Refinery Pivot Points in a Refinery – Petrochemical Integrated Complex

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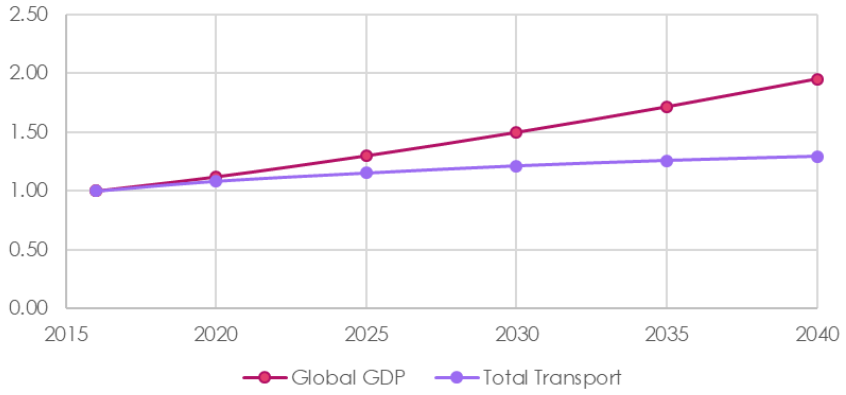
MCDERMOTT
TECHNOLOGY

Challenges Facing Refiners

GDP vs Total Transport



CAGR

2.8%

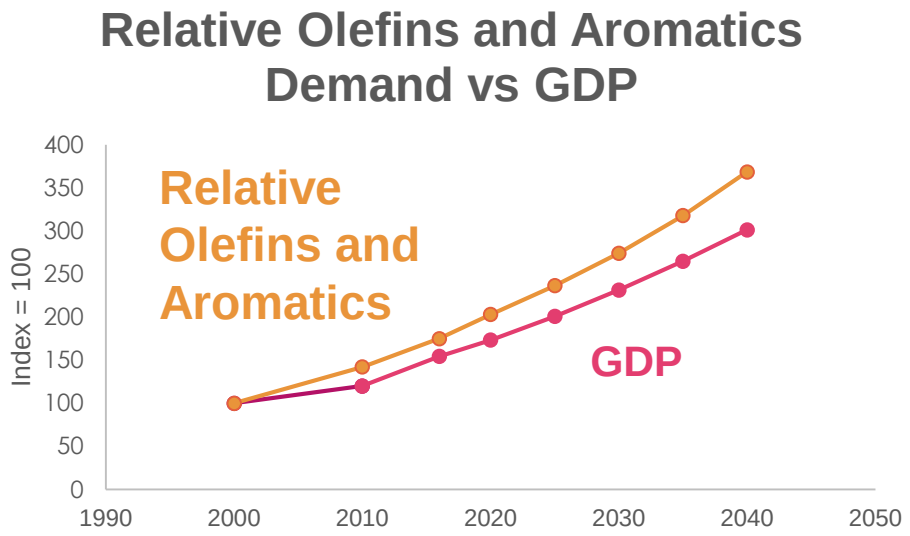
1.1%

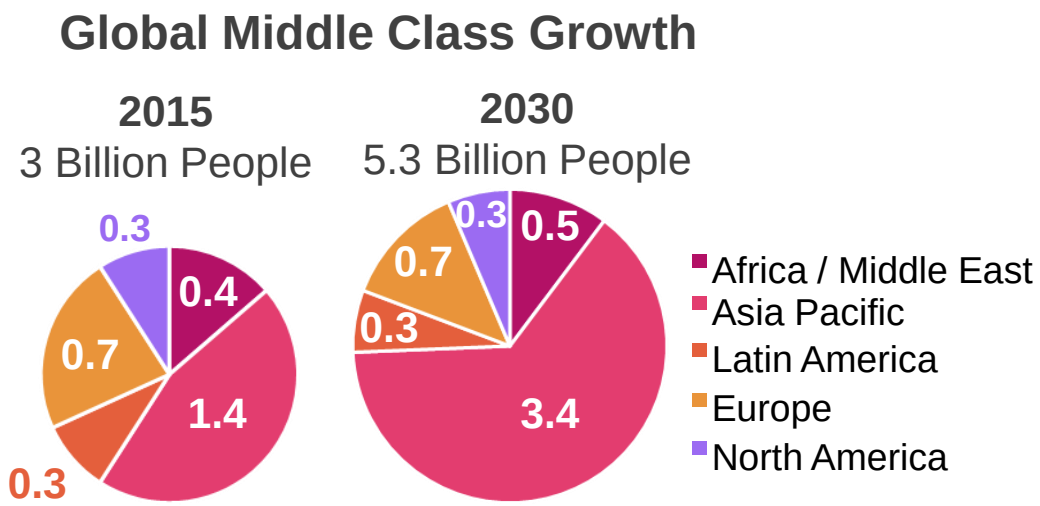
- **Total Transport:** Oil, Biofuels, Gas, Other

Reduced Growth in Fuel Demand

- Extended Fuel Mileage
- Enhanced Electric Vehicles
- Environmental Headwinds

Drivers of Rapid Petrochemicals Growth





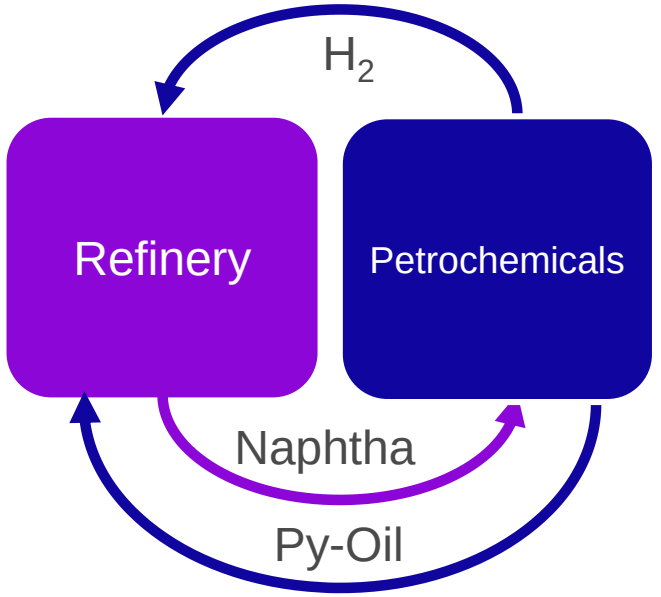
- **From 2016 to 2040, 40% chemicals sector growth**
  - Quality of Life Improvement
  - Rising Prosperity
  - Development of Middle Class
- **Petrochemical growth exceeds GDP growth**
  - Emerging Markets unprecedented Growth

McDermott: Profit Pivot Points

- ***Recent Trend:*** Greater Integration not just Co-location

- Position Petrochemicals Plants near:
  - Low-cost feedstock
  - Lower Transportation Costs for Feedstocks
  - Fuel Sources
  - Existing Infrastructure
  - Downstream Markets: PE / PP / PET

Complimentary Units



- Petrochemicals Provide High Value Outlet for Refiners

MCDERMOTT TECHNOLOGY

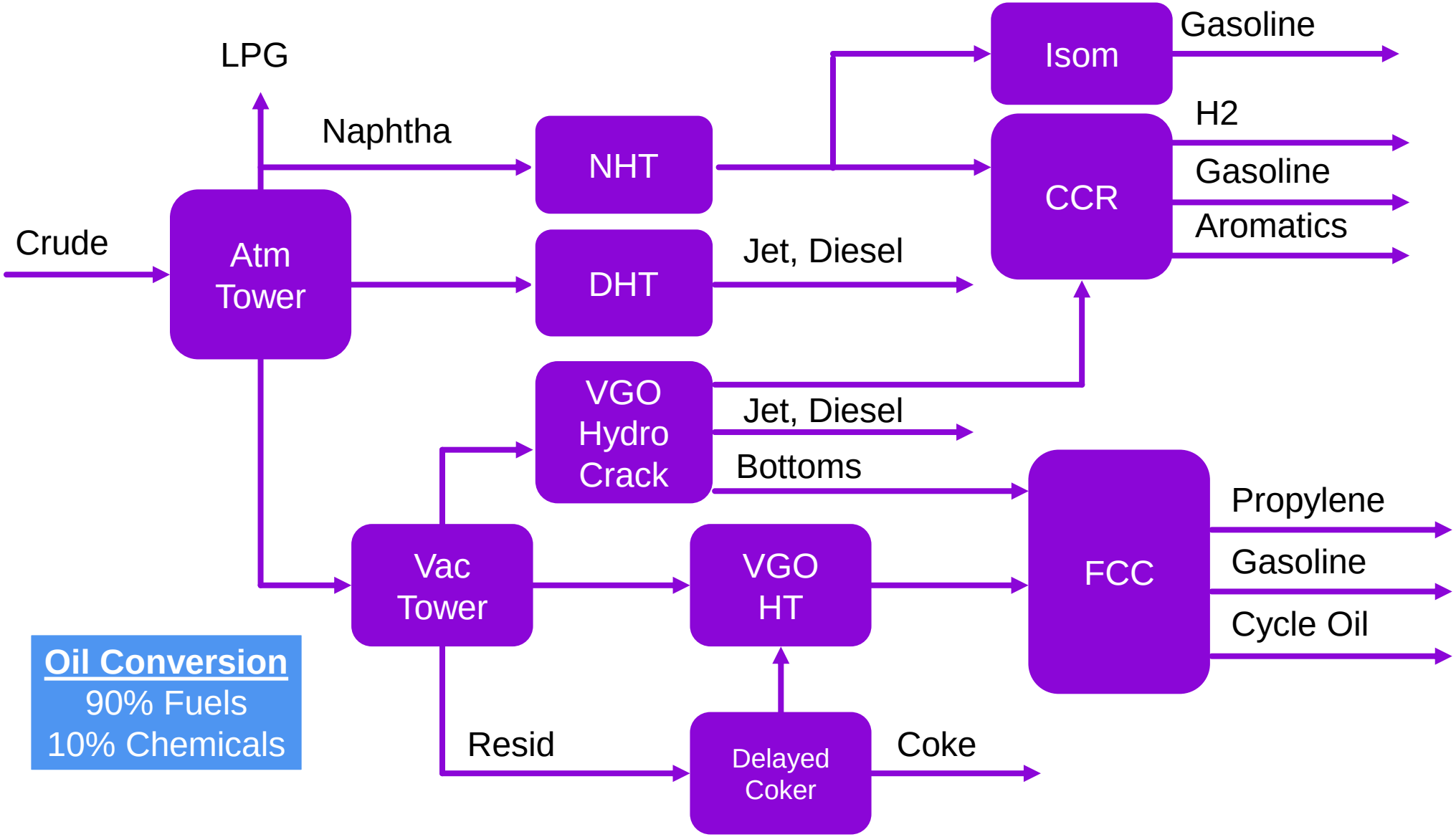
Chevron Lummus Global (CLG)

- Joint Venture
  - **Chevron:** Major Oil Company
  - **McDermott:** A Premier EPC Company
- 100+ Hydroprocessing Plants Designed Worldwide
- Active R&D Programs, Pilot Plant in Richmond, CA and Pasadena, TX

Lummus Technology

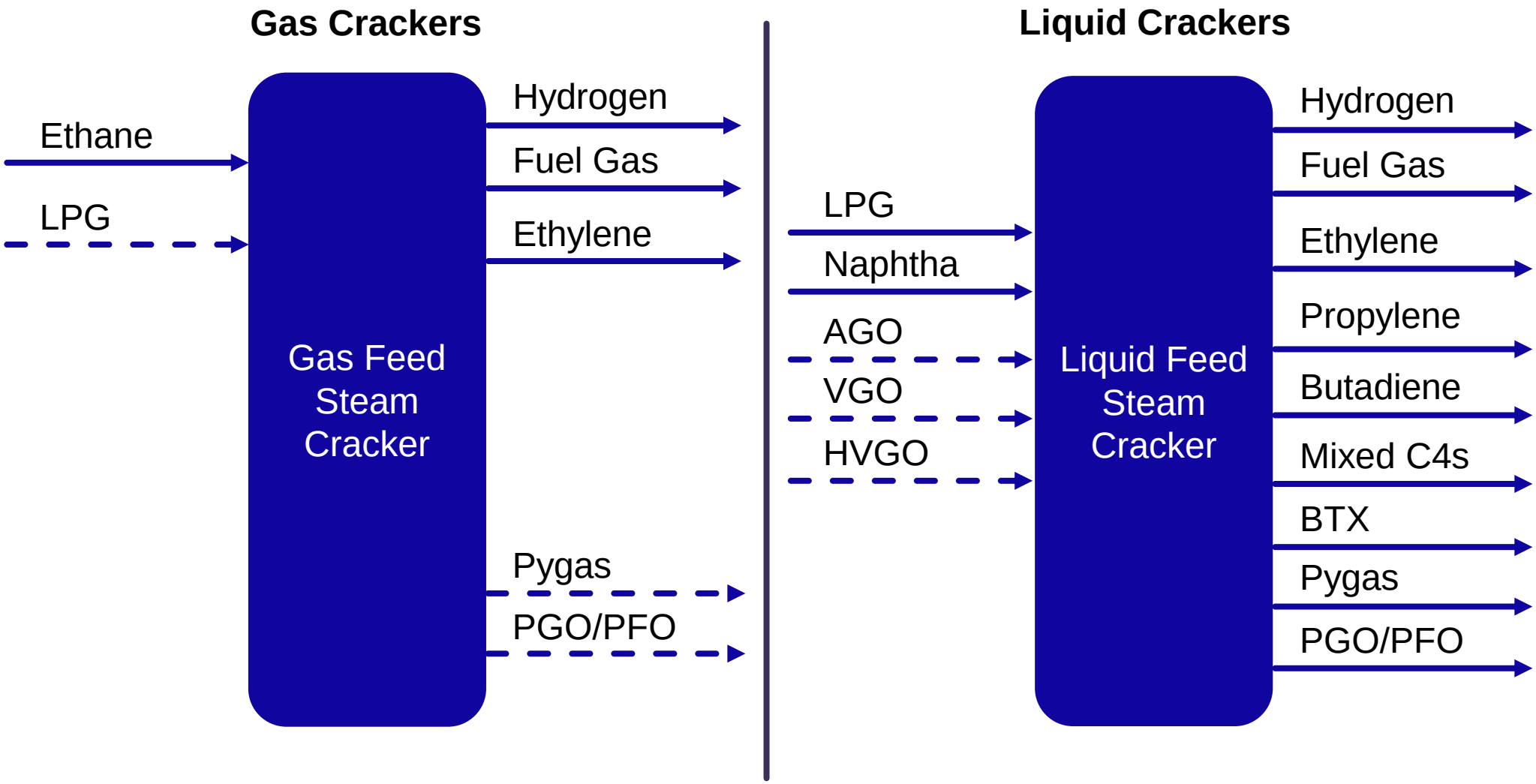
- Leading Technology Licensor
  - Refining
  - Petrochemical
  - Gas Processing
  - Coal Gasification Technologies
- 120+ Licensed Technologies
- 3000+ Patents, Applications, Trademarks
- Industry Leading Ethylene Technology

Traditional Refinery

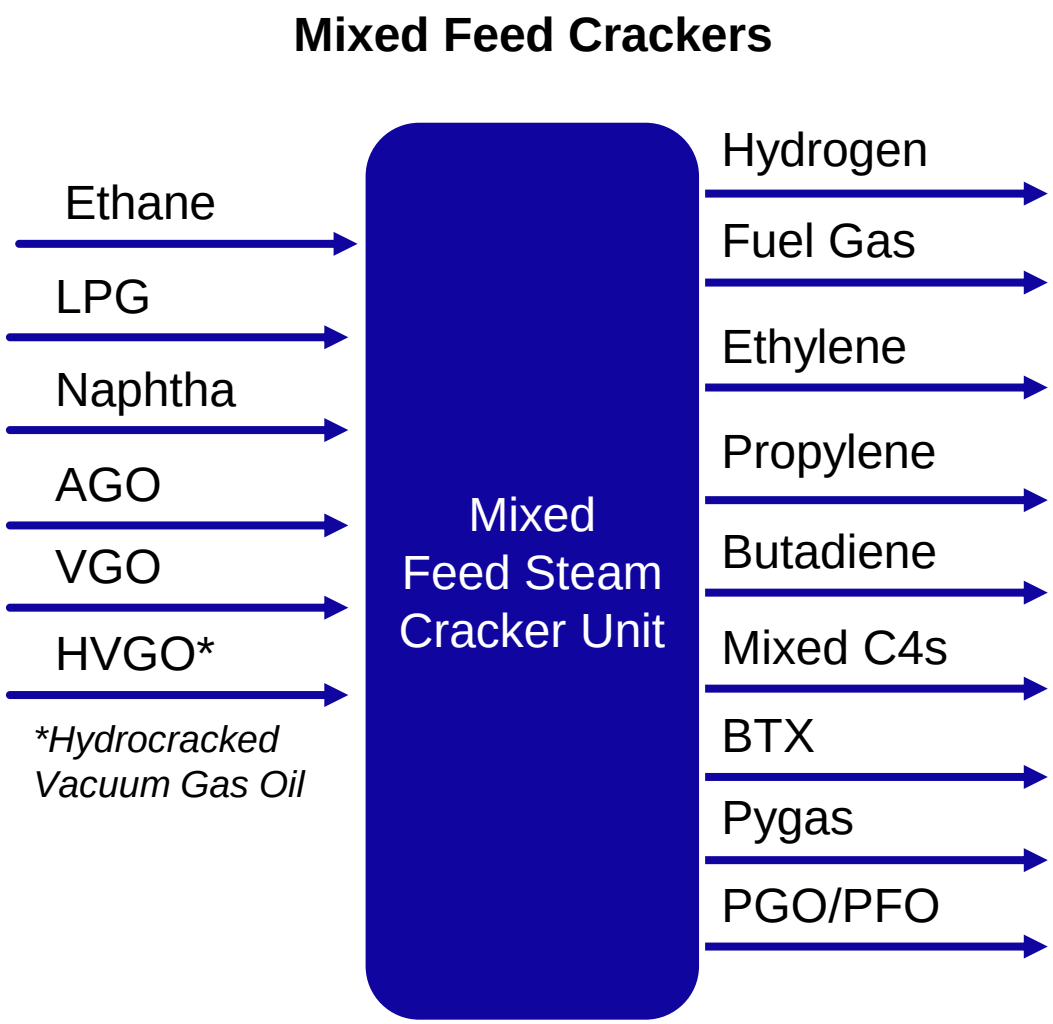


Oil Conversion
90% Fuels
10% Chemicals

Traditional Petrochemicals

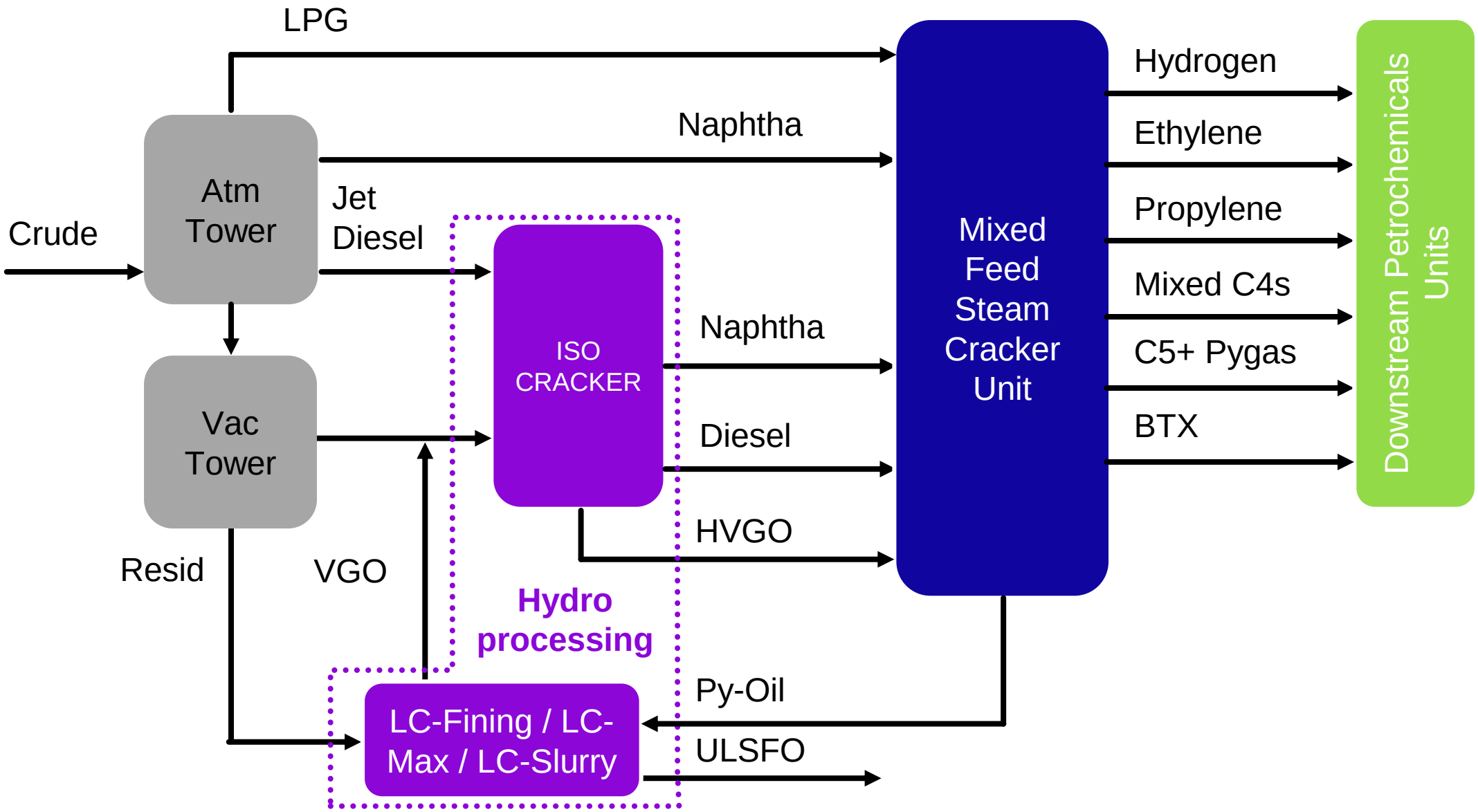


Feed Flexible Petrochemical Complex



- **Mixed Feed Steam Crackers Provide Ultimate Flexibility**
  - Multiple Feeds and Products
  - Larger Capacity

Integrated Refinery and Petrochemicals Unit



Hydroprocessing

- Optimize Cracker Feeds
- Balance Hydrogen Consumption to Optimize Production of Chemicals
- HVGO Excellent Lubes or Cracker Feedstock

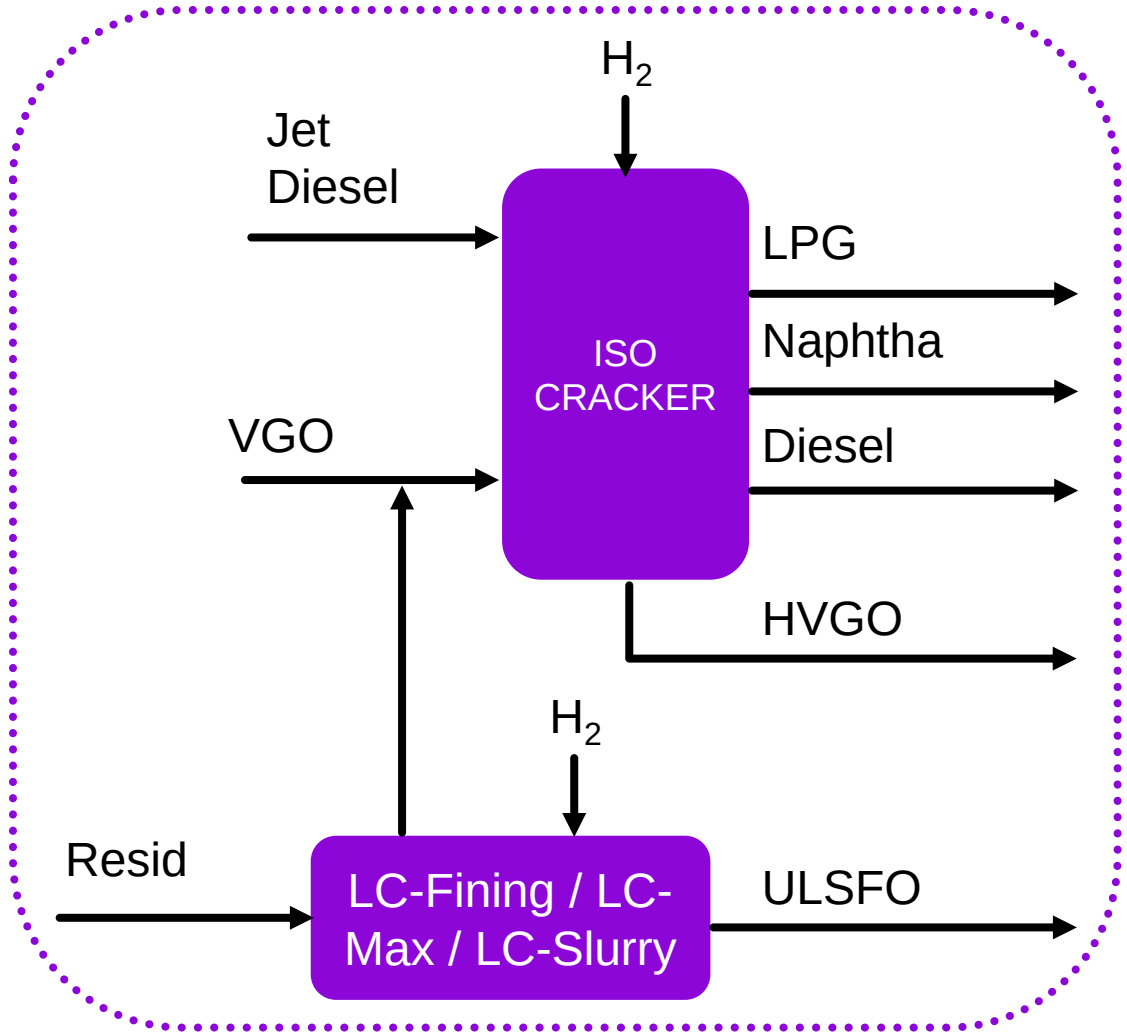
Mixed Feed Steam Cracker

- Feed Flexibility
- Cracking Severity Determined by Propylene to Ethylene (P/E) Ratio

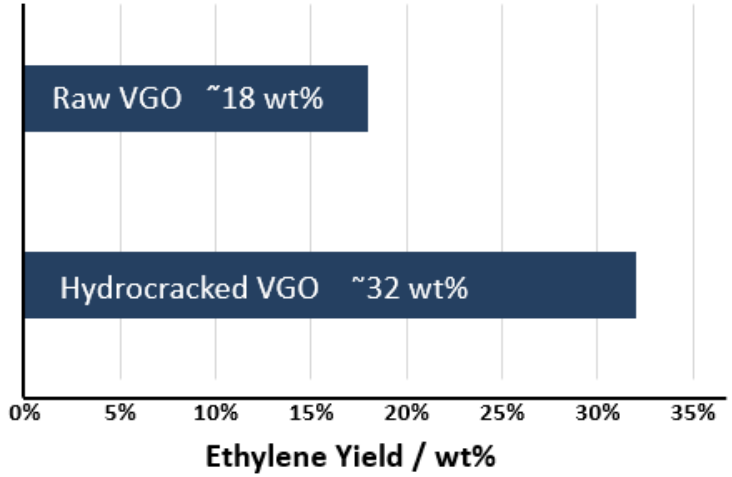
Co-Product Selectivity

- Monetize valuable Co-products such as Butadiene, Paraxylene, BTX
- Olefins Conversion Technology maximizes C2-C3-C4 Product flexibility

Hydroprocessing

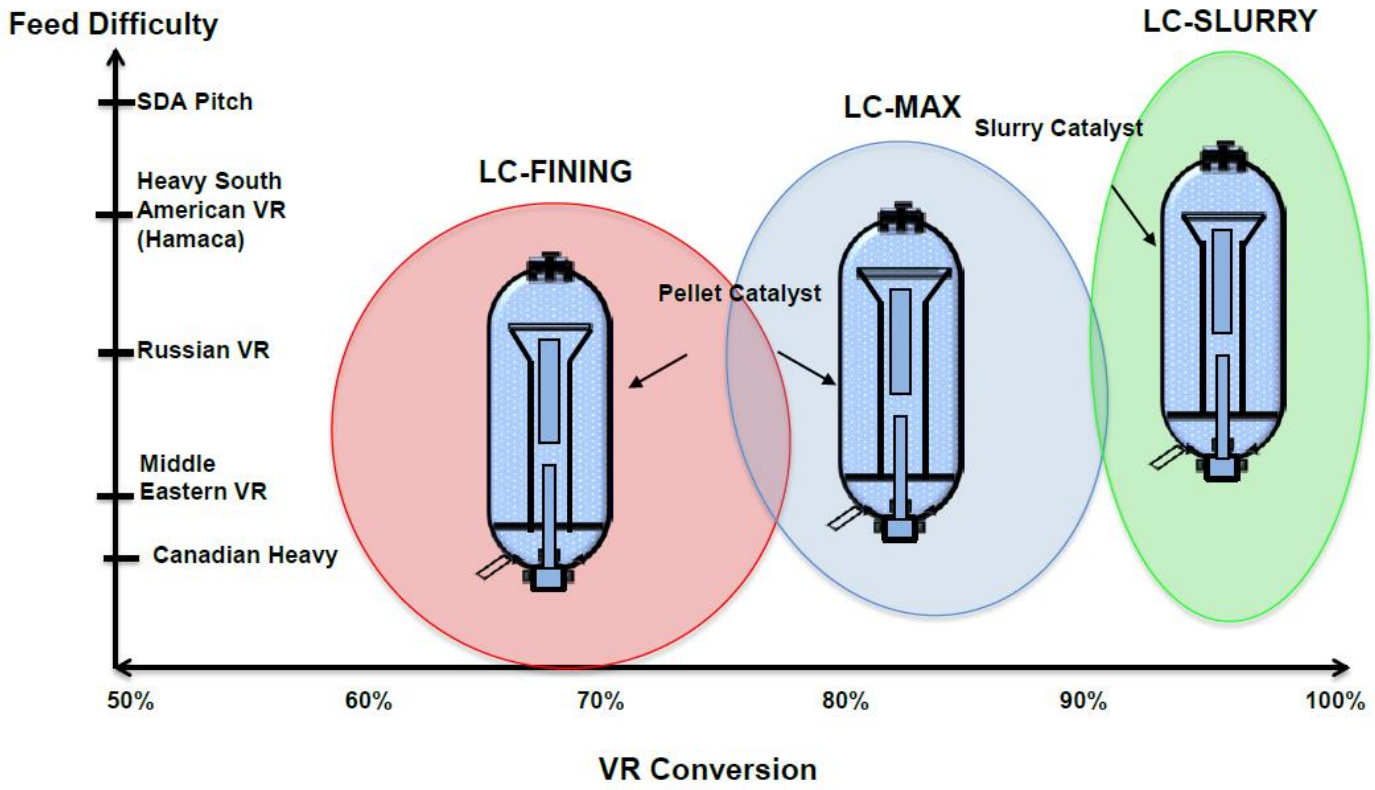


Miracle of Hydrogen Addition



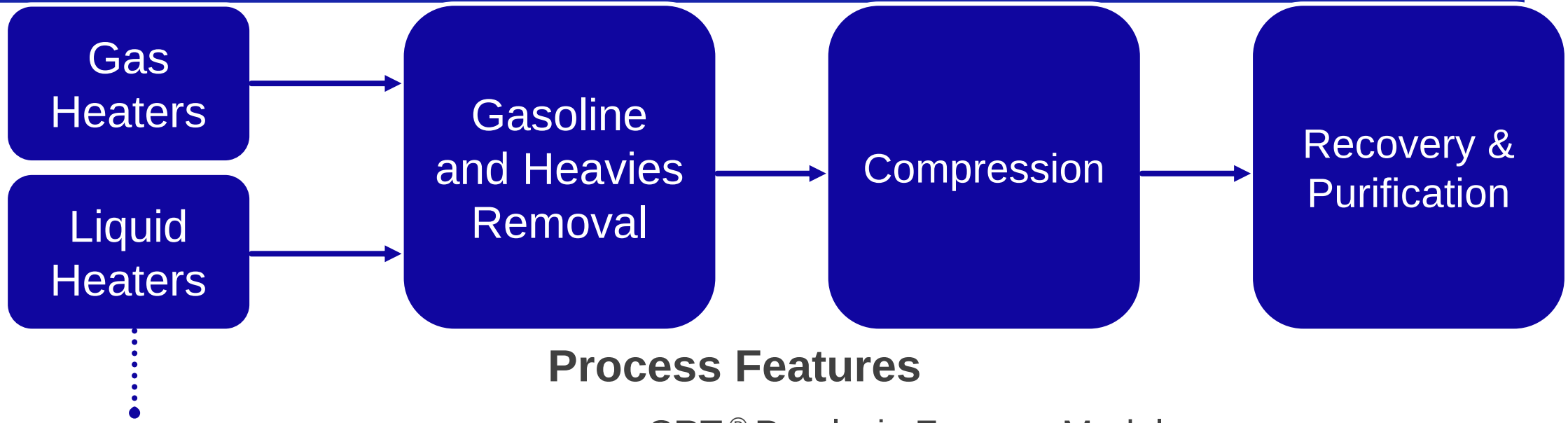
Effectively prepares Feed to Mixed Feed Steam Cracker in terms of **Feed Flexibility, Conversion, and Yield**

Upgrading the Bottom of the Barrel



- Catalyst and Reactor configurations determine range of conversion
- Outlet for Py-Oil upgrading from Steam Cracker

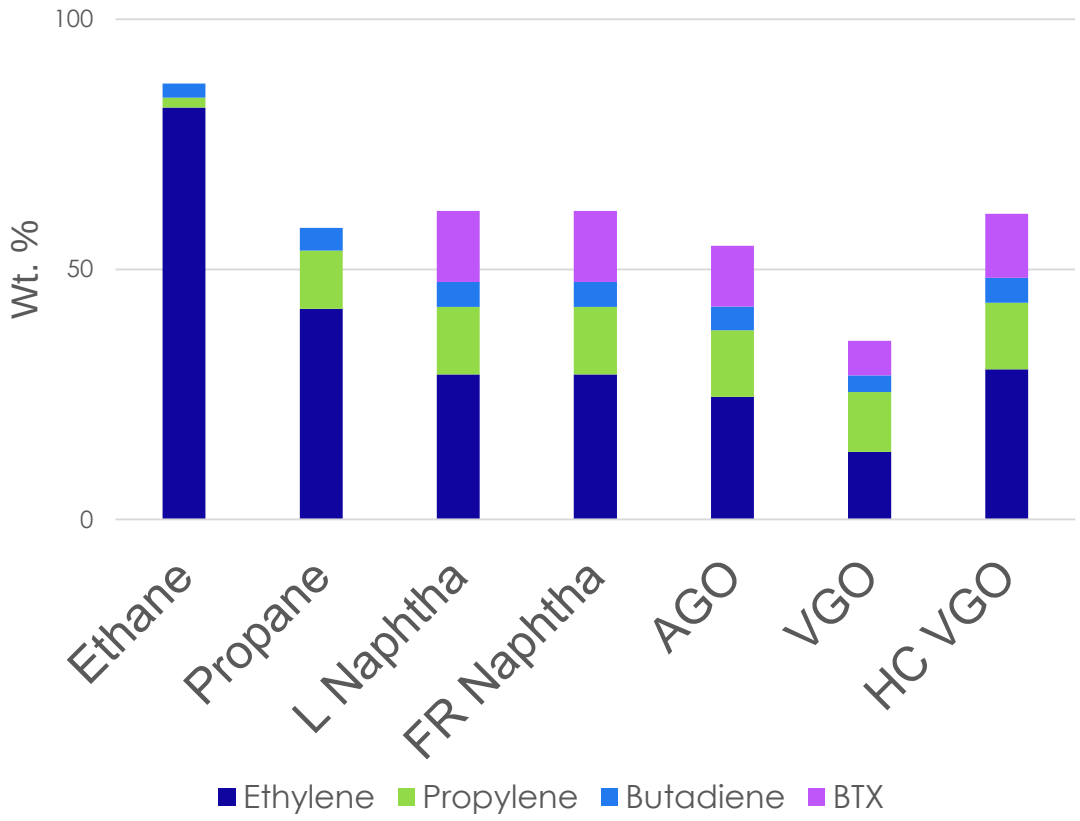
Mixed Feed Steam Cracker



Process Features

- SRT® Pyrolysis Furnace Module
  - High Yield
  - Long Run Length
- Optimized CAPEX / OPEX
  - Low Pressure Design vs Conventional Plants
  - Multi Component Refrigeration
  - Reduced Compressor Casings and Equipment Count

Feed Flexibility
Typical Pyrolysis Yields
(High Value Chemicals)

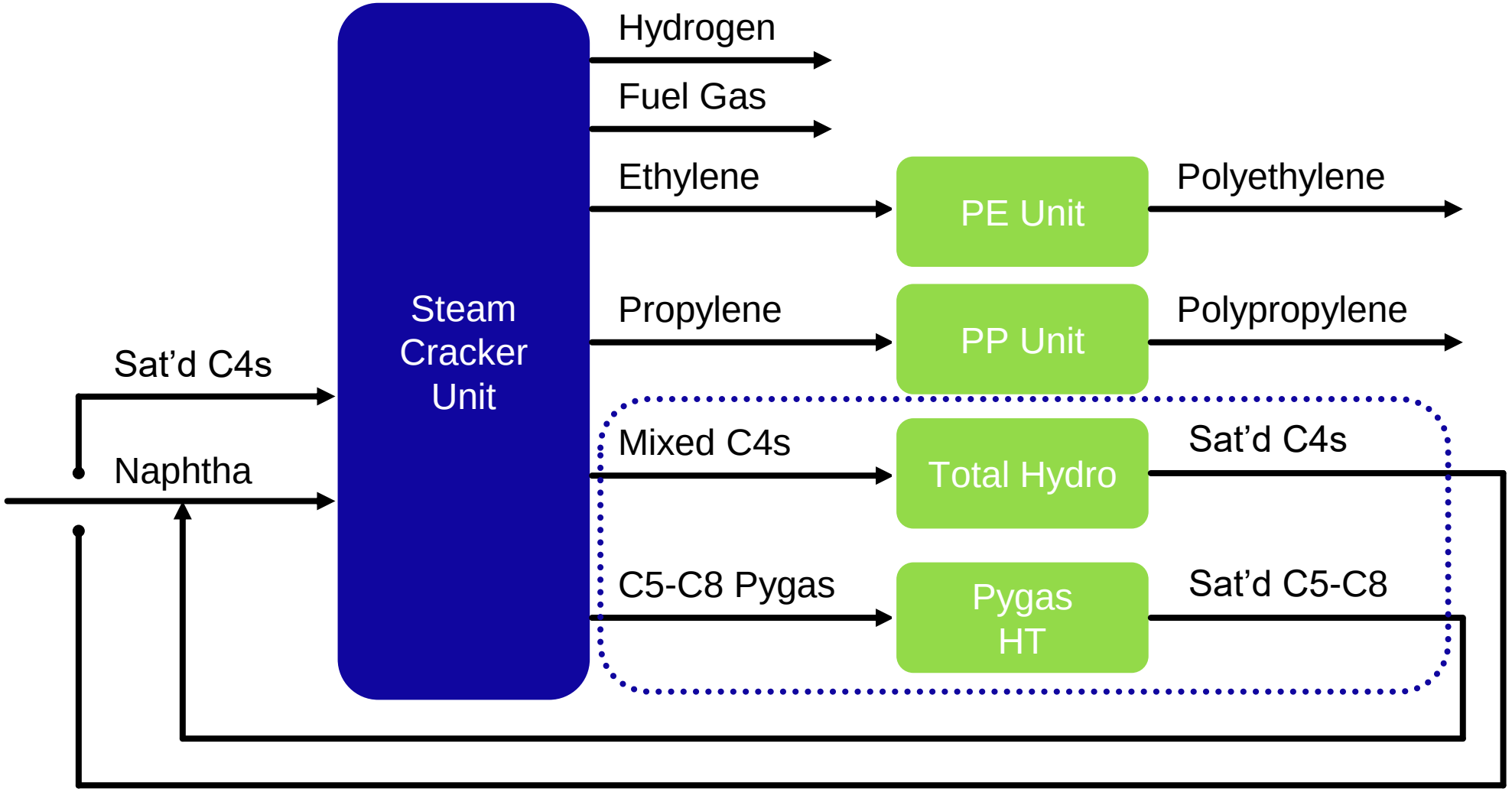


Cracking Severity

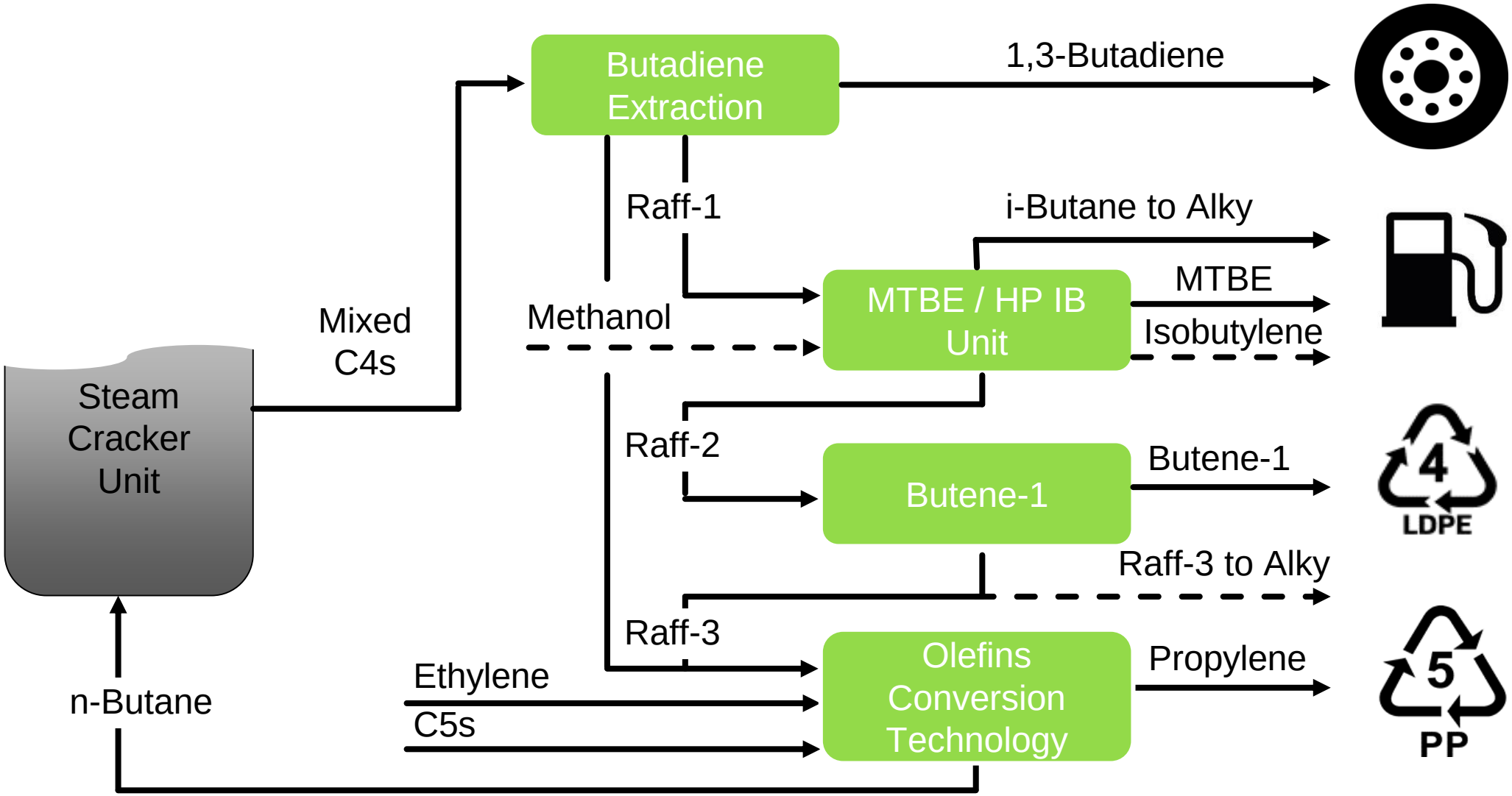
Cracking Severity	High	Low
P/E Ratio	0.45	0.65
Energy / kg Ethylene	Base	+ 16%
Feed Rate	Base	+ 14%
Ethylene Production	Base	Base
Propylene Production	Base	+ 46%

P/E Ratio defined as Propylene / Ethylene Ratio

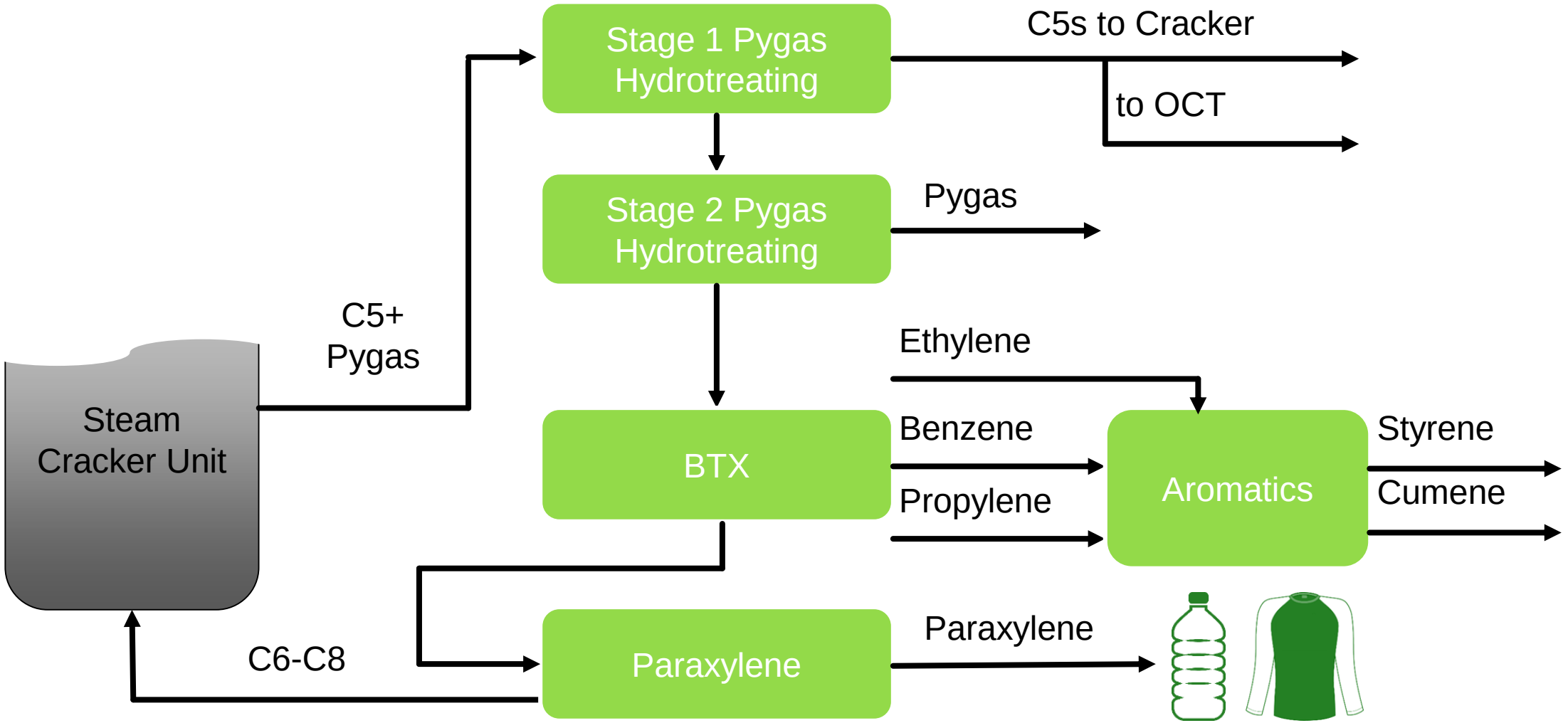
Co-Product Profit Pivot Point



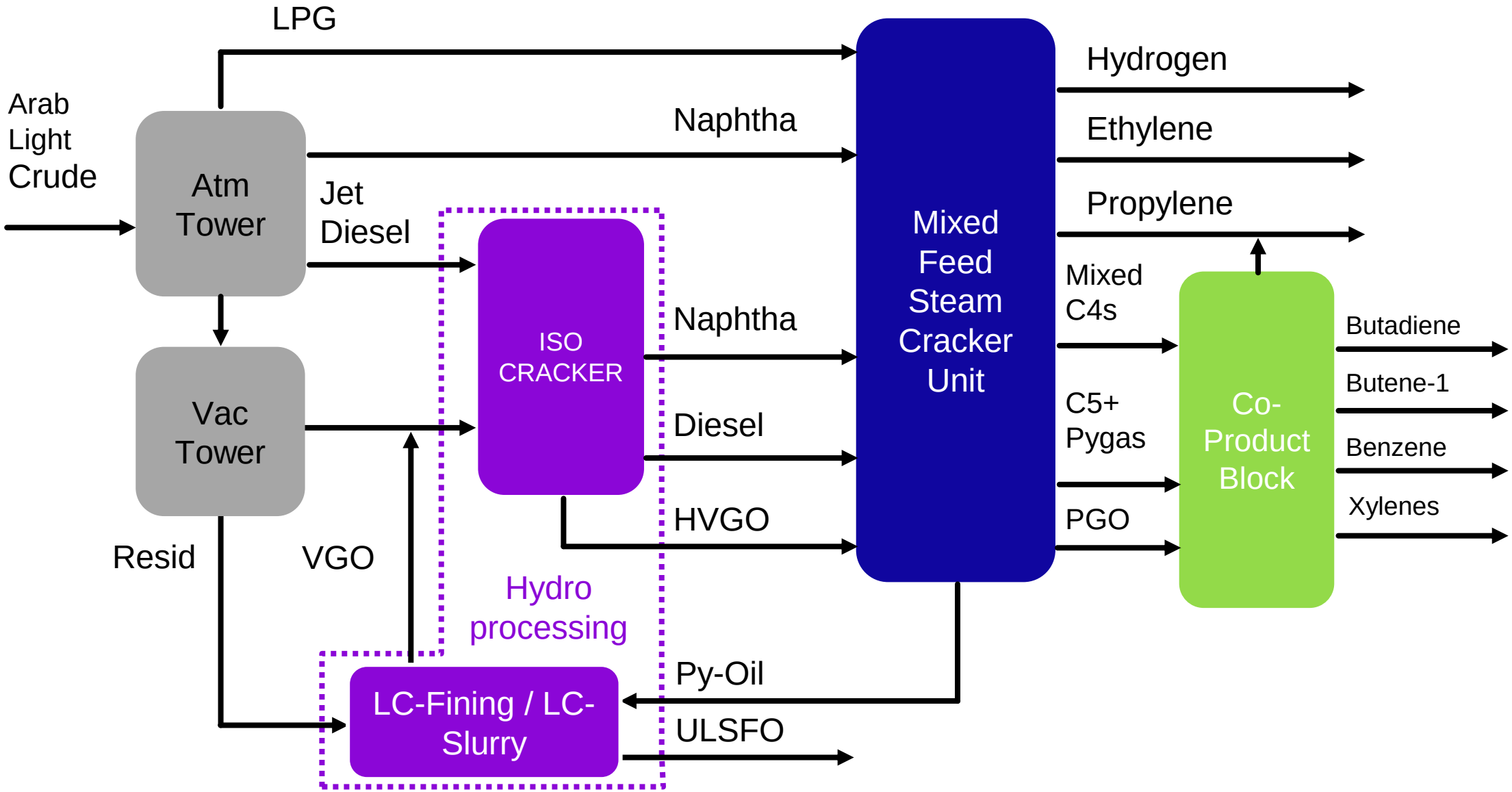
Co-Product Profit Pivot Point C4 Train (Optimized)



Co-Product Profit Pivot Point Pygas (Optimized)



Profit Pivot Points: Putting it all together



Case Study – Refinery / Petrochemicals Integration

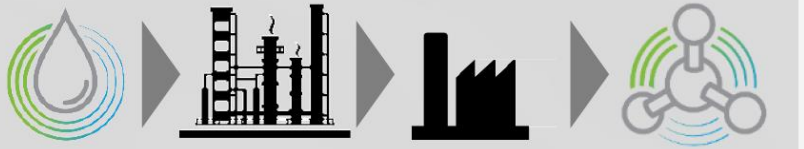
Case	1	2	3	4	5
Reside Upgrading	No	**LC-FINING**	LC-FINING	LC-FINING	**LC-SLURRY**
Fuels Production	No	No	**Yes**	Yes	Yes
Fuel Oil Type	3% HSFO	**1% LSFO**	1% LSFO	1% LSFO	**0.1% ULSFO**
Additional Processing					
Crude (Arab Light), BPD	195,000	162,000	227,000	400,000	246,515
Ethylene, KTA	2,000	2,000	2,000	4,000	2,000
Propylene, KTA	1,480	1,493	1,469	2,805	1,489
Butadiene, KTA	357	357	347	774	326
Euro VI Diesel, BPD	0	0	**74,500**	94,265	106,000
Fuel Oil, BPD	**54,000**	**25,000**	20,000	36,935	**8,500**
Anode Coke, KTA					
Chemical Yield on Crude, %	58%	70%	49%	57%	45%
% IRR	Base	+7.8%	+9.8%	+18.4%	+10.4%

Notes

1. All cases includes Hydrocracker + Olefins Conversion Technology
2. All cases produce MTBE, Butene-1, Benzene, Xylenes
3. 3% HSFO priced at $21/Bbl less than crude

Crude to Chemicals: A Disruptive Technology

Phase I: Integrated Crude to Chemicals



2025
Target Completion

9 Million Tons
Annual Chemical Products

400 MBD
Crude Processed

Innovative and Unprecedented Configuration

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سابك sabic

Phase II: Direct Crude to Chemicals

Proprietary Technology
Thermal Crude to Chemicals (TC2C™)

Higher
Chemicals yield

Maximize
value of each barrel of crude

Technology First - Direct Conversion Process

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CB&I

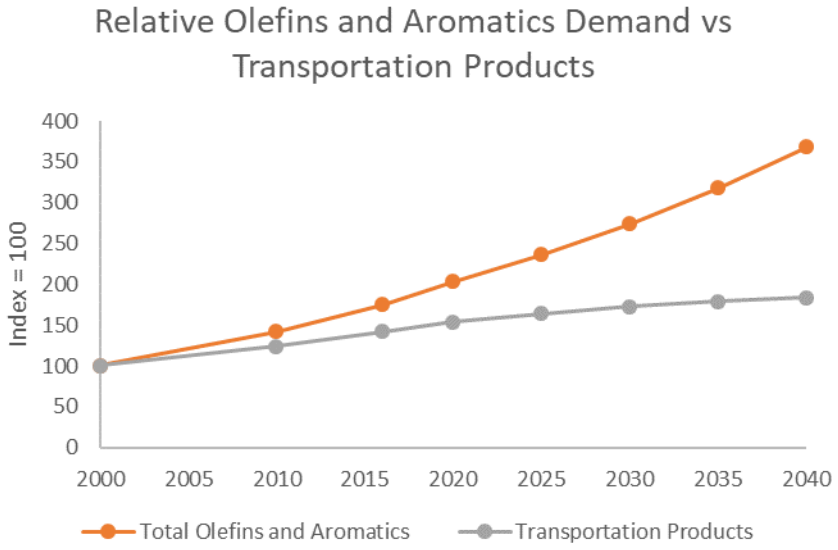
CLG
Chevron Lummus Global

MCDERMOTT TECHNOLOGY

Source: Saudi Aramco Presentation At Baker Hughes (GE) 2018 Annual Meeting, Mr. Abdulaziz Al-Judaimi

Conclusion

- Focus on integration of refinery and Petrochemicals Units
- Rapid Petrochemicals Demand Provides Opportunities for Refiners to shift to Chemicals
- Profit Pivot Points will allow producers to pivot to meet changing market demands:
  - Hydrocracker
  - Mixed Feed Steam Cracker
  - Co-Product Management



Source: EIA and Global Data

Technology solutions exist to upgrade refined products to valuable petrochemicals

Contact Information:

Contact

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