Global Petrochemical Market Outlook: 
*Impact of Energy at the Extremes*

*Presented to:* Valve Manufacturers Association of America

**MARKET OUTLOOK WORKSHOP**
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Agenda

- Energy, Economy & the role of Chemicals
- Impact of Energy At The Extremes
- Investment Trends
- Chemical Demand & Trade
- Impact On Profit Cycle
- Closing Thoughts
The Chemical Industry Enables Modern Living

...Connecting Energy Products With Consumer Markets

ENERGY

Energy markets provide essential BTU’s to power operations and feedstock sources including natural gas liquids, naphtha and coal that are consumed in the production of basic chemicals.

CHEMICALS

Chemical industry converts energy and feedstock's into basic chemicals, intermediates, plastics and fibers that are used to produce durable and non-durable consumer goods.

ECONOMY

Economic growth in developed and developing economies around the world drive consumer buying trends for durable and non-durable goods; hence creating demand for the chemical industry.
Customers of the Chemical Industry

- Automotive / Transportation
- Consumer products
- Packaging
- Construction
- Recreation / Sport
- Industrial
- Medical
- Pharmaceuticals
- Personal care
- Textiles
- Electronics
- Aerospace
- Business equipment

Natural Resources

- Oil
- Gas
- Coal
- Minerals
- Renewables

Chemical Industry Value Chain

<table>
<thead>
<tr>
<th>Natural Resources</th>
<th>Chemical Industry Value Chain</th>
<th>Customers of the Chemical Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining, Drilling, Refining &amp; Gas Processing</td>
<td>Basic Chemicals</td>
<td>Commodities</td>
</tr>
<tr>
<td>• Oil</td>
<td>Olefins (ethylene, propylene, butylene)</td>
<td>Commodity</td>
</tr>
<tr>
<td>• Gas</td>
<td>Aromatics (benzene, toluene, xylenes)</td>
<td>Differentiated Commodity</td>
</tr>
<tr>
<td>• Coal</td>
<td>Chlor-Alkali (chlorine, caustic soda)</td>
<td>Differentiated Commodity</td>
</tr>
<tr>
<td>• Minerals</td>
<td>Methanol</td>
<td>Differentiated Commodity</td>
</tr>
<tr>
<td>• Renewables</td>
<td>Others (e.g., ammonia, phosphorous)</td>
<td>Technical Specialties</td>
</tr>
</tbody>
</table>

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Extreme Energy Differentials Create Opportunities and Risks – July 2015

Constant 2012 Dollars Per MMBtu

Brent Crude & US Energy Prices

Brent Crude
USGC Light Naphtha
Henry Hub Gas
Ethane

Forecast by: IHS Energy

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Increasing Complexity In The Ethylene Value Chain

Emerging changes in ethylene supply drivers and demand drivers make modeling the ethylene supply/demand balance more complex than ever before.

Increased volatility in conventional feedstock's from traditional sources: naphtha, NGL’s, coal. Feedstock shifts create volatility in co-product markets.

- Gas or Coal to methanol
- Methanol to Olefins (MTO)
- Coal to Olefins (CTO)
- Catalytic / Oxidative Coupling of Methane to Ethylene (OCM)

Ethylene

Demand Shocks (GDP related) or Demand Shifts (product substitution related)

- Polyolefins Recycle, PE/PVC/PET
- Coal to MEG (skipping EO)
- Coal to VCM (skipping EDC)

Co-product impact: On purpose propylene via PDH, metathesis, coal, methanol
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Investment Drivers Vary By Region By Value Chain

- **North America (USA)**
  - Leverage low cost natural gas based chemicals into investments in ethylene, propylene and methanol based derivatives.
  - Invest to establish export channels to market that exceed historical norms.

- **Middle East (Saudi Arabia)**
  - Moderated investment pace, diversified feedslate to support downstream market development and continued industrial expansion well beyond ethylene chemistry.

- **North East Asia (China)**
  - Strong domestic investment focused on reducing import dependencies.
  - Leverage coal to chemicals technology near term.

Chemical Industry Investments Seek A Sustainable Advantage
Investment capital has shifted to North America, however, the vast majority of new investment continues to accelerate in Asia/Pacific, dominated by China.
Petrochemical Investment In China Moves West

- PX
- Olefins
- Olefin (Operating CTO/MTO)
- Olefin (CTO/MTO Construction)
- MEG (Operating)
- MEG (Construction)

*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>BASF/Total</td>
<td>Port Arthur, TX</td>
<td>128</td>
</tr>
<tr>
<td><strong>ChevronPhillips</strong></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>220</td>
</tr>
<tr>
<td>Eastman</td>
<td>Longview, TX</td>
<td>17</td>
</tr>
<tr>
<td>Equistar</td>
<td>Various sites</td>
<td>1,112</td>
</tr>
<tr>
<td><strong>ExxonMobil</strong></td>
<td>Baytown, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Flint Hills</td>
<td>Port Arthur, TX</td>
<td>100</td>
</tr>
<tr>
<td><strong>Formosa</strong></td>
<td>Point Comfort, TX</td>
<td>1,150</td>
</tr>
<tr>
<td>Oxy/Mexichem</td>
<td>Ingleside, TX</td>
<td>550</td>
</tr>
<tr>
<td>Shin-Etsu</td>
<td>Plaquemine, LA</td>
<td>500</td>
</tr>
<tr>
<td><strong>Sasol</strong></td>
<td>Lake Charles, LA</td>
<td>1,550</td>
</tr>
<tr>
<td>Westlake</td>
<td>KY and LA sites</td>
<td>216</td>
</tr>
<tr>
<td>Williams</td>
<td>Geismar, LA</td>
<td>258</td>
</tr>
<tr>
<td><strong>Braskem Idesa</strong></td>
<td>Mexico</td>
<td>1,000</td>
</tr>
<tr>
<td>Nova</td>
<td>Sarnia</td>
<td>168</td>
</tr>
</tbody>
</table>

North American ethylene capacity will increase to 45+ million metric tons by 2020, driven by low-cost ethane feedstock.

Total Additions: 11,469
North America Ethylene Projects “In The Press” 2020+
Projects Noted Below Are Not Firm, But Announced And Under Study

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Total Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aither Chemicals</td>
<td>West Virginia</td>
<td>200</td>
</tr>
<tr>
<td>Appalachian Resins</td>
<td>Salem Township, OH</td>
<td>275</td>
</tr>
<tr>
<td>Ascent</td>
<td>West Virginia</td>
<td>1,000</td>
</tr>
<tr>
<td>Axiall/Lotte</td>
<td>Lake Charles, LA</td>
<td>1,000</td>
</tr>
<tr>
<td>Badlands NGL 1</td>
<td>North Dakota</td>
<td>1,500</td>
</tr>
<tr>
<td>ChevronPhillips 2</td>
<td>Cedar Bayou, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Hanwha</td>
<td>TBA</td>
<td>1,000</td>
</tr>
<tr>
<td>Indorama</td>
<td>LA or TX</td>
<td>1,500</td>
</tr>
<tr>
<td>PTTCG/Marubeni</td>
<td>Shadyside, OH</td>
<td>1,000</td>
</tr>
<tr>
<td>Shell</td>
<td>Monaca, PA</td>
<td>1,500</td>
</tr>
<tr>
<td>Total</td>
<td>Port Arthur, TX</td>
<td>1,000</td>
</tr>
<tr>
<td>Williams</td>
<td>Geismar, LA</td>
<td>1,500</td>
</tr>
<tr>
<td><strong>Total Additions</strong></td>
<td></td>
<td><strong>12,975</strong></td>
</tr>
</tbody>
</table>

IHS Chemical & IHS Energy long term forecast assumes an additional 15 million metric tons ethane based ethylene in NAM from 2020 to 2030.
Global Base Chemicals Cumulative Demand Growth
2010 - 2020 = 224 Million Metric Tons

<table>
<thead>
<tr>
<th></th>
<th>Total Growth MM Tons</th>
<th>AAGR: 2010/20 MM Tons/Yr</th>
<th>AAGR: 2010/20, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene</td>
<td>61.6</td>
<td>5.6</td>
<td>3.5</td>
</tr>
<tr>
<td>Methanol</td>
<td>52.4</td>
<td>4.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Propylene</td>
<td>47.8</td>
<td>4.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Chlorine</td>
<td>28.1</td>
<td>2.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Paraxylene</td>
<td>19.4</td>
<td>1.8</td>
<td>4.5</td>
</tr>
<tr>
<td>Benzene</td>
<td>14.7</td>
<td>1.3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

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Regional Trade Is Critical To Success

- Trade is an essential element of basic chemical supply chains
- Low cost regions such as North America and the Middle East will export increasing volumes
- On-purpose technology will change trade patterns
- Significant investment in ships, ports, and infrastructure is needed to support increasing trade volumes

5 Countries Adding 75% of Base Chemical Capacity: 2010 to 2020 (231 MM Metric Tons)
China Remains Central To Basic Chemical Trade

US Ethylene Demand & Equivalent Trade

- **MM Metric Tons**
- **% of Capacity**

<table>
<thead>
<tr>
<th>Year</th>
<th>Net Equiv Exports</th>
<th>Domestic Demand</th>
<th>Net Exports, % of Cap.</th>
</tr>
</thead>
<tbody>
<tr>
<td>05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Net Equiv. Imports**
- **Domestic Demand**
- **Self-Sufficiency**

Net Exports, % of Capacity, Self-Sufficiency

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When Energy Markets Move
Chemical Will Markets Respond

- The rapid decline in crude oil pricing causes supply-chains to “pause” as buyers anticipate lower prices “tomorrow”.
- Combination of a pause in demand and the decline in costs for high-cost producers results in price decreases.
- As market prices “chase” falling costs, cash margins for high-cost producers can expand while cash margins for low cost producers will decline.
Chemical Markets Respond To Lower Crude Oil

“Price Setters” Driven By Crude Oil

“Price Setters” Driven By Coal or Gas

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Ethylene Cash Cost Comparison
*With Energy At The Extremes*

**US$ / Metric Ton**

![Graph depicting ethylene cash cost comparison with energy extremes.](image)

**Brent Crude ($/Bbl) and USGC Natural Gas ($/MM Btu)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Brent Crude</th>
<th>USGC Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>109</td>
<td>3.76</td>
</tr>
<tr>
<td>2015</td>
<td>59</td>
<td>2.82</td>
</tr>
</tbody>
</table>

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

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High Density Polyethylene Integrated Cash Margins

US Ethane Vs. Asia Naphtha

Ethane-based margins decline; maintain advantage near term

Source: IHS

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The Impact of Energy At The Extremes...

Conclusions

• Basic chemicals and derivatives markets adjust to “new energy”
• Price setters have lower cost...prices decline seeking new steady state; impact on trade
• Integrated margins for low-cost producers decline, some high-cost producer margins improve
• Approved “advantaged” projects advance; new projects may pause
• Demand declines followed by demand surge; trade patterns shift; potential upcycle in ethylene; propylene oversupply
The Impact of Energy At The Extremes...

Beyond 2020...

- **Availability of low-cost ethane and propane in North America** to support continued investments; both domestic and international.
- **Developments in on-purpose technology for olefins** versus traditional routes, including the use of methanol as a route to olefins.
- **Impact of coal-to-chemicals and on-purpose propylene in China**: private/provincial investment versus state-owned; self-sufficiency and surplus capacity impacting trade; economic slowdown and impact on need for imports for China.
- **Need for ethylene supplied from naphtha cracking**: both higher operating rates for existing assets and investments in new naphtha cracking.
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