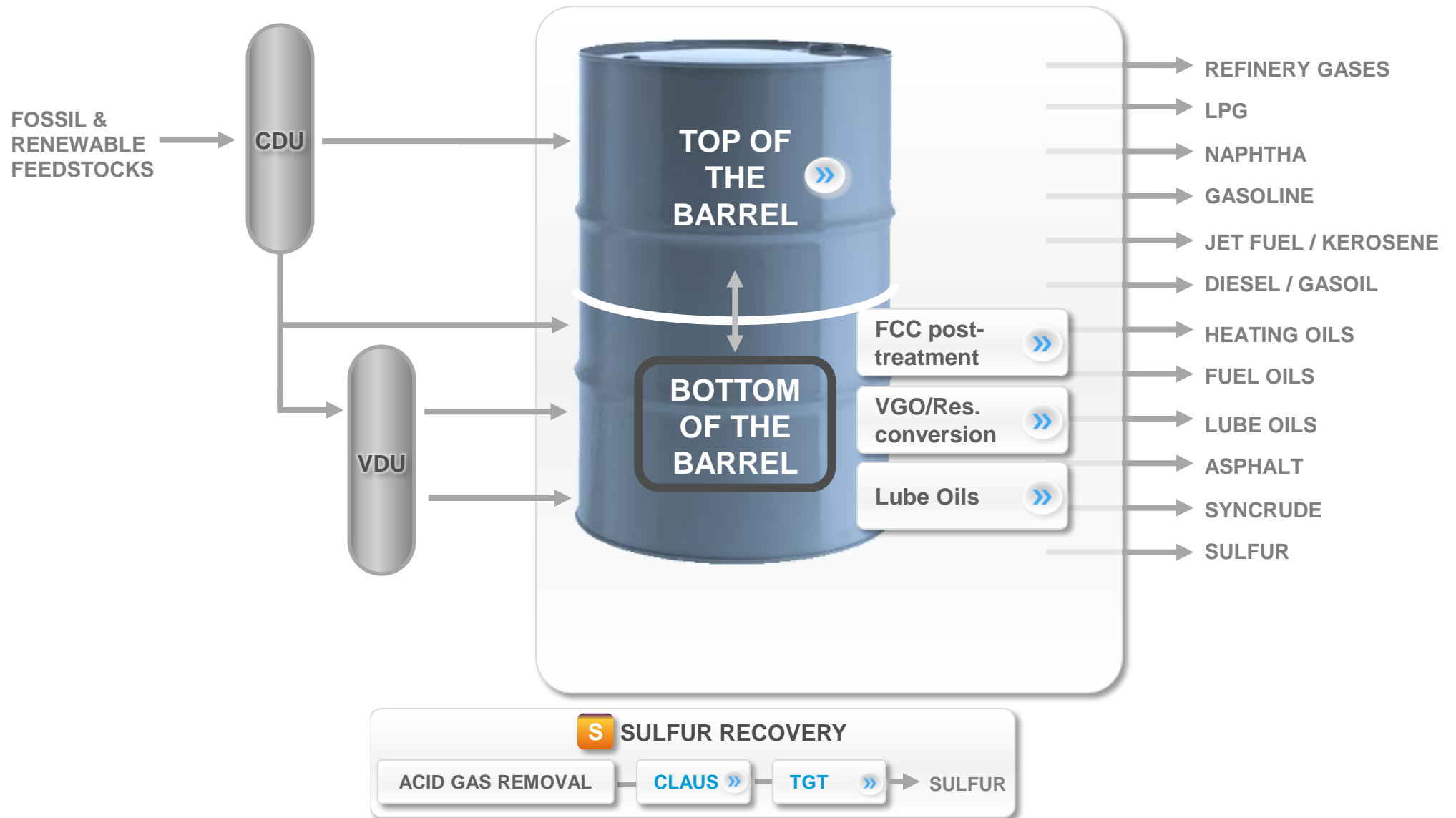


H-Oil technology description



Alexandre Javidi
Jean-Philippe Toupance

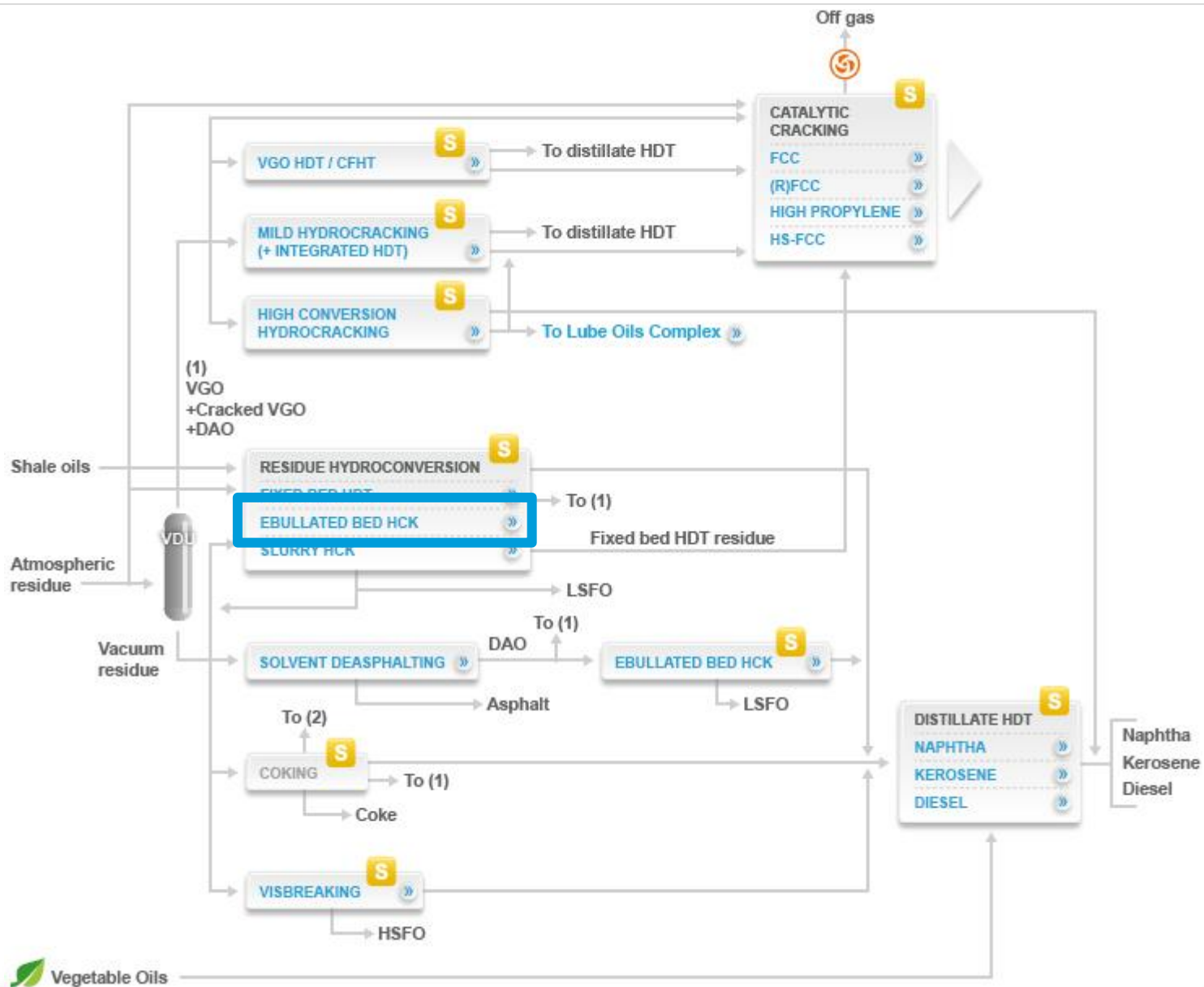
Oil Refining



Bottom of the Barrel Axens Offer



- DRYING & PURIFICATION
- SULFUR RECOVERY
- RENEWABLES

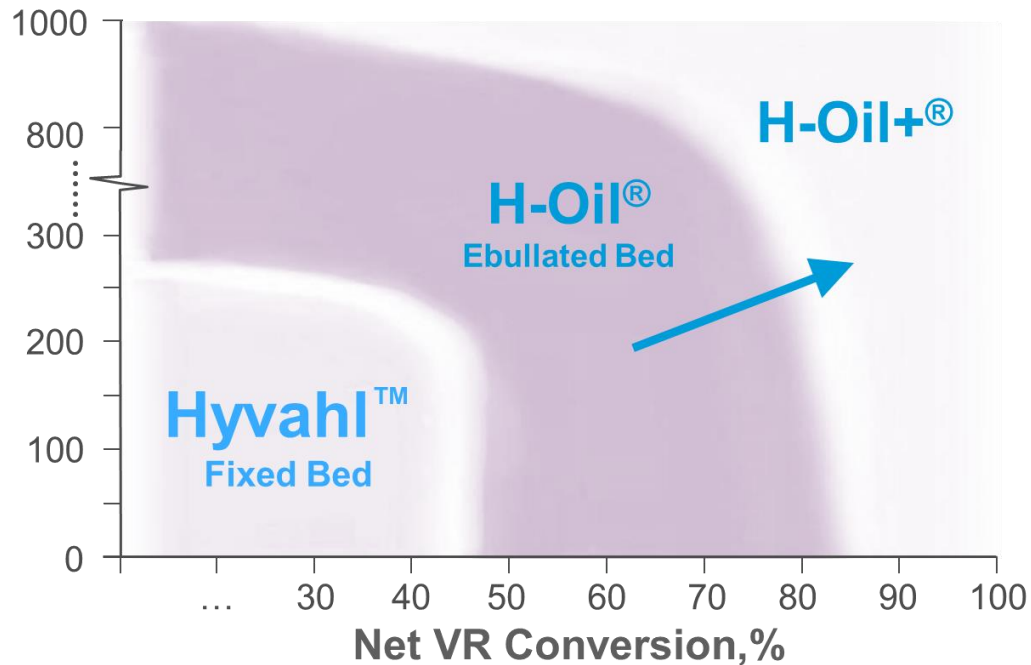


Axens Residue HydroCracking Offer



Objective: Conversion of Vacuum Residue (VR) Feedstock into Valuable Products

Ni + V in the Feed, wppm



- **Fixed Bed Technology**
 - Limited conversion level
- **Ebullated Bed Technology**
 - Deep conversion level possible



Deep Conversion



High Flexibility

Axens H-Oil[®]_{RC} Residue HydroCracking Feedstock

Vacuum Residue (VR) Feedstock

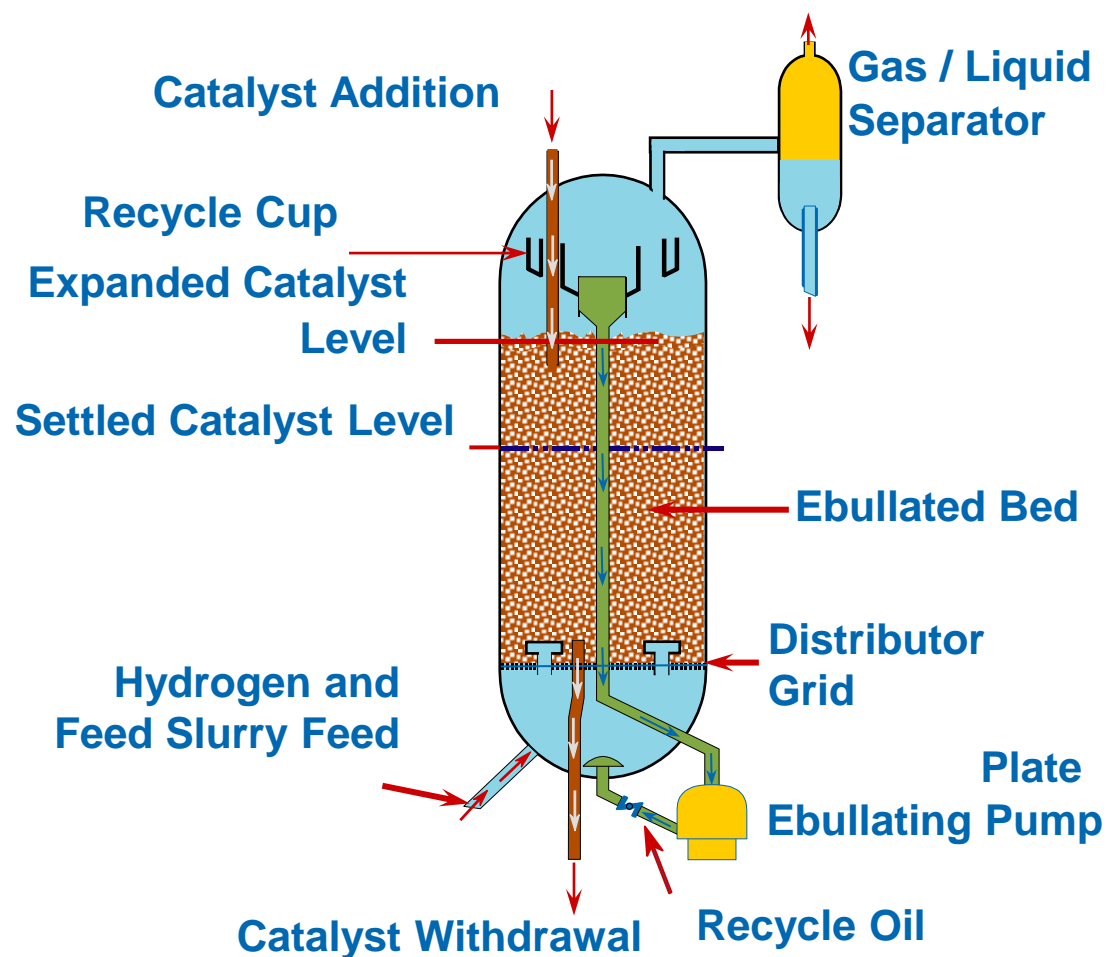
- Conversion into valuable products
 - › Naphtha, Diesel, VGO
- Unconverted Residue (UCO)
 - › Low Sulfur & Stable Fuel Oil
 - › Feed for Coker, SDA, Boilers or Gasification



⇒ **High Value Products**

⇒ **UCO is a Liquid Fuel
Various Options for UCO Outlet**

Axens H-Oil_{RC} – Residue HydroCracking



- Vacuum Residue (VR) Feedstock
 - 40 - 85% VR conversion
- Unconverted residue application
 - Low sulfur (up to S < 1%) & stable fuel oil
 - Feed for coker, SDA or gasification units
- On-line Addition/Withdrawal of catalyst
 - Fully Automated System
 - Constant product quality
 - APC from Axens used to control catalyst bed expansion
- Availability > 96%
 - 2 to 6 years cycle
 - No shutdown for catalyst required

Axens H-Oil Process - Flexibility

Design Feedstock of Motiva unit

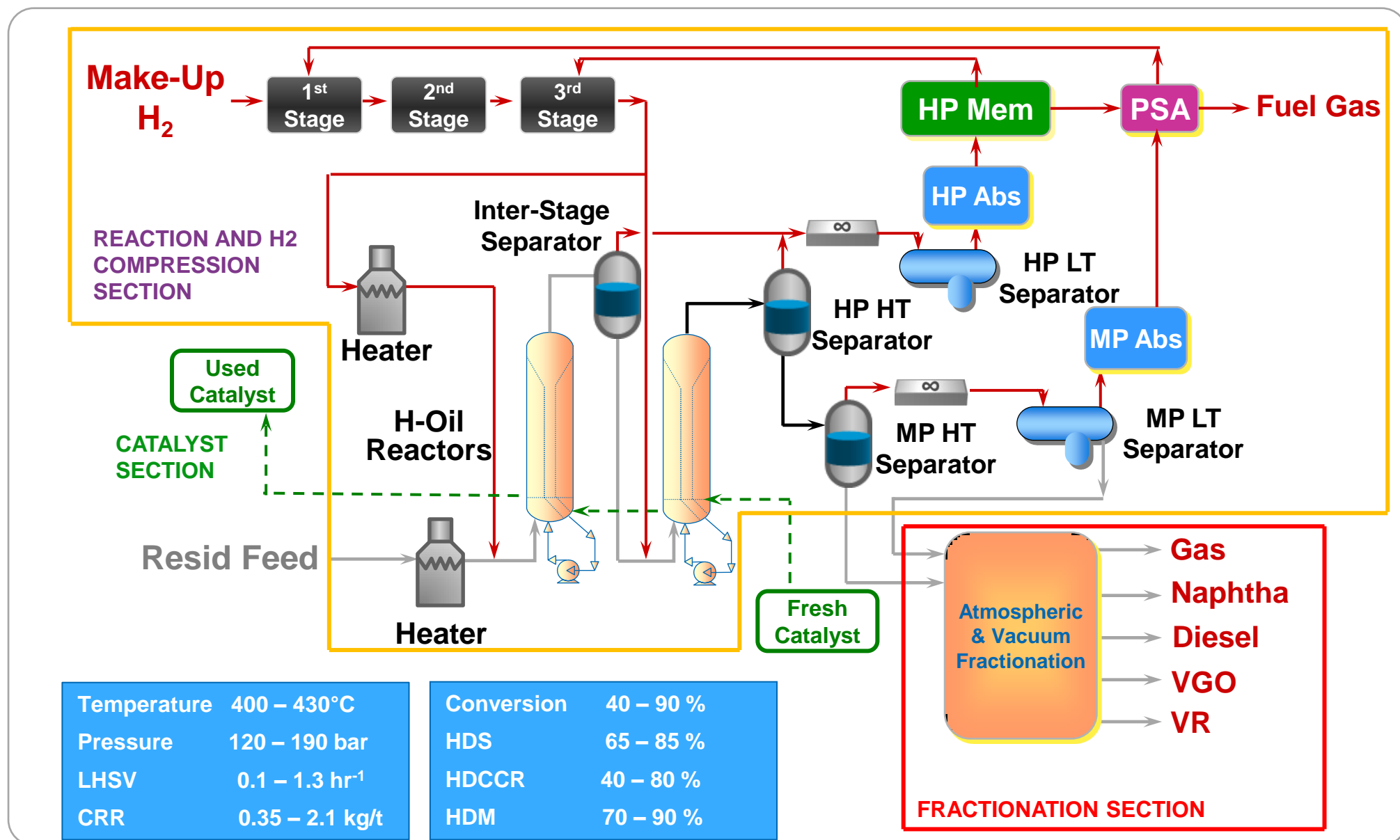
- 70% Arabian Light
- 30% Arabian Medium

Feedstock of Motiva Refinery

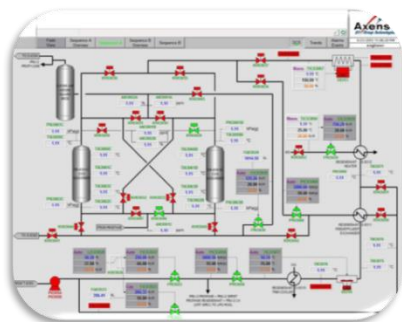
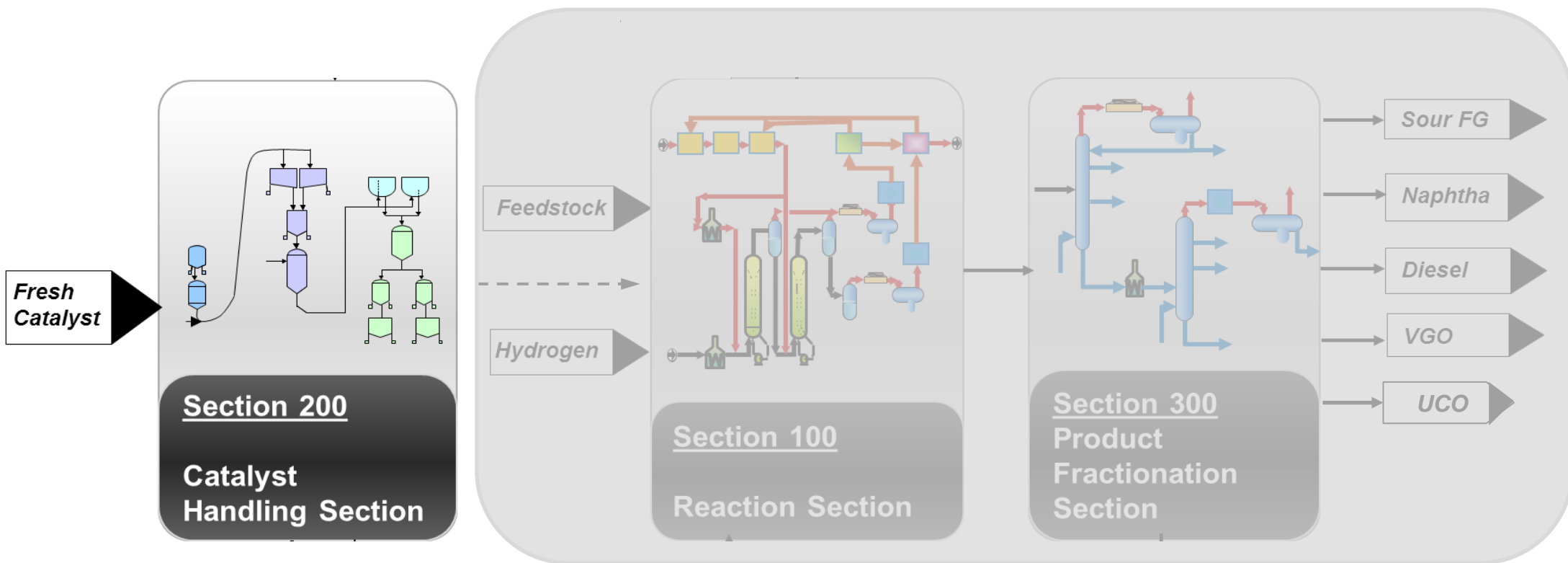
- Arabian Light
- Arabian Medium
- Arabian Heavy
- Basrah
- Bonny Light, Brass River
- Brent, Ekofish and Escravos
- Iranian Light
- Kirkuk
- **Maya**
- Alaskan North Slope
- Eugene Island
- ...



Axens H-Oil[®]_{RC} – Simplified scheme overview



H-Oil Overall Block Flow Diagram



- Outstanding catalytic system
- H-Oil ACS

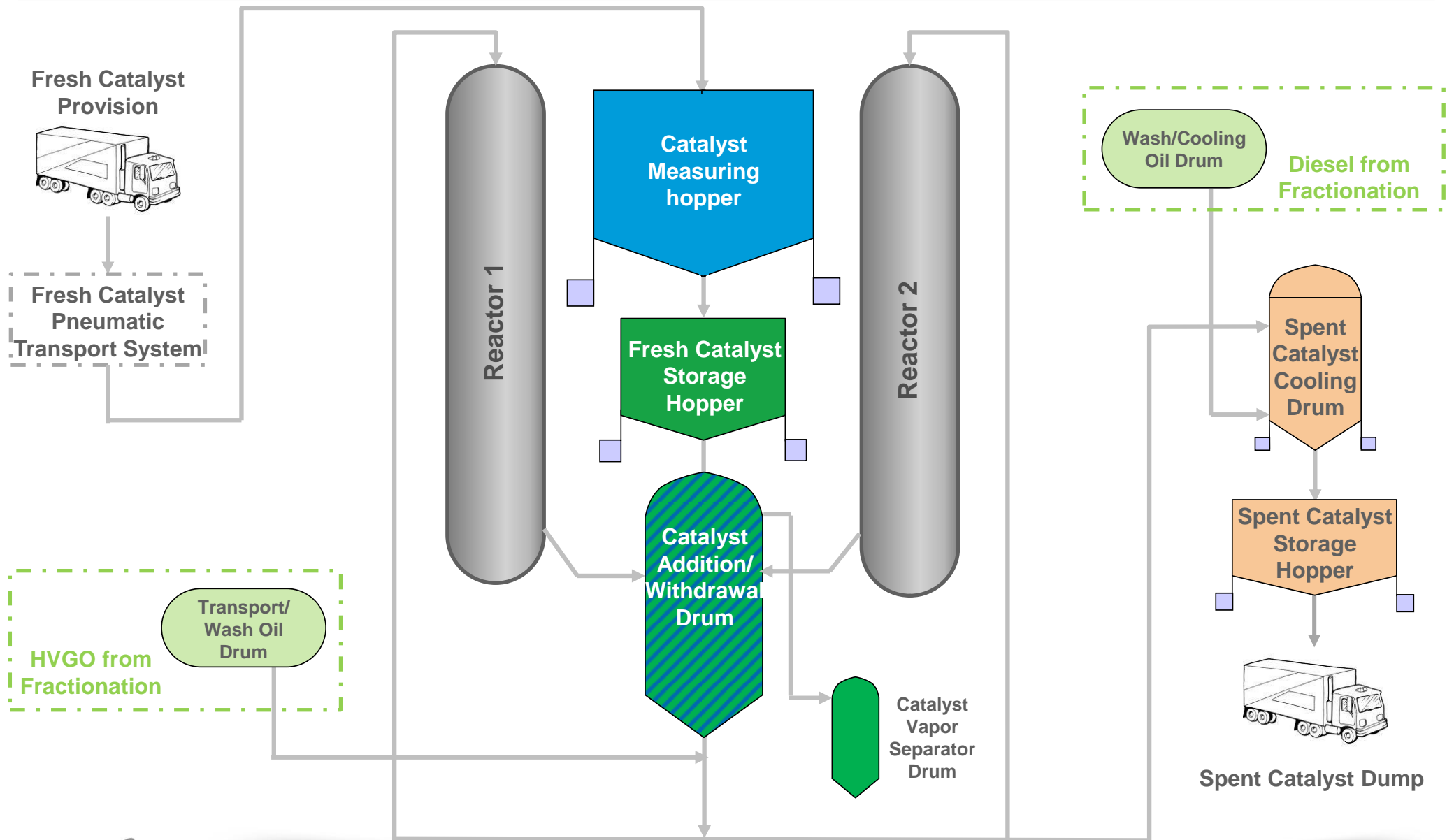
H-Oil Catalyst

- Type: NiMo/Alumina 1.0-mm Extrudate. (**Hydrotreatment catalyst type**)
- Catalyst replacement rate : metals in feed & objectives depend.
- Vendor : Axens



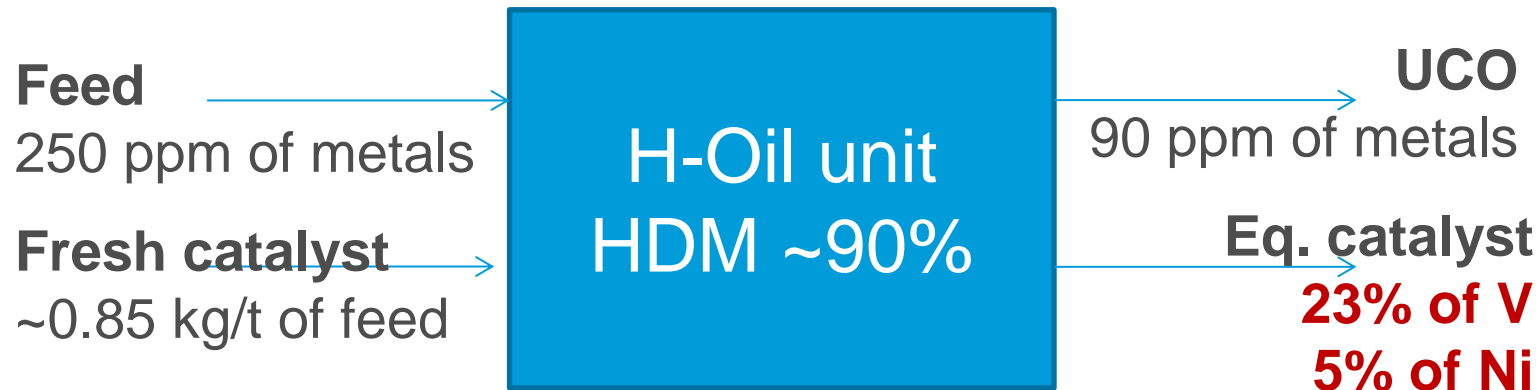
- Spent Catalyst Re-Processing
 - Worldwide based companies which process spent catalyst for metals reclamation (Mo/Ni/V) – 15 references all around the world.
 - ➡ **Additional revenue for customer from reclaimed metals**
- **Catalyst Cascading**: spent 2nd stage catalyst is used as replacement catalyst for 1st stage reactor

Catalyst Handling Section Overall Scheme

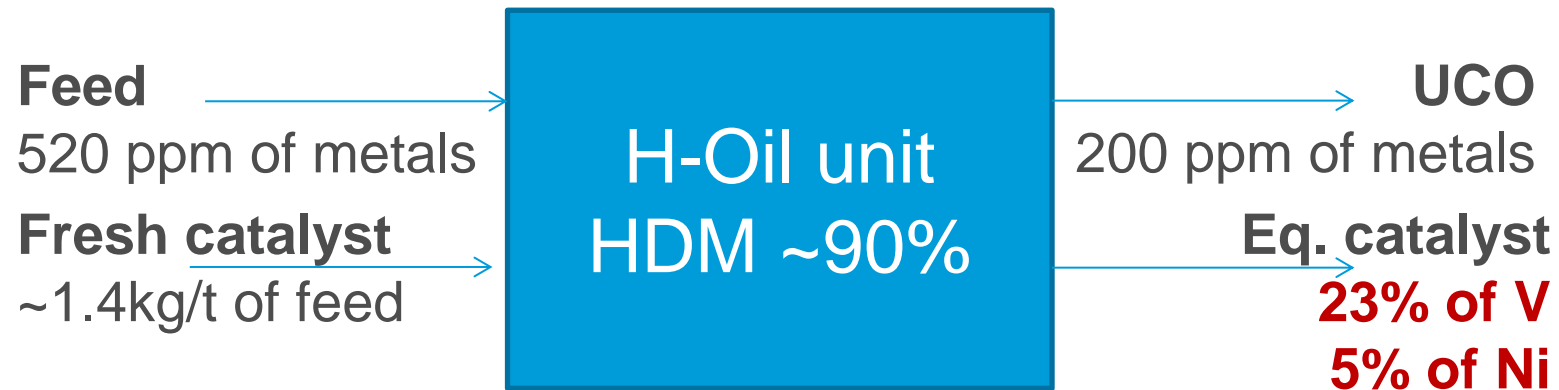


Why an H-Oil is not impacted by metals content in the feed?

Case 1



Case 2



Catalyst Addition Rate Adjustment maintains constant catalyst activity irrespective of metals in the VR feed

H-Oil Pilot Scale Experience

■ Origin of the crudes

- ❖ Canadian (Athabasca mined, Athabasca SAGD, Athabasca PFT, Lloydminster, Cold Lake, ...)
- ❖ Middle East (Safaniya, Buzurgan, Arabian Heavy, ...)
- ❖ South-American (Zuata, Morichal, Cerro Negro, Boscan, Chichimene, ...)
- ❖ Russian (Ural, Siberian, ...)
- ❖ Chinese (Tahe)...

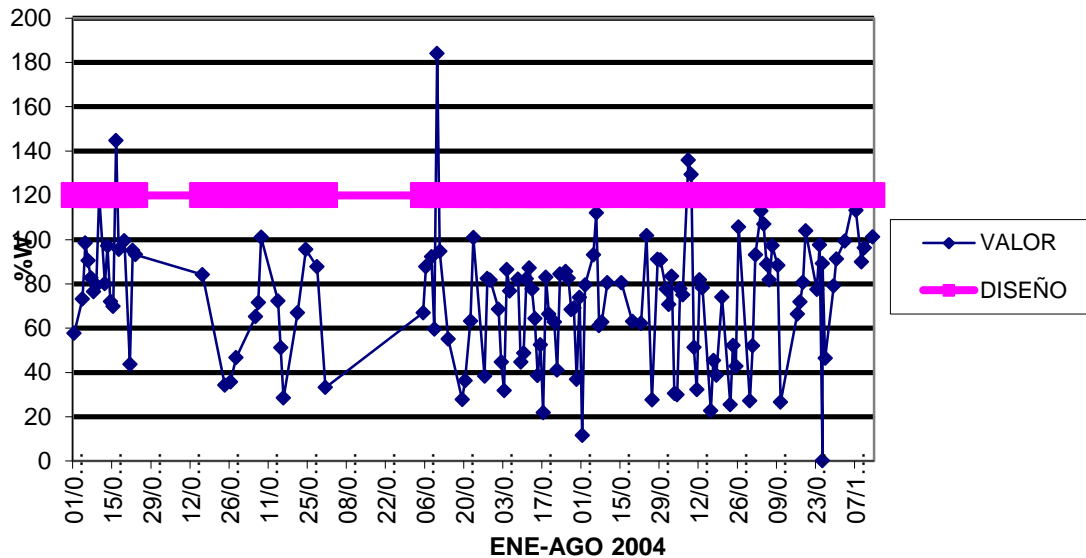
➔ **Metals: 0 to 1500 ppm, S: 0.2 to 6wt%, CCR: 0.1 to 35wt%, N: 10 to 8000 ppm**

Focus on high metals feed

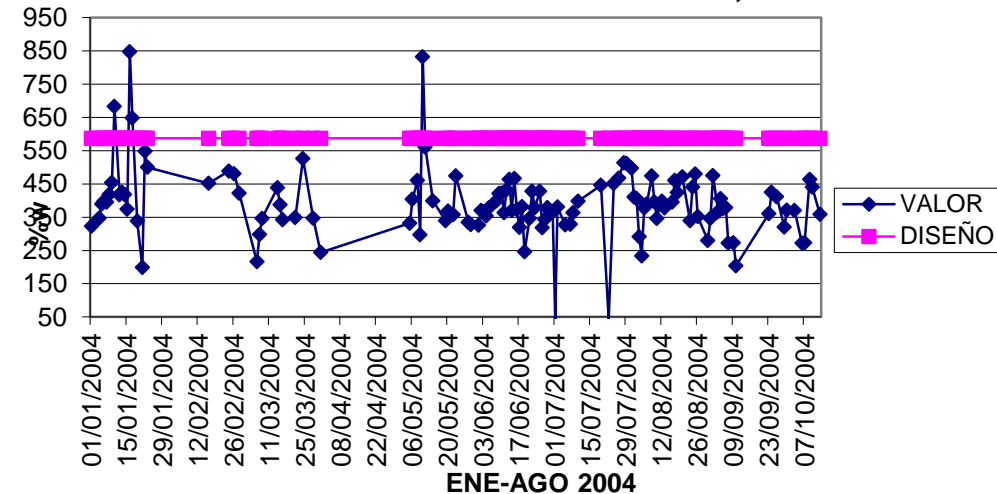
Feedstock origin	Metals content, ppm	% conversion
Athabasca	431	58 to 78
Maya-Ismuth	566	45 to 50
Maya-Ismuth	688	45 to 50
Tahe	447	40 to 50
Athabasca/Cold lake	540	50 to 75
Maya/Ismuth	1040	54 to 65

H-Oil Industrial Scale experience

CONTENIDO DE NIQUEL, CARGA NEGRA

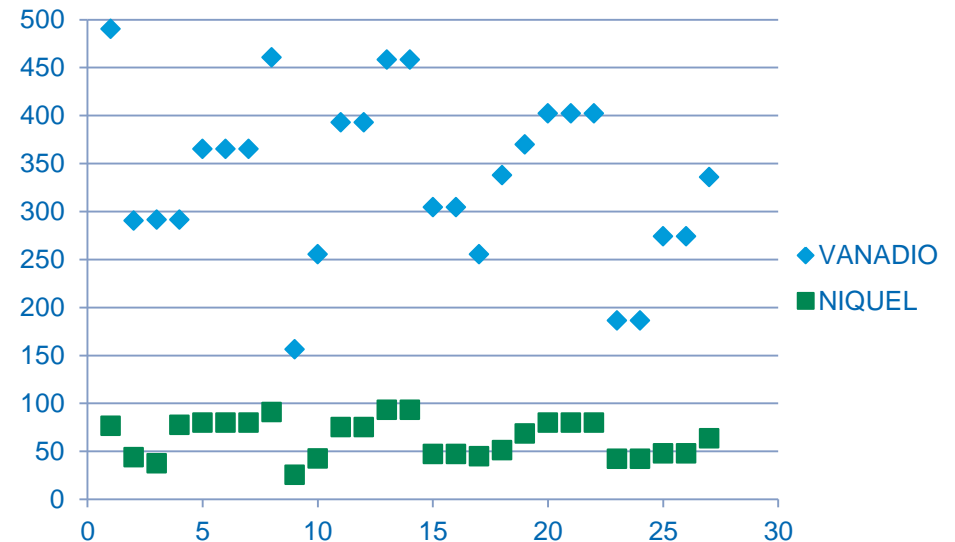


CONTENIDO DE VANADIO, CARGA NEGRA

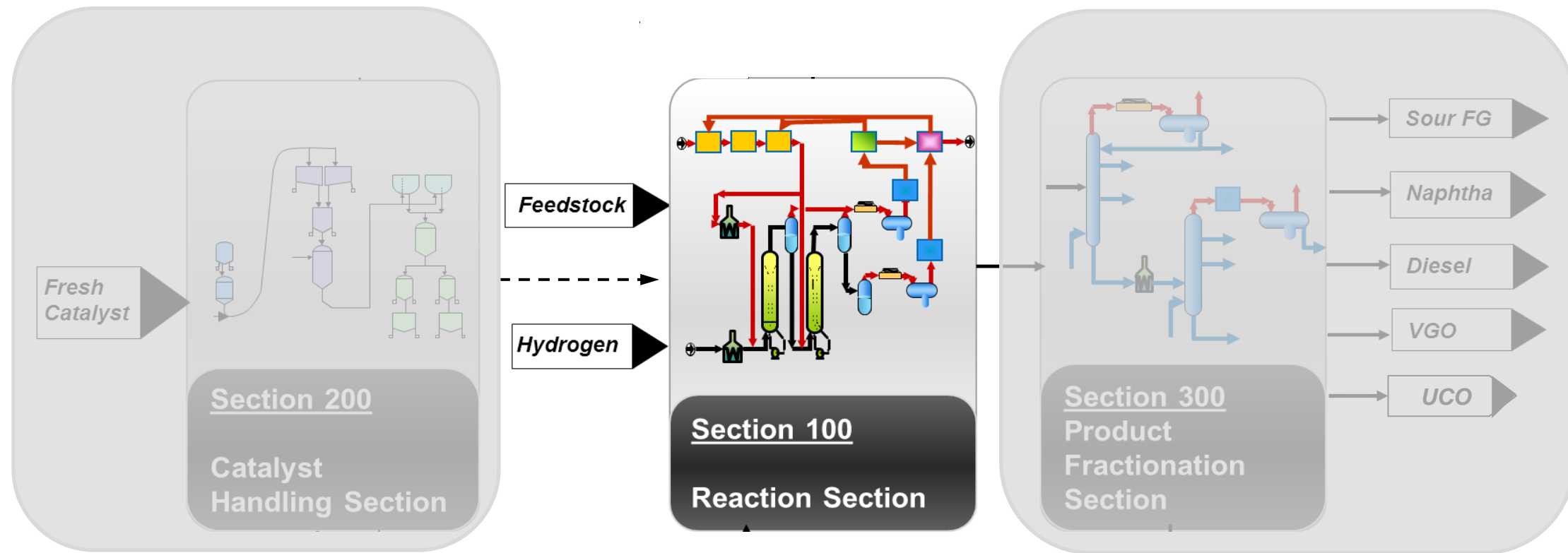


- ❖ More than 430 ppm of V+Ni is contained in the feed.
- ❖ Design was made for 670 ppm in the feed
- ❖ Quantity of vanadium in the feed varies a lot : no issue

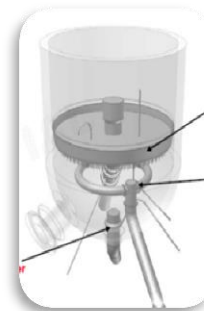
Flexibility of the H-Oil towards metals



H-Oil Overall Block Flow Diagram



- **Safe and robust design**



- **Superior Internals**

Axens H-Oil[®]_{RC} Ebullating pump

■ Safety

- Easy leak detection when external
- Should a fire occur, risk to the reactor is minimal when external

■ Maintenance

- Direct access to the pump (easier & safer)

■ Operability / Reliability

- Direct flow measurement
- Butterfly valve on pump discharge
 - › Easy start up and shutdown
 - › Avoids reverse flow through pump and catalyst bed collapsing in emergency situation

“H-Oil[®]” Ebullating Pump
(External: case mounted)



Axens H-Oil[®]_{RC} Ebullating Pump

- Axens H-Oil unit design features an external location for the ebullating pump for:



- *safety*
- *maintenance*
- *operability*

➤ **Available Only from Axens**



Axens H-Oil[®]_{RC} Ebullating Pump – Iran case

■ Type of pump

- Pump flowrate in the middle range of existing pump in operation (Typical sizing of reactor)

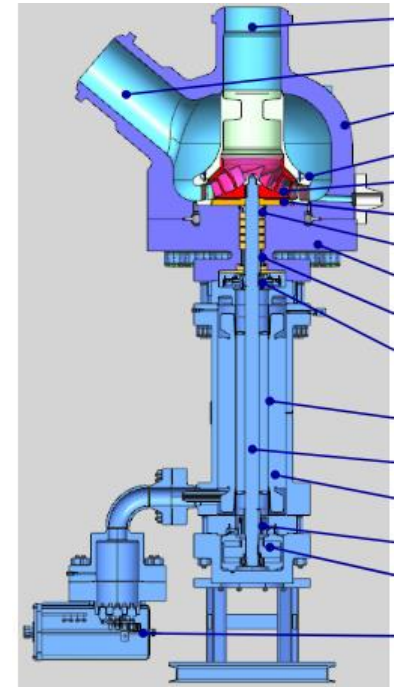
■ Supplier

• Sulzer

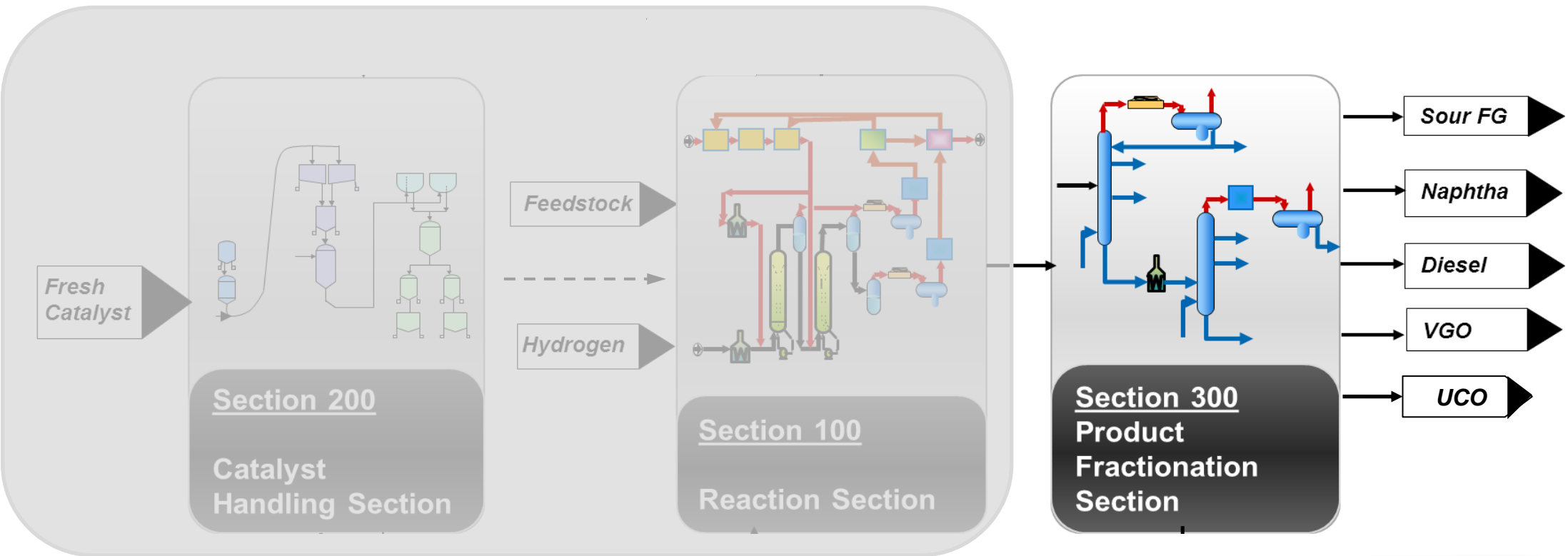
- › Relevant experience with “**Isotherming**” process
- › Have been short listed by Hengli (China) for H-Oil unit

• Flowserve

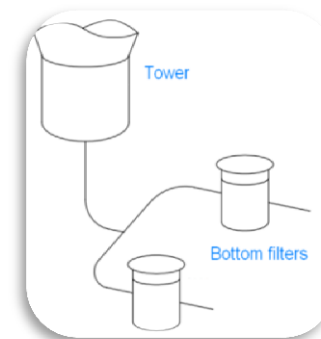
- › Leader in EB market
- › Latest two EB pumps supplied and serviced 100% from EU base
- › On-going Company business compliance process



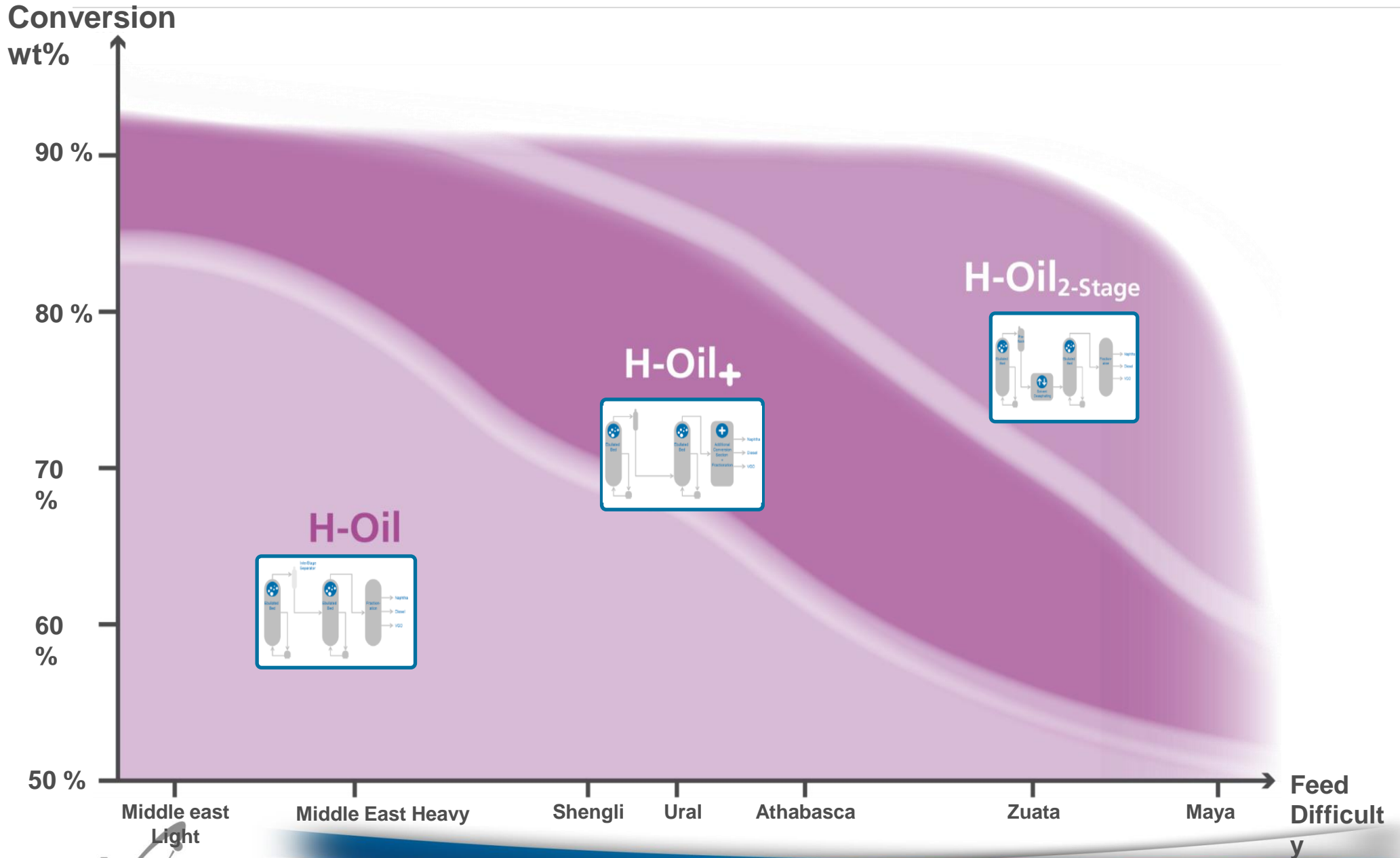
H-Oil Overall Block Flow Diagram



- **Optimal Vacuum Tower bottoms arrangement**
- **Energy efficient Spiral heat exchangers**



How much conversion can you get with H-Oil?



H-Oil[®]₊: Assets & Values Streamline

H-Oil[®] reactor design leverage



- **Maximize** catalytic performance for both conversion and hydrorefining
- **Balance** reactor size and operating conditions
- **Control** sedimentation

Sequential Deasphalting



- **Accommodate** high capacity
- **Overcome** stability issues thanks to asphaltene rejection
- **Balance** Hydrogen and/or utilities with pitch valorisation

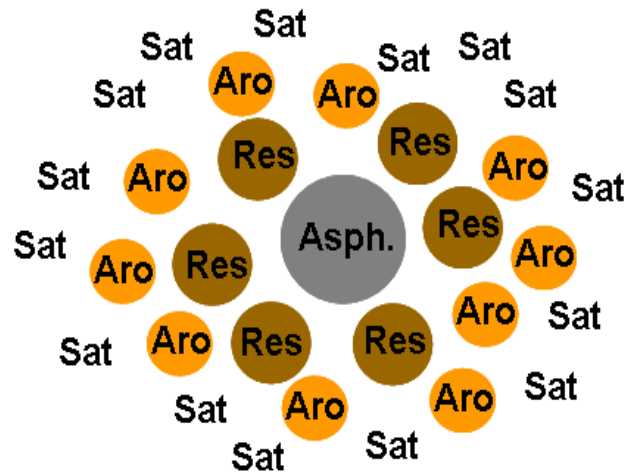
Coker Integration



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

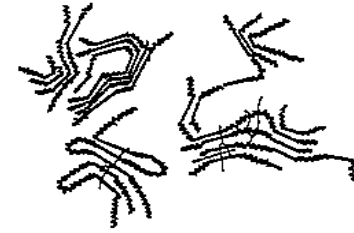
Understanding Effluent Stability

Saturates / Aromatics / Resins / Asphaltenes
MATRIX

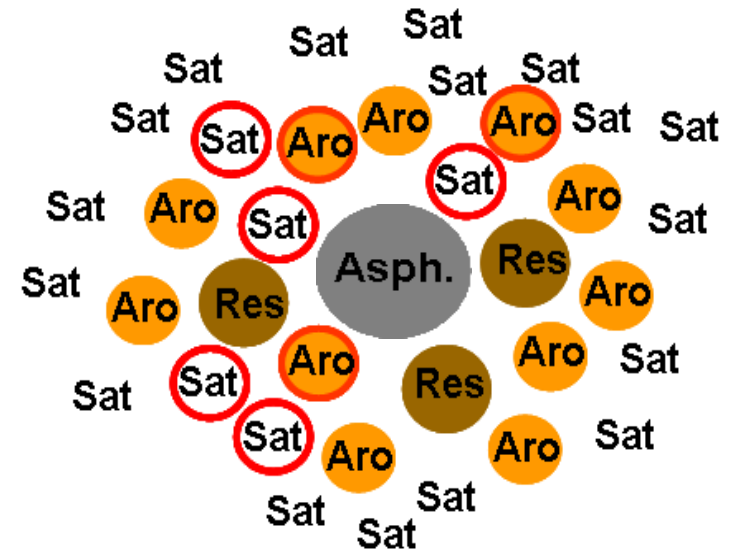


Asphaltenes are:

- the heaviest structures
- difficult to characterize
- difficult to convert
- potentially unstable



Conversion



When destabilized, Asphaltenes flocculate and cause:

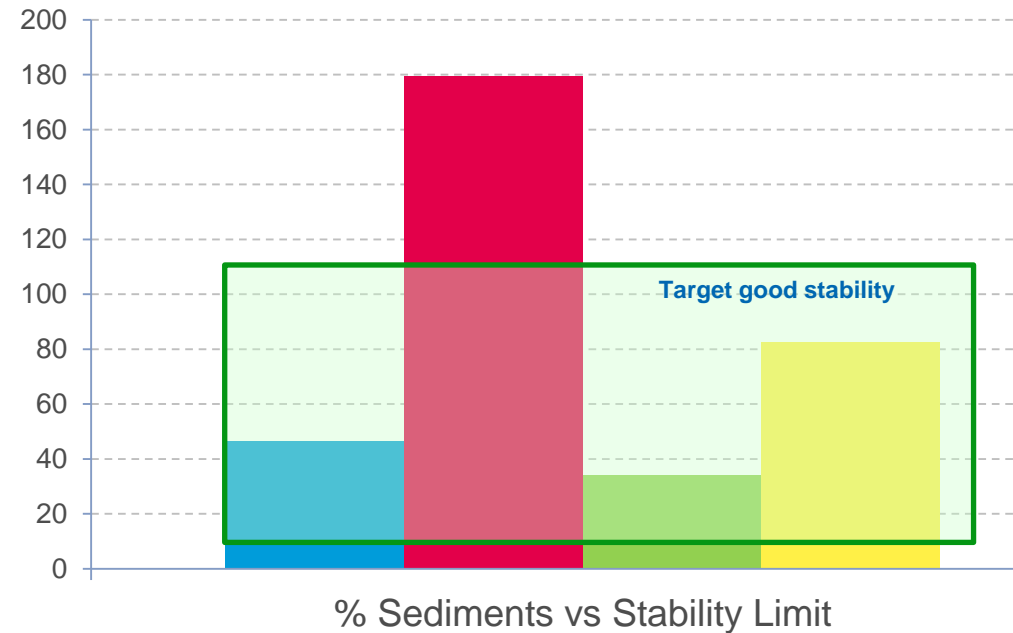
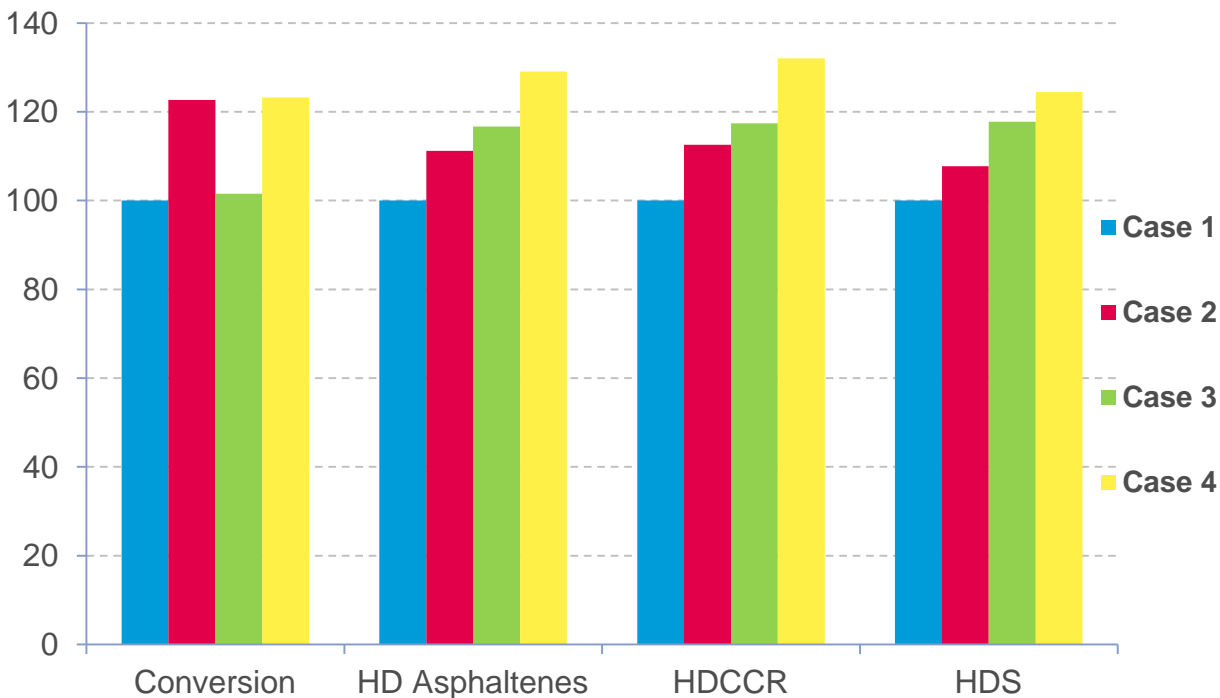
- Fouling & downtime for cleaning
- Sediment in products

How to Push the Conversion?

- Increase Temperature or Reduce space velocity?

	LHSV	Temperature	Conversion
Case 1	Base	Base	Base
Case 2	Base	Base + 14°C	Base x 120%
Case 3	Base/3	Base - 18°C	Base
Case 4	Base /3	Base	Base x 120%

- From Pilot Test Results with true EB pilot testing unit



How to Push the Conversion?

■ Temperature Increase

- Conversion increase driven by thermal cracking: compromises operability (sediments, fouling)

■ Reduce LHSV

- Lower LHSV is favorable towards sediment control at iso conversion
- At same temperature, lower LHSV is a powerful way to boost conversion and hydrogenation reactions
- Effluent quality is improved
- Catalytically driven conversion increase: delivers higher performance in HDCCR and HDAsph. Unlocks sedimentation barrier

H-Oil[®] Suite

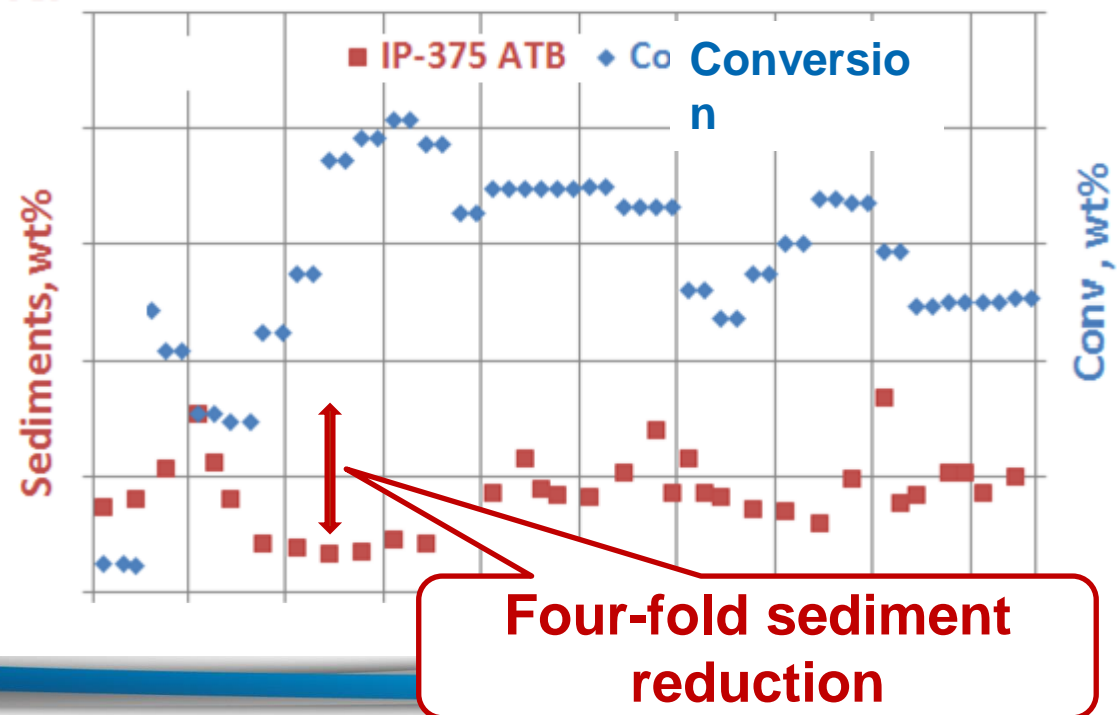
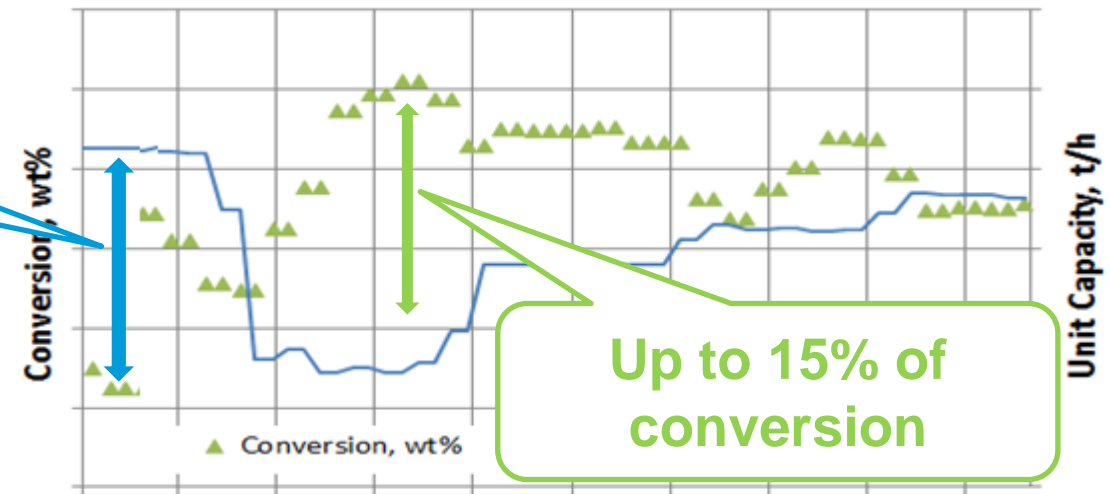
Conversion To Capacity Effect

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



H-Oil[®]₊: Assets & Values Streamline

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