State of the Global Petrochemical Industry

IHS Asia Chemical Conference
Singapore
September 3–4, 2014

Mark Eramo
Vice President, Chemical Insights
IHS Chemical
Houston, TX
mark.eramo@ihs.com
Agenda: State of the Industry

- Key Drivers In Base Chemicals
- Impact of Energy at the Extremes
- Regional Strategies
- Evolving Trade Dynamics
- Final Thoughts
Basic Chemicals Global Capacity

2000

- Ethylene, 97,691
- Benzene, 42,327
- Propylene, 59,623
- Chlorine, 53,144
- Methanol, 37,316

290 Million Metric Tons

2020

- Ethylene, 201,808
- Benzene, 70,269
- Chlorine, 94,578
- Propylene, 142,318
- Methanol, 131,536

640 Million Metric Tons
Changes In Energy & Demand Growth
Incentives Show Varied Results

Basic Chemicals Capacity Growth, Million Metric Tons

- Benzene
- Chlorine
- Methanol
- Propylene
- Ethylene

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Energy & Feedstocks

...make up 60-70% of the costs of chemical production. Investments seek a competitive advantage in energy and feedstock costs.

Demand Growth

Proximity to demand growth essential without distinct cost or technology advantage. Trade access is also key.

Technology

Technology to enable competitive production costs, economies of scale, high performance products. First to market is important.
Strategic Issues In Base Chemicals

• Incentives to build on-purpose threaten oversupply near term; US market shift in value to chemicals versus refining; demand trending towards GDP

• Crude oil to natural gas ratio is key to location of new capacity; and keep one eye on coal in China; new technology developments underway

• Understanding China is key; light olefins feedstock and fuels end-uses stimulate demand growth
Strategic Issues In Base Chemicals

- Electricity cost is the major factor; demand growth linked to construction materials; integration from ethylene to PVC provides competitive edge in US.

- Supply trends complicated by refining and chemicals; benzene trades while derivatives are local; Asia supply to North America is key.
The Demand Pull On Chemicals Starts With Consumers

Consumers -> Energy

Energy -> Petrochemicals

Petrochemicals -> Retail

Retail -> Consumer Goods

Consumer Goods -> Derivatives
Methanol Demand Growth Driven By Olefins & Fuel End-uses in China

Light Olefins Demand Growth Trends at 1x GDP

Benzene & Chlorine Demand Growth Trend Less Than GDP

Steady Global GDP Growth Essential To Chemical Demand

GDP Elasticity Vs Global GDP

Ethylene
Propylene
Methanol
Benzene
Chlorine
Global GDP, %

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Energy at the Extremes

Opportunities & Risks

- **Crude oil** priced near $100/bbl, and NAM natural gas prices near $5/MMBtu, likely sustained based on energy supply/demand outlook.

- **North American gas** cost structure is fundamentally changed by Shale Gas; low-cost supply dominates the landscape.

- **US Ethane** infrastructure expanding to supply new facilities; however, an increasing cost structure will pull prices for incremental supplies higher.

- **Coal price** declines resulting in high spreads to oil/naphtha – such differentials are needed to pay for higher capital required for CTO.

- **A sustained advantaged** for NAM natural gas and China coal versus crude oil will attract investment and shift the balance of new supply and product trade.
Feedstock Price Differentials vs. Crude Oil

Create opportunities in coal, gas, ethane

Price Difference, $MMBtu

-4.0
0.0
4.0
8.0
12.0
16.0
20.0


Brent - Nat Gas
Brent - Coal
Brent-ethane

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Three Regions with Different Markets all Focus on ‘Advantaged’ capacity

- Slowing investments, feed diversification
- Downstream market development
- Leverage resources for job creation
Middle East Industry Development Forged By Advantaged Feedstock

<table>
<thead>
<tr>
<th>Light Feedstock – C1/C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely High Margins – Substantially higher than industry average</td>
</tr>
<tr>
<td>Easy investment decision</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mixed Feedstock – C1/C2/C3/C4/Lt. Naphtha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Margins but still very competitive – Above industry average</td>
</tr>
<tr>
<td>Still relatively easy investment decision</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heavy feedstock – Naphtha (Market Linked Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drastic reduction in margins - margins in line with marginal producers or even lower</td>
</tr>
<tr>
<td>Competitiveness Challenged – Investment decisions relatively difficult</td>
</tr>
</tbody>
</table>
Kingdom of Saudi Arabia Chemical Landscape Continues to Evolve

Performance Plastics and Materials
- Engineering Resins and Rubber
- Nylon
- Acrylics and SAP
- MMA, PMMA, TPOs

Emerging KSA Portfolio

HISTORICAL
- Different Commodities
  - Polyethylene
  - Polypropylene
  - Polystyrene
- Commodities
  - Ethylene Glycol
  - Styrene

NEW
- Performance Polymers
  - ABS
  - Synthetic Rubber
  - Polycarbonate
  - Polyacetal Resins
  - Nylon 6
  - C8 PE/Elastomers
- Specialty Chemicals
  - MDI/TDI
  - Polyols
  - EO/PO
  - Amines
  - Glycol Ethers
  - Acrylate Monomers
  - Epichlorohydrin

Source: Saudi Aramco
Three Regions with Different Markets all Focus on ‘Advantaged’ capacity

- Strong domestic investment focused on import substitution
- High-growth market
- Monetize ‘stranded’ coal
A Wave of Investment in China Seeking to Reduce Dependency on Imports

Capital Expenditure, Billion US Dollar

- C2 Cracker
- MEG
- MTO
- CTO/CTP
- PDH
- CTMEG
China Is Reducing Ethylene Derivative Import Dependencies

Ethylene, Million Metric Tons

Self-Sufficiency (right axis)

Net Equiv. Imports (Exports)

Domestic Deriv. Ethylene Demand

Self-Sufficiency (right axis)
Three Regions with Different Markets all Focus on ‘Advantaged’ capacity

- Monetize shale resources
- Leverage to exports but service manufacturing renaissance
- CAPEX substantive concern
United States Basic Chemicals Growth
2000/2010 versus 2010/2020

Million Metric Tons

<table>
<thead>
<tr>
<th>Chemical</th>
<th>2000-2010</th>
<th>2010-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>-6</td>
<td>2</td>
</tr>
<tr>
<td>Chlroine</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>Methanol</td>
<td>-4</td>
<td>12</td>
</tr>
<tr>
<td>Propylene</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Ethylene</td>
<td>-2</td>
<td>10</td>
</tr>
</tbody>
</table>

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
## Impact Of Shale Gas On North America Downstream Chemical Value Chains

<table>
<thead>
<tr>
<th>Value Chains</th>
<th>Main Products</th>
<th>Investment 2000-2010 (Kta)</th>
<th>Investment 2010-2020 (Kta)</th>
<th>Downstream Derivatives</th>
<th>Quartile on Cost Competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>Methanol</td>
<td>-6,300</td>
<td>+17,200</td>
<td>Formaldehyde, Acetic Acid, VAM</td>
<td>Q1-Q2</td>
</tr>
<tr>
<td></td>
<td>Ammonia</td>
<td>-7,000</td>
<td>+9,700</td>
<td>Urea, Nitric Acid, Fertilizers</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Ethylene</td>
<td>+0.3</td>
<td>+13,800</td>
<td>PE</td>
<td>Q1-Q2</td>
</tr>
<tr>
<td>C3</td>
<td>Propylene</td>
<td>+1,831</td>
<td>+4,788</td>
<td>EO/EG</td>
<td></td>
</tr>
<tr>
<td>C4</td>
<td>Butadiene</td>
<td>+.91</td>
<td>+.32</td>
<td>PVC</td>
<td></td>
</tr>
<tr>
<td>C6-C9</td>
<td>Aromatics</td>
<td>Declining</td>
<td>Declining</td>
<td>PP</td>
<td>Q1-Q2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oxo Alcohols, Acrylics, PO, ACN</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rubber, Dispersions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Oxo Alcohols, Plasticizers</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>B: cumene; ethylbenzene</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MX: PX; MX; OX</td>
<td></td>
</tr>
</tbody>
</table>

©2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
North America Ethane Production Forecast

Limited by logistics & economics, not by availability

Geographic, technical, and economic constraints limit total ethane availability; pipeline and waterborne exports included in demand growth assumptions. More ethane is available at the right price.

Source: IHS Energy
Ethylene Cash Cost Snapshot

Regional Comparison: 2013 vs 2023

U.S. Dollars Per Metric Ton

- Western Canada
- U.S. Ethane
- U.S. Weighted Average
- China CTO
- West Europe Naphtha
- Northeast Asia Naphtha
- Southeast Asia Naphtha
- China MTO

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Unprecedented Ethylene Capacity Additions
Driven By Low Cost Ethane Supplies

- North America forecast to start up more than 12 million tons of new ethane based ethylene capacity by 2020.
- Current wave of new capacity mainly built by existing producers; only two new companies.
- Braskem-Idesa scheduled to start up the first grass-roots ethylene unit since 2000.
- Peak additions forecasts to overlap in 2018/19, which could result in an oversupply scenario.

### Ethylene Capacity Additions

<table>
<thead>
<tr>
<th>Company</th>
<th>Location</th>
<th>Total Additions 2014 - 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASF/Total</td>
<td>Port Arthur, TX</td>
<td>170</td>
</tr>
<tr>
<td>ChevronPhillips</td>
<td>Cedar Bayou, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Dow</td>
<td>Freeport, and Plaquame</td>
<td>1,720</td>
</tr>
<tr>
<td>Eastman</td>
<td>Longview, TX</td>
<td>17</td>
</tr>
<tr>
<td>Equistar</td>
<td>All Locations</td>
<td>862</td>
</tr>
<tr>
<td>ExxonMobil</td>
<td>Baytown, TX</td>
<td>1,500</td>
</tr>
<tr>
<td>Flint Hills</td>
<td>PT Arthur</td>
<td>100</td>
</tr>
<tr>
<td>Formosa</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>Sasol</td>
<td>Lake Charles, LA</td>
<td>1,550</td>
</tr>
<tr>
<td>Westlake</td>
<td>All Locations</td>
<td>216</td>
</tr>
<tr>
<td>Williams</td>
<td>Geismar, LA</td>
<td>1,758</td>
</tr>
<tr>
<td><strong>Braskem Idesa</strong></td>
<td><strong>Mexico</strong></td>
<td><strong>1,000</strong></td>
</tr>
<tr>
<td>Nova</td>
<td>Sarnia</td>
<td>168</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>12,261</strong></td>
</tr>
</tbody>
</table>

©2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Three Routes to Produce Propylene

- **Crude Oil**
  - Crude Unit
  - FCC Unit
  - Motor Gasoline
  - Ethane
  - Naphtha
  - Refining Industry
  - Chemical Industry
  - Purification Splitter Unit
  - On-Purpose

- **Natural Gas**
  - Steam Cracker (Olefins Plant)
  - Ethylene & Olefins

- **Other Propylene consumers**
  - Polypropylene
  - Injection Molding, Fibers, Films

- **Direct Refinery Grade chemical consumption**
  - High Octane Motor Gasoline
  - Other Fuel Uses
On-Purpose Propylene Production Trends
PDH & CTP Investments Accelerate

On Purpose Propylene Production, Million Metric Tons


- Ex Dehydro - PDH
- Metathesis
- Via Methanol: CTP
- HS FCC
- Olefin Cracking
- Others On-Purpose

25%
45%

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Trade Patterns Will Continue To Evolve

- Investment in advantaged feedstock regions will push trade volumes higher connecting resource-rich geographies with higher growth markets.
- Significant infrastructure investments are needed to expand capabilities to meet future demand growth in trade volume.
- Supply-chain expertise and well crafted go-to-market strategies will increase in importance.
- The pressure on high-cost producers servicing markets targeted by advantaged capacity will intensify.
- Finished goods trade patterns are also shifting, as supply-chain efficiency requirements change and cost structures evolve.
2020 Exports & Total Trade
Basic Chemicals & Plastics

% 2020 Production Exported

- MEG
- Methanol
- Polyethylene
- Xylenes
- Styrene
- Polystyrene
- Polypropylene
- Vinlys
- PET

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Profit Cycle & Finished Goods Manufacturing

- **Chemical industry profitability** greatly influenced by value-chain and regional access to low-cost energy and feedstocks. Significant pressure builds on high cost “crude-based” technologies and regions.

- **Downstream manufacturing** expected to grow in North America for products with a high “supply-chain intensity”, enabled by sustained low energy and renewed chemicals investments.
Global Profit on the Upswing; Down-Cycle Muted for Advantaged Regions

Basic Chemicals & Plastics EBIT Comparison

© 2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Supply Chain Intensity (SCI) Drives Future Decisions for Manufacturing

**Off-shoring**
Shift to low-cost locale distant from end market

**Near-shoring**
Shift to medium-cost locale co-regional or proximate to end market

**On(re)-shoring**
Return local supply & services to the domestic market

---

**Low SCI**
- Small Impact of Delays
- Low Shipping Cost vs. Value
- High Labor Input
- Quality Insensitive

**Apparel** – Glycol, Polyester, Nylon

**Footwear** – PU, EVA, SBS

**Furniture** – PU, (Outdoor - PP, HDPE)

**Appliances** – PP, ABS, Nylon, PU, PS, PC

**Electronics** – ABS, PC, PBT, POM, Nylon

**Autos & Assemblies** – PP, PU, PBR, Nylon, PC, ABS

**Aerospace** – Carbon Fiber, Epoxy, PEEK

---

©2014 IHS, Inc. No portion of this presentation may be reproduced, reused, or otherwise distributed in any form without prior written consent.
Final Thoughts...
...Base Chemical Producer Perspective

What Could Be Different?

Upside Influences
- Economic strength
  - Level and duration
- Constraints on new assets or existing supply
  - Capital costs, skilled labor, unplanned outages

Downside Influences
- Economy slowdown/crash
  - China, Eurozone, US
- Energy price shock
  - Crude flow or natural gas disruptions
- Logistics/trade flow constraints
- Geopolitical chaos

Un-expected Events
- Government action; regulation, trade barriers, market subsidies
- Environmental Health & Safety Impact
- New technology developments
State of the Global Petrochemical Industry

THANK YOU !!

Mark Eramo
Vice President, Chemical Insights
IHS Chemical
Houston, TX
mark.eramo@ihs.com