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Design Philosophy of a Mega Mixed Feed Cracker

Mixed Feed Cracker

Basis for a mixed feed cracker

- Be designed to crack ethane, LPG, and Naphtha feeds in one train

Strong advantage

- Take benefit of availability of low cost feedstock
- Production of broad range of High Value Chemicals
- Possibility to adjust plant production profile to the market
- Improve revenues

Requirement

- Be flexible!

Existing Mixed Cracker "Plant A"

Plant "A" Mixed Feed Cracker

First mixed-feed cracker in Middle-East

Capacity

Ethylene	1345 kTA
Propylene	305 kTA

Feedstock

- Gas Feed: Ethane
- Liquid Feed:
  - Mix of 6 different feed streams (from LPG to Condensates)
  - Mostly C4-C8 boiling range
- Design based on 40% ethane feed – 60% liquid feed

Plant started-up in 2007

Plant "A" Mixed Feed Cracker

Plant Configuration

Gas and liquid furnaces

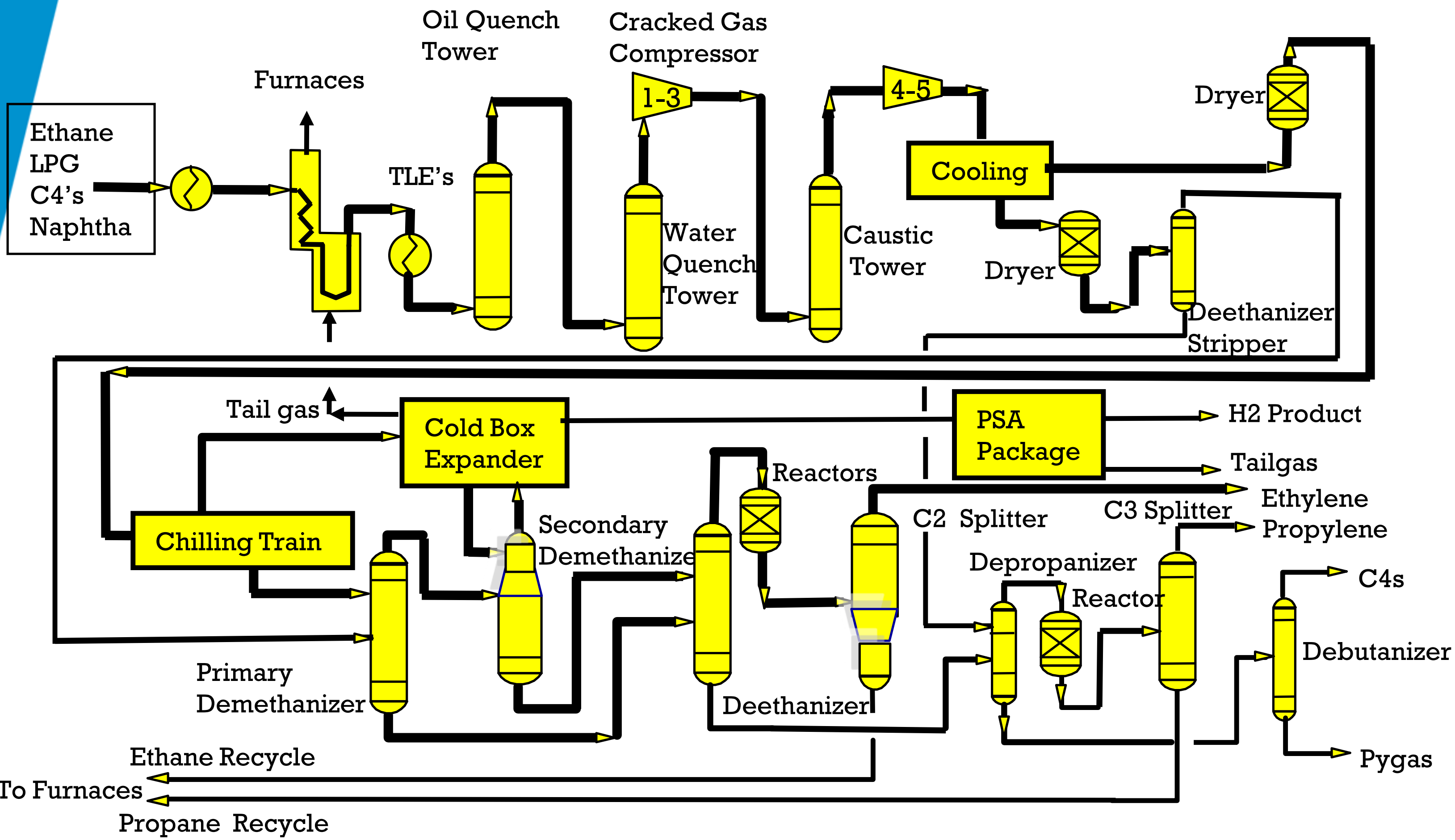
One single fractionation train

- Plant flexibility to variation of gas and liquid feed ratio requested

Front-End Demethanizer, Back-End Hydrogenation, Closed Heat Pump C3 Refrigerant cycle, Open cycle C2 Refrigerant cycle

Common Utilities and Feed preparation, Storage area: atmospheric ethylene storages

Process Arrangement



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Cracking Furnaces

10 Furnaces - 3 types

- 3 SMK gas furnaces for fresh ethane feed and ethane recycle
- 4 GK5 liquid furnaces for fresh liquid feed and propane/butane recycles
- 3 swing furnaces

Swing furnace concept

- Swing furnaces can crack any type of feed
- SMK Gas type furnaces, with some adaptations to crack liquid feeds
- Spare furnace is a gas type furnace as liquid furnace design is not optimum to reach the 60 days run length when a gas furnace is being decoked

Normal operation

- Gas feed cracked in 3 gas furnaces plus 2 swing furnaces
- Liquid feeds cracked in 4 liquid furnaces
- One swing furnaces in HSSB

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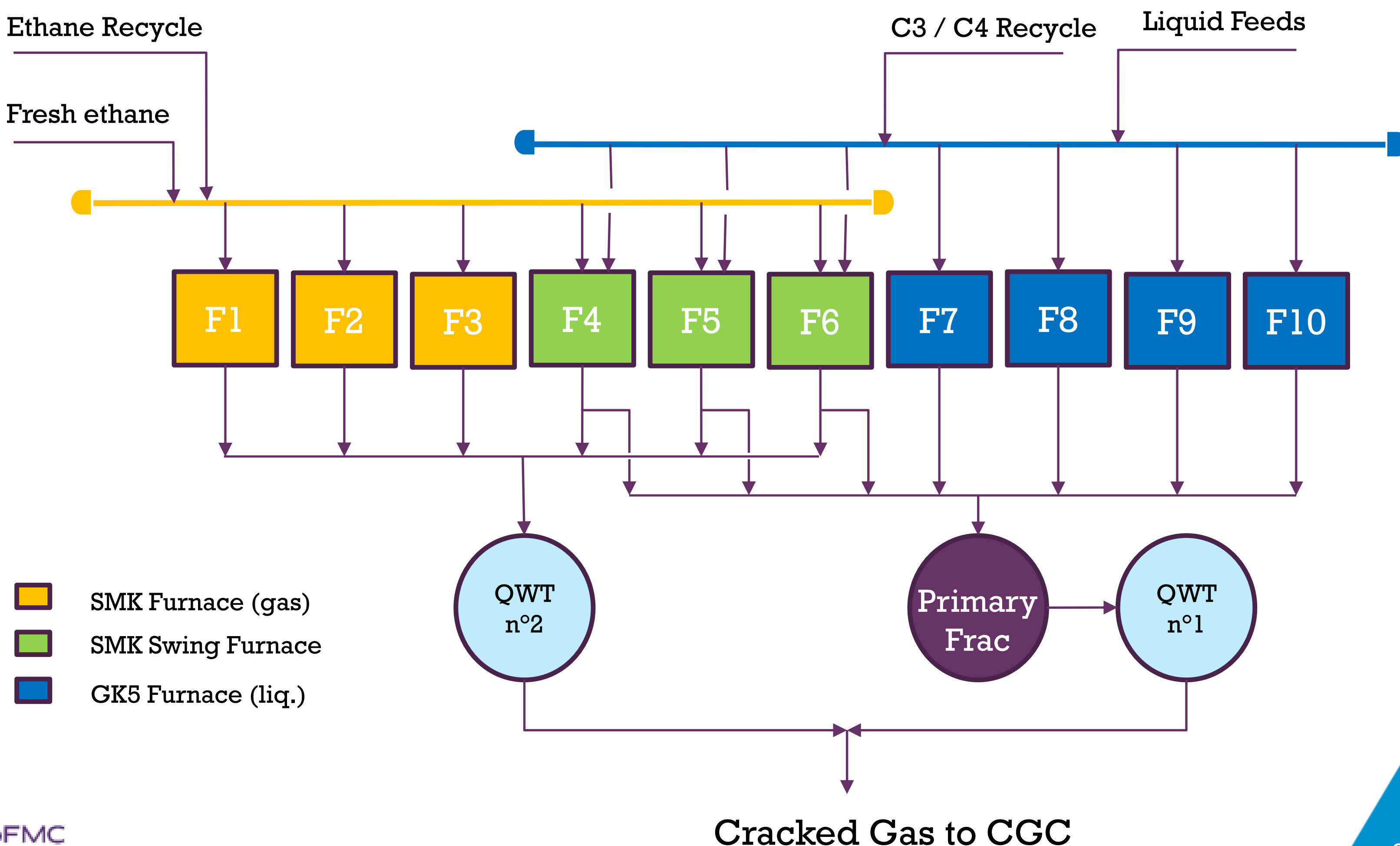
Challenges

- High fresh ethane to fresh liquid feed ratio
- Light liquid feedstock
- Limited availability of flux oil
- First mixed feed cracker reference

Plant designed with two hot sections

- Primary Fractionator & Quench Tower processing cracked gas from liquid feeds
  - Primary Fractionator bottom temperature 190°C
  - Middle-Oil loop and Flux-Oil
- Dedicated Quench Tower processing cracked gas from gas feed
- Each Quench Tower having its dedicated Process Water processing systems
- One common Dilution Steam generation system
  - Partial generation of Dilution Steam from Quench Oil

Hot Section


Ethane Recycle
Fresh ethane
C3 / C4 Recycle
Liquid Feeds
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
SMK Furnace (gas)
SMK Swing Furnace
GK5 Furnace (liq.)
QWT n°2
Primary Frac
QWT n°1
Cracked Gas to CGC

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Chilling Train

Front-end Demethanizer first

TechnipFMC two-Demethanizer scheme

- MP Demethanizers
- Reboilers of demethanizers integrated with cracked gas
- Turbo-Expanders on tail gas or methane fuel-gas

Cold box (with integration of cryogenic purification of H2)

- 20 streams

Very flexible arrangement – proven operation

- Ethane/propane feed crackers
- Mixed gas/liquid feed crackers
- Liquid feed crackers

Concept applicable to front-end and back-end crackers

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Plant Characteristics

Olefin Production	1650 KTA
Oil Quench Tower, m (diam x height.)	6.6 m x 37.9
Water Quench Tower, m (diam. x height)	6.5 x 28.8 – 6.5 x 23.9
C2 Splitter, m (diam. x height)	6.0 x 76.4
C3 Splitter, m (diam. x height)	6.0 x 83.9
CGC shaft power, MW	56.1
C3R Compressor shaft power, MW	36.9
C2R Compressor shaft power, MW	11.6

Energy efficiency

Specific Compression Power

- Sum of 3 main compressors shaft power per ton of ethylene/olefin
- Plant A Specific Compression Power = 610 KW/t ethylene
- Plant A Specific Compression Power = 497 KW/t ethylene+propylene

High energy performance (benchmark)


TK-901

Existing Mixed Cracker "Plant B"

Plant "B" Mixed Feed Cracker

Planned Feedstock

- Purity Ethane - Gas Cracking Furnaces with Gas Cracking Recovery Train
- Full range Naphtha - Liquid Cracking Furnaces with Liquid Cracking Recovery Train

Capacity

- Gas Cracking Train 985 kTA
- Liquid Cracking Train 900 kTA

Train Configuration

- Gas Cracking - Front-End Deethanizer/Front End Hydrogenation Reactor, Open-Loop C2 Splitter
- Liquid Cracking - Front-End Depropanizer/ Front-End Hydrogenation Reactor, Open-Loop C2 Splitter
- Common Utilities Feed Treatment, DMDS/Caustic/Wash Oil Storage, Polisher, Spent Caustic Treatment, Decoke Air Compressors, Flare, Cooling Tower

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Project Progress

Three FEED packages prepared – Gas Cracker, Liquid Cracker and Common Utilities

Cost Estimate prepared

Cost too high

Cost cutting ideals

- Combine gas train and liquid train into one train
- Reduce overall capacity to 1500 kTA
- Simplify plant operation
- Gas feed contributes to ~900 kTA
- Liquid feed contributes to ~600 kTA

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Furnace Allocation Comparison

	Separate Train		Combined Train
	Gas	Liquid	Gas/Liquid
Plant Capacity, kTA	985	900	1500
Gas Cracking Furnaces,	7 + 1	-	6 + 1
Capacity, kTA (each)	140.7	-	150
Liquid Cracking Furnaces,	-	7 + 1	4 + 1
Capacity, kTA (each)	-	128.6	150

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Large Equipment Comparison

	Separate Train		Combined Train
	Gas	Liquid	Gas/Liquid
Plant Capacity, kTA	985	900	1500
Oil Quench Tower, m (diam.)	-	10.7	12.4
Water Quench Tower, m (diam.)	6.4	9.2	10.0
C2 Splitter, m (diam.)	5.7	5.4 / 3.8	7.35 / 5.95
CGC power, MW	25.7	37.3	52.4
C2R Compressor power, MW	18.0	10.5	22.6
C3R Compressor power, MW	19.8	35.1	57.4

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Steam System Comparison

	Separate Train		Combined Train
	Gas	Liquid	Gas/Liquid
Plant Capacity, kTA	985	900	1500
101.5 bar Steam make from furnaces, t/hr	371	480	744
Turbine to accept 101.5 bar steam	CGC	CGC	CGC / C3R
Power, MW	25.7	37.3	52.4 / 54.3
Steam Throttle flow, t/hr	371	480	368 / 368

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Project Execution

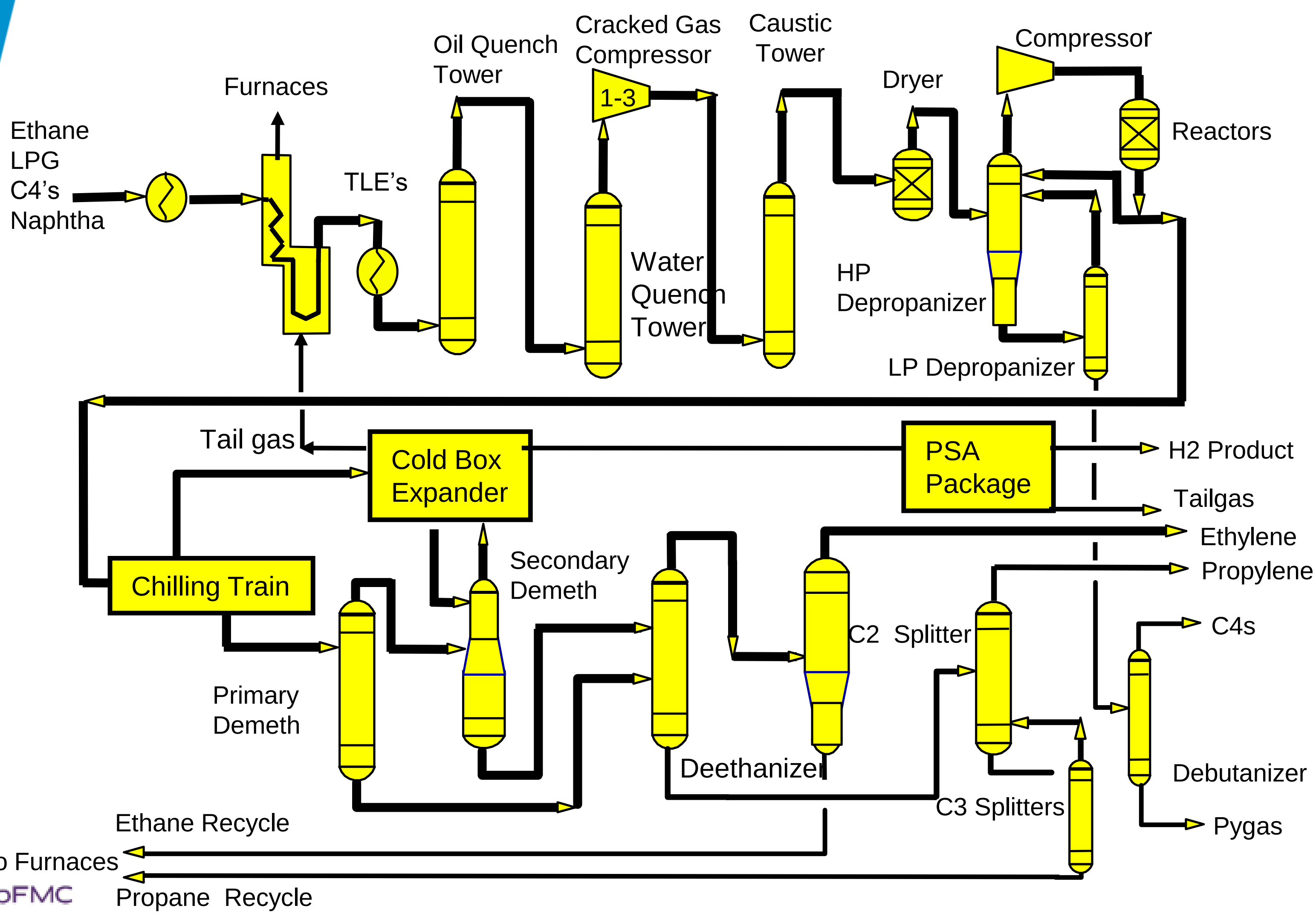
Flow scheme

Front-End Depropanizer

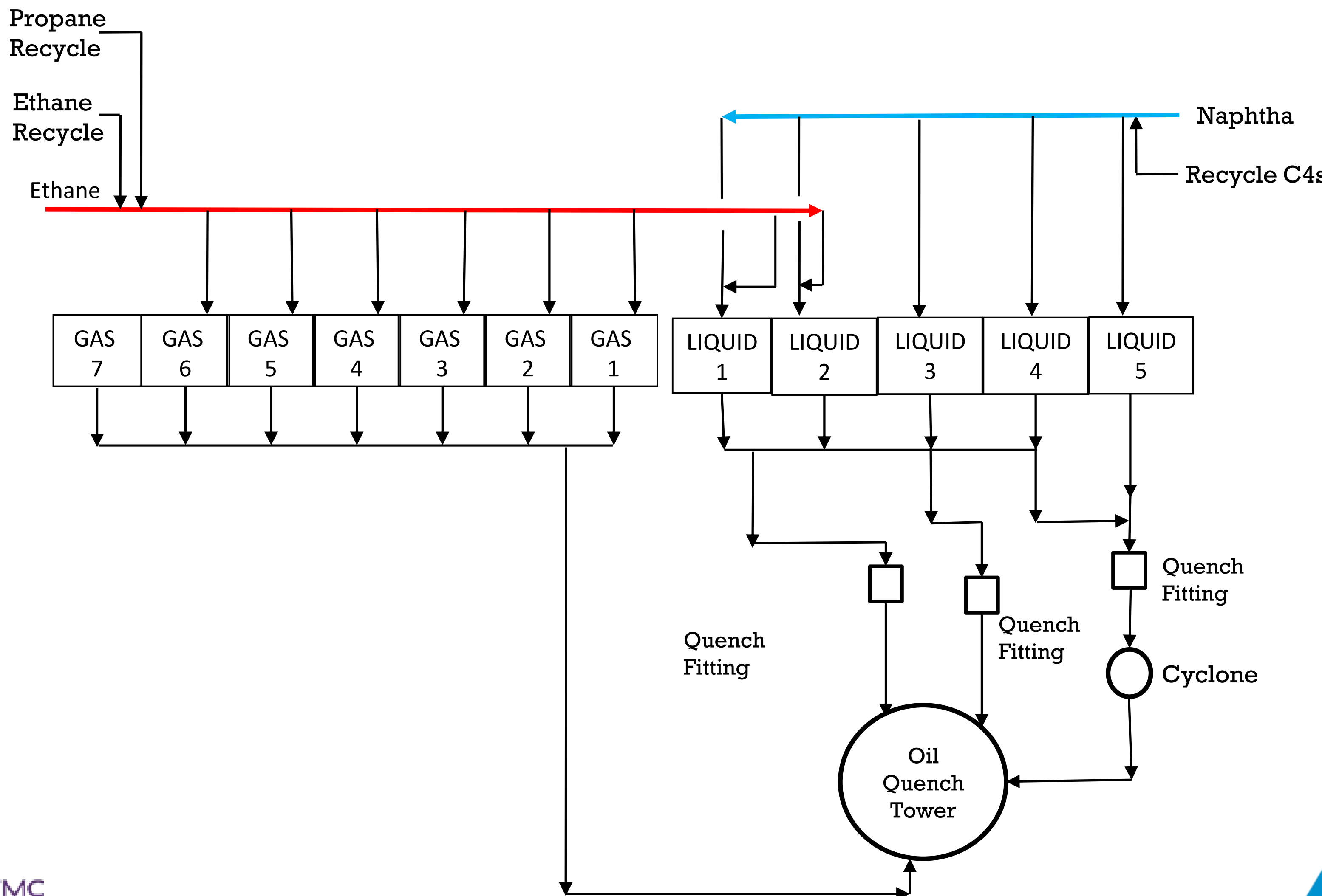
Front-End Hydrogenation Reactor

Open-Loop C2 Splitter

Process Flow Scheme



Furnace Feed/Effluent Header



Conclusion

Maximized Flexibility for Maximum Revenue

- Two grassroots Plants in operation with olefin production up to 1900 kta.
- Technology solutions for maximum flexibility
- Furnaces
    - Optimisation of both yields and run length
    - Swing furnaces concept
- Hot section
    - Single or dual hot sections
    - Primary Fractionator bottom temperature
- Front-end or back-end hydrogenation
- Chilling train with TechnipFMC patented two-demethanizer scheme applied to both technologies

CAPEX Optimized

Mixed feed cracker above 2500 kta olefins is feasible

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Thank you

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