GDA
الإتحاد الخليجي للتكرير
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Profitable Schemes to Maximize Refinery Profits Post 2020

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CLG
Chevron Lummus Global

Broad Objectives

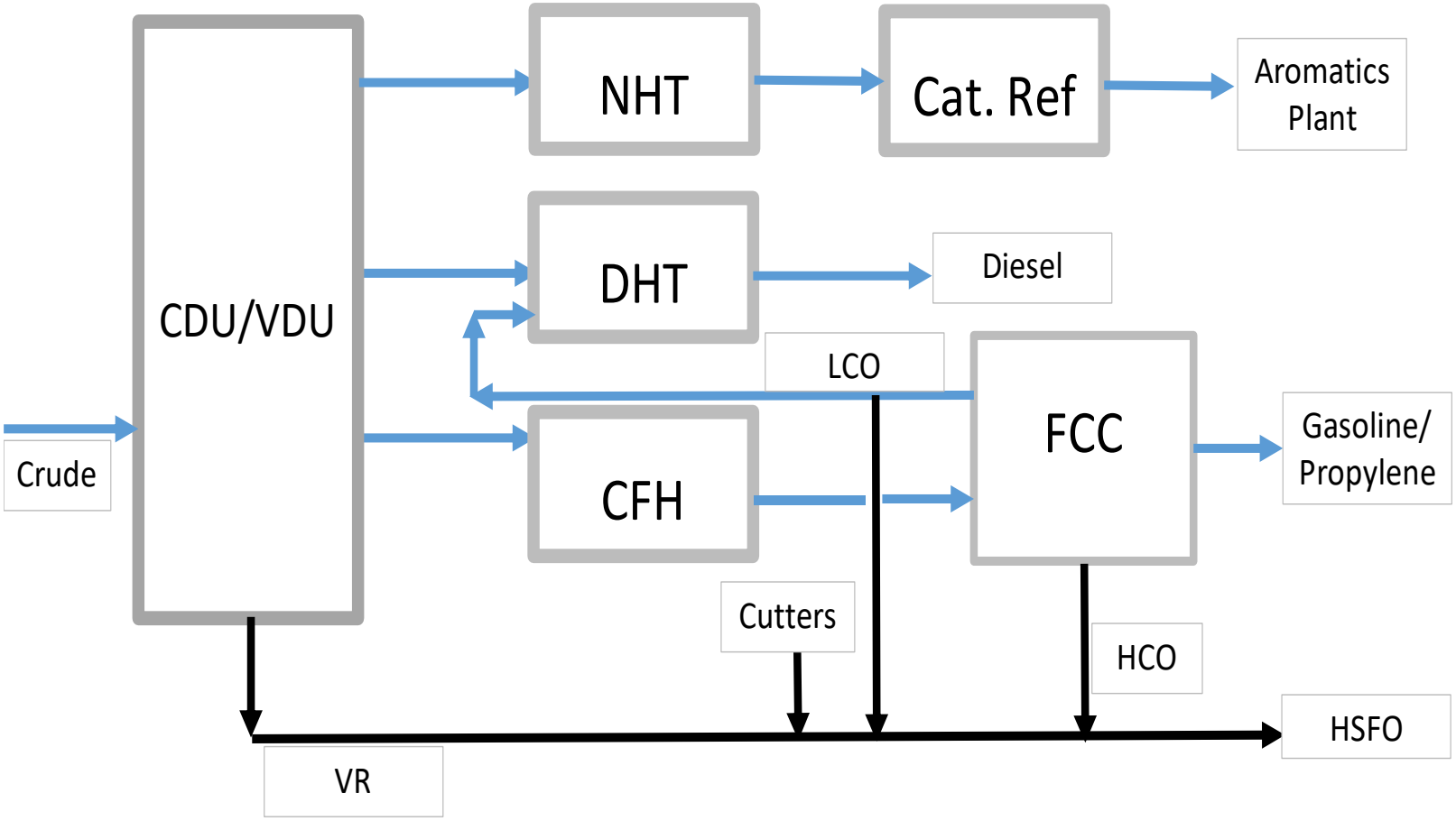
- No high sulfur fuel oil
- No product priced below crude
- High Feed and Product Flexibility
- High On-stream Factor
- Tier-1 in terms of Energy Intensity Index
- Ability to maximize petrochemicals feedstock

Cost of Doing Nothing

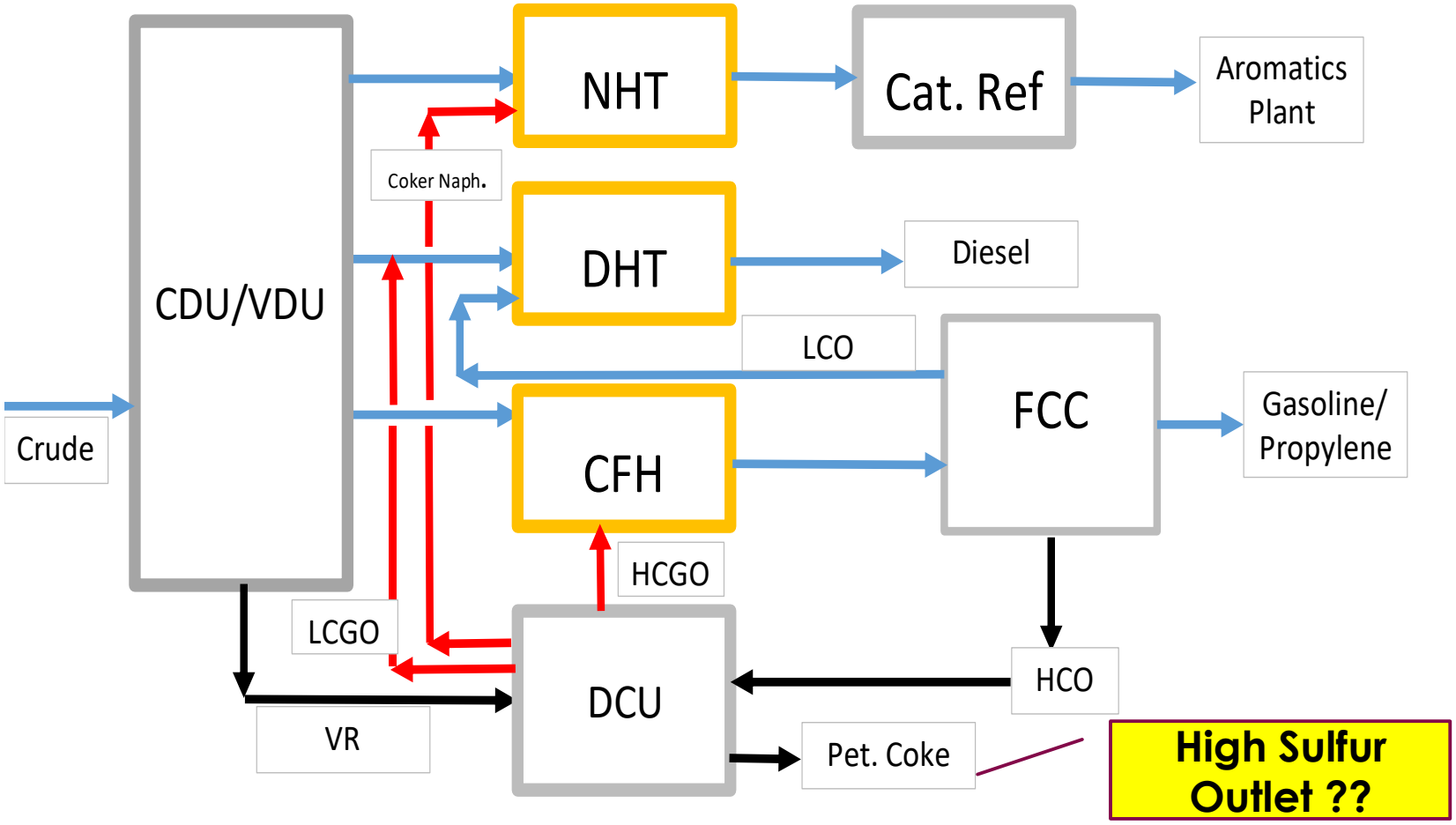
- For a 200,000 bpsd refinery post 2020 opportunity cost of NOT upgrading the VR will be approximately - $ 350-400 million dollars/year!
- Blending will not reduce opportunity cost because high value products (ULSD or FCC feed) at several times the volume of VR (6 to 8 times) will be needed to get down to less than 0.5 wt.% Sulfur for high sulfur Middle Eastern VR.

Technological Solutions are needed for Bottoms Upgrading

Pre-2020 Refinery



Low CAPEX Upgrade



Challenges of Adding Coker

NHT

- Silica; impacts catalyst life 2 ppm Si reduces catalyst life to half – Add Si Guard
- Higher feed nitrogen – will be a challenge to meet <0.5 ppm nitrogen; need > 300 psi H2 pp.
- Olefins: SR requires 50 scfb; Coker naphtha; 350 scfb. Reactor/F/E Exchanger/Heater fouling; Quench required.
- Provide a Guard Reactor for

Low-Temp Diolefins saturation; use liquid recycle quench if Coker Naphtha concentration is high; wash water to F/e exchanger for feed N > 50 ppm; Blanket Tank or send direct from coker.

DHT

- Much higher sulfur and nitrogen
- Much higher density; difficult to meet density specification 0f 0.845
- Catalyst life will be shorter.
- Will need much more wash water
- Higher aromatic saturation will require much higher quench; RGC

CFH/HCK

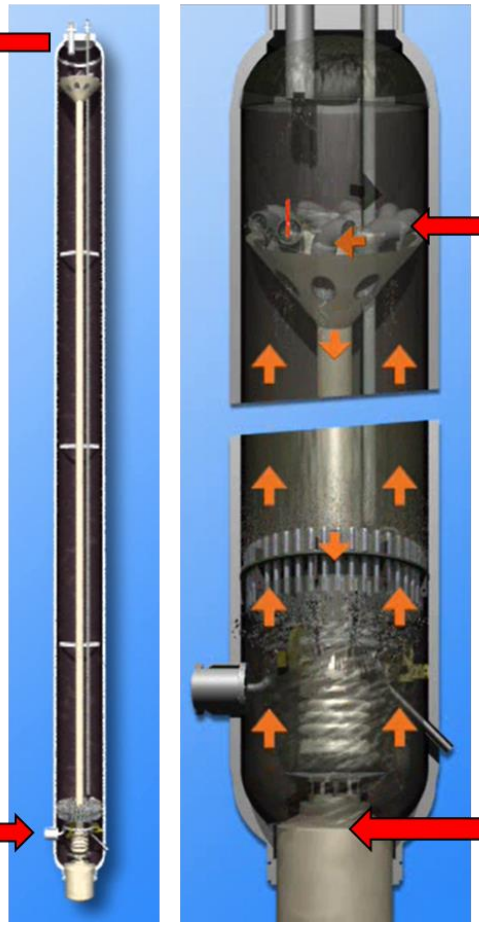
- VGO is very high in HPNA
- Full-range VGO can be processed in mild conditions with conventional HDT catalysts (80-100 bar)
- HCK will require:

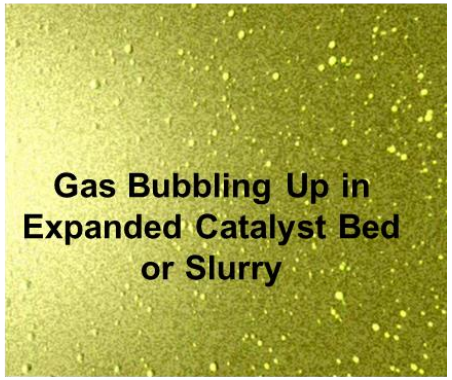
A. Careful attention to EP
B. High hydrogen partial pressure
C. Special Catalyst systems

Robust Liquid Circulation Platform LC-FINING, LC-MAX, LC-SLURRY

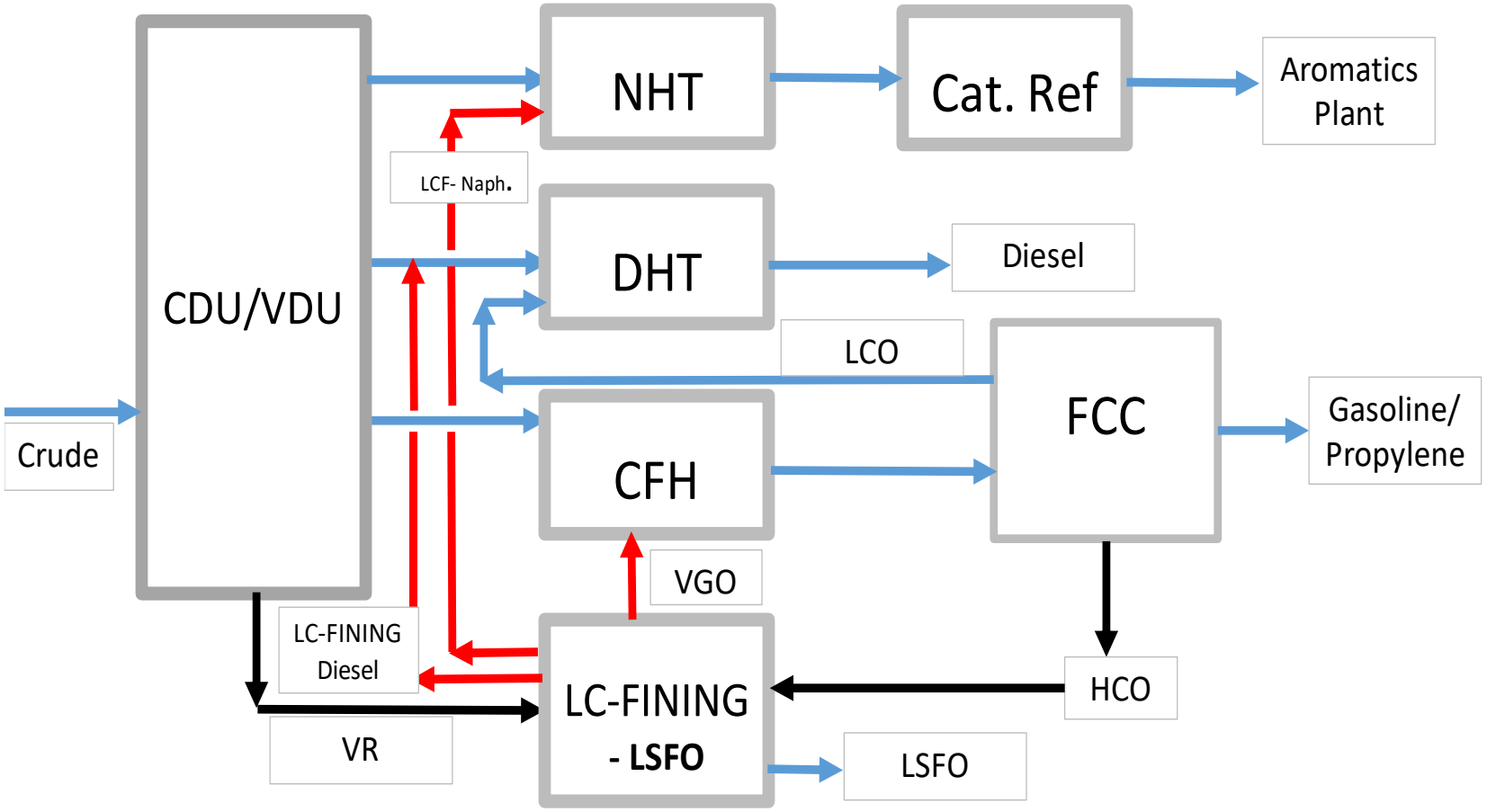
Reactor Features

- Upflow Reactor
- Low pressure drop
- Nearly isothermal
- Catalyst can be added and withdrawn on line
- Recycle pump backmixes extrudates or slurry





Bottomless Refinery with LC-FINING Platform



Challenges of Adding Residue Hydrocracking in Scheme

NHT

- Much higher sulfur and nitrogen . Hydrogen partial pressure and reactor volume will not be adequate to meet Catalytic Reformer sulfur and nitrogen specifications.

DHT

- Much higher sulfur and nitrogen
- Much higher density; difficult to meet density specification 0f 0.845
- Catalyst life will be shorter.
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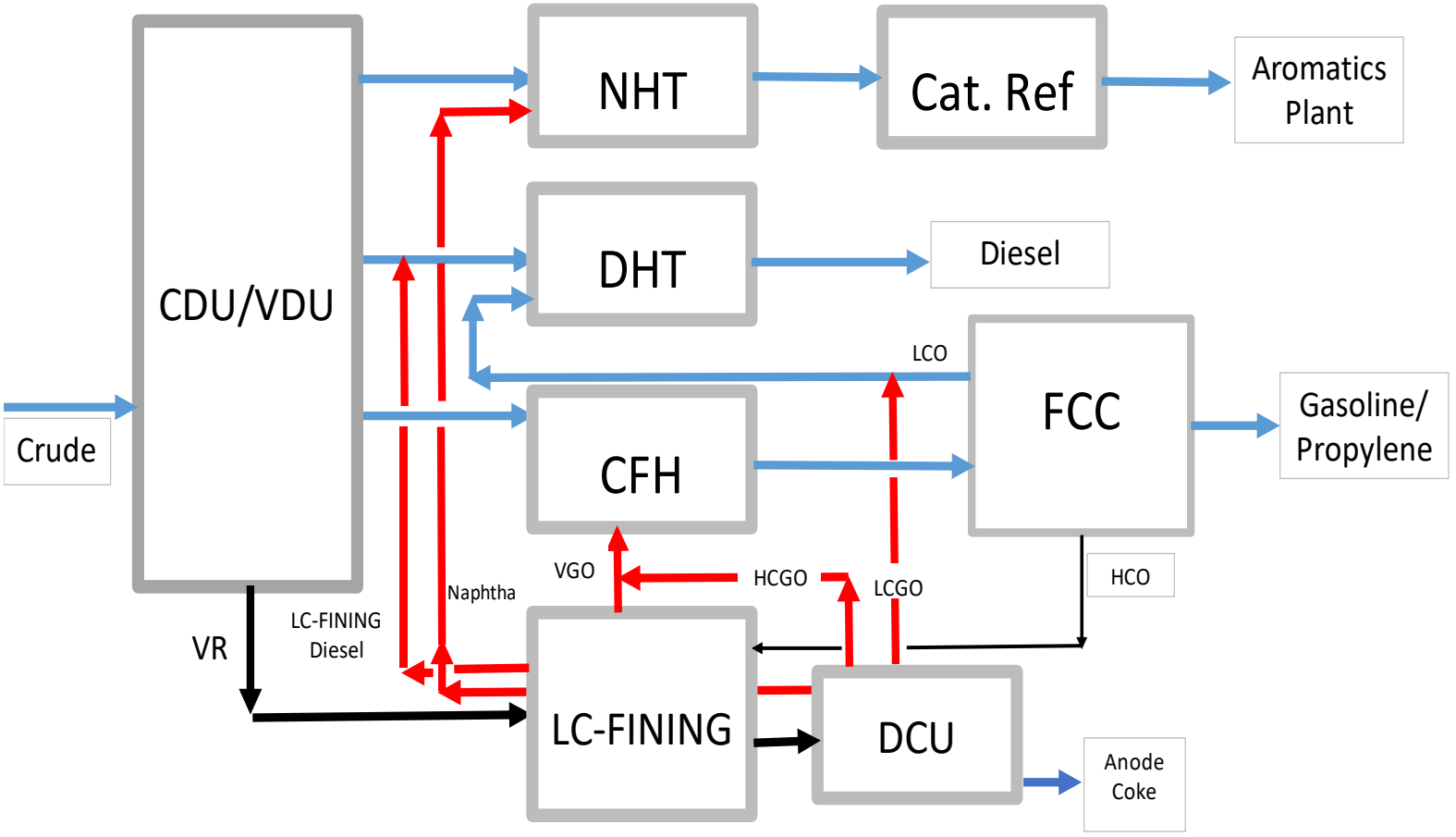
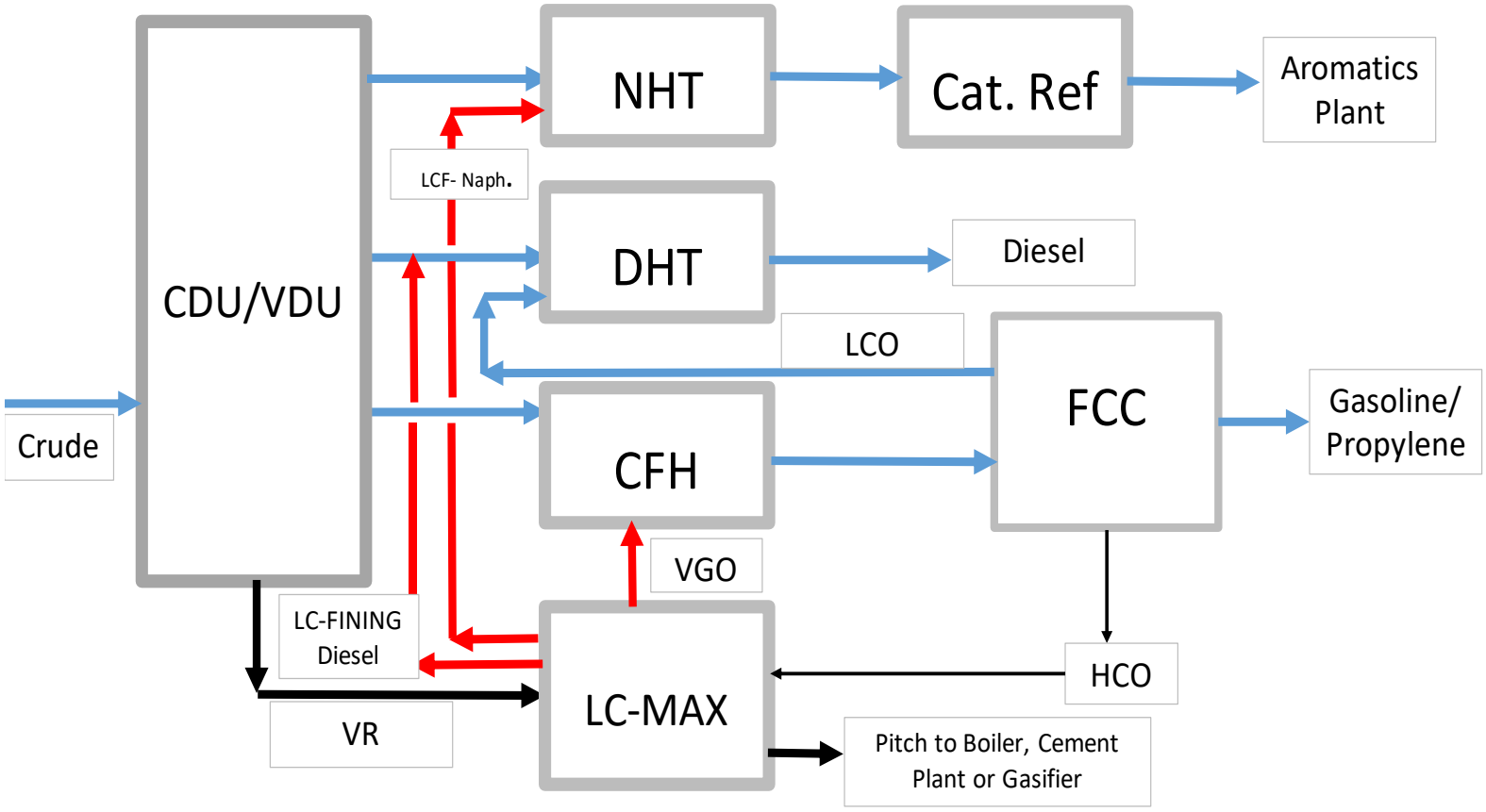
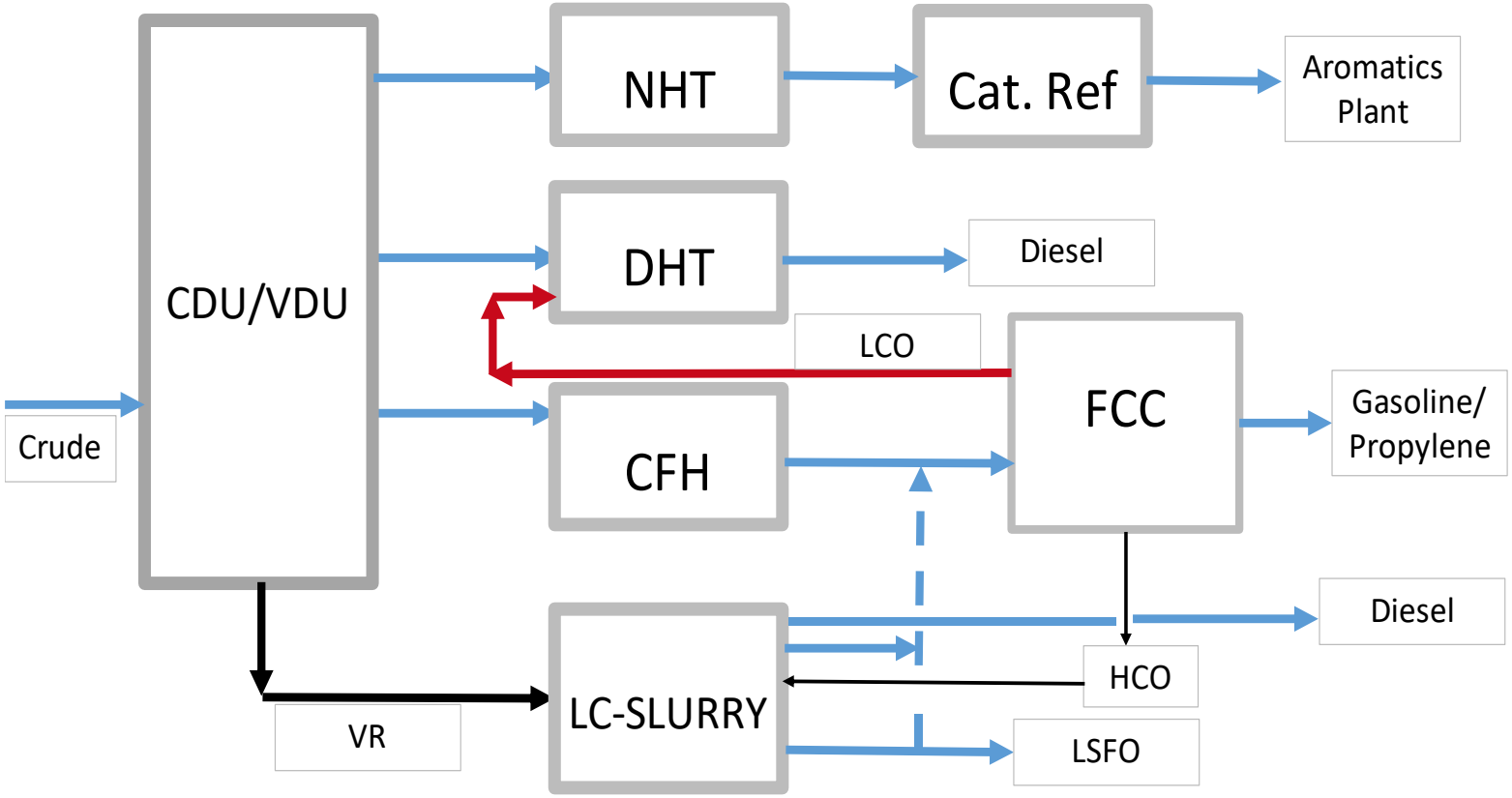
For Refineries with Existing Cokers



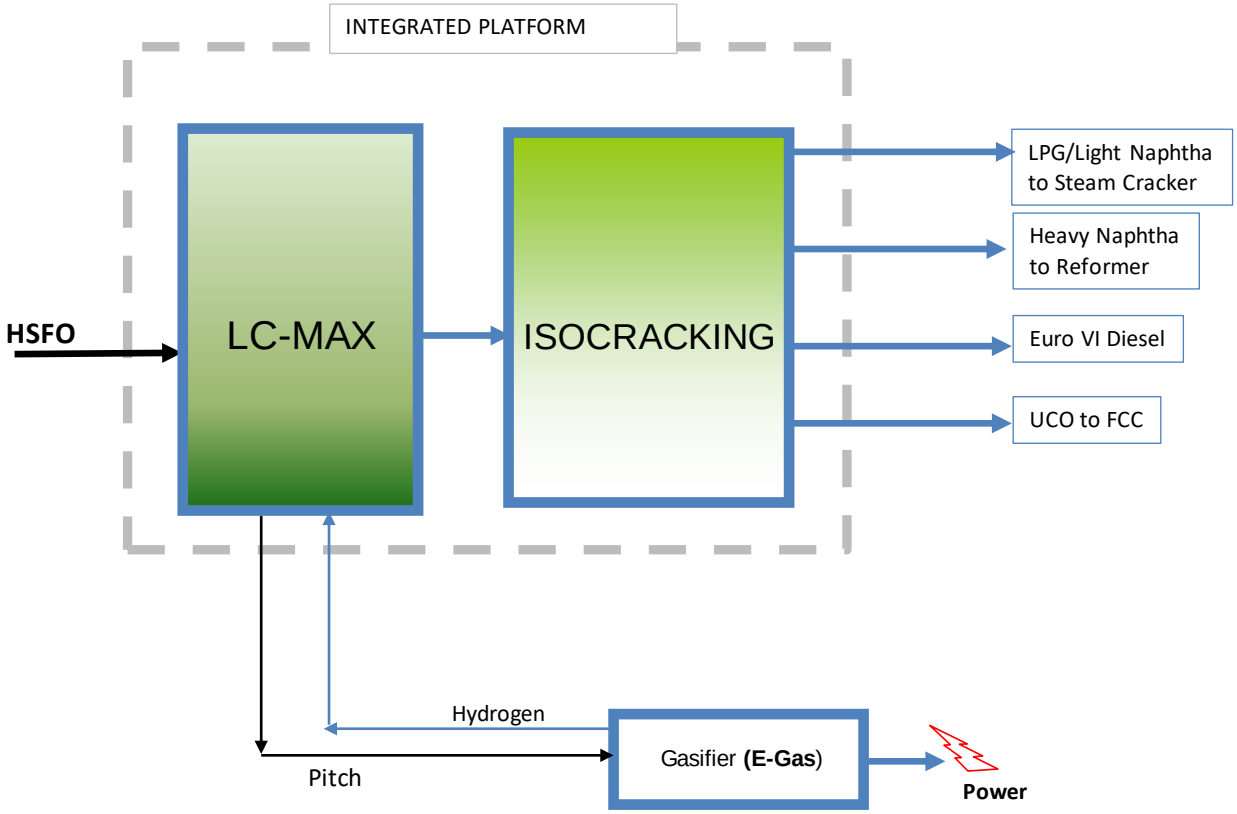
Very High Conversion with outlet for Pitch



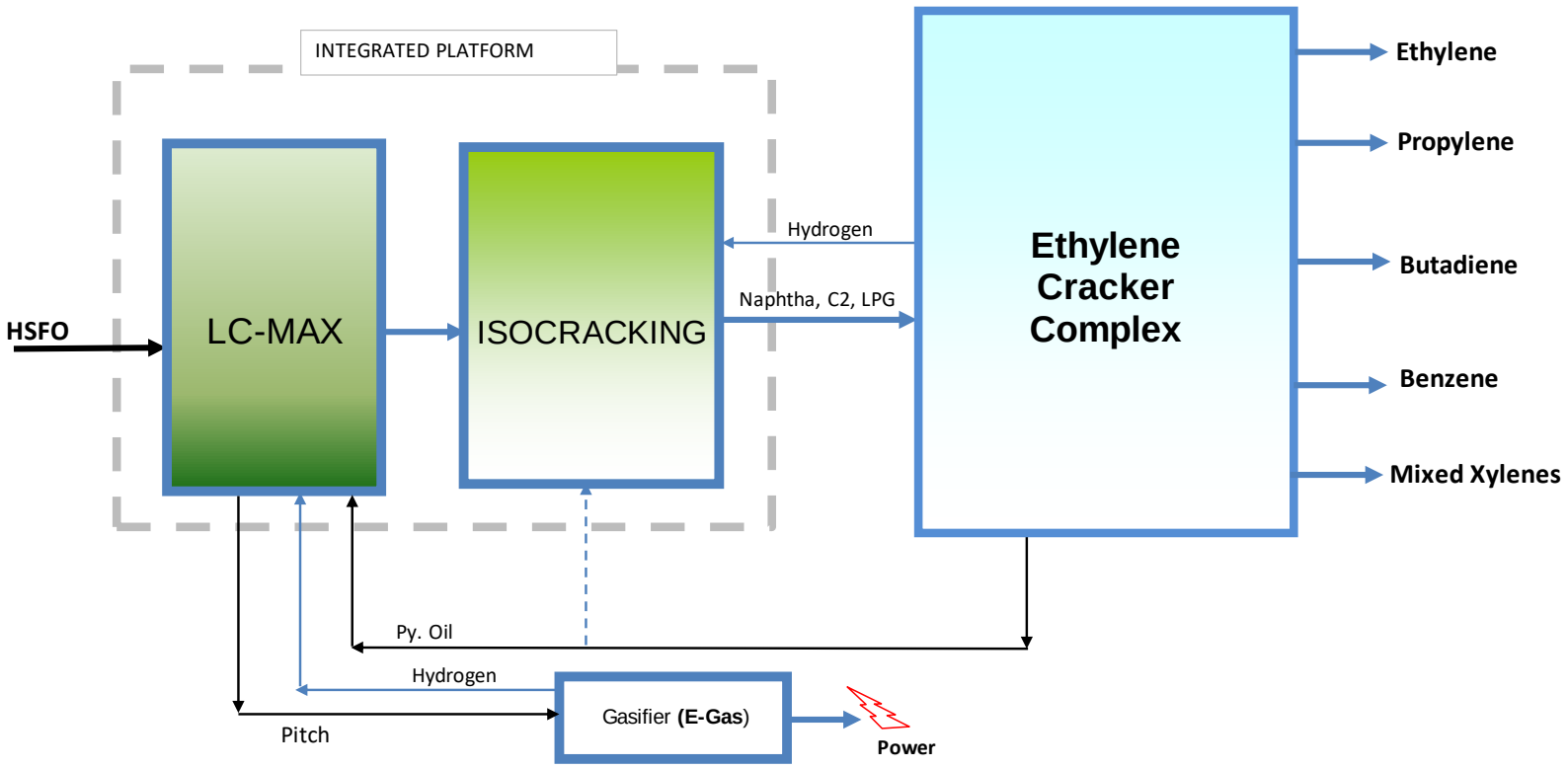
Bottomless Refinery using LC-SLURRY



HSFO to Transportation Fuels



Case -1 HSFO to Petrochemicals



Balance For an LC-MAX-HCU Based Complex

Feeds	BPSD	M TPA
HSFO FEED	87418	4972
Coke to Gasifier		2109
Products		
Ethylene		1500
Propylene		925
Butadiene		308
Benzene		362
Toluene		181
Xylenes		128
C9+ Aromatics		130
Sulfur		406

Total Investment, $ millions	**4,832**
Net Operating Revenue, $ millions	1,841
Simple Payback, Years	2.62

Conversion to Chemicals ~ 71% wt.%

Case-2 Study Basis

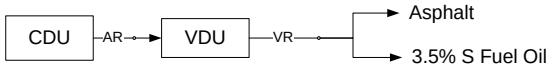
- 200 KBD (~9.6 MM TPY) Base Refinery:
  - Processing 50/50 Arab Light / Arab Medium blend
  - Produces Euro V quality gasoline / diesel
  - Produces 3.5%S HSFO and asphalt
- Crude /Product prices from Platts (March 2018)

Upgrading Configurations Considered

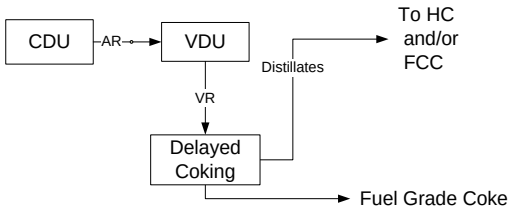
- Delayed Coking
  - Produces fuel grade coke
- LC-FINING
  - Produces 1.5%S Fuel Oil
- LC-FINING + Delayed Coking
  - Produces anode grade coke
- Residue Desulfurization
  - Produces 0.5%S Fuel Oil
  - Includes revamp of FCC to process DS Residue

- Every configuration includes a new Hydrocracker to convert heavy distillates resulting from the addition of upgrading processes

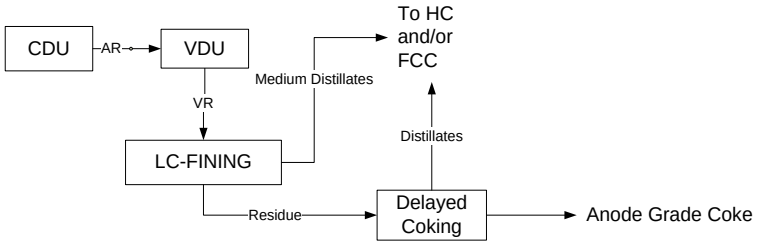
Simplified Upgrading Schemes



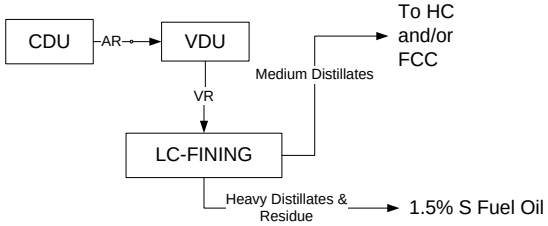
Base Refinery



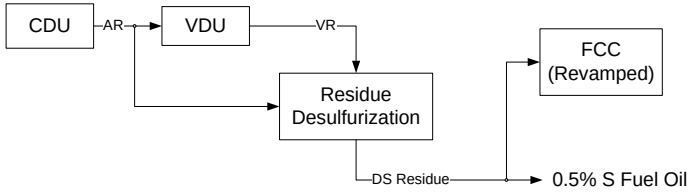
Delayed Coking



LC-FINING + Delayed Coking



LC-FINING



Residue Desulfurization

Comparing Product Yields (Volume)

Product Yield on Crude, VOL %	Base Refinery	Delayed Coking	LC-FINING	LC-FINING + Delayed Coking	Residue Desulfurization
LPG	3.7	3.9	4.4	4.5	4.6
Naphtha	10.0	14.3	13.7	14.6	11.1
Gasoline	14.5	15.7	14.5	15.7	14.0
Jet	15.0	15.0	15.0	15.0	15.0
Diesel	33.5	48.6	45.3	52.2	43.7
C3+ Distillate, Vol%	**76.7**	**97.5**	**92.9**	**102**	**88.4**
0.5% S Fuel Oil					14.5
1.5% S Fuel Oil			10.9		
3.5% S Fuel Oil	19.8				
Asphalt	5.0				
Fuel grade Coke		5.2 (FOE)			
Anode grade Coke				2.2 (FOE)	
Volume Gain,% on Crude	**1.44**	**2.71**	**3.80**	**4.21**	**2.96**

Comparing Product Yields and Economics

	Base Refinery	Delayed Coking	LC-FINING	LC-FINING + Delayed Coking	RDS+RFCC
TIC, $ Million	Base	+1040	+1138	+1564	+1194
Net margin, $ Million	Base	+507	+557	+728	+490
IRR, %		20.3	20.4	19.6	17.5
NPV, Million		296	327	371	147
Profitability Index (PI)		4.1	4.2	3.9	3.3

Summary

- Post 2020, Bottoms Upgrading offers the most profitable route
- Addition of Bottoms Upgrading has major impact on the rest of the refinery
- Delayed Coking offers reasonable returns but requires an outlet for high sulfur Pet. Coke
- Refiners with Existing Cokers can benefit from Residue Hydrocracking
- CLG Liquid Circulation Platform based solutions (LC-FINING, LC-MAX, LC-SLURRY) offer proven bottoms upgrading solutions post-2020
- Combined with ISOCRACKING and Lummus Ethylene Technology Suite – the refiner can dramatically improve profitability