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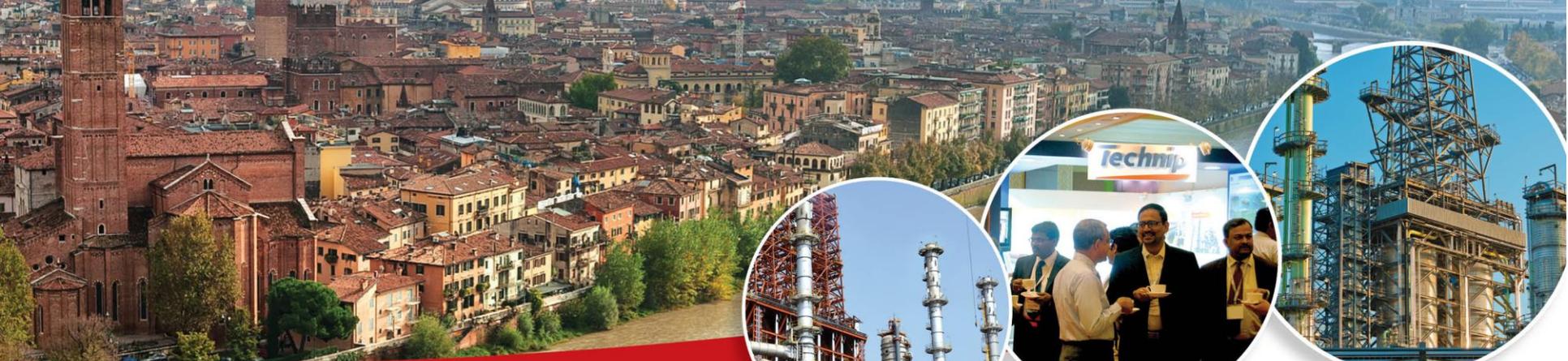
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Value Addition through Refinery and Petrochemical
Integration

Vineet Bakshi & Vinay Gupta
Engineers India Ltd



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ABSTRACT

Value addition through Refinery and Petrochemical Integration

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Given the spiralling prices of the crude oil and shrinking margins in the Refineries, it has become almost inevitable to look for value added opportunities to be integrated in the Complexes through Petrochemical integration. The fact that most of the petrochemical produces invite a higher degree of margin vis-à-vis the fuels, there is a strong case for integration between refinery and Petrochemical Complex, wherein, both feed as well as energy integration can be exploited for soliciting higher revenues.

In the context of the same, a comprehensive study has been conducted at our end, wherein, an existing refinery has been integrated to a Catalytic Olefins unit to generate Ethylene, Propylene, and BTX cut for downstream Petrochemical units. Additionally, to enhance the scale of the project, a PDH Plant has been integrated with Catalytic Olefin facility to ensure world scale production facilities of Polypropylene, Acrylic Fibre, Propylene and Phenol. The BTX cut from the integrated PDH / Catalytic Olefin facility is integrated with an existing Aromatics Complex, thus leading to saving in OPEX. Opportunities are present to pinch the low value streams from the refineries as feed stock to the Catalytic Olefins Unit including integration of PFCCU off- gases for generating additional Ethylene feedstock. The MEG Plant is foreseen to completely utilize the Ethylene produce for meeting the captive requirements of an upcoming PTA / PET Complex nearby. The returns from the project are extremely attractive and have invited the attention of major oil majors and several investors in India and abroad.

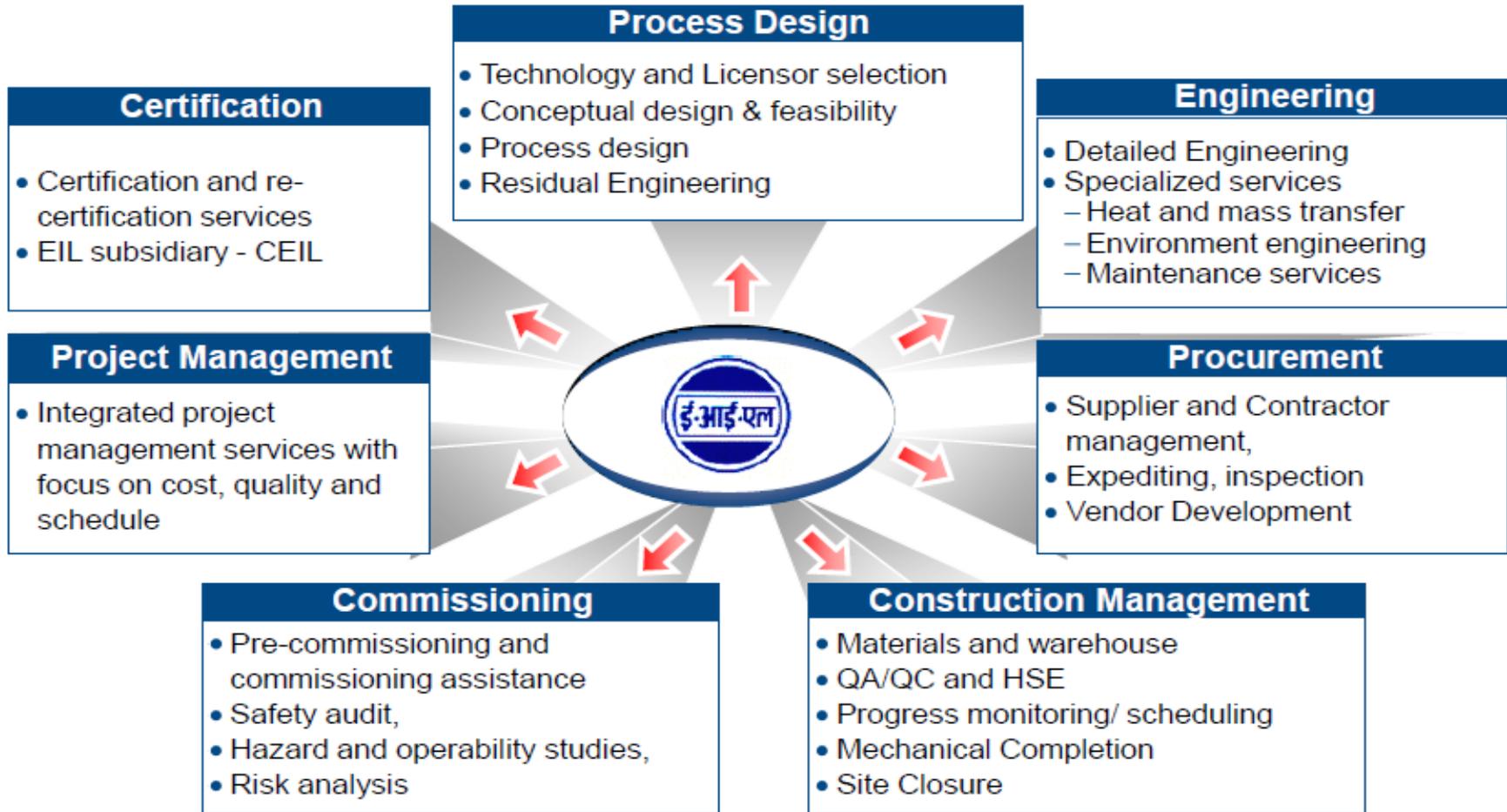
AGENDA

- ❖ Engineers India Ltd: Company Profile
- ❖ Challenges for a Refiner/ Petrochem Owner
- ❖ Drivers for Refinery Petrochemical Integration
- ❖ Working out the Synergy: Potential Available
- ❖ Premium Available for Integration
- ❖ Case Study

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Engineers India Limited: Concept to Commissioning

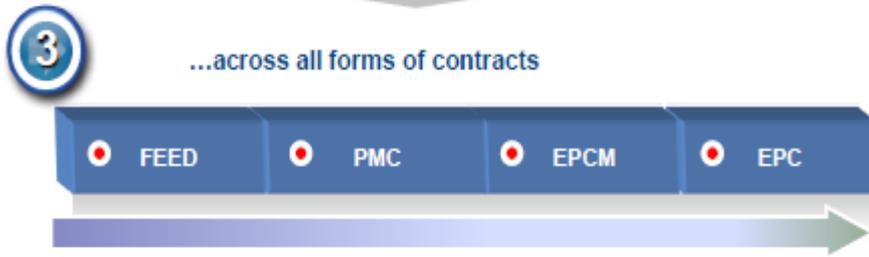
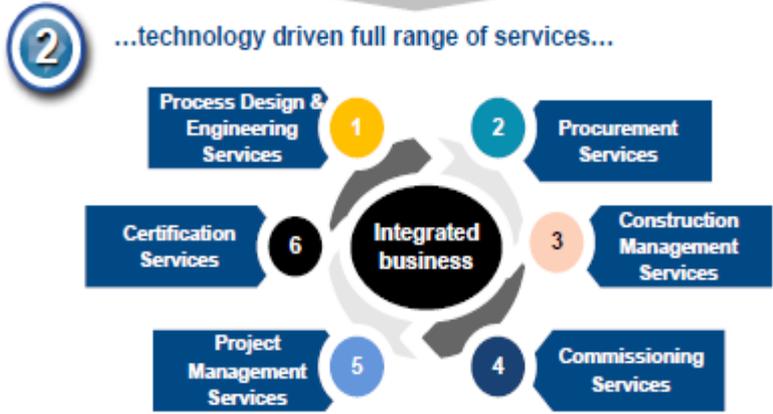


Significant track record across entire Oil & Gas value chain including **10 greenfield refineries, 37 Oil & Gas processing plants, 40 offshore process platforms, 42 pipelines and 7 petrochemical complexes**

Engineers India Limited: Technology Driven Competencies

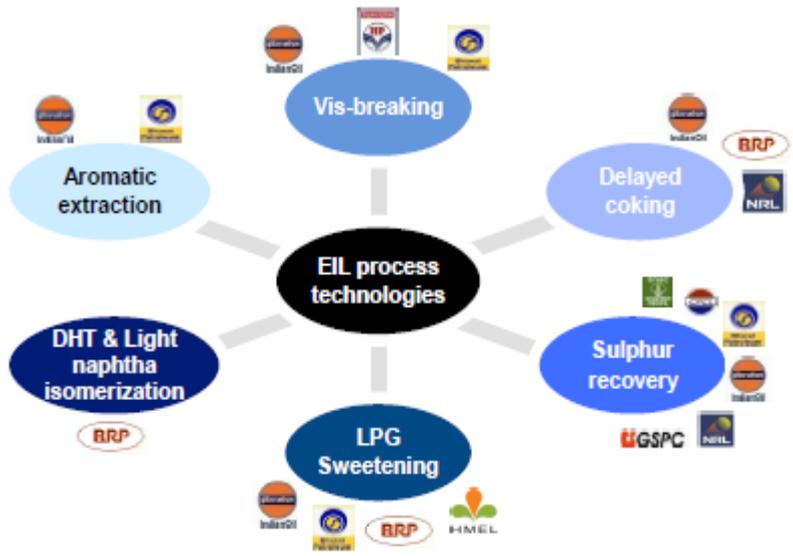
India's leading Engineering services firm with a comprehensive business model

1 State of the art R&D centre at Gurgaon...

Technology driven organisation

- ✓ EIL has developed over 30 process technologies for the oil & gas processing, refineries and petrochemical industries
- ✓ Currently holds 13 Live patents and have 15 pending patent applications relating to various process technologies
- ✓ Comprehensive environment engineering services
- ✓ Comprehensive Hazop, Hazan, Risk and consequence analysis services



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Challenges for a Refiner/ Petrochem Owner

- Spiraling prices of crude oil: Low Refinery Margin
- Existing old inefficient refineries
- Product quality: Ultra low sulfur, Aromatic content, RVP, Cetane etc.
- Minimization/ Elimination of Fuel oil



Challenges for a Refiner/ Petrochem Owner

- Surplus low value Naphtha from Refinery
- Feed mix selection for cracker: Lack of advantageously priced feedstock
- Increasing Fuel & utility cost
- Volatility: Cyclical margins in Petrochem
- Environmental Concerns



Emerging Trends

- Impact of Shale :
 - ✓ Falling ethylene cash cost putting Naphtha crackers under pressure
 - ✓ C3+ material production is dropping in the region
 - ✓ Emergence of On purpose olefin production technologies esp. for C3=
 - ✓ Deficit of Aromatics to be made up by naphtha reforming and naphtha cracking in the Middle East and Asia .
- A shift from Gas to Liquid crackers in ME. Low utility cost still advantages their position over Europe and Asian crackers
- CTO model adoption in China due to advantageously priced coal
- Residue/Petcoke Gasification for power, fuel and chemicals
- Emergence of Petro-FCCs in refineries globally



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Emerging Trends

- Substantial demand & growth rate of downstream specialty petrochemicals like Acrylic Acid/ Acrylates/ Oxohols/ Ethylene Oxides/ Propylene Oxides, cumene phenol etc to support an investment in India
- Petroleum Chemicals & Petrochemical Investment region (PCPIR)/ cluster concept
- Refiners opting for integrated aromatic complex
- Concept of petrochemical refinery

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Drivers for Refinery Petrochemical Integration

- Targeting low COP in competitive globalization era.
- Premium available in olefins vis-à-vis transportation fuels
- Stability over Value chain
 - ✓ Diversified Product slate dampens cyclic & non cyclic profitability impact (Fuels Vs Petchem)
 - ✓ Flexibility to dynamic market demand
- Feedstock and product flexibility
 - ✓ Assured Feedstocks Availability
 - ✓ Absorption of return streams
 - ✓ Optimal upgrading & conversion
- Upgrade low value refinery streams to high value products

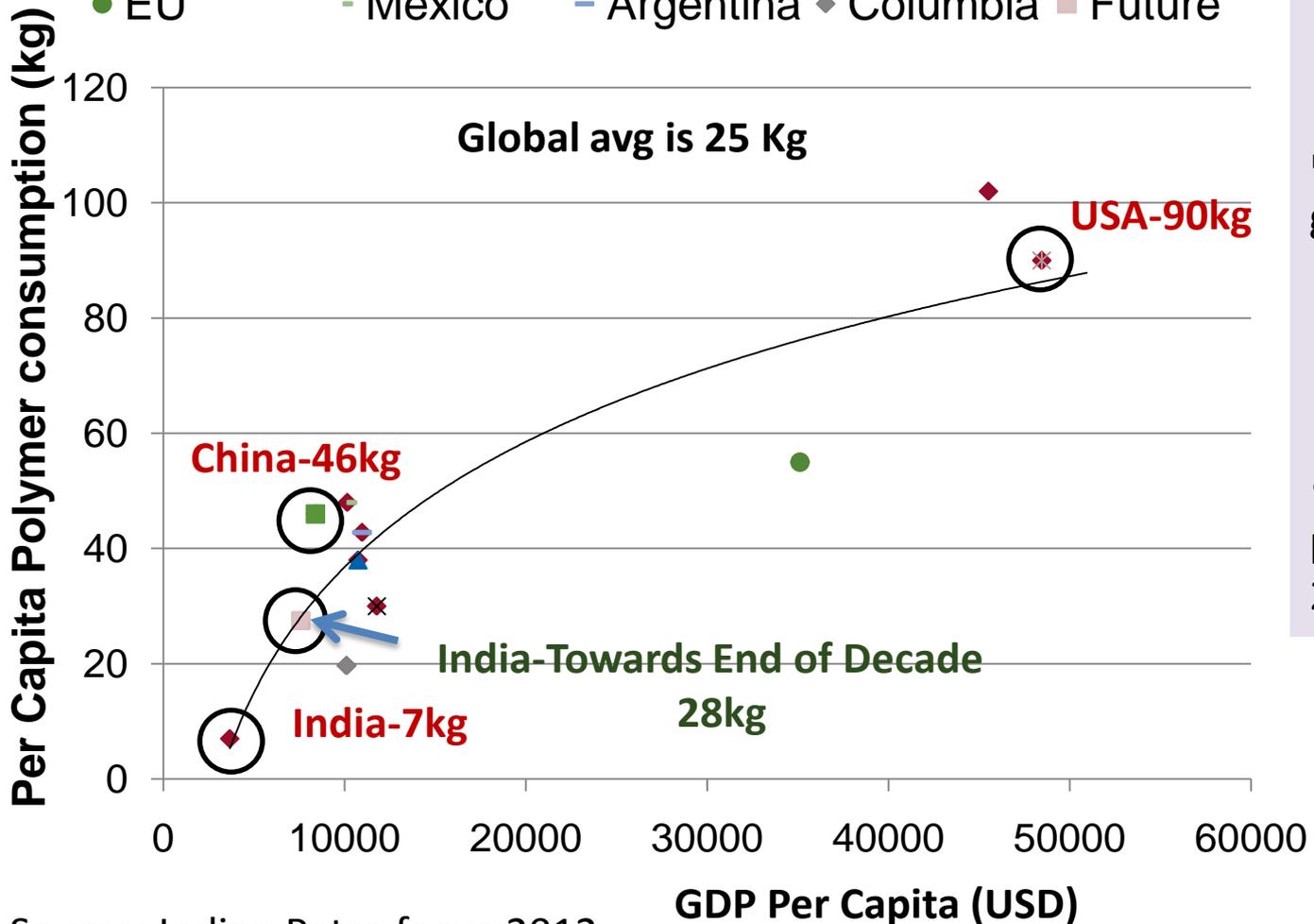
Drivers for Refinery Petrochemical Integration

- Capital, OPEX and Resource Optimization
 - ✓ Shared Infrastructure, storage & Utilities
 - ✓ Lower logistic & Energy cost
 - ✓ Minimize overhead and waste
- More stringent environmental regulations impacting the operational costs
- Incentives available in SEZ for promoting PCPIR/ cluster concept.
- Petrochemical industry growing at much higher rate than fuel market

Essence of any Integration is to work out synergies between them in order to achieve opportunities for more profitability

Polymer consumption: A Lot to Make up

◆ India ■ China ▲ Russia × Brazil * USA
 ● EU - Mexico - Argentina ◆ Columbia ■ Future



The Indian Scenario

(as per FICCI, CPMA):

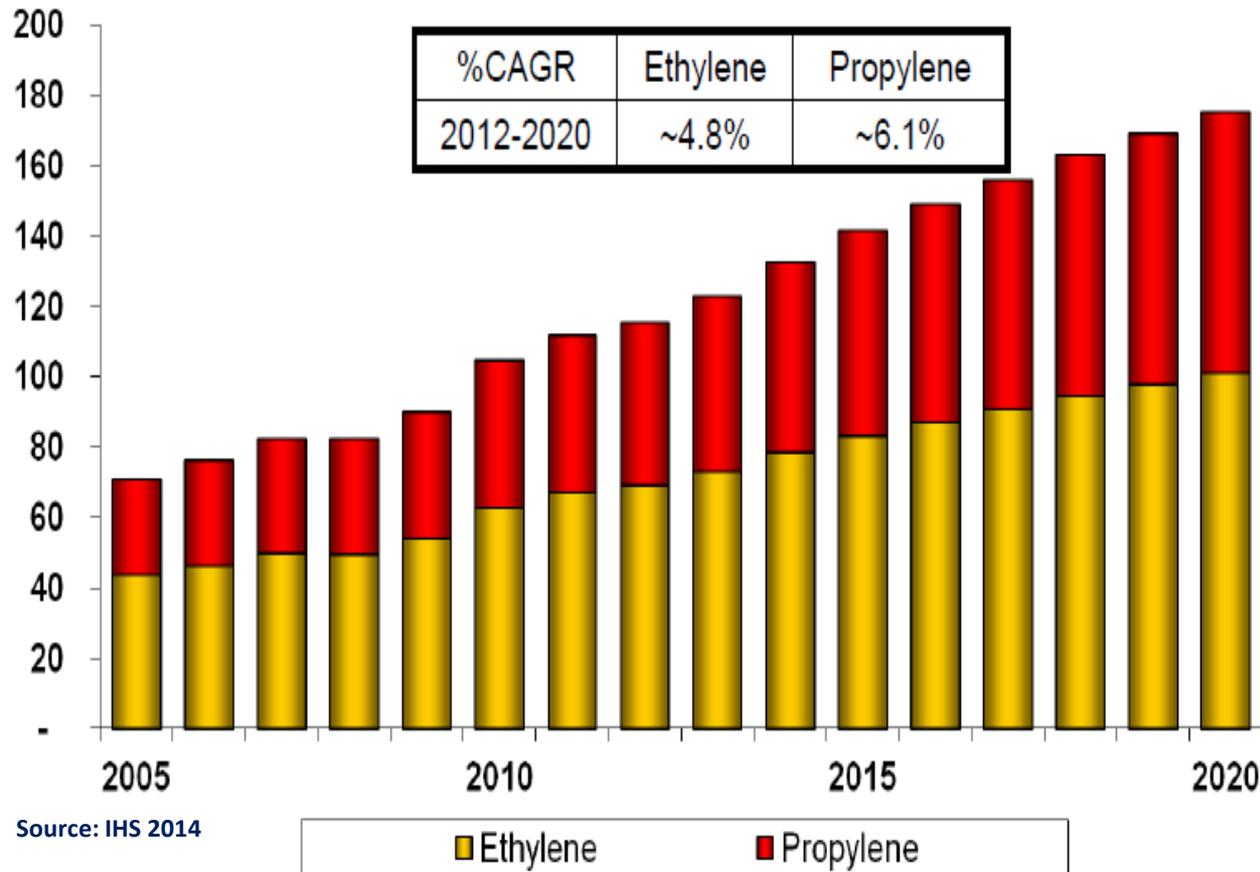
- 2007-2012, polymer growth at CAGR of 10.3%.
 - PP-12%;
 - PE-9%;
 - PVC-11%

- Demand growth projected for polymers in 2012-17: **10.3%**

Source: Indian Petro focus:2012

Strong Demand Growth in Asia & ME

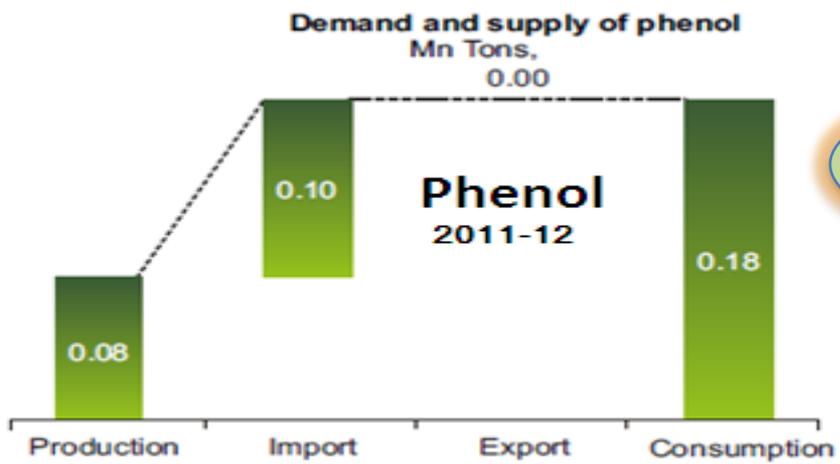
Million Tonnes per year



The Indian Scenario *(FICCI, industry source)*

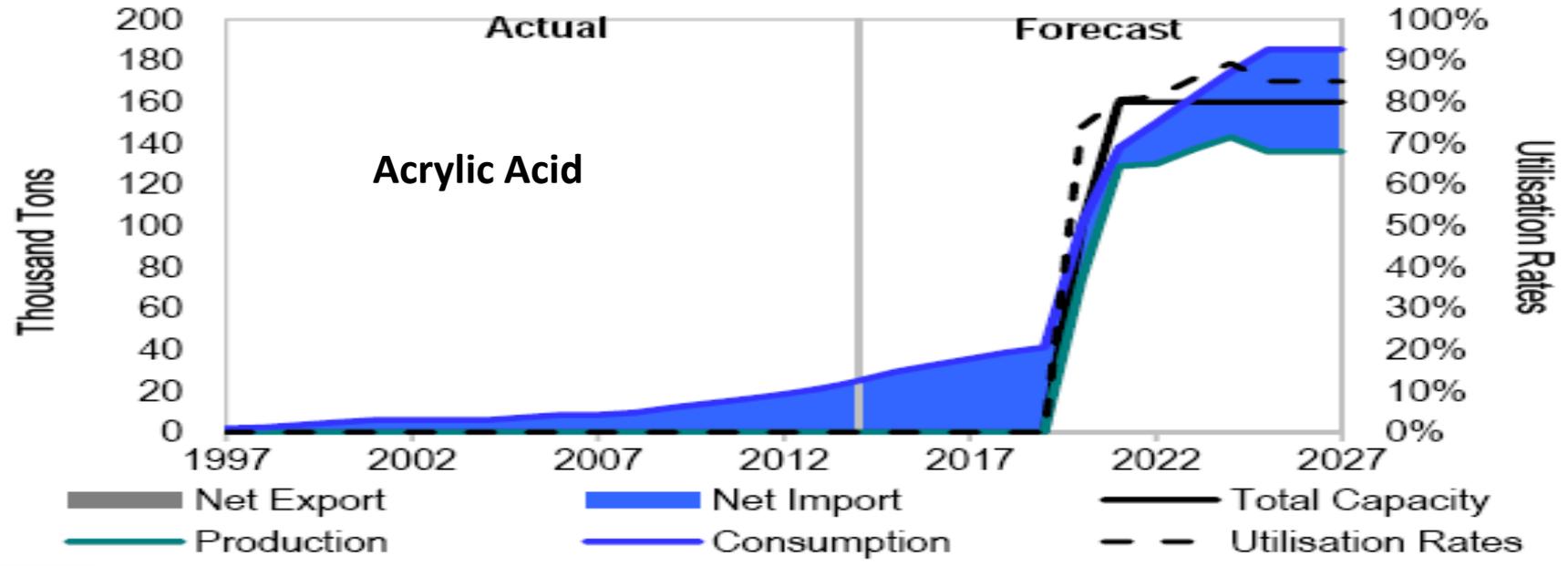
- Demand for basic petrochemicals expected to grow a CAGR of 9.3% in 2012-17

Phenol & Acrylic Acid Scenario - INDIA



World scale plant of 200-250 KTPA justified

source: FICCI, CII



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Working out the Synergy: Potential Available

- Process Integration – integrating low value streams through innovative technologies
- Utility Integration –
Hydrogen, water, power, steam, nitrogen, air.
- Utilization of gas fuel - Utilization of Hydrogen, HC present in gas fuel as feedstock
- Common Fractionation/ recovery sections for CAPEX savings
- Refinery and Petrochemical industries are inter-related
 - ✓ Similar bases for Technology
 - ✓ Identical approaches for operation & Maintenance

Potential Process Streams for Integration

- Off gasses & LPG from Refinery:

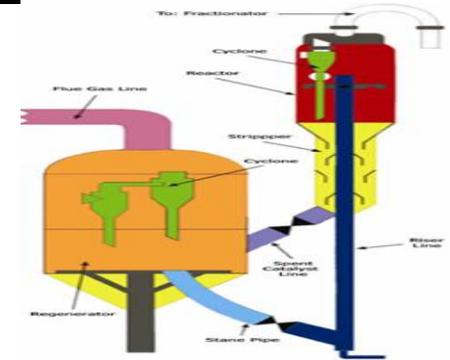
- ✓ Petro FCC off gases ~ 30-35% Ethylene
- ✓ DCU off gases ~ 30-35% Ethane

- Naphtha Stream:

- ✓ Predominant feedstock for crackers in South Asia, Europe and now even ME. Off late has come under pressure due to gas crackers.
- ✓ The position of naphtha conversion to aromatics as yet seems unchallenged and is likely to remain so for the next decade
- ✓ Emerging new technologies taking even cracked Naphtha and providing higher P/E ratio wrt steam crackers

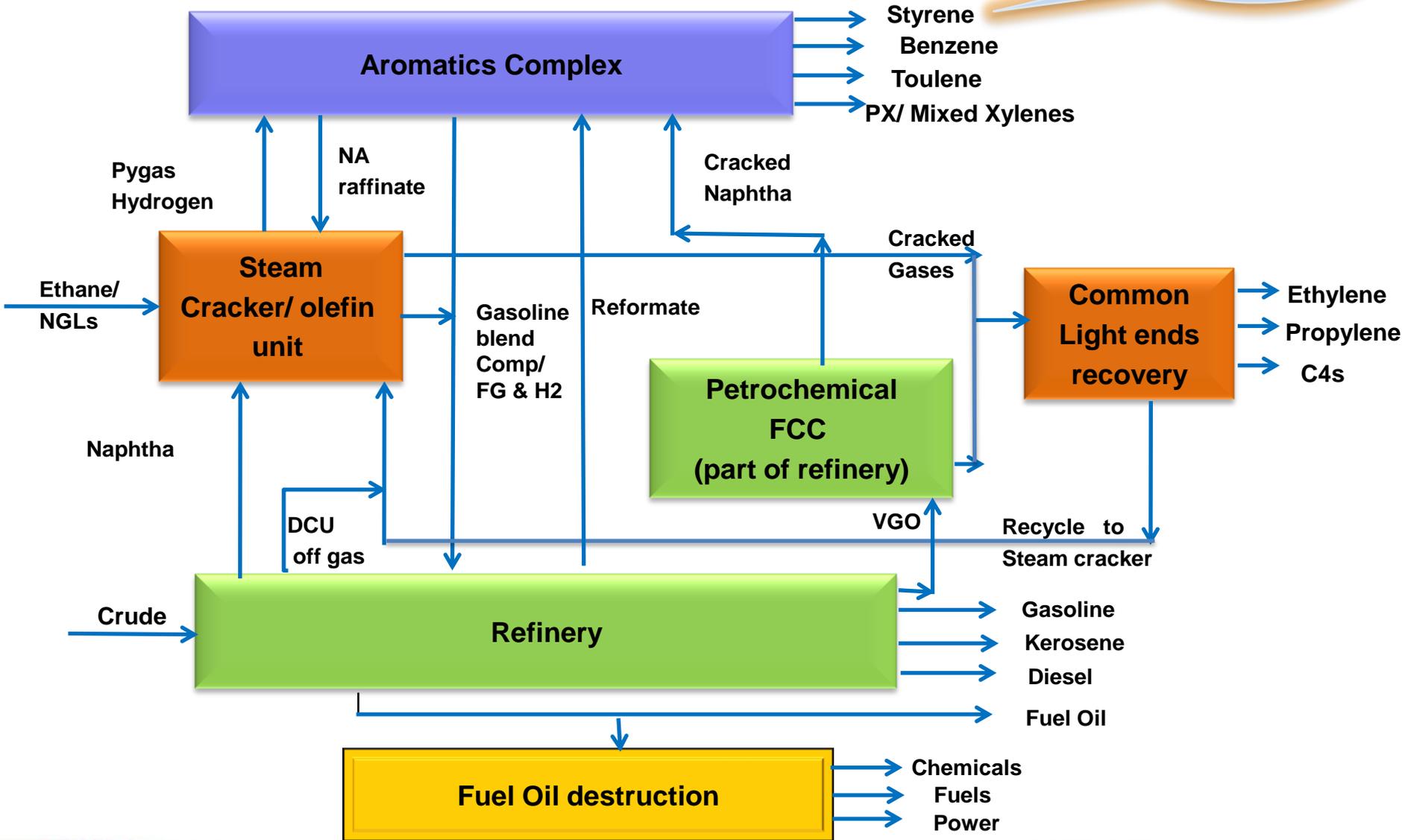
- BTX potential in Reformate and CR-Naphtha stream

- Kerosene streams after extraction of N-paraffins are used to produce LAB.



A complex Integrated Flowscheme

if potential exists



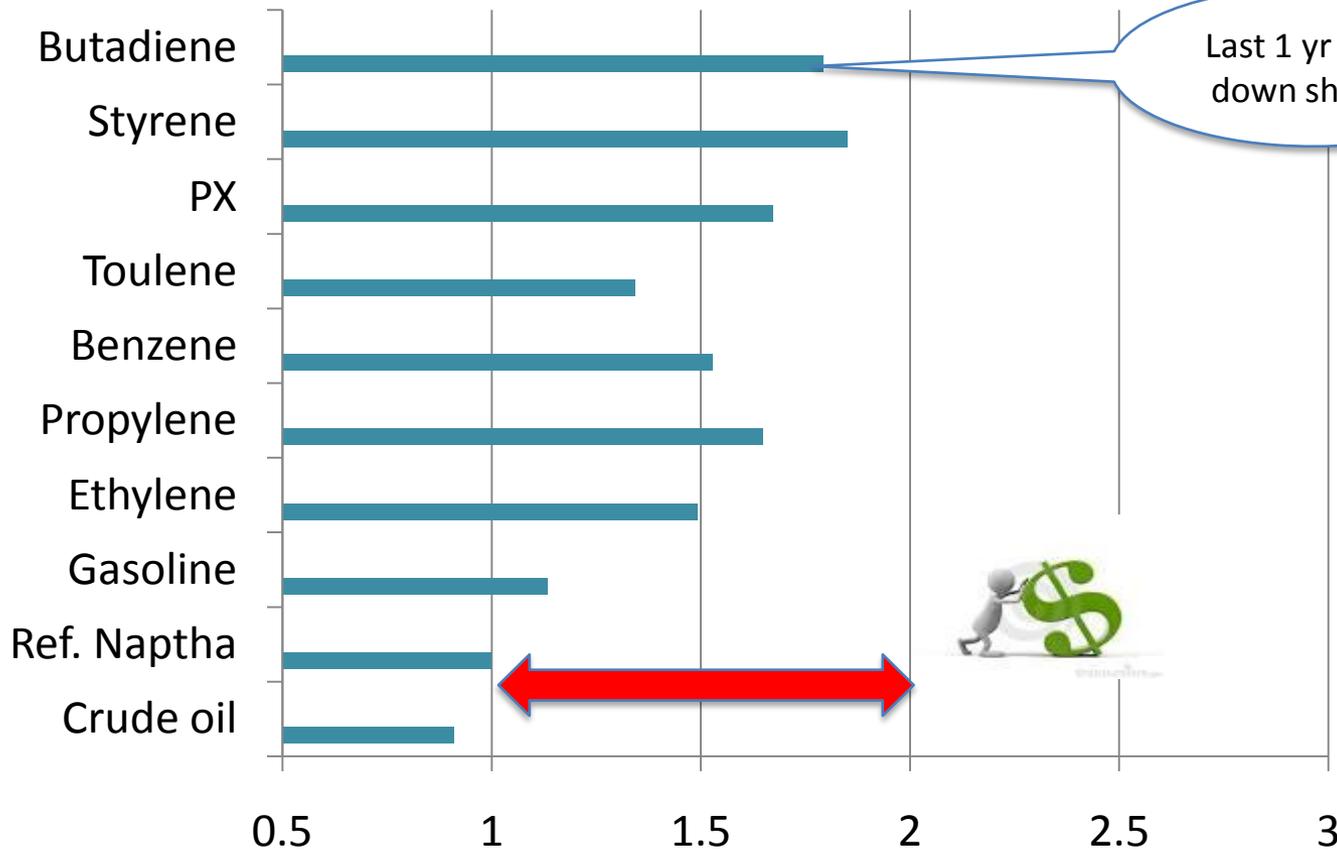
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Premium available for Integration



Prices relative to Naphtha: Key Driver for Integration

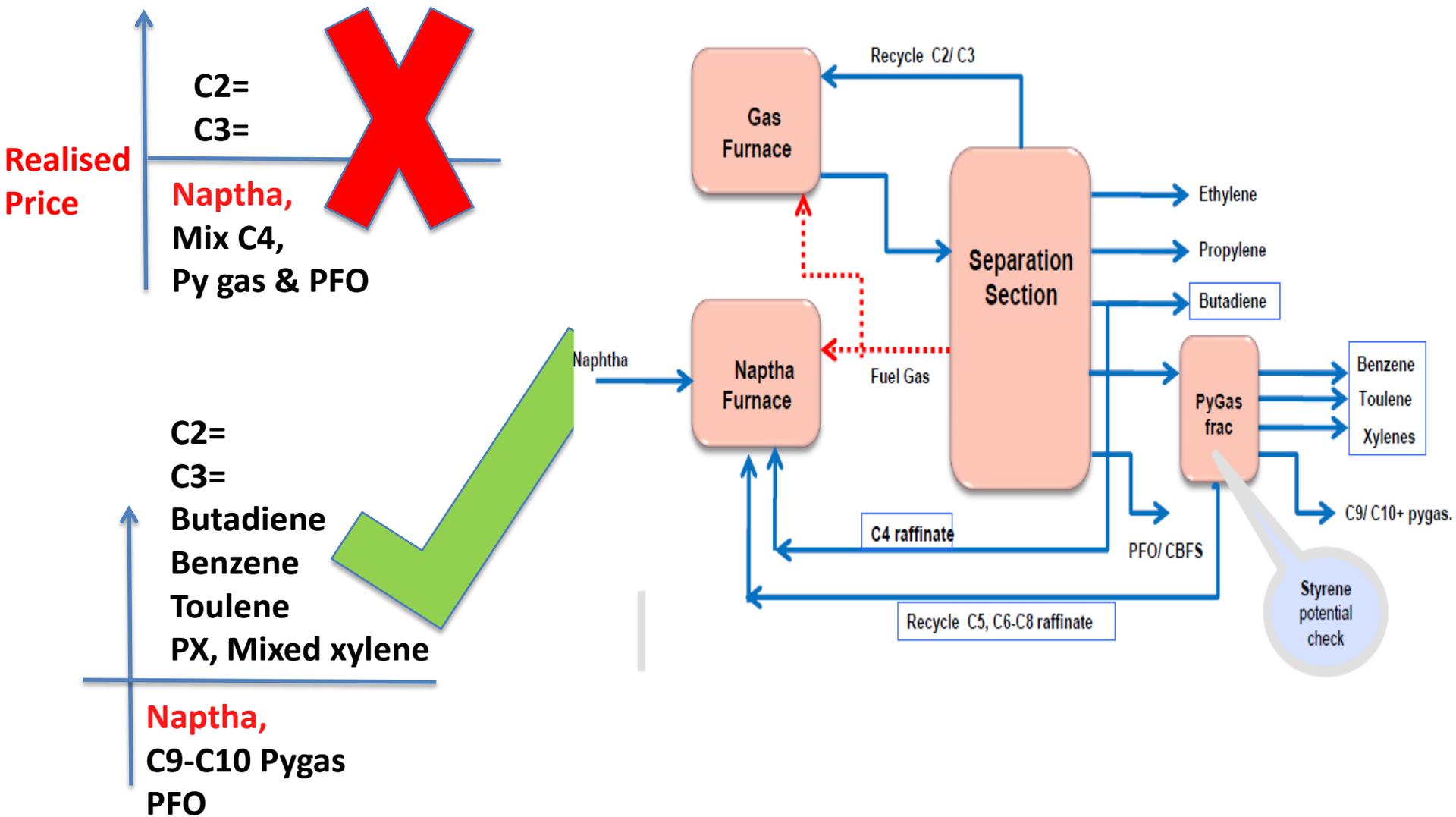


Last 1 yr came down sharply

▪ Rising Delta thus calls for mitigation of Naphtha

▪ Cost penalty marginal but returns are extremely attractive

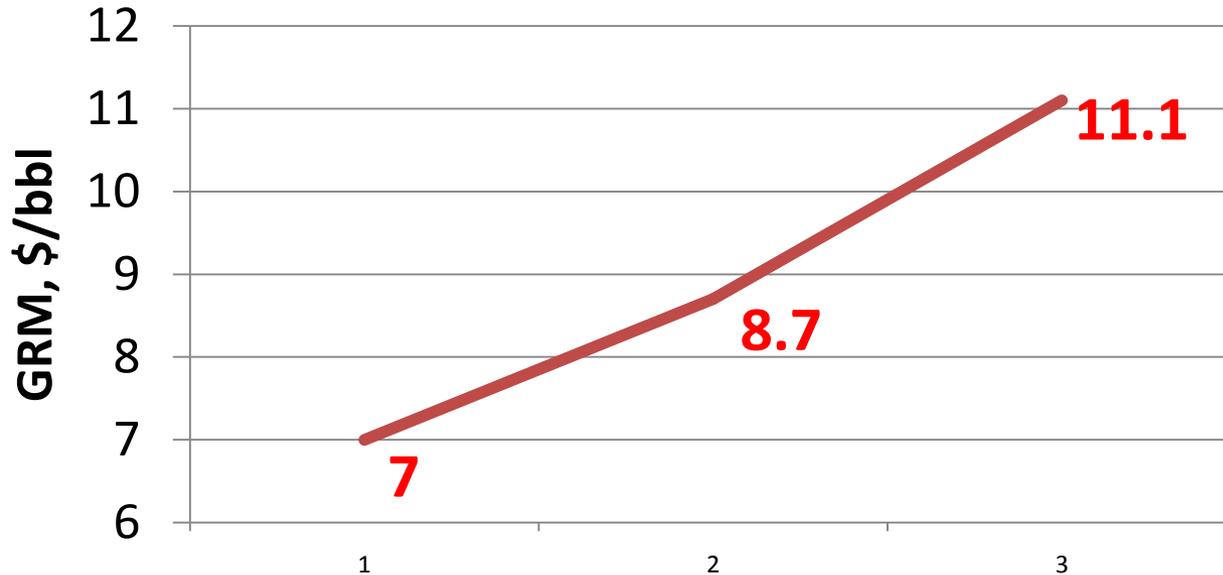
Value Cracking: The way to go



Value Addition Through Integration



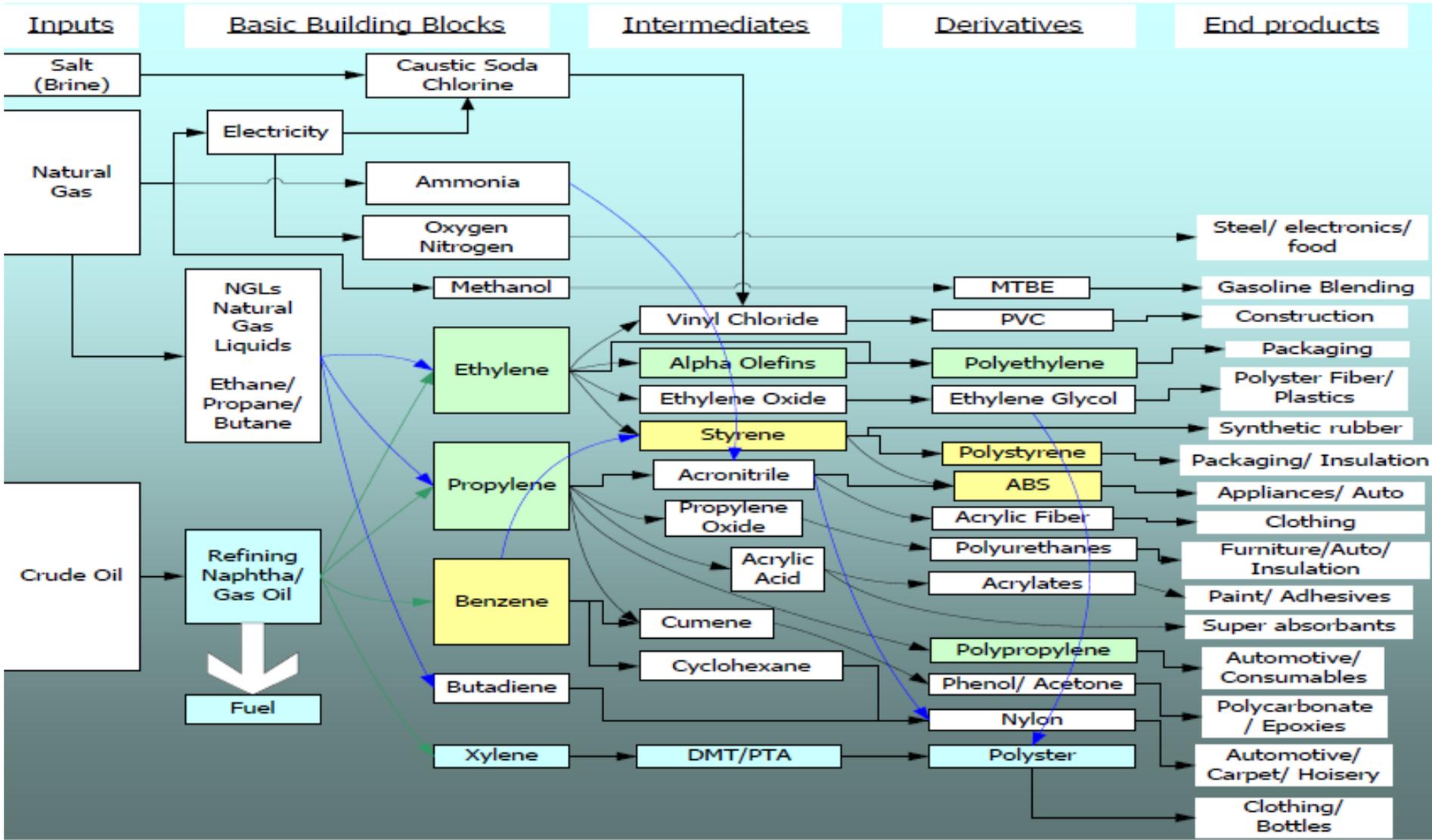
(deficit feed for Cracker is made up by import)



Basis: 15 MMTPA refinery
3 yr avg. prices

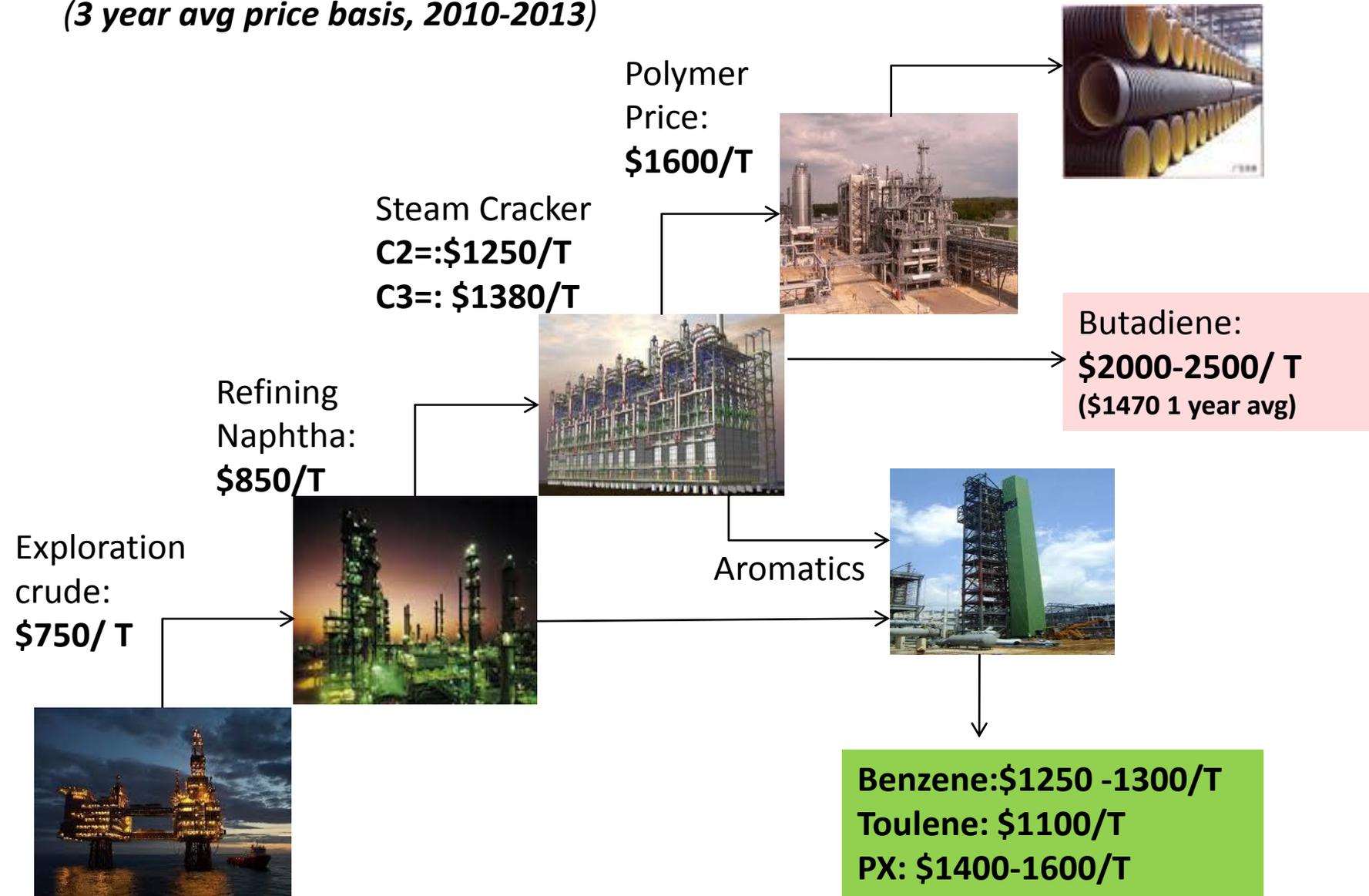
Integration of refinery & Petrochemicals also improve ROI significantly by ~ 4-5%.

Large Market Access & Customer Base



Opportunity ladder : step wise approach

(3 year avg price basis, 2010-2013)



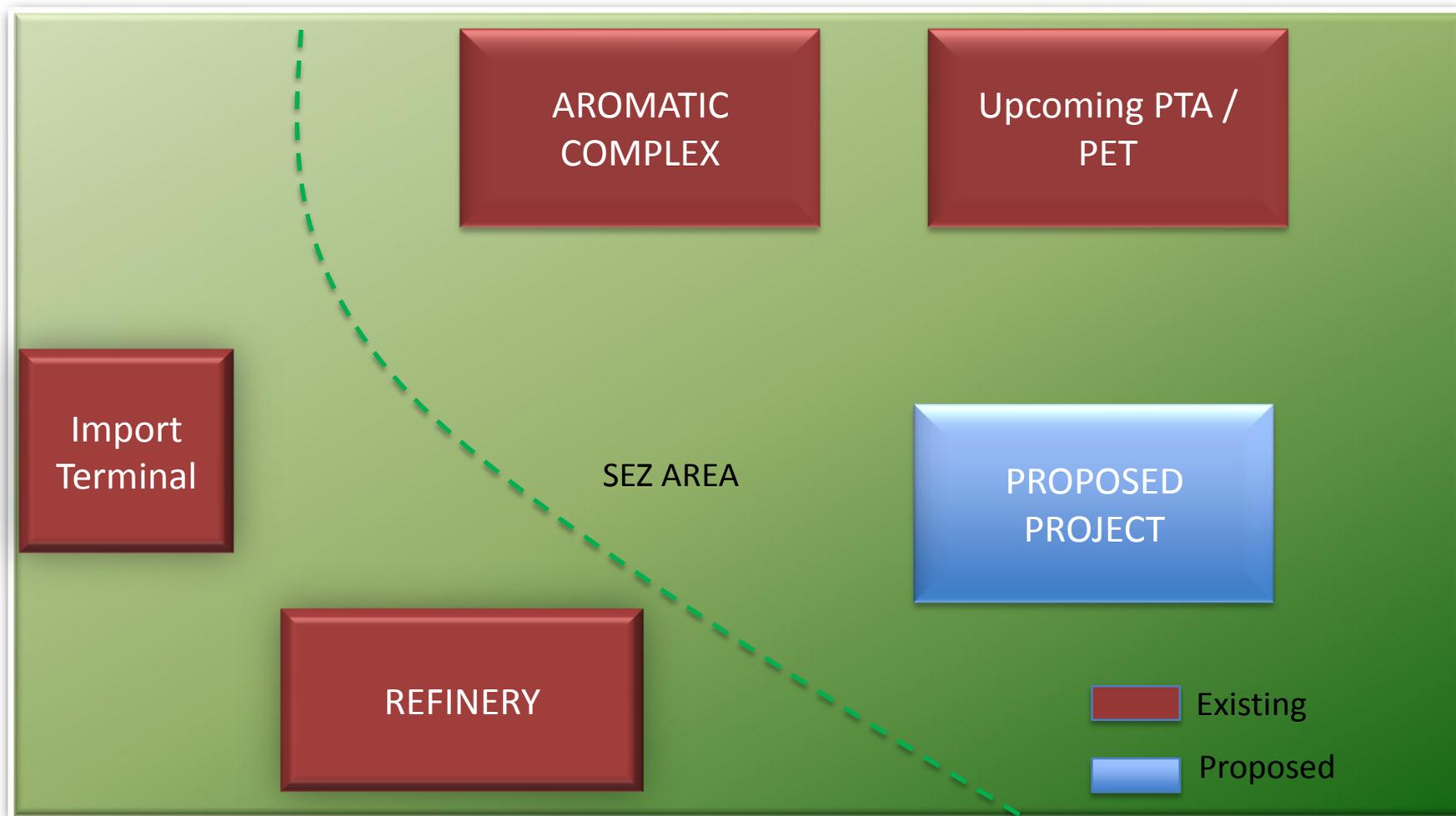
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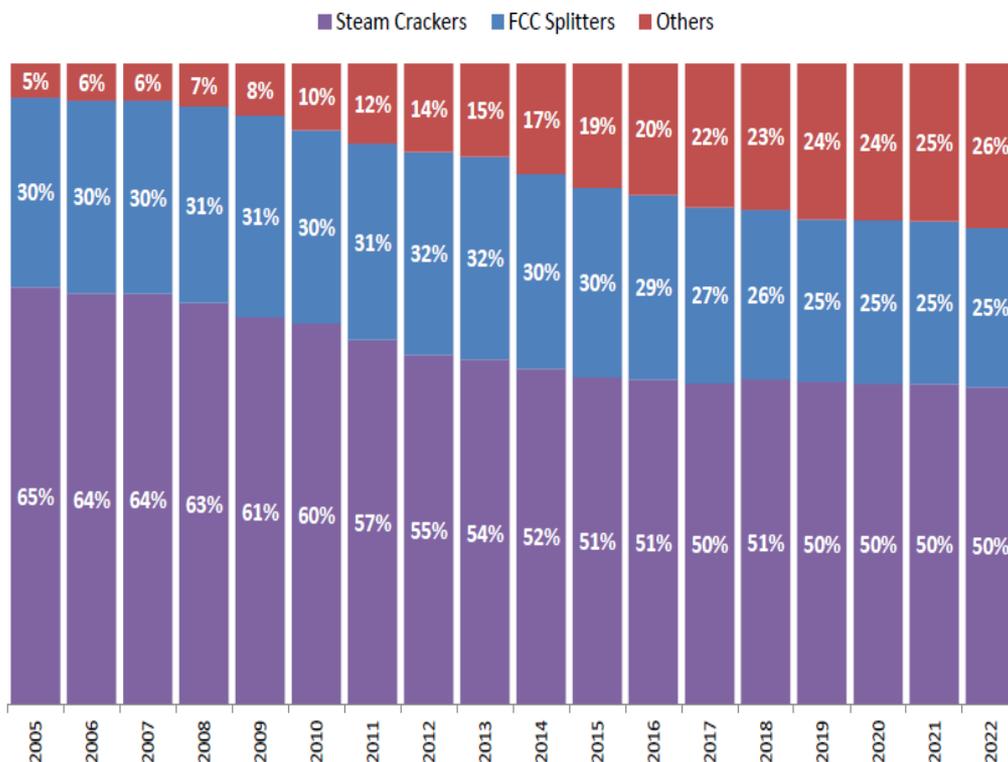
Case Study

- Sanjay Gupta - Project convener
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- Vinay Gupta, Dy. Manager – Strategy & Business and Development – EIL, vinay.gupta@eil.co.in
- Vineet Bakshi, Sr. Process Engineer – Strategy & Business and Development – EIL, vineet.bakshi@eil.co.in
- Manoj Kumar, Sr. Manager – Cost Engineering – EIL, manoj.kr@eil.co.in

AREA LAYOUT



PROPOSED OLEFIN PROJECT- OVERVIEW



- Propylene demand continues to soar.
- Recent trend of Lighter feed stocks for crackers.
- Refiners limited by flat gasoline growth
- LPG & Propane are traded as surplus, Low LPG price
- Price differential of \$450 - \$350/ton : C3 & C3=

On purpose (PDH) propylene production increasing

Source: CMAI

“On- Purpose Propylene” is filling the gap.

On-Purpose Propylene will supply 20% of global Propylene by 2020

POINTERS

Potential Opportunities:

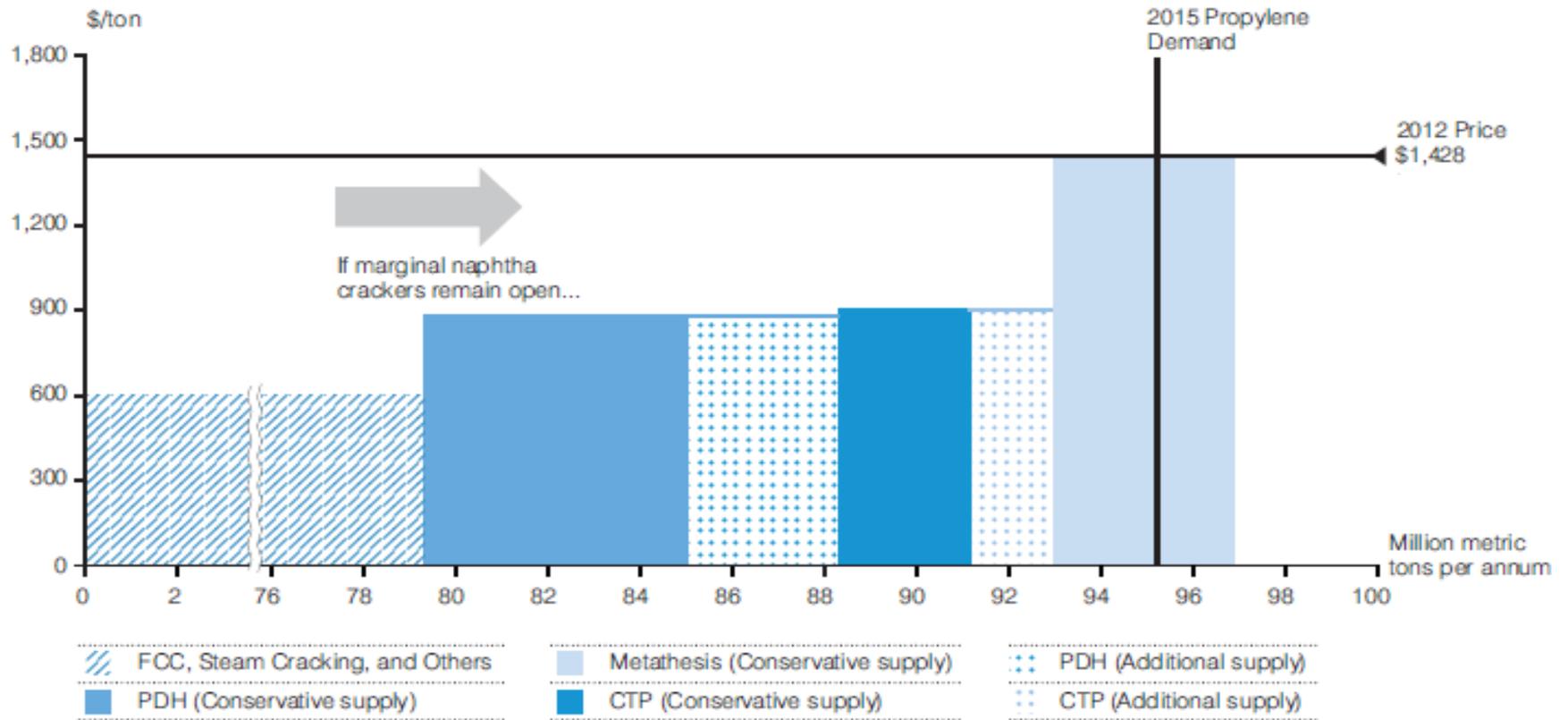
- Opportunity in global propylene production on account of displacement of liquid feed to Crackers by natural gas, which produces less Propylene.
- Surplus LPG / Propane traded internationally – essentially from Middle East & shortly from United States
- Surplus Naphtha available in nearby refinery for value add
- Ethylene rich Refinery Off Gases (ROG) available in nearby refinery

Technologies best suited to exploit above opportunities are:

- On- Purpose Propylene
- Naphtha to Olefins conversions with higher P/E ratio (catalytic route)

Propylene Cost Curve

PROJECTED GLOBAL PROPYLENE COST CURVE, 2015



Note: Analysis assumes steam cracking and FCC units are the most economical sources of propylene, and assumes an oil price of \$90 per barrel. Conservative PDH and MTP supply is based on a 60% utilization of existing capacity and new additions. Additional supply is based on realization of all announced plants and 80% utilization.

Source: ChemSystems; Nexant; ICIS

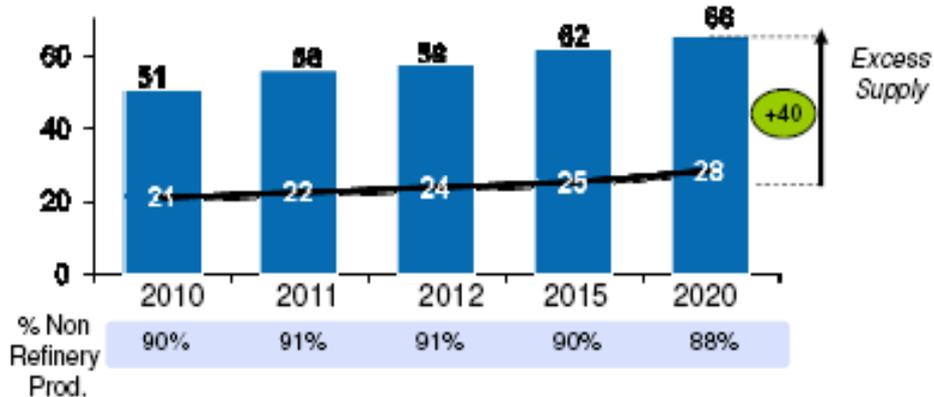


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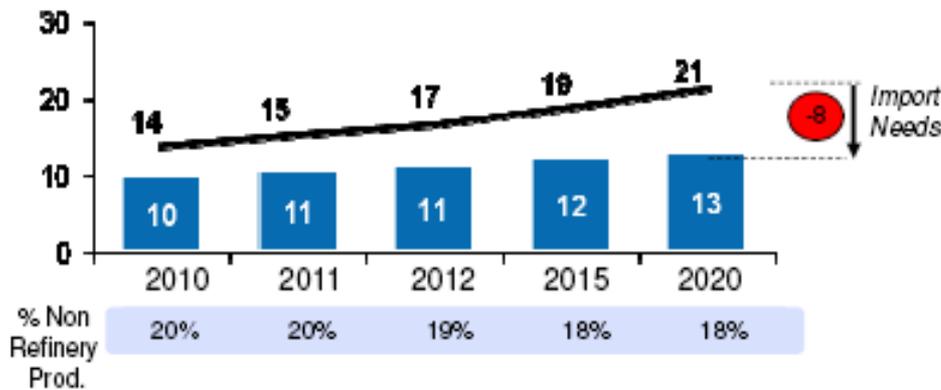
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Propane Sourcing

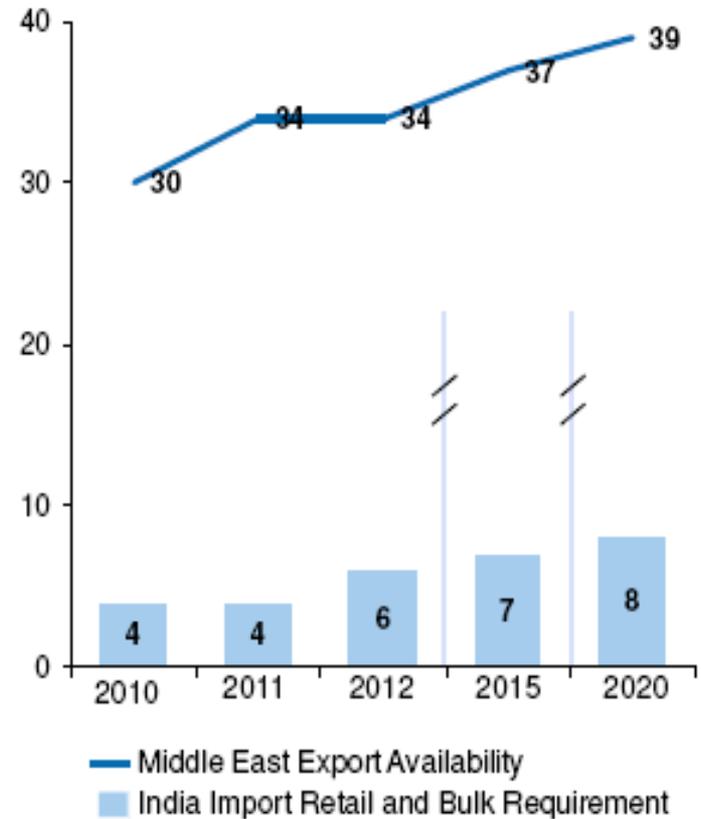
Middle East LPG Supply Demand Balance
MMTPA, 2010 - 2020



India LPG Supply Demand Balance
MMTPA, 2010 - 2020



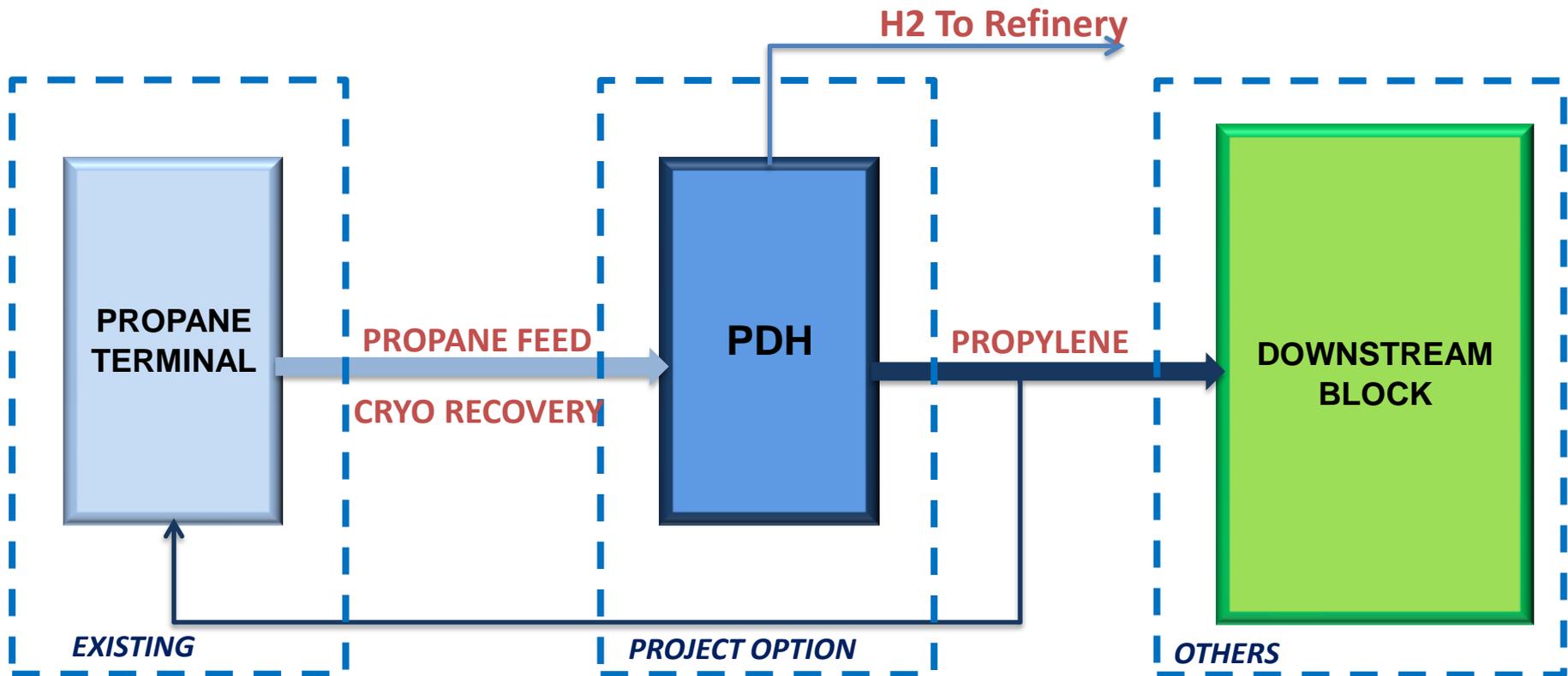
Middle East LPG Export Availability and India Import Requirement
MMTPA, 2010-2020



Source: FACTS, UCP Analysis

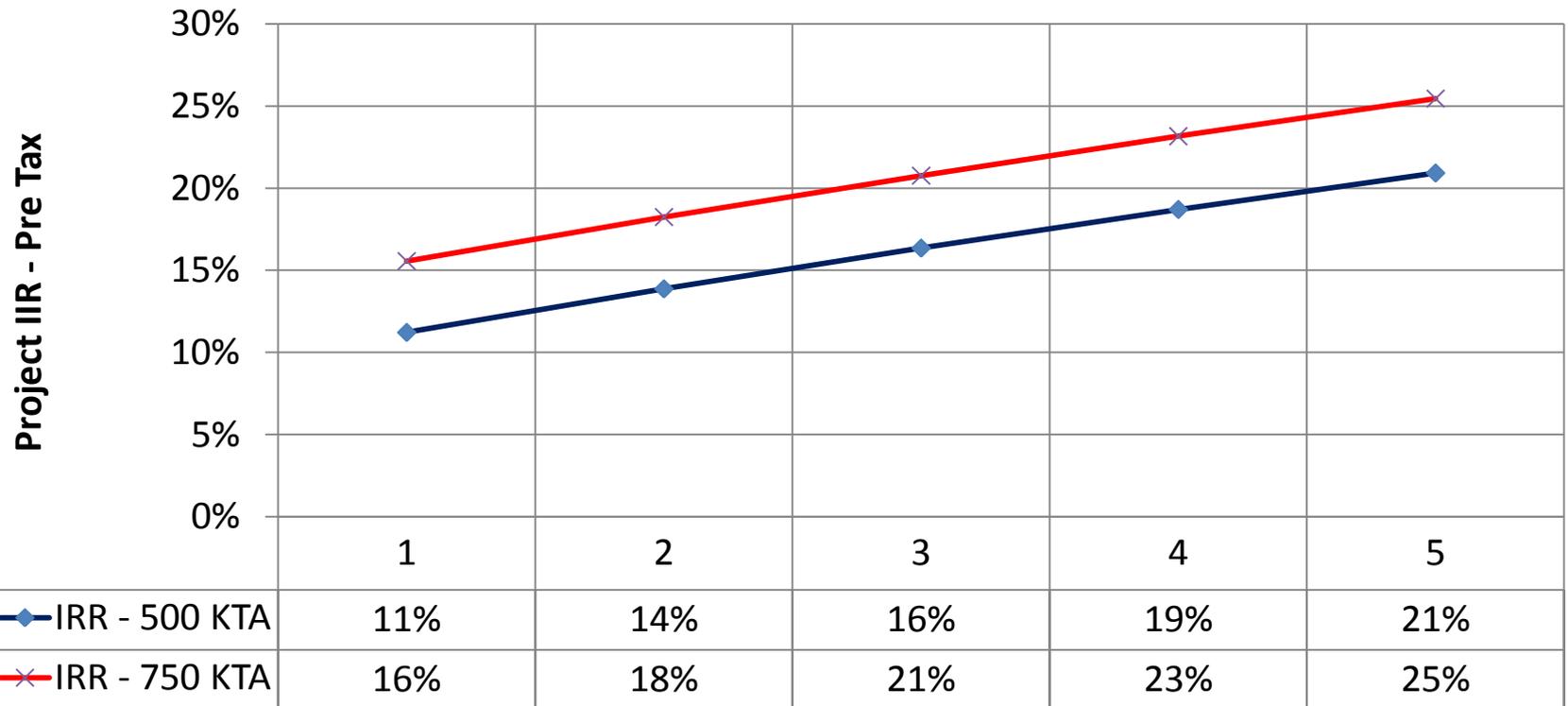
■ Supply — Demand

Proposed Complex at SEZ



PROJECT ECONOMICS- Stand Alone PDH

Project IRR Trend (India)



Differential Price (Propylene - Propane): 450 US\$

Standalone – PDH Complex

- The Propane and Propylene *price differential* is a strong incentive for setting up a PDH facility in India.
- The project economics is extremely *attractive*.
- *Propane supplier presence* in SEZ and further commitment to enhance it to the committed levels for meeting the PDH facility requirements can be contracted on a *long term basis*.
- Before commencement of the PDH facility, *long term take off contracts* for Propylene by others would need to be in position.
- The SPV for setting up the PDH facility could review possibilities of taking up *equity in the downstream* units set up by others.
- Propane supplier would be encouraged *to pick up equity* in the PDH facility to further bridge the risks associated with uninterrupted and reliable feedstock supply to the facility.

Stand Alone PDH- Issues

Risks

- High risk with interfaces both on feed stock & product- take off and prices.
- Standalone PDH Facility justified only when a commensurate Propylene commitment for evacuation is in place.
- Production of non impact Polypropylene grade in India may exceed demand in view of foreseen PP Plants

Opportunities to minimize risk via Refinery Integration

- Excess Naphtha available from refinery for Ethylene production
- With Ethylene as a product, possibility of producing impact Polypropylene etc. - demand significantly higher. Limited production as of now in India.
- MEG produced from ethylene, could be used for captive consumption in the PTA/PET facility.
- Lesser dependency on single feedstock.

Additional Opportunities Available Via Integration

- Coker Naphtha - **Low Octane, High in Olefins, unstable Di-Olefins & High Sulphur** content make it unsuitable for direct blending into gasoline pool.
- **Surplus** Coker Naphtha, FCC Naphtha & SR Naphtha is low value & has limited domestic market. Partly disposed as internal fuel in CPP.
- More **Value Add to Naphtha** through production of Petrochemical products
- **Refinery Off Gases (ROG)** from cracking units (typ. FCC & Coker) carry potential **ethylene** – can be integrated with petrochem unit for value add.
- Between Naphtha and Propylene / ethylene, a price differential of **~\$500/ton** provides ample incentive to look for petrochemical options.
- To exploit price advantage, Refiner's prefer to produce **Propylene and BTX** than motor gasoline from their FCC units.
- **MEG** can be produced from ethylene in proposed complex which shall be consumed in PTA/PET facility in SEZ , thus assured off take.

Realizing Opportunity

Naphtha to Olefins technology is available through catalytic route with following features:

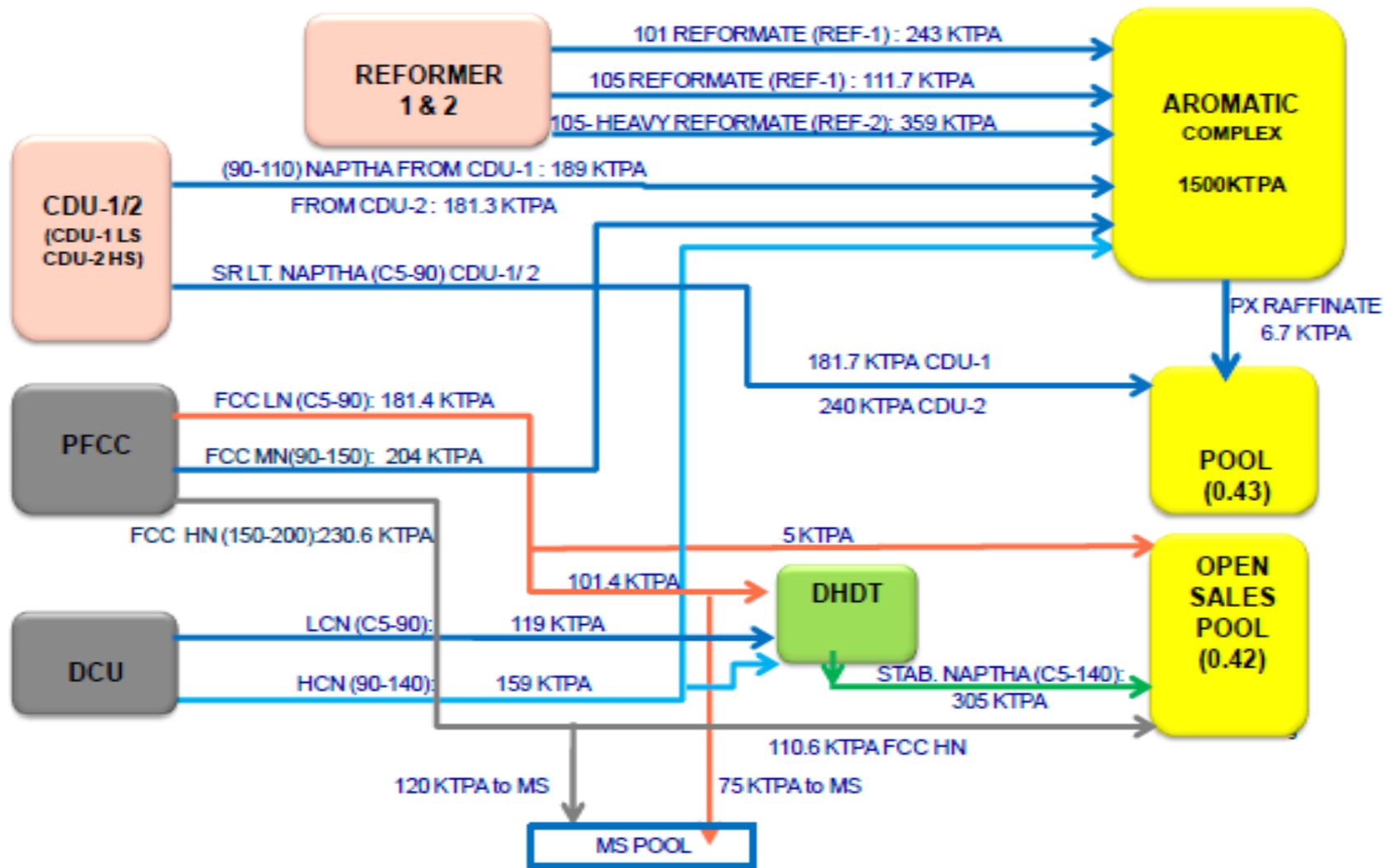
- Utilize most common liquid feeds available- *SR & cracked naphtha*
- Hydrotreated feed not required, process *favorable* to *un-hydrotreated feed*
- Continuous operation design
- Operates at *lower temperatures than naphtha cracker*
- *Higher olefin yields* and much higher propylene yields than cracker
- Opportunity to *recover ethylene from FCC off gases.*



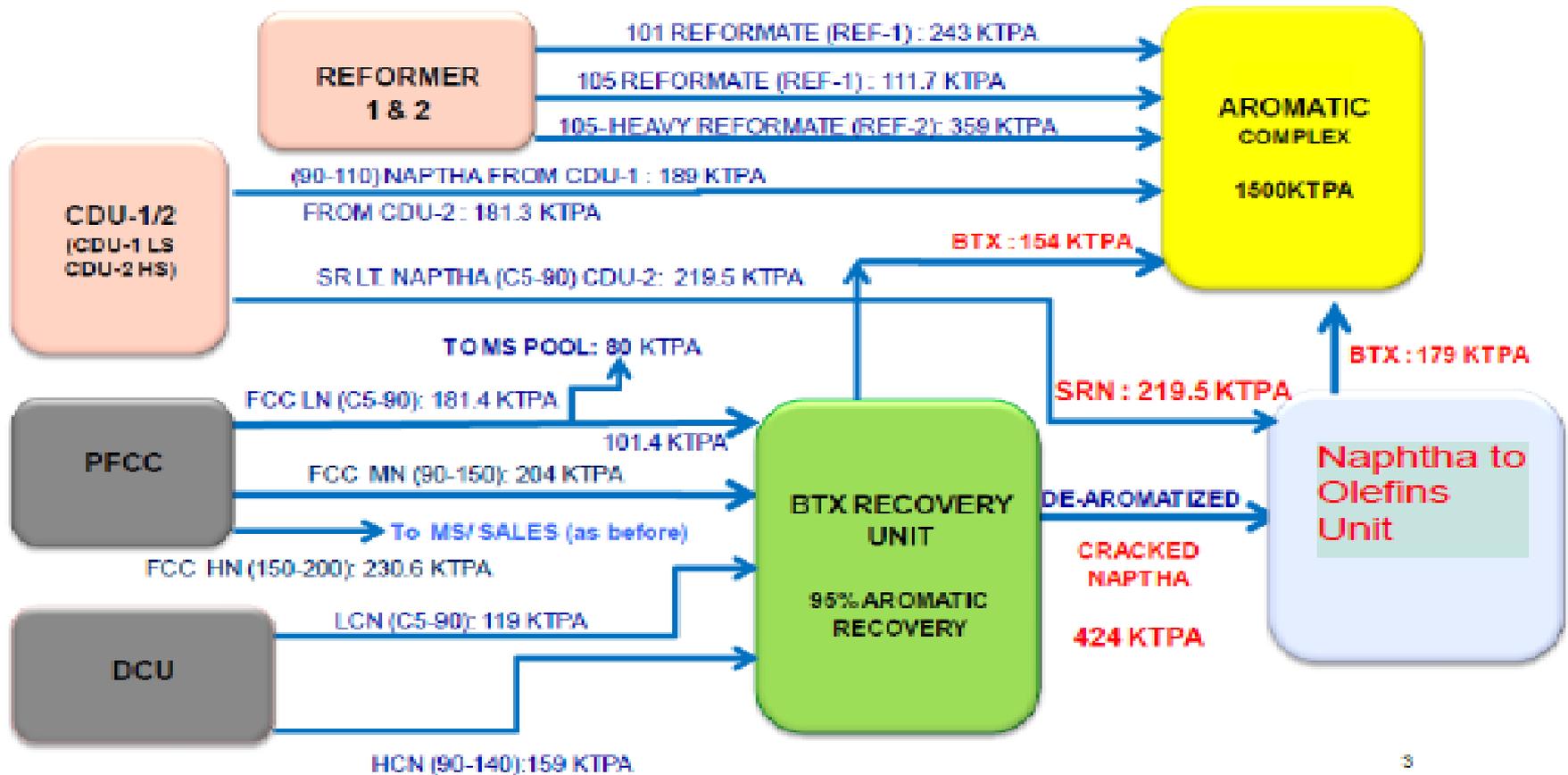
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Existing Naptha Balance

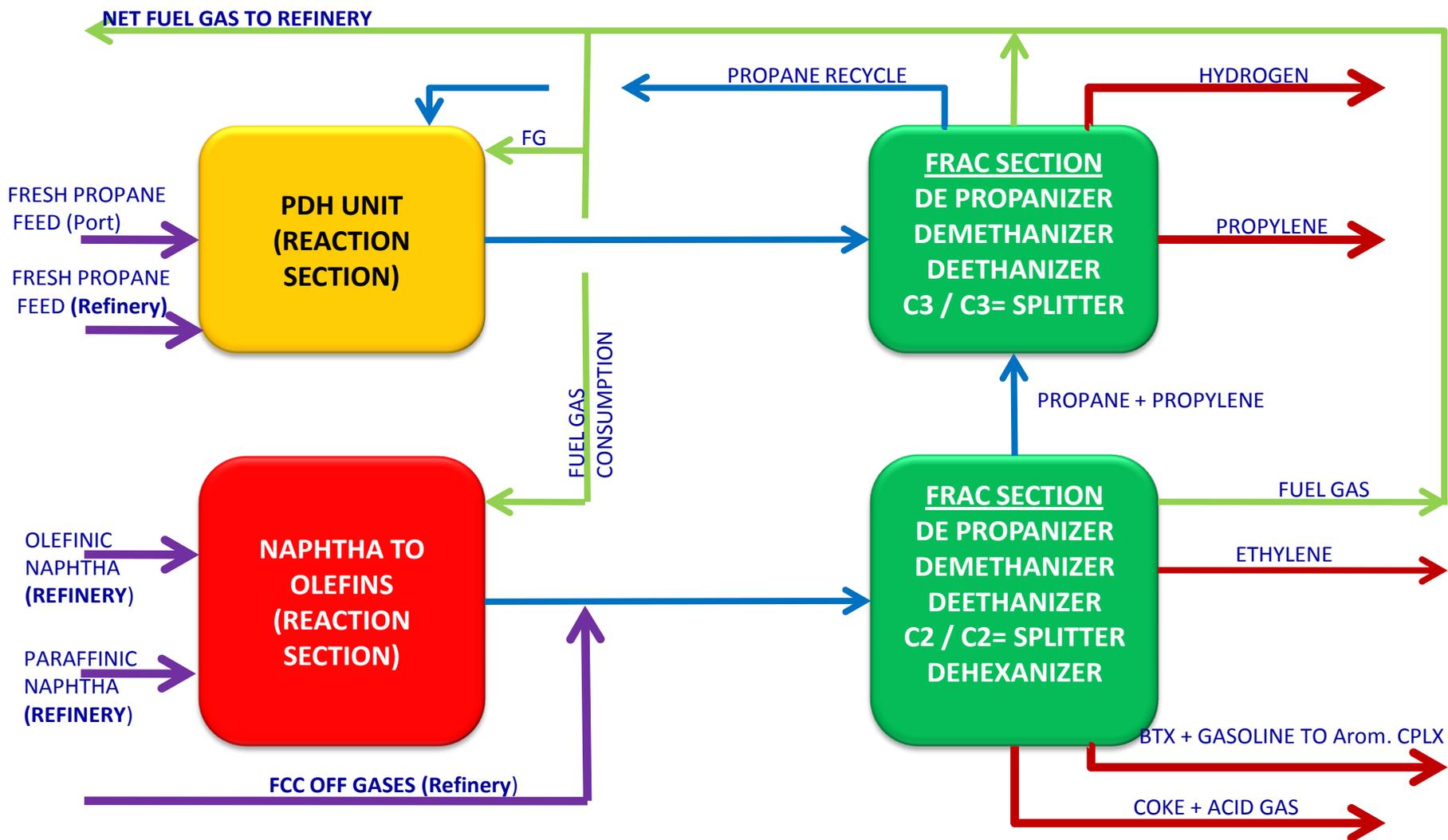


Proposed Naphtha Balance



- Replaced Coker HN & FCC mid cut naphtha streams with highly aromatic BTX streams - *leading to substantial saving in OPEX of CCR.*
- Unhydrotreated Coker LN now routed Olefin instead of DHDT-*savings in Refinery Hydrogen consumption*

Proposed Integrated Scheme



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Benefits Of Proposed Integrated Complex

- Less dependence on propane import
- Feedstock security, higher unit run length
- Excess naphtha available at adjacent refinery
- Disposition of cracked Coker naphtha
- Easier to transport naphtha
- Co production of ethylene
- Ethylene recovery from FCC off gas
- HDT of cracked naphtha feed to Olefin unit (Catalytic) is not required thus minimizing hydrogen demand
- Valuable hydrogen is the byproduct of both units which can be utilized in refinery

Further Optimization Opportunities

- Existing C4/C3 Storage terminal. Propane to be imported in *Cryogenic state*.
- *Double wall storage tanks* and associated systems considered at storage terminal. Chilled Propane (@~ -40 DegC) feed to the unit.
- Propane will be first routed through the *PDH chilling / separation section to reduce the chilling load* of the unit.
- Additional chill expected from integrated common refrigeration system and expanders in the Naphtha to Olefins unit (Demethanizer Overhead). This *may eliminate* Cold Box in PDH unit.
- *BOG from the storage terminal* to PDH unit directly as feed.
- *Common Propylene splitter*. significant CAPEX savings.
- *Common Hydrogen recovery* systems (PSA) for both units
- *Common refrigeration* systems

INTEGRATED BTX, NAP. TO OLEFIN, MEG & PDH COMPLEX CONFIGURATION



-650 KTPA NAPHTHA TO OLEFIN UNIT
(Naphtha Feed)

-500 KTPA C3=PDH REACTION SECTION

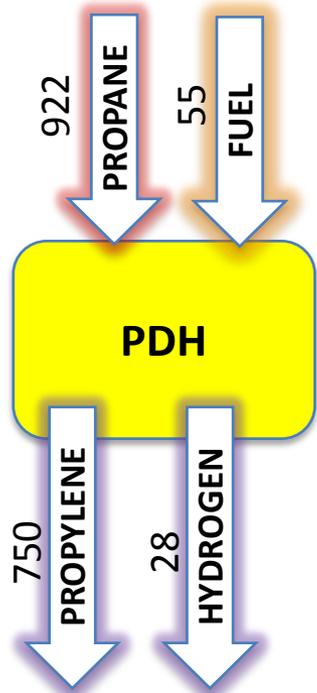
~700 KTPA C3= COMMON
FRACTIONATION SECTION

-MEG UNIT (223 KTPA C2= FF)

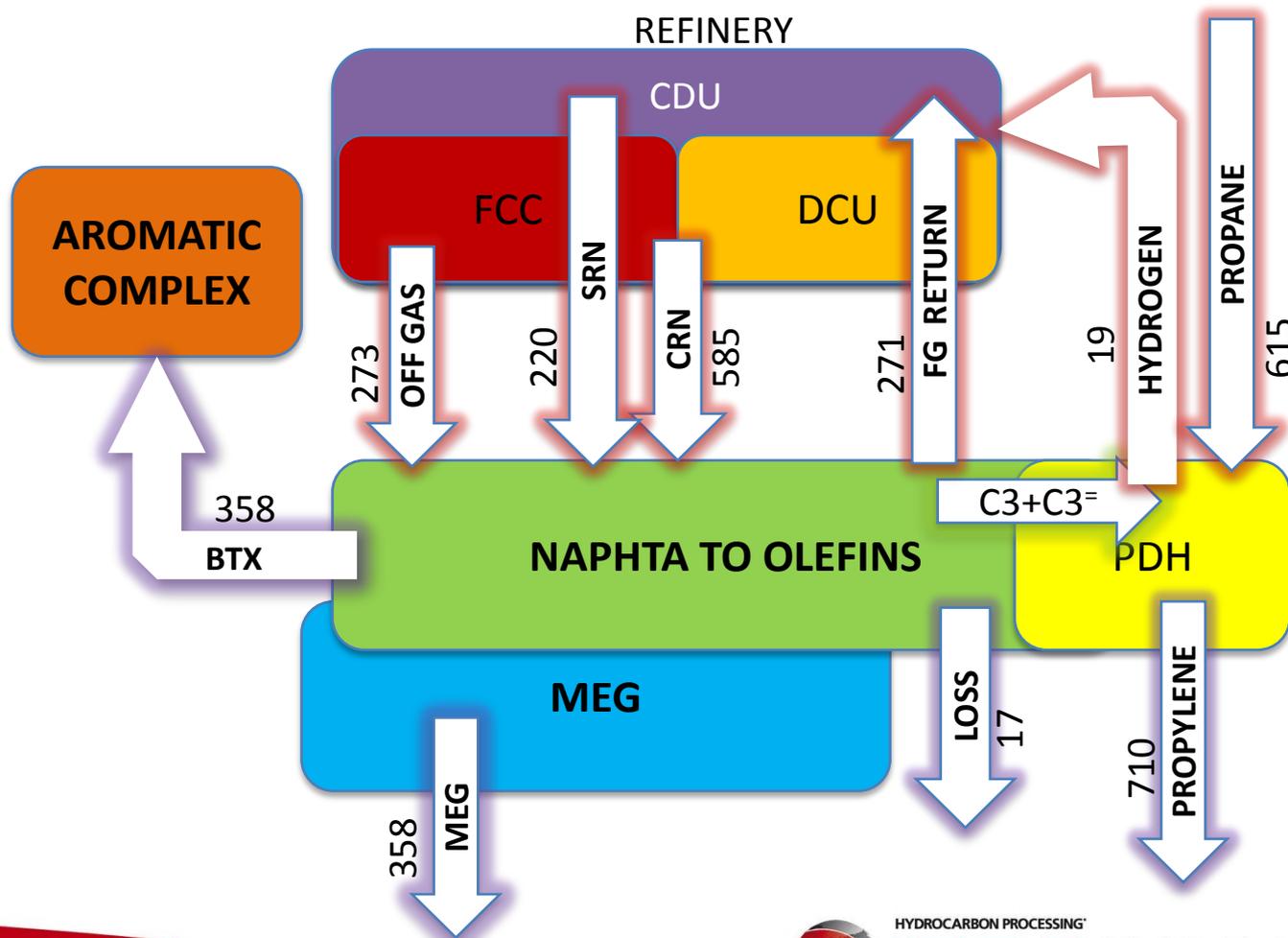
-BTX UNIT (583 KTPA Naphtha FF)

FEED / PRODUCT SLATE COMPARISON

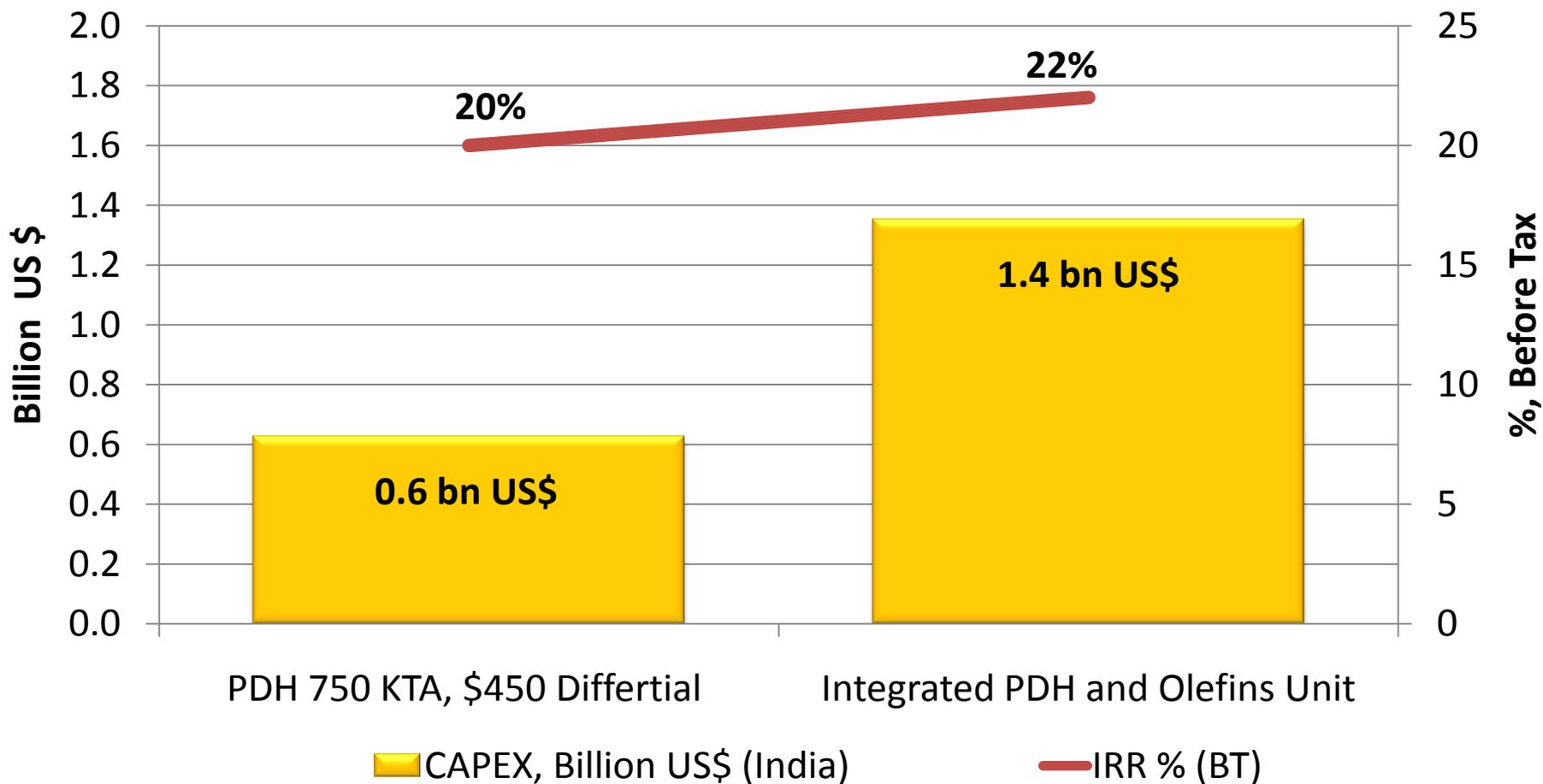
STAND ALONE PDH



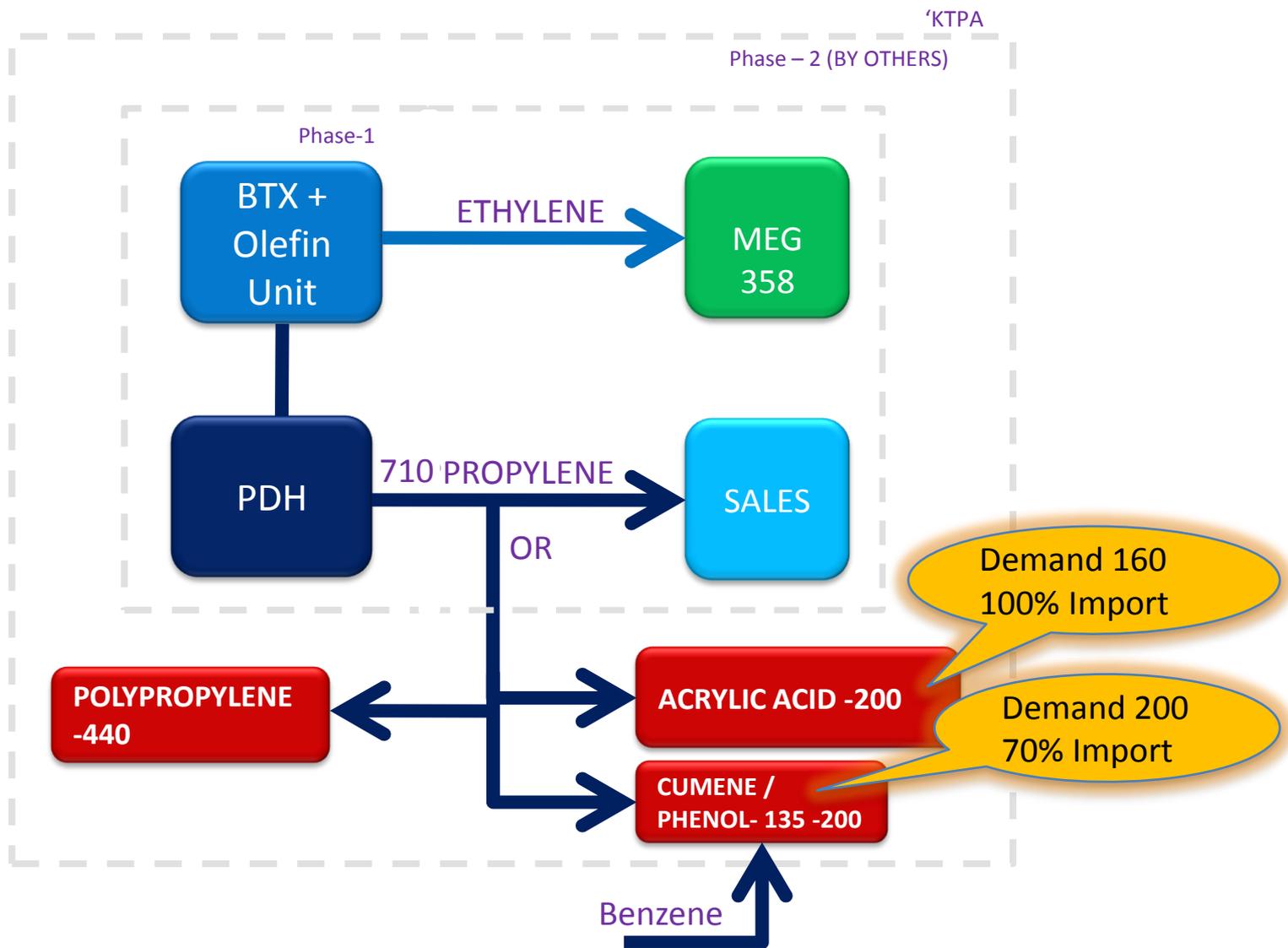
INTEGRATED COMPLEX



Case Economic Comparison



DERIVATIVE COMPLEX PHASES



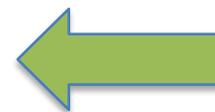
Thank you



The information upon which this presentation is based comes from our own experience, knowledge and databases, supplemented by reference to primary sources and published industry data.

Any opinions expressed are those of the author as of this date. They have been arrived at following careful consideration and enquiry but we do not guarantee their fairness, completeness or accuracy. We do not accept any liability for your reliance upon them.

FCC: Olefin machine in the Refinery



Components	Conventional yields on resid VGO feedstock – gasoline mode	Conventional yields on resid VGO feedstock – max propylene mode	Yields on hyd. VGO feedstock now available
Ethylene	<1%	<2%	~ 4-5%
Propylene	3%	~8%	~ <20%
C4 olefins	~6%	~8%	~ >11%
Total aromatics	~12%	<15%	~ >25%

Valuable Olefins & Aromatics can be incidentally recovered if a downstream petrochemical & Aromatic unit exist.

Cracking Yields



Product	Feedstock					
	Ethane	Propane	Butane	Naphtha	Atmospheric Gas Oil	Vacuum Gas Oil
Hydrogen 95% Purity	9	2	2	2	1	1
Methane	6	28	22	17	11	9
Ethylene	<u>78</u>	42	40	<u>34</u>	26	21
Propylene	3	17	17	16	16	14
Butadiene	2	3	4	5	5	5
Pyrolysis Gasoline of which	<u>2</u>	7	7	<u>19</u>	18	19
Benzene	2	3	3	7	6	4
Toluene	0	1	1	3	3	3
Fuel Oil	0	1	2	5	18	25

* Values obtained at high severity and with recycling unconverted E/P Stream ! Chauvel & Lefebvre 198

BTX extracted by Sulfolane ($C_4H_8O_2S$), furfural ($C_5H_4O_2$), tetraethylene glycol ($C_8H_{18}O_5$), dimethylsulfoxide (C_2H_6OS), and N-methyl-2-pyrrolidone (C_5H_9NO)