remainder of the year with Cosmar undergoing a turnaround at its 1.2 million mt/year facility at Carville, Louisiana. Styrolution also was heard to be undergoing a turnaround at its 453,000 mt/year facility in Texas City, Texas, during November. The turnaround is expected to last 65 days, sources told Platts.

This comes amid eight other planned turnarounds in the Middle East and Asia between August and November. These outages should keep the styrene market tight into Q4 and will likely curb benzene demand, lengthening supply and pressuring prices lower.

**TOLUENE**

Toluene prices in 2013 have been relatively strong amid increasing supplies. The 2013 average thus far has been $4.01/gal compared to the historical average of $3.08/gal from 2005-present. Steep gains in pricing were seen in August and September as supply tightened due to production issues at extraction units.

Overall production of toluene at the steam cracker was expected to increase by 4.9% from 2012-2013, although it should subsequently decline through 2016.
From 2016-2020, production is expected to increase by 5.3%. From the refiners’ point of view, toluene garners little attention as reformer feedstock fraction is a relatively small part of crude oil. Octane-short refiners may look to utilize naphtha with a higher content of precursors such as methyl cyclohexane or dimethyl cyclopentane in an effort to generate a higher toluene yield.

Still at the end of the day the question is really one of profitability between toluene as a blendstock for gasoline or as a feedstock for chemical production.

As a blendstock, toluene demand is seasonal in nature and it is most attractive for blenders during the driving season, which in the US extends from May to August. In 2013, blend demand was hurt by stronger pricing, which made toluene less attractive as a blendstock.

As a feedstock, the demand for mixed xylenes has been limited given competition from products such as toluene and ethanol. The majority of demand comes from the chemical segment, where mixed xylenes serve as feedstock for paraxylene or for use as solvent.

The US mixed xylene market is unique in that demand for both mixed and paraxylenes will be largely dictated by the xylene chain in Asia. The US is a net exporter of mixed xylenes and paraxylene and accounts for roughly 25% of Asian mixed xylene imports, volumes equating to roughly 800,000 mt/year.

### MIXED XYLENES AND PARAXYLENE

Mixed xylene prices have fallen off in 2013 and were mostly lower, with the average for the year thus far at 417 cents/gal on an FOB USG basis. Despite the overall declines in 2013, prices were still well above the historical average of 333.50 cents/gal between 2008 and 2013.

From the cracker, mixed xylenes production is expected to grow by 2.1% from 2012-2013 but is expected to dip slightly in 2014-2015 and could remain flat up until 2020. While production primarily comes from the refinery, the volume of production coming from disproportionation units is increasing.

Outside of driving season, toluene is most appealing as a feedstock for chemical production. Via the disproportionation process, toluene can be used as a feedstock to produce benzene and xylenes. MSTDP units, which use toluene to produce benzene, mixed xylene and paraxylene, have been the most profitable in 2013, while TDP margins followed. Margins for both peaked early in the year on the back of strong benzene and mixed xylene prices with MSTDP margins breaching the $350 mark in early January while TDP margins were closer to the $250 mark. Notable MSTDP margins were seen again briefly in April, as well as in June.

Going forward, toluene production is expected to be flat into 2014 and demand will continue to be a function of blend demand versus chemical demand.

Chemical demand for feedstock will be driven by paraxylene and PET, markets that could be oversupplied in the next 3-5 years. Blend demand will be a function of toluene’s competitiveness price-wise against other octane boosters as well as gasoline prices and macro-economic health in the US.

The Asian mixed xylene market is net short, with a production capacity estimated at near 2.4 million mt/year. This deficit has served the US well in recent years. However, the Asian market will flip into a long position on both paraxylene and downstream terephthalic acid (PTA) between 2015-2017.
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In pricing, paraxylene values in the US are driven by the Asian market, which itself is influenced by dynamics in the PTA and ultimately polyethylene terephthalate markets (PET). Though subject to the whims of the Asian markets, paraxylene values in the US have been largely profitable in 2013, with margins peaking in May at $124/mt. Margin calculations are an estimate only, with production costs estimated at mixed xylenes plus $150/mt. While profitable in 2013, US xylenes will face significant hurdles going forward as capacity in Asia grows.

To better understand how US xylenes will be impacted by increasing Asian capacities, one need look only at PTA production in the region. PTA, along with ethylene glycol, serves as the feedstock for PET. PTA capacities in Asia are growing and doing so at a rapid clip. More specifically, a surge of new PTA capacity is expected to come online between Q4 2013 and 2015. In total, producers in China have announced capacities totaling 19 million mt/year by 2015, with Xianglu announcing the largest project at 4.5 million mt/year.

If all of the announced projects are realized, China would see its PX requirement increase by more 12.5 million mt/year between 2013-2015. However this does not exactly spell good news for US producers.

Though PTA capacity in Asia is expected to increase at a rather rapid clip, paraxylene production in both the Middle East and Asia will grow at an even faster rate. Producers have announced new paraxylene capacities that will total near 21 million metric tons between 2013 and 2017, assuming all projects are realized and run at expected rates. The largest project is Adnoc’s 1.6 million mt/year facility at Ruwais in Abu Dhabi.

Although new PTA capacities in Asia will necessitate the production of some 12.5 million mt of paraxylene per year, paraxylene supply will outpace demand and by 2017 supply is expected to be sufficient to produce almost 32 million metric tons of PTA, assuming all projects are realized. The increased supply of both PTA and paraxylene will negatively impact US mixed and paraxylene prices as demand for US material will likely wane.

Another factor impacting the US xylenes markets is a widening spread between domestic PTA prices in China and prices of imported product. Domestic PTA prices in China opened the year at near CNY 8,965/mt (with an exchange rate of near 6.22/dollar) but have since fallen to CNY 7695 (with an exchange rate of near 6.12/dollar).

During that same period, the price of PTA imports fell from $1,215/mt CFR China to start the year to near $1,055/mt CFR China in mid-September. In short, the lower PTA values will negatively impact margins and could force producers to run at lower rates, as was seen in March when producers in China and South Korea slashed production on the back of negative margins. Lower operating rates from PTA producers also translates into diminished demand/increased supply for paraxylene, a move that puts downward pressure on pricing.

Perhaps the most daunting news for the US xylenes chain is found in the textile industry in China. As mentioned previously, PTA is a feedstock for PET. While in the US, PET demand is largely driven by the resin’s use in the bottled beverage sector, Asian PET demand is used as a fiber and is driven by the textile industry in China. This spells bad news in the near term for US producers given the bearish outlook for textiles in China.

In addition to high cotton prices, the outlook for the Chinese textile industry is bearish on the back of huge clothing inventories. Clothing inventories in the country are so extensive that China’s National Garment Association noted that even if all of the country’s clothing industry came to a complete halt for one year, there would still be enough clothing to satisfy the needs of every Chinese person for three years. The takeaway here is that unless there are some drastic changes in the market, demand for PET, and accordingly PTA, PX and ultimately MX, will be muted in the near term.

Textile sales bearish in China, cotton prices too high, huge clothing inventory:

“Even if all of China’s clothing industry comes to a halt for 1 year, there’ll still be enough clothes to house every Chinese for 3 years”
– China National Garment Association

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Total PX requirement for 2013-2015: 12.54 million mt
CONCLUSIONS

Though aromatics production in the US has increased at the refinery, output has been significantly curbed by the shift to lighter feedstocks at the cracker.

In the near term, the US will remain net short benzene, with supplies dented as lighter feedstocks at the cracker yield less product. (This holds true for toluene and xylenes as well.) Benzene prices will continue to be impacted by supply/demand fundamentals as well as the downstream styrene market.

For toluene, demand, production and pricing will remain a function of blend demand from gasoline and toluene’s profitability as a feedstock for chemical production. For mixed and paraxylens, the US market will likely become victim to overcapacity in the Asian PX, PTA and PET markets, textile demand and, taking it a step further, could depend on the macro-economic performance of developed and developing nations.

Future aromatics production in the US will be tied to refineries’ ability to increase processing capacity of unconventional tight oils. Crude from shale plays has a lighter N+2A cut, i.e. a lower aromatic content, and refineries currently must blend heavier and lighter crude or run at reduced rates. Going forward, those able to capitalize on vast reserves of unconventional tight oil will be the winners.

To that end, several US refiners including Marathon, Flint Hills, Phillips 66, Citgo and Valero have begun investing in operations in an effort to capitalize on reserves of shale crude. While oil extracted from shale plays in the US has not yet seen the same cost advantage as shale gas, US crude production has increased notably in the past six years from 5.1 million barrels/day in 2007 to an estimated 7 million barrels/day in January 2013. The expectation is for the trend to continue, with production from the Eagle Ford play in Texas slated to rise to near 1.8 million barrels/day by 2020. If one factors in similar expected production from the Bakken shale play, US crude production could increase by as much as 4 million barrels/day by 2020.

If producers are able to avoid logistical constraints and realize such production levels, the US would compete with the Middle East as the world’s leading producer of crude oil. Considering that naphtha constitutes between 15-30% of a barrel of crude depending on the weight, the US could theoretically see an additional 600,000 barrels/day of naphtha production by 2020 and possibly as much as double that amount. Logic dictates that increased naphtha supply would put downward pressure on pricing and could ultimately make the product more appealing as a feedstock. By 2020 the Energy Information Administration estimates that global crude production by 2020 could surpass 96 million b/d, levels which could theoretically translate into over 14 million b/d of naphtha at a minimum.

Naphtha’s appeal could also be enhanced by virtue of the fact that yields of heavy products at the cracker have been cut and with tight supply comes higher prices. Higher-priced derivatives and falling feedstock values ultimately mean greater margins.

Of course there are a number of variables that could impact the future landscape of the North American petrochemicals industry, and many questions remain.

Will all of the announced steam cracker projects be realized? How long will it be until other countries are able to capitalize on their own shale gas reserves? Will all of the announced PTA and PX projects in Asia come to fruition?

Despite these questions, it is unlikely that the US will see a scenario in the near term in which gasoline is not king. Refiners will do everything within their power to capitalize on vast reserves of unconventional tight oil. The relationship between crude and petrochemicals is clear as petrochemical prices historically trace crude movements. Using the Platts Petrochemical Index as a proxy for the industry, the R-squared correlation between WTI and petrochemical prices is .8353 or just over 83.5%. Running the same R-squared function between the Platts Petrochemical Index and Brent crude increases the correlation to .8578 or near 85.8%.

Additionally, looking at the petrochemical industry as a whole, it seems to follow an eight-year cycle of profitability. During such a cycle, overbuilding prevails and results in lengthened supply. The most recent cycle hit its nadir in 2010 and should now be on the upswing. This is evident in the petrochemical industry by the numerous announcements of additional steam cracker capacities, the investments in pipeline and infrastructure, and the thousands of jobs created as a result of the shale boom.

Source: Platts
Given that the cycle appears to have started in 2010, it is reasonable to expect that it will peak around 2018, the same time that all of the previously announced new steam cracker capacities will be online, assuming that all are fully realized. When the cycle of profitability bottoms out, the average time prior to signs of a rebound is between 2-4 years.

If the expectations for crude production today are realized by 2020, some two years after the profitability cycle bottoms out and begins to trend upward, the US should see a significant cost advantage on both the petrochemical and crude oil fronts. The US will be in a very profitable position, and even if it loses its cost advantage associated with shale gas as a result of discoveries in other countries, the advantage associated with unconventional tight oil could serve as a hedge if producers play their cards right.

No matter what the outcome, North America, in theory, will benefit from the shale revolution. The question then becomes: Who has the capacity to capitalize now and the foresight to be ahead of the curve in the future? As the old saying goes, make hay while the sun shines.