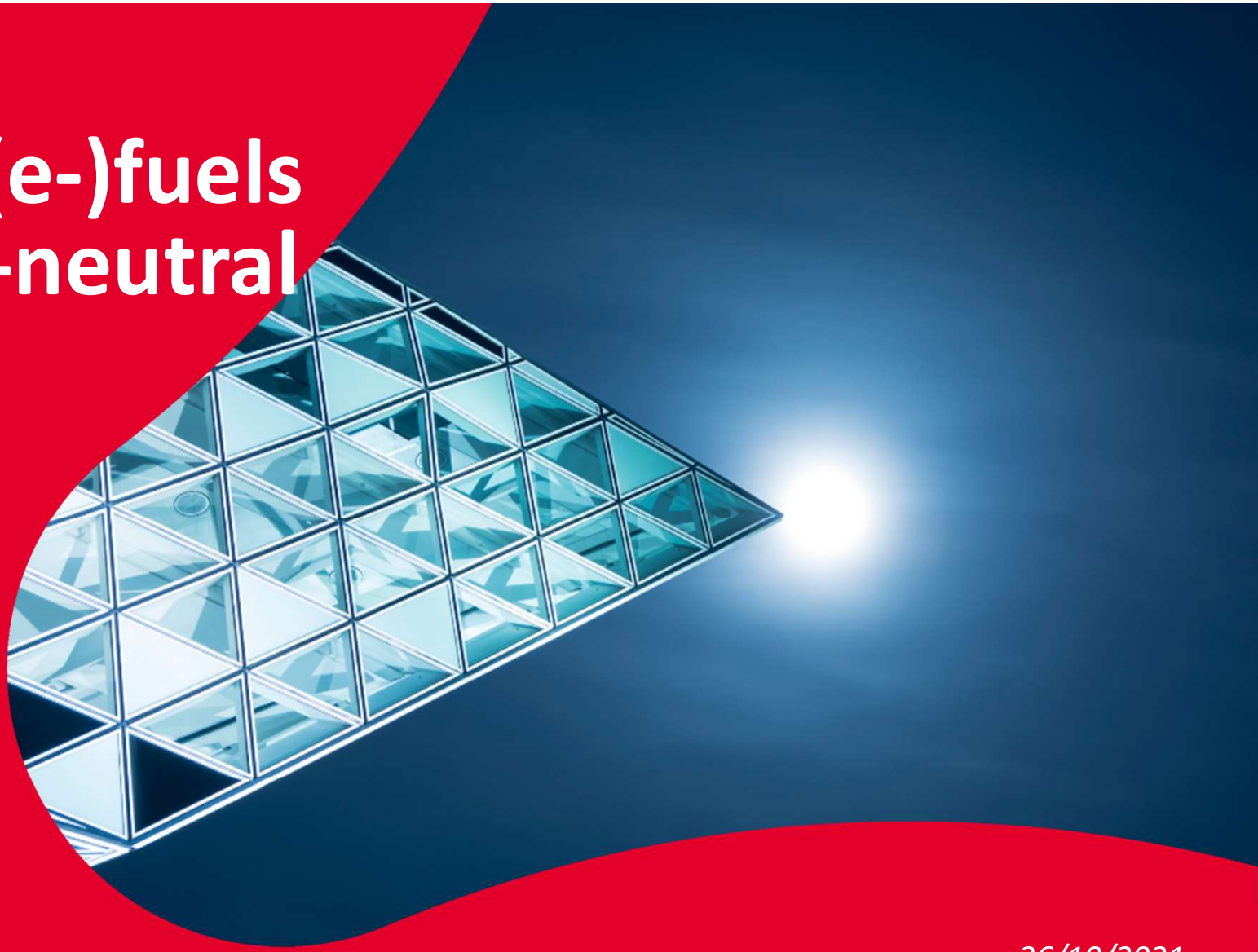
The role of (e-)fuels in a climate-neutral future

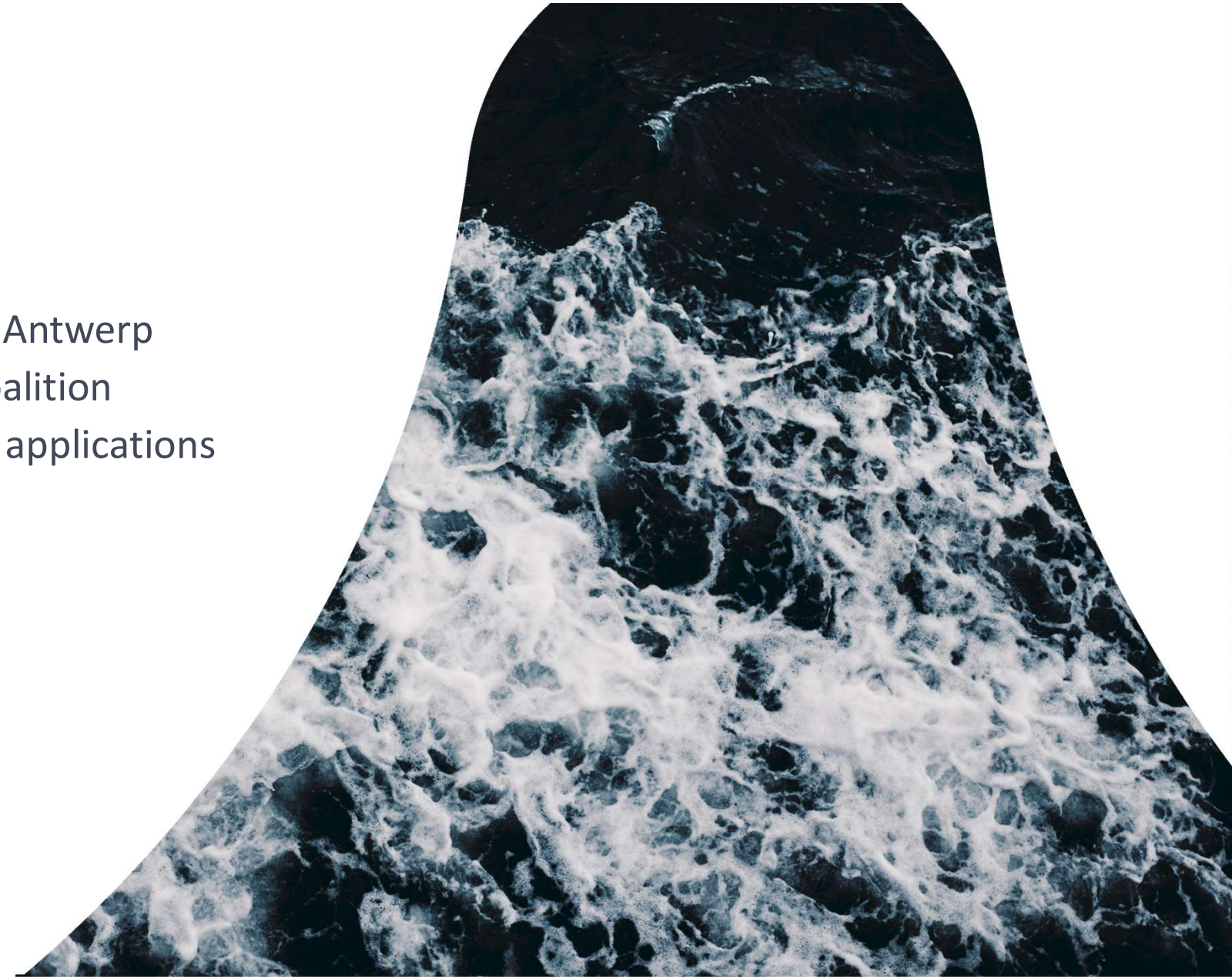


Port of Antwerp

26/10/2021

Agenda

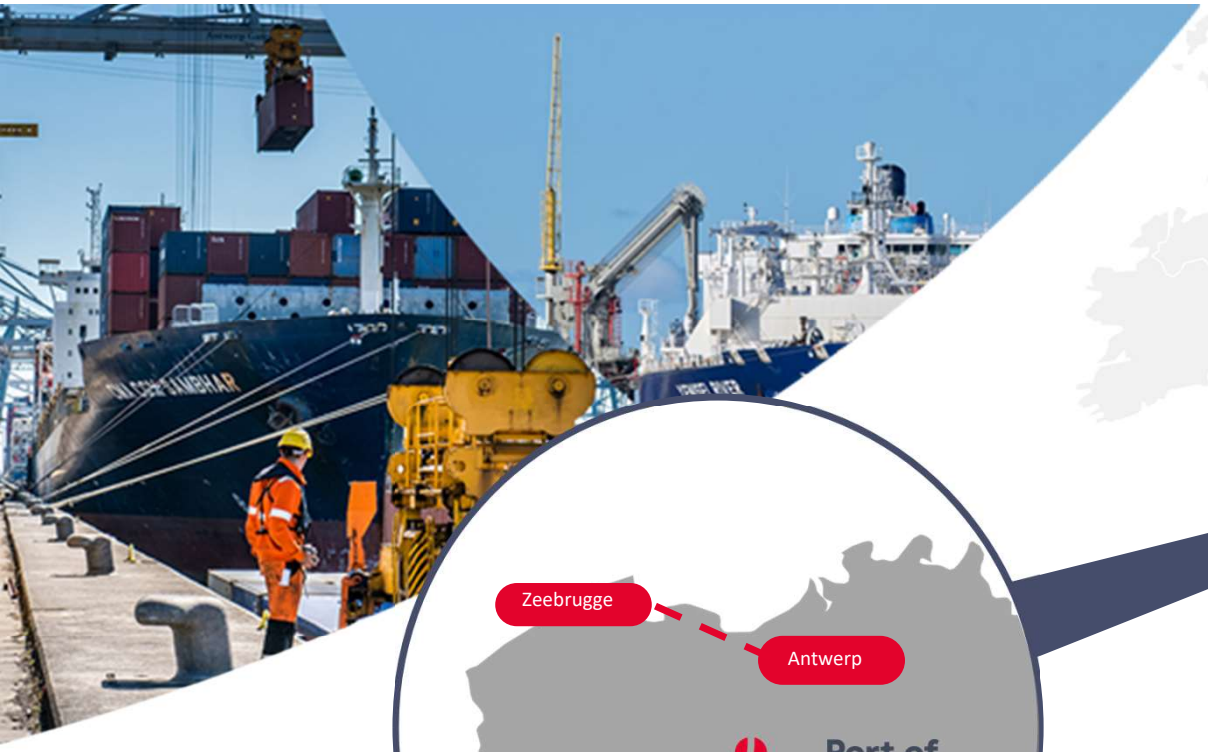
1. Port of Antwerp
2. Power-to-Methanol Antwerp
3. Hydrogen Import Coalition
4. Renewable (e-)fuels applications
5. Conclusions



Port of Antwerp

Port of Antwerp

Port of Antwerp



One port
Two locations

World port that
reconciles people, climate and the economy

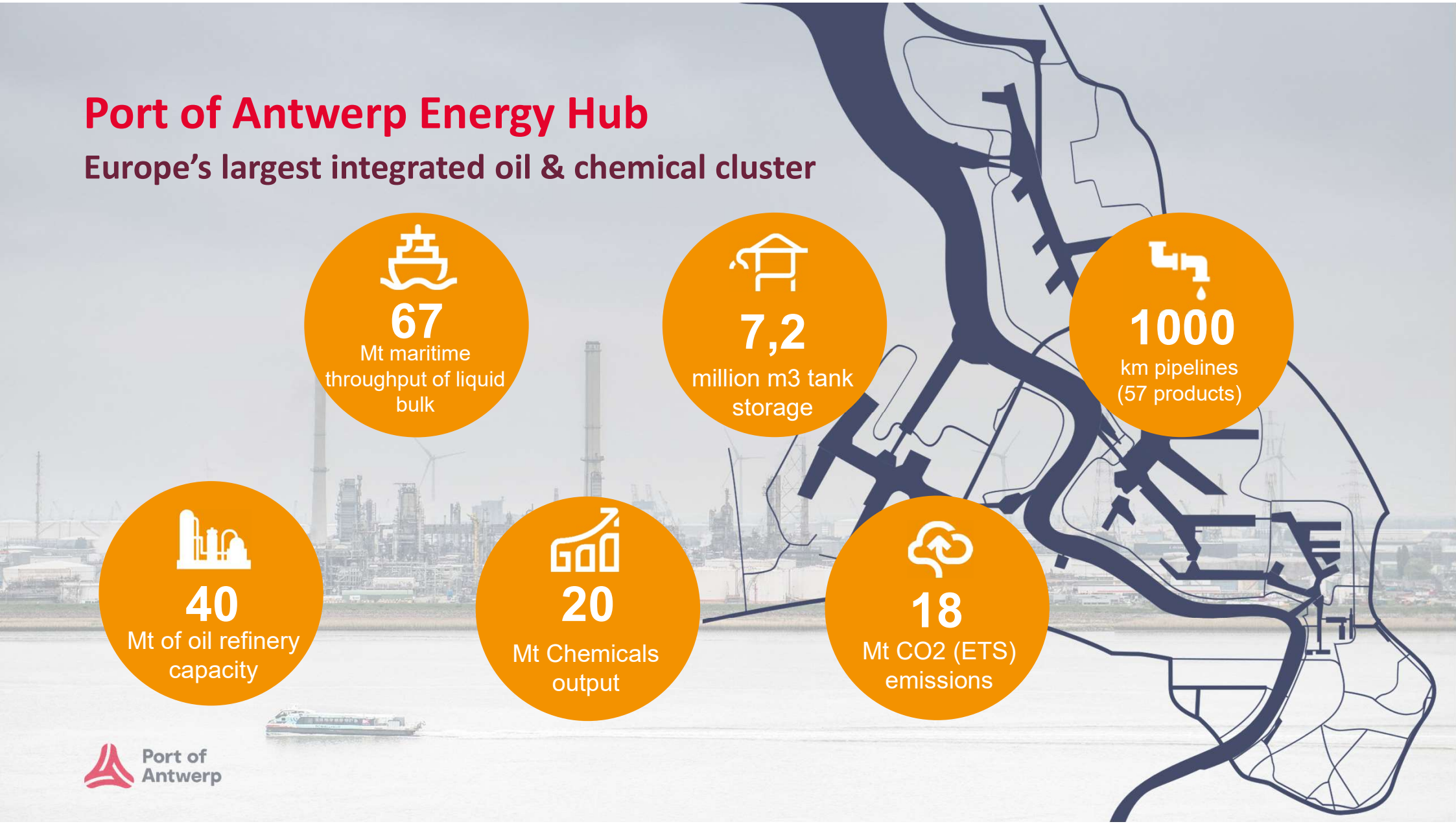
In a centuries-old
cosmopolitan region
in the heart of Europe

Stronger position of logistical chain
Sustainable growth and interconnectivity
Leading on the energy transition


Belgium's largest economic engine
231
million tonnes of maritime freight
11,246
hectares
€ 19
billion in added value
143,000
jobs
1,000
companies
4.1%
BBP
Port of Antwerp

Port of Antwerp Energy Hub

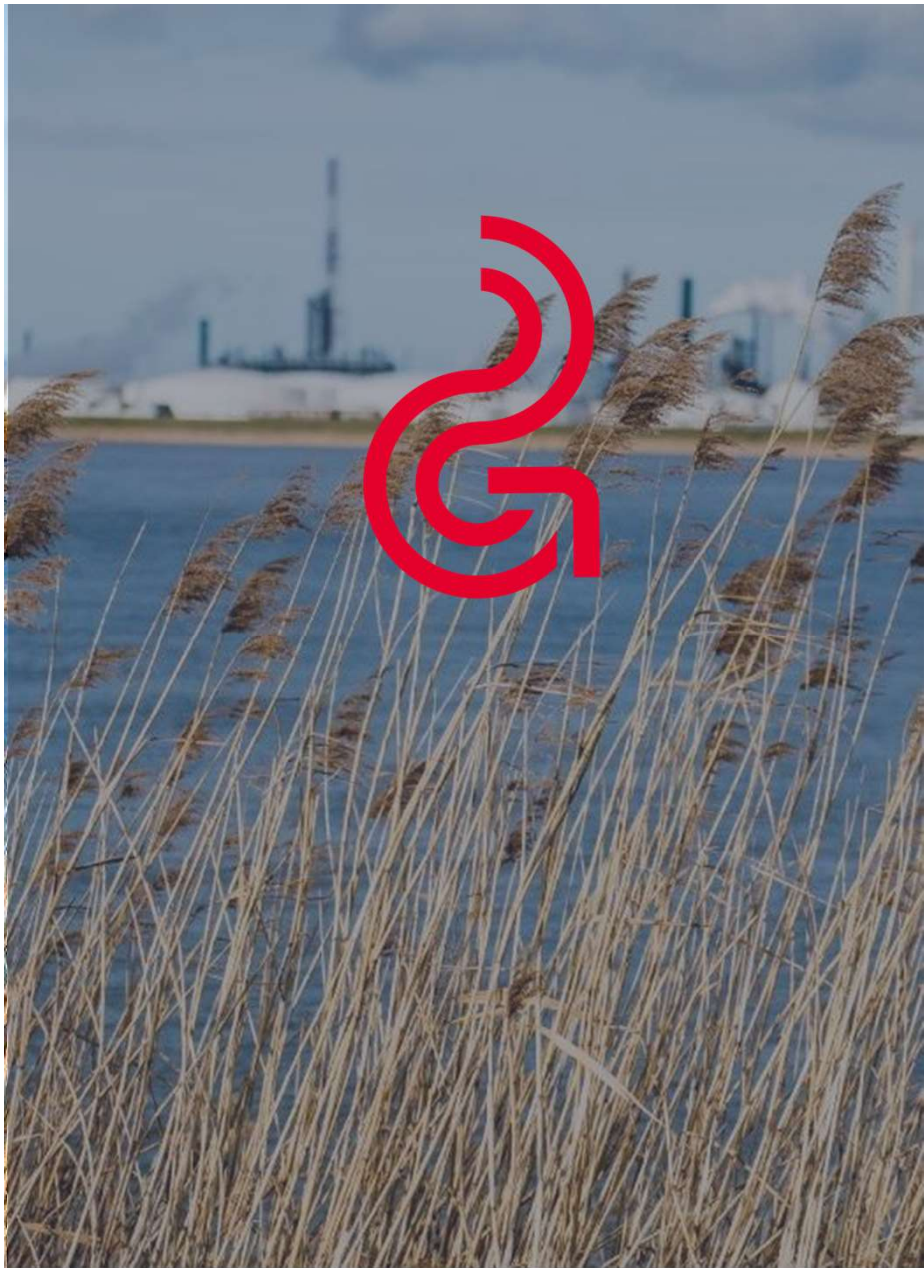
Europe's largest integrated oil & chemical cluster



This is where change begins

Fully engaged to energy transition and circular economy

- Working towards a **CO_2-neutral port**
- Developing **new energy sources**
- Creating **space** to **embed** this ambition



Port of Antwerp

Energy Transition

Large scale, cost effective solar and wind energy will be the cornerstone of a carbon neutral economy.

Renewable energy will be produced locally as well as imported, because

- Solar and wind energy is not always available where we need it

  → in a best case scenario for Belgium only, 100-120 TWh of wind and solar could be produced (representing a tenfold of wind and sun today!). Today's energy need is 400 TWh, excluding throughput to hinterland!

- Solar and wind energy is not always available when we need it

  → a local self-sufficient wind and sun based system will be costly due to huge storage needs

- Electricity is not always the most appropriate energy form

  → pipelines where transmission lines fall short in term of timing (acceptance) or cost (efficiency)

  → shipping, aviation: autonomy!

- Don't forget the feedstock: our chemical industry requires hydrogen and carbon

Port of Antwerp

Our future energy supply

A robust approach as a guarantee for a sustainable future

Our **energy supply** = biggest climate issue. **Wind and solar** = main energy sources

Need for a **robust and flexible climate neutral energy system**:

1. Local (EU) RE production + electric transport

→ Ongoing with large scale funding
→ Limits to transport; limits to acceptance

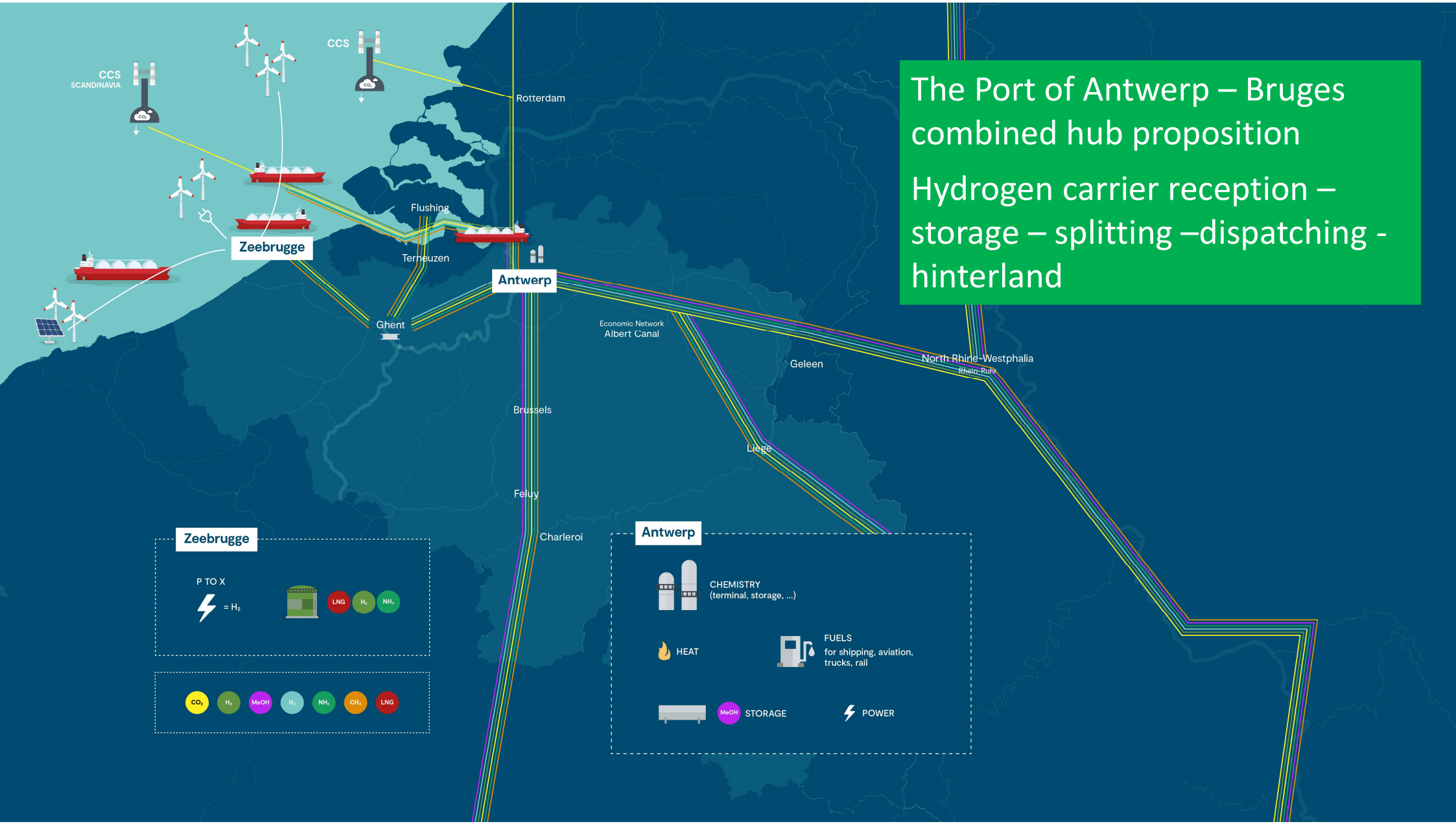
2. Hydrogen transport by EU-pipeline icw local climate neutral production

→ Deployment upcoming years, Green Deal means for 1st stepping stones
→ Multi purpose for green-blue-pink-turquoise
→ Consumer optics: need for molecular energy voor industry, heavy transport

3. Import of renewable hydrogen carriers through Flemish Seaports Zeebrugge -Antwerp

→ Necessity: security of supply, robustness, competivity
→ Opportunity: efficient hinterland logistics is our core competence and business
→ Consumer optics: need for molecular energy voor industry, heavy transport

Port of Antwerp


CCS
SCANDINAVIA
CCS
Rotterdam
Flushing
Zeebrugge
Terneuzen
Antwerp
Ghent
Economic Network
Albert Canal
Geleen
North Rhine-Westphalia
Rhein-Ruhr
Brussels
Liege
Feluy
Charleroi
The Port of Antwerp – Bruges combined hub proposition
Hydrogen carrier reception – storage – splitting –dispatching - hinterland
Zeebrugge
P TO X
= H2
LNG
H2
NH3
CO2
H2
MeOH
H2
NH3
CH4
LNG
Antwerp
CHEMISTRY
(terminal, storage, ...)
HEAT
FUELS
for shipping, aviation, trucks, rail
MeOH
STORAGE
POWER

Flanders Energy Hub

3 pillar approach

Local wind & solar - grid development

Belgium
EU n°1 interconnection MS
WW N°5 offshore wind

BE@Sea
Further grid deployment and interconnectors (6 to 11 GW)

Wind and solar cluster Port of Antwerp
- Smart wind cluster project
- + 200 MW wind cluster
- 60 MW solar cluster

Power-to-Methanol Antwerp
Sector integration

NOW

EU hydrogen transport & production

Hybone Port of Antwerp – JV Pipelink-Fluxys
Belgian open access H2 network

Antwerp@C – CCS
Blue hydrogen

Turquoise H2 initiative BASF

NextGen District
Port of Antwerp demonstrator area

TOMORROW

Green Hydrogen imports

Hydrogen Import Coalition

Import cooperations Chili, Egypt,…

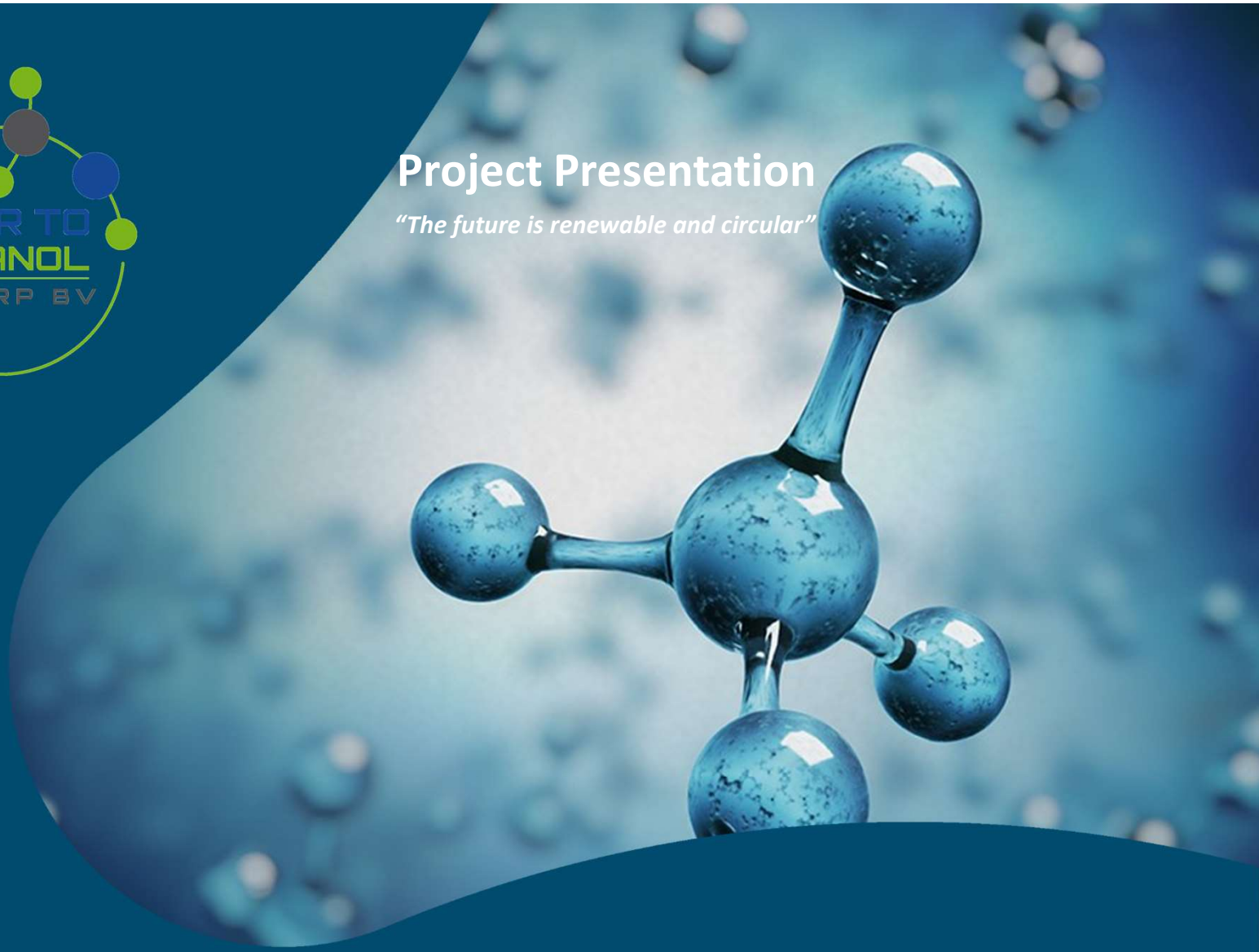
Port of Antwerp – Port of Bruges
terminal analysis

THIS DECADE

Port of Antwerp

Project Presentation

"The future is renewable and circular"



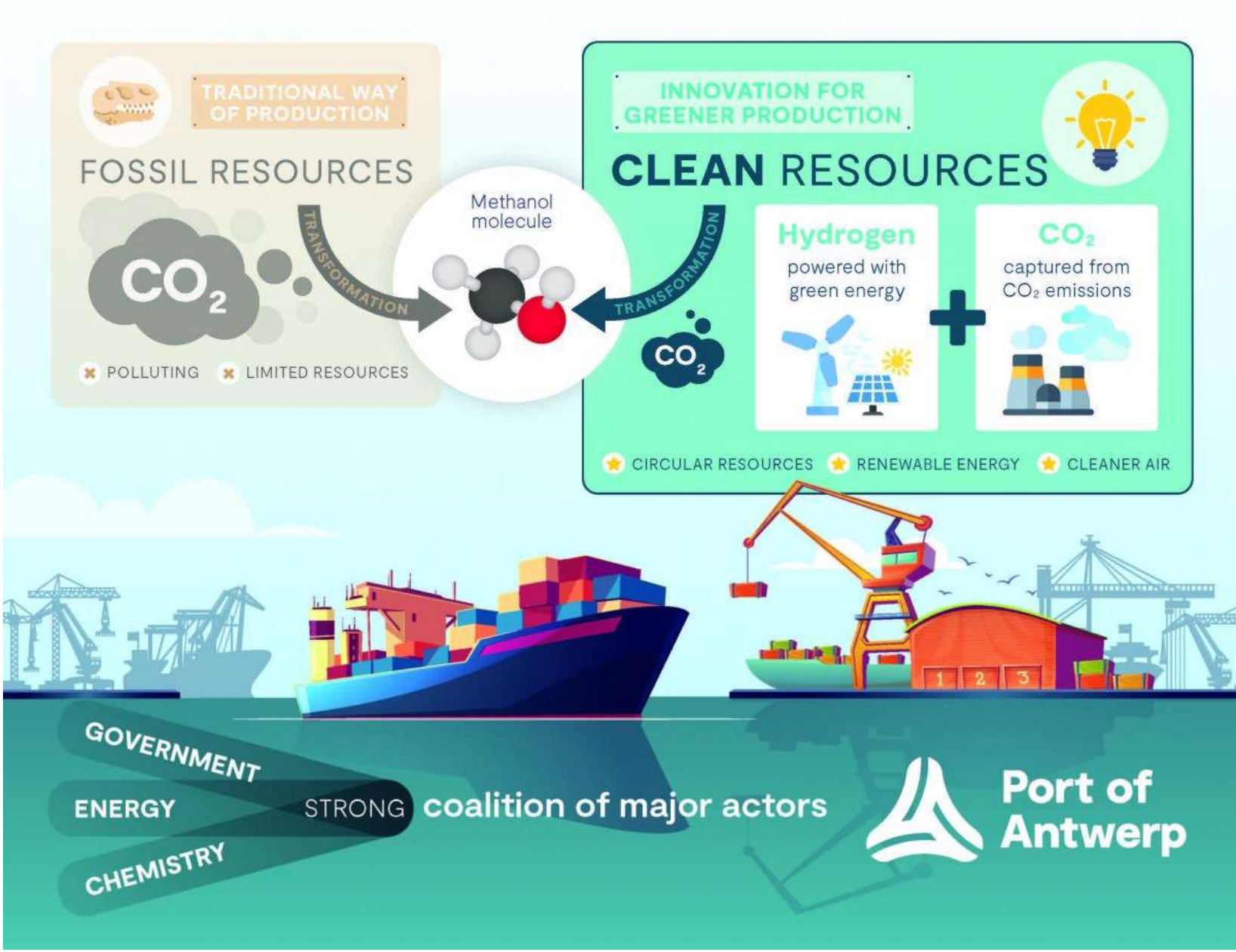
Power to Methanol Antwerp B.V.

Power to Methanol demonstrator

with 7 partners

ENGIE
INDAVER
inovyn An INEOS company
fluxys
Oiltanking
PMV DOE- EN DURFBEDRIJF

Port of Antwerp



The investment partners

The investment partners have the ambition to accelerate the energy transition and enhance their position on the processes of the future in the Antwerp port area

ENGIE's purpose is to act to accelerate the transition towards a carbon-neutral economy, through reduced energy consumption and more environmentally-friendly solutions. The purpose brings together the company, its employees, its clients and its shareholders, and reconciles economic performance with a positive impact on people and the planet.

Indaver operates specialist facilities and smart systems for waste management, processing around 5 million tonnes of waste annually for industry, government departments and households. Indaver creates value from this waste by recovering materials and energy, thus playing an essential role in the circular economy.

INOVYN is a vinyls producer that ranks among the top three worldwide. Our portfolio consists of an extensive range of class leading products arranged across General Purpose Vinyls, Specialty Vinyls, Organic Chlorine Derivatives, Chlor Alkali and Electrochemical & Vinyls Technologies.

Fluxys is a fully independent gas infrastructure group active across Europe in gas transmission & storage and liquefied natural gas terminalling. Fluxys is committed to accommodate hydrogen, biomethane or any other carbon-neutral energy carrier of the future and to help developing Carbon Capture and Storage/Utilisation chains

Oiltanking Is one of the largest independent operators of tank terminals for oils, gases and chemicals worldwide. As Oiltanking we want to ensure "peace of mind in liquid storage logistics" going forward. This peace of mind should extend to all stakeholders. As a quality service provider, we focus on our customers' needs by providing innovative solutions, responsibly and safely.

Participatie Maatschappij Vlaanderen is a government-owned investment company that aquires stakes in the companies considered strategic by the Flemish government. It provides risk capital for companies at an early stage of development that speed up the transition to the circular economy.

Port of Antwerp is a public authority and above all an active landlord for the port area. Energy transition is in the heart of our sustainability mission. As a community builder and innovation partner, we commit to boosting transition. A Home port as a lever for a sustainable future!

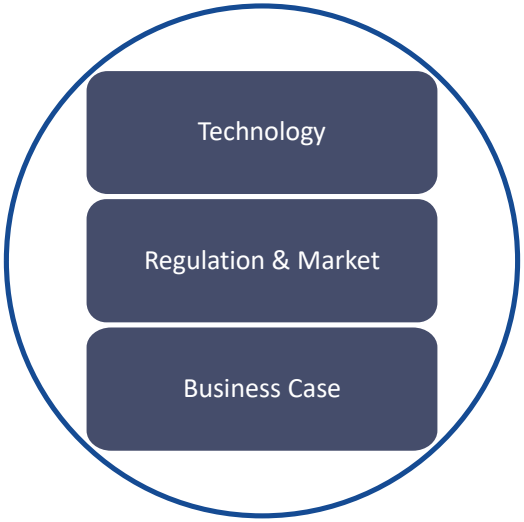
Main demonstration purposes

The Power to Methanol Antwerp project shows very concretely and innovatively the importance of industrial symbiosis to let the energy transition succeed

Solar and wind energy is not always available where & when we need it

Technological project on H2-carrier (MeOH) production

→ Matching process efficiency with the variability in RE



Showcase for CCU-molecules

→ As a RED II(I) RFNBO project

→ Important circular feedstock for our (chemical) industry

Flexibility can contribute to feasibility

→ Play on electricity market dynamics, implement by-product H2 and develop optimal operational strategy

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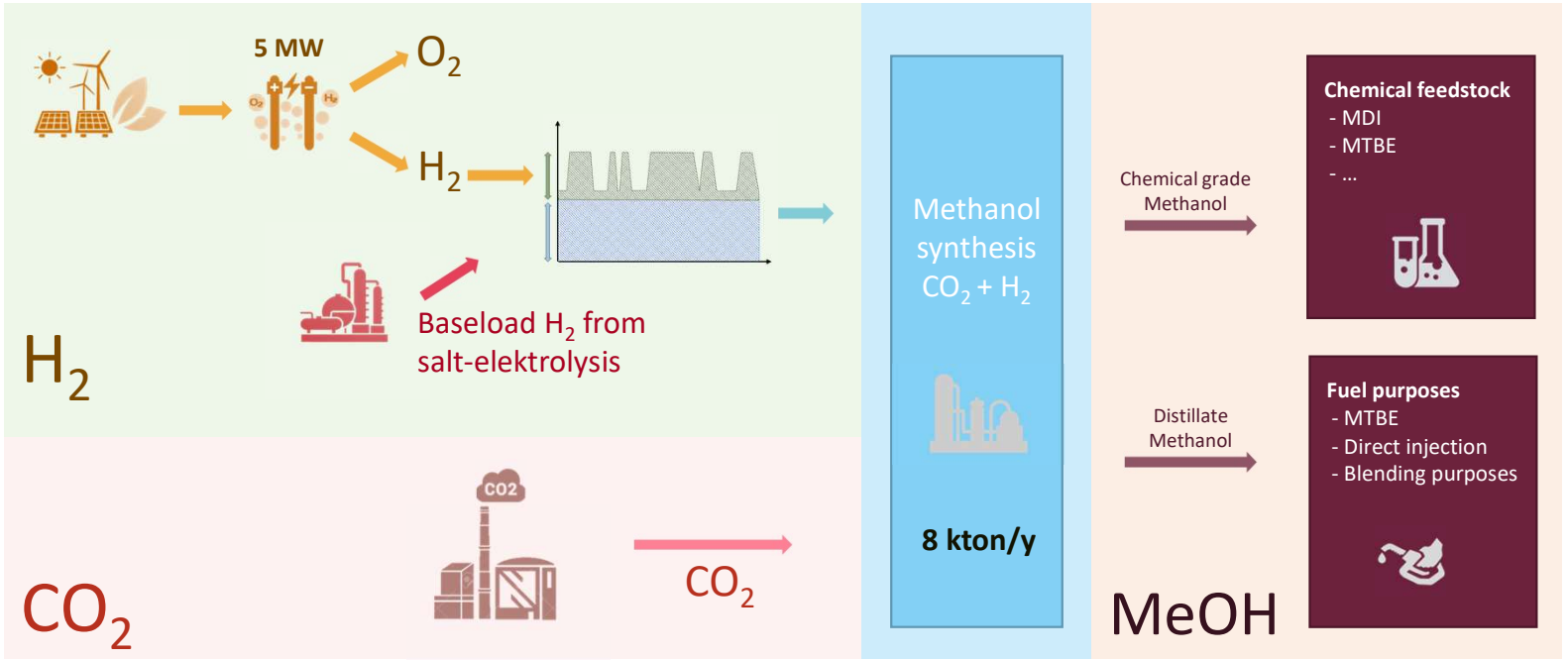
High level concept

The concept is based on a high level of flexibility, both in feedstock intake, process capacity and output. This combination is the focal point and the strength of the project.



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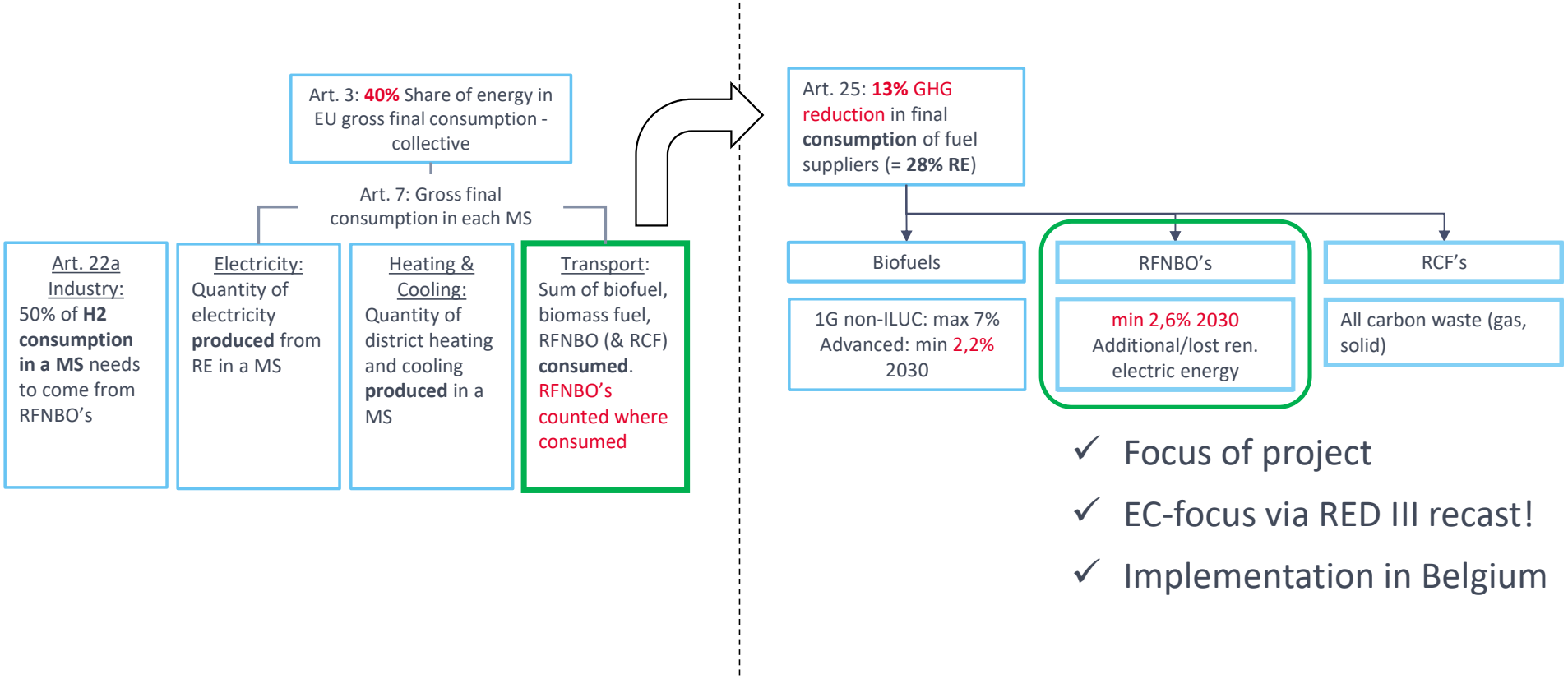
The fuel route - relevant RED II(I) framework

"In a RED II(I) market, the project will focus on the production of 'renewable fuels of non biological origin'."



- ✓ Focus of project
- ✓ EC-focus via RED III recast!
- ✓ Implementation in Belgium

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Timeline & Milestones

2019
Initial studies
Market analysis
Risk analysis
Site selection

2020
Start SPV with 7 partners
Power To Methanol Antwerp BV
Engineering study

2021
Final Investment Decision

- Technology
- Regulation & Market
- Business Case

2022
Construction

2023
Commissioning
Production renewable methanol

Hydrogen Import Coalition

We have gathered industrial actors in a coalition °2019

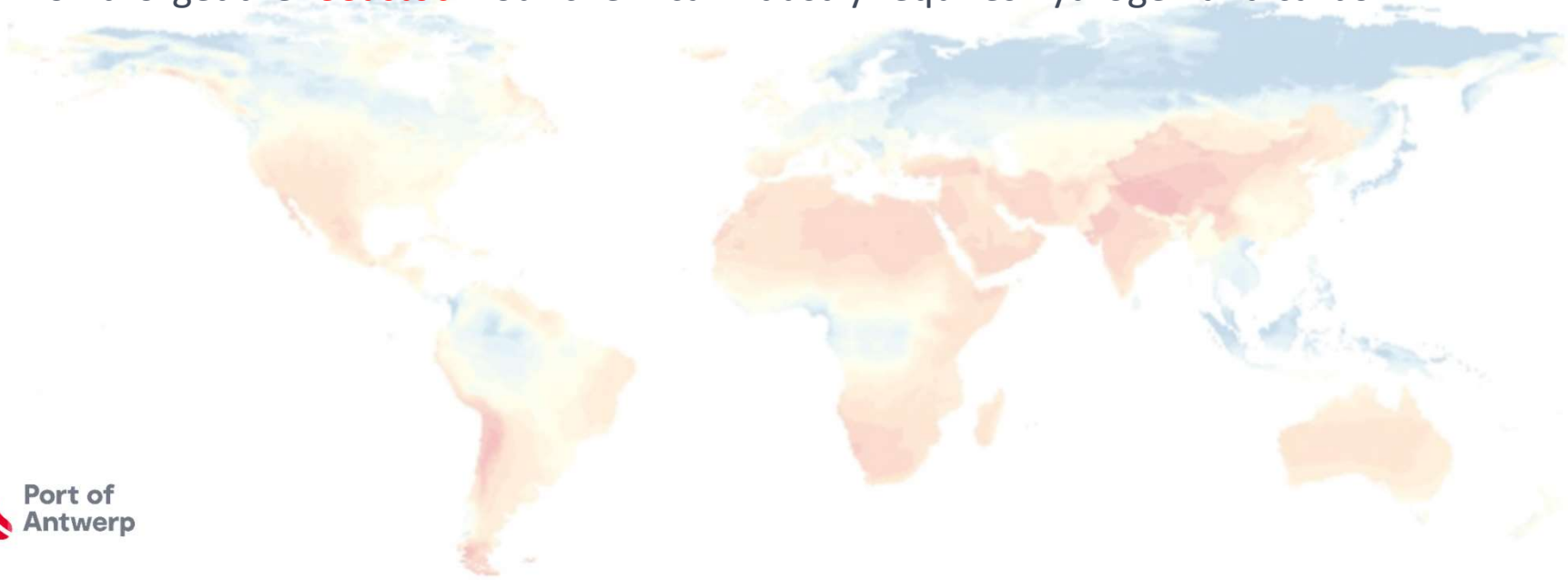
DEME ENGIE EXMAR fluxys Port of Antwerp PORT OF ZEEBRUGGE WaterstofNet

Why we need to import

Large scale, cost effective solar and wind energy will be the cornerstone of a carbon neutral economy.

Renewable energy will be produced locally as well as imported, because

- Solar and wind energy is not always available where we need it
- Solar and wind energy is not always available when we need it
- Electricity is not always the most appropriate energy form
- Don't forget the feedstock: our chemical industry requires hydrogen and carbon



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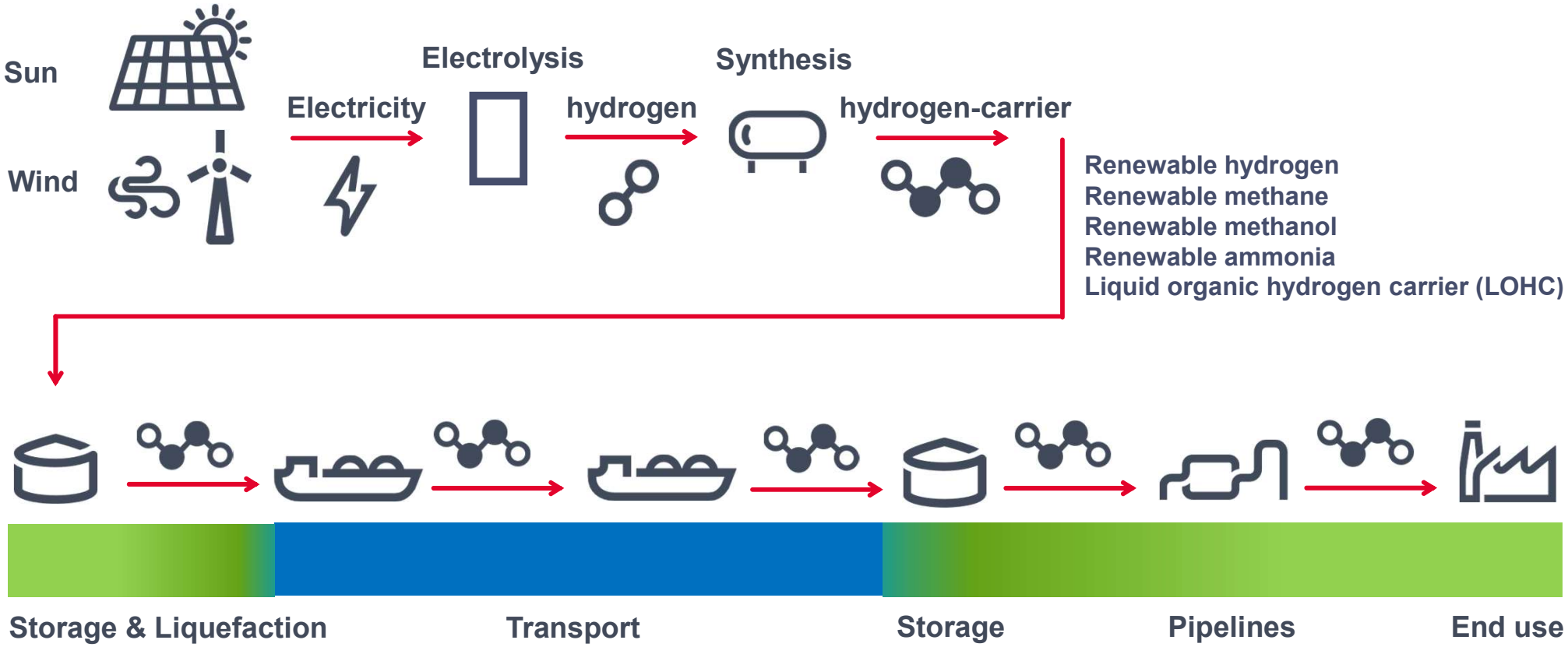
Renewable molecules – green hydrogen value chain

From remote wind and sun to end-user market

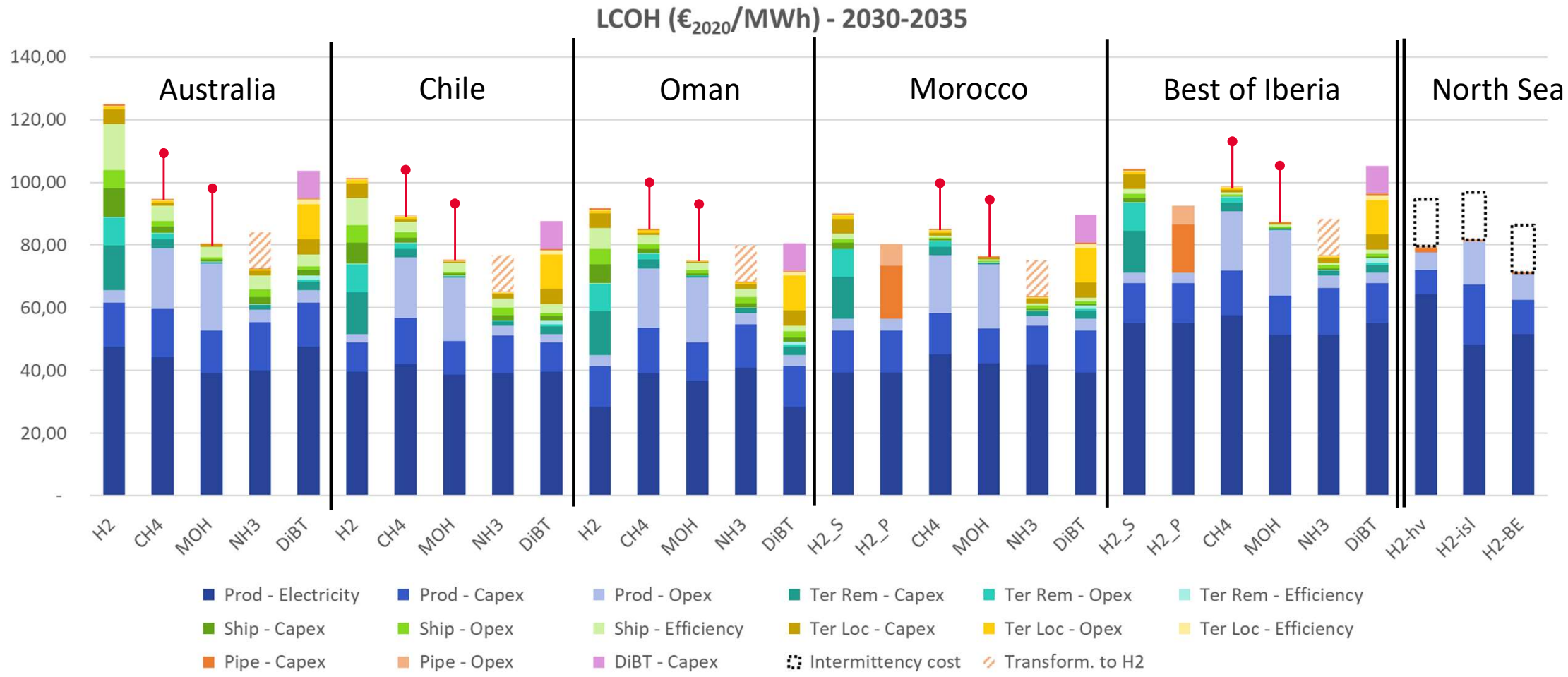


Locations and shipping routes

A representative sample of possible regions providing low cost renewable energy

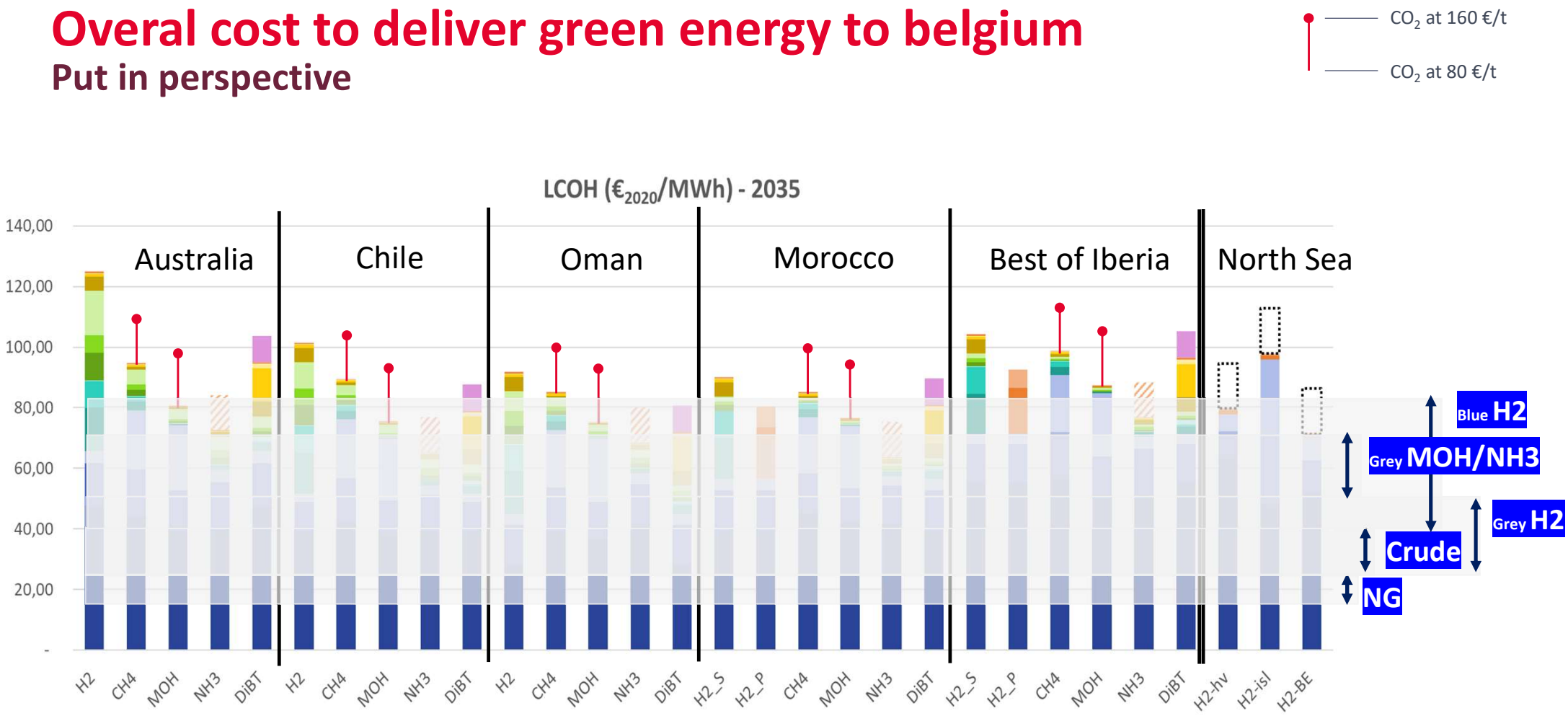
Overall cost to deliver green energy to Belgium

Feasible cost levels achievable within a decade from now



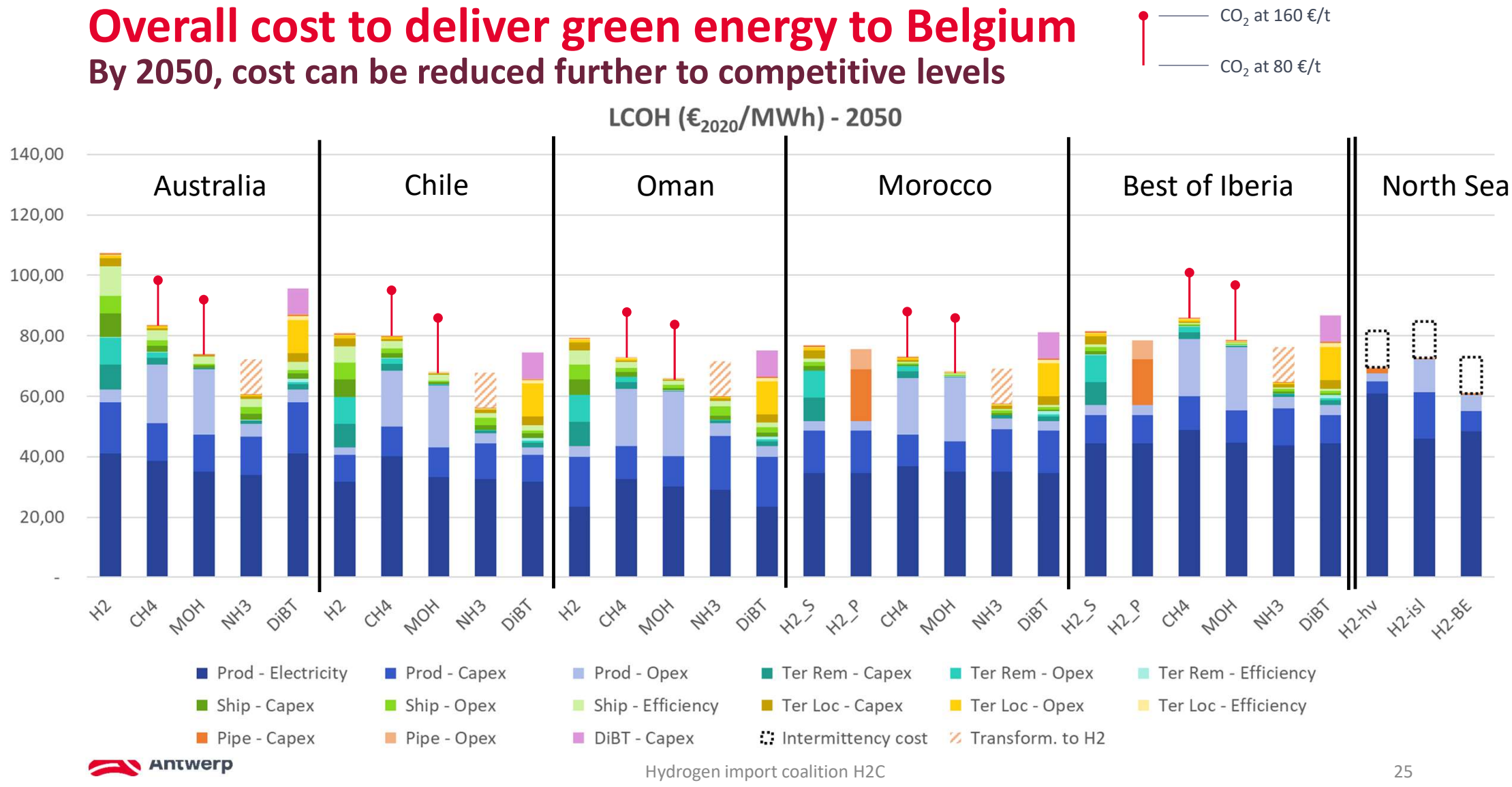
Overal cost to deliver green energy to belgium

Put in perspective



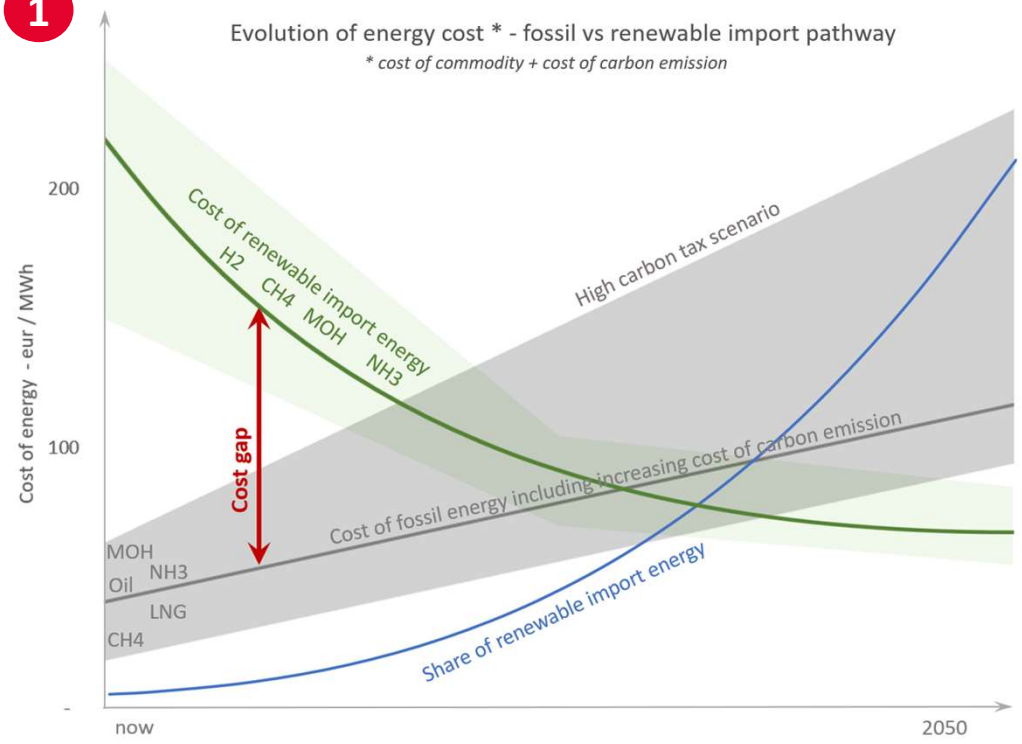
Overall cost to deliver green energy to Belgium

By 2050, cost can be reduced further to competitive levels



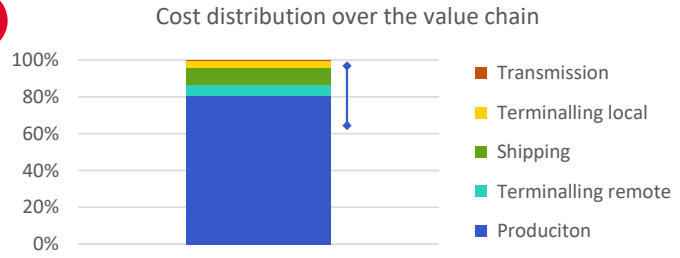
General conclusions of the study

1



The renewable import pathway will become competitive on the longer term thanks to significant cost reduction potential. ➔ Financial incentives are required on the short term in order to support industrial scale up.

2



Renewable electricity accounts for the vast majority of the overall molecule cost : 60%-95% depending on the scenario ➔ Preference for production locations with low LCOE

3

No silver bullet: no clear winner scenario. Market demand (Use case scenarios) will strongly influence the outcome. ➔ multiple carriers and locations remain feasible

Renewable (e-)fuels applications

Applications

Analysis of use case economics - renewable vs fossil

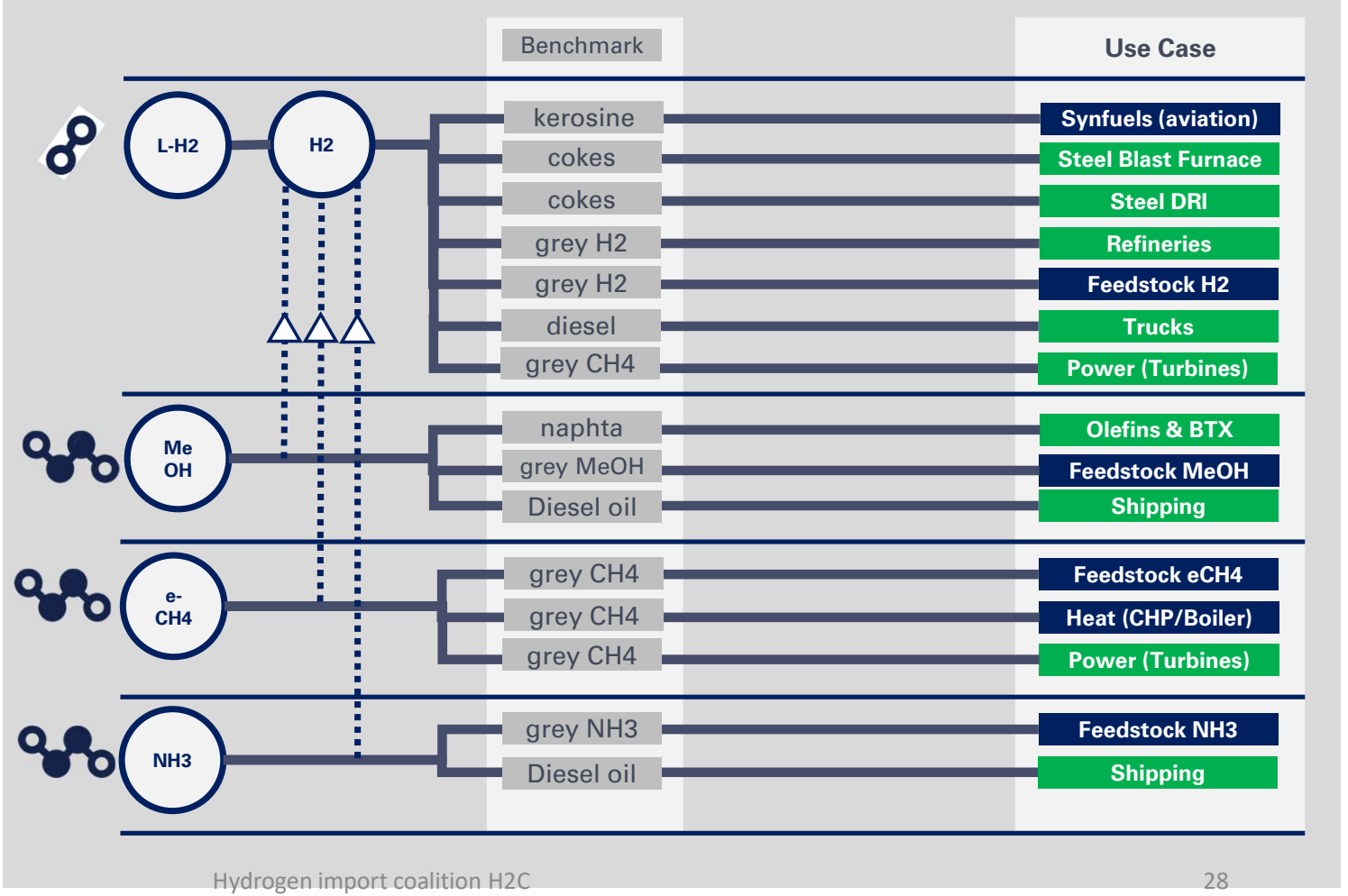
INDUSTRIAL USE CASES OF H2 CARRIERS

Feedstock
– new processes (capital inv.)
– direct replacement

Heat
– medium grade (100-500°C)
– high grade (>500°C)

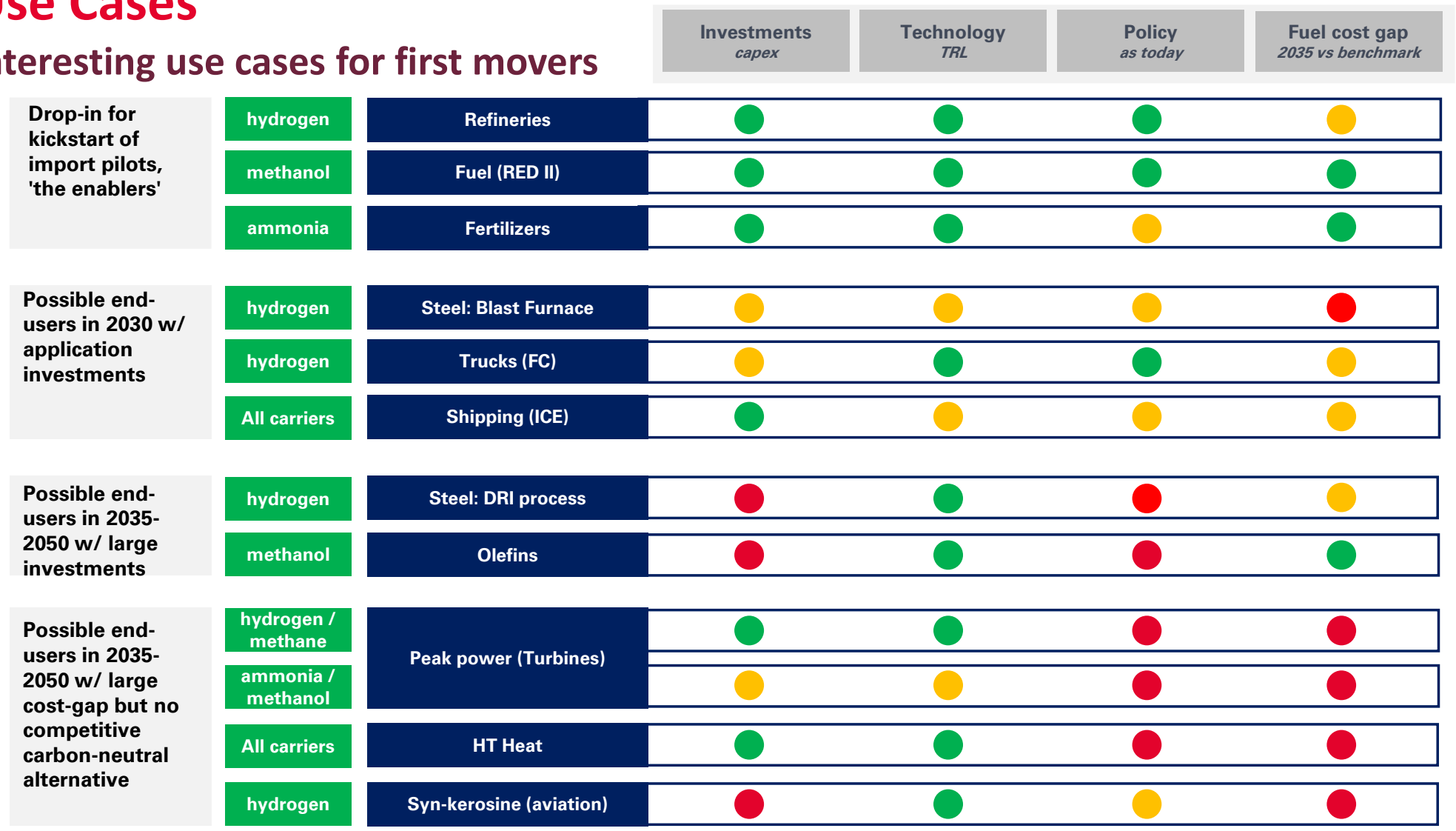
Power

Transport



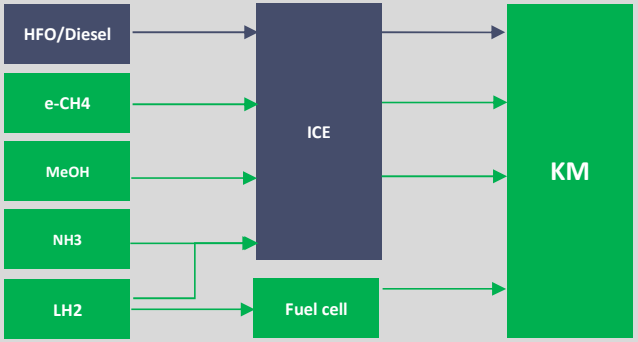
Use Cases

Interesting use cases for first movers



Use case **ICE (for shipping)**

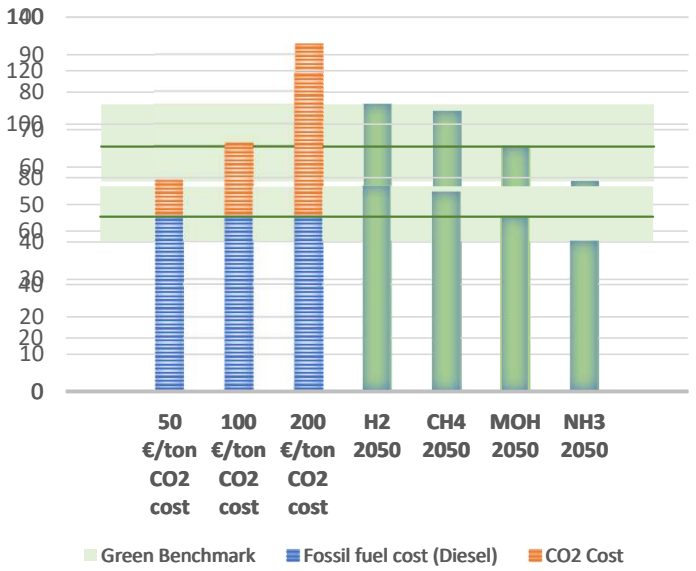
For engines there are different fuel options:



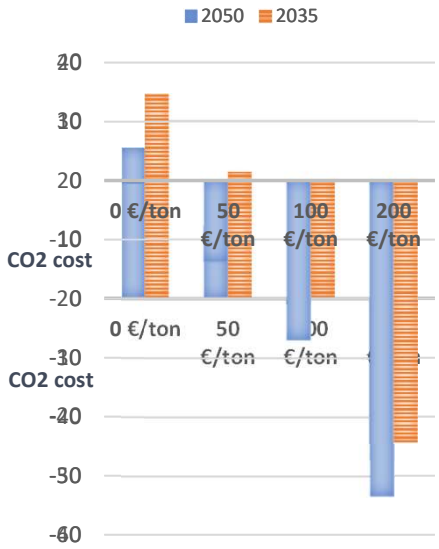
Storage of LH2/e-CH4 as cryogenic liquid or NH3/MeOH as a liquid.
Maritime transport seems promising market for alternative ICE's
Storage volume required in relation to required autonomy is critical.
MeOH or NH3 beneficial
Interest for NH3 as fuel in recent studies: lowest cost, no CO2, no cryogenic storage needed. But toxicity is still a point of environmental concern.

- **Volume potential:** large
- **Timing:** First demo's in operation
  Slow volume increase; different fuels in parallel?
- **Decarbonisation alternatives:** Biofuel

Fuel cost-gap for ICE (€/MWh of fuel)



Cost gap (€/MWh)



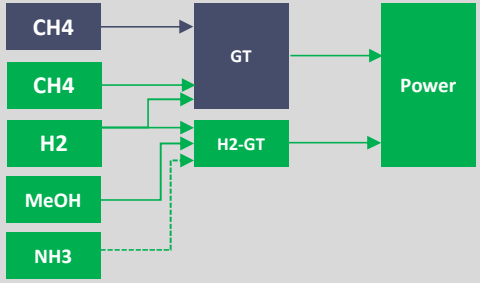
Investments		**Large investment** for LH2 (storage HRS) but relatively small compared to full ship cost **Limited investments** for MeOH & NH3
Fuel cost-gap		**Increasing fossil fuel prices**
Policy		**Medium push** IMO agreement 50% CO2 reduction in 2050. Shipping in ETS
Technological		**TRL: 9** for e-CH4/MeOH **TRL: 7** for LH2 **Low TRL** for NH3 (combustion engine)

Conclusions

- **CO2 abatement via replacement of HFO/Diesel by H2 is not (yet) very cost-efficient under present CO2 prices**
- **NH3 is considered very promising for maritime ICE, LH2 will require advances in storage technology**
- **Policy support for CO2 reduction in shipping is increasing (IMO agreement & inclusion in ETS)**

Use case **Gasturbines** (O/CCGT)

Besides renewable energy production there is a need for back-up power to fill in the gaps in the future. Gas turbines could play a role, where renewable energy based fuels could make production carbon neutral. For power production in Gas Turbines (OCGT & CCGT) there are different fuel options:

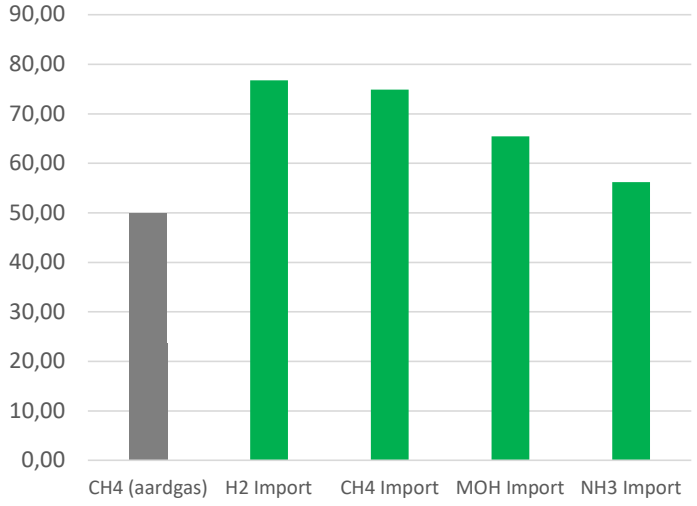


Admixture, in a flexible amount, in existing gas turbines is sometimes possible (up to 30%), or at a limited conversion cost. The suppliers have the ambition to launch 100% H2 turbines by 2030, within the cost range of a classic CH4 turbine. Also MeOH and on a lower TRL level NH3 could be burned in these gasturbines.

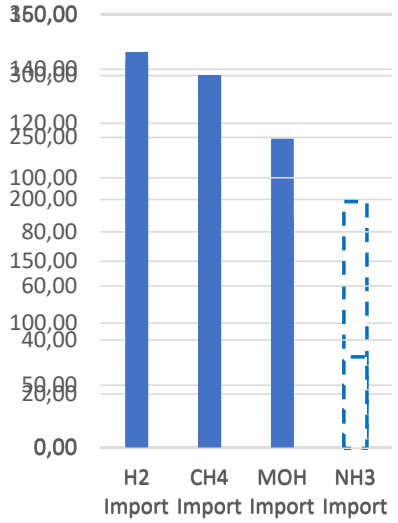
- **Volume potential:** unclear role for gasplants in future energymix. From mainly balancing grid and peak power to baseload capacity
- **Timing:** 2030: 100% H2 turbine to be expected
- **Decarbonisation alternatives:** Batteries, Grid balancing through Power-to-X, Demand Side Response, CCS, Bio-methane (volume?)

Fuel Cost for Gasturbine (€/MWh fuel)

note: 2050 import costs VS current fossil gas price



ETS cost for cost parity with CH4 fuel (€/ton, 2050)



Investments		**Small investment for H2 (or MeOH):** adaptation existing GT or cost-gap new GT (unclear for NH3 turbine) **No investment/drop-in for e-CH4 or admixture**
Fuel cost-gap		**Increasing fossil fuel prices**
Policy		**Small push** ETS cost (large CO2 cost needed to bridge the gap) & (small) role in EU hydrogen strategy
Technological		**TRL:** 5 (H2/MeOH) & 9 (admixture 30% H2) **TRL:** 3-4 (NH3) **TRL:** 9 (e-CH4)

Conclusions

- **Limited extra investments for conversion and new available hydrogen(carrier) ready turbines.**
- **Fuel cost-gap is large, however possibilities with high ETS cost & high gas prices**
- **Role for gasplants is unclear: from peak power OCGT (<1.000h) to baseload capacity.**
- **Target for 100% climate neutral electricity needed (+subsidies).**

Conclusions

Port of Antwerp

Conclusions

- **Carbon-neutral, affordable and secure energy** is vital for our port cluster & our whole society
- It is important to approach the energy transition from the **complete value chain**, to identify different valuable possibilities. It will not be a single solution.
- Focus on **3 complementary pillars**
- **Invest**(igate) now in concrete technologies and infrastructure to enable the transition
- Public-private partnerships and funding will be needed to combine expertise and enable the transition **together**

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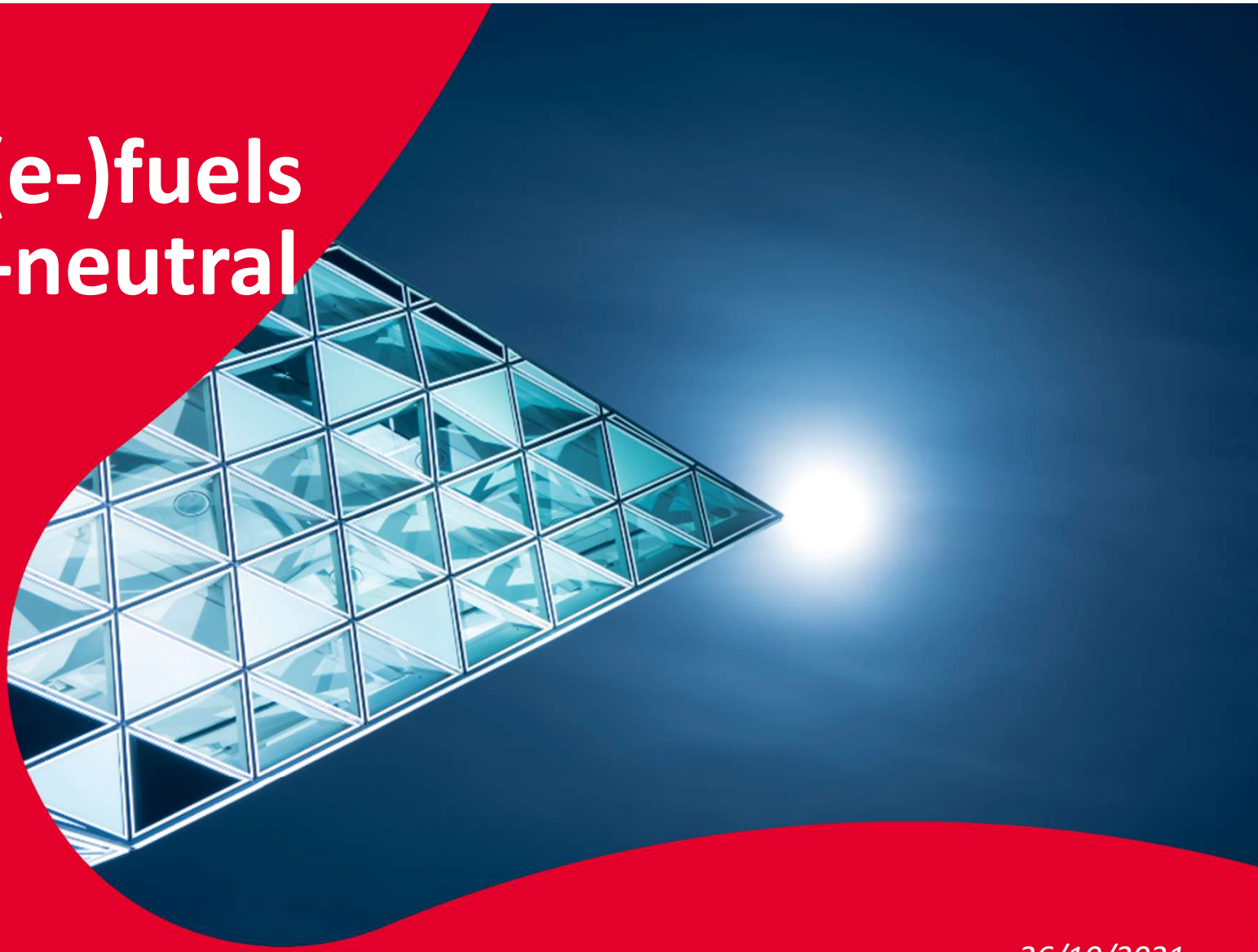
The role of (e-)fuels in a climate-neutral future



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