Agenda

India – A Growth Perspective
Petrochemicals – Growth Pre-Requisites
- Crude & Refining – An Overview
- Petrochemicals – Demand/Supply
- Feedstocks & Building Blocks - Outlook
- Paradip Refinery – An Overview
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India-A Growth Prospective

3rd Largest Economy in terms of GDP-PPP Valuation (2015)

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>USA</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18,976</td>
<td>18,125</td>
<td>7,997</td>
</tr>
</tbody>
</table>

Source: International Monetary Fund, World Economic Outlook WEO, April 2015

Fastest growing large Economy
- India 7.5%
- China 6.5%
### Polymers: India Vs World

#### Global Rank in Polymer Consumption

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</tr>
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<tbody>
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<td>1</td>
<td>USA</td>
<td>16.6</td>
<td>USA</td>
<td>27.3</td>
<td>USA</td>
<td>38.9</td>
<td>3.6%</td>
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<tr>
<td>2</td>
<td>Japan</td>
<td>6.4</td>
<td>China</td>
<td>14.4</td>
<td>China</td>
<td>31.3</td>
<td>8.1%</td>
</tr>
<tr>
<td>3</td>
<td>Germany</td>
<td>4.3</td>
<td>Japan</td>
<td>9.1</td>
<td>India</td>
<td>12.5</td>
<td>14.0%</td>
</tr>
<tr>
<td>4</td>
<td>China</td>
<td>3.7</td>
<td>Germany</td>
<td>6.4</td>
<td>Japan</td>
<td>11.5</td>
<td>2.3%</td>
</tr>
<tr>
<td>5</td>
<td>Italy</td>
<td>3.1</td>
<td>S. Korea</td>
<td>4.7</td>
<td>Germany</td>
<td>9.4</td>
<td>3.9%</td>
</tr>
<tr>
<td>6</td>
<td>CIS</td>
<td>2.4</td>
<td>Italy</td>
<td>4.7</td>
<td>S. Korea</td>
<td>7.4</td>
<td>4.8%</td>
</tr>
<tr>
<td>7</td>
<td>France</td>
<td>2.4</td>
<td>France</td>
<td>4.1</td>
<td>Italy</td>
<td>6.8</td>
<td>3.8%</td>
</tr>
<tr>
<td>8</td>
<td>UK</td>
<td>2.2</td>
<td>UK</td>
<td>3.5</td>
<td>Brazil</td>
<td>6.7</td>
<td>7.0%</td>
</tr>
<tr>
<td>9</td>
<td>Taiwan</td>
<td>1.9</td>
<td>India</td>
<td>3.4</td>
<td>CIS</td>
<td>6.2</td>
<td>9.1%</td>
</tr>
<tr>
<td>10</td>
<td>S. Korea</td>
<td>1.8</td>
<td>Brazil</td>
<td>3.4</td>
<td>France</td>
<td>6.1</td>
<td>4.1%</td>
</tr>
<tr>
<td>16</td>
<td>India</td>
<td>1.6</td>
<td>Taiwan</td>
<td>3.3</td>
<td>UK</td>
<td>5.2</td>
<td>4.0%</td>
</tr>
</tbody>
</table>

Source: CPMA

India - Already the 3rd largest polymer consumer globally...
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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.
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Key Change Drivers – Crude Oil Market

Offline Production

Changing Crude Oil Economics

China Slowdown

Post Iran Sanctions Gulf Crisis

US Shale Gas
North America is a major producer & consumer; Europe is a major consumption hub and Asia a major processing hub with a growing end-use market.

- **PETROCHEMICAL MATERIAL FLOW-2015**

  - Both a competitive producer and end-use market
  - Competitive feedstock due to shale gas
  - Key end use market
  - Competitive sources of feedstock/raw material
  - Increase in downstream capacity
  - Competitive processing hubs and growing end-use markets
  - Increasing consumption

  **Feedstock flow** ➔ **Finished product flow**

  **India is one of the lowest consumers of plastics in the world; expected to increase consumption in the coming future.**
India: Refining capacity

**Map of Refineries in India**

*(Capacity in MMTPA)*

- **IOC/CPCL**: 31%
- **BPC/NRL/BORL**: 14%
- **HPC/HMEL**: 11%
- **ONGC/MRPL**: 7%
- **RIL**: 28%
- **ESSAR**: 9%

**Capacity Share**

- **IOC/CPCL**: 31%
- **RIL**: 28%
- **ESSAR**: 9%
- **BPC/NRL/BORL**: 14%
- **ONGC/MRPL**: 7%
- **HPC/HMEL**: 11%

**Capacity (IOC):** 69.3 MMTPA

**Capacity (CPCL):** 11.5 MMTPA

**Group Capacity:** 80.8 MMTPA

**India Capacity:** 230.1 MMTPA
India : Refining Capacity Growth

As on January 1, 2016, India has a total refining capacity of 230.0 MMTPA.

* Paradip Refinery Commissioned
India: POL Scenario

Refining Capacity of 215 MMT vs Consumption of 164 MMT – Surpluses Exist

POL Consumption India - MMT

POL – Imports/Exports
US$ billion

Source: PPAC
Agenda

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India Import Requirement Grows Despite New Capacity Build

Million Metric Tons, Equivalent Ethylene

Net Exports

Net Imports

08 09 10 11 12 13 14 15 16 17 18

Ethylene  Vinys  Styrenics  Polyethylene
Glycol  Others  Net Trade

Source: IHS
Polyolefin Global Market Snapshot

- **North America**
  - HDPE
  - PP
  - LLDPE
  - LDPE

- **Europe**
  - HDPE
  - PP
  - LLDPE
  - LDPE

- **Asia & ME**
  - HDPE
  - PP
  - LLDPE
  - LDPE

**Polyolefins Market (MMTPA)**
- North America: 23.4 MMTPA
- Europe: 27.3 MMTPA
- Asia & ME: 77 MMTPA

- **Global Market (MMTPA)**
  - **2005**
    - Total: 103
    - PE: 62
    - PP: 41
    - Growth Rate (%p.a.): PE, PP, Total
  - **2014**
    - Total: 145
    - PE: 86
    - PP: 61
    - Growth Rate (%p.a.): PE: 3.6, PP: 4.3, Total: 3.9

**Competitors**
- **20 Competitors:** Mostly Major Shale Players
- **25 Competitors:** Mostly Majors
- **>100 Competitors:** NOC’s, Majors, JVs and Small Players

**Population Statistics**
- 30% of World Population (~30 Kg Per person)
- 58% of World Population (~9 Kg Per person)

Source: ICIS
Polyolefin Global Market Snapshot

Projected CAGR %

Polyolefin Per Capita Consumption and Growth Rate

- INDIA
- AFRICA
- ASIA
- CHINA
- CENTRAL & SOUTH AMERICA
- EASTERN EUROPE
- MIDDLE EAST
- NORTH AMERICA
- WESTERN EUROPE

IndianOil
Polyolefins - Domestic Market Outlook

KT

PE

PP

Growth Rate
10.6%

Growth Rate
11.8%
PTA/MEG - Domestic Market Outlook

Growth Rate

**PTA**

Growth Rate 7.7%

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Capacity</th>
<th>Domestic Demand</th>
<th>Surplus/Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>7,075</td>
<td>5,319</td>
<td>(728)</td>
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<tr>
<td>2017</td>
<td>7,400</td>
<td>5,678</td>
<td>(250)</td>
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<tr>
<td>2018</td>
<td>7,400</td>
<td>6,047</td>
<td>(399)</td>
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<tr>
<td>2019</td>
<td>7,700</td>
<td>6,431</td>
<td>(554)</td>
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<tr>
<td>2020</td>
<td>8,900</td>
<td>6,878</td>
<td>(336)</td>
</tr>
<tr>
<td>2021</td>
<td>8,900</td>
<td>7,362</td>
<td>(532)</td>
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</table>

**MEG**

Growth Rate 7.6%

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Capacity</th>
<th>Domestic Demand</th>
<th>Surplus/Deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>5,047</td>
<td>2,182</td>
<td>(728)</td>
</tr>
<tr>
<td>2017</td>
<td>5,115</td>
<td>2,329</td>
<td>(250)</td>
</tr>
<tr>
<td>2018</td>
<td>5,815</td>
<td>2,478</td>
<td>(399)</td>
</tr>
<tr>
<td>2019</td>
<td>5,815</td>
<td>2,633</td>
<td>(554)</td>
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<tr>
<td>2020</td>
<td>6,315</td>
<td>2,815</td>
<td>(336)</td>
</tr>
<tr>
<td>2021</td>
<td>6,815</td>
<td>3,011</td>
<td>(532)</td>
</tr>
</tbody>
</table>

Source – IHS Chemical
PVC/Styrene - Domestic Market Outlook

Growth Rate (YoY) – 9.75%

Growth Rate (YoY) – 8.8%

Source – IDS Mkt Survey 2012
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Steam Cracking Around the World

The Heavier the Hydrocarbon Feed the more complicated the economics

North America:  
Shale Gas

Middle East:  
Ethane  
Refinery Integration  
Liquids

Russia/CIS:  
Ethane  
Refinery Integration  
Naphtha

Asia:  
Naphtha  
Heavy Liquids

Configuration is Important
Naphtha Cracker Complex

Steam Cracker

Hydrocarbon Feed

Utilities

Operations & Maintenance

Waste

Ethylene

Co-Products
- Hydrogen
- Methane
- Propylene
- C4's
- PFO
- Etc..

Traditional focus

Co-products drive Economics
India – Ethylene Capacity by Feedstock

- Naphtha: 63%
- Ethane: 18%
- Propane: 16%
- Others: 3%
Challenges in Naphtha Utilisation

- **Naphtha Quality for petrochemicals.**
- **Naphtha availability at a single location for world scale petrochemical Unit**
  - Naphtha Pooling at a single location:
    - Logistics cost
    - Inadequate infrastructure
- **Price fluctuation impacts the profitability of Naphtha based petrochemicals**
- **Competition from gas/coal based petrochemicals.**
Indian Industry is faced with following challenges:-

- **Feedstock Constraints**
  - Insufficient availability of natural gas to drive high petrochemicals growth
  - Non availability of indigenous Coal & its poor quality

- **High Energy Cost**
  - Refineries & Petrochemical industry dependent on its own CPP based on LNG or Naphtha or LSHS resulting in higher power/ utilities cost.

- **Non availability of advantage feed stocks**
CHALLENGES FOR REFINERIES

- High Operating Cost – energy costs
- No plug & play system for utilities
- High Logistics Cost
  - Poor infrastructure for raw material/product movement at ports/roads etc.
- High Capital Cost
- Cost competition from:
  - Olefins from Middle East (NG based)
  - Olefins from China (Coal based)
# India – Ethylene Derivatives – Gap Analysis

<table>
<thead>
<tr>
<th>Product</th>
<th>Demand/Supply Gap (kTa)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2035</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Prod Cap</td>
<td>Demand</td>
<td>Gap</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>4400</td>
<td>5500</td>
<td>1100</td>
</tr>
<tr>
<td>PVC</td>
<td>1535</td>
<td>3650</td>
<td>2115</td>
</tr>
<tr>
<td>MEG</td>
<td>1970</td>
<td>3100</td>
<td>1130</td>
</tr>
<tr>
<td>EVA</td>
<td>40</td>
<td>260</td>
<td>220</td>
</tr>
<tr>
<td>Styrene</td>
<td>0</td>
<td>800</td>
<td>800</td>
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<tr>
<td><strong>Total Ethylene Gap</strong></td>
<td><strong>3200</strong></td>
<td></td>
<td></td>
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</table>

Based on Name Plate Production Capacity, Announced Expansions and Expected Growth
## India – Propylene Derivatives – Gap Analysis

<table>
<thead>
<tr>
<th>Product</th>
<th>Demand/Supply Gap (kTa)</th>
<th>2020</th>
<th>2035</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prod Cap</td>
<td>Demand</td>
</tr>
<tr>
<td>Polypropylene</td>
<td></td>
<td>5115</td>
<td>6100</td>
</tr>
<tr>
<td>Acrylonitrile</td>
<td></td>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>Propylene Oxide</td>
<td></td>
<td>37</td>
<td>125</td>
</tr>
<tr>
<td>Phenol</td>
<td></td>
<td>82</td>
<td>420</td>
</tr>
<tr>
<td>Super Absorbent Polymer</td>
<td></td>
<td>0</td>
<td>130</td>
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<tr>
<td><strong>Total Propylene Gap</strong></td>
<td></td>
<td><strong>1450</strong></td>
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</tr>
</tbody>
</table>

*Based on Name Plate Production Capacity, Announced Expansions and Expected Growth*
## India – Feedstock Requirement Analysis

<table>
<thead>
<tr>
<th>Product</th>
<th>Requirement (kTa)</th>
<th>Feedstock Requirement (kTa)</th>
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</thead>
<tbody>
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<td></td>
<td>2020</td>
<td>Case 1</td>
</tr>
<tr>
<td>Ethylene</td>
<td>3200</td>
<td>Naphtha - 10300</td>
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<tr>
<td>Propylene</td>
<td>1450</td>
<td></td>
</tr>
</tbody>
</table>

**Case 1 – Naphtha as Feedstock**  
**Case 2 - Mix of Propane and Naphtha**  
**Case 3 – Ethane Crackers & PDH**
Feedstocks – What can India Do?

- **Mixed Feed Crackers**
- **Pool Naphtha from Existing and New Refining Sources for Cracker**
  - Taxation for Pooling – Stock Transfer.
  - Coastal Shipping
  - Rail Utilisation
- **Reverse SEZ Offshore**
  - Opportunity with the Opening up of Iran
  - Modification/Clarifications in Exim Norms/Tariffs
- **Import Naphtha from Middle East**
  - Surplus Naphtha Available in ME
  - Long Term Contracts
  - Port and Transportation Infrastructure
- **Import Ethane from US**
  - Surplus Ethane in US
  - Long Term Contracts
  - Port, Shipping and Pipeline Infrastructure
- **Import Condensate**
  - Higher Percentage of Oil Production now in Condensate form ~ 12%
  - Availability of Field Condensate on the rise in US and ME
  - Port, Shipping and Pipeline Infrastructure
  - Long Term Contracts
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# Paradip Refinery: Product profile

## Feedstock

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Capacity (KTA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>15000</td>
</tr>
<tr>
<td><strong>Products</strong></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>870</td>
</tr>
<tr>
<td>Ethylene Potential</td>
<td>200</td>
</tr>
<tr>
<td>Propylene Potential</td>
<td>700</td>
</tr>
<tr>
<td>MS</td>
<td>3400</td>
</tr>
<tr>
<td>ATF/ SKO</td>
<td>1200</td>
</tr>
<tr>
<td>Diesel</td>
<td>5750</td>
</tr>
<tr>
<td>Pet coke</td>
<td>1250</td>
</tr>
<tr>
<td>Sulfur</td>
<td>200</td>
</tr>
<tr>
<td>Internal Fuel &amp; Loss</td>
<td>1430</td>
</tr>
<tr>
<td><strong>Total Products</strong></td>
<td>15000</td>
</tr>
</tbody>
</table>

Feedstock for Chemicals
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IndianOil - Current Presence in Petrochemicals

India’s Second Largest Petchem Player

LAB at Gujarat ($185 Million)
- 120 TMTPA capacity plant commissioned in 2004
- 24% capacity of the Indian industry

PX/PTA at Panipat ($682 Million)
- 553 TMTPA PTA capacity plant commissioned in 2006
- 14.3% capacity of the industry

Polymer/Glycol (Naphtha Cracker at Panipat) ($2585 Million)
- Commissioned in 2010
  - Polymer
    - 1250 TMTPA Capacity
    - 19.2% Capacity of the Industry
  - Glycol
    - 325 TMTPA Capacity
    - 25% Capacity of the Industry

Polyolefins
- Polyethylene
- Poly-propylene

Aromatics
- PTA
- LAB

Surfactant F/s
- MEG

Glycols
- DEG
- TEG

Export: LAB to 21 countries, Polymer to 50 countries & Glycols to 12 countries
Current Presence in Petrochemicals

<table>
<thead>
<tr>
<th>Indian Synthetic Rubber Ltd (ISRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>JV PARTNERS:</strong></td>
</tr>
<tr>
<td>IOC;</td>
</tr>
<tr>
<td>M/s Taiwan Synthetic Rubber Corp (TSRC);</td>
</tr>
<tr>
<td>M/s Marubeni, Japan</td>
</tr>
<tr>
<td><strong>Feedstock:</strong></td>
</tr>
<tr>
<td>Styrene and Butadiene</td>
</tr>
<tr>
<td><strong>Capacity:</strong></td>
</tr>
<tr>
<td>120TMTPA</td>
</tr>
<tr>
<td><strong>Start of Operation:</strong></td>
</tr>
<tr>
<td>December 2013</td>
</tr>
</tbody>
</table>
A. DEVELOPMENT OF PETROCHEMICAL HUB AT PARADIP

- 700 kta Polypropylene Unit based on FCC propylene under implementation
- Planning for C2 Derivatives - MEG
- Integrated pX/PTA units being examined
- Accelerated development of downstream petrochemical industry for polymer processing like packaging, fibre & filament, automotive, health care & personal care
- Creation of employment opportunities
- Impetus to petrochemical demand growth in Eastern India where petrochemical consumption is the lowest.
Initiatives Planned for Future Growth

B. UTILISATION OF UNCONVENTIONALS FOR CHEMICALS/PETROCHEMICALS

• Acetic Acid from Petcoke Gasification
• Synthetic Ethanol from Petcoke Gasification
• Targeting Olefin Generation from Petcoke/Lean Gas
• Recovery of Styrene from PyGas

C. UTILISATION OF STRANDED MOLECULES FOR SPECIALTIES

• Acrylates/Oxoalcohols/SAP from Propylene
• Cumene/Phenol/IPA from Propylene
• MMA/PMMA from C4’s
• DCPD/Piperlene/HCR from C5’s
• Speciality chemicals currently imported in the country
D. DEVELOPMENT OF GAS/CONDENSATE BASED PROJECTS

- Major transition in global landscape for petrochemical feedstock post development of shale gas and availability of cheap feedstock/fuel in US.
- IndianOil examining opportunities for collaboration with petrochemical players for setting up gas/condensate based, cost competitive Petrochemicals Complexes
- Possibility of setting up petrochemical plant in India, on a coastal location, being explored by sourcing feedstocks from ME/USA – transportation remains a concern
- Objective – to enhance availability of low cost polymers in India
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Key Imperatives for India

Initiatives that Industry can take to compete globally

1. **Ethylene**
   - Secure off-take agreements with upcoming crackers in USA, Middle east
   - Investing in downstream derivative unit or through reverse SEZ route

2. **Propylene**
   - Set up High Severity FCCs in refineries which can process heavier crude for Propylene production

3. **Aromatics**
   - Invest in extracting feedstock like Toluene from Naphtha Cracker py-gas

4. **Alternate Feedstocks**
   - Focus on alternatives like Coal Bed Methane, Coal To Olefins, Biofeedstocks, Domestic Shale gas
CONCLUSION

• South Asia will have large deficits of feedstocks/building blocks

• Although Refining Capacity is Surplus, Naphtha availability at a single location is not enough to set up world scale Naphtha Crackers

• Either Products have to be imported or Ethane, Naphtha and/or Condensate has to be imported as feedstock

• Infrastructure & Supply Chain Constraints Exist

• India needs new mixed feed crackers which can accept ethane as feedstock
Thanks !!
Feedstock Evolution - Regional Variations on Ethylene supply

North America

Asia

Europe

Middle East

Ethane  LPG  Liquid  Others

Ethane  LPG  Liquid  Others

Ethane  LPG  Liquid  Others

Ethane  LPG  Liquid  Others
India – Ethylene Capacity Vs Total Downstream Demand

- Production
- Demand
- Deficit
Net additions to global ethylene capacity

Source: MSI
Regional Propylene Supply Sources

North America

Middle East

Europe

Asia

Steam Cracking
Refinery Gas
PDH
Others

2010 2014 2015 2020

2010 2014 2015 2020

2010 2014 2015 2020

2010 2014 2015 2020

Steam Cracking
Refinery Gas
PDH
Others
India – Propylene Capacity Vs Total Downstream Demand

![Graph showing propylene capacity vs total downstream demand from 2014 to 2025.](image)

- **Production**
- **Demand**
- **Deficit**

The graph illustrates the comparison between propylene production, demand, and the resulting deficit over the years from 2014 to 2025.
## India – Feedstock Requirement Analysis

<table>
<thead>
<tr>
<th>Product</th>
<th>Requirement (kTa)</th>
<th>Feedstock Requirement (kTa)</th>
<th>Case 1</th>
<th>Case 2</th>
<th>Case 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2035</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene</td>
<td>12800</td>
<td>Naphtha – 47500</td>
<td></td>
<td>Propane-11800 Naphtha-35000</td>
<td>Ethane-16300, Propane-9000</td>
</tr>
<tr>
<td>Propylene</td>
<td>7700</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Case 1 – Naphtha as Feedstock**  
**Case 2 - Mix of Propane and Naphtha**  
**Case 3 – Ethane Crackers & PDH**
Paradip Refinery – From Aspirations to Reality

Capacity: 15 MMTPA; Approved Cost: US$ 4970 Million

One of the most modern refineries in the world

Crude Mix: 100% HS; 40% Heavy
- Ability to process toughest crudes

Distillate Yield: 81%
- Even with high % of heavy crudes

Complexity Factor: 12.2
- Superior secondary processing

Energy Consumption (MBN): 50
- Among the best in the Industry

Commissioned