

Petrochemical Outlook

Challenges and Opportunities

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- Introduction and Objectives
- Petrochemical Industry Characteristics
- Current Issues for the Industry
- Outlook for the Medium and Long-Term
- Conclusions

- Discussion



Introduction and Objectives

Petrochemical Outlook: Challenges and Opportunities

- OPEC launched the project with Nexant in May 2014 to analyse and understand the global and regional petrochemical industry and markets
- Objectives of the project
 - To develop an overview of the petrochemicals industry, its market and its drivers
 - To formulate an understanding of the key issues and challenges facing the industry
 - To provide global and regional medium- and long-term outlooks including the impact on feedstocks, in particular, ethane and naphtha
- This presentation provides the major findings of the project

Scope of the project

Petrochemical Outlook: Challenges and Opportunities

- Scope of the Project
 - Medium-term = 2014-2020
 - Long-term = 2021-2040
 - Basic petrochemical olefins and aromatics
 - Substitution and competition between naphtha and ethane
 - The role of refineries
 - Capacity expansion plans and investments
 - Interregional links and trade implications
 - R&D and technology developments

Independent Industry Consulting in Energy & Chemicals

- Established 2000
- 700 staff: engineers, chemists, economists with industry experience
- Global reach: 30 offices in 10 countries
- Deep insight into the industries
- Recognized by the energy & chemicals industry for its
 - Thought leadership
 - Strategic advice
 - Technical, market and commercial insight
 - Financial and techno-economic analysis
 - Strong research, analysis and forecasting



Petrochemical Industry Characteristics

The petrochemical industry supplies raw materials to manufacturing industry

Demand is in the major markets..

..and into many market sectors



 = major population regions

- The main end uses of petrochemicals are:
 - Construction
 - Packaging
 - Agriculture
 - Industrial production
 - Automotive
 - Fibres
- These end use markets are driven by GDP and population growth.

There are three major production processes of basic petrochemicals

Large scale production of ..



..olefins and aromatics

Steam Cracking

- Produces olefins and some aromatics.
- Processing feedstocks including ethane, LPG and naphtha

Fluidized Catalytic Cracking

- Produces propylene (olefin)
- As a by-product of gasoline

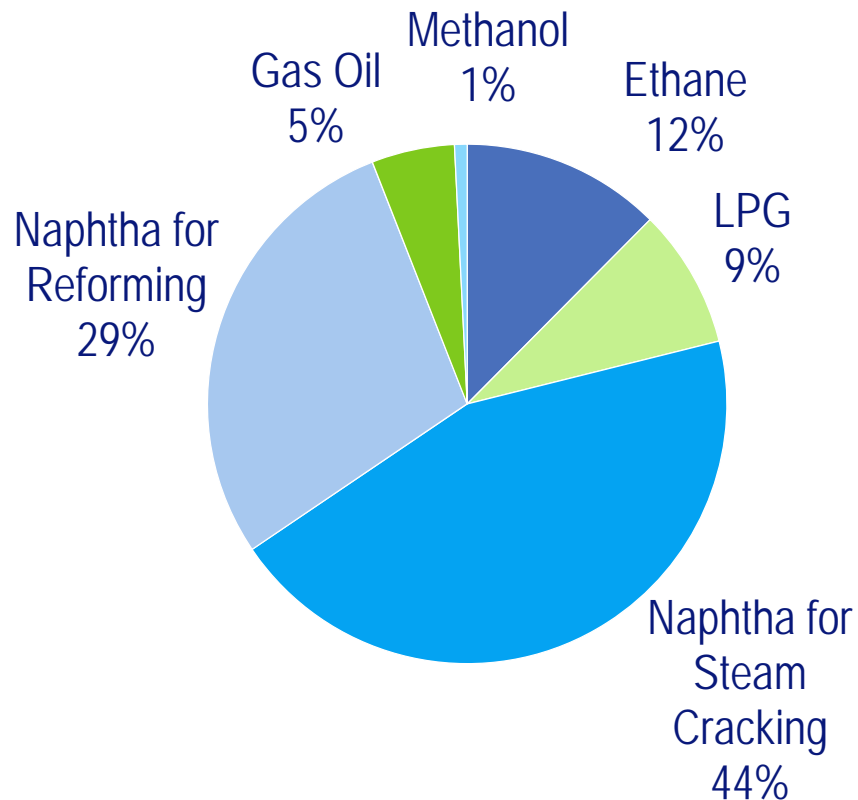
Catalytic Reforming

- Produces aromatics
- As a by-product of gasoline

The basic petrochemicals are further processed in the industry to polymers, fibres, solvents, and many chemical materials

Feedstocks come from oil refineries and gas processing

Petrochemical Feedstock Consumption (Global)

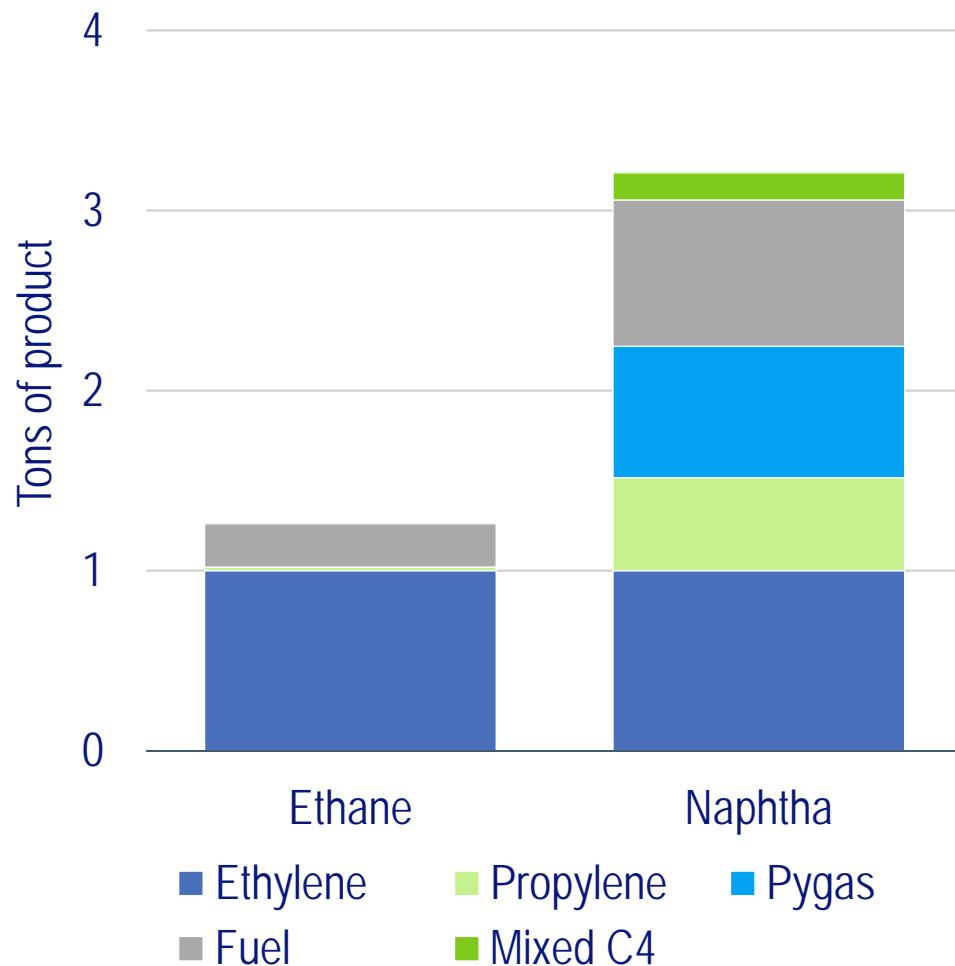


- Most petrochemicals are made from ethane, propane or naphtha
- Regions with surplus, low priced ethane are attractive for steam cracking
- Olefins (ethylene, propylene and butadiene) and aromatics (benzene, toluene and xylenes) make up 90 percent of the petrochemical production, and are the building blocks to almost all other petrochemicals and polymers
- These petrochemicals are commodity products, and so this market is cost-driven and very price sensitive

Cost competition is key to petrochemical success

Feedstock cost can be a competitive advantage

Products of Ethane and Naphtha cracking



Naphtha

- Is the most common feedstock for crackers
- Produces a broad range of products
- For each ton of ethylene produced, 3.3 tons of naphtha has to be cracked

Ethane

- For each ton of ethylene produced, 1.2 tons of ethane has to be cracked
- There are no other products (aside from fuel)

Ultimately, their relative market prices determine the cost advantage

Logistics costs can be a source of advantage or disadvantage

Physical state of materials

	Feedstocks	Petrochemicals	Transportation Costs
Gases	Ethane LPG	Olefins	High
Liquids	Naphtha Gas Oil	Aromatics	Low
Solids	(Coal) (Biomass)	Plastics	Medium

Minimise costs

- To be a competitive petrochemical producers must keep costs to a minimum
- Gas transportation costs are high, so their movement over long distances is avoided
- So ethane and olefins are consumed close to their source
- Naphtha, aromatics and polymers are traded around the world.



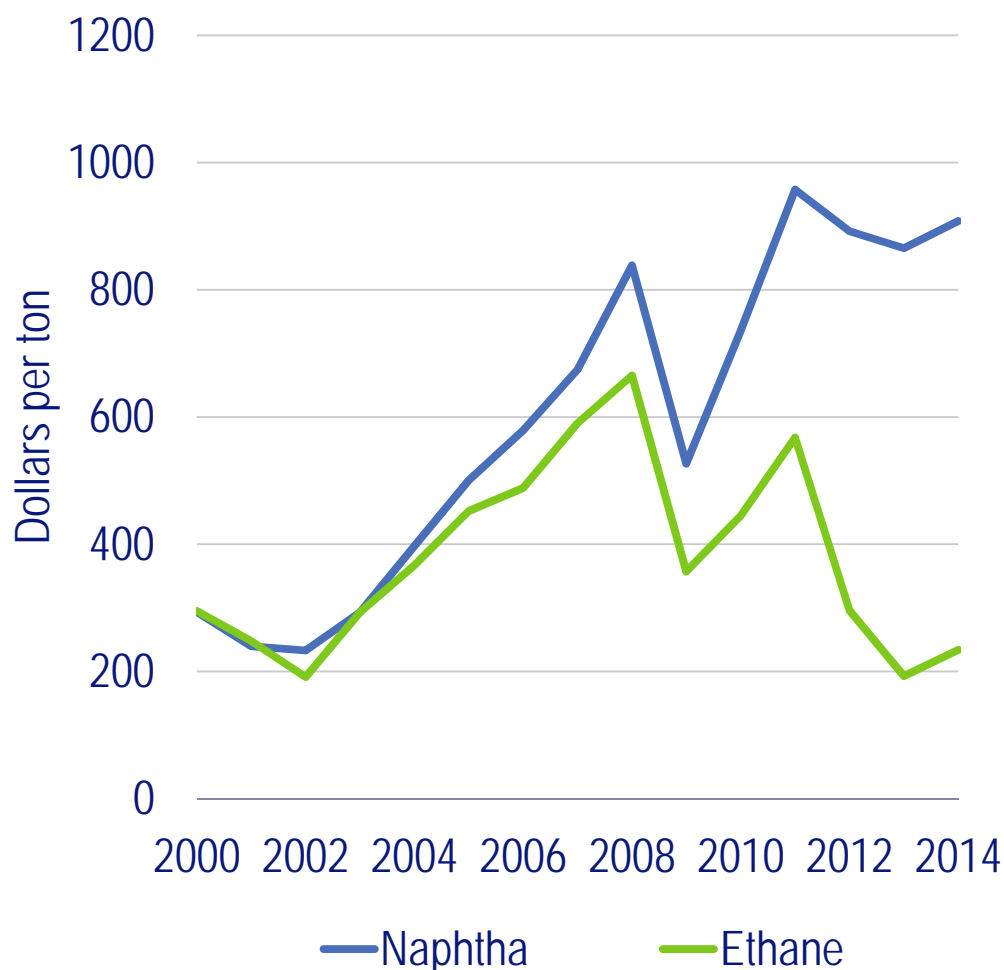
Current Issues for the Industry

Petrochemical Outlook: Challenges and Opportunities

- Shale Gas in North America
- Coal in China
- The European Position
- Biotechnology

Shale gas production has boosted natural gas liquids in North America

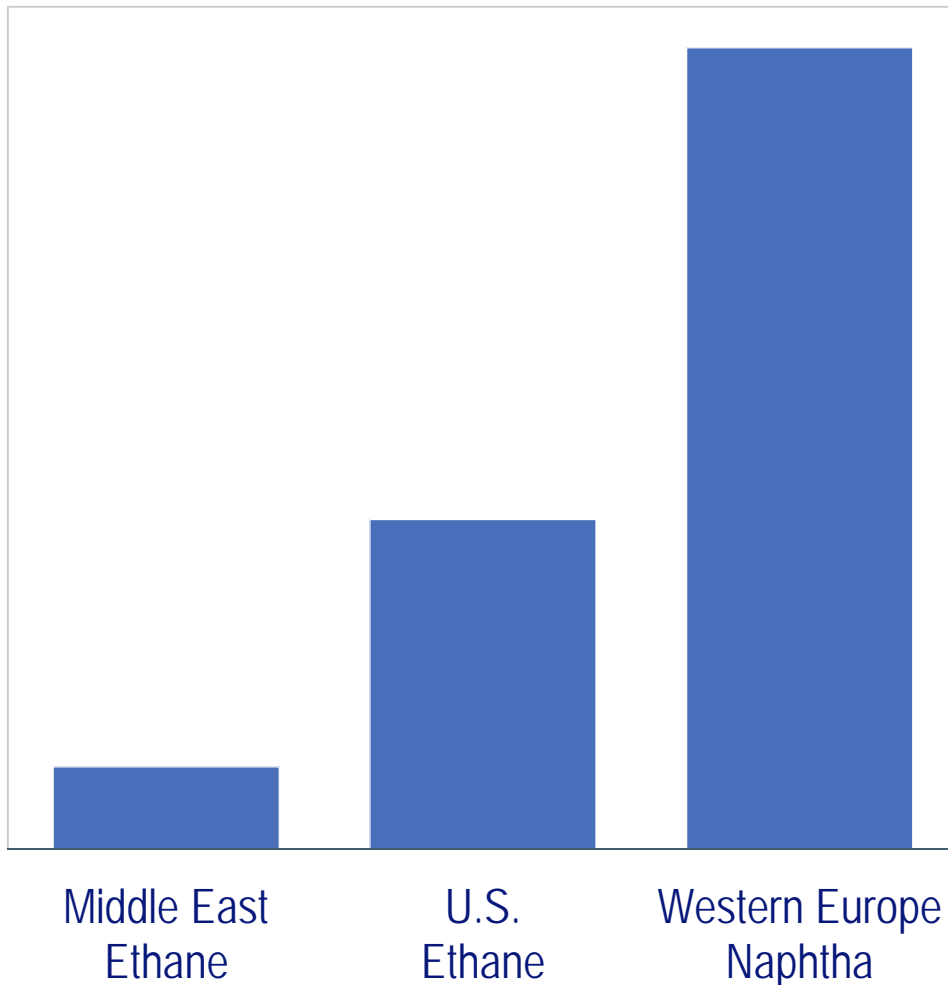
Naphtha & Ethane Price (United States)



- Directional drilling and hydraulic fracturing make tight gas formations productive
- A well-developed gas pipeline and processing infrastructure allows the shale gas to get to market easily
- Gas processing removes natural gas liquids (including ethane) from the gas
- The only consumption of ethane is for steam cracking, which had limited capability to consume additional ethane
- The rapid increase in gas production has led to surplus ethane
- Surplus ethane led to lower prices

Low ethane price has given cost advantage to U.S. steam crackers

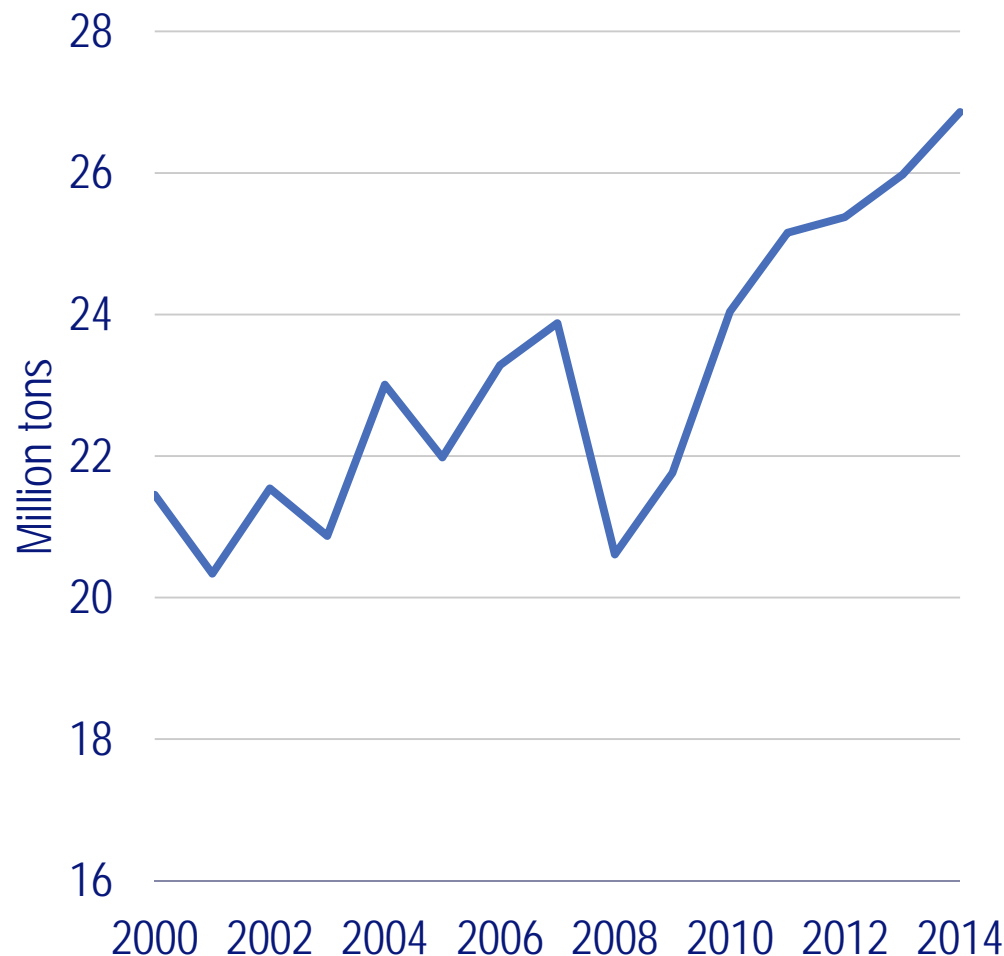
Cash cost of ethylene production



- The Middle East ethane crackers produce the lowest cost ethylene – based on ethane at \$0.75 per million Btu
- The U.S. ethane is around \$4 per million Btu
- The cost of ethylene production in Europe (and Asia) from naphtha is about 2.5x that in the U.S. and 10x the cost in Middle East
- The capital cost of building an ethane cracker is less than half that of a naphtha cracker
- Naphtha crackers are at a considerable disadvantage in cash cost and return on capital

Ethane consumption for steam cracking has grown due to its low price

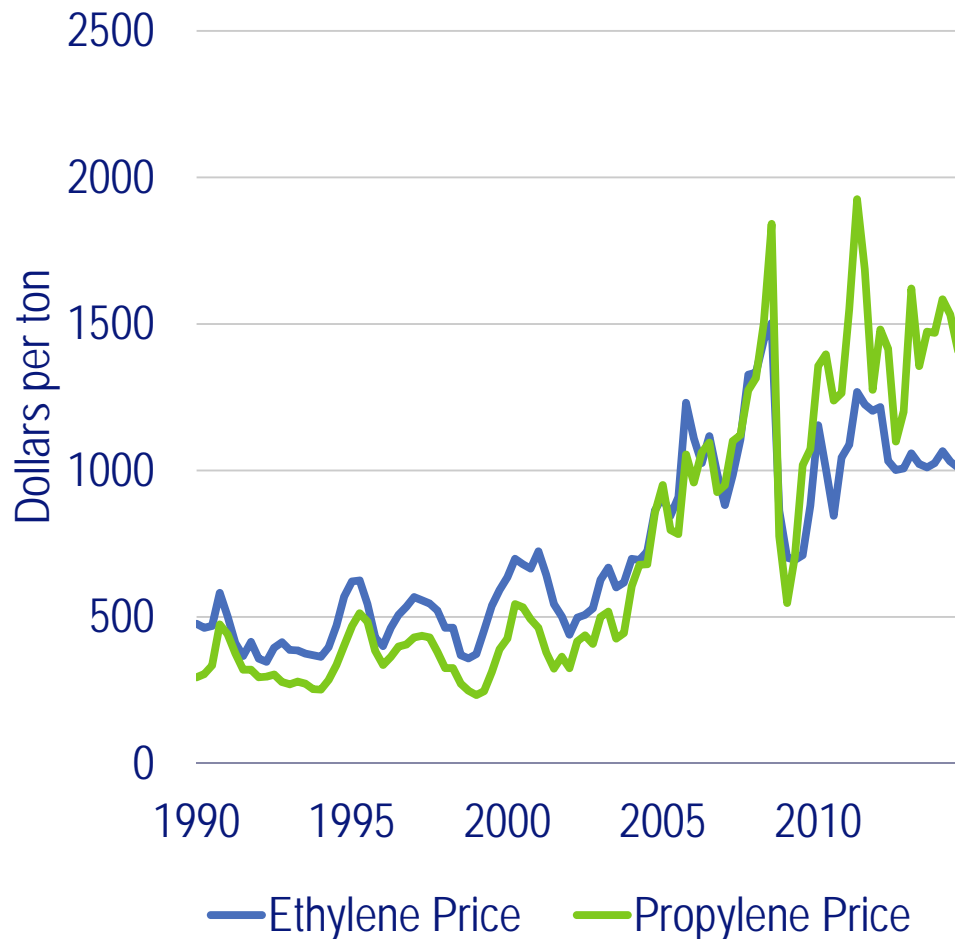
North American Ethane Consumption



- After the recession of 2008/09 flexible crackers switched to ethane
- The operating rate of naphtha crackers decreased and of ethane crackers increased
- Some crackers were converted to crack more ethane
- U.S. producers are building new ethane crackers
- It is 20 years since the last new steam cracker was built in the U.S.
- There are also plans to export ethane

More ethane cracking reduces propylene production and increases its price

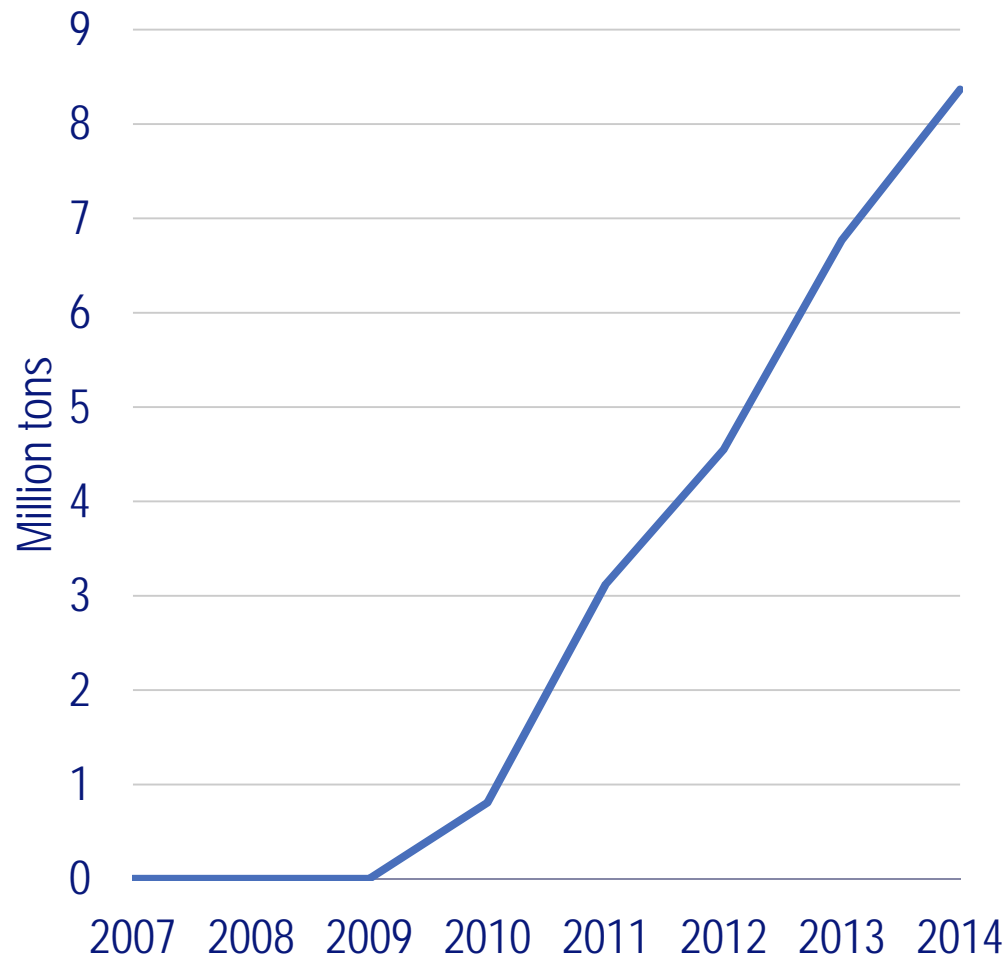
Olefin Prices (United States)



- Cracking ethane produces only ethylene (and some fuel), whereas cracking naphtha yields many co-products, including propylene, butadiene and aromatics
- The increase in U.S. ethane cracking has led to a drop in propylene production
- The decrease in propylene supply has driven up the propylene price
- The increase in propylene price makes polypropylene less competitive
- So costs of ethylene derivatives in North America have dropped but propylene derivative costs have increased

China has used coal to gain feedstock cost advantage

Methanol consumption for olefins (China)



- China has vast coal reserves, much of which is used for power generation
- Coal reserves in western China are of low quality and remote from population centres
- China is using this low value coal to feed its Coal To Liquids and Methanol To Olefin (MTO) technologies to produce ethylene and propylene
- The increase in crude oil price since 2009 has made petrochemicals from coal viable

A SWOT analysis illustrates the poor competitive position for European petrochemicals

Strengths

- Culture of innovation in chemicals
- Large market

Opportunities

- Development of shale gas in E.U.
- Import of advantaged U.S. ethane
- Increase in propylene and butadiene production
- No cost disadvantage in aromatics

Weaknesses

- Old, small production assets
- High feedstock and energy costs
- High labour costs
- High environmental and legislative cost
- Low market growth

Threats

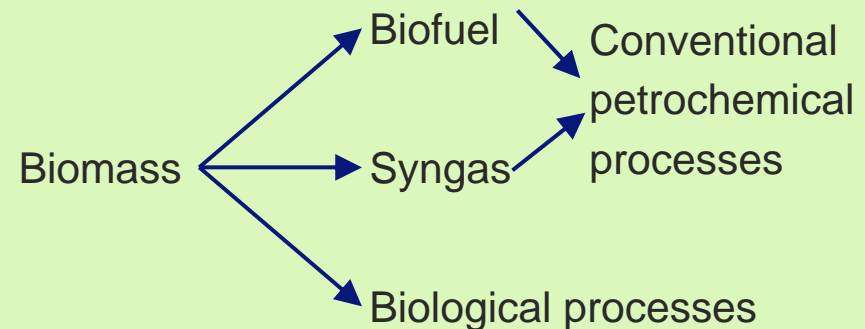
- Imports of petrochemical derivatives
- Declining petrochemical production
- Closure of refineries and steam crackers

Biotechnology has the potential to impact feedstock use

Drivers of biofuels and biochemicals

- Increasing cost of oil and gas feedstocks
- Sustainability and environmental impact
- Consumer preferences

Process routes



Status

- Significant development in Brazil for sugar cane
- Currently in use for petrochemical derivatives
- Very minor impact on basic petrochemicals
- Major growth would require:
 - Technology breakthrough in enzymes
 - Sustained crude oil price increase

Technology is behind many of the industry issues

Technology

- Directional drilling and hydraulic fracturing
- Coal gasification and MTO
- Biotechnology

Impact

- Competitive advantage of U.S. olefins
- Competitive advantage of China olefins
- Limited impact so far



Outlook for the Medium and Long-Term

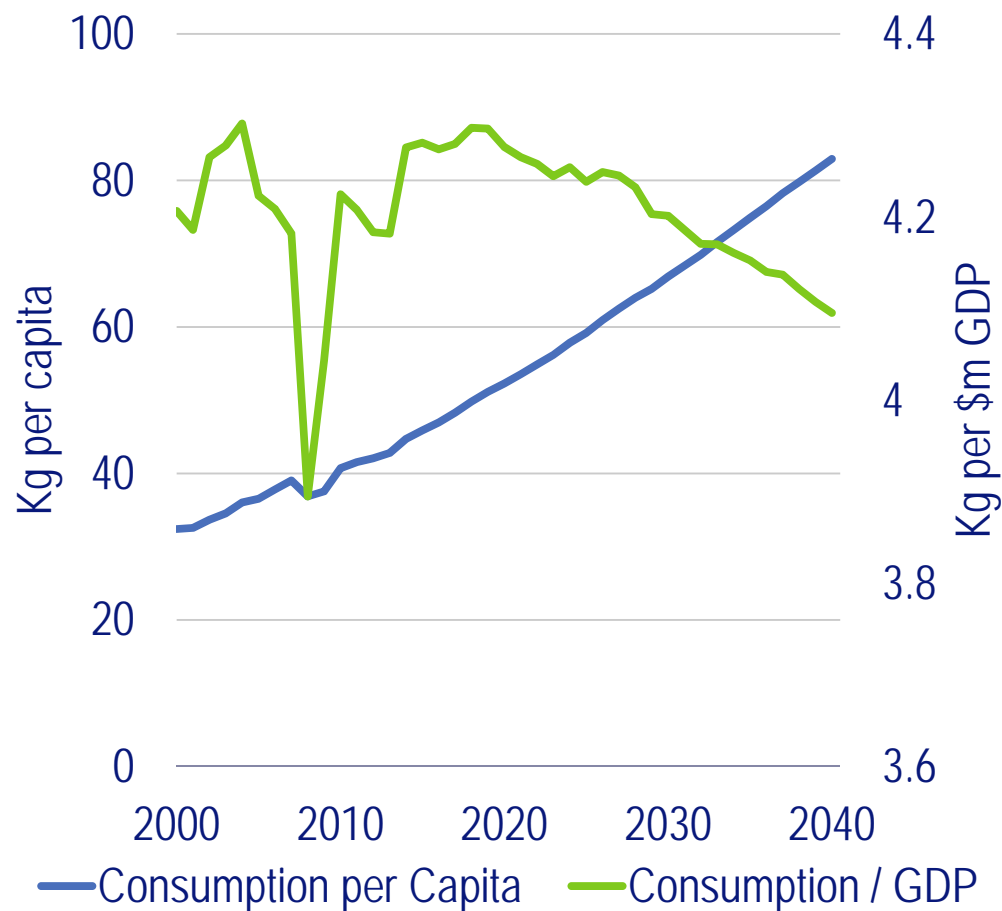
Outlook for the Medium- and Long-Term

The Impact of Current Issues on Supply, Demand and Trade and on Feedstock

- Consumption forecasts were built from end use market growth
- New capacity and planned closures impact supply
- Production and trade are driven by competitive cost position
- Feedstock provides the largest cost advantage

Petrochemical consumption growth is driven by growth in economic activity and population

Petrochemical consumption drivers

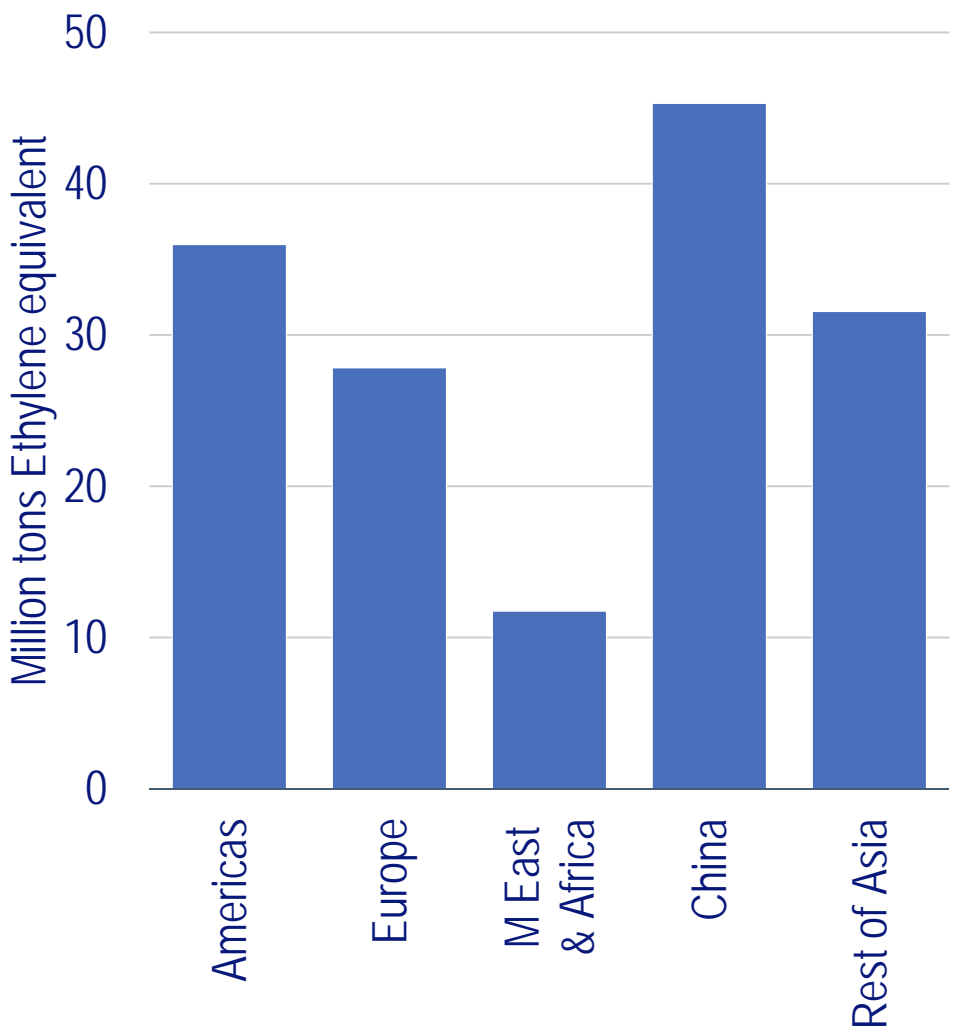


- The global recession of 2008/09 led to a drop in petrochemical consumption
- Consumption recovered quickly in 2010
- Per capita consumption of petrochemicals continues to grow, mainly in developing regions
- Consumption increases strongly with developing manufacturing industry...
- ..but can decline in service economies

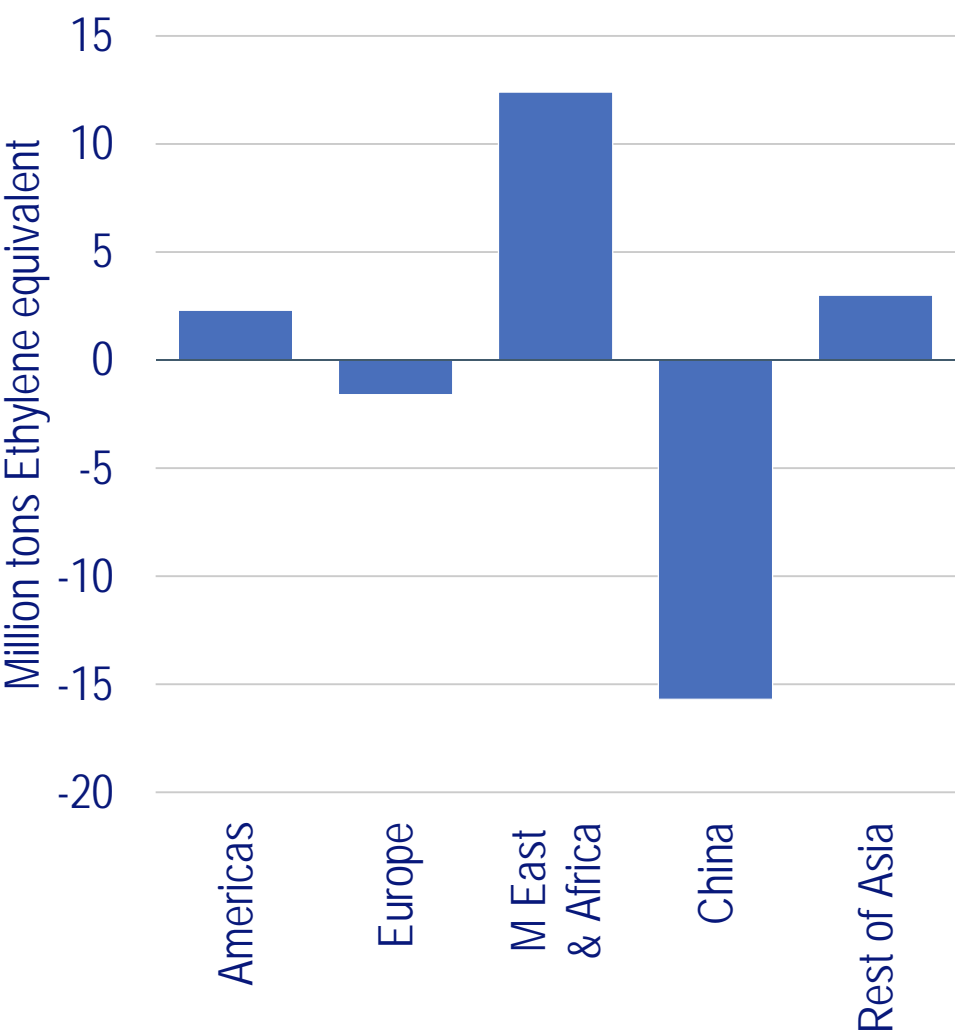
The Middle East is the largest exporter and China the largest importer of ethylene derivatives



Consumption of Key Ethylene Derivatives



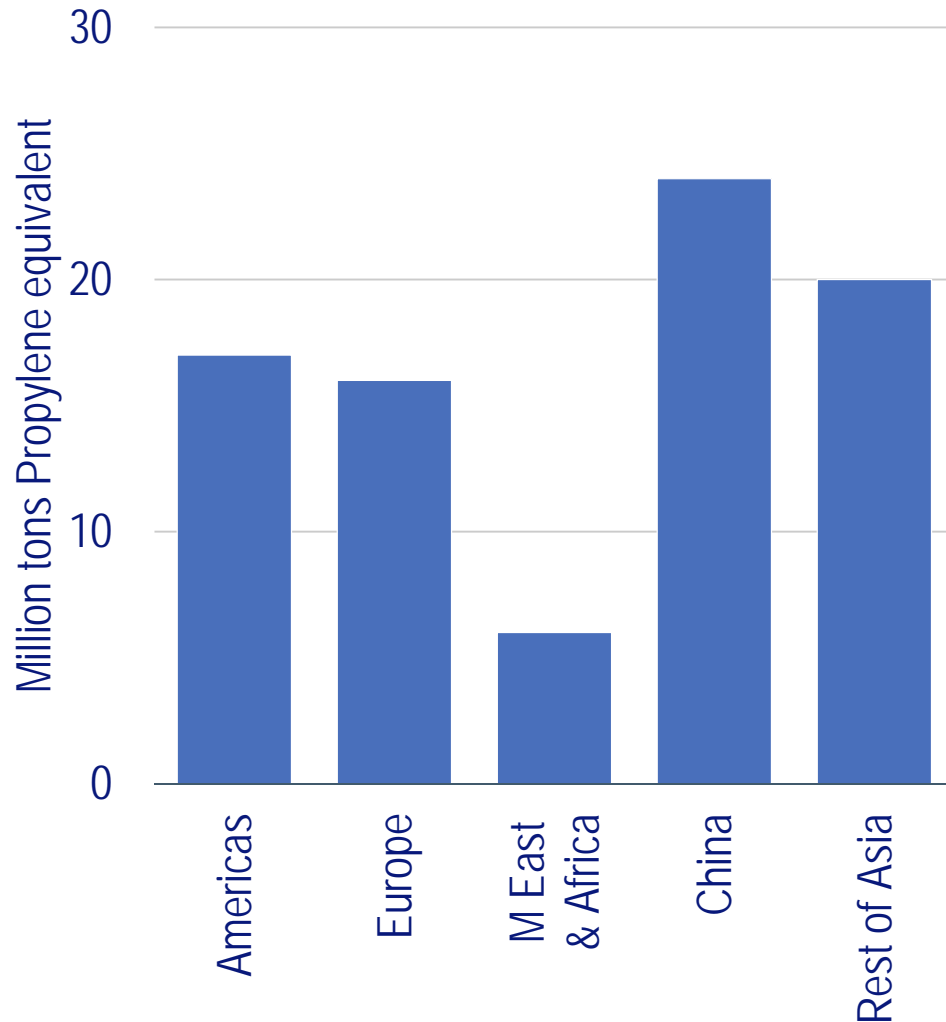
Net Trade in Ethylene and Key Derivatives



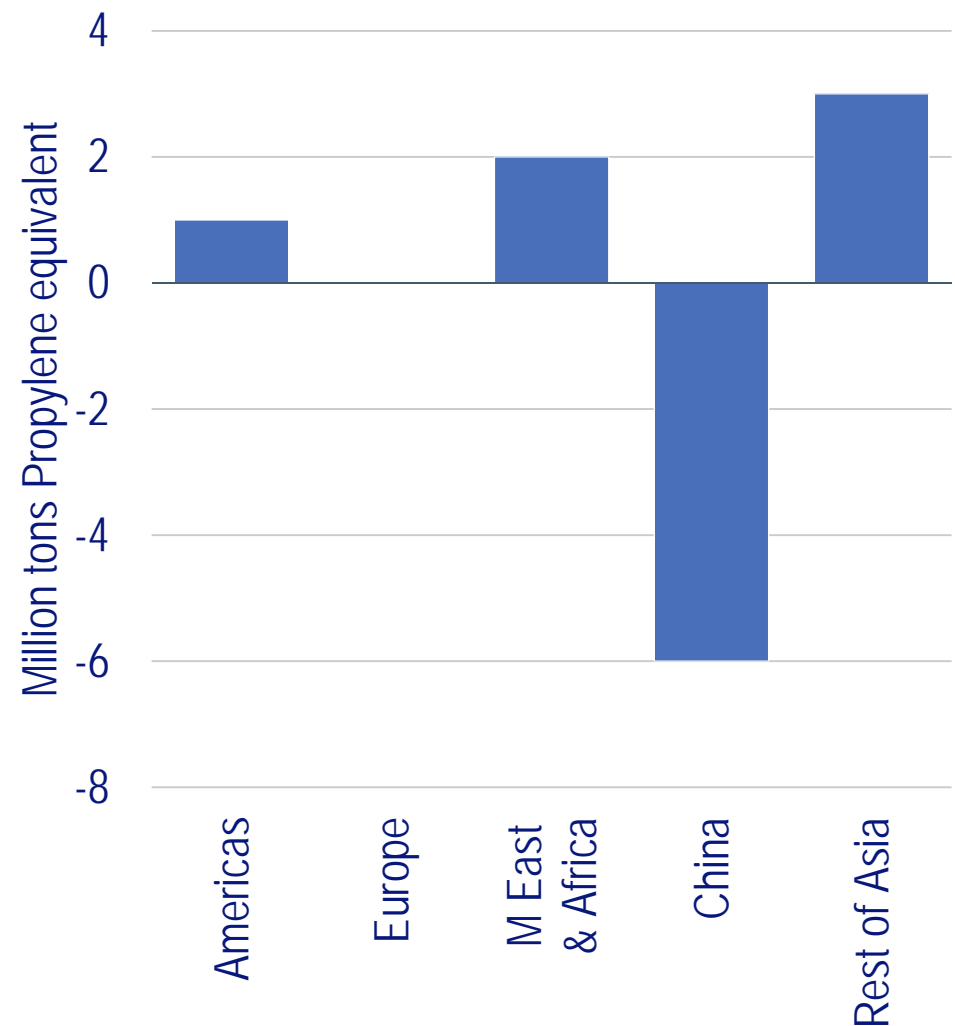
The Middle East, Japan, Korea and Southeast Asia supply propylene derivatives to China



Demand for Key Propylene Derivatives

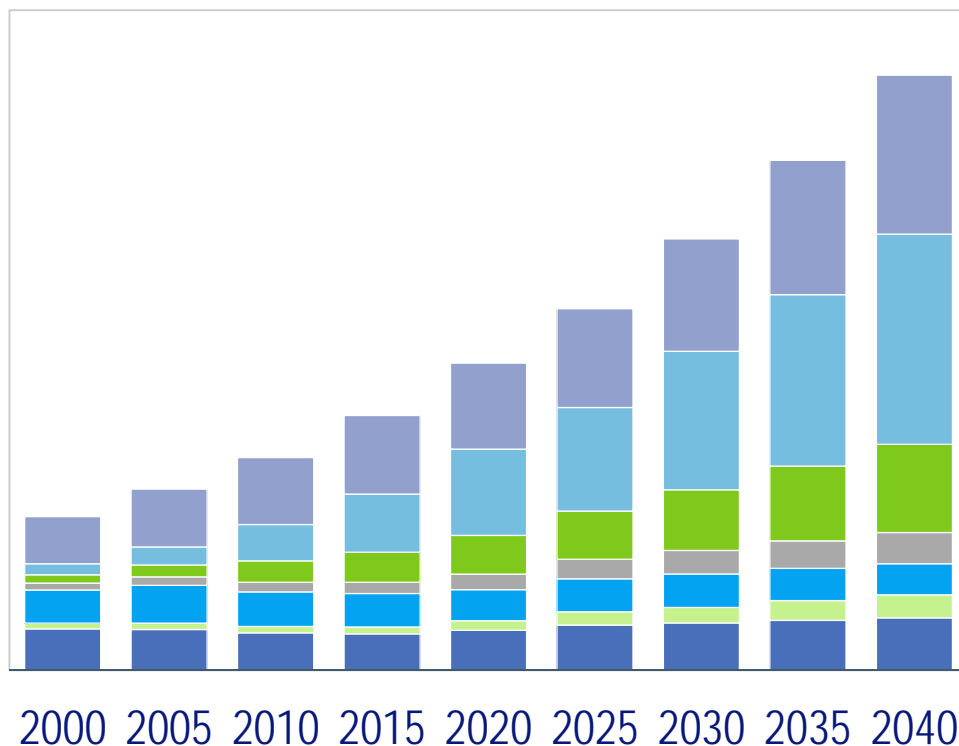


Net Trade in Propylene and Key Derivatives



Long-term annual average growth in consumption will average 3.5 percent per year

Feedstock Consumption

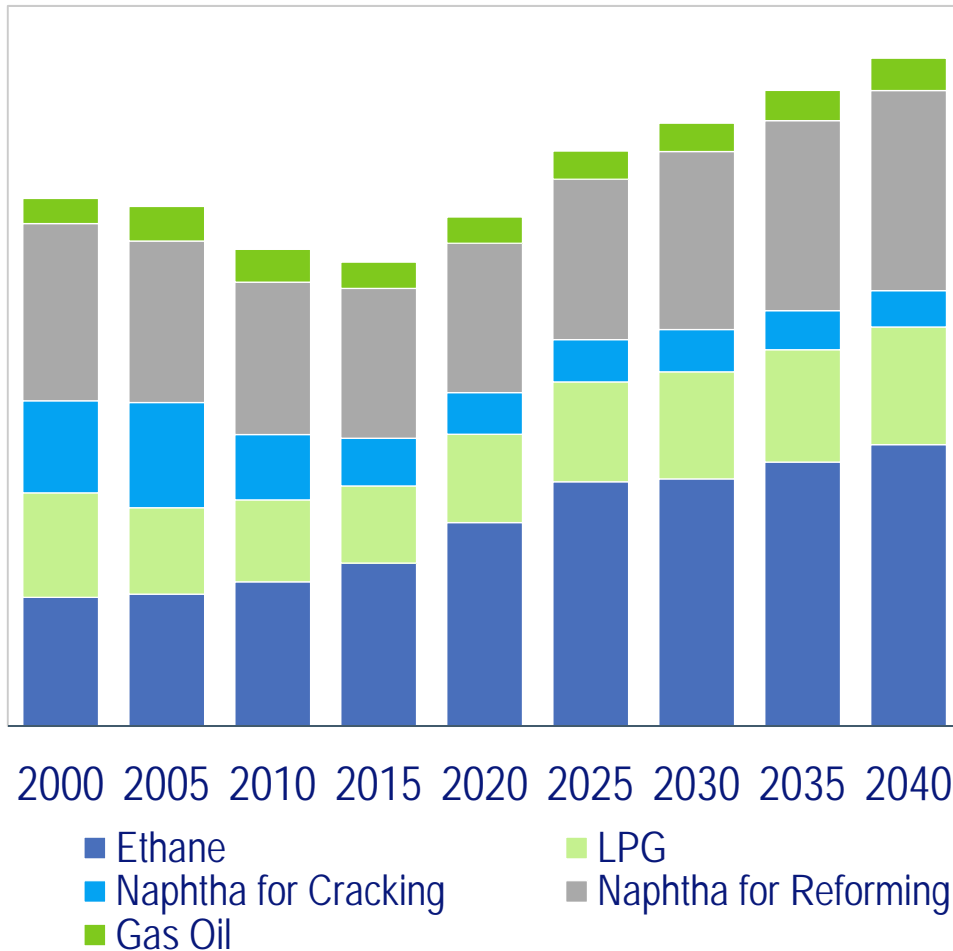


- The growth in feedstock advantaged regions such as North America and the Middle East will account for 20 percent of global growth to 2040
- China's feedstock consumption growth will account for 45 percent of the global total, although half of this demand growth will be for methanol
- China will also import growing volumes of derivatives



Following decades of stagnation North America has returned to investment and growth

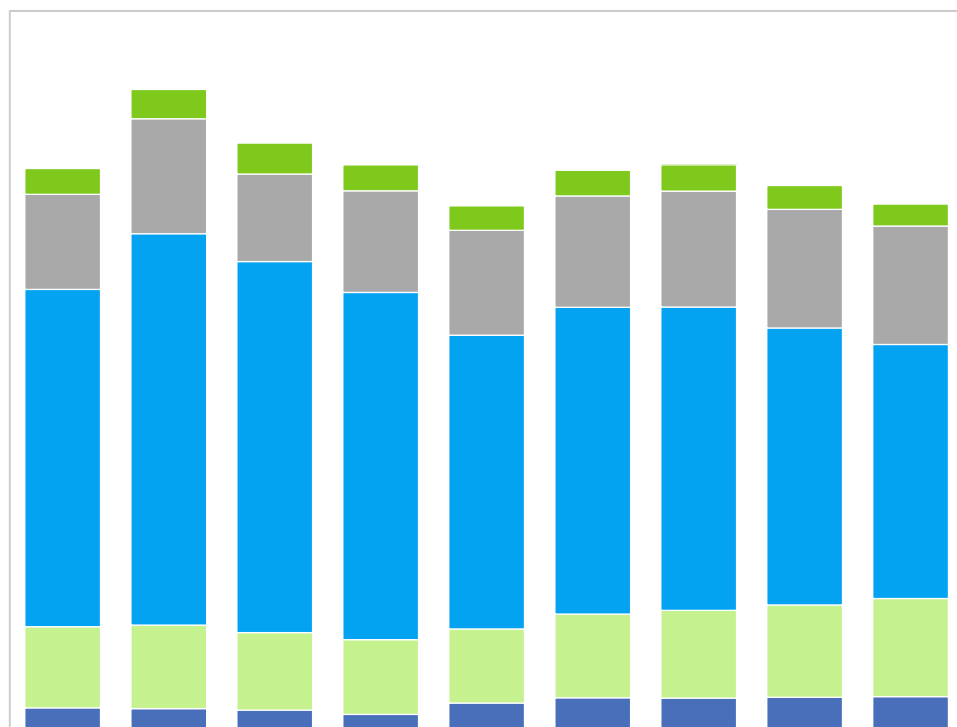
Feedstock Consumption – North America



- Shale drilling is focussed on “wet” gas regions containing ethane and other natural gas liquids
- Low cost ethane is boosting demand from steam crackers and several steam crackers have converted from naphtha to ethane feed
- Naphtha consumption for steam cracking has halved since 2005
- Several major new ethane crackers are planned
- Mandatory ethanol blending in gasoline has replaced some reformat, and therefore reduced naphtha demand for reforming.
- Demand growth for ethylene derivatives in the Americas is limited and expansion is mostly for derivative exports
- Ethane exports to existing plants in other regions are also planned

Further decline in E.U. petrochemical production is expected

Feedstock Consumption – Western Europe



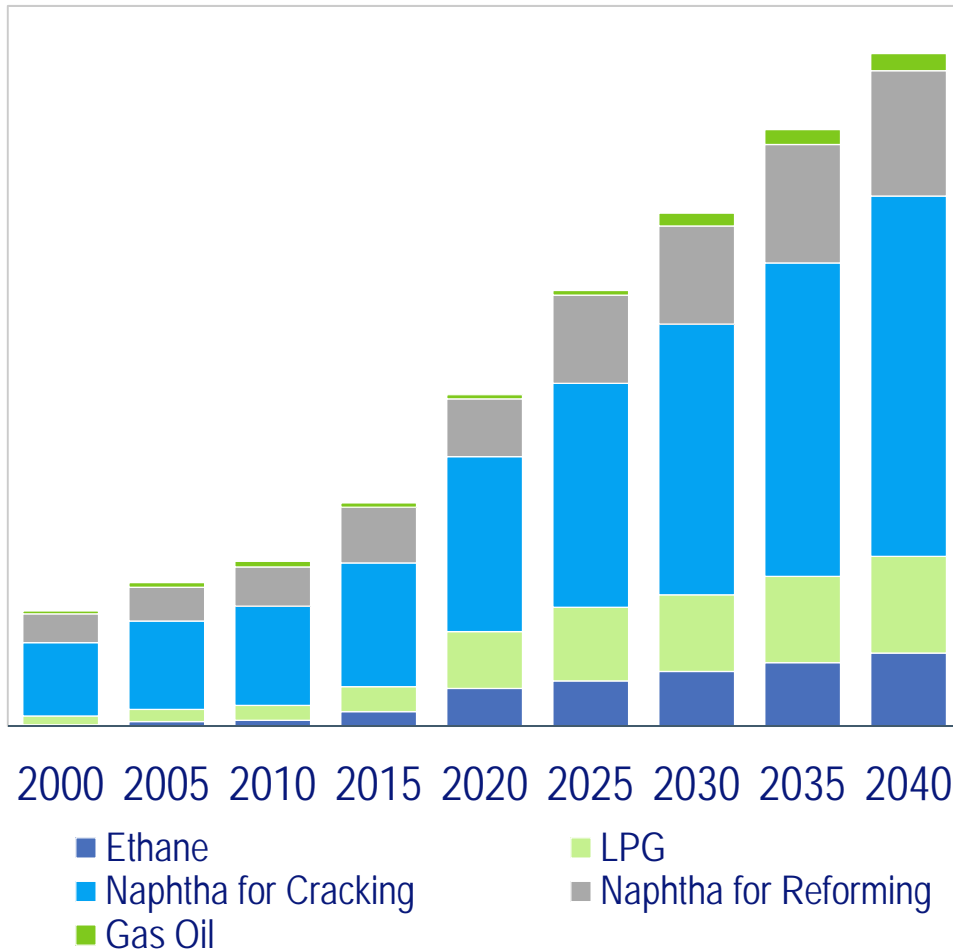
2000 2005 2010 2015 2020 2025 2030 2035 2040

- Ethane
- LPG
- Naphtha for Cracking
- Naphtha for Reforming
- Gas Oil

- Petrochemicals production in Western Europe has a competitive disadvantage due to high energy and labour costs
- Capacity has gradually been closed due to low margins at laggard plants
- The closure of several small steam crackers has reduced naphtha consumption
- Imports of U.S. ethane will start in 2015, and will grow to 2-3 million tons per year
- Well integrated and specialised sites will survive but some more subscale crackers will close
- Some refinery closures are also expected
- Reforming activity at the operating refineries is not at risk due to the value of hydrogen for desulphurisation

Strong demand growth and low feedstock prices in Eastern Europe

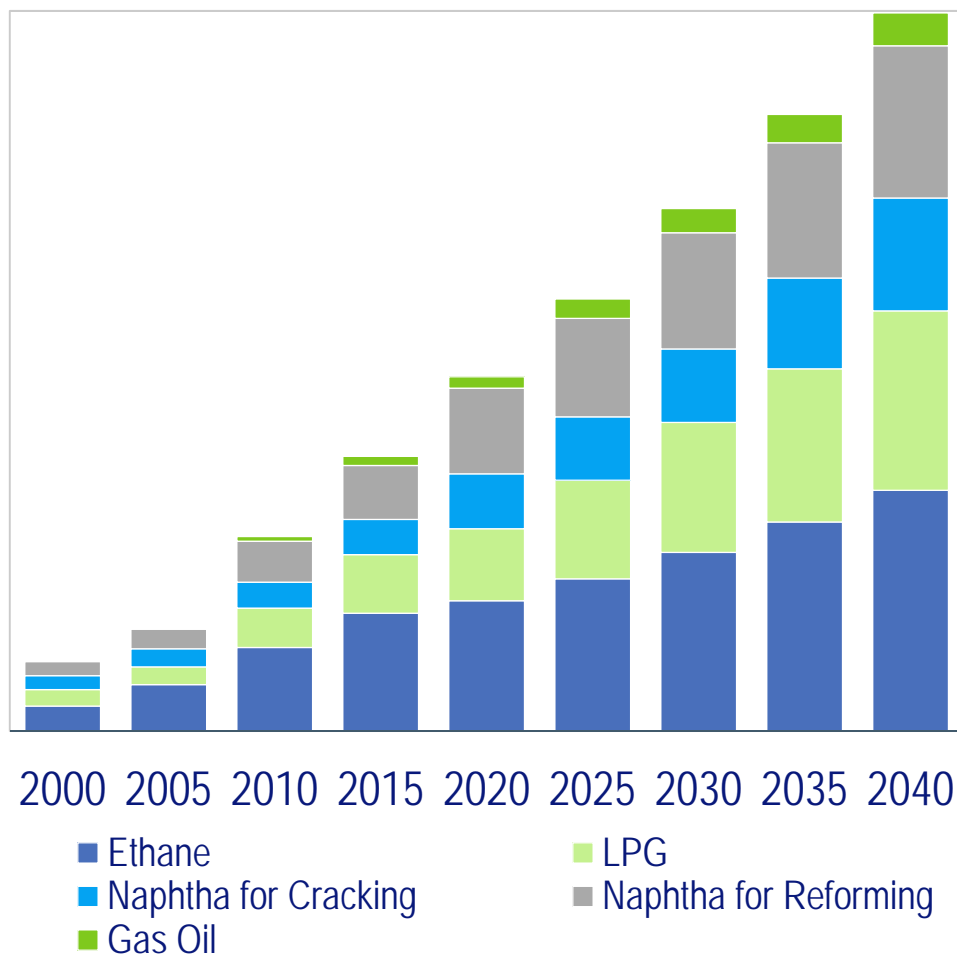
Feedstock Consumption – Eastern Europe



- Feedstock prices give Russia a cost advantage and will drive growth
- Naphtha cracking will provide the majority of petrochemicals growth in the long term
- Gas gathering systems to reduce flaring in oilfields are providing increasing supply of NGLs for olefins production
- Russian oil companies have several east-facing projects under consideration, including export-oriented refinery/cracker complexes on the eastern seaboard, and joint ventures in China
- Kazakhstan and Uzbekistan have growing, energy-advantaged chemicals production, while output in Ukraine and Belarus is declining due to high feedstock costs and uncompetitive facilities

Diversification of feedstocks and petrochemicals drives Middle Eastern growth

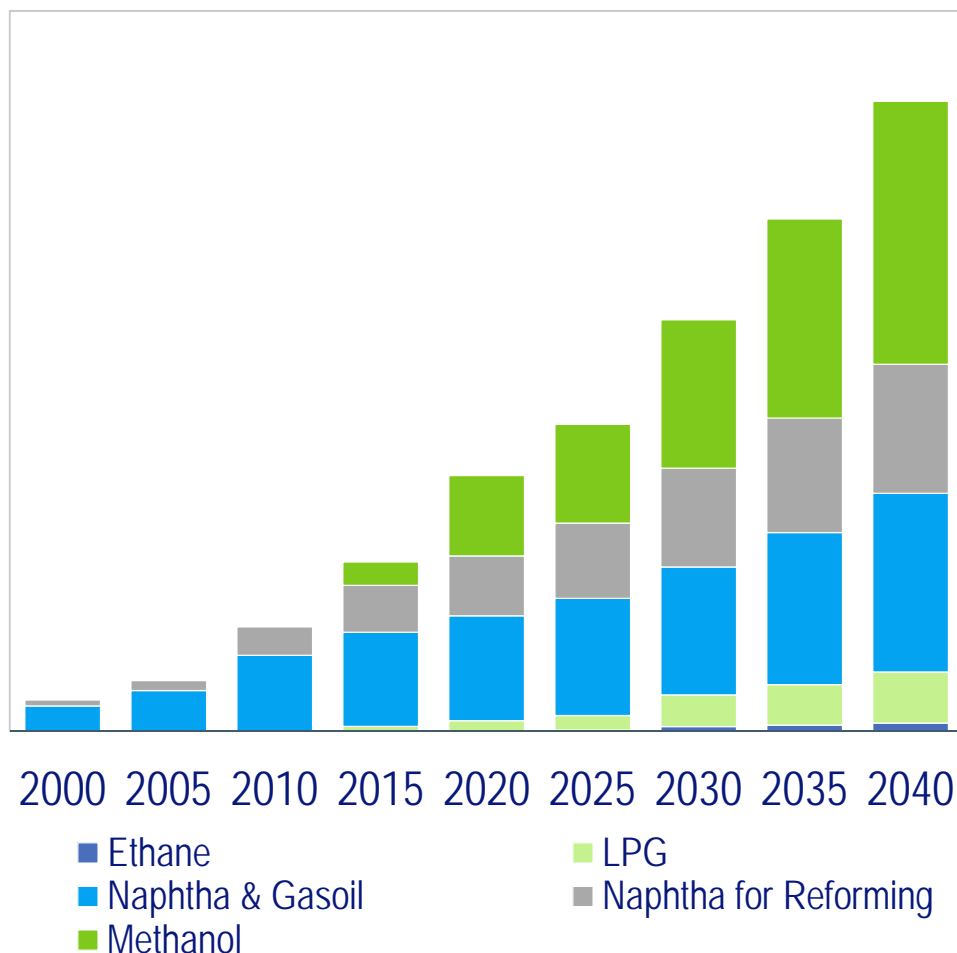
Feedstock Consumption – Middle East



- The Middle East constitutes the largest and lowest cost block of export-oriented petrochemicals production globally
- The low, fixed prices for ethane have provided massive competitive advantage since the upwards shift in oil prices in 2005
- There will be additional ethane available in the region but attention is shifting to heavier feedstocks to sustain growth
- Aromatics and gasoline production is providing strong growth in naphtha demand for reforming
- Naphtha-based olefins production is significantly higher cost but does enjoy the region's low energy costs

Industrialisation and urbanisation drives consumption growth of petrochemicals in China

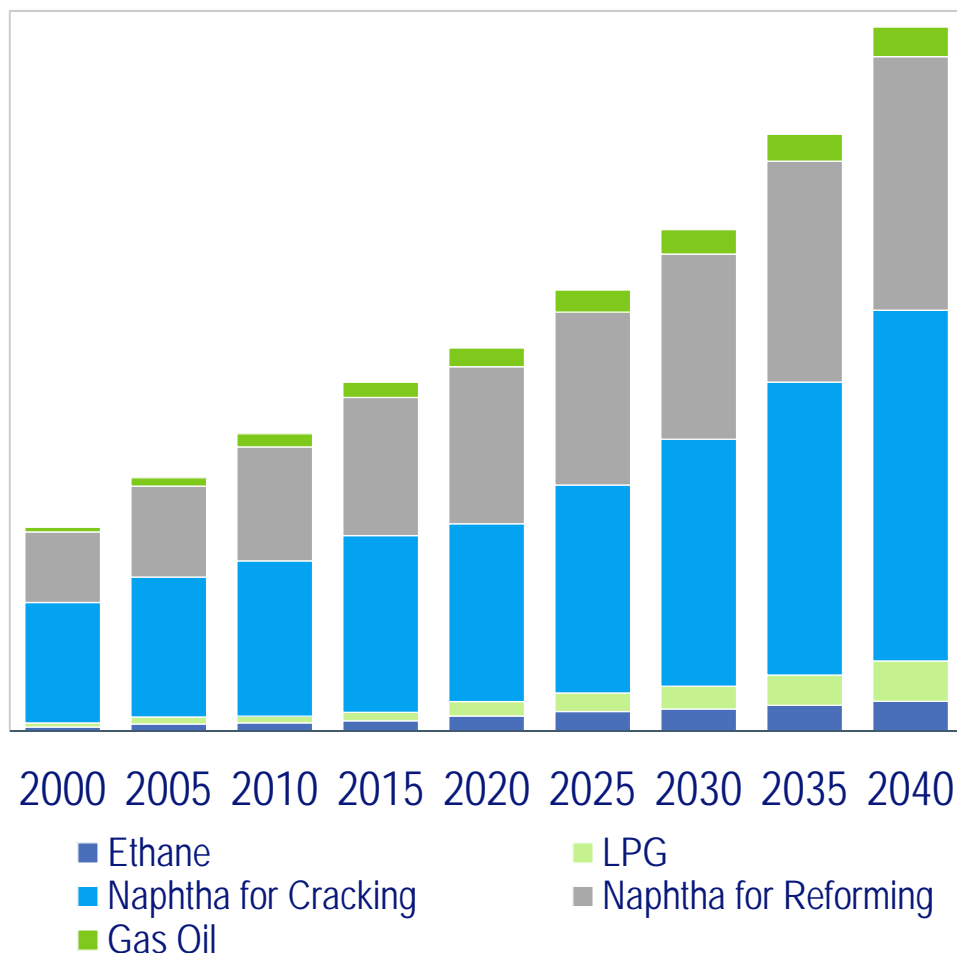
Feedstock Consumption – China



- Industrialisation increases consumption of plastics and chemicals while urbanisation leads to higher use of packaging and household products
- Feedstock consumption is mainly driven by refinery integrated naphtha/gasoil based steam crackers
- Poor refining and chemicals margins have greatly reduced investment in new refinery/chemical complexes in the medium term
- Methanol-based olefins production is soaring with 5 plants now operating and 25 more under construction
- Almost all methanol in China is produced from coal
- Although not commercially proven, methanol-to-aromatics could become significant in the long term replacing imports

Population growth, industrialisation and exports to China are driving Asian production

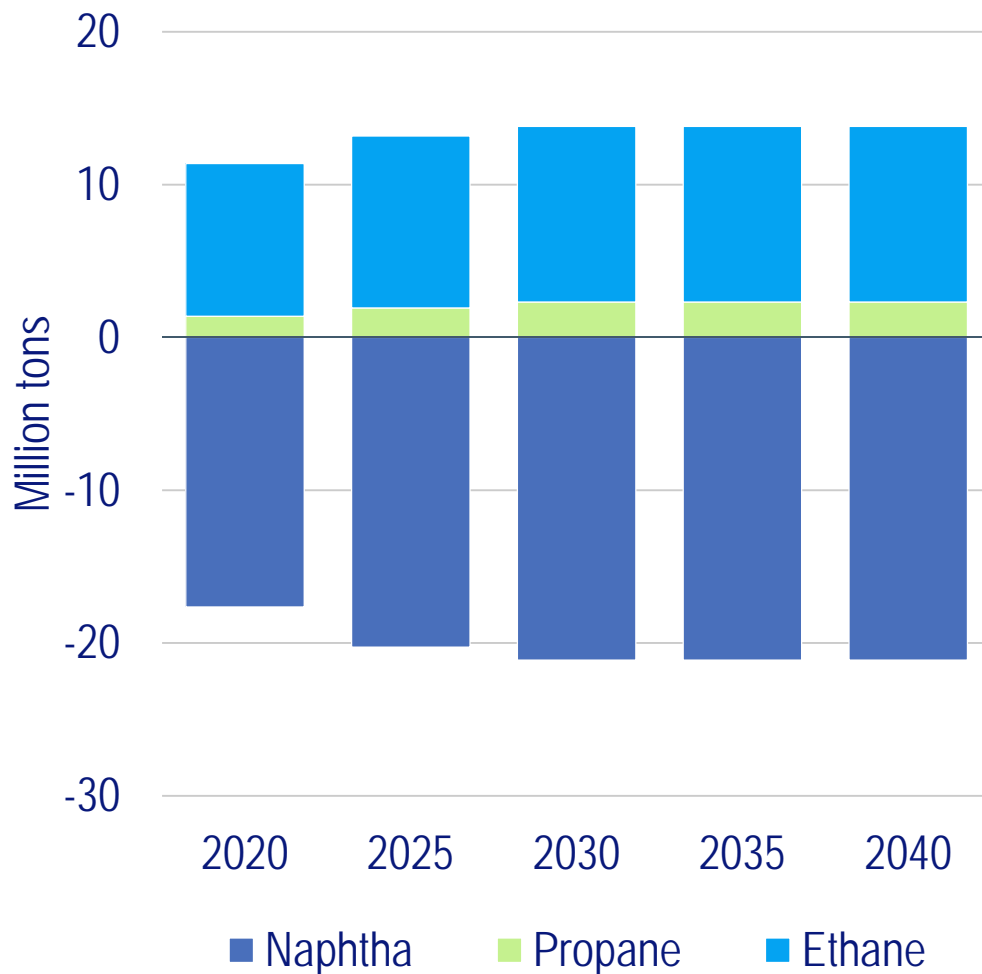
Feedstock Consumption – Rest of Asia



- Japan, South Korea, Taiwan, Singapore and India have large-scale, refinery integrated naphtha-based chemicals production
- South Korea and Japan are among the key global exporters of polyolefins and aromatics, although Japan's output is declining
- U.S. ethane is to be imported into India from 2016. Asia shale gas/oil developments are not expected to yield sufficient volumes of ethane to provide low-cost feedstock
- Asian naphtha cracking is higher cost than production based on advantaged NGLs in the Middle East and North America
- However, Asia has lower construction and labour cost, and is in the major growing market
- Asian naphtha-based crackers will make up the demand growth that cannot be covered by advantaged feeds

A scenario of even higher shale gas based ethylene production would impact naphtha

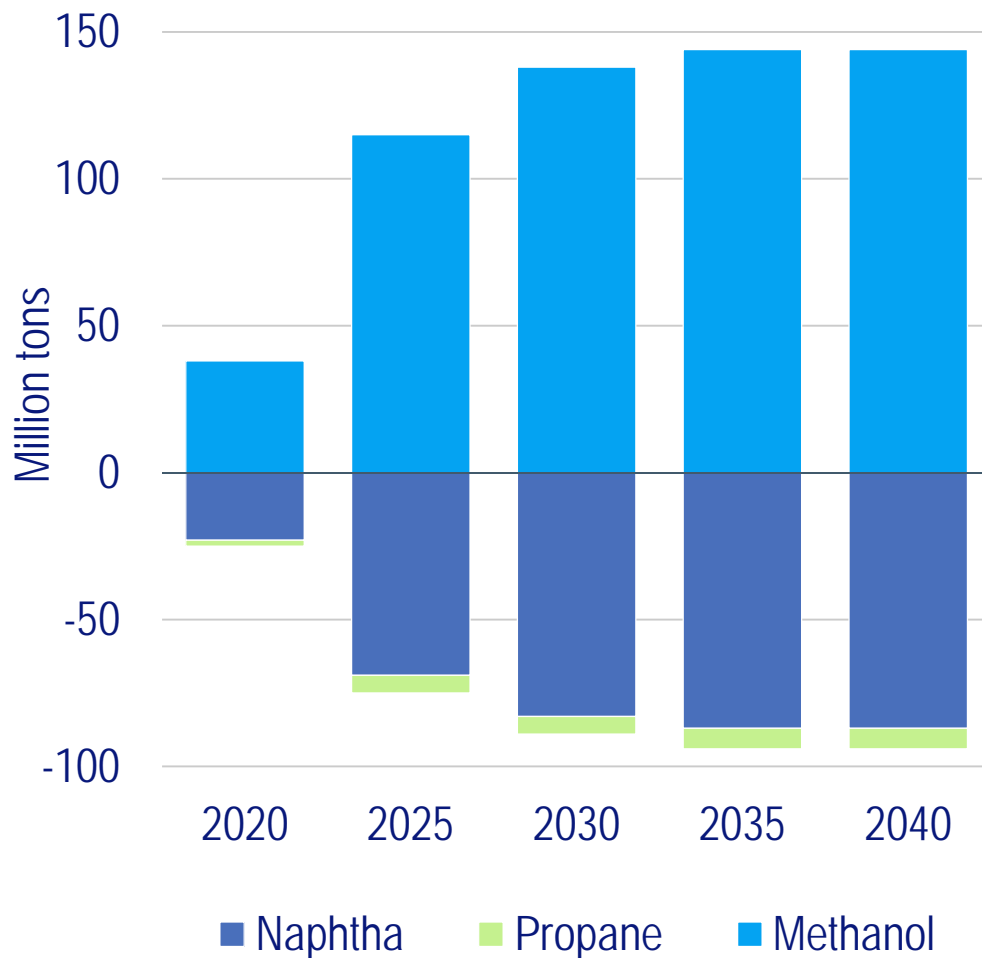
Global Feedstock Consumption Change



- U.S. ethane exports would rise to nine million tons per year by 2020, at least one more ethane export terminal will be built
- Ethane exports will go to operators of mixed-feed crackers. The increase in ethane cracking is assumed to displace propane and naphtha in equal measure.
- The high ethane scenario would also mean greater availability of propane. Propylene production from propane dehydrogenation (PDH) will develop to meet demand.
- Additional aromatics production from naphtha will be required to meet demand

A scenario of higher production from non-oil & gas feedstock would also impact naphtha

Global Feedstock Consumption Change



- A scenario of higher petrochemical production from coal and biomass, via methanol, has been developed
- The high alternative feedstock scenario would lead to further MTO developments in China but also in the U.S.
- Methanol-to-aromatics capacity could also develop, reducing investment in conventional naphtha reforming
- Additional MTO production would substitute naphtha-based steam crackers
- MTO production of ethylene and propylene would reduce the propane requirement for PDH



Conclusions

Shale gas

- The pace of North American shale gas has changed the competitive landscape
- Investment in new ethane crackers in North America will lead to exports of competitive ethylene derivatives
- However, propylene and butadiene derivatives will be imported
- Shale development elsewhere will not lead to such low ethane prices

China's use of coal as a feedstock

- China is using MTO/MTP technology to manufacture olefins from its low-value coal reserves
- The growth in consumption in China will be met from increased Chinese production and imports

Issues faced by the E.U.

- European petrochemical production is declining due to high feedstock and energy prices, small and inefficient facilities and high overhead costs

Biotechnology

- Currently, Brazil is leading the world in the development of bio-derived chemicals
- Elsewhere it will have a small impact on petrochemicals at current oil & gas prices



1 King's Arms Yard,
London, EC2R 7AF

Telephone: +44 20 7950 1600
Facsimile: +44 20 7950 1550

www.nexant.com

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