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Energising a Brighter Tomorrow

Brownfield Integration of a World-Scale Petrochemical Complex with an Operating Refinery

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HMEL Overview

JV Structure

49 % Hindustan Petroleum Corporation Ltd

49 % Mittal Energy Investments Pte Ltd

2% Financial Institutions

Core Values

Key Assets

Township: Best in class housing facility at Bathinda equipped with recreational facilities.

Oil Refinery: 12.5 MMTPA capacity *(~5% of India's Crude Oil demand in 2023)* Amongst the 2nd highest Nelson Complexity Index in India

Petchem Complex: 1.2 Polyethylene and 1.0 MMTPA Polypropylene capacity. Meeting ~12.5% of India's total polymer demand

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Single Point Mooring: For handling VLCCs (Largest Crude carriers in the world) 7 km in the sea.

Biofuel Unit:
- 300 KLPD Bioethanol Plant.
- Only Refinery in India integrated with Bio-Fuel Plant

Crude Pipeline: 1,017km Crude Oil Pipeline traversing across 4 states in India

Crude Oil Terminal: >1bn litres of storage. (~1.5 times the daily consumption of Crude Oil in India)

MMTPA – Million Metric Tonne Per Annum
VLCC – Very Large Crude Carrier
KLPD – Kilo Liter Per Day
BPD – Barrels Per Day

Highlights

- Largest Foreign Direct Investment (FDI) in refining at the time.
- Among highest FCC-yields of propylene and almost twice that of earlier processes.
- One of the highest refining margins in the region.
- Largest mixed feed cracker in the country
- One of the only 3 Indian refineries integrated with steam cracker.
- Highest petrochemical intensity among Indian refiners

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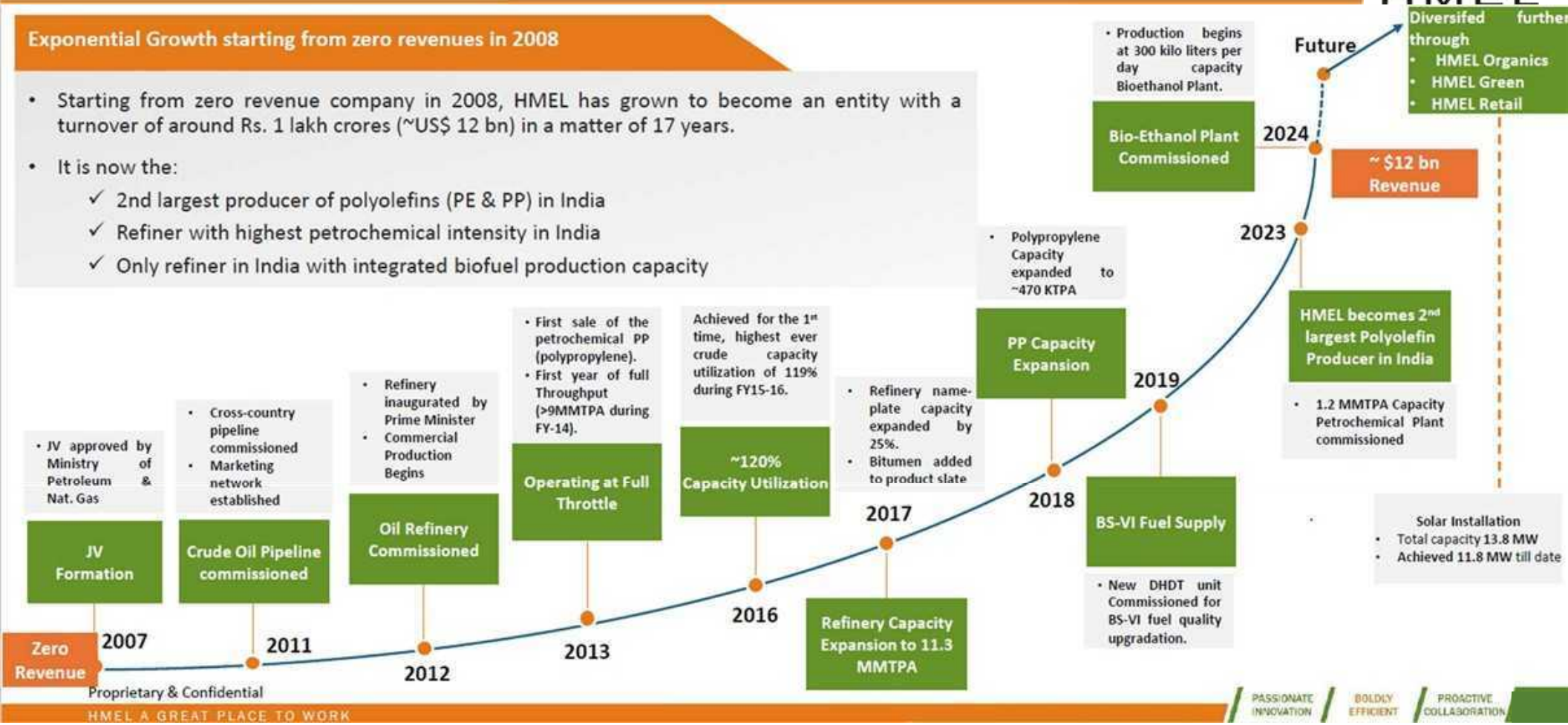
Journey / Milestones



HMEL Products

Refinery	Petrochemicals	Biofuel
HMEL Liquids & Fuels • LPG • Naphtha • Jet Fuel • Petrol • Kerosene • Diesel • MTO (Mineral Turpentine Oil) • Bitumen • Hexane	**HMEL Solids** • Polypropylene • Sulphur • Petcoke	**Polysure Polymers** • HDPE • LLDPE • Polypropylene HMEL has produced 53 grades of polymers	**HMEL Aromatics** • Benzene • PyGas • CBFS (Carbon Black Feedstock)	**HMEL Biofuels and Food & Feed Products** • Bio-ethanol • DDGS (Distiller's Dried Grains Solubles) • Carbon-Dioxide

Products directly marketed by HMEL

Products marketed through HPCL

World-class Technology Partners/Licensors

Rail and Road loading facilities

Products compliant to Euro VI norms

Excellent customer services driven by latest IT technologies

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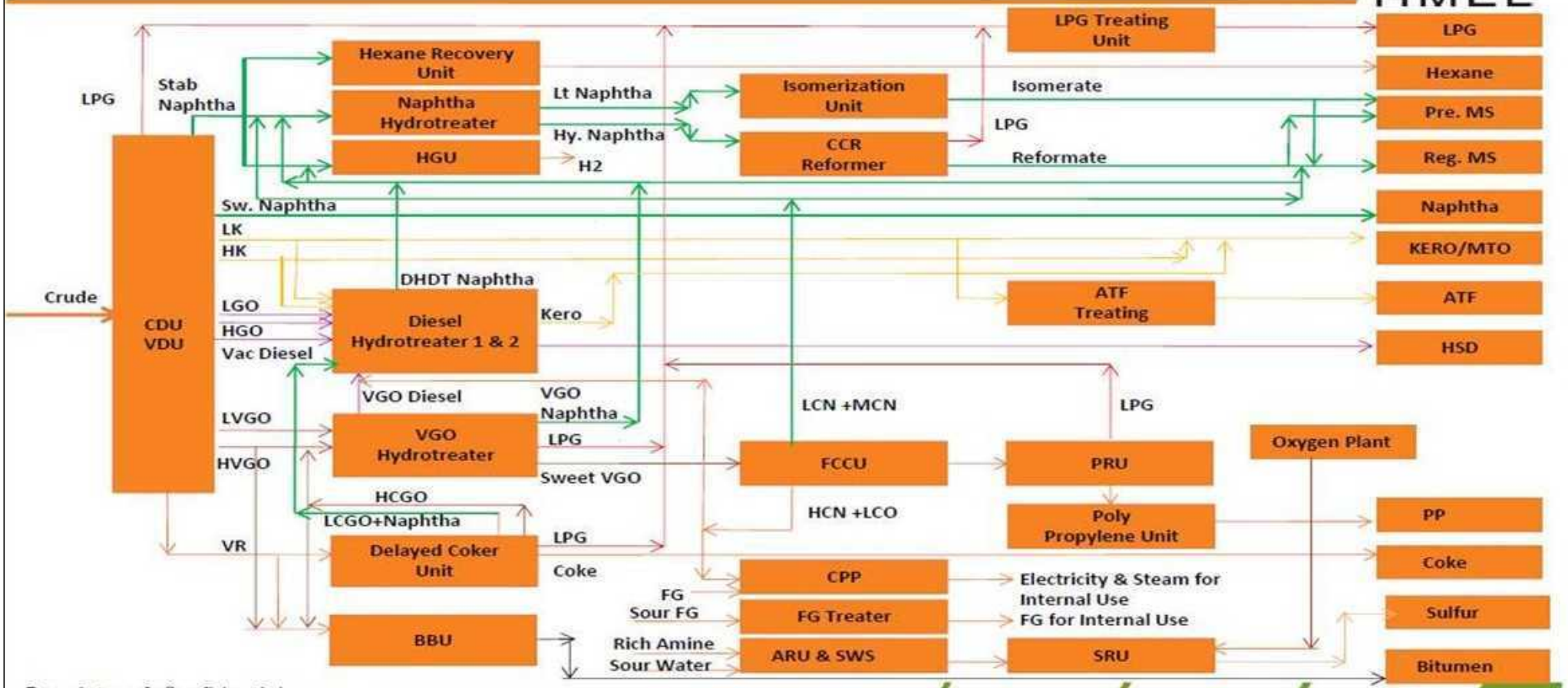
HMEL Refinery Block Flow Diagram



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GGSR Unique Features

- **Most Modern** & integrated Refinery of the Country - Refinery produces best value (BS-VI fuel – World' cleanest fuel) out of the most tough crudes.
- Collaboration with **Best-in-class** Licensors & Partners like Lummus-USA; Chevron Phillips-USA; Lyondell Basel-Italy; Axens-France; Technip-France; Novolen-Germany; SAP and Honeywell
- Commissioned in a record time of **four years**.
- The first refinery to **integrate a Polypropylene plant with Petro-FCCU** for value-added PP production.
- Use of **Advance Technologies** – Extensive use of Digitalization, Advance Analytics. Equipped with Honeywell-USA supplied MES, Yokogawa-Japan DCS & APC, and Aveva-UK supplied RTO Systems.
- Fully **Automated** Processes like ASRS (Automated Storage and Retrieval System) for Polymer Bagging, Storage, Retrieval & Loading
- Use of **Environment Friendly** technologies like Sulphur Recovery Units, Flare Recovery System, Low NOx burners & Vapour Recovery Systems.
- **Zero Liquid Discharge** Refinery with use of State-of-the-art Effluent Treatment Plant

Major Processes to Produce Petrochemicals

- Cracking
  - Thermal or Steam Cracking
  - Catalytic Cracking (FCC)
- Reforming
  - Catalytic Reforming
  - Steam Reforming

Cracking: Feed Stock - Ethane, Propane, Naphtha, Gas oils

- Ethylene
- Propylene
- Butadiene
- BTX

Reforming: Feedstock - Naphtha, Natural gas, Coal, Coke

- Naphtha to BTX
- Syn-gas to alcohols

Steam Cracking

- **Thermal** (Pyrolysis) Cracking
- Cracking Reactions Occurs in **Gas Phase**
- Converts **High Mol. wt.** Low value Feedstock to **Low Mol. wt.** High Value-added Products
- **Severity** and **Residence time**
- Steam is Mixed with Feedstock to lower the **Partial Pressure** and **Coke Formation**
- Petrochemical Building block (**Ethylene & Propylene,** etc.)
- **Other By-Products**: Fuel gas, Hydrogen, C4s, C5s, C6s, Benzene, HPG, C9, PFO.

Steam Cracking - Overall Process

Cracking Furnaces

Oil Separation and Cooling

Cracked Gas Compression

Chilling

Refrigeration Compressors

Separation

Specific Energy Consumption

Pyrolysis	65 %
Compression	15%
Separation	20%

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HMEL Petrochemicals

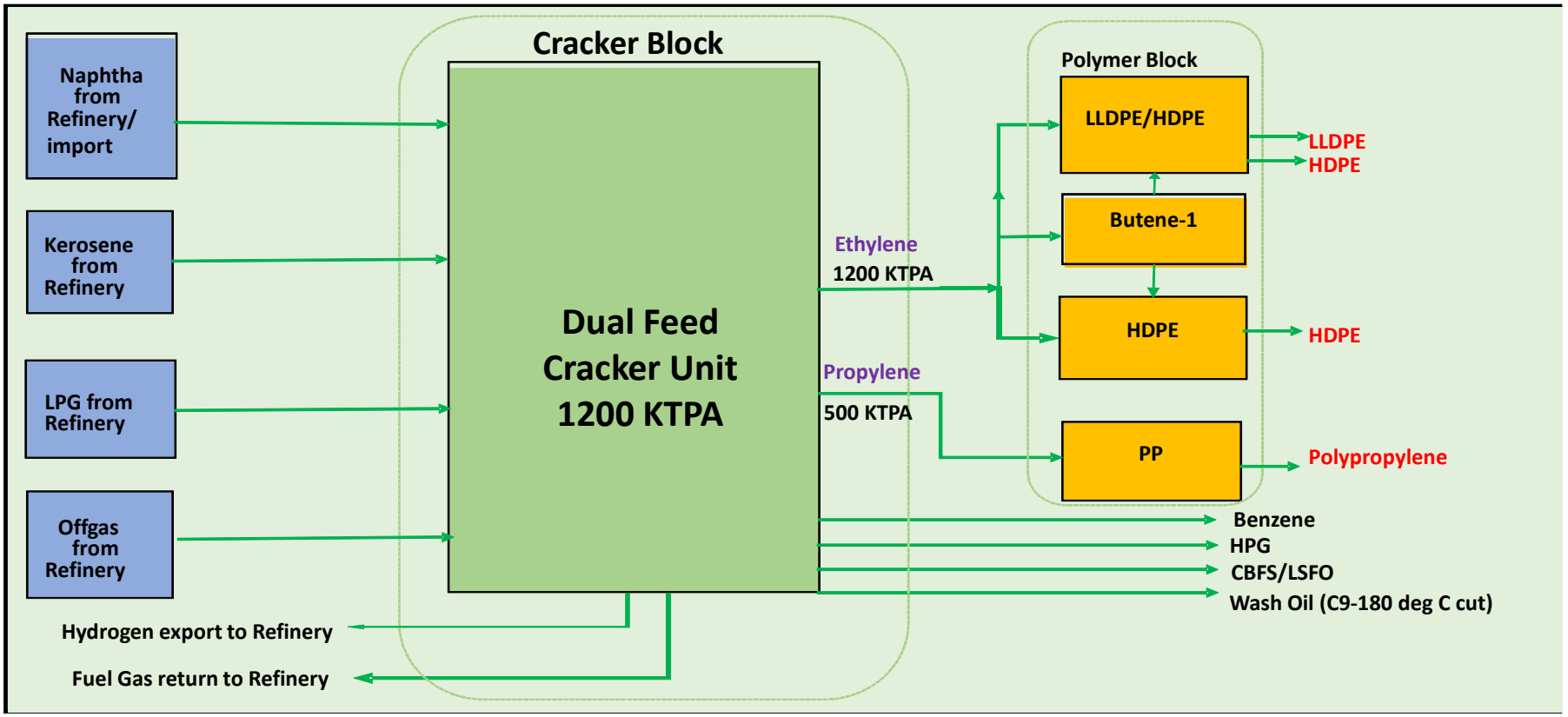
Introduction

- HMEL has completed a **Low Cost Expansion** of the existing refinery from 9.0 to 11.3 MMTPA in 2017. **Expanded** to 12.5 MMTPA in year 2025.
- HMEL post refinery expansion intended to **diversify** into the field of petrochemicals due to associated higher profits and value addition.
- **Petrochemical Complex** comprising of Steam Cracker unit and downstream polymer block was conceptualised.
- The Petrochemical block is **integrated** with the existing facilities and is located within the **existing refinery battery limits**.
- Project started in April 2017, completed in 2022.

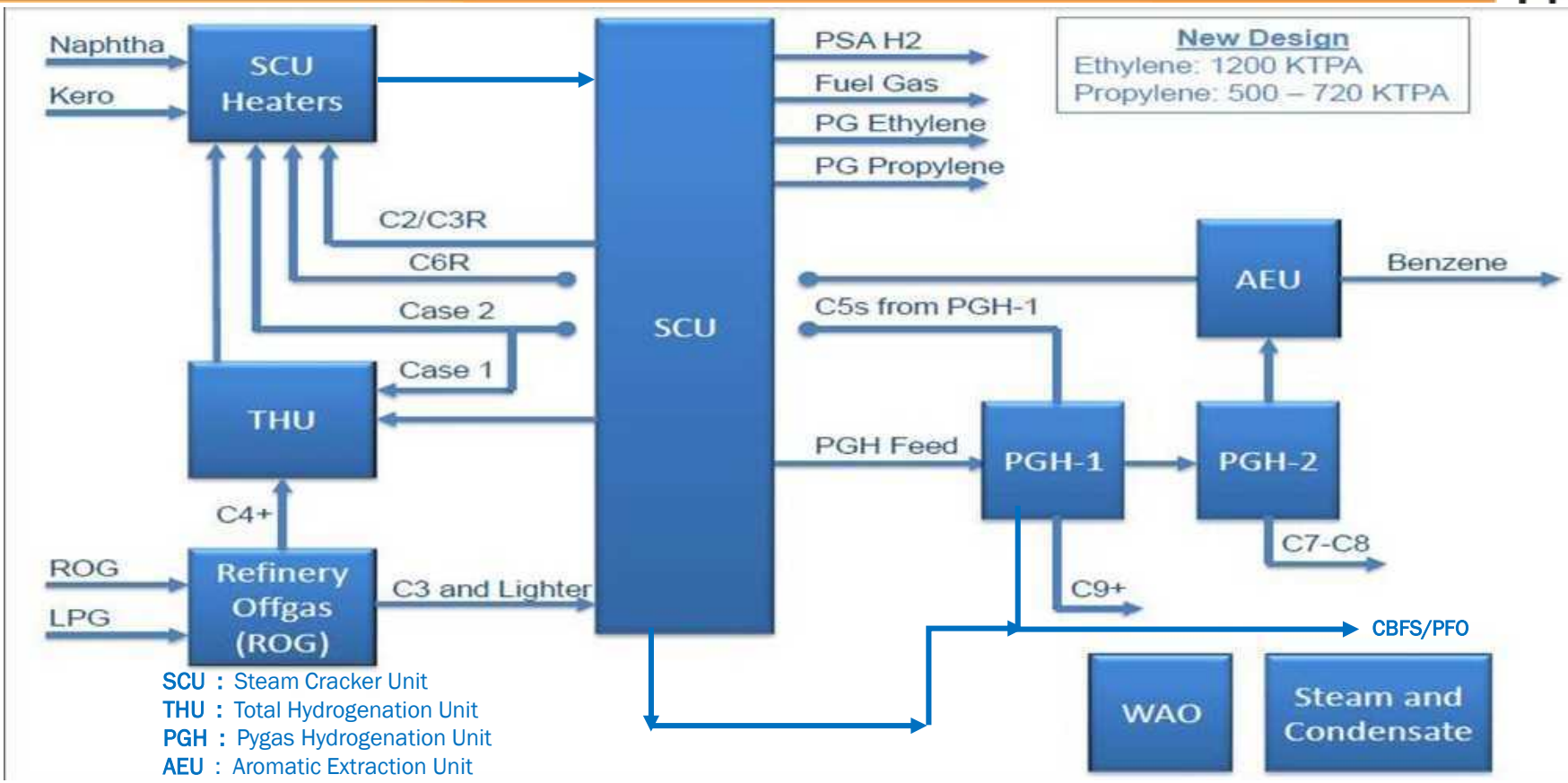
Objectives

- To provide **robust refinery configuration** along with **integrated petrochemical complex** to sustain healthy GRM.
- Maximize **value added petrochemical products** from the refinery.
- **Naphtha export** from the refinery shall be ''ZERO".

Petrochemical Configuration



DFCU - Block Flow Diagram



SCU : Steam Cracker Unit
THU : Total Hydrogenation Unit
PGH : Pygas Hydrogenation Unit
AEU : Aromatic Extraction Unit
WAO : Wet air Oxidation

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HMEL GGSPAP - Project Scale at a Glance

We have established a **world-class petrochemical plant** designed to meet India's rapidly growing demand for polymers.

- **DFCU Capacity:** 1.2 MMTPA Ethylene (expandible to 1.5 MMTPA), **biggest** in India. One of the **world's largest** Dual Feed Cracker.
- **Polymer Capacity:** 1.75 MMTPA (1.25 MMTPA Polyethylene and 0.5 MMTPA Polypropylene plant).
  - ✓ India's largest capacity (0.5 MMTPA) single-line Polypropylene plant of Lyondell-Basell Technology, with largest PPU extruder (86.4 TPH).
  - ✓ India's first CP-Chem licensed HDPE plant (0.45 MMTPA) for niche grades.
  - ✓ Highest Butene-1 capacity plant of 55 KTPA in India.
- Integrated with one of India's largest Automatic Storage and Retrieval Systems **(ASRS)** warehouses.

- **Project Duration:** 2017-2022, Demonstrating remarkable cost efficiency and execution speed.
- **Peak Manpower:** 25000
- **Refinery Capacity at Integration:** 11.3 MMTPA
- **Petrochemical Intensity Index** Increase: 5% → 21%

Refinery Streams and their Alternative Uses

The refinery streams are generally producing fuels, however, they also have uses in petrochemical facilities and can be used to generate higher profitability products.

Stream	Origin	Refinery Use	Alternative
Refinery Dry Gas	CDU, Process Units	Refinery Fuel System	Petrochemical Feedstock
Ethylene	FCC, Coking, Visbreaking	Refinery Fuel System	Petrochemical Building Block
Propylene	FCC, Visbreaking	Alkylation Value	Petrochemical Building Block
Propane	CDU, Conversion Units	Refinery Fuel System	Petrochemical Feedstock
Butane	CDU, Conversion Units	Gasoline Blend Component	Petrochemical Feedstock
Naphtha	CDU, Process Units	Reformer Feedstock	Petrochemical Feedstock
Reformate	Reformer	Gasoline Blend Component	Aromatics Production

Integrated Refineries and Petrochemicals

Integration of a refinery and petrochemical complex implies **identifying synergies** and **optimising** them for operational and economic gains where they share and exchange many streams such as feedstock's, by-products and utilities.

Refinery and petrochemical complexes can typically be integrated as follows:

- Refinery Integrated with a **steam cracker** to produce ethylene, propylene and other derivatives.
- Refinery integrated with an **aromatics complex** to produce benzene, toluene, and xylene.
- Refinery integrated with an **aromatics complex** and a **steam cracker**.

The extent of integration depends on technical feasibility and the resulting economic benefits. This is a complex discussion and requires further detailed study on a case by case basis.

Existing Refinery Challenges

- Refineries have been into a **transition stage** caused by probable **dip in fuel oil demand** in future due to vehicle electrification, improved fuel efficiency standards, and policy shifts towards decarbonization.
- Switch from Fossil Fuels to **Renewables.**
- Minimization of **Carbon Footprint.**
- Competition for getting higher **Gross Refinery Margin (GRM)** due to uncertainty in **product cracks**, fluctuating crude oil prices, and changing geo-political situation.
- **Lower refinery utilization rates** leading to margin compression.
- **Growing mismatch** between existing refinery product slate and rising petrochemical feedstock demand driven by rising prosperity in Asia, infrastructure development, and increased use of plastics and synthetic materials across industries.
- **Stricter emission norms** for refineries leading to invest CAPEX which does not payback in terms of increased fuel prices.
- **Market demand** and new technologies are setting a platform for Refineries to integrate with petrochemical units for getting more value added products.

Global Petrochemical Industry – Current Status

- Petrochemicals are expected to be the **largest driver of world oil demand growth**, surpassing that of gasoline or diesel by 2030.
- The **outpacing of fuels demand** by petrochemicals is mainly due to growing electrification of vehicles and increasing fuel efficiency of new vehicles.
- **Government mandates** to increase vehicle fuel efficiency and reduce CO2 emissions.
- Petrochemicals will likely **remain the mainstay** of all products, industrial, or consumer, which the world consumes on a daily basis.
- Major refining and integrated oil and gas players to **reconfigure their plants** towards producing more petrochemicals rather than just fuels.
- **Extracting more value** from new products rather than just augmenting the existing product slate is the way to go for such revamps.
- While standalone refineries are gradually **exploring integration opportunities** with petrochemical complexes, it is only right for new refineries to feature such integration from the start.

Petrochemical Industry Challenges – India Specific

- **Lack of advantageous Feedstock** like **Ethane** and **Propane** due to limited gas production. India still imports 55% and depends upon other countries.
- Surplus, however, scattered Liquid Feedstock like Naphtha and Kerosene. Currently, there is **no common pool.**
- Alternate route via **Gasification** demands high CAPEX.
- **High utility & fuel cost -** Fuel is required even for generation of utilities.
- **No allocation** of depleting domestic gas, and there is no new allocation of reservoirs.
- **Logistics** especially for cryogenics & NGL, currently through ships only.

Drivers for Integration

1. Higher Profit Margins

- Refiner's options - **reducing crude capacity or diversifying** into higher value petrochemicals.
- **Diversification** into petrochemical production ensures crude capacity is maintained, and results in a much **higher margin** compared to just producing fuels.
- Petrochemicals typically command **higher profit margins** than transportation fuels.
- With **global demand growing** for plastics, chemicals, and specialty materials, integrating refinery and petrochemical operations helps producers **capture more value** from each barrel of crude. Rather than selling only low-margin fuels, companies benefit from diversified revenue streams.

2. Demand Shift

Global energy demand patterns are changing:

- **Fuel demand growth is slowing** in many markets due to efficiency gains, electrification (e.g., EVs), renewables and carbon footprint minimization.
- **Petrochemical demand is rising**, driven by population growth and higher usage in packaging, textiles, consumer goods, and industrial applications.
- Global petrochemicals demand is expected to grow **three to six times** the global fuels demand driven by the **rise of the middle class** in emerging nations.

In India:

- By 2030, **shortfall in demand** by 31.8 MMTPA vs installed capacity.
- **Per Capita consumption** of petrochemicals in India lower i.e. 10 kg as compared to global average of 34 kg.

3. Feedstock Optimization

Refineries produce **intermediates** like naphtha, LPG, and other light hydrocarbons that can be leveraged as **pragmatic feedstocks** for petrochemical plants.

Benefits include:

- Reduced need to **buy external** (often costlier) feedstocks.
- Better **utilization** of refinery outputs.
- Ability to process **heavier or lower-value crude** while producing high-value chemicals.

4. Strategic Long-Term Growth

Many oil companies see petrochemicals as part of their **growth strategy**, especially where fuel demand is plateauing. Integrated operations help companies **reposition** for future energy and material demands.

Drivers for Integration

5. Economies of Scale & Operational Efficiency

By co-locating units and **sharing utilities** (e.g., steam, power, water), companies reduce:

- Operating costs
- Capital expenditures per unit of product
- Logistics and transportation costs (internal transfer is cheaper than external shipping)
- Blending of Petrochemical byproducts into Refinery fuel products, leading to lower cost of conversion.

6. Flexibility & Product Diversification

Integrated complexes can **adjust production** based on market conditions:

- Increase petrochemical output when margins are high
- Shift to fuels when fuel prices strengthen
- Paradigm shift with respect to integrated Refinery Petchem complex to **hedge** the cyclic downturns and margin risks.

7. Competitive Advantage & Market Position

Integration helps firms:

- Produce a wider product slate
- Build longer value chains
- Strengthen relationships with downstream customers (e.g., plastic manufacturers, chemical distributors)
- Demographic advantage for India Low cost manufacturing hub.

8. Environmental & Regulatory Factors

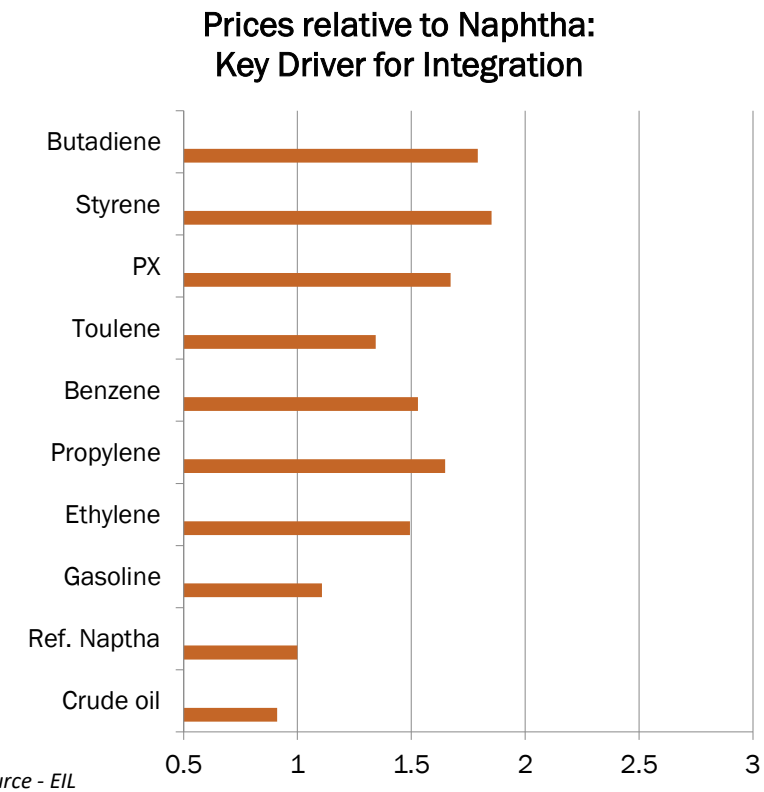
New regulations encouraging **cleaner fuels and reduced emissions** make simple fuel-only refineries less attractive. Integration can help by:

- Reducing carbon intensity per unit output
- Creating products with better environmental profiles (e.g., petrochemical feedstocks).

Although environmental considerations aren't always the primary driver, they increasingly influence investment decisions.

Benefits of Integration

Naphtha Value Addition



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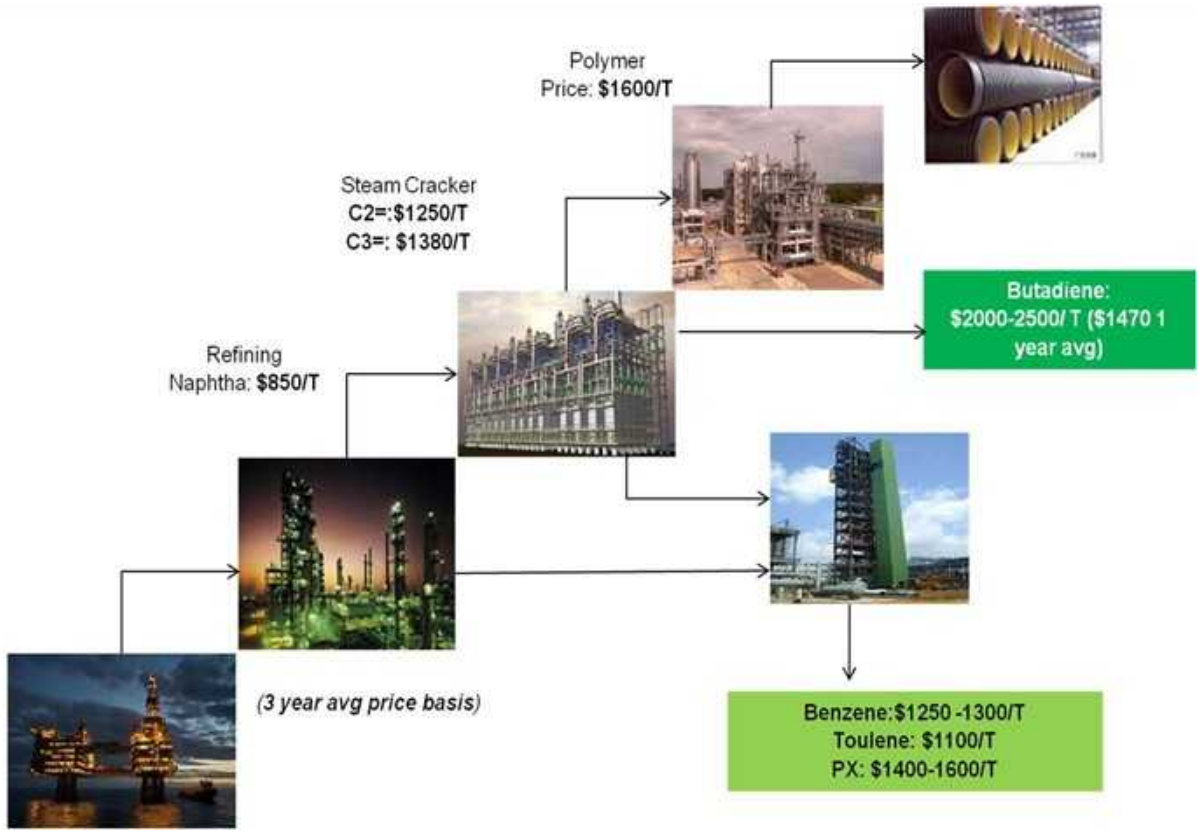


Typical numbers

Benefits of Integration

1. Higher Overall Profitability

- Petrochemical products (olefins, aromatics, polymers) generally have **higher and more stable margins** than fuels.
- **Converts** low-value refinery streams (naphtha, LPG, kerosene, off-gases) into high-value chemicals.
- **Blending** of Petrochemical byproducts into Refinery fuel products leading to lower cost of conversion.
- Improves gross refining margin **(GRM)** on a crude-to-chemicals basis.

2. Better Utilization of Crude Oil (value per barrel)

- Maximizes chemical **yield** from each barrel of crude.
- Reduces production of low-margin products like **fuel oil.**
- Enhances crude-to-chemicals (C2C) **conversion** (some modern complexes achieve 40-70%).

3. Hedge Against Fuel Demand Decline

- Transport fuel demand growth is slowing due to EV penetration, Fuel efficiency norms, and Energy transition policies
- Petrochemical demand continues to grow (packaging, textiles, construction, healthcare).
- Hedging the cyclical downturn and risk

4. Feedstock Security, Reliability & Cost Advantage

- Internal supply of naphtha, kerosene, LPG, hydrogen, fuel gases.
- Reduced dependence on imported feedstocks.
- Lower logistics and procurement costs.

Benefits of Integration

5. Operational Synergies & Cost Reduction

- **Shared utilities**: Power, Steam, Water, Hydrogen, Cooling systems, Integrated utility and Offsite facility.
- **Shared Services**: Engineering, Maintenance, Procurement, Laboratory, HSE, Security, HR, Admin, etc.
- **Common infrastructure**: Tankage, Pipelines, Port facilities, Loading facilities for ease of Feed and Product dispatch.
- **Energy savings** in well-integrated hydrocarbon process.
- Lower **OPEX and CAPEX** per ton of product.

6. Product Slate Flexibility

- Ability to **swing** production between:
  - ✓ Fuels ↔ petrochemicals
  - ✓ Different chemical intermediates
- Helps **optimize operations** based on market margins and demand cycles.
- **Diversification** of product value chain

7. Improved Asset Utilization

- Better **load balancing** of refinery units.
- **Value** extraction from off-gases.
- Reduces product **giveaways** by routing streams.

8. Stronger Competitive Position

- Integrated players are **more resilient during downturns**.
- Long chemical value chains improve **customer retention**.
- **Enables entry into downstream** polymers, specialty chemicals.

9. Environmental & Sustainability Benefits

- **Reduced** fuel oil production.
- Lower Environmental **emission**.
- Supports **circular economy** through plastics and advanced materials.

Integration at HMEL

- HMEL started with a base refinery of 9.0 MMTPA having **5 %** of the chemical as Polypropylene wrt crude oil processing.

- The refinery was expanded to 11.3 MMTPA and integrated with a new Petrochemical Complex to increase chemicals to **21%** by adding more Polypropylene, and new LLDPE, HDPE and Benzene to maximize value by meeting domestic consumption needs and increasing the profitability.

- The **Petrochemical Intensity Index (PII)** is a refinery performance metric that indicates how much of the crude oil processed is converted into petrochemical products (like polyolefins, aromatics, etc.) instead of traditional fuels (like gasoline and diesel).

  PII = (Crude converted into petrochemicals ÷ Total crude throughput) × 100%
  A higher PII reflects a greater focus on **petrochemical output**, which are typically higher margin products vs. conventional fuels.
  Current levels in some Indian state-run refineries average around 5%, though top-tier facilities can exceed 20%.

- For Petrochemical complex integration, **LP model** was developed by EIL and **validated** during Low Cost Expansion Project (LCEP) for 11.3 MMTPA Refinery with BS-VI fuels production. The products slate arrived from this model was used as the basis for economic analysis.

Brownfield Project Execution Challenges

Brownfield Integration = New Complex + Existing Operating Assets + Interfaces

Engineering Challenges

- Existing brownfield plot
- HC/utility crossings
- Existing pipe rack interfaces
- Utility integration requirements

Construction Challenges

- SIMOPS with operating refinery
- Heavy equipment transportation
- Limited construction fronts
- Tie-ins during shutdown windows

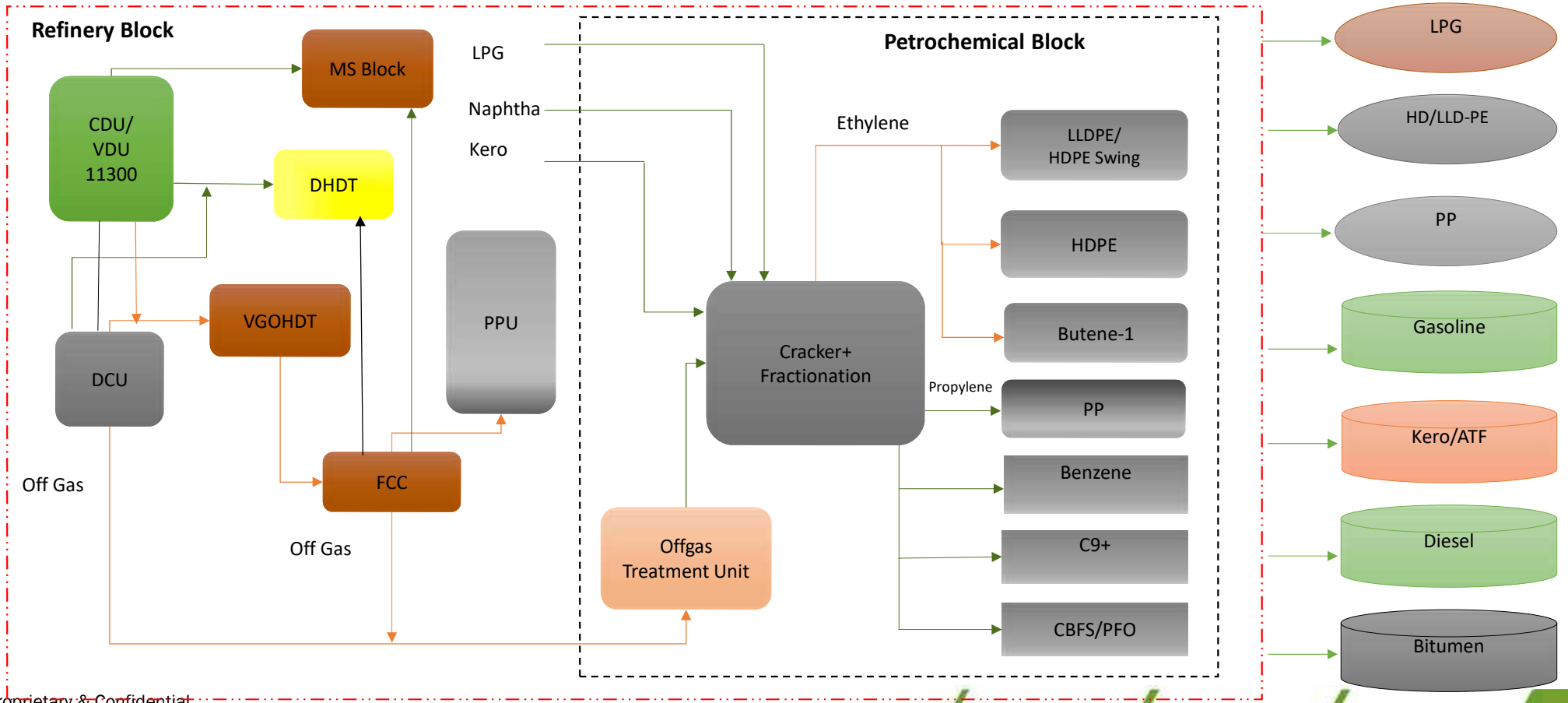
Operational Challenges

- Zero impact on running refinery, its reliability and maintenance
- Assessment and safe commissioning of interfaces
- Utility continuity

Safety Challenges

- Hydrocarbon environment
- Interface control

Integration at HMEL



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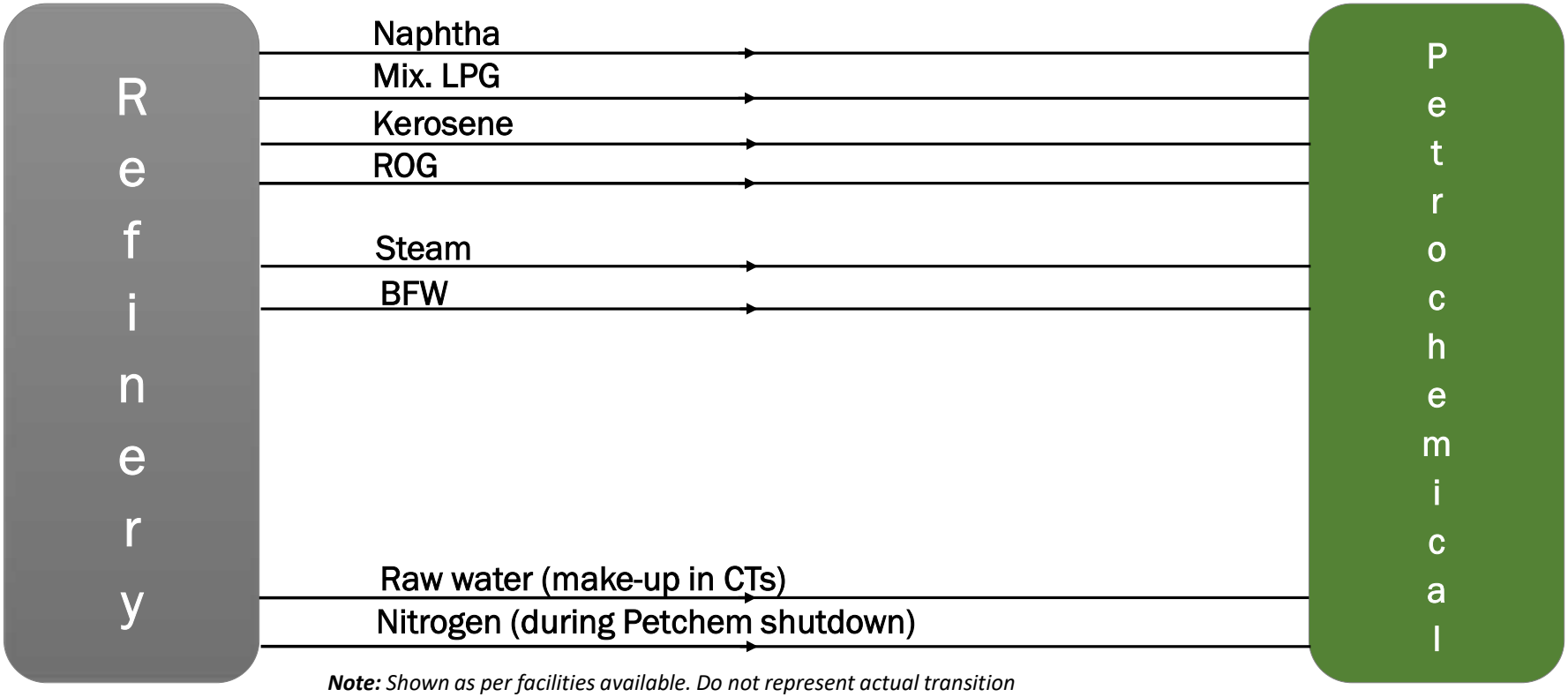
Integration at HMEL

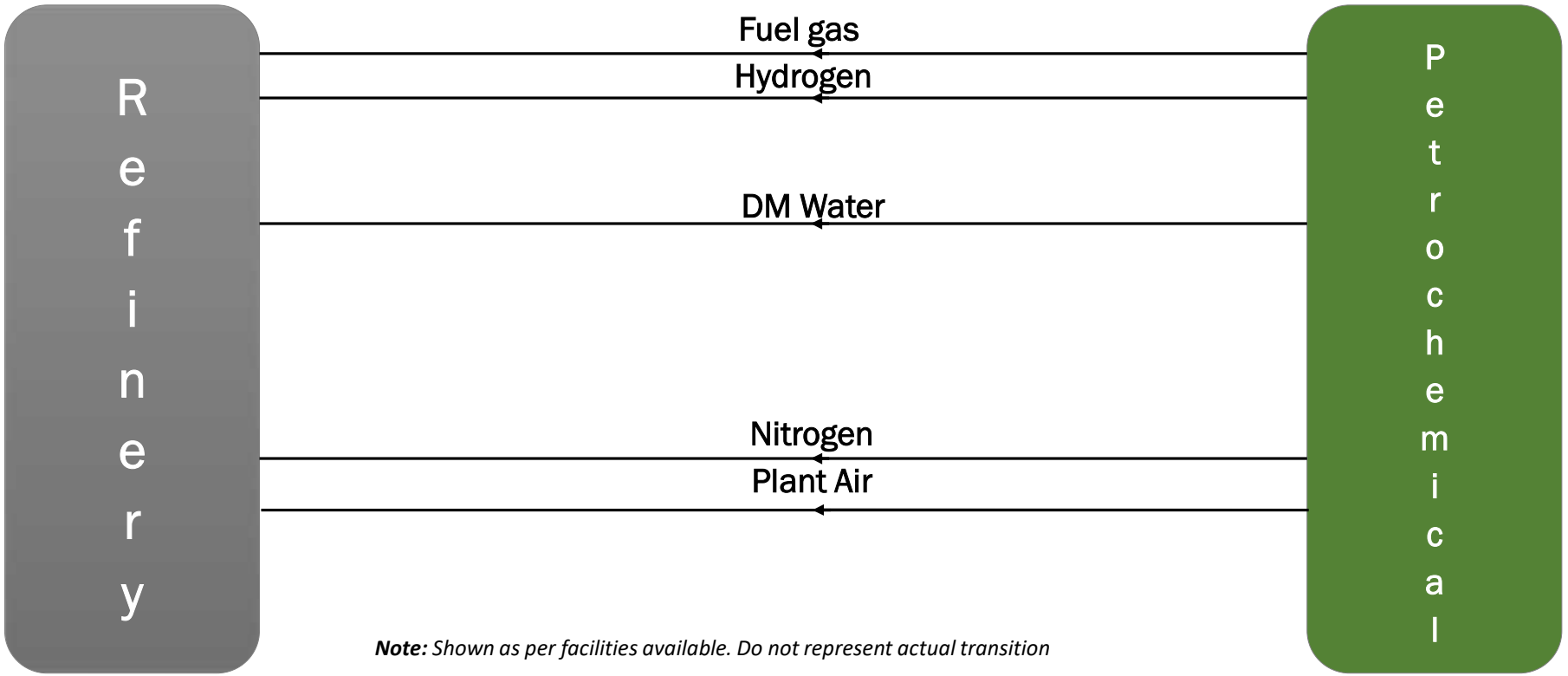
Stream coming from Refinery to Petrochemicals



Note: *Shown as per facilities available. Do not represent actual transition*

Integration at HMEL

Stream going from Petrochemicals to Refinery



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Key Lessons Learned

Development Phase

- ✓ Evaluate multiple configurations
- ✓ LP model based decision making
- ✓ Integration philosophy finalized early

Execution Phase

- ✓ Interface management is a separate project
- ✓ SIMOPS governance is critical
- ✓ Tie-ins must be designed, engineered and planned as a separate project and frozen early

Operations Phase

- ✓ HC streams and Utility integration delivers highest synergies
- ✓ Operations involvement from BDEP to Commissioning is critical
- ✓ Successful commissioning starts with construction and operability readiness - not at first feed
- ✓ Continuous optimization creates value after startup

Summary

- ✓ Petrochemicals are expected to be the **largest driver** of future oil demand growth, making refinery-petrochemical integration a **strategic necessity** for future competitiveness.
- ✓ While standalone refineries are gradually exploring **integration opportunities** with petrochemical complexes, it is only right for **new refineries** to feature such integration from the start. The **extent of integration** depends on technical feasibility and the resulting economic benefits.
- ✓ Integration improves **GRM, feedstock security, asset utilization, product diversification,** and **operational flexibility**.
- ✓ Shared utilities, infrastructure, and services result in **lower OPEX, reduced conversion costs,** and **energy optimization opportunities**.
- ✓ HMEL increased its **Petrochemical Intensity Index** (PII) from **5% to 21%** through the successful integration of a world-scale petrochemical complex with an operating refinery.
- ✓ Successful brownfield integration requires **early integration philosophy, disciplined interface management, robust SIMOPS governance,** and **strong operations involvement**.
- ✓ **Brownfield refinery-petrochemical integration** is not merely a capacity addition project. It is an **enterprise transformation exercise** requiring simultaneous management of technology selection, interface engineering, construction in a live hydrocarbon environment, operational readiness, and long-term value optimization.

Refinery-petrochemical integration is no longer optional; it is essential for long-term competitiveness, resilience, and value creation in the evolving energy landscape.

Thank You