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Chemical & Energy

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Charting the right course

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Chemical makers are enjoying a solid year as 2017 enters the homestretch. Earnings, demand and capital markets are favorable as the global economy and chemical demand powers through hurricane and earthquake impacts as well as geopolitical risks.

While our latest Insights bulletin finds that favorable prospects remain in place into 2018, and likely beyond, there are underlying shifts that will impact, and in some cases transform, how and where industry growth and investment play out into the next decade. Demand trends overall are positive but important shifts in mobility, M&A, China, and digitization bear watching and should be reflected in strategy to fully capture opportunities in the chemical industry .

In North America, the **petrochemical investment surge** has made landfall. A second expansion wave, with strategic decisions required in 2017-2019, faces uncertainties and challenges ranging from competitiveness of energy and feedstock costs to capital costs.

In **specialty chemical markets**, despite the market stalling in 2016, the forecasts remains bright for specialty chemicals demand. In the next five years, the global specialty market will grow at 3–3.5% annually.

Transformation in **mobility** is reshaping outlooks for energy, feedstock and materials markets. Nearly one of every two new car sales will be hybrid-electric or plug-in electric by 2030, IHS Markit's mobility study, *Reinventing the Wheel* finds. As global oil demand will flatten or even decline, producing and selling oil and refined products remains a massive global enterprise. The move from an internal combustion engine diminishes the need fuel tanks, molded by high-density polyethylene, as well as high-temperature and chemical-resistant polymers under the hood. The changes, however, favor wire and cable insulation, electronic materials connectors, and design emphasis shifts toward materials that enable thermal insulation, sound-deadening and aesthetic advances. Structural changes continue to shift toward lighter materials, including plastics, adhesives, composites and alloys that reduce weight and enable design shifts.

Also worth watching on the mobility front is how maritime fuel regulations are changing. **International Maritime Organization (IMO)** rules calling for a reduction of the maximum sulfur content in marine bunker fuel from 3.50% to 0.50% in 2020 will shake the refined products markets with implications for chemical feedstocks derived from refining operations.

Adapting to shifts in China must also remain a critical part of strategy. China remains the most attractive market by volume growth but the government's tightening grip on environmental regulation will be long lasting. The "raw growth" model where economic growth supersedes everything else is no longer applicable. That will impact the shape of chemical production capacity, including builds, expansions and closures, in the coming years.

Uncertainty and weak demand growth have driven chemical industry spending away from basic chemicals and plastics capacity and toward **M&A**. And activists are likely to influence the nature of M&A with calls for near-term results and more focused portfolios.

And **digitization and industrial internet of things** (IIOT) is opening up new opportunities for understanding the details of factors impacting plant construction and operations in the chemical and hydrocarbons industry.

Our current analysis and forward view says we are in the midst of a strong upcycle, and it should carry into the end of the decade and potentially the early 2020s. However, the fundamental assumptions about the chemical industry that carried your business through the past decade are not likely to carry through the next. There are a number of fundamental changes beginning to emerge in energy and refined products, chemical markets, and end-use consumer demand. Understanding how these changes will impact the chemical industry in the next decade is critical to your continued success. IHS Markit stands ready to support your business with data, analysis, forecasts, and valuable insight from colleagues with decades of experience in the energy and chemicals markets.

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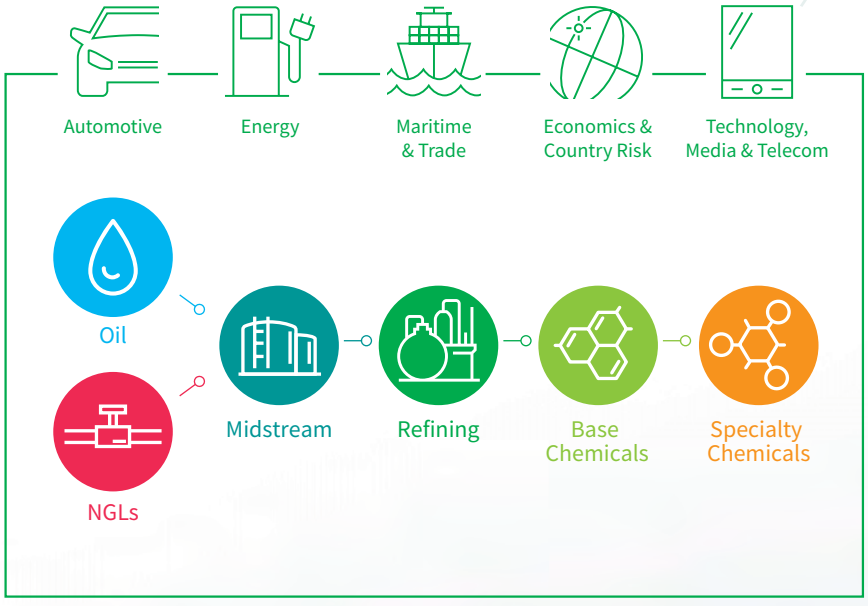

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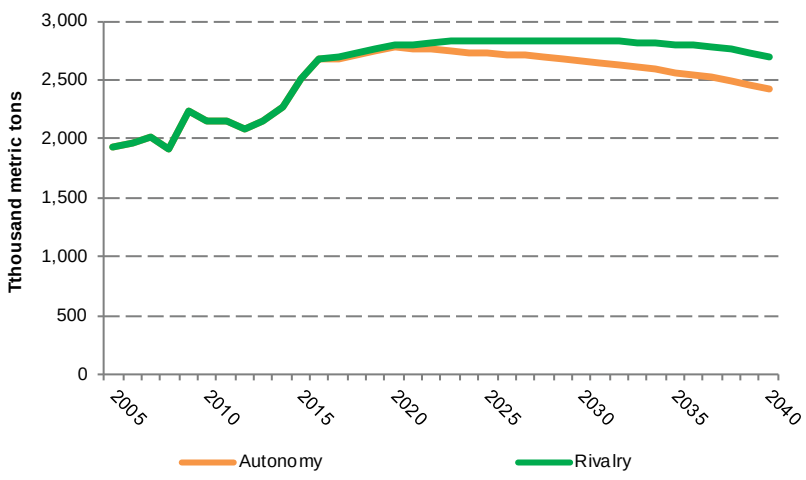
Reinventing the Wheel

The Future of Cars, Oil, Chemicals and Electric Power

For the first time in more than 100 years the automotive ecosystem faces a convergence of technological, political, and economic forces that could fundamentally alter how cars are sold, used, and powered. Driverless technology, electric vehicles, new mobility services, and public policy are prime disruptive forces. These forces will enhance the value of car transport, including lowering costs in many cases. This change is underway; the only question is how quickly it will occur and how transformative it will prove. Not only will the automotive industry see significant change, so will the energy industry and the chemical industry as they are inextricably linked.

To address this transformation, IHS Markit has just completed a new mobility study, Reinventing the Wheel (RTW): the Future of Cars, Oil, Chemicals, and Electric Power. To analyze the full impact of the changes on these three industries, IHS Markit created a core team drawn from IHS Chemicals, IHS Automotive, and IHS Energy. The RTW study modeled the penetration of new mobility services and powertrains, including electric vehicles, under two scenarios to 2040. It also detailed the impact on global oil demand, implications for chemical feedstocks and chemical and plastics inputs into the automotive industry supply chain. IHS Markit established an entirely new modeling approach, quantifying fuel demand and vehicle miles traveled, not only by power train, but also by channel (ride hailing, car sharing, personal use). In Detroit and London, leading chemical, energy, and automotive companies offered their input into the IHS Markit scenario assumptions which underpin RTW.

Reinventing the Wheel - Engineering resins markets volume



Source: IHS Markit

Several headlines emerge from the study

Competition in the automotive ecosystem is becoming multi-dimensional because of a shift from selling cars to selling mobility. The century-old model of selling oil-powered cars to consumers for personal use is challenged by new mobility services and powertrain options. Three distinct but related rivalries exemplify the new multi-dimensional competition:

- Personally-owned cars versus mobility services
- Gasoline/diesel versus electric powertrains
- Human-operated versus driverless cars

These rivalries will overlap--they are not isolated. For example, a mobility company offering driverless electric cars will challenge those selling gasoline-powered, personally-owned and human-driven cars. Rivalries are not isolated.

Nearly 1 of every 2 new car sales will be hybrid-electric or plug-in electric by 2030 in RTW markets. RTW forecasts that hybrids will become the new "conventional" vehicle by 2030 in many markets, and the recent policy announcements by governments in Europe and Asia support this view. This highlights the growing diversity of sales in terms of powertrain and degree of automated technology.

Global oil demand will flatten or even decline, but producing and selling oil will still be a big business. In 2016, light duty vehicles accounted for approximately 35% of global refined product demand. We expect refined product demand will decline, and this will be due as much to tightening fuel economy standards as to increasing EV sales.

Driverless technology is the major disruptive force because it can lower mobility costs, increase access to mobility, reduce road deaths and injuries, and amplify the impact of electric vehicles, mobility service companies, and alter urban design. However, adoption of autonomous technology will proceed at different rates in different markets.

Demand for mobility via the car will increase, even as vehicle sales decline. The rise of $1 trillion+ mobility service industry will broaden access to cheaper transportation. But demand for

mobility does not necessarily translate into higher vehicle sales. Even though vehicle miles travelled will increase, particularly in areas where where people access mobility services, light duty vehicle sales will slow in some markets.

The increase in electrification and automation are creating opportunities for companies outside of the traditional automotive supply chain. The opportunities for new entrants are in areas such as machine learning, software development, data collection and analysis, and sensing and automation technology. "Auto-tech" companies will emerge as a result of both competition and partnership between incumbent companies and new entrants. Interdependencies will emerge because of growth in ride-hailing and increasing automation and electrification of cars. New entrants will need the manufacturing knowledge of incumbents. Incumbents will need the technology innovations from new entrants.

But the scale of the current automotive ecosystem is a moderating influence on the pace of change. The global automotive ecosystem is built to manufacture and service oil-powered cars—there were 1.15 billion of them on roads in 2016. The global fleet of EVs is growing, but still very small in comparison. In 2016 there were 1.8 million EVs on roads—0.2% of the global car fleet. Decades of consumer experience—and aspirations—with personal car ownership will need to be overcome if change is to accelerate. The Reinventing the Wheel study analyzed the implications of the changes in the auto industry on the chemical industry, and quantified the impact of these changes.

Cascading into chemical feedstocks

The decreased use of liquid transportation fuels, as the automotive industry moves vehicle powertrains away from ICEs, will have rippling effects throughout the energy and chemical sectors. Extensive quantitative analysis of this important trend for the Rivalry (base case) and Autonomy scenarios has been performed in support of the Reinventing the Wheel study.

Some changes will be noticeable in the near term, but most of the changes are expected in the 2030-40 timeframe. Demand for gasoline and diesel used in LDVs will weaken, and as a result, more refinery cuts will be available to serve as chemical feedstock.

Also, lower oil and natural gas demand in the

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Autonomy case reduces energy production and prices. As oil prices decline in the long term, prices for related products such as naphtha and NGLs will decline with them, reducing feedstock costs for petrochemicals. Lower crude prices could potentially force naphtha values downward to the point where they become the long-term favorable feedstocks for steam crackers. Such a shift in favorability would encourage investment in naphtha crackers in the growing Asian demand centers, such as China and India, and in the low-cost naphtha regions.

Materials shift

Changes in the volume of cars built and sold, as well as trends in miles travelled, will impact the materials used by the automotive industry. One of the many significant impacts from the move away from ICEs is the elimination of fuel tanks, which will have a negative effect on high-density polyethylene demand in the auto sector. The move will also result in reduced demand for engineering plastics used in under-the-hood applications which require high-temperature resistance and chemical resistance. In a battery EV, there will not be a need for a radiator, so there will also be less need for monoethylene glycol for antifreeze in the OEM and Refill markets.

There will also be "gainers," which will see increased use because of design changes, including increased use of polyurethane foams in sound-deadening applications, as well as increased use in thermal insulation to minimize the need for battery power consumed by air conditioning. Polymers used in wire and cable insulation and connectors will take on increased importance to meet the demands of higher voltage and higher amperage power distribution in electricity-based cars. In addition, more use of adhesives is expected as changes evolve in the structural materials used, and in the way cars are assembled.

While plastics will continue to play a role in the lightweighting of automobiles, the use of high-strength metals and alloys, as well as composites, will take on a more prominent role in this trend. Lightweighting will remain a key trend given its importance to maximizing the miles per charge of EV batteries.

As autonomous vehicle designs evolve, more significant design changes will affect the use of chemicals and polymers in the automotive sector. However, during RTW period, autonomous vehicles will have to coexist on roadways alongside human-driven vehicles, and for safety reasons, will need to maintain many of the basic design features of a conventional vehicle. The more futuristic design changes afforded by a new autonomous vehicle platform are not expected to occur until the post-2040 timeframe.

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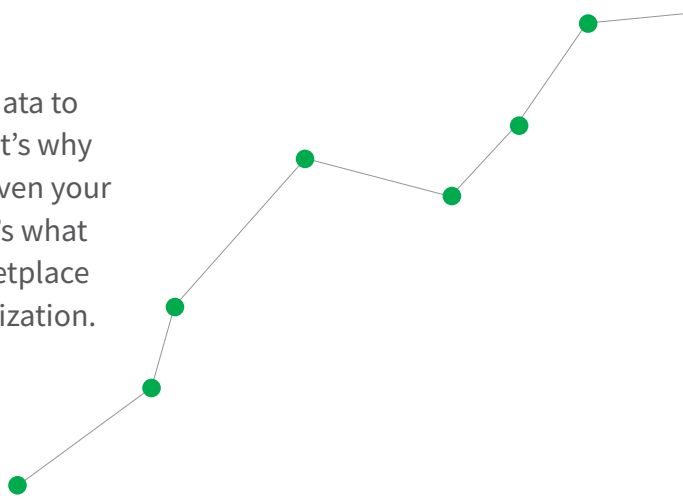

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Digitalisation and the industrial IoT revolution – why should you care?

Chemical processes have been optimised and improved since the earliest industrialisation in the 18th century. Each time a new plant is built or an existing facility is updated, more efficient digital devices are installed as part of this process of continuous improvement and drive towards ever greater efficiency. So why are major chemical producers such as BASF and Evonik suddenly announcing investments of $100's millions in digitalisation?

Henrik Hahn, who coordinates digitalisation activities for Evonik in his role as Chief Digital Officer (CDO), said, "By the year 2020, we aim to see around € 100 million going into development and testing of digital technologies and the development of digital skills. It's not just about data and technology, but especially about new business models, solutions, services for customers, and training qualified staff."

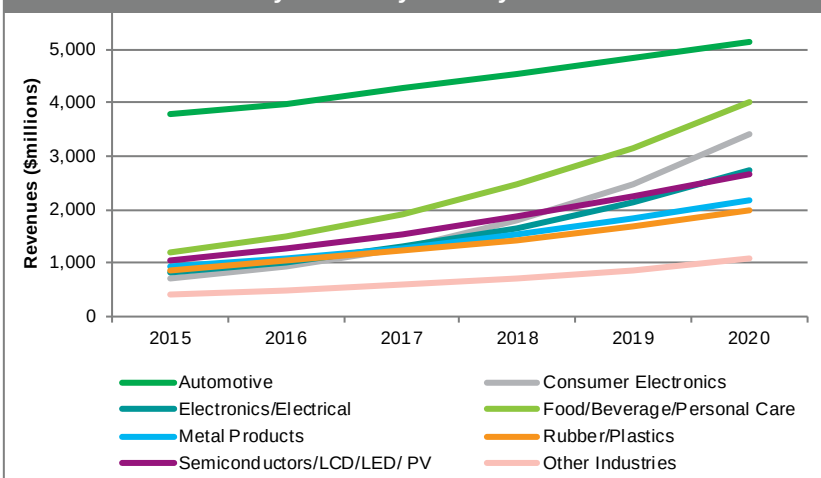
According to Alex West, Principal Analyst – Smart Manufacturing at IHS, the use of digital technologies is influencing many different industries to support a range of applications and business needs, from improving efficiency and factory throughput, to saving on energy consumption and waste. As an example, Siemens' Digital Factory division employed IIoT (Industrial Internet of Things) solutions to provide end-to-end automation of their factory in Amberg, Germany. The factory was originally built in 1989 to produce Programmable Logic Controllers (PLCs). During the digitisation process and upgrade of the plant, it installed 1000's of scanners and sensors and now analyse around 50 million pieces of process information every day in order to monitor and optimise their production system. After integrating software systems, retraining employees to operate the new digital plant and installing cybersecurity systems to protect their data, it was able to reduce costs by 25%, reduce time to market by up to 50% and offer 24 hour delivery lead-times. The production facility had 500 defects per million (dpm) back in 1989, it now has a mere 11 dpm.

In the power generation sector, the North American Duke Energy began a centralised program across the company to use new technology to address increasing reliability demands and optimise the activities of their workforce, initiated in 2010. Duke Energy wanted to replace its traditional route-based data collection with technology capable of automating data collection, supporting identification of problems, allowing them to spend time on higher value tasks and do their jobs regardless of location. Duke Energy began to look at the use of elements of IIoT and big data analytics to help it meet some of these challenges.

Over four years, Duke Energy has avoided costs of 130% of the capital budget spent to avoid the higher costs associated with failures. Since the systems are analysing data constantly, operator rounds can be greatly reduced while the frequency of data collection can be dramatically increased. Data no longer needs to be collected every month; it can be collected several times per day resulting in many terabytes of data per week and allowing issues to be discovered and tracked on a more frequent, consistent basis. As a result analysts were able to spend 80% of their time on analysis, rather than on data collection; thus the analysis is more robust.

One challenge faced by many companies integrating IIoT technologies is getting employees, many of whom have spent their entire careers practicing route-based data collection, to change to these new methods and to trust the technology and its information. Even now, with IIoT technologies in place, it is still common to hear of specialists receiving a warning based on the data, and then following up by manually checking equipment with handheld devices. Consequently, it is important for companies to invest in improving and simplifying the visualisation of the data. Other

The market for Industry Robots by Industry Sector: World



Source: IHS Markit

common challenges faced are finding ways to get the OT (Operational Technology) and IT (Information Technology) departments to cooperate, when in some cases they have their own, and sometimes competing, priorities (and budgets). Having senior executive sponsorship of the project is beneficial in ensuring both successful collaboration as well as on-going funding for these projects.

Jenalea Howell, Director for IoT at IHS Markit expects to see some 1.8 billion IoT devices shipped into the industrial automation segment by 2020, which is more than 2.5 times more devices than in 2017, and spending on industrial robots within the plastics and rubber industry is expected to grow by over 60% in the same time period. Given the achievable benefits through digitalisation, it is easy to understand why so many companies across so many different industries are making such considerable investments in new technologies and business practices to implement fully digitalised operations.

Companies like Evonik see themselves at the forefront of digitalisation within the Chemical Industry and are working to introduce mobile apps that offer access to online product information, which can potentially be extended to introduce online order processing and remove the need for paper processing. They have also announced partnerships with logistics companies to minimise supply chain risks and costs. Likewise, BASF have been deepening relationships with providers of enterprise solutions such as SAP to optimise their sites, plants and processes. Ultimately, they are moving closer to full digitalisation, bringing their customers closer to the factory and by connecting with their feedstock suppliers, they aim to achieve operational excellence, reduce supply risks, control inventory levels and increase profitability through cost reduction. The appointment of Chief Digital Officers within the industry also demonstrates the commitment and desire to fully benefit from the digitalisation process as well as coordinating the integration of all divisions within the organisation.

Across all industries and applications, it is actually expected that the total number of connected IoT devices will increase from nearly 27 billion in 2017 to over 125 billion devices in 2030. The emerging IoT movement is impacting virtually all stages of industry and nearly all market areas, from raw materials to production to distribution and even the consumption of final goods. Such growth opens opportunities for new specialty plastics and materials to meet emerging market demands for IoT devices. Not only will each of these devices require housings to protect from the environments in which they are placed, but any wirelessly connected device has a requirement to allow signals to be transmitted for communication purposes and at the same time protect other sensitive equipment from interference. The casing materials used will therefore become a fully integrated part of the end product design, which is already very apparent in the mobile handset industry. This results in a need for far greater co-operation and communication across the value chain, from the system design engineers to the chemical engineers developing the plastics, resins and additives used in the final product.

An organisation needs to have an understanding of not only their own markets, but also to be aware of developments and technical trends within adjacent market sectors and throughout their complete value chain in order to really benefit from digitalisation. Internally, all company departments need to accept new working practices and business models in order to make best use of a fully digitalised and connected infrastructure. Digitalisation and the use of IIoT technologies not only offers optimised processes and cost savings to individual chemical organisations, but also opens opportunities for new market developments and increased business. IHS Markit has been researching developments within the chemical industry as well as monitoring the technology markets that, together, build the components necessary to create a more efficient chemical industry ecosystem. We have supported companies evaluating the adoption of IIoT solutions through examples of technology implementations across industries and for different projects and applications, as well as providing best practices. It's time to plan for a digitalised future, today.

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Bunker fuel in 2020

Smooth sailing or shipping shambles?

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↘ **The International Maritime Organization (IMO),** first adopted in 1948 by the United Nations, is the international body devoted to shipping matters. In 1973, the International Convention for the Prevention of Pollution from Ships (MARPOL) expanded the powers of the IMO to regulate the environmental impacts of shipping. A MARPOL update in 2008 called for a reduction of the maximum sulfur content in marine bunker fuel from 3.50% to 0.50% in 2020, unless a supply study would conclude insufficient availability of compliance fuels and a delay to 2025 deemed necessary.

This study was commissioned in 2015 and awarded to consortium led by Dutch consultancy CE Delft. It concluded that there would be enough supply of low-sulfur fuel by 2020, but did not address residue disposition, pricing or transitional matters, since these items were not part of the IMO's terms of reference. On 27 October 2016, the IMO came to a broad agreement to implement the global reduction in the sulfur content of marine bunker fuel from 1 January 2020.

From a shipping perspective, IHS Markit estimates that about 55,000 ships of a total fleet of about 110,000 vessels burn heavy fuel oil bunkers, and that roughly 30,000 ships account for about 80% of global fuel oil bunker use.

Compliance with the new fuel specification will entail significant costs for both the refining and the shipping industries. For the refining industry, the regulation means that the industry will have to shift its product mix, increasing supply of low-sulfur bunker fuels while managing excess supply of high-sulfur residual streams that make up the majority of today's 200 million tonnes high-sulfur bunker fuel. Crude producers will see changes in refined product spreads affect their sales netbacks, while chemical producers would see the cost of their oil-based feedstocks change.

How the shipping industry adapts will influence refiners

The impact of the IMO specification change on refined product demand will depend largely on the compliance methods adopted by ships and the level of compliance in general. There are three main options for ships:

- Don't change anything to the vessel, and purchase compliant bunker fuel.
- Install on-board exhaust gas cleaning systems, known as scrubbers. These remove sulfur dioxide emissions from the exhaust, and allow shippers to continue burning high-sulfur bunkers.
- Make vessel modifications, and switch to alternative fuels such as liquefied natural gas (LNG) bunkers.

The first option drives up demand for low-sulfur fuels and complicates high-sulfur residue disposition. The second would be less disruptive for the refining industry and more aligned with the current refinery product slate but comes at a high initial investment for vessel owners. The third would reduce demand for both gasoil and fuel oil.

Several factors, including vessel ownership, type, route, size, design, and age, will determine the preferred compliance method. For the largest ships, which account for most bunker fuel demand, IHS Markit expects that scrubbers will be the preferred solution, as they would be economically attractive from 2020 onwards. Based on the IHS Markit price spreads between low-sulfur and high-sulfur bunkers, the payback period for installing a scrubber on the largest vessels would be two to four years in 2022–25, but less than one year in 2022–21. Smaller ships instead are expected to burn low-sulfur bunker fuel.

Currently only a small number of ships, about 400, have installed or ordered scrubbers. Adoption prior to 2020 is expected to be slow since there is currently no economic incentive outside of emission control areas (ECA), and uncertainty about enforcement and compliance remains. A rush on demand for scrubber installations just before and after the specification change becomes effective could be constrained by factors such as available shipyards and dry docks, and qualified crews. The capacity to install scrubbers is difficult to assess but IHS Markit assumes that these limitations would restrict maximum adoption to about 3,000 vessel retrofits per year.

LNG is expected to be applied to newly build vessels, particularly those that operate on fixed, predictable routes, or within a geographic area, particularly ECAs. Retrofits have been rare so far; a recent example is the WES Amelie, a container ship operating almost exclusively in the Baltic and North Sea ECA.

The current infrastructure for LNG bunkering is limited and will need to rapidly expand if LNG bunkers are to become more common for the largest consumers. IHS Maritime counts 218 ships fitted for LNG fuel in service or under construction, and another 123 deemed "LNG ready". Although the switch to LNG requires a higher up-front investment, lower LNG prices could enable a healthy return, while LNG also has lower carbon emissions, providing methane slip is controlled. LNG bunker consumption growth is expected to accelerate,

yet by 2020, LNG bunkers will form only a very small percentage of total bunker consumption.

Laws without enforcement are just good advice

Besides the three main compliance routes, some level of non-compliance can be expected. There is significant uncertainty regarding the enforcement framework the IMO and its members will set up, and policing the sulfur cap on the high seas is not obvious. The IMO is a treaty organization and has no legal powers of its own. Its member states implement new legislation individually, and several countries with a coastline are not signatories. Flag states (where the ship is registered) have jurisdiction over violations in international waters, while port states could only fine vessels breaching the rules in their territorial waters.

Indications are that most IMO members are taking a firm position, and focus on consistent implementation and setting up a level playing field, rather than on exemptions. Compliance in the ECAs has been relatively high, with 2017 North Sea non-compliance as reported by EMSA only 8%. Although the available data is imperfect, inspections have increased and the estimates have become more reliable since 2015. The campaign for a level playing field is being led by the Trident Alliance, including high-profile corporations concerned about their reputation and ability to compete in a marketplace if compliance is lax. Based on this information, IHS Markit assumes reasonably high compliance in 2020, equivalent to 85% of residual bunker demand.

The IMO or individual signatories may allow for transitional arrangements targeted at smoothing the transition, such as grace periods or exemptions if a scrubber or LNG retrofit was already order before 2020. Another issue relates to dealing with unavailability of compliant bunker fuel in remote locations. The discussions are expected to continue in 2018, possibly even until 2019.

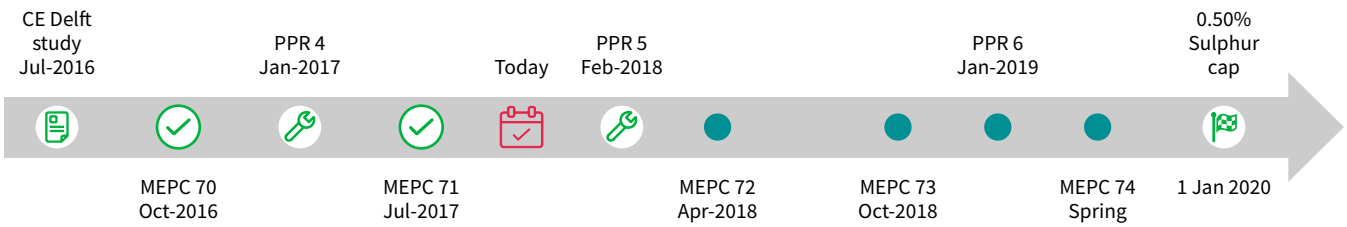
Overall, the IMO specification change is expected to increase demand for various types of low-sulfur bunkers and erode high-sulfur fuel consumption. IHS Markit refining balances indicate that there will be enough refining capacity to meet increased demand for low-sulfur bunker fuel, albeit with an increase in overall crude runs. New low-sulfur "hybrid" formulations will likely be developed to meet this new bunker market demand. However, some of these new fuels would be based on streams that come with handling and compatibility challenges. Suppliers will need to convince buyers that these new fuels are fit for purpose.

The main challenge for refiners will be disposing of the excess high-sulfur residue, containing some of the most difficult streams to upgrade. Although deep conversion units exist in refineries today, most are fully utilized, and new conversion units take several years to design and to build—far too long for a start-up by 2020. Still, there are some conversion projects currently under construction for start-up before 2020, and debottlenecking of existing units is likely, for instance during refinery maintenance in 2018-2019.

IHS Markit projects that the refining industry will produce an excess volume of high-sulfur residual fuel oil in 2020. In the short term, a significant portion of this surplus would have to clear into lower price tiers, such as oil-fired power generation— at prices which could be as low as thermal parity with coal.

Hédi Grati, Director, works in the European downstream consulting practice based in London. Hédi specializes in the refinery's heavy fractions and the marine bunker market. Before joining IHS Markit, he worked for ExxonMobil, most recently as Heavy Products Optimiser for Europe, where he helped prepare the 2015 bunker specification change in the Emission Control Areas. He also worked at two of ExxonMobil's refineries where he held various technical, economic and supervisory roles.

IMO decision-making timeline



The North America investment wave hits landfall- what about the second wave?

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The first extended wave of new capacity is arriving now in North America. Total petrochemicals capacity arriving from 2016 through 2020 is approximately 3.8 million metric tons per year. Incremental ethylene capacity alone during this timeframe will average 2.4 million metric tons per year. This comes after an initial surge in total capacity of nearly 2 million metric tons in 2015.

While demand for petrochemicals grows at a multiple above GDP growth rates, North America will experience a large share of the global capacity expansion. With global petrochemical capacity in 2017 at 610 million metric tons, North America's installed capacity is 90 million metric tons, representing 15 percent of the world's capacity. On the horizon of the next decade, North America will construct 25 percent of the new capacity needed worldwide.

The North American base chemical total capacity growth in 2021-2030, will continue to experience a surge of 2.6 million metric tons per year, with ethylene growing at 1 million metric tons per year, propylene at 0.6 million metric tons per year, and methanol at 1 million metric tons per year, respectively.

A vital market condition for North America's investment is its advantaged feedstock, position. Gas to Liquids differentials also create significant advantages for North American investment. The Northeast Asia naphtha (often the marginal price setting region) spread over ethane is $5.50 per MMBTU in 2017, and over $6 per MMBTU in 2021 and beyond, providing significant headroom for investment. The crude to U.S. natural gas spread of $5 per MMBTU in 2017,expands to over $8.50 per MMBTU in 2021. The risk in the gas to liquids differentials is expected to be driven by crude price uncertainty with North American natural gas and natural gas liquids in extended surplus.

Financial performance in petrochemicals continues to see healthy earnings. While 2014-2015 brought exceptional margins to North American petrochemicals with high crude prices and low gas prices, the plunge in crude prices in 2015 amid political and economic uncertainty created a pause in new project decision-making. Global financial performance in petrochemicals for 2017 is the best in a decade, averaging $200 per metric ton on a weighted average cash earnings basis, with North America averaging nearly $300 per metric ton. However, the pause in new projects decision-making in the 2015-2017 timeframe will exhibit itself in near term higher operating rates as demand continues to grow and excess capacity is consumed. In the olefins market, for example, a cycle peak is likely in the early 2020's followed by a potential down-cycle as significant new capacity decisions are under consideration with lags of five to seven years before the results of those decisions are reflected in the market.

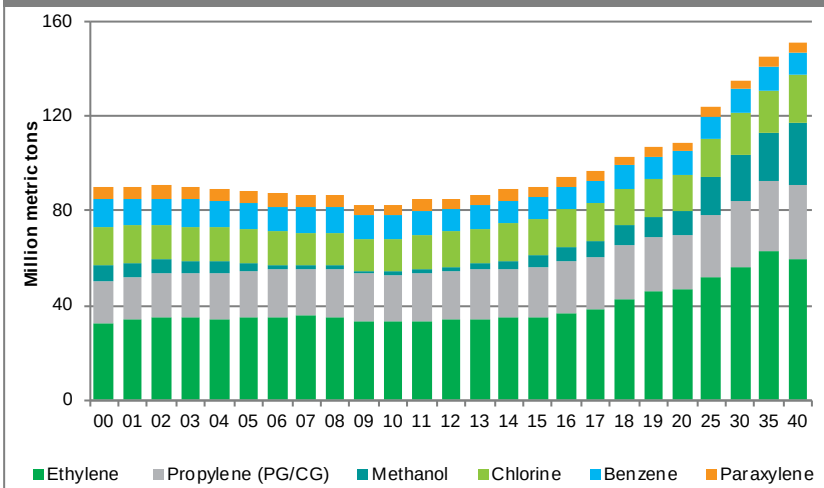
The second wave

North America's second wave of new capacity expansions is faced with a number of uncertainties and challenges ranging from relative competitiveness of energy and feedstock costs, competitiveness of global supply, to economic and political forces.

The crude -to -gas spread is the most critical competitive lever for North America. Ethane is expected to remain advantaged relative to naphtha with sufficient incremental supply to support an additional 10 million metric tons of ethylene production. However, North American ethane export volumes, especially to China, creates the largest uncertainty for North American ethane-based investment. North America's advantage in propane has higher certainty with a significant excess supply, as North America becomes the largest global exporter of propane. Finally, US natural gas remains in significant excess and is geographically stranded, providing significant advantaged costs for decades on the horizon.

Global competitiveness of supply is also determined by the relative capital cost of construction. With the US

North America base chemical total capacity



Source: IHS Markit

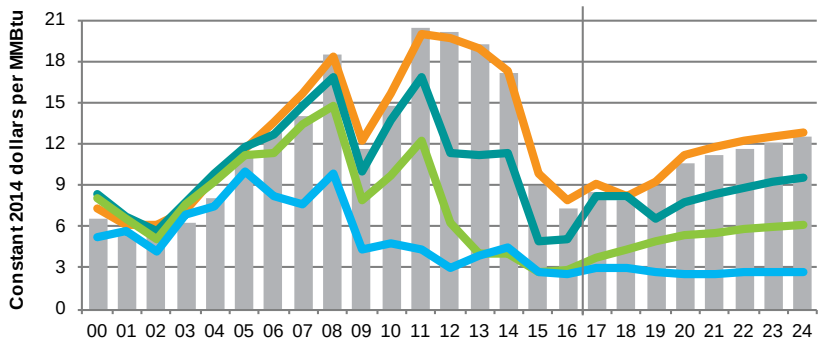
Gulf Coast at a capital cost index of 1.0, China is achieving a capital cost index below 0.7 and in some cases as low as 0.5. China's productivity of capacity execution with proximity to a large hub of demand growth creates a significant advantage versus North American exports. In addition, much of China's next wave of chemicals consists of large scale integrated refinery-petrochemical complexes creating scale and flow-through refinery economics. Further, North America's challenge in the next wave of capacity expansion is a significant improvement over the most recent performance where many projects experienced delays and project cost overruns.

North America's next wave of capacity exceeds domestic demand requirements, requiring producers to export incremental supply. This export position exposes producers to not only the economic uncertainty of their home market but also to the health and stability of economies in their target export markets, including South America, India, and China. As North America becomes a large net exporter of petrochemicals, unrestricted trade is critical. This is in the face of increasing protectionism in a number of petrochemical markets.

While much uncertainty exists, North America has many robust advantages and opportunities. The US is especially resource rich with low cost abundant gas (natural gas and natural gas liquids), crude, and coal, creating a diversified feedstock mix and low power costs for petrochemical production throughout its value chains. North America remains a hub for innovation throughout the value chains from wellhead to consumers. This is demonstrated in the emergence and continued cost productivity advances in U.S. tight oil and shale gas in the upstream. Process innovation continues in areas such as on-purpose propylene production and refinery unit process designs (High severity-FCC units producing increased propylene). North American chemical value chains are also well positioned to address major shifts in downstream markets, such as changes in mobility (hybrid and electrical vehicles and user habits) and digitisation of retail channels (Amazon's penetration into food, pharmaceuticals, etc. and FedEx expansions in logistics). North America shows robust operational flexibility with a highly developed infrastructure with integrated and optimized logistics systems (marine, pipeline, rail, trucking). The region also has efficient financial and capital markets providing access to competitive capital and enabling efficient product trade in liquid markets. Finally, the region exhibits low political and security risks, creating a safe environment for long term asset performance.

A second wave of significant investment in North America petrochemicals is expected with strategic decisions needed in 2017-2019. Winners will leverage the full benefits of the region with advantaged feedstocks and energy, a critical mass of well-developed infrastructure, a balanced portfolio of customer markets, and integrated scale. Operational flexibility is the critical element as producers embrace across their enterprises abundant and diversified feedstocks from gas to liquids on the upstream with diversified customers and market access across consuming derivatives and downstream uses. The large scale complex North American refineries will also provide another avenue of diverse competitive feedstock supplies for petrochemicals. Finally, winners continue integration throughout their value chains to achieve low cost and baseload demand for their production units. The extensive diversity on petrochemical feedstock supplies and well developed large end-use markets along with North America's proven innovation engine creates a market that enables high flexibility in an ongoing uncertain environment.

Crude oil - vs - natural gas (naphtha vs NGLs)



Source: IHS Markit

Dewey Johnson is the Vice President for Base Chemicals at IHS Markit. Dewey is responsible for global insight and research covering the major chemical value chains including aromatics and fibers, olefins and derivatives, inorganics (chlor-alkali, vinyls, and soda ash), plastics and polymers, and syngas chemicals (methanol, acetyls, and ammonia).

"Activist Investors" amid an active M&A market: short term gains versus long term strategy

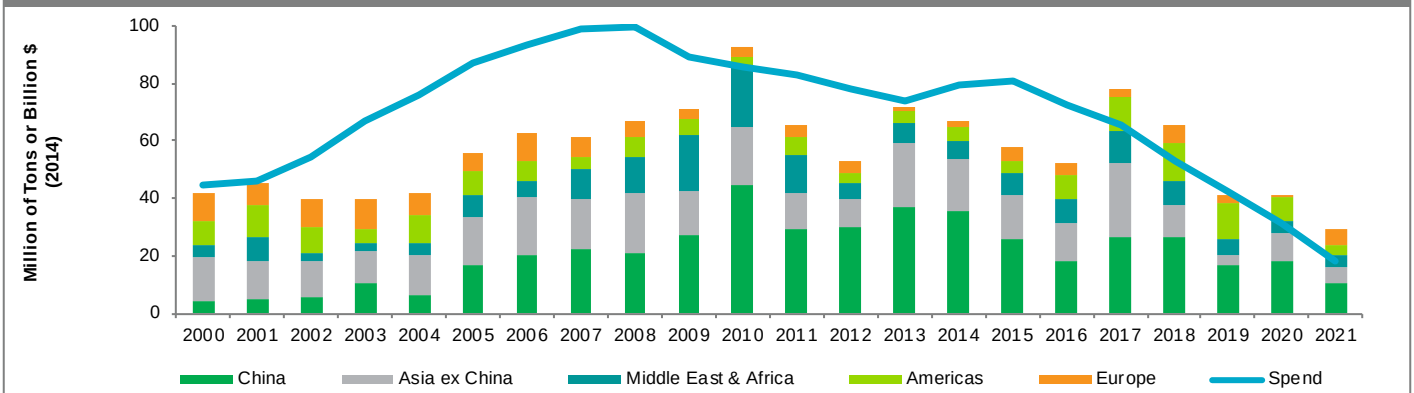
Chemical industry M&A has remained highly active in 2017 while capital spending on expansions is forecast to decline to levels not seen since the late 1990s. The industry this year has seen activist investors flex some muscle and impact the outcome of two major mergers: DowDuPont and the Huntsman-Clariant. Is this a one-time phenomenon or another complication company leadership must navigate while employing M&A strategies for the future?

Basic chemicals are the essential building blocks from which significant quantities of durable and non-durable goods are produced. Chemicals such as such ethylene, propylene, methanol, benzene, chlorine and paraxylene are the feedstocks for major value chains that produce a wide variety of intermediates, plastics, elastomers and performance materials that ultimately are converted into consumer goods. Energy market trends, global economic growth and regional trade dynamics are all key factors influencing investment decisions to add new world-scale capacity. These are multibillion dollar investments that are seeking a sustainable competitive advantage in terms of energy and feedstock costs, technology and scale, proximity to markets, and degree of integration.

Uncertainty in global crude oil markets, along with the high degree of economic uncertainty that developed during 2014 through 2016, were key factors leading to what IHS Markit sees as a disruption in the chemical industry build cycle. As decisions to build new capacity were delayed or cancelled during this period, chemical industry capital spending shifted toward mergers and acquisitions. While shale-based investments in the United States are providing a boost to chemicals capital spending, the overall trend is a decline, dominated by reduced spending in China and the rest of Asia.

Low-cost access to debt, strong equity pricing, and weak earnings resulting from falling commodity prices in 2014 and 2015 have also been key factors behind the surge in M&A activity. During the latter half of 2017, commodity prices and global GDP are increasing and industrial production is improving. Demand growth in basic chemicals is steadily improving and is forecast to continue accelerating, as long as global economic growth continues. Given forecast demand growth and the basic chemical capacity expansion profile during the next three to four years, asset utilization will rise resulting in strong profitability for the industry. **Targeted M&A activity can provide producers the opportunity to grow capacity and margins through cost savings and growth synergies.** For both commodity and specialty markets, M&A deals surged during 2015 and 2016, both in terms of deal volume and multiples being paid. Merger activity in 2017 has continued, although it appears at this point that 2016 will represent a peak year. We expect to see more attempts at mergers as we head into 2018 as M&A represents an opportunity for growth.

Capital Spending in the Chemical Industry



Source: IHS Markit

During 2016 and 2017, activist investors have made their presence felt in the chemical sector. Investors were successful in disrupting a deal that would have created a specialty chemical leader, Huntsman-Clariant, and while the DowDuPont deal was not prevented from advancing, investors were successful in pressing for significant changes in the makeup of planned spinoffs.

Clariant abandoned a planned $20-billion merger with Huntsman after activists gained a 20% stake, enough to effectively block a deal.

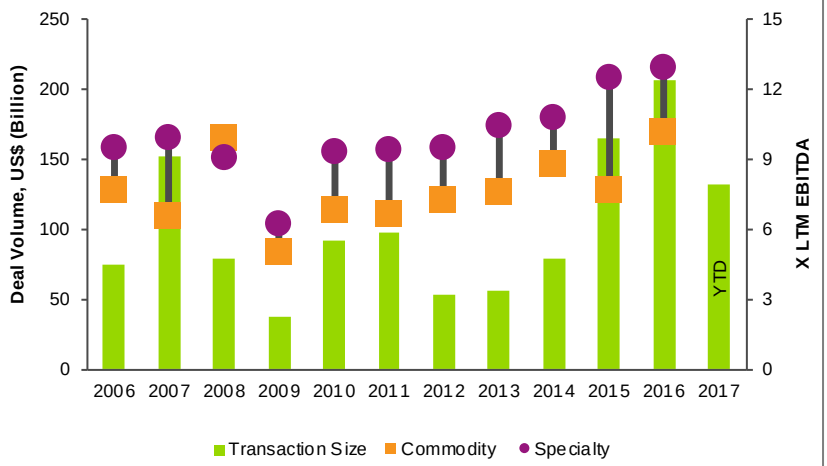
DowDuPont, meanwhile, will shift businesses with $8 billion in annual revenue from its planned material science spinoff, which will retain the Dow Chemical name, to the specialty products spinoff as part of a previously announced portfolio review amid pressure from a group of activist investors who had pressed leadership for the shifts. A chemical industry executive recently referred to this shareholder activism as a "destructive and dangerous development for chemical companies." From the industry perspective, the activist shareholder is seeking a fast payout, with little regard for long term strategic implications of their recommendations. They want faster money and have shorter timeframes that are generally measured across quarters or a few years.

If the activist shareholder is here to stay, it creates significant challenges for chemical industry executives. Activists are seeking more focused and narrower portfolios along with near-term initiatives to drive higher results and higher valuations. Long-term strategic planning likely does not exist in the activist shareholder playbook. Chemical industry executives must balance this against the need to build, sustain and improve the enterprise value against a backdrop of volatile and changing market cycles. Energy markets, consumer markets, technology and regulatory framework are all in a constant state of change, creating uncertainty and volatility in market profitability. Today's short term initiatives that result in high profits could be tomorrow's fatal flaw, given a shift in energy or demand trends.

In the chemical industry, investment planning, spending and project execution for critical assets can take five years and billions of dollars. The assets are built and sustained in order to have a useful life of 50-plus years. It's a business driven by short-term tactical decisions that must be aligned with long-term strategic planning. Today's decisions to maximize profitability must contribute to long-term strategic plans aimed at building up enterprise value and reputation over time, meeting the needs of all stakeholders including investors, employees, local communities and the general public.

Assuming that the activist investor is only focused on short term gains with little to no regard for long term strategic implications, then the warning that this development is "destructive and dangerous" for the industry may have merit. Considering the global perception of the chemical industry today and the increasing need for corporate metrics that demonstrate as much concern for sustainability programs as there is for an acceptable return on investment; all stakeholders in the industry must work together to ensure there is an appropriate balance of priorities and investment that continues to advance sustainability efforts while building long term value in the enterprise.

Chemical Industry M&A Trends



Sources: Company research, FactSet, Capital IQ, press releases, HSBC

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Bright future ahead for specialty chemicals after 2016 hiccup

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The global market for specialty chemicals totaled $556 billion in 2016, driven by the strong demand for personal electronics and the increasing buying power of Chinese consumers. Despite the strong performance of these consumer markets, other economic headwinds joined forces to stall market growth: a slowing Chinese economy, the recession in several South American countries, the weakness in the oil and gas industries, and the spotty performance of the construction markets. Consequently, the global market value for specialties fell slightly (-0.2%) from the 2015 level.

Electronic chemicals, industrial and institutional cleaners, and specialty polymers, each accounted for 7% to 8% of the total global market, with a market value of $40 billion to $45 billion in 2016. Surfactants, construction chemicals, flavors and fragrances, catalysts, specialty coatings, and water-soluble polymers accounted for roughly $30 billion each in market value. The food additives market was about $25 billion.

While consumer-driven categories such as electronics chemicals had robust demand growth, one casualty of the market has been oilfield chemicals. The amount of specialty chemicals consumed by the oil and gas industry was about 4% in 2016, which was down from 6% during 2013–15, due to the continued weakness in crude oil prices.

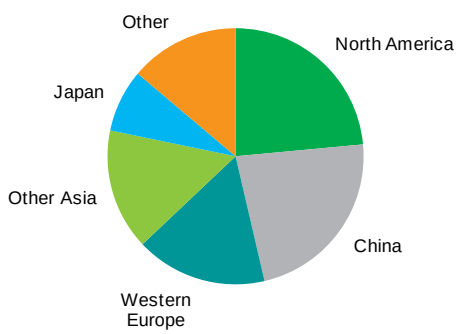
In terms of regional markets, North America, Western Europe, and Japan had a combined market value of almost $270 billion, or half of the global specialty chemicals market, which means the established regions still consume the largest portion of specialty chemicals. However, China's market share of 23% has grown considerably, and is now almost as big as that of North America, which holds 24%of the specialty chemicals market.

This was not the case just a few years ago. In 2012, China's market share of specialty chemicals was less than 20%, compared with North America's 25% market share. In addition, the market shares held by Western Europe and Japan have steadily declined. In 2012, Western Europe accounted for 21% of the global value in the specialties sector, but as of 2016, Western Europe's share of the global specialty chemical market was down to 17%. Japan carried 12% of the market in 2012, compared with just 8% in 2016.

Specialty chemicals are consumed in every sector of the economy. In terms of end-use industries, almost 55% of the global specialty chemicals market in 2016 went into only four end-use sectors—soap, cleaning, and cosmetics; food and beverages; electrical and electronics; and construction. Soap and cleaning was about 20% of the market, food and beverages was at 14%, electrical/electronics represented 12% of the specialty chemicals market, while construction accounted for 9% of the market. Other important end-use industries for specialty chemicals include motor vehicles, paper and pulp, plastic products, printing and publishing, and oil and gas extraction.

Despite the market stalling in 2016, the future remains bright for the industry. In the next five years,

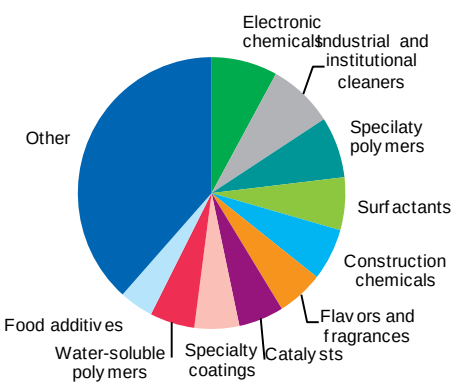
World specialty chemicals markets by region—2016



Total value = $556 billion

Note: Other includes Central and South America, Central and Eastern Europe, and the Middle East and Africa.
Source: IHS Markit

Global specialty chemicals market size by sector—2016



Source: IHS Markit

Total value = $556 billion

the global specialty chemicals market will grow at 3–3.5% annually, paralleling the growth in the economy.

The combined consumption in North America, Western Europe, and Japan will grow more slowly at about 2% per year. This is not a reflection of sluggish or shrinking markets but rather because the specialty chemicals industry is fully established in these regions. In terms of per capita consumption of specialty chemicals, these areas already have the highest in the world (3-4 times the world average of $75 per capita). In contrast, there is still higher growth potential in the emerging markets because of rising consumer-driven economies and industrialization. In particular, China will have the highest consumption growth rate of all regions. China's economy is experiencing some short-term setbacks, and the forecast of consumption for specialty chemicals has been downgraded slightly from the historical 8–9% per year to 6–7% per year. Nevertheless, the country will continue to power the growth of global specialty chemicals in the foreseeable future. China's market is getting a boost from a government effort to move away from heavy industries to more advanced, differentiated sectors. The government policy is called "Made in China 2025" and its implementation is expected to facilitate industry restructuring that will ease the shift from commodity to specialty chemicals. We at IHS Markit expect China's share of the specialty chemicals market to surpass that of North America by 2021.

The other regions of the Middle East and Africa, South and Central America, and Eastern Europe will all be growing faster than the developed regions, albeit from very small bases.

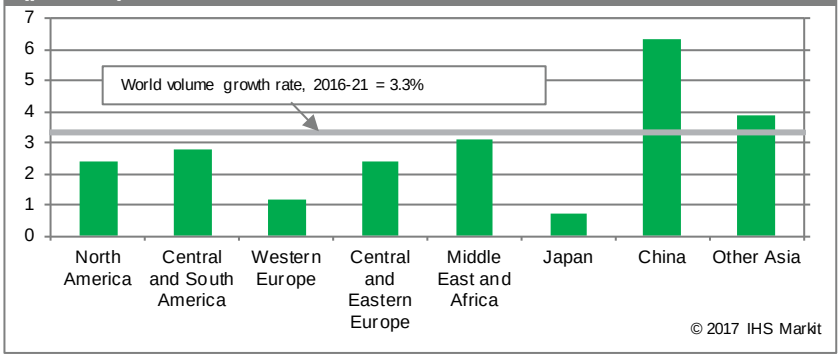
In terms of category growth, several specialty chemicals such as nutraceuticals, electronic chemicals, flavors and fragrances, and specialty coatings will grow faster than the world average due to the positive outlook for the corresponding end uses.

Specialty chemicals require more formulation and customization than commodity chemicals such as ethylene or polyethylene, and as a result, they often provide a competitive market niche and better margins for producers, so they are an important part of the chemical producer's portfolio. As we have seen over time, companies are increasingly shifting their portfolio toward the specialized chemicals in order to hedge their position in the business.

BASF is the largest specialty chemical company in the world, with an estimated $43 billion in revenues generated from specialties. It is present in all major market segments and is among the leaders in catalysts, construction chemicals, and plastics additives. BASF further competes among the top three players in the biocides, food additives, nutraceuticals, and cosmetic chemicals market segments.

Dow Chemical and DuPont have occupied the second and third positions globally in specialty chemicals for many years. However, with the merger of those two companies now complete, the future rankings will change. DowDuPont will subsequently split into three independent, publicly traded companies within 18 to 24 months. One of these companies will specialize in specialty chemicals, the others in agriculture and in material science. Given the extent of both Dow's and DuPont's current participation in the industry, there is no doubt that the new specialty chemical company will remain in the top 10 list.

Specialty chemicals volume growth rates by region—2016–21 (percent)



The finalization of the DowDuPont merger is but one of a number of mergers and acquisitions in the specialty chemical industry at present, but it is not likely to be the last, since several companies are divesting of less productive assets and seeking to strengthen core assets where they have a competitive advantage. Acquisitions also give global companies a means to enter a regional market where they seek to grow.

All of the contents in this article were distilled from the July 2017 edition of the Overview of the Specialty Chemicals Industry from IHS Markit's Specialty Chemicals Insights. Find out more at http://www.ihs.com/scup.

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A delicate balance

China's economic growth versus its deteriorating environment

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After nearly two decades of fast economic growth, China has achieved huge success in growing its economy and generating wealth for its citizens. However, this success comes at a large cost – a deteriorating environment. Air pollution and water pollution are particularly serious in the economically developed North and East regions. The government has been addressing pollution issues for some time, but when economic growth and environmental protection cannot be achieved simultaneously, the former has superseded the latter.

In his opening speech, at the 19th National Congress of the Communist Party on October 18th, 2017, Chinese president, Xi Jingping, laid out his view to maintain economic growth while tackling pollution over the next five years. The use of both an economic lever and executive regulations to squeeze out environmentally unfriendly and small-scale capacity will continue to be the government's long-term approach. In the short-term however, this tactic may cause disruption in several sectors. Nonetheless, it benefits the industry as a whole by reinforcing consistent environmental policy, phasing out outdated capacity, creating a fair market, and in the end having long-term sustainable growth. This represents a major shift in the central government policy, evident from the start of 2017.

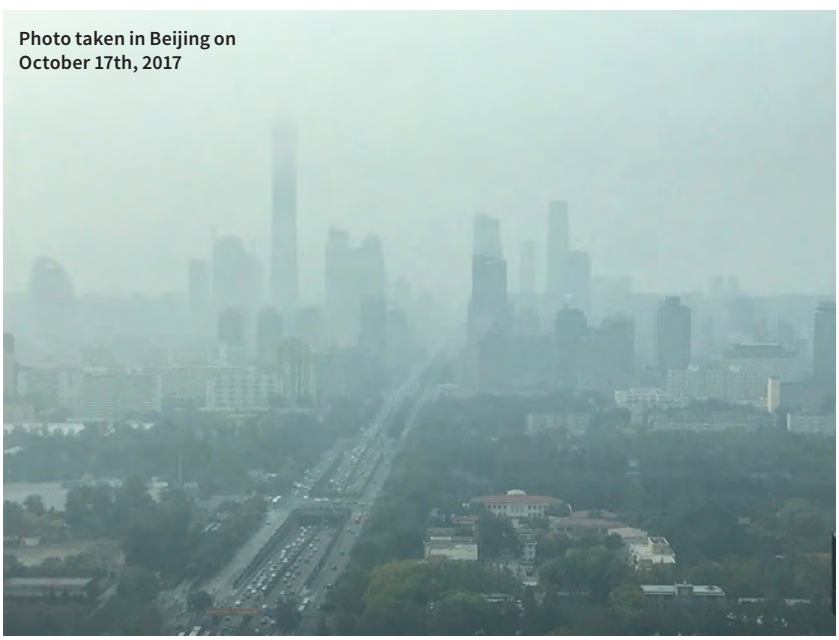

Photo taken in Beijing on October 17th, 2017

Critically, the enforcement of the series of policies and regulations on environmental protection that the central government has issued, is now more stringent than it has ever been. This round of enforcements applies nation-wide with a focus on the regions most affected by pollution. North China, particularly the region around Beijing and Tianjin - China's most heavily polluted area - is the main target.

Policies

Since January 2017, various government agencies, including the State Council, Ministry of Environment Protection, Ministry of Industry and Information Technology, and NDRC have issued 11 policies and memorandums addressed to local government and industry sectors, mandating the reduction of energy consumption, carbon emissions and more strict pollution controls. The central government has launched three rounds of comprehensive environment inspection to enforce implementation.

Among these policies, the "2017 environment protection act in Beijing, Tianjin, Hebei and surrounding area" has the strongest impact on the energy and manufacturing sectors. The policy – called '2+26 Act' for short - targets Beijing, Tianjin, eight cities in Hebei province, four cities in Shanxi province, seven cities in Shandong province and seven cities in Henan province, and was jointly issued by the Ministry of Environment Protection and NDRC in March. The key element for this Act includes:

- Reducing energy consumption
- Enforcing stricter waste discharge permit
- Implementing tougher control on volatile organic compounds (VOC) emissions
- Eliminating redundant capacity (supply-side correction)
- Tightly scrutinizing environmental impact, and energy-saving evaluations for any new project prior to project approval
- Pollution control targeting aluminum, coal coking, steel, construction materials, carbide, and ammonia sectors

Impact

First of all, this round of policy enforcements have a profound impact on energy sector. Coal has been the dominant fuel for power and heating. As a means to combat air pollution, the central government requests local governments and manufacturers to reduce the

consumption of coal. They are ordered to replace coal with natural gas and/or electricity in densely populated cities. As such, this policy immediately affects the energy sector. With this mandate, the demand for natural gas surges. As North China enters its winter season, natural gas demand is expected to increase further. Major energy companies are looking into increasing gas supply through all possible sources, including domestic gas production, gas import via pipeline, LNG imports, and coal-bed methane.

A second effect of these policies, is the removal of surplus capacity from the supply chain. Although the primary intention is to control pollution, the side effect is to eliminate large amount of capacity, and tighten the supply and demand relationship and therefore improve industry profitability. The result is to ease off cut-throat price competition in the oversupplied sectors, such coal mining, steel, glass, construction materials and some chemicals. These chemical products include ammonia, caustic, soda ash, carbide and polyvinyl chloride.

There are clear winners and losers following the implementation of these policies over the past nine months.

In general, large and well-established companies are mostly winners, while small and medium-sized companies are generally losers. Those companies not (or less) affected, have been enjoying improved margins for the year so far.

Most large companies, especially large state-owned enterprises, are equipped with modern plants and implement tighter waste and emissions control. Rather than being affected by capacity shutdowns or cutbacks, these companies have benefited from tighter supply, higher product prices, and thus enjoyed higher margins.

Some of small and medium-sized companies, which are generally privately owned and have less systematic control on waste discharge and emissions, were forced to shut down. Even those lucky enough to survive the crackdown, have had to cut back production, by 30% on average.

While the manufacturing sectors have benefited overall, it has not been without sacrifice. In the coal mining, coking steel and cement sectors, all producers faced production cuts, even when they met the environmental standards.

Policy implementation also varies in consistency from one region to another. In some cities, companies failing to meet the standards were given a grace period for upgrading. In other instances, some local governments took a "single knife-cut" approach, and force shutdown all producers in certain product chains, or all plants in entire industry parks. In these instances, the policies have also hurt local economies and employment.

This has caused disruption through entire supply chains, the level of disruption varying depending on the supply chains in question. The crackdown for the chains with large surplus capacity, has been tougher than for these with little to no surplus capacity.

The tougher stance on environment control by the government is largely welcome, and come bit too late. However, the unpredictability of government policy along with its way of implementing is a cause of concern. It is for sure that the central government's tightening grip on environmental regulation will be long lasting and likely to remain in place in the near future.

Paul has been in the chemical industry for 28 years in various areas, including technology, operation, process engineering, business planning and consultancy. Paul currently serves as vice president with IHS Markit covering Greater China.

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What competitive strategies are employed by the chemical industry's largest companies?

Market conditions have remained steady despite growing political uncertainty, and big mergers look set to remake the ranking of the top chemical companies in the years to come.

Keep abreast of changes in the competitive landscape with **IHS Markit Competitive Company Analysis (CCA)**. Access a unique combination of in-depth analysis and data, which compares the strategic direction of the top chemical producers globally and provides a holistic point of view for effective decision making, based on the following attributes:

- Feedstock cost position
- Product integration
- Proximity to market
- Process efficiencies
- Geographic diversification
- Technology position
- Portfolio diversification

Companies highlighted are analysed as part of the IHS Markit Competitive Company Analysis portfolio

EMEA

Company (country)	Sales	Operating income	Capex	R&D spending
BASF (Germany)	$57,665	$6,080	3,161	1,920
Sabic (Saudi Arabia)	33,018	6,381	NA	NA
Ineos (Switzerland)	31,289	4,897	NA	NA
Air Liquide (France)	18,243	3,409	2,165	213
Linde (Germany)	17,840	4,314	2,109	127
Akzo Nobel (Netherlands)	14,944	1,599	677	382
IPIC (UAE)	13,881	NA	NA	NA
Evonik (Germany)	13,402	1,752	1,011	457
Syngenta (Switzerland)	12,790	1,647	425	1,299
Covestro (Germany)	12,531	1,401	441	273

AMERICAS

Company (country)	Sales	Operating income	Capex	R&D spending
Dow Chemical (US)	$48,158	$4,413	3,804	1,584
ExxonMobil (US)	36,663	4,615	2,200	NA
LyondellBasell (US)	29,183	5,060	2,243	99
DuPont (US)	24,594	3,265	1,019	1,898
PPG Industries (US)	14,751	877	751	466
Braskem (Brazil)	14,666	1,831	1,263	50
Agrium (Canada)	13,665	596	724	NA
Monsanto (US)	13,502	2,375	923	1,512
Ecolab (US)	13,153	1,915	707	189
Sherwin-Williams (US)	11,856	1,595	239	NA

APAC

Company (country)	Sales	Operating income	Capex	R&D spending
Sinopec (China)	$48,218	$2,988	1,273	NA
Formosa Plastics Group (Taiwan)	46,360	8,685	NA	NA
Mitsubishi Chemical (Japan)	5,399	1,877	1,589	1,131
Toray Industries (Japan)	18,183	1,320	1,365	530
LG Chem (South Korea)	14,487	1,696	NA	NA
Reliance Industries (India)	14,300	2,000	NA	NA
Sumitomo Chemical (Japan)	13,552	711	1,032	664
Shin Etsu (Japan)	11,102	2,146	1,311	440
Lotte Chemical (South Korea)	10,988	2,117	NA	NA
PTT Global Chemical (Thailand)	9,762	808	506	NA

All figures in millions of US dollars. Ranking includes companies with chemical revenues of more than $3 billion for fiscal years ending 1 July 2016 through 30 June 2017.

Visit www.ihs.com/cca to find out more about company analysis for strategy and portfolio optimisation.