Direct Production of 10 ppm Sulfur Euro-IV Diesel with HyC-10™

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- Introduction
  - Strategy for European refining
  - Which level of MHC conversion?
- HyC-10™ Process
  - The integrated route to 10 wt ppm sulfur diesel
- Commercial results
- Future Developments
- Conclusion

Timetable for European Sulfur Specs.

	Sulfur, wt ppm		
	EU 2000	EU 2005	EU 2009
Gasoline	150	50	10
Diesel	350	50	10 under review

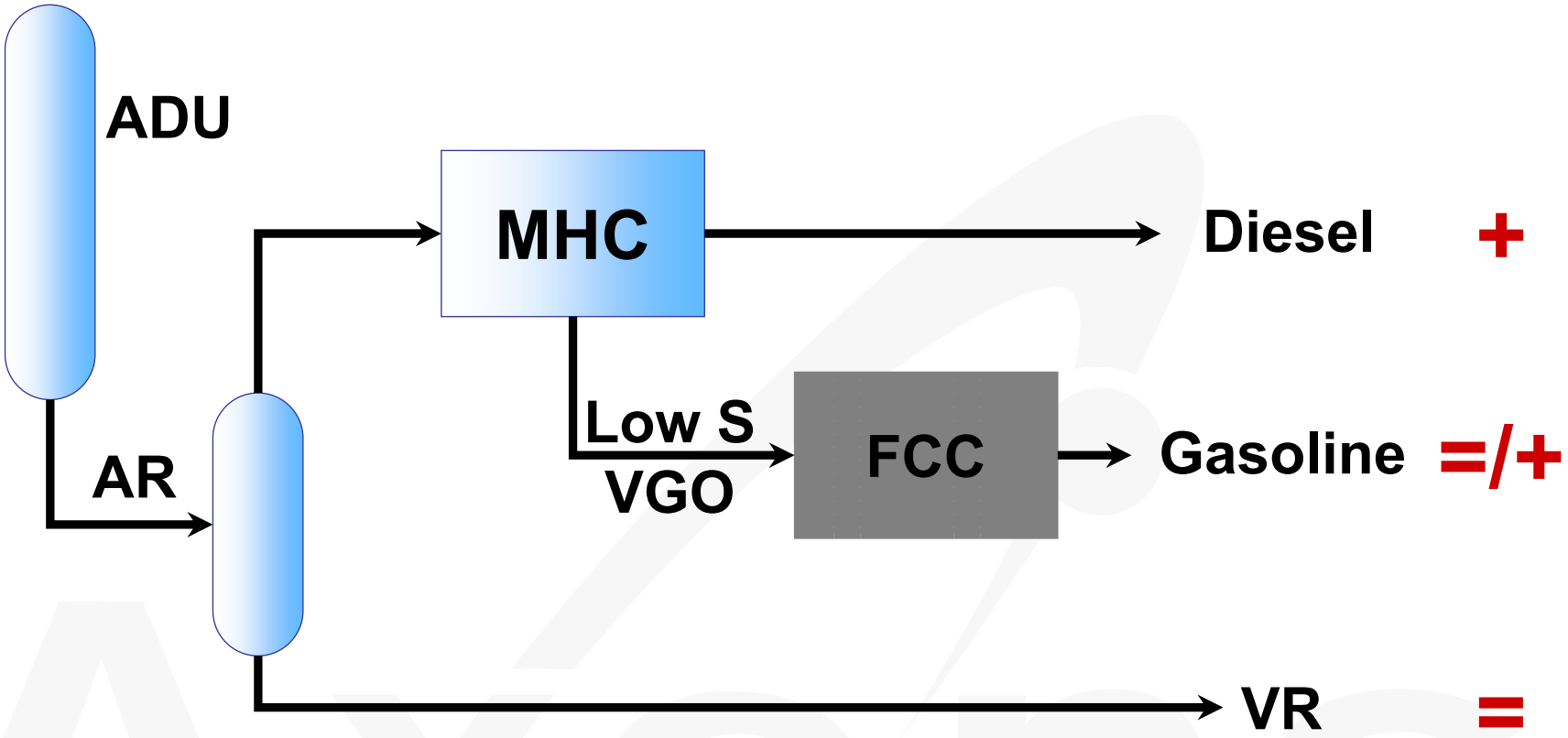
Strategy for European Refining

- **Mid-term**
  - **Steady demand for low sulfur gasoline**
  - **Continuous increase in ULSD**
  - **Reduction of fuel oil demand**
- **High oil prices**

Conversion is becoming a key word

MHC is a sensible first step

MHC integration



Which level of MHC Conversion?

- Low-medium conversion (20 to 40 %)
- Advantage
  - Sufficient FCC feed throughput to maintain gasoline production
  - FCC product yields and qualities
  - Optimized hydrogen consumption
- Drawback
  - Diesel quality not matching future spec.
  - Quality not constant along the cycle

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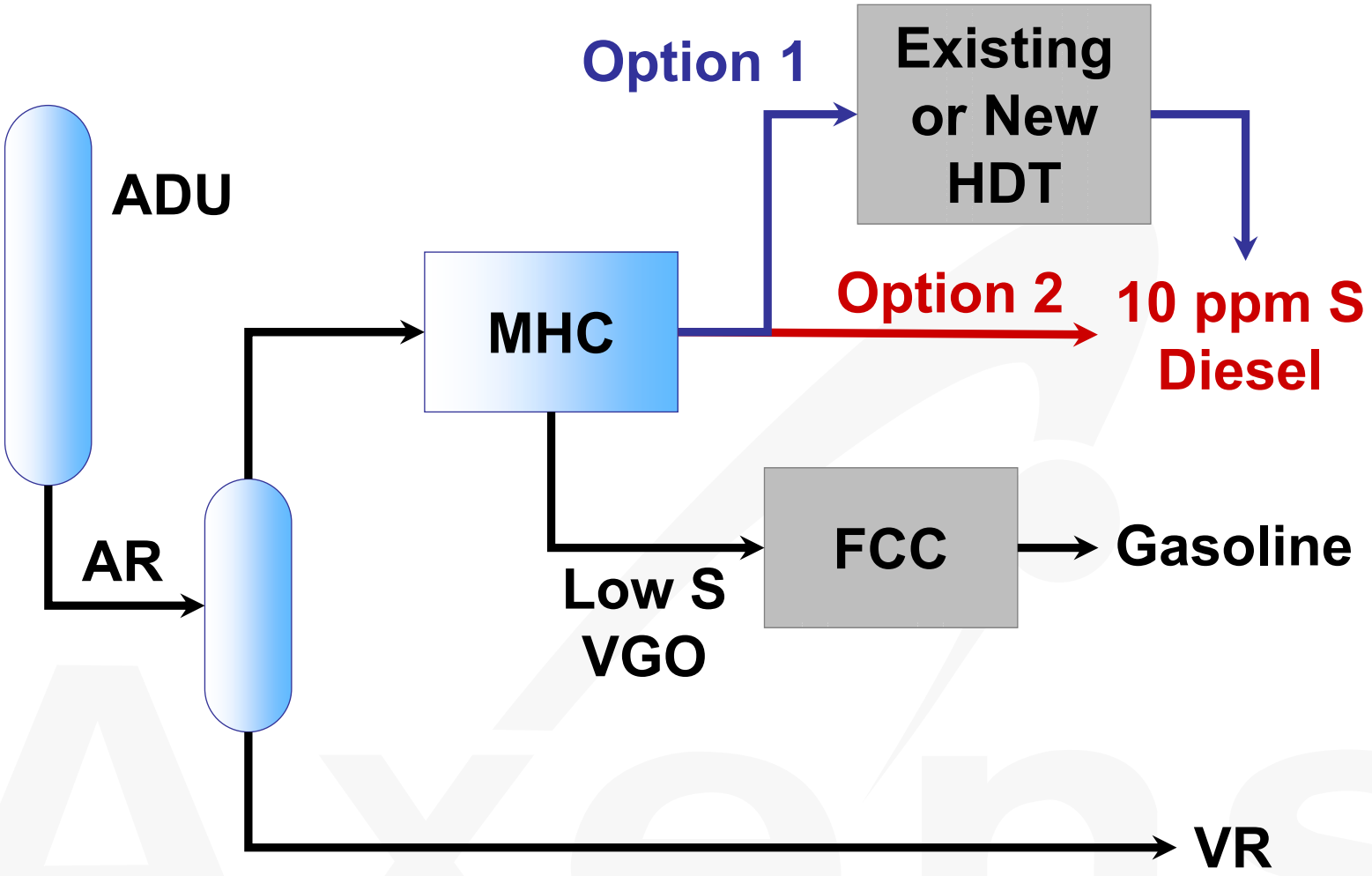
Typical MHC Characteristics

- H_2 partial pressure: 30 - 80 bar
- Conversion level: 20 - 45 vol.%
- Optimized quality of VGO for FCC
- Diesel quality: Cetane 43 - 49

How to reach < 10 ppm sulfur?

Producing 10 ppm sulfur diesel through mild hydroconversion



HDS Test Comparison
What Makes MHC Diesel Different?

	Partially hydrotreated straight run diesel	MHC Diesel
Specific gravity	0.8373	0.8867
Sulfur, wt%	265	340
ASTM D-2887, °C		
5%	217	182
50%	315	318
95%	402	382
DBT,% of total sulfur	6.0	5.1
4-DBT,% of total sulfur	56.7	59.2
4,6-DBT,% of total sulfur	37.4	35.7
Operating Conditions	Base	Base

HDS Test Comparison
Feed and Product Differences

	Partially hydrotreated straight run diesel		MHC Diesel
Feed			
Nitrogen, wt ppm	14		254
Aromatics, wt%	25		56
Product			
Sulfur, wt ppm	1.2		30
HDS,%	*99.55*	⟷	*88.19*

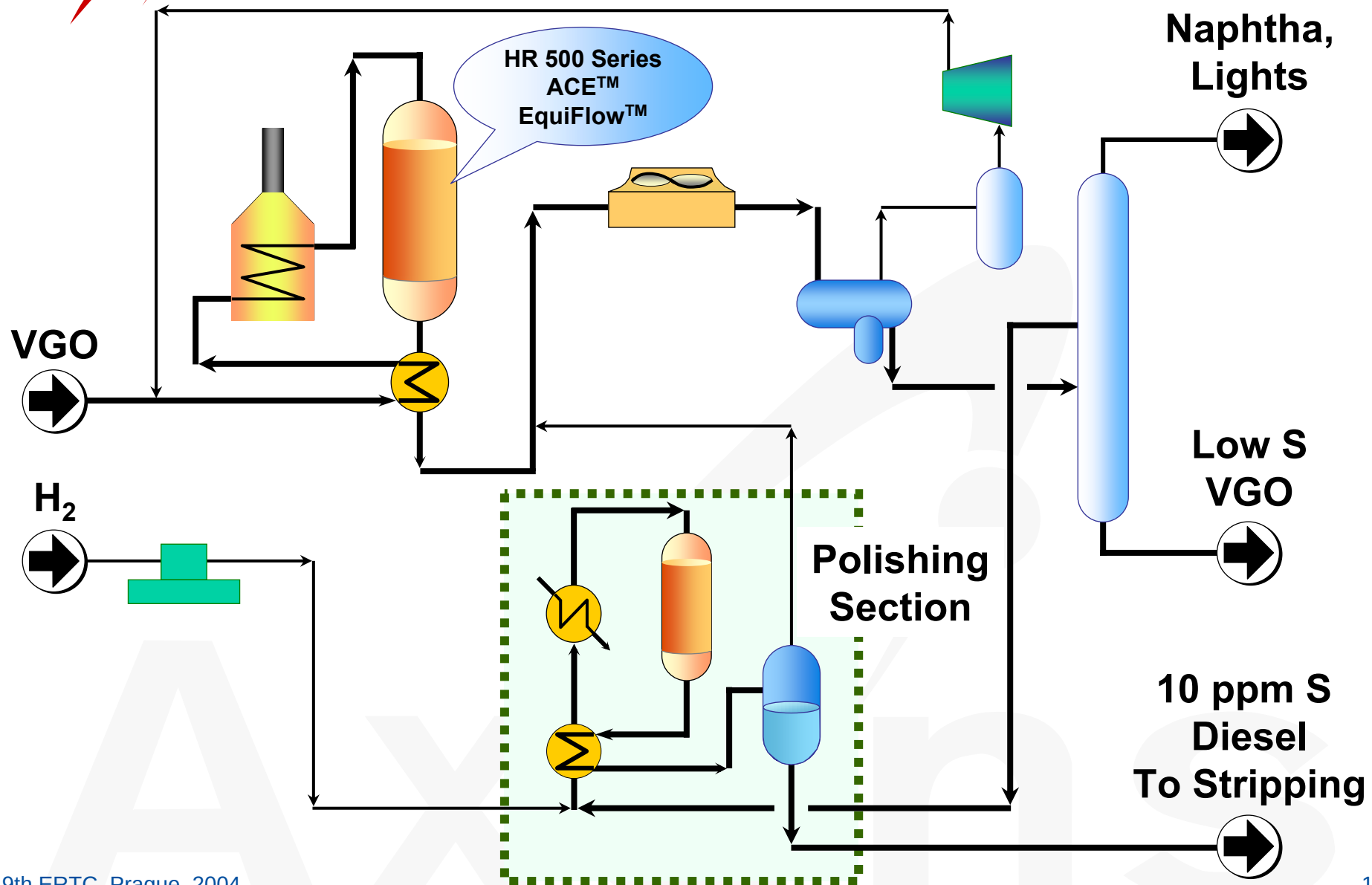
Conclusions from HDS Testing

- **MHC Converted diesel is more refractory than Straight Run diesel**
- **Difficult to make ULSD directly from the typical MHC diesel cut in an existing HDS unit**
- **New HDS unit needs more severe operating conditions compared to a standard SR HDS unit**

HyC-10™ Development Guidelines

- Retain MHC & FCC investment
- Limit CAPEX & OPEX
- Adjust production toward diesel demand
- Limit H_2 consumption
- Ensure constant MHC conversion AND ULSD production independently

HyC-10 Process



HyC-10 Scheme Advantages

- **Operating conditions of diesel HDT reactor**
  - **Optimized hydrogen partial pressure due to pure hydrogen injection**
  - **Optimized reactor size by lowering H_2S partial pressure**
- **Equipment savings**
  - **Saves 2 compressors, 1 air cooler**
- **Utilities**
  - **Optimized H_2 usage**
  - **Allows for better heat integration between the 2 sections**
- **Consequence**
  - **Saves 35 - 40% of the diesel HDT ISBL cost**

Economics*

- **HyC™ Processes**

H_2 consumption, wt%	0.6 – 1.5
ISBL investment, €/bbl	1,600 – 2,200
Catalysts + utilities, €/bbl	0.30 – 0.50

*** Order of magnitude figures**

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Repsol YPF – First Commercial Plant

- June 2004 start-up at Puertollano Refinery
- VGO conversion objective ~ 35 %
- 10 ppm diesel production
- Low sulfur & nitrogen feed to FCC
- HR 400 Series catalysts
- EquiFlow distributor trays technology

Feedstock to HyC-10 unit during test run

Capacity, BPSD	37,000
Specific gravity	0.9253
Sulfur, wt %	2.11
Nitrogen, wt ppm	1 523
ASTM D-1160, °C	
10%	337
50%	439
90%	520

Yields from Repsol YPF HyC-10 unit

	vol.%
Naphtha	3.0
Diesel	33.6
Residue	65.8
Conversion, wt%	35

Diesel and Residue Product Quality

Diesel

Specific gravity	0.868
Sulfur, wt ppm	3.8
Cetane Index	47.7
ASTM D-86 – 95%, °C	359

Residue

Specific gravity	0.909
Sulfur, wt ppm	< 100
Nitrogen, wt ppm	< 100
H_2 content, wt%	13.0

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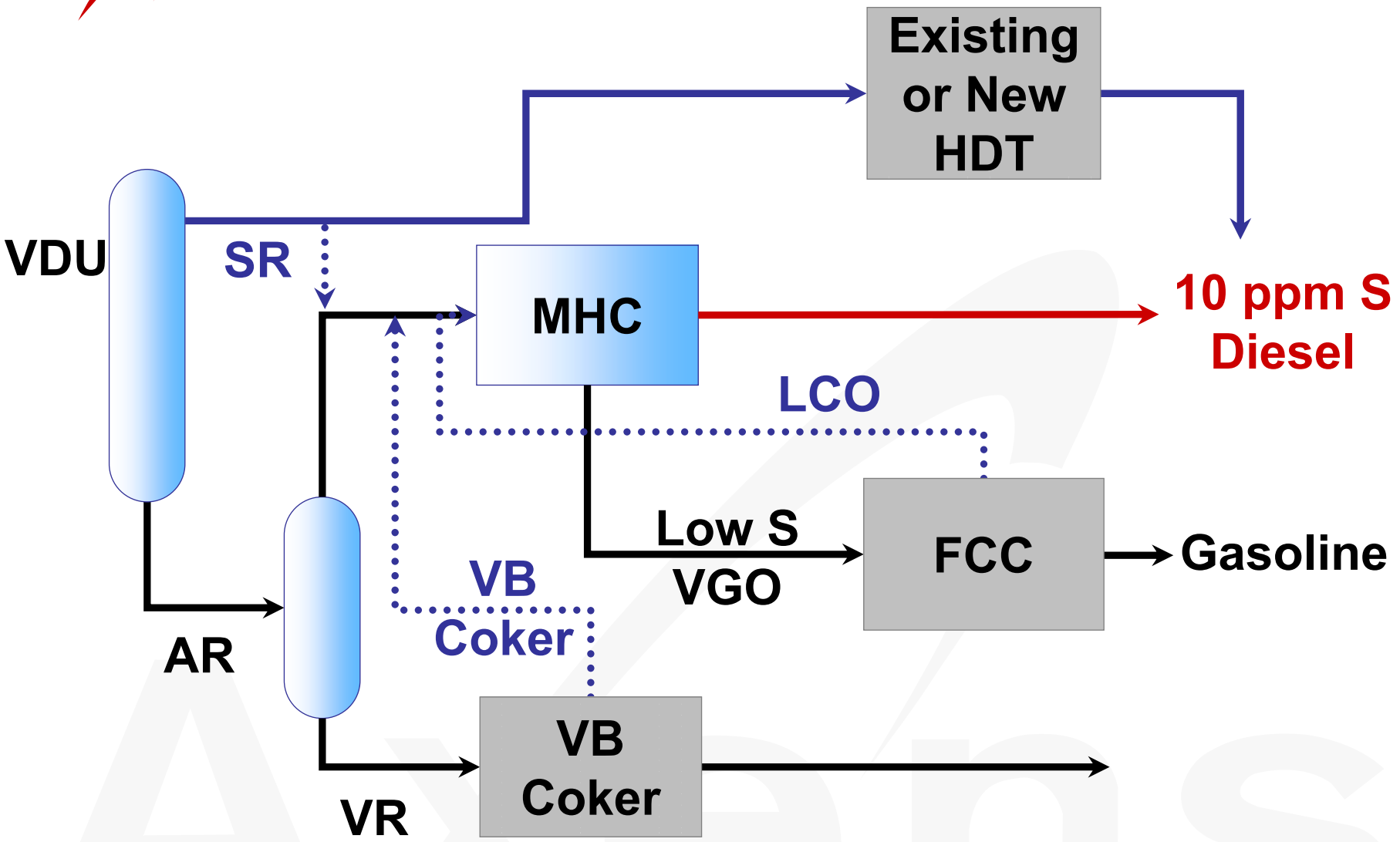
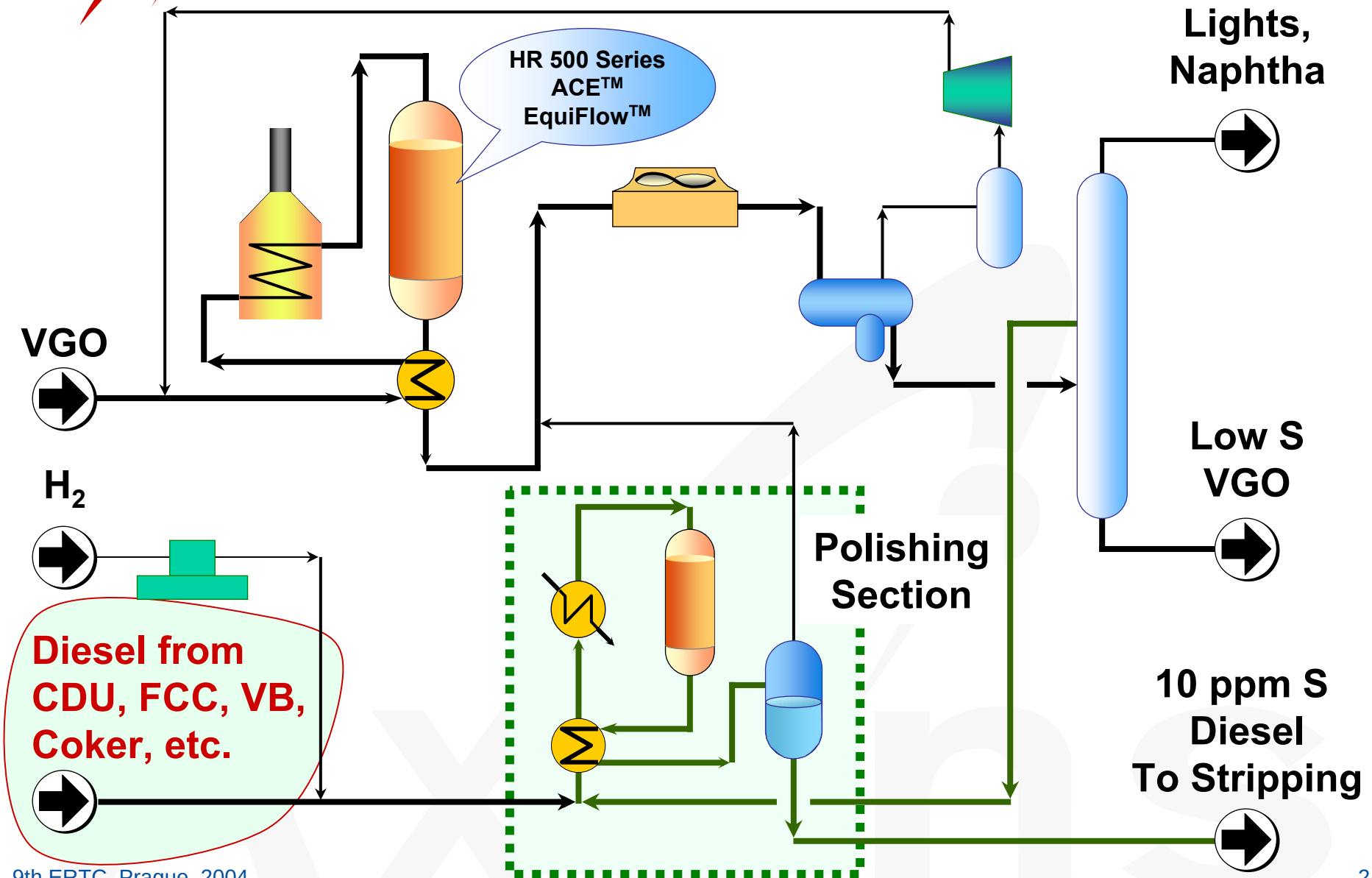
Future Developments HyC-10+



HyC-10+ Process



Motor Oil Hellas's HyC-10+ Unit Feedstock Design Bases

	VGO to MHC	SR Diesel + Light Cycle Oil to polishing
Capacity, BPSD	37,000	22,000
Specific gravity	0.932	0.873
Sulfur, wt%	2.67	1.85
Nitrogen, wt ppm	1 392	523
ASTM, °C	D-1160	D-86
10%	363	210
50%	447	322
90%	548	358
Feed Conversion, wt%	**32.5**	

Motor Oil Hellas's HyC-10+ Design Bases Product Quality

	Diesel
Specific gravity	0.845
Sulfur, wt ppm	8 max.
Cetane Index	47 min.
Polyaromatics, wt%	5 max.
	Residue
Specific gravity	0.897
Sulfur, wt ppm	< 600
Nitrogen, wt ppm	< 500
H_2 content, wt	13.2

HyC-10+: Latest Developments

- Processing cuts other than MHC diesel—light cycle oil, heavy atmospheric, VB, Coker diesels—in the polishing reactor
- Additional Advantages
  - Up-grade FCC Light Cycle Oil for 10 ppm diesel pool
  - Avoid revamping existing HDS unit or investing in new HDS unit
- One license awarded (start-up 2005)

Conclusion (1/2)

- **VGO conversion: key to coping with stable ULSG demand and increasing demand for ULSD**
- **HyC-10 technology separates ULSD quality & steady MHC conversion throughout cycle**
  - **ULSD, ULSG and optimum CAPEX, OPEX**
  - **Excellent FCC feed**
  - **Lower hydrogen consumption, more efficient utilization**

Conclusion (2/2)

- **Benefit from HR 500 Series catalysts with ACE™ technology**
- **Use EquiFlow™ internals: distributor trays and quench devices**

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