Refining/Petrochemical Integration – A New Paradigm

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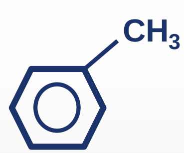
Presentation Themes

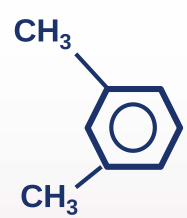
- Present integration schemes focus on propylene, and miss the potential to capture added value from aromatics
- Valuable components exist in FCC gasoline – heavy olefins & aromatics
- Patented GTC purification and conversion technology can upgrade traditional fuel components to high value petrochemicals

Component	Value Relative to Unleaded Gasoline
Naphtha	0.87
Unleaded Gasoline	1.00
Toluene	1.13
Benzene	1.15
Ethylene	1.24
Mixed Xylenes	1.26
Paraxylene	1.43
Propylene	1.55
Styrene	1.63

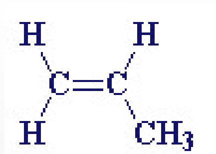

Benzene



Toluene



Mixed Xylenes



Propylene

Presentation Overview

- Gasoline demand and clean fuel regulations around the world
- Process for recovering aromatics from FCC Gasoline - GT-BTX-Plu**S**®
- Processes for utilization of FCC olefins
- Case study – No gasoline, only p-xylene and benzene

World Gasoline Demand – Stagnant or Decreasing

Major Regions Gasoline Supply/Demand

Unit: 1,000 B/D	2006	2008	2010	2012*
US				
Gasoline Demand	10,929	11,120	11,340	10,850
Gasoline Surplus (Deficit)	(1,135)	(1,100)	(870)	(200)
EUROPE				
Gasoline Demand	2,546	2,430	2,334	2,250
Gasoline Surplus (Deficit)	902	1,000	1,200	1,150
MIDEAST GULF				
Gasoline Demand	1,193	1,368	1,545	1,750
Gasoline Surplus (Deficit)	(250)	(120)	(200)	(300)
ASIA PACIFIC				
Gasoline Demand	3,966	4,210	4,505	4,800
Gasoline Surplus (Deficit)	150	250	300	200

Source: Asian Pacific Energy Consulting

* Estimated

Gasoline Specification

Limitation Imposed on Aromatics

	1993/1995	2000	2005	CURRENT	
Vehicle Emission Standard Equivalent	Euro II	Euro III	Euro IV	Euro V	U.S.
Sulfur, ppm, max	1,000/500	150	50 (10)	10	30
Aromatics, vol%, max	**-**	**42**	**35**	**35**	**25**
Olefins, vol%, max	-	18	18	18	8.5
Benzene, vol%, max	**5.0**	**1.0**	**1.0**	**1.0**	**0.62**

Aromatics Trends

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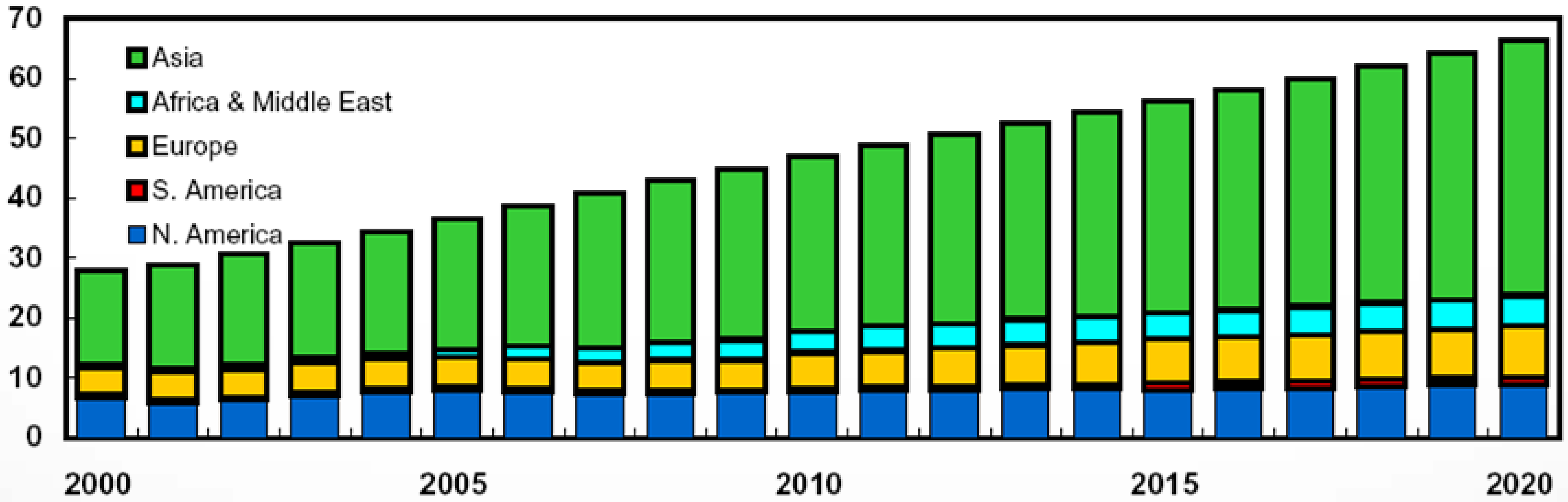
Aromatics demand for petrochemicals is growing

MIXED XYLENES DEMAND BY REGION
(Million Tons)



Sources: CMAI

FCC Gasoline Desulfurization

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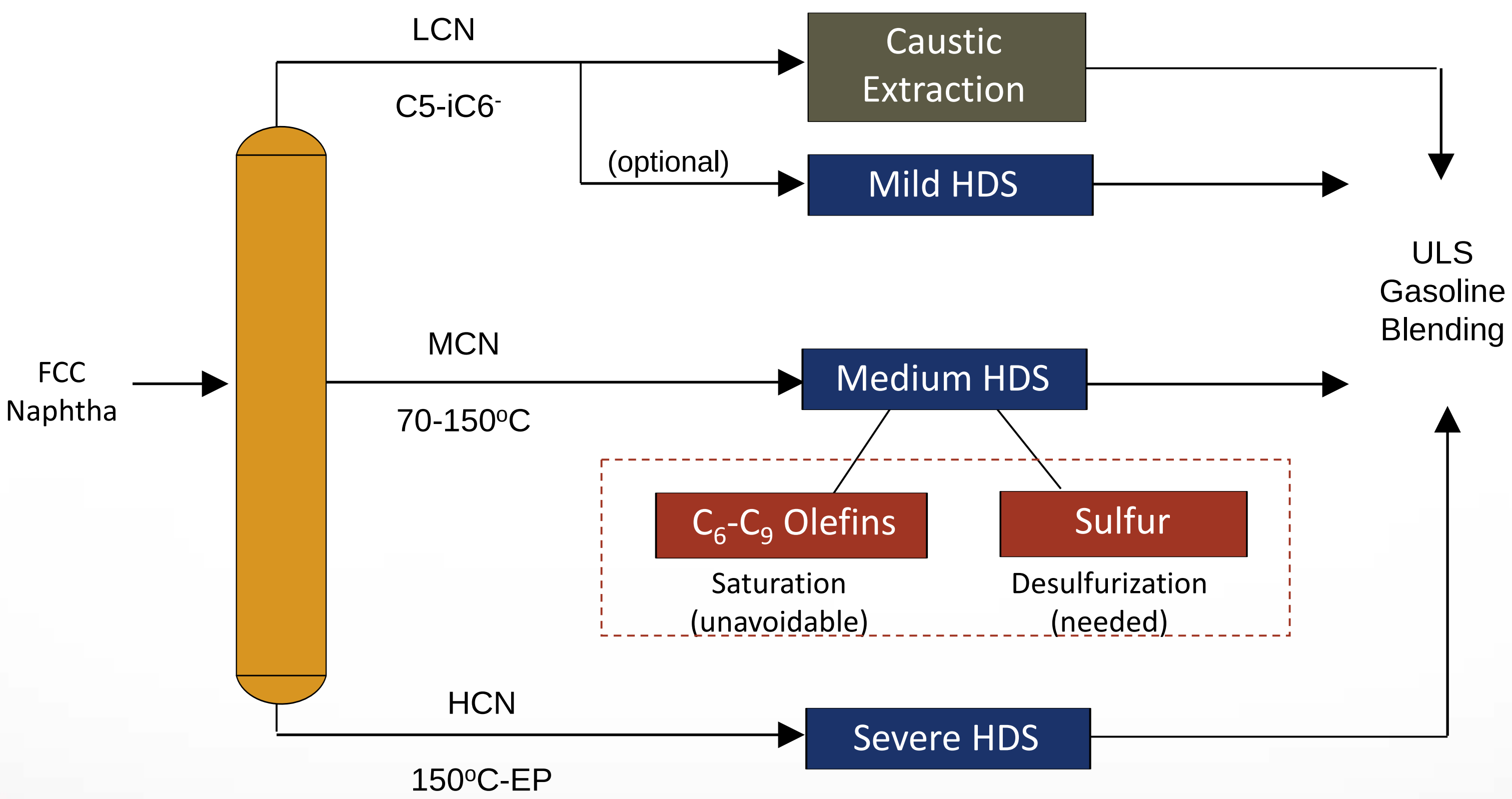
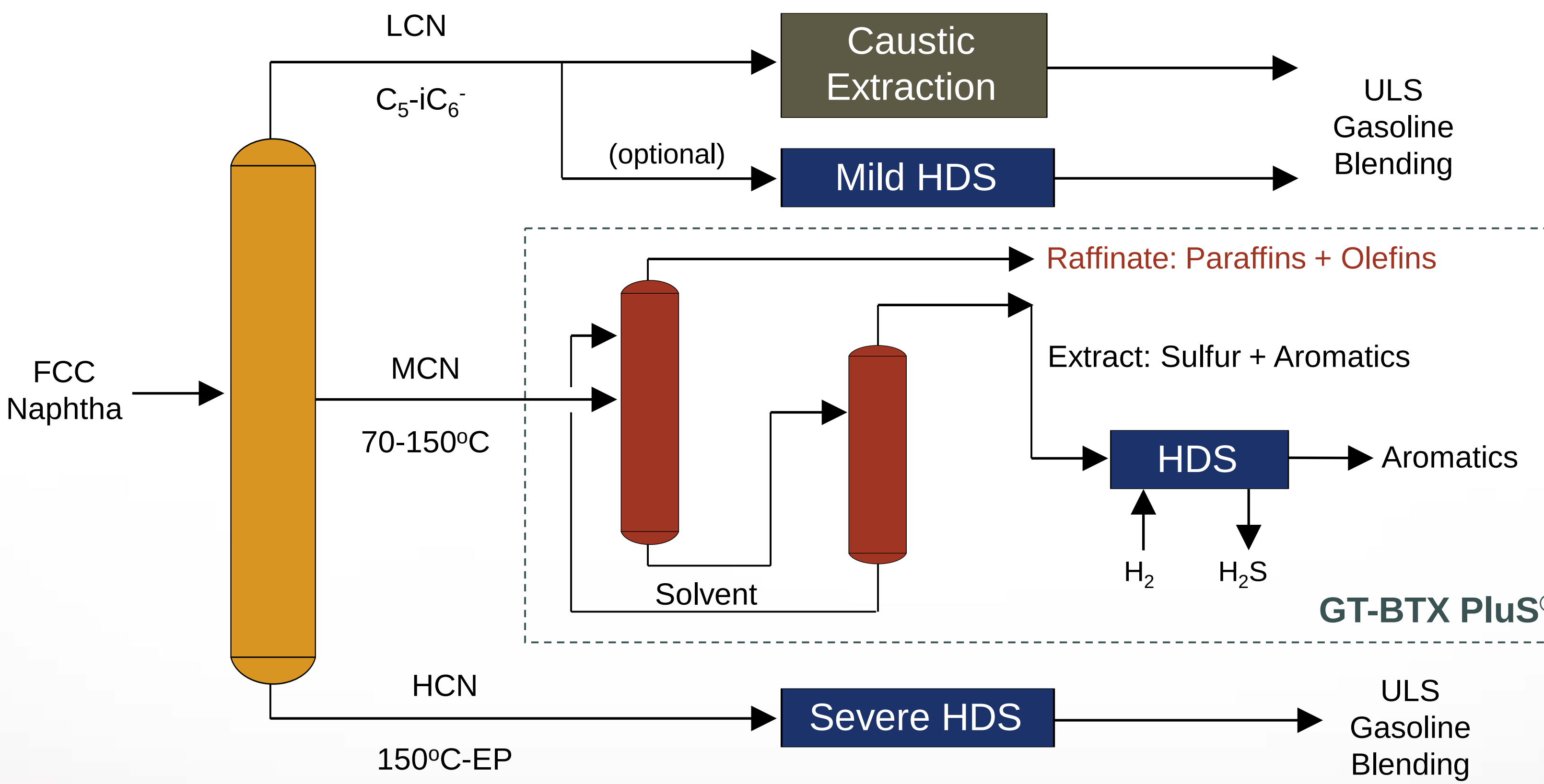
Conventional Three-Stage Process

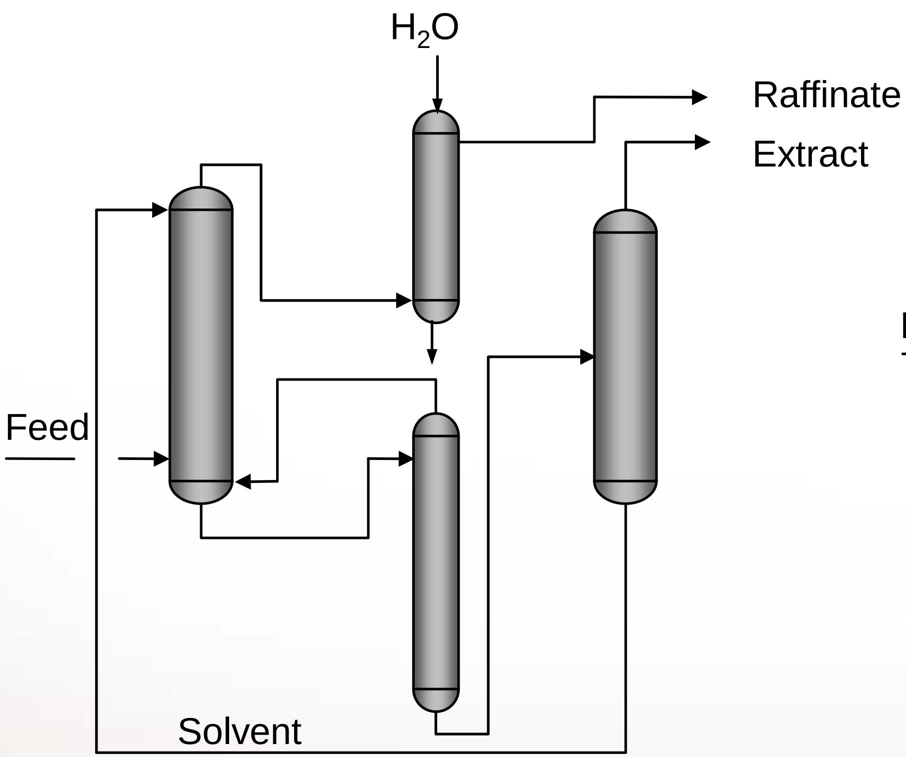


Aromatics Extraction with GT-BTX PluS®

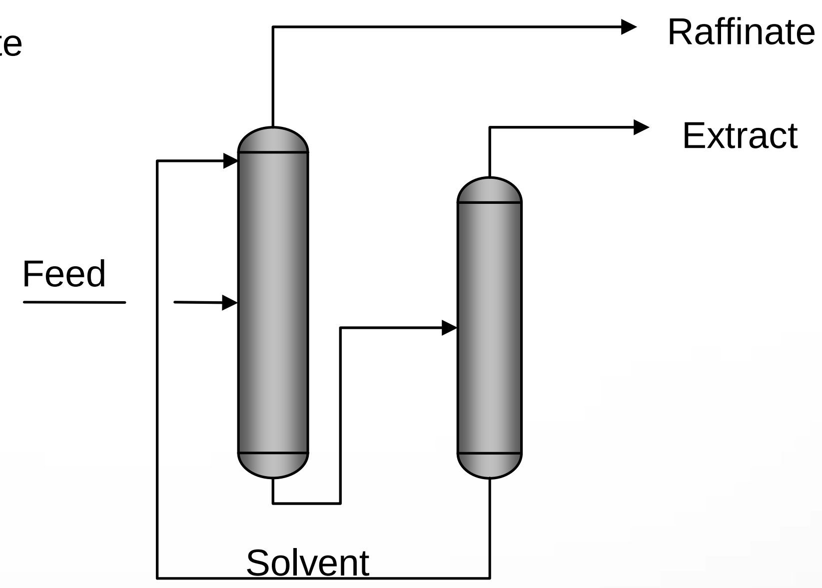


Aromatics Extraction Alternatives

Liquid-liquid Extraction



Extractive Distillation



Different Solvent Systems for Aromatics Recovery

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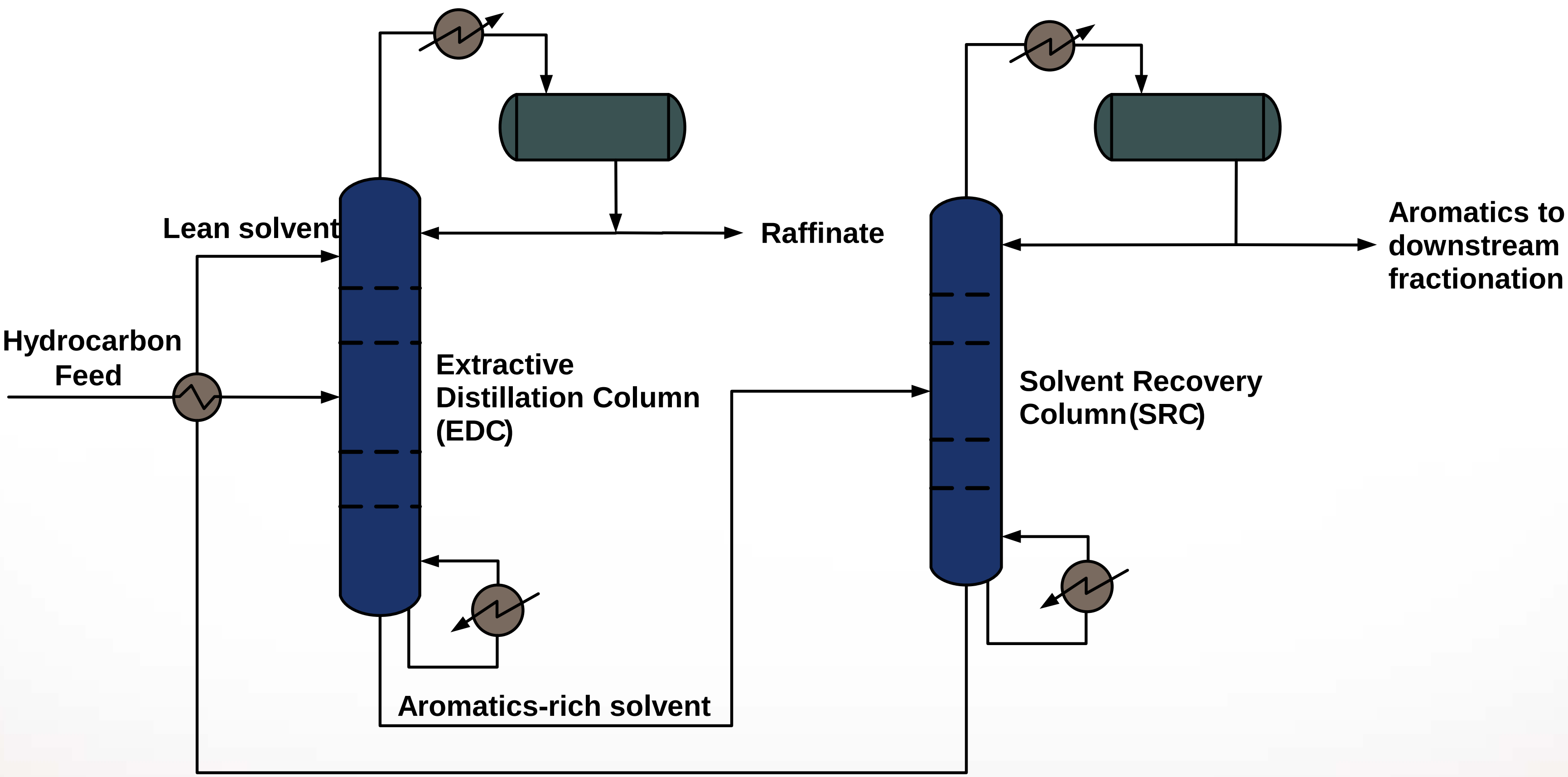
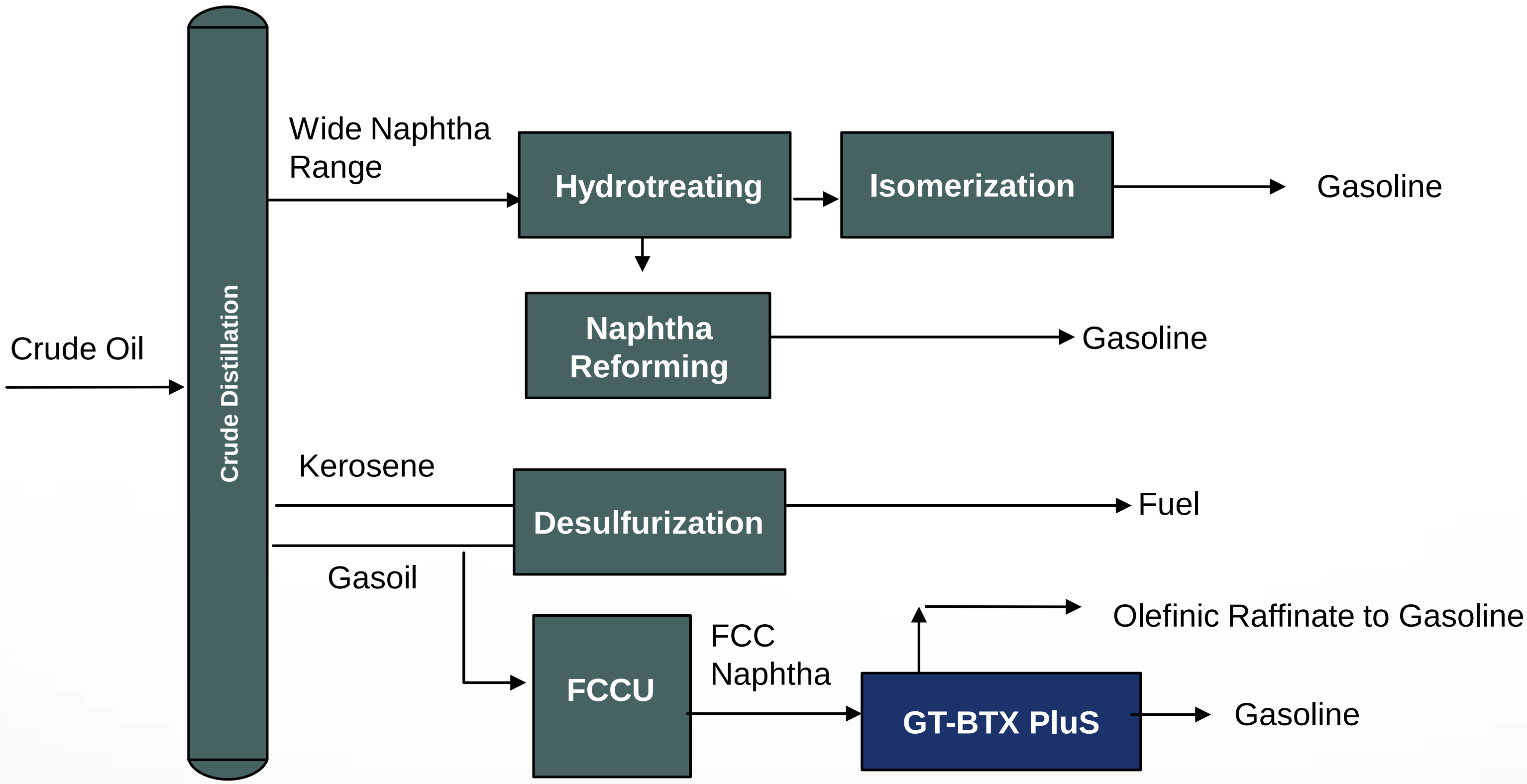
Solvent	S/F	Relative volatility (α) n-C_7/benzene
Techtiv (GT-BTX®)	3.0	2.44
Sulfolane	3.0	2.00
N-methyl pyrrolidone	3.0	1.95
N-formyl morpholine	3.0	1.89
Tri-ethylene glycol	3.0	1.44
Tetra-ethylene glycol	3.0	1.39
Glycol blends (CAROM)	3.0	1.35
No solvent	0	0.57

(α) R.V. = $(y_A/x_A)/(y_B/x_B)$

GT-BTX PluS® - General Flow Scheme

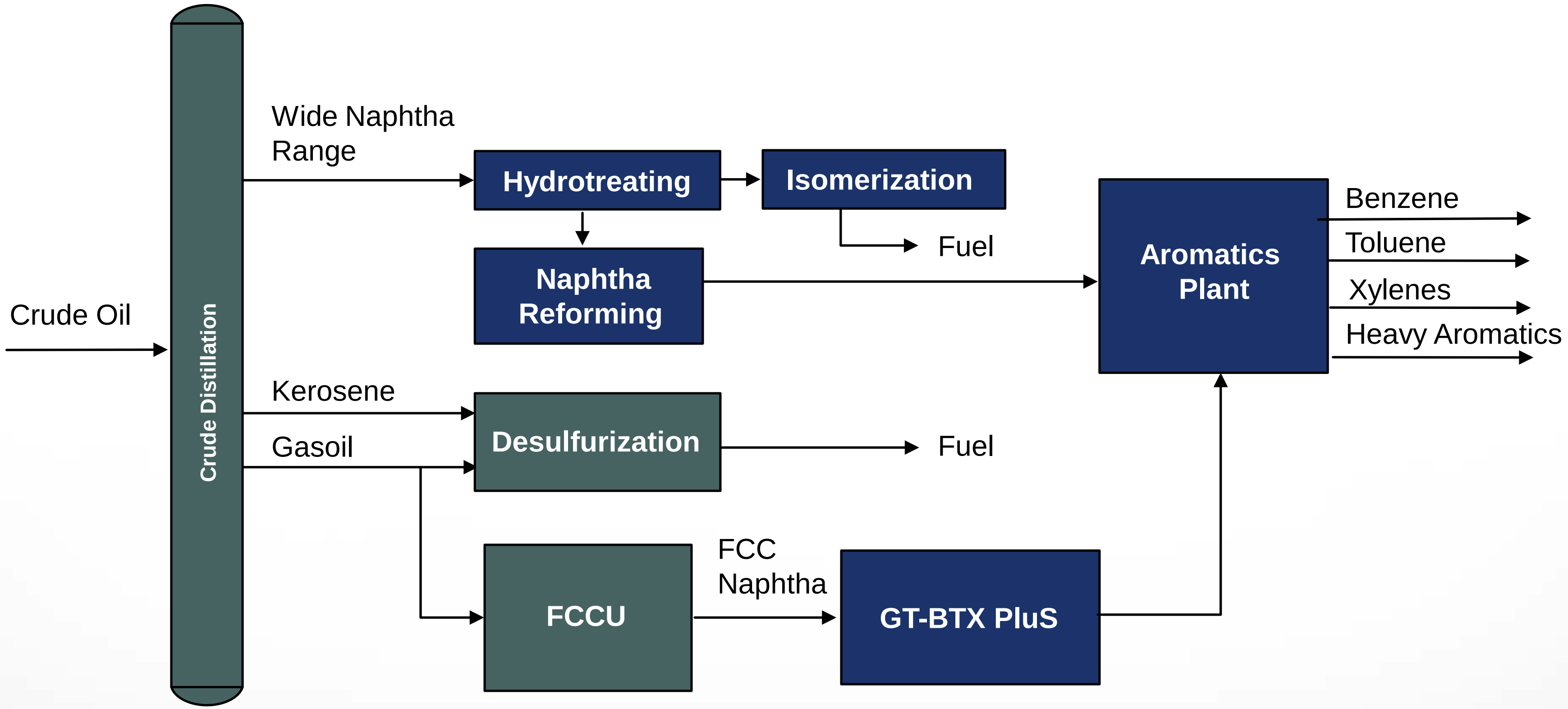


Typical Refinery Configuration with GT-BTX PluS® - Products to Gasoline



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

Typical Refinery Integrated with Aromatics using GT-BTX PluS®



Much preferred to recycling FCC naphtha to catalytic reforming

Options for FCC C_4^+ Olefins

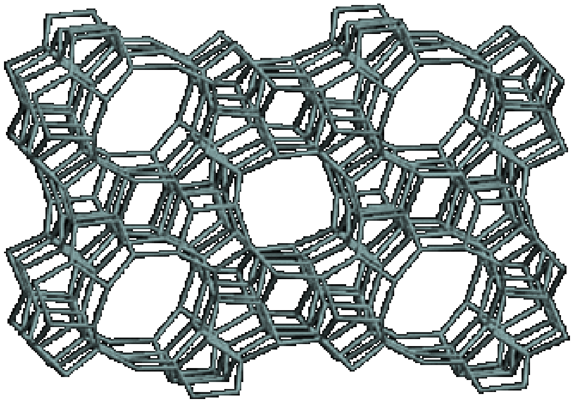
- Gasoline blending → zero change in octane value
  desulfurized
  de-benzenized
- Aromatization → BTX, PX
- Re-cracking → $C3^=$

Aromatization: Generate BTX from Low Value Streams

FCC C4/C5 →

FCC C6 –C8, non-aromatic cut →

Steam Cracker heavy olefins →



→ Dry Gas

→ LPG

→ Aromatics

Additional Aromatics from FCC C_4 – C_8 Olefin Fraction

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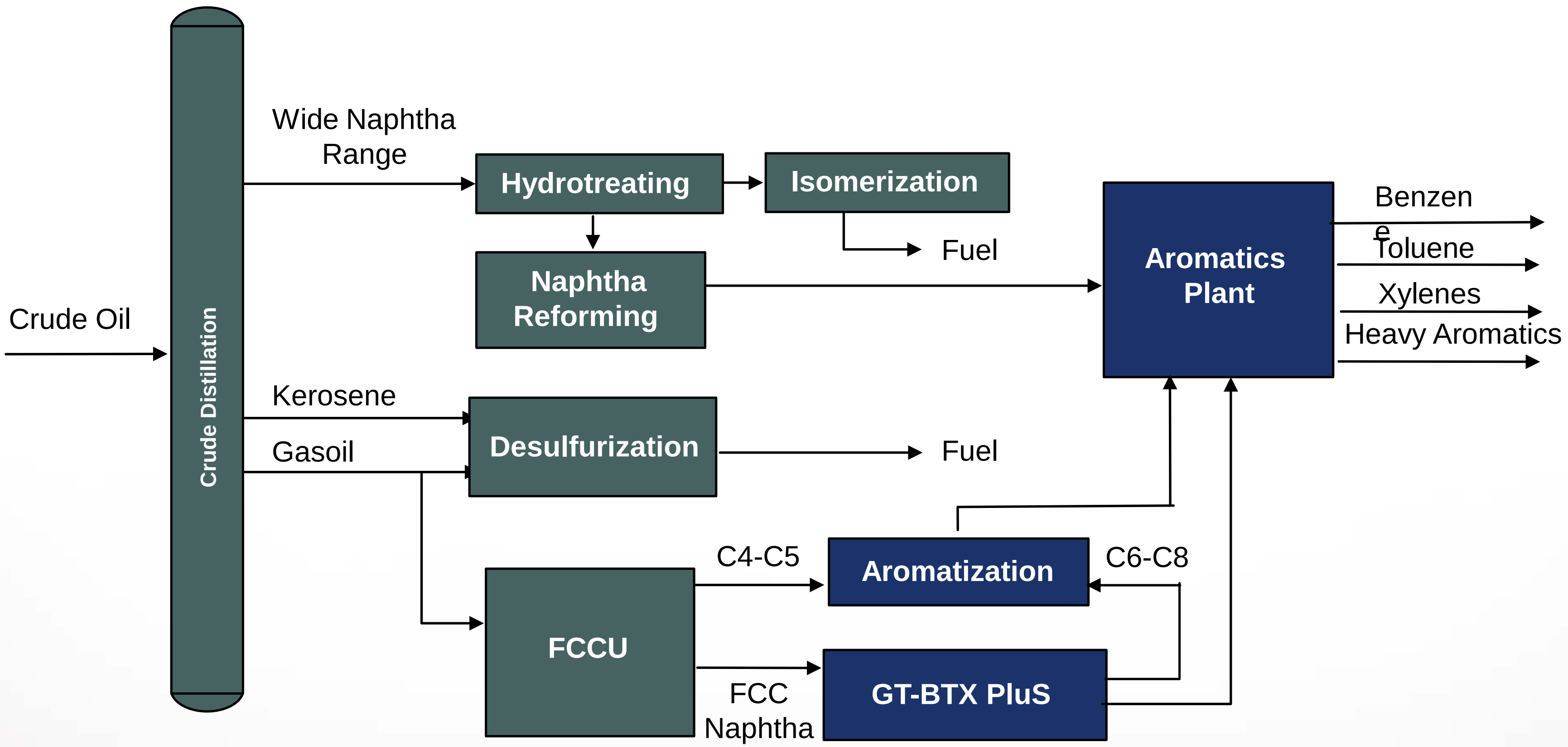
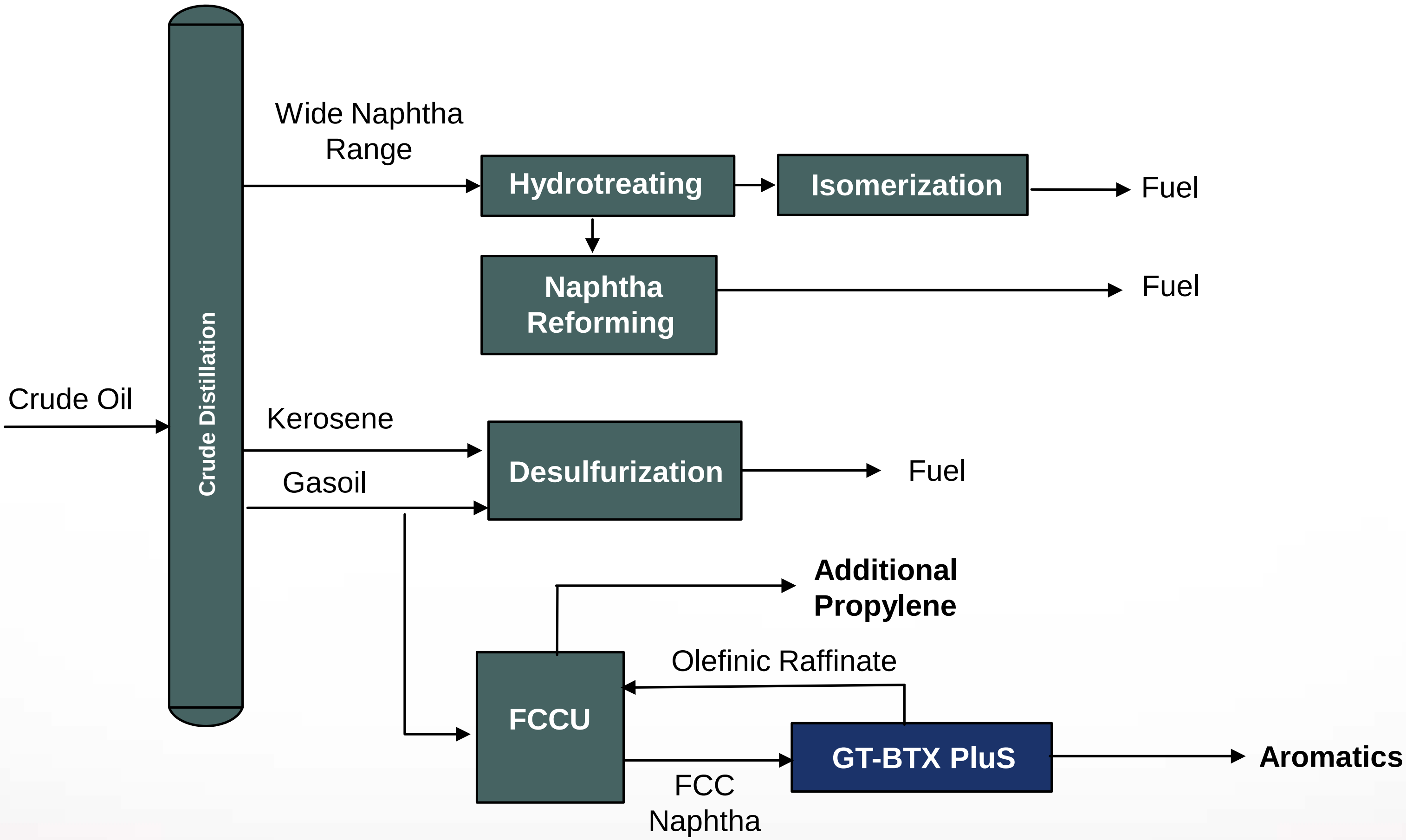


More Aromatics from Non-Traditional Feedstock

Refinery configuration with GT-BTX PluS® to facilitate increased Propylene



Extends Range of FCC Naphtha Recycle

GT-BTX PluS® - Enabling Technology

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- 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

Case Study – GT-BTX PluS® & GT-Aromatization℠

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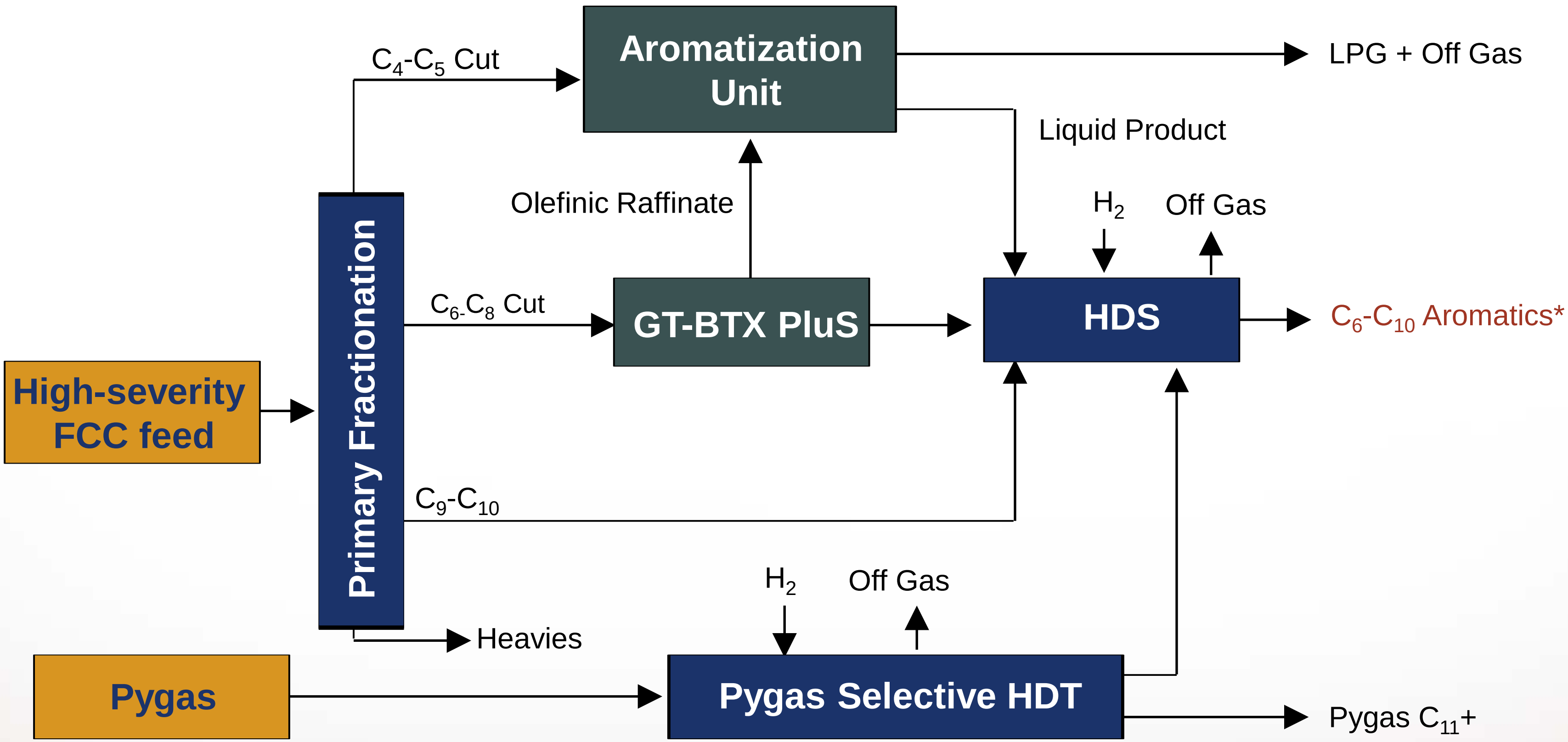
Part of a recent project implemented for Rafinerie Onesti



*Stream is sent to Aromatics Complex for Benzene and Paraxylene recovery

Incremental Aromatics from Gasoline Source

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C_6-C_9 AROMATICS	KG/HR	TPA
INDIGENOUS FCC	11,427	97,126
PYGAS	8,029	68,245
AROMATIZATION	26,525	225,471
TOTAL	45,981	390,842

Total incremental BTX = 320 KTA

Conclusions

- Refinery/Petrochemical integration involves more than simple propylene recovery
- Recycling FCC gasoline to naphtha reforming is not true integration, and misses the main point of process efficiency
- GT-BTX Plu**S**® is the enabling technology which permits the best use of molecules to their highest value

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