



GTC Technology

RETHINK
NAPHTHA

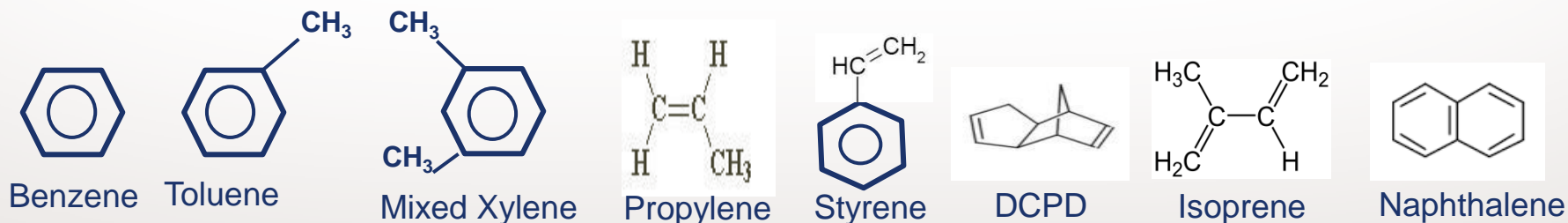
Naphtha Valorization to its Highest Value

Presented at IOCL Petrochemical Conclave by
Joseph C. Gentry – Director, Global Licensing
February 12, 2015

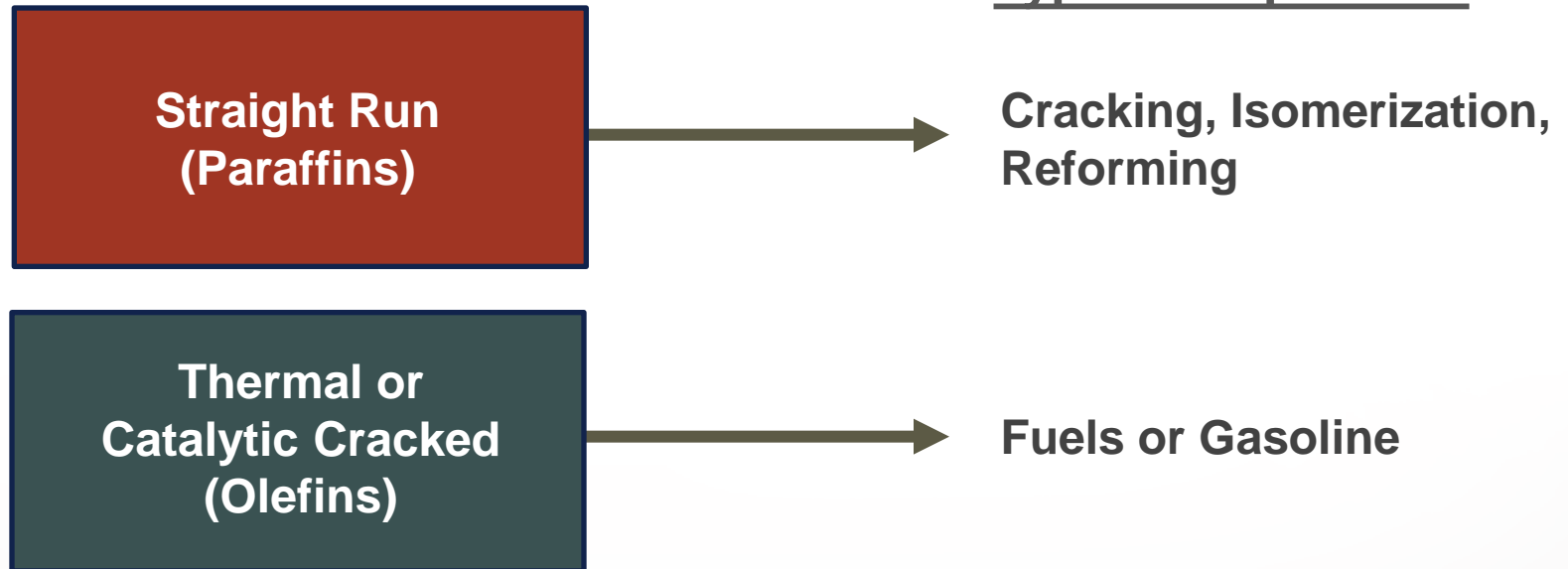
Petrochemicals Have Higher Value

- Refiners have opportunity to upgrade naphtha into higher-value blendstock or petrochemicals
- By-product naphtha from cracking processes have great potential for upgradation
- Molecule management is the key to understanding the best method to process the naphtha

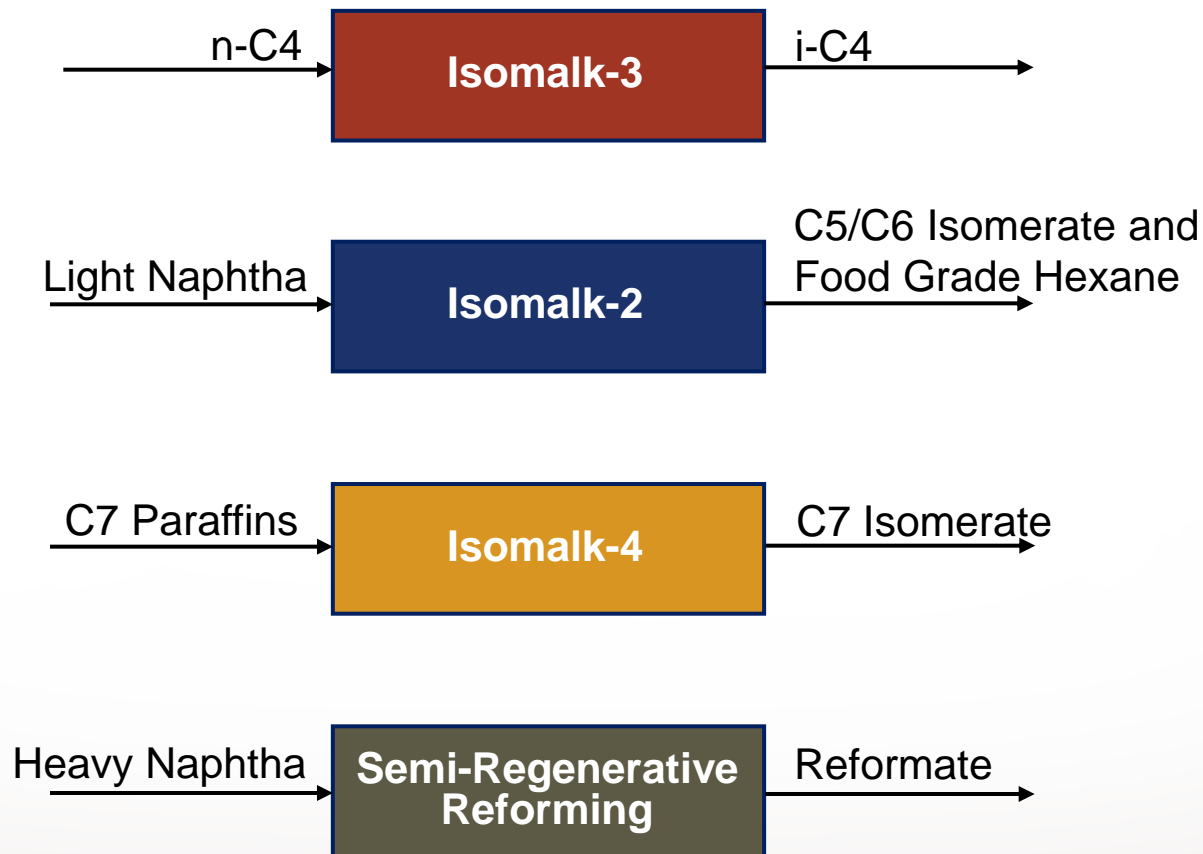
Component	Value Relative to Naphtha (Average Estimates)
Naphtha	1.00
Unleaded Gasoline	1.15
Toluene	1.20
Mixed Xylenes	1.25
Ethylene	1.50
Benzene	1.50
Paraxylene	1.55
Propylene	1.55
Styrene	1.70
Isoprene	2.10
C5/C9 HCR	2.5-3.00



Conventional Refinery Naphtha Utilization



Technology Options for Straight Run Gasoline



C5/C6 Isomerisation: Technology Choices

Three light gasoline isomerization processes

- **Zeolite catalysts**
 - High operating temperature
 - Less favorable for formation of high-branched isomers
- **Chlorinated aluminum oxide catalysts**
 - Reasonable octane increase
 - Regular organochloride additions required
 - Spent caustic disposal also required
 - Extreme measures for H₂O and impurity removal
- **SI-2 Mixed metal oxide catalysts**
 - Advantages over chlorinated aluminum and zeolite, with none of the disadvantages

Technology	Performance	Robust Operation	Environment
Zeolite		✓	✓
Chlorinated Alumunim	✓		
Isomalk-2 SM	✓	✓	✓

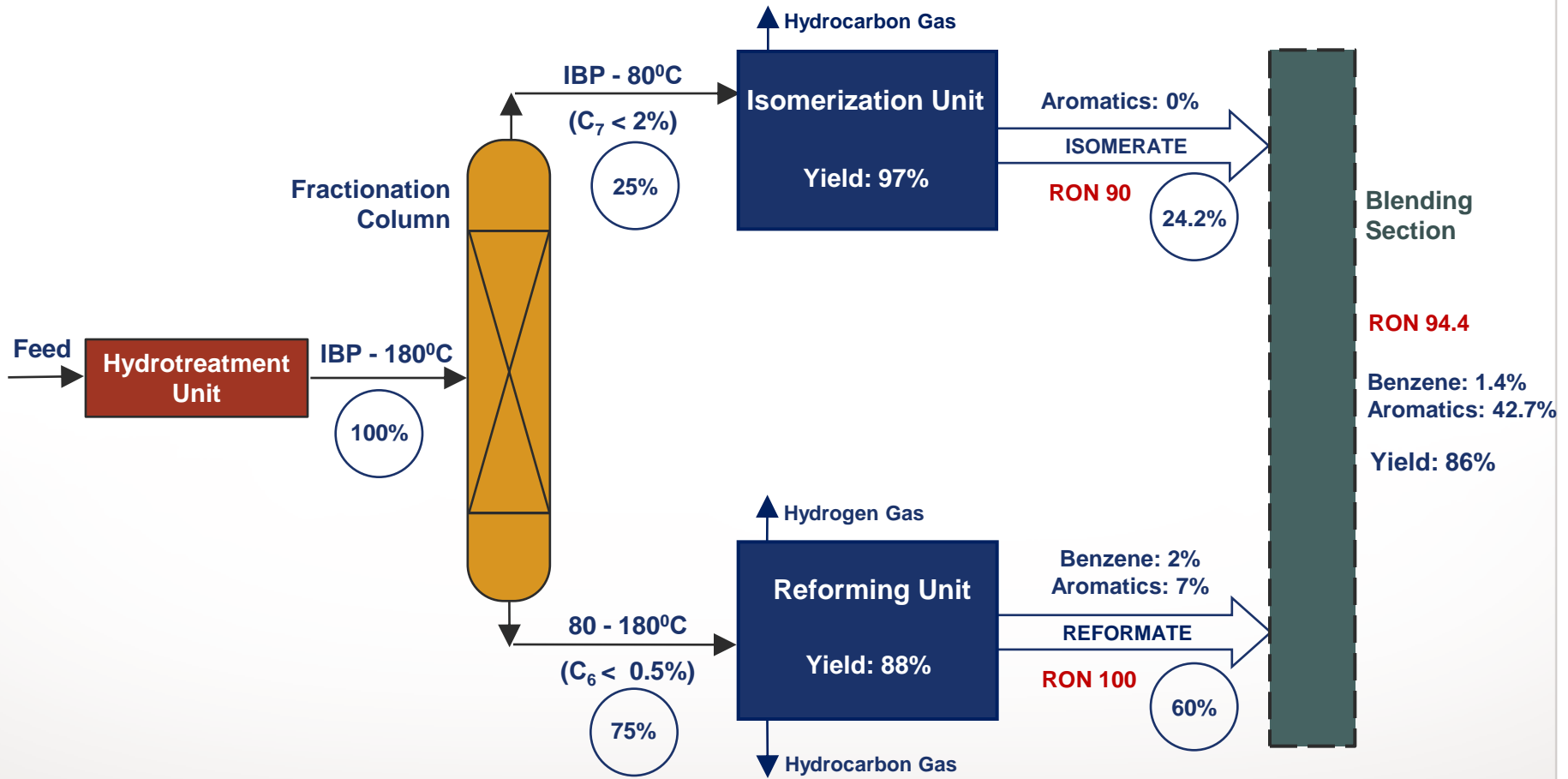
Case study, World-Scale Grass-Root Isomalk-2SM Unit.



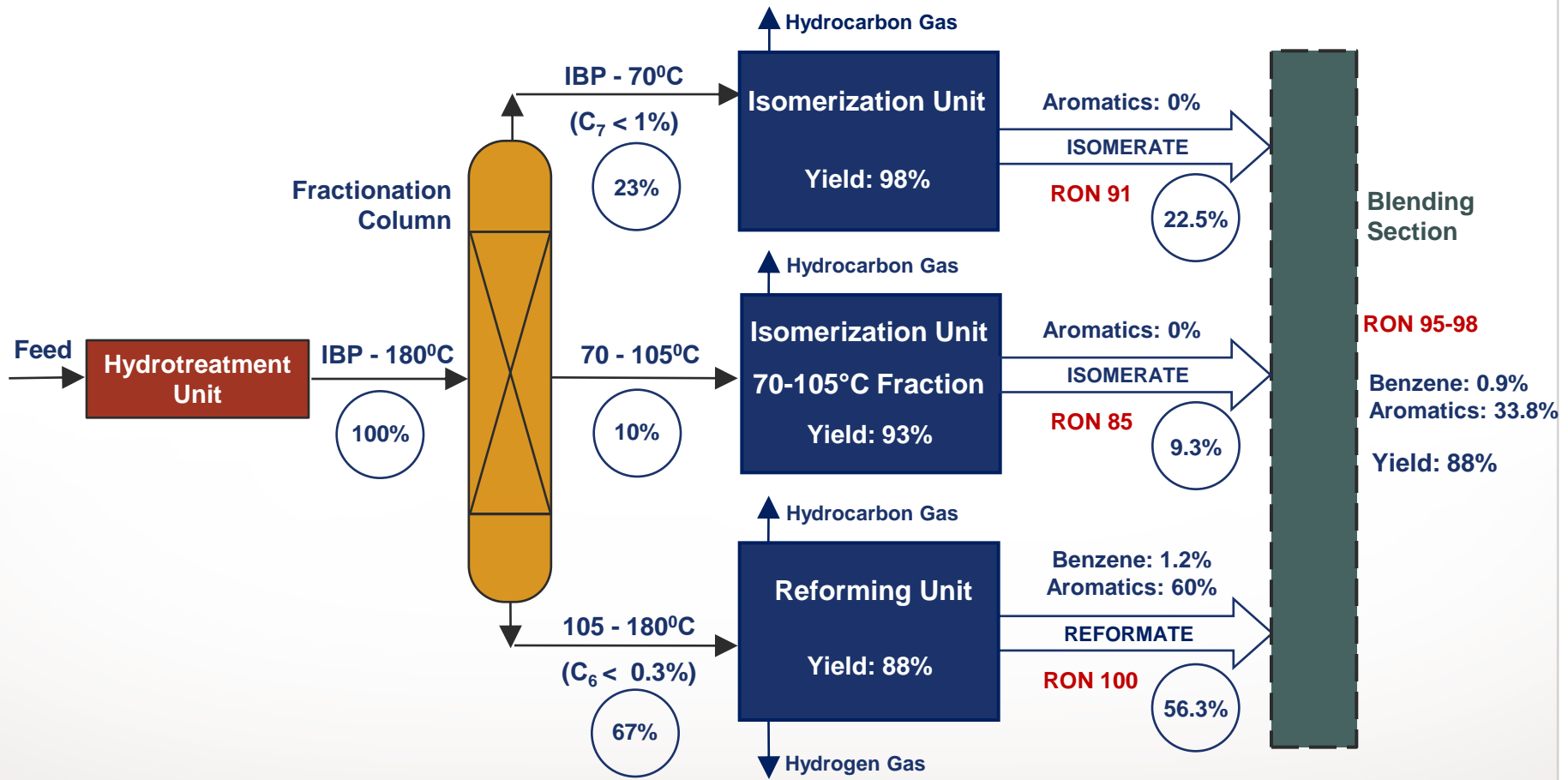
Process scheme	Full Recycle Scheme (DIP, DIH, DP)
Capacity, t/y	1.0 MMTA
Isomerate yield, %	99
i-Pentane cut, RON	92.0-93.0
Light Isomerate, RON	91.5-92.5
Space velocity in the reactor block, hour ⁻¹	2.0 -2.5
Start-up year	November, 2010

First World-Scale isomerization unit to use non-chlorinated catalyst and achieve 92.5 RON for final isomerate

Typical BFD for Processing Light and Heavy Naphtha



BFD for naphtha processing with C₇ isomerization technology available



Comparison of the 2 process configurations

From a recent case study made for a plant with light naphtha Isomerization unit (DIP, Super DIH) and CCR Reforming unit for a 2 MMTA naphtha stream.

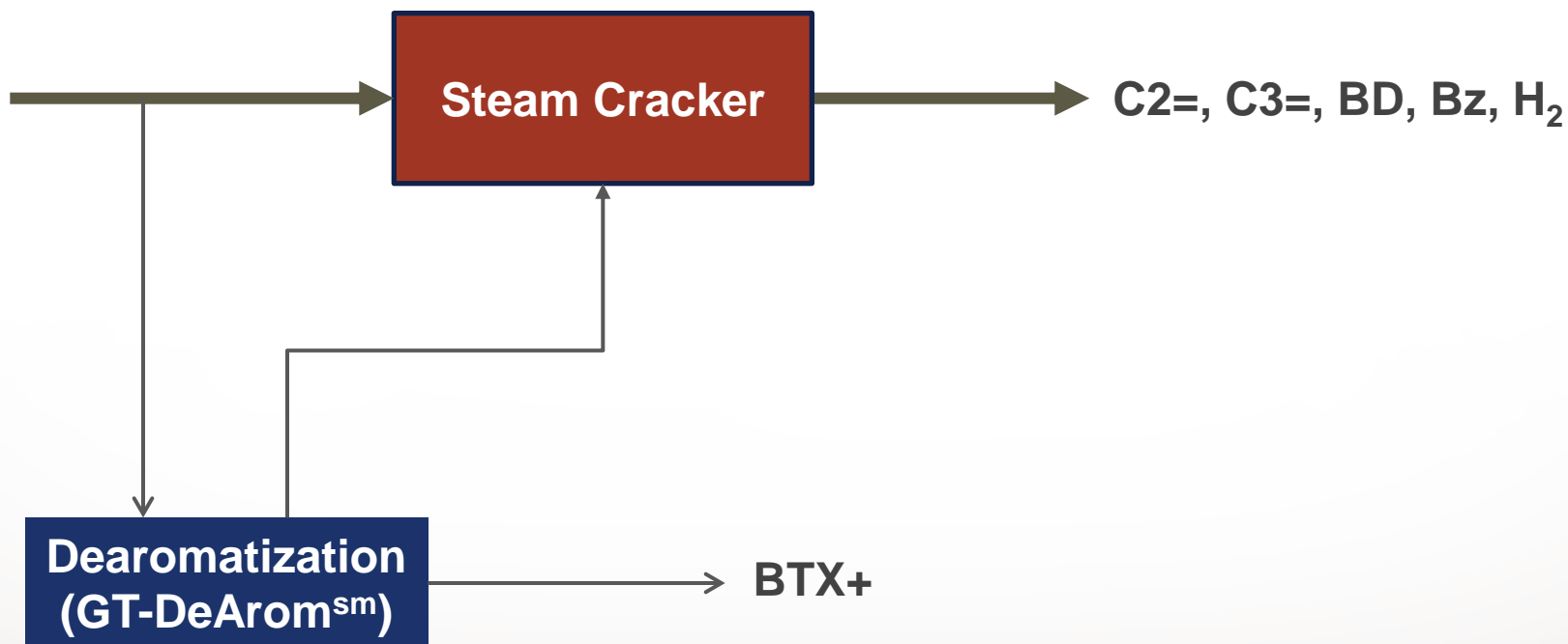
Configuration	Conventional	With Isomalk-4 SM	Benefit	Value to Refinery Per Annum
Overall gasoline yield, wt.%	88.7%	90.8%	2.1%	16.8 MM USD *
Octane Number, RON	94.0	95.5	1.5	15.0 MM USD *
Benzene in the gasoline pool, vol.%	1.5%	0.6%	0.9% less	Varies
Aromatics in the gasoline pool, vol.%	37.0%	33.5%	3.5% less	Varies

* - based on \$400/ton differential for liquid yield over gas; and \$5/ton-octane number

Total benefit is over 30 MM USD/yr with the C₇ paraffins routed to Isomalk-4SM

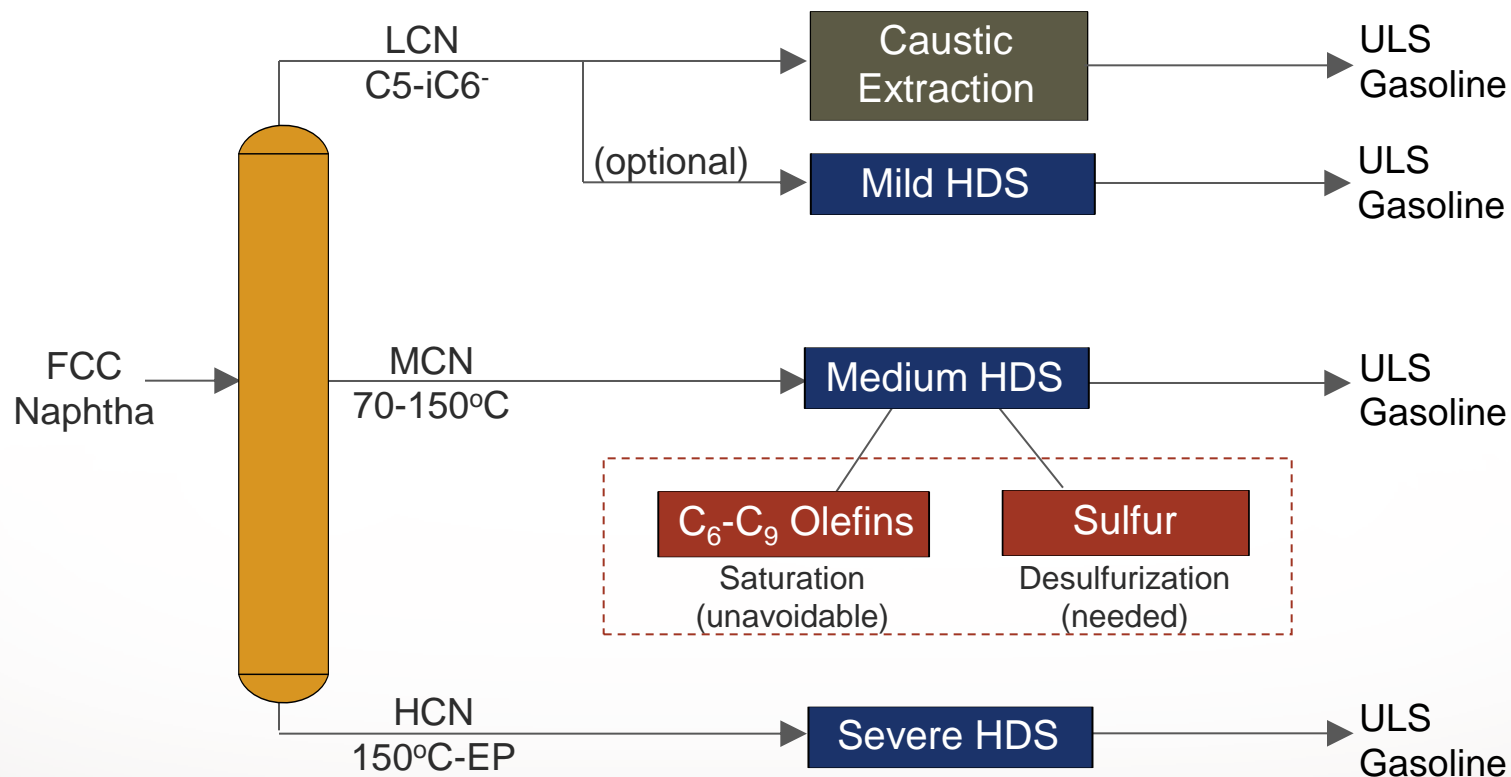
Aromatics Removal from Steam Cracker Feed

Tailoring the feed
may be useful



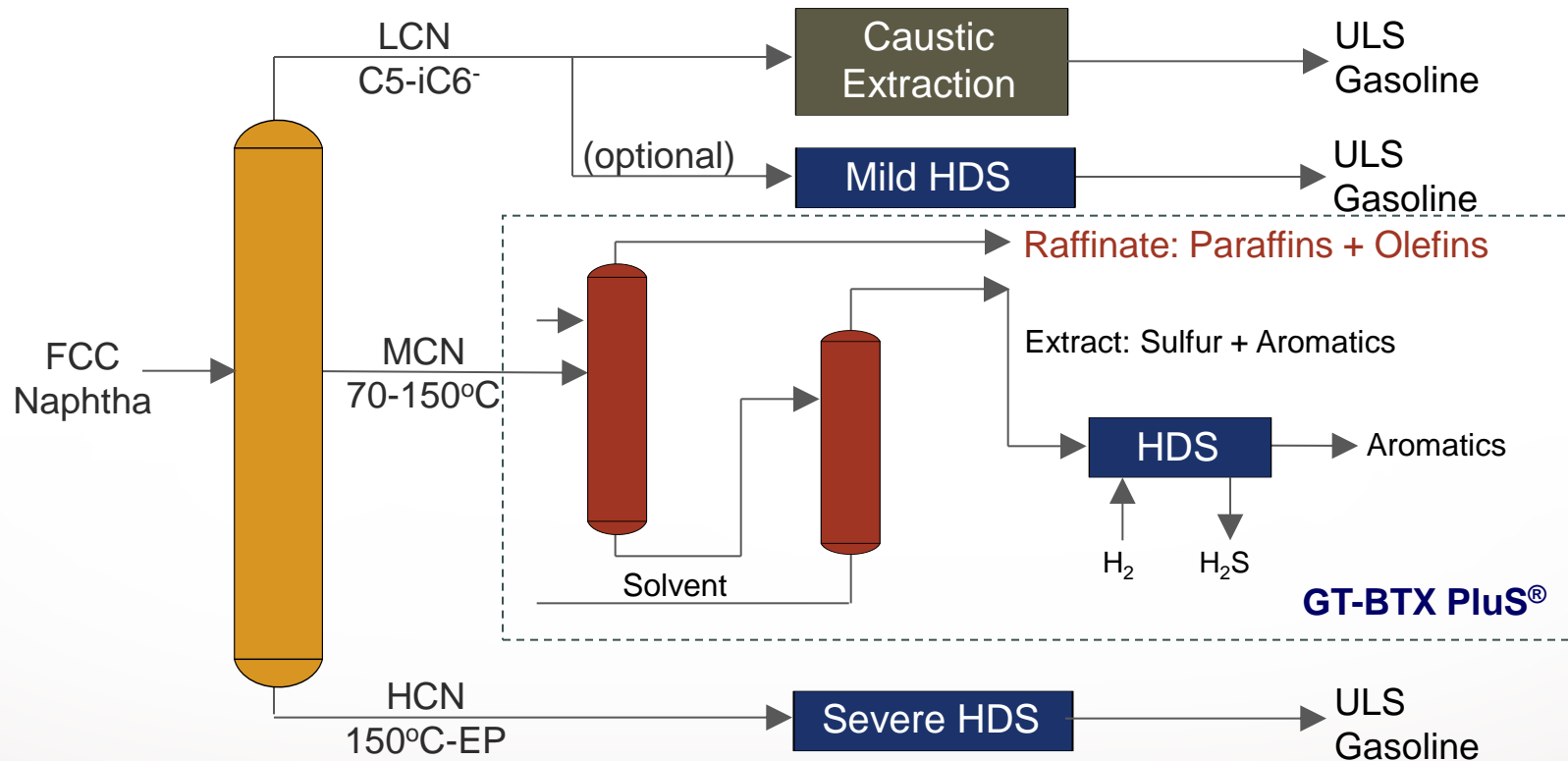
Cracked Gasoline Management – FCC Desulfurization

Conventional Three-Stage Process



FCC Gasoline Desulfurization

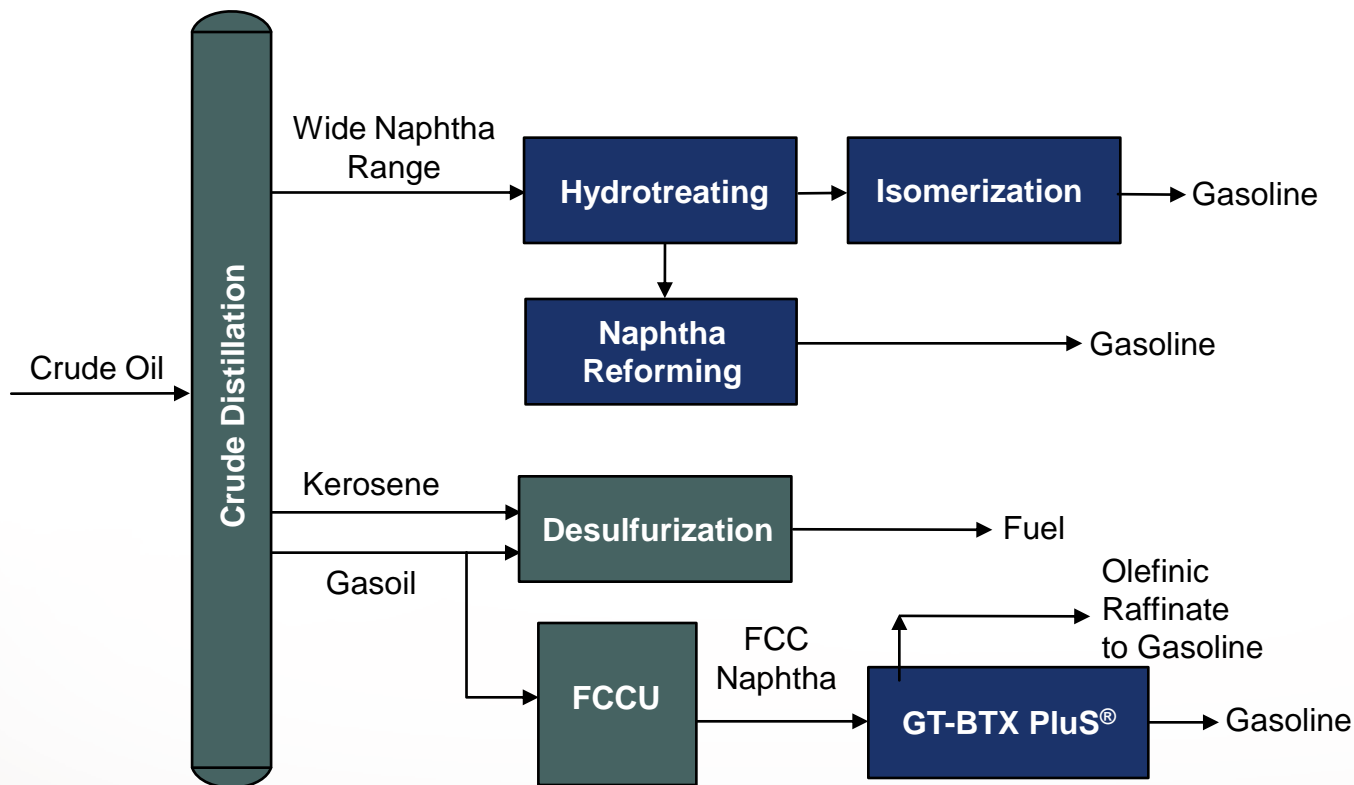
Alternate Option to Extract Sulfur from the Olefins



- Technically advanced extraction process enables
 - Desulfurized gasoline to < 15 ppm sulfur with zero octane loss
 - Reduced benzene in cracked gasoline to < 0.5% benzene
 - FCC olefins preserved for conversion to aromatics or propylene

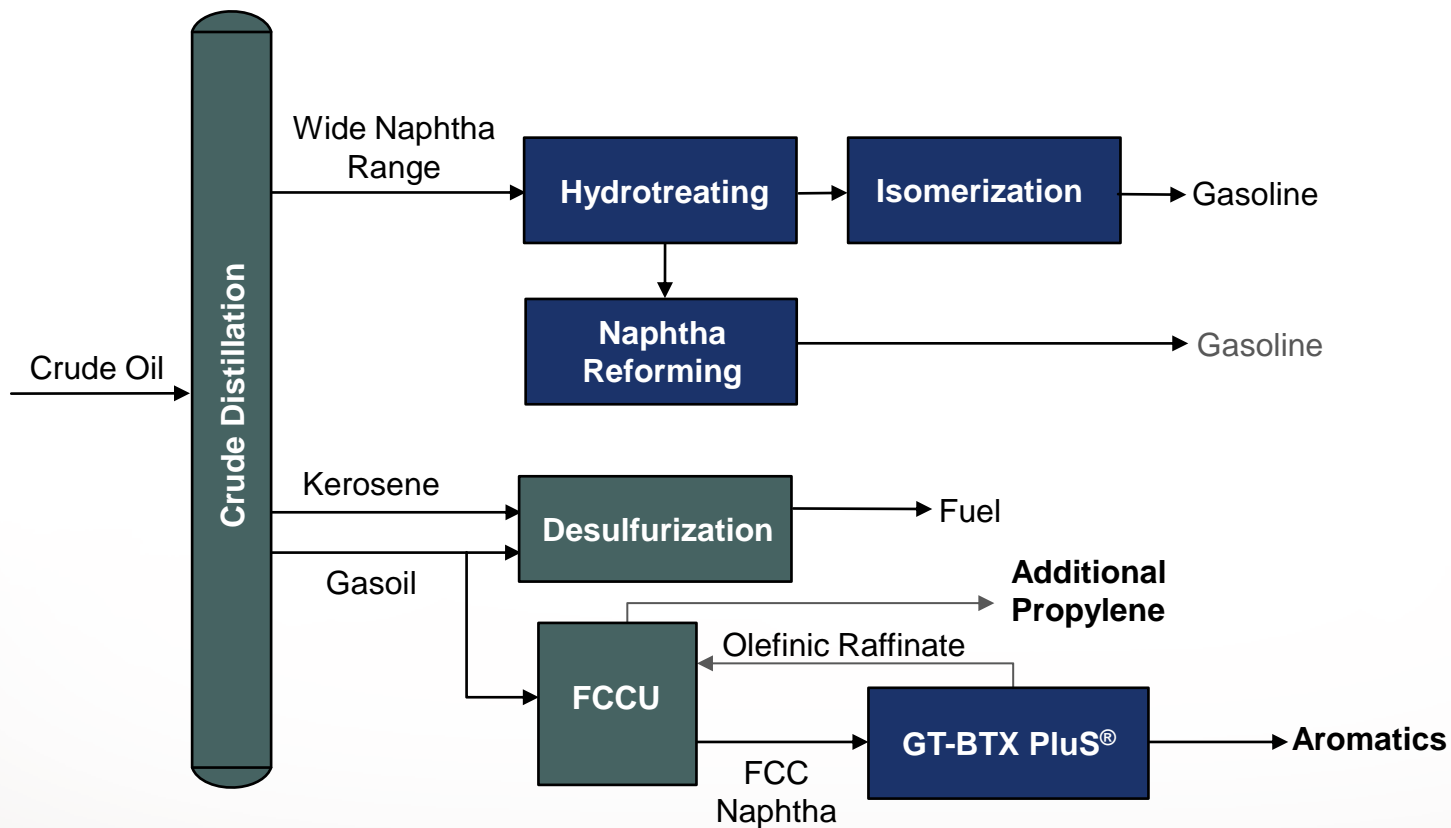
Patented process – available through GTC Technology

Typical Refinery Configuration with GT-BTX Plus® - Products to Gasoline



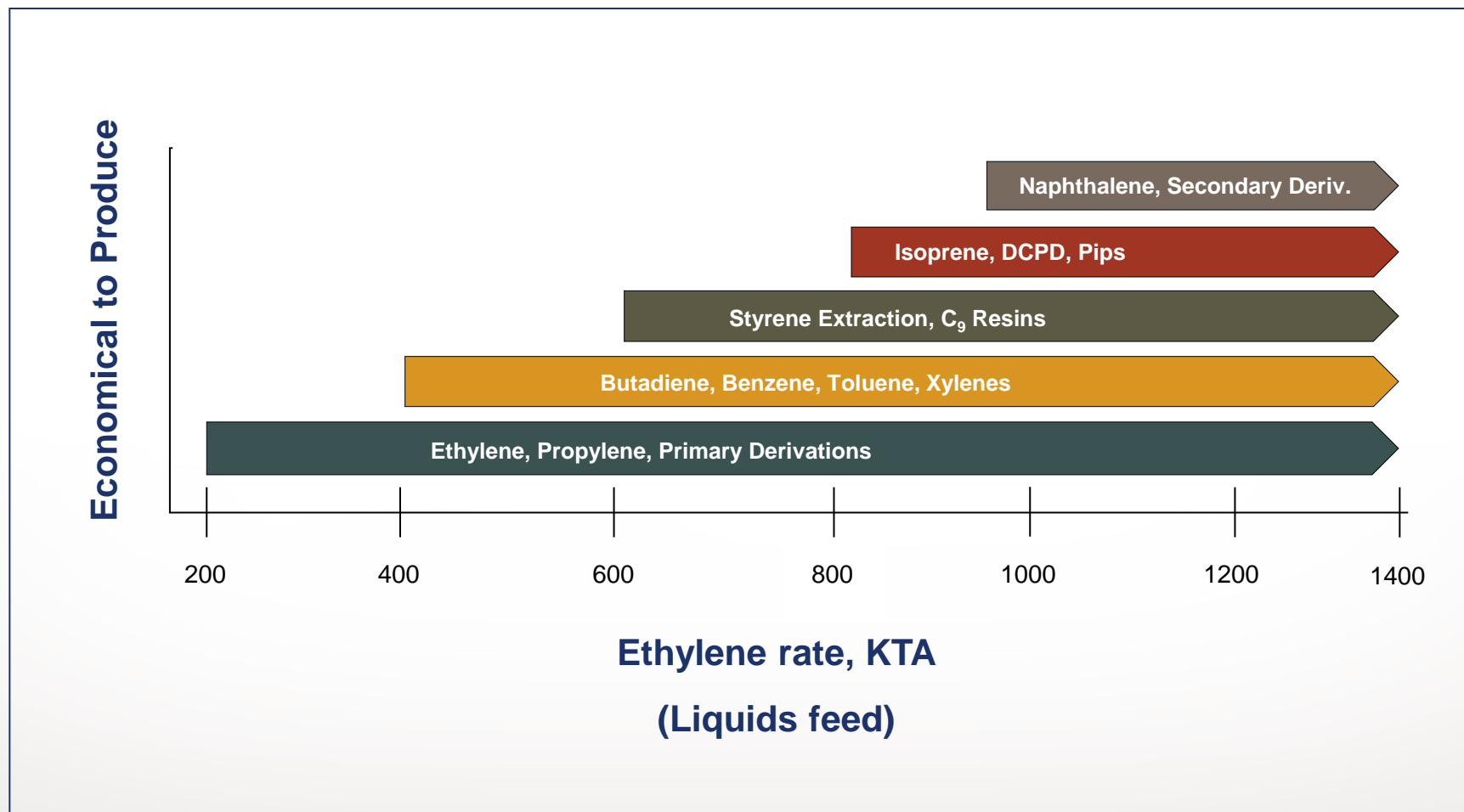
- Zero Δ in octane value
- Low benzene
- Low sulfur

Refinery Configuration with GT-BTX Plus[®] to facilitate **increased Propylene**

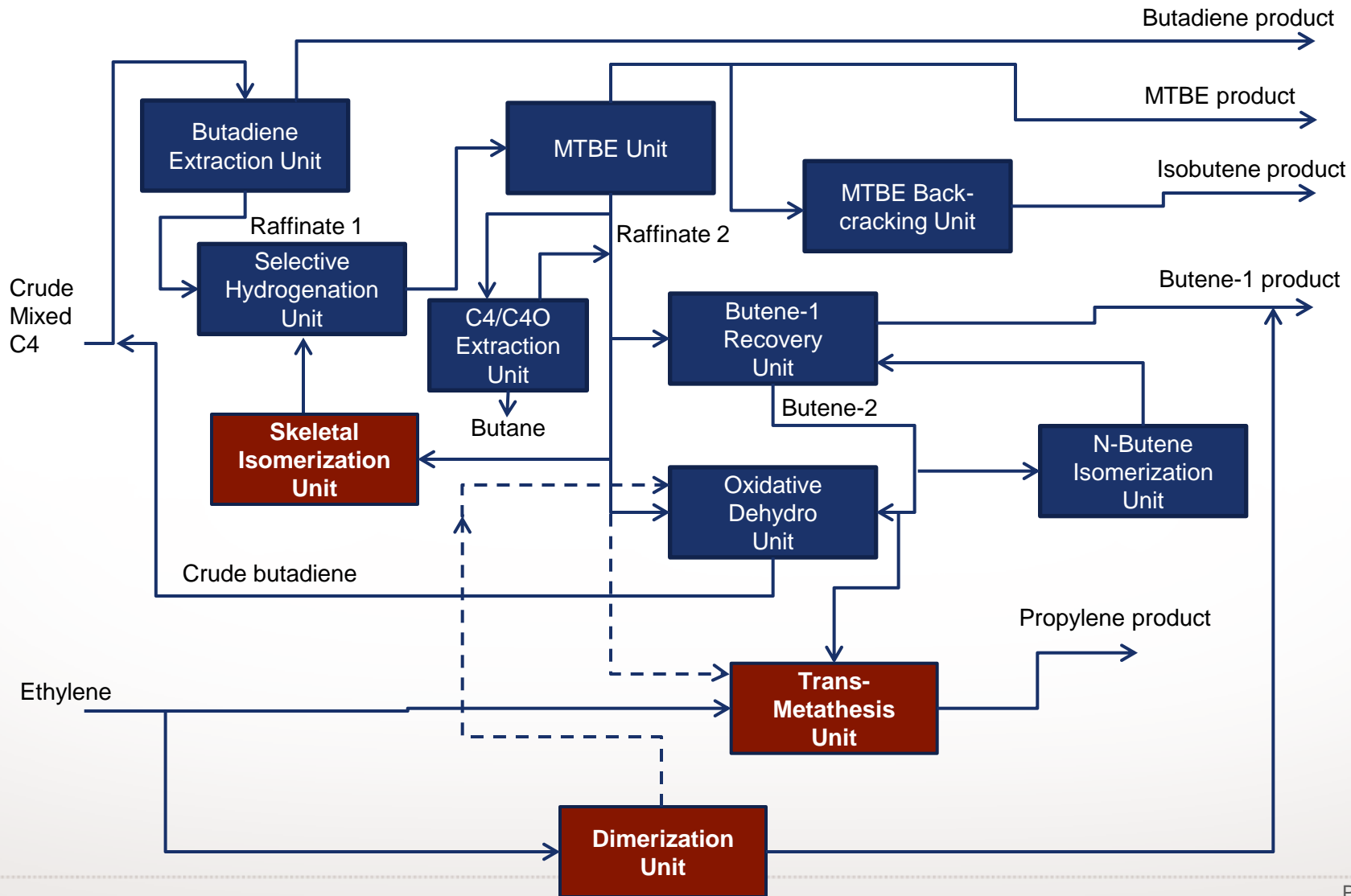


Extends Range of FCC Naphtha Recycle

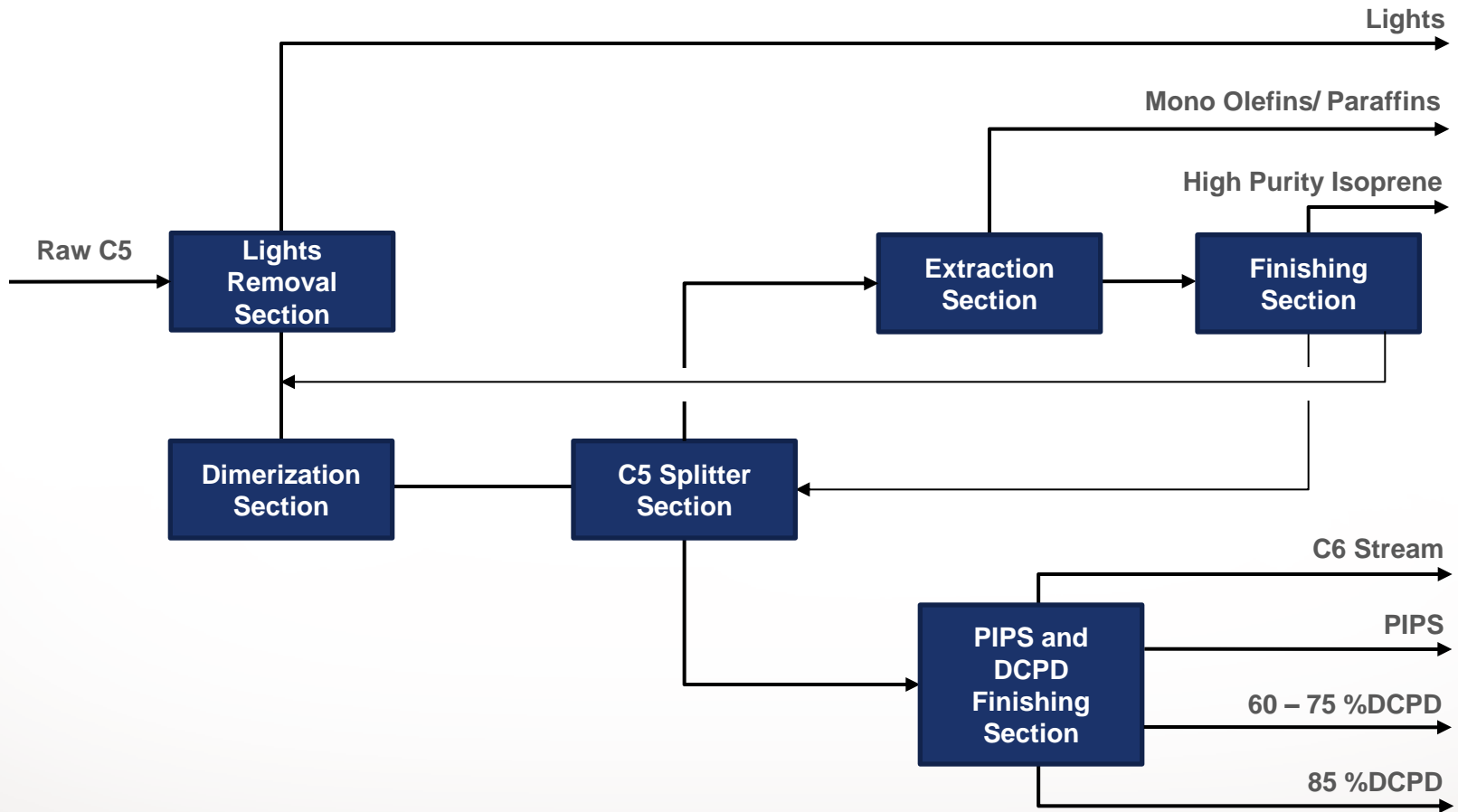
Economical Ethylene Capacity for Recovering By-products



C4 Utilization



Pygas C5 Utilization – GTC GT-C5/Isoprene



Pygas C6-C8 Utilization: GT-BTX[®]



Extractive Distillation depends on a selective solvent to alter the boiling points of aromatics & non-aromatics to facilitate their separation by distillation.

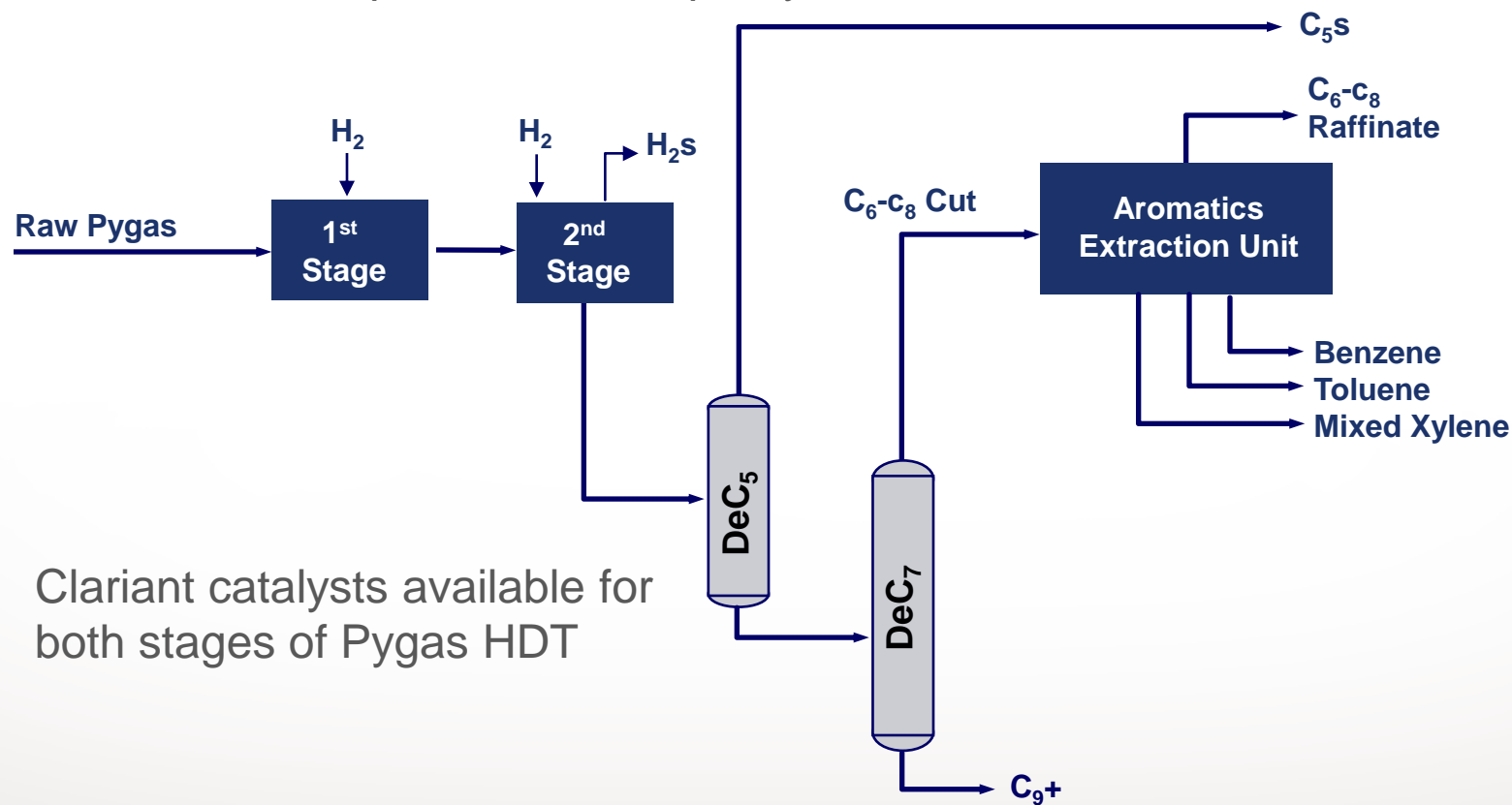
★ Solvent selectivity is critical

Solvent	α n-C ₇ /Benzene
Techtiv-100 tm	2.44
Sulfolane	2.00
N-methyl Pyrolidone	1.95
N-formyl Morpholine	1.89
Glycol blends	1.35
None	0.57

Proprietary solvent of
GT-BTX[®] Technology

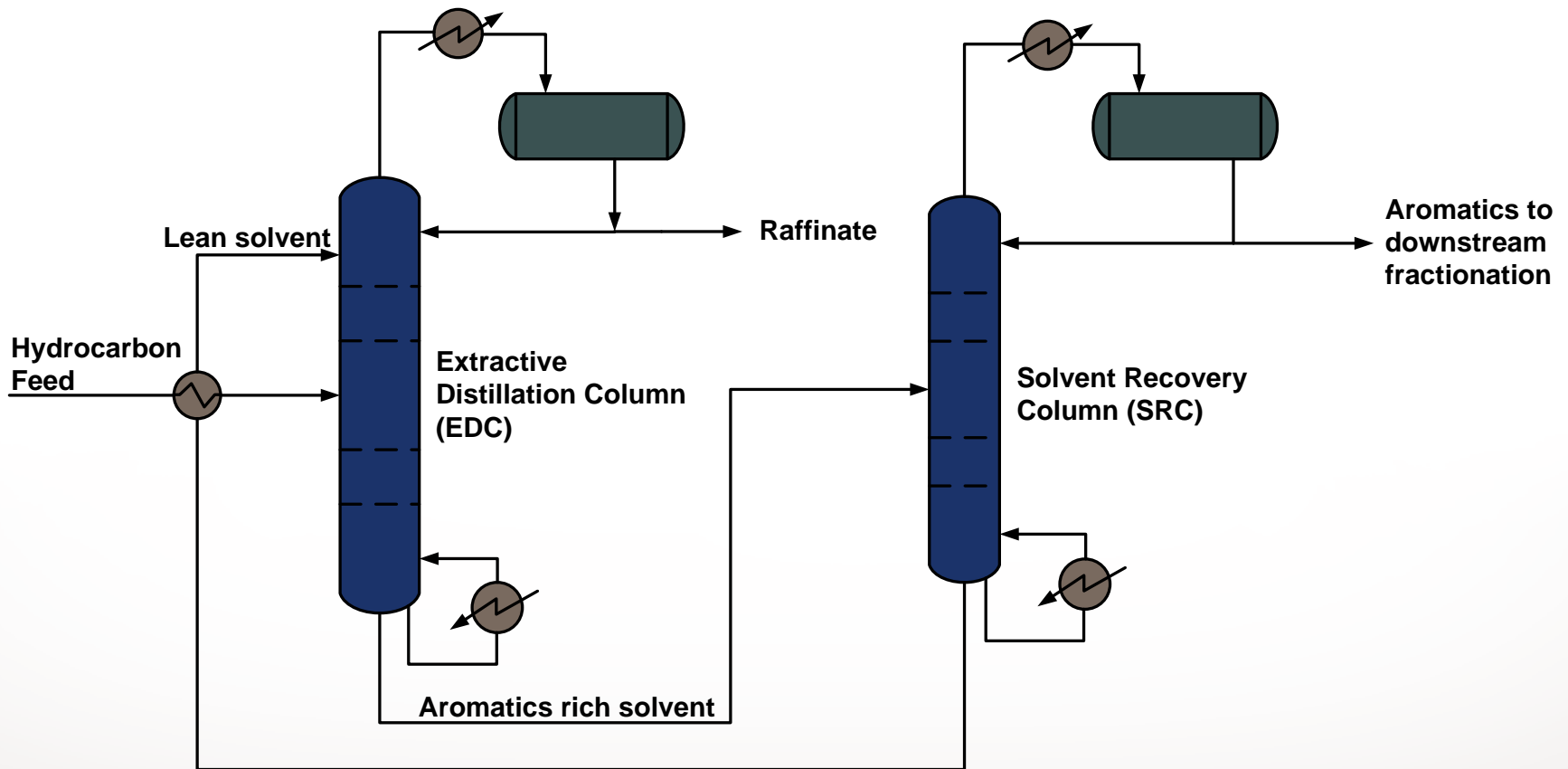
Pygas C6-C8 Utilization

Benzene, Toluene, Xylene need to be extracted from C6 – C8 cut of pygas in order to meet petrochemical quality



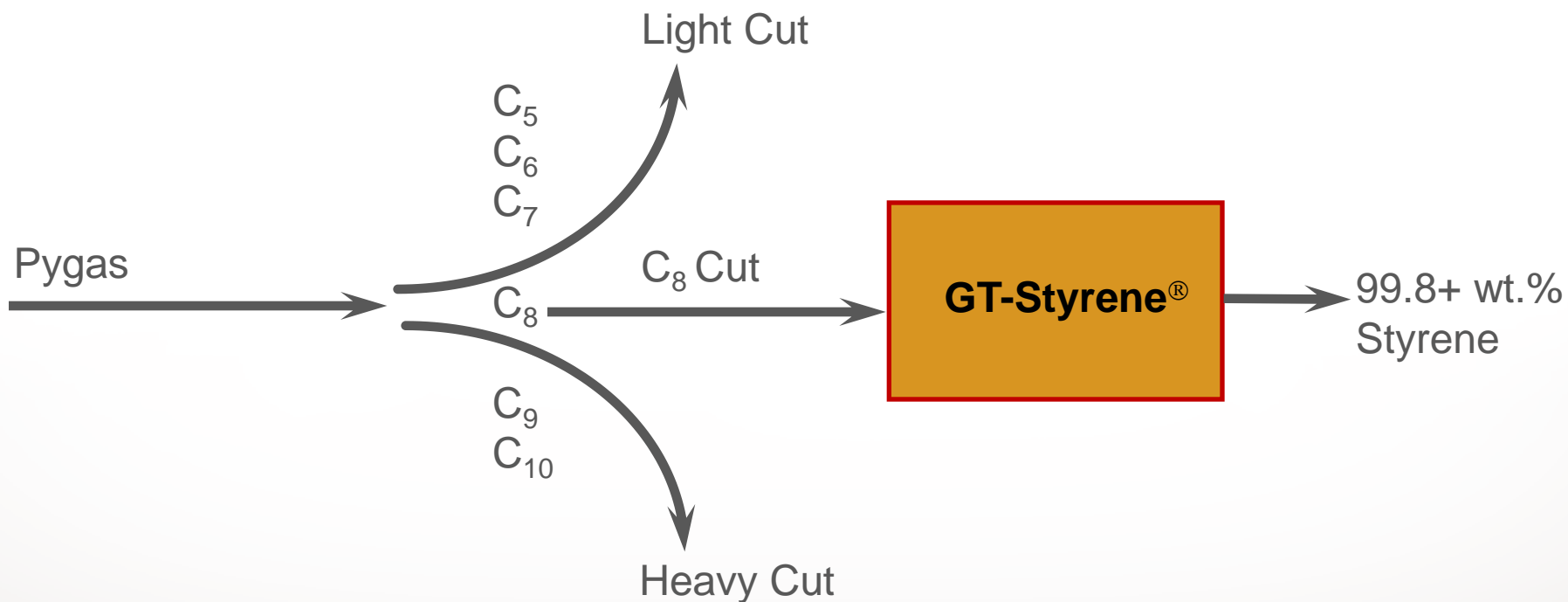
Clariant catalysts available for both stages of Pygas HDT

World-Class Extraction Technology for BTX Purification



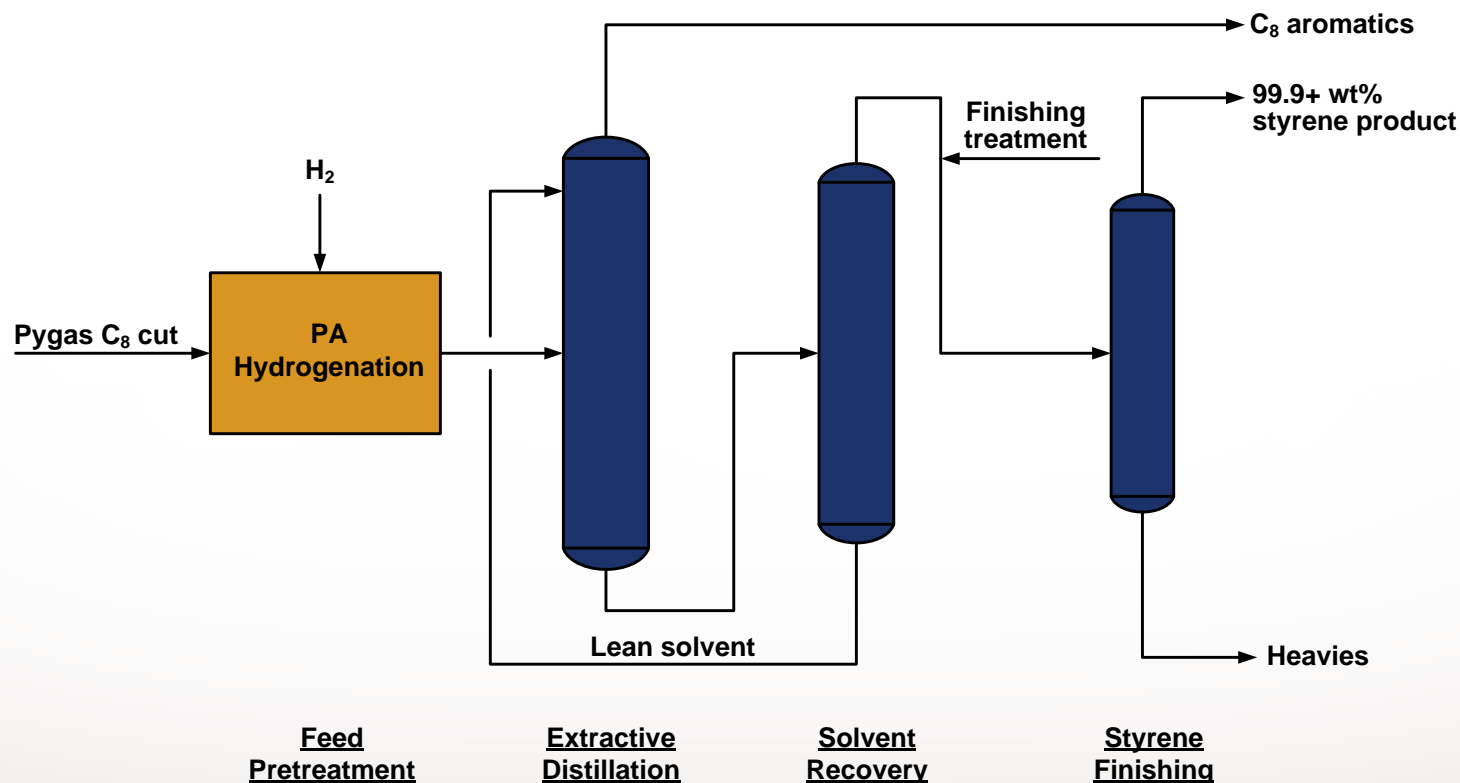
Pygas C8 Utilization – GT-Styrene

Heart cut distillation followed by ED



Pygas C8 Utilization – GT-Styrene

- Recovery of styrene from the raw pyrolysis gasoline derived from the steam cracking of naphtha, gas oils, and natural gas liquids (NGL)

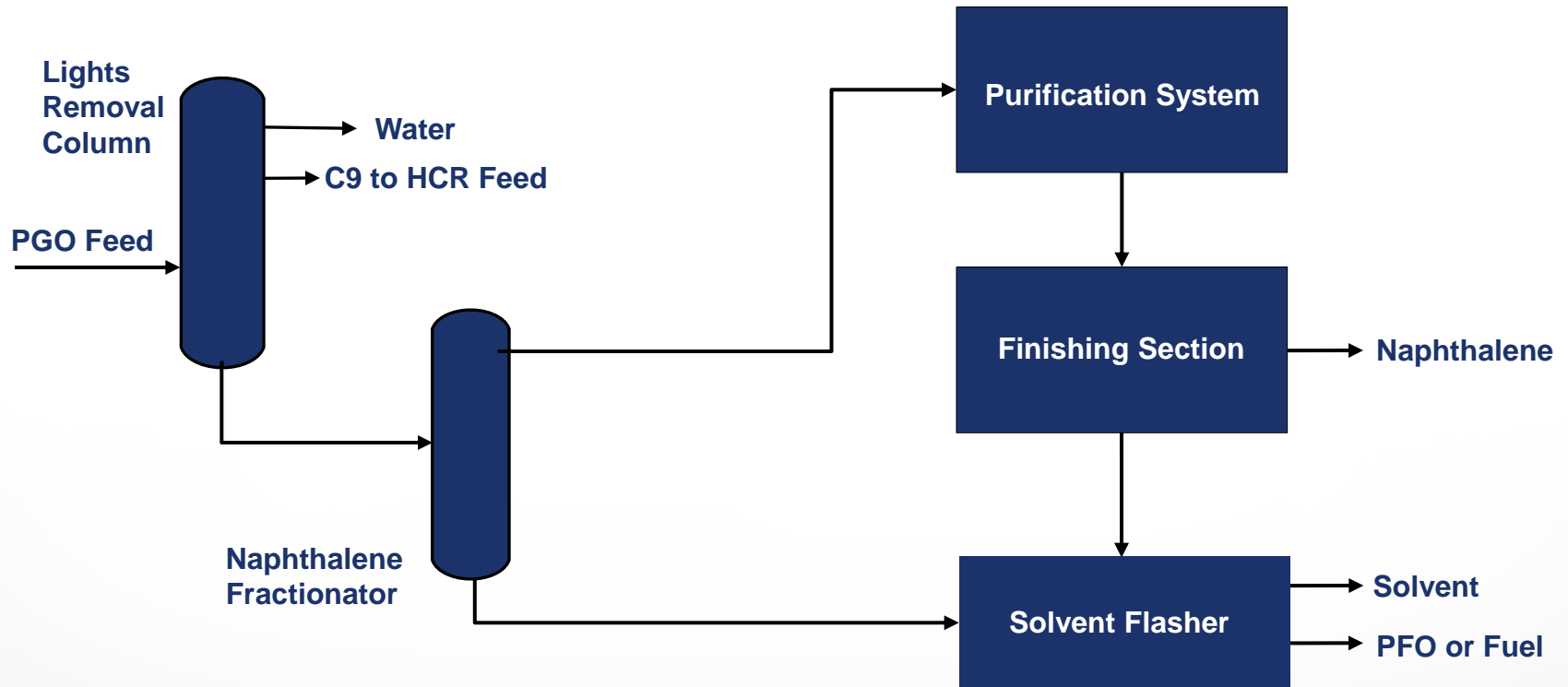


Economics of Styrene Recovery

Basis - 25,000 mt/yr Styrene (2014 pricing)

Parameters	GT-Styrene®
Capital cost	\$28 MM
Feedstock cost, \$/ton	\$600
Processing cost, \$/ton	\$200
Total production cost, \$/ton	\$800
Sales price, \$/ton	\$1250
Net margin	\$11.25 MM
Pre-tax ROI	40%

Pygas C9+ Utilization – Naphthalene, Solvent, & Resin



- The nature of raw materials leads to proper processing scheme
- Non-chlorinated isomerization catalysts are the optimum to boost gasoline octane for C4 – C7 fractions of straight run gasoline
- Refinery/petrochemical integration, in addition to propylene recovery, captures aromatics and preserves olefins from FCC gasoline
- Steam cracker by-products are important to recover from large plants using naphtha feedstock
- Technology is available to upgrade products from C4 – C12 boiling range



+ Engineered to Innovate



+ Engineered to Innovate

