The IRIS CCUS Project

BioTheRoS workshop
October 23rd ,2025

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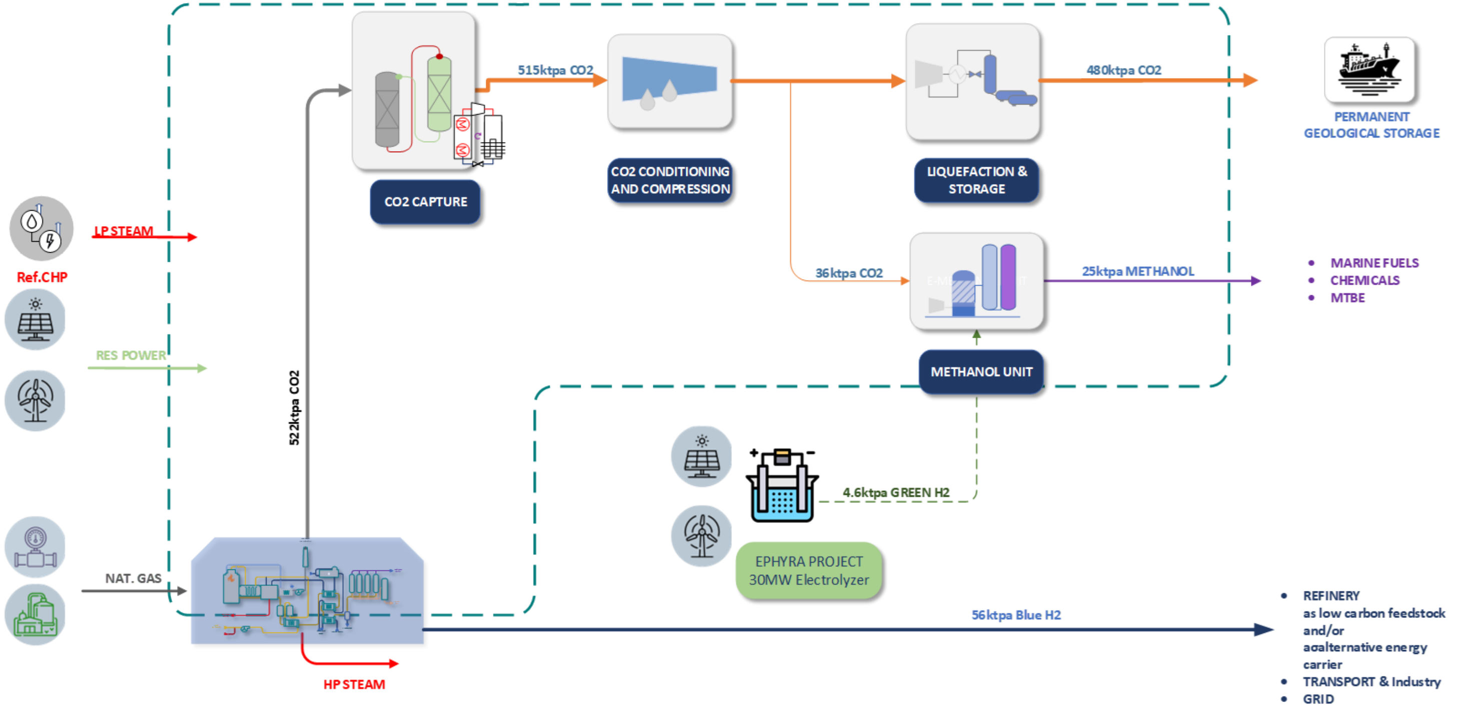
Project IRIS | Scope and Status

Scope

A project that serves MOH's main strategic directions

- Increases resilience by drastically reducing GHG emissions
- Defending MOH's sustainability targets
- MOH becomes a large Blue Hydrogen producer in Europe
- Materializes CO_2 circularity via the production of e-Methanol
- Innovation Fund grant: EUR127m
- Interacts with existing projects (Ephyra, Trieres)



Current Status: Engineering

1	**Pre-FEED Conclusion & FEED start**	Multicriteria methodology based on technical and financial KPIs combined with weight factors for the selection of licensed units (i.e. Carbon Capture and Methanol production). Re-design and re-assessment.
2	**Intermediate on shore storage & shipping infrastructure**	Definition of key logistical parameters for the assessment of the currently available jetty facilities in conjunction with shipping conditions and specs.
3	**Market development**	PPA engineering for green electricity and geological storage allocation.

Oil Refining Industry Decarbonization: 4 pillars problem approach

Oil Refining Decarbonization

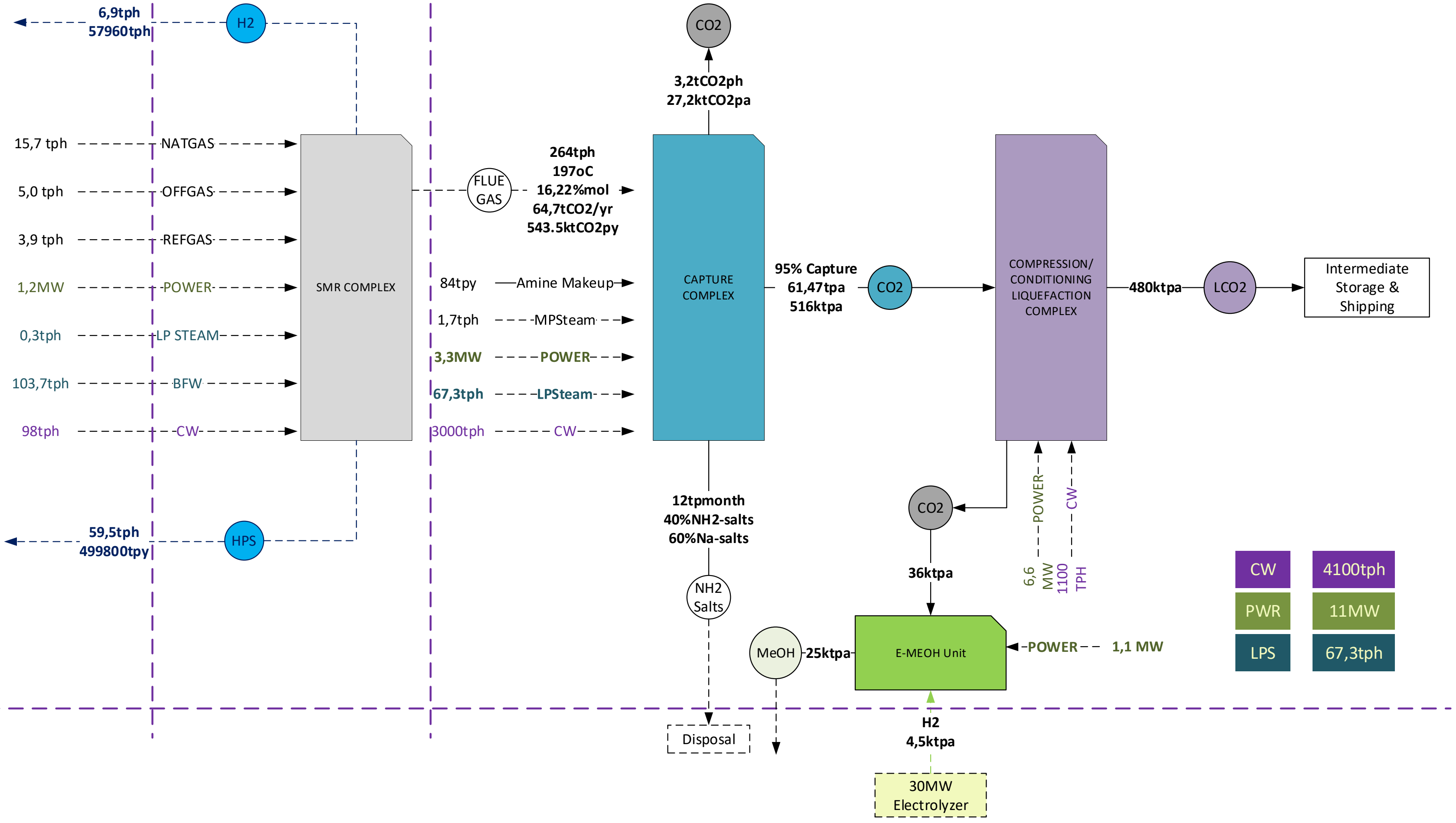
Energy Efficiency	Electrification	Carbon Capture, Utilization & Storage	Low Carbon Fuels, Feedstocks & Energy Sources
Energy efficiency advancements minimize industrial energy demand, directly reducing the GHG emissions associated with fossil fuel combustion.	Industrial process technologies that utilize electricity for energy, rather than combusting fossil fuels directly, enable the sector to leverage advancements in low-carbon electricity from both grid and onsite generation sources.	Substitution of low- and no-carbon fuels and feedstocks for fossil fuels can further reduce combustion-associated emissions for industrial processes.	This multi-component strategy for mitigating difficult-to-abate emissions involves capturing generated CO2 before it can enter the atmosphere; permanently storing captured CO2 and utilizing it whenever possible
• Energy management approaches • Smart manufacturing • Improved technologies & processes; system integration • **Thermal integration of process heat**	• CHP • Electrification of H2 production for industrial process use • **Electrification of process heat (i.e. heat pumps, electric boilers)**	• **Post combustion chemical absorption of CO2** • **CO2 pipelines and other supportive infrastructure**	• Fuel flexible processes • Biofuels and bio-feedstocks • Geothermal energy • Concentrated solar power • **Clean H2 fuels and feedstocks**

Carbon Capture, Compression, Conditioning & Liquefaction

Abated SMR configuration (Base case)

Post combustion amine-based carbon capture followed by a compression / liquefaction unit and intermediate storage is the simplest configuration for this purpose

- Connects at the stack, not interfering heavily with the process side of the refinery
- Large LP steam (67,4tph) and CW (4,1ktph) consumer for amine regeneration as well as for the liquefaction phase
- Large power consumer (+10,7MW) for flue gas compression through the quencher and liquefaction
- OPEX governed by LP steam which also affects the carbon abatement performance (+70000 tCO2 as indirect emissions)



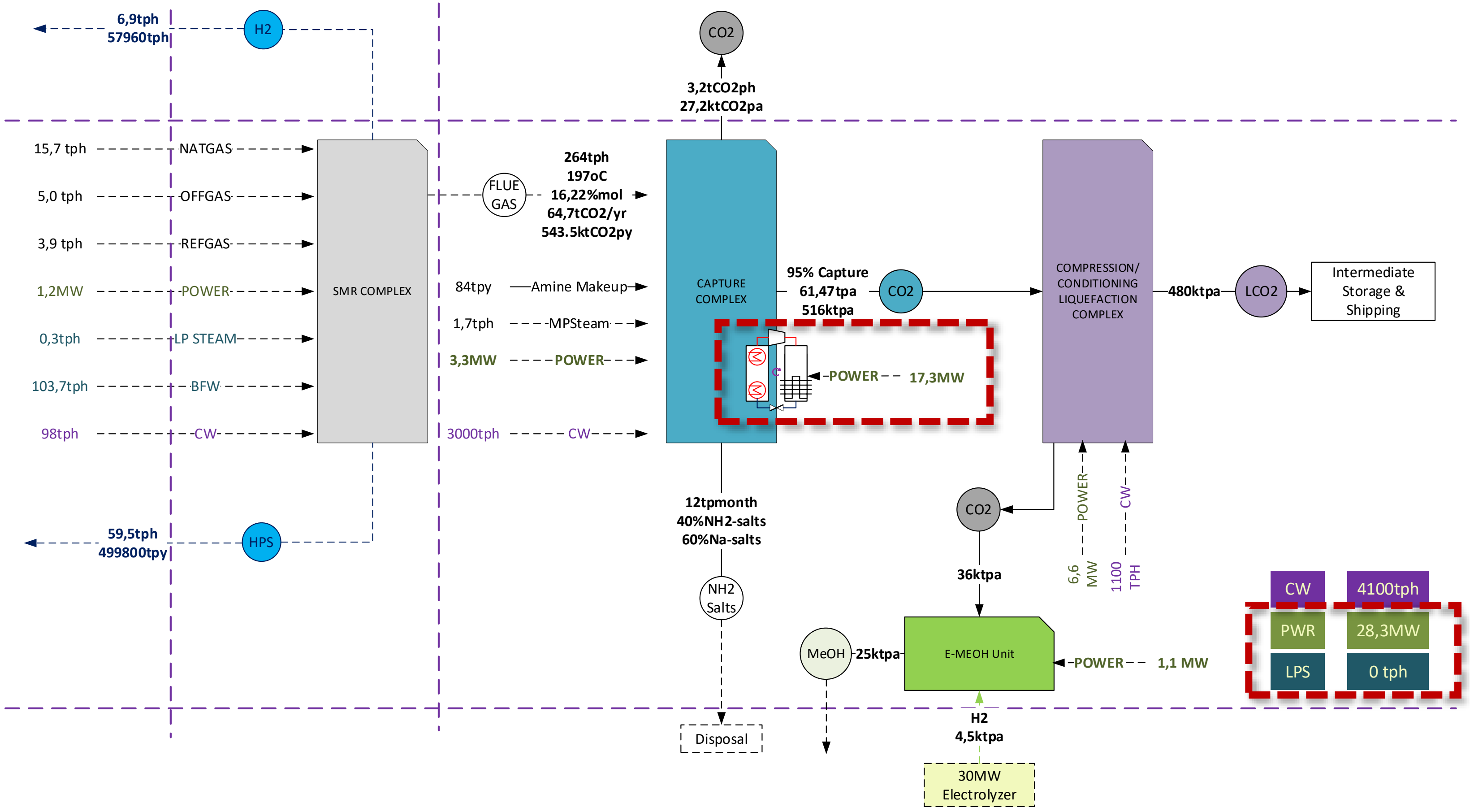
Heat pump-based configuration

Improving Carbon Capture concept by reducing OPEX and carbon footprint

IRIS

Heat pumps can utilize heat streams with low temperature differentials to produce steam

- The hot streams from the quencher's outlet and the lean amine returns from the regenerator can provide the required heat to produce 68tph of LPS.
- The capture unit becomes LP steam independent while the reducing the OPEX attached to it.
- With a COP of 2,4 the power required is 17,1MW while the plot plan required is appx 1000sqm.
- Liquefaction utilities remain unaffected
- Less than 2 years payback time
- Additional plot space requirements: **1000qm**



CW	4100tph
PWR	28,3MW
LPS	0 tph

Geological Storage

Pathways for final deposition of CO_2

IRIS

Case 1: Ag. Theodoroi - Prinos

ENERGEAN OIL & GAS

Loading port	Discharge port
Aghioi Theodoroi	KAVALA (PRINOS)
	Type: Oil field **Injection Capacity**: 3 Mpta **COD**: 2030

Distance (nm)	No # ships
267	1

Size of ship (m3)	Number # of trips	Utilization Rate
7,500	59	69%

Size of ship (m3)	Number # of trips	Utilization Rate
12,000	37	43%

Case 2: Ag. Theodoroi - Ravenna

Eni

Loading port	Discharge port
Aghioi Theodoroi	RAVENNA
	Type: Gas fields **Injection Capacity**: 4 Mpta **COD**: 2029

Distance (nm)	No # ships
850	1 or 2

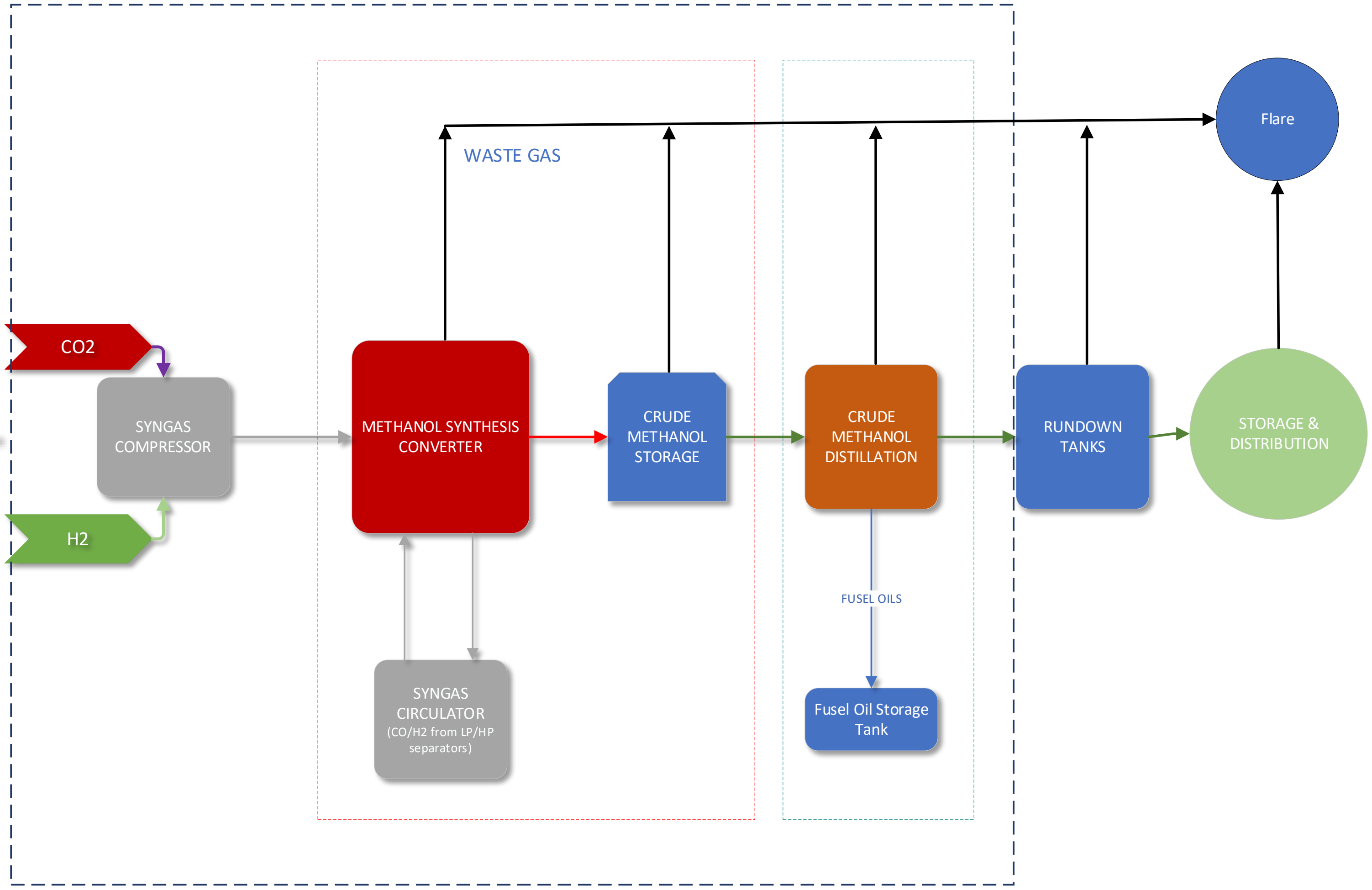
Size of ships (m3)	Number # of trips	Utilization Rate
7,500	2x30	65%

Size of ship (m3)	Number # of trips	Utilization Rate
12,000	37	82%

Carbon Dioxide Utilization: Methanol Unit

Carbon Utilization in IRIS: Methanol production

- ✓ E-fuels (**LCF & RFNBO**): an option for the hard to abate sectors
- ✓ Methanol is the precursor of high value chemicals
- ✓ Current regulatory framework provides for the **use of captured fossil CO_2 until 2041**
- ✓ On-site availability of green H_2 is a major contributing factor; Investigating the use of Blue H_2 for specific uses
- ✓ Catalytic hydrogenation of CO_2 is gaining momentum with new plants coming online



EU Maritime decarbonization
EU ETS and FuelEU provisions and methanol

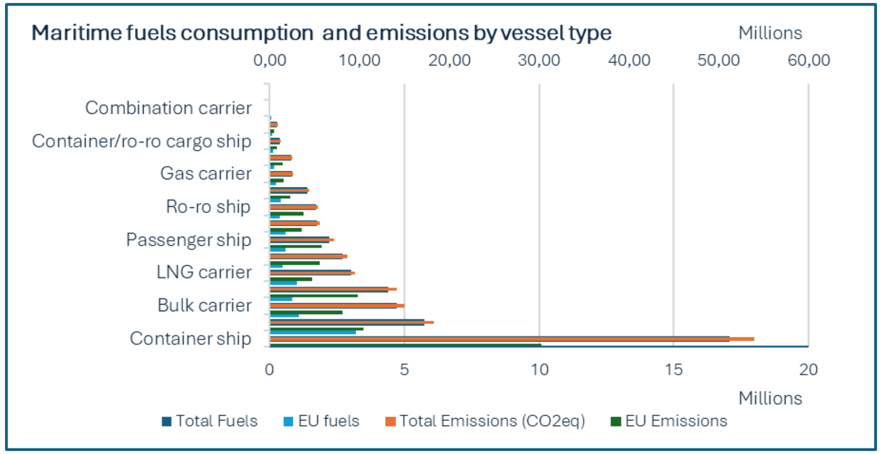
In 2024, appx 13900 vessels over 5.000GT sailed between EU ports or from/ to Extra EU ports

Approximately 47.2mtons of fuels were used and appx. 150mtonCO2eq were emitted

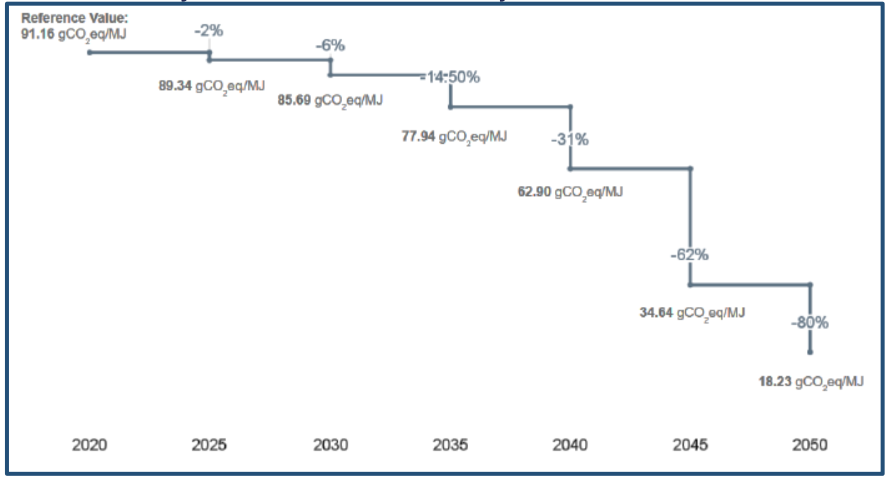
Two main regulatory levers for the maritime decarbonization:

- EU ETS, as extended to cover maritime transport
  - Covers Tank - to – Wake emissions
  - No free allowances; EUAs purchased in the secondary market
  - GHG emission are monitored, reported and validated in accordance to MRV Maritime Regulation
  - Certified sustainable fuels (**biofuels, RFNBOs, synthetic LCF**) are **zero rated** (no EUAs need to be surrendered for the emissions attached to them)
- FuelEU, aims to decrease the over-the-lifecycle GHG emissions intensity of the vessels by 80% in 2050
  - Aims to promote vessel's efficiency, Onshore -Power – Supply and alterative fuels
  - Vessels are audited annually in accordance to MRV regulation; depending on the gap between the achieved intensity and the provisioned for that, the vessel suffers a penalty;
  - Simlarly overperformance can be banked or pooled for used in coming years or by other vessels of the operator

Both regulatory tools are applicable to vessels over 5000GT and 100% of the energy used between EU ports and 50% of the energy between EU and Extra EU (from/to) ports.



GHG Intensity reduction mandated by FuelEU



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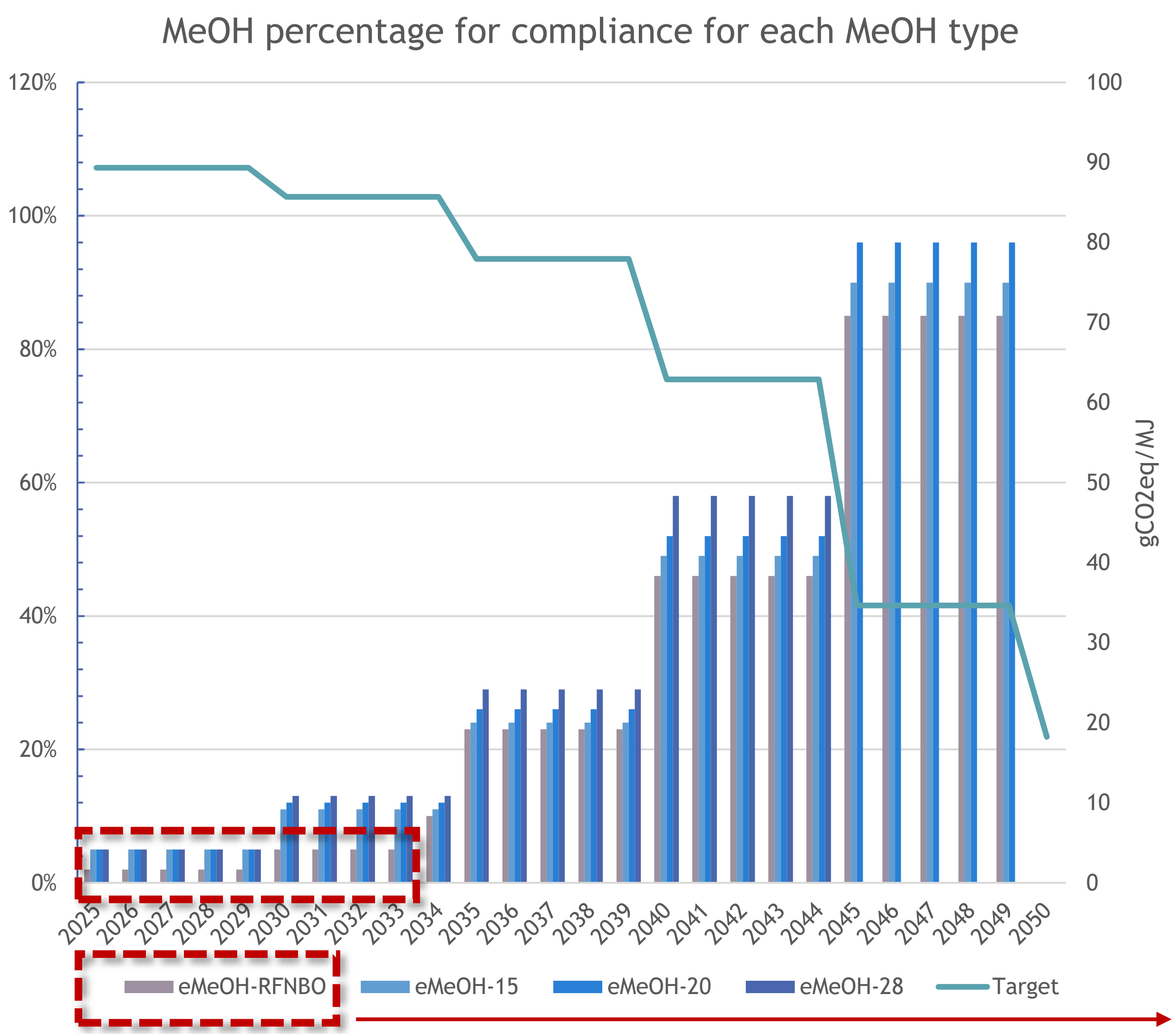

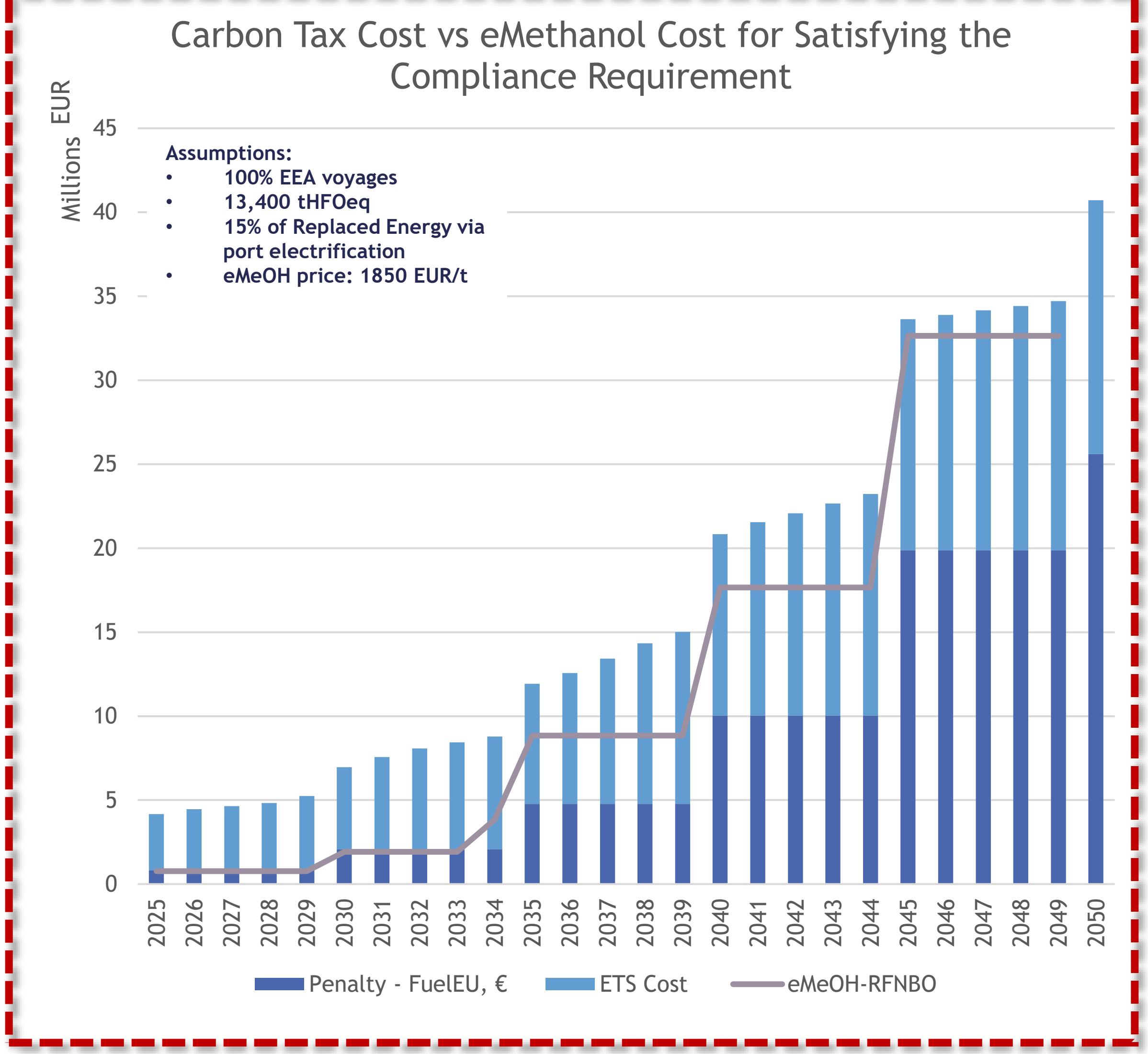

Closing remarks

A project that serves MOH's main strategic directions

Facing challenges as underlined in the Industrial Carbon Management Strategy

IRIS

- ✓ Increases resilience by drastically reducing refinery's GHG emissions, both directly and indirectly
- ✓ MOH becomes a major Blue Hydrogen producer while expanding the capacity to further decarbonize its operations
- ✓ Provides for wider thermal integration of the refinery
- ✓ Materializes CO_2 circularity via the production of e-Methanol
- ✓ Reduces Scope 3 emissions through the introduction of low carbon methanol and hydrogen to end users
- ✓ Synergies with existing projects

- ? …significant **up-front investment** capital required, uncertainty of future CO2 prices, storage capacity readiness..
- ? …lack of a **comprehensive regulatory framework** across the value chain….
- ? …first movers involved in building carbon value chains also face **CO2-specific cross-value chain risks**, such as liability for leakages or the unavailability of transport and supporting infrastructure..(+ …lack of **specifications**…)
- ? …insufficient **coordination and planning** in conjunction with appropriate regulatory framework..
- ? …insufficient **incentives for private** and public investment to proof the business case for industrial carbon management…

Thank you very much!