

AXENS' IRAN SEMINAR  
TEHRAN - 28 TIR 1396 (19 JULY 2017)

# Latest Developments in Middle Distillates Hydroprocessing



**Cédric PERAT**

# Agenda

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- **Challenge about producing ULSD**
- **Axens Prime-D™ Offer**
- **Impulse™ Technology**
- **Case study**

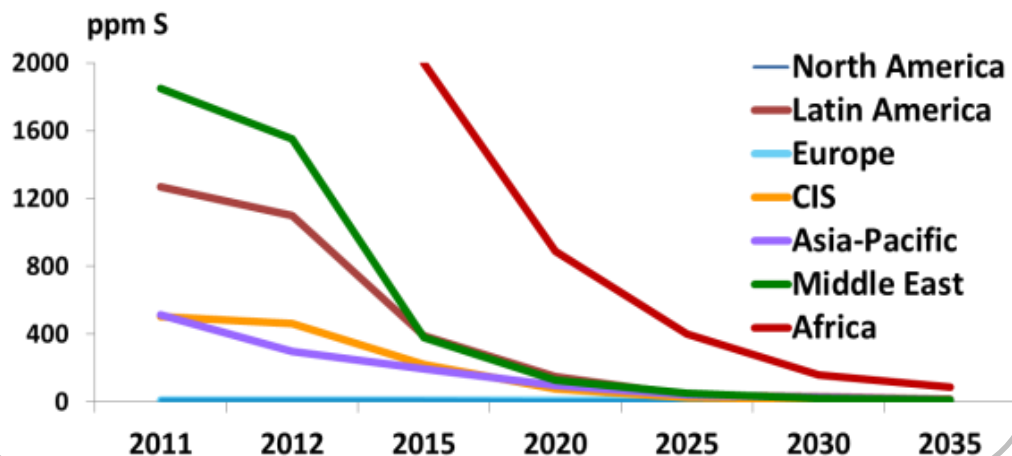
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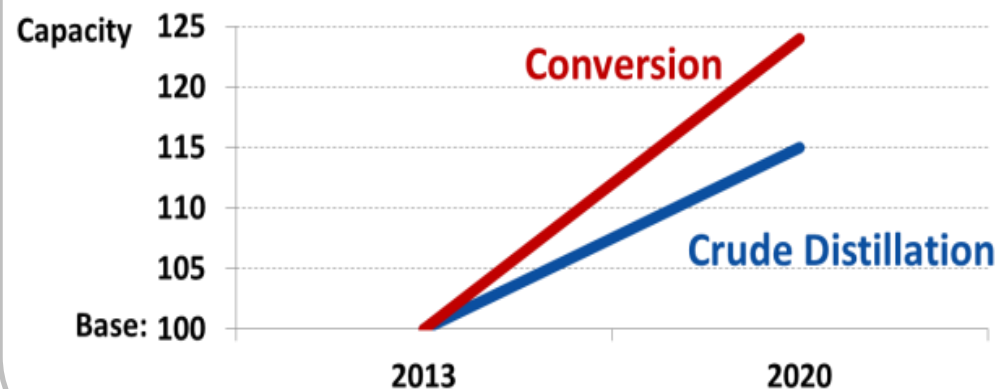
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# Trend for the Near Future

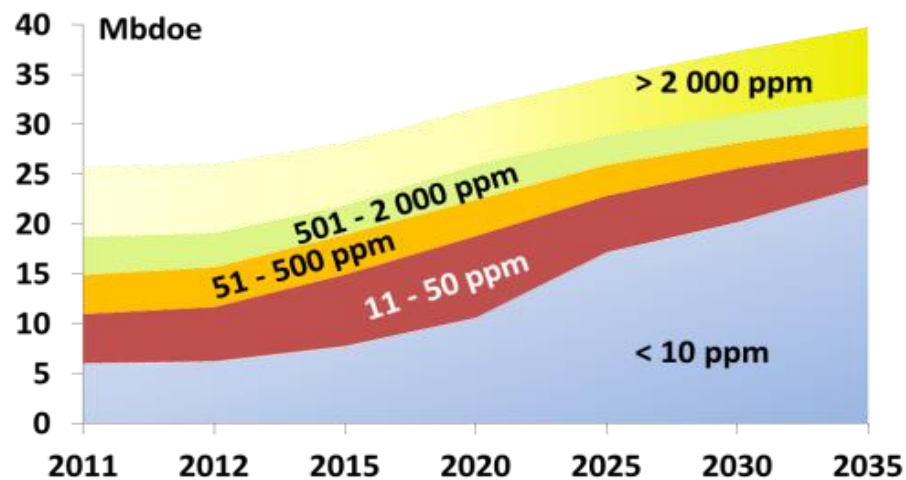
## More stringent Specifications



## Larger cracked feedstock



## Higher ULSD demand forecasts

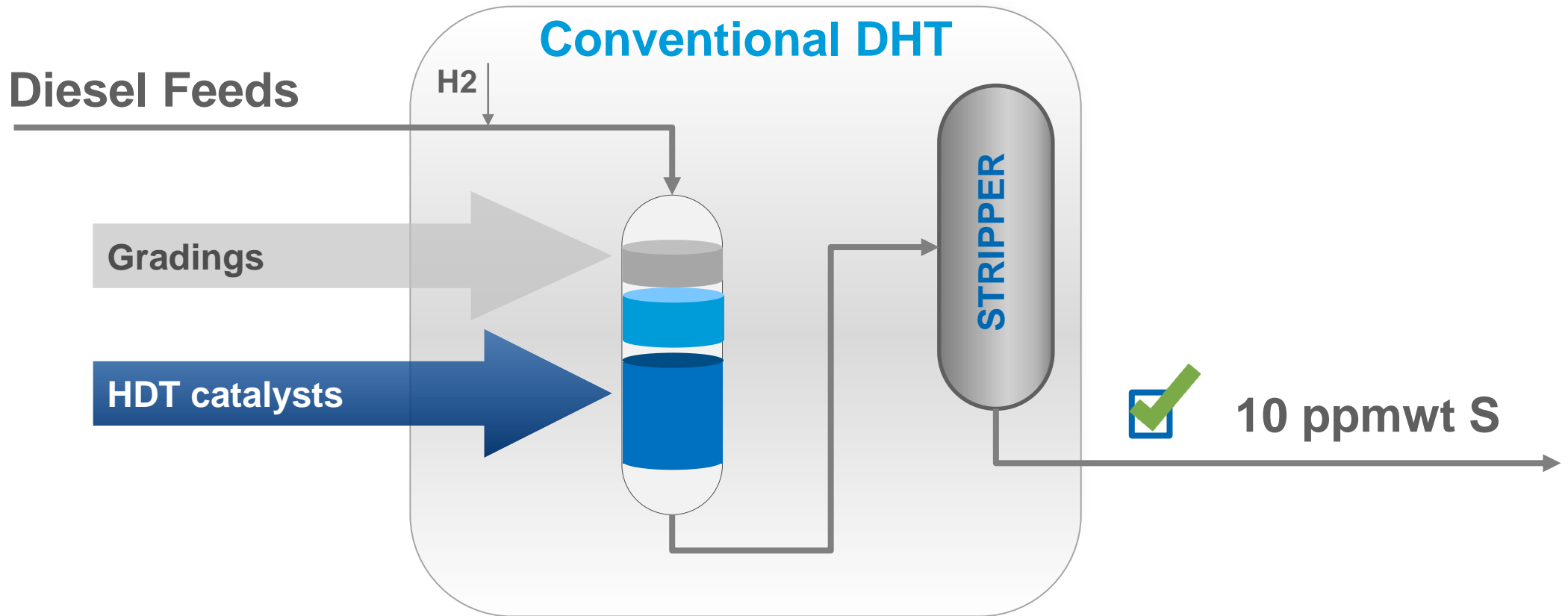


## Need for:

- High activity Catalysts
- Revamping & Grassroots Solutions

# Distillates Hydrotreatment

## Is it that Simple?



But...

- How to handle more and more refractory feedstocks?
- What about Condensates?



# ULSD Production Challenges: Cracked Feedstock

Cracked feed stocks origins:

**Thermal cracking:  
LCGO, VBGO**

**Cracked diesel:  
H-Oil, MHC, ARDS/VRDS**

**FCC : LCO**

Cracked feedstock is refractory:

**Higher level of difficult sulfur, nitrogen and  
polyaromatics compounds**

Performance & Operation Issues:

**Poisons**

**Hydrogen  
consumption**

**Fouling**

**Overtreating /  
feed fluctuations**

**Cycle length**

**Temperature  
effect**

**Deactivation**

**Little blending  
options**

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  - LCO / LCGO
  - H-Oil Diesel
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# Refractory Feedstocks

## LCO & LCGO Hydroprocessing Challenges

Same range of total Sulfur but lots of refractory species

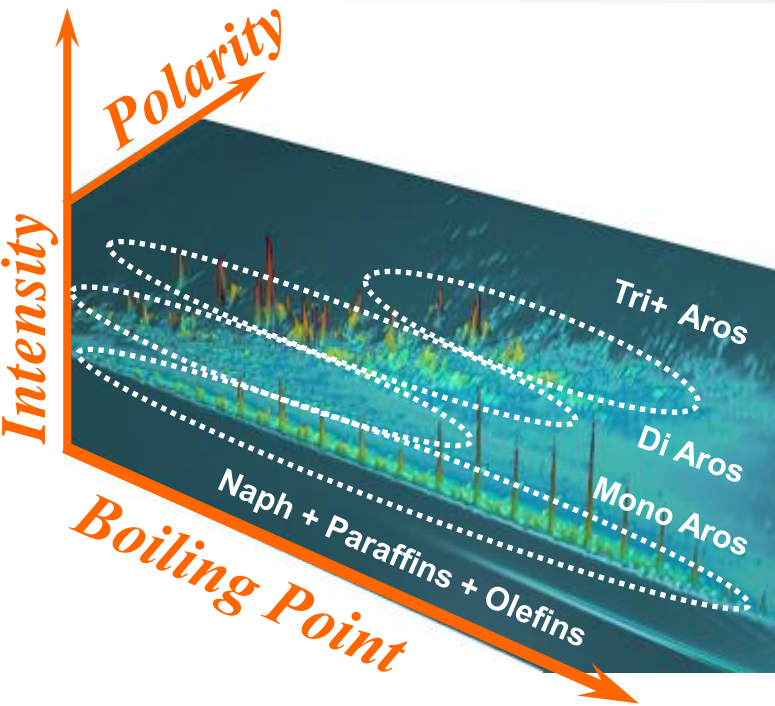
	SR Diesel	LCO	LCGO
S, wt %	0.5 – 2.0	0.2 - 2.5	0.5 – 3.0
S as DBTs, wt %	15 – 30	30 – 70	15 - 30
N, wtppm	50 - 300	200 - 1200	100 – 2000
Total Aro, wt %	20 – 30	65 – 90	30 – 50
Di-Aro+, wt %	5 – 15	40 – 70	10 – 20
Density	0.830 – 0.870	0.900 – 0.980	0.850 – 0.900
Cetane Number	45 - 60	15 - 30	35 - 50

Higher density / Lower cetane due to Higher aromatics content: Hydrogenation required

# Refractory Feedstocks

## Comprehensive Reaction Progress by GC 2D

LCO initially



Sulfur, ppm	15600
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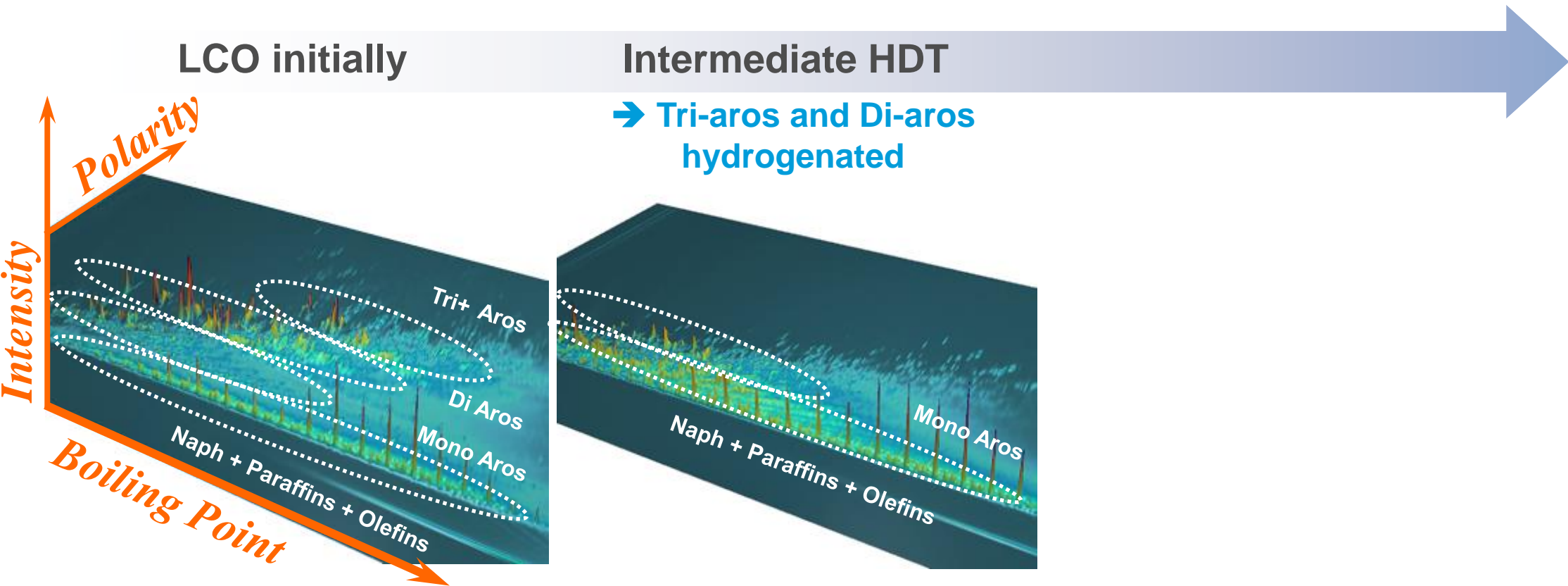
Nitrogen, ppm	1088
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Density	0.9415
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Cetane	27
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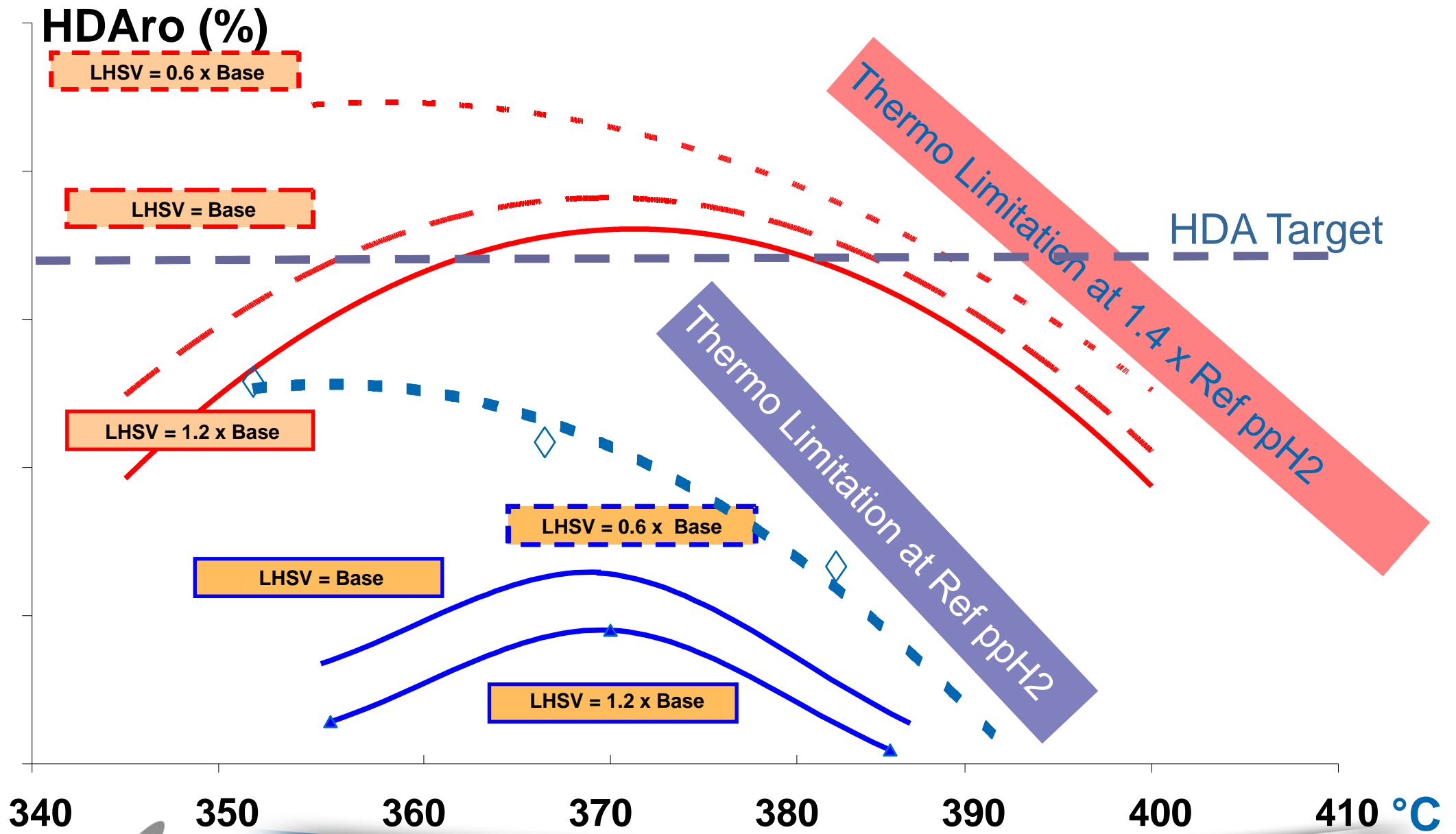
# Refractory Feedstocks

## Comprehensive Reaction Progress by GC 2D



Sulfur, ppm	15600	3
Nitrogen, ppm	1088	1.5
Density	0.9415	0.87310
Cetane	27	44

# Aromatic Hydrogenation Equilibrium Thermodynamic Limitations



# LCO processing

## Reference - Recently Awarded in South Asia



AWARD

### Objectives:

- Euro V specifications in diesel pool
- 4 years life cycle



### ULSD and Density & Cetane improvement targets for a mix of SRGO and LCO

Sp Gr@15°C 0.890

Cetane Index 36.7

Sulfur %wt 1.7

△ Density  
required: - 45

△ Cetane  
required: 12

- ✓ Medium pressure: 80 bar ppH<sub>2</sub>
- ✓ Impulse NiMo catalyst

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# Refractory Feedstocks

## Diesel Effluent from Residue Upgrading

	SR Diesel	H-Oil Diesel	Specification
S, wt %	0.5 – 2.0	0.1- 0.5	
N, wtppm	50- 200	1000- 2000	
Total Aro, wt %	20- 30	40	
Density	0.830 – 0.870	0.850- 0.870	0.845 max
Cetane Number	45- 60	42 - 44	51 min

Low content but refractory species

Strong inhibition

Low cetane  
Hydrogenation required

Refractory aromatics remained after Residue conversion unit, difficult to hydrogenate

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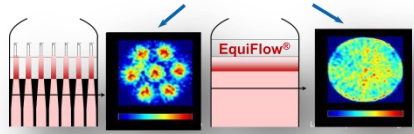
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- **Axens Prime-D™ Offer**
  - Hydrotreating Licensing
  - Catalyst Portfolio
- Impulse™ Technology
- Case study

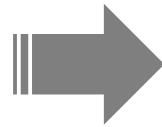
# Design Features

## Prime-D™ Process Optimization

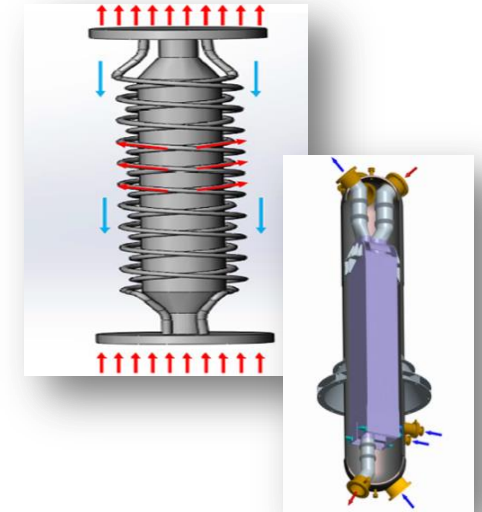
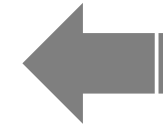


### EquiFlow® Hy-Tray™ & Hy-Quench™

- ✓ Improved distribution
- ✓ Improved Mixing efficiency
- ✓ Highly compact mixing boxes
- ✓ Higher flexibility



**Robust,  
Highly reliable and  
Energy efficient  
Prime-D™ process**



### High efficiency Heat Exchangers

- ✓ Spiral Tube exchanger (ZPJE) or Welded Plate exchanger (Packinox)
- ✓ Compacity
- ✓ CAPEX & OPEX reduction



### Custom & Efficient Early Design

- ✓ In House software for Heat Exchangers network optimisation
- ✓ Strong knowledge in Energy Efficiency

# Reactor Internals: EquiFlow<sup>®</sup> Hy-Tray<sup>™</sup> and Hy-Quench<sup>™</sup>

## ▪ New Quench Box developed

- ⇒ Flexibility of operation
- ⇒ Improved Mixing Efficiency
- ⇒ Height Reduction – Compact Design



New mock-up

Example for HCK service: new design showed potential for 10% more catalyst for a given typical reactor with several beds

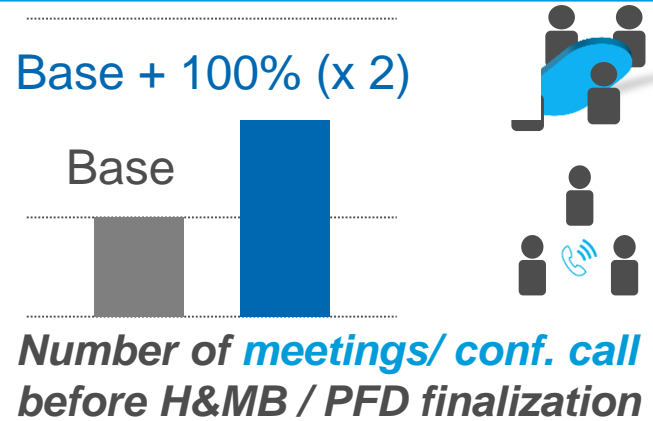
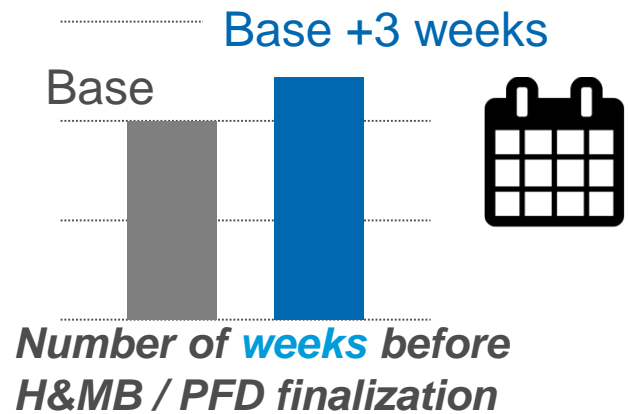
⇒ Significant Gain

Space reduction: up to 800 mm

# CEED: Collaborative Phase & Powerful Decision-Support Tool



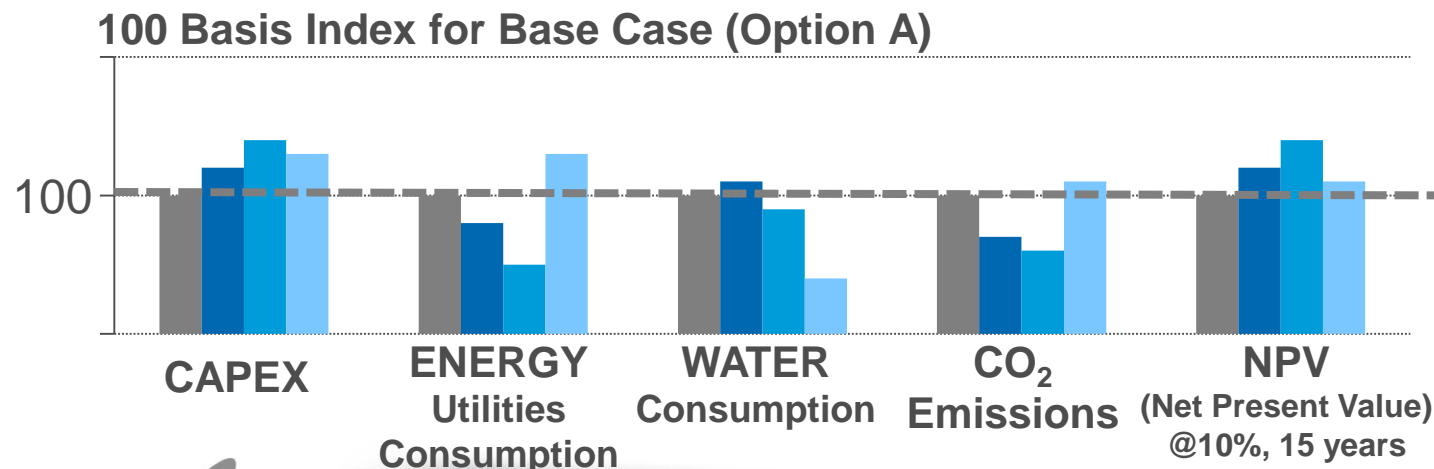
**A lot of exchanges with customer in a tight schedule...**



After licensor selection

- Typical
- With CEED

**... To propose various options evaluated using several criteria selected by the customer ⇒ A powerful decision-support tool**



+ Dedicated operability report for each option

**Options**

- A Base Case
- B Low Energy
- C Very Low Energy
- D Low Water



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# Axens' Unique Position Catalyst Portfolio



## Challenges

- **Conventional HDS/HDT Target**
  - With low H<sub>2</sub> consumption
- **Cracked/Heavy Feedstock**
- **Maximum Aromatics Saturation**
  - Volume Swell / Density Reduction
  - High Cetane Gain
- **Max T95/Density Reduction**
- **CFP Improvement**
- **Vegetal Oil Co Processing**

## Solutions

- ✓ **Highly active, outstandingly stable HDT catalysts**
  - CoMo / NiMo Catalysts
  - Ace™ & Impulse™ series
  - **Combined with Stacking knowledge**
- ✓ **Grading Strategy**
  - Scale Traps
  - Iron Sulfide, Si, Ni+V, As traps
  - Di-olefins and Olefin saturation catalyst
- ✓ **Complete Catalyst Portfolio**
  - Dewaxing / Cracking / Noble Metals solutions

# Middle Distillates Hydroprocessing Catalysts

Catalyst Type	CoMo		NiMo	
Unit Pressure	Low to Medium		Medium To High	
Target	High HDS	Max HDS	High HDS & HDA	Max HDS & HDA
Products	<div style="border: 1px solid black; background-color: #0070C0; color: white; padding: 5px; display: inline-block; margin-bottom: 5px;">HR 616</div> <div style="border: 1px solid black; background-color: #0070C0; color: white; padding: 5px; display: inline-block;">HR 626</div>	 <div style="border: 1px solid black; background-color: #0070C0; color: white; padding: 5px; display: inline-block;">HR 1246</div>	<div style="border: 1px solid black; background-color: #6A329F; color: white; padding: 5px; display: inline-block; margin-bottom: 5px;">HR 608</div> <div style="border: 1px solid black; background-color: #6A329F; color: white; padding: 5px; display: inline-block;">HR 648</div>	 <div style="border: 1px solid black; background-color: #6A329F; color: white; padding: 5px; display: inline-block; margin-bottom: 5px;">HR 1218</div> <div style="border: 1px solid black; background-color: #6A329F; color: white; padding: 5px; display: inline-block;">HR 1248</div>
Achievements	<div style="background-color: #0070C0; color: white; padding: 5px; display: inline-block;">HDS services</div>		<div style="background-color: #6A329F; color: white; padding: 5px; display: inline-block;">HDT services</div>	
	Lower H <sub>2</sub> cons.	Highest HDS Activity	Highest HDS & HDA Activity	Highest H <sub>2</sub> cons. Volume swell

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# Refractory Feedstocks



- Heavy Coker Gasoil – HCGO
- Heavy Light Cycle Oil – LCO
- Bitumen derived Diesel (Venezuelian crudes, ...)
- H-Oil<sup>®</sup> Diesel (ebullated bed)
- Coal Tar Diesel
- Vegetable fat Oil

**Refractory  
feedstocks**

=

**Low  
cost**

=

**High  
profit!**

**Upgrade required to:**

- ✓ Produce low Sulfur Diesel
- ✓ Maximize volume swell
- ✓ Product Properties Improvement (Cetane; Distillation)

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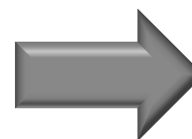
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# General Conclusion

Process Licensor + Catalyst Manufacturer  
Combination = maximum **client satisfaction**

Extensive  
Licensing  
Experience



**Unrivalled  
Refining  
Profitability**

New Superior Performance  
Impulse™ Catalysts



# Thank you! And see you on Axens' Blog axens.net/blog

