INTEGRATION OF REFINERY AND PETROCHEMICALS WITH “OVER THE FENCE” SUPPLY OF GAS UTILITY MOLECULES

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BHARAT PETROLEUM CORPORATION LIMITED - KOCHI REFINERY

India - 0.23 Billion Crude oil processing capacity and Crude oil import of 70 Billion USD

BPCL – 13% share in refining capacity of India. Kochi Refinery is one among the four Refineries

Refinery is located in Kochi, the port city on the south-west coast of India, also known as Queen of Arabian Sea

Refining
- Capacity of 190,000 BPSD
- Complexity of 6.3
- Crude API of 38.7 & 0.65 wt% Sulfur

Environment
- Energy Intensity Index of 105.2
- Specific Green house Gas emission of 0.179

Value Maximization
- Refining Margin of 6.0 $/bbl, against Singapore Cracking margin of 7.5
- 4.6 $/bbl lower than USGC coking margin

Kochi Refinery today

Benchmark with World class Performance (Solomon Associate 2014 Analysis)
- Fourth Quartile
- Energy Intensity Index
- Net Cash Margin
- Process Unit Utilization
- Operational Availability

Source: PPAC
Indian Economy shifting to a higher growth path

Indian Oil demand to grow more

Growth of Petroleum products

Market study suggested 120,000 BPSD capacity expansion

THE NEED FOR AIMING HIGH..

Oil Consumption Per capita, bbls

<table>
<thead>
<tr>
<th></th>
<th>FY 15</th>
<th>FY 16</th>
<th>FY 17</th>
<th>FY 18</th>
<th>FY 19</th>
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<tbody>
<tr>
<td>USA</td>
<td>7.4</td>
<td>7.5</td>
<td>7.6</td>
<td>7.6</td>
<td>7.7</td>
</tr>
<tr>
<td>China</td>
<td>6.5</td>
<td>6.6</td>
<td>6.5</td>
<td>6.4</td>
<td>6.5</td>
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<tr>
<td>India</td>
<td>5.9</td>
<td>5.7</td>
<td>5.7</td>
<td>5.7</td>
<td>5.6</td>
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<tr>
<td>World Avg</td>
<td>6.2</td>
<td>6.1</td>
<td>6.0</td>
<td>5.9</td>
<td>5.7</td>
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</table>

Source: ENI annual World Oil and Gas review, PPAC

In MMT

<table>
<thead>
<tr>
<th></th>
<th>FY15</th>
<th>FY21</th>
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</thead>
<tbody>
<tr>
<td>Light Distillates</td>
<td>65</td>
<td>88</td>
</tr>
<tr>
<td>Middle Distillates</td>
<td>82</td>
<td>114</td>
</tr>
<tr>
<td>Heavy Distillates</td>
<td>22</td>
<td>30</td>
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Present 190 Expanding to 310

GDP

<table>
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<tr>
<th></th>
<th>FY 15</th>
<th>FY 16</th>
<th>FY 17</th>
<th>FY 18</th>
<th>FY 19</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>6.5</td>
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<td>7.7</td>
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<td>5.9</td>
<td>5.7</td>
<td>5.7</td>
<td>5.7</td>
<td>5.6</td>
</tr>
</tbody>
</table>

Inflation

Present 2.7 Expanding to 5

Oil Consumption Per capita, bbls

Source: EIU, IMF

Inflation

Indian Economy shifting to a higher growth path

Growth of Petroleum products

Market study suggested 120,000 BPSD capacity expansion

Source: ENI annual World Oil and Gas review, PPAC
THE TRIGGERS..

Accelerated Global demand for fuels

Changes in Marine Fuel sulfur specifications

Growing market demand for Petrochemicals in India

- Indian Petrochemicals demand increased by 7% CAGR over 2011-16 vis-à-vis GDP of 5.5%.
- Value of Net import of petrochemicals increased from 1.63 Billion USD in 2007-08 to 8.25 Billion USD in 2015-16.

Source: MoPNG-working group
WHY KOCHI REFINERY..

- Land availability
- Close to international maritime route and port infrastructure
- Single Point Mooring facility, which can support up to 15.5 MMTPA
- Excellent product evacuation facilities
- Higher demand of products in Southern region of India
- Natural Gas availability
FINDING A PERFECT CONFIGURATION...

**Key Areas**

- **Making a Product portfolio that meets market demand with maximum value addition**
- **Optimum Hydrogen addition and Carbon rejection technology**
- **Flexibility to optimize between Transportation fuels and Petrochemical feedstock**
- **Conversion of bottom of the barrel to Value added products**

**Configuration Study**

- **Secondary Processing Options**
  - Full Conversion Hydrocracker.
  - Once-through Hydrocracker with High Conversion FCCU.
  - Conventional FCCU with downstream treatments.

- **Residue Upgradation Options**
  - Slurry Hydrocracker.
  -Delayed Coker.
  - Flexi-coking.
  - Solvent De-asphalting.

**Final Selection**

- **Delayed Coker Unit**, ranked second on margins, selected for residue up-gradation. Slurry Hydrocracker was not preferred,
  - i. high capital cost
  - ii. expected difficulties in operation including disposal of pitch
- Diversification of value added petrochemicals gave edge to **Once-through Hydrocracker with High Conversion FCCU**.
HIGHLIGHTS OF THE PROJECT..

- Capacity Expansion from 1,90,000 bbl/day to **3,10,000 bbl/day (15.5 MMTPA)**.
- Meeting Auto Fuel compliant to 100% BS-IV and part BS-VI grade.
- Flexibility to process crude oils with 30 – 38 API.
- Facility for bottom up gradation and diversification to Petrochemicals.
- Production of 0.5 MMT of propylene and 1.3 MMT of Petcoke.
- Hydrogen demand is 16.4 TPH & Syngas requirement for Petrochemical plant is 14 TPH.
- Capital cost of 3 billion USD for Refinery expansion, 700 million USD for Petrochemical plant & 400 million for Utility gas molecule complex.
Entry of BPCL into the field of Propylene based Petrochemicals.

PDPP taken up as a BPCL Project, a ‘Make in India’ initiative as envisaged niche petrochemicals are predominantly imported.

Production of Niche Petrochemicals utilizing 250 TMT out of 500 TMT of Polymer grade Propylene available post IREP.

- Acrylic Acid
- Acrylates: Butyl Acrylate, 2 Ethyl Hexyl Acrylate
- Oxo Alcohols: Normal Butanol, 2 Ethyl Hexanol, Iso Butanol

Total project cost: 700 Million USD.
Technology selection was done with the objective of maximizing the net present value from the entire life cycle of the unit.

Syngas, Hydrogen and Nitrogen to be sourced from Build-Own Operate (BOO) facilities being installed as part of IREP.
The operational synergy between IREP & PDPP made sense to outsource Industrial Gases required for both.

The selection of Build-Own Demand (BOO) would minimize the capital required for IREP & PDPP.

- **Pricing** of Hydrogen, Syngas & Steam depends on operating efficiency at varying capacities.
- Pricing model arrived was each product from BOO shall attract a Fixed monthly charge and Variable Charge based on actual consumption.
- The Variable Charge calculation was based on 12 windows of operation.
TRANSFORMATION TO A WORLD CLASS GREEN REFINERY..

Routine expansion project in a growing economy has been turned into well thought out plan for efficiency improvement, value addition, risk reduction and transformation as a modern industrial complex with World Standards.

World best Refinery Characteristics (Solomon Associates 2014)

- Crude Capacity - 380 Kbbl/day
- Complexity – 13.3
- Crude oil API – 31.9, Sulfur – 1.6 wt%
- Total conversion – 52%

Kochi Refinery Post Expansion

- 310
- 10.3
- 30.6, 2.6
- 48
THANK YOU
## HIGHLIGHTS OF THE PROJECT – UNIT CAPACITIES & PRODUCT PATTERN

<table>
<thead>
<tr>
<th>Process Units</th>
<th>Present Capacity, MMTPA</th>
<th>Additional Capacity, MMTPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDU/VDU</td>
<td>5 + 4.5</td>
<td>10.5</td>
</tr>
<tr>
<td>DHDT</td>
<td>2.54</td>
<td>4.3</td>
</tr>
<tr>
<td>VGO HDT</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>FCCU</td>
<td>1.45</td>
<td>2.2</td>
</tr>
<tr>
<td>NHT/Isom (Revamp)</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>DCU</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>HGU</td>
<td>18,000 TPA</td>
<td>130,000 TPA</td>
</tr>
<tr>
<td>SRU</td>
<td>3 X 72 TPD</td>
<td>2 X 340 TPD</td>
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<table>
<thead>
<tr>
<th>Product</th>
<th>Pre-expansion, TMT/Anm</th>
<th>Post expansion, TMT/Anm</th>
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</thead>
<tbody>
<tr>
<td>Propylene</td>
<td>50</td>
<td>540</td>
</tr>
<tr>
<td>Gasoline</td>
<td>480</td>
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<tr>
<td>LPG</td>
<td>1115</td>
<td>2209</td>
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<tr>
<td>SKO</td>
<td>360</td>
<td>240</td>
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<tr>
<td>HSD</td>
<td>4384</td>
<td>8112</td>
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<tr>
<td>ATF</td>
<td>400</td>
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<td>Naphtha</td>
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<td>Bitumen</td>
<td>250</td>
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<td>FO/ LSHS</td>
<td>1400</td>
<td>0</td>
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<tr>
<td>Sulphur</td>
<td>33</td>
<td>303</td>
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<tr>
<td>Petcoke</td>
<td>0</td>
<td>1337</td>
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HIGHLIGHTS OF THE PROJECT – PROJECT ENORMITY..

<table>
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<tr>
<th>Item Description</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Piling</td>
<td>21,000 Numbers</td>
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<tr>
<td>Structural Erection</td>
<td>60,000 MT</td>
</tr>
<tr>
<td>Above ground Piping Work</td>
<td>7,300,000 Inch Meter</td>
</tr>
<tr>
<td>Equipment erection</td>
<td>2062 Numbers / 41,000 MT</td>
</tr>
<tr>
<td></td>
<td>(250+ Over Dimensional Consignments)</td>
</tr>
<tr>
<td>Electrical/Instrument cable laying</td>
<td>7,000 Km</td>
</tr>
</tbody>
</table>
Hot Water Belt (HWB) system at Petro-FCCU.
- Total heat recovered will be **84.3 MMKCal/hr.**

Power Recovery Expander (PRE) at Petro-FCCU
- PRE receives flue gas from Regenerator and produces **11 MW of power.**
- Considering this, PFCCU is a net-exporter of power.

Electrostatic Precipitator at Petro-FCCU.
- Ensures Suspended Particulate Matter in the flue gas is less than **50 mg/NM³**

Back Pressure Turbines with VHP steam.

Sulfur Recovery Units with Tail Gas Treaters ensure **99.9% sulfur removal** and emissions well below the norms of 1518 Kg/hr.

Coke handling system in DCU.

Reverse Osmosis based De-mineralized water plant.
PDPP - PROCESS FLOW..

PROPYLNE
(250)

CRUDE ACRYLIC ACID
(160)

SYN GAS
(6.5)

HYDROGEN
(99.8)

(113)

(150)

N-BUTANOL
(160)

(110)

(160)

(50)

GLACIAL ACRYLIC ACID (Future)

(137)

2-ETHYL HEXANOL
(55)

(106)

BUTYL ACRYLATE

(110)

2-ETHYL HEXYL ACRYLATE

(4)

(8)

I-BUTANOL
(7)

OXO ALCOHOL
(212)

(250)

(137)

(106)

Sales

47

180

38

10

47

All figures in ‘000 TPA
‘OVER THE FENCE’ GAS UTILITY SUPPLY - PRICING..

Variable charges / Ton of Hydrogen with Natural Gas as Feed/fuel.

Scenario – 1: With Power from CPP of BOO Operator
C1*NG1+C2*DM1+C3*RW1-(C4*ST1)

Scenario – 2: With Power from BPCL/Other sources
C1**NG1+C2**DM1+C3*RW1-(C4**ST1) +C5*P1

For Syngas, all “D” factors quoted by the BOO Operator as per the table will be used for the above two scenarios.
<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment Opportunities</td>
<td>Workmen from length &amp; breadth of the nation have received employment opportunities.</td>
</tr>
<tr>
<td>Gain for Cochin Port</td>
<td>Increased traffic and revenue for Cochin Port.</td>
</tr>
<tr>
<td>Further foray into Niche/Specialty Petrochemicals</td>
<td>Potential for major Petrochemical plants in the area &amp; resultant employment generation.</td>
</tr>
<tr>
<td>Petrochemical Park</td>
<td>For medium and small scale industries.</td>
</tr>
<tr>
<td>Community Development</td>
<td>Portion of Project expenditure is earmarked for developing nearby community.</td>
</tr>
</tbody>
</table>