Global Petrochemical Market Outlook
Planning For An Uncertain Future

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IHS Chemical ....represents the most comprehensive source for chemical market research, expertise, analytics and consulting in the world.
## The Global Chemical Industry…

... Enabling Of Modern Living

### Natural Resources

<table>
<thead>
<tr>
<th>Mining, drilling, refining, gas processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
</tr>
<tr>
<td>Gas</td>
</tr>
<tr>
<td>Coal</td>
</tr>
<tr>
<td>Minerals</td>
</tr>
<tr>
<td>Renewables</td>
</tr>
</tbody>
</table>

### Chemical Industry Value Chain

#### Base Chemicals
- Olefins (Ethylene, propylene, butylene)
- Aromatics (benzene, toluene, xylenes)
- Chlor-akali (chorine, caustic soda)
- Others (ammonia, phosphorous)

#### Chemical Intermediates
- Commodities
- Differentiated commodities
- Technical specialties

#### Formulated products / performance materials
- Plastics and engineering resins
  - Extruded films, pipe, profiles, coatings, sheet, foams
  - Blow-molded parts
  - Composites
- Synthetic fibers
- Rubber products
- Paints and coatings
- Adhesives and sealants
- Lubricants
- Water treatment products
- Cleaning products
- Industrial chemicals
- Flame retardants

### Customers
- Automotive / transportation
- Consumer products
- Packaging
- Building / construction
- Recreation / sport
- Industrial
- Medical
- Pharmaceutical
- Personal care
- Textiles
- Electrical / electronics
- Aircraft / aerospace
- Business equipment
Gas-to-Crude Ratio Drives Regional Investment Activity In The Chemical Industry

US Energy Price Trends: 1990 to 2022

Source: IHS

© 2016 IHS
Impact of Changing Energy Dynamics On Regional Chemical Production

Annual Change - Total Basic Chemicals Production: Ethylene, Propylene, Methanol, Benzene, Paraxylene, Chlorine

- Total Basic Chemicals Production: Ethylene, Propylene, Methanol, Benzene, Paraxylene, Chlorine
Developing World Economic Growth Is Evolving Along With Contribution To Chemicals Growth

- BRICs fueled global economy from 2000 to 2008; resulting in strong demand growth.
- Russia & Brazil have not recovered from 2009 and face current recessions.
- India remains a bright spot with steady growth.
- China economic reform full impact has yet to be seen.

Source: IHS © 2016 IHS
Global Energy & Economic Fundamentals Have Changed…Impacting Chemical Investment Decisions

• Crude oil price trends impact regional competitiveness, cash margins, investment decisions.

• Ethane/gas based investments in North America see lower margins in low crude oil market.

• Key decisions of location, feedstock, technology, scale, growth, cost position: are much less “obvious”

• Result is a slowdown in approving new investments for 2020+
Planning For An Uncertain Future - Agenda

- 2015 Performance & Short Term Forecast
- Impact of Energy at the Extremes
- Near Term & Future Capacity Additions
- Profit Cycle Has Major Role
- Looking Beyond 2020
Basic Chemicals 2015 “Demand Performance”
Near term forecast is strong for light olefins, methanol

2014 vs 2015 Demand Growth, Average Growth to 2020, and GDP Elasticity

- Ethylene
- Propylene
- Methanol
- Paraxylene
- Benzene
- Chlorine

Million Metric Tons

2014
2015

2015 Elasticity (right axis)

Source: IHS

© 2016 IHS
Basic Chemicals 2015 “Demand Performance”
Near term forecast is strong for light olefins, methanol

2014 vs 2015 Demand Growth, Average Growth to 2020, and GDP Elasticity

Source: IHS

© 2016 IHS
Significant Demand Growth Could Challenge Supply

130+ MM Metric Tons from 2014 to 2020

- Ethylene, Methanol show strength, with 36+ MM metric tons each; Propylene growth at 32+ MM; stronger than GDP growth.
- Benzene, Chlorine and Paraxylene growth is modest, near 1xGDP or below.
- Total demand for basic chemicals by 2020 forecast over 560 MM metric tons (approx. 4% per year).
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- Near Term & Future Capacity Additions
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Extreme Energy Will Impact Chemical Industry Trends

- Rapid decline in crude oil pricing causes supply-chains to “pause”.
- Lower costs combined with a pause in demand, result in price declines……lower prices can stimulate chemical demand in some markets.
- Falling prices / lower margins force re-assessment of capital spending.
- Combination can create tight markets near term and will influence future investment decisions.
Low Crude Oil Drives Chemical Market Price Declines

- Basic chemical regional spot prices respond to lower crude oil pricing.
- Crude oil feedstock based products declined between $500 - $700/MT.
- Methanol prices, driven by gas and coal economics, show less of a response.
- Price response in derivative markets show varied impact on cash margins. Demand stimulus in plastics markets.

Regional spot prices: ethylene, propylene, benzene, paraxylene, methanol

Source: IHS © 2016 IHS
Response To Low Crude Oil Is Varied By Region, By Market

USGC PE & Ethylene Price and Cash Margin Trends

USGC Integrated Polystyrene Cash Margins

Source: IHS © 2016 IHS
Chemical Investments Dominated By Asia/Pacific With China Leading The Way

Current wave is set; what about beyond 2020?

From 2014 to 2020, total capacity will increase by 144 MM metric tons.

Source: IHS

© 2016 IHS
Key Assumptions Regarding *Future Investments*…
…No Longer “Obvious”

**Investment Assumptions:**
- Global crude oil price scenarios
- Global economic growth outlook
- North American energy market
- Current state of the profit cycle
- China structural changes
- Iran sanctions
- Non-conventional technology
- Sustainability
- Levels of integration
- Logistics investments
- Geo-political considerations

Photo courtesy of Braskem Idesa
Energy Will Influence Location & Technology For New Capacity Decisions

Crude Oil -Vs- US Natural Gas & NGLs

<table>
<thead>
<tr>
<th>Year</th>
<th>Brent Crude</th>
<th>USGC Light Naphtha</th>
<th>USGC Ethane</th>
<th>USGC Propane</th>
<th>Henry Hub Gas</th>
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<td>2020</td>
<td>45</td>
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Source: IHS © 2016 IHS
Non-conventional Technology Providing Options For Future Investments In Olefins Production

<table>
<thead>
<tr>
<th>Year</th>
<th>Brent Crude ($/Bbl)</th>
<th>Natural Gas ($/MM Btu)</th>
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</thead>
<tbody>
<tr>
<td>2011</td>
<td>111</td>
<td>4.14</td>
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<td>2013</td>
<td>109</td>
<td>3.76</td>
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<tr>
<td>2015</td>
<td>52</td>
<td>2.76</td>
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</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>Conventional Olefins Cash Cost</th>
<th>Non-conventional Olefins Cash Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2011</td>
<td>2013</td>
</tr>
<tr>
<td>US Ethane</td>
<td>800</td>
<td>1200</td>
</tr>
<tr>
<td>US PDH</td>
<td>1000</td>
<td>1400</td>
</tr>
<tr>
<td>NEA PDH</td>
<td>1200</td>
<td>1600</td>
</tr>
<tr>
<td>NEA Naphtha</td>
<td>1400</td>
<td>1800</td>
</tr>
<tr>
<td>WEP Naphtha</td>
<td>1600</td>
<td>2000</td>
</tr>
<tr>
<td>US GTP</td>
<td>2000</td>
<td>2400</td>
</tr>
<tr>
<td>US GTO</td>
<td>2200</td>
<td>2600</td>
</tr>
<tr>
<td>NEA CTO</td>
<td>2400</td>
<td>2800</td>
</tr>
<tr>
<td>NEA MTO</td>
<td>2600</td>
<td>3000</td>
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</table>

PDH = Propane Dehydro; GTP = Gas to Propylene; GTO = Gas to Olefins; CTO = Coal to Olefins; MTO = Methanol to Olefins
Where To Invest The Next Wave Of Capacity Beyond 2020?

<table>
<thead>
<tr>
<th>Region</th>
<th>2015</th>
<th>2020</th>
<th>Delta</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>90</td>
<td>121</td>
<td>31</td>
</tr>
<tr>
<td>South America</td>
<td>24</td>
<td>26</td>
<td>2</td>
</tr>
<tr>
<td>Europe</td>
<td>89</td>
<td>91</td>
<td>2</td>
</tr>
<tr>
<td>Middle East + Africa</td>
<td>78</td>
<td>94</td>
<td>16</td>
</tr>
<tr>
<td>Asia/India - China</td>
<td>130</td>
<td>146</td>
<td>16</td>
</tr>
<tr>
<td>China</td>
<td>175</td>
<td>216</td>
<td>41</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>586</strong></td>
<td><strong>694</strong></td>
<td><strong>108</strong></td>
</tr>
</tbody>
</table>

* Ethylene, Propylene, Methanol, Benzene, Paraxylene, Chlorine
Where To Invest The Next Wave Beyond 2020?

Global Chemical Capital Expenditures

Source: IHS © 2016 IHS
Next Ten Years Will See Slower Investment Pace In China and New Countries In The Top 10

**Base Chemical Capacity Growth: 2005-15**

- Total Additions, MM Ton: 298
- Total top 10 Countries, MM Tons: 252
- Top 10 Countries, % of total: 84%
- Total Closures, MM Tons: 11.5

**Base Chemical Capacity Growth: 2015-25**

- Total Additions, MM Ton: 265
- Total top 10 Countries, MM Tons: 222
- Top 10 Countries, % of total: 83%
- Total Closures, MM Tons: 7.5

Source: IHS © 2016 IHS
Chemical Industry Marco-Trends For China

13th Five-year plan calls for change

- Capacity overbuild has created supply surplus in certain product chains.
- Private company investment continues to gain market share.
- Overseas investment becomes active.
- Policy – moving toward market-driven dynamics to drive investments.
- Government promotes industry consolidation to combat pollution and improve industry efficiency and safety.
In China, Headlines Mask Underlying Growth In Domestic Markets

- Chinese growth slowing, but absolute growth dwarfs other economies
- Growth shifting to services sector and away from fixed investment
- Slowdown concentrated in industrials – primarily in mining, utilities and heavy manufacturing
- Increasing consumer spending will continue to drive domestic consumption of basic chemicals and plastics
  - >75% of Chinese plastics demand is in consumer non-durable
China Aggressively Adds Chlorine, Methanol, Propylene

- China demonstrating aggressive investments in basic chemicals to maintain a high degree of self-sufficiency.
- China will add nearly 250 MM metric tons during a period of three decades.
- Since 2010, major additions in propylene, methanol, and chlorine.
Private Investment Continues to Gain Market Share

- SOE’s dominance has been challenged
- Private and provincial companies continue gaining market share
- But, the growth will slow down
- Private investment intensifies competition and drives down prices and margins

Aggregated capacity for benzene, PX, ethylene, propylene, MEG, PTA, methanol
China Seeking To Develop Industry In Strategic Locations

- Over 140 chemical industry parks in China
- Chemical facilities will be relocated or built inside industrial parks
- The government will focus on seven national chemical industrial parks
- Several major petrochemical projects are planned
Chemical Industry Marco-Trends For North America

- Low cost energy and natural gas liquids provide sustainable advantage for new investment wave.

- Advantaged feedstock will enable an additional wave beyond 2020, assuming crude oil price recovery (near $80/bbl) and low natural gas pricing (near $3/MM BTU).

- Domestic and International companies are seeking to invest to leverage the low-cost opportunities. New entrants to create increased competition in domestic markets.

- Logistics & port infrastructure investment needed to support higher level of exports.
North America & Middle East *(conventional)* Remain Low Cost

Non-conventional routes perform well in high crude oil scenario

**World Ethylene Cast Cost Comparison**

(Cash cost = Feed + VC + FC – co-product)

<table>
<thead>
<tr>
<th>Year</th>
<th>Brent Crude ($/Bbl)</th>
<th>USGC Natural Gas ($/MM Btu)</th>
<th>2011</th>
<th>2016</th>
<th>2021</th>
<th>SAR @ $1.75/MMbtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>112</td>
<td>4.14</td>
<td></td>
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<tr>
<td>2016</td>
<td>42</td>
<td>2.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2021</td>
<td>91</td>
<td>3.5</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Source: IHS

GTO = Gas-to-Olefins; CTO = Coal-to-Olefins; MTO = Methanol-to-Olefins

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US Low Cost Brings Back Methanol and Ethylene

- After peaking near 80 MM metric tons near 2001, the US shut down capacity in methanol and ethylene near 2010.
- Shale oil & gas have brought back competitive economics to the US, resulting in expansions in methanol and ethylene capacity.

Source: IHS

*Completed or Firm Projects (Thousand Metric Tons)*

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Total Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>ChevronPhillips</td>
<td>Cedar Bayou, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Dow</td>
<td>Freeport, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Dow</td>
<td>Plaquemine, LA</td>
<td>250</td>
</tr>
<tr>
<td>Equistar</td>
<td>Various sites</td>
<td>401</td>
</tr>
<tr>
<td>ExxonMobil</td>
<td>Baytown, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Flint Hills</td>
<td>Port Arthur, TX</td>
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<tr>
<td>Formosa</td>
<td>Point Comfort, TX</td>
<td>1,150</td>
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<td>Indorama</td>
<td>Lake Charles, LA</td>
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<tr>
<td>Lotte/Axiall</td>
<td>Lake Charles, LA</td>
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</tr>
<tr>
<td>Oxy/Mexichem</td>
<td>Ingleside, TX</td>
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</tr>
<tr>
<td>Shell</td>
<td>Monaca, PA</td>
<td>1,500</td>
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<tr>
<td>Shin-Etsu</td>
<td>Plaquemine, LA</td>
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<td>Sasol</td>
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<td>Westlake</td>
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<td>Williams</td>
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<tr>
<td>Braskem Idesa</td>
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</table>

**Total Additions**: 13,097

North American ethylene capacity will increase to 45+ million metric tons by 2020, driven by low-cost ethane feedstock.
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Near-term Chemical Industry Earnings Modestly Lower Before Improving on Tighter Markets and Higher Crude

- **2014**: Peak of earnings driven by regions with high proportion of gas-based production
- **2015**: Earnings down 15% due to M. East and Americas; APAC/Europe stronger on outages
- **2016**: Earnings decline 10% further with energy and capacity add; equal drop across all regions
- **2017-2018**: earnings improve as demand grows into supply base
- **2019-2020**: Earnings peak as oil recovers and demand grows into installed capacity base
Planning For An Uncertain Future…

Strategic Implications

- The investment landscape is changing with shifting demand growth and non-conventional options on technology and feedstock selection.

- High level of uncertainty in energy and economic fundamentals present planners with difficult scenarios for identifying the best path forward.

- Board level decisions require higher returns for approval; risk premiums escalate; defer approvals until conditions signal more predictable outcome.

- Where investment decisions in 2016 are “on hold”, could lead to supply limitations in the 2020+ time-period, as demand growth accelerates.