INNOVATION DAY

Decarbonization of Existing Assets

Keith A. Couch: Senior Director, Business Development

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AGENDA

1. Sustainability and Emissions Glossary
2. The 6-Efficiencies
3. Four Pillars for Reducing Emissions
4. Technology Revamp Innovation
5. Emissions Reduction Roadmaps
6. Conclusions

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EMISSIONS QUICK GLOSSARY

SCOPE 1: (DIRECT)

On-site fossil fuel combustion and fleet fuel consumption:

- Electricity
- Heat
- Steam
- Cooling
- Company Vehicles
- Fugitive Emissions
- Stack Emissions

SCOPE 2: (INDIRECT)

Off-site fossil fuel combustion to enable purchased utilities:

- Electricity
- Heat
- Steam
- Cooling

ELIMINATES AVOIDANCE THROUGH BUY VERSUS MAKE

SCOPE 3: (RELATED)

Value Chain Emissions related to firm's activities:

- Business Travel
- Employee Commuting
- Transportation & distribution
- Utility transmission line losses
- Investment accountability; JVs, Leases, Franchises
- Purchased goods and services
- New capital assets
- Waste disposal
- End use of sold products

Requires a culture for continual progression of change in processes, equipment and products

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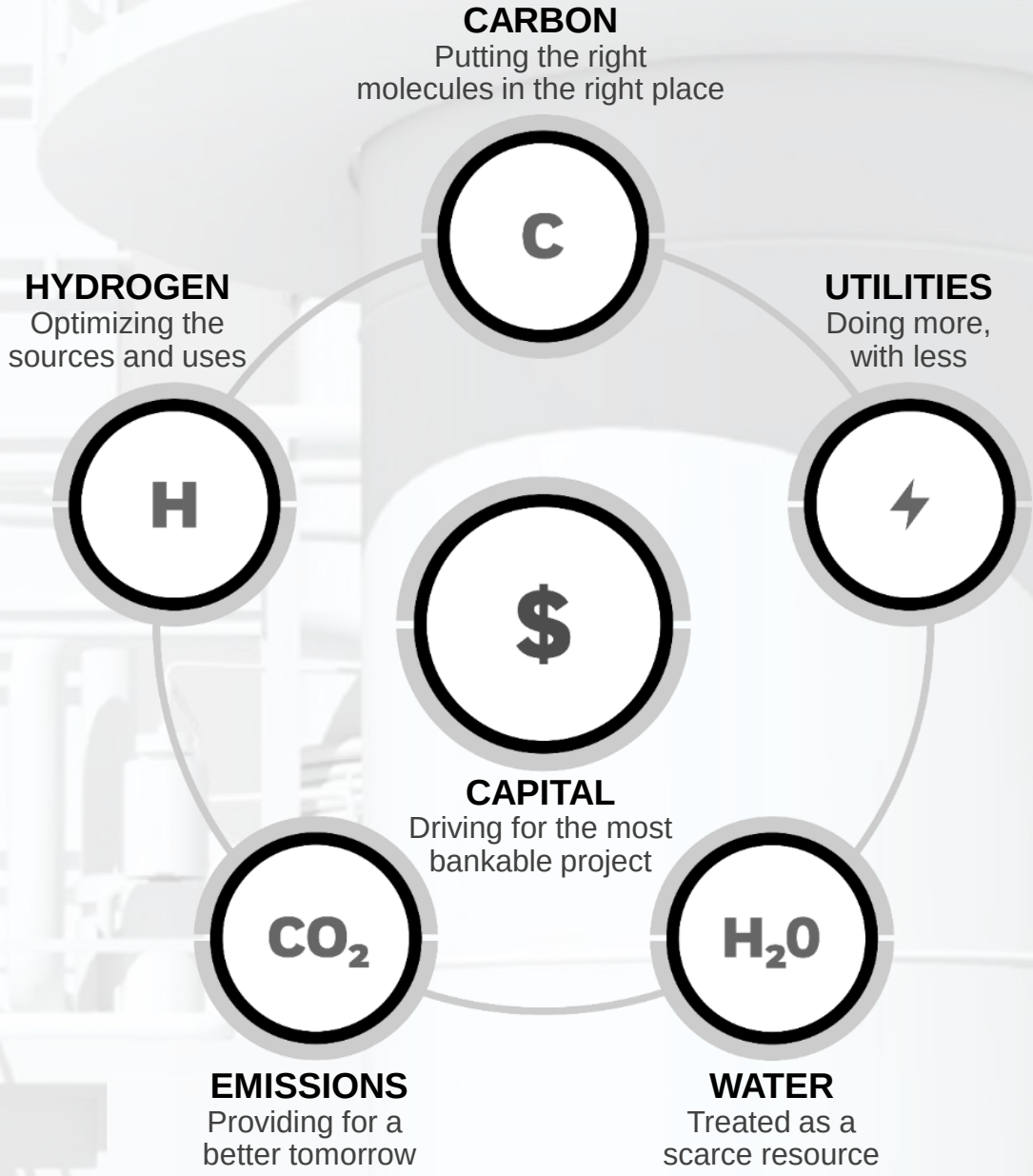
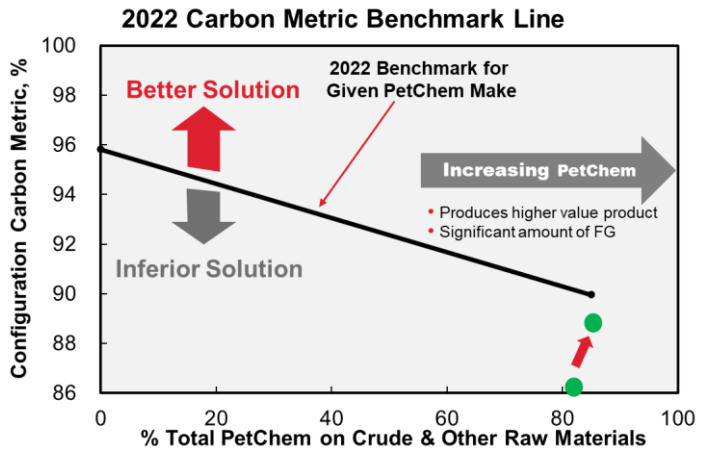
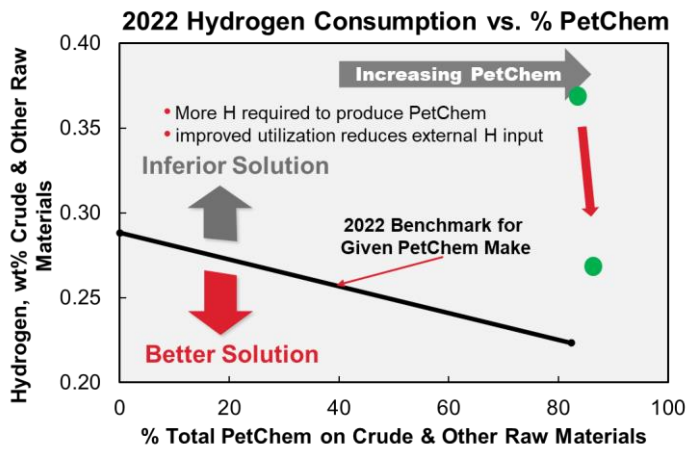
EFFICIENCY METRICS FOR BUSINESS ALIGNMENT ON ALL LEVELS

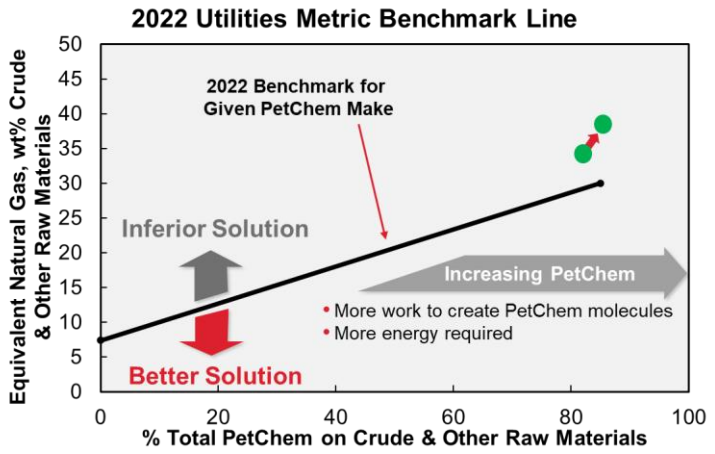
THE UOP E6 DRIVES A PROGRESSION OF CHANGE

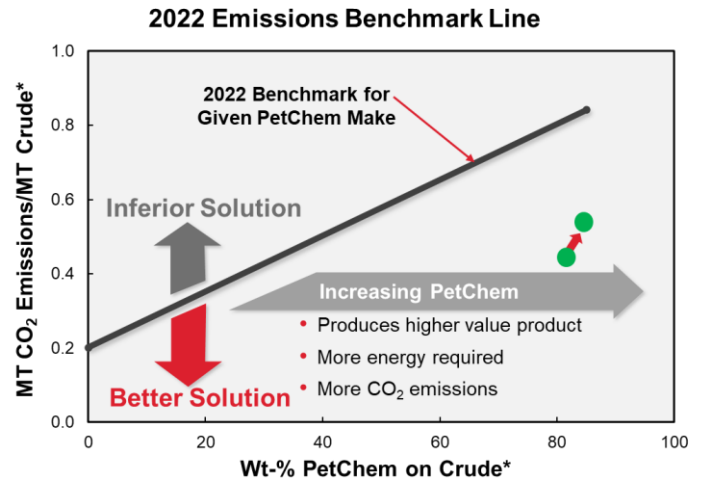


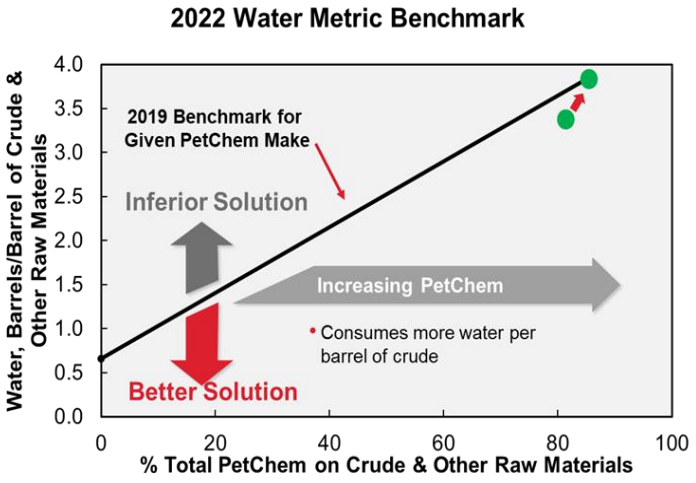
UOP E6
A QUANTIFIED LEADING INDICATOR

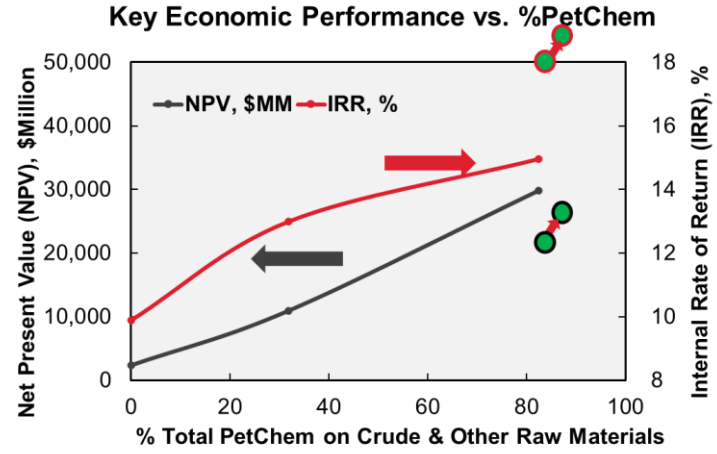












Notes:
Based on UOP Process and LP Modeling for commercial complexes. Calculation methodology available upon request.

FOUR PILLARS FOR REDUCING EMISSIONS

Strategic Shifts (Profits) ⟷ **Tactics (Efficiency & Control)**

FUELS TO PETCHEM PIVOT

- Slowing demand for fuels
- Growing demand for petrochemicals
- Ability to increase IRR

FEEDSTOCK SUBSTITUTION

- **Profit expansion** thru credits, where available, when using Renewable feedstocks for fuels
- **Co-Processing**
  - Within a Hydrotreater
  - Within a Hydrocracker
  - Within an FCC

CARBON CAPTURE, UTILIZATION & STORAGE

- Solution for Scope 1 stack emissions
  - Capture
  - Transport
  - Sequester

TECHNOLOGY & ENERGY IMPROVEMENTS

- Leverage UOP E6 methodology
  - Yields
    - Carbon
    - Capital
  - OPEX
    - Hydrogen
    - Utilities
    - Water
    - Emissions
- **New units & revamps**

Existing complexes have strategies available to reduce emissions

JOURNEY FOR REDUCING CO_2 FOOTPRINT

What you should be focused on / looking at now –
Establish base CO_2 footprint & benchmark to identify gaps, then…

ENERGY EFFICIENCY NO/LOW-COST[1]

- Reduce slops reprocessing
- Reduce/eliminate flaring
- Avoid over-refluxing columns
- Minimize recycles
- Steam trap maintenance
- Fired heater excess O_2 minimization
- Assess turndown protocols to avoid energy throwaway
- Lower (e.g., lighter / sweeter) CO_2 intensity crudes

ENERGY EFFICIENCY LOW-COST[2]

- Higher activity catalysts
- Column upgrades (trays and packing) to improve separation efficiencies
- Tube inserts to achieve better approach and/or manage fouling
- Impeller/control valve sizing to optimize pump efficiencies
- Improved compressor anti-surge control system

ENERGY EFFICIENCY MODERATE/HIGH COST[3]

- Heat exchanger network additions/spares for cleaning
- Hydrogen network optimization
- Electrification
- Fugitive emissions monitoring and mitigation
- Replace exchangers w/ higher efficiency plate and frame or other
- VFD Motor upgrades
- Cogen - CCPP

Leverage internal resources, local engineering firms & technology licensors

Notes:
1 Procedural/training/process controls
2 Low cost - <$5MM per area of focus (especially where sustaining capital needed)
3 Moderate cost - $5-$10 MM investment; high cost >$10 MM

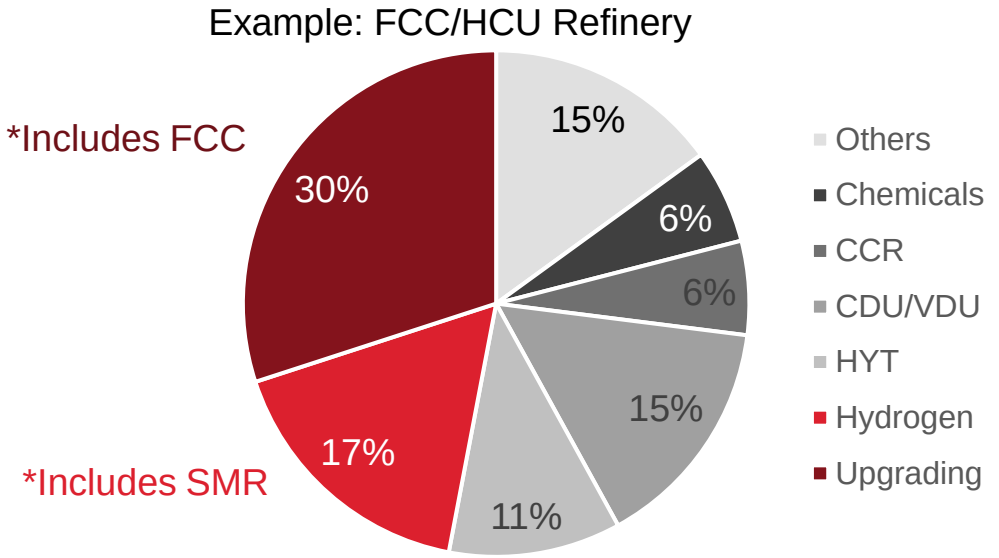
WHERE ARE EMISSIONS BEING GENERATED

- Refineries are estimated to represent 4% of global CO_2 emissions[1]
- Differing complexity of configurations, will drive different sources of the CO_2 emissions
- Majority of emissions will remain from fuel combustion

Example: furnaces, boilers & heaters to generate heat & steam

Estimated Emissions by Unit

Example: FCC/HCU Refinery

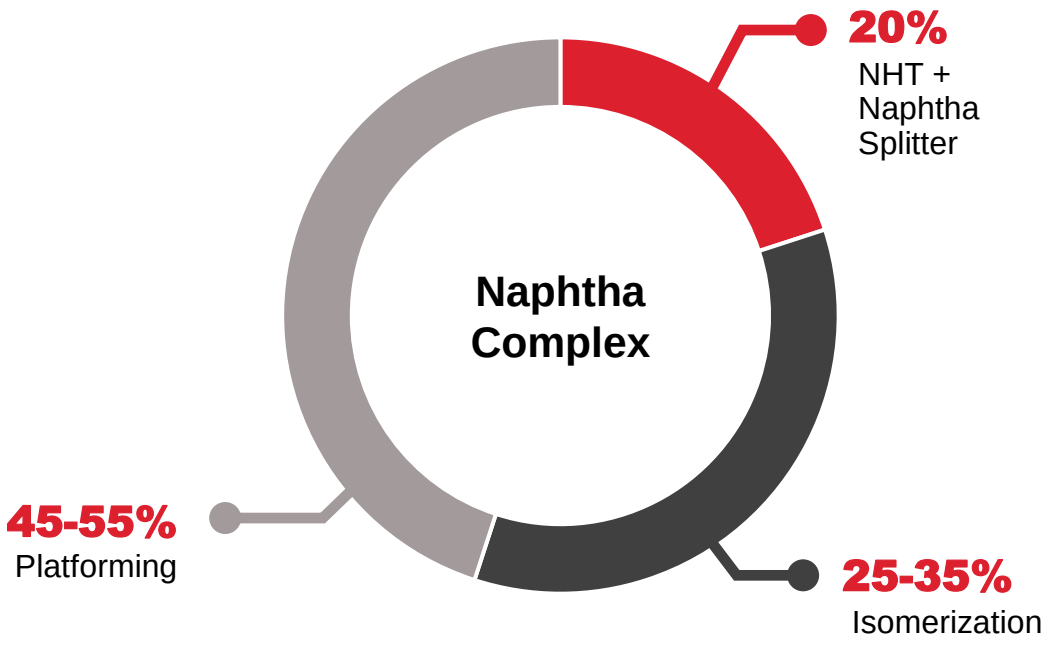


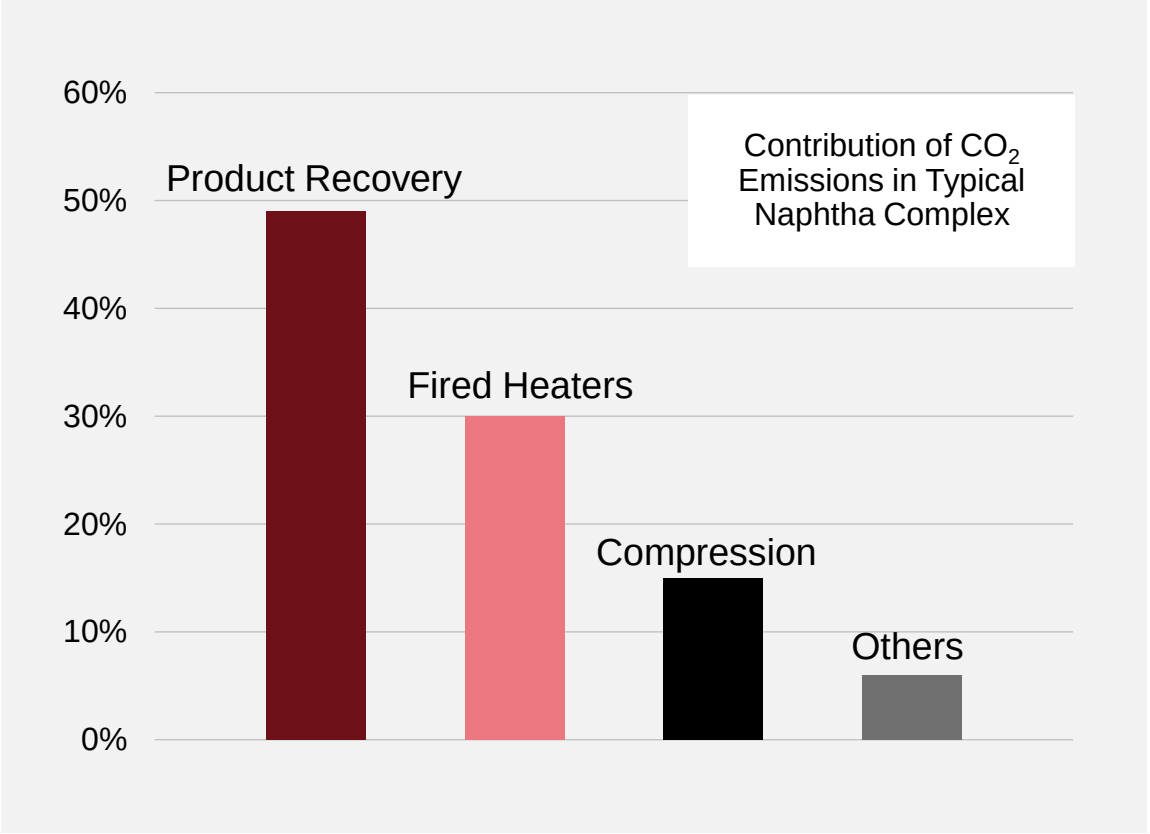
SMR & FCC are typically the first units evaluated – both with 16-18% CO_2 concentration

Source 1 : Science Direct

Source:
WoodMac with subsequent UOP analysis of the data in this report
https://www.woodmac.com/news/opinion/survival-of-the-fittest-refineries-what-are-the-metrics-that-matter/

NAPHTHA COMPLEX CO_2 EMISSIONS





Product recovery, fired heaters and compression are the key contributors for CO_2 emissions

Notes:
Estimates of Scope 1 and 2 CO_2 emissions represent the average from UOP Naphtha technology offerings designed in last 10 years over the span of unit sizes, configurations and processing objectives requested by our customers. Data is generated by using UOP internal yield estimating, kinetic and emissions calculation models.

RecoveryMax™

WHAT IS RECOVERYMAX?

- An energy efficient system to recover high value products from Platforming gases
- **Plays pivotal role for refinery H_2 balance**
- Modular supply revamp option

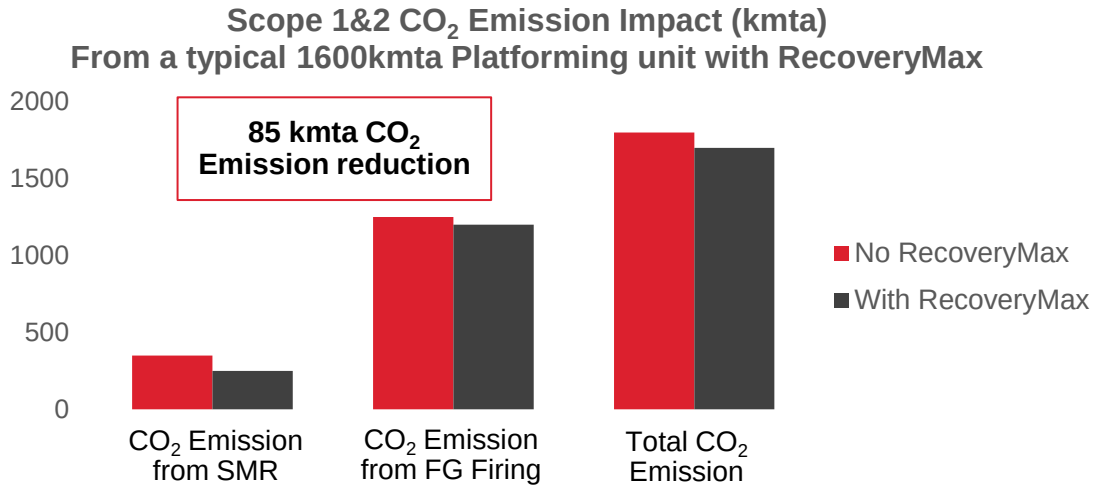
ECONOMIC AND EMISSION REDUCTION VALUE

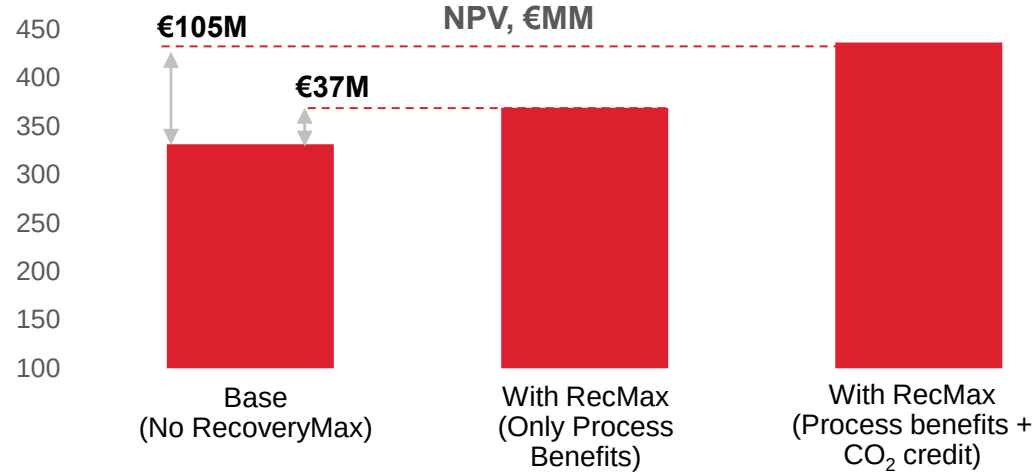
Enables higher economic return

- ~10% higher H_2 recovery
- ~30% higher LPG recovery
- ~0.5% higher reformate production

A cost-effective choice for CO_2 emission reduction[1]

- Improve H_2 supply from low emission source and reduce need of SMR H_2
- Improve refinery fuel gas quality by enhanced C_3/C_4 recovery





Notes:
1 Scope 1 & Scope 2 CO_2 emission. Assumed €100/mt CO_2 credit
2 For NPV assessment standard SEA price set is considered
3 85kmta CO_2 reduction is based on UOP internal calculation for a typical refinery H_2 and fuel gas balance where SMR is being fed by NG and is a primary H_2 source to meet refinery process requirements

RecoveryMax Reduces Scope 1 & 2 Emissions while improving profitability

UOP E6 – NPV SUMMARY

RecoveryMax

C

€7.0 MM additional product value from LPG and Reformate

H

€43.0 MM additional production of hydrogen

⚡

(€5.0) MM additional power consumption and utility

CO_2

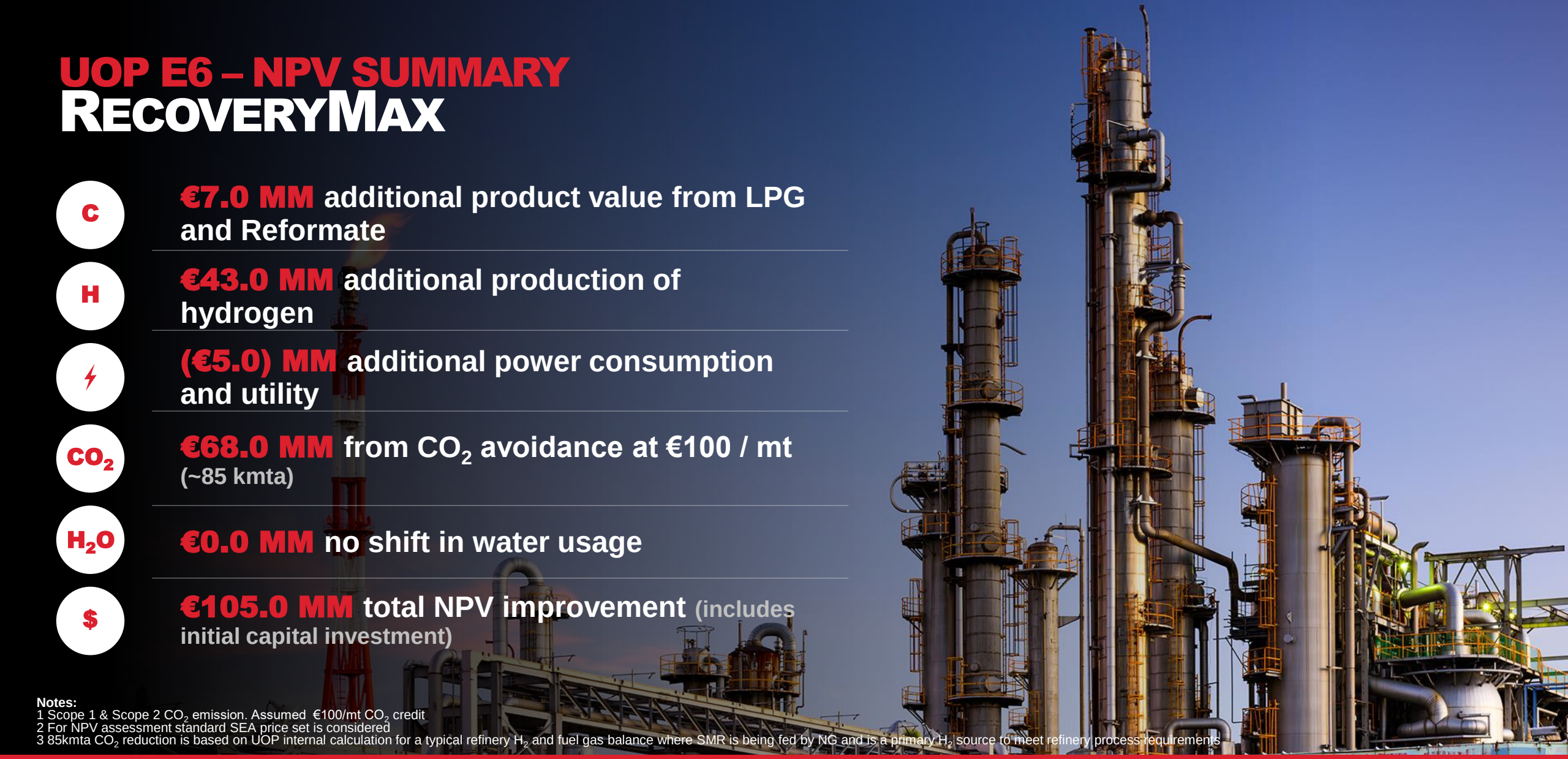
€68.0 MM from CO_2 avoidance at €100 / mt (~85 kmta)

H_2O

€0.0 MM no shift in water usage

$

€105.0 MM total NPV improvement (includes initial capital investment)



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Product recovery and CO_2 avoidance drive RecoveryMax attractiveness

NEXT STEP

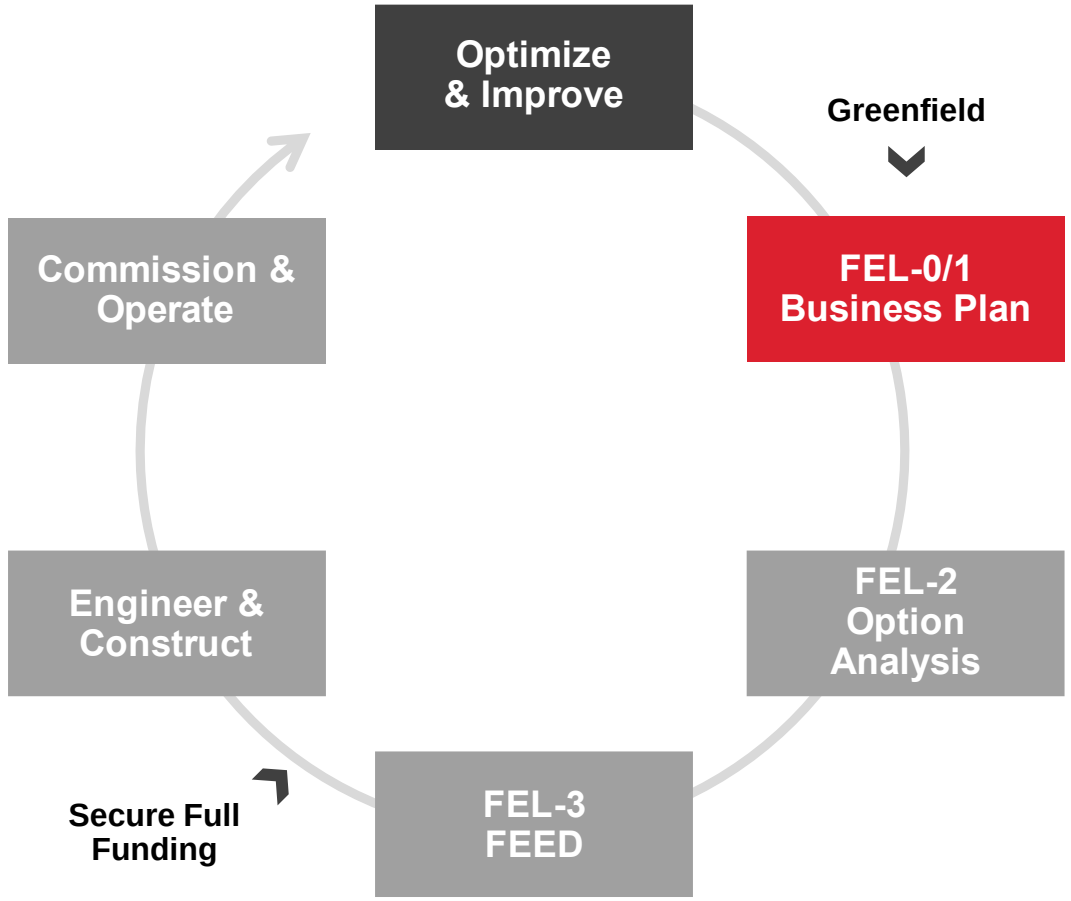
CONCEPT DEVELOPMENT WORKSHOP

Align on key project drivers – market and business

Jointly identify ideas and concepts for evaluation in a subsequent process or configuration study

UOP PROJECT DEVELOPMENT SERVICES

Concept Development Workshop	Market Study Support
Scoping Configuration Study	Project Execution Workshop
Scoping Process Studies	Detailed Configuration Study
Insurer Risk Assessment	Detailed Feasibility Support
Project Financing Support	Bankability Study
Permitting Support	Managing Licensor



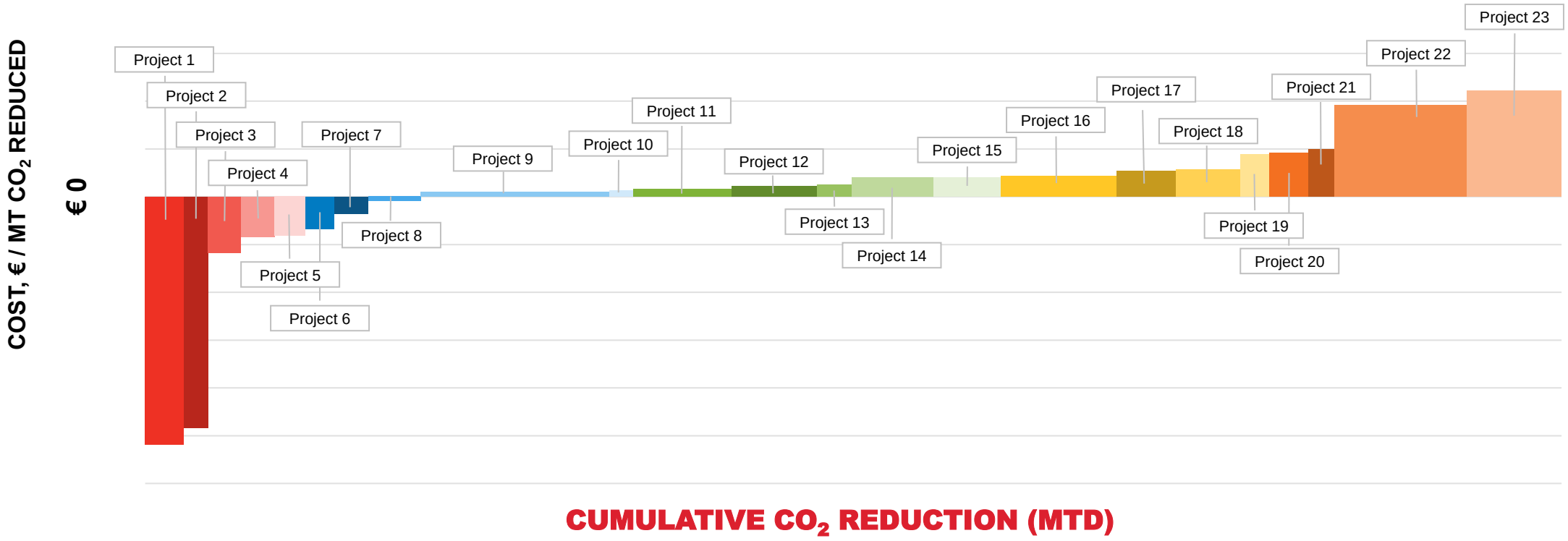
Identify the right ideas to assess

EXAMPLE

EMISSIONS REDUCTION ROADMAP STUDY

(ALSO KNOWN AS A CARBON ABATEMENT CURVE)

SCOPE 1 AND 2 - € / MT CO_2E vs CO_2 REDUCTION



Identify top 5 – 10 most attractive projects and develop further

Illustrative example only. Results will vary

CONCLUSIONS

1. Emissions reduction is the key strategic decision facing Oil & Gas companies.
2. Emissions reduction will need a combination of approaches including feedstock substitution, product pivots, technology upgrades, carbon capture, detection and monitoring systems, advanced process control and digitization.
3. UOP's Six Efficiencies (E6) framework drives a progression of change, with an emphasis on doing more with less while delivering bankable and ESG focused project solutions.
4. Continued innovation in equipment, catalyst, process design, data collection and use and control systems all play a part in decarbonizing existing assets.
5. An Emissions Reduction Roadmap study can be valuable in identifying the numerous options to reduce scope emissions and their economics which can guide the operator in proper project sequencing.

Bankable, ESG focused solutions for YOUR Refinery of the Future

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