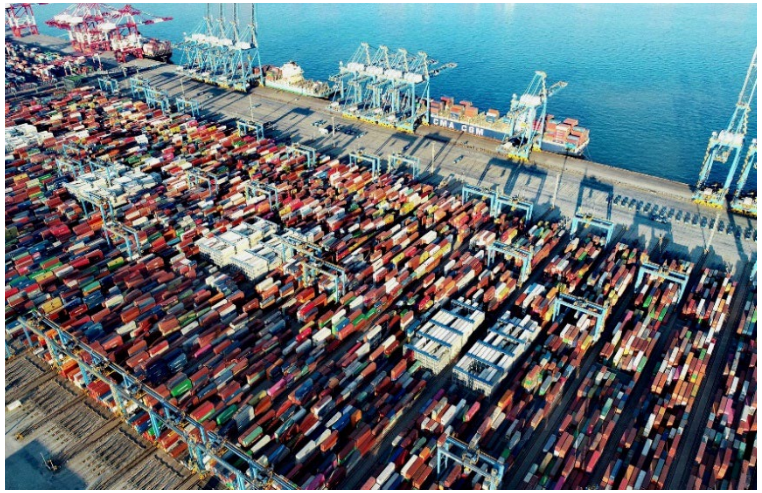

ASSESSING THE DECARBONATION POTENTIAL OF METHANOL & AMMONIA FOR MARITIME TRANSPORTATION

Maxime LUCAS, IFP Energies Nouvelles – Pau Motors Festival 28/04/2025

STUDY BY IFP ENERGIES NOUVELLES

M. LUCAS, O. GUYON, X. GUICHET, M. MARICAR-PICHON

COMMISSIONED BY CMA CGM

2025

IMO APPROVES HISTORIC NET-ZERO REGULATIONS FOR GLOBAL SHIPPING (APRIL 2025)

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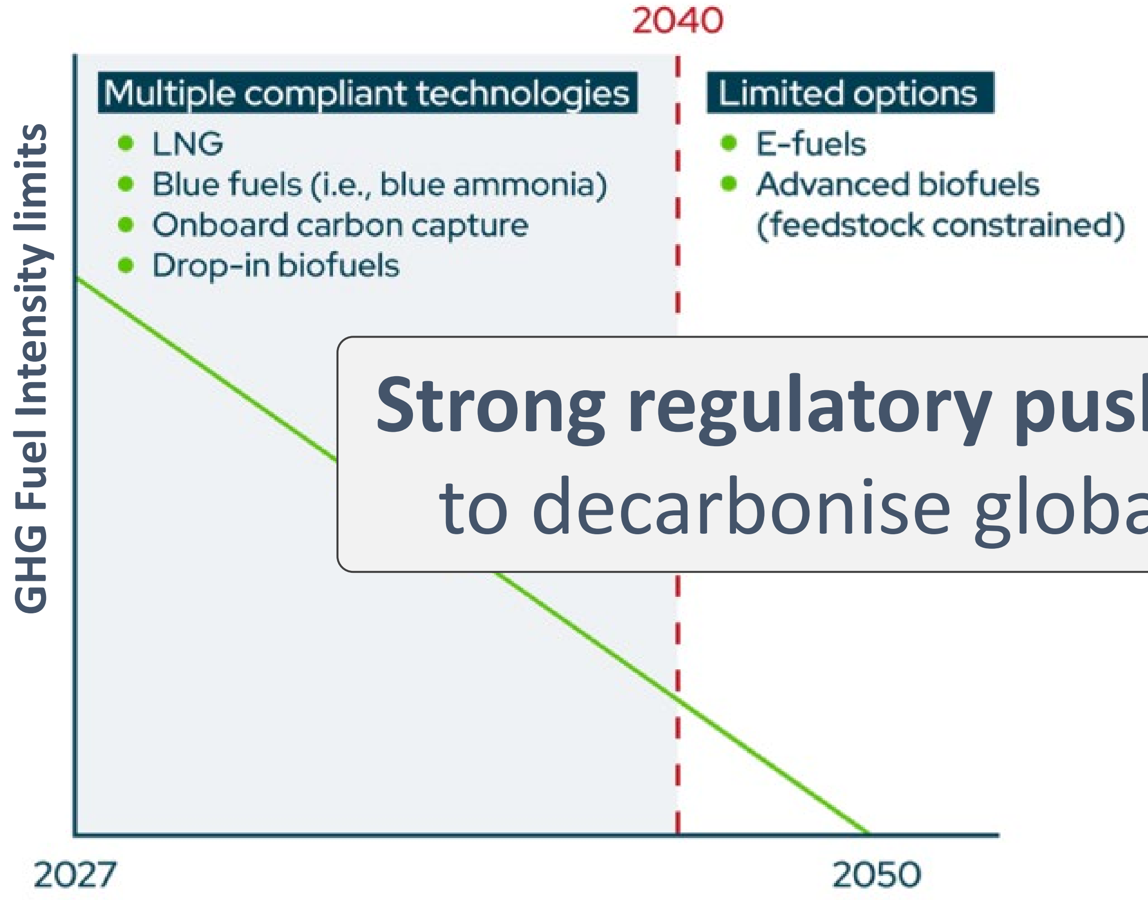
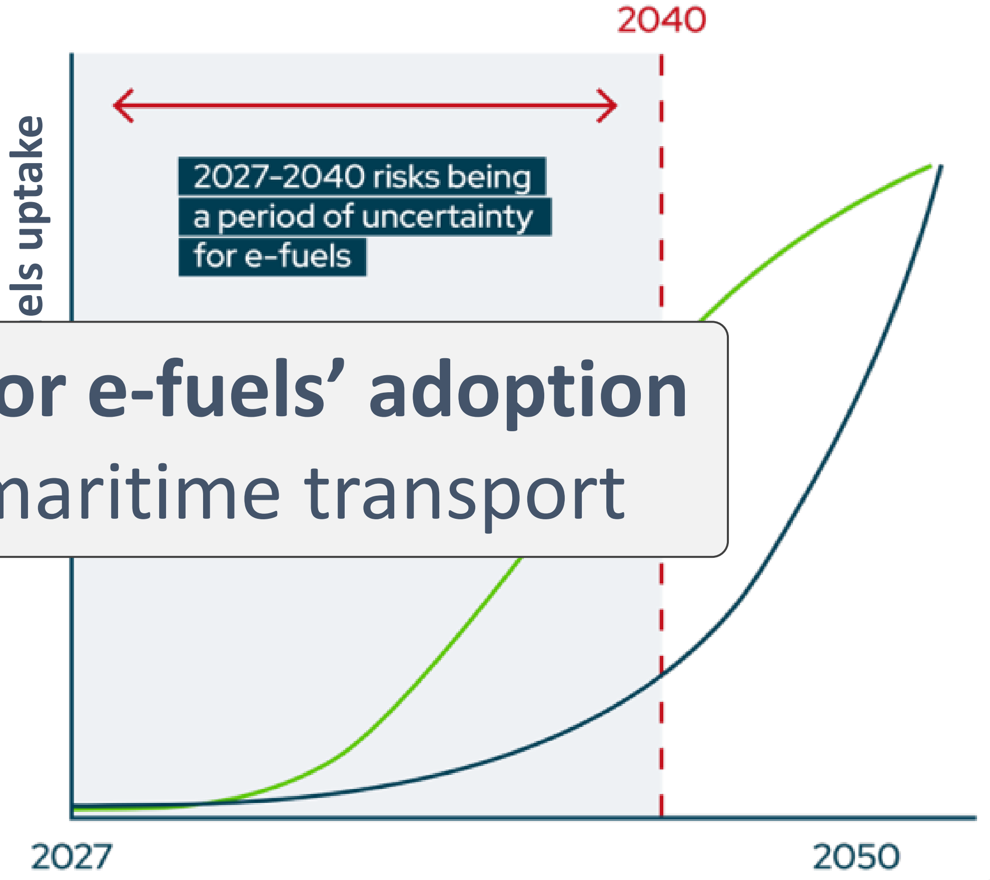
Mobilité durable

Increasing requirements on greenhouse gas (GHG) fuel intensity,

in combination with a **pricing and reward mechanism** create certainty, ensure e-fuels are cost-competitive, and reduce investment risks





Strong regulatory push for e-fuels' adoption
to decarbonise global maritime transport

Credit: adapted from Global Maritime Forum

~80 LARGE SCALE E-FUEL PROJECTS (>200 KTOE) AROUND THE WORLD (2024)

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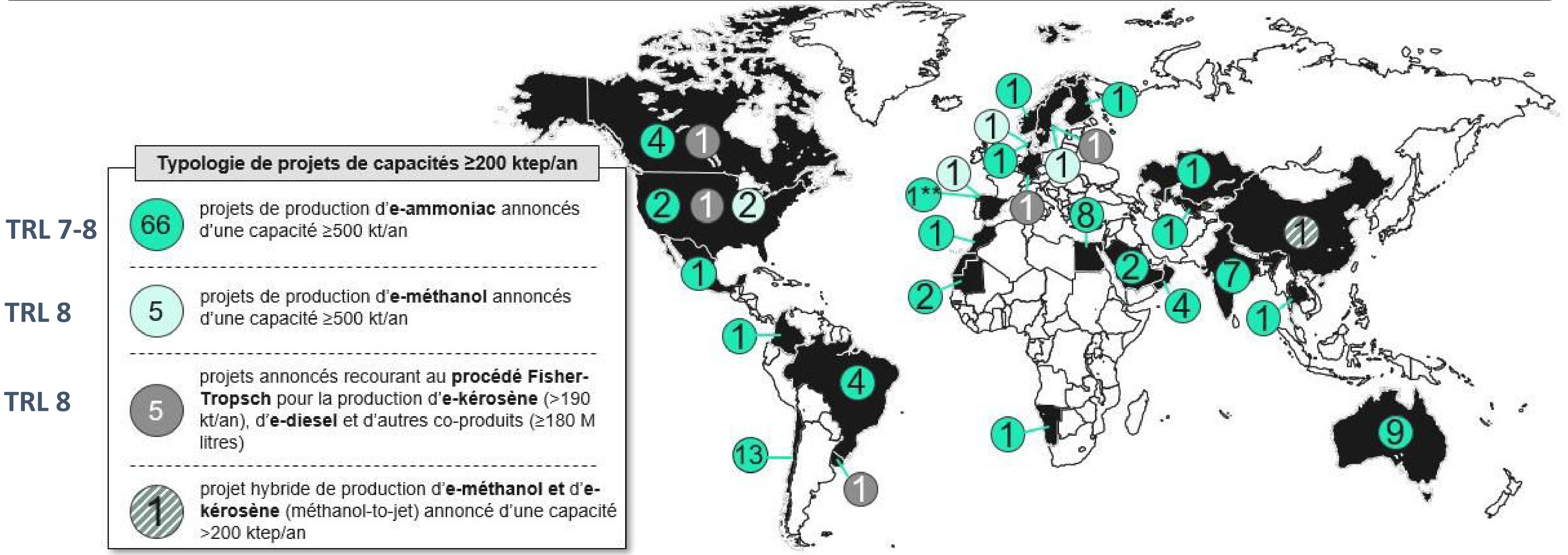
- **E-ammonia** projects mainly **driven by consuming countries**, for fertilizers production and H2 transportation
- **E-methanol** projects mainly **driven by consumer areas**, that have an advantage in mobilizing carbon capture



Credit: Sia partners – Observatoire des e-fuels – Edition 2024

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LCA STUDY COMMISSIONED BY AND CONDUCTED FOR CMA CGM

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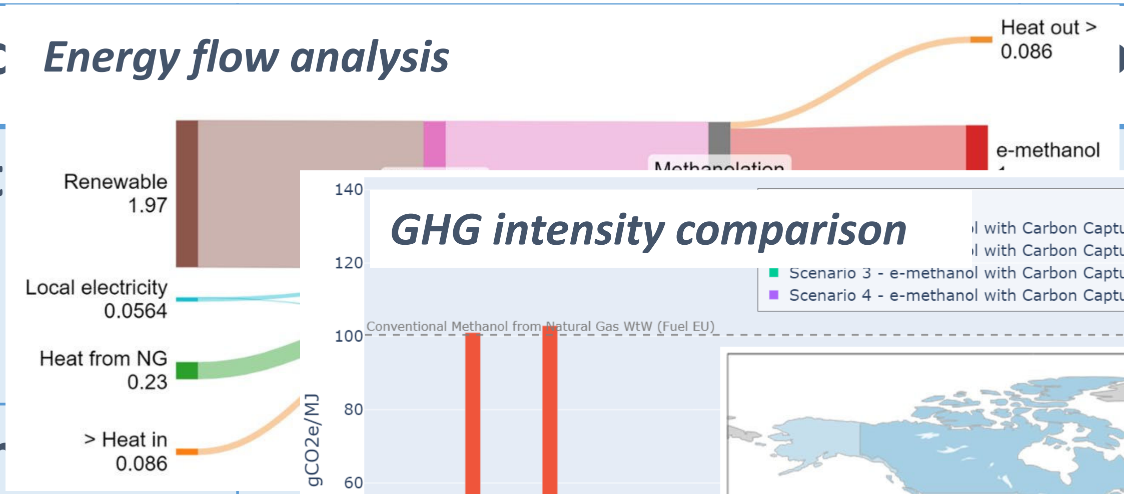
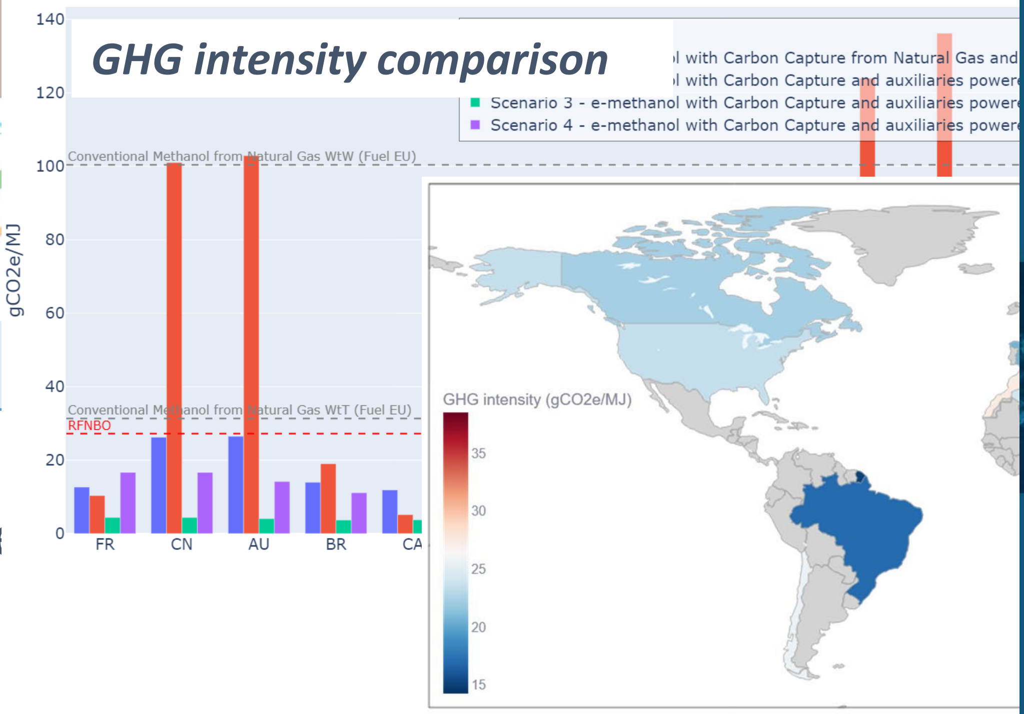
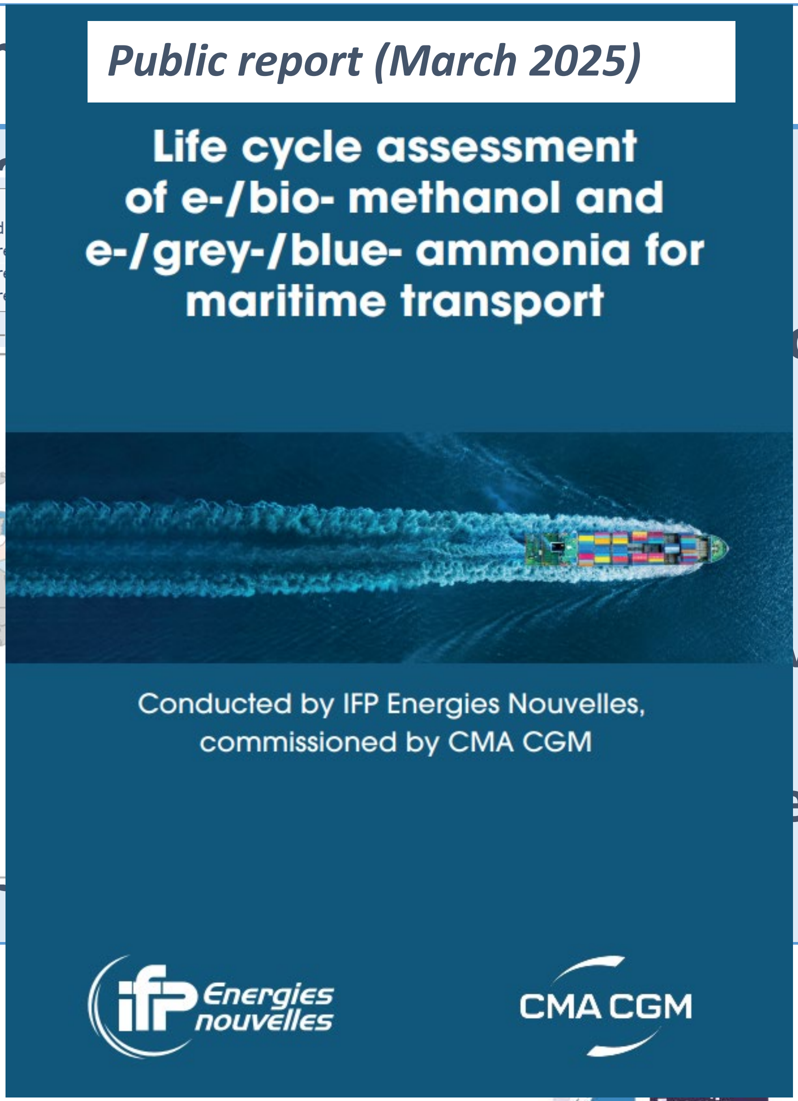
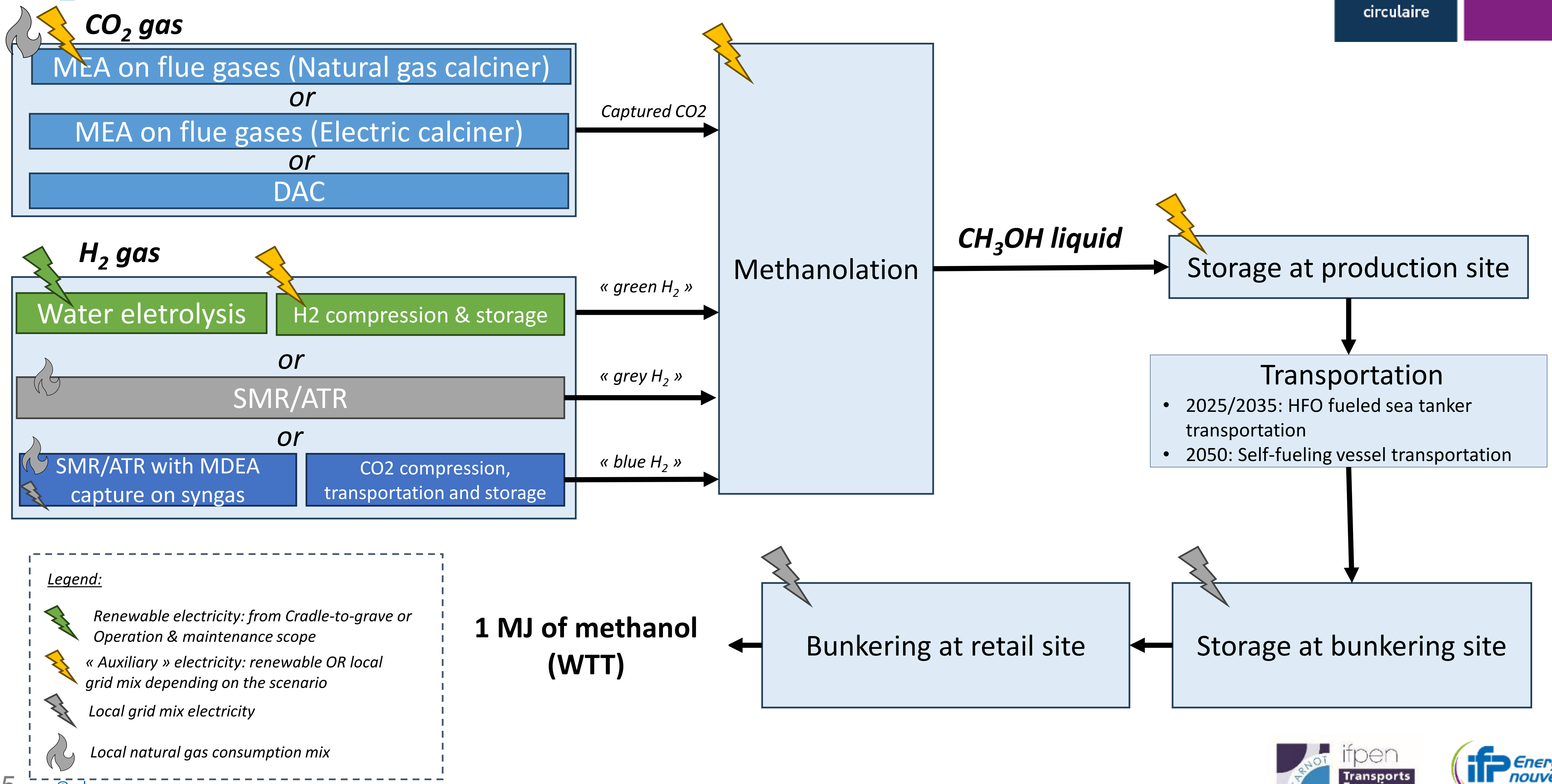






E-METHANOL VIA METHANOLATION



PROBABILISTIC METHANOL WELL-TO-WAKE GHG INTENSITY

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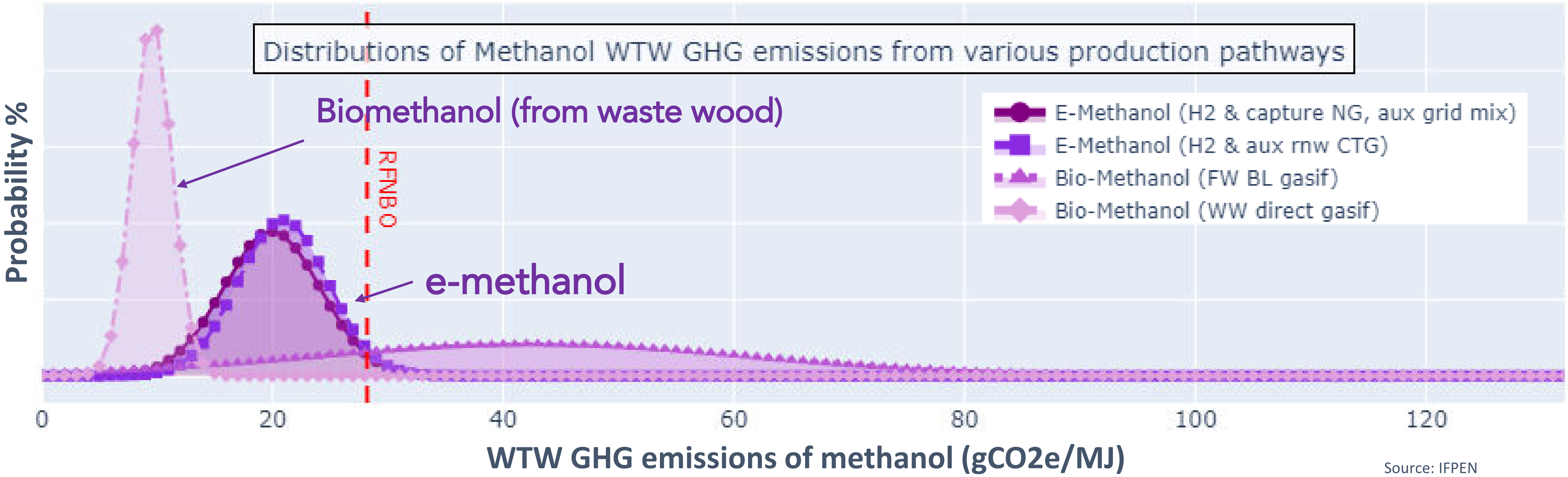
Mobilité durable



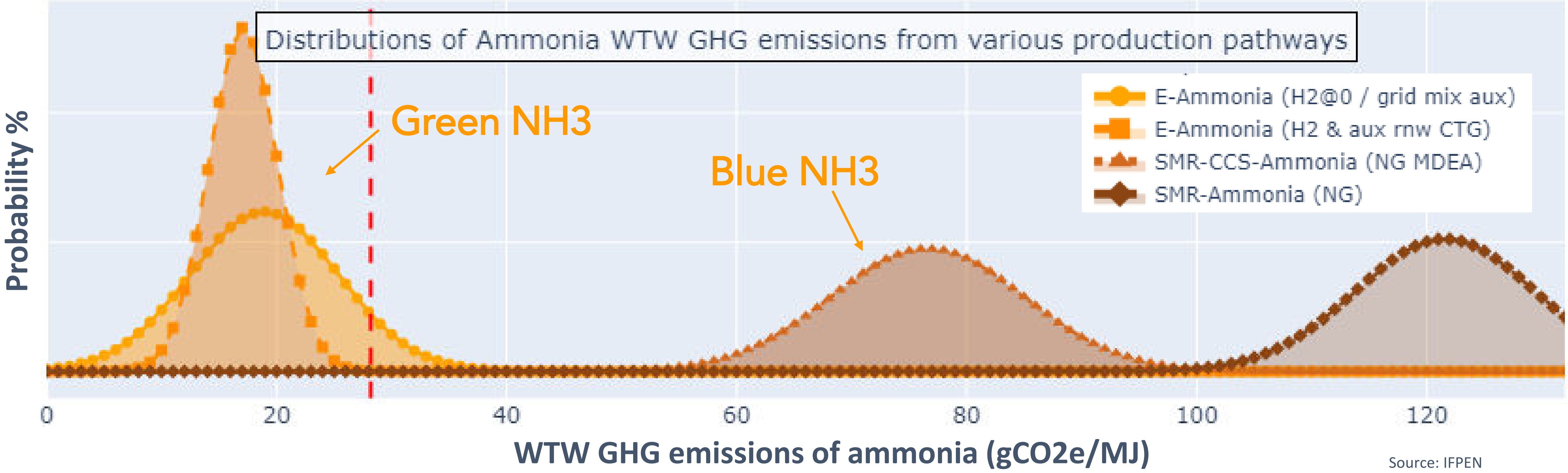
Source: IFPEN

Mean value for **E-methanol ~20 gCO2e/MJ (-79% RED ref.)**
Mean value for **Bio-methanol ~10 gCO2e/MJ (-90% RED ref.)**

PROBABILISTIC AMMONIA WELL-TO-WAKE GHG INTENSITY

Climat, Environnement et Économie circulaire

Mobilité durable



Source: IFPEN

Mean value for **E-ammonia ~18 gCO2e/MJ (-81% RED ref.)**
Mean value for **Blue-ammonia ~75 gCO2e/MJ (-20% RED ref.)**

COMPARISON OF AMMONIA, METHANOL AND VLSFO TRANSPORTATION WORK

Climat, Environnement et Économie circulaire

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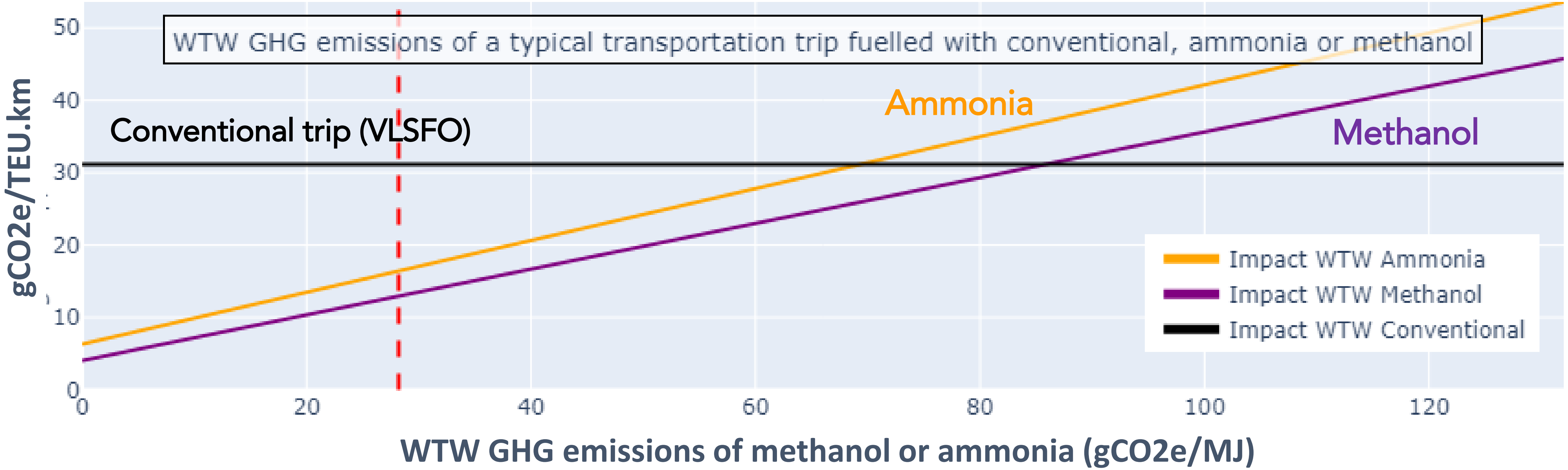

For a given fuel emission factor (x-axis), transportation work with **NH3 is more GHG intensive** (y-axis) than with Methanol due to

- **Lower engine efficiency** (i.e. more energy consumed per unit of output power), partly due to a non-optimized engine size and architecture).
- Higher needs of (fossil VLSFO) **pilot fuel consumption** to ignite the combustion
- **N_2O emissions**, a powerful greenhouse gas

➔ Engine development, ship architecture, and including a PTO to reduce N2O will improve the overall picture.

COMPARISON OF AMMONIA, METHANOL AND VLSFO CONTAINER TRANSPORTATION WORK

Climat, Environnement et Économie circulaire

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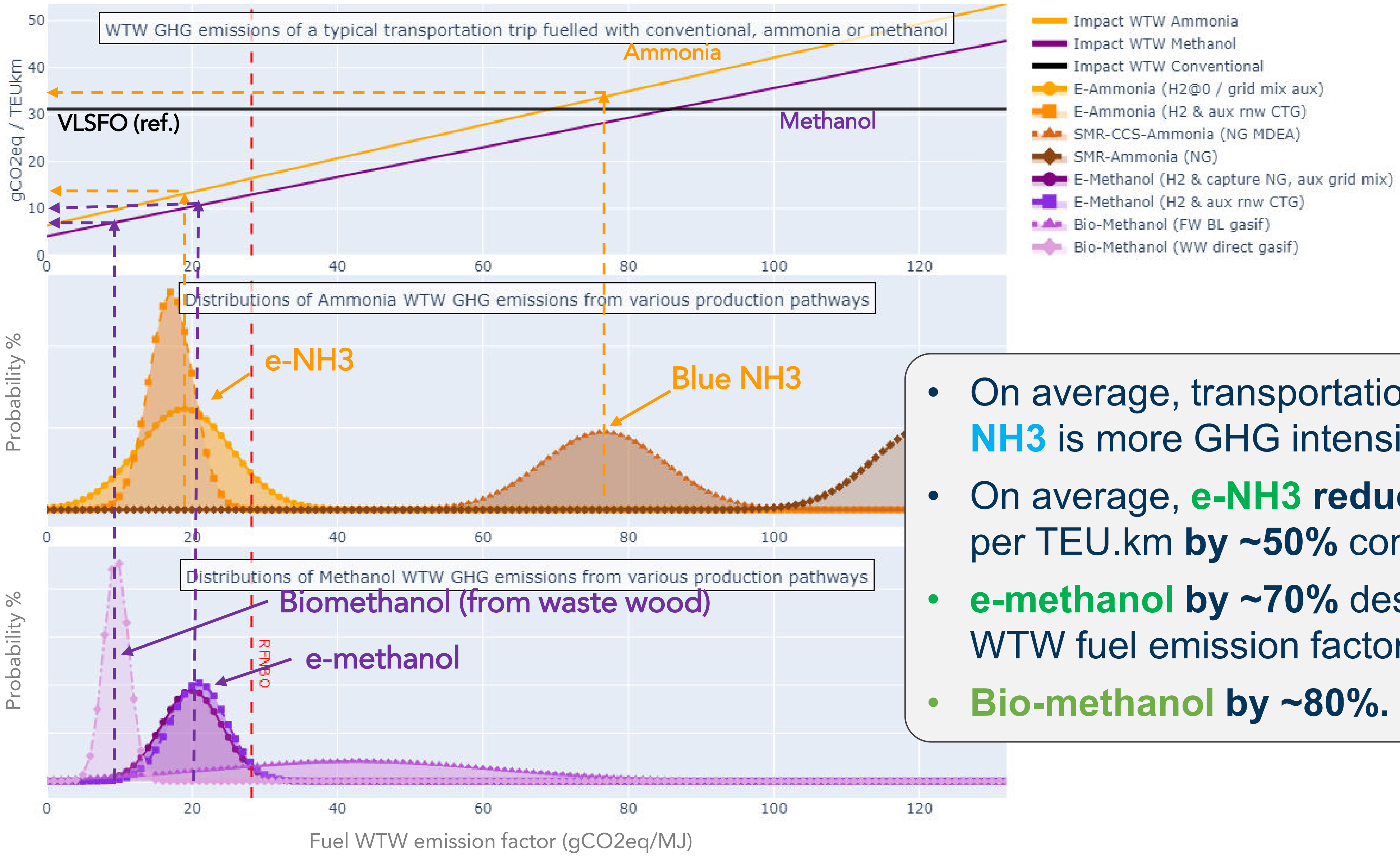

- On average, transportation work with **blue NH3** is more GHG intensive **than VLSFO**
- On average, **e-NH3 reduces GHG emissions** per TEU.km **by ~50%** compared to VLSFO.
- **e-methanol by ~70%** despite slightly higher WTW fuel emission factor than NH3.
- **Bio-methanol by ~80%.**

Source: IFPEN

PROSPECTIVE ASSESSMENT METHODOLOGY

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	Today	2035	2050
Electricity			
PV efficiency	19%	23%	23%
Methanolation unit configuration	S4 (renewable CTG for H2 & capture)	S4 (renewable CTG for H2 & capture)	S4 (renewable CTG for H2 & capture)
Transportation & conditioning			
Type and source of energy for transportation	HFO (ship)	HFO (Ship)	E-methanol (Ship)

Technological evolutions assumptions

Parameterized life cycle inventory:
- Renewable load factors,
- share of wind/solar,
- electrolyzer efficiency,
- …

Foreground data

Ecoinvent database (v3.9.1)

ecoinvent

Background data

Prospective GHG assessment of the fuels produced in 2025, 2035 and 2050

Coupled with Integrated Assessment Model:
REMIND - SSP2-NDC

premise

PIK

Shared Socio-economic Pathways (SSP2) - MIDDLE OF THE ROAD
A scenario that represents a **continuation of current trends**, with some pro…
ene…
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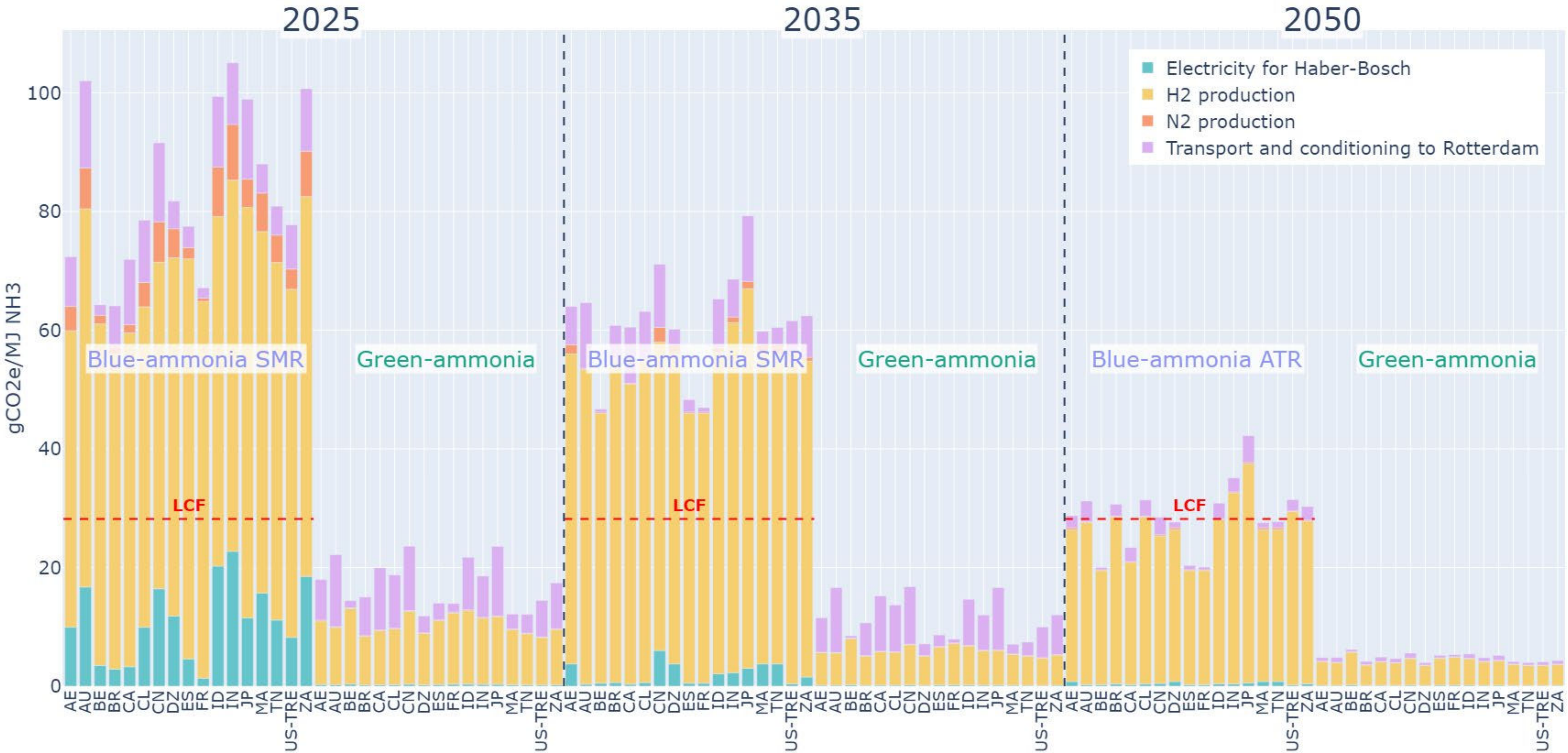
Global economy decarbonation assumptions

NATIONAL DETERMINED CONTRIBUTIONS
Nationally Determined Contributions, where individual **countries set emissions reduction targets in line with the Paris Agreement** to limit global warming to well below 2°C.

PROSPECTIVE GHG INTENSITY ASSESSMENT OF E- AND BLUE- AMMONIA



Source: IFPEN

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TAKE AWAY MESSAGES

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Regulations & methodologies

- With RED methodology, **e-fuels show a significant GHG reduction potential (~90% vs RED fossil reference).** Loopholes in this methodology, currently not accounting for the emissions related to renewables infrastructure**, lead to overoptimistic emissions reduction levels for e-fuels.**
- Considering the **Cradle-to-Grave scope,** they can achieve ~80% reduction potential **- still passing RFNBO threshold.**

GHG intensity of assessed fuels

Overall, **e-Ammonia and e-Methanol products have similar order of magnitude of WTW GHG results**. However, **lower ammonia engine efficiency results in higher overall WTW GHG emissions at transportation trip level.**

- **Blue-Ammonia** is **not fit for decarbonation.** It emits **more overall WTW GHG emissions per TEU.km than VLSFO**, on average. Even by 2050 under optimistic scenarios, blue NH3 only satisfies 70% threshold in 6 out of 17 considered locations due to large footprints when extracting methane.
- **E-Ammonia** is **fit for decarbonation ~50% GHG emissions savings** per TEU.km compared to VLSFO
- **E-Methanol** is **fit for decarbonation ~70% GHG emissions savings** per TEU.km compared to VLSFO

  … but it is hard to produce (requires capture of biogenic CO2).
- **Bio-Methanol** is **fit for decarbonation ~80% GHG emissions savings** per TEU.km compared to VLSFO

  … providing that it is produced with the appropriate bio-feedstock… and that it is available.

Innover les énergies

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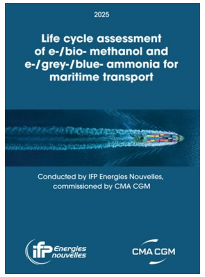

More at: https://www.ifpenergiesnouvelles.com/article/evaluation-alternative-marine-fuels-decarbonization-maritime-transport

Maxime.lucas@ifpen.fr

