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Heavy Oil Upgrading Environment
Market and Technology

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Market - where are we now?

- Continued economic growth
- After several years of under-investment in oil and gas, refining and petrochemicals, there has been significant growth in new projects
- Investment has been by international oil companies, national oil companies and independents

And at the same time:

- Continuing investment in non-hydrocarbon sectors, e.g. hotels, airports, housing, ports
- Concurrent industrial investment in Middle East, China and India

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Market - where are we now?

This growth in projects has led to:

- Capex risen significantly over the past two to three years – costs still rising, but not at the same rate
- It is not just refining that has experienced this rapid growth – all business lines continue to see upward pressure on costs
- Rising costs has an impact on economics
- However, margins currently remain sufficiently high to support projects in most regions
- Therefore very important to select correct project

Looking at specific drivers to upgrade residues …

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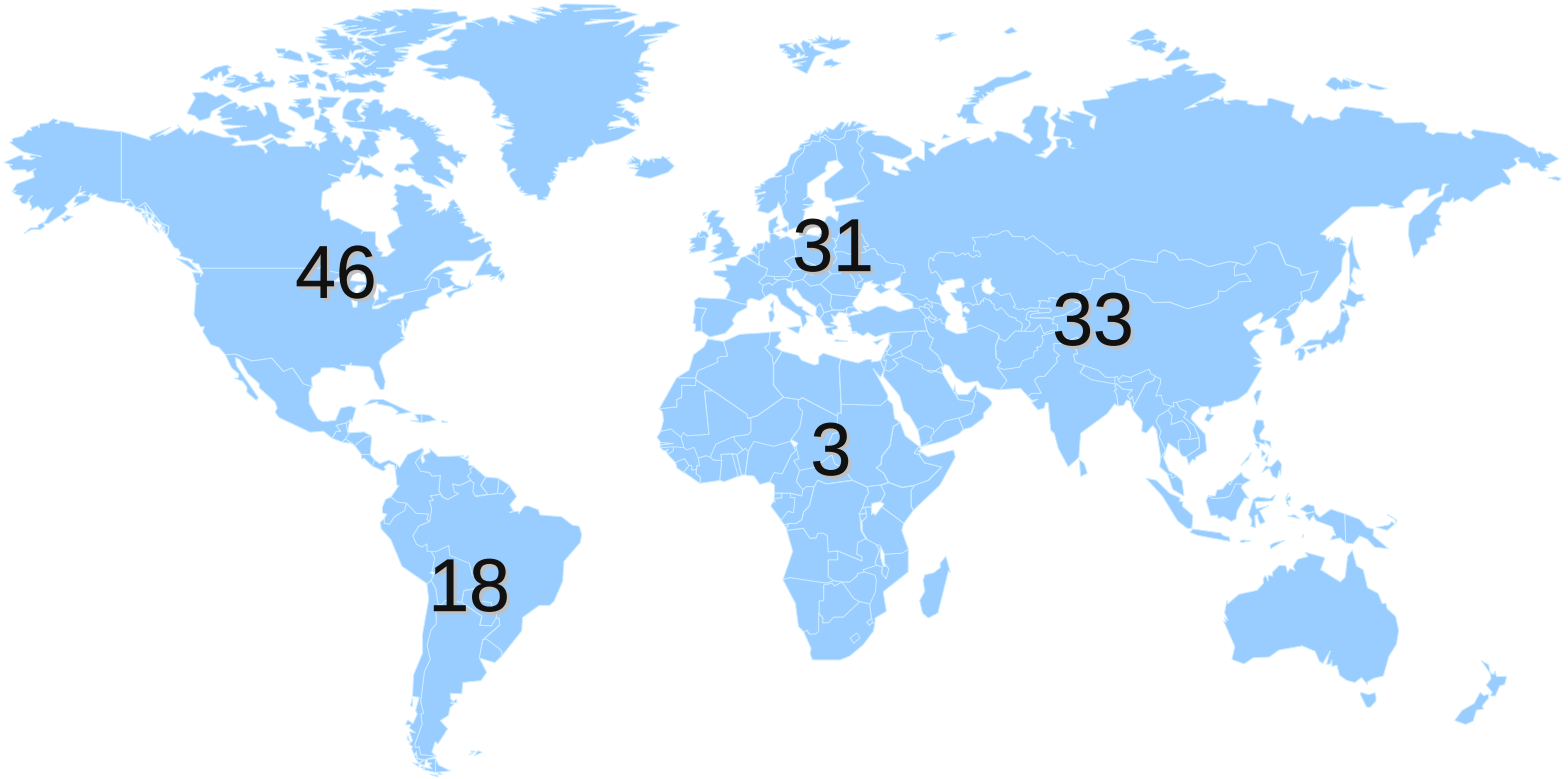
Global Heavy Oil & Residue Upgrading Projects Including Those Under Evaluation



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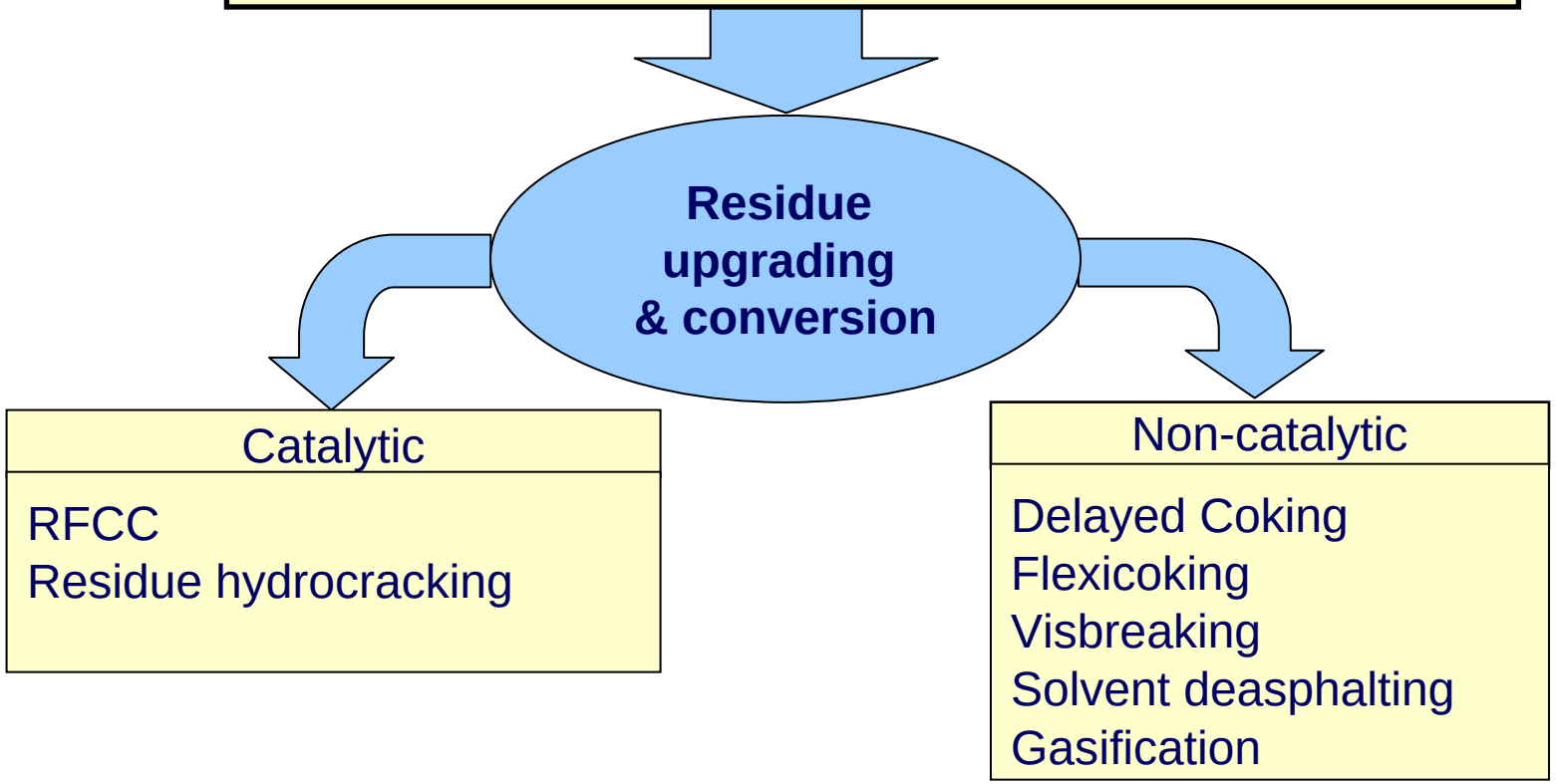
Residue upgrading – drivers & routes

Increasing light – heavy crude differential
Declining markets for high sulfur fuel oil
Increased demand for distillates
Extra heavy crude & bitumen upgraders



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Residue upgrading options

Visbreaking	Delayed Coking	Flexi coking	Solvent Deasphalting	Residue Hydrocracking	Gasification	Residue FCC
Low TIC	Moderate TIC	High TIC	Low TIC	High to Very high TIC	Very high TIC	Moderate TIC
Low conversion Fuel oil residue	Easy to integrate into refinery Readily available coke market	Complex Operation Low Btu Gas Challenge Very Small Volumes of Purge Coke	Expensive product treatment Pitch residue	Complex operation Large hydrogen demand Fuel oil residue	Needs electricity market and / or Produces syngas / hydrogen	Carbon Residue Limited Use with ATB or light residues

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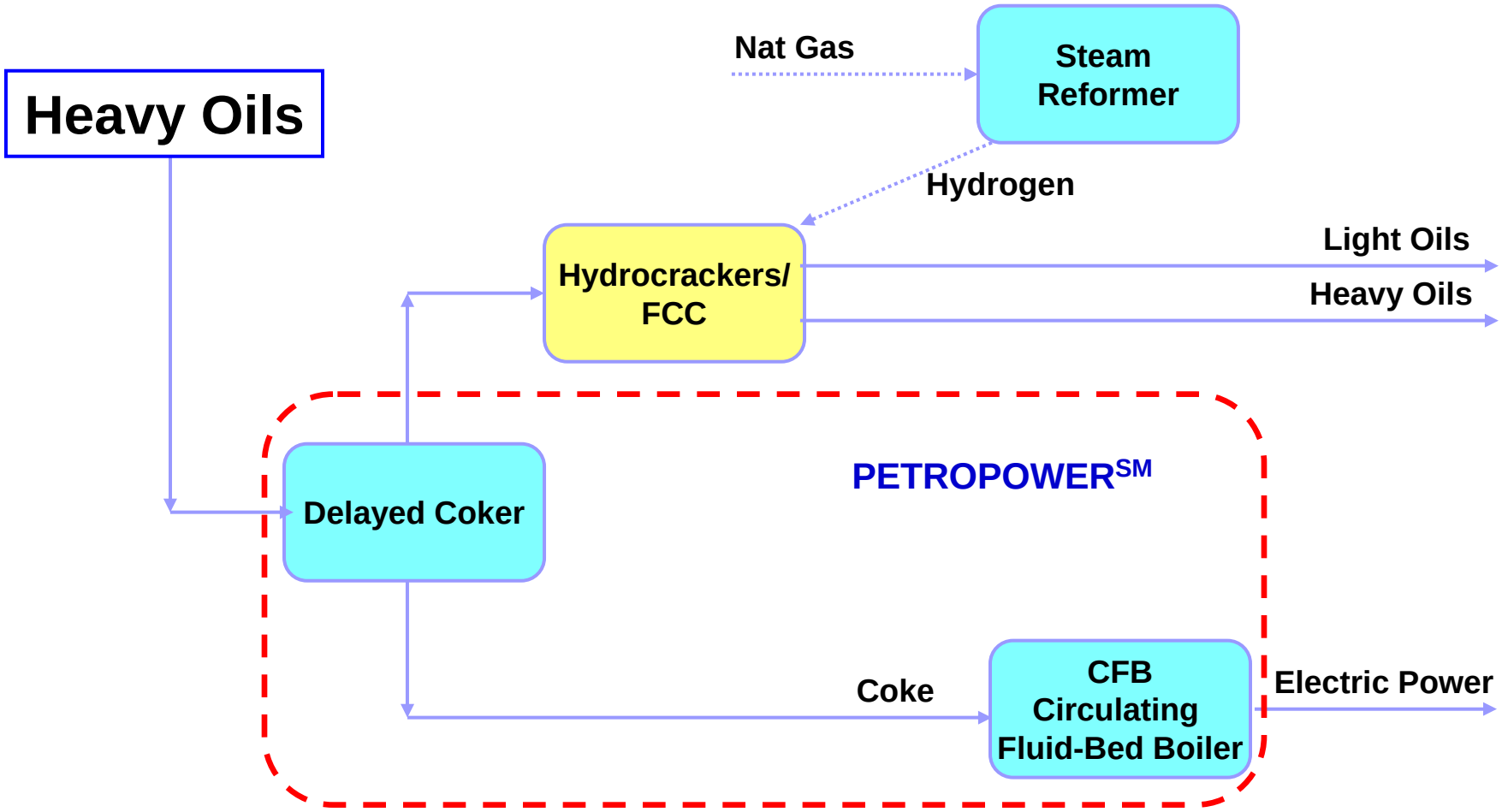
Processing schemes



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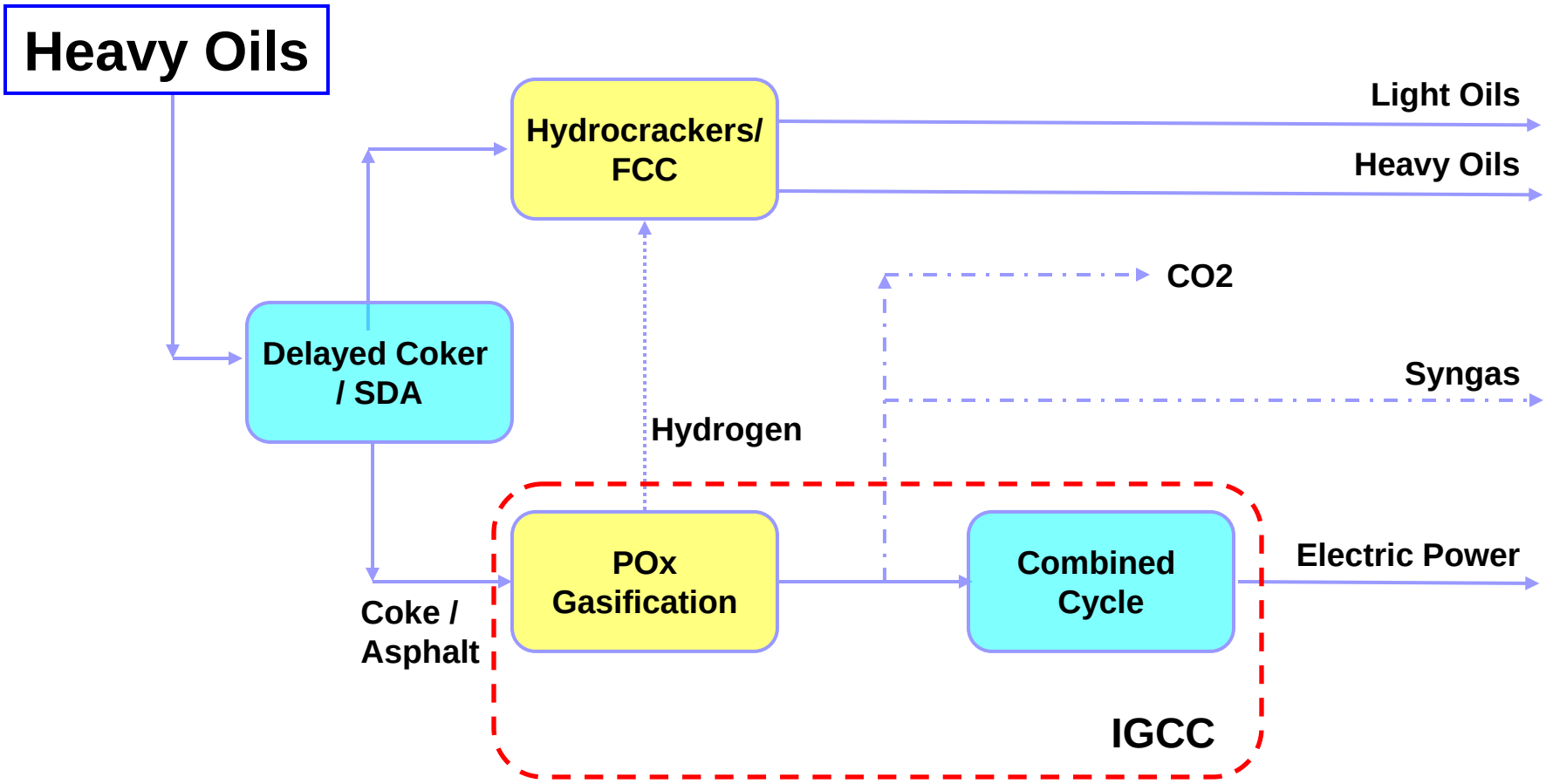
Processing schemes



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Processing solutions:

SYDEC^{SM} Delayed Coking

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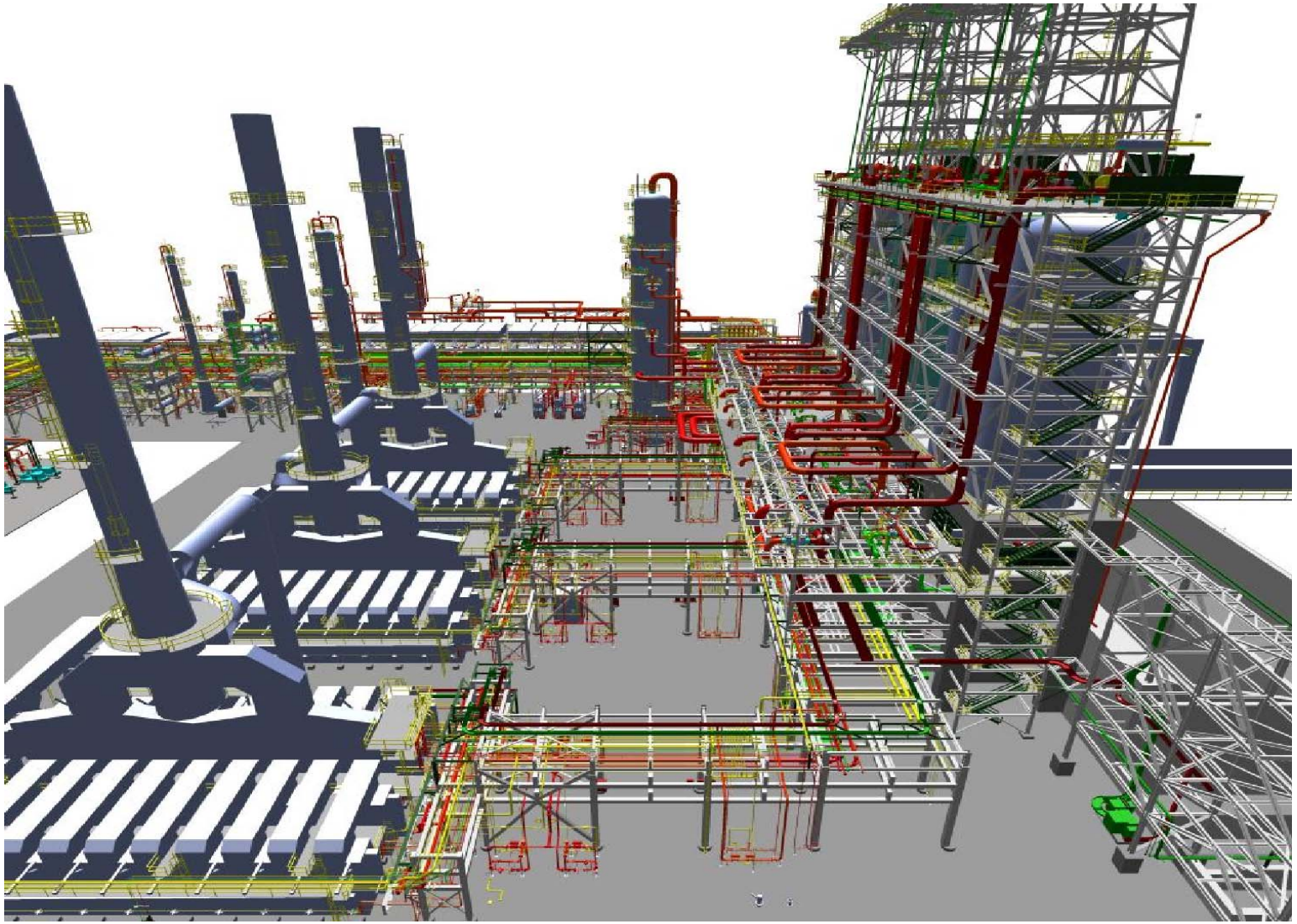
Sydec^{SM} Delayed Coking Process



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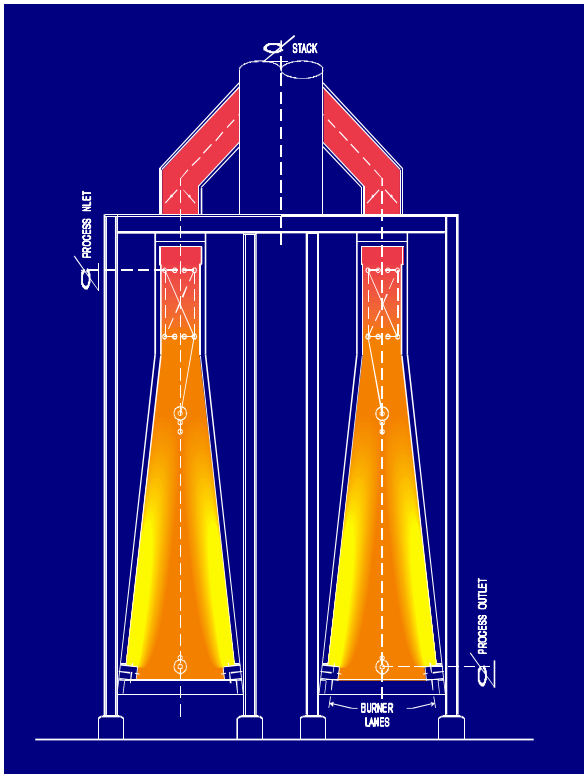
SYDEC^{SM} coker heaters

Foster Wheeler Double Fired Furnace

- Long heater runs
- Use with on-line decoking techniques



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Benefits of delayed coking

- Proven technology
  - Past experience: large available knowledge base on design, operations and maintenance
- Strong 3rd party support services and equipment vendors
- Long turnaround periods: 5 years +
- Excellent margins
  - Fast realisation of project payback
- Anode product coke for low sulphur / metals feed
- Modern designs are safe and clean
- By-product fuel coke is easily marketed

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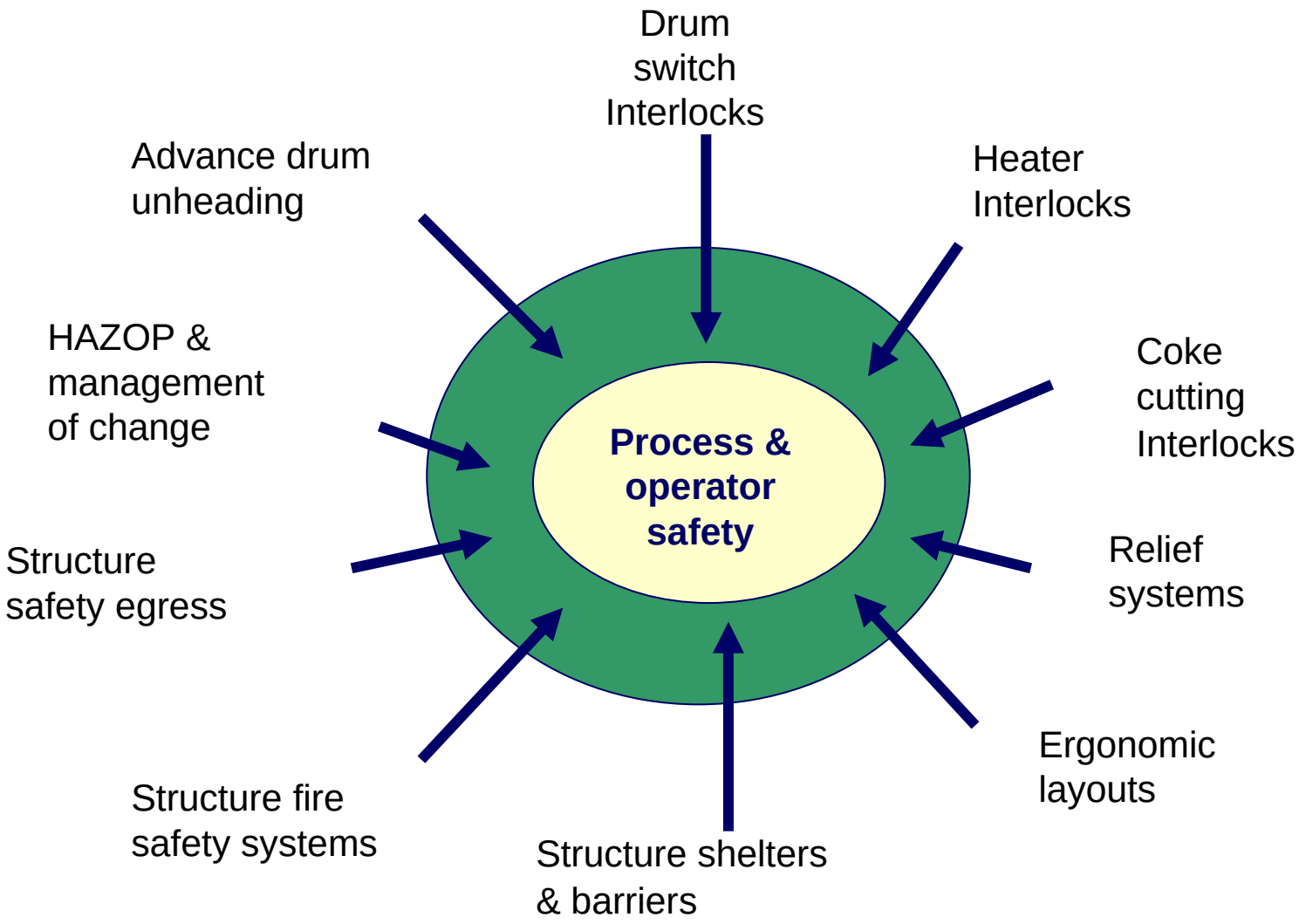
SYDEC^{SM} - design for safety



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Environmental controls

- **Fines wetting and containment / collection**
- **Enclosed blowdown system with recovery of vent vapors and unconverted oils**
- **Heater NO_X controls**
  - SCR; low NO_X burners
- **Coke particulates**
  - Wind barriers & wetting systems to prevent windage loss
  - Wash stations for mobile equipment
  - Coke handling
    - Enclosed conveyors or tubular conveyors
    - Covered storage ‘barns’ and reclaimers/silos
- **Water reuse**
- **Refinery sludge disposal**

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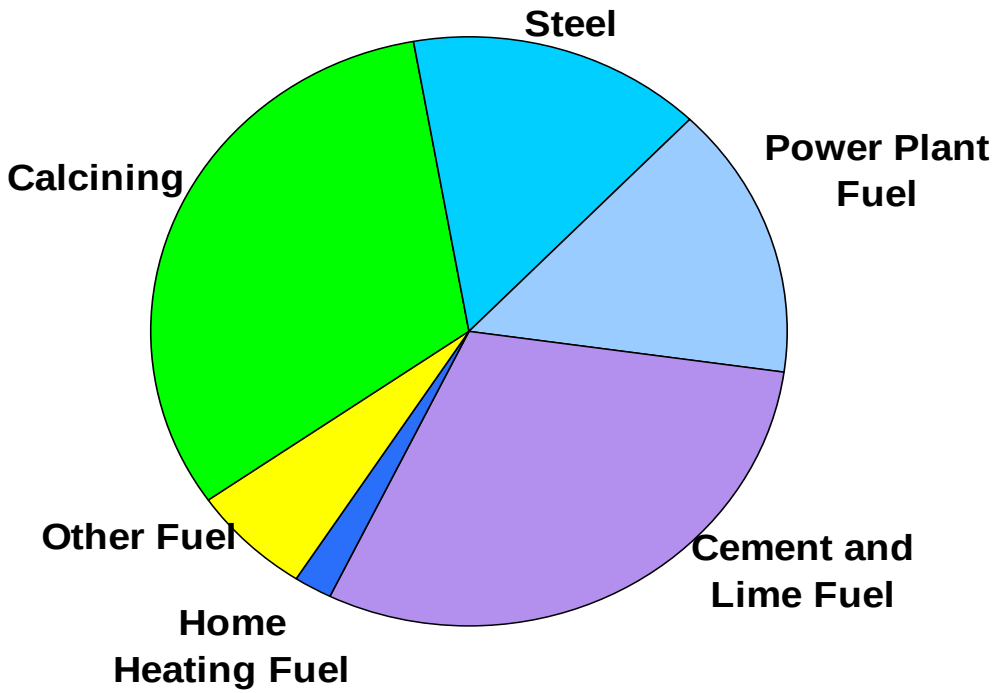
Global Petcoke Uses

- **By Industrial Application (Courtesy of Oxbow Carbon)**



Fuel coke sells at a discount to coal and is a low profit product with no disposal issues

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Processing solutions:
Solvent Deasphalting (SDA)

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Why solvent deasphalting?

- Physical separation of residues into:
  - Deasphalted oil (DAO)
  - Highly viscous, asphaltene-rich stream (pitch)
- Separation is by density differences
- Light liquid paraffins precipitate asphaltenes and resins from heavy oils
- Non-thermal process
- Separation of DAO and solvent by
  - Subcritical
  - Supercritical
- Can be combined with SYDEC^{SM} for ASCOT process

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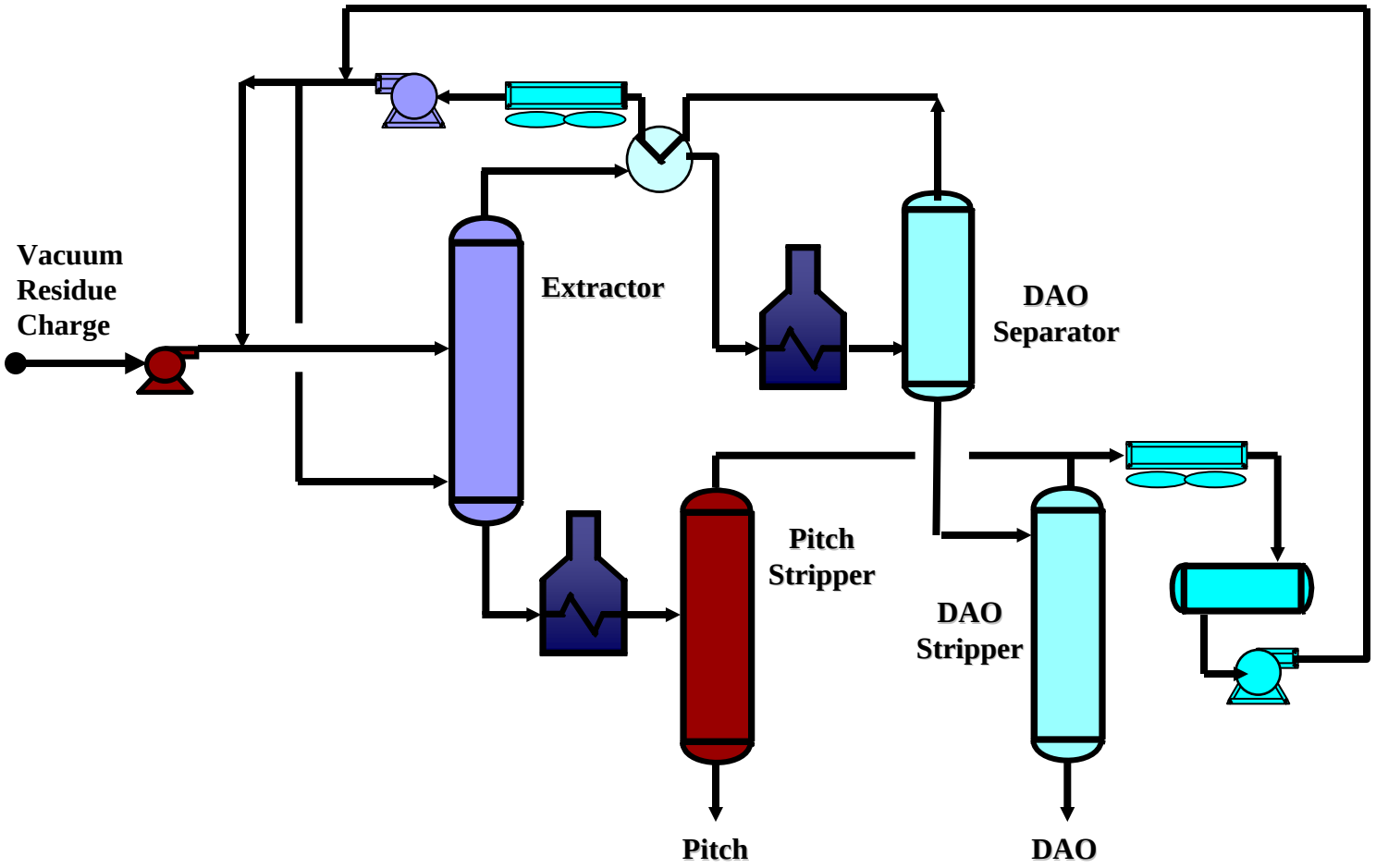
Why solvent deasphalting?

UOP/FW SDA Process Supercritical Design



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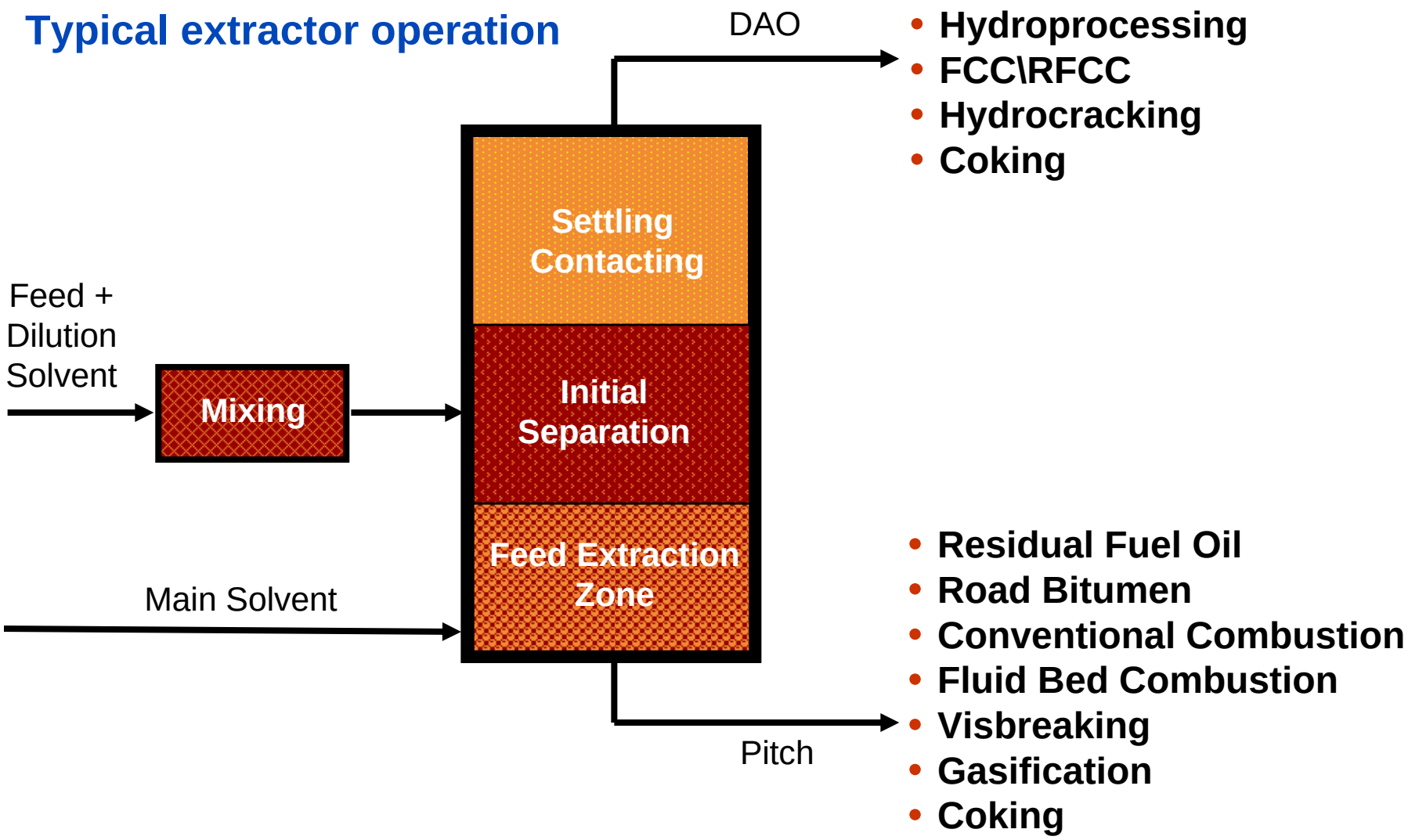
Why solvent deasphalting?

Typical extractor operation



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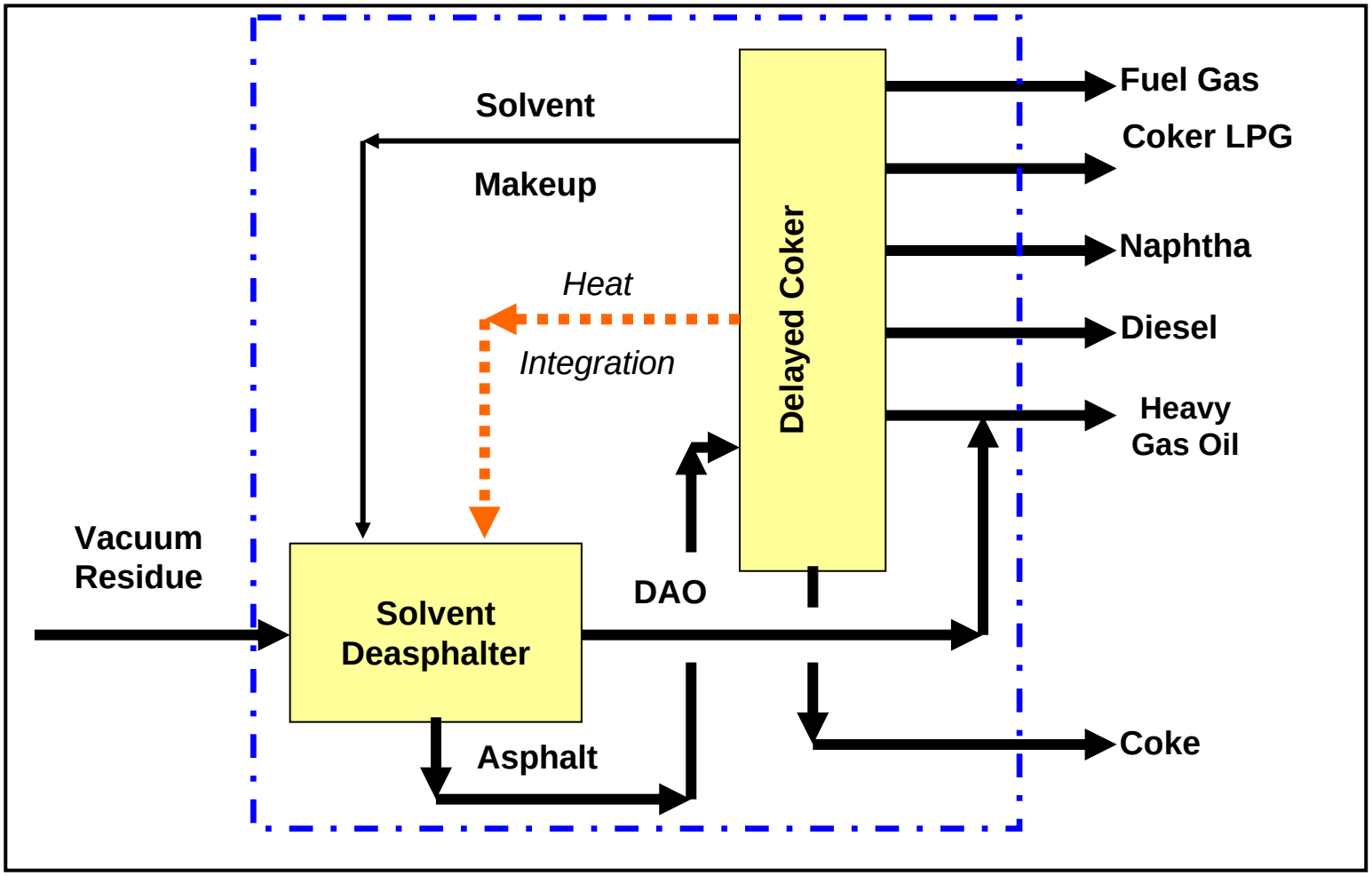
ASCOT^{SM}: SDA and coking



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Processing solutions:

Visbreaking / Thermal Cracking

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UOP Foster Wheeler Visbreaking: Technology Overview

- **Mild Thermal Conversion Process**
  - ✓ Limited by Product Stability
- **Primarily used to reduce Fuel Oil Cutter Stock**
  - ✓ Can produce VB VGO for FCC or Hydrocracker
  - ✓ Utilizes relatively low-cost equipment
  - ✓ No Hydrogen, low-pressure design
- **Two (2) Types:**
  - ✓ Coil - Heater only Conversion
  - ✓ Soaker - Heater Plus Soaking Vessel with patented internals
- **Configure with Recycle Gas Oil Thermal Cracking for higher conversion (with or without Vacuum Tower)**
- **High lift Woods technology for increased gas oil production**

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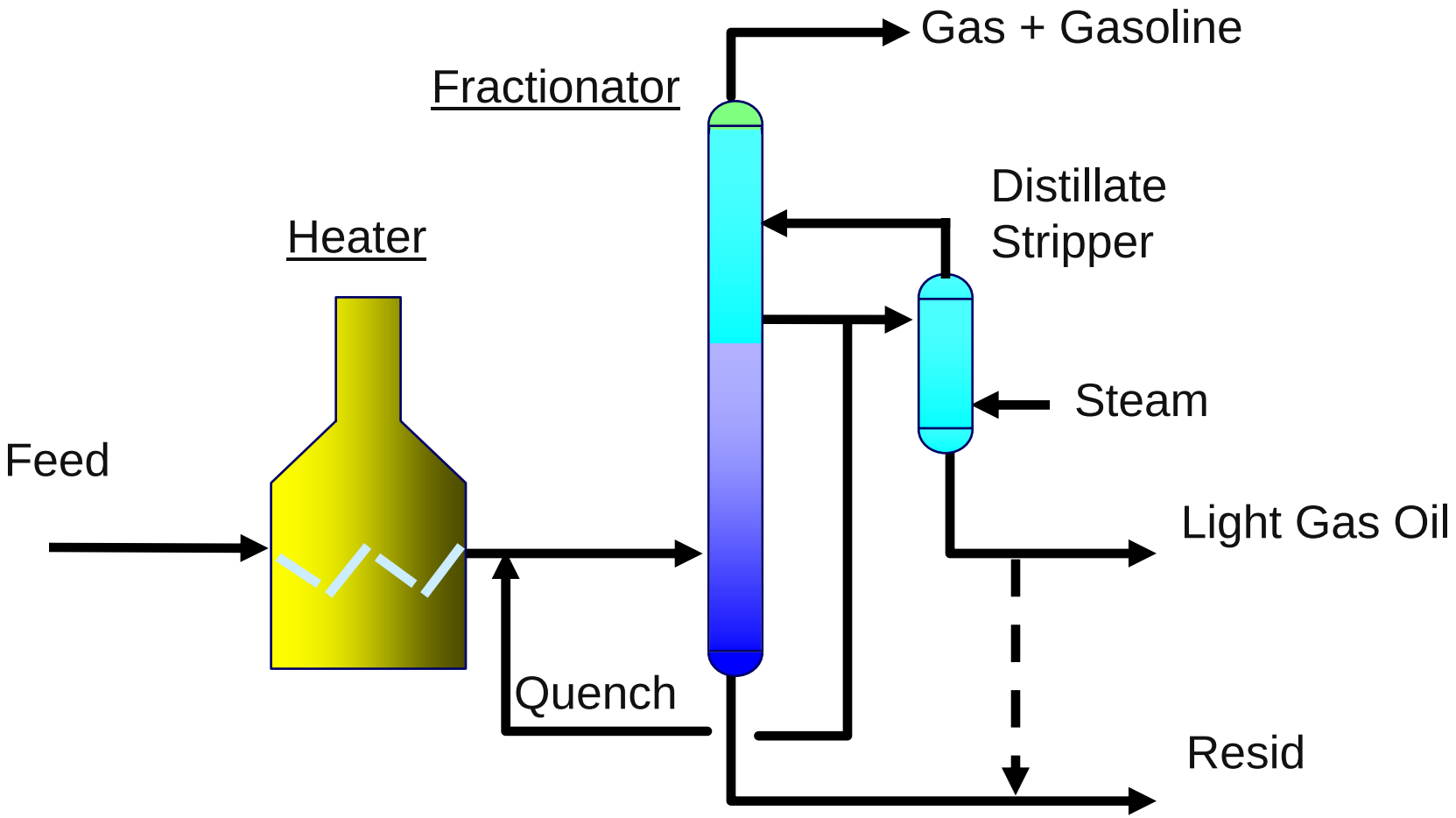
Typical Coil Visbreaker Layout



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Processing solutions:
Residue Hydrocracking

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Residue Hydrocracking Technology

- **Ebullated Bed**
  - **Established Process**
  - **Licensors: CLG, Axens, HRI**
  - **Achieves 75%+ Conversion with Unconverted Residue stream**
  - **Expensive**

- **Slurry Phase**
  - **Developing Technology**
  - **Nearly complete conversion**
  - **Licensors & Developers: Eni, PDVSA, UOP, Chevron**
  - **Very Expensive (?)**

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Carbon Rejection Processes: Integration With Resid HCR

- **Ebullated Bed Resid HCR with Very Heavy Residues Produces Bottoms Pitch Stream**
  - Solvent Deasphalting
    - **Pitch reduction**
    - **Greater liquid yield**
  - Delayed Coking
    - **Pitch elimination**
    - **Greater liquid yield**
    - **Anode coke possibility**

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Residue HCR & Delayed Coking

Middle East Vacuum Residue (23 CCR)
75% Conversion Residue HCR + Coking

		Ebullated Bed Resid HCR	Delayed Coking	Total
Gas	LV% FOE	4.16	1.48	5.64
C3 / C4	LV%	6.16	1.74	7.90
Naphtha	LV%	17.48	3.06	20.54
LGO	LV%	29.47	5.40	34.87
HGO	LV%	32.27	6.30	38.57
Residue	Wt%	24.36		
Coke	Wt%		9.38	9.38

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Processing solutions: Gasification

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Gasification

Integrated gasification combined cycle

- Partial oxidation of the fuel for syngas production, syngas clean-up (upstream combustion with possible CO_2 removal for EOR) and syngas combustion in a combined cycle unit
- Suitable for both heavy oils and pet coke
- Approx. 100 t/h of petcoke are required to generate 320 MWe complex plant
- Power station with superior environmental performances
- A must if H_2 production may be foreseen in the future

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Gasification

Technology Suppliers

- Solid feed stocks (coal, petcoke):
  GE Energy, Shell, Conoco Phillips, Siemens, Sasol, Lurgi

- Liquid feed stocks (heavy oils, asphalts):
  GE Energy, Shell

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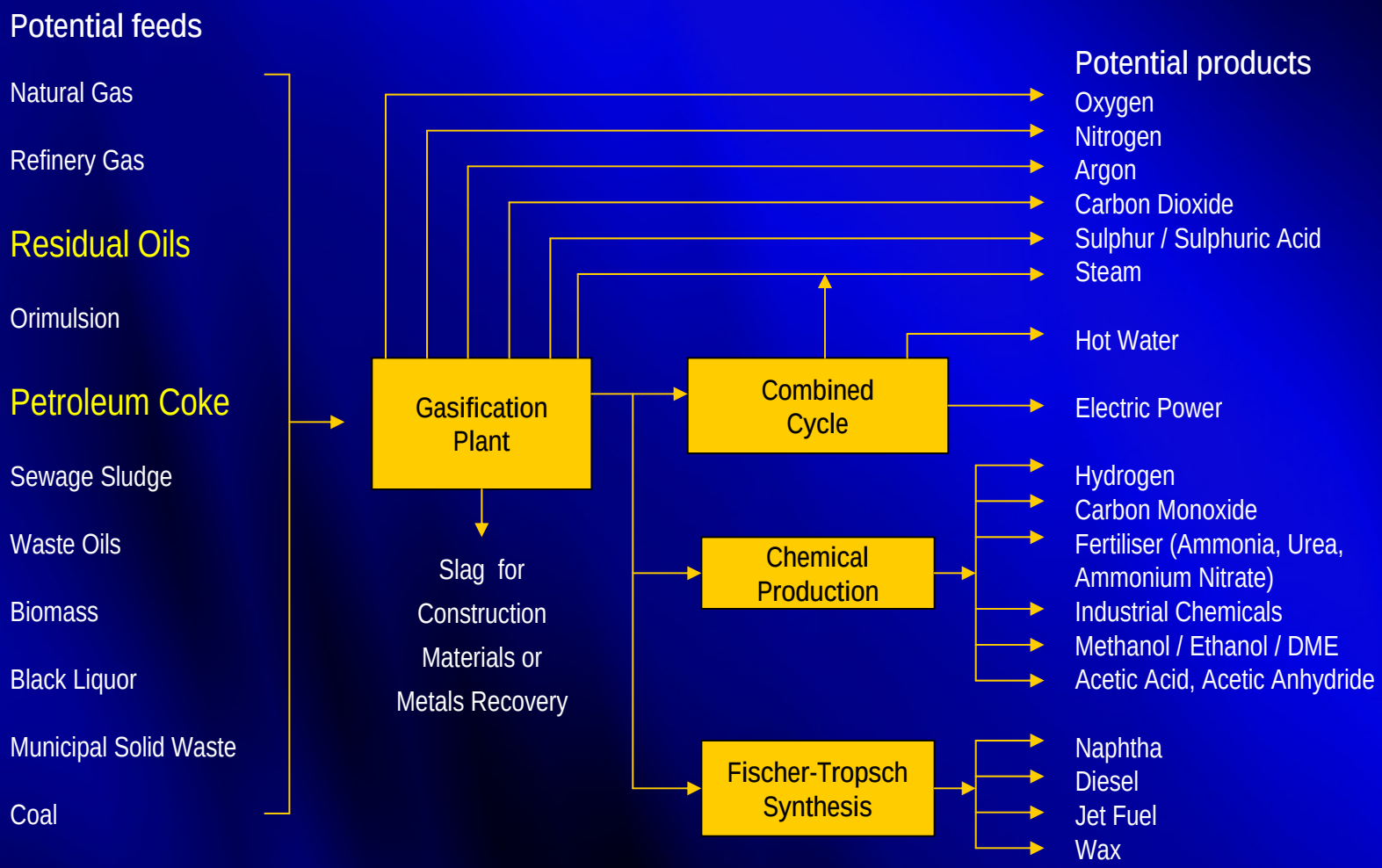
Potential Gasification Feeds and Products



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Processing solutions for Heavy Oil Upgrading and Conversion Needs

Combination of processes

Process Attributes

- **Coking completes conversion**
- **SDA reduces tar stream volume**
- **Visbreaking reduces distillate demand for Fuel Oil**
- **Hydrocracking provides high conversion**
- **Gasification allows complete utilization**

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Summary

- **Growing need for residue conversion processes**
  - **Heavier feeds**
  - **Oil sands, Extra-heavy crude oil**
  - **Regulations**
- **Range of technologies available**
  - **Stand-alone**
  - **In combination**

Foster Wheeler – The Heavy Oils Engineering Company

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