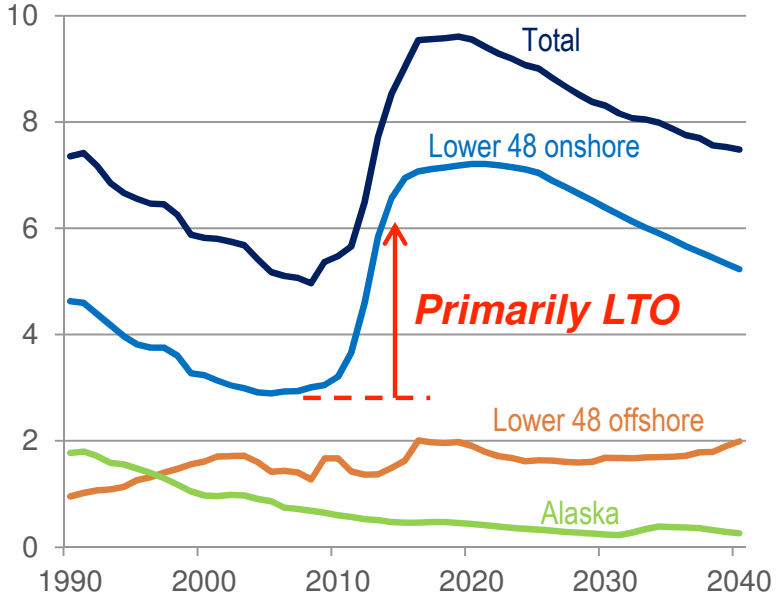
Overview

- Recent Trends toward Shale-Derived Crudes
- A Case Study – LTO Impact on Refinery and Coker Feedstocks
- Overview of Distillate Recycle®
- Impact on Coker Furnace Operation

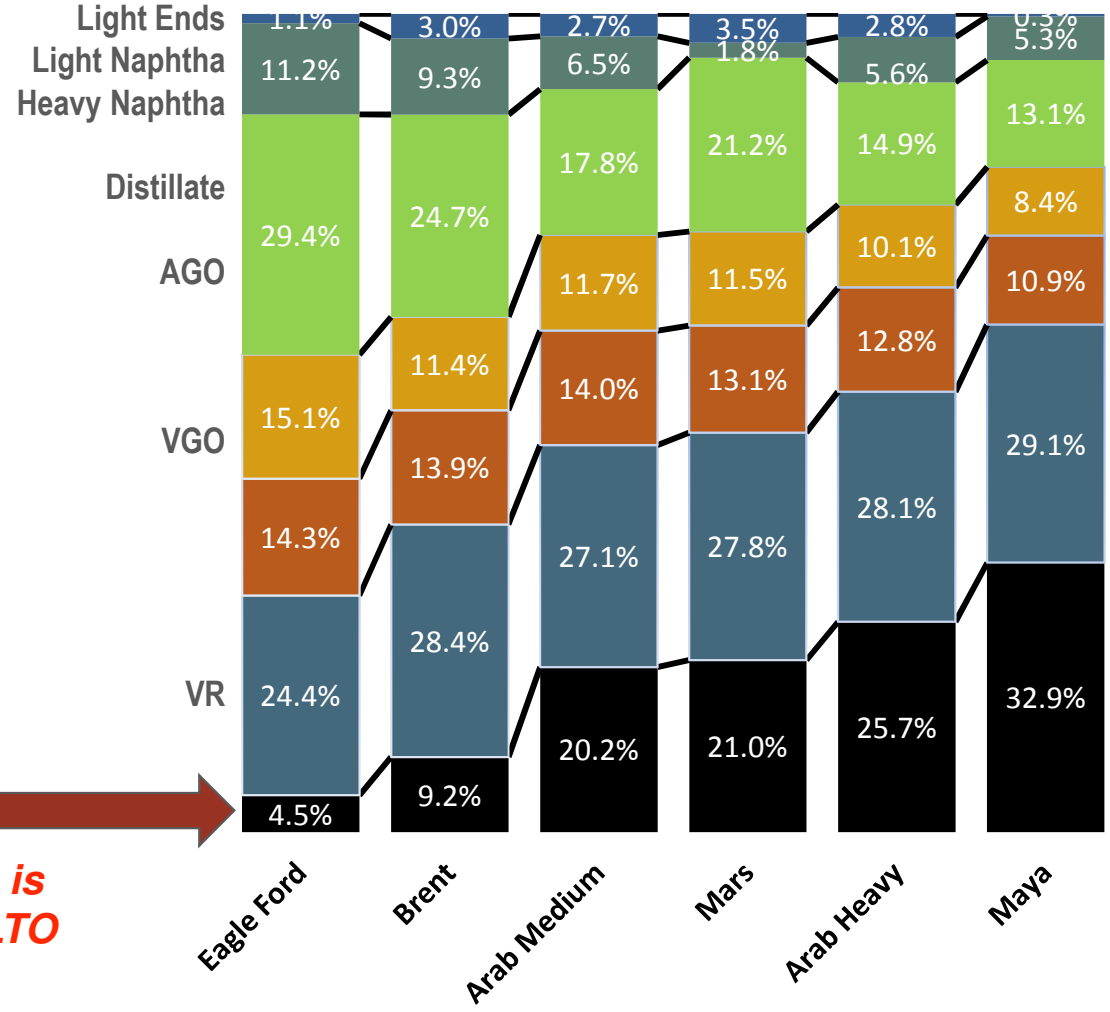
Light Tight Oil in North America

3 Million bpd New Crude Supply in 3 Years

Figure MT-53. Domestic crude oil production by source in the Reference case, 1990-2040 (million barrels per day)



Source: EIA AEO 2014

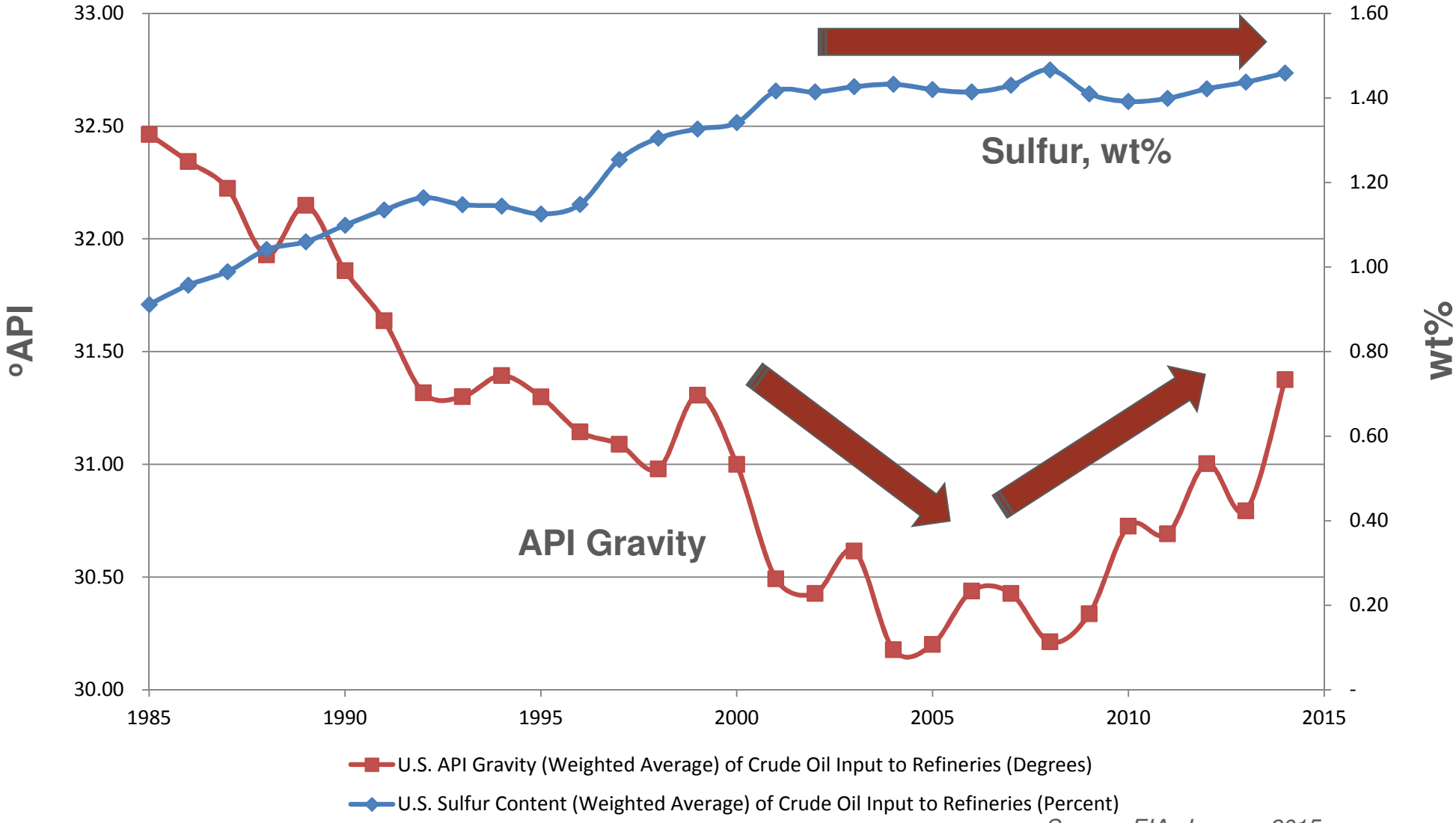


Vacuum Residue fraction is significantly smaller for LTO

Assay sources: Oil & Gas Journal, Haverly, and ConocoPhillips lab testing

Reversal of a Trend

US Refinery Crude API Up +1 Point since 2009



Source: EIA, January 2015

Case Study
US Gulf Coast Refinery

Basis for Refinery Configuration: 300 kbpd crude capacity, with Gas Oil Hydrocracker and 55 kbpd coker

- 40 kbpd of LTO (Eagle Ford) **displaces** imported light sweet crudes, resulting in a **coker feed reduction** of approximately 3.565 kbpd.
- Assumes that the Crude Distillation and naphtha processing facilities **are not limiting light crude** throughput.
- Typically filling coker capacity with heavy sour crudes makes economic sense. However in cases where logistical, downstream process, or metallurgy conditions limits processing of heavy sour crude, there is another option to **increase your liquid yields**.

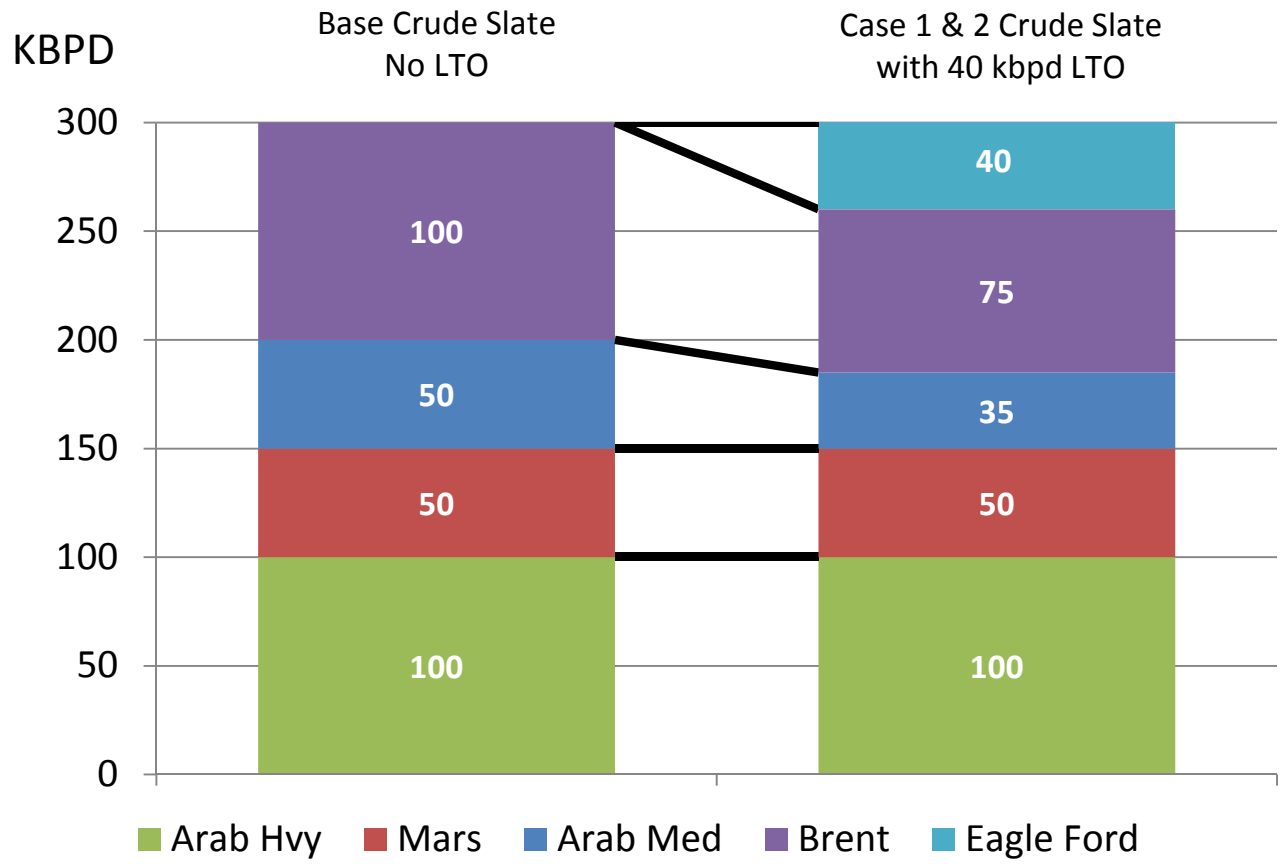
Case Study examined the use of Distillate Recycle® to maximize utilization of the coker.

- Bottom line: ***Converting coke to barrels of products is always a good thing***

Case Study
US Gulf Coast Refinery – Crude Slates

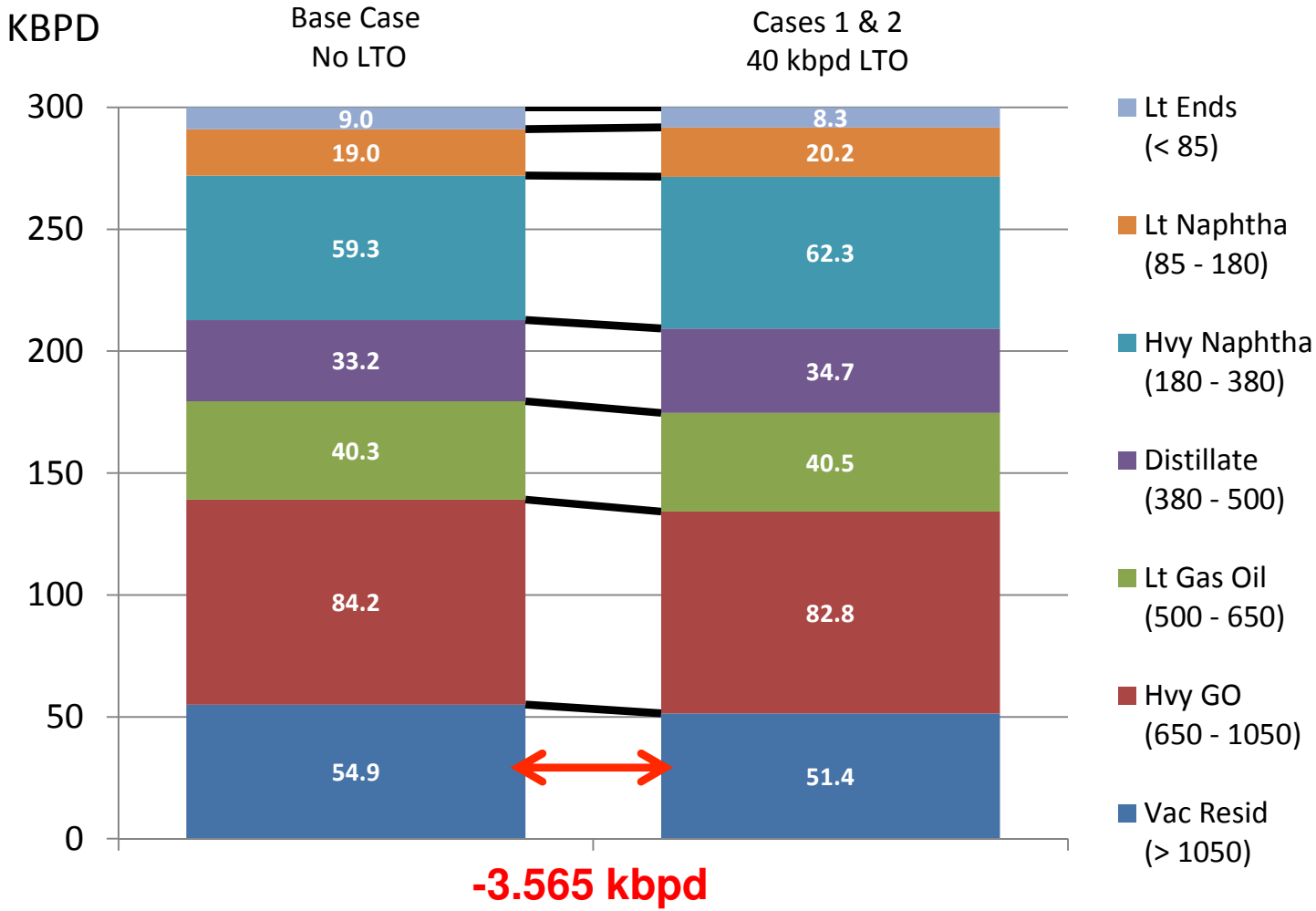
The typical refinery will have many more crudes available to blend into the slate.

For simplicity, cases were selected to portray **how LTO is displacing imported crudes** at US refineries.



- **Base Case:** Mix of Arab Heavy, Brent, Arab Medium, and Mars.
- **Case 1 – No DR:** Eagle Ford crude displaces some Arab Medium and Brent, Coker operates at reduced throughput.
- **Case 2 – With DR:** Same crude mix as Case 1, and coker adopts LCGO Distillate Recycle® to utilize available furnace and fractionation capacity.

Case Study
US Gulf Coast Refinery – Straight Run Liquids



Effects of displacing Light or Medium Crudes with LTO (Case 1 or 2 vs. Base)

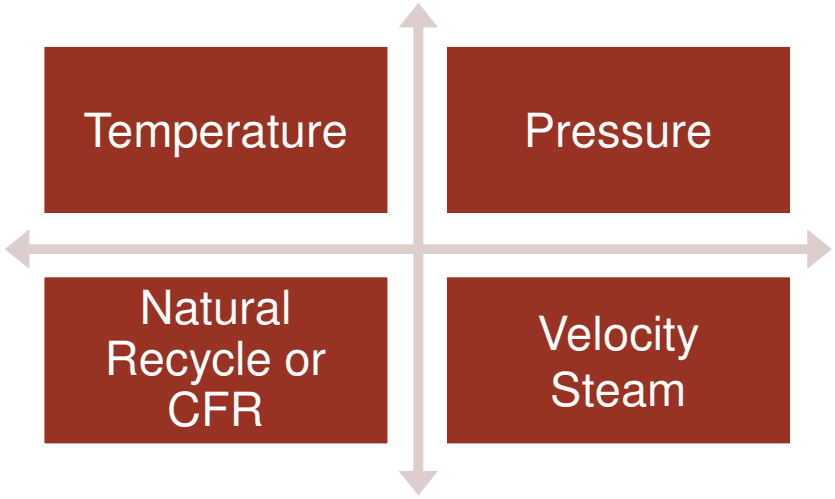
- SR **Naphtha** yield **goes up**
- **HGO and VR** yields **go down**

Distillate Recycle®

- BHTS Patented Technology
  - Can be any distillate: Naphtha, LCGO, HCGO, or dedicated draw of MCGO
  - Recycled through Furnace and Coke Drums
  - Reduces coke make and increases liquid yield, improves furnace operation
- Yield Effects
  - Coke yield ——> reduced.
  - Yield of the distillate being recycled ——> reduced.
  - Yield of other distillates ——> increased.
- Heater Effects
  - Increases run length through higher tube velocities, lower residence time
  - Increases overall firing rates, but allows reaching optimum coke drum overhead temperature at slightly lower heater outlet temperature.
  - Increases aromaticity of furnace charge, helps stabilize asphaltenes.

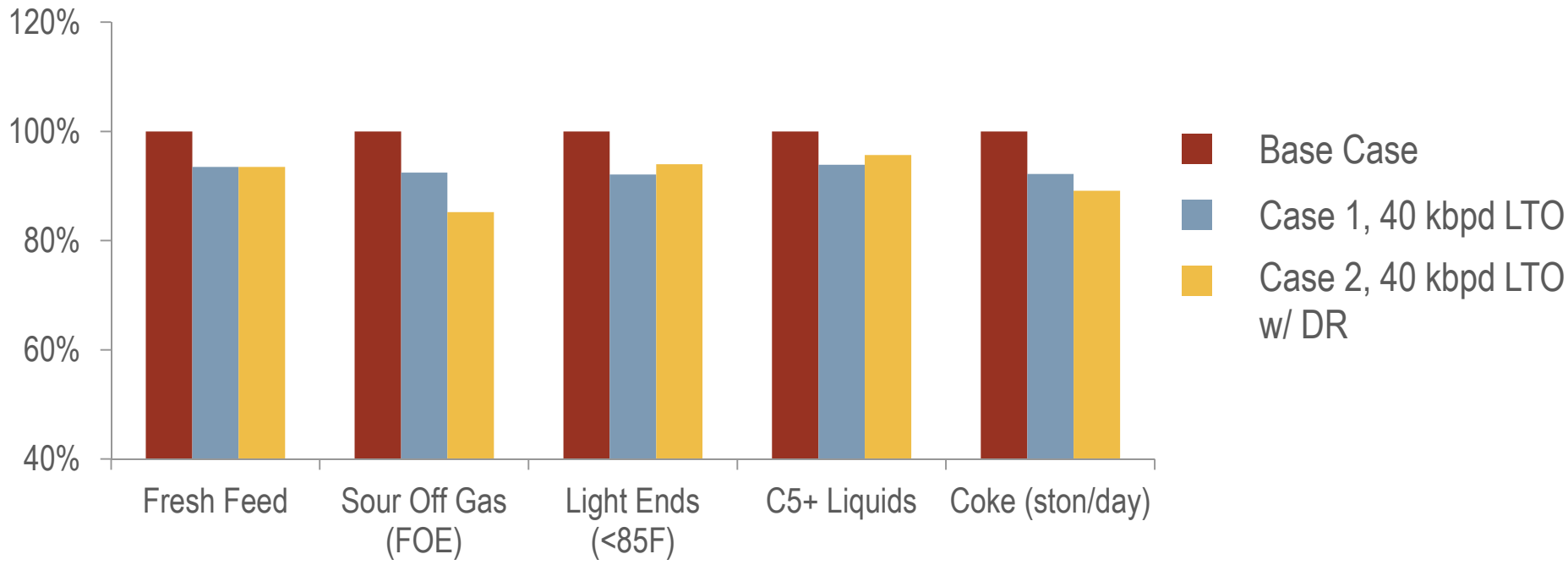
Distillate Recycle®

- Conventional Delayed Cokers have four variables to influence coke and liquid yields for any given feed:



- Distillate Recycle® provides an additional control parameter:
  - Increases concentration of products in recycle boiling range, suppressing formation.
  - Inhibits propagation of some of the condensation and polymerization reactions that follow initial thermal cracking.
  - Increases relative volatility of higher boiling point components so they vaporize and leave drum, don't stay in drum long enough to form coke.
  - The heat carried by recycle medium is transferred to mesophase, stays at higher temperature longer and helps drive endothermic coking reactions to completion.

Case Study
US Gulf Coast Refinery – Coker Yields



Adding LCGO Distillate Recycle® regains lost liquid yields:

- Reduces Sour Off Gas and Coke production.
- Increases Light Ends recovery.
- Increases C5+ Liquids by about 660 bpd versus Case 1.

Case Study
US Gulf Coast Refinery – Product Rates

	Base Case	Case 1 40 KBPD LTO Less Coker Feed		Case 2 40 KBPD LTO Less Coker Feed, w/ Dist Rec		
	kbpd	kbpd	Δ Base	kbpd	Δ Base	Δ Case 1
Sour Off Gas (FOE)	5.019	4.586	-0.432	4.357	-0.662	-0.229
Lt Ends (< 85)	20.752	19.632	-1.120	19.717	-1.035	0.085
Lt Naphtha (85 - 180)	29.662	30.459	0.797	30.668	1.006	0.208
Hvy Naphtha (180 - 380)	78.400	80.437	2.037	80.854	2.454	0.418
Diesel (380 - 650)	176.541	175.317	-1.224	175.537	-1.004	0.221
UCO (> 1050)	1.463	1.429	-0.034	1.456	-0.007	0.027
Coke (stons/day)	2984	2811	-173	2742	-242	-69
Total Liquid Volume	306.818	307.274	0.456	308.232	1.415	0.959

Change in **crude slate** results in:

- Net **Increase** in **naphtha** production.
- Net **loss** of **diesel** production.

Adopting LCGO Distillate Recycle® **recovers** about 0.220 kbpd of lost diesel product and **reduces coke production** by 70 ston/day over Case 1.

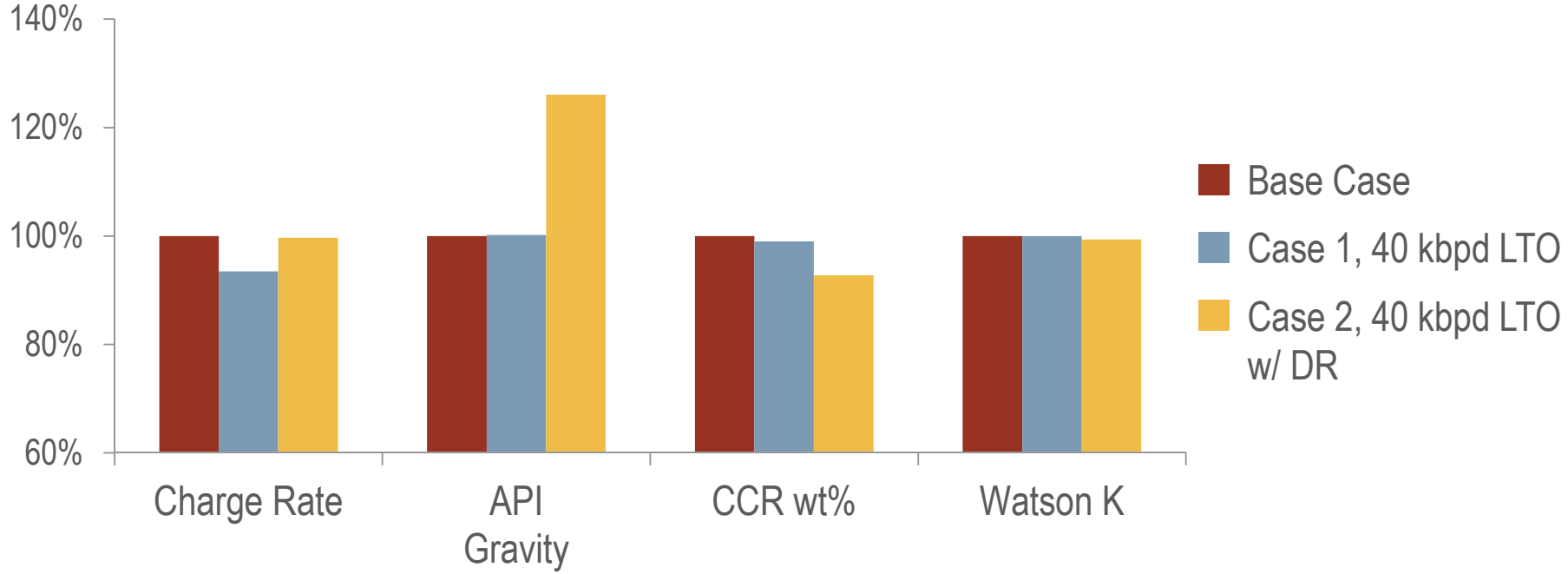
Case Study
US Gulf Coast Refinery – Product Values

	Product Prices	Δ Product Rates Case 2 vs. Case 1	Δ Product Values Case 2 vs. Case 1
	$/gal	kbpd	$ MM/year
Sour Off Gas (FOE)	0.42	-0.229	-1.4
Lt Ends (< 85)	0.50	0.085	0.6
Lt Naphtha (85 - 180)	1.60	0.208	4.9
Hvy Naphtha (180 - 380)	1.40	0.418	8.6
Diesel (380 - 650)	1.70	0.221	5.5
UCO (> 1050)	1.50	0.027	0.6
Coke (stons/day)	60.00	-69	-1.5

Notes and Simplifying Assumptions:

- *Provided as a general indication of the economic impact of the coker yield shift on the refinery.*
- *Unfinished liquid product prices were estimated based on monthly data from US EIA "Spot Prices for Crude Oil and Petroleum Products".*

Impact on Coker Furnace
Furnace Charge Properties



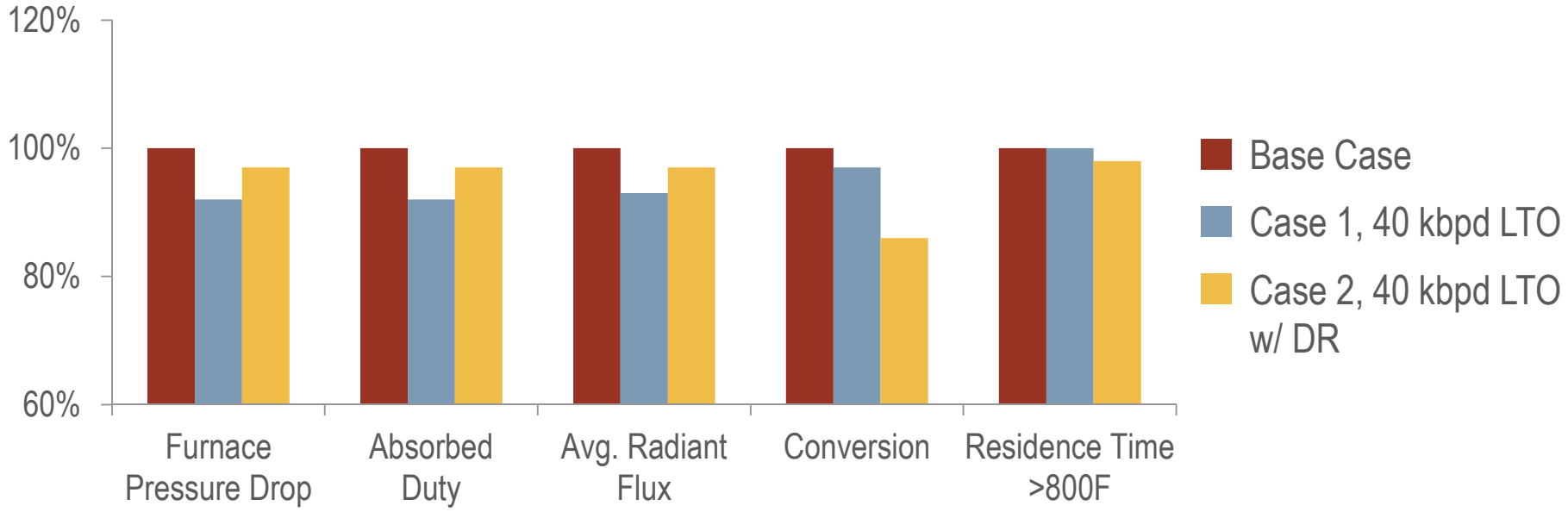
Change in **crude slate** results in:

- Significant reduction in furnace charge rate
- Slightly lower furnace charge CCR
- Potential destabilization of asphaltenes, no significant change in K Factor

Adopting **LCGO Distillate Recycle®** results in:

- Return of furnace charge rate back up to design
- Reduction of furnace charge CCR which impacts thermal coke fouling
- Reduction of Watson K Factor which impacts asphaltene stability

Impact on Coker Furnace
Furnace Operation



Change in **crude slate** results in:

- Significant reduction in Furnace Charge absorbed duty, and average radiant section flux, slightly lower % of feed converted at outlet.
- No significant change in Residence Time >800F.

Adopting **LCGO Distillate Recycle®** improves critical **factors that affect fouling**:

- **Reduces** % of feed converted at outlet.
- **Reduces** Residence Time over 800F.

Summary

Changes in the crude slate as LTO displaces light imported crudes can result in:

- Net loss of refinery's diesel production rate
- Reduction in coker utilization
- Potential degradation in furnace operation due to increased Residence Time >800F and destabilization of asphaltenes.

Adopting Distillate Recycle® is another option to address changes and improve furnace operation:

- Improves coker yields, recovers some diesel production while reducing coke make
- Improves critical factors that affect furnace fouling:
  - Increases furnace feed aromaticity, asphaltene stability
  - Reduces feed conversion occurring in the furnace
  - Reduces residence time in furnace significantly

Bechtel Hydrocarbon Technology Solutions (BHTS) is a standalone Center of Excellence focused on technology evaluation, licensing and front-end engineering studies serving the refining, gasification, and emerging energy markets.

Contact Us
Bechtel Hydrocarbon Technology Solutions, Inc.
3000 Post Oak Boulevard
Houston, Texas 77056
bhts@bechtel.com

T: +1 713 235 4300

Q & A

