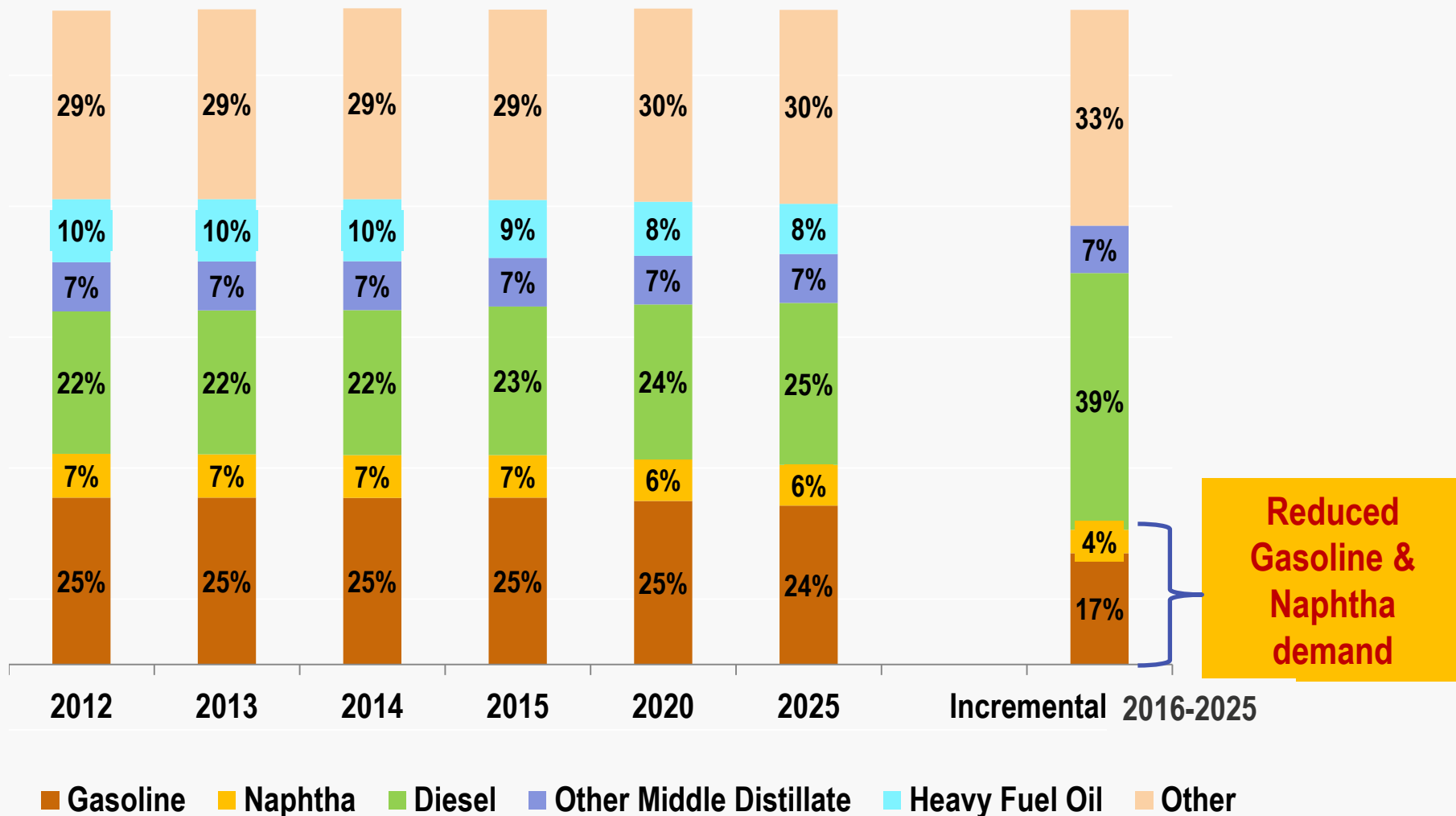


Maximizing Refinery Margins by Petrochemical Integration

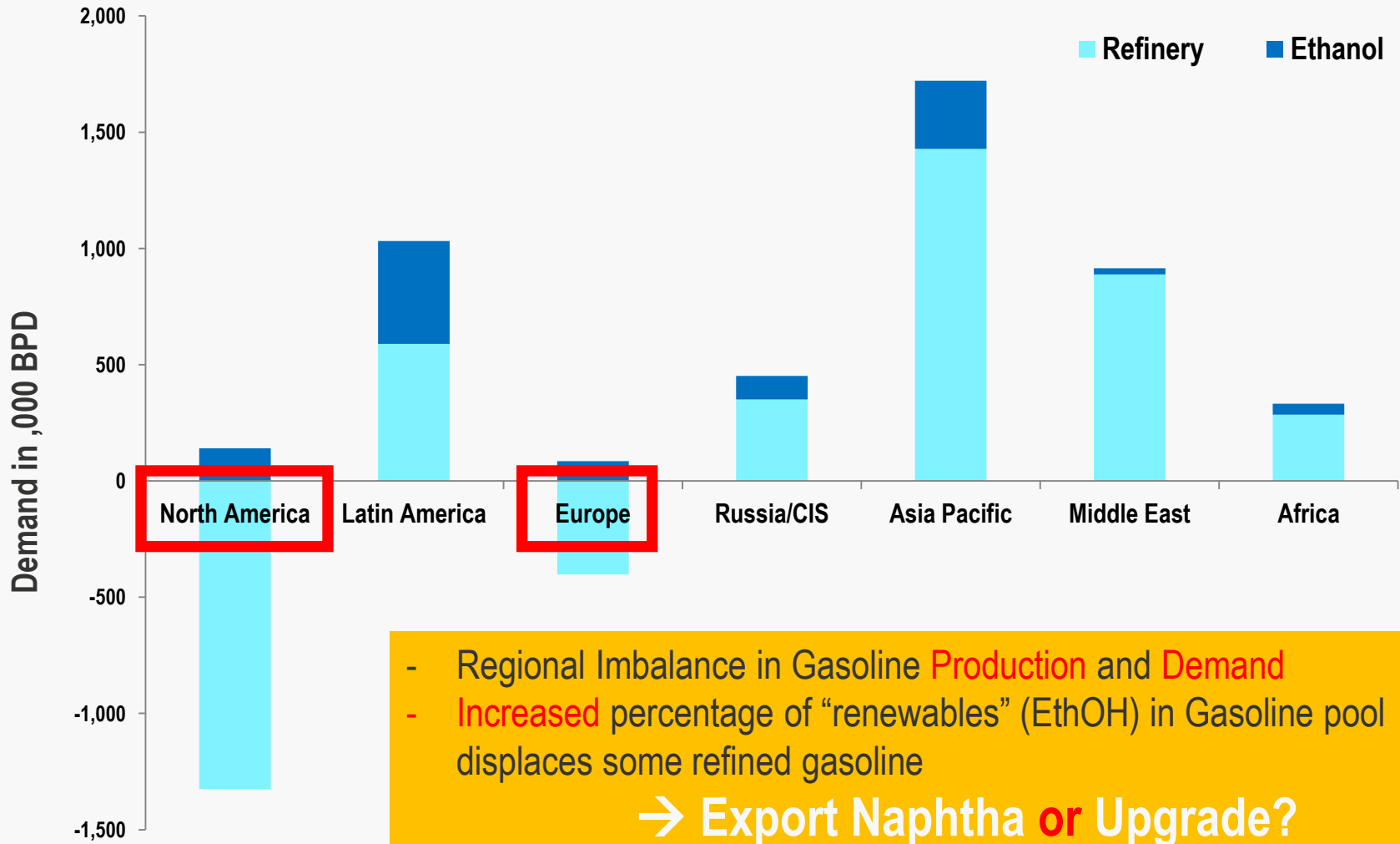
Rajeev Singh, LKMT Workshop, 13th Oct 2017, New Delhi

KBR
TECHNOLOGY

Global Demand for Refined Products

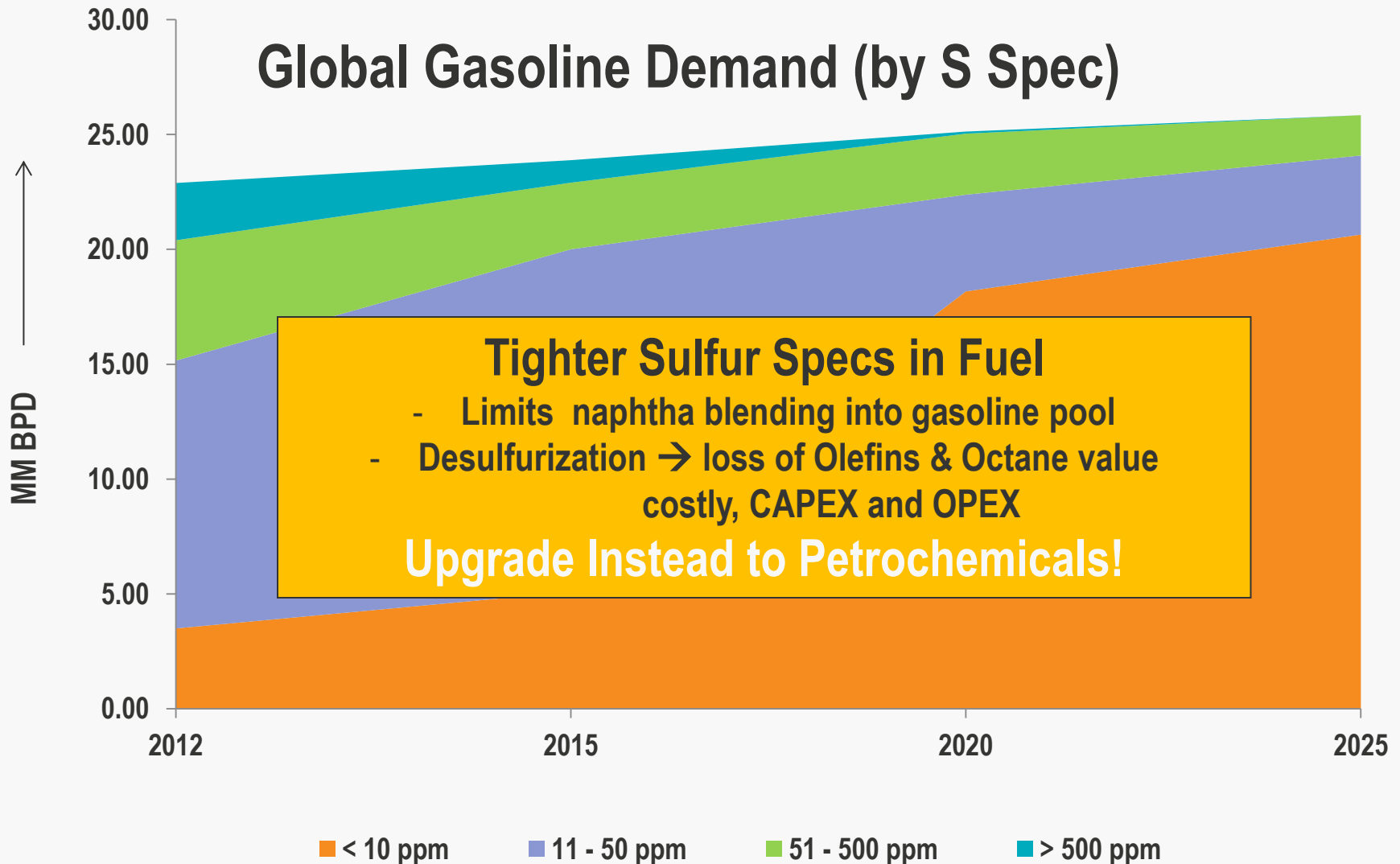


Regional Gasoline Growth



Source: Hart Energy Research & Consulting

Tightening Fuel Specifications



Refinery Trends: India

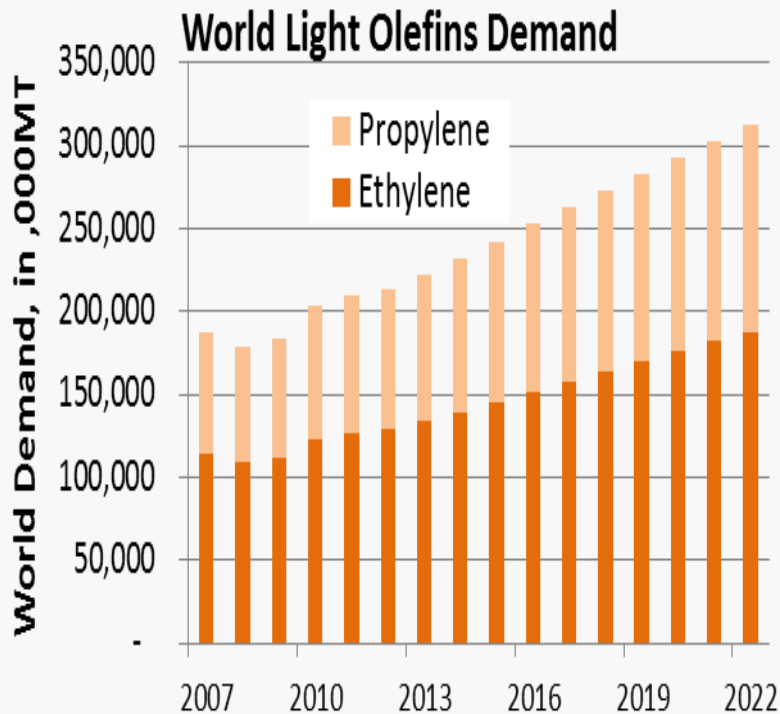
- ◆ Implementation of **BS IV** in India From **April 2017**.
- ◆ Gasoline Specification gets stringent to meet BS IV Standards.
- ◆ In rural areas, a shift in **Gas for cooking** and **electricity for lighting** has resulted in decrease in Kerosene Demand.
- ◆ There are **23 refineries** spread across in India with refining Capacity of **237 MTPA**.

Surplus

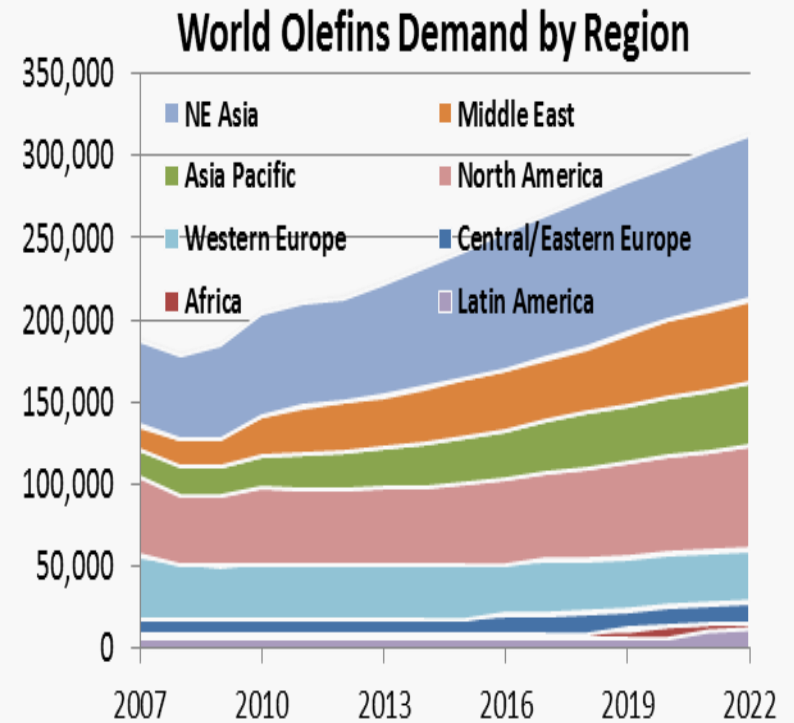
Naphtha & Kerosene ?



WORLD LIGHT OLEFINS DEMAND



WORLD OLEFINS DEMAND BY REGION



Benefits of Refinery Petrochemical Integration

- ◆ Assured Refinery Product **uptake**
- ◆ **Secure** Petrochemical Feedstock availability
- ◆ Significant **savings** in investment
 - Shared utilities, infrastructure, logistics
- ◆ **Savings** in operating costs
 - Energy integration, shared resources
- ◆ FeedStock & Product **Flexibility** to Meet market Demand
- ◆ **Improved** Gross Refinery Margin (GRM)

TECHNOLOGY PORTFOLIO



KBR Olefins Technology Portfolio

What	Feeds	Features
SCORE™ (Steam Cracking)	Ethane through Gas Oil	<ul style="list-style-type: none"> • Residence time ~0.08 – 1.0 sec • Low CAPEX • Superior Performance • Offered via Agreement with ExxonMobil
Off Gas Recovery	Low value refinery Off gases	<ul style="list-style-type: none"> • Recovers Most of Ethylene & Propylene • Recovers Paraffins (Ethane & Propane) in recycle Stream • Low Capital Cost & Low Energy Consumption
K-COT™ (Catalytic Olefins)	<u>Olefinic</u> C4-C10	<ul style="list-style-type: none"> • P/E ratio ~ 2/1 • Gasoline by-product >50% aromatics • Recycle C4-C6 NA to extinction without additional treating
	<u>Paraffinic</u> naphtha, light distillates	<ul style="list-style-type: none"> • P/E ratio ~ 1/1 • Recycle C4s/C5s without additional treating
	Non-traditional	<ul style="list-style-type: none"> • High olefin yields from methanol, ethanol and other oxygenates and MTO/MTP and FT by-products

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SCORE™, is the traditional steam cracker technology offered in collaboration with ExxonMobil that combines **S**elective **C**racking furnace technology with an **O**ptimum **R**Ecovery section.

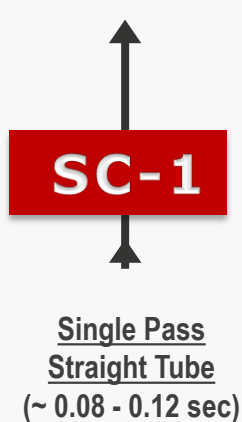


Selective Cracking Optimum REcovery

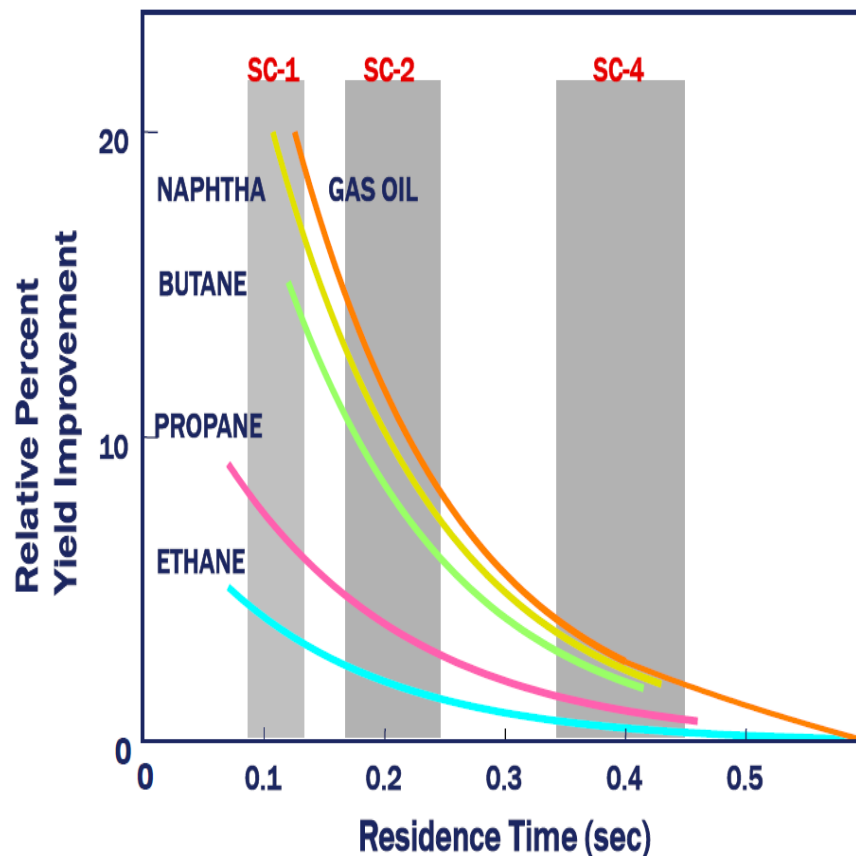
- ExxonMobil has a long history of development and application of their own pyrolysis furnace technology.
- ExxonMobil brings the perspective and experience of a furnace operator to the design.

SCORE™ Furnace Portfolio

Coil Type	One pass	Two pass	Four pass
Residence Time (sec)	0.1	0.2	0.4
SCORE	SC-1	SC-2	SC-4
Competitors	No	Yes	Yes



Furnace Coil Portfolio



Broadest range of residence times in the Industry

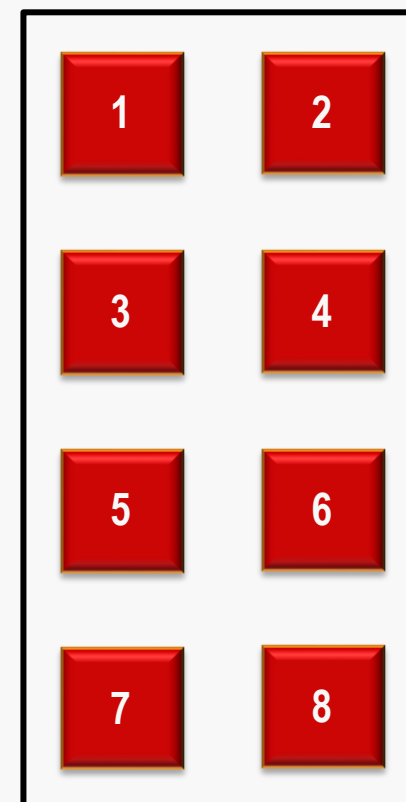
Highest Ethylene Yield In Industry

Multi-Feed (Hybrid) Cracking

SCORE™ Furnaces

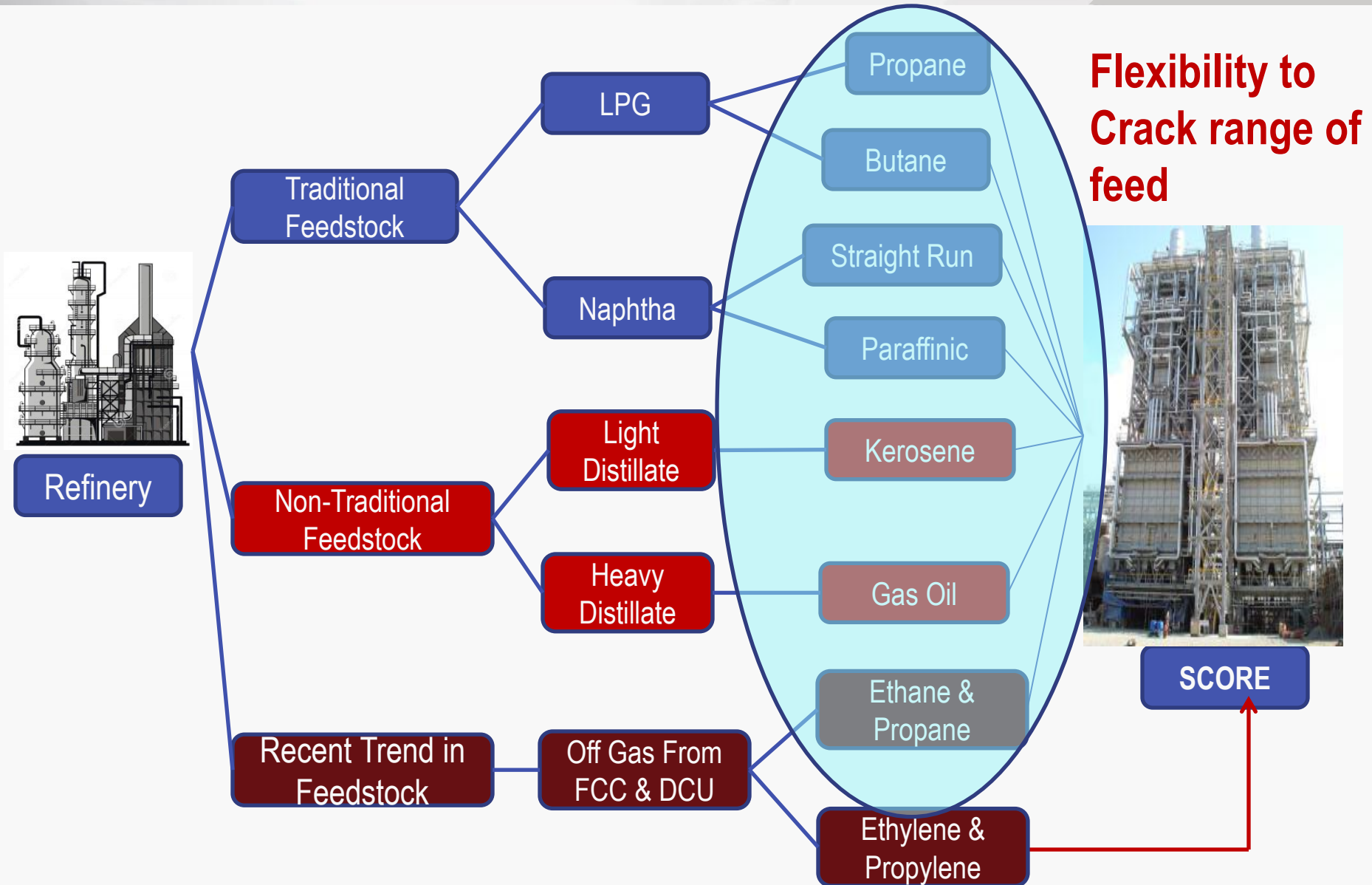
- Large Capacity
- Single Cabin Firebox
- 8 individually flow controlled passes
- Number of Feeds only limited by inlet piping arrangement
- Each Feed can be cracked at optimum conditions:
 - Temperature
 - S:HC Ratio

Furnace

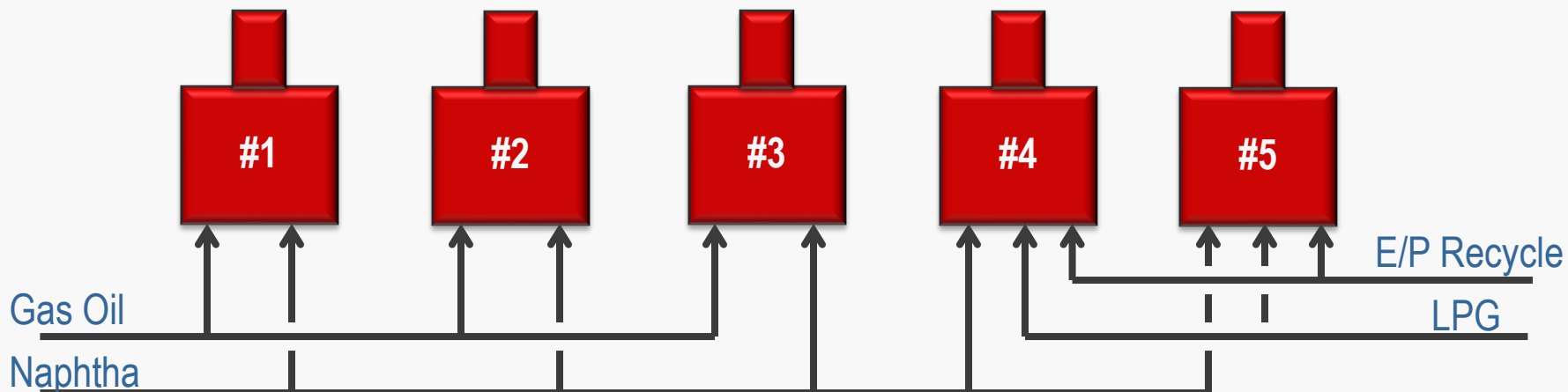


Flexibility of 8 Mini Furnaces within a Single Firebox

Petrochemical Feedstock Flexibility



SCORE™ Reference Facility



Configuration

- Four (4) Hydrocarbon Furnace Feeds
- Furnaces 1 – 3: 50/50 Flexibility
- Furnaces 4 – 5: Full Flexibility

Advantages

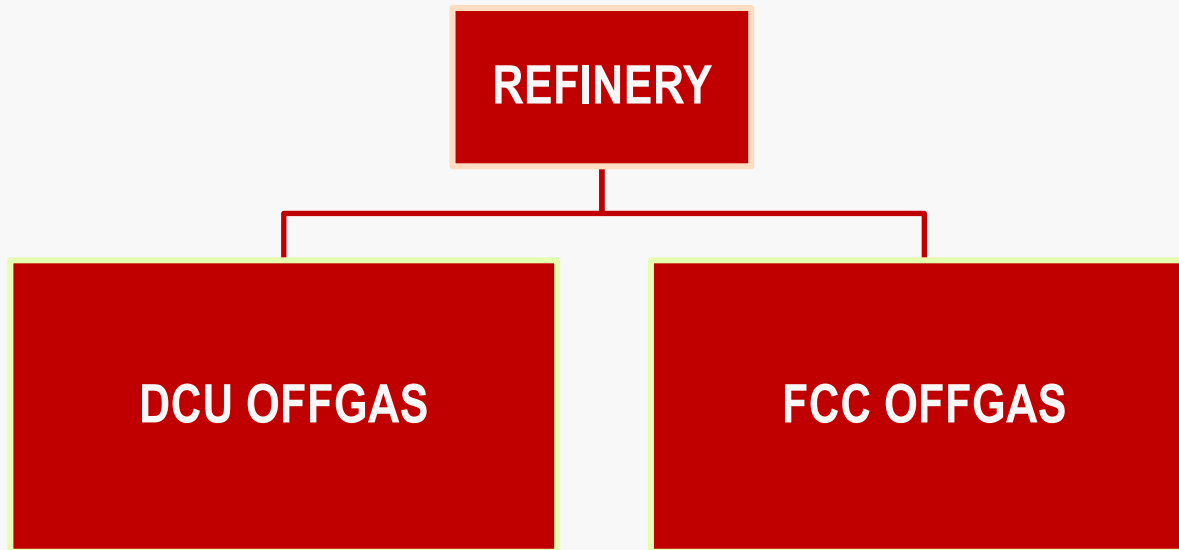
- No Dedicated Recycle Gas Furnace
- No Co-Cracking:
 - Feeds cracked at optimum conditions
- High Flexibility
- Low TIC

Flexibility allows Maximum Profitability

Off Gas Recovery Unit Technology

What	Feeds	Features
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	Non-traditional	<ul style="list-style-type: none"> High olefin yields from methanol, ethanol and other oxygenates and MTO/MTP and FT by-products

Off Gas Recovery Unit – Introduction



OffGas Stream Rich in High Value Olefins

- ♦ Refinery Off Gas- Rich in Olefins, C2 & C3 saturates, normally used as fuel gas.

KBR Provides solution to recover – high value olefins, C2 & C3 saturates and fuel gas products with - Off Gas Recovery Technology.

Off Gas Recovery Unit – Overview

PROCESS BLOCK

STANDALONE

CONTAMINANT REMOVAL

RECOVERY SECTION

PG ETHYLENE, ETHANE, C3 PRODUCT HIGH HEATING VALUE FUEL GAS

INTEGRATED

CONTAMINANT REMOVAL

REFINERY GAS RECTIFIER

PRODUCT- FUEL GAS AND C2+ RICH STREAM INTEGRATED WITH STEAM CRACKER)

UTILITIES AND ANCILLARIES BLOCK

STANDALONE

PROPYLENE REFRIGERANT

CW, STEAM, ELECTRICITY
(CAN BE INTEGRATED WITH REFINERY)

INTEGRATED

SAME AS STEAM CRACKER
(PR & ER REFRIGERATION, CW, STEAM, ELECTRICITY)

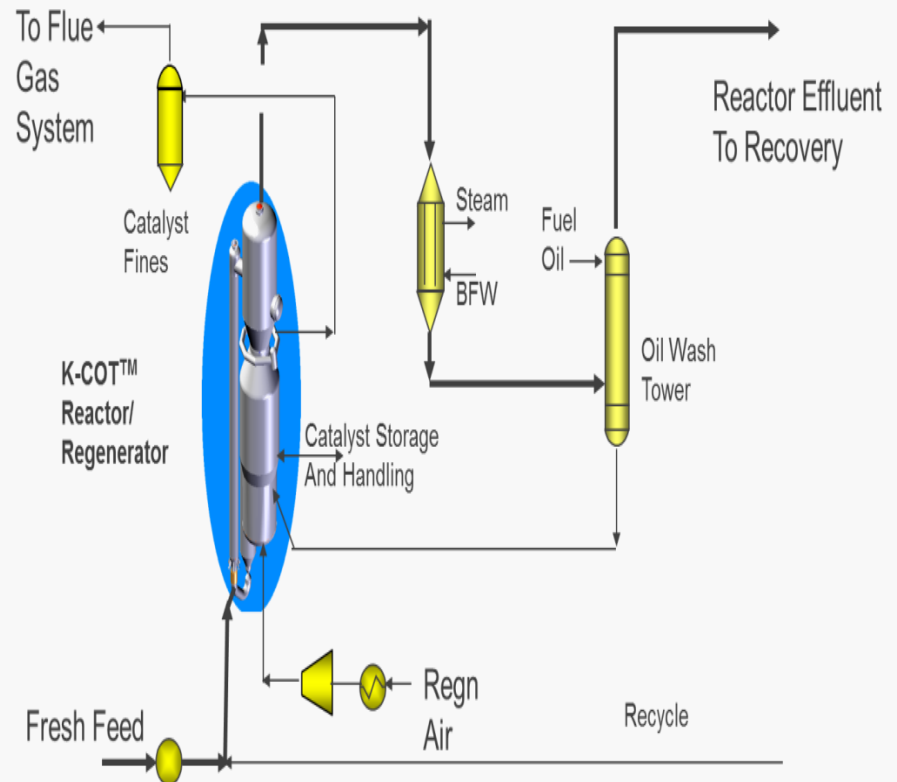
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- ◆ K-COT™ is KBR's Catalytic Olefins Cracking Technology (FCC) that processes light **Olefinic, Paraffinic** or **mixed** feeds, resulting in high propylene yields with ethylene and aromatic-rich gasoline by-products.

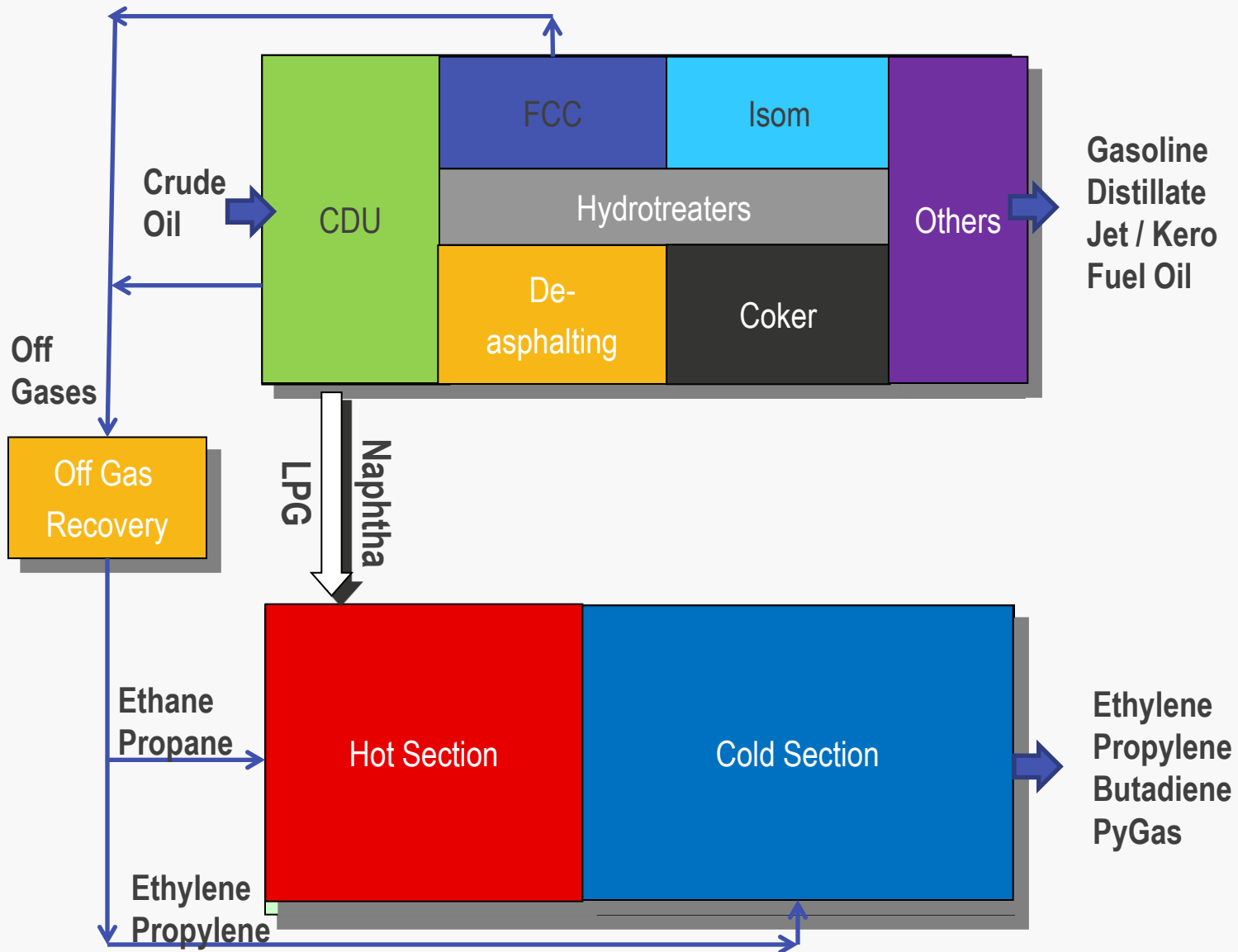


Reactor Converter

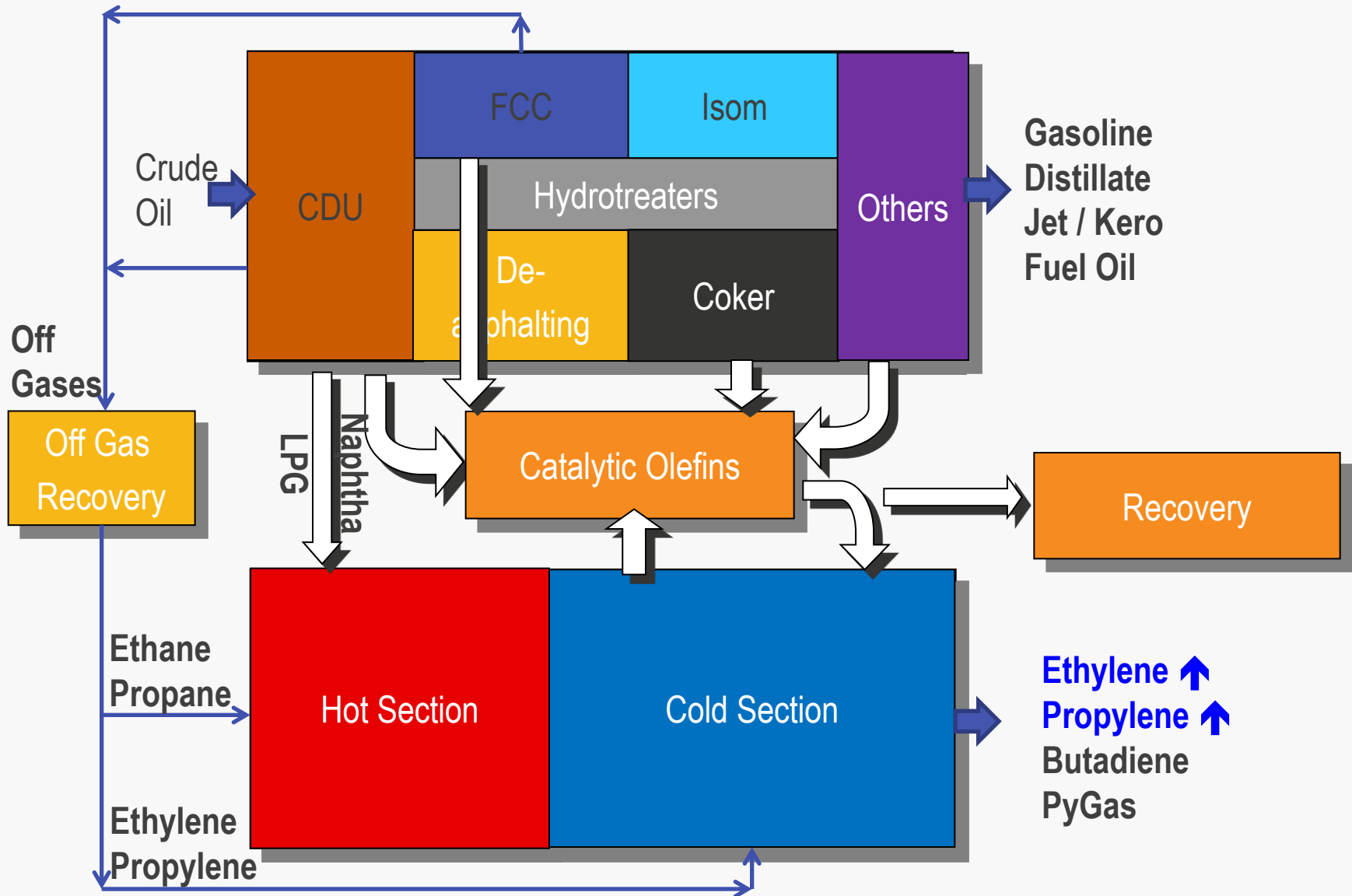
- ◆ Proven FCC-based technology
- ◆ Tailored catalyst maximizes propylene yield
- ◆ Smooth Startup
- ◆ Simple operation
- ◆ Low maintenance
- ◆ Wide Feed flexibility



Traditional Integration Scheme

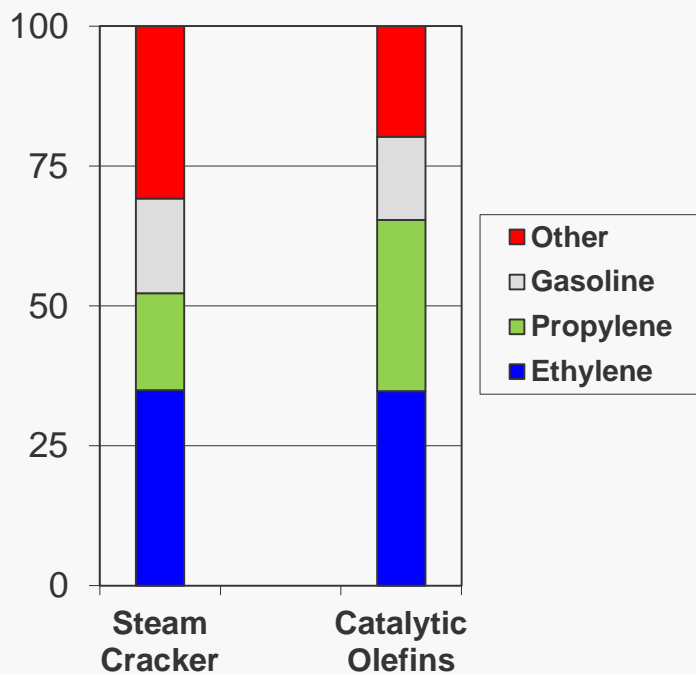


Optimized Integration Scheme

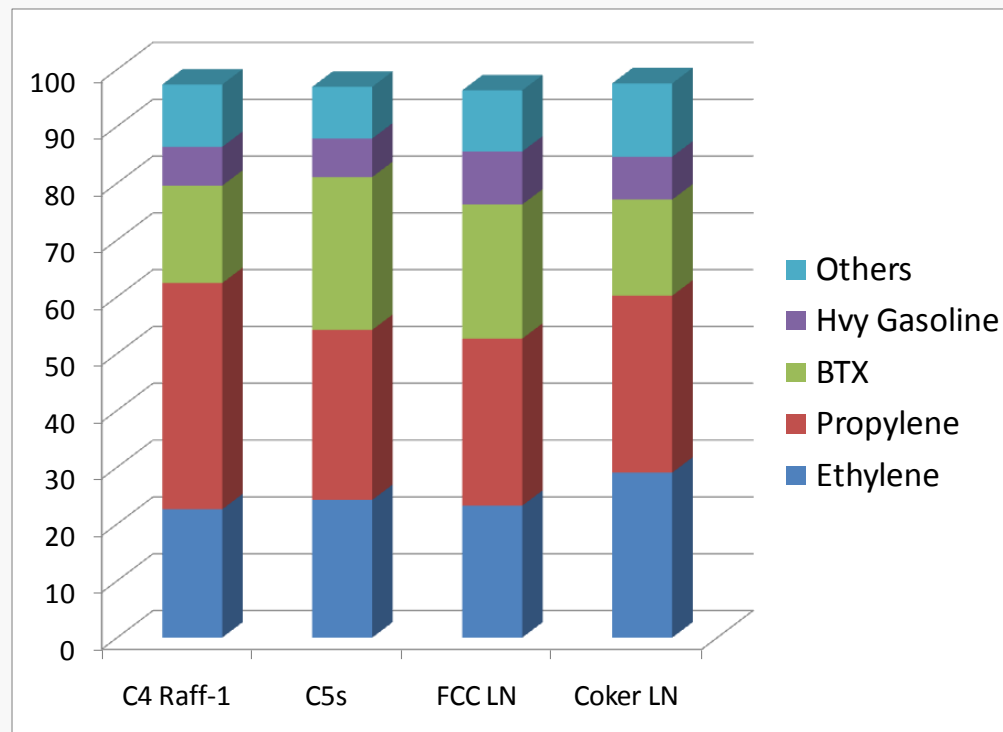


Typical Ultimate Yields from KCOT™ Unit

Paraffinic Feed



Olefinic Feed



- Global trend reflects **decrease** in demand for Gasoline & Naphtha
- Petrochemicals show **incremental Growth** across the world.
- Market volatility & Sustainability **demands** Integration of Refinery with Petrochemicals
- KBR Offers technology with **unmatched Feed & Product Flexibility** to meet market demand.
- Higher Flexibility Offers **Higher Profit Margin** for Refineries.