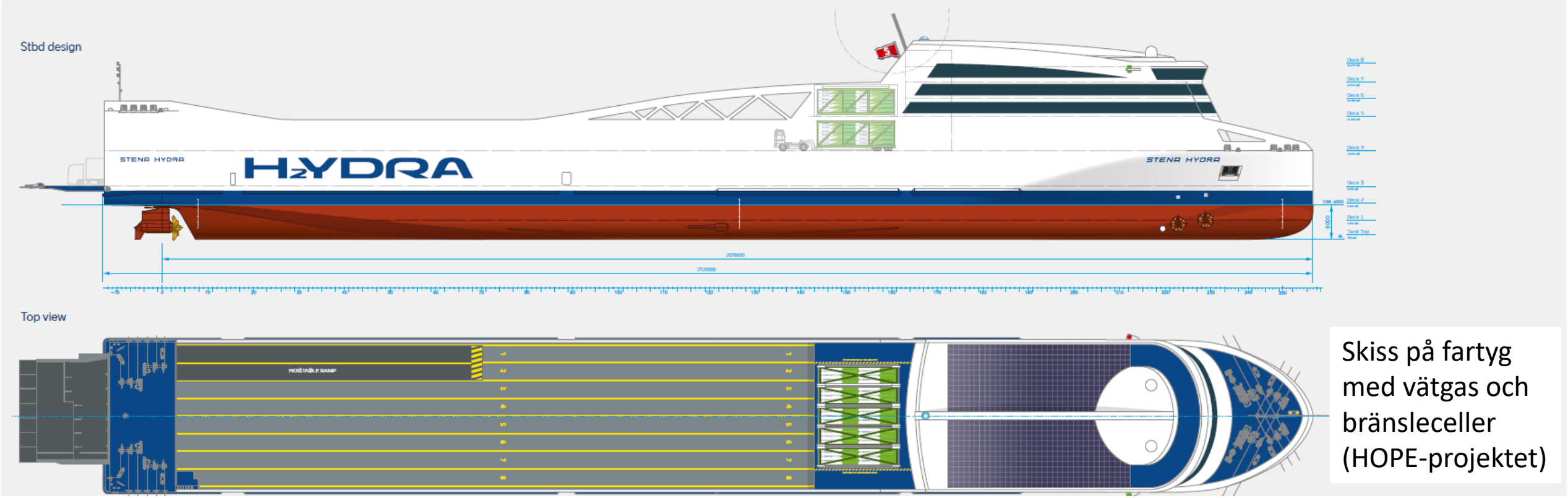
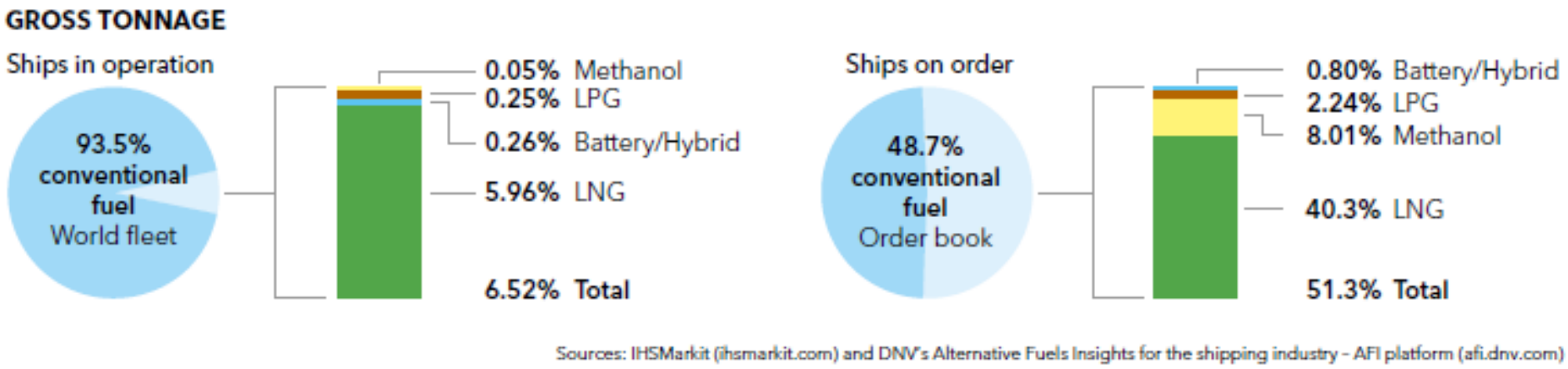


Skiss på fartyg med vätgas och bränsleceller (HOPE-projektet)

Förutsättningar för vätgas och elektrobränslen som marina bränslen

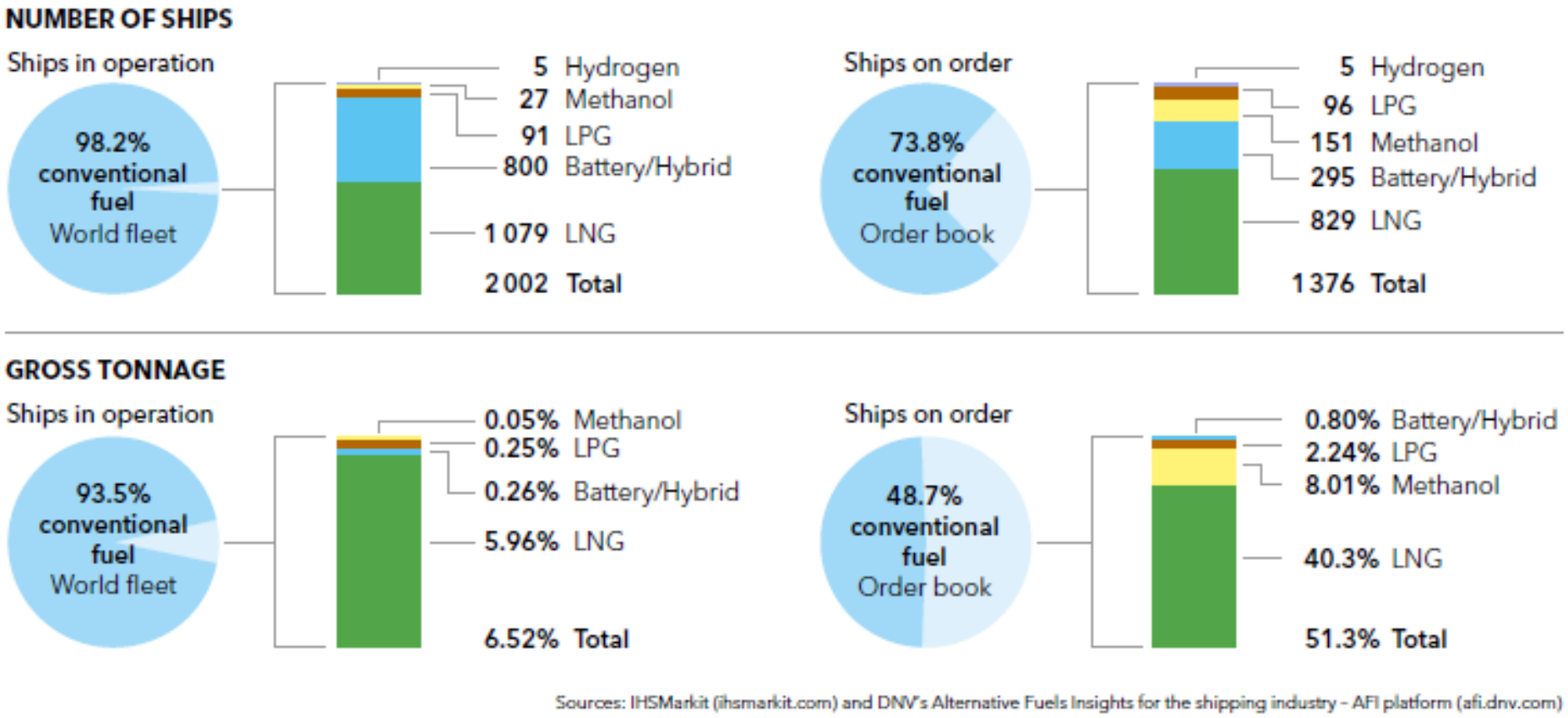
Julia Hansson, IVL Svenska Miljöinstitutet/Chalmers tekniska högskola

Global alternative marine fuels uptake (readiness) 2023



Source: DNV, 2023. DNV Energy Transition Outlook 2023 - Maritime forecast to 2050.

Global alternative marine fuels uptake (readiness) 2023



Source: DNV, 2023. DNV Energy Transition Outlook 2023 - Maritime forecast to 2050.

Future role of hydrogen and electrofuels for shipping depends on

- development of hydrogen-based solutions (cost, emissions etc)
- GHG emission performance
- expansion of low-carbon electricity generation
- availability of sustainable (marine) biofuels
- hydrogen demand in other sectors
- cost development of electrified options
- development of carbon capture & storage/CCS and bio-CCS
- **policies and details in the design**

Nordic Energy Research

HOPE - analyzing the potential role of marine hydrogen fuel cells solutions for regional shipping in the Nordic region

HOPE outlines and evaluates a concept design for a short sea shipping vessel using hydrogen and fuel cells for propulsion…

…including technical and cost aspects, barriers for and environmental impact of realization in the Nordics.

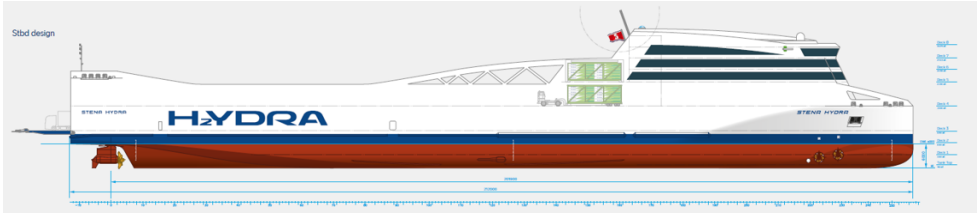
https://www.nordicenergy.org/project/hope/ + https://www.ivl.se/projektwebbar/hope.html

Funded by Nordic Energy Research, Danish EUDP, Business Finland, Swedish Transport Administration, Norwegian Research Council, Icelandic Research Center and in-kind from participating companies

Some findings from HOPE

Route and case vessel:
Gothenburg-Fredrikshavn, Ropax ship

- Hydrogen appears to be a cost-effective solution for reducing ship's GHG emissions, in some form *(liquified, compressed, ammonia or electrofuels)*, from a global long-term perspective.
- It seems *possible from a technical perspective* to use *hydrogen for a regional RORO-ROPAX vessel*, between the Nordic countries, even if electrification has advantages on certain routes.
- Hydrogen-based solutions for shipping is *not the lowest cost option for regional shipping*. Problems also for other options.
- *Primarily economic barriers* e.g., high costs, uncertainty and high risk.
- Availability of hydrogen/electrofuels for shipping uncertain



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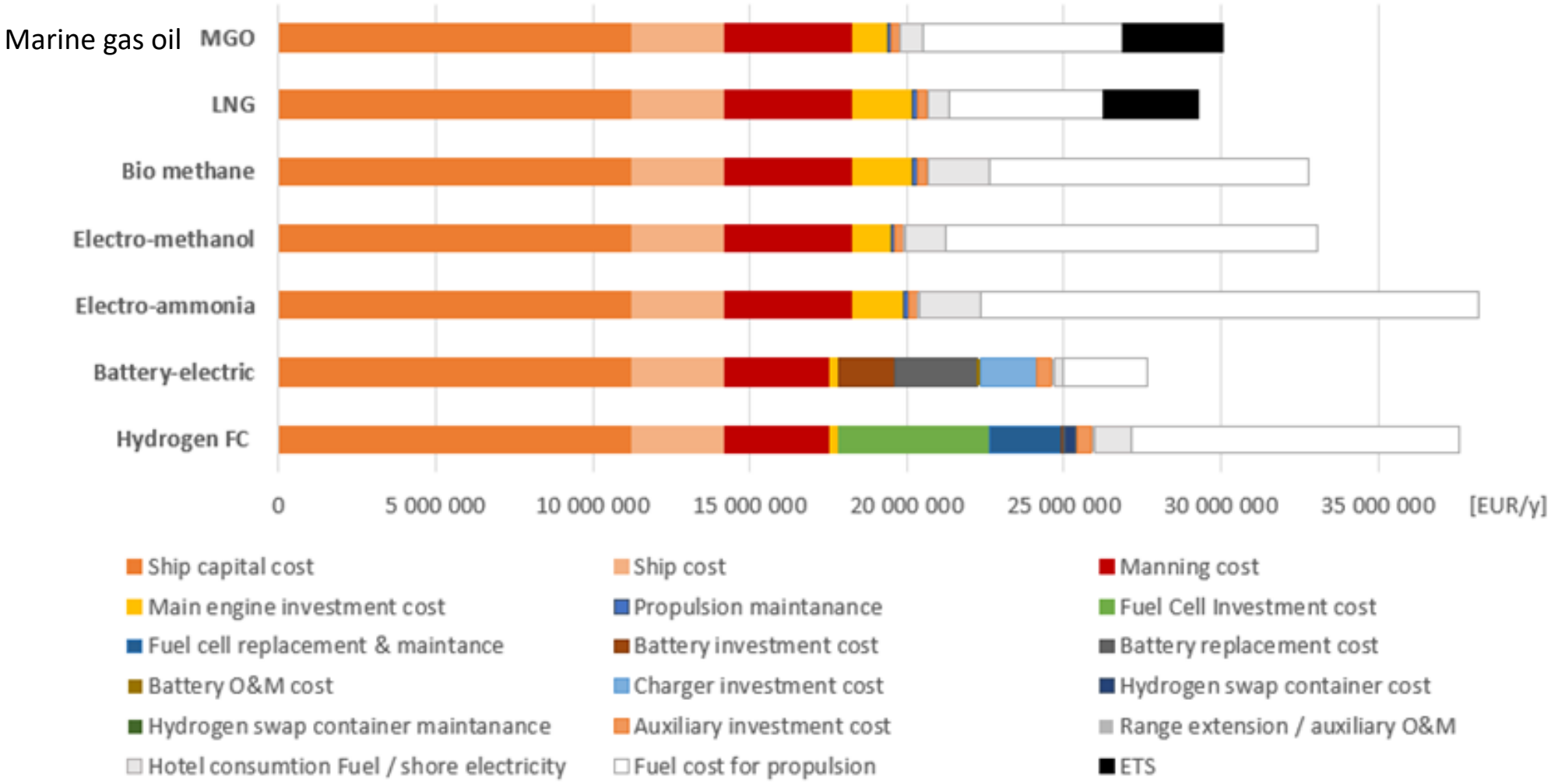
What about the possible cost for marine hydrogen based solutions?

Cost HOPE RoPax case study



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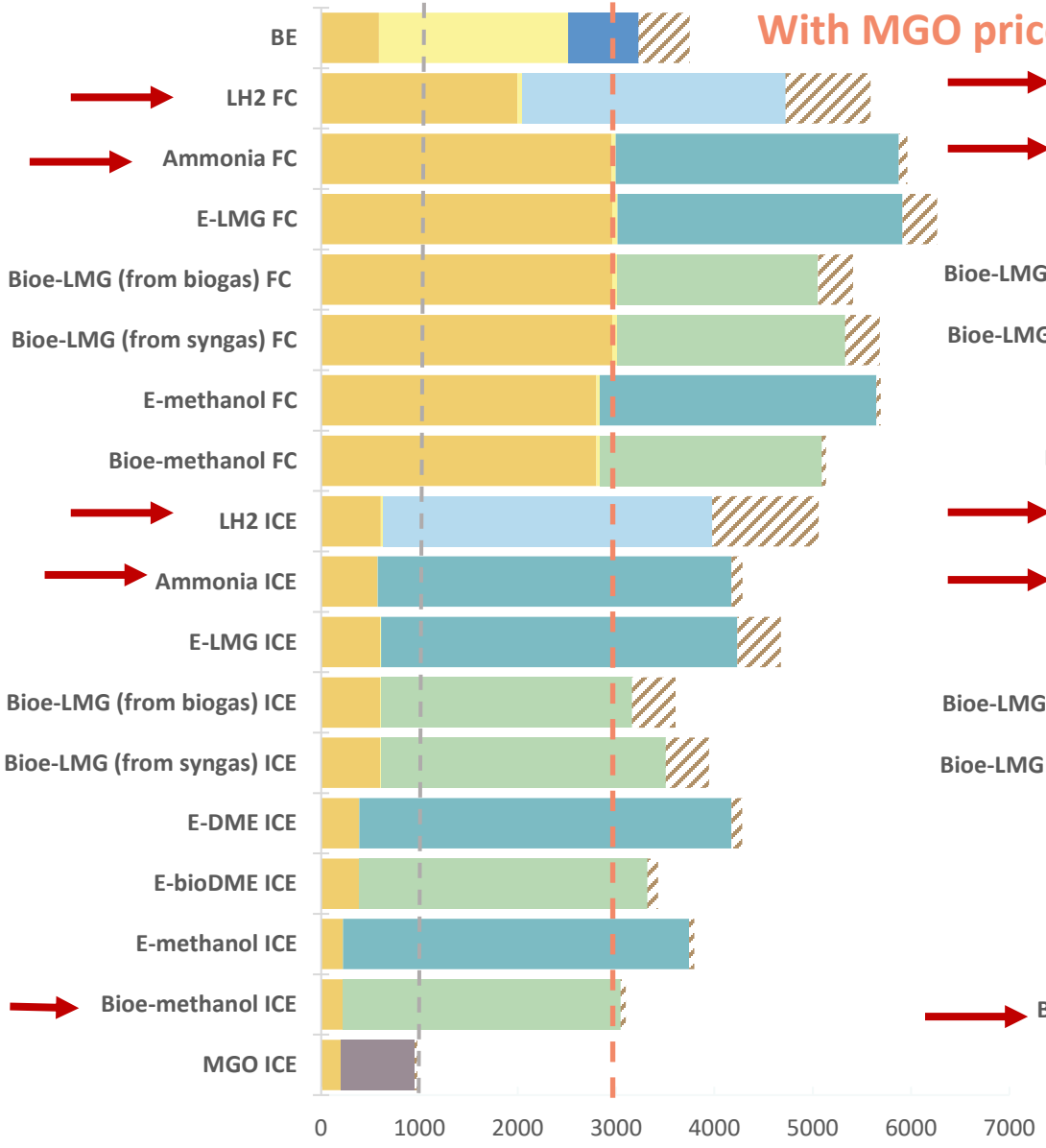
More cost comparisons for marine hydrogen based solutions

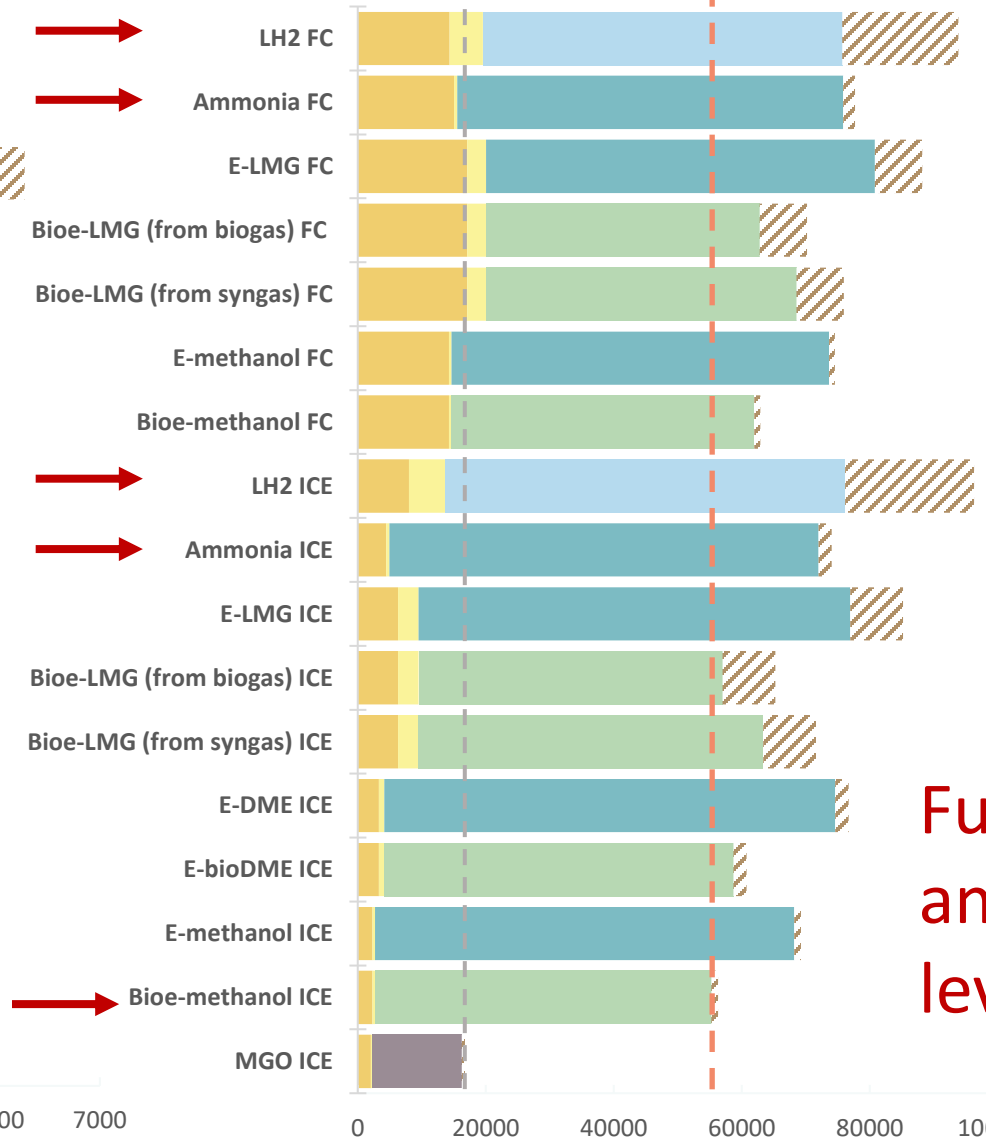
- Cost (2030) incl. fuel production, distribution + propulsion cost
- Large ferry & Container ship
- Fuels: Liquid hydrogen, ammonia, electrofuels combined bio- and electrofuels
- Internal combustion engines (ICE), fuel cells (FC)

Large ferry

Container ship

With MGO price March 2022





BE: battery-electric, LH2: liquifed hydrogen, FC: fuel cell, ICE:internal combustion engine
LMG: liquifed methane gas; bioe: bioelectrofuel, formed by adding H2 into biofuel prod.

Source: Brynof el at., 2022

For the assessed ships:

- Bio-e-methanol in ICE lowest cost
- If H2/ammonia or fuel cell/ICE less costly depend on ship type
- Battery-electric propulsion also interesting for ferry

Future cost of fuels and EU ETS price levels important!

CHALMERS

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What about GHG performance of marine hydrogen based solutions?

Assessment of the climate impact of selected alternative marine fuels (incl. hydrogen, ammonia and methanol) using life cycle assessment (LCA)

Nordic Roadmap for introduction of sustainable zero-carbon fuels

A four year Nordic collaboration *paving the way*

Nordic Council of Ministers

Technical deliveries

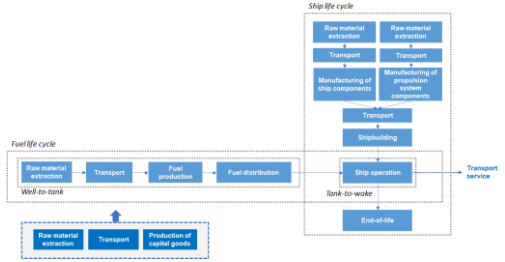
Fuel scorecard

Identify relevant fuels:
Ammonia, Hydrogen, Methanol

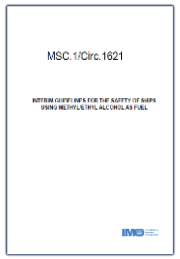
Develop KPIs

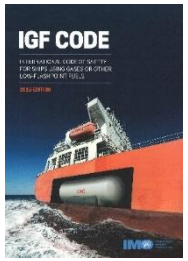
Evaluate KPIs for each fuel

Life-Cycle Assessment

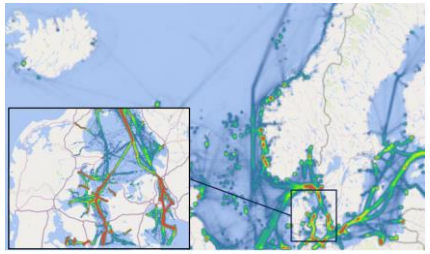


Regulatory framework





Traffic & infrastructure



Co-operation platform

Join us today at: *futurefuelsnordic.com*

Contributing partners:

CHALMERS UNIVERSITY OF TECHNOLOGY
ivl Swedish Environmental Research Institute
MAN Energy Solutions
MENON ECONOMICS
DNV
LITEHAUZ

Supporting partners:

Gasum
WÄRTSILÄ
SAMORKA Icelandic Energy and Utilities
YARA
DFDS
Swedbank
Norges Rederiforbund Norwegian Shipowners' Association
Sjøfartsdirektoratet Norwegian Maritime Authority
PORT OF OSLO
CHNL CENTRE FOR HIGH NORTH LOGISTICS
NORD University

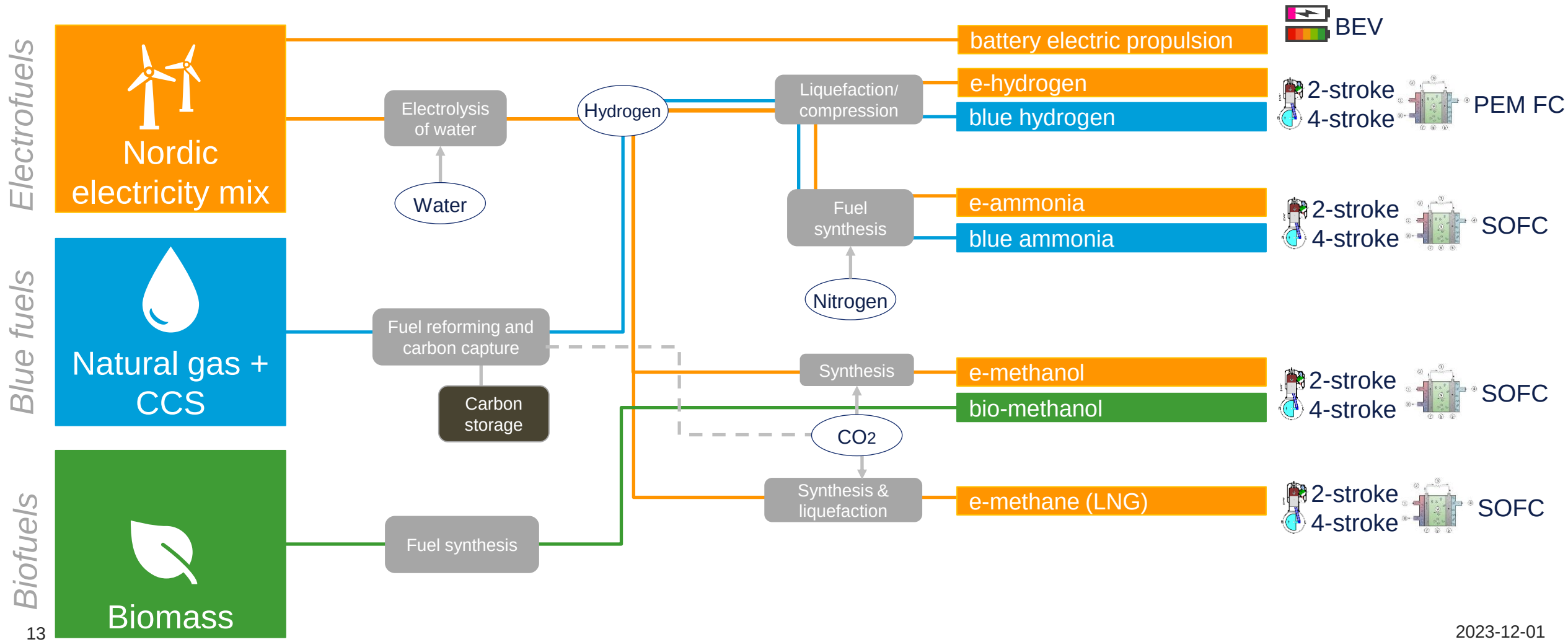
Goal

Reduce key barriers to implementation and establish a common roadmap for the Nordics towards zero-emission shipping

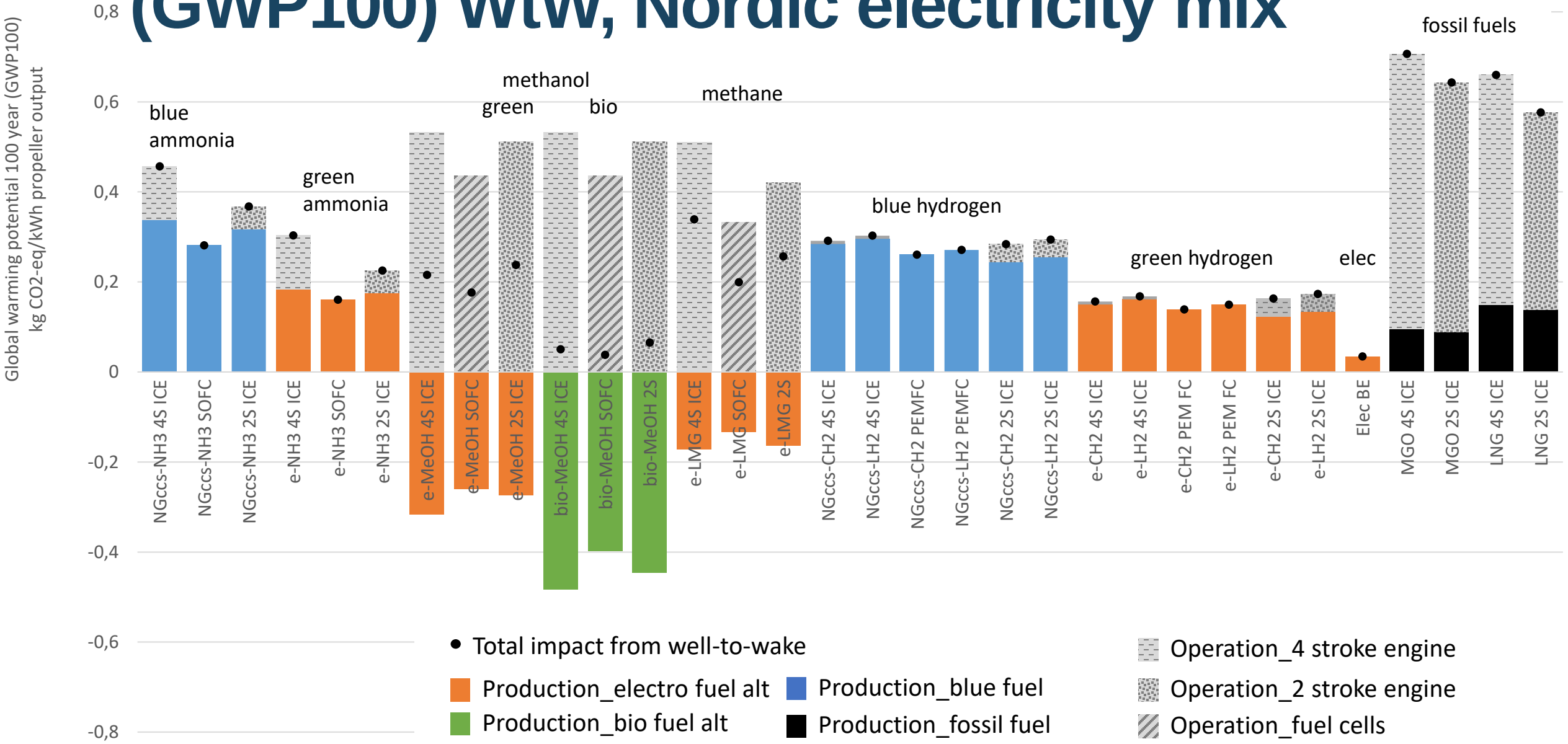
Objectives

- Gain technical knowledge/ regulatory development (H_2, NH_3, CH_3OH)
- Develop a Nordic Roadmap for future fuels
- Establish a Nordic co-operation platform and piloting of Green Shipping Corridors

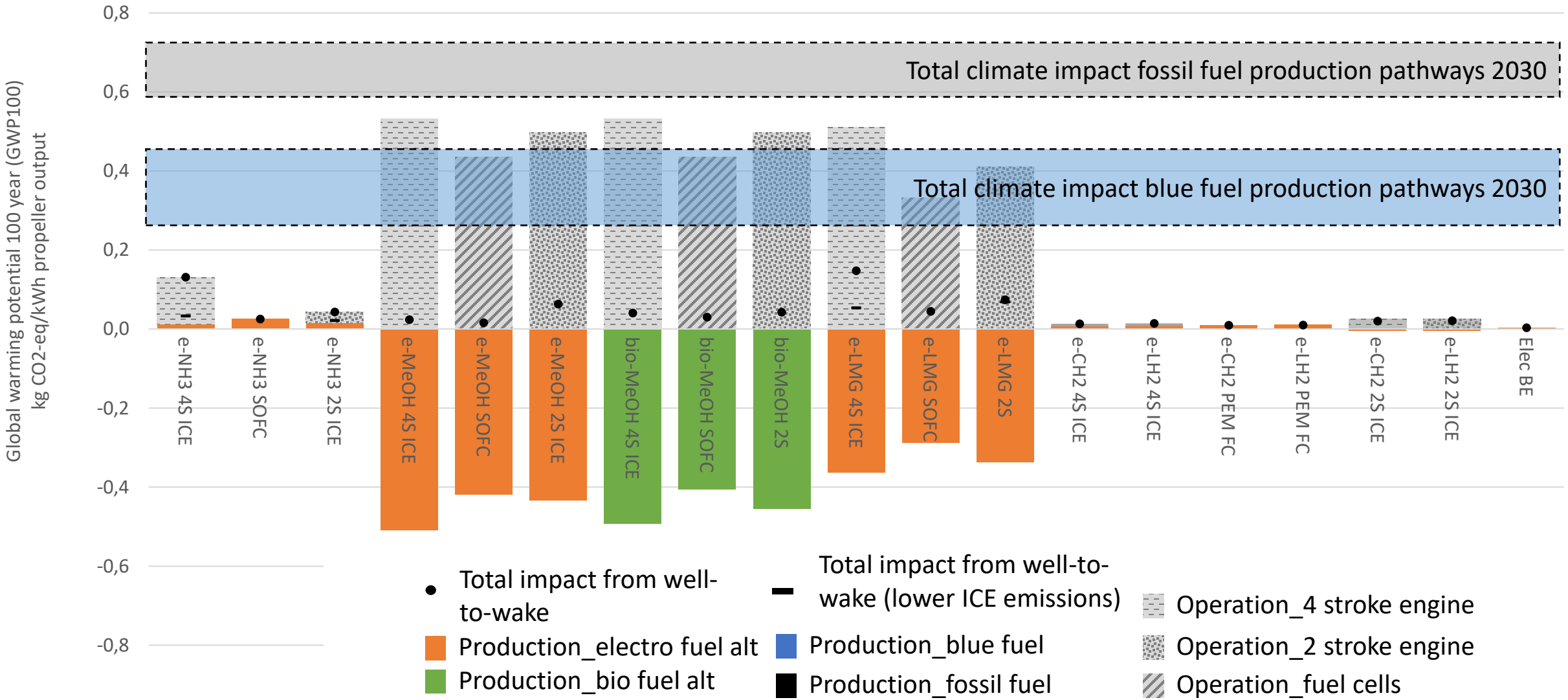
Pathways considered



Estimated life cycle climate impact in 2030 (GWP100) WtW, Nordic electricity mix



Outlook life cycle climate impact in 2050 (GWP100), WtW, Nordic electricity mix



Findings climate impact

- Possible to substantially reduce climate impact by hydrogen-based options by 2030 (2050 even more).
- Green/renewable methanol, hydrogen and electricity pathways show lower climate impact compared to ammonia and methane pathways
- For ammonia and methane to have low climate impact, policies that regulate also other GHGs (CH_4 and N_2O) are needed.
- Some other emissions will decrease too.
- Other environmental impacts also need to be assessed.

Interested in more? Check our publications

“HOPE Hydrogen fuel cells solutions in NORDIC shipping. Project summary”, Hansson, J., Jivén, K., Yum Koosup, K., et al., 2023, https://www.ivl.se/projektwebbar/hope.html

“Concept design and environmental analysis of a fuel cell RoPax vessel”, Jivén, K., Parsmo, R., Fridell, E., J., et al., 2023, Report C781, IVL, https://www.ivl.se/projektwebbar/hope.html

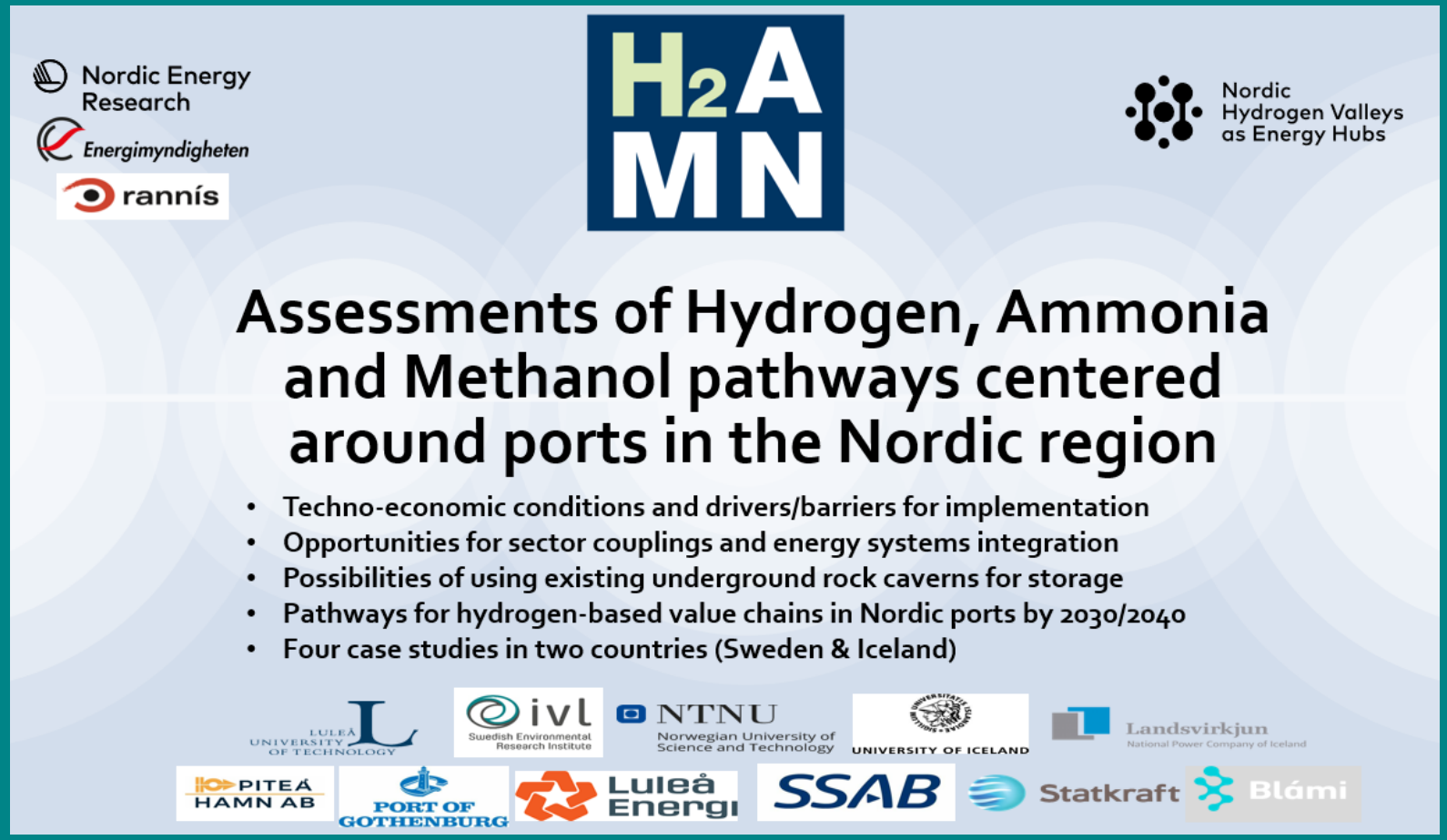
“Life-Cycle Assessment and Costing of Fuels and Propulsion Systems in Future Fossil-Free Shipping”, Kanchiralla, F.M., Brynolf, S., Malmgren E., Hansson, J., Grahn, M., *Environmental Science & Technology* 56 (17), 2022

"**Review of electrofuel feasibility - Prospects for road, ocean and air transport**", Brynolf, S., Hansson, J., Anderson, J., et al., *Progress in Energy* (4) 042007, 2022

"**Review of electrofuel feasibility - Cost and environmental impact**", Grahn, M., Malmgren, E., Korberg, A., et al., *Progress in Energy* (4) 032010, 2022

“How do variations in ship operation impact the techno-economic feasibility and the environmental performance of fossil-free fuels? A life cycle study”, Kanchiralla, F.M., Brynolf, S., Olsson, T., et al., *Applied Energy* 350, 2023

“**Life Cycle Assessment of Marine Fuels in the Nordic Region – Task 1C Roadmap for the introduction of sustainable zero-carbon fuels in the Nordic region**”, Brynolf, S., Hansson, J., Kanchiralla, F.M., et al., Report No.1-C/1/2022, 2022, https://futurefuelsnordic.com/project-deliverables/



Thank you! julia.hansson@ivl.se

Grateful for funding from: Nordic Energy Research, Swedish Transport Administration, Swedish Energy Agency, Nordic Council of Ministers, Formas (Mistra Carbon Exit)