The Future of Petrochemicals:
Growth Surrounded by Uncertainty

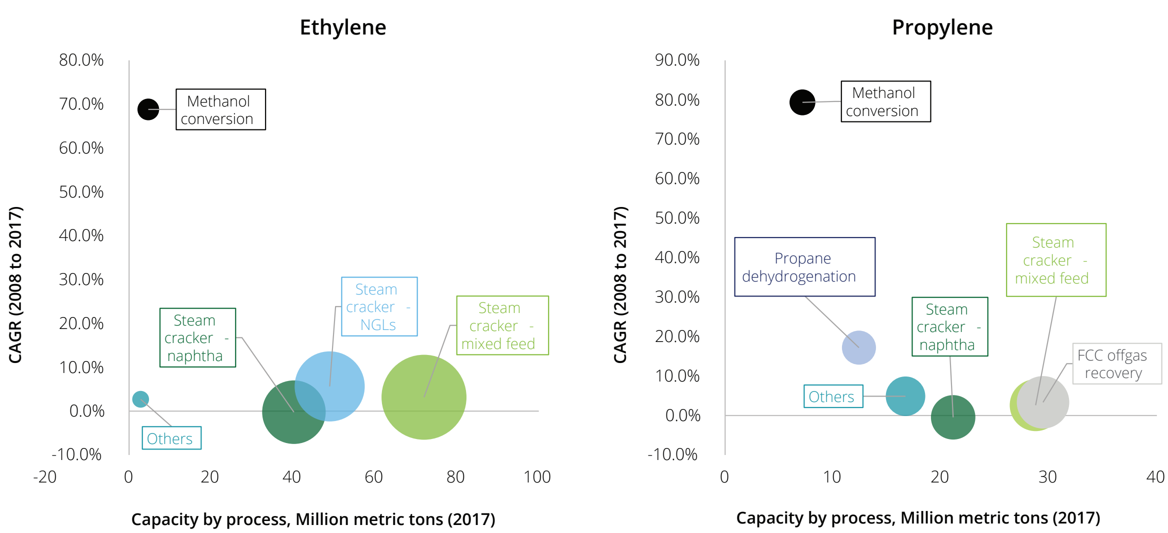
The global petrochemicals industry appears to be experiencing a gradual but possibly massive shift. Many forces emanating from either end-markets or upstream oil and gas sector are changing the way base chemicals capacities are added and utilized. The choice of feedstock, demand patterns, government directives, and capital efficiency paradigms are influencing how regional base chemicals capacity additions are happening and which feedstocks remain or become the most preferred. Furthermore, the adoption of new chemicals manufacturing technologies may completely transform the capacity game by 2030, a lot of it driven by national policies to either reduce import dependency of some key base chemicals or capture a large share in the petrochemicals markets. Finally, price dynamics of crude oil and natural gas are expected to continue to heavily influence how, where, and what base chemicals capacities will be added in the future.

Automotive and oil and gas sectors hold the key to petrochemicals growth

Many commentaries are already being written about how fuel markets are not growing in line with historical rates. According to these commentaries, petrochemicals are expected to be the largest driver of world oil demand growth, surpassing that of gasoline or diesel by 2030.[1] The outpacing of fuels demand by petrochemicals is mainly due to growing electrification of vehicles, and increasing fuel efficiency of new vehicles. Government mandates to increase vehicle fuel efficiency and reduce CO_2 emissions are also leading to a more moderate outlook for fuel demand, though short-term regulatory uncertainties remain.[2] In addition, petrochemicals will likely remain the mainstay of all products, industrial, or consumer, which the world consumes on a daily basis. It then seems natural for major refining and integrated oil and gas players to reconfigure their plants towards producing more petrochemicals rather than just fuels.

From the upstream oil and gas sector perspective, the shale gas revolution has already triggered a wave of low-cost production of chemicals feedstocks, primarily natural gas liquids (NGLs) or ethane. NGLs/ethane-based ethylene capacity has grown by more than 3 percent per year on an average from 2008 onwards. With the coming up of ethane-only crackers in the US and the recently started exports of US NGLs/ethane[3], many new petrochemical plants are biased towards maximizing ethylene production from ethane, that comes at the cost of foregoing production of other base chemicals types (figure 1).

Figure 1: Global ethylene and propylene capacity (2017) and growth (CAGR) by production process

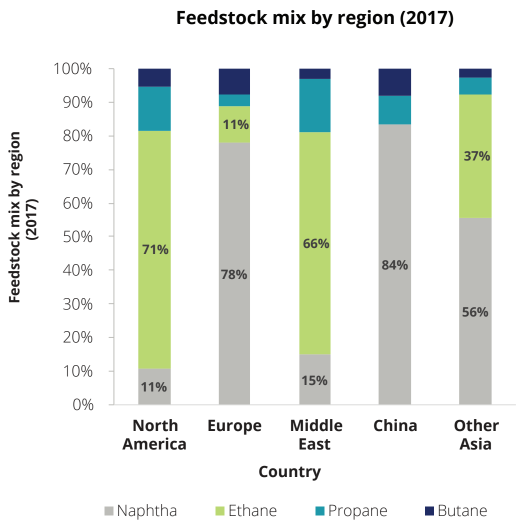


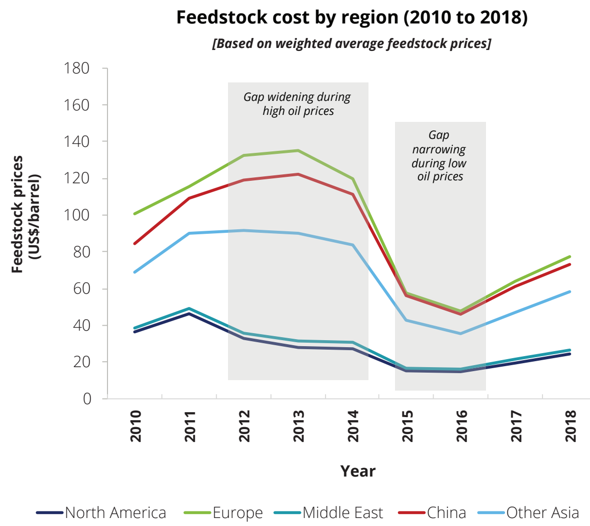
Note: Size of the bubbles indicates relative share of capacities by process technology. GAGR refers to compound annual growth rate.
Source: Deloitte Development LLC analysis based on data from Bloomberg Intelligence, accessed in February 2019.

Regional feedstock dynamics: Where does the advantage lie?

Overall feedstock mix and costs vary across regions with North America and the Middle East being the lowest cost petrochemical producers. While ethane remains the dominant feedstock in North America and the Middle East, naphtha is the most favored in Europe and China. North America and the Middle East remain the most advantaged in terms of overall feedstock costs, with the gap narrowing between North America/the Middle East and Europe/China during low oil price regime (figure 2). However, despite access to low-cost feedstocks, North American chemicals shipments growth has been flat over the last ten years, while Chinese shipments have more than tripled.

Figure 2: Regional trends in feedstock mix and costs





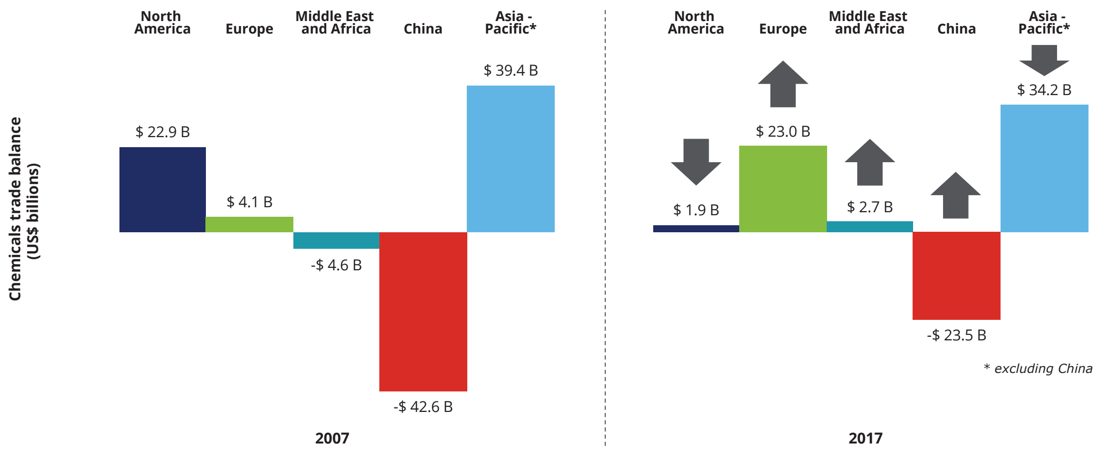
Note: Contribution of 'Gasoil' as feedstock is not considered here.
Sources: Deloitte Development LLC analysis based on data from Krungsri Research and Bloomberg Intelligence, accessed in February 2019.

Feedstock flexibility and economics would continue to evolve given the price volatility and fuel decoupling in the oil and gas industry. Globally, increasing reliance on naphtha in the future i.e., from 2021 to 2025 could be driven by the fact that from naphtha more diverse petrochemical products can be obtained, compared to ethane. However, regional variations in feedstock usage remain. For instance, US petrochemical plants are expected to continue to rely on ethane as feedstock to produce chemicals and materials downstream through 2020. Increased US ethane demand will likely drive ethane prices higher. At the same time, naphtha's percentage in Western European cracker feedstock supply is projected to go down from 73 percent in 2010 to 54 percent by 2020, according to IHS Markit. Also, China is shifting to producing ethylene from crude-oil-based naphtha and natural-gas-based ethane instead of relying on coal-to-olefins and methanol-to-olefins routes due to environmental regulations, water shortage, and low oil prices.

Source: Deloitte analysis based on data from Krungsri Research, Bloomberg Intelligence, American Chemistry Council, and IHS Markit, accessed in February 2019.

At the same time, policies from national governments in the Middle East and China appear to be playing a prominent role in shaping the future of petrochemicals. The Saudi government, for instance, is pushing for a more significant presence in the downstream industries, especially petrochemicals, to diversify the country's economy away from over-reliance on crude oil. This involves taking the national oil and energy companies public[4]; merging companies to realize synergies across businesses[5]; investing in growth markets[6], and capitalizing on state-of-the-art manufacturing technologies that enable higher chemicals yields.[7] China, however, seems to have a different vision for its country. It wants to reduce import dependency of key base chemicals. For this purpose, it has progressively decreased its chemicals trade deficit over the last ten years (figure 3), and a few Chinese large-scale chemicals companies are back-integrating to directly produce heavier C4 chemicals like para-xylene from crude oil.[8]

Figure 3: Chemicals trade balance (US$ billions) by region, 2007 and 2017



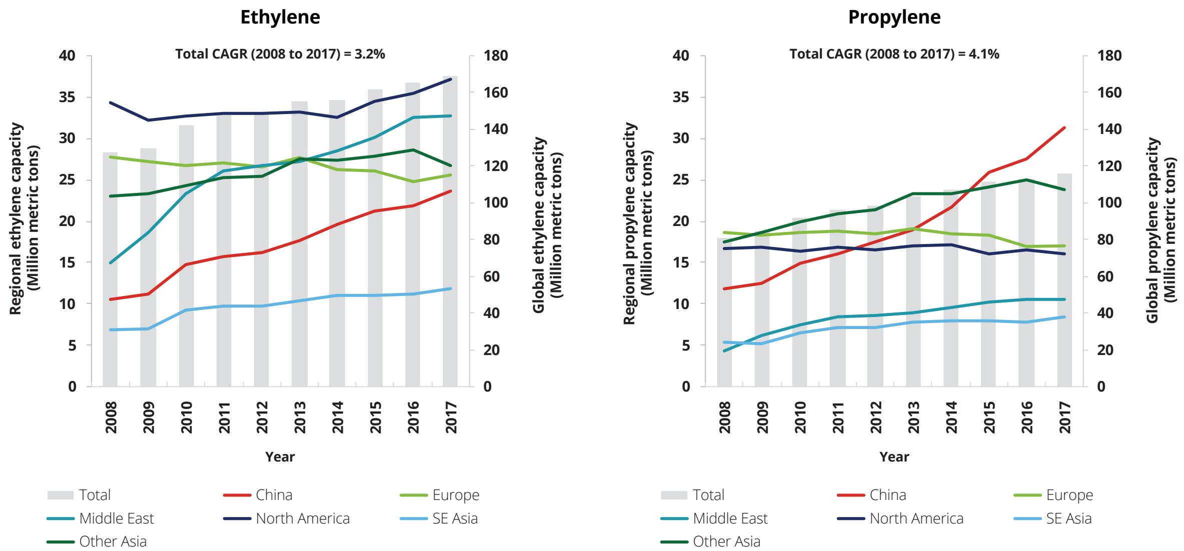
Note: Chemicals trade balance = Chemicals exports – Chemicals imports.
Source: Deloitte Development LLC analysis based on data from the American Chemistry Council, *2018 Business of Chemistry*.

Finally, from a regulatory point of view, the International Maritime Organization (IMO) bunker fuel directive to reduce sulfur content in marine fuels, mainly heavy/residual oil from refineries, is pressuring refineries to produce more ultra-low-sulfur diesel fuel for shipping. Because of the increasing requirements, the price of diesel has shot up and the price differential between diesel and gasoline has increased.[9] This could give less incentive for refiners to continue producing gasoline, largely from lighter crude oil fractions, and is, therefore, pressurizing them to run their fluid catalytic cracker (FCC) units at lower utilization rates. FCC units running at lower utilization rates would likely produce lower amounts of naphtha – the primary feedstocks to produce a variety of petrochemicals, including ethylene and propylene. While for ethylene the feedstock requirements can be met to a great extent (since ethane mainly comes from natural gas processing plants), a less than optimized run of FCC units may be a challenge to maintaining propylene production because a large portion of propylene supply comes from these FCC units.[10] Thus, the effect of IMO bunker fuel regulations has triggered a cascading effect on the supply of petrochemicals.

Ethylene capacity growth likely but what about propylene and C4 chemicals?

Over the last ten years or so, the growth in demand for base chemicals, especially ethylene and propylene, has been impressive. To keep up with the rising demand, global petrochemical and integrated oil-and-gas players have constantly worked to add new capacity (figure 4). However, there have been constraints and delays in capacity additions in the recent past, due to which capacity utilization rates have also gone past the 90 percent mark, for example, in case of ethylene.[11] While high capacity utilization rates generally bode well since they indicate strong demand, they can also indicate a downside – in case of any shutdowns or maintenance activity, the current capacity may not be able to sustain the production needed to keep up with demand, thereby introducing volatility in base chemicals prices.

Figure 4: Global and regional ethylene and propylene capacity growth trends, 2008 to 2017



Note: GAGR refers to compound annual growth rate.
Source: Deloitte Development LLC analysis based on data pulled from Bloomberg Intelligence, accessed in February 2019.

However, such volatility may be short-lived and quite regional in nature. The question is about, how new capacity, even if it comes online, manages to reach its intended destination. This is particularly true of the ethylene new capacity additions that are expected to come online in 2019 on the US Gulf coast but may not be able to reach global markets downstream due to insufficient logistics.[12] This would most likely put upward pressure on global ethylene prices.

Now, most petrochemical plants coming online are relying on NGLs, primarily ethane, as the feedstock. The yield of other key base chemicals types like propylene and aromatics is especially constrained when ethane is used as feedstock since ethylene yield (from ethane) is significantly higher (around 80 percent), which leaves little room for production of other base chemicals. On the other hand, yields of various base chemicals produced from naphtha as feedstock is more balanced.[13] Due to such heavy reliance on using ethane as a feedstock, as well as the less than optimized run of refinery FCC units as elaborated earlier, propylene capacity increases might not be sufficient to meet future demand. Thus, there is an emerging need to shift to dedicated propylene production like propane dehydrogenation (PDH), methanol-to-olefins (MTO), and coal-to-olefins (CTO), which is expected to absorb propylene demand growth. In fact, the growth of MTO, and CTO routes to base chemicals production has been phenomenal over the last ten years, primarily driven by Chinese investments (figure 4). Still, due to the shelving of many MTO and CTO projects in China because of environmental and water shortage issues, dedicated propylene capacity growth faces constraints, which may just push up the price of propylene in the short-to-medium term.[14] Accordingly, the capacity utilization of such dedicated propylene production plants could trend higher.

Capital costs and efficiency: Key determinant of petrochemical plant economics

Capital costs remain a major determining factor for establishing petrochemical plants in specific regions. In some cases, they also provide an effective buffer against high feedstock costs. For example, capital costs of constructing an ethane-based ethylene cracker in China is 50 to 70 percent of that in the US. Added to the lower capital costs, is the reduced finished product shipping cost in China which effectively offsets the higher feedstock (ethane) costs, making Chinese ethane-based capacity competitive.

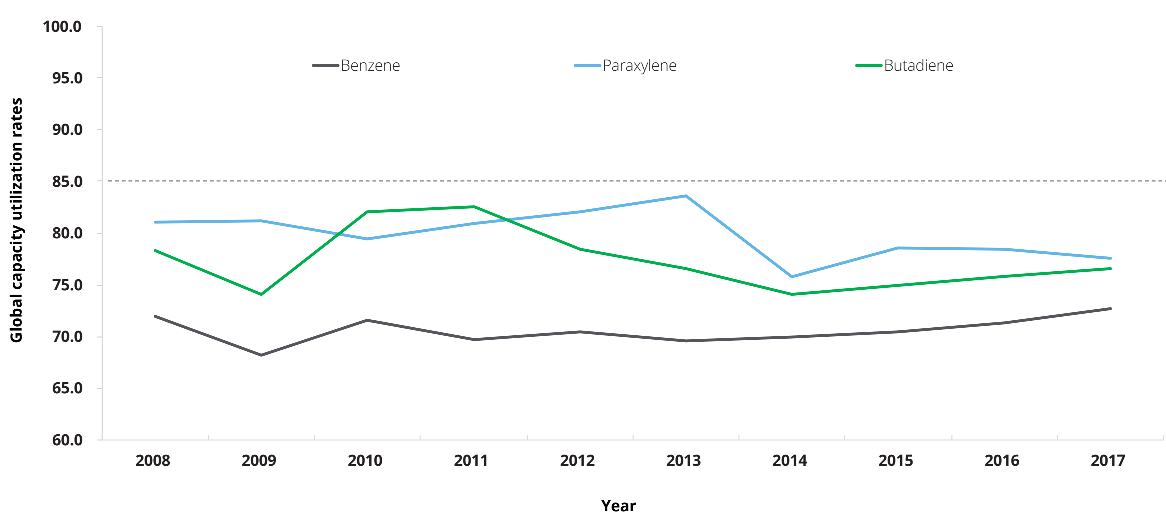
Given that petrochemical facilities require billions of dollars in investments, and a longer time frame, it is important for companies to consider true product value which, in turn, is determined by capital, process, and feedstock costs. For instance, though the CTO route to ethylene production is five times more expensive (than naphtha-based production) in terms of capital costs in China, lower raw material costs (of coal) offset this to a considerable extent during the high oil price regime (2012 to 2015). However, as oil prices continued to trend lower post-2015, naphtha-based ethylene production became more economically viable compared to the CTO route.

In a similar vein, for new emerging technologies like crude-oil-to-chemicals (COTC) different regions have varying capital costs. For example, COTC complexes coming up in China have approximately 50 percent lower capital costs versus those coming up in the Middle East. This lower capital intensity along with proximity to a burgeoning demand end-markets confer a high competitive advantage to the Chinese petrochemical players, especially in a low-price oil environment.

Source: Deloitte Development LLC analysis based on data from Bloomberg Intelligence and IHS Markit, accessed in February 2019.

The switch to lighter feedstocks over the past five to ten years has also impacted the production of heavier C4 chemicals such as benzene, toluene, paraxylene, and butadiene. Benzene, paraxylene, and butadiene capacity utilization rates are trending lower, though the market has recovered from the lows of 2014 to 2015 (figure 5). Since 2015, these C4 chemicals markets are riding on increased demand, though the future looks a little uncertain. This uncertainty stems from feedstock inflexibility of new and upcoming steam crackers built on ethane as well as new CTO plants that will not co-produce C4 chemicals like benzene; lower production runs of refinery FCC units, and a demand slowdown in China, which has been a major consumer and importer of C4 chemicals till now to serve its domestic end-markets.[15] Despite the surrounding uncertainty, many crude-oil-to-chemicals complexes are coming up in China by 2022, which are expected to focus primarily on producing C4 chemicals, mainly paraxylene and benzene. This could sufficiently take care of C4 chemicals supply in case the demand spikes.[16]

Figure 5: Global capacity utilization rates of C4 chemicals, 2008 to 2017



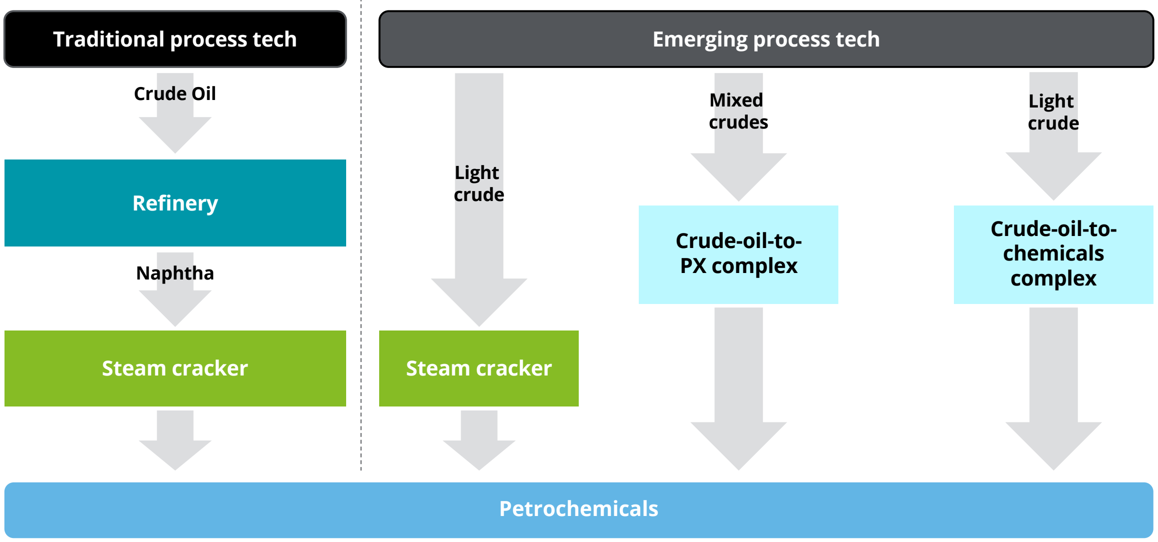
Source: Deloitte Development LLC analysis based on data from IHS Markit and Bloomberg Intelligence, accessed in February 2019.

Advanced process technologies: Changing industry dynamics

New process technologies may change the entire chemicals landscape by 2025. Among these, COTC holds the highest potential because of its large chemicals yields. COTC enables direct production of chemicals from crude oil with yields of over 40 percent. Many such COTC complexes are coming up in China and the Middle East, with most of them becoming fully operational before 2020.

These COTC projects are mostly pursued by large, integrated oil-and-gas companies hoping to make a dent in the petrochemicals industry. For example, a single COTC complex coming up in the Middle East could produce about 10 million tonnes of chemicals per year once it becomes operational. Thus, for the first time in history, chemicals production is getting expanded to refinery scale.

Figure 6: Crude-oil-to-chemicals production routes



Source: Deloitte Development LLC analysis of IHS Markit, accessed February 2019.

What will this mean for existing petrochemical producers and other integrated oil and gas players who are not pursuing these advanced technologies? There is a high chance that the current trend of increased refinery-petrochemical integration pursued by these players might not match the scale and scope of COTC complexes. Companies could strategically respond by cooperating with integrated oil and gas players pursuing COTC or venturing further downstream in the chemicals value chain i.e. producing intermediate or specialty chemicals. They can also independently pursue COTC technology by tying up with process tech companies. But that would require large financial resources and a higher-than-usual risk appetite, which every player might not be able to muster.

Advanced process technologies like COTC could be augmented by digital technologies like the Internet-of-Things (IoT), drones, robotics, artificial intelligence, machine vision, cloud computing, and blockchain. In general, these digital technologies are expected to continue to transform chemicals manufacturing through real-time monitoring of chemical assets, enhancing predictive maintenance accuracy, cost-effective safety monitoring, and improving efficiency and reliability of logistics across diverse supply chains.

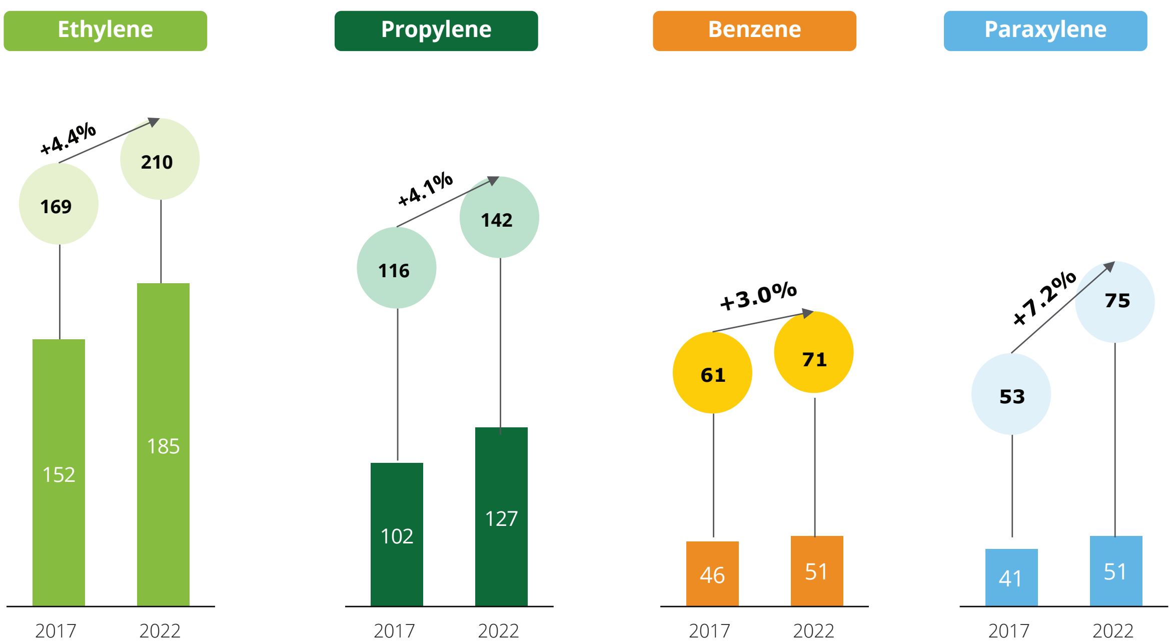
Source: Deloitte Development LLC analysis based on data pulled from IHS Markit, accessed February 2019.

Petrochemical growth forecasts belie underlying issues

Growth projections of base chemicals capacities like ethylene, propylene, and paraxylene, are more than 4 percent per annum through 2022 (figure 7). These forecasts assume strong demand end-markets, following which all major petrochemical players could continue building and ramping up capacities. Yet, there are already murmurs of an imminent slowdown in 2019 to 2020 doing the rounds. The recent economic forecast from Deloitte Development LLC too has raised the possibility of a slowdown in growth in 2019 or 2020.[17]

This time around, however, the nature of global slowdown could be different. It may not hit the markets as strongly as it did in 2008 to 2009 but might be mild as companies are still exercising caution and are well prepared after an extraordinarily long cycle of economic expansion.[18] The chemical activity barometer (CAB) – a leading indicator of the US economy's business cycle declined for three consecutive months recently, pointing to a possible near-term economic downturn.[19]

Figure 7: Global base chemicals capacity and demand forecasts, 2017 to 2022



Note: Bars represent total demand (million metric tons or MMT), circles represent total capacity (MMT).
Source: Deloitte Development LLC analysis based on data from IHS Markit and Bloomberg Intelligence, accessed in February 2019.

Given the increased possibility of a slowdown, what are the implications for the petrochemical industry in the short-to-medium term? First, the lower demand for petrochemicals resulting from a slowdown might lead to an excess capacity surplus, lowering the capacity utilization rates for all major base chemicals. Second, the construction of new petrochemical plants might get delayed, and some may even get scrapped, as companies grapple to maintain margins, cut costs, and rationalize capital allocation. Third, the cash margin performance gap between petrochemical production based on Naphtha versus NGLs/ethane could diminish, as crude oil prices are expected to remain low and steady. This would motivate companies to use more of naphtha as a feedstock in their upcoming petrochemical plants. Fourth, base chemicals capacity may continue to shift to demand markets like China and India, though North America and the Middle East are expected to continue to exert their power through cheap exports. Fifth, new manufacturing technologies like COTC will totally reconfigure global trade flows and supply chains for certain types of base chemicals, especially C4 chemicals. And finally, with sustainability as a megatrend driving up the re-usability and recyclability of plastics, the demand for base chemicals, especially ethylene might become lower than anticipated earlier.

Sustainability and the circular economy: The effect of plastics waste ban

China's recent ban on plastics wastes imports has triggered widespread concerns among developed regions which earlier used to export huge quantities of plastics waste into China. In fact, since 1992, around 45 percent of the world's plastics waste has been exported to China, which amounts to 7 million tonnes of plastics waste annually. This poses a challenge to developed nations and regions but also presents opportunities to players within the ecosystem, specifically established recyclers, and recycling start-ups who now have a convincing business case to pursue and market recycling technologies. Some start-ups have already started commercializing their patented chemical recycling technology that can turn various forms of plastic waste into a crude oil equivalent. Even some established petrochemicals players are now trying to innovate and commercialize production of 'circular' polymers manufactured from feedstocks sourced from mixed plastics waste. Additionally, a few players are acquiring recycling companies to pre-empt the demand for recycled plastics from their customers. These recent developments could trigger a new wave of M&A and R&D investments in plastics recycling with interested entities cutting across petrochemical producers, plastics producers, and converters.

Sources: Deloitte Development LLC analysis based on data from Recycling Today, Raconteur, and Hydrocarbon Processing, accessed in February 2019.

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Endnotes

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