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# Next-level hydrocracking: Unlocking high performance in today's turbulent markets

**Shell Global Solutions**

**Simon Cackett**

Licensing Technology Manager, Shell Global Solutions

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# Agenda

- The challenges facing refiners – and potential responses
- Integrated line-ups
  - Enhancing the vacuum distillation unit (VDU)–hydrocracker interface
  - Coker–hydrocracker line-up
  - Solvent deasphalting (SDA)–hydrocracking line-up
  - Hydrocracking–base oils line-up
- Key takeaways



# The challenges facing refiners – and three potential responses

## CHALLENGES

- New International Maritime Organization (IMO) regulations
- Volatile margins
- Uncertain future
- Extremely competitive fuel commodities market
- Declining demand for traditional hydrocarbon fuel products
- Increased refining competition

## POTENTIAL RESPONSES

**Process heavier, cheaper crudes**

**Process difficult or unconventional feeds**

**Exploit enhanced margins in lubricant base oils or petrochemicals**

**Hydrocrackers are highly versatile assets and can help with all these issues**

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## Process heavier, cheaper crudes

Shift from traditional Middle Eastern or Russian crudes to lower-priced opportunity crudes from West Africa, Mexico, Colombia and Venezuela

These are typically high in:

**Total acid  
number  
(TAN)**

**Metals**

**CCR**

**Nitrogen  
and sulphur**

**Aromatics  
content**

**Careful consideration of contaminants on process unit performance needed**

## Process difficult or unconventional feeds

- Traditional hydrocracker feedstock (e.g. straight-run VGO) often supplemented with cracked stocks originating from residue upgrading technologies:

Deep-cut  
vacuum  
distillation

Coking

SDA

Residue  
hydrocracking

- However, such feeds can:
  - Have higher levels of contaminants
  - Exhibit an “inhibition” nature through having already been cracked

**Latest-generation catalysts are key to the economic upgrading of these feedstocks**

# Exploit enhanced margins in lubricant base oils or petrochemicals

## Lubricants

- Group II/III base oils
- Feed hydrocracker bottoms
- Key product properties (VI, aromatics, sulphur, etc)

## Petrochemicals

- Modern ethylene crackers flexible for variety of feedstocks (refinery off-gas, LPG, naphtha, hydrocracker bottoms)

Hydrocracking advantages:

- Selective hydrogen addition to bottoms for base oils/ethylene cracker
- Wide range of yield profiles: max naphtha, max diesel

# Refinery complexity increasing in 2018 as refiners react to changing product demands

- New refinery crude capacity builds in Middle East and China
- Increase in complexity led by construction of new hydrocracker units, particularly in China and Middle East
- Naphtha reformers being built across all regions

New conversion unit capacity (2018), kbd

**Reformer [360]**

**FCC [430]**

**HCU [590]**

**Coker [200]**

Source: Oil Markets Analysis Q3 report



# Integrated line-ups

- Enhancing the VDU–hydrocracker interface
- Coker–hydrocracker line-up
- SDA–hydrocracking line-up
- Hydrocracking–base oils line-up

# Enhancing the VDU–hydrocracker interface

- Maximise the amount of VGO the VDU supplies to the hydrocracker
- Remove residue from the VGO
- Minimise the contaminants left behind

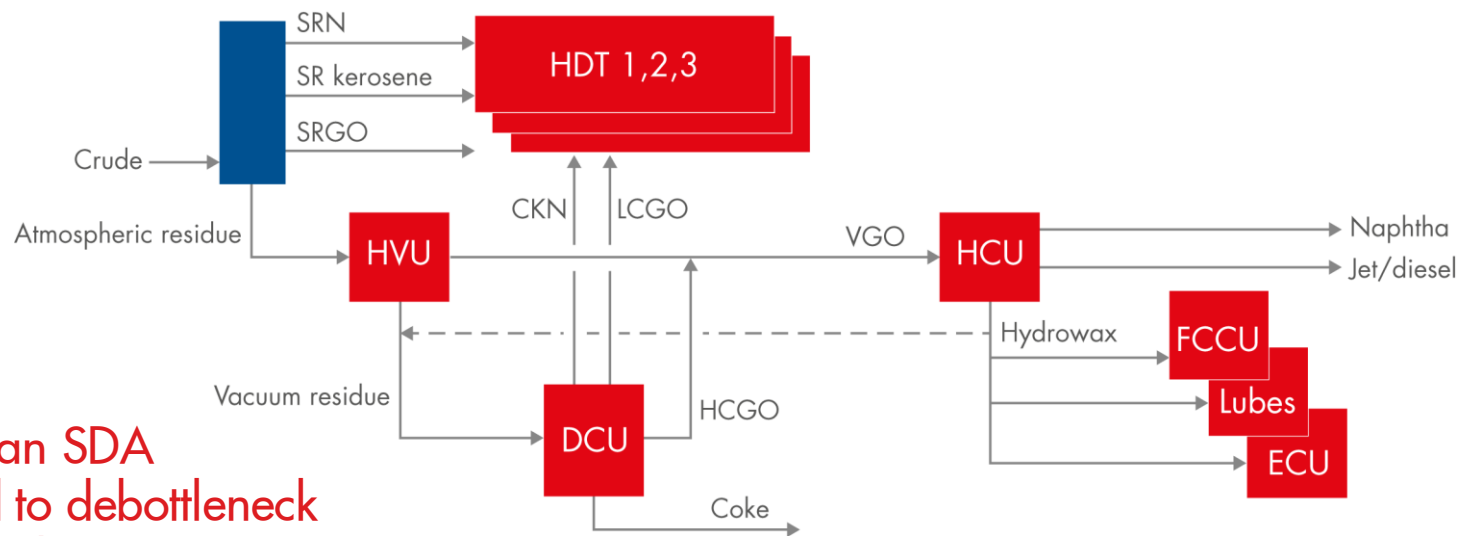
## VDU revamp customer example

- Objectives: increase the feed rate to the hydrocracker, extend the VDU run length before decoking
- Cost of modifications and downtime: **\$26 million**
- Annual margin improvement: **\$46 million.**

The latest separation technologies make it possible to go deeper into the VR and extract more VGO that is still within the hydrocracker's acceptable limits

# Coker-hydrocracker line-up

- Provides zero fuel oil production and crude flexibility

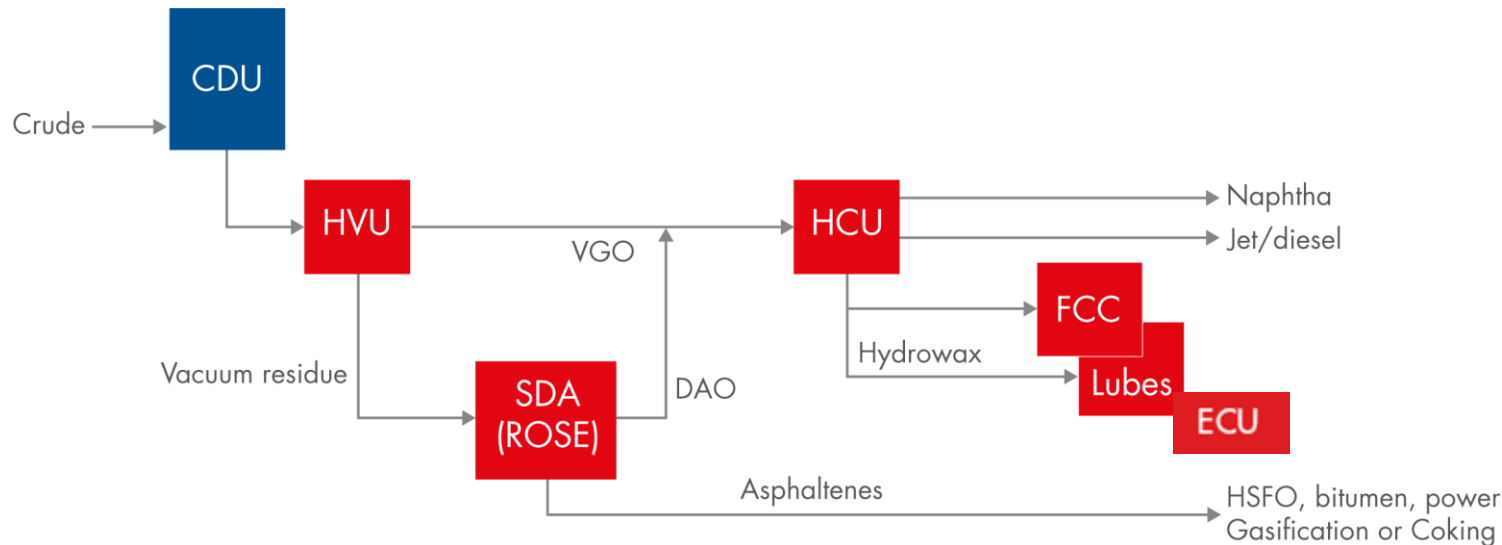


An HVU or an SDA can be used to debottleneck an existing coker.

- The interfaces with the rest of the plant are key, adding to the implementation costs
- Hydrogen consumption can be an issue
- The output is 65 wt% liquid yields and petcoke production

# SDA-hydrocracking line-up

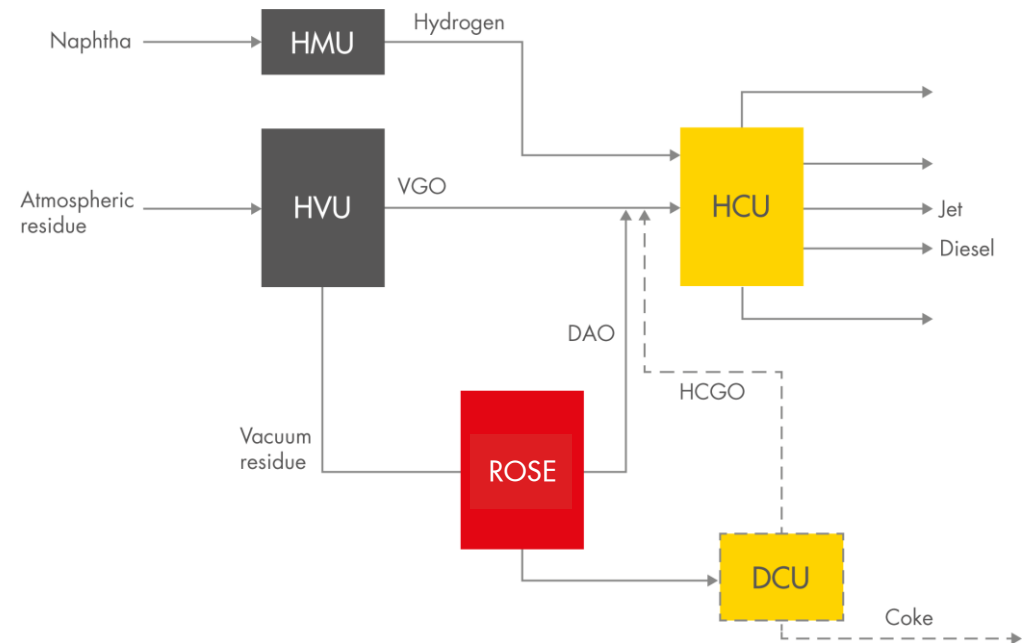
- A modern SDA unit can provide high-quality DAO suitable for hydrocracking



- Today's well-designed hydrocracker catalyst systems can handle the high metals and CCR content
- One of the lowest capital expenditure options for residue conversion
- A mild hydrocracking (MHC) option can be used with an existing FCCU

# Case study: Grupa LOTOS unlocks the potential of DAO hydrocracking

- A DAO hydrocracker processes VGO and DAO, yields jet fuel and diesel straight off the unit
- An advanced SDA unit produces DAO that can be sent directly to the hydrocracker
- Future coker addition



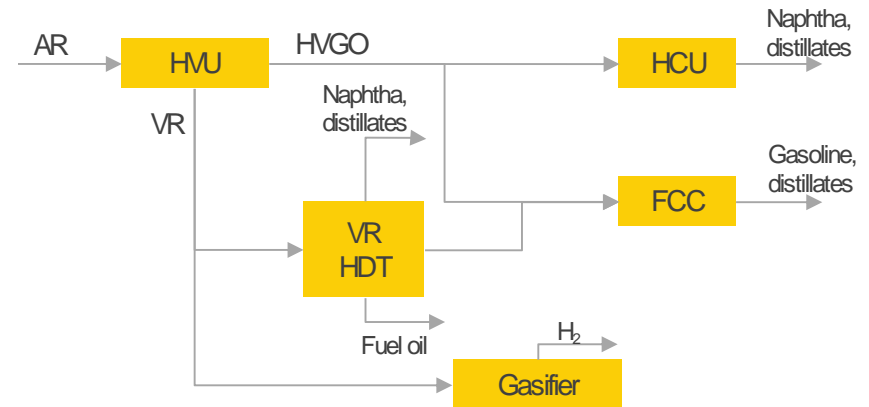
## High flexibility

- Feed diet varied from **100 to 50% VGO with 50% DAO**
- Furfural extracts processed
- Operates in both once-through and recycle modes
- Operates at conversion levels between **60 and 90%**

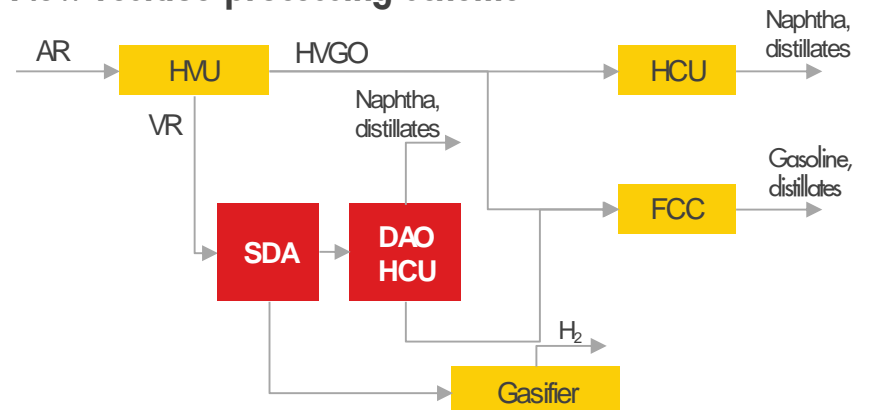
# Pushing DAO hydrocracking extraction depth

- New SDA plus revamp of RDS/RHC
  - 100% DAO (>70% DAO yield)
  - 65% conversion/two-year cycle
  - UCO will be used as FCC feed
- SDA asphaltenes gasified, optional routing to bitumen/fuel oil pool
- Economic drivers: reduced fuel oil and increased crude flexibility
- Project started up Q3 2018 at Shell Pernis refinery in the Netherlands
- Further project under way for a non-Shell customer

Former residue processing scheme



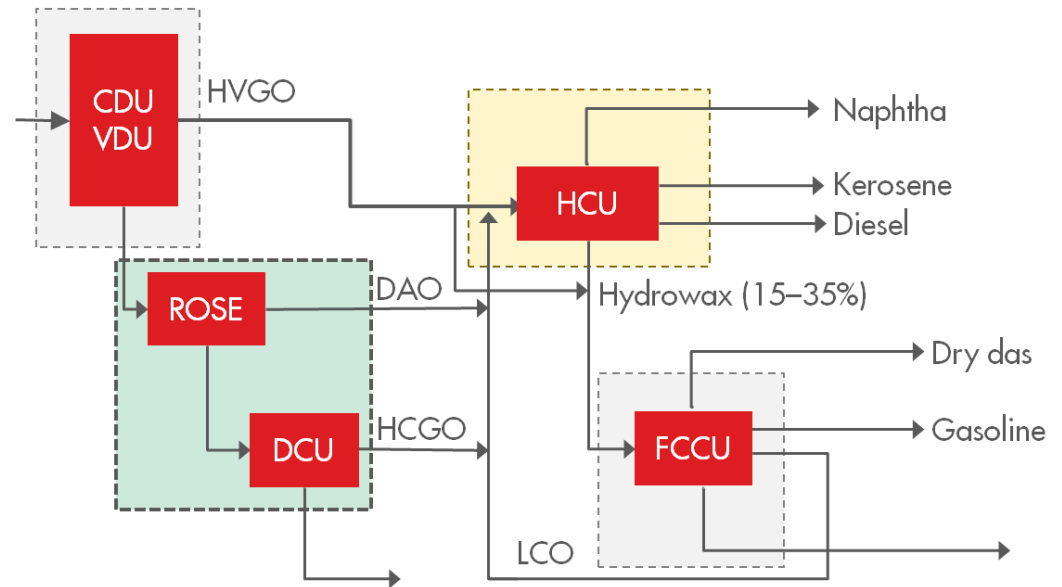
New residue processing scheme





# Integrated hydrocracker refinery – Marathon

- Hydrocracker feedstocks include HVGO, HCGO, DAO and LCO
- Process requirements for flexible, optimal yields:
  - ultra-low-sulphur diesel (ULSD)
  - naphtha to reformer
  - low-sulphur UCO to FCCU

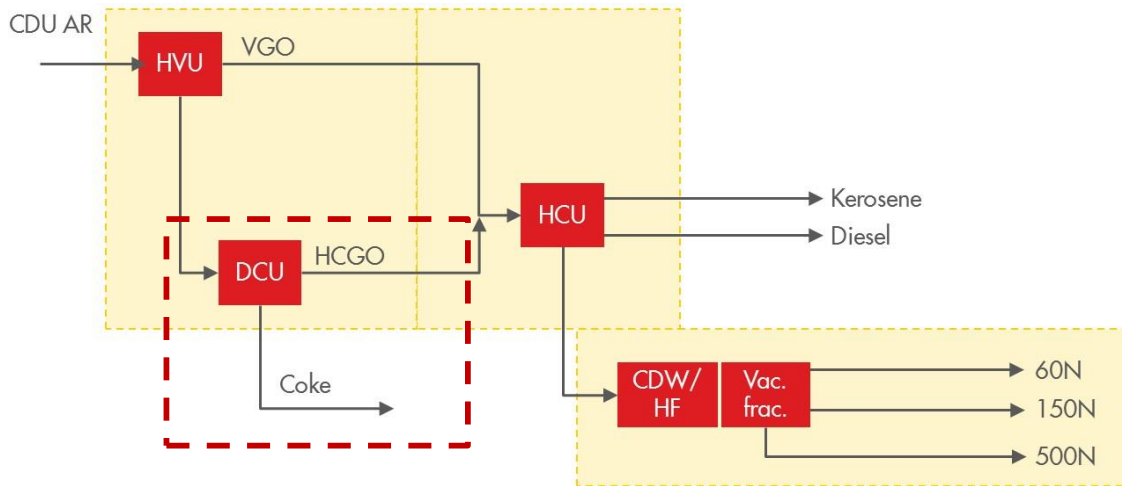


## Value delivered

- Increased refining capacity
- Feedstock and product slate flexibility
- Improved overall fixed cash cost per barrel **by 20%**

# Hydrocracking-base oils line-up

Base oil production is rapidly moving toward the catalytic hydroprocessing route



## Process integration

- HVU – deep-flash VGO
- Hydrocracker – heavy feed/optimum conversion
- Base oil plant – Group II base oil quality

## Catalyst integration

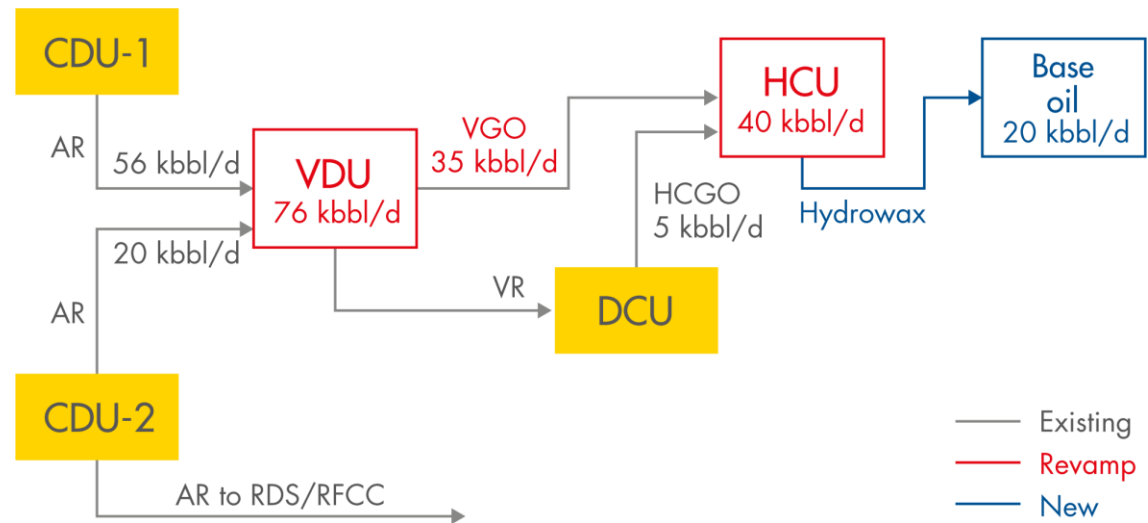
- Demetallisation
- Pretreatment
- Hydrocracking
- Isomerisation dewaxing

# Case study: Hyundai's HVU-hydrocracker-base oils value chain

Adding a new 20,000-bbl/d Group II lubricant base oil plant required changes to the existing refinery:

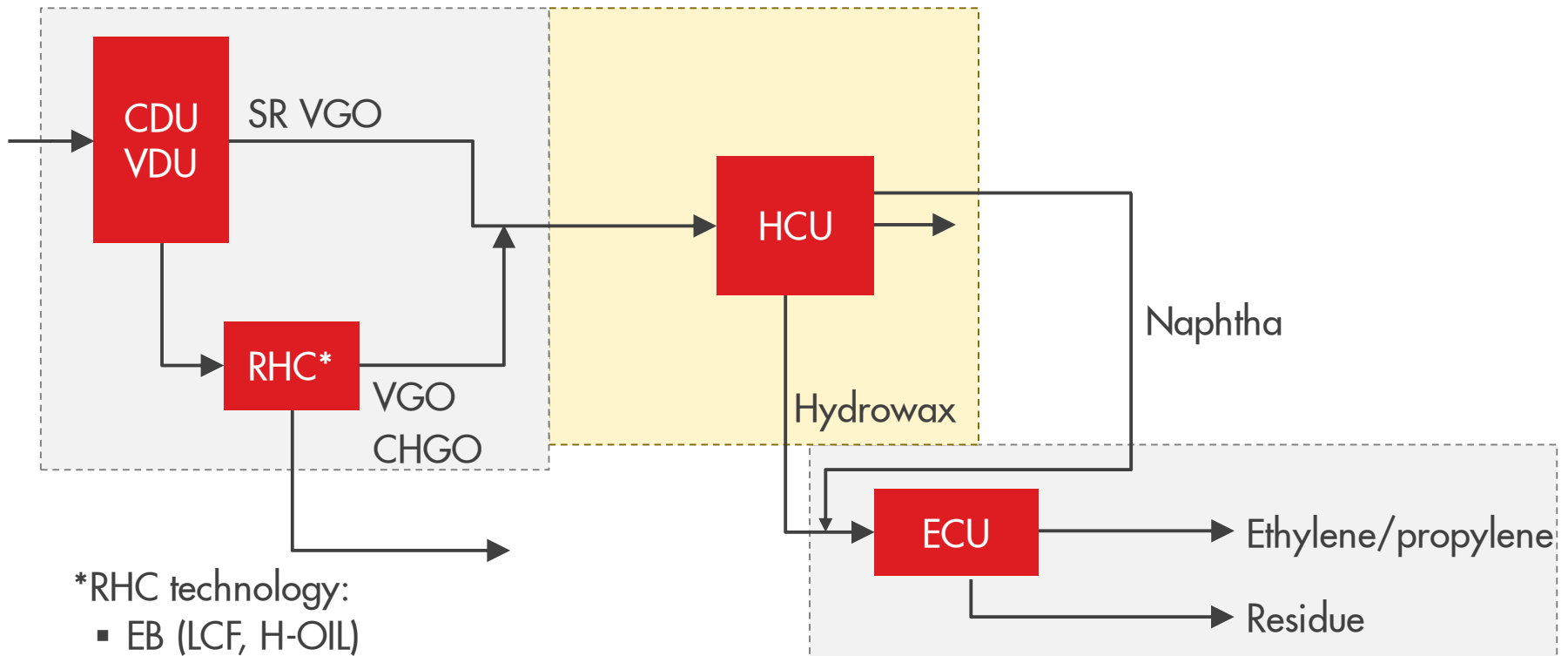
- An HVU revamp to get sufficient and suitable feed for the hydrocracker
- A hydrocracker revamp to process the right amount of feed at the right quality to:
  - Increase throughput
  - Decrease conversion
  - Increase cycle length

**Both revamps achieved their objectives and the base oil plant met its performance guarantees**



# Shell naphtha hydrocracker for petrochemicals

- Naphtha hydrocrackers mainly produce petrochemicals today



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## Key takeaways

Refiners worldwide are enhancing their competitiveness by:

- Processing heavier, cheaper crudes or non-standard feeds
- Optimising the product slate and producing higher-value products such as lubricant base oils or petrochemicals

Exploit integration opportunities between:

- VDU-hydrocracker
- Coker-hydrocracker
- SDA-hydrocracking
- Hydrocracking-base oils



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# Questions and answers

Q&A



