Research Institute of Petroleum Industry

Petrochemical Research & Technology Co.

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

M. R. Jafari Nasr

Research Institute of Petroleum Industry (RIPI)

Saeed Sahebdelfar, Maryam Takht Ravanchi,

Majid Daftari Beshelli

Petrochemical Research and Technology Company (NPC-RT)

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Contents

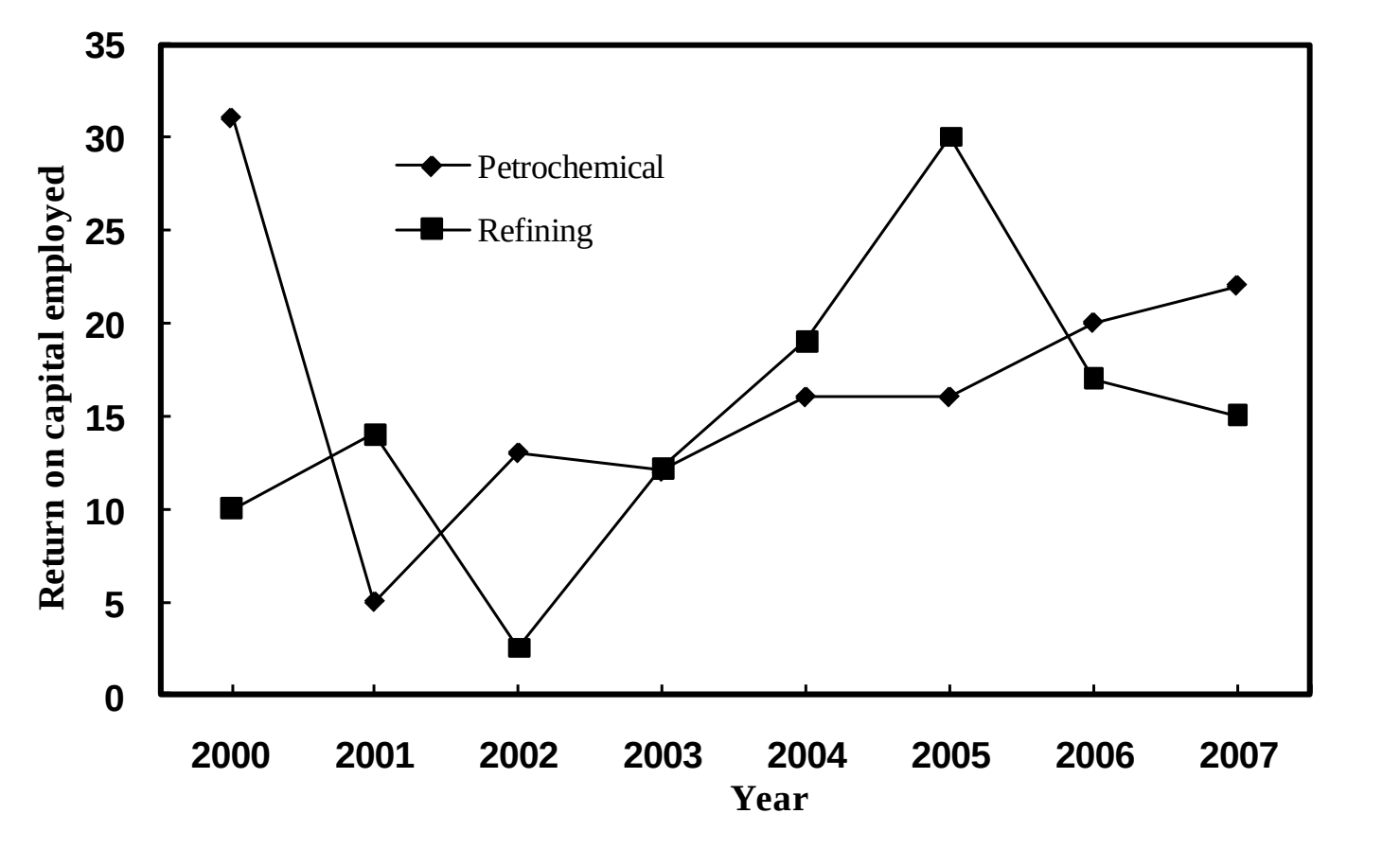
Integration drivers for petrochemical industry

- 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



Source: P. R. Costa, *"Panorama of the Petrochemical–Refining Integration at Petrobras"*, Rio Oil & Gas Expo and Conference, Brazil, 2008

What Does Integration means?

Possible synergy between Refining & Petrochemical industries to achieve opportunities for more profitability.

Alternative usage of refinery streams in petrochemical industry

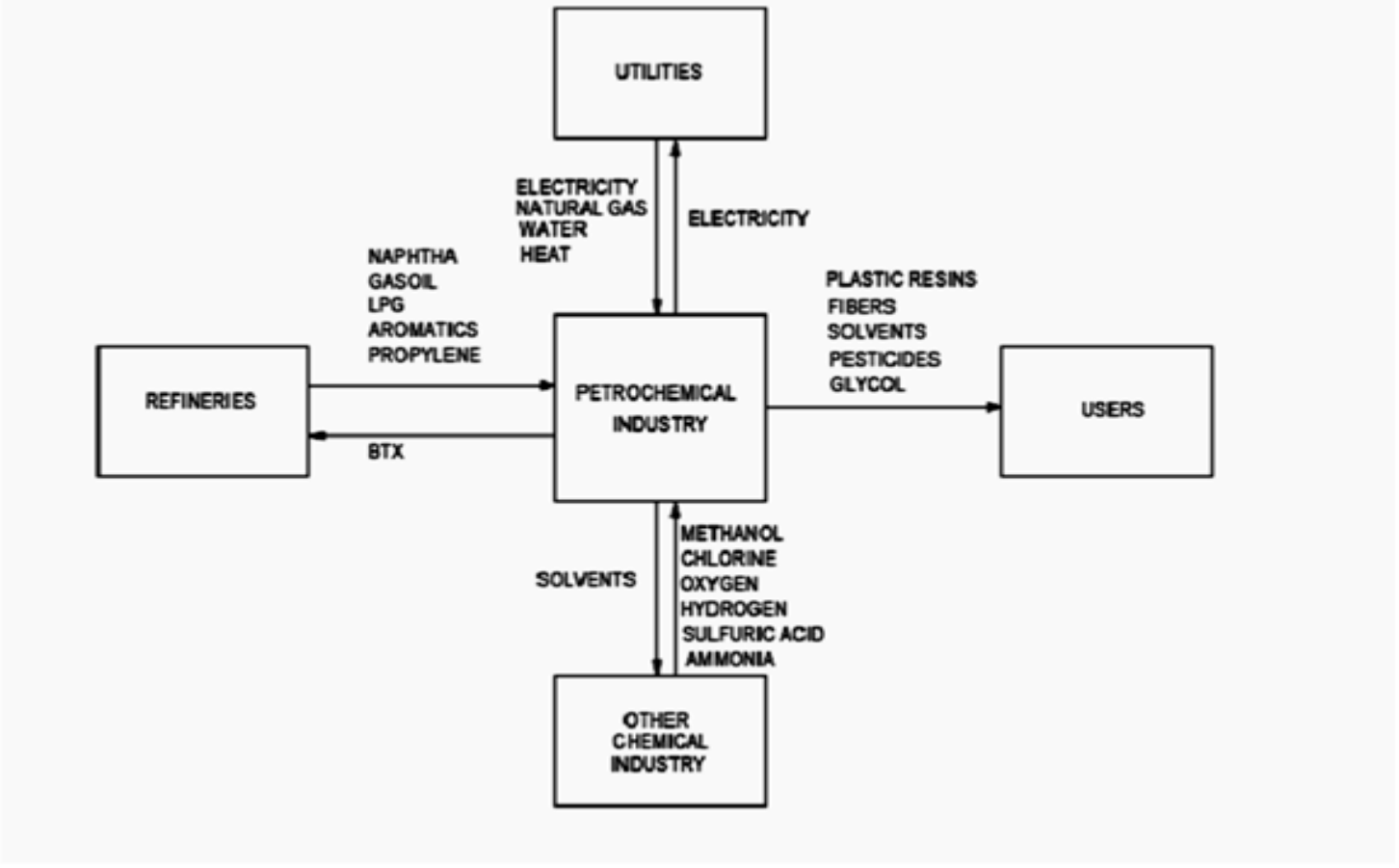
Refinery Stream	Petrochemical Stream	Alternative Refinery Use
FCC offgas	Ethylene	Fuel gas
Refinery propylene (FCC)	Propylene	Alkylation/polygasoline
Reformate	Benzene, toluene, xylenes	Gasoline blending
Naphtha and LPG	Ethylene	Gasoline Blending
Dilute ethylene (FCC & delayed coker offgas)	Ethylbenzene	Fuel gas
Refinery propylene (FCC product)	Polypropylene, Cumene, Isopropanol, Oligomers	Alkylation
Butylenes (FCC and delayed coker)	MEK (methyl ethyl ketone)	Alkylation, MTBE
Butylenes (FCC and delayed coker)	MTBE	Alkylation, MTBE
Refinery benzene and hydrogen	Cyclohexane	Gasoline blending
Reformate	o-xylene	Gasoline blending
Reformate	p-xylene	Gasoline blending
Kerosine	n-paraffins	Refinery product
FCC light cycle oil	Naphthalene	Diesel blending

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.

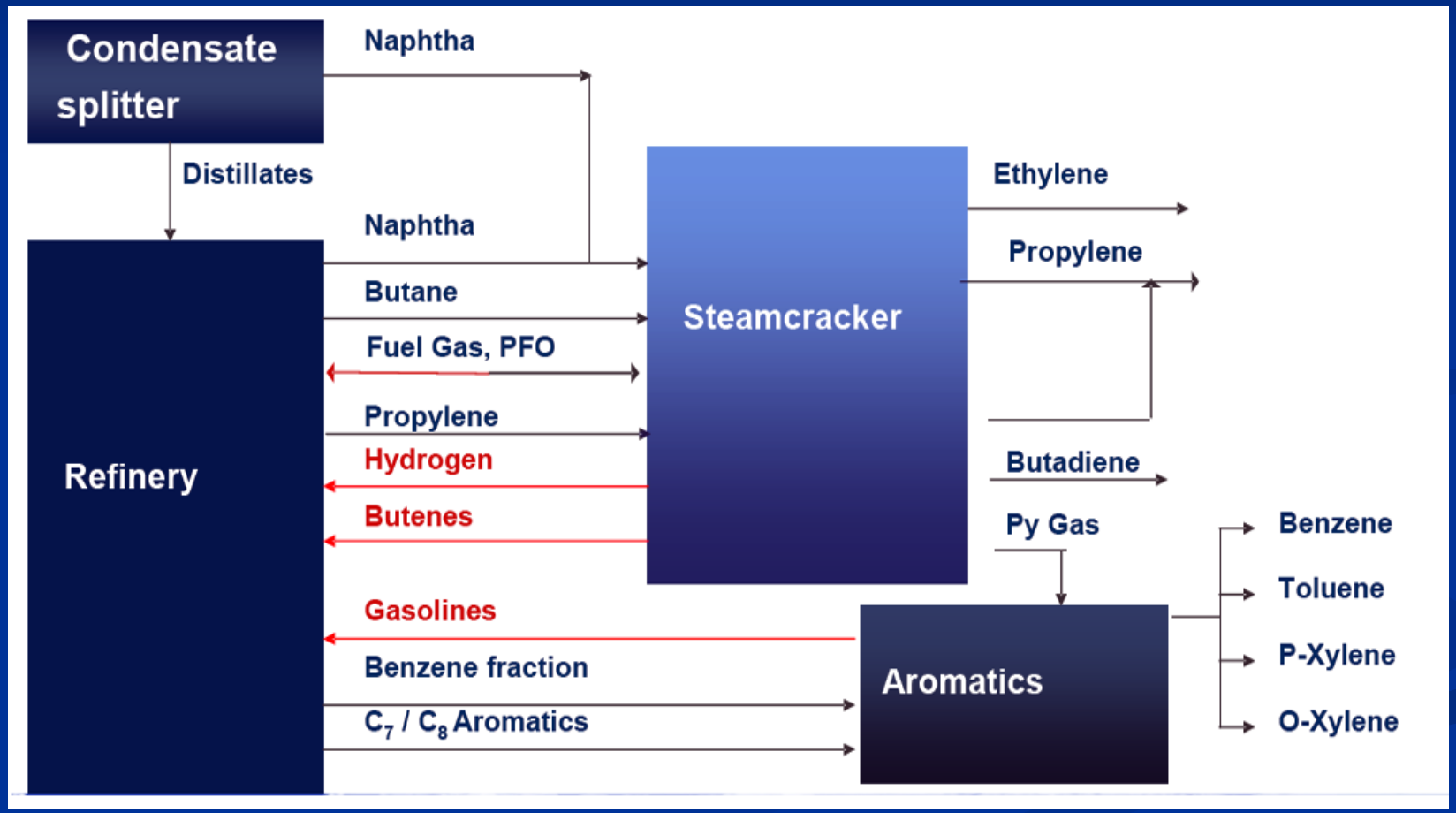
Utilities integration

- 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.
- Energy Saving by Heat Recovery in Isomerization of Petroleum Refineries.
- Hydrogen management between Refinery Units & Petrochemical Plants.

Fuel gas upgrading

- Extraction of C_2/C_3 from Refinery FCC off gas Streams to Petrochemical Plants as feed stocks.
- Recovering H_2 from Petroleum Refineries to Petrochemical Plants and vice versa.

Refining/petrochemical process links



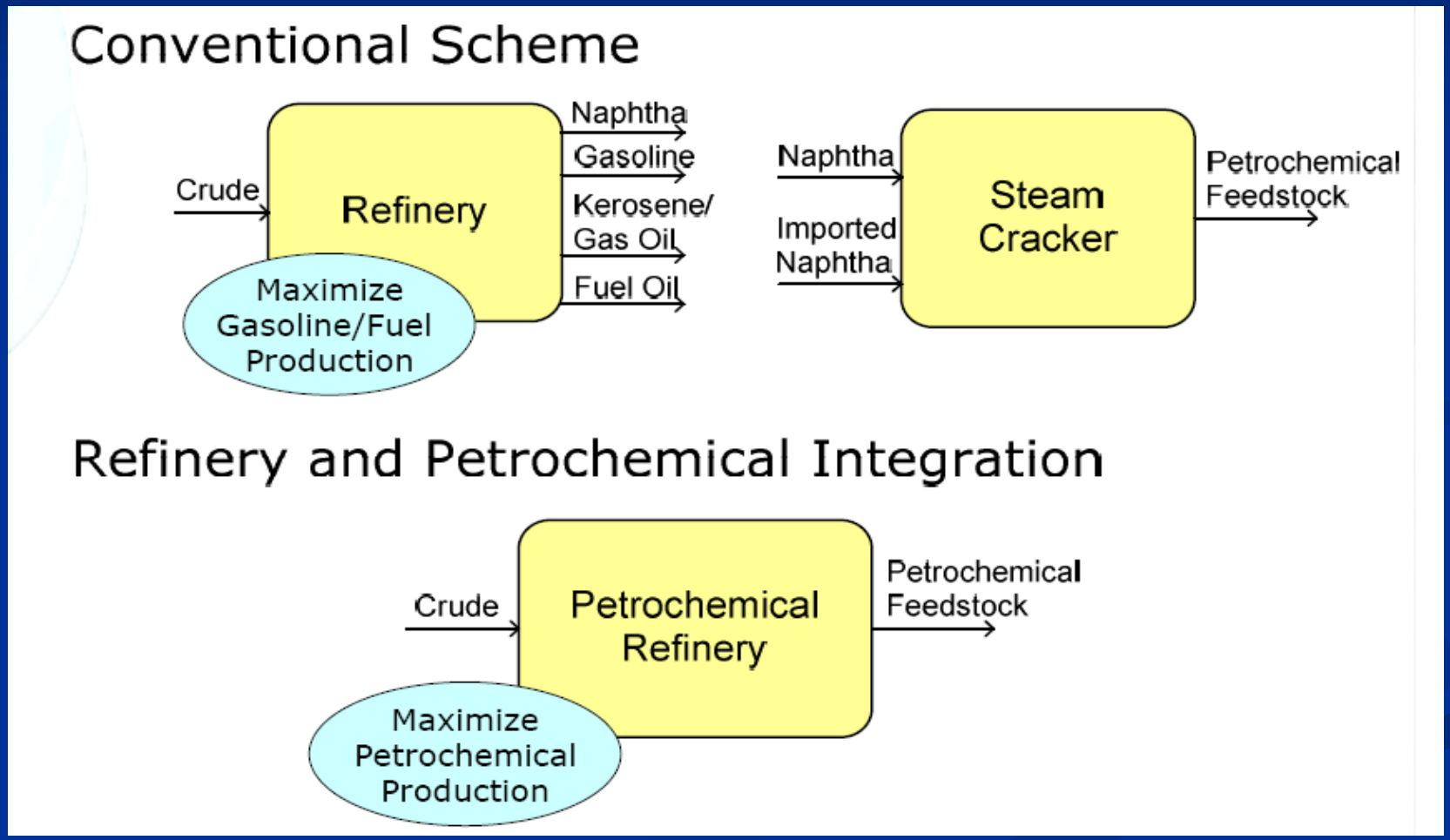
Source: Total Raffinaderij Antwerpen, February 29th 2008

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



Source: Toyo Engineering Corporation, Petrochemical Refinery, 2011

Basic building blocks for petrochemicals:

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

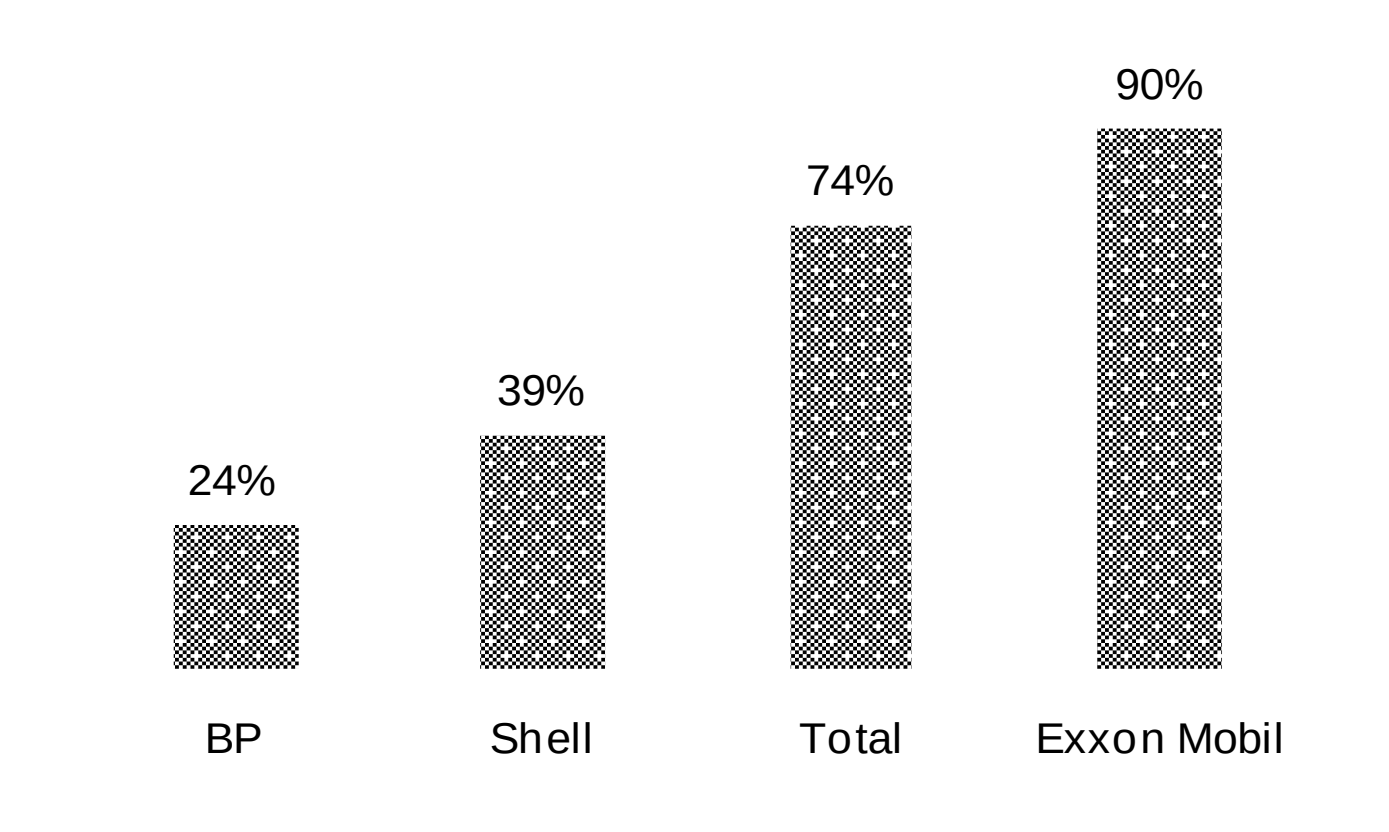
Integration challenges

- 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

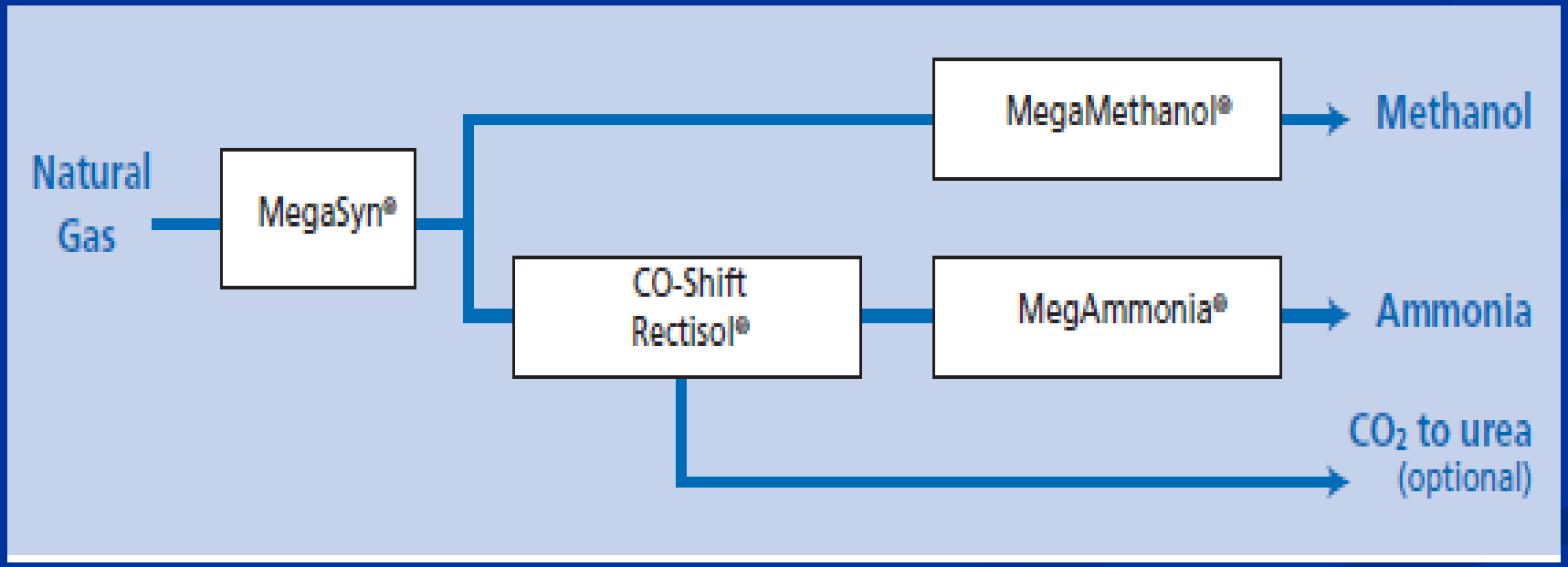
- Several important oil companies have employed the integration of refining-petrochemicals in different ways
- Many of the new licenses are offered in integrated form or are capable of adopting integration mode of operation

Petrochemical – refinery integration in Europe



Source: T. Schockaert, *"Synergies between Refining and Petrochemicals"*, High Level Group on the Competitiveness of the European Chemical Industry Conference, Brussels, Belgium, 2008, pp 1-23.

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



Source: www.lurgi.com

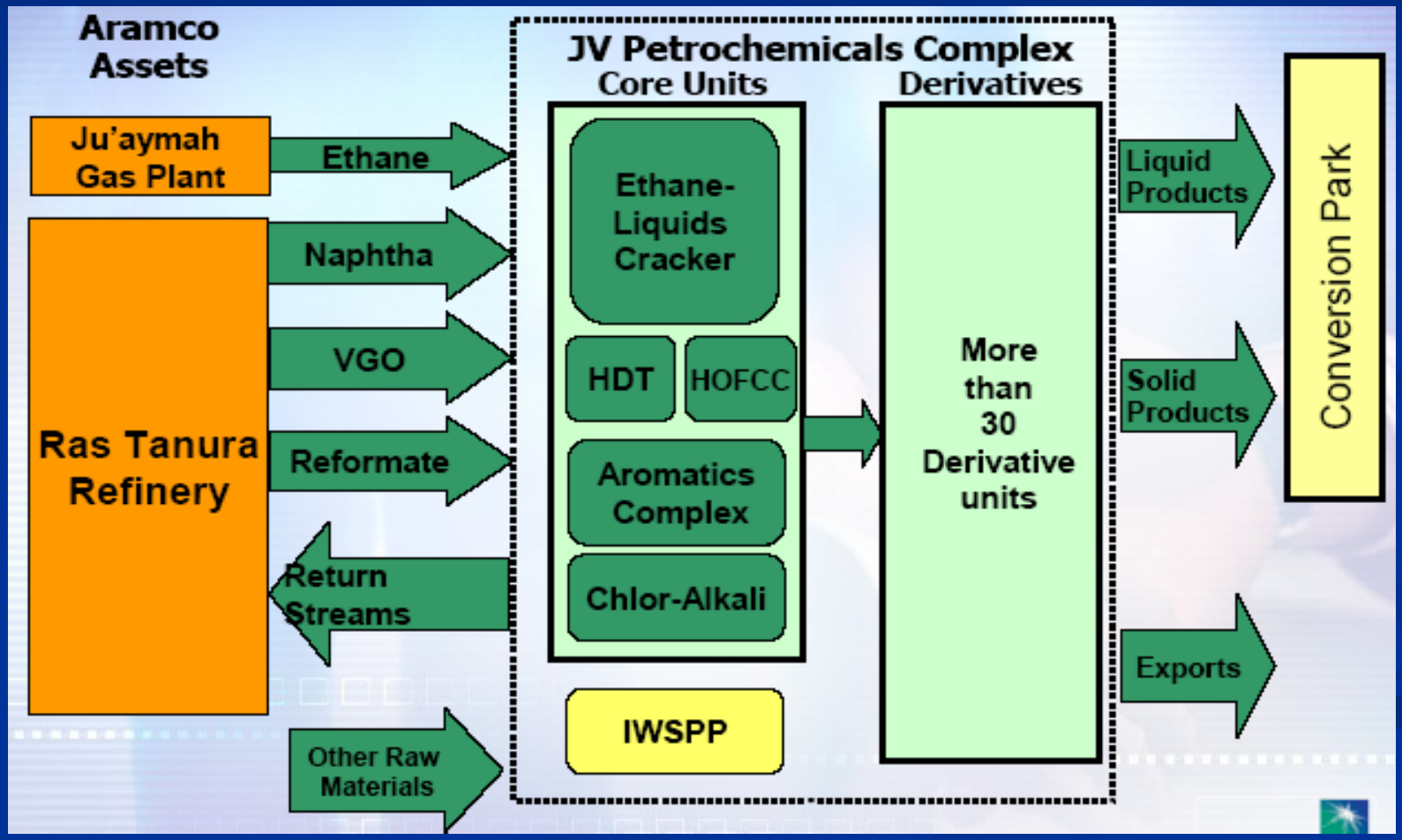
Overall advantages of this integrated technology

- Large scale production of more than one product;
- Cost reduction due to shared process equipment and utilities;
- Reduction in gas consumption and CO_2 emissions to atmosphere;
- High efficiency;
- Flexibility in methanol and ammonia productions;
- Pure CO_2 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.

Ras Tanura refinery complex and Jua`ymah gas processing plant (cont'd)

- 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 m^3 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, acetaldeyhde, 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

Presenter:
Saeed Sahebdelfar, Petrochemical Research and Technology Co.
Catalysis Research Group
s.sahebdel@npc-rt.ir