SULZER

Sulzer GTC Technology

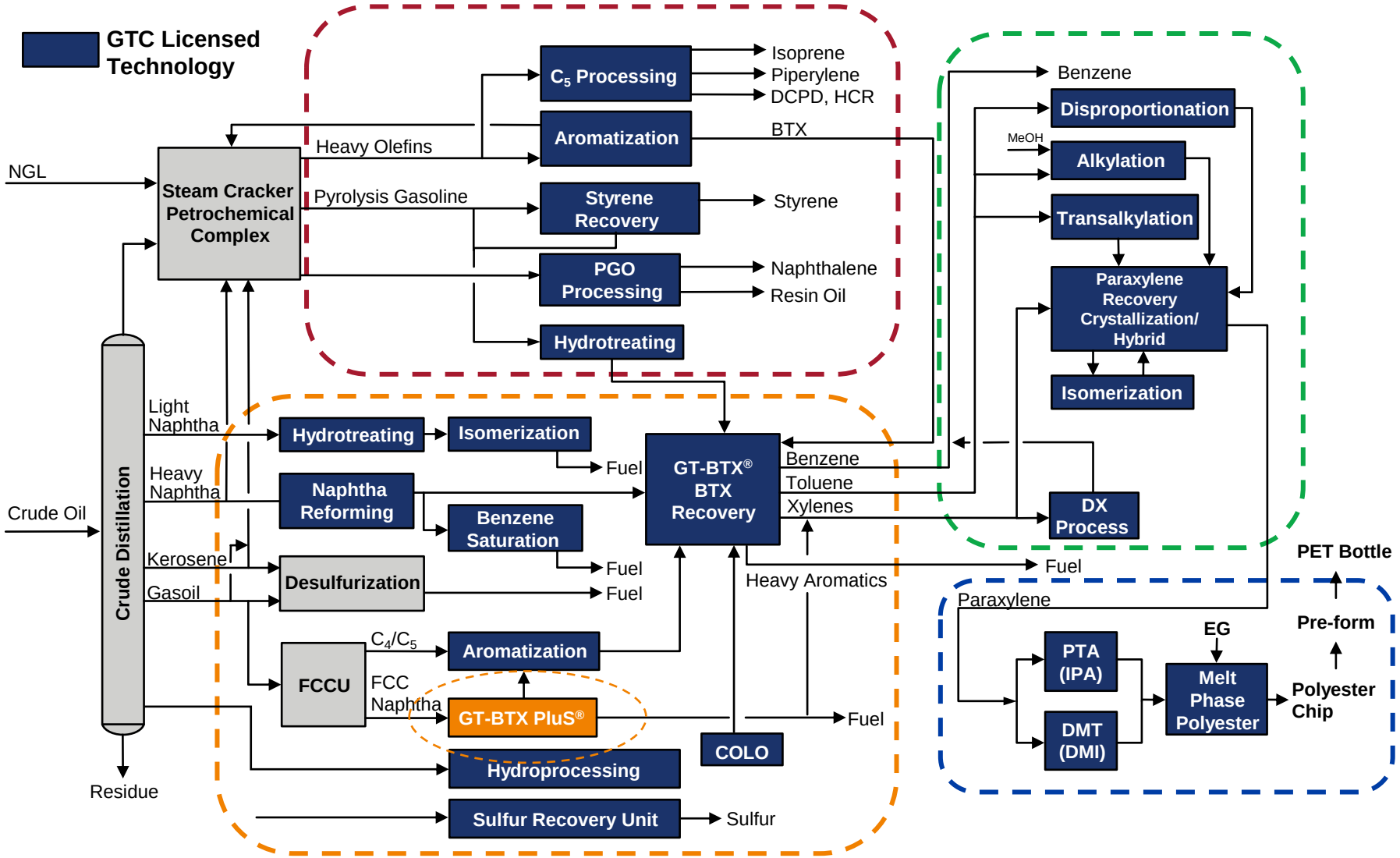
Refining of the Future

- FCC Naphtha Processing for ULS Gasoline with No RON Loss, and Flexibility for Gasoline-to-Petrochemical

Charlie Chou

charlie.chou@sulzer.com

Sulzer GTC Portfolio



Alliance with Axens Prime G+

Axens and GTC formed alliance for the combined offer of **Prime G+** technology and **GT-BTX PluS** technology

Intend for –

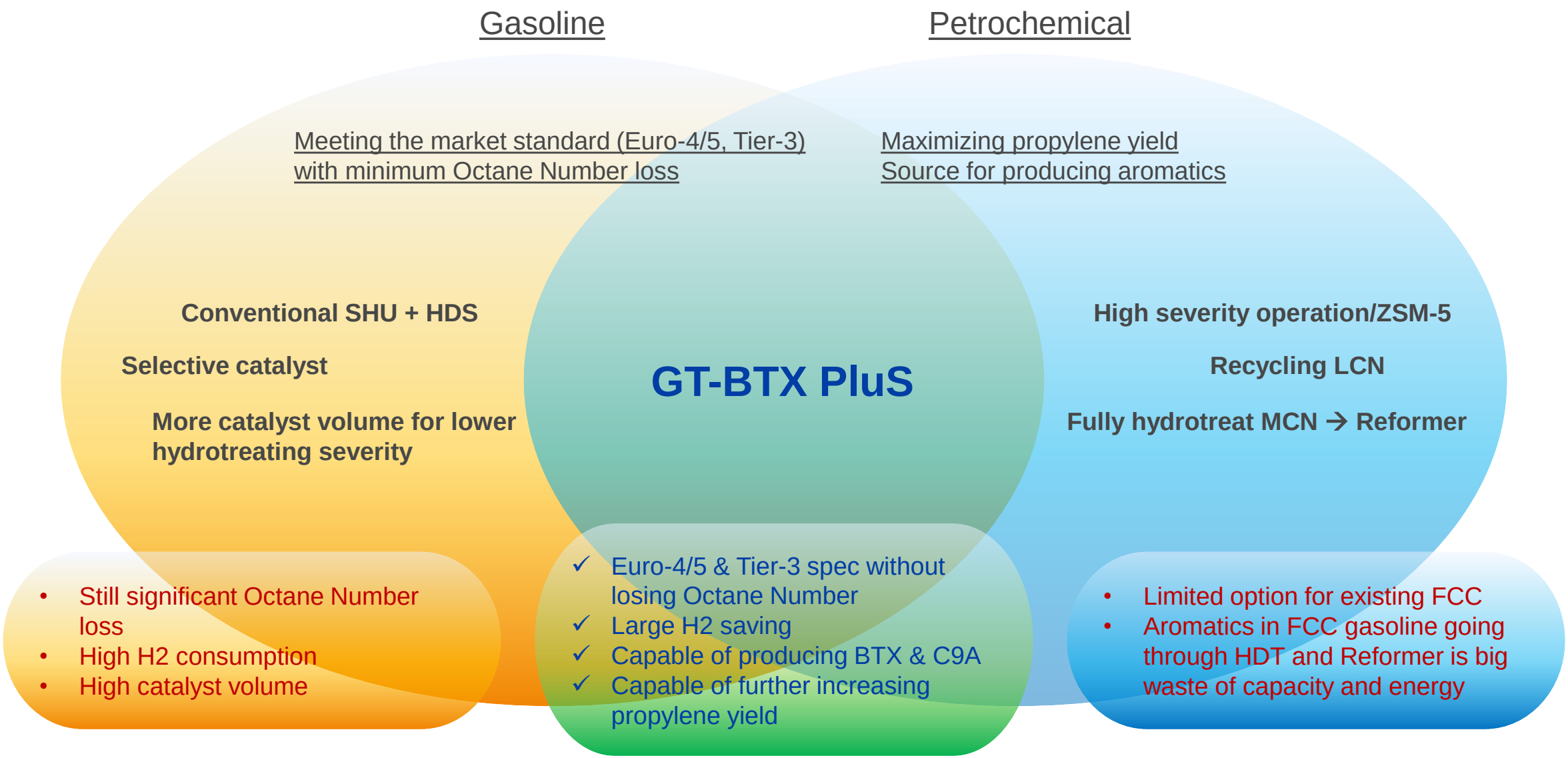
- **Gasoline purpose:**

  Further reduce the RON loss than what Prime G+ can do alone.

- **Petrochemical purpose:**

  Provide flexibility to convert FCC gasoline to petrochemical products.

FCC Unit Target



GT-BTX PluS® is used for

- Euro-5 (Tier-3) Ultra Low-Sulfur FCC Gasoline without Losing RON
- Converting FCC Gasoline to Petrochemical (Aromatics and Propylene)

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Gasoline Specification

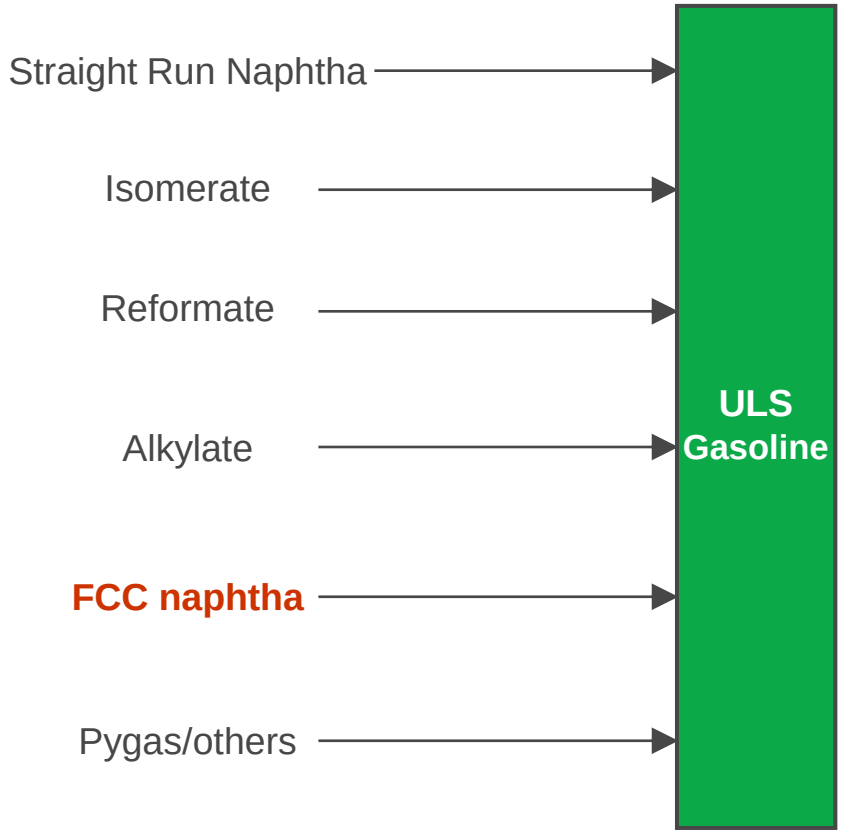
Limitation Imposed on Sulfur and Aromatics/Benzene

	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	Tier-III 10 (Tier-II 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
Oxygen, wt%, max	-	2.7	2.7	2.7	2
RON/MON, min	95/85	95/85	95/85	95/85	Road Octane 87/92/95

Countries with lower gasoline specs are moving for higher spec for environmental reasons and as newer vehicles replace older ones.

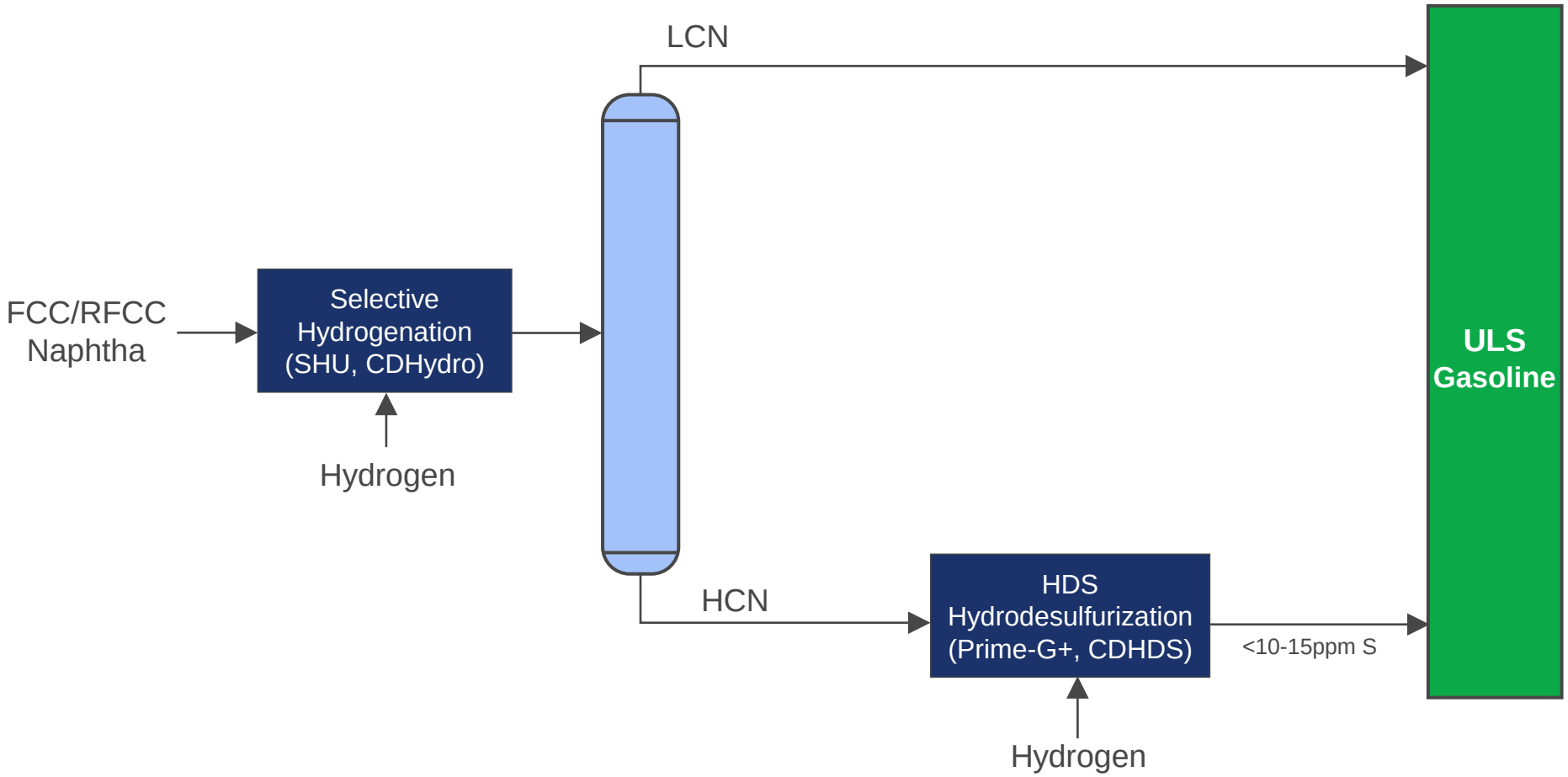
Gasoline blending sources

FCC naphtha is the only major gasoline blending source that contains significant sulfur



FCC Gasoline Desulfurization – Typical Scheme

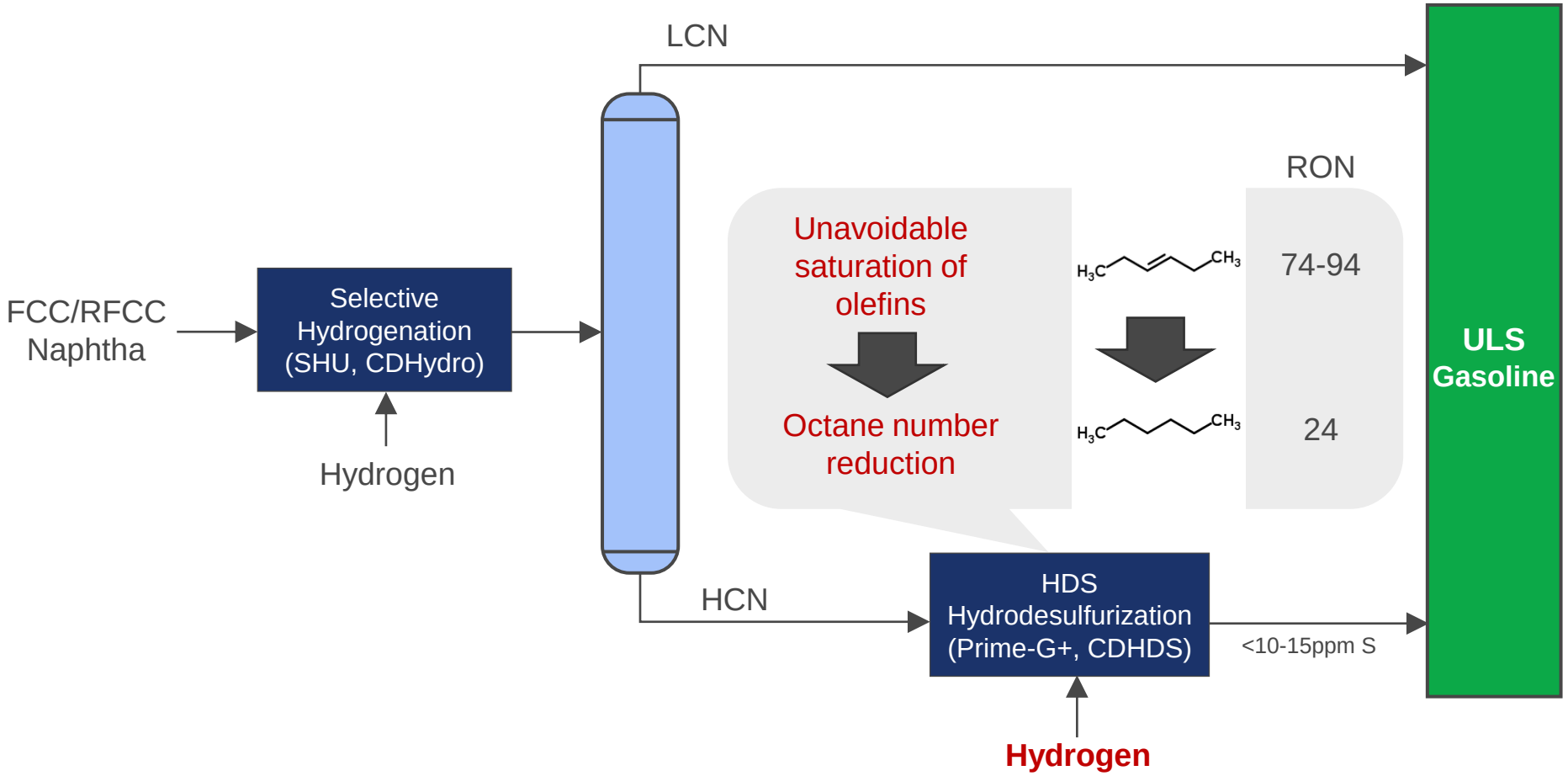
Typical Gasoline Desulfurization Process



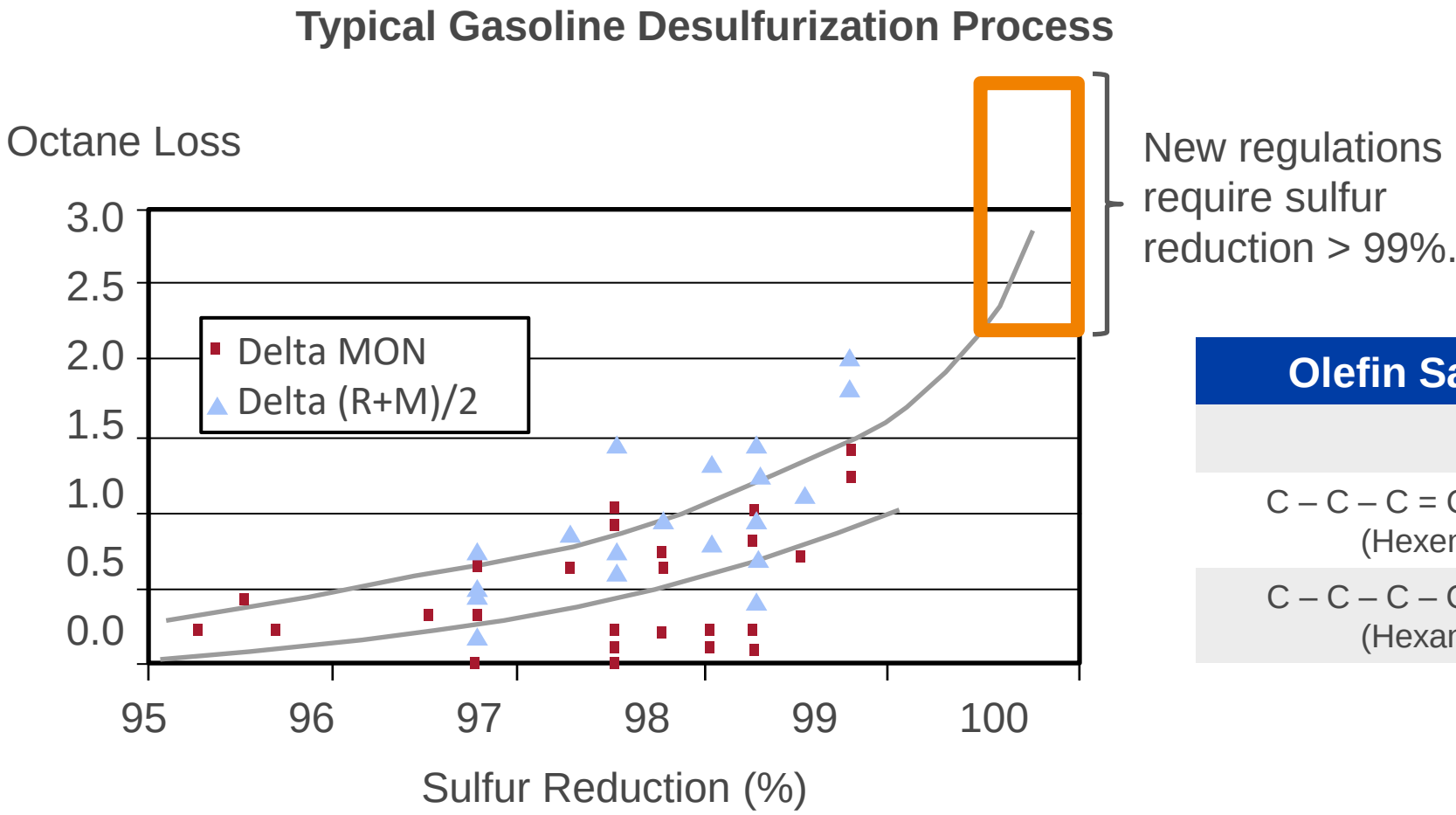
FCC Gasoline – RON Loss in Typical Scheme

Typical Gasoline Desulfurization Process

Octane Loss & H2 Consumption



FCC Gasoline Desulfurization



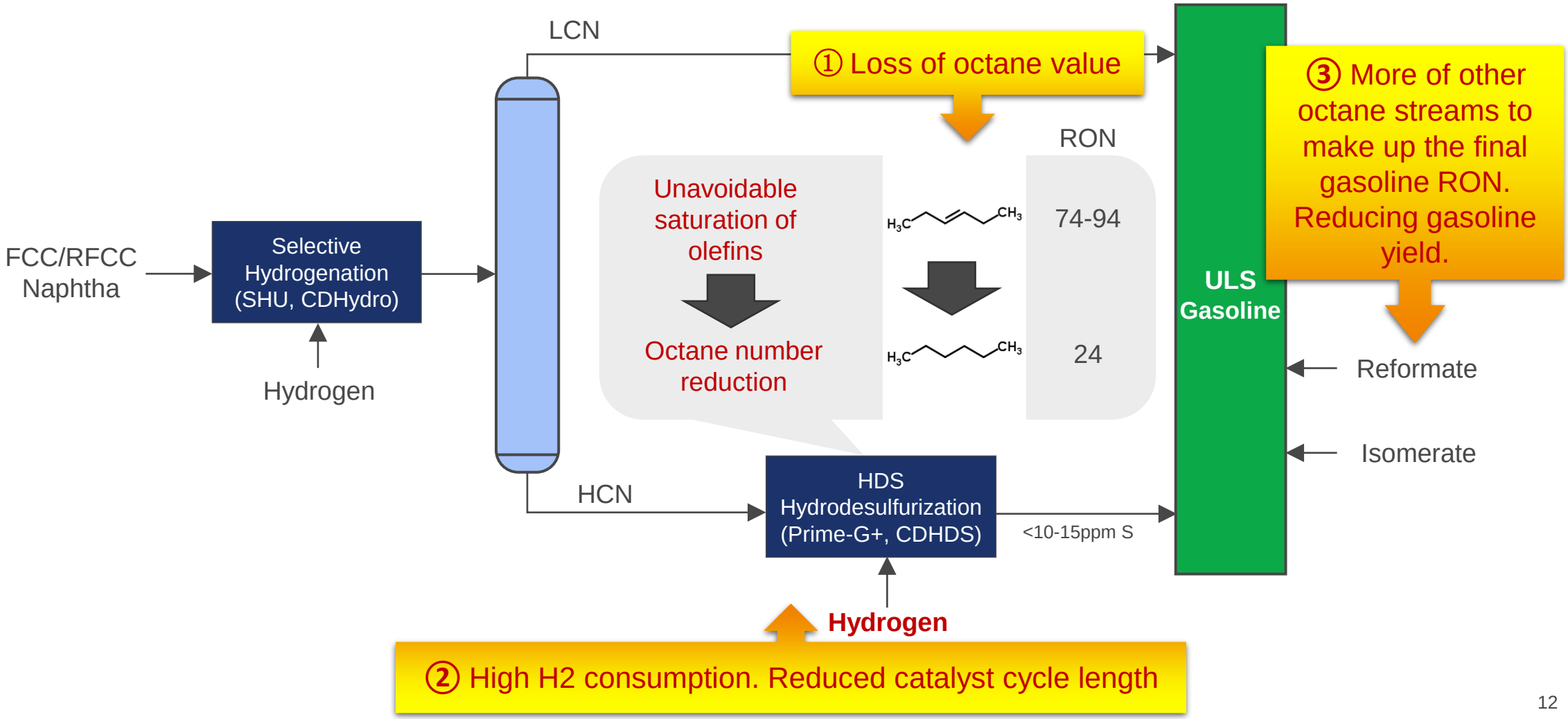
Olefin Saturation is a Problem	
	RON
C – C – C = C – C – C (Hexene)	74-94
C – C – C – C – C – C (Hexane)	24

Figure 3 – Dependence of the loss of octane number on the level of hydrodesulfurization in HDS section of Prime G based on data by Axens

FCC Gasoline – RON Loss in Typical Scheme

Typical Gasoline Desulfurization Process

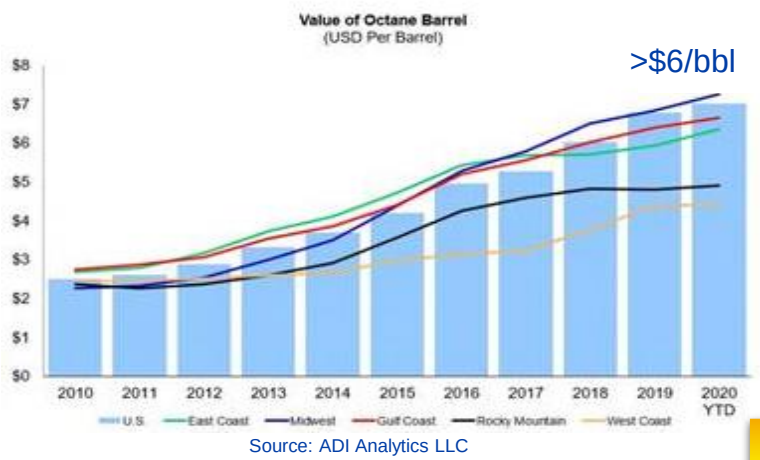
Octane Loss & H2 Consumption



FCC Gasoline – RON Loss in Typical Scheme

For a 50,000 b/d FCC
assuming
3 Octane Number loss
with
US$1.5 octane-bbl value

The loss for octane value is
US$37,000,000 per year



>$6/bbl

Source: ADI Analytics LLC

Typical Gasoline Desulfurization Process
Octane Loss & H2 Consumption

LCN

① Loss of octane value

RON

Unavoidable saturation of olefins

Octane number reduction

74-94

24

ULS Gasoline

③ More of other octane streams to make up the final gasoline RON. Reducing gasoline yield.

← Reformate

← Isomerate

HCN

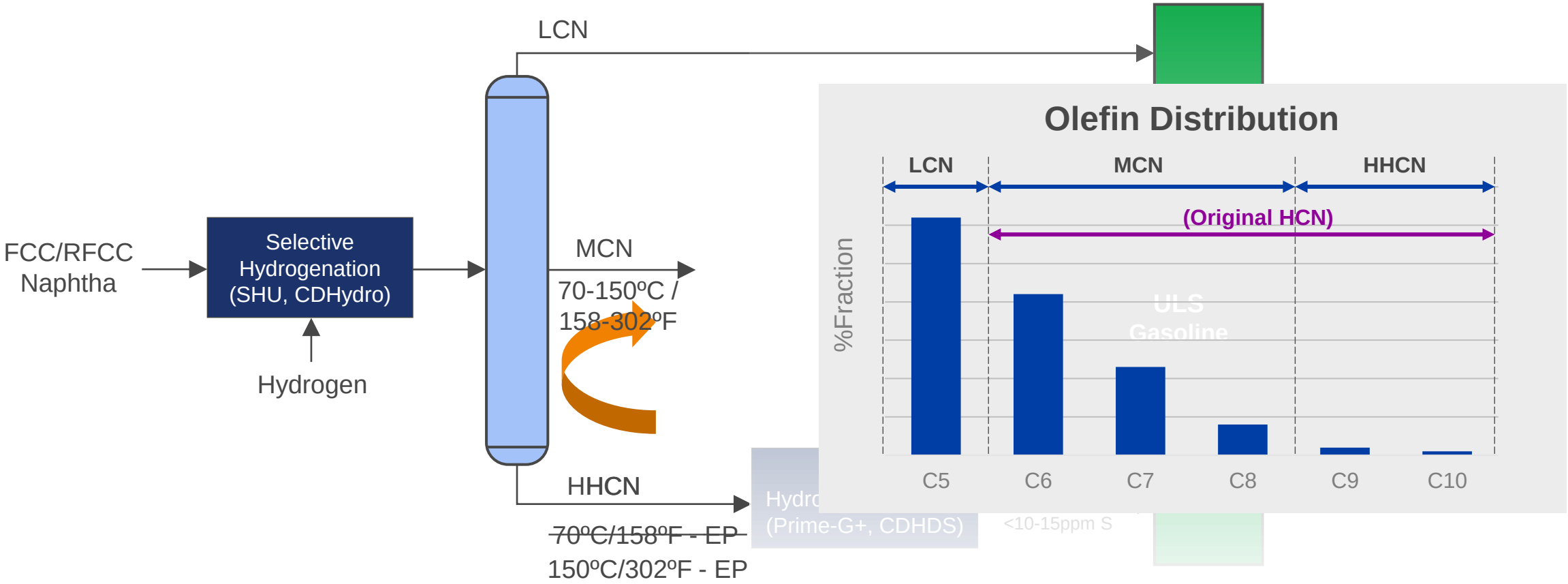
HDS Hydrodesulfurization (Prime-G+, CDHDS)

<10-15ppm S

Hydrogen

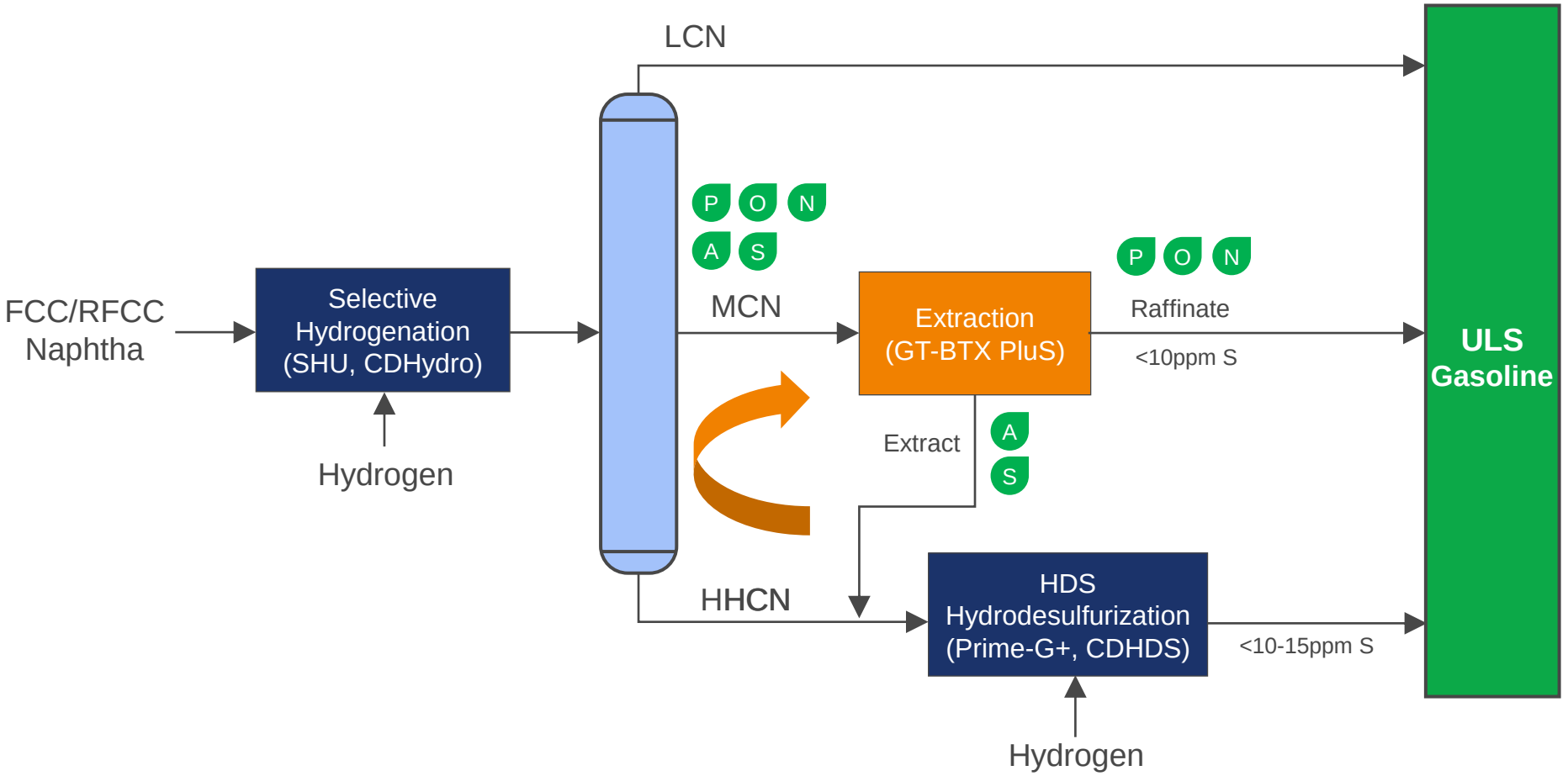
② High H2 consumption. Reduced catalyst cycle length

FCC Gasoline – Adding a middle cut MCN



FCC Gasoline with GT-BTX PluS®

Gasoline Desulfurization Process with GT-BTX PluS®



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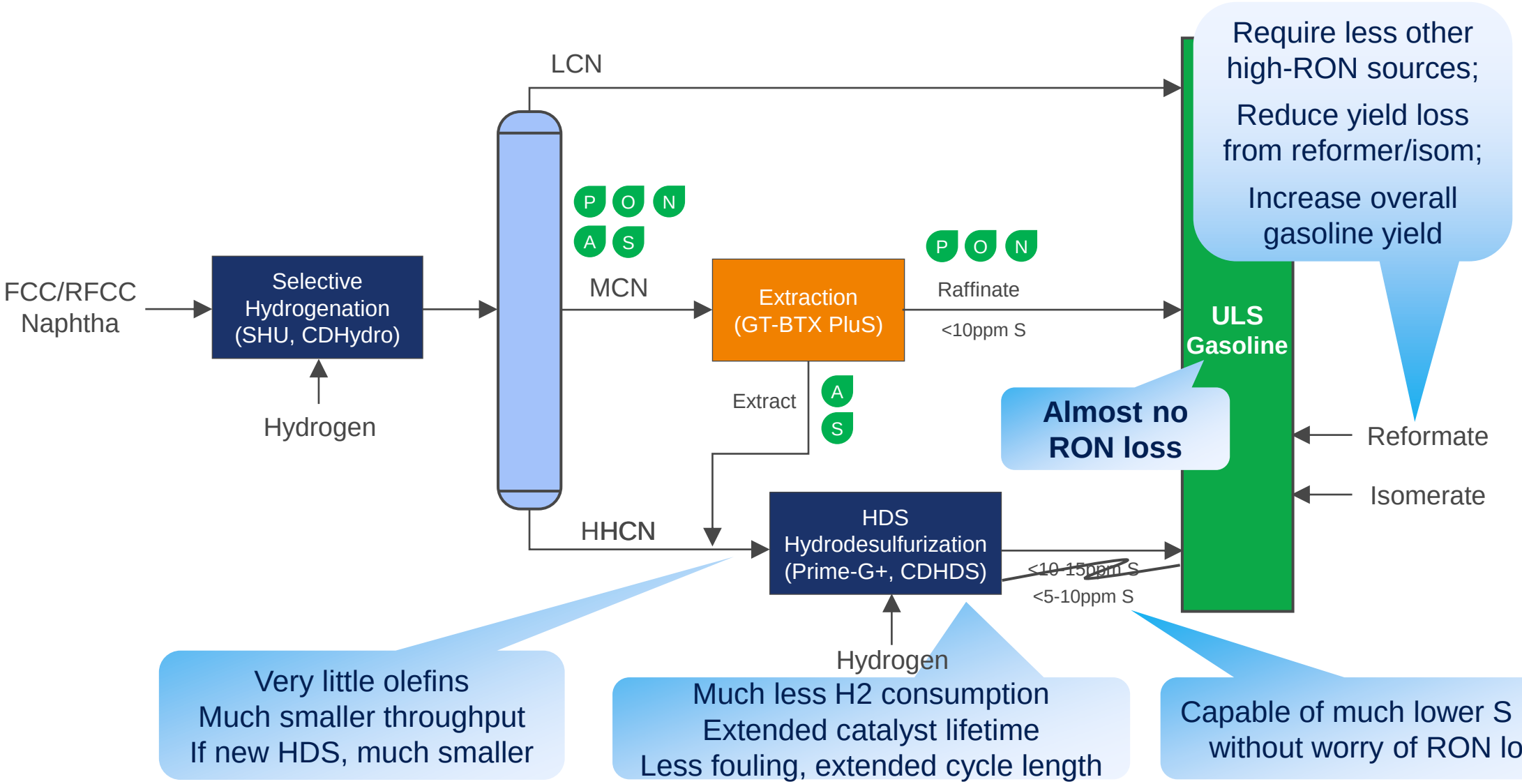
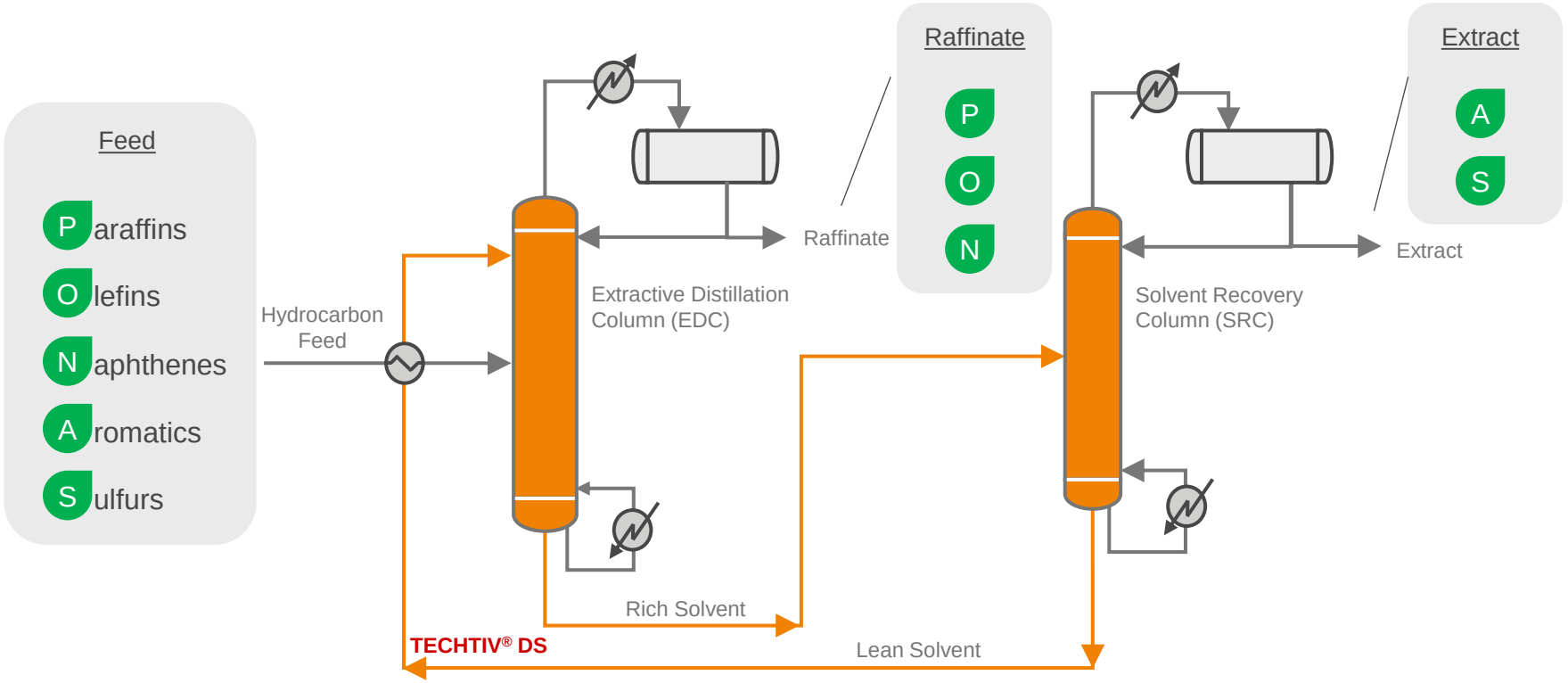
Gasoline Desulfurization Process with GT-BTX PluS®



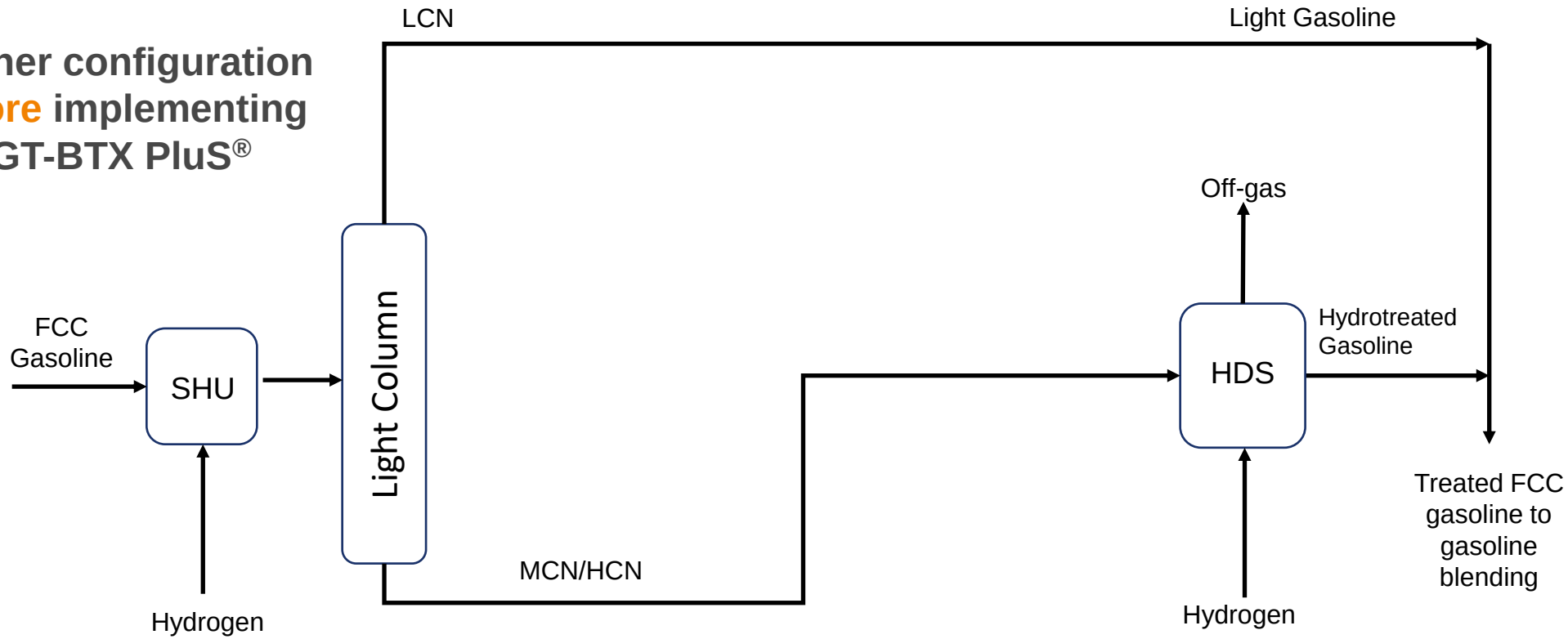
GT-BTX PluS® - Simple two-column system



Extractive Distillation process - Major equipment are EDC & SRC columns

GT-BTX PluS® - Case Study of Actual Operating Unit

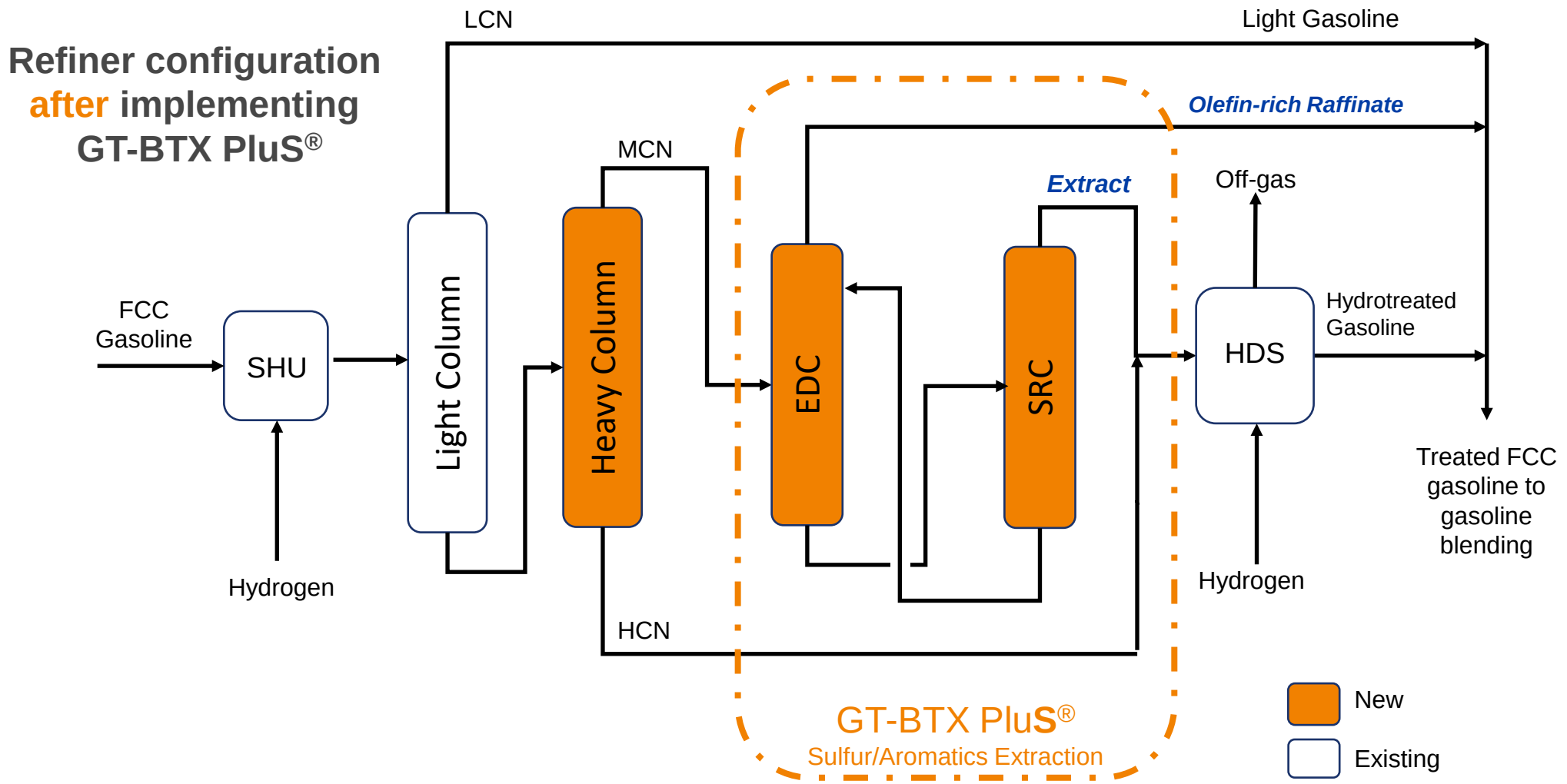
Refiner configuration before implementing GT-BTX PluS®



- **50,000 b/d FCC**
- **RON loss across FCC naphtha processing – 4.0**
- **High H2 consumption in HDS**

Existing

GT-BTX PluS® - Case Study of Actual Operating Unit



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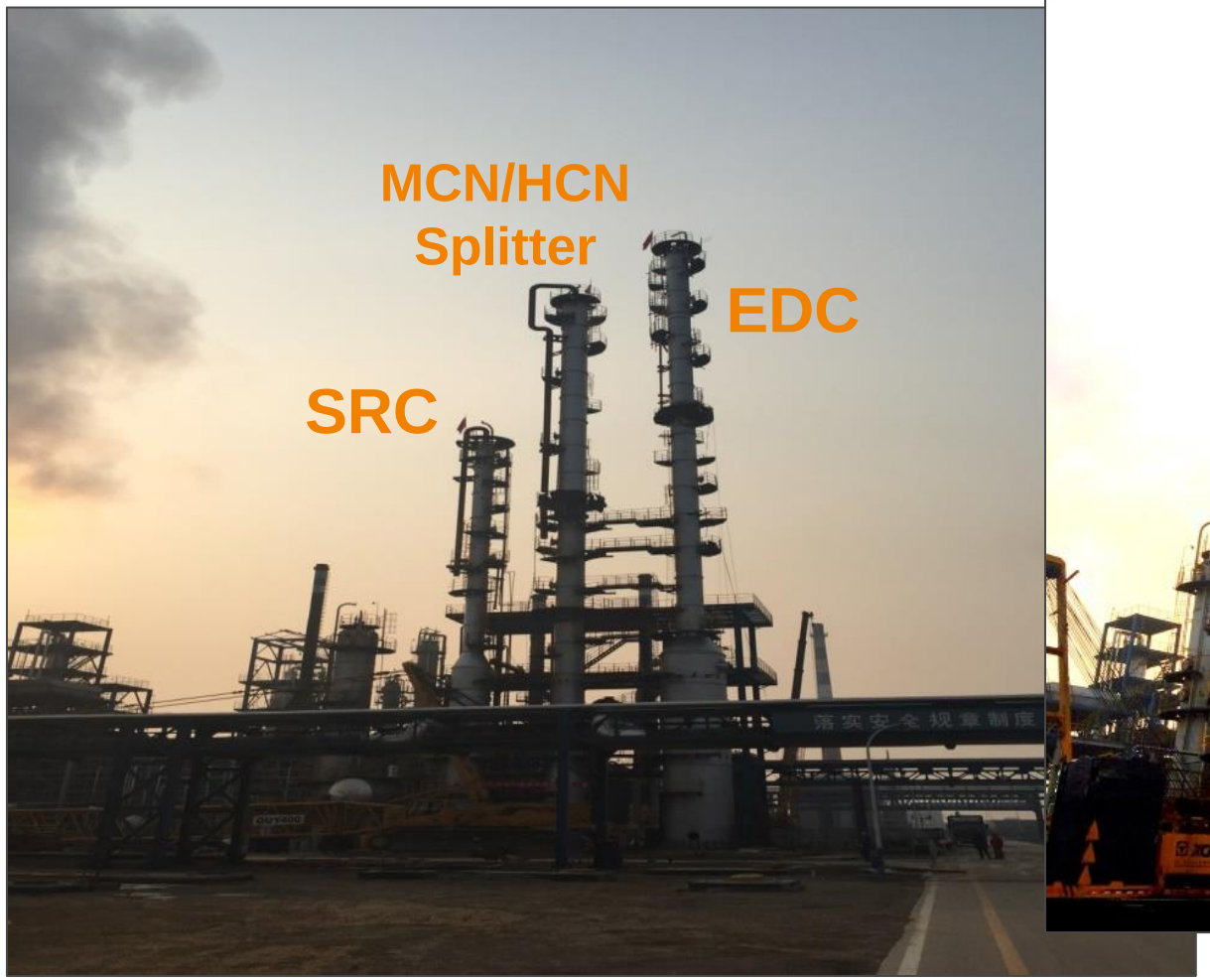


GT-BTX PluS® - Case Study of Actual Operating Unit

FCC Gasoline Desulfurization Performance Before/After GT-BTX PluS®

	Before GT-BTX PluS drop in	After GT-BTX PluS drop in
Octane loss	**4.0**	**0.6**
H2 consumption for HDS	Base	Base x 40%
Cost of operation for GT-BTX PluS unit		Zero (operating cost balanced out by H2 saving)
Payback period		1 year

GT-BTX PluS® - Octane Number Saving

For existing refinery, GT-BTX PluS unit can be drop-in application

<u>If not yet Euro-5/Tier-3</u>

- Meeting Euro-5/Tier-III <10ppm sulfur with almost no RON loss. No need to buy credit.
- If needing new HDS/Prime G unit, the HDS unit can be much smaller.

<u>If already Euro-5/Tier-3</u>

- Greatly reduce H2 consumption.
- Extend HDS catalyst cycle length.
- As FCC gasoline RON will significantly increase:
  - Be able to sell credits.
  - Be able to reduce reformer severity to increase liquid yield.
  - Be able to bypass some straight run naphtha to gasoline, which increase the gasoline yield.
  - Be able to shut down or reduce severity of the pre-hydrotreating unit for feed to FCC, resulting in OPEX saving and more LCO.

For a 50,000 b/d FCC
that would have
3 Octane Number loss
with
US$1.5+ octane-bbl value

GT-BTX PluS can gain the octane value of
US$37,000,000+ per year
Payback period <2 years most cases

GT-BTX PluS® is used for

- Euro-5 (Tier-3) Ultra Low-Sulfur FCC Gasoline without Losing RON
- Converting FCC Gasoline to Petrochemical (Aromatics and Propylene)

GT-BTX PluS® for Petrochemical Production

Where the market demand moves

- Global gasoline demand growth is dropping fast. Some regions foresee gasoline demand shrinking.
- Global Petrochemical/Chemical demand continues to have steady growth rate.

How refineries adapt

- New refineries build units for maximum crude to petrochemical/chemical yield
- Existing refineries look at ways for gasoline-to-petrochemical/chemical

GT-BTX PluS provides refineries capability to convert *gasoline to petrochemical/chemical*

Projected global demand growth of gasoline from 2001 to 2025

(in million barrels per day)

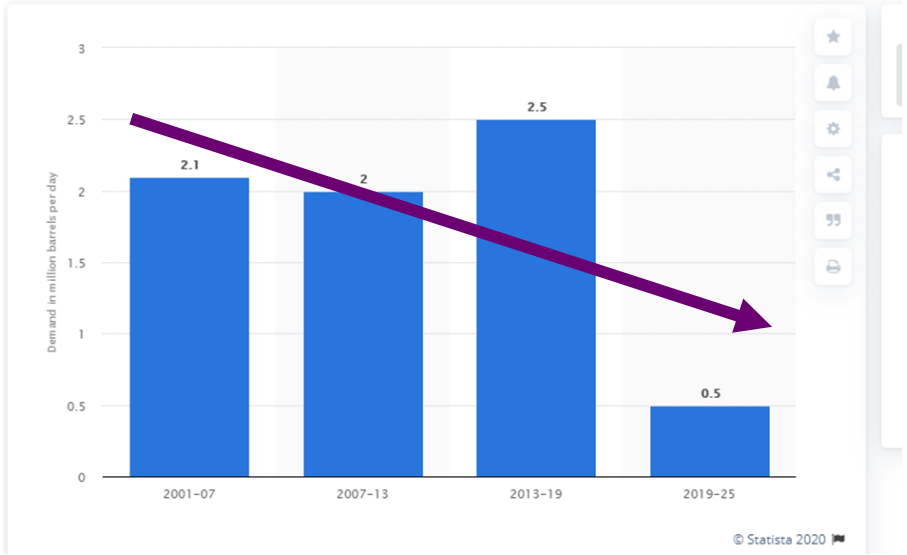
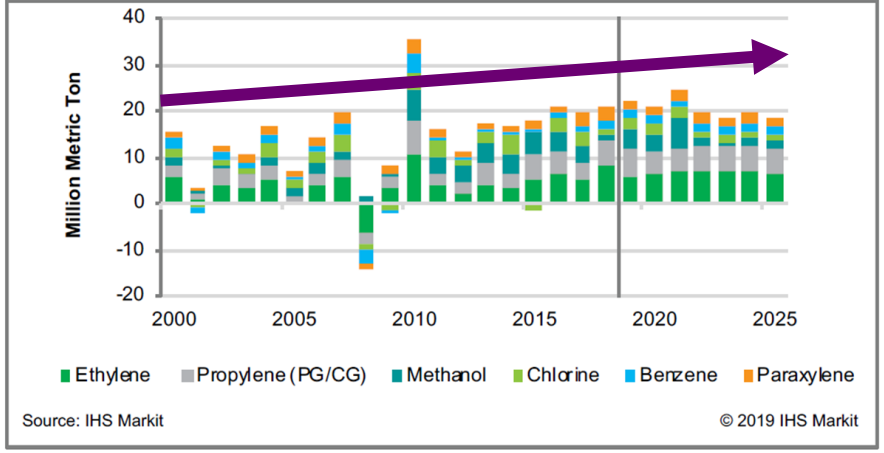
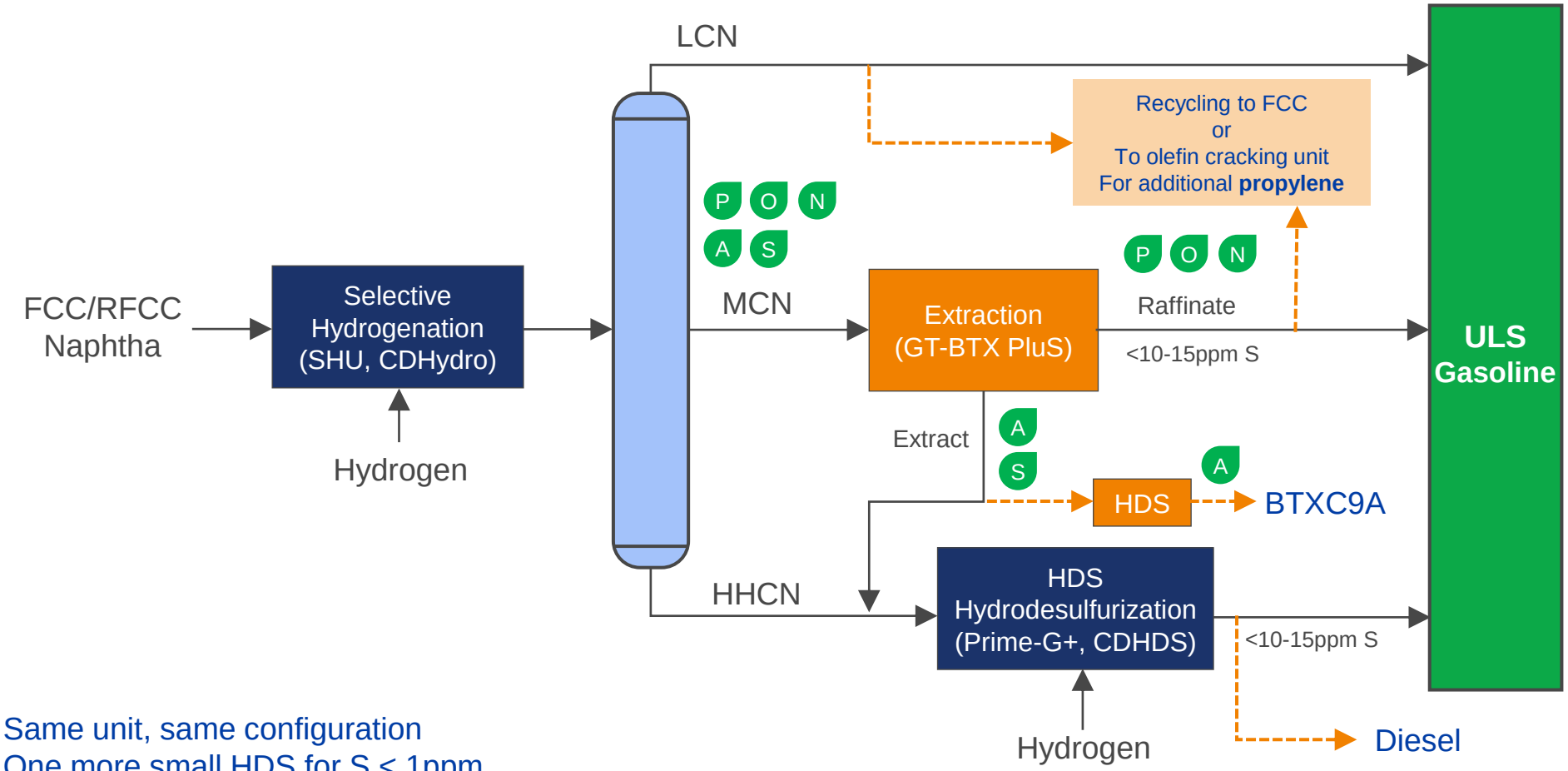


Figure 1: Growing Demand for Base Chemicals



GT-BTX PluS® for Petrochemical Production

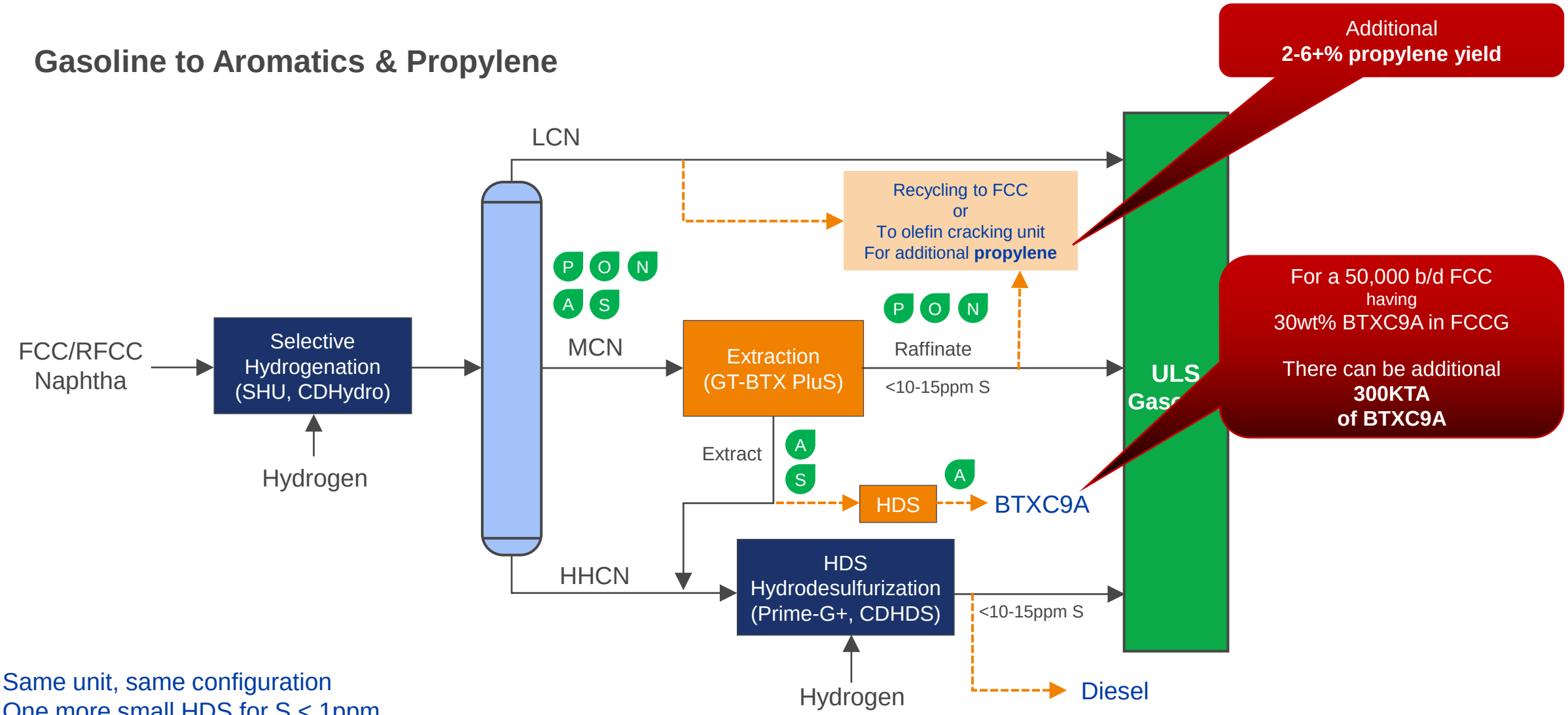
Gasoline to Aromatics & Propylene



- Same unit, same configuration
- One more small HDS for S < 1ppm
- Easily switch between the mode of Euro-5/Tier-3 gasoline with no RON loss, and the mode of gasoline to petrochemical

GT-BTX PluS® for Petrochemical Production

Gasoline to Aromatics & Propylene



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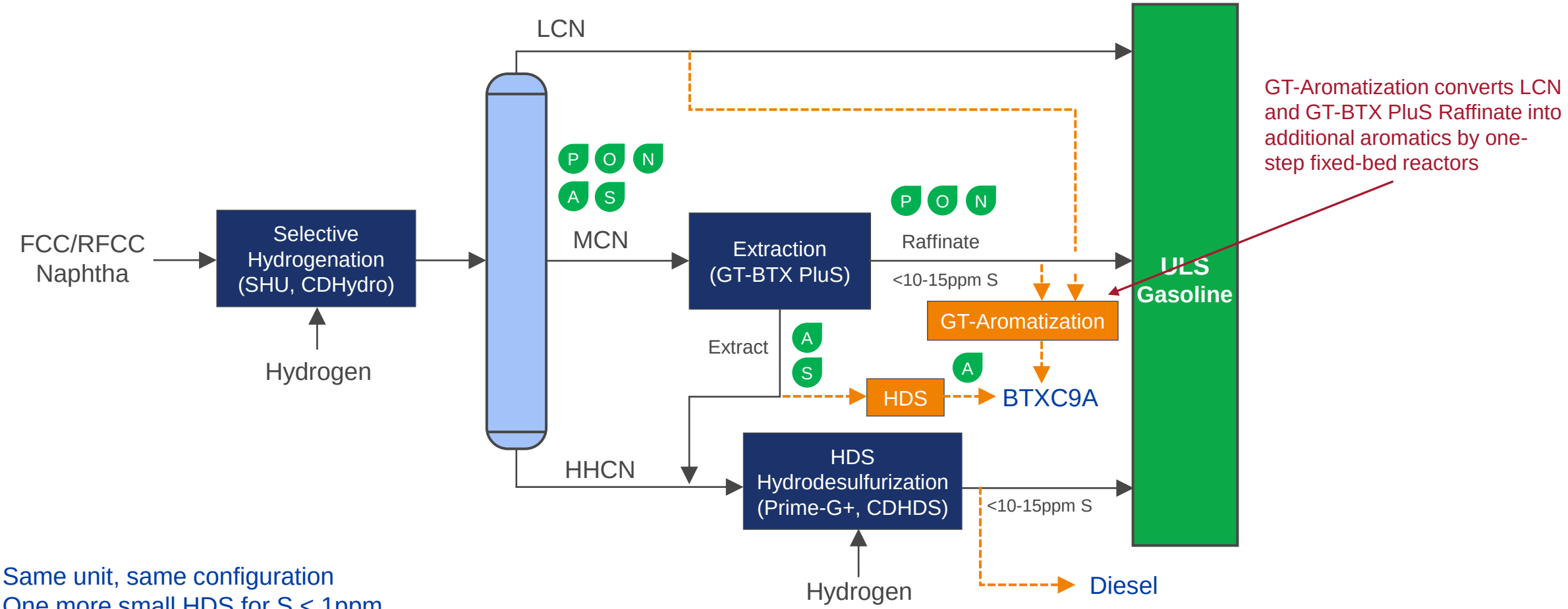
GT-BTX PluS® for Petrochemical Production

Gasoline to max Aromatics



- Same unit, same configuration
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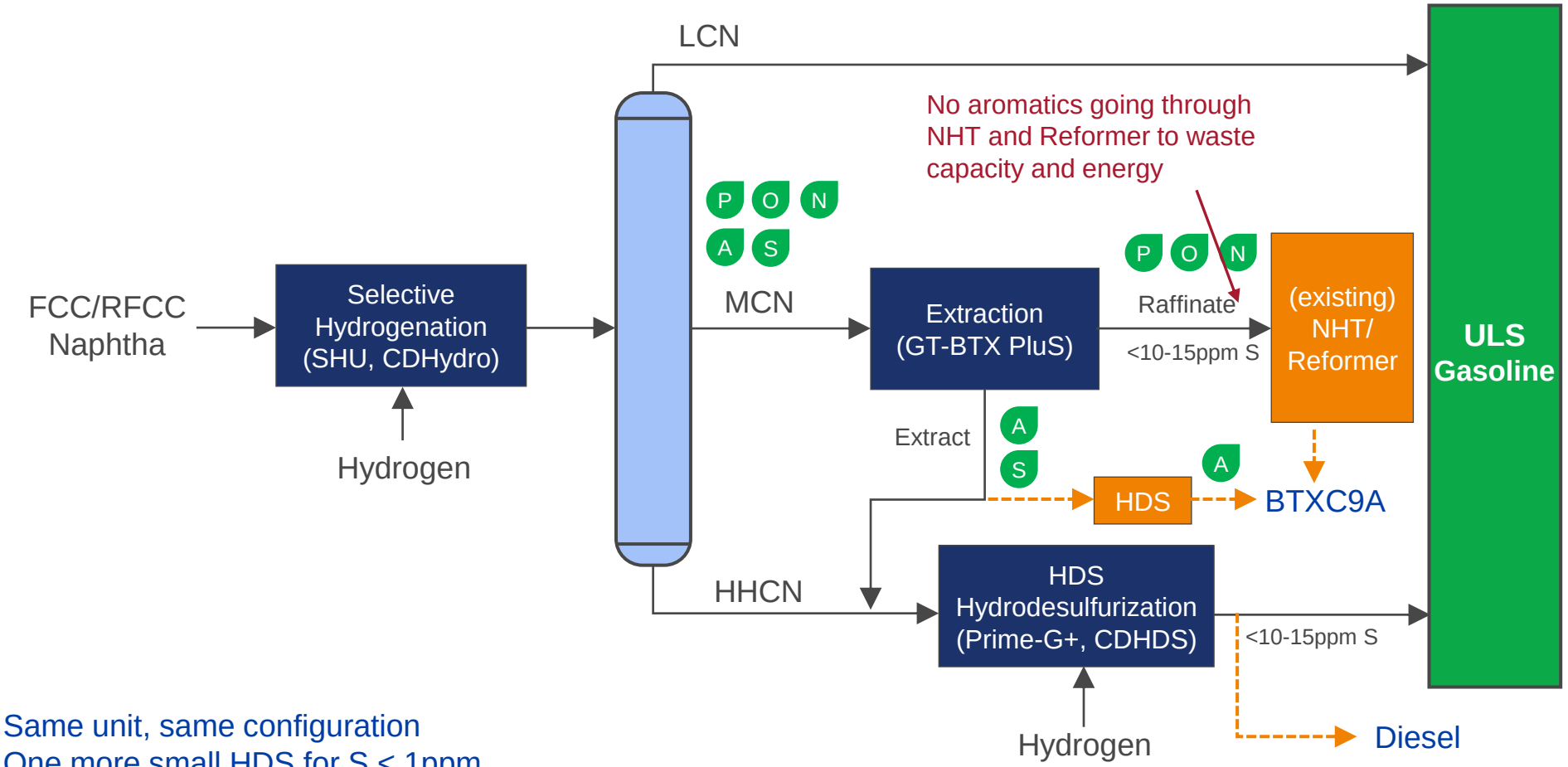
GT-BTX PluS® for Petrochemical Production

Gasoline to Reformate



- Same unit, same configuration
- One more small HDS for S < 1ppm
- Easily switch between the mode of Euro-5/Tier-3 gasoline with no RON loss, and the mode of gasoline to petrochemical

GT-BTX Plu**S**® Summary

GT-BTX Plu**S** for FCC Gasoline - advanced extraction process enables

- Low-CAPEX & OPEX simple two-column system
- Desulfurized gasoline to < 10 ppm sulfur (Euro-5/Tier-3) with nearly no octane loss
- Reduced benzene in cracked gasoline to < 0.5% benzene
- Additional aromatics and propylene production by petrochemical mode
- Best way to balance olefins without losing RON and/or with value addition
- Flexibility to switch between high-quality gasoline and petrochemical production by a single unit.
- Commercially proven technology.
- Over 65 references for GT-BTX family of technologies (@ 4Q, 2020).

Patented process – available through Sulzer GTC

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