KM : PROPYLENE MARKET

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Propylene Supply Chain

**Oil Refining Industry**
- crude oil
  - Fractional Distillation
    - refinery gases
    - gasoline
    - naphtha
    - kerosene (paraffin)
    - gas oil (diesel)
    - lubricating oil
    - fuel oil
    - bitumen
  - natural gas/ LPGs †

**The Petrochemical Industry**
- Olefin Plant (Cracker)
  - OLEFINS (50%)
    - ethylene (30%)
    - propylene (15%)
    - butadiene (5%)
  - AROMATICS (15%)
    - benzene
    - toluene
    - xylene
    - Others
  - FUELS/GASOLINE (35%)

† Liquified petroleum gases

Source: Deutsche Bank

Aim High • Deliver • Work and Live Happily Together
Propylene Derivatives

% Asian Demand in 2015

- Propylene Oxide
  - Polyols
    - Polyurethane
- Polypropylene
  - Acetone
  - Methyl Methacrylate
    - Solvents, Coatings, Cosmetics, Health Care
- Oxo-Alcohols
  - Plasticizers
    - PVC Plastics
- Acrylonitrile
  - Modacrylic Fiber
    - Coatings, Synthetic Furs
- Cumene
  - ABS Resins
    - Phenol Resins, Nylon Fibers, Solvents
  - Phenol
    - Coatings, Adhesives, Super Absorbent Polymers, Detergents
- Acrylic Acid, Acrylates
  - Miscellaneous

Auto Patch Compounds, Furniture Parts, Boats, Fibers
Auto Steering Wheels, Knobs, Auto Grills, Pipe, Film, Shrink Packages, Strapping, Rope & Twine
Indoor/Outdoor Carpets, Matting
Plastics, Signs, Plexiglass, Pants, Tail-light Lenses, Lighting Panels
Rain Coats, Inflatable Toys
Carpets, Sweaters, Dropers, Furs, 전기
Lenses, Light Fixtures, Domestic, Coatings
Phones, Auto Parts, Bathtubs

6% 63% 3% 5% 8% 6%
Propylene from other “on-purpose” sources is becoming an increasingly important element of the global supply.

On-purpose sources include propane dehydrogenation (PDH), metathesis, high severity catalytic cracking, olefin cracking, Coal-to-Olefins (CTO) and Methanol-to-Olefins (MTO).

On-purpose production currently makes up an estimated 14% of global propylene supply, and is projected to grow to 30% of global supply by 2019.
Propylene On-Process Technology

- Propane Dehydrogenation (PDH)
- Metathesis
- Methanol to Propylene (MTP)
Global on-purpose propylene production grows from 14% to 30% of supply over the next five years as the wave of new PDH and coal-to-olefin (CTO) projects start production.

The majority of the new on-purpose propylene capacity is being built in China via both CTO and PDH. North America is also seeing a significant build in PDH units with its ample propane supplies from shale plays.

Source: IHS, MAR15
• China propylene production will increase to nearly 40 million metric tons by 2020

• While refinery and steam cracker capacity additions were the main avenue of supply growth just a few years ago, coal and merchant methanol-based units along with PDH are set to bring ample new supplies over the next four years.

• In fact, the total on-purpose propylene capacity additions in China over the next two years are enough to supply the total propylene demand growth for the world.

Source: IHS, MAR15

• Main driver is for market penetration

• Most of the PDH project owners are private companies. Depends on import propane.

• Located along coastal regions

• PDH projects are mostly backward-integration projects that provide feedback to non-PP derivatives.
Propylene Cash Cost in Northeast Asia

2014 NE Asian Propylene Cost Comparison

Cash Cost of Production, Dollars Per Metric Ton Light Olefin

2015 NE Asian Propylene Cost Comparison

Cash Cost of Production, Dollars Per Metric Ton Light Olefin

Source: IHS, MAR15

Dubai 97$/Barrel @ 2014

Dubai 60$/BBL @ 2015

#Basis: Inner Mongolia, NW China
^Basis: Shanghai, E China
IRPC Propylene Process

2014 NE Asian Propylene Cost Comparison

Cash Cost of Production, Dollars Per Metric Ton Light Olefin

- UHV 320 KTA
- DCC 130 KTA
- ETP 170 KTA
- PRP 100 KTA

#Basis: Inner Mongolia, NW China
^Basis: Shanghai, E China

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Dubai 60$/BBL @ 2015

Source: IHS, MAR15
### 2014 Propylene Statistic Record

<table>
<thead>
<tr>
<th></th>
<th>2014 Key Statistics</th>
<th>Historical Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity MM Tons</td>
<td>Production MM Tons</td>
</tr>
<tr>
<td>Ethylene</td>
<td>156</td>
<td>137</td>
</tr>
<tr>
<td>Methanol</td>
<td>106</td>
<td>64</td>
</tr>
<tr>
<td>Propylene</td>
<td>107</td>
<td>89</td>
</tr>
<tr>
<td>Chlorine</td>
<td>90</td>
<td>68</td>
</tr>
<tr>
<td>Paraxylene</td>
<td>46</td>
<td>35</td>
</tr>
<tr>
<td>Benzene</td>
<td>61</td>
<td>44</td>
</tr>
</tbody>
</table>

Top 5 Countries Adding Propylene > 79% within 2010-2020
(only China Adding 55% of World)

<table>
<thead>
<tr>
<th>Country</th>
<th>Ethylene</th>
<th>Propylene</th>
<th>Methanol</th>
<th>Benzene</th>
<th>Paraxylene</th>
<th>Chlorine</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>14,920</td>
<td>26,868</td>
<td>37,470</td>
<td>4,880</td>
<td>6,850</td>
<td>13,759</td>
<td>104,747</td>
</tr>
<tr>
<td>United States</td>
<td>11,075</td>
<td>5,091</td>
<td>11,448</td>
<td>0</td>
<td>450</td>
<td>1,897</td>
<td>29,961</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>3,683</td>
<td>1,575</td>
<td>0</td>
<td>1,974</td>
<td>4,950</td>
<td>888</td>
<td>13,070</td>
</tr>
<tr>
<td>South Korea</td>
<td>1,092</td>
<td>2,649</td>
<td>0</td>
<td>2,066</td>
<td>5,950</td>
<td>412</td>
<td>12,169</td>
</tr>
<tr>
<td>India</td>
<td>3,374</td>
<td>2,305</td>
<td>330</td>
<td>1,122</td>
<td>2,895</td>
<td>252</td>
<td>10,278</td>
</tr>
<tr>
<td><strong>Five Country Total</strong></td>
<td><strong>34,144</strong></td>
<td><strong>38,488</strong></td>
<td><strong>49,248</strong></td>
<td><strong>10,042</strong></td>
<td><strong>21,095</strong></td>
<td><strong>17,208</strong></td>
<td><strong>170,224</strong></td>
</tr>
<tr>
<td><strong>Five Country % of World</strong></td>
<td><strong>68%</strong></td>
<td><strong>79%</strong></td>
<td><strong>67%</strong></td>
<td><strong>70%</strong></td>
<td><strong>85%</strong></td>
<td><strong>87%</strong></td>
<td><strong>74%</strong></td>
</tr>
</tbody>
</table>
• Looking ahead to the next five years, the pace of propylene capacity additions, namely from on-purpose facilities, is set to significantly outpace expected propylene demand growth.

• The next two years show the highest level of new capacity, but the additions several years’ out are projected to be near the demand growth pace. So additions will need to slow or demand growth will need to accelerate to rebalance the market.
• Propylene capacity additions will be heavily concentrated in China, especially in the next five years.
• China has long been the largest importer of propylene and propylene derivatives and the drive towards reducing its reliance on imports has catalyzed a wave of investments.
• With over 10% of global propylene being imported into China in 2014, either as monomer or derivative, the impact of any change in this import requirement will be felt globally.

Source: IHS, MAR15
China’s propylene self-sufficiency is forecast to increase to 80%.
China propylene production will increase to nearly 40 million metric tons by 2020.
China propylene equivalent demand in China will increase to about 45 million metric tons.
Net imports of propylene equivalents will decline from about 10 million metric tons in 2010 to 7 million metric tons by 2020.
This reduction in imports (primarily for polypropylene) will force the global market to rebalance at a time when other regions will be expanding and seeking to increase export volumes.

Source: IHS, MAR15
North America in the global propylene market occupies a unique position as more than 50% of the regional supply is based on FCC production rather than steam cracker coproduct production.

The balance is expected to continue to shift in favor of FCC units and on-purpose units as the major sources of propylene supply over the next 10 years, primarily due to the anticipated decreases in production from steam crackers in response to the shift towards lighter feedslates in the region.

Source: IHS, MAR15
North American propylene demand will continue to be dominated by PP consumption that in 2014 is estimated to account for 56%. A relatively flat propylene demand profile through 2016 is projected due to limited new propylene capacity before all the new PDH units are in full operation.

Starting in 2017/18, as all the new PDH production begins to come on-stream, new derivative plants are expected to be built, which will rapidly increase the demand for propylene from about 13.8 million metric tons to 18.6 million metric tons early in the next decade.

Source: IHS, MAR15
Propylene in Southeast Asia is mainly supplied from steam crackers due to the relatively high percentage of liquid steam crackers in the region.

In addition to these new steam cracker-based capacities expected to start up over the next five years, alternate sources of propylene will add over 800,000 metric tons of propylene capacity in Southeast Asia. Projects include Petron Corp (2015) in the Philippines, IRPC (2015) in Thailand, Pertamina (2015) in Indonesia, and Nghi Son PC (2017) in Vietnam.

The Southeast Asian market historically has suffered from insufficient supplies of propylene. However, with the start-up of the aforementioned projects, the region’s supply and demand will become more balanced-to-long over the next five years.

Source: IHS, MAR15
Southeast Asia Propylene Outlook

Southeast Asia Propylene Price Forecast

Source: IHS

Source: IHS, MAR15
Outlines

Propylene Supply Chain

Propylene Market Outlook

Key Issues in World’s Chemicals

Q&A
Key Issues of World’s Chemicals

A. US Shale Gas Boom
B. OPEC Fight for Market Share
C. China Factors
D. Asia Growth
US Shale Gas Boom

A. US is Much Less Energy Dependent

US Refining is exporting position, diesel, LPG, Naphtha, Gasoline

US imports of petroleum products
(billions of 2009 dollars)

Asia is one of export target, especially Naphtha

Diluent for Alberta Bitumen
Naphtha
550 kB/d

Gasoline
600 kB/d
Exports to Americas

Exports to Asia are increasing
Saudi Arabia stepped back from being the market balancer to guard market share

INNOVATION is new focus for more value added and sustainability

Moderated investment pace, diversified feed slate to support downstream market development and continued industrial expansion well beyond ethylene chemistry
Key Changes in Chemical Industry

Shifts in the market structure and changes in energy prices continue to reshape the Chinese chemical industry...

- **Feedstock**
  - Conventional petrochemical growth slowed down
  - Unconventional chemicals take the shape, including CTO, MTO, CTMEG, PDH, etc.

- **Ownership**
  - Major SOEs are losing market shares
  - Private companies expended market share
  - Foreign investment dwindled

- **Geographic**
  - Demand remained mainly in East and South
  - Capacity growth shifted to West

Unconventional chemicals will continue to grow, as many CTO, MTO, and PDH projects currently under construction will be brought onstream within the next three years.

Any further growth in CTO will be constrained by water availability. The growth in MTO and PDH will be limited by an unfavorable return on investment.

Oil-based petrochemicals will likely come back as growth area after 2019.
Asia-Huge share of global population, huge growth in GDP, huge regional variation remain

### Population (Billion, %)

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Population</th>
<th>China</th>
<th>World excl. Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>6.6</td>
<td>36%</td>
<td>20%</td>
</tr>
<tr>
<td>2014</td>
<td>7.2</td>
<td>36%</td>
<td>19%</td>
</tr>
<tr>
<td>2025</td>
<td>8.0</td>
<td>36%</td>
<td>18%</td>
</tr>
</tbody>
</table>

### Real GDP (2010 $ Trillion, %)

<table>
<thead>
<tr>
<th>Year</th>
<th>GDP excl. China</th>
<th>GDP China</th>
<th>GDP World excl. Asia</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>60</td>
<td>6%</td>
<td>17%</td>
</tr>
<tr>
<td>2014</td>
<td>72</td>
<td>11%</td>
<td>17%</td>
</tr>
<tr>
<td>2025</td>
<td>106</td>
<td>15%</td>
<td>18%</td>
</tr>
</tbody>
</table>

### 2014 GDP per Capita ($ x1000)

- Singapore: 50
- Japan: 45
- Korea, Rep.: 25
- Taiwan: 21
- Malaysia: 10
- China: 6
- Indonesia: 4

### Urbanization in Asia

- No. of Asian Megacities (-)
  - 2010: 12
  - 2025: 20

- Population living in Cities (%)
  - 2010: 42
  - 2025: 52

Source: IHS, Asian Development Bank, SABIC
Conclusion

• The chemical industry continues to be buffeted by unpredictability and volatility in regulatory, economic, and energy dynamics.

• The global economic recovery continues to be divergent. China, Europe, and Brazil remain sluggish whereas North America and Southeast Asia the only real bright spots.

• The next two years show the highest level of new Propylene capacity, but the additions several years’ out are projected to be near the demand growth pace. So additions will need to slow or demand growth will need to accelerate to rebalance the market.