

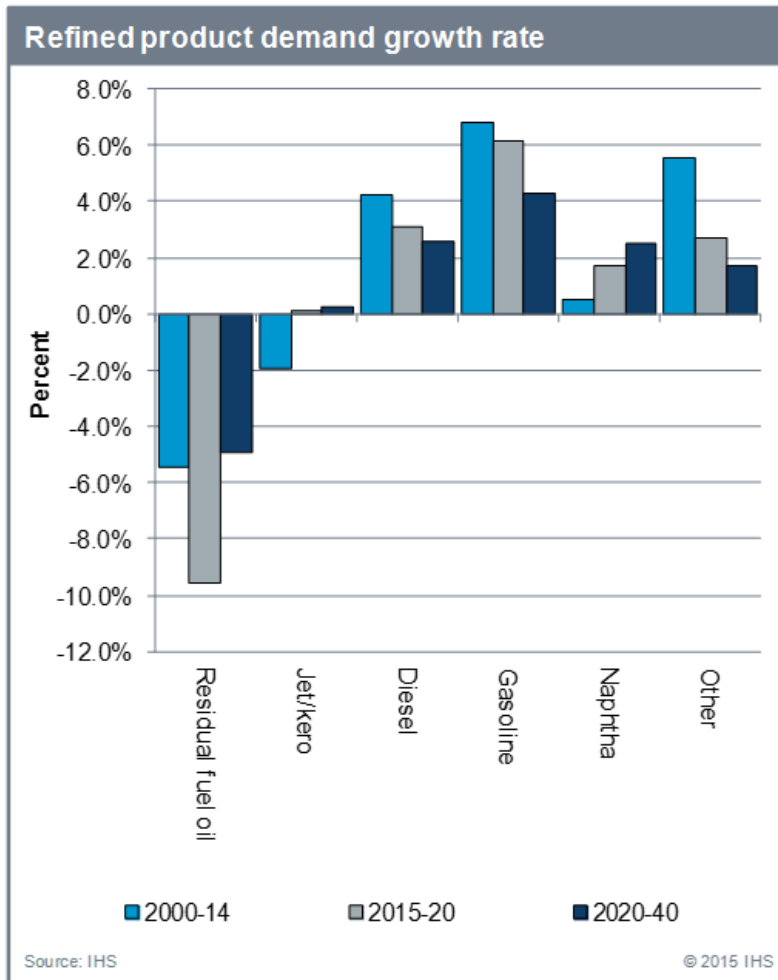
Jim Rekoske
VP & Chief Technology Officer
Honeywell UOP

Quenching Our Thirst for Clean Fuels

22 April 2016 | Petrofed Smart Refineries | New Delhi, India

Honeywell
UOP

India's Demand for Clean Gasoline



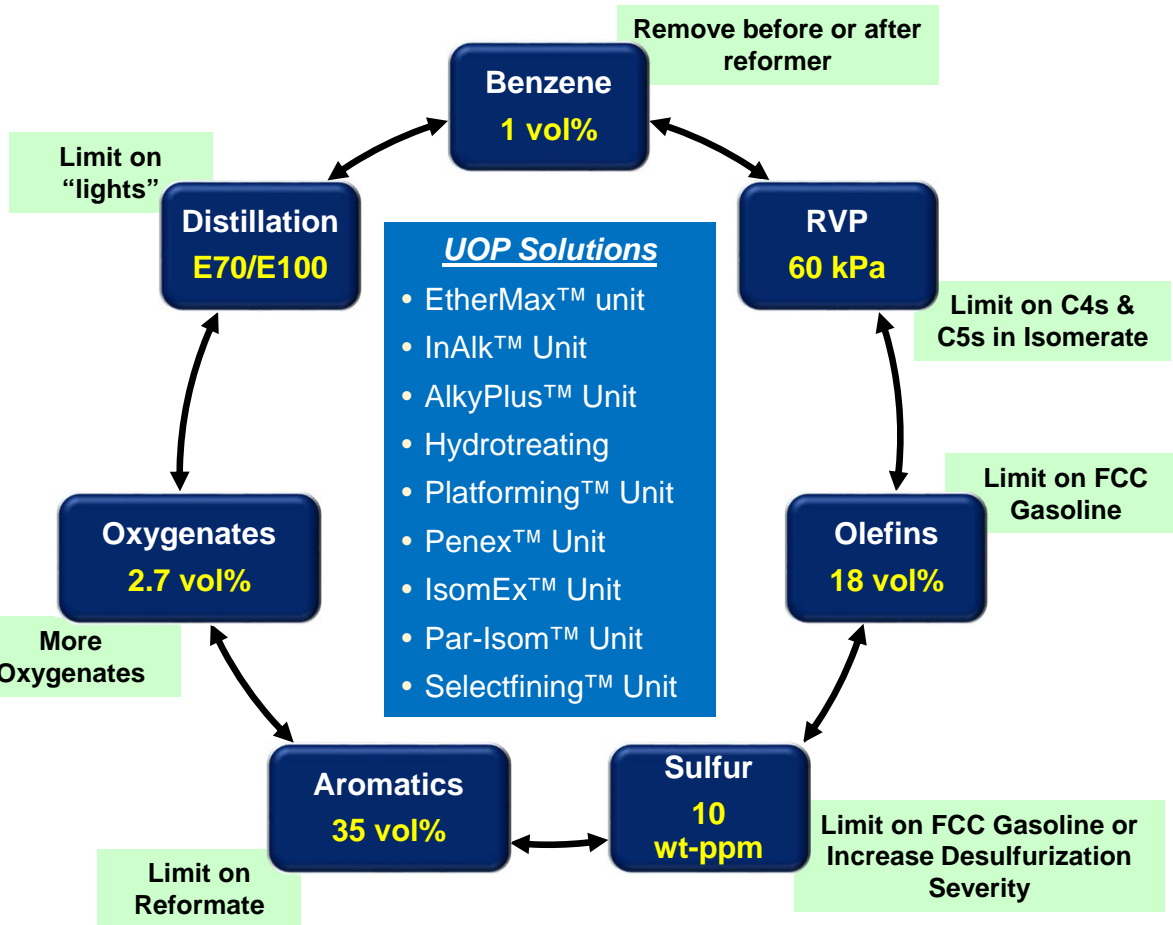
Drivers

- Improved economic outlook – higher spending on Fuels and Plastics – 7.6% annual GDP growth possible over next 5 years
- Need for air quality Improvement – regulations for Fuel specs upgrade
- Dependence on imported crude
- Refinery utilization at or near 100% (nominal basis) for many units

Trends

- Demand has caught up with supply – need for new investment planning
- Nationwide upgrade to BS IV fuel by Q1'17 and EBSVI by 2020
- Maximize value from crude imports through efficiency, upgrading
- Automobile sales growth of ~10%
- Gasoline growth outpaces diesel

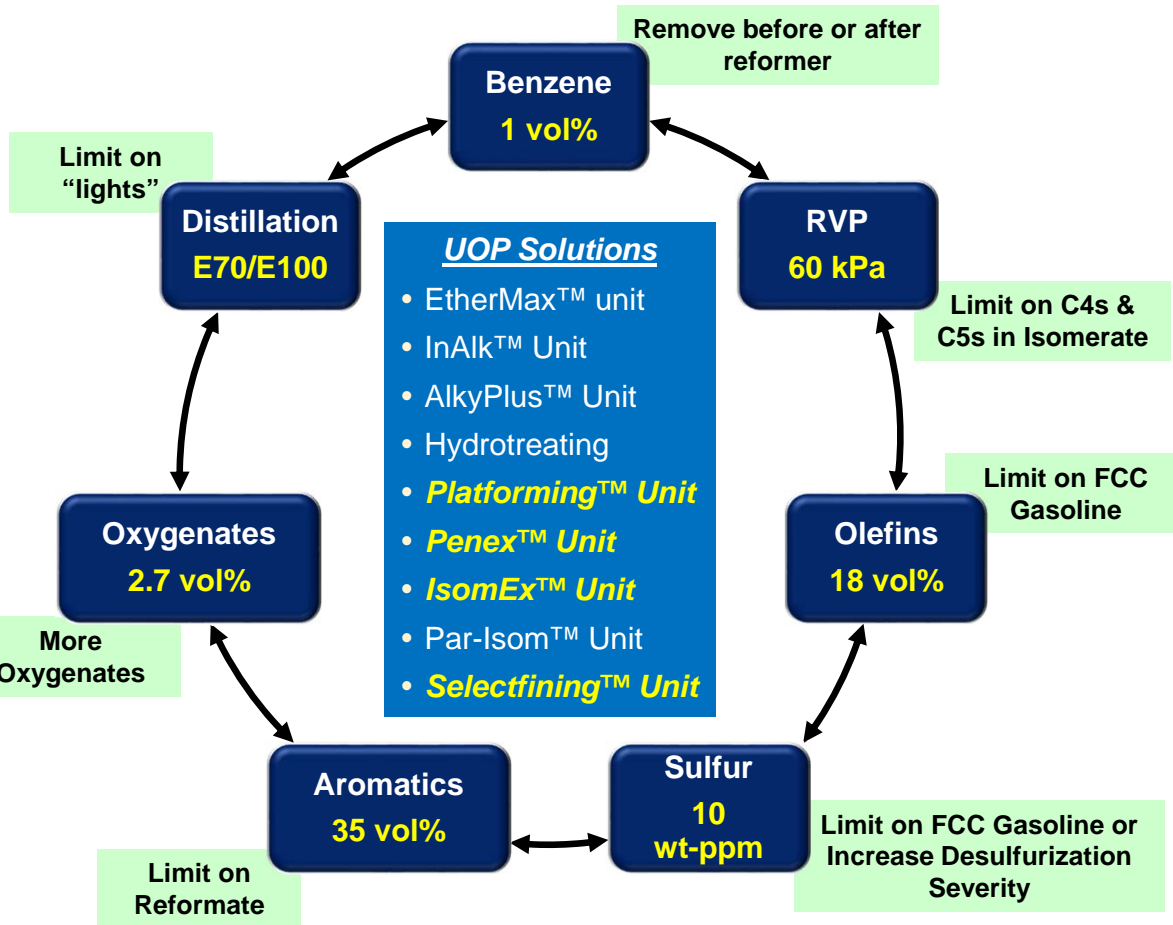
A Balancing Act: Bharat VI Specs with Maximum Profit



- How can I blend more FCC Gasoline and control olefins and sulfur?
- How do I drive octane yield and aromatics to the limit?
- Where is the rest of my octane going to come from?

Many constraints – optimal solution?

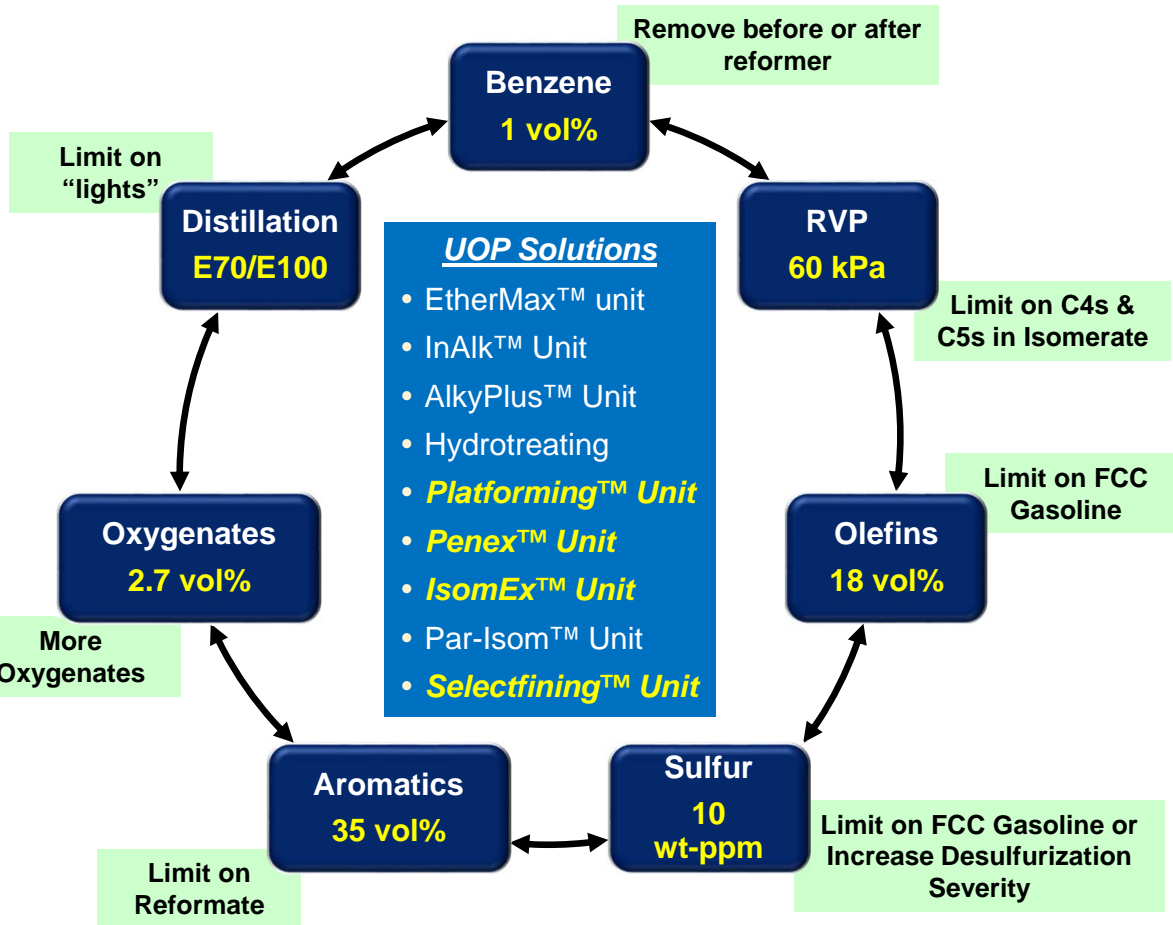
A Balancing Act: Bharat VI Specs with Maximum Profit



- How can I blend more FCC Gasoline and control olefins and sulfur?
- How do I drive octane yield and aromatics to the limit?
- Where is the rest of my octane going to come from?

Many constraints – optimal solution?

A Balancing Act: Bharat VI Specs with Maximum Profit



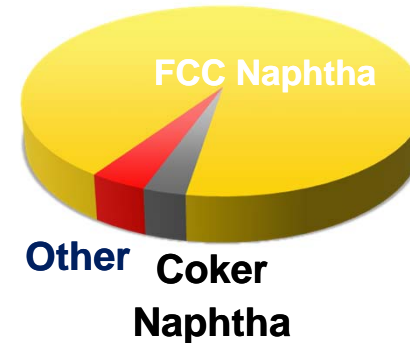
- How can I blend more FCC Gasoline and control olefins and sulfur?
- How do I drive octane yield and aromatics to the limit?
- Where is the rest of my octane going to come from?

Many constraints – optimal solution?

Indian Refiner Gasoline Pool Requirements

		BS III	BS IV	BS VI
Density @ 15 °C	kg/m ³	720-775	720-775	720-775
E-70	% vol	10-45	10-45	10-45
E-100	% vol	40-70	40-70	40-70
E-150	% vol min	75	75	75
FBP	°C	210	210	210
Sulfur	ppm max	150	50	10
RON	Min	91	91	91
MON	Min	81	81	81
RVP @ 38 °C	kPa	60	60	60
Benzene	vol % max	1	1	1
Aromatics	vol % max	42	35	35
Olefin	vol % max	21	21	18
Oxygen	wt% max	2.7	2.7	2.7

Sources of sulfur in typical gasoline pool



- FCC naphtha represents ~40% of the volume of the typical refinery's gasoline pool

UOP Confidential Information

How do we manage both S and olefins in FCC gasoline?

UOP's Portfolio of FCC Naphtha Desulfurization Technologies

- **Merox™ process**
 - extraction or sweetening of mercaptan components of FCC Light Naphtha (LCN) and Mid-cut Naphtha (MCN)
 - Does not remove thiophenes
- **SelectFining™ process**
 - desulfurization and octane retention for FCC FBR, MCN or HCN

Technology choice is based on octane requirements, feedstock composition, product values and required desulfurization.

SelectFining Technology Overview

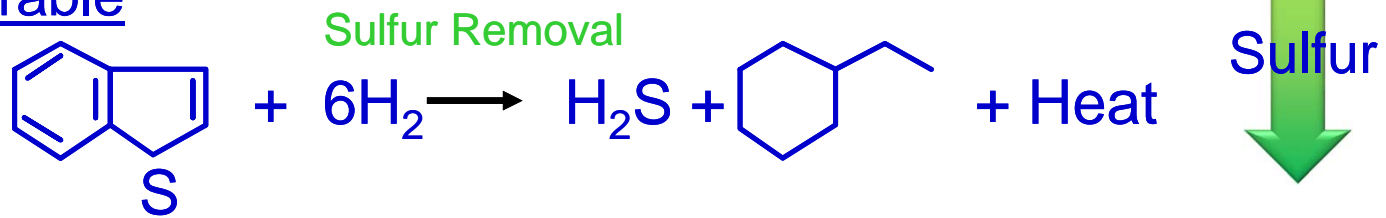
- Achieve low S target in Gasoline Pool
 - Can achieve <10 wt-ppm S in FCC Gasoline
- Maximum Octane Retention to Meet Specifications
 - Lowest Hydrogen Consumption
- Flowschemes for Various Feedstocks Optimized for Maximum Economical Value
 - One Stage for low sulfur feedstock (or $\leq 90\%$ HDS)
 - Two Stage for high sulfur feedstock and $> 90\%$ HDS
 - Depends on feed characteristics and product requirements
- High Stability Specialized Catalysts
 - Specialized Co/Mo catalyst with optimized metals levels and distribution
 - Suitable for all FCC naphtha hydrotreating applications where selectivity to favor desulfurization over olefin saturation is required

UOP Confidential Information

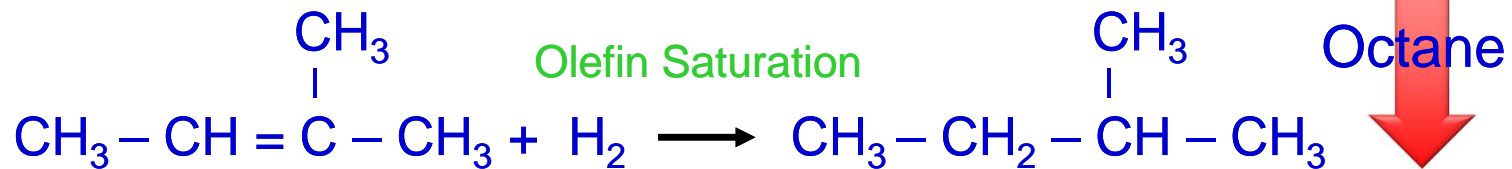
Optimum Flowscheme and Catalysts for particular needs

Issues Relating to Hydrotreating FCC Naphtha

Desirable

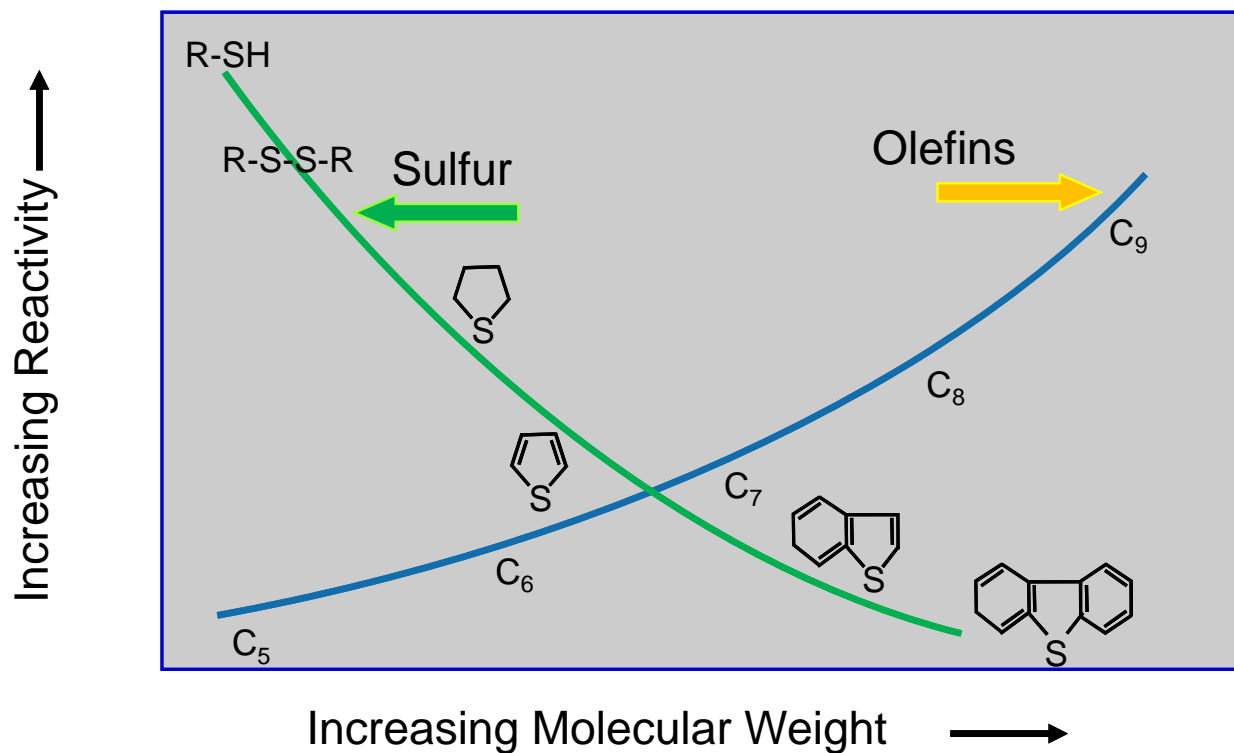


Undesirable



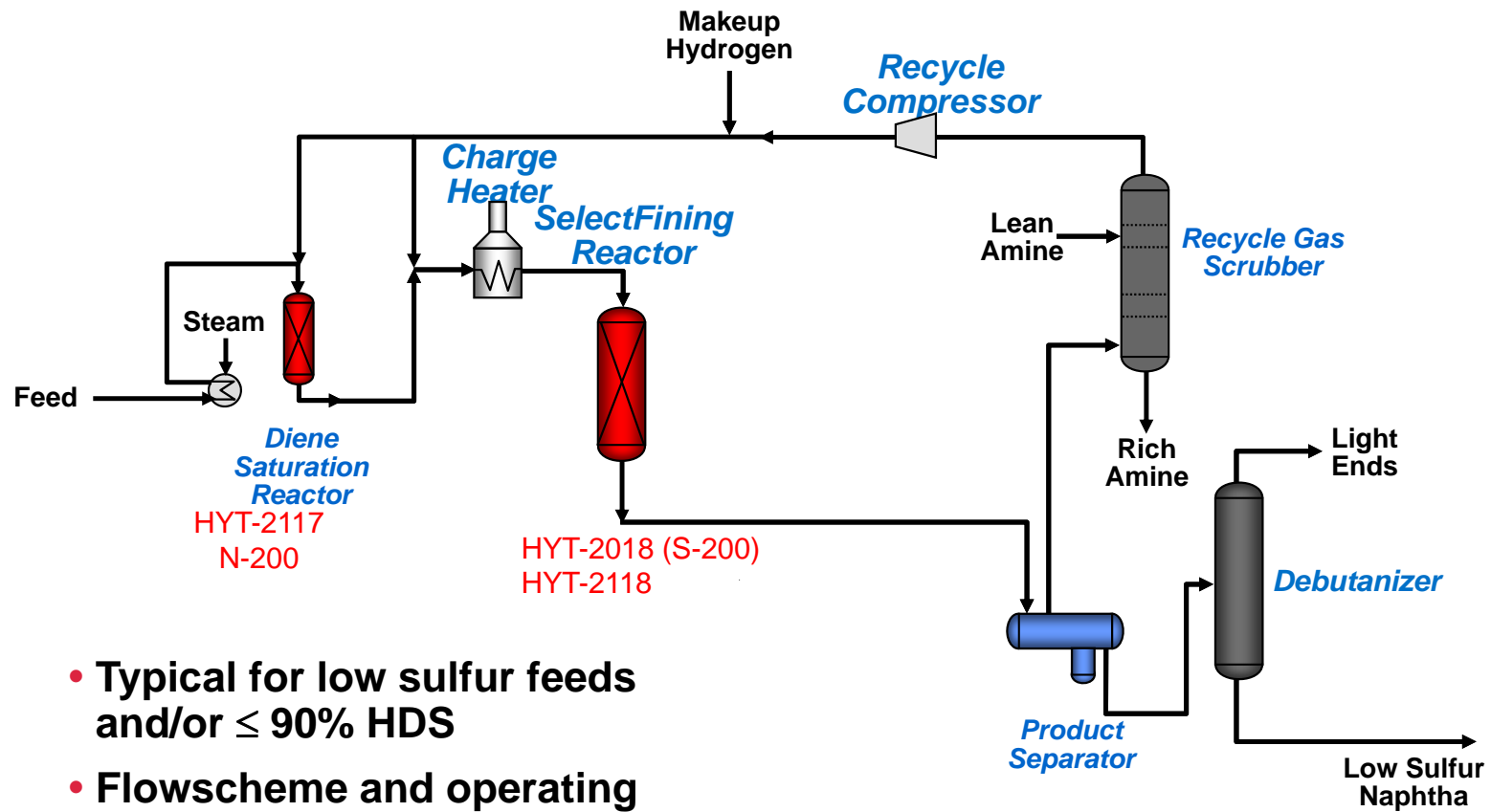
Octane loss is dependant on feed/product sulfur contents, and quantity/types of naphtha's sulfur and olefin species!

Relative Reactivity of S and Olefins in FCC Gasoline



UOP Confidential Information

UOP One-Stage SelectFining Process

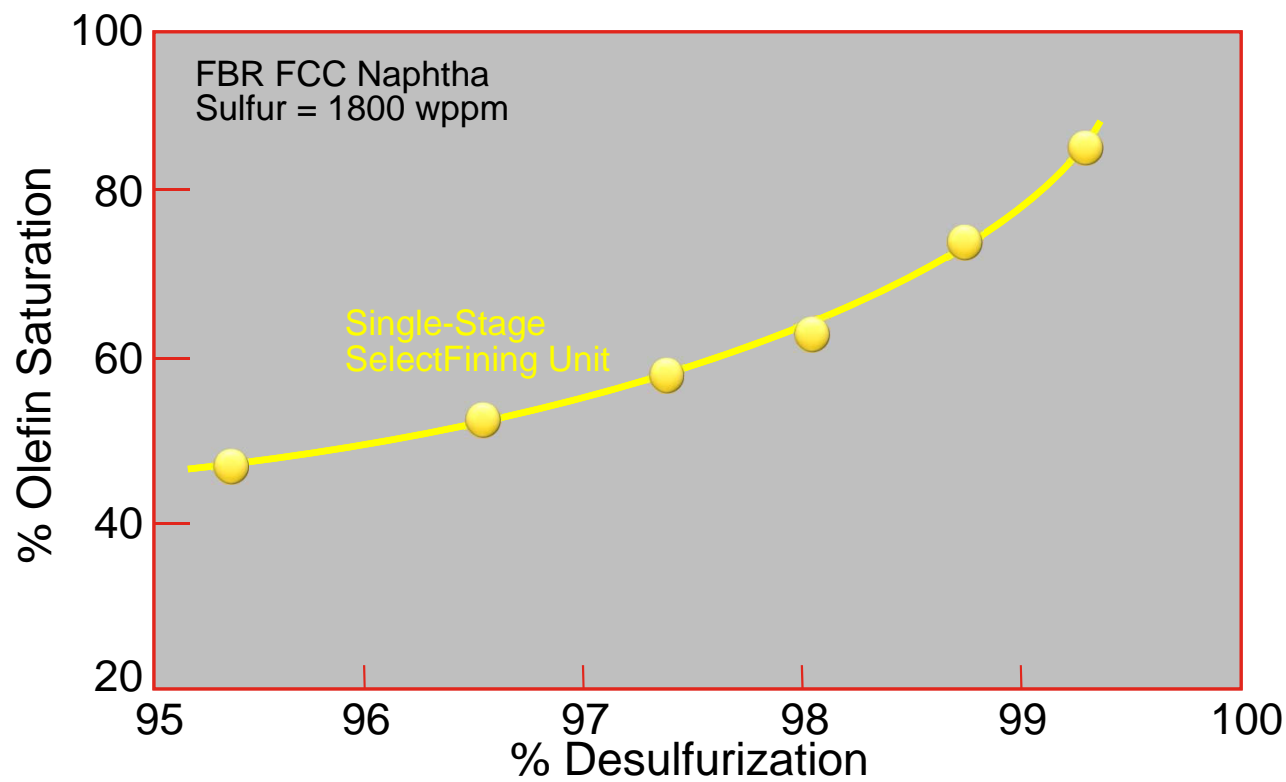


- Typical for low sulfur feeds and/or $\leq 90\%$ HDS
- Flowscheme and operating conditions are similar to NHTs

UOP Confidential Information

Impact of % Desulfurization on Olefin Saturation

Single-Stage SelectFining Performance



Typical Product S

90 ppm

72 ppm

54 ppm

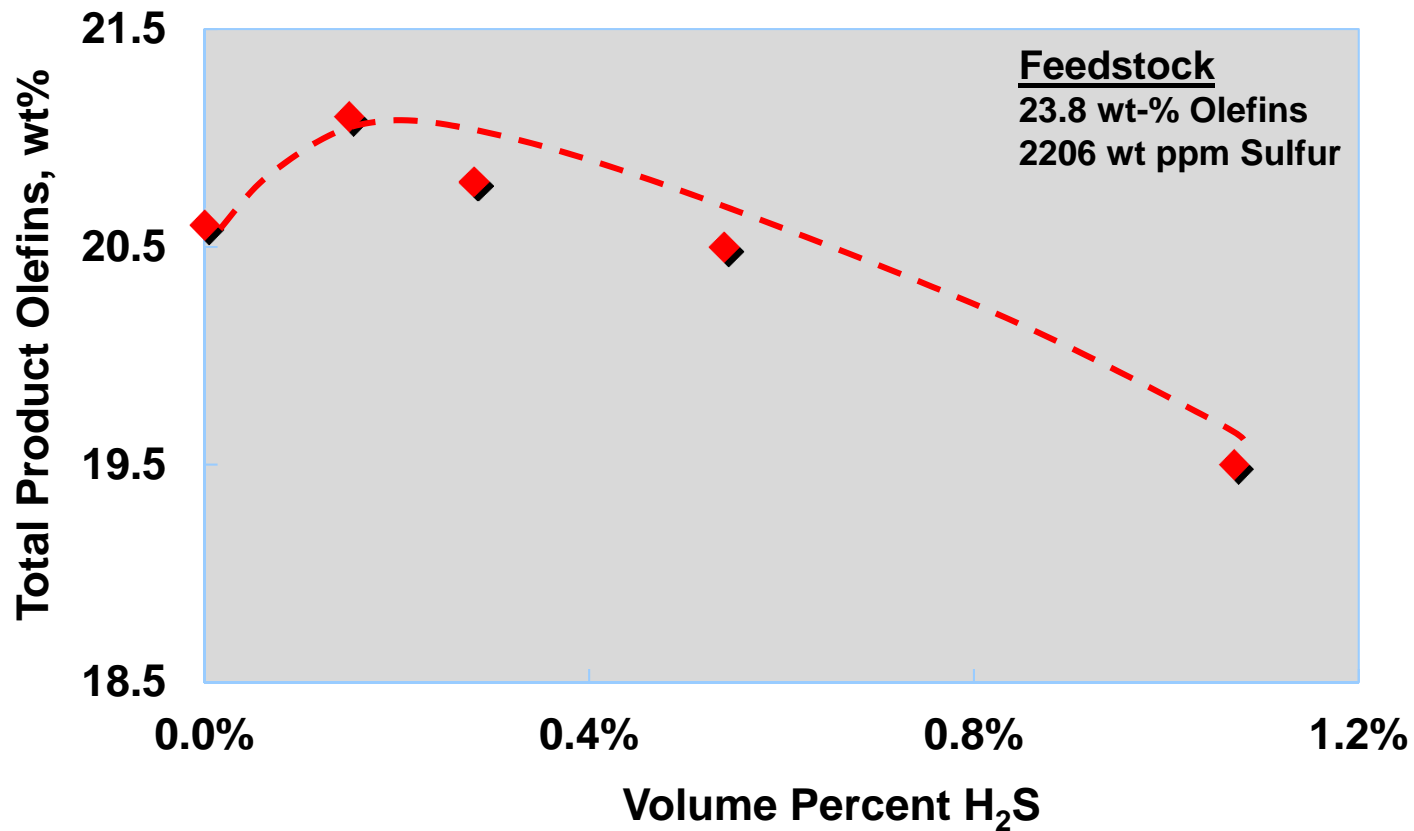
36 ppm

18 ppm

UOP Confidential Information

Honeywell
UOP

H₂S Impacts Olefin Retention

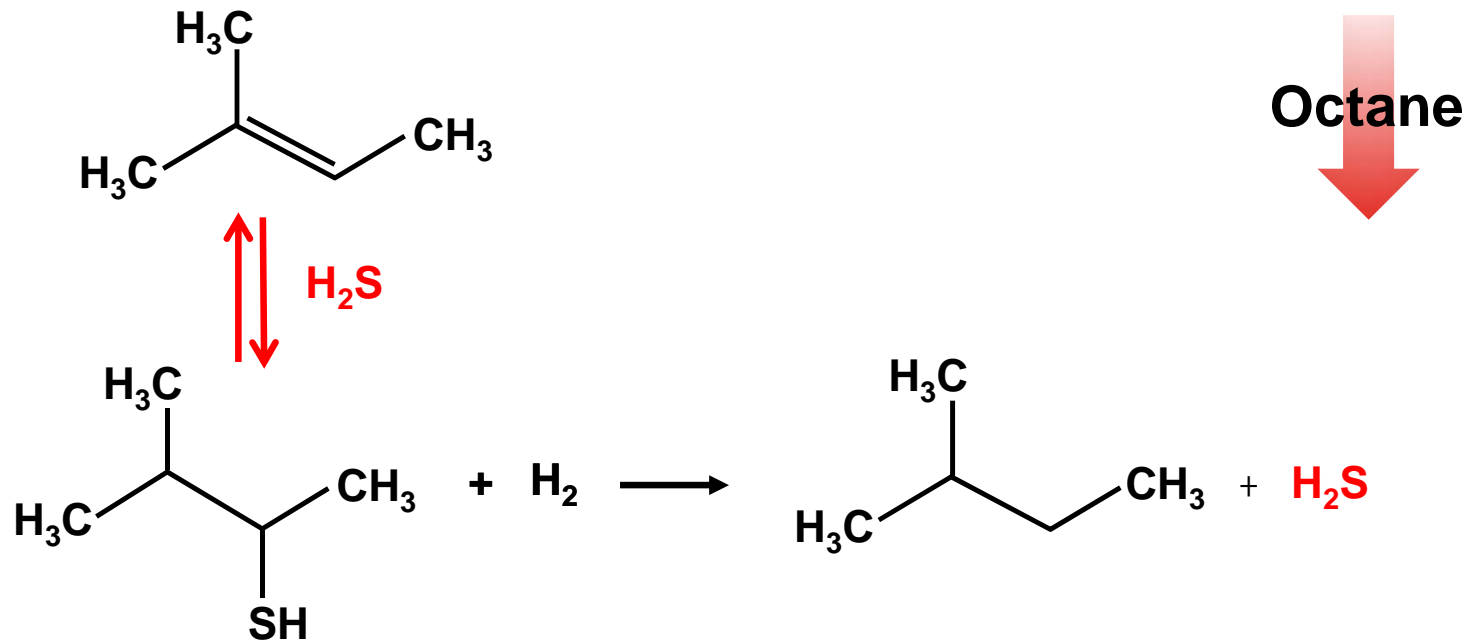


***Understanding recombination is critical
as it directly impacts olefin retention***

UOP Confidential Information

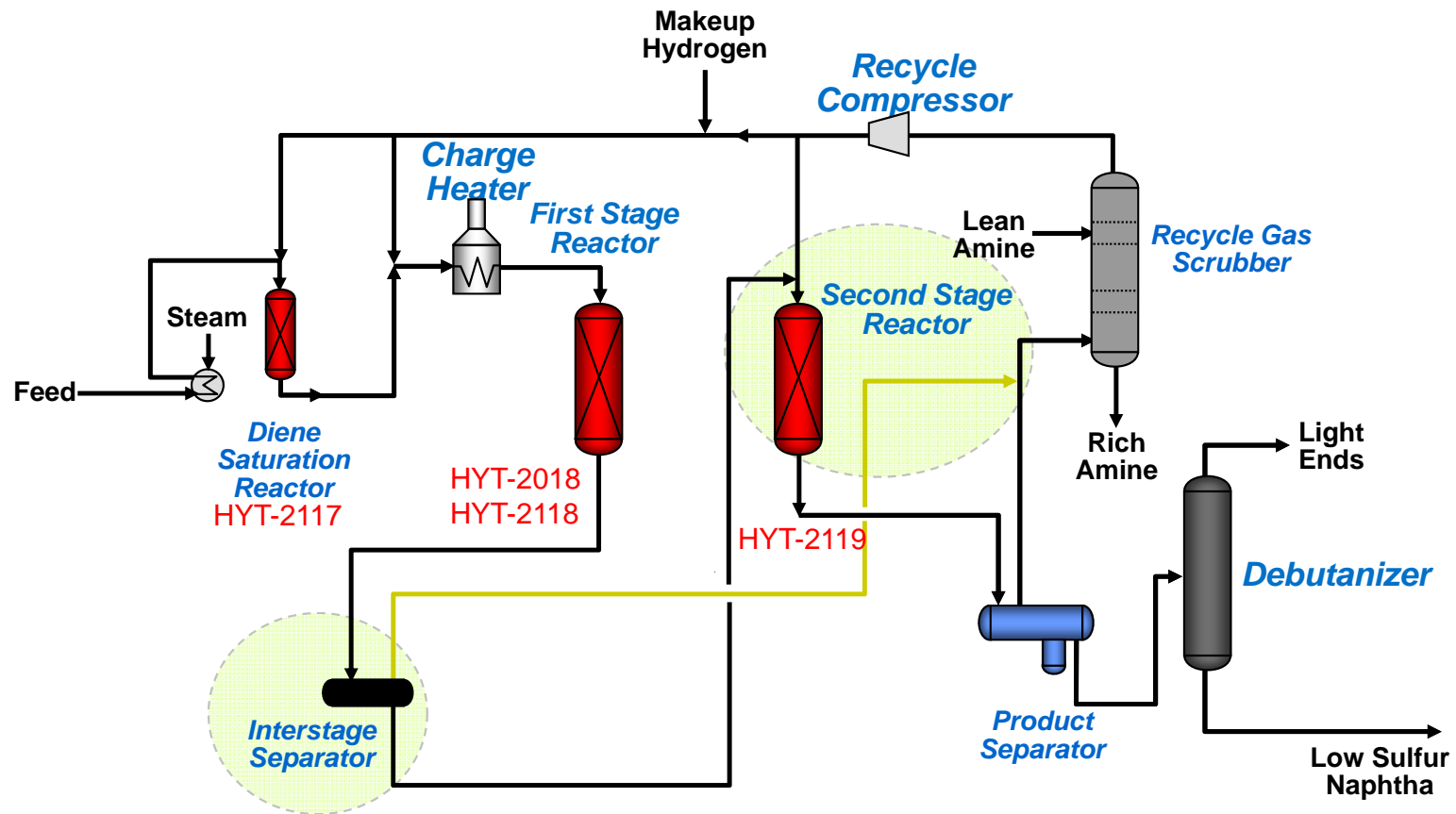
Honeywell
UOP

Mercaptan Recombination



- Mitigate with two HDS stages – strip out H_2S between stages, as dictated by feed sulfur and product sulfur and octane targets
- Mitigate with polishing reactor downstream of SHDS

UOP Two-Stage SelectFining Process

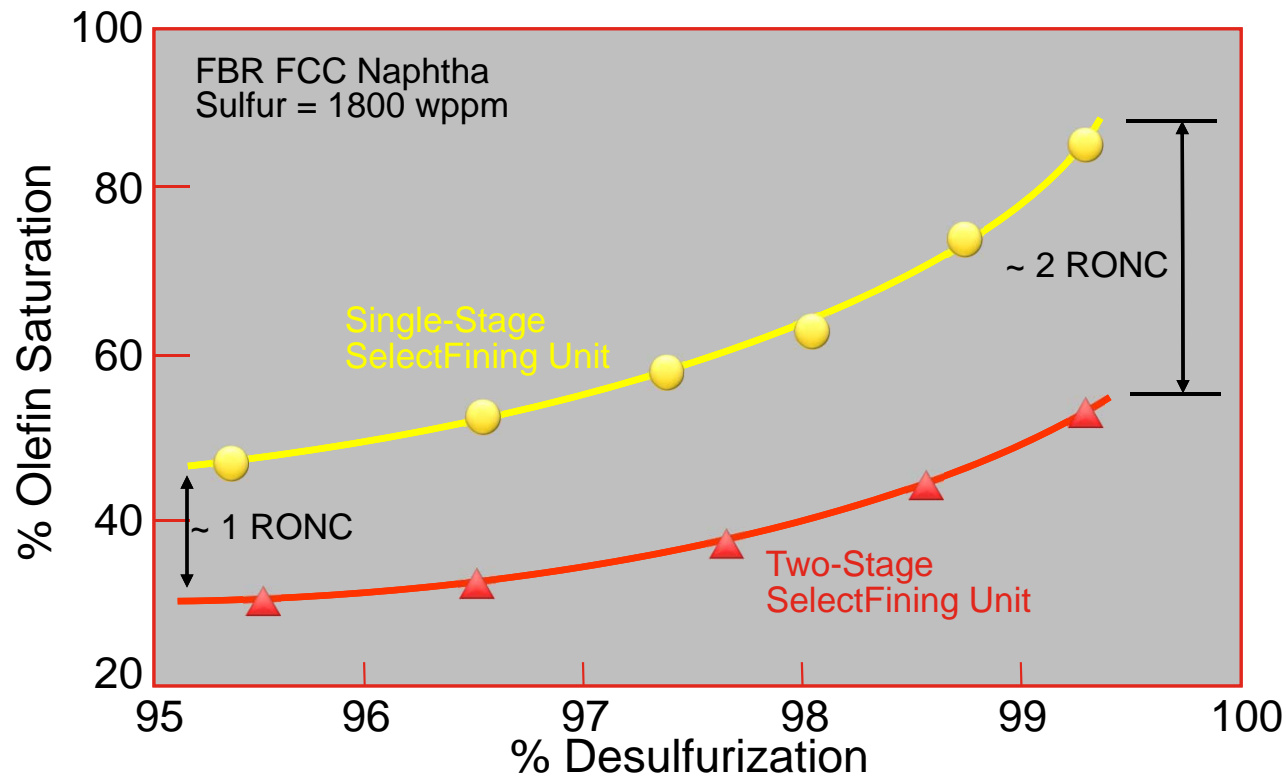


- Typical for high sulfur feeds with $\geq 90\%$ HDS
- Interstage H₂S Stripping Mitigates Recombination

UOP Confidential Information

Impact of % Desulfurization on Olefin Saturation

Single-Stage vs Two-Stage SelectFining Performance



Typical Product S

90 ppm

72 ppm

54 ppm

36 ppm

18 ppm

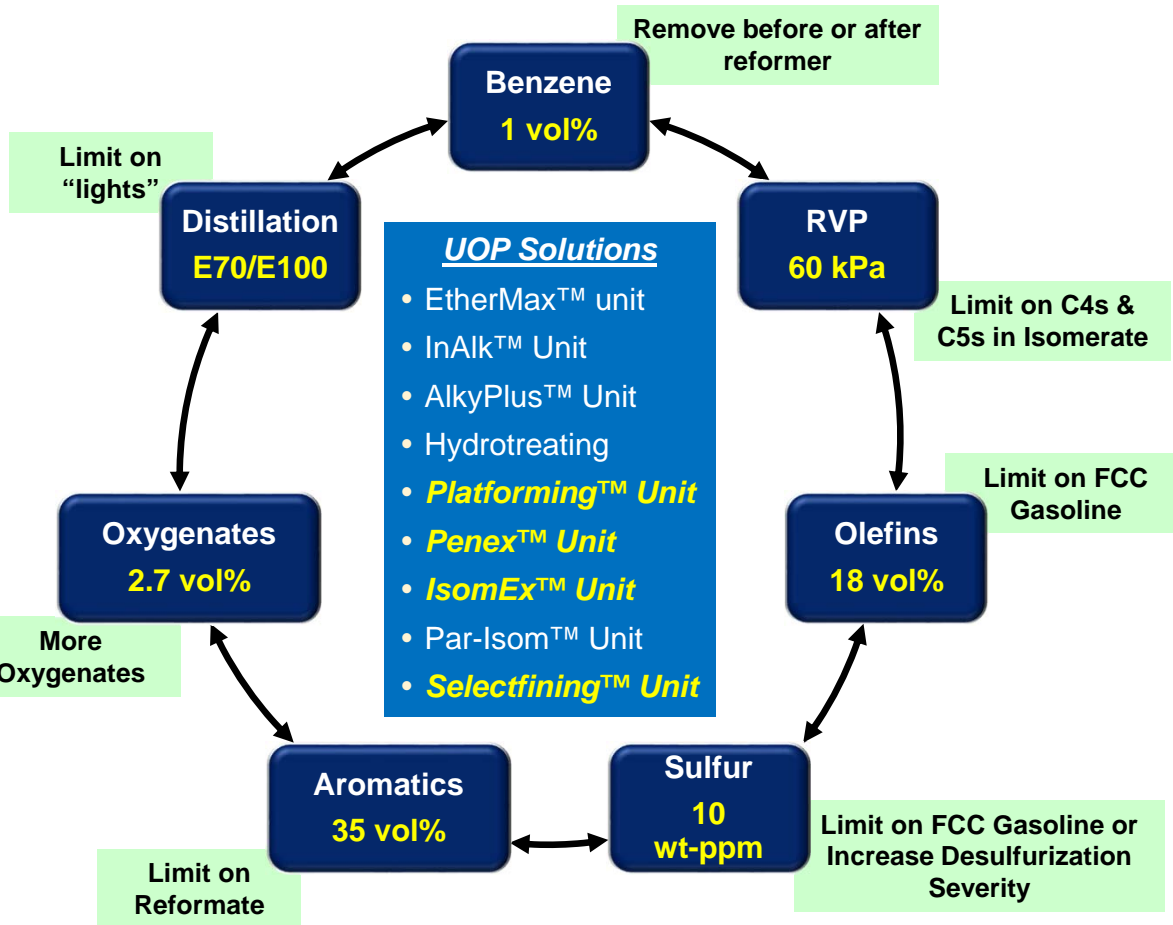
UOP Confidential Information

Honeywell
UOP

SelectFining – Gasoline Desulfurization Optimized, *Simply*

- Flexible configurations to meet the most demanding challenges of octane retention and sulfur removal
- State-of-the-art, commercially proven catalysts with best-in-class performance
- Configurations in combinations with UOP Merox™ sweetening technology
 - Enables “molecule management” – directing the sulfur species to the most efficient conversion process
 - Unique offerings which can lower both capital and operating costs

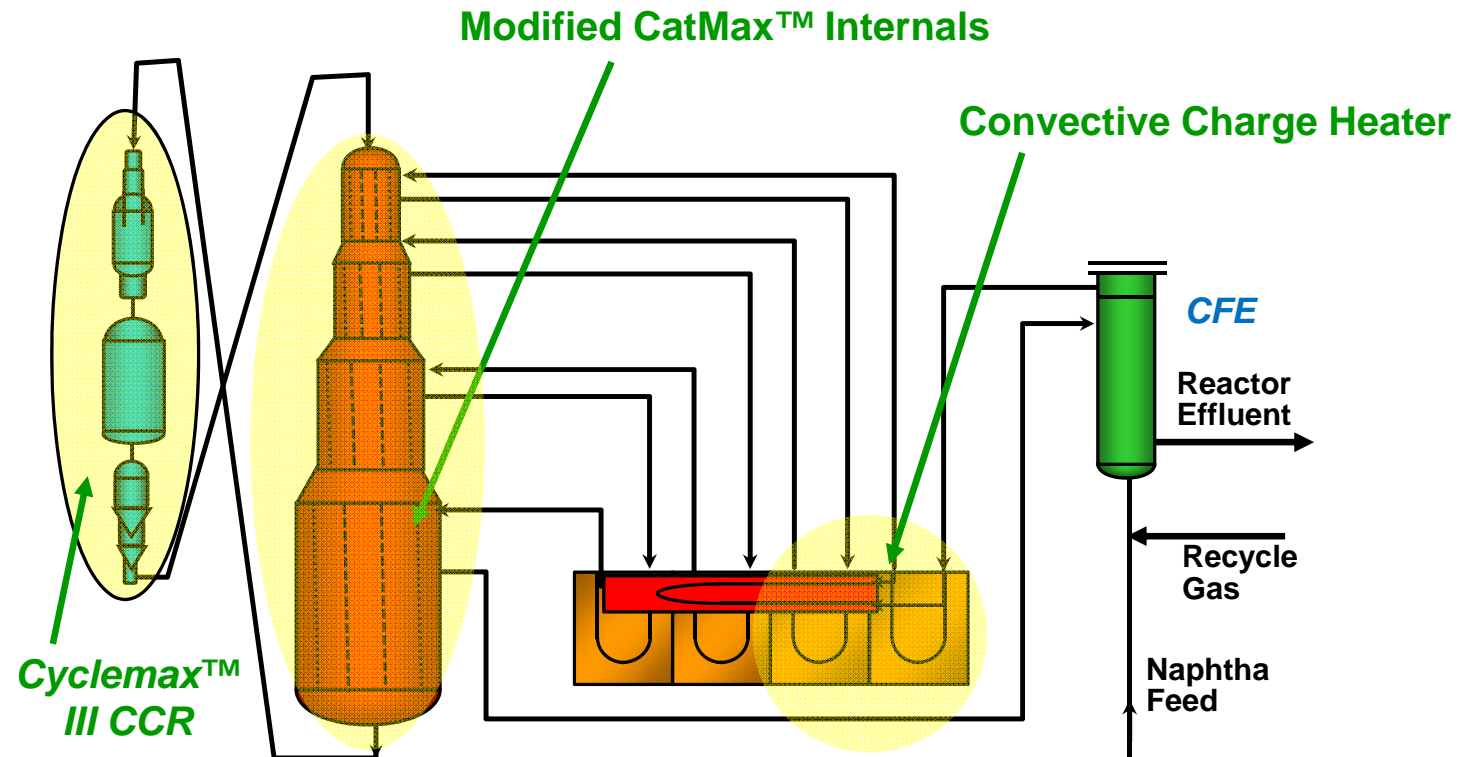
A Balancing Act: Bharat VI Specs with Maximum Profit



- How can I blend more FCC Gasoline and control olefins and sulfur?
- **How do I drive octane yield and aromatics to the limit?**
- Where is the rest of my octane going to come from?

Many constraints – optimal solution?

UOP's Recent Platforming Innovations

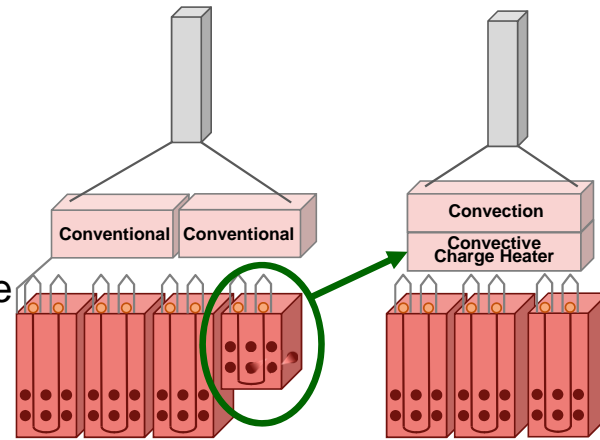


Project IRR improved by 2 - 6 %

Convective Charge Heater

• Features

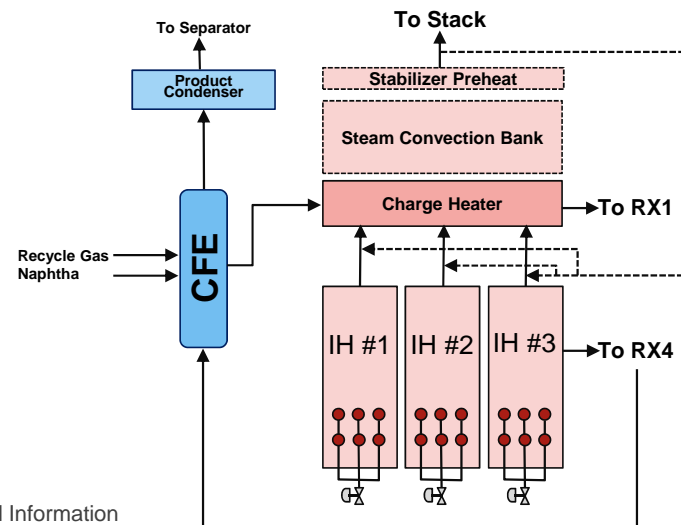
- Charge heater moved to convection section displacing portion of steam generation
- Temperature control achieved by stack gas recycle
- Radiant section fouling reduced with stainless steel tubes
- 1 less heater box



• Benefits:

- Lower capital cost
- Reduced plot space
- Less fuel fired
- Lower emissions*

*Applicability for individual units to be evaluated

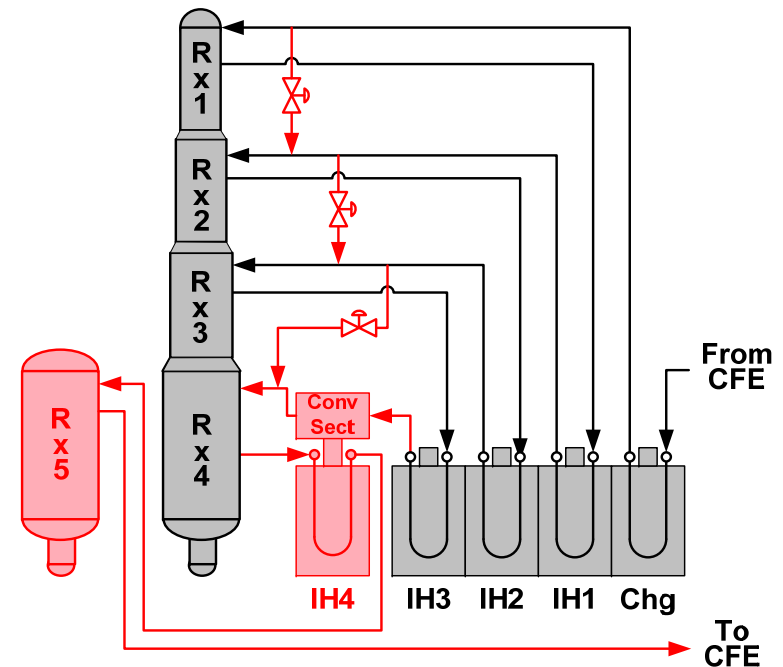


UOP Confidential Information

Estimated savings is \$5MM for 50,000 BPSD Unit

Meeting the Expansion Challenge: Example Max Throughput Revamp

- Capacity raised to 190% nameplate
 - Unit met / exceeded guaranteed revamp performance
- Key features:
 - R-264 catalyst
 - Reactor Bypasses with Rx Addition
 - CCR expanded 1500 to 3250 lb/hr
 - **Radiant–Convection fired heater**
 - Add a 4th Net Gas Compressor – which also supplies additional recycle gas
- UOP's revamp experience:
 - Over 50 CCR Platforming Units and over 25 Regenerator revamp designs



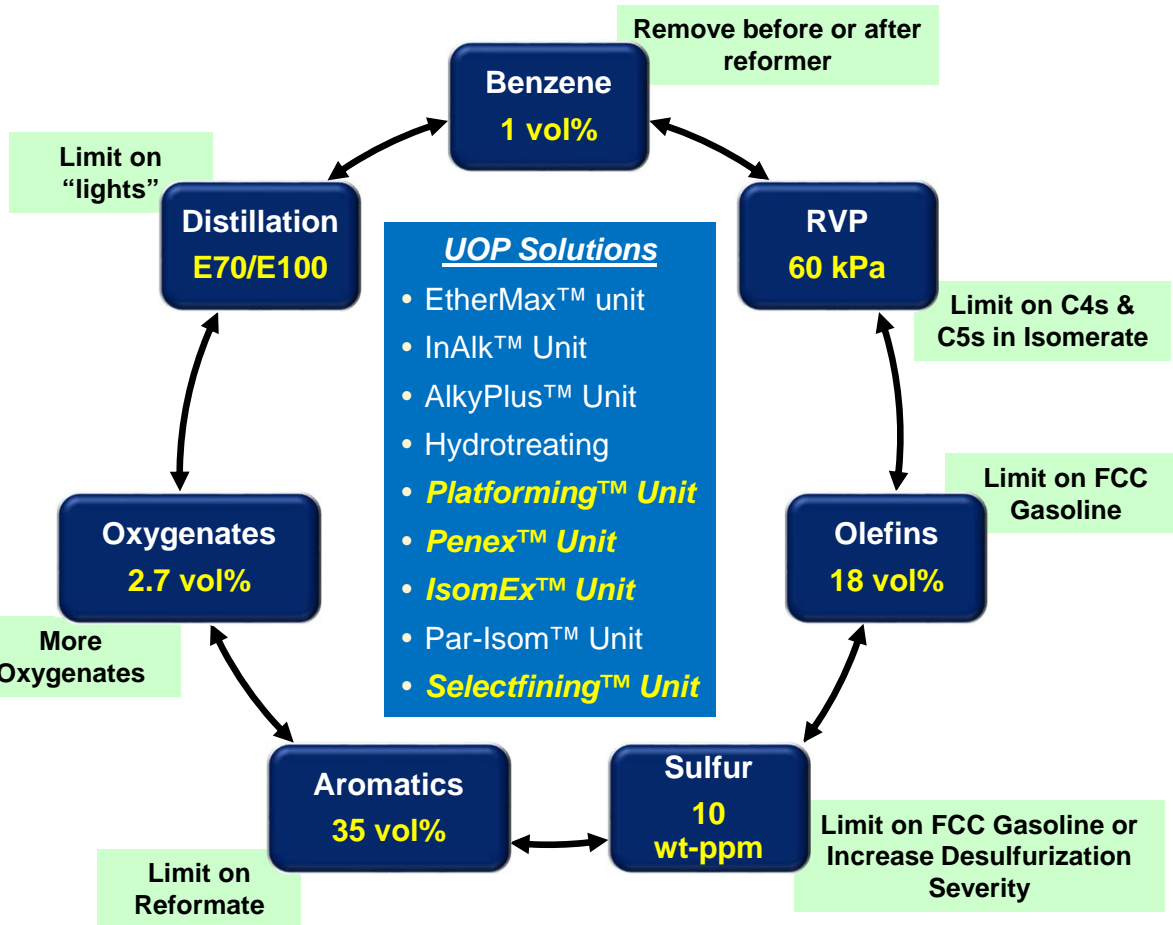
UOP Confidential Information

Convective heater was a key part of this revamp

Platforming Innovations Summary

- UOP continues to improve best-in-class naphtha reforming technology
- Innovations include all critical sections of the process:
 - Regeneration
 - Catalyst
 - Reactor / Internals
 - Heaters
- Innovations drive substantial incremental customer value
- Innovations enabled because of unique R&D / Engineering / Equipment interaction

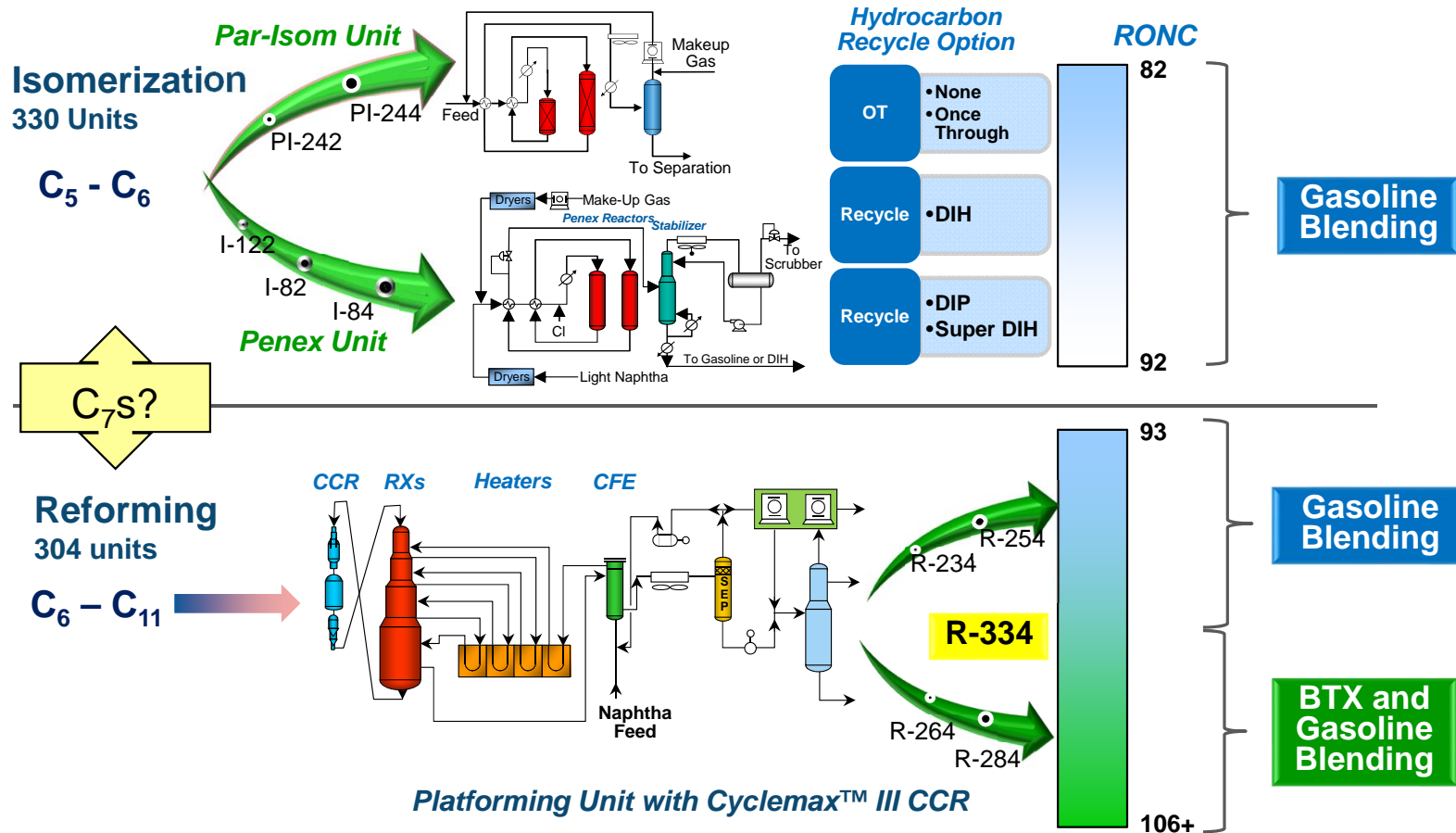
A Balancing Act: Bharat VI Specs with Maximum Profit



- How can I blend more FCC Gasoline and control olefins and sulfur?
- How do I drive octane yield and aromatics to the limit?
- Where is the rest of my octane going to come from?

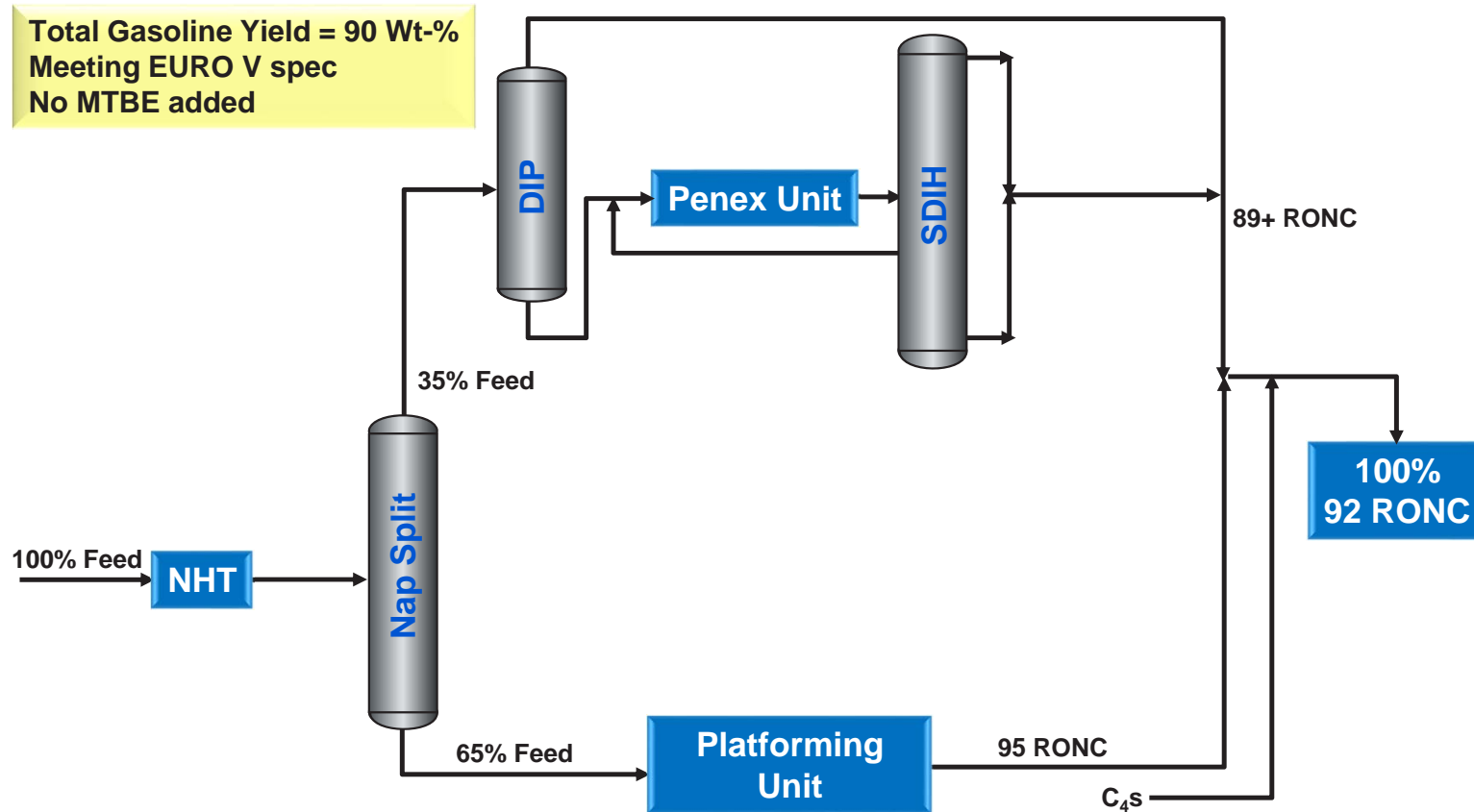
Many constraints – optimal solution?

Where should your C7s go?



C7 Management is critical for meeting BS VI specs

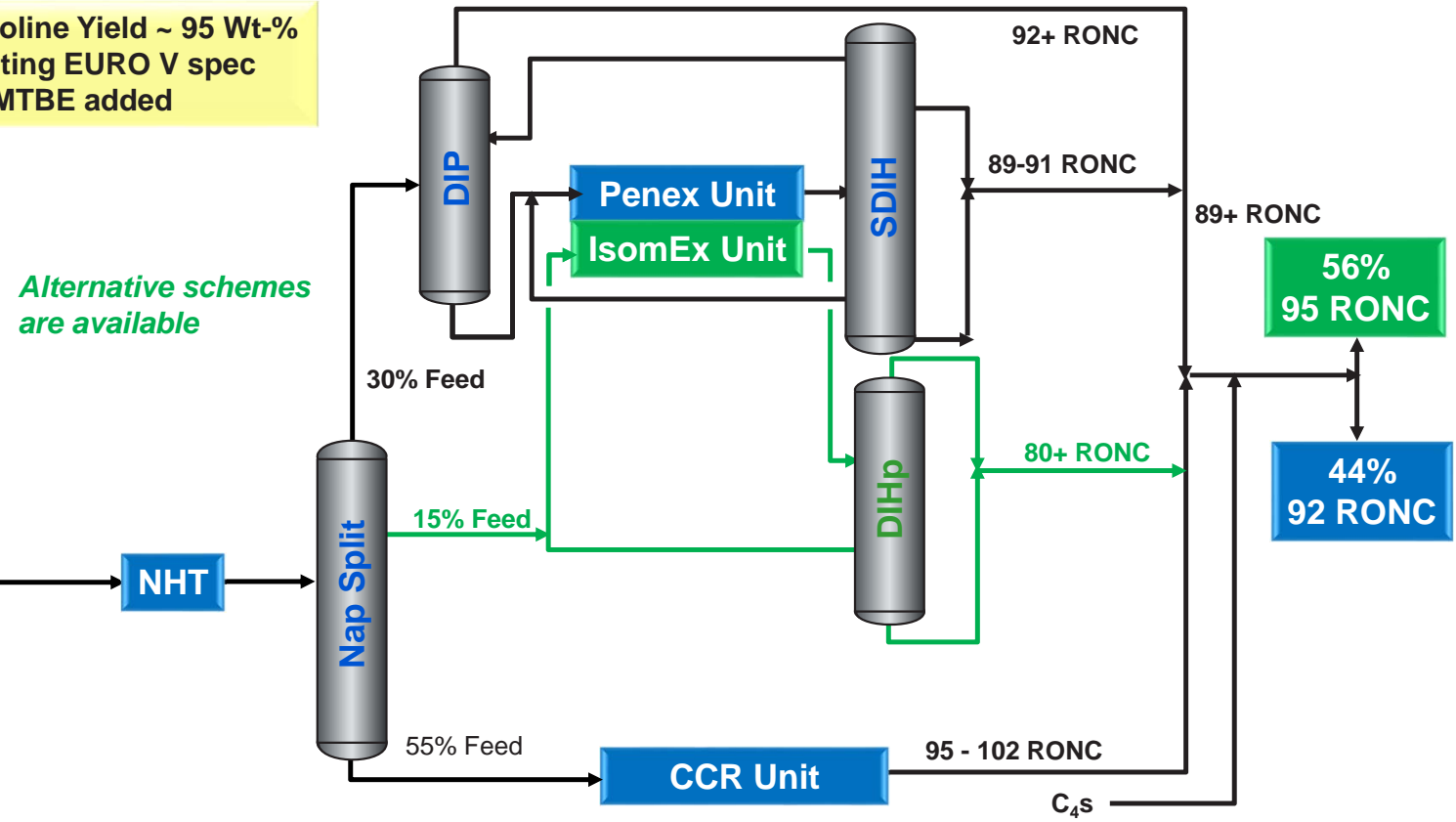
Processing Feed with Low Light to Heavy Naphtha Ratio in Naphtha Complex



Naphtha Complex achieves 92 RONC pool without MTBE

Naphtha Complex with Penex/IsomEx Process Maximizes Gasoline Yield

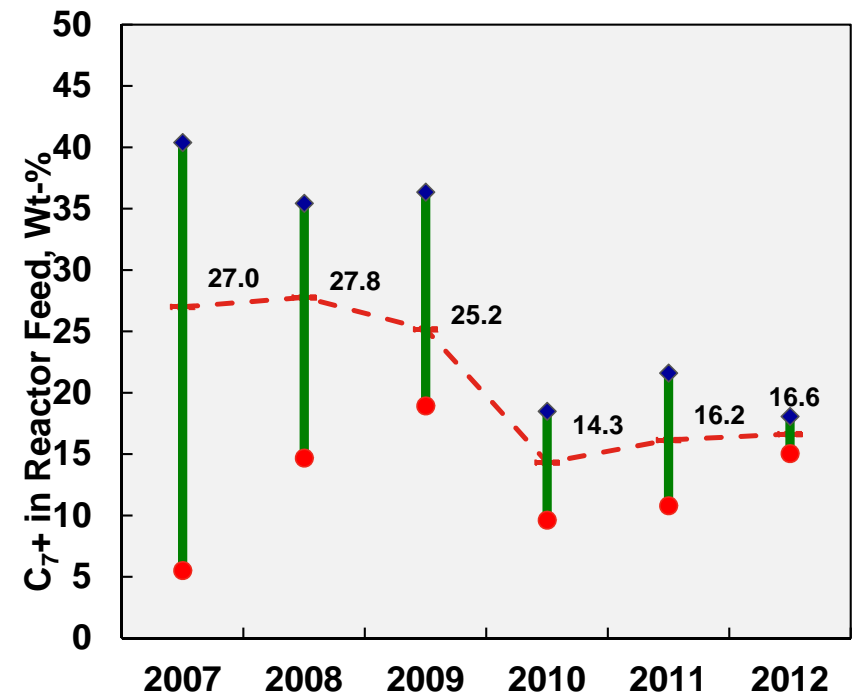
Gasoline Yield ~ 95 Wt-%
Meeting EURO V spec
No MTBE added



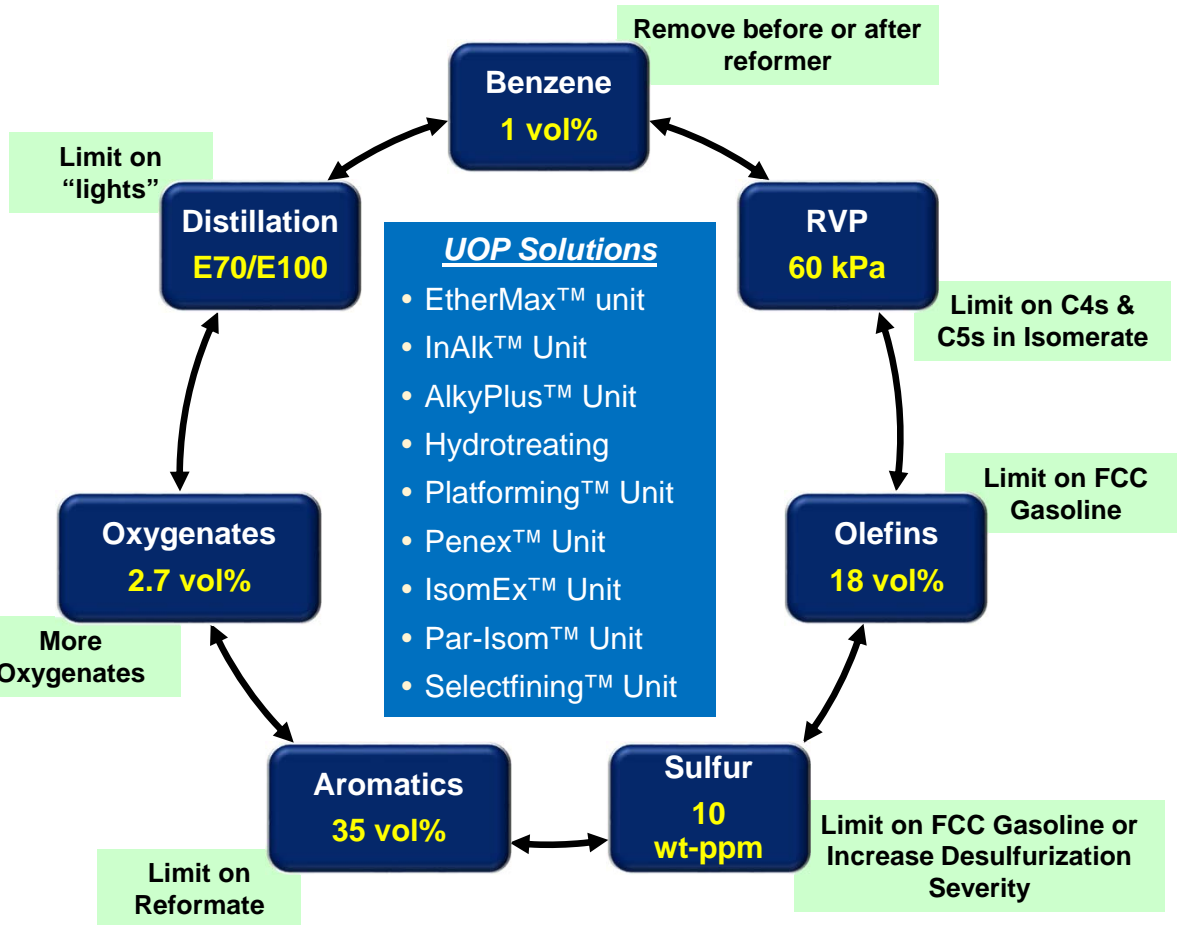
IsomEx™ achieves higher yield and RONC gasoline without MTBE

UOP IsomEx: C7 Solutions for Octane Challenges

- Simultaneous increase of gasoline yield and quality
 - Meets stringent Euro V specifications without MTBE addition
 - Increases naphtha block gasoline yield from 90 to 95%
 - Upgrades 56% of the product to premium gasoline (95 RONC)
- Built on generations of paraffin isomerization experience
 - Proven process configuration
 - Proven catalysts, yields and stability
- Molecule management: direct the molecules to the perfect technology.



A Balancing Act: Bharat VI Specs with Maximum Profit



- UOP technologies can help refiners meet the rigorous specifications of Bharat VI while maintaining or increasing profit
- The principle of Molecule Management – directing molecules to the most efficient, advanced technology – provides real benefits
- Complex processing / blending solutions require a strong partner with broad experience...

UOP has the proven, commercialized solutions

