



# Pathway to Maximizing Residue Upgrading Margins

AICHE Meeting

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*Steve Beeston*

*Vice President – Technology*

# FW Technology Group Overview

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- Manages FW's technology portfolio

- Delayed Coking
- Solvent Deasphalting
- Visbreaking
- Hydrogen Production
- Sulfur Recovery

- Activities include

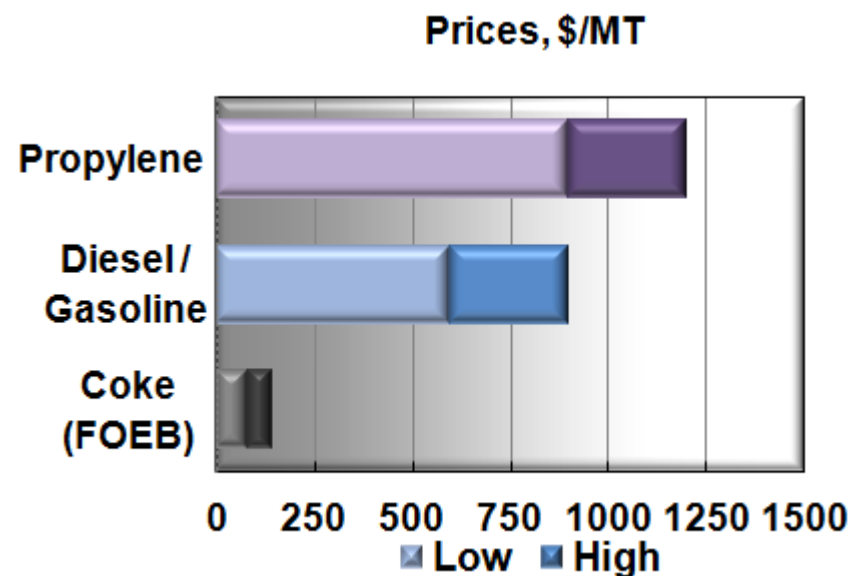
- Marketing
- Selling
- Development
- Technical support
- Relationship management

- Global business



# Business Environment Requirements

- Improve refinery economics
  - Produce higher quantities of transportation fuels
  - Allow processing of heavier and sourer crudes
  - Allow processing of opportunity crudes
  - Reduce or eliminate heavy fuel oil production
- Improve refinery flexibility
  - Not limited to one crude or products market
- Meet financing criteria
  - Rate of return hurdles
  - Based on proven technologies



*Aim is to convert low value vacuum resid into higher value products*

# Residue Processing Options

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## Catalytic

- RFCC
- Hydrotreating
- Hydrocracking
- Developing technologies



## Non-Catalytic

- Visbreaking
- Solvent Deasphalting
- Coking



# Delayed Coking

- Most commonly used residue upgrading process
  - Over 5,000,000 BPSD installed capacity
  - FW is market leader
- Very attractive economics
- Complete residue conversion
  - Gas
  - Naphtha
  - Gas oils
  - Coke (disposal not an issue)
- Specialty coke production
- Maximized diesel yield with Hydrocracker integration
- Wide variety of feedstocks



# Key Features of FW's SYDEC Delayed Coking Process

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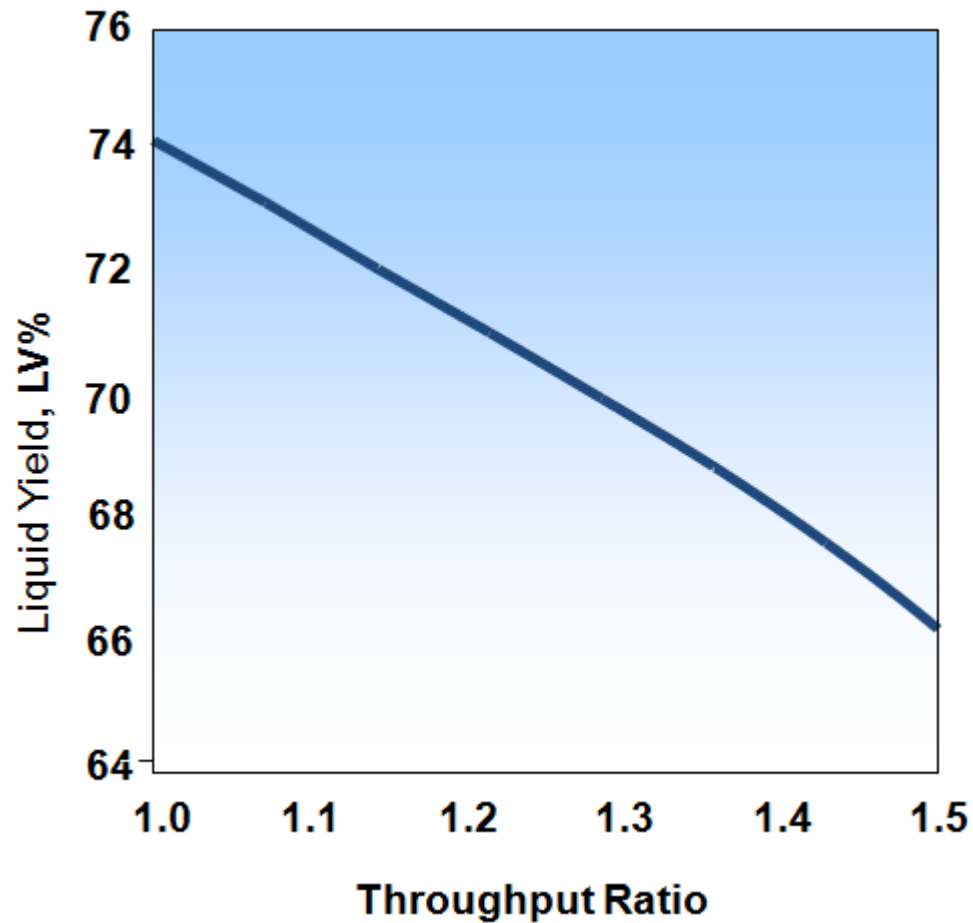
- Proprietary Terrace Wall™ double-fired furnace
- Maximum liquid product yields
  - Low pressure
  - Ultra low recycle
- Designed in safety and reliability
- Large coke drums
- Unique Fractionator design
- Environmentally friendly
- Total automation capability
- Operations support



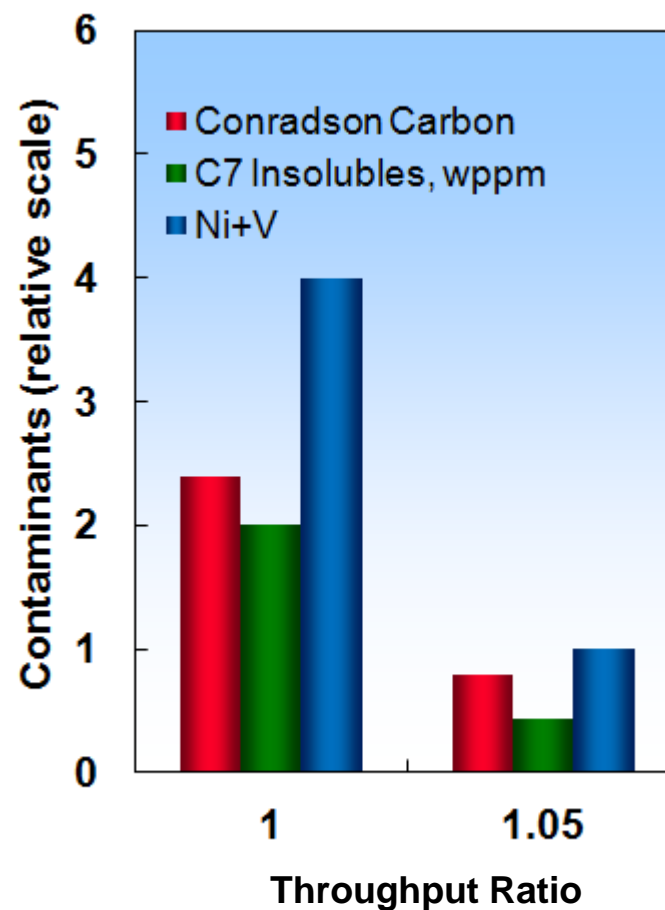
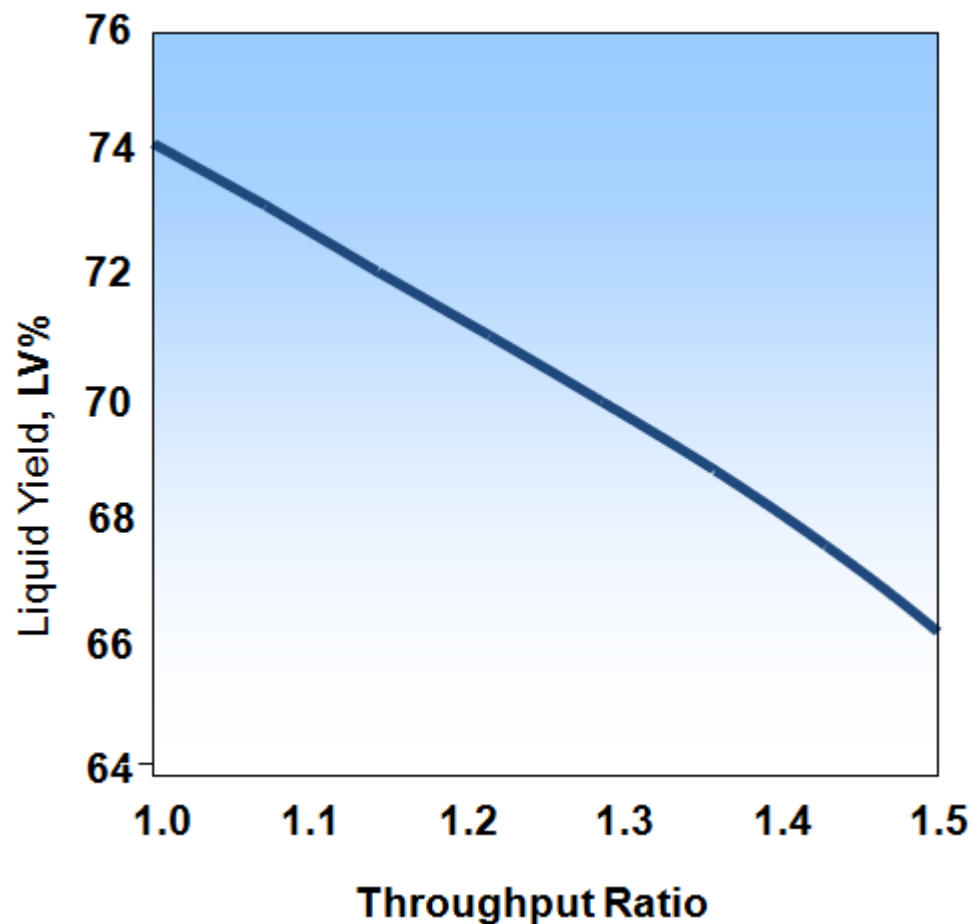
*Innovative design leads to  
superior technology and  
operations*

# Impact of Recycle on Liquid Yields and HCGO Quality

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# Impact of Recycle on Liquid Yields and HCGO Quality



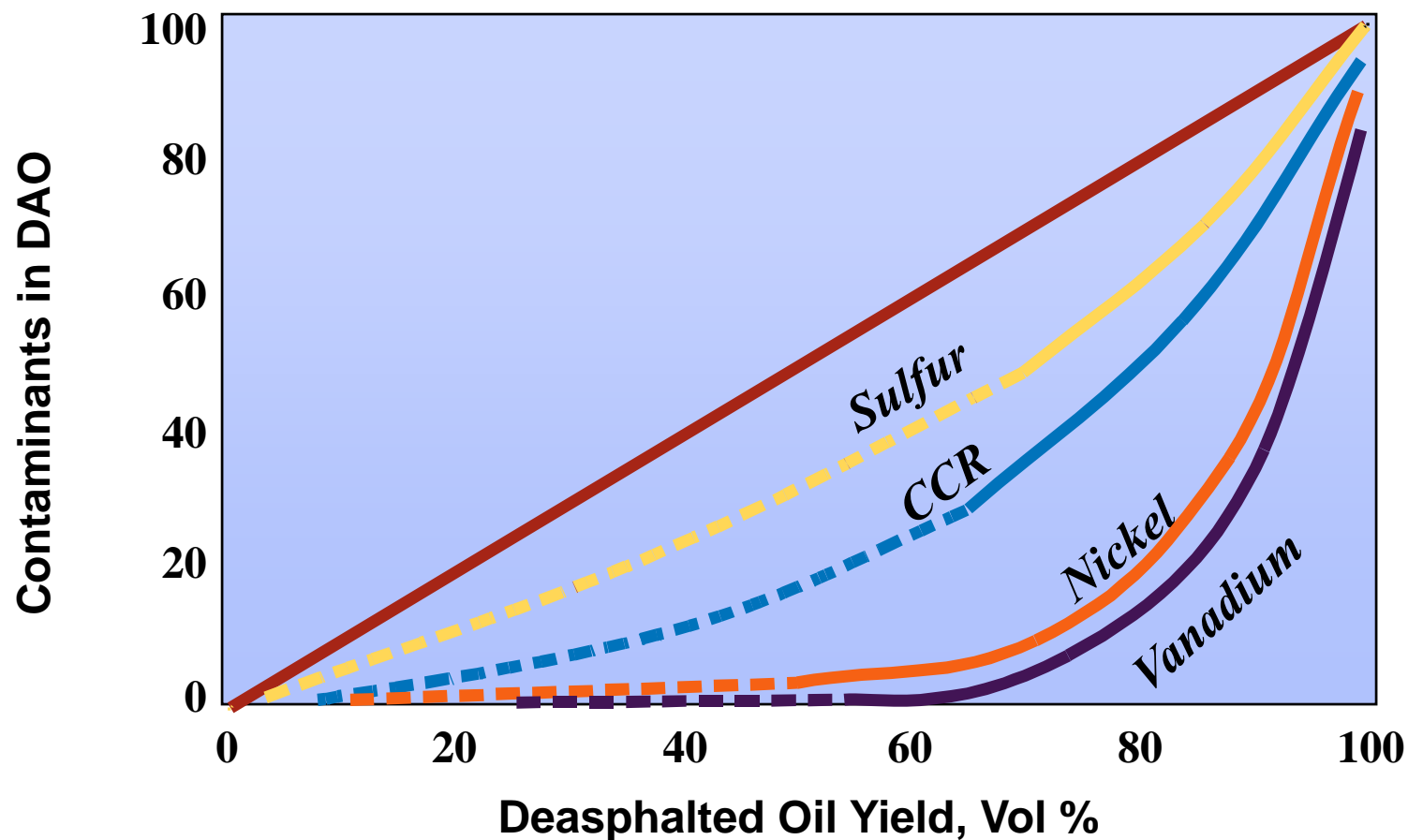
# UOP/FW Solvent Deasphalting Process

- Physical separation by molecular type
  - Deasphalted oil (DAO)
  - Pitch
- Light paraffin solvent
- Commercially proven
  - Over 70 licenses
- Advanced, counter-current extractor with packing
- Minimizes utilities
  - Supercritical solvent recovery
  - Optimized heat integration



# Solvent Deasphalting Selectivity

*Rejection of Asphaltenes and Resins Determines DAO Quality*



# VGO Hydrocracking FEED Comparison

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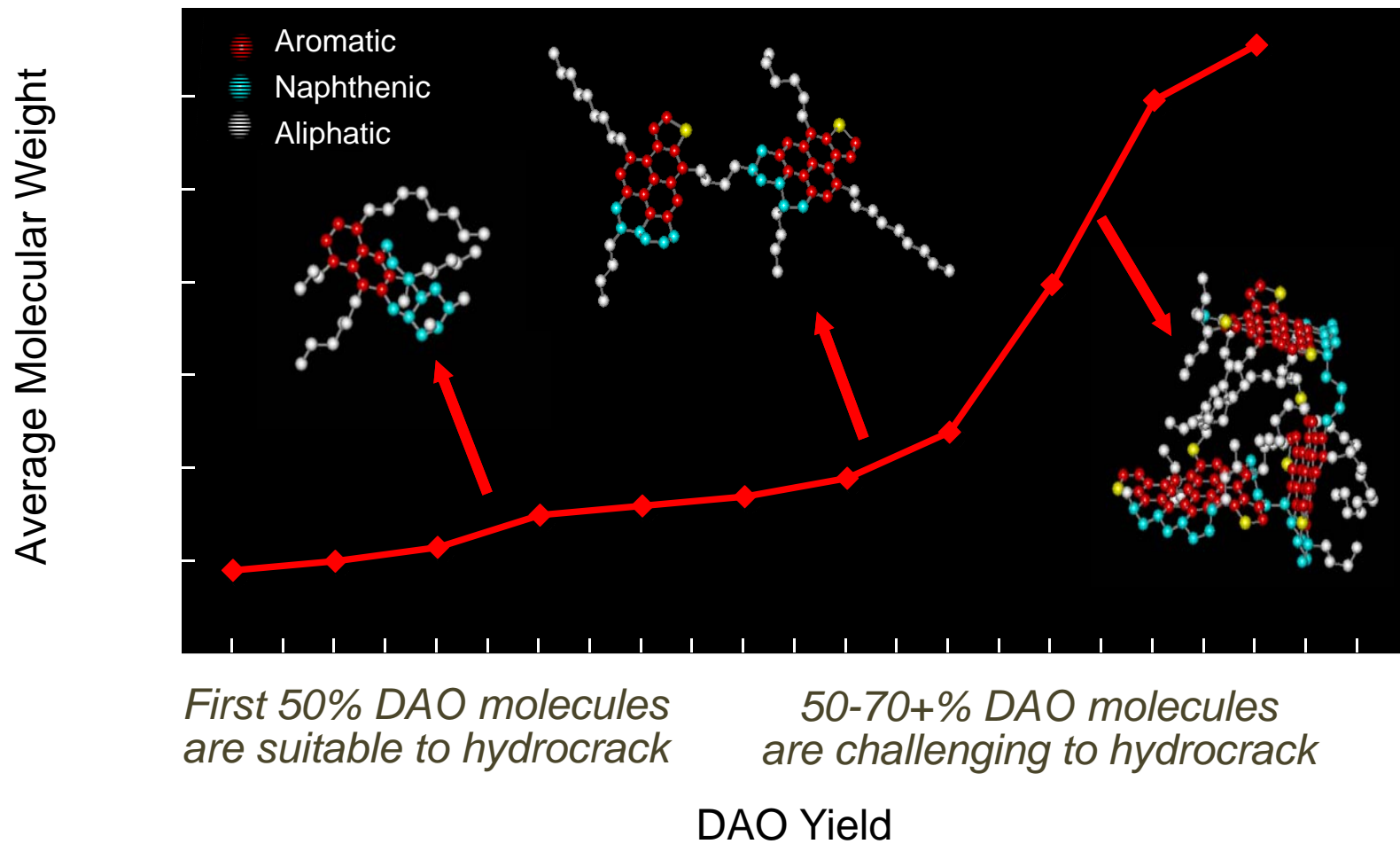
## *Middle East Sour Vacuum Residue*

	<u>Medium Lift</u>	<u>High Lift</u>
	<u>DAO</u>	<u>DAO</u>
VOL-%	50	70
API	16.7	12.9
Sp.Gr.	0.955	0.980
S, wt-%	2.9	3.2
N, wppm	1310	1930
Con Carbon, wt-%	2.9	7.4
C7 insols, wt-%	0.02	0.04
Ni +V , wppm	5	15

<u>Color Scheme</u>
Okay
Desirable
Undesirable

But high lift DAO is undesirable hydrocracking feed

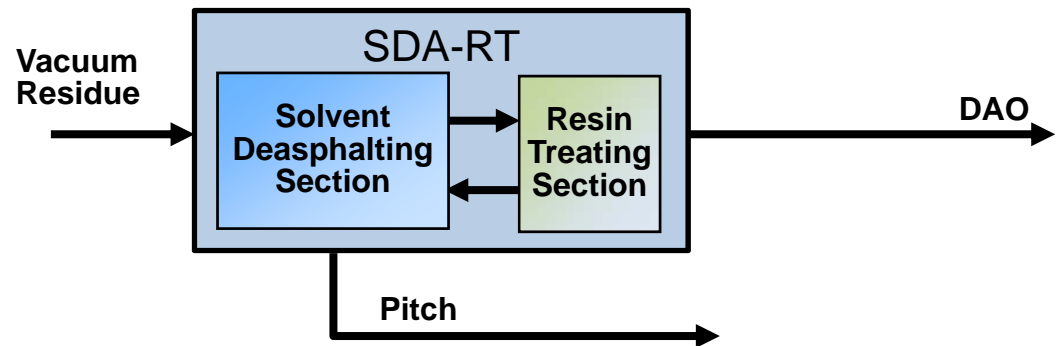
# SDA - Molecular Distribution in Products



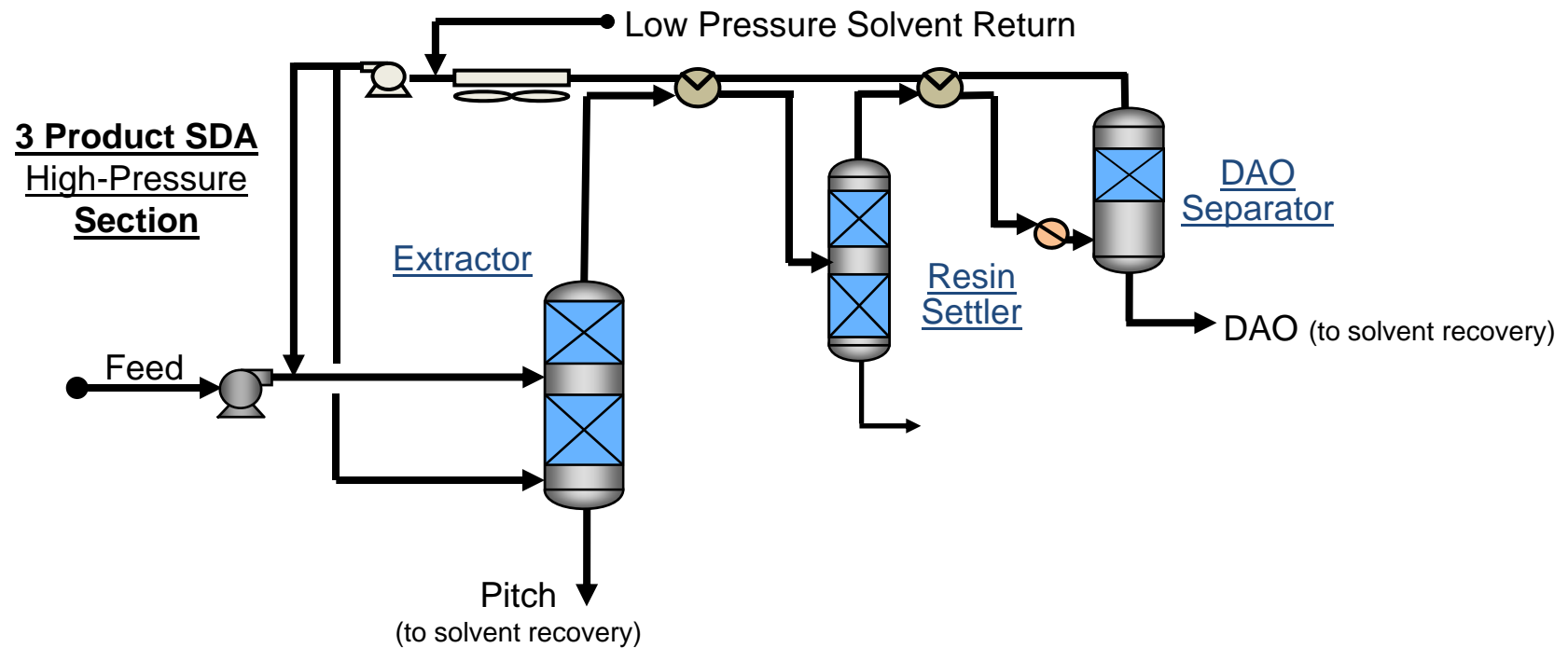
# SDA-RT

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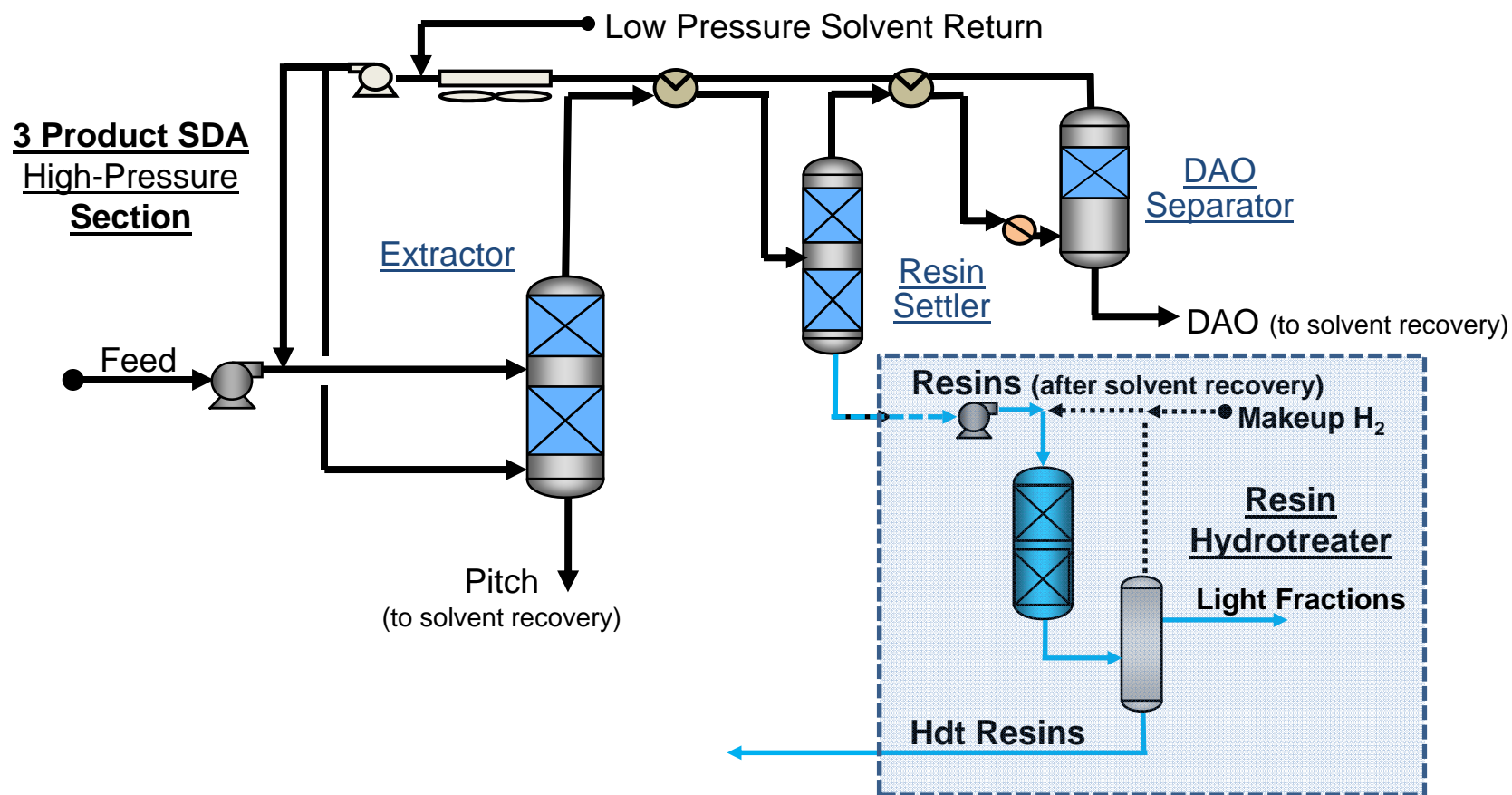
- SDA-RT
  - Unique 3 product SDA based flow scheme
  - Resins treated and further separated in SDA unit
  - Increases high quality DAO yield



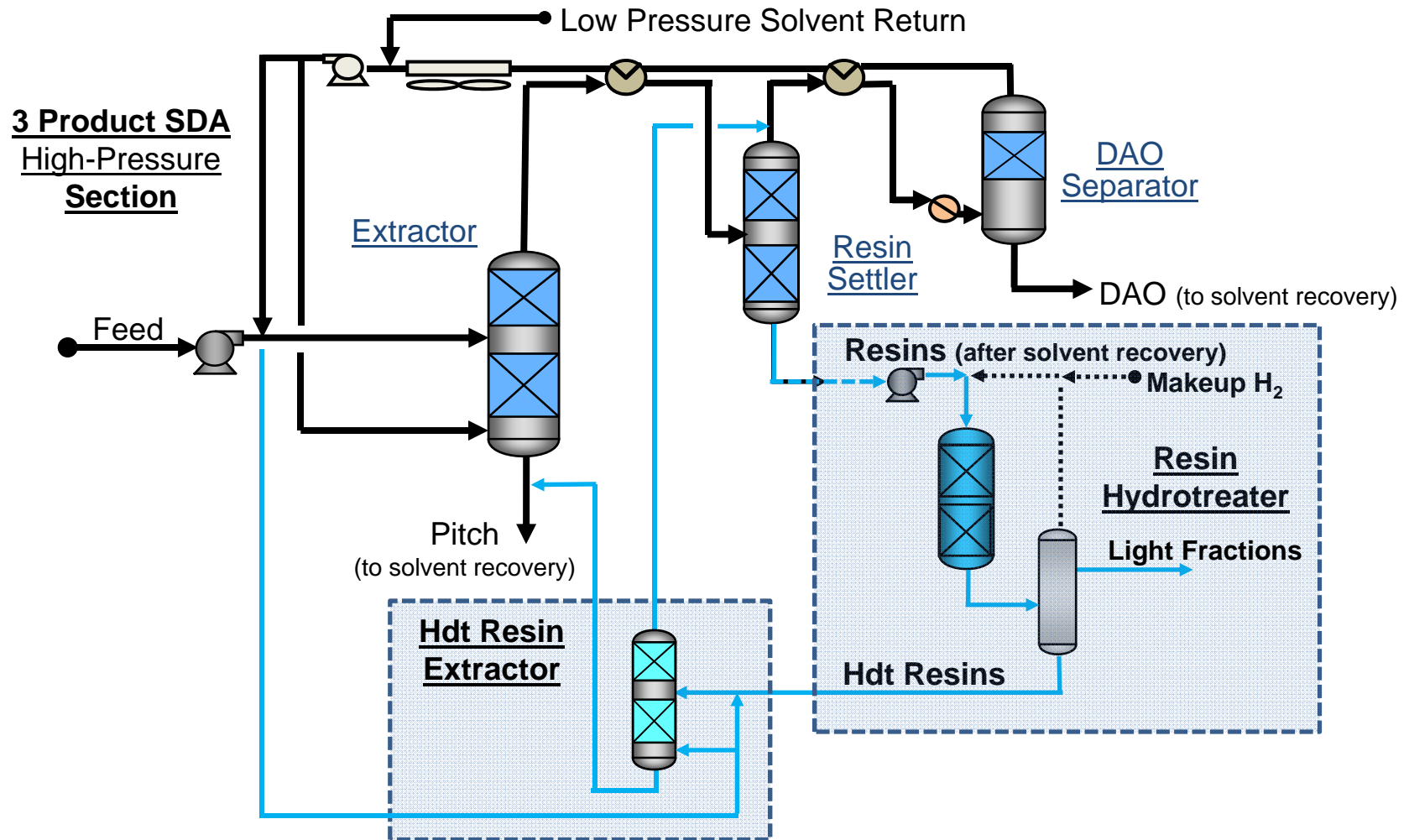
# Foster Wheeler SDA-RT Flow Scheme



# Foster Wheeler SDA-RT Flow Scheme



# Foster Wheeler SDA-RT Flow Scheme



*Uses proven technologies to maximize high-quality DAO*

# SDA DAO Quality Comparison

## *Middle East Sour Vacuum Residue*

	<u>Medium Lift</u>	<u>High Lift</u>	<u>SDA-RT</u>
	<u>DAO</u>	<u>DAO</u>	<u>DAO</u>
VOL-%	50	70	66
API	16.7	12.9	15.9
Sp.Gr.	0.955	0.980	0.960
S, wt-%	2.9	3.2	2.0
N, wppm	1310	1930	1360
Con Carbon, wt-%	2.9	7.4	3.1
C7 insols, wt-%	0.02	0.04	0.01
Ni +V , wppm	5	15	4

### Color Scheme

Okay

Desirable

Undesirable

SDA-RT maximizes high quality VGO  
conversion unit feed

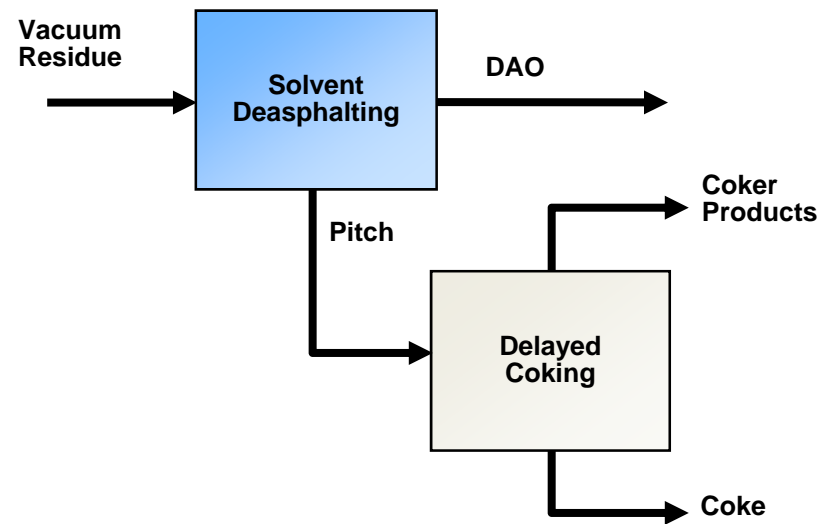


# Process Combinations

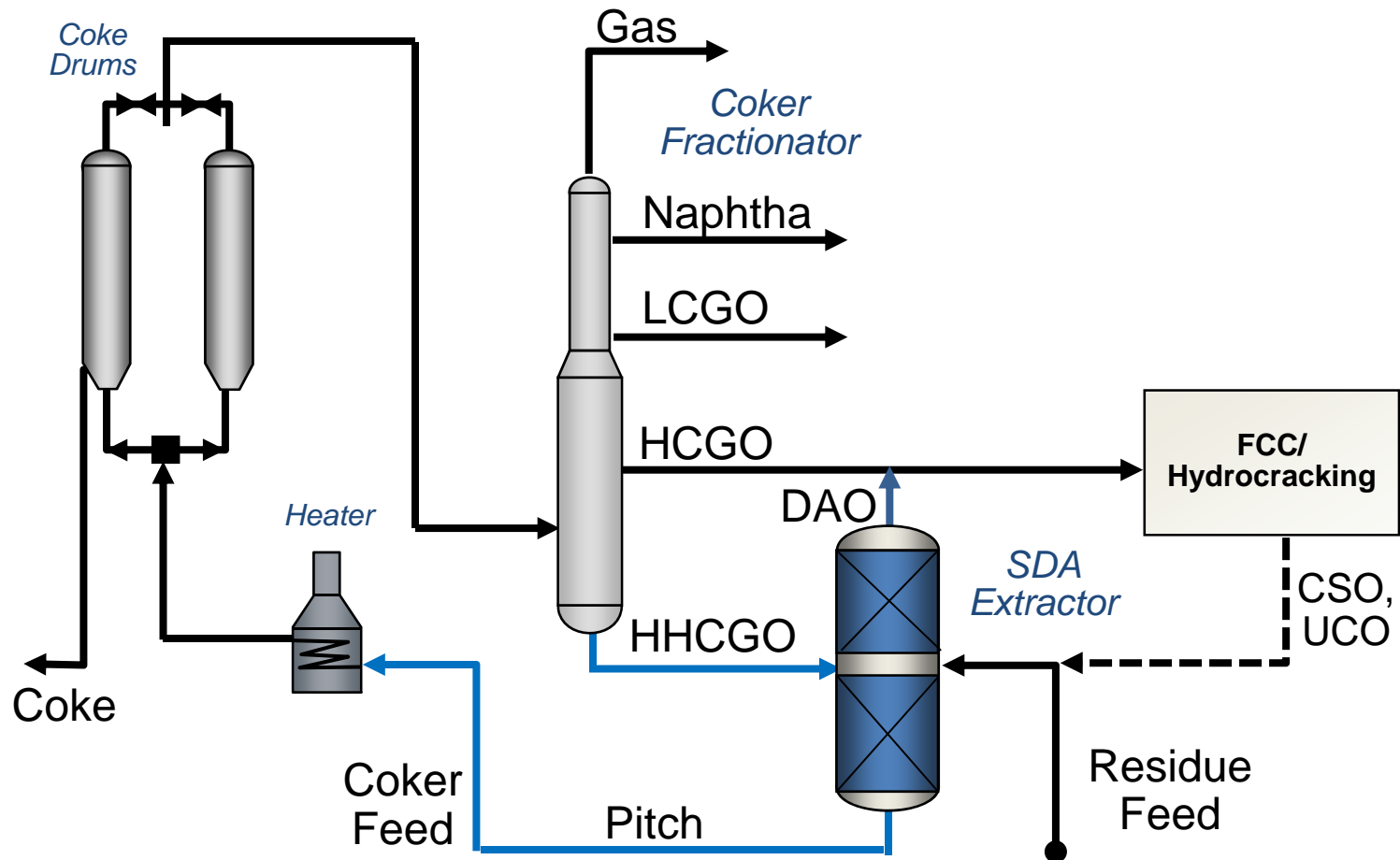
# Integrating Solvent Deasphalting With Coking

## *Managing the Molecules*

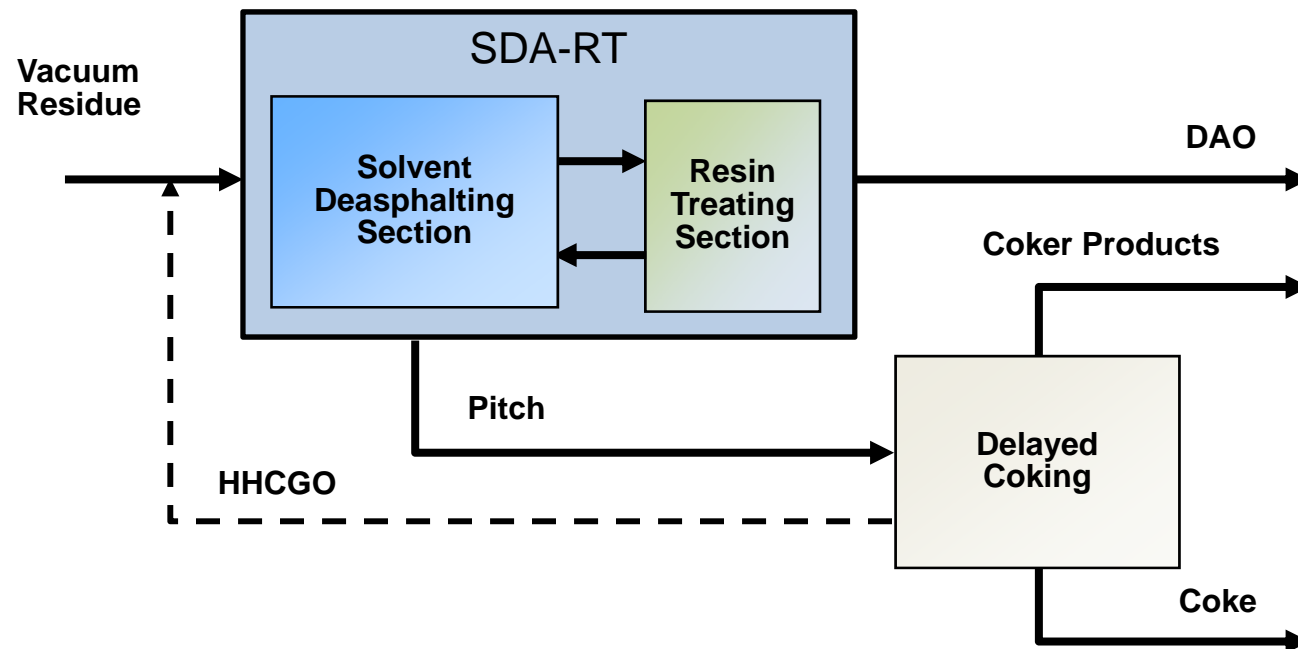
- SDA selectively separates residue components into those:
  - suitable for catalytic conversion (DAO)
  - suitable for thermal conversion (Pitch)
- Increases yields of desirable products
- Further increases margins
- SDA + Coking overall capital cost similar to Coking



# FW's Integrated SDA + Zero Recycle Coking

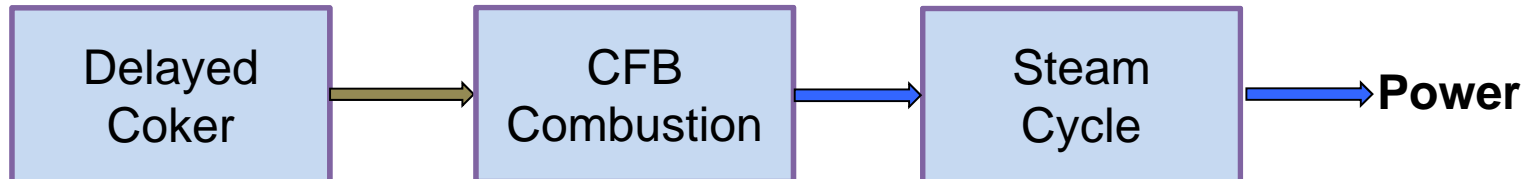


# SDA-RT & Coking Integration



# PetroPower<sup>SM</sup>

*Foster Wheeler's integrated solution to generate liquid fuels and power from residue feedstocks*



# PetroPower Project

*ENAP, Chile*

- Integrated DCU/CFB/Power production
  - 12,000 BPSD Coker
  - 700 MTD coke production
  - 59 MW net power production
- Started-up in 1998
- Original ownership
  - 85% Foster Wheeler
  - 7.5% ENAP
  - 7.5% Petrox
- Still operating today



# Residue Upgrading Case Studies

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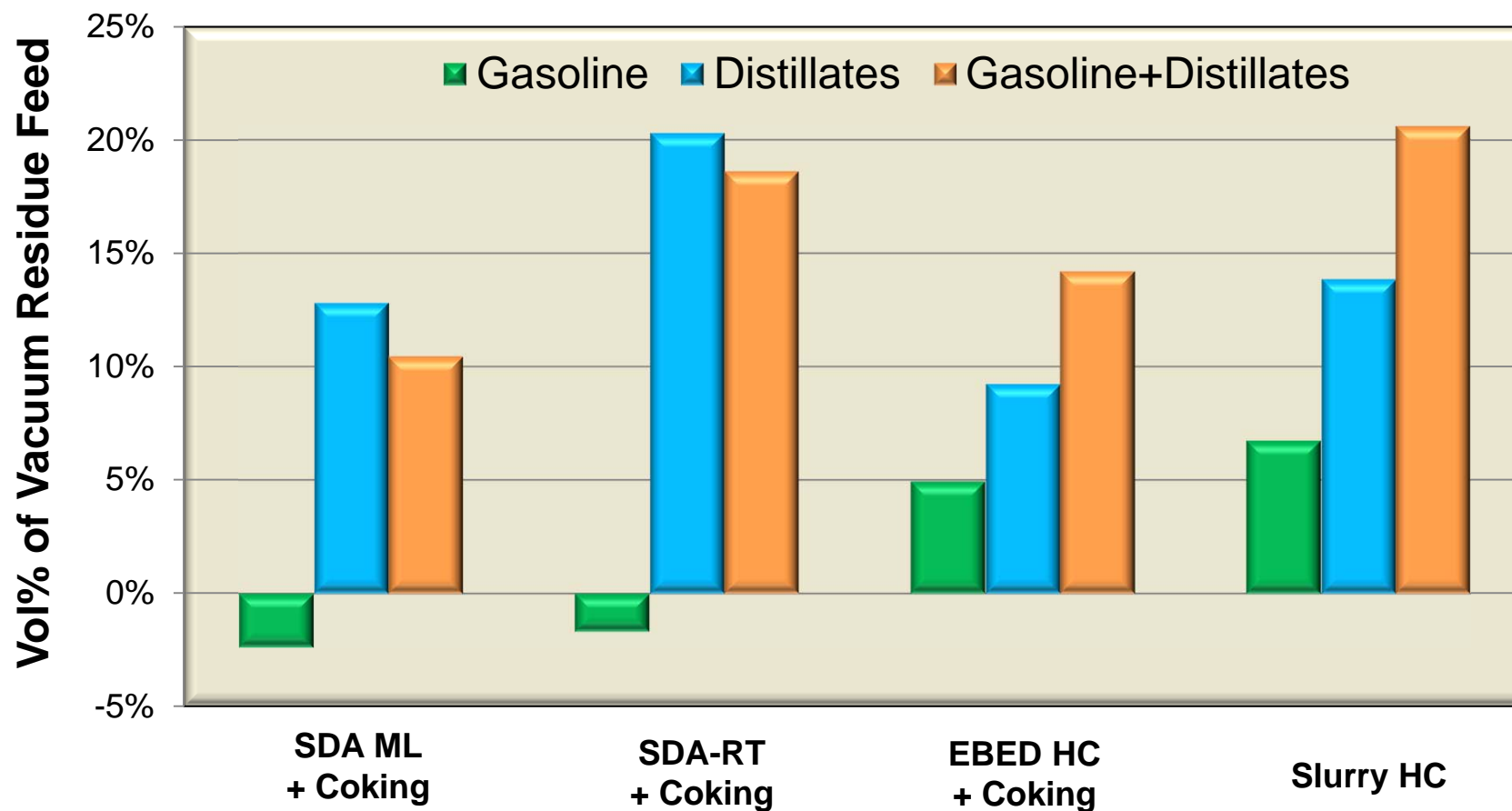
## *Case 1: Distillate Hydrocracking Based Refinery*

- Basis:
  - 300,000 BPD Middle East sour crude
  - 2015 forecast price set
  - Full conversion hydrocracking
- Options:
  - Coking
  - SDA + Coking
  - SDA-RT + Coking
  - EBED HC + Coking
  - Slurry Hydrocracking
  - Coke combustion to power and steam



# Refinery Product Yields Relative to Delayed Coking

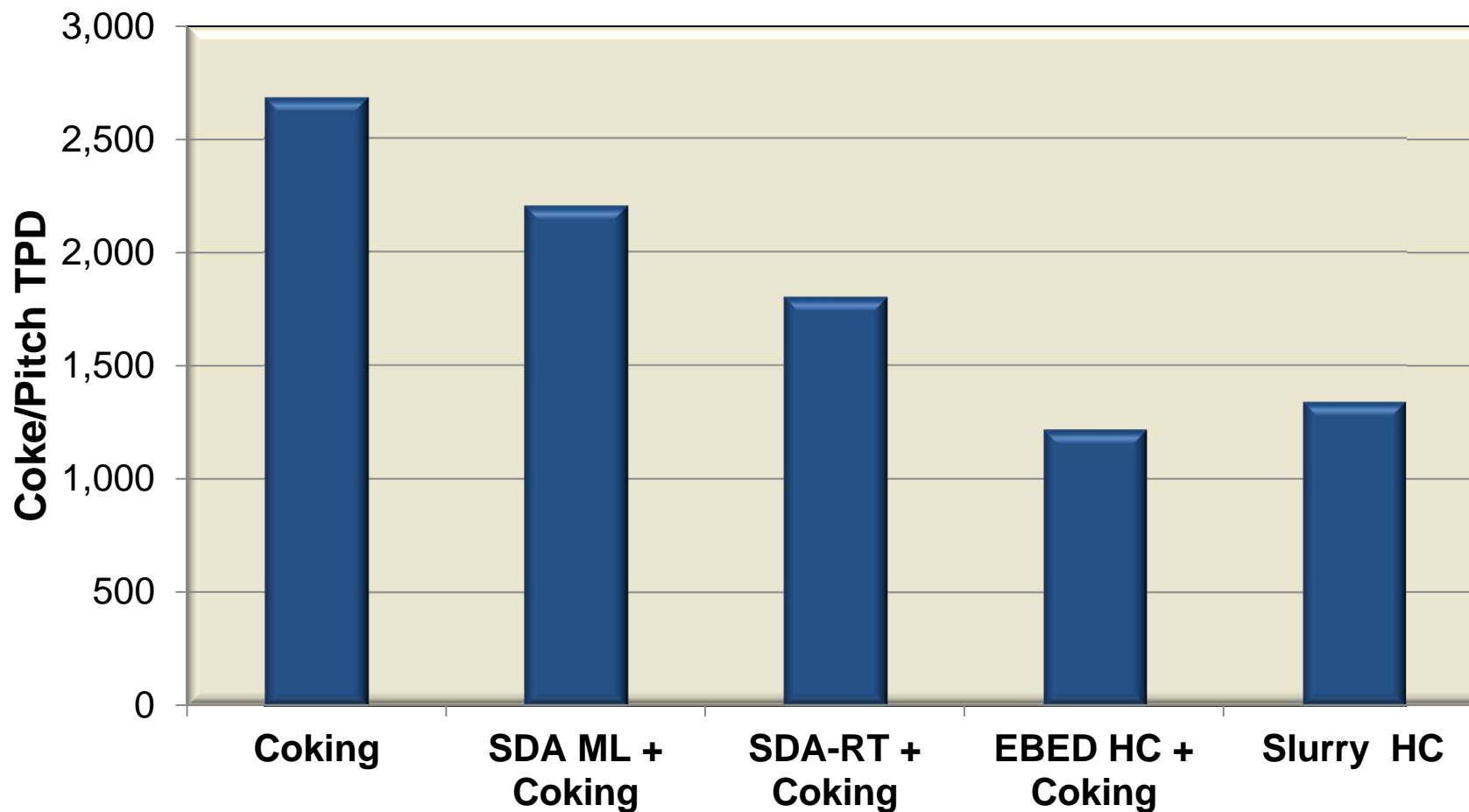
## *Case 1: Distillate Hydrocracking Based Refinery*



SDA-RT + DCU has highest distillate yield

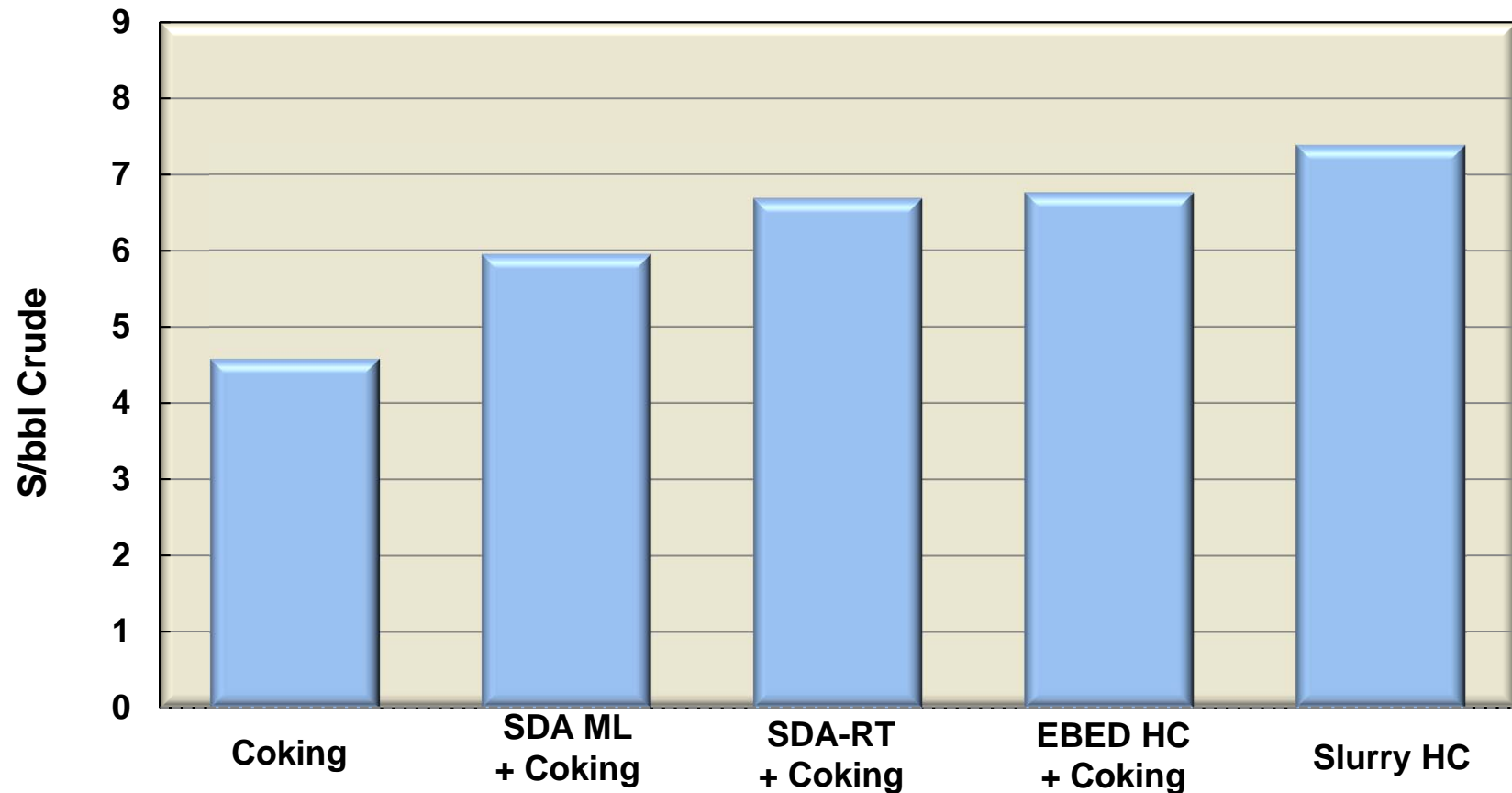
## Coke/Pitch Yields

*Case 1: Distillate Hydrocracking Based Refinery*



# Net Refinery Operating Margins

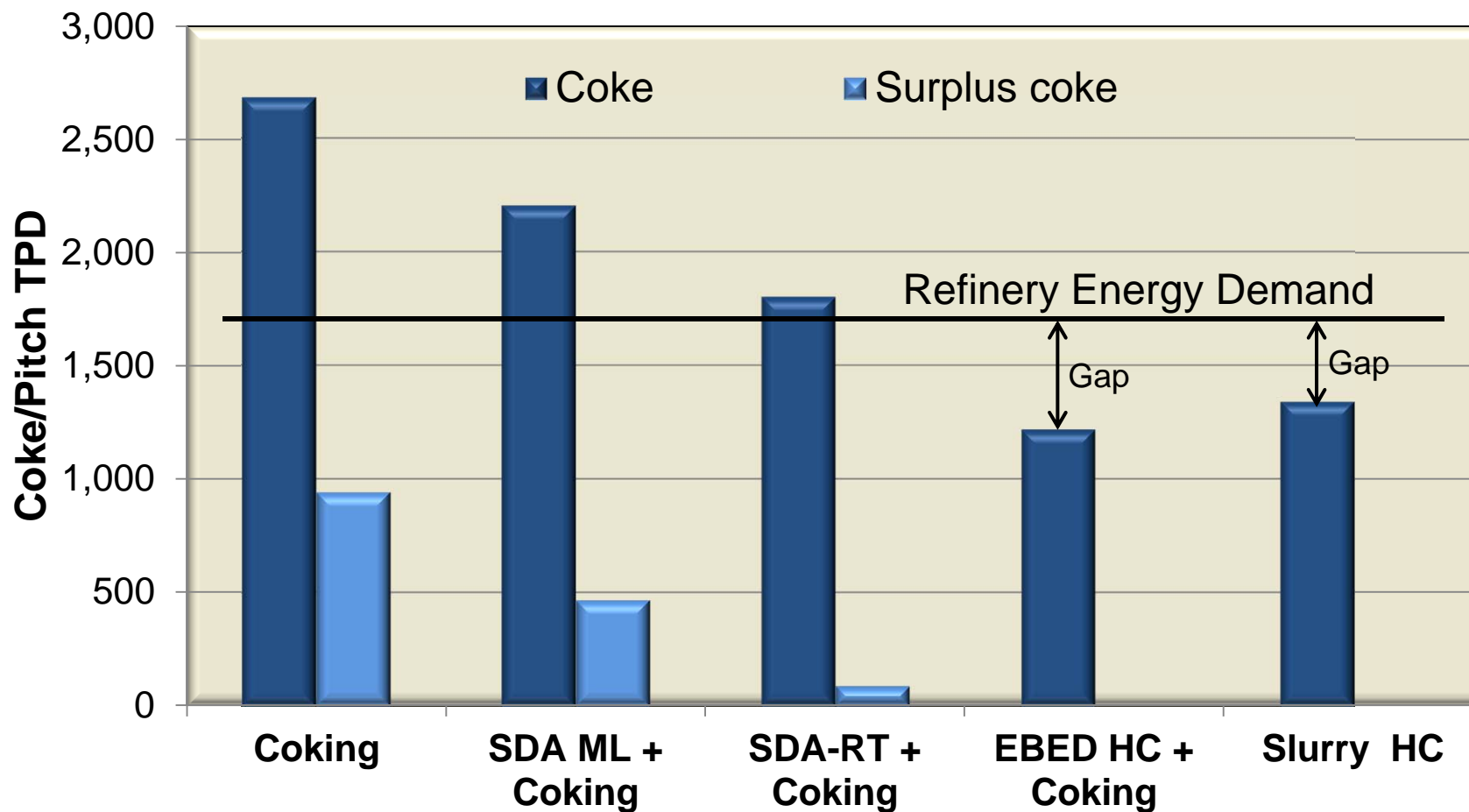
## *Case 1: Distillate Hydrocracking Based Refinery*



SDA-RT + Coking competes with residue hydrocracking

## Coke/Pitch Yields

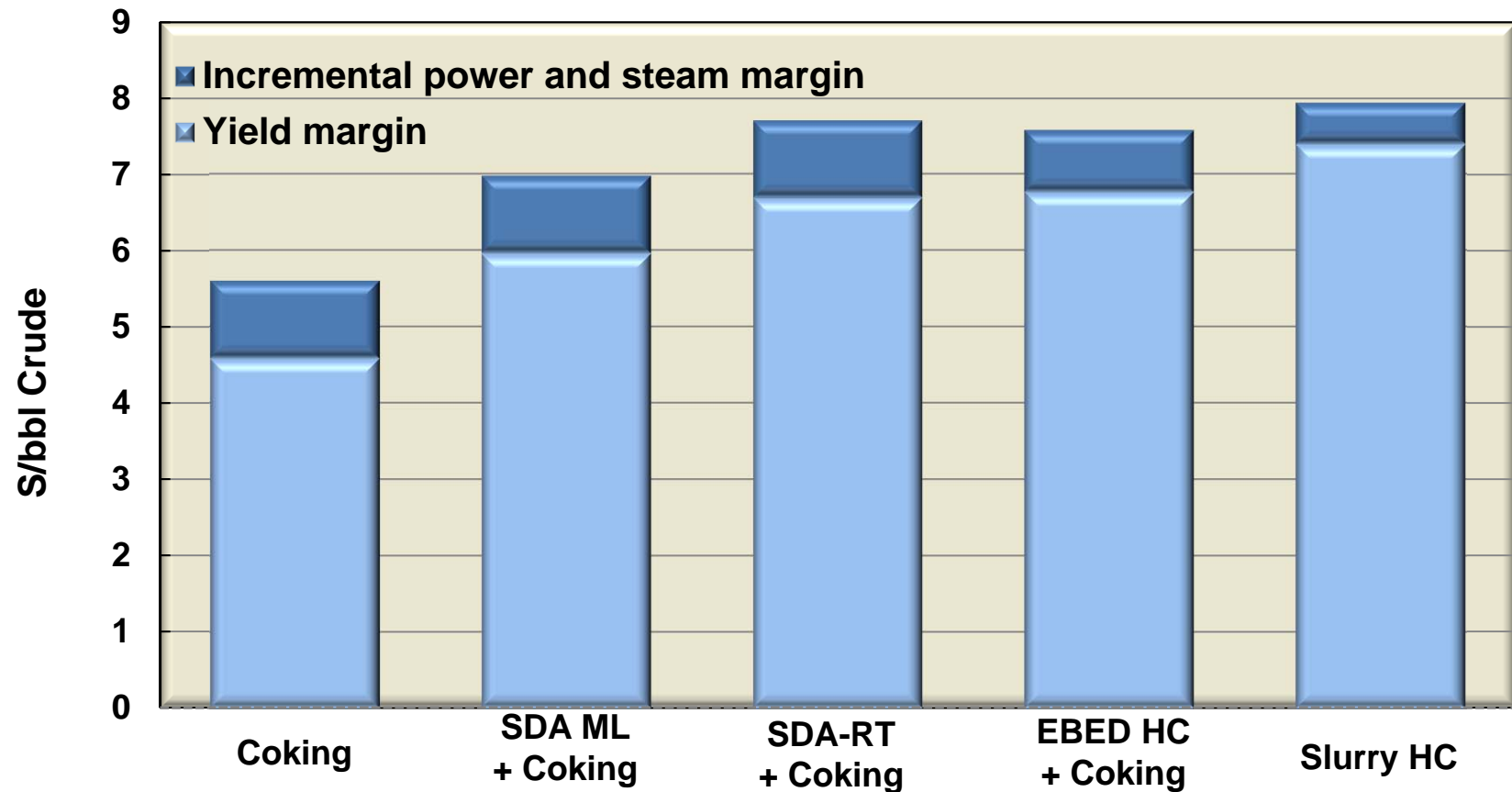
### Case 1: Distillate Hydrocracking Based Refinery



SDA-RT + Coking coke make in balance with energy demand

# Net Refinery Operating Margins

## *Case 1: Distillate Hydrocracking Based Refinery*



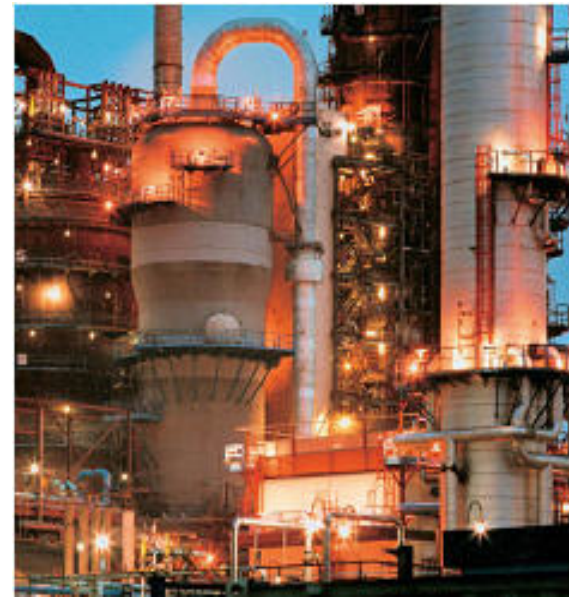
SDA-RT + Coking after coke conversion to energy has margins similar to residue hydrocracking

# Residue Upgrading Options

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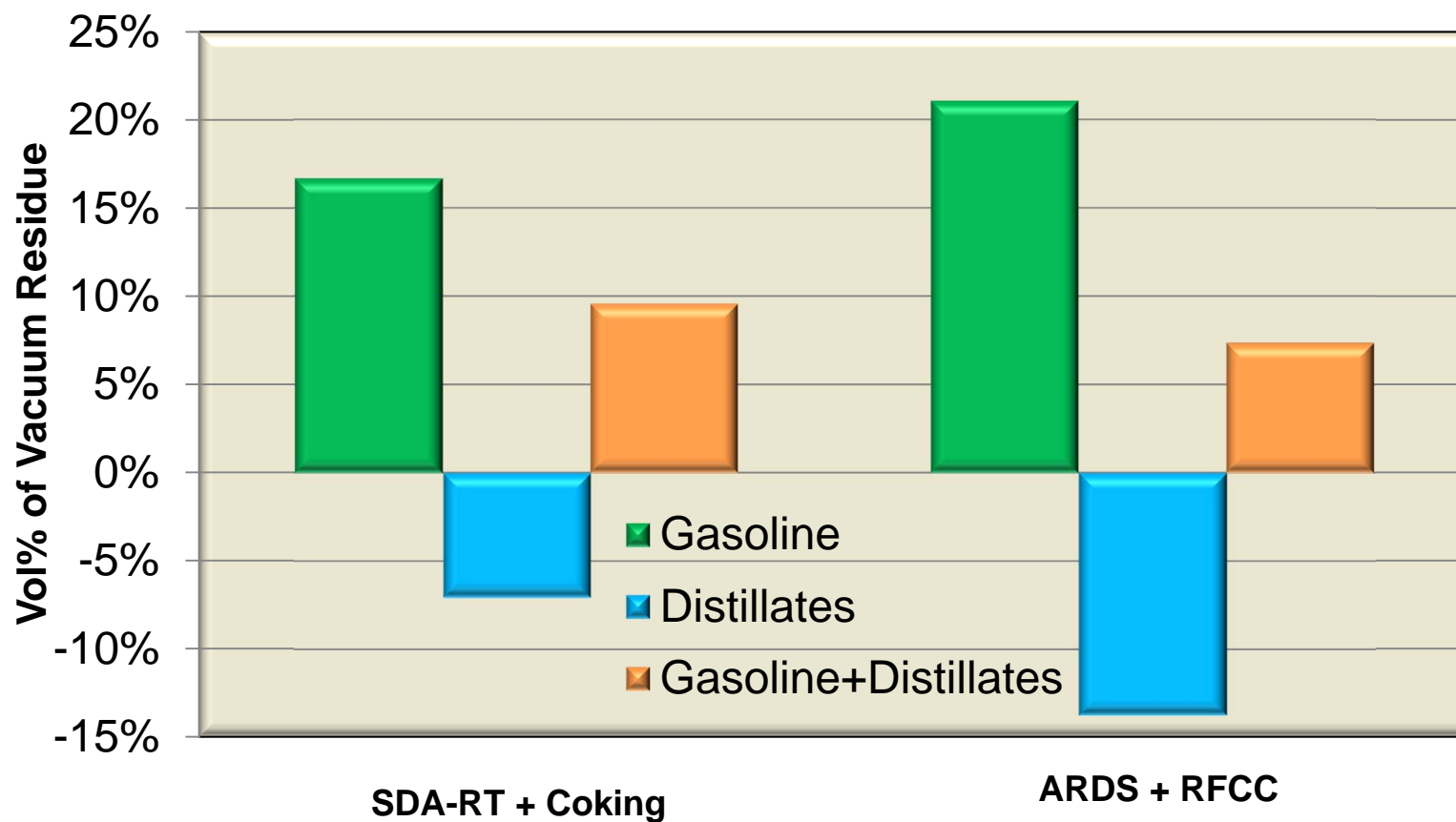
## *Case 2: FCC Based Refinery*

- Basis:
  - 300,000 BPD Middle East heavy crude
  - 2015 forecast price set
  - FCC to produce gasoline and Propylene
- Options:
  - Coking
  - SDA-RT + Coking
  - ARDS + RFCC
  - Coke combustion to power and steam



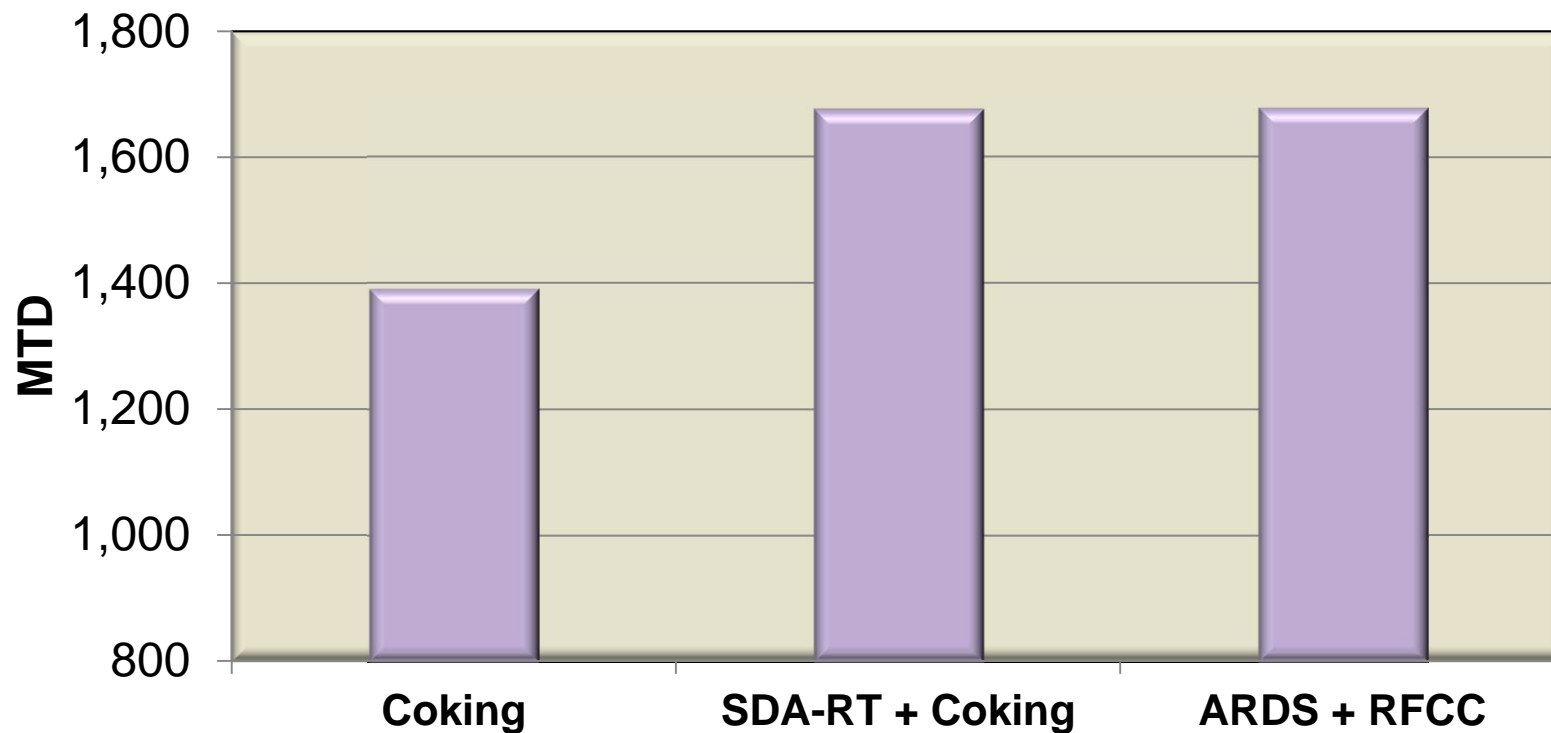
# Refinery Product Yields Relative to Delayed Coking

*Case 2: FCC Based Refinery*



# Refinery Propylene Yields

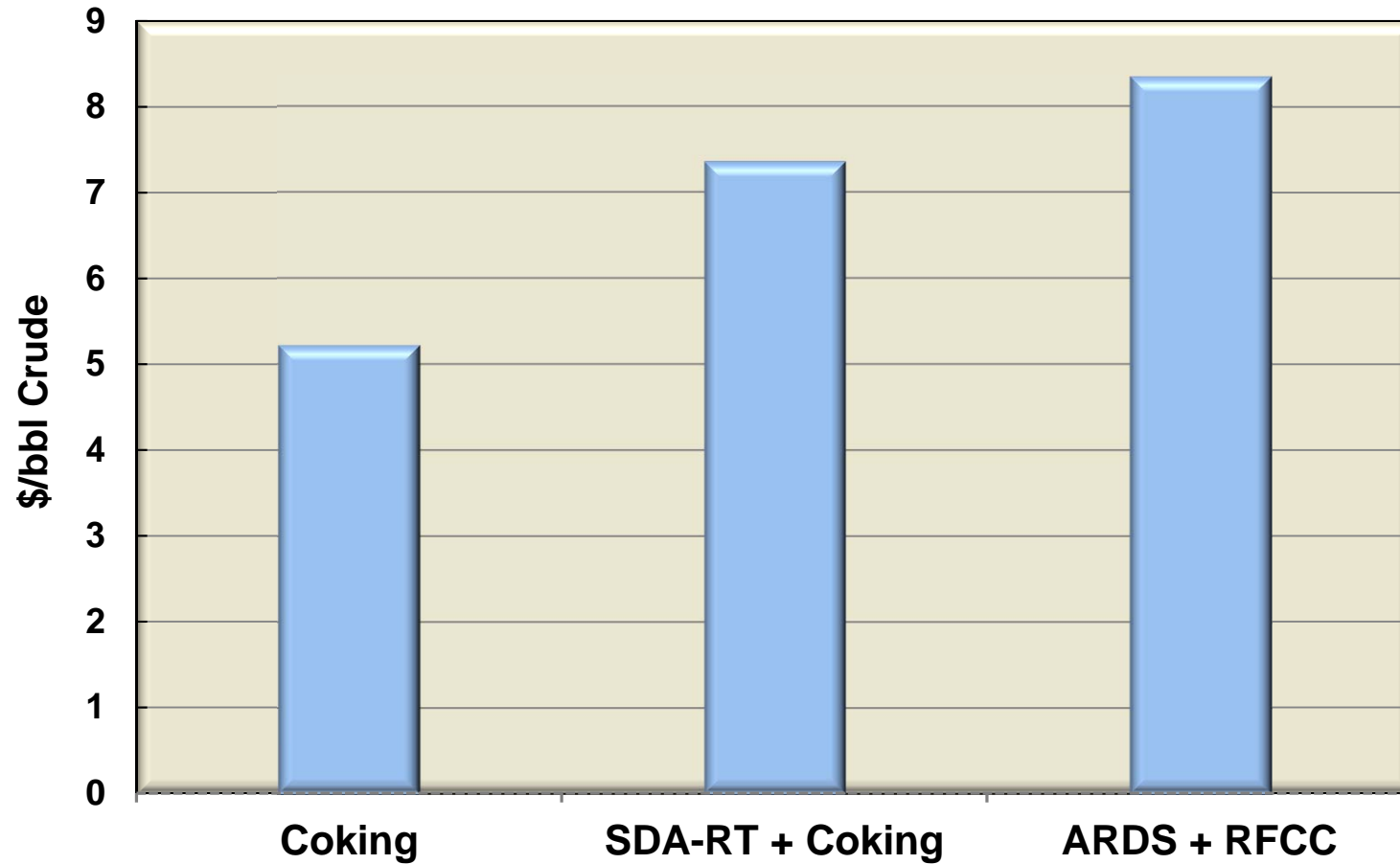
## *Case 2: FCC Based Refinery*



SDA-RT + Coking competes with ARDS for Propylene yields as its FCC feed is higher quality

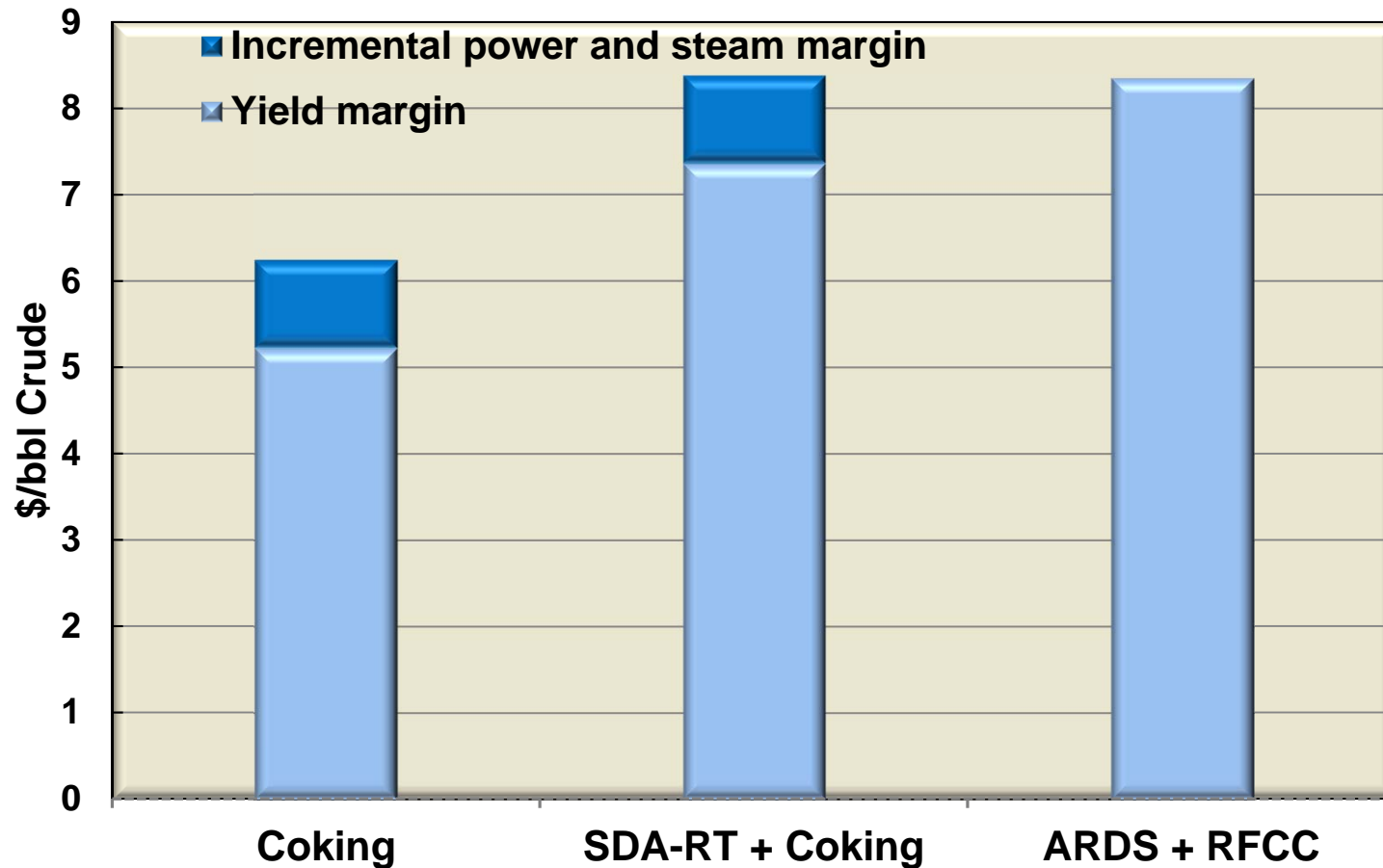
# Net Refinery Operating Margins

## *Case 2: FCC Based Refinery*



# Net Refinery Operating Margins

## Case 2: FCC Based Refinery



SDA-RT + Coking has similar margins to ARDS + RFCC

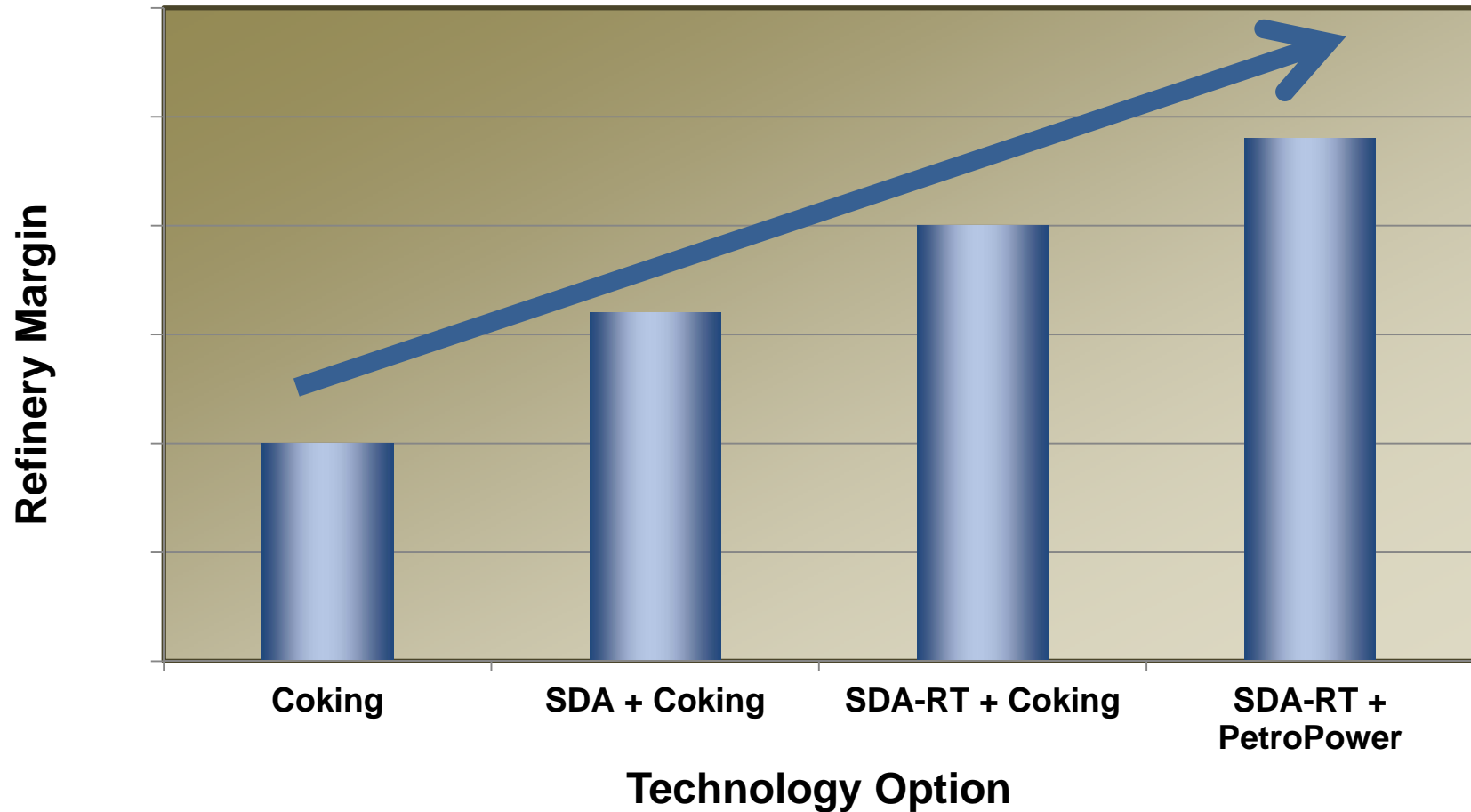
# Summary

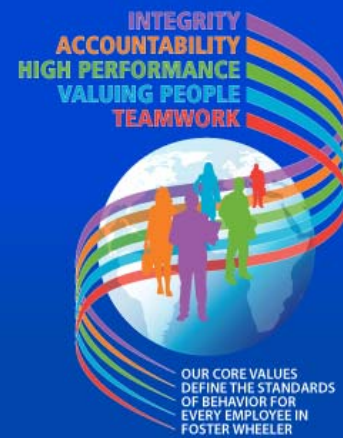
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- There are a number of options for residue upgrading
- Foster Wheeler can offer a choice of processing routes
- Foster Wheeler's integrated SDA/Coking schemes
  - Increase liquid yields over Coking alone
  - Reduce coke make
  - Increase refinery margins
  - SDA-RT + Coking approaches Residue Hydrocracking performance at significantly lower cost
  - No residual heavy liquid product
- On site production of power and steam from pet coke can further improve margins

# Foster Wheeler Residue Conversion Solutions

*Providing a Pathway to Maximizing Margins*





[www.fwc.com](http://www.fwc.com)