Enhance Naphtha Value and Gasoline Reformer Performance Using UOP's MaxEne™ Process

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1st IndianOil Petrochemical Conclave
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Refining-Petrochemical Integration

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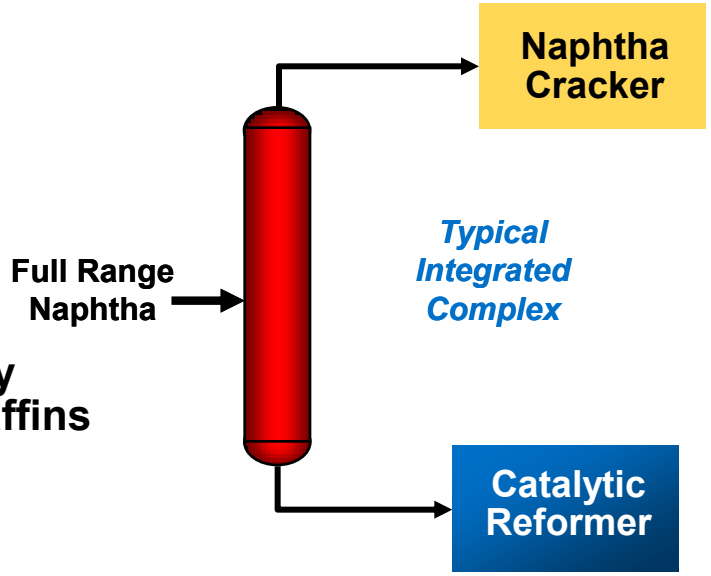
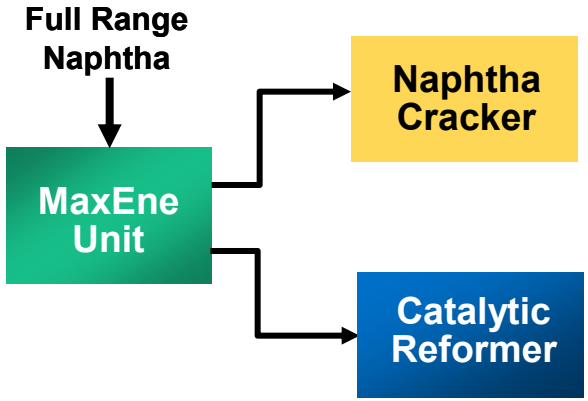
The MaxEne Process was developed to help optimize the integration of refining and petrochemical facilities

- Normal paraffins are the preferred feed to naphtha crackers for optimized yields of light olefins (ethylene + propylene)
- Catalytic reforming yields increase significantly (octane barrels and aromatics yield) when paraffins are removed from the feed



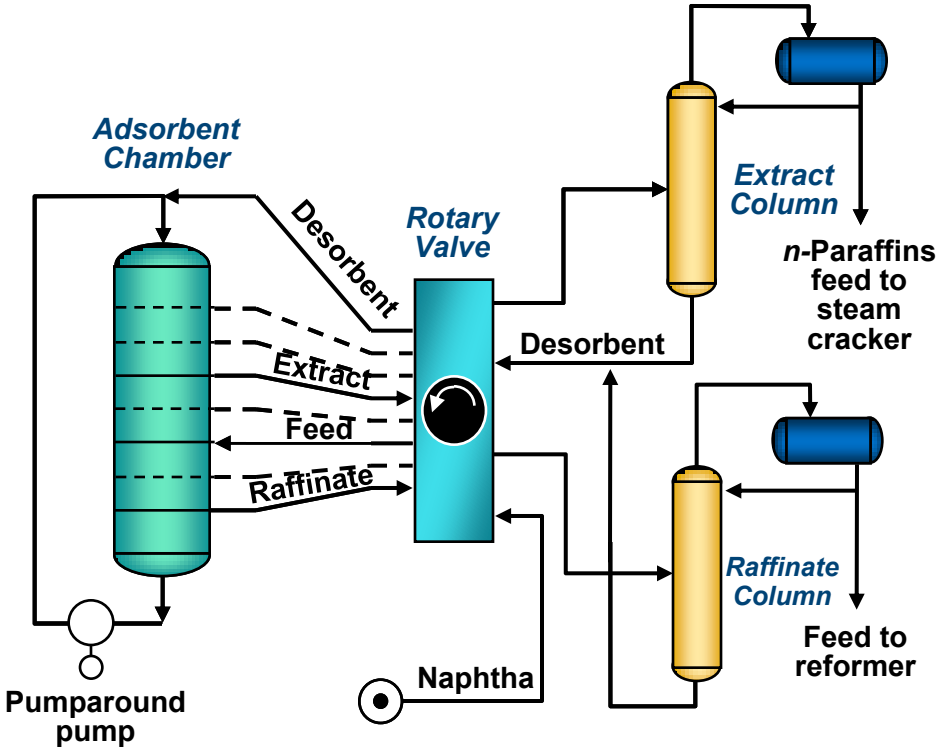
In an optimally integrated complex with MaxEne Process:

- N-paraffins are fed to the cracker resulting in:
  - Upto a 30% increase in ethylene and propylene yield
- Paraffin depletion (and enriching of napthenes/ aromatics) in the feed to the Platformer results in:
  - 4-6% increase in C_5+ yield at constant octane
  - 2-3% increase in aromatics yield



The MaxEne Process delivers benefits in an integrated facility and can also provide substantial benefits to the stand-alone refiner

How Does the MaxEne Process Work?



Adsorptive separation

- Based on Sorbex™ Technology
- The adsorbent has greater affinity for *n*-paraffins

Simulates a moving bed

- The process influent and effluent points move, but the actual mechanical connections do not
- The solid adsorbent is in fixed, non-moving beds
- The liquid feed flows counter-currently relative to the solid

More than 130 process units based on Sorbex Technology licensed worldwide

Extension of Previous UOP Experience in Naphtha Separation

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- Liquid phase extraction technology widely used to recover *n*-paraffins
- Gasoline Molex process (C_5 to C_6) in light naphtha isomerization applications for octane improvement
  - 15 licensed units
- Kerosene Molex process (C_{10} to C_{13}) for detergent applications. Heavy Molex process (C_{14} to C_{18}) for other surfactant applications
  - 35 licensed units

MaxEne process (C_6 to C_{11}) bridges the carbon range between Gasoline and Kerosene Molex

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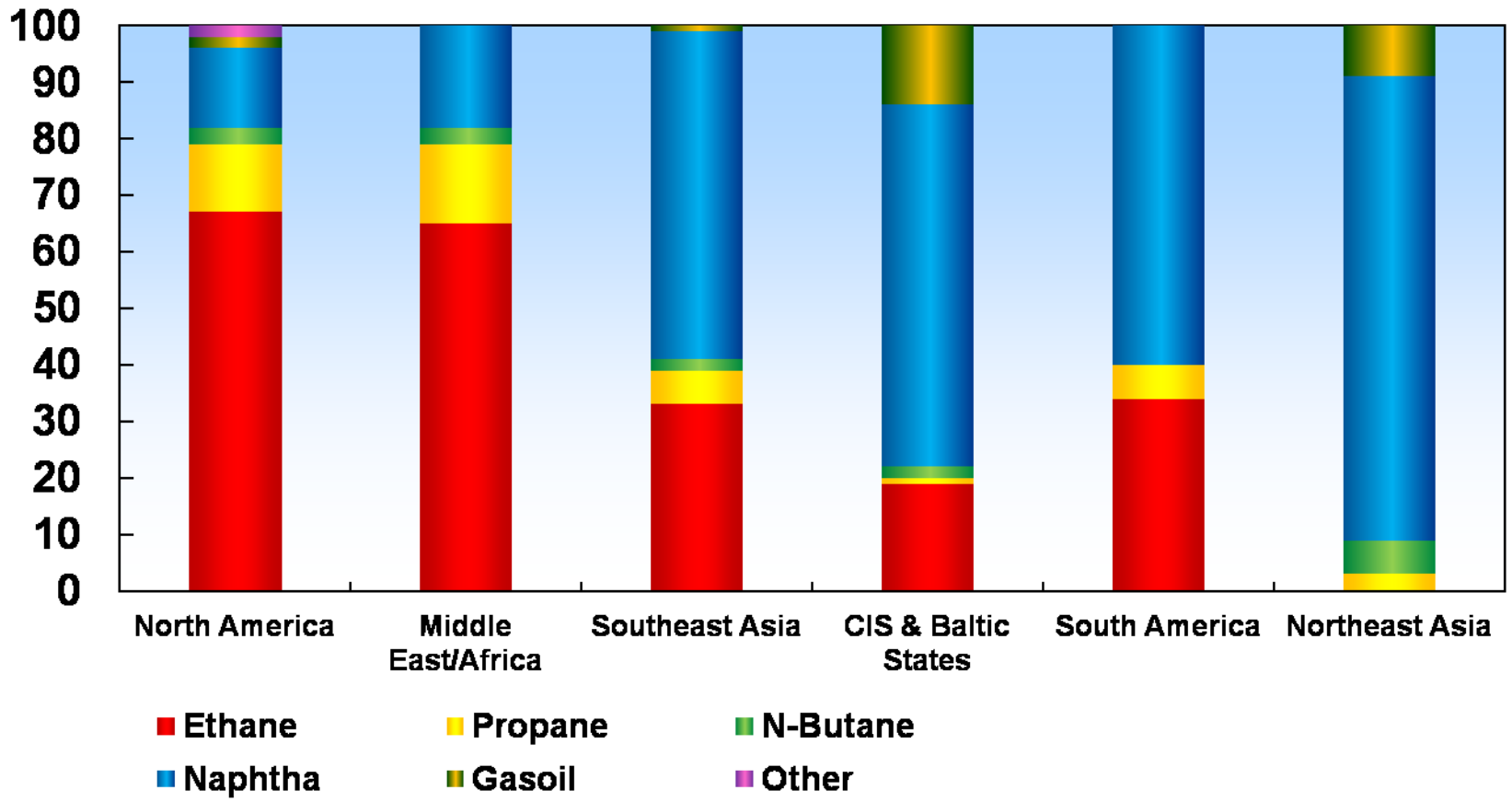
Average 2010 Steam Cracker Feedstock Slates



Source: CMAI 2011 World Ethylene Cost Study

Other than in N America and the ME, most steam cracker capacity is from naphtha -- presents an opportunity to refiners

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Case Study 1: MaxEne Process Integration

Integration with a Catalytic Reformer

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Goal

Maximize Catalytic Reformer profitability when market demand requires less gasoline production

Produce high quality petrochemical naphtha for domestic or export sales

Basis for integration

Feed is a full range naphtha (FRN). FRN rate kept constant.

MaxEne unit, catalytic reformer and steam cracker yields based on feed composition

Feed, major products, and by-products included

W. Europe price-set assumed with reformate price based on octane value

Catalytic Reformer originally designed for 102 RONC but currently running at 96 RONC based on market need

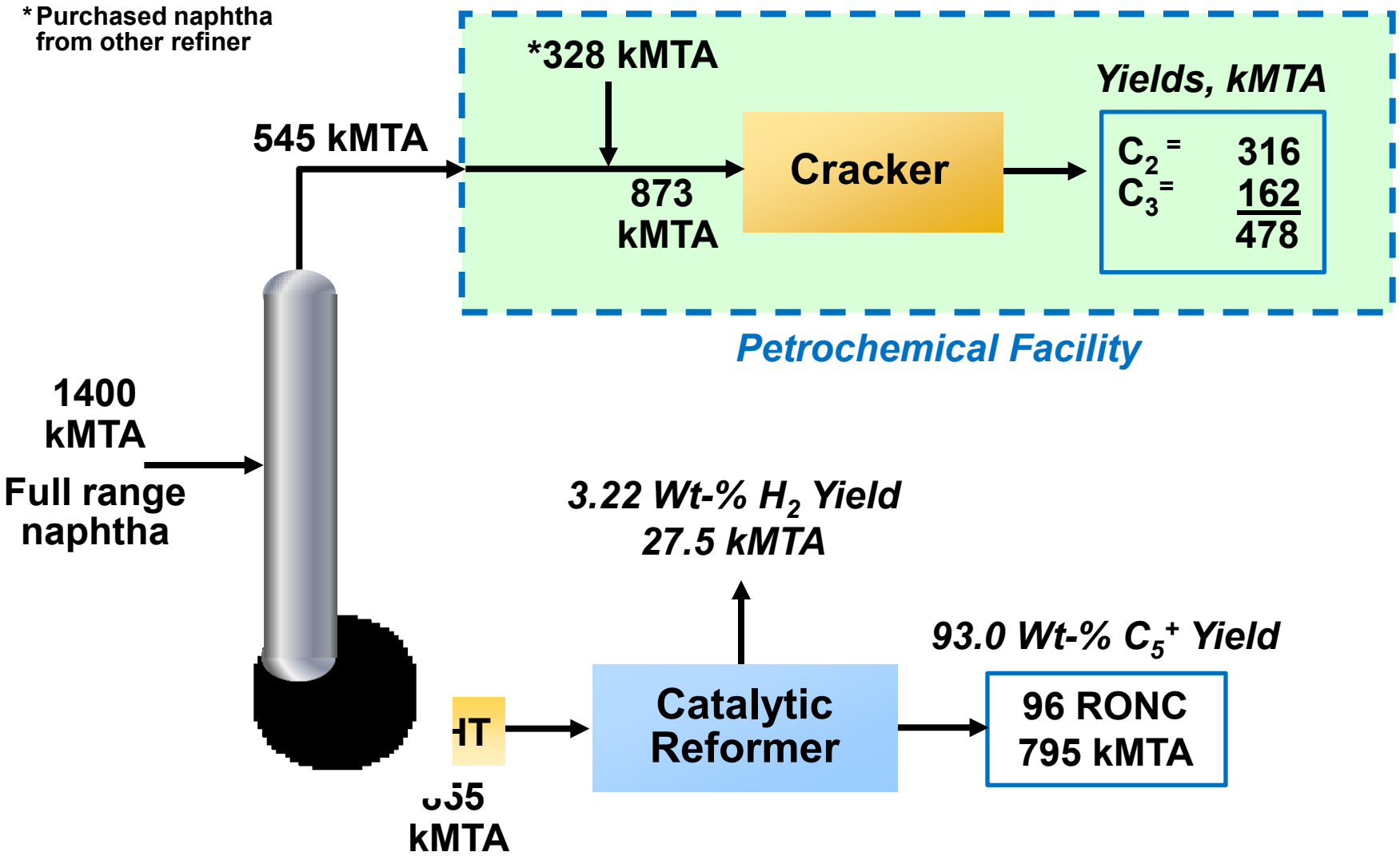
Why was MaxEne considered?

Flexibility to increase reformate yield and/or octane

Minimize changes to catalytic reformer

Increase value of export naphtha

Existing Refinery Complex



Refinery Complex with MaxEne
Constant Full Range Naphtha

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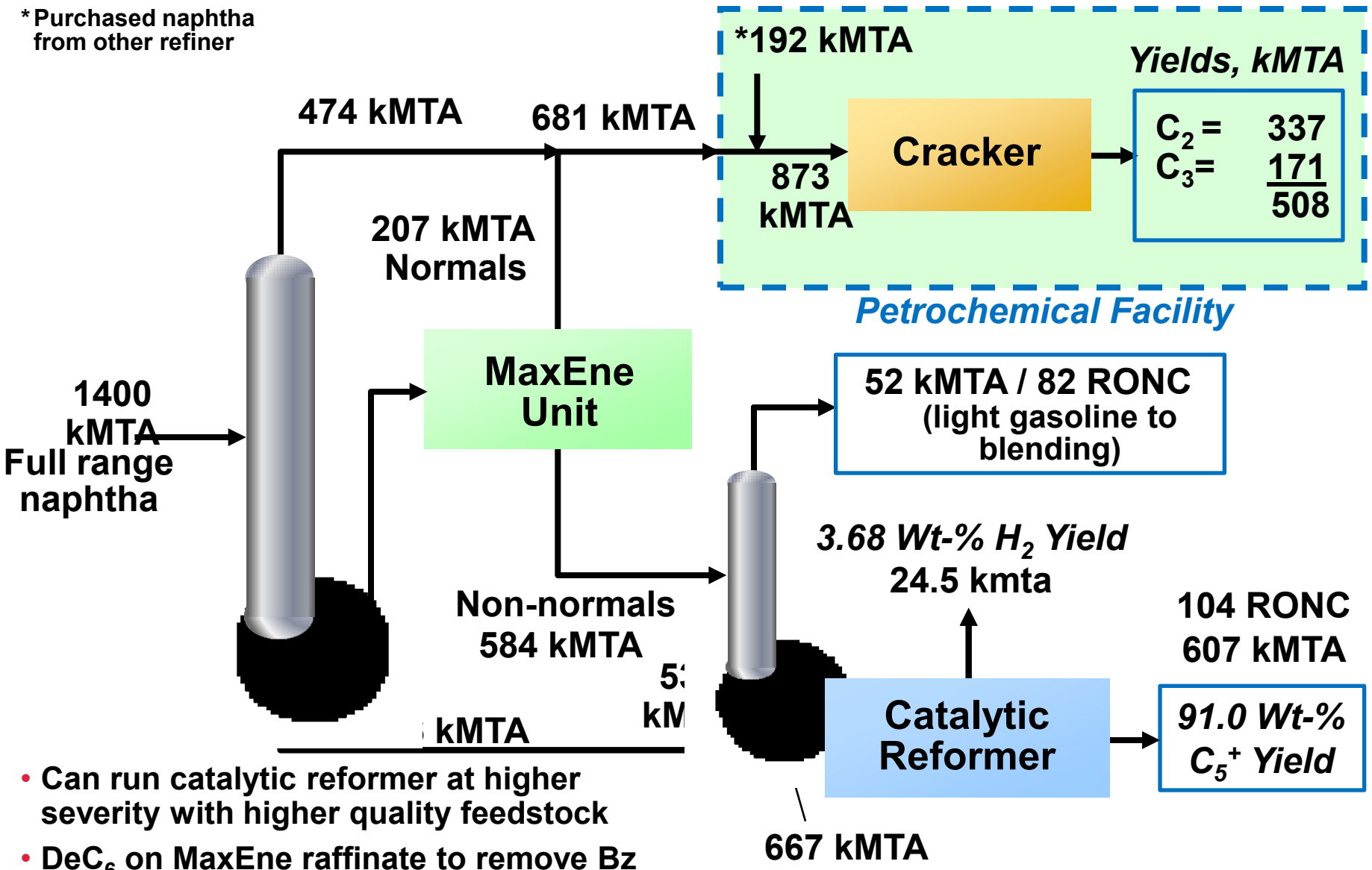

- Can run catalytic reformer at higher severity with higher quality feedstock
- DeC$_6$ on MaxEne raffinate to remove Bz pre-cursors from reformer feed

The MaxEne Process Effect

Case Study #1 - Refinery Balance

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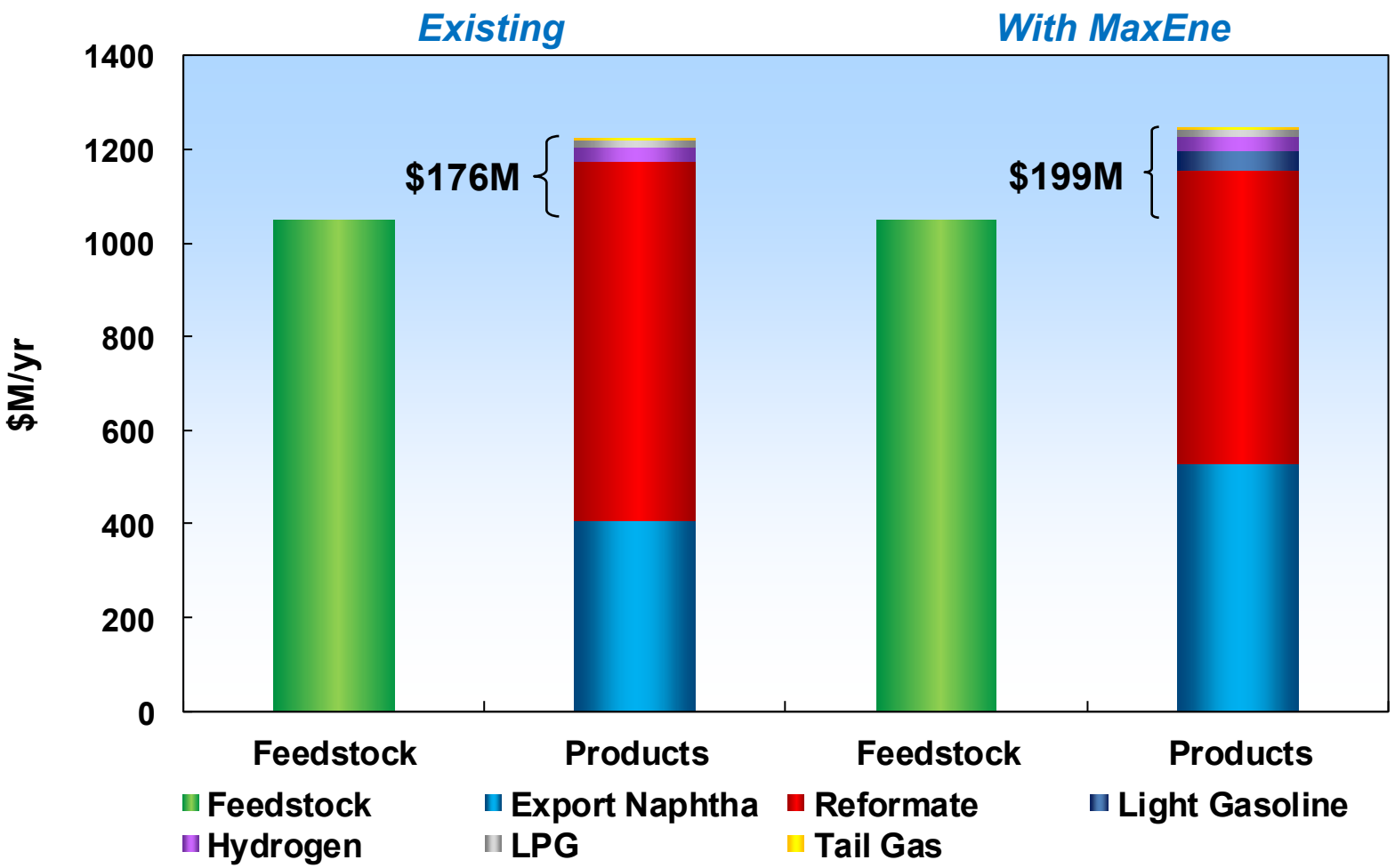
	Existing	*with MaxEne*
	kMTA	kMTA
Full Range Naphtha	1400	1400
Export Naphtha	545	681
n-paraffin Wt-%	*42*	*62*
Reformer Feed	855	667
Light Gasoline	0	52
Reformer Gasoline	795	607
RONC	*96*	*104*
Hydrogen	28	25
Tail Gas	11	12
LPG	22	24

MaxEne minimizes financial impact of lower reformate production via:

- **Production of Light gasoline with 82 RONC**
- **Production of 104 RONC Reformate (within existing unit constraints of WAIT, Heater Duty and CCR Size)**
- **Production of Higher Quality (higher % *n*-paraffin) Petrochemical Naphtha Export**

The MaxEne Process Effect

Case Study #1 - Refinery GM Comparison



- MaxEne resulted in $23M/yr incremental gross margin increase
- GM increase supports capital investment for MaxEne with simple payback periods < 3 years
- Export Naphtha value increase of $30/MT assumed based on sharing benefit with Ethylene Cracker

The MaxEne Process Effect
Case Study #1 - Steam Cracker Balance

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	Existing KMTA	w/MaxEne KMTA		Existing $M/yr	w/MaxEne $M/yr
Feed	872	872		654	674
H2	11	9		12	10
Fuel Gas	138	107		36	27
C2=	316	337	+7%	462	493
C3=	162	171	+6%	243	256
C4's	95	87		89	81
pygas	150	163		135	148
Total	872	872		324	341
GM Increase				-	17

Pay MaxEne refiner 4% premium for high quality PC Naphtha Feedstock to get 5% GM increase

Increased paraffin content to cracker results in $17M/yr additional GM with $30/MT premium on refiner export naphtha price for 500 kmta cracker (ethylene+propylene).

MaxEne Process Integration Case Study #2
Integration with a Catalytic Reformer

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Goal

- **Maximize yields of catalytic reformate (and hydrogen)**
- **Produce high quality petrochemical naphtha for domestic or export sales**

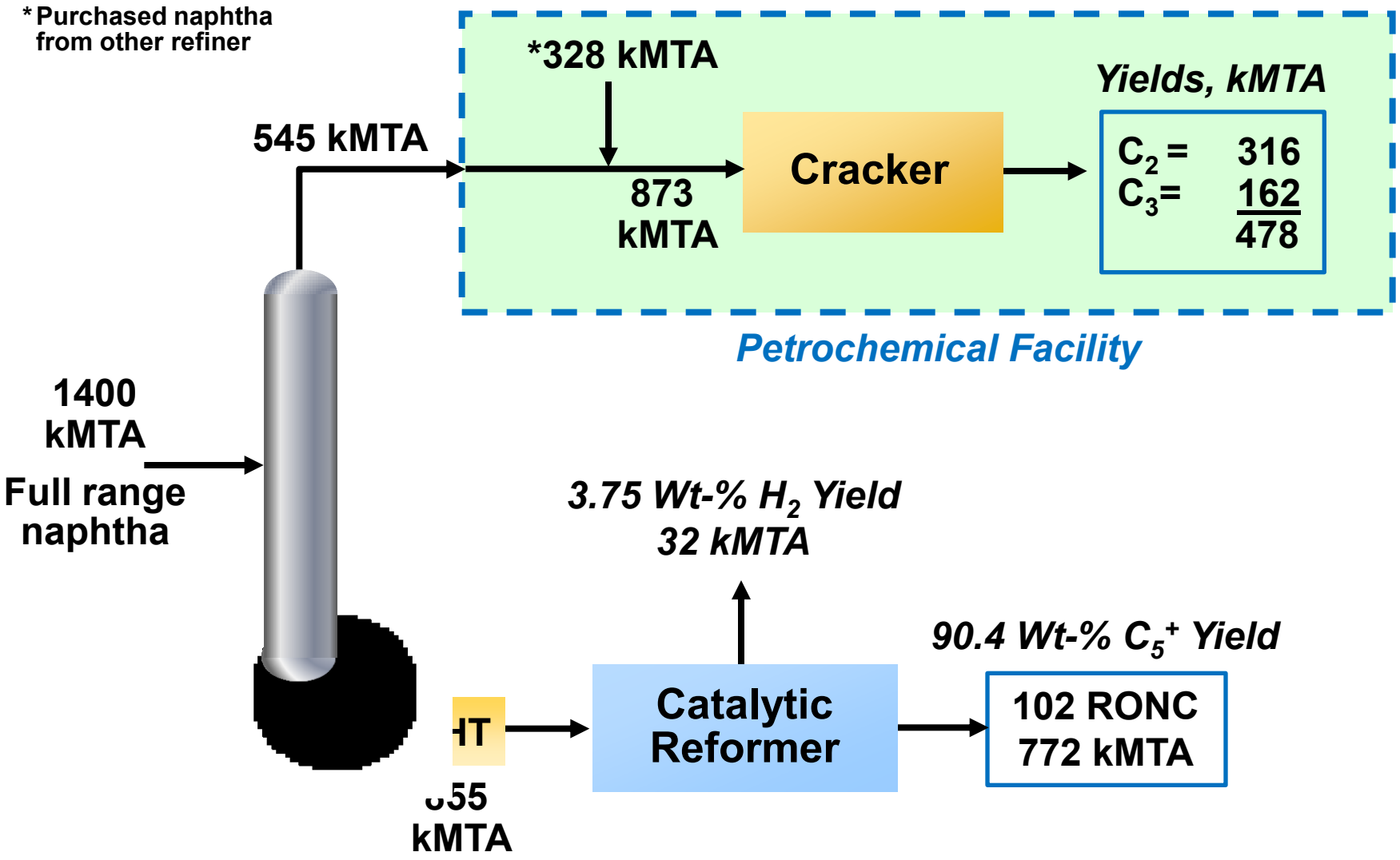
Basis for integration

- **Feed is a full range naphtha (FRN).** **FRN rate allowed to increase.**
- **MaxEne unit, catalytic reformer and steam cracker yields based on feed composition**
- **Feed, major products, and by-products included**
- **W. Europe price-set assumed with reformate price based on octane value**
- **Feed rate to catalytic reformer kept constant and increased.**
- **Catalytic Reformer originally designed for 102 RONC and running at nameplate conditions**

Why was MaxEne considered?

- **Increase reformate and hydrogen yield**
- **Minimize changes to catalytic reformer**
- **Increase value of export naphtha**

Existing Refinery Complex



Refinery Complex with MaxEne
Constant Reformer Feedrate

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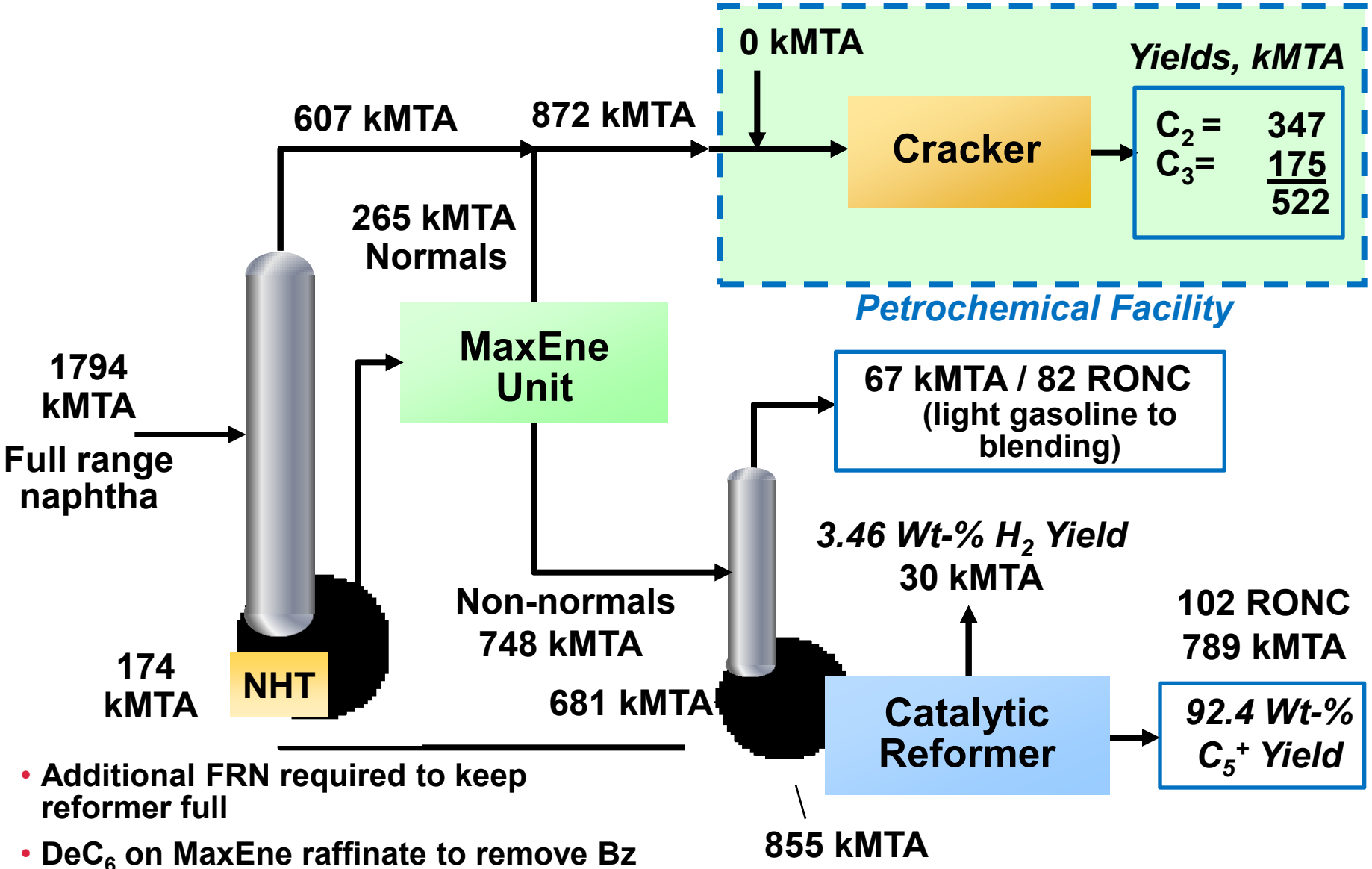

- Additional FRN required to keep reformer full
- DeC_6 on MaxEne raffinate to remove Bz pre-cursors from reformer feed

Refinery Complex with MaxEne
Constant Reformer Feedrate

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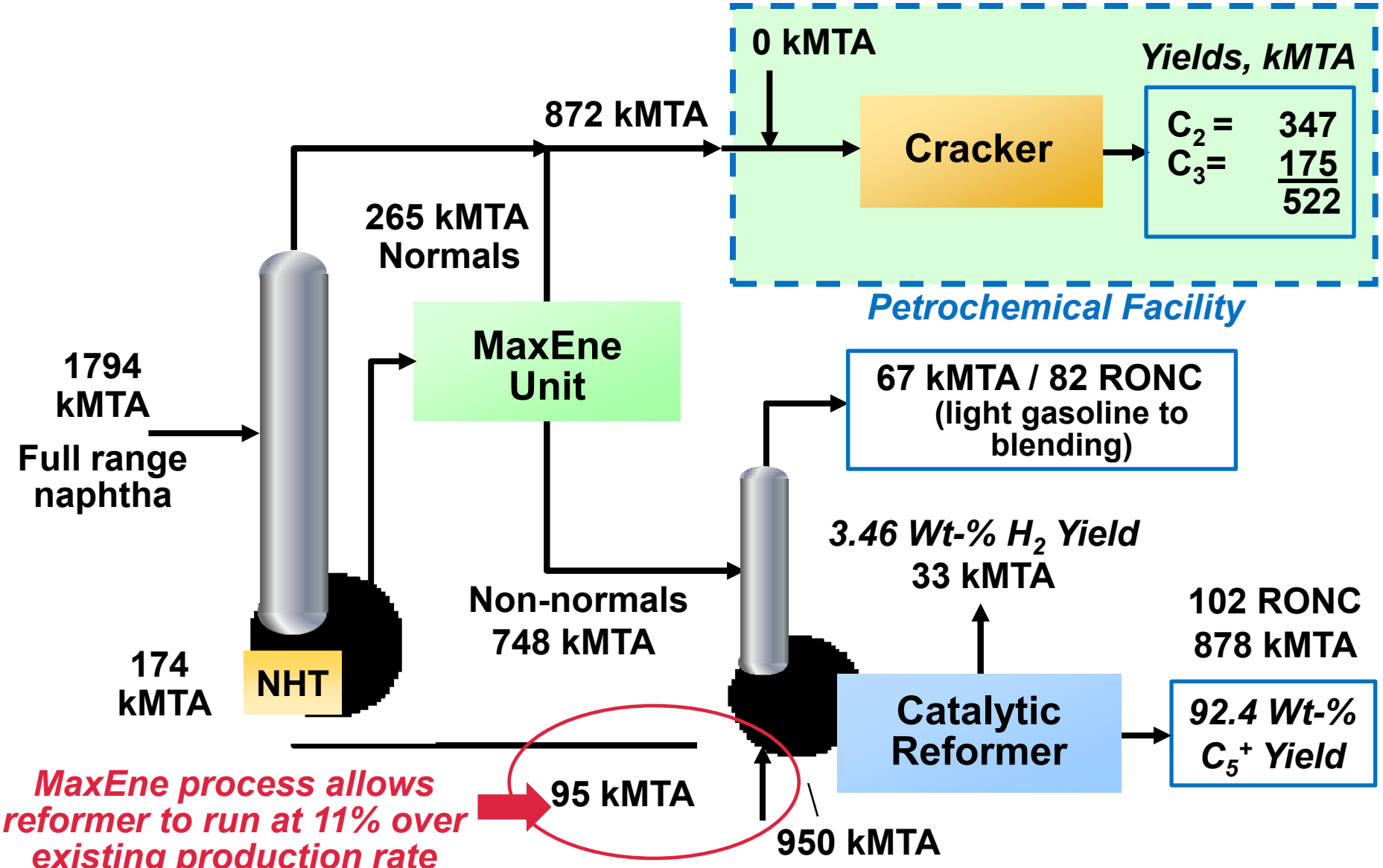

The MaxEne Process Effect
Case Study #2 - Refinery Balance

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	Existing	*with MaxEne Cases*	
	kMTA	kMTA	kMTA
Full Range Naphtha	1400	1794	1794
CCR Range Naphtha			95
Export Naphtha	545	872	872
Reformer Feed	855	855	950
Light Gasoline	0	67	67
Reformer Gasoline	772	789	878
Hydrogen	32	30	33
Tail Gas	17	12	13
LPG	34	24	26

Richer feed allows reformer to run at higher capacity while still staying within CCR regenerator capacity, Rx WAIT and heater duty

MaxEne enables:

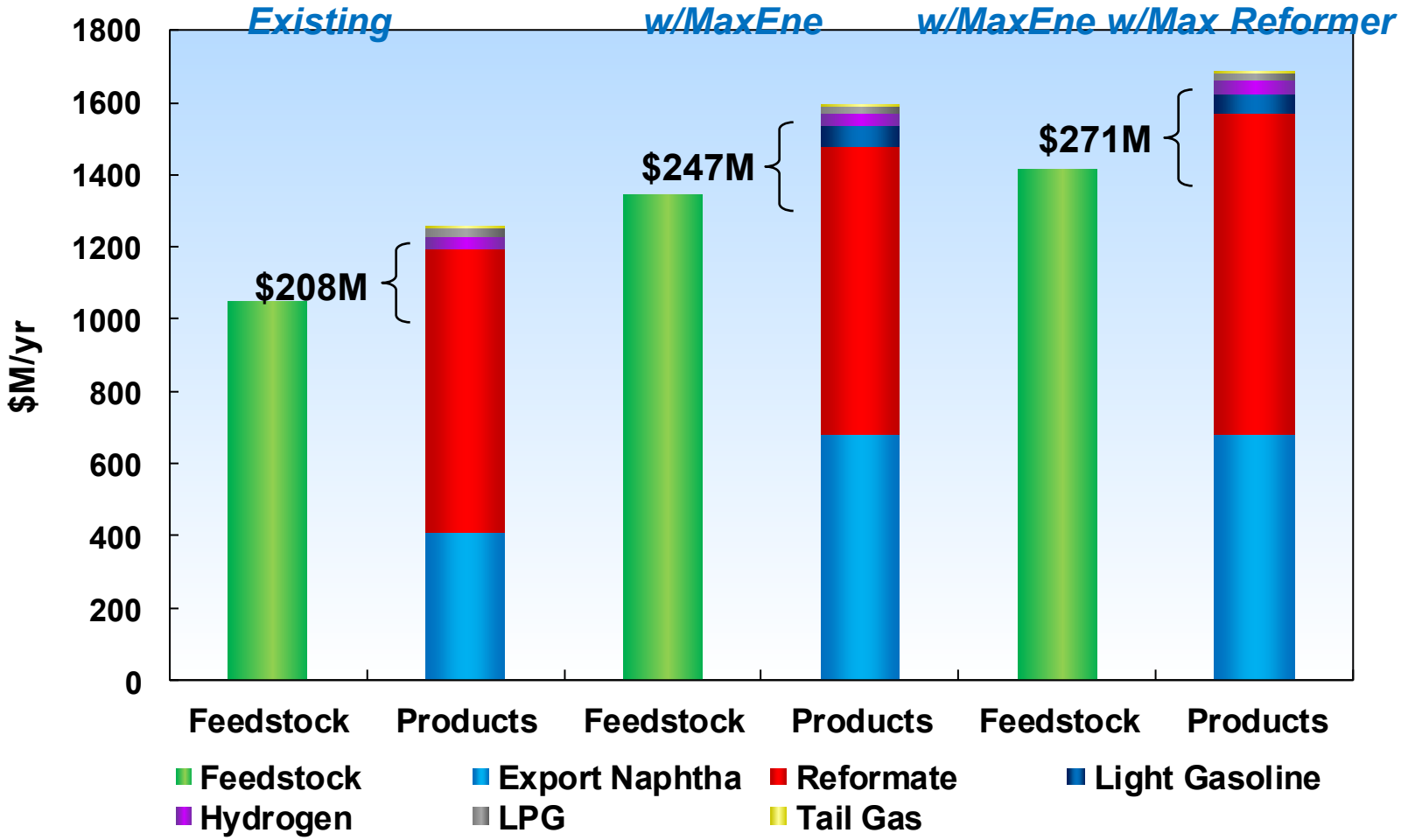
Production of Light gasoline with 82 RONC

Increase in C_5^+ gasoline yield at constant octane

Higher quality (higher % paraffin) Petrochemical Naphtha Export that can command premium pricing…

The MaxEne Process Effect

Case Study #2 - Refinery GM Comparison



MaxEne resulted in $39-63M/yr incremental gross margin increase

GM increase supports capital investment for MaxEne with simple payback periods < 2 years

Export Naphtha value increase of $30/MT assumed based on sharing benefit with Ethylene Cracker

The MaxEne Process Effect
Case Study #2 - Steam Cracker Balance

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	Existing KMTA	w/MaxEne KMTA		Existing $M/yr	w/MaxEne $M/yr
Feed	872	872		654	680
H2	11	8		12	9
Fuel Gas	138	103		36	27
C2=	316	347	+10%	462	507
C3=	162	175	+8%	243	262
C4's	95	83		89	78
pygas	150	156		135	141
Total	872	872		324	344
GM Increase				-	20

Pay MaxEne refiner 2% premium for high quality PC Naphtha Feedstock to get 10% GM increase

Increased paraffin content to cracker results in $20M/yr additional GM with $30/MT premium on naphtha price for 500 kmta cracker (ethylene+propylene).

Contents

MaxEne Commercialization Status

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First unit to come on-stream in Asia in 2012

Refinery-Petrochemical Integration Application

- **Licensee is refinery and cracker operator**

MaxEne feedrate is 1.2 MMTA (1200 kMTA)

In Conclusion

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European and Asian refiners will need outlet for naphtha as diesel continues to be transportation fuel of choice.

Over half of the world's ethylene comes from cracking naphtha

MaxEne can help refiners face the increasing shift towards diesel by …

- **Maximizing existing catalytic reforming assets**
- **Producing a premium petrochemical naphtha feedstock for sales to petrochemical producers**

MaxEne is an extension of well-proven, reliable commercial Sorbex technology used in aromatics, refining and detergents applications.

First commercial unit start-up in 2012 in Asia


Q&A