Carbon Utilization and Petrochemical Integration: Capturing value via residue to chemicals projects

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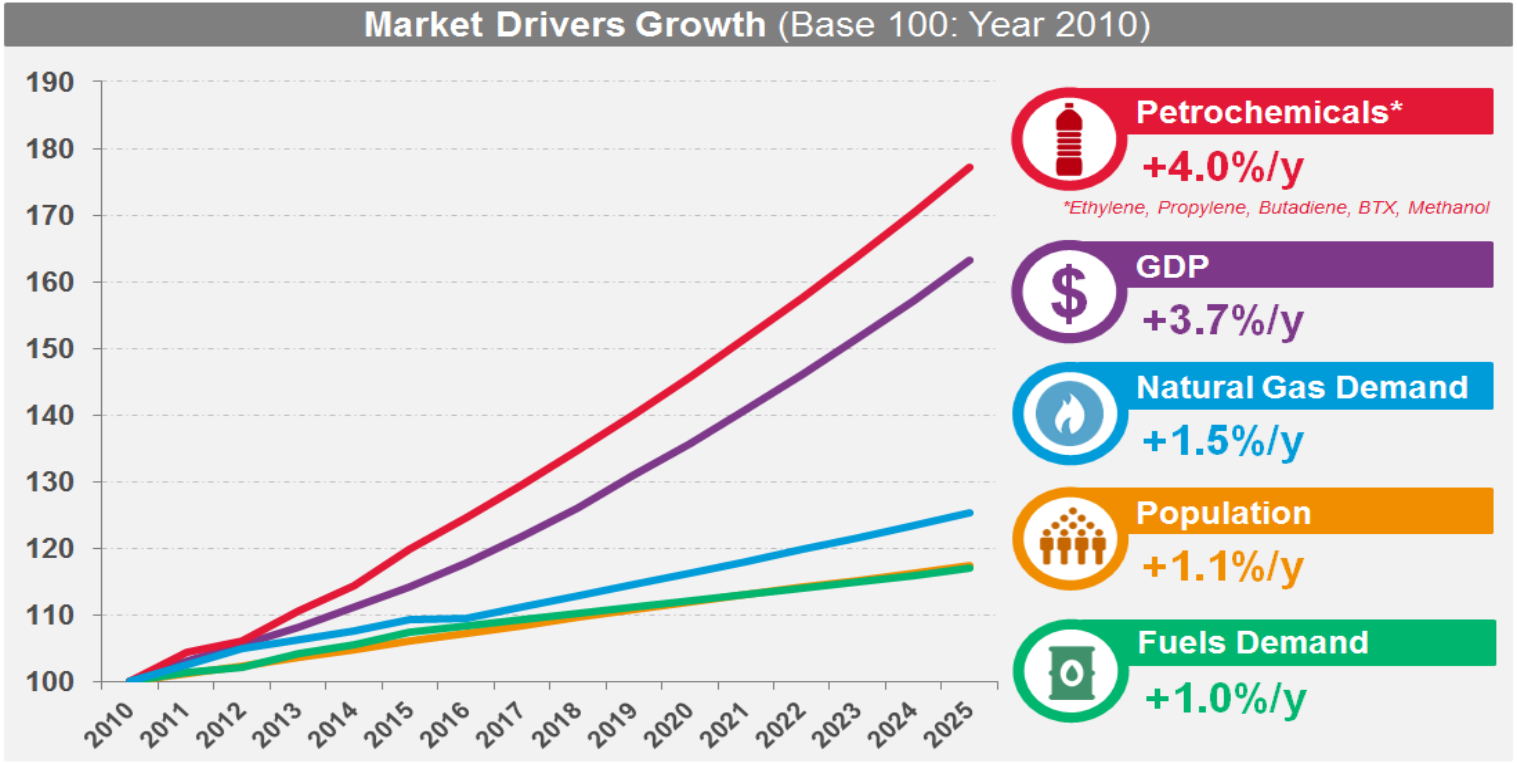
Agenda

- **Oil & Petrochemicals Market Dynamics and Challenges**
- **H-Oil Ebullated Bed Technology**
- **Crude to Chemicals Solutions**
  - Aromatics Case Study : Grassroot Complex Towards Aromatics
  - Olefins Case Study : Integration with Steam Cracker Complex

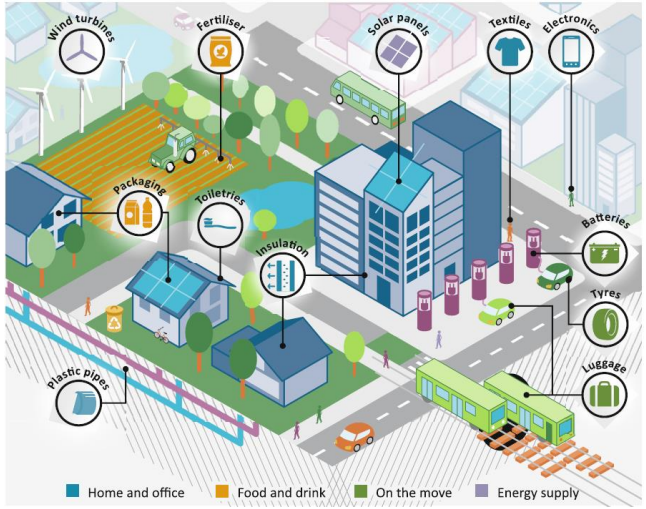
Oil & Petrochemicals Market Dynamics and Challenges

Strong Petrochemicals Demand Growth



Source: Bank, CEH, Axens

In 2035, How Much Oil will be Converted into Petrochemicals? (RTS Scenario, IEA 2018)



In 1990, 5.3 Mbpd were converted into petrochemicals

1. **10.2 Mbpd**
2. **12.3 Mbpd**
3. **15.6 Mbpd**
4. **17.3 Mbpd**

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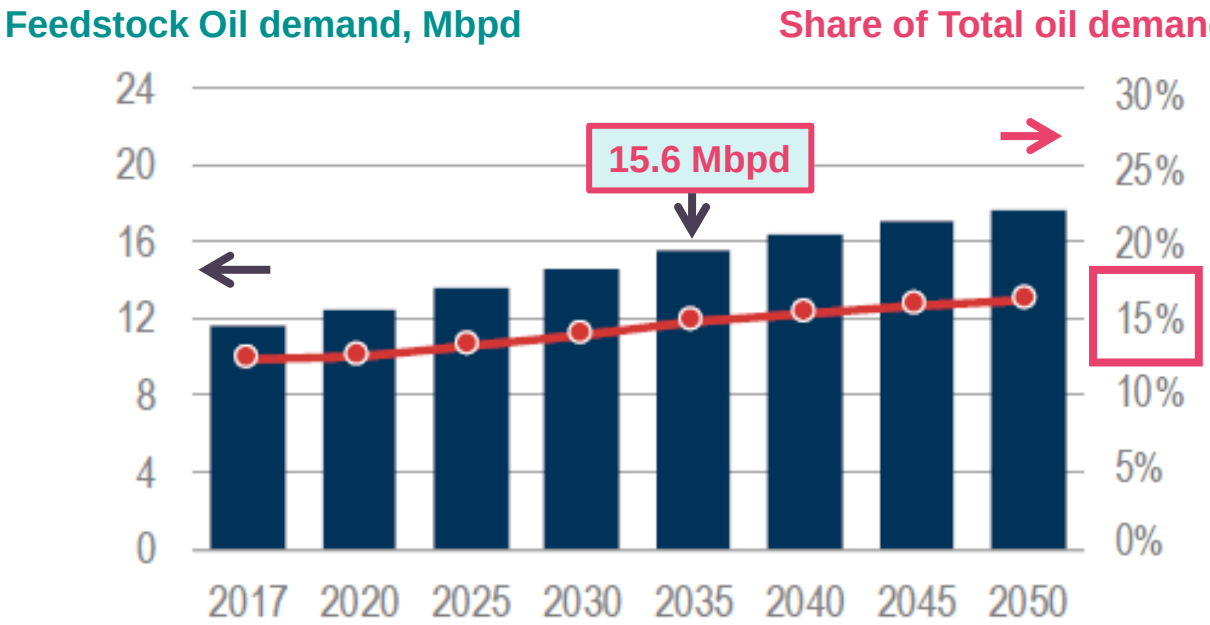
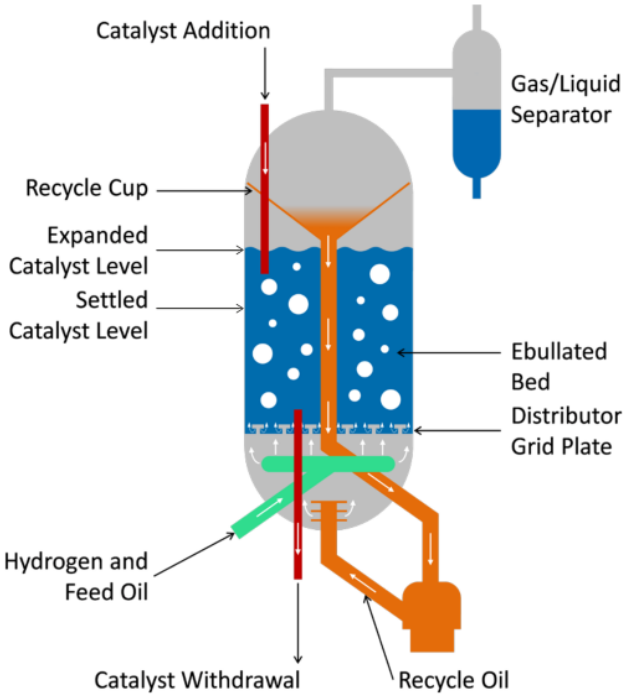


Source : The Future of Petrochemicals, IEA, 2018

H-Oil Technology

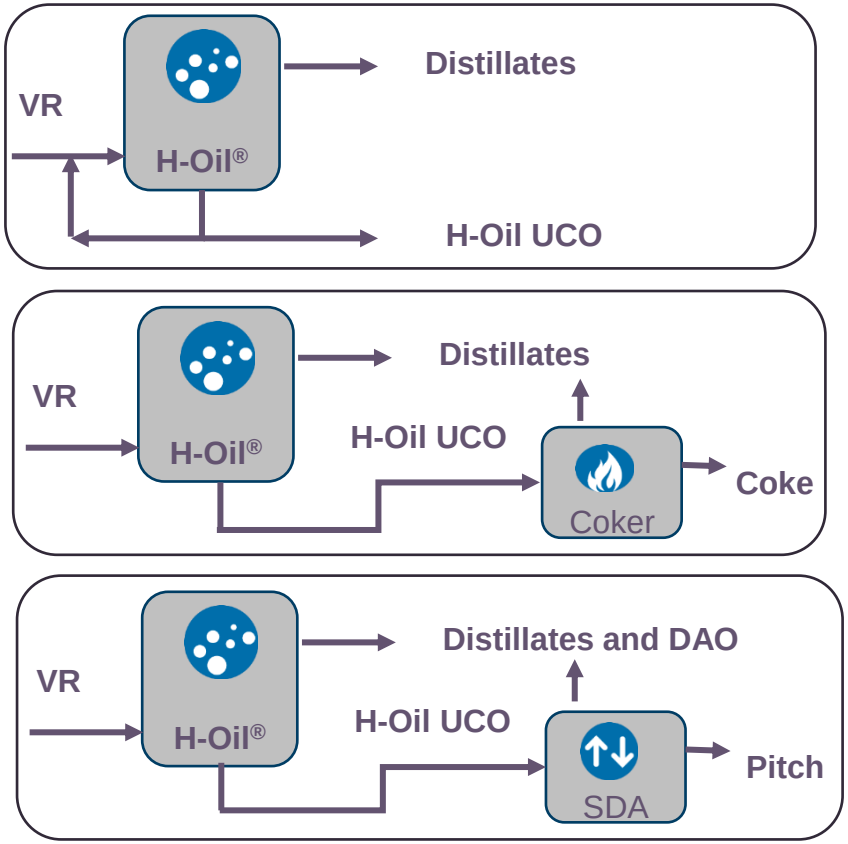
Ebullated Bed Residue Hydrocracking H-Oil®



- Demonstrated high conversion levels
- No limitation on feed properties
- Mature & reliable technology more than 1.2 MBPSD licensed capacity
- High availability> 96% demonstrated on several units
- 2 new high conversion H-Oil® units starting-up in 2019
- 3 recent awards in 2019

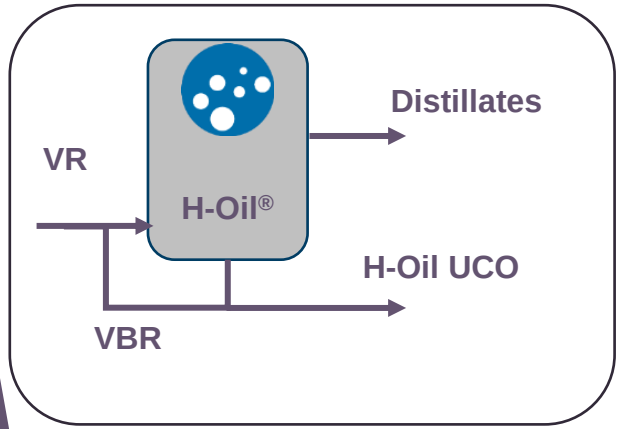
VR High Conversion: Main technology routes

- **Vacuum Bottoms Recycle**
- **Residence Time Path**:
  - Low Space Velocity Design
- **Coker Integration:**
  - Concentration of the CCR in the Coke
- **SDA Integration:**
  - Concentration of Asphaltenes in pitch



H-Oil Reactor Design : Paths for High Conversion

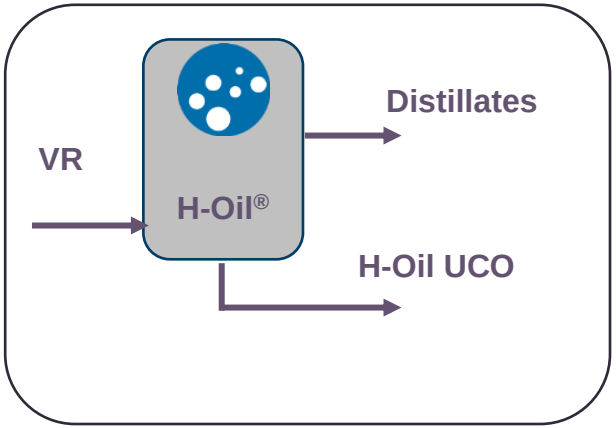
- **Recycle of the Vacuum Bottom** – VBR
  - VBR **reduces** the severity per pass, low conversion per pass and reduced formation of sediment levels
  - **Demonstrated Commercially** : H-Oil unit started-up in the 80's had operated at high conversion of VR with VBR , this mode was part of the design.

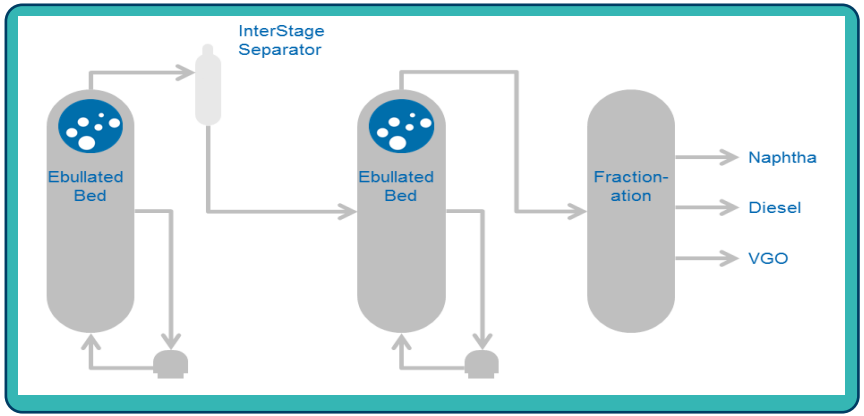


Operating Mode	LSFO	High Conversion	Maximum Capacity
VR Feed Capacity	Base	Base Plus VBR	Base + 25%
1000 °F+ Conversion,	Base	Above 85%	Base

H-Oil Reactor Design : Paths for High Conversion

- **Low LHSV Design – Long residence time**
  - **Maximize** catalytic performance for both conversion and hydrorefining
  - **Control** the sediment with reactor temperature
  - High quality Effluents due to High HDS and High CCR Removal
  - **Demonstrated** in commercial unit :
  - H-Oil under start-up in 2019 at low LHSV is design for more than 85% of conversion.



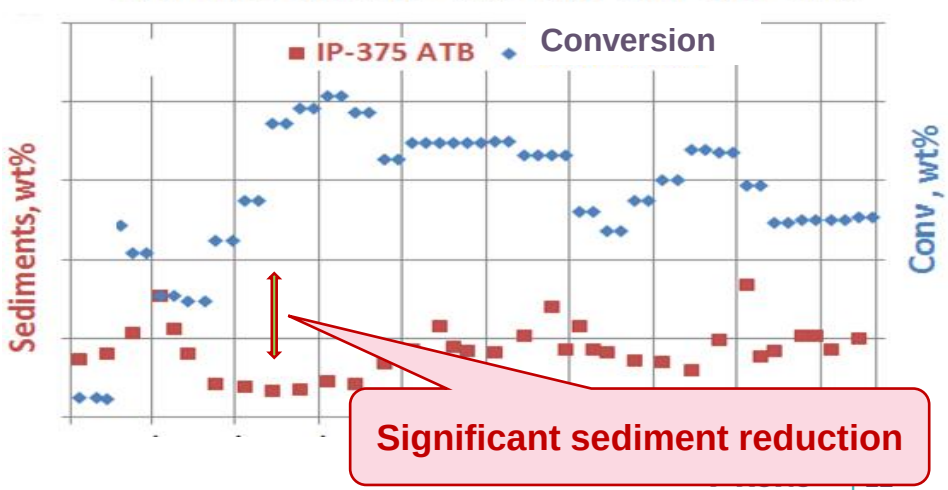


H-Oil® Suite : Low LHSV Commercial Follow-up

H-Oil®

40% VR availability reduction

- Lower capacity operation industrial demonstration
  - Higher conversion
  - Less sediment production
  - Enhanced refining performance
- LHSV / WABT prove powerful to break conversion ceiling



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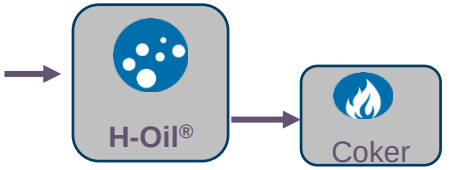
Coker Integration



- **Unlock** sediment constraints for H-Oil® UCO
- **Create** value not only with high conversion but also with better coke quality
- **Maximize** the use of existing assets

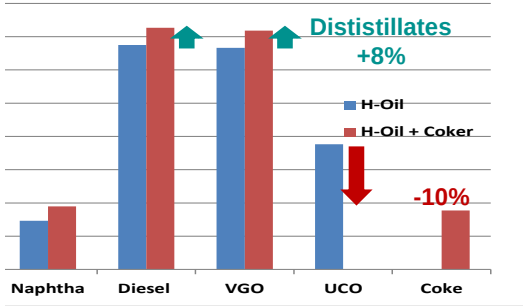
Case Study

%wt	Overall Conversion
H-Oil Unit	75
H-Oil Unit + Coker	88

Coke quality is improved:

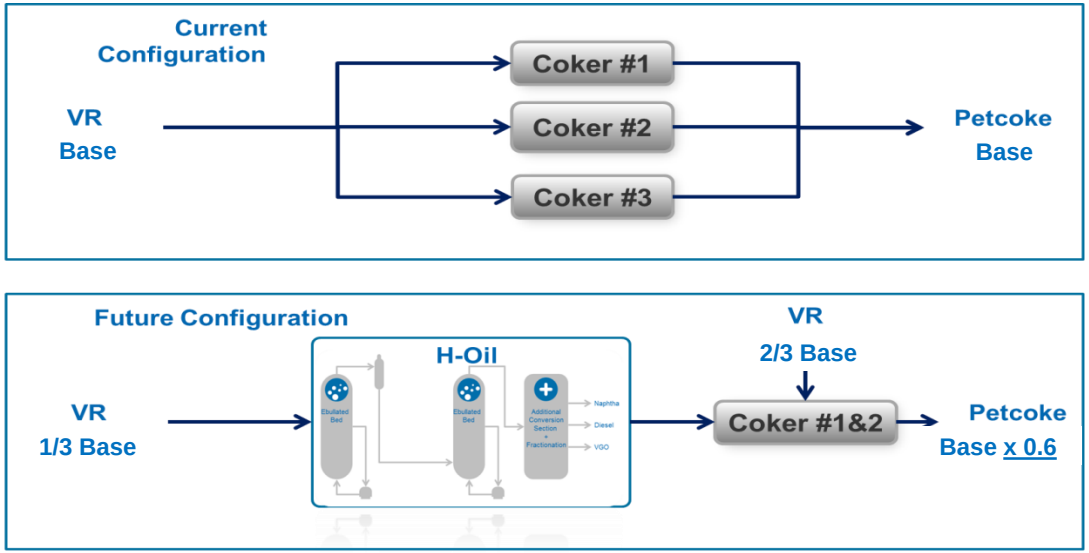
- **Lower Sulfur and metal**
- **Up to Anode grade coke**

Additional Conversion with Coker

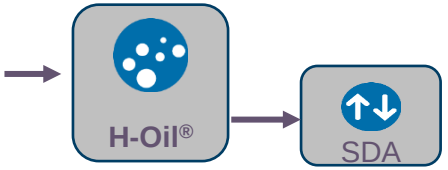


UCO to Coker Unit

- **Commercial Reference: Asia Location, under commissionning**
- **Maximize** the use of existing assets:
  Combination H-Oil + Coker reaches 94% of VR conversion

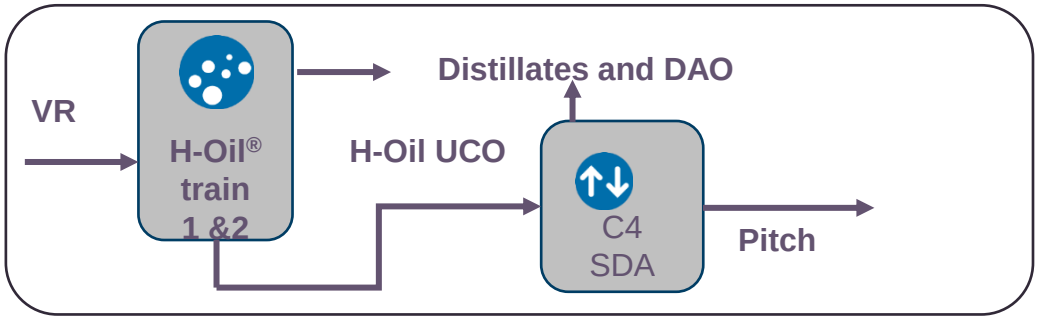


SDA Integration

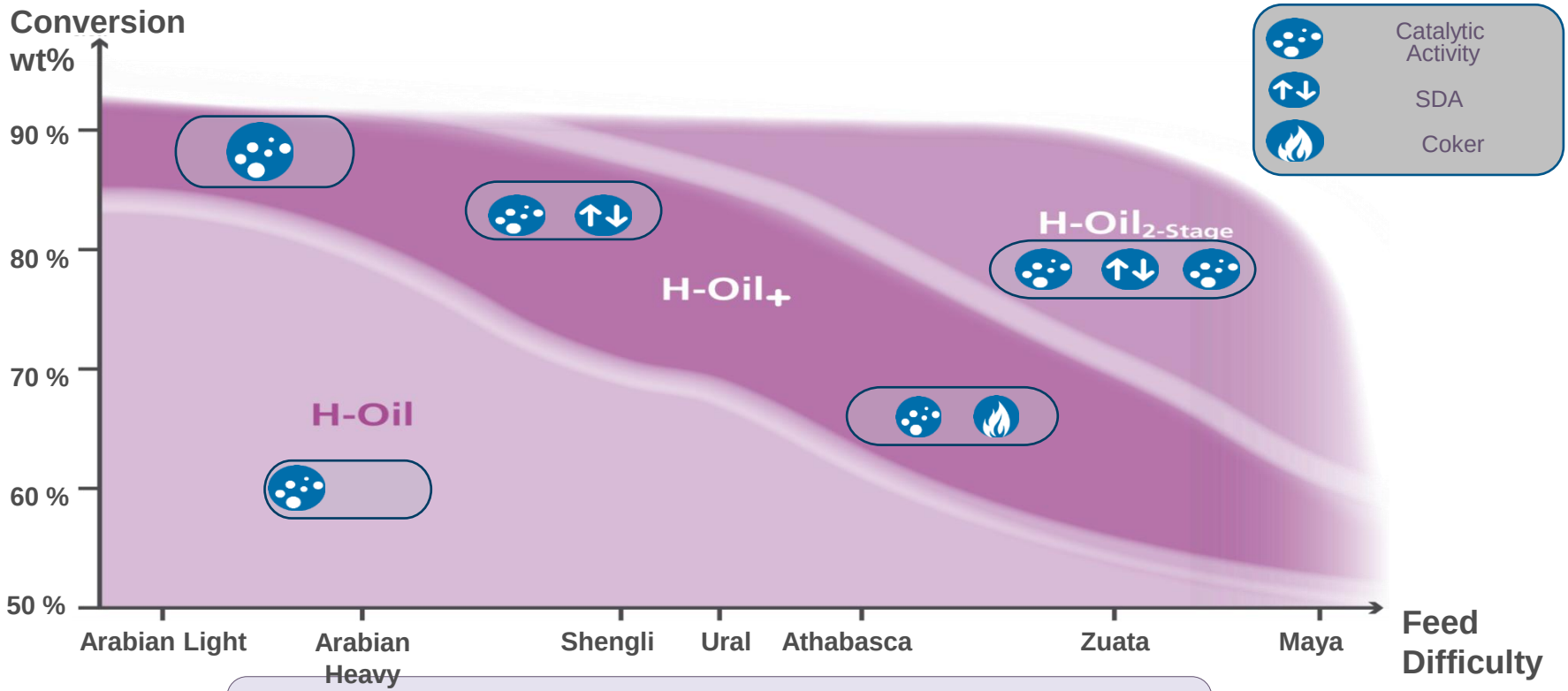


- **Unlock** sediment constraints for H-Oil® UCO and concentration of Asphaltens in the pitch
- **Reduced CAPEX** in comparison with Coker Unit
- **High Incremental Conversion** for refinery with pitch disposal
- Pitch is better than Coke for hydrogen production in Gasification

- Commercial References:
  - Hengli Crude to Paraxylene Complex. H-Oil unit has started-up



H-Oil® Suite



- Each H-Oil Design is unique to fit Refiner's VR destruction objectives

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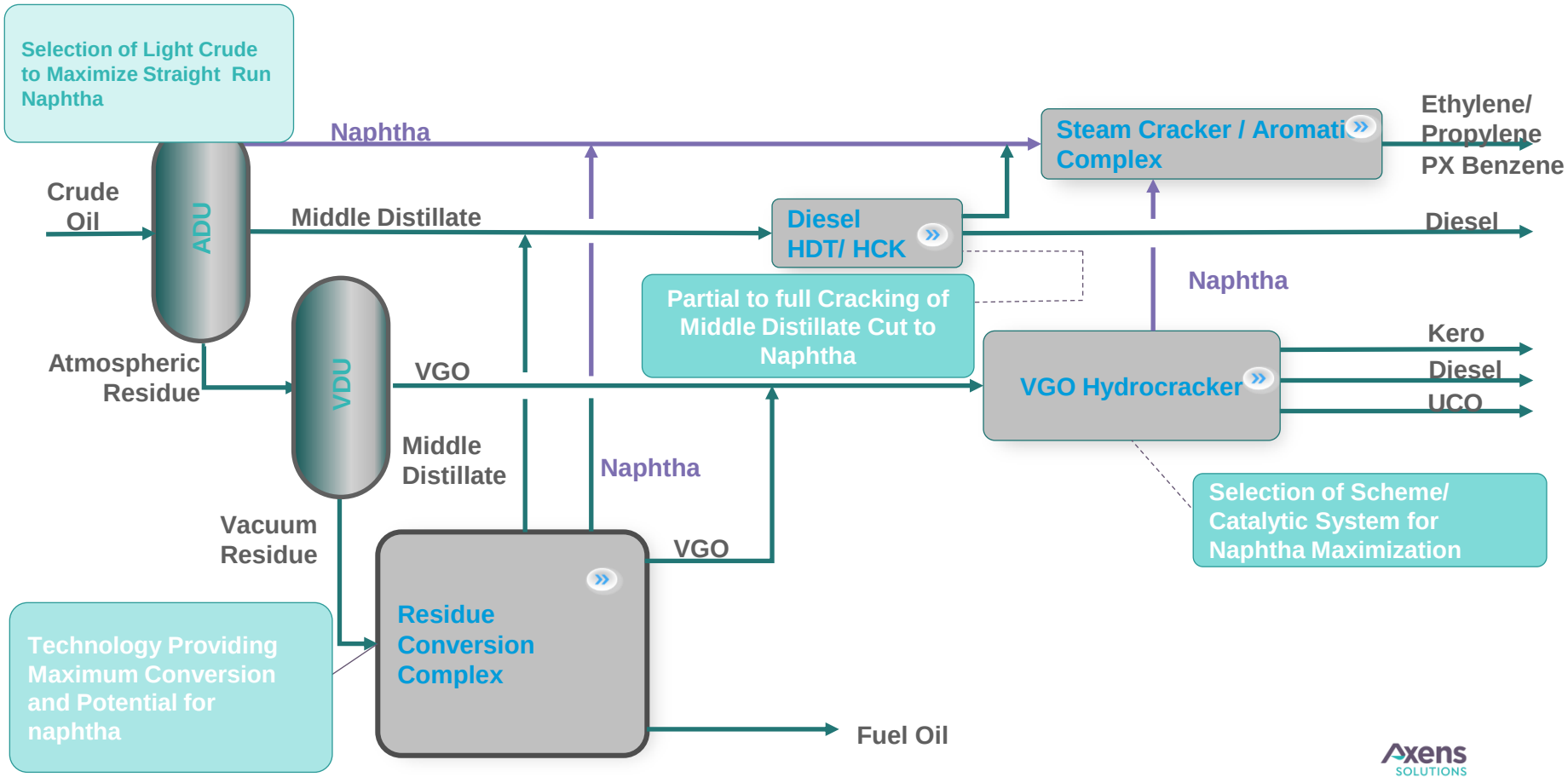
Refining & Petrochemicals Integration
How to Increase Naphtha Production?



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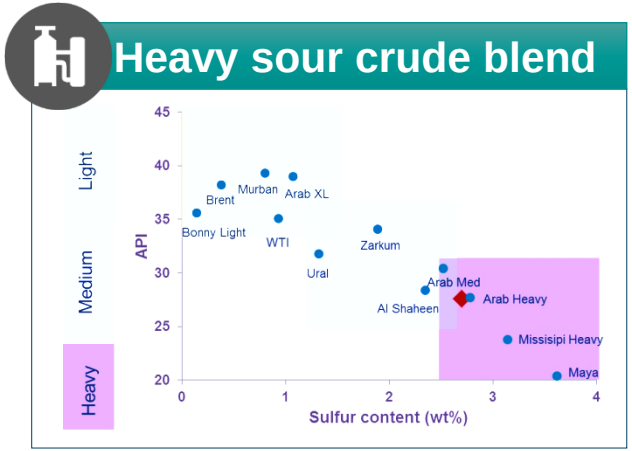
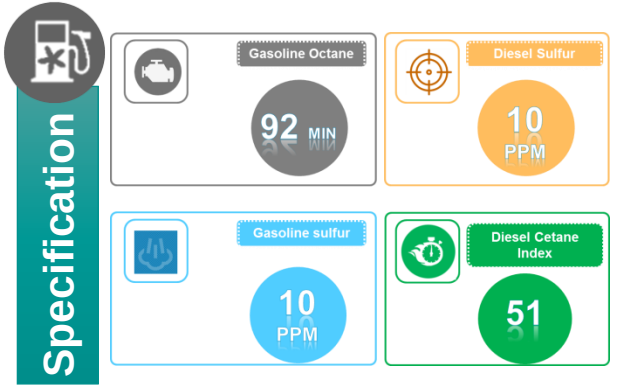
Crude to Chemical Options

Aromatics Production

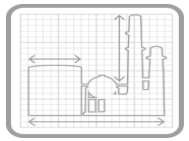
Crude to PX Project - Feed and Products

- Feed 400,000 BPSD of crude oil
  - 60% Arabian Heavy
  - 30% Arabian medium
  - 10% Marlim
- Product Requirement
  - 211,000BPSD of Heavy Naphtha for PX production
  - Co-Production of high quality gasoline, diesel & jet fuel
  - Production of Group III Lube Base Oil
  - Minimization of residue production





Crude to PX - Conversion Block



Heavy sour crude
20 MTA

ADU

HN = Heavy Naphtha

AGO

Diesel HCK

GO

VGO

SR VGO HCK *HyK™*

AR

VDU

VR

Ebullated bed HCK *H-Oil®RC*

VGO

Full Conversion HCK *HyK™*

UCO

Solvent Deasphalting *Solvahl™*

DAO

Pitch

HN = Heavy Naphtha
LN = Light Naphtha

LN → Steam Cracker

HN
9 MTA
→ Aromatic Complex ParamaX®

KERO → Kero Pool

DIESEL → Diesel Pool

UCO → Group III Lube Complex

PITCH → Gasification

Highly efficient scheme

90 wt.% conversion on VR

45 wt.% heavy naphtha yield

Margin capture by converting lowest value VR to high value molecules

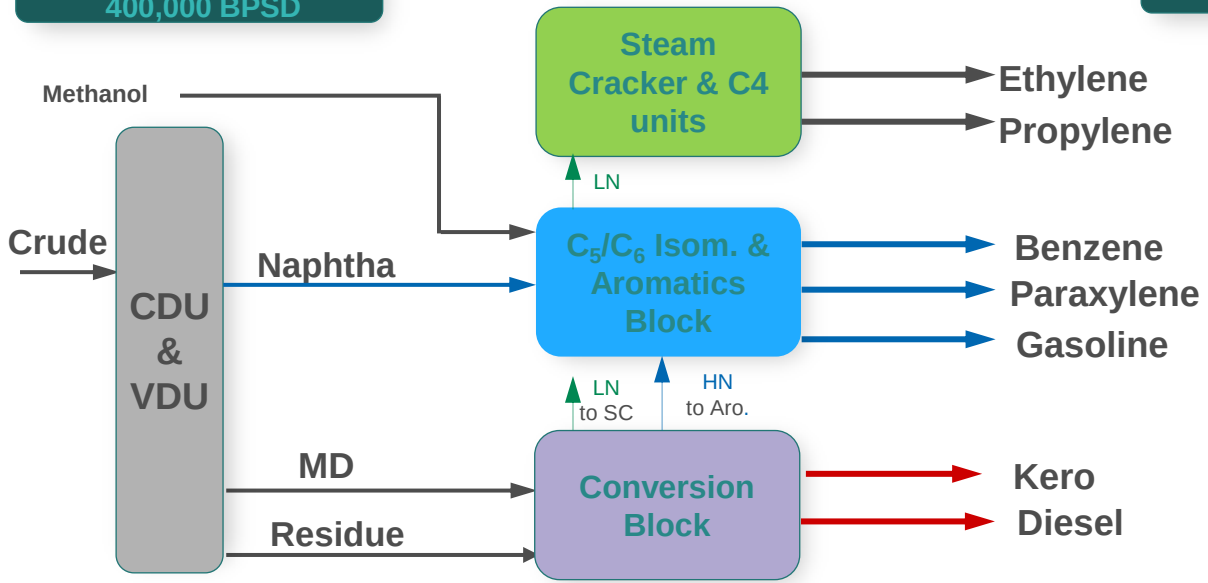
Crude to Chemical Options

Olefins Production

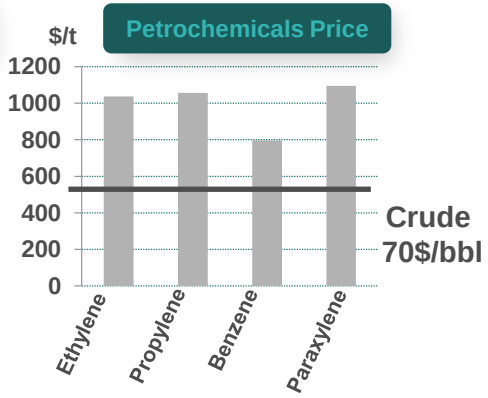
World-class Integrated Project – Asia Location

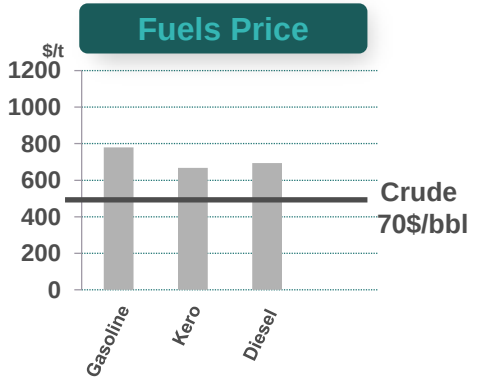
Petrochemicals & Fuels Production

Refinery Capacity
400,000 BPSD



Production (kta)

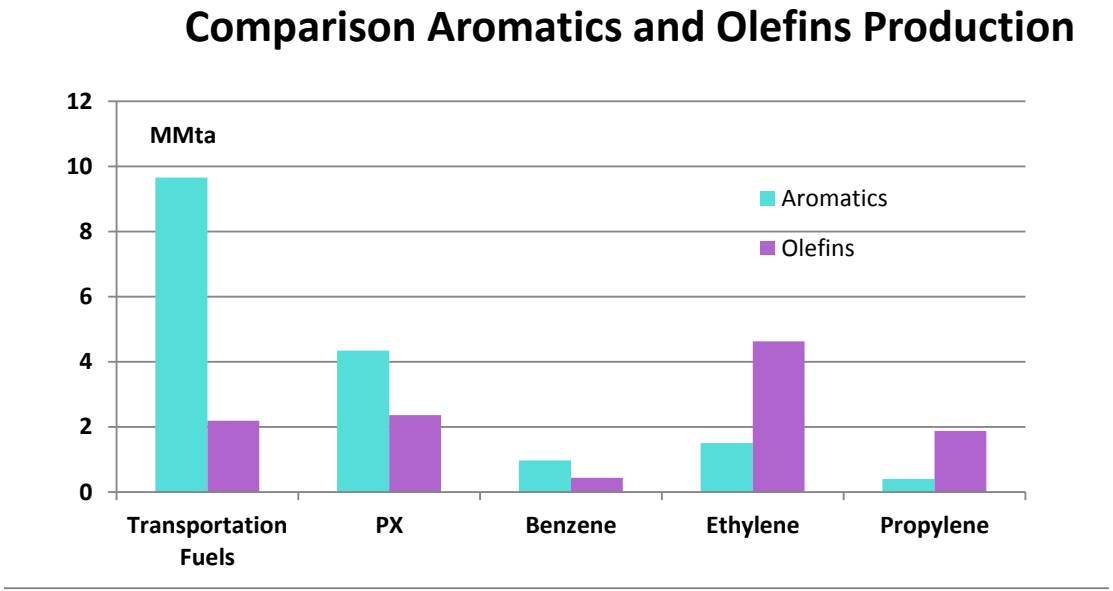




Crude

- Middle East Light & Heavy
- Arabian Medium
- Brazil Frade

Products Distribution for the two cases studies



Same VR Conversion

- **Case Study 1**

High transportation fuel and Paraxylene Products

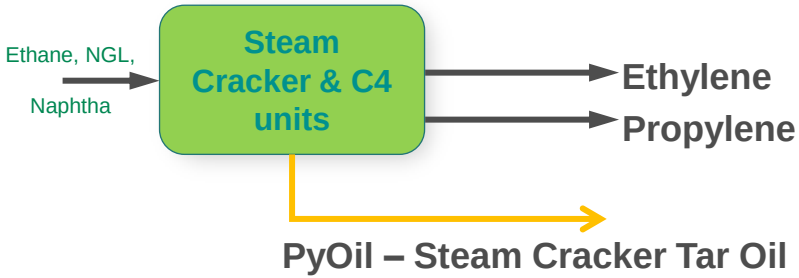
- **Case Study 2**

Less transportation fuel but high Paraxylene and Olefins production

Chemical Complex design has a large panel of technologies to cover from Maxi PX to Maxi Olefins.

Flexibility in the design is Key to maximize products value

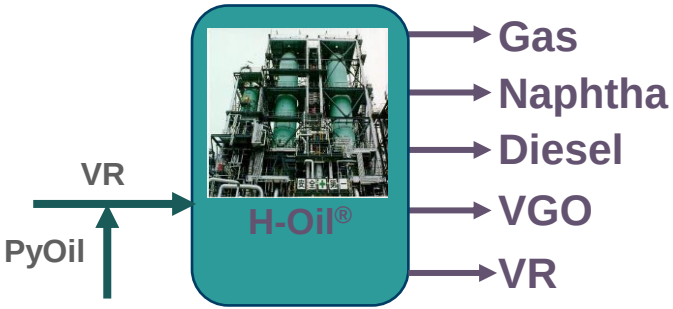
Olefins Market : Steam Cracker Complex

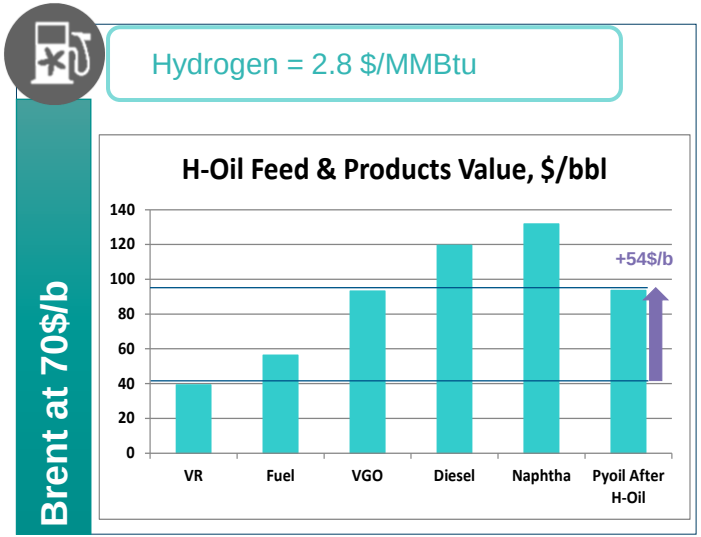


- PyOil are:
  - High content of CCR
  - High Asphaltenes
  - Typically burned in the refinery due to low value on the market

Pyoil Co-processed in H-Oil Unit

- Two Recent Awards : Crude to Chemical complex with pyOil in the H-Oil feed





Initial Case: PyOil to Fuel

Design Case: PyOil is sent to the H-Oil Unit

PyOil is hydrogenated and converted

PyOil Value is more than double

H-Oil : Capturing Value from the Heavy Ends

- Petrochemicals demand growth higher than that of fuels
- Crude Oil-to-Chemical complexes offer many advantages:
  - Expanding into higher growth markets
  - Mitigating risks related to raw material and product price variations
  - Improving asset profitability
- Crude Oil-to-Chemical projects implementing advanced technologies is a way to catch these opportunities
- Ebullated Bed Residue Hydrocracking H-Oil® has commercially proven High Conversion Operation