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The implications of globalization

Protectionism versus opportunity

Chemicals and globalization

Dave Witte | Senior Vice President, IHS Markit & General Manager, Chemical
E dave.witte@ ihsmarkit.com
T +1 (281) 752-3276
L Houston

Chemicals is truly a global industry. Whether it is enabling monetization of resources in countries with supply in excess of local demand, or connecting intermediates with competitive labor that can manufacture more competitively or leverage a better capital cost, there are few other supply chains that are more globally connected. As such, the growing anti-globalization backlash mandates an assessment of the potential implications and risks for the industry. Interestingly, it is mostly the developed world where the outcry is loudest. And these indictments are from political circles that have historically been the proudest advocates of free-trade.

In hindsight, it is apparent the post-millennial WTO entry of China onto the world stage that was the catalyst recent protectionist movements. Rapid dislocation of workers cloistered in relatively tight geographies has meant concentrated pockets of under-employment. Local governments were slow to react and this inability to minimize workforce dislocation sowed the seeds of what is now manifesting as a discontented workforce clamoring for protection.

It is probably too early to say with any certainty how policy actually progresses, but directionally some themes are emerging. These include more protectionist trade and labor policy and fewer multilateral trade blocks. Potential scenarios such as promoting tax schemes like the US GOP-backed Border Tax Adjustment (BTA), India's 'Make in India' or China's 'Made-in-China 2025' policy are clearly aimed to this end while the potential demise of TPT in favor of bilateral agreements or rising anti-immigration sentiment create uncertainty and threaten to de-rail many of what have been primary drivers of global economic growth.

There are a range of potential outcomes impacting chemical industry. An all-out trade war is possible, though unlikely. More likely are policies that encourage domestic production and dis-incentivize imports. Industry de-regulation and a lower overall corporate tax are likely to support this repatriated investment as are policies that encourage capital repatriation. But the net effect is likely to slow global demand growth, especially for consumer products that have low margin and/or high price elasticity. Sectors that have a large import cost component (such as US autos) would also be negatively affected. On the supply-side, high-margin sectors that have a high material or labor component are likely to see increased investment over time.

While it is too early to quantify the impact on specific countries or sectors, it is clear that countries are increasingly focusing on protectionist policies that will impact market development. . Only those countries with clear competitive advantage will have the position needed to support or grow exports.

AMERICAS
T +1 800 447 2273
E ChemicalSalesAmericas@ihs.com
or ChemicalConsulting@ihs.com

EUROPE, MIDDLE EAST, AFRICA
T +44 (0) 1344 328300
E ChemicalSalesEMEA@ihs.com
or ChemicalConsulting@ihs.com

ASIA PACIFIC
T +65 6439 6000
E ChemicalSalesAPAC@ihs.com
or ChemicalConsulting@ihs.com

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Midstream ties that bind USA 'unconventionals' with Petrochemicals

Cindy Poynter | Senior Director, Midstream
E cindy.poynter@ ihsmarkit.com
T +41 22 721 1766
L Geneva

Unconventional oil and gas resource developments in the United States has been a "game changer" for the global oil market causing many oil companies to substantially alter their business strategies with respect to regional exploration deployment. Not only has this rocked crude oil and gas market stakeholders, but there has been a substantial ripple effect (some might claim tsunami) for the petrochemical industry as well. Much of the unconventional gas in North America has been wet gas, which requires the removal gas liquids in order to meet pipeline heat content specifications, thus, the North American natural gas liquids market has seen a renaissance in activity to the benefit of U.S. ethylene producers utilizing gas liquids as a feedstock. This surge in North American NGL supplies has not only impacted the regional market, the USA's shift from an NGL importer to a major export source, also has substantial global implications.

Mont Belvieu Bound

Prior to the addition of Oneok's Overland Pass pipeline connecting new Rocky Mountain supplies with the Conway NGL hub in 2009, the US natural gas liquids infrastructure had remained fairly static for 30 years. The subsequent boom in unconventional oil and gas resource developments spawned a flurry of new projects. Since late 2011, NGL transport capacity to Mont Belvieu and the area's ethylene plants has increased by 2.4 million B/D (barrels per day) more than doubling capacity to 4.0 million b/d.

NGL pipeline additions tapping into Permian supplies include DCP's Sand Hills, ETP's West Texas Gateway and ETP's Lone Star Express. New ties into the Midcontinent and Rockies plays via the Borger, Conway and Medford NGL hubs have been Enterprise's Front Range/ Skelly-Belvieu/Texas Express network, Oneok's Sterling III and DCP's Southern Hills. Note that the latter was a conversion of the Seaway Products Pipeline to NGL service. Also to support the level of NGL infrastructure investment required, Spectra and Phillips 66 formed the 50/50 joint venture company, DCP, which has had a major role in the capacity expansions.

Northeast USA's Revolutionary Role

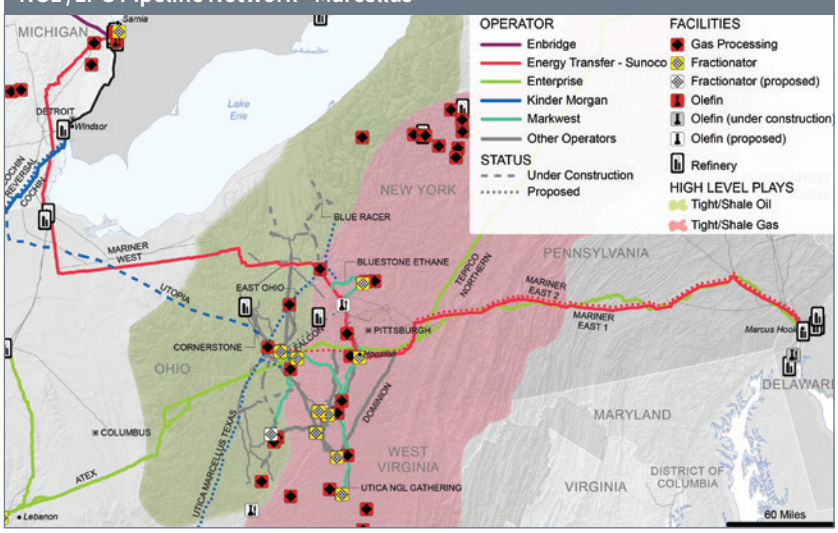
In addition to the increase in NGL supply availability west of the Mississippi, the Utica/Marcellus basins in the US Northeast are also playing a major part in the NGL market revolution in North America. Gas processing capacity in the area has surged to 9.5 billion cubic feet per day at the end of the first quarter of 2017 from less than1 billion cubic feet per day in 2010. IHS Markit study **"Shale Gas Reloaded"** assessed that unconventional gas development in the region would continue to be economic with gas prices at a threshold level of $1.80-2.00/MMBTU. This analysis has been verified by the comparatively high level of drilling that has been sustained in the area since the collapse in oil prices in late 2014. IHS Markit projects a continued increase in regional ethane and propane production, exceeding 600 thousand B/D by 2020.

Market options for the rising US Northeast NGL production have included:

- Ethylene plants in Marcus Hook, Sarnia, as well as Chicago
- Exports to Europe, Latin America and Asia
- Transport to the US Gulf Coast petrochemical market

To provide access to the Sarnia, Ontario, petrochemical hub, the joint venture of Sunoco Logistics and MarkWest brought the 65 thousand B/D Mariner West line on-stream in December 2013, moving ethane northwestward from the MarkWest NGL fractionator at Houston, Pennsylvania. Also currently under construction is Kinder Morgan's Utopia Pipeline which would also move ethane destined for Sarnia and effectively double the ethane transport capacity from Utica/

NGL /LPG Pipeline Network - Marcellus



Marcellus.

As a result of increased LPG availability in the US Northeast, Kinder Morgan has considered reversing the eastern section of the Cochin Pipeline which had been the primary source of ethane and propane feedstock to the Sarnia petrochemical complex. Under the plan the eastern section of the Cochin Pipeline would supply NGL from the Utica/Marcellus basins to the Chicago area. The western section of the Cochin pipeline originating in Kankakee County, Illinois, was reversed previously in March 2014 to supply condensate northwestward to Alberta as diluent for the heavy oil production there. In the interim, the eastern section of Cochin has been inactive for the most part.

Sunoco Logistics and MPLX's MarkWest remain key players in the development of the NGL infrastructure in the Utica/Marcellus basins. The Mariner East line is an oil line conversion to LPG service brought online in fourth quarter of 2014 (ethane service also began early in 2016) providing access from eastern Pennsylvania to Sunoco's Marcus Hook ethylene plants as well as export markets. The increase in export volumes has supported the expansion of the pipeline capacity to Marcus Hook. The Mariner II pipeline began construction earlier this year and is scheduled to begin operation in the fourth quarter of 2017. This project will increase LPG transport capacity to Marcus Hook by 275 thousand B/D and will add 2.1 million barrels of storage at the terminal.

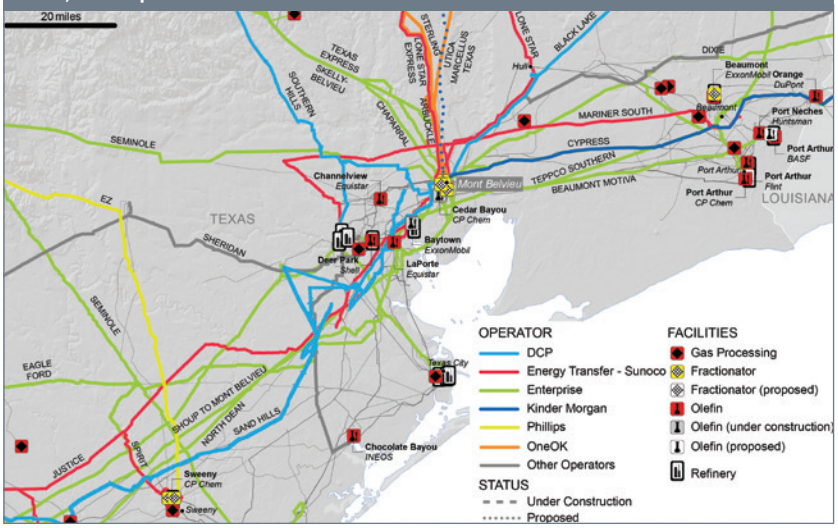
Looking south to the established NGL market on the US Gulf Coast, in its 125 thousand B/D Appalachia-to-Texas-Express (ATEX) project, Enterprise's decided to convert an existing refined product line to NGL service as well as add new lines to provide access to Mont Belvieu for the Utica-Marcellus suppliers.

Destinations South, West as well as East

The surge in the NGL supply picture induced US ethylene producers to expand capacity. Over 4.0 million tons per year was added on the US Gulf Coast from 2013 through the first quarter of 2017, including a restart of a Dow Taft cracker that was shut in 2009. Another 6.7 million tons per year under construction with over half scheduled to come online this year; 7.5 million tons per year remain on the books (second wave) if NGL supply availability and prices remain favorable. Ethane consumption as a USA petrochemical feedstock exceeded 1.1 million B/D in 2016, almost double the 2005 level, and IHS Markit expects sector demand to exceed 1.5 million B/D by 2020.

Investment in LPG export terminals also has surged on the US Gulf Coast to exceed 1.2 million B/D. 'in annual capacity'. According to IHS Waterborne data, US exports of LPG were over 1.0 million barrels per day in the first quarter of this year with exports to Asia exceeding that for Europe and Latin America. The expansion of the Panama Canal has substantially

NGL /LPG Pipeline Network - Texas



reduced the transport time for VLGC's (very large gas carriers) to Asia thus making this growth market for supplies more attractive. This is certainly a step change from 2010 when the USA was in a net NGL import position.

IHS Markit expects drilling to continue in key NGL rich basins such as the Permian and Utica/Marcellus and that NGL supply availability will remain on the rise albeit at a slower pace than in recent years. Thus the second wave of ethylene plant additions can be expected online post 2020. Ethane and propane surplus to domestic needs will find outlets in the global petro-chemical and fuels markets.

IHS Markit monitors oil and gas pipeline, gas processing, and associated infrastructure developments globally on a daily basis in our Midstream Essentials Database which can be mapped and queried online by clients. A database sample is represented in our North American NGL/LPG Pipeline map which can be downloaded at www.ihs.com/NAMpipelines. ■

Cynthia Poynter, Senior Director - Midstream, manages the IHS Energy Infrastructure & Markets Database portfolio of products which provide critical information on oil & gas transportation, processing and primary market facilities worldwide. The database has been designed to support IHS clients in the assessment of investment opportunities all along the energy chain from the supply source to the market level. Ms. Poynter's expertise includes the pipeline, refining, gas & power, LNG and renewable energy sectors globally with an in-depth under-standing of the inter-relationship of the sectors and implica-tions for clients' decision support information needs. She holds a Bachelor of Science in Chemical Engineering from the University of Kentucky and started her professional career in DuPont's Engineering Services Division.

Identifying opportunities in a turbulent time - China's chemical industry outlook

Paul Pang | Vice President, IHS Chemical
E paul.pang@ ihsmarkit.com
T +86 21 2422 9016
L Singapore
W www.ihs.com/chemical consulting

Economic

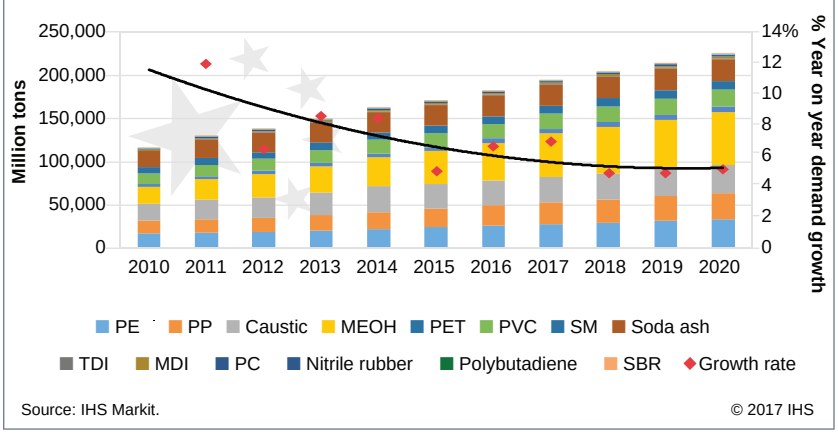
↘ The Chinese economy has been clouded by global economic and political uncertainty for over two years, with economic growth slowing down throughout 2015 and 2016. The good news is that economic expansion began to gain momentum towards the end of 2016 and beginning of 2017.

Looking back, 2016 has not been short of "surprises". The biggest surprise is probably Trump winning the US election. The implications of a Trump presidency will depend on whether the incoming Trump administration follows through with some of its extreme campaign promises (e.g., a trade war and mass deportations) or takes a more pragmatic approach and focuses more on growth. For China, a Trump administration comes to power during a challenging time for the country. Growth is slowing and the central bank is trying to manage a gradual depreciation of the renminbi, which has fallen to its lowest level against the dollar since 2008. While frictions between China and US are likely to remain elevated over the next few years, an all-out trade war between China and the United States seems unlikely. The recent increase in US interest rates and appreciation of the dollar have worsened capital outflows and put more downward pressure on China's currency, which could add more fuel to the political fires. The key reason behind the currency devaluation is capital outflow. In mid-2016, the Chinese government tightened controls on moving money out of the country, sold massive US dollar denominated reserves and bought back renminbi to try to stabilize the currency. The measure seems to be working and the currency has been stable since Q4 2016. On the other hand, with the United States walking away from the Trans-Pacific Partnership (a free-trade agreement that excludes China), doors will open for China to develop its own Asian free-trade area.

On the supply side, growth was led by the tertiary (services) sector's 7.6% y/y expansion. The primary sector (agriculture) grew 4.0% y/y, while the secondary sector (manufacturing, mining, and construction) expanded 6.1% y/y. From the demand side, growth was overwhelmingly supported by consumer spending, which accounted for 71% of China's real GDP growth in 2016. Consumer spending will be the key for continuous economics growth, and will account growing share of the country's GDP.

China will enter (or has already entered) the "New Normal", i.e. economic growth trending down and growth being driven less by manufacturing and capital investment. IHS Markit projects China's real GDP is projected to increase by 6.4% in 2017 and 2018.

Chart 1: Development of petrochemical demand in China: 2010-2020



Source: IHS Markit.

China Chemicals

China has been the key driver for global growth in both chemical demand and investment for nearly two decades. In 2000, China did not play a significant global role in either chemical consumption or production. Following its rapid expansion in consumer product manufacturing industry, chemical demand also experienced its fastest growth period from 2005 to 2012. By 2015, China accounted for one-third of the demand for global base chemicals, and is by far the largest consuming and producing country in the world. As the economy began to slow from 2012, the demand growth for chemicals also showed signs of weakness. The most challenging year was 2015 when demand growth dropped to the lowest level since global financial crisis in 2008. Even in olefin value chains which enjoyed the best profitability, the demand growth for most derivatives has been slow.

As China gradually enters into a "New Normal", the demand growth for chemical is expect to slowdown as well. IHS Markit forecasts the demand growth for key chemicals will be at around 5-7% per year for the next four years, significantly below the historically growth rate. This "New Normal" growth rate will likely extend beyond 2020. However, even as growth in

China slows, the country continues represents over half of global demand growth, and remains to be the largest growing country. It is still the key driver for global chemical demand growth.

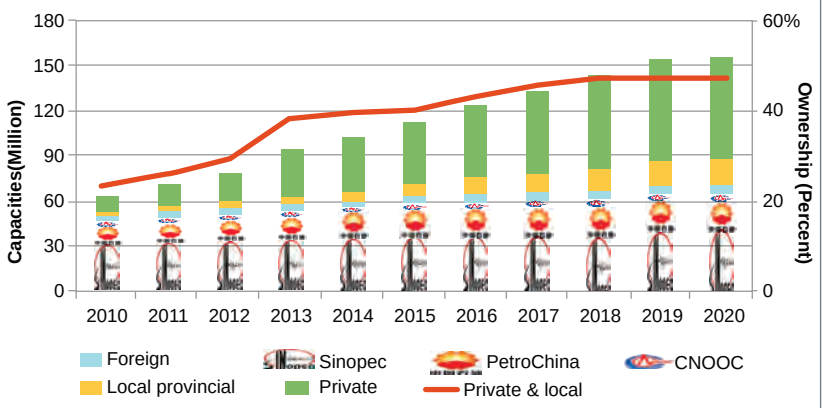
In the meantime, China continues to build up domestic production capacities in both conventional petrochemicals and unconventional chemicals. These unconventional chemicals include coal-to-chemicals, MTO (from imported methanol), propane dehydrogenation (PDH), and coal-to-MEG. Most of these unconventional investments were committed during the period of high crude oil price when profitability for these unconventional routes to chemicals was very attractive. However, after the collapse of crude oil pricing, the profitability of these unconventional chemicals has been severely compressed. The new investment in this area has fallen sharply after 2015. Conversely, the conventional petrochemical routes have turned profitable again, and investment in this area has picked up again. Several mega-size integrated petrochemical complexes are either under construction or in the planning phase.

On the back of slower demand growth and a continuous capacity growth plan, China will become more self-sufficient. The percentage of import materials will decline, but the absolute import volume will continue to grow.

One of the major structural shifts that has happened over the past decade is a move to private ownership. Back in 2000, there were almost no privately-owned chemical companies in China. During the rapid growth period, particularly from 2009 to today, there has been a surge in private investments into chemical industry. In fact, the majority of investments over the past six years were made by private companies. *Figure 2* shows the growth of capacity and percent of share by major State-Owned-Enterprises (SOEs), local provincial companies and private companies for the key base chemicals. In 2016, private companies and local provincial companies accounted for over 40% of capacity share. This trend of privatization makes the Chinese market more dynamic, and much less dominated by a few major SOEs. The competition will become more intense, drive down profit margins, and put significant pressure on the SOEs. The private companies tend to be more efficient in capital investment and production management. Therefore, privatization will lead to a more competitive and more efficient chemical industry for the country as a whole.

The trend will also benefit the country's downstream manufacturing sectors. It will force chemical manufacturers to be more efficient and provide a higher quality of products and better services. The downstream consumers will benefit from a diminished supply monopoly, lower costs and high quality products.

Chart 2: Aggregated capacity for benzene, PX, ethylene, propylene, MEG, PTA, methanol



Source: IHS Markit. © 2017 IHS

In terms of macro policy, the Chinese government is gradually deregulating the chemical industry. The entry barriers into the Chinese chemical industry for private companies is now much lower. The government has even started to deregulate the upstream refining sector, which used to be tightly control by a few state-owned oil majors. This lays the foundation for private companies to enter into petrochemicals. At the same time, the government is tightening environmental and safety regulations, thereby increasing costs incurred by chemical producers. The private companies have the highest cost escalation. This will narrow the cost gap between SOEs, foreign companies and private companies. The government is also trying restructure the industry to increase industry efficiency, and also combat pollution which has become a major problem in most of China. This will lead to industry consolidation mainly among local provincial companies.

Chinese companies have been looking for overseas growth opportunities through acquisition or grass-root investment. The pace of overseas investment will likely slowdown in the near term due to government capital outflow control put in place in Q4 2016. However, this trend is unlikely to come to a halt as companies continue to look to grow their market share outside China, as well as access resources and technologies in their ambition of becoming global first-tier companies. ■

Paul has acquired more than 27 years of experience in the chemical industry in various areas, including technology, operation, process engineering, business planning and consultancy. Paul currently serves as vice president with IHS

Naphtha faces competition from abundant natural gas liquids

Nick Rados | Global Business Director, Chemical Feedstocks IHS Markit
E nick.rados@ihsmarkit.com
T +1 (832) 619-8593
L Houston

↘ Current oversupply of NGL is depressing naphtha demand and pricing, but naphtha tightness is possible after 2020

Growing competition from less costly natural gas liquid (NGL) feedstocks—much of them coming from North American shale gas - have dealt a blow to global demand for naphtha.

Naphtha, a refined petroleum product derived from crude oil and marketed in heavy and light varieties, is an important feedstock for production of petrochemicals and blendstock for gasoline. Together, light and heavy naphtha constitute about 40 percent of the global gasoline pool. Naphtha is no longer the dominant petrochemical feedstock it once was thanks to competition from the surging production of NGLs, particularly ethane and propane, as reported in our recently published IHS Markit report "Light and Heavy Naphtha International Market Analysis: Balancing the Naphtha Surplus," an indepth naphtha market analysis.

Prior to the U.S. shale gas and tight oil renaissance, naphtha was the leading feedstock for petrochemical and gasoline production, but the jump in production of ethane and propane feedstocks gave North American and Western European petrochemical producers a cheaper alternative to naphtha and a significant profit advantage. U.S. and Canadian NGL production has surged at an average annual growth rate of 6.2 percent, from 104 million metric tons (MMT) in 2011, to 141 MMT in 2016, due to supplies from both wet gas fields and tight oil production, and more growth is expected.

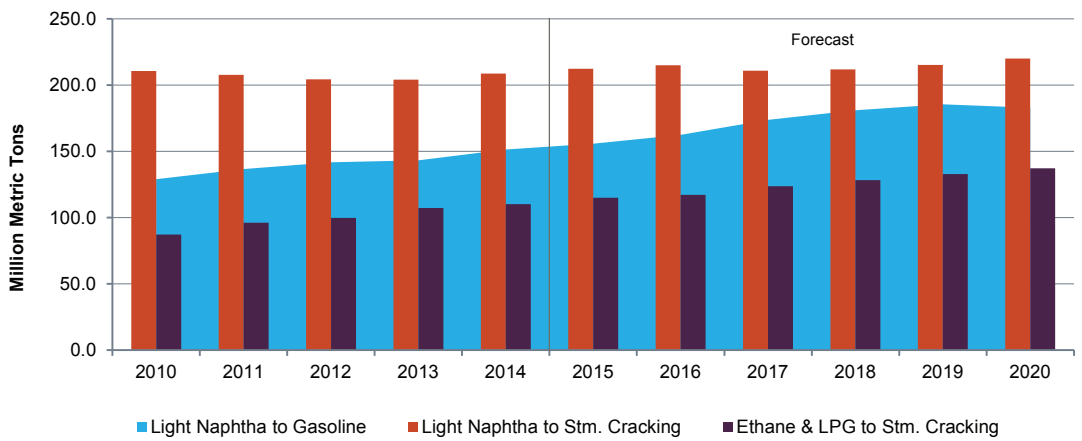
Olefins producers with the existing flexible, or new, ethane-feedstock plants in the U.S., are enjoying an advantage due to lower feedstock costs, and for European producers, the access to abundant supplies of U.S. ethane feedstocks has given their plants new life.

We are headed into an increasingly oversupplied market. Demand growth for petrochemicals and gasoline has slowed due to a global economic slowdown, while many producers have been adding naphtha production capacity—resulting in excess of naphtha and depressed prices.

Entering 2017, global demand for naphtha (including natural gasoline) is 1,180 MMT, and the demand growth has been projected to increase to nearly 1,260 MMT by 2020. That translates to an average annual growth rate of 1.7 percent—a strong growth rate for a refined product, but not enough to absorb increasing production of both naphtha and NGLs.

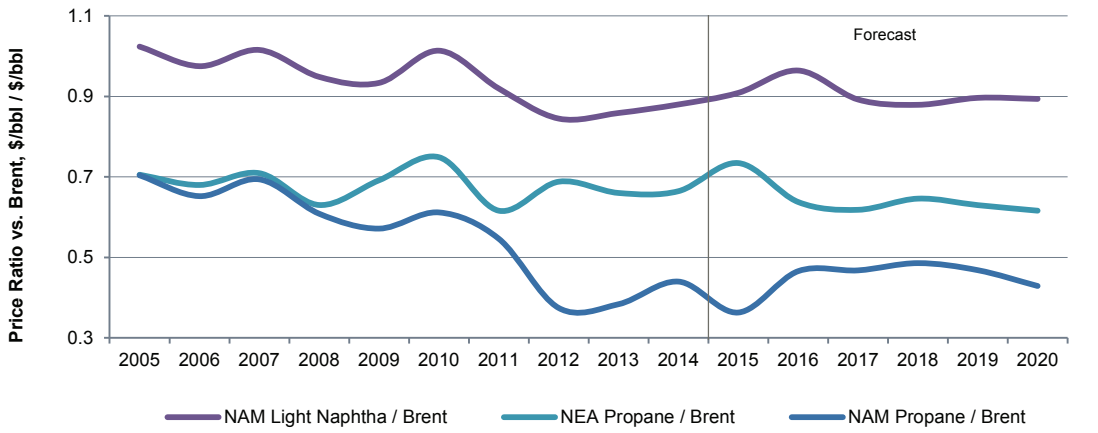
While the global market for naphtha will be

Ethane & LPG to Olefins Displaces Naphtha to Gasoline



Source: IHS

Large Supply of NGL Pushes Feedstocks Prices



Source: IHS

oversupplied until at least 2020, the propane market is even more oversupplied, with increasing production coming, not only from U.S. shale resources, but also from the Middle East and Russia. Propane prices were sliding before the onslaught of the U.S. shale renaissance, but since then, have plummeted, which in turn put downward pressure on prices for naphtha.

The current length in the propane shipping fleet, along with the opening of the Panama Canal expansion supports incremental trade, but anticipated increase in crude and naphtha prices will drive even greater volumes of low-cost propane to Asia.

The abundance of petrochemical feedstocks is unlikely to end anytime soon, according to our IHS Markit analysis, with Saudi Arabia, U.A.E., Kuwait, and Russia investing in more naphtha production capacity. For example, the recent addition of just one large condensate splitter (Novatek in Russia), has added 4 million tons of naphtha supply, or 3.5 percent of global naphtha trade.

Ethane imports to Western Europe have already started from both the Enterprise Products Partners terminal on the U.S. Gulf Coast and the Sunoco Logistics terminal on the U.S. East Coast. Those shipments will supply the European facilities of INEOS, SABIC, Reliance, ExxonMobil and others.

Companies are essentially making two different bets on feedstocks in Europe. While some have bet on excess of U.S. ethane (like those just mentioned above), others like Dow and BASF have bet on global oversupply of cheaper propane coming from Russia, the U.S. and Algeria.

In spite of strong penetration of NGLs, a lighter, paraffinic naphtha is still the predominant feedstock for production of olefins, such as ethylene and propylene, while heavy naphtha remains the most important feedstock for production of high-octane gasoline and aromatics chain products, such as polystyrene, PET (polyethylene terephthalate) plastic and polyester fiber. Gasoline blenders are also at an advantage in the current market because they can buy cheaper blendstock at lower prices. Naphtha is cheaper and octane is relatively cheap at present.

The current market oversupply does not mean that producers will not have investment opportunities in the near to mid-term. Starting in 2020, we foresee a period where some markets could become short of naphtha, particularly heavy naphtha, if investments fall off today. Unlike with light naphtha that can be substituted with NGL feedstocks to make olefins, heavy naphtha is indispensable for production of PET plastic and polyester fiber, the fastest growing demand segment for naphtha. ■

Industry-specific insight alone is not sufficient to make decisions of great scale. Connecting the dots to reveal interdependencies between both adjacent and seemingly unrelated sectors is required. It's at these connection points where the greatest risks and opportunities await.

Nick Rados, Global Business Director, Chemical Feedstock IHS Markit, provides an overview of the global naphtha market

Adrian Beale
Vice President, IHS Chemical
E adrian.beale@ihsmarkit.com
T +1 832 619 8580
L Houston
W www.ihs.com/SCUPinsights

Speciality chemicals – surfing the wave of globalization

Recent political developments are resulting in a mixture of anticipation and anxiety, but some tides cannot be turned back…

The global economic outlook is brighter in early 2017 than it was a year ago, but political and policy uncertainties are also higher now. The rise of anti-globalization movements in the US and Europe could result in policies that hurt growth, bigly. However, because specialty chemicals are consumed in more industries and consumer segments than virtually any other materials, the global specialty chemicals industry rides on a tide of underlying demographic, social and technological megatrends which drive demand despite short term economic swings. These megatrends represent key facets of economic, cultural and political globalization and include:

Dramatic global population growth (the world's population has doubled in the last 40 years) which results in increased need for:

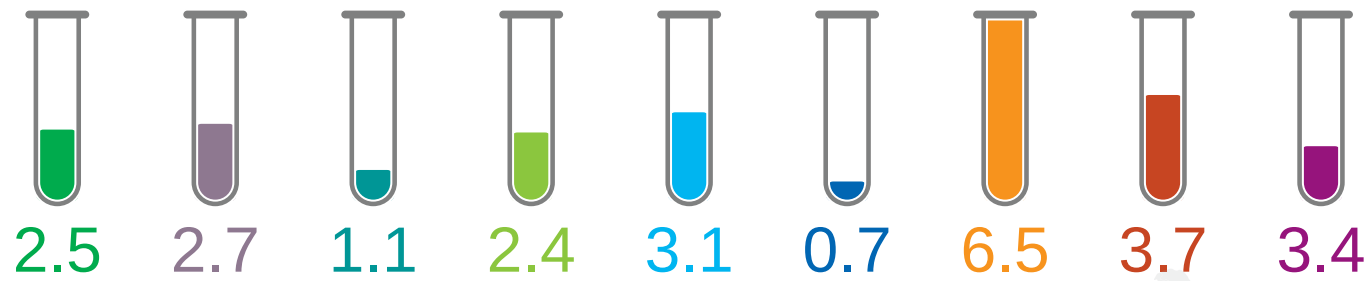
- Resource Efficiency - agrochemicals for higher crop yields, photovoltaic cells for solar power, epoxy resins for wind powered turbines, urbanization and consequent reduced emissions and mandated higher fuel efficiency standards lead to specialty chemical needs for light-weighting automobiles, etc.
- Health & Nutrition – an aging and increasingly health-conscious global population demands better health, nutrition and fitness products in addition to management of basic issues like clean water in developing economies, resulting in rapid growth in nutraceuticals, personal care products, flavors & fragrances, cosmetic chemicals and water treatment chemicals.
- Technological Development – The constant improvement of high performance materials, renewable fuels, electronics and nutraceuticals, is essential for further leaps in achievement in order to keep up with the pace of technology change

Regional shifts from West to East driven by China and India both in population and in terms of the economic center of gravity (as shown in the attached graphic) are leading to a changing profile for the specialty chemical industry.

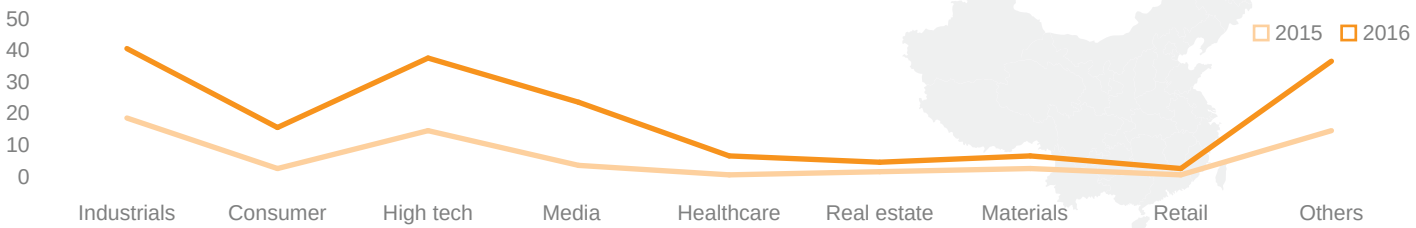
Colour coding key

Regional specialty chemicals consumption per capita, 2015 (dollars)

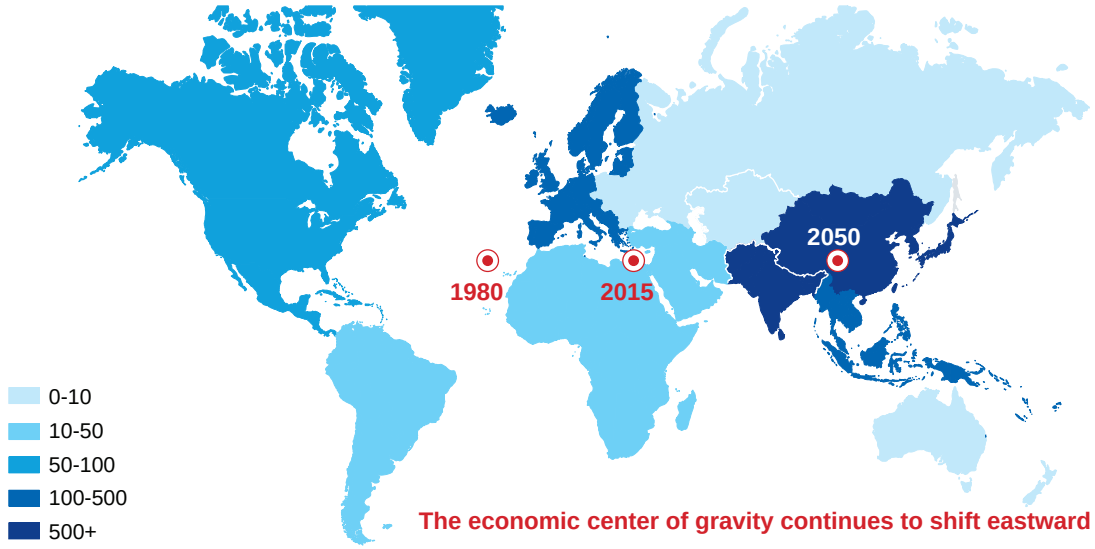
Specialty chemicals volume growth rates by region, 2015-20 (%)



China outbound M&A activity 2015-16 (US$ billions)



Global population in Q1 2017 = 7.5 billion people. World population density (people/km2)



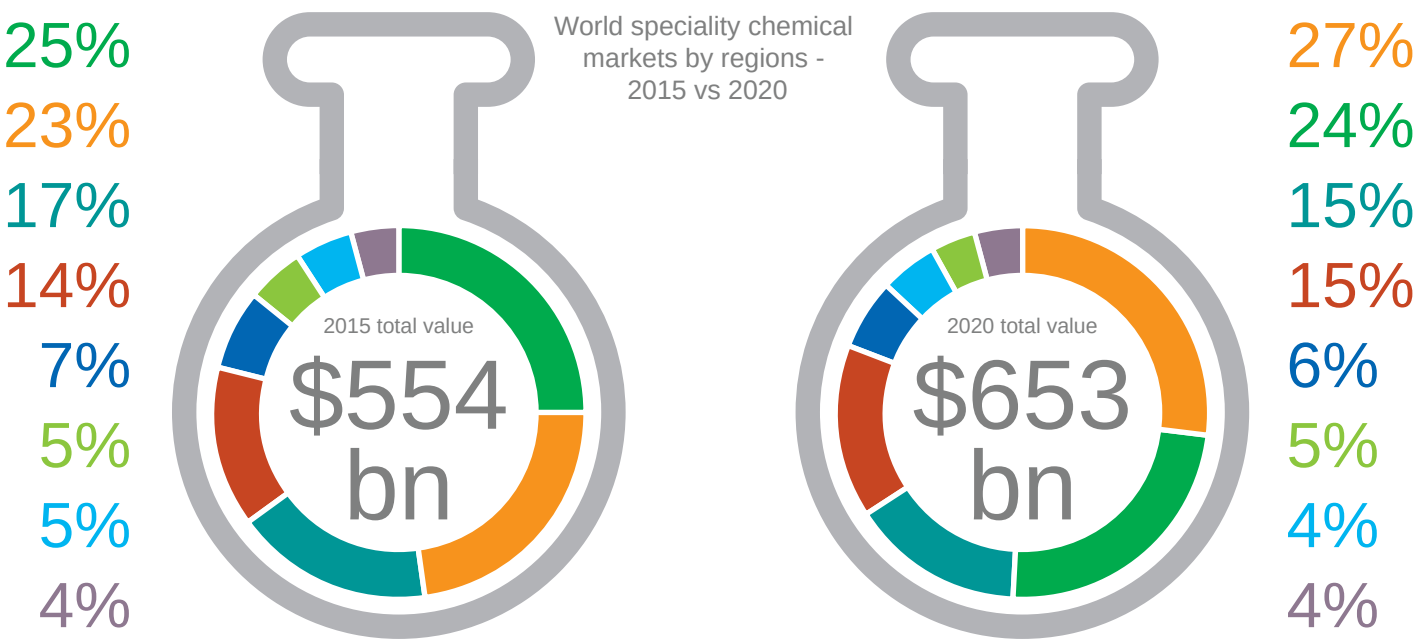
With a relatively low consumption per capita of specialty chemicals in India and China, demand has significant room to grow. In China the current drive towards specialty chemicals can be traced to 3 main factors:

- The slowdown in heavy industries is reducing demand for basic chemicals and prompting a diversification in portfolios.
- Societal factors such as demand for a more environmentally-conscious way of life have resulted in new environmental protection laws requiring increased use of specialty chemicals for water treatment; chemicals to combat hazardous air pollutants and many new industrial and institutional cleaning chemicals.
- There is a highly consumer-driven shift as the rapidly growing middle classes require more consumer goods such as electronics, personal care, high-end cosmetics and food & nutrition products stimulating demand for the specialty chemicals which are used to produce them.

All of these factors are encapsulated in China's 13th 5 year plan which will also shift emphasis from investment and exports to domestic consumption and innovation in many of these specialty areas. However most Chinese chemical companies are still relatively weak in specialty chemical R&D capabilities. They lack experience in developing specialty chemicals and have little familiarity with diversifying products and developing close technical partnerships with consumers. All of these factors are contributing to a critical need for China to partner with, or acquire, specialty chemical producers outside of China in order to obtain not only strategic resources but also to secure greater advanced technology and market access and we are seeing strong evidence of this externally focused M&A activity. So the geographical shift is turning full circle as attention turns to the West again, but now it is expertise and people, rather than investments in plant and machinery which is key.

Adrian Beale, Vice President, Specialty Chemicals
adrian.beale@ihsmarkit.com

World speciality chemical markets by regions - 2015 vs 2020



Commercialization opportunities for chemical technology

Author | Michael Kratochwill
Managing Director Transaction Advisory Consulting
E mike.kratochwill@ihsmarkit.com
T +1 201-476-7904
L New Jersey
W www.ihs.com/chemical consulting

The greatest advances in technology development have occurred during times of commercial disruption and other great technical challenges. Witness the dramatic advances during and after the two world wars, and also the leaps in technology in the West after the USSR launched Sputnik I into Earth orbit in 1957. The world may now be in another such disruption due to the populistic anti-globalization political trend in major democracies. However, disruption alone is not a strategy for successful technology commercialization, since it brings increased economic risks.

Achieving maximum value from new technologies is critical for chemical companies. Developers have historically used the build & operate business model to commercialize their research breakthroughs. However, as many products became commoditized starting in the 1980s, some companies have used the licensing business model. A review of licensed chemical technologies indicates a wide range of licensing revenue:

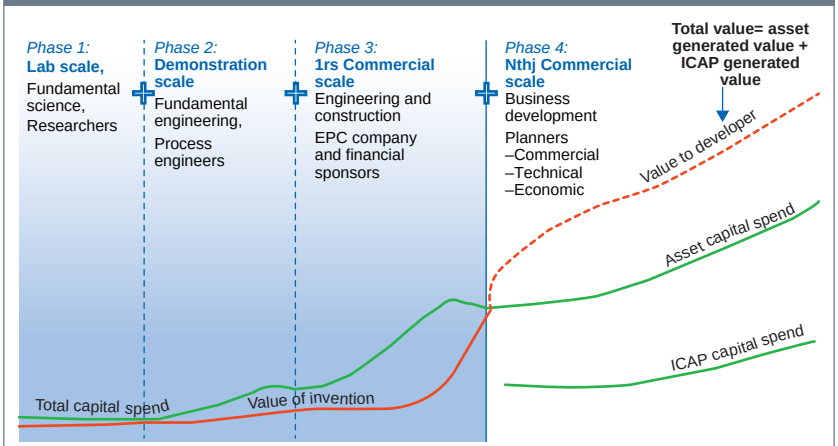
- As low as 1 to 3% of total product revenue
- As high as 7 to 10% of product revenue

The wide range is primarily due to differences in the strengths and advantages of technologies, potential for market growth, and alternatives available.

Risks in commercialization and scale-up are high for many technologies. Furthermore, many inventions turn out to have only modest advantages compared to competitors. While successful inventions do abound in the history of the chemical industry and notable research discoveries continue, there have been many commercialization disappointments. Those illustrate the aspects of risk and reward in technology development. The risks are amplified by the need to build plants at a competitive economy of scale, which requires a "large capital expenditure bet" on a new technology.

For these reasons R&D companies frequently lack resources to fully commercialize their technologies. As a result, the most difficult development hurdles for inventors are frequently to get the first demonstration scale plant and then the first commercial scale plant successfully built. Except for companies with substantial financial and management resources, this is extremely difficult without effectively selling the invention to either a large investor or a strategic buyer.

Chart 1: Project development lifecycle



Source: IHS Markit.

Commercialization Phases:

The typical overall pattern of investment and value realization, and the role of key parties in each stage, can be viewed as four phases (see Chart 1). The challenge of commercialization is frequently termed the "Valley of Death" in the first three phases for new technologies that don't "make it". As a result, many inventors must cede control of their technology to successfully commercialize.

Considering the resources required, technology licensing may be a plausible route to commercialization, but it is rare for a major undemonstrated process technology to be licensed under normal arrangements, due to the risks incurred by a licensee. However, there are many examples of successful partnership arrangements for new technologies. A few notable examples:

- Houdry, Socony-Vacuum and Sun Company on catalytic cracking in the 1930s
- Halcon International and Atlantic Richfield on propylene oxide in the 1960s
- Cargill and Dow Chemical on polylactic acid biopolymers in the 1990s

Licensing versus a Build/Operate Business Model

Proprietary technologies continue to be a key strength of many successful chemical companies:

- Commodity companies compete primarily via value chains, raw material access, operations and logistics. Nevertheless, they are subject to

business fluctuations with the commodity chemical cycle and prices that track with raw material prices.
- Specialty companies compete primarily on the advantage of their products in-use and continual application-oriented development research. Specialties are less vulnerable to industry cycles, but remain subject to broad economic cycles.
- In both the commodity and specialty segments, companies with advantaged proprietary technologies build value by managing new plant investments to satisfy the market growth, while they advance their technology. This supports customers paying for value, and gives the technology holder early-mover market strength compared to subsequent "me-too" competitors.

The pros and cons for a licensing approach are as follows:

Licensing Approach Advantages:
- Low capital investment (the inventor does not need to build out its own plants)
- Lower financial and organizational resources (compared to owning and operating)
- Leveraging licensees for improving IP (All licensees benefit from technical advances.)

Licensing Approach Disadvantages:
- Sharing intellectual property with licensees
- Potential for intellectual property to be "lost"
- Lower barriers to entry for competitors
- Litigation against follow-on infringers
- Lower revenue (than own/operate)
- Need to continue to invest in the technology

Additionally, if a licensing business model has been undertaken, it is typically not practical to revert to a build and operate model, since licensees may have the right to build new plants. However, after having commercializing on a build and operate business model, a company can switch to licensing. (e.g. Union Carbide's approach with LLDPE in the 1970s)

In IHS' experience, the R&D steps needed to successfully license a technology usually follow a pattern:

Typical Path to Process Technology Licensing
- 1 to 5 years lab scale test results
- 1 to 3 years integrated pilot plant operation to reduce scale up risks
- 1 to 2 years of a semi-works demonstration plant
- Special terms may be needed for early licensees

When a new process is licensable, it is common for the first demonstration plant and commercial plant to be royalty-free to the operating company funding the commercialization.

What is New Now?

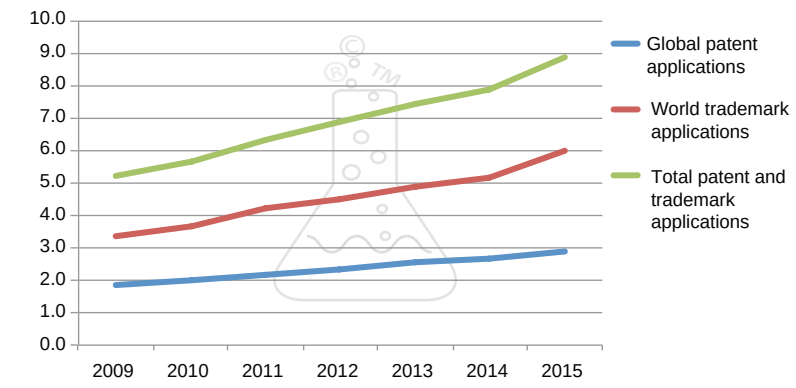
The rise in populist political pressures in much of the world, combined with continuing nationalistic objectives, appears disruptive for the global chemical industry. Global trade in chemicals and the products made from them has been very active in recent years, but it appears that local objectives for economic development, jobs growth and security will now supplant globalization trends. The changes may very well be chaotic, but overall they are thought likely to shift the chemical value chains to reward competitiveness at a national level. This should open the proverbial policy "door" for new technologies to gain footholds on a more regional basis worldwide.

Fortunately, global research and development appears ready to support the economic shift. The trend in total new patent and trademark applications worldwide (Chart 2) shows an average annual growth rate for the last six years of about 9%.

While the information technology sectors have shown the highest recent Intellectual Property development, R&D efforts have been strong in many industry sectors. IHS estimates that global chemical industry R&D spending has grown at about 5% per year. Thus, IHS concludes that the world is capable of addressing the technical challenges faced by the global economy. But, the risks and rewards in technology development remain, and the diverse factors affecting successful commercialization continue to be formidable. IHS can help in forecasting the addressable market for new technologies and also by providing independent analyses and opinions on the feasibility of full commercial success. ■

Mike Kratochwill is Managing Director – Transaction Advisory Consulting, with experience in chemical business transaction due diligence, technology commercialization, project finance, independent engineering and litigation support.

Chart 2: Global patent and trademark applications*



Source: WIPO published statistics on global intellectual property filings.

Trends in Petrochemicals Futures Markets:

Ethylene hedging is a new option

Lyn Tattum |
Vice President,
VP, Oil, Mid-Downstream and
Chemicals, IHS Markit
E Lyn.Tattum@ ihsmarkit.com
T +44203 159 3711
L London
W www.ihs.com/mds

Increasing volatility in global oil prices, dislocation between new feedstock supply sources and consumption growth of petrochemicals, heightened geopolitics, proclivity towards risk taking in certain markets, are all factors driving the chemicals sector towards greater usage of hedging instruments on futures exchanges.

In a world of rapidly changing prices and uncertain supply and demand patterns, it is sensible for buyers and sellers to hedge price risk against fixed benchmarks offered by bodies such as the USA's Chicago Mercantile Exchange (CME) and Intercontinental Exchange (ICE), or the newer Singapore Exchange (SGX), or Shanghai Clearing house (SHCH).

These bodies enable a company to buy or sell products at a pre-agreed price based on benchmark figures supplied by expert price reporting agencies.

IHS Markit is one such agency. We have a long tradition of price discovery across a range of petrochemicals in different regions and at different frequencies: monthly, weekly and daily. Lately we have moved deeper into discovering prices on a daily basis, as increasingly required by the market and exchanges.

It is commonplace in the world of oil and energy, to hedge risk via usage of exchanges and futures prices. In the energy sector IHS Markit has strong positions in coal and gas futures via the (former McCloskey) coal index and the Oil Price Information Service (OPIS). Both are in compliance with rigoros requirements of the International Organization of Securities Commissions (IOSCO) principles established in 1983.

Futures trading in the petrochemical sector is still a nascent activity and the volume of trades, or liquidity, is relatively low. However, we believe that this activity will increase because of the new global risk factors and expanded petrochemicals trade in the future.

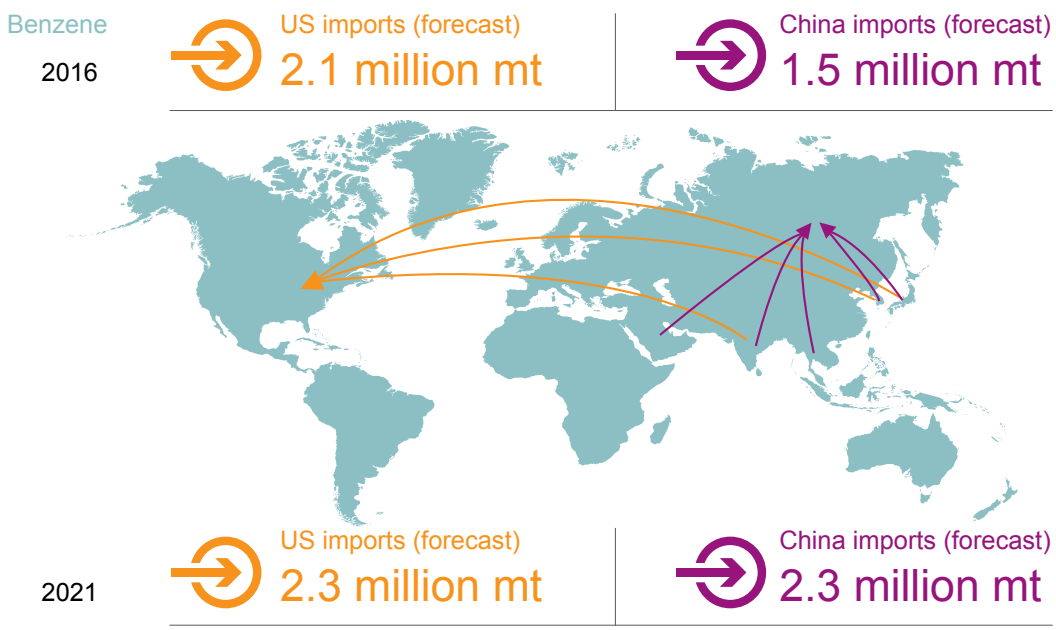
Asia and China are at the vanguard of petrochemicals futures trading

Asia is a particular focus of market volatility. It is interesting to note that a general trend towards speculative trade on Chinese exchanges is speeding the development of Chinese commodity futures markets.

The Shanghai Clearing House (SHCH) was established in November 2009 and in 2015 styrene monomer and monoethylene glycol (MEG) swaps were launched. Small styrene lots of 100 metric tons can be quoted in RMB.

Purified terephthalic acid (PTA) futures trading options are available available in with lots as small as 5 metric tons. Holding times can be short and daily volumes high.

Overall, Chinese PTA makers are successfully using futures and almost every PTA producer has a futures



Source: IHS Markit

team to manage risks, with new dedicated trading offices opening up in Shanghai.

Beyond China, Singapore's Securities and Derivatives Exchange, SGX, operates South East Asia's largest stock market and is increasingly showing interest in petrochemicals markets, as are the exchanges of Indonesia, Hong Kong and others.

Western markets are becoming more risk aware as volatility grows

Elsewhere in the world, drivers for growing interest in futures trading have included the spate of outages experienced in Europe's polymer plants in summer 2015 which caused a surge in prices and unplanned risk.

Around the same time period, lower global oil prices led to soaring gasoline and octane demand, plus greater US tight oil production, with its lower octane component, also put strain on octane supply. As a result, PX prices surged in the US and Europe, awakening further interest in protective tools such as future trading, to lock in prices.

Across the range of petrochemicals, benzene has often been regarded as the most likely candidate for activity in futures trading. In China alone, benzene imports will escalate from 1.5 MMt/year in 2016 to 2.3 MMt/y in 2020, driven by the demands of 300 million middle class consumers.

Meanwhile, US benzene imports will rise in the same period - from 2.1 MMt/ year to 2.3 MM t/year. Much of the US supply will be from Asia with a 6-8 week shipping time providing a large window of potential price volatility and risk.

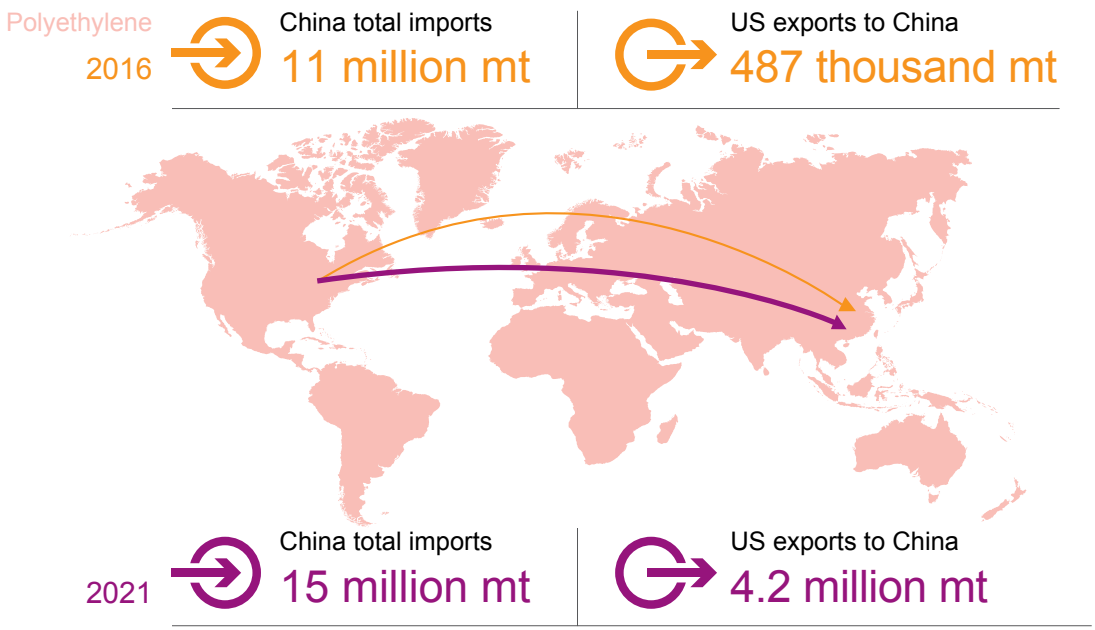
In North America the build - up in shale- based petrochemicals has led to a vast quantity of very competitive ethylene and a new production base for polyolefins and other derivatives - encouraging more consumption, trading activity, market volatility and desire to trade and hedge the trades.

Historically, consumers of ethylene and derivatives such as polyethylene (PE) might have hedged against West Texas Intermediate (WTI) crude oil. Futures for natural gas liquids (NGLs), currently the dominant ethylene feedstock in the United States, became available through CME in 2008. But a sustainable petrochemical futures market did not emerge until 2009, when CME launched futures for ethylene at the Williams hub in Mont Belvieu, TX.

The hub is crucial to the market because it gathers ethylene from multiple sources into a single pool, which aggregates market-wide supply and demand signals, although the producer-shared ethylene pipeline delivery system itself acts as a disincentive to spot trades.

As downstream products build up based on the new olefins supply, the new trading contracts on offer point to the option of using ethylene as the hedge for polyethylene and other products in the olefins value chain, in place of oil.

IHS Markit forecasts that the volume of US PE exports to China alone will escalate from 487 thousand mt/y in 2016 to 4.2 MMt/y in 2021 – surely a figure in itself that calls for robust pricing mechanisms to manage the anticipated heightened trading activity and all the accompanied market complexity that will arise. ■



Source: IHS Markit

NAFTA – The balance 23 years later
Good? Bad? Just ugly (to some)?

Raul Alvarez | Director, IHS ChemicalsConsulting Group
E raul.alvarez@ihsmarkit.com
T +1 (832) 619-8602
L Texas

NAFTA – The basics

President Trump's declared intention to "renegotiate or break" the North American Free Trade Agreement (NAFTA) has revitalized the debate around the joys and woes that the agreement has brought to its members, Canada, Mexico and the United States.

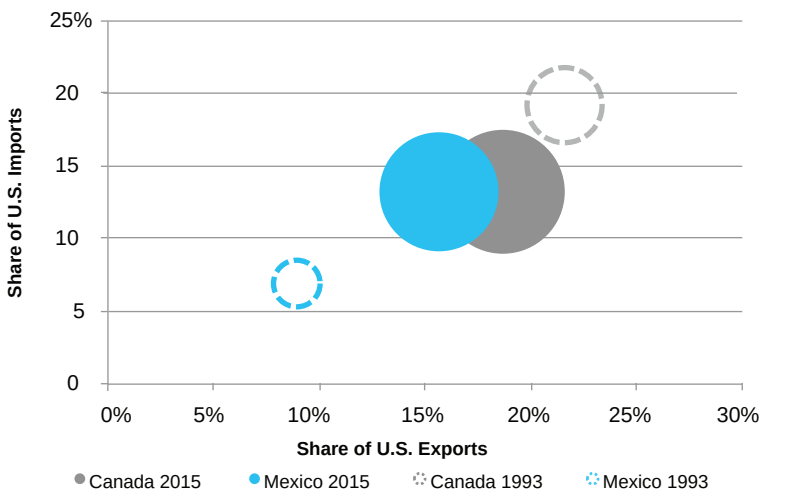
Before rushing into any kind of analysis or premature conclusions, it may be advisable to take a moment to review NAFTA's original objectives.

As stated by one of its own articles (102), NAFTA's objectives were to:

(a) eliminate barriers to trade in, and facilitate the cross-border movement of, goods and services between the territories of the Parties;
(b) promote conditions of fair competition in the free trade area;
(c) increase substantially investment opportunities in the territories of the Parties;
(d) provide adequate and effective protection and enforcement of intellectual property rights in each Party's territory;
(e) create effective procedures for the implementation and application of this Agreement, for its joint administration and for the resolution of disputes; and
(f) establish a framework for further trilateral, regional and multilateral cooperation to expand and enhance the benefits of this Agreement.

NAFTA became effective on January 1st of 1994. The signing partners also negotiated two side agreements, on environmental cooperation and labor cooperation.

Chart 1: Canada and Mexico - relevance for the US as trade partners



Canada and Mexico - Relevance for the US as trade partners
Importance of North America as source of imports - evolution
X= Share of US exports, Y= Share of US imports, Bubble size proportianate go imports

Source: IHS Markit.

Fears were present from day one, South and North of the Rio Grande

The goal to create a regional ecosystem based on free trade and fair competition that would facilitate economic growth and investment across the region was the flagship argument of those who favored NAFTA. Beyond this argument, the moment for getting NAFTA approved by all three countries seemed right, despite innumerable challenges. Almost a quarter of a century ago, the world was still going through the first years of a new global order (think Berlin wall and reunified Germany). In February of 1992 the Treaty on European Union was signed, and in January of 1993 the single market was established, creating the, thus far, most important integrated commercial block in the world. Meanwhile, on the other side of the world, China showed off two-digit economic growth rates and was quickly gaining weight as a global trade hub.

Thus, the need to counterbalance shifts in the economic center of gravity may also have been in the minds of those with a grander vision of NAFTA (of course, without ever contemplating the dramatic level of political integration pursued by the EU).

Despite the promised benefits of NAFTA, nay-sayers showed up early on both sides of the Rio Grande with opposing arguments. The huge economic and social asymmetries across the region were one of the major fuels for concerns (job shifts and losses, destruction of local industry, investment reallocation, etc.)

A complex balance

Evidently, a simplistic answer to the somewhat simplistic question of whether NAFTA has been good or bad for its members may result in misleading conclusions (e.g. because of unwanted distortions and potential intentional manipulation). Moreover, any retrospective that flashes back beyond 2008 will inherently capture the dislocations associated with the global economic crisis that was ignited that year. Nonetheless, a few data points on regional evolution between 1993, before NAFTA became effective, and

2015 may serve as food for thought for the reader.

In 1993, goods' exports made by NAFTA countries represented slightly more than 23% of the global total. By 2015, NAFTA's participation had decreased to slightly more than 14%. Imports followed the same, albeit weaker, trend: they decreased from almost 28% of the global total to about 19.5%. In other words, the role of the NAFTA countries in global trade diminished—most certainly a NAFTA-agnostic development.

Looking at developments within NAFTA, we find that during the same period, Canada and Mexico have repositioned themselves as trade partners of the U.S. Canada's share as a destination of U.S. exports and, more notably, as a source of imports suffered a contraction. Mexico, on the other hand, improved its position in both cases. In 2015, Mexico received close to 16% of exports made by the U.S. and supplied about 13% of goods imported by the U.S. (a similar share as Canada).

Although total goods traded between the U.S. and Canada exceeded the size of the trade between the U.S. and Mexico by almost $45 billion in 2015, the U.S. had a bigger trade deficit with Mexico than with Canada (roughly $45 billion more).

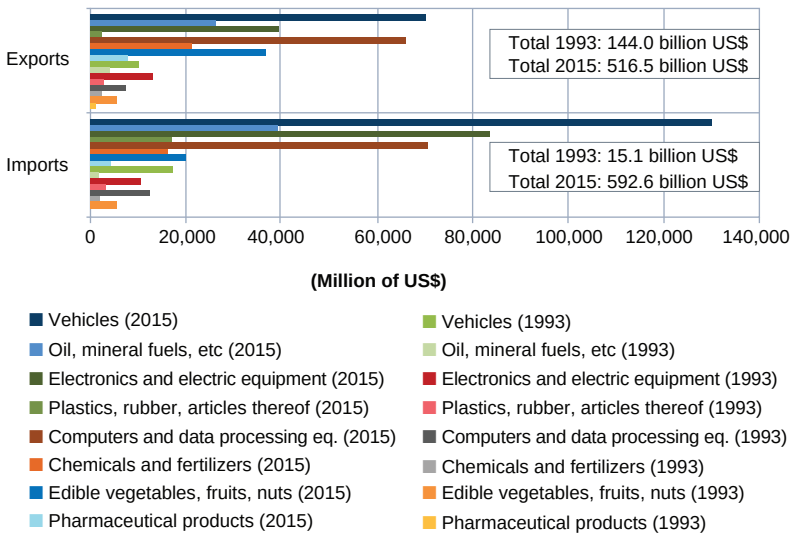
While the participation of NAFTA partners in U.S. imports has remained basically unchanged (at around 26%), Canada and, more significantly, Mexico have reduced the portion of goods that they source from within the region (from more than 69% to over 59%, and from more than 75% to roughly 50%, respectively).

Interestingly, the share of intraregional exports made by the U.S. increased between 1993 and 2015, from slightly more than 30% to over 34%, whereas Canada and Mexico slightly reduced the proportion of exports made within the region. In 2015 they represented around 78% for Canada and approximately 84% for Mexico.

A serious evaluation of NAFTA's impact on its members is a complex task. On the other hand, it seems shockingly easy to confirm the arguments of isolationists through a superficial glance at trade data looks like an easy way.

Shifts in car production are a common topic in debates about NAFTA. U.S. vehicle exports to Canada and Mexico more than doubled between 1993 and 2015, and imports increased more than three-fold. Other developments have also taken place during this time, though. Through this period, the ups and downs of crude oil prices, and consequently of gasoline, were followed by shifts in consumer behavior (in the same period, car sales dropped by almost 12% while light truck sales grew by more than 84%). During the global economic crisis, the U.S. government had to come to the rescue of the local auto industry. Foreign brands have strengthened their position in the region. The net result has been that —despite production

Chart 2: Evolution of US goods traded with Canada and Mexico



Source: IHS with data from Census Bureau.

relocation-- regional growth in light vehicle production has not been able to keep pace with growth in light vehicle sales resulting in a higher proportion of extra-regional light vehicle imports.

At this point, it seems fair to ask whether NAFTA's extra regional goods imports, such as vehicles, would not be even higher today, had the local companies not had the possibility to equip their supply chains with the most cost-effective and efficient elements (or locations) in order respond to global competition

Chemicals trade, saw huge increases—but remained a small portion of total trade. The share of Chemicals and Fertilizers in U.S. imports decreased slightly (to less than 2% of the total, while their participation in U.S. grew (from about 2% to more than 2.5%). One may ask: was the shift caused by NAFTA? By the shale revolution? By Mexico's petrochemical stagnation? By none of the above? Whatever one's point of view on the subject, it is important to be reminded about all positive and negative consequences of NAFTA that are not as palpable. Here are just a few of the positive ones:

- A stronger region, with a stronger sense of partnership
- A model for the rest of the Americas
- Access to a wider variety of affordable products
- Level playing field
- Increased flexibility for producers to optimize value chain
- Reduced product piracy

Right now, it is hard to predict what will be next for NAFTA. Whatever its mid-term destiny, let us hope that when we look back at it many years in the future, we will be able to say that it was as good for all of North America as it was for each one of its members. ■

Raul joined IHS Chemicals Consulting team as a Director in 2013. Before joining IHS, Raul served for six years as a Sr. Consultant and Manager for Latin America at Nexant. During his twenty years in the industry, Raul was a long-time collaborator of BASF, where he occupied management positions in strategic planning, marketing & sales, and as a business unit leader. Raul holds Masters in Engineering (Plastics) and Mechanical Engineering degrees from RWTH Aachen University in Germany, and an Industrial Engineering degree from CeNETI, Mexico. He completed the coursework towards an MBA at UNAM Mexico and was trained in Management in the Plastics Industry at SKZ/IHK, Germany.

Feeding the Bear – the outlook for petrochemical feedstock in Russia

Sean Stevenson |
Managing Director,
IHS Chemicals Consulting
E sean.stevenson@ ihsmarkit.com
T +442082764775
L London
W www.ihs.com/chemical consulting

A switch from liquid to gaseous steam cracker feedstocks has been occurring throughout the world petrochemical industry since the 1970s and it is likely that the distribution of commodity petrochemical manufacturing will continue to become more closely related to the geography of natural gas production. Historically, naphtha had been considered a more attractive feedstock than ethane because the value of by-products obtained from heavy feed cracking had risen faster than the naphtha feedstock cost. More recently, however, the advantage has clearly shifted to NGLs, particularly in the Middle East and in the US, although heavy feedstocks including naphtha and condensate feeds are still favoured in Europe, Japan, South Korea, and China. Construction costs of crackers based on NGL feedstock are also lower: a naphtha-based cracker is 1.5-1.7 times more capital intensive than an ethane-based plant. NGL feedstocks have caught up rapidly and in 2016 an estimated 49.4% of ethylene feedstock was comprised of ethane, propane, and butane versus a 41% share for naphtha. IHS expects the use of light feedstocks to increase to just over 50% of the total by 2020.

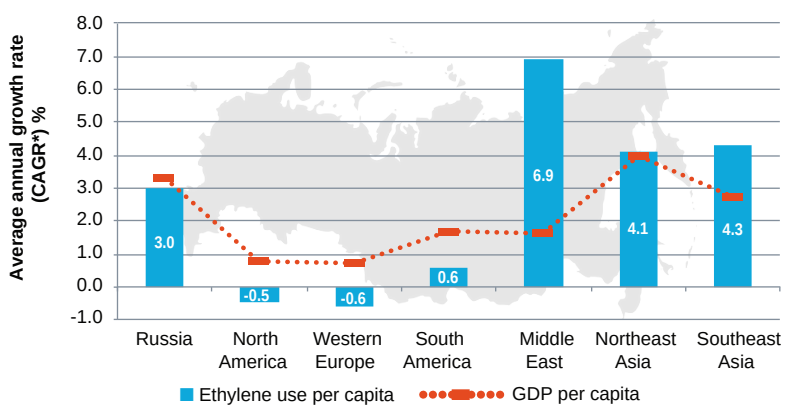
It is interesting to contrast the different approaches of the former Cold War superpowers to petrochemical investments based on NGLs.

The North American "shale gale" over the last decade and accompanying deflation of NGL prices has clearly accelerated the uptake of ethane use for petrochemical feedstock relative to other parts of the world, but even in the 1980's about 70% of ethylene was produced from gaseous hydrocarbons (ethane, propane, butane) in the United States, whereas in Europe and Asia (Japan) over 85% of ethylene at the time was produced from liquid naphtha and other feedstocks. The mature state of the American gas-processing sector made available a sizeable amount of light hydrocarbons (ethane and C3-C4 streams), in addition to some of these light materials coming from deeper oil refining. Moreover, high US motor gasoline demand favoured the use of any gasoline fractions as a component for automotive fuel production. In Europe, crude oil refining has long experienced a surplus of gasoline fractions which frequently found use as feedstock for petrochemical operations.

Russia, in stark contrast, historically neglected NGLs in the Soviet era and for many years continued to do so following the end of the Soviet Union. Whereas globally the recovery of petroleum liquids (gas condensate and other NGLs) has been integral to the economics of natural gas production, this has been less true for Russia. The Soviet Ministry of Gas (and its successor, Gazprom) remained largely indifferent to liquids, which were viewed as the purview of the Oil Ministry and thus neither the Soviet state nor Gazprom invested substantial capital or resources into NGLs recovery.

The overall picture has begun to change in recent years, particularly given the rise of a new class of "independent" (non-Gazprom) gas producers for which liquids production is a central part of their overall business. The continued absence of much necessary equipment, dedicated pipelines, markets, or a receptive corporate culture in the gas sector means that the Russian gas industry still remains largely focused on pipeline gas (albeit with significant consumption into natural gas based chemicals such as methanol and fertilizers) and less receptive to the potential of the associated gas liquids-certainly when compared with the United States. Ethane for example has till now remained a niche feedstock for ethylene manufacturing in Russia, due to its low availability: only 0.74 million metric tons per year of ethane was used in ethylene production in 2016 (around 11 weight percent of the cracking feedstock mix). It is separated at only a handful of gas plants, all of which are located in the Volga-Urals region near petrochemical consumers.

Chart 1: Ethylene consumption and GDP growth per capita in Russia versus other regions of the world, 2000-16



*Compound average annual growth rate. Source: IHS Markit.

The underutilization of relatively economical NGLs by the Russian petrochemical industry has, in turn, undermined the competitiveness of petrochemical products—a key reason Russian consumption of petrochemicals has lagged well behind the growth seen in other emerging markets, even during periods of robust economic growth. Over the past 15 years Russian GDP demonstrated substantial growth overall (notwithstanding two recessions): during an era of high commodities prices: its average annual growth rate (CAGR) over this period exceeded 3.5%. Moreover, since the population of the country slightly decreased during this period, GDP growth per capita was quite substantial, even compared with the rapidly expanding economies of Asia. At the same time, growth in ethylene consumption in Russia over 2000-16, though significant, lagged behind GDP expansion, unlike the pattern in other emerging markets. In Northeast and Southeast Asia, for example, ethylene consumption grew faster than GDP during this period, while ethylene production growth was quite remarkable in the Middle East due to the availability of abundant and low-cost NGL feedstocks (see Figure 1. Ethylene consumption and GDP growth per capita in Russia versus other regions of the world, 2000-16)

A growing realization of the poor competitive position of Russian petrochemical assets due partially to feedstock choice along with improving infrastructure for NGL separation and transportation has seen this start to change. Since 2010, the pace of ethylene expansion has picked up: in 2016 total capacity amounted to 3.1 million metric tons per year, up 13% from 2010. Even more important than the expansion of plant capacity during this period was the launch of new transportation infrastructure reconstruction of existing pipelines for rising volumes of NGL production in West Siberia (Purovsk-Tobolsk raw NGL transportation system).

Although the bulk of Russian output of key petrochemical products, including ethylene, remains concentrated in the Volga-Urals region, the emerging new centers of petrochemical production are mainly in West Siberia and other regions in relatively close proximity to abundant gaseous feedstock supplies. At the vanguard of this was SIBUR's propane dehydrogenation (PDH) unit supplying a 500kta polypropylene plant which became operational in Tobolsk in 2014, consuming propane separated from West Siberian fields. Further investment here includes SIBUR's huge new Zapsibneftekhim II petrochemical complex, which will be one of the largest crackers in the world and will become a major consumer of NGLs and is due for startup in 2020. Other ambitious ventures centered around light hydrocarbon feedstock supplies include Gazprom's planned Noviy Urengoy gas chemical complex in Yamal-Nenets Okrug (West Siberia) and the Amur gas chemical complex in Amur Oblast (Russian Far East) that partners SIBUR and Gazprom in a joint venture. Rosneft is aiming to shift to gaseous feedstock for an existing ethylene cracking unit at the Angarsk petrochemical plant. The plant's LPG loading rack and storage capacity were reconstructed in 2014, enabling the plant to have increased LPG consumption from last year.

These ambitious plans to utilize gas and NGLs as cracker feedstocks significantly redress the historical balance which favoured heavier feedstocks in Russian crackers. The competitiveness of the new NGL based units is allowing them to target export as well as domestic markets and will swing Russia from being a net importer of polyolefins such as polyethlene and polypropylene to a net exporter for the first time.

> The development of Russia as a player in global polymer markets, predicated on its new found appetite for lighter petrochemical feedstocks, is only likely to increase over the next decades.

Whilst heavy feedstocks continue to be leveraged where there is seen to be advantage (reflected in proposed projects at Nizhnekamskneftekhim and FEPCO's proposed refinery + naphtha cracker at Nakhodka in the Russian Far East), the development of Russia as a player in global polymer markets predicated on its new found appetite for lighter petrochemical feedstocks is only likely to increase over the next decades. ■

This article is a condensed and updated version of a 2016 IHS research note "Russia's Petrochemical Feedstocks Shift to NGLs with Increasingly Abundant Domestic Supply" by Aleksandr Scherbakov, Senior Research Analyst and John C. Webb, Director of IHS's Russian and Caspian Energy team. Additional contributions by Sean Stevenson.

Sean Stevenson is a Managing Director of IHS Chemicals Consulting based in London. He has almost 29 years' experience in the Petrochemicals industry including plant operations management, commercial and business development roles and consulting. He has managed numerous consulting engagements in Russia and the CIS and monitors industry developments in this region closely.

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2017 Events Calendar

WPC 2017: 32ND ANNUAL WORLD PETROCHEMICAL CONFERENCE
Houston, TX, USA | March 20-24, 2017

INTERNATIONAL LPG SEMINAR & WORKSHOPS
Houston, TX, USA | April 4-6, 2017

EMEA AROMATICS AND OLEFINS CONFERENCE 2017
Düsseldorf, Germany | June 13-14, 2017

PEPP 2017: 25TH ANNIVERSARY POLYETHYLENE-POLYPROPYLENE CHAIN GLOBAL TECHNOLOGY & BUSINESS FORUM
Düsseldorf, Germany | June 14-16, 2017

ASIA LPG SEMINAR & WORKSHOPS
Singapore | July 11-13, 2017

GLOBAL CHLOR-ALKALI CONFERENCE
Antwerp, Belgium | September 13, 2017

WORLD SODA ASH CONFERENCE 2017
Dubrovnik, Croatia | September 19-21, 2017

35TH ANNUAL WORLD METHANOL CONFERENCE
Berlin, Germany | September 29-30, 2017

GPS 2017: THE 5TH ANNUAL GLOBAL PLASTICS SUMMIT
Chicago, Illinois, USA | October 11-13, 2017

LATIN AMERICA LPG SEMINAR & WORKSHOPS
Location TBD | November 7-9, 2017

LAPPC 2017: 7TH LATIN AMERICAN PETROCHEMICALS AND POLYMERS CONFERENCE
Rio de Janeiro, Brazil | November 10-11, 2017

ACRYLONITRILE, DERIVATIVES & FIBRES CONFERENCE
Singapore | November 1-3, 2017

5TH ANNUAL ASIA CHEMICAL CONFERENCE
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