Integration of Petrochemical and Refinery Plants as an Approach to Compete in Hydrocarbon Market

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Integration drivers for petrochemical industry

- Increased competitive pressures on petrochemical industries due to globalization
- Fluctuations in products' price and high price of energy and feed stocks
- More stringent environmental regulations impacting the operational costs
Refining challenges

- Low margin of refining
- High price of petroleum
- High volatility of feedstocks and products prices
- Environmental concerns
Petrochemical and refinery profits

What Does Integration means?

Possible synergy between Refining & Petrochemical industries to achieve opportunities for more profitability.
### Alternative usage of refinery streams in petrochemical industry

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<th>Refinery Stream</th>
<th>Petrochemical Stream</th>
<th>Alternative Refinery Use</th>
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<td>FCC offgas</td>
<td>Ethylene</td>
<td>Fuel gas</td>
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<td>Refinery propylene (FCC)</td>
<td>Propylene</td>
<td>Alkylation/polygasoline</td>
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<td>Reformate</td>
<td>Benzene, toluene, xylenes</td>
<td>Gasoline blending</td>
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<td>Naphtha and LPG</td>
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<td>Dilute ethylene (FCC &amp; delayed coker offgas)</td>
<td>Ethylbenzene</td>
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<td>Refinery propylene (FCC product)</td>
<td>Polypropylene, Cumene, Isopropanol, Oligomers</td>
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<td>Butylenes (FCC and delayed coker)</td>
<td>MEK (methyl ethyl ketone)</td>
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<td>o-xylene</td>
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<td>Reformate</td>
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<td>Kerosine</td>
<td>n-paraffins</td>
<td>Refinery product</td>
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<td>FCC light cycle oil</td>
<td>Naphthalene</td>
<td>Diesel blending</td>
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</tbody>
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Source: Petrochemcomplex shields refining profits, Oil & Gas Journal; 96 (1998) 62-65
Mutual relationship benefits

- Lowering the costs and improving the efficiency
- Ensuring the security of feed supply to petrochemical industries
- Re-processing of materials
Integrative optimization of refining and petrochemical plants
Potential types of petrochemical-refining integrations

- Process integration (innovative designs considering down-stream petrochemical plants)
- Utility integration (heat, hydrogen, water, steam and electricity)
- Treatment of gas fuel (utilization of hydrogen and hydrocarbons present in gas fuel as petrochemical feedstock)
Process integration

- Max. Olefin Production by Integration of Refinery Crackers & Petrochemical Reformer.
- Recovering more Aromatics by Integration of Extractive Distillation in Petroleum Refineries & Petrochemical Solvents.
- Recovering Aromatic Components by Integration of Steam Cracking Products & BTX Petrochemical Complex and also Blending the Rafinate after Extraction into the Gasoline or Naphtha pool.
Utilities integration

- Up to 60% Energy Saving by Integration of Sources & Sinks of Steam Cracking & Gas Processing.
- Up to 10% Energy Reduction by using Gas Turbine Integration between Petrochemical Units & Ammonia Plants.
- Hydrogen management between Refinery Units & Petrochemical Plants.
Fuel gas upgrading

- Extraction of $\text{C}_2/\text{C}_3$ from Refinery FCC off gas Streams to Petrochemical Plants as feed stocks.
- Recovering $\text{H}_2$ from Petroleum Refineries to Petrochemical Plants and vice versa.
Refining/petrochemical process links

Source: Total Raffinaderij Antwerpen, February 29th 2008
Purpose of petrochemical refinery

Refinery aimed at production of petrochemical feedstock

- Propylene production should be maximized.
- Old and small ethylene plants are not competitive.
- Demand of petrochemical products, especially propylene, will increase.
The petrochemical refinery

Conventional Scheme

Refinery

Maximize Gasoline/Fuel Production

Crude → Refinery → Gasoline, Kerosene, Gas Oil, Fuel Oil

Steam Cracker

Naphtha

Imported Naphtha

Naphtha

Petrochemical Feedstock

Refinery and Petrochemical Integration

Petrochemical Refinery

Maximize Petrochemical Production

Crude → Petrochemical Refinery → Petrochemical Feedstock

Source: Toyo Engineering Corporation, Petrochemical Refinery, 2011
Basic building blocks for petrochemicals:

- Olefins
  - Ethylene
  - Propylene
  - Butadiene
- Aromatics
  - Benzene
  - Xylenes
- Synthesis gas
Integration challenges

- Integrated plants are more complex and, consequently, could face with some technical difficulties
- They are operationally less flexible
- Integration may result in conflicting of planning and operational objectives and diffusing of business focus
Global approach

- Several important oil companies have employed the integration of refining-petrochemicals in different ways
- Many of the new licenses are offered in integrated form or are capable of adopting integration mode of operation
Petrochemical – refinery integration in Europe

Lurgi’s integrated process for co-production of methanol and ammonia

Source: www.lurgi.com
Overall advantages of this integrated technology

- Large scale production of more than one product;
- Cost reduction due to shared process equipment and utilities;
- Reduction in gas consumption and CO₂ emissions to atmosphere;
- High efficiency;
- Flexibility in methanol and ammonia productions;
- Pure CO₂ production as a by-product to be used in methanol synthesis or ammonia conversion to urea.
ATOFINA/UOP Olefin Cracking Process

- Integration of UOP OCP-Total Petrochemicals into steam cracking allows maximizing the propylene to ethylene yield ratio.

- Heavier by-product olefins of MTO are converted to propylene and some associated ethylene in the Olefin Cracking process.
Integrated plant of Ras Tanura refinery complex and Jua`ymah gas processing plant

Source: www.sudiaramco.com
Ras Tanura refinery complex and Jua`ymah gas processing plant

- Saudi Aramco Co. - Dow Chemicals joint project
- Ras Tanura refinery delivers naphtha, vacuum gas oil (VGO) and reformate to petrochemical plants from which more than 30 value-added products will be produced.
By-products will recycle back to refinery for re-processing. This integrated plant, valued $20 billion.

- Ethylene, propylene, aromatic and chlorine derivatives are main products of this integrated plant.
Iran situation: Historical

- Construction of petrochemical complexes adjacent to refineries for feed provision is historical samples of this approach.
- The importance of integration as a necessity rather than an option is realized both by NIORDC and NPC.
- Propylene deficiency due to increased ethane crackers capacity
Northern Isfahan Petro-Refinery Complex (NIPRC)

- Two olefin and aromatic petrochemical units
- One refinery unit (150,000 bpd)
- Seven related down-stream chemical units
- An investment of more than 4 billion Euros+4500 billion Rials.
- 2.4 billion m³ of NG per year
Northern Isfahan Petro-Refinery Complex (NIPRC)-cont.,

- Refinery section products: $C_4$, gasoline, white oil, fuel oil, gas oil, naphtha, sulfur, lube cut and grease are produced from crude oil.

- Petrochemical section products: polyethylene, polypropylene, polybutadiene, polyester and gasoline, acetaldehyde, acetic acid, vinyl acetate, butanol, 2 ethyl hexanol, ethylene oxide and glycols are produced from natural gas.
Conclusions

- Integrated refining-petrochemical plants will balance one another
- Extend the petrochemical feedstock to unusual hydrocarbon sources such as heavy oils and residues
- By-products can be re-processed to increase more valuable products
- Employing more sophisticated process technologies and catalyst formulations required bringing about the licensors to develop joint venture cooperation
Thanks for your attention

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