HOPE - Hydrogen fuel cells solutions in shipping in relation to other low carbon options – a Nordic perspective

On the overall possibility for using hydrogen in Nordic shipping, Julia Hansson (IVL)

ivl SVENSKA MILJÖINSTITUTET

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/drivers for and environmental impact of realization in the Nordics.

Contact: julia.hansson@ivl.se

ivl SVENSKA MILJÖINSTITUTET

SINTEF

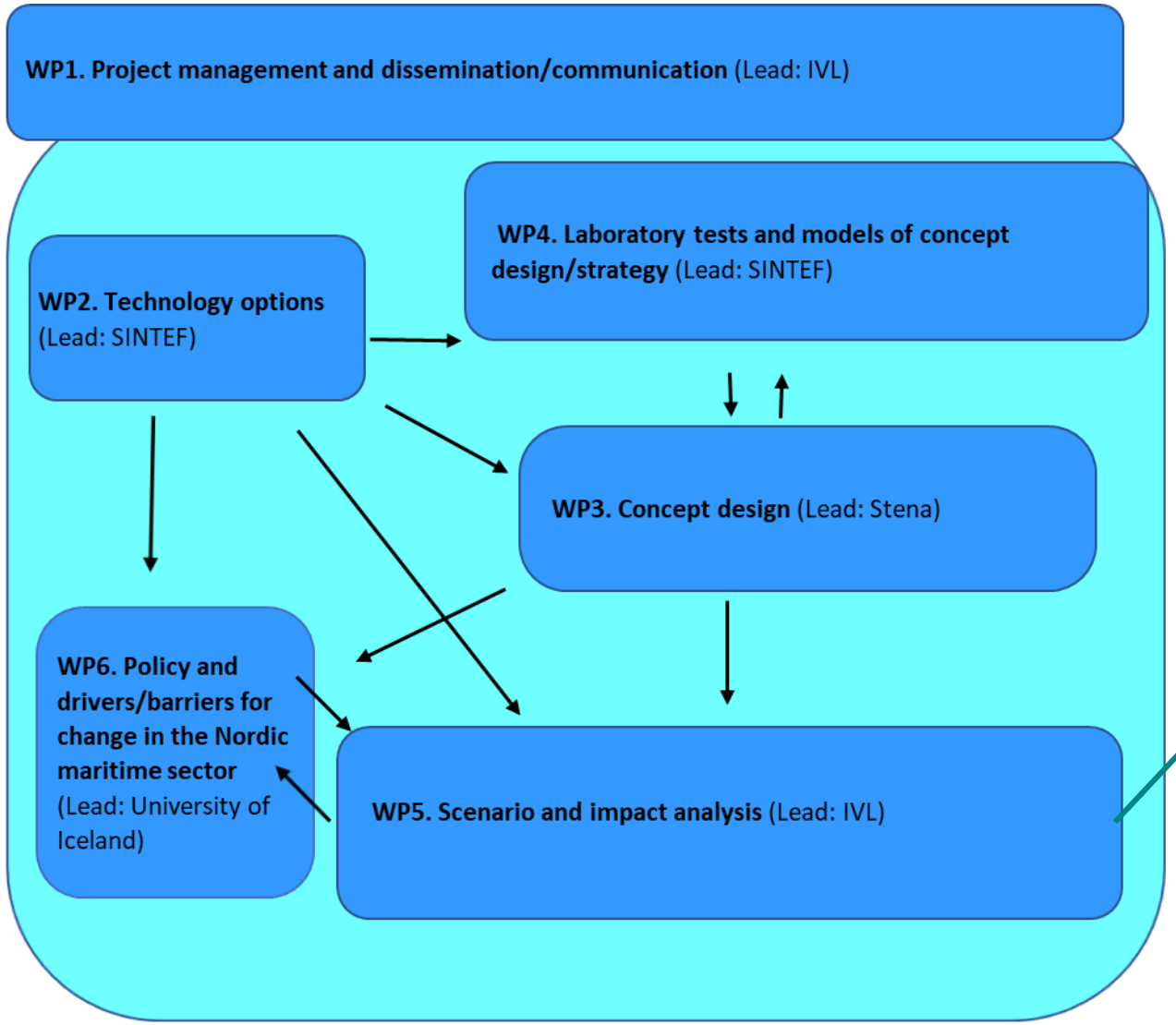
Stena

UNIVERSITAS ISLANDIAE SIGILLUM

UNIVERSITY OF ICELAND

POWERCELL

Overview of Work packages



- Cost-benefit analysis
- Assessment of uptake in Nordic fleet
- Emission impacts in scenarios for uptake in Nordic fleet: GHG and air pollutants
- Cost-effective fuel and propulsion technologies - Times-Nordic modelling

Earlier study: Decarbonizing Nordic Transports – the Role of Different Alternative Transport Fuels

- Assessments of cost-effective alternative fuel options for aviation, shipping and road transport in an energy system context given carbon reduction requirements
- Open Nordic TIMES model: Bottom-up, optimization (cost minimization) energy system model
- Cover the national energy system in Sweden, Norway and Denmark
- Model satisfies defined modal demands for entire time horizon by deploying the technology mix with lowest costs while fulfilling CO_2 constraint (no net CO_2 emissions by 2050)

ivl SVENSKA MILJÖINSTITUTET

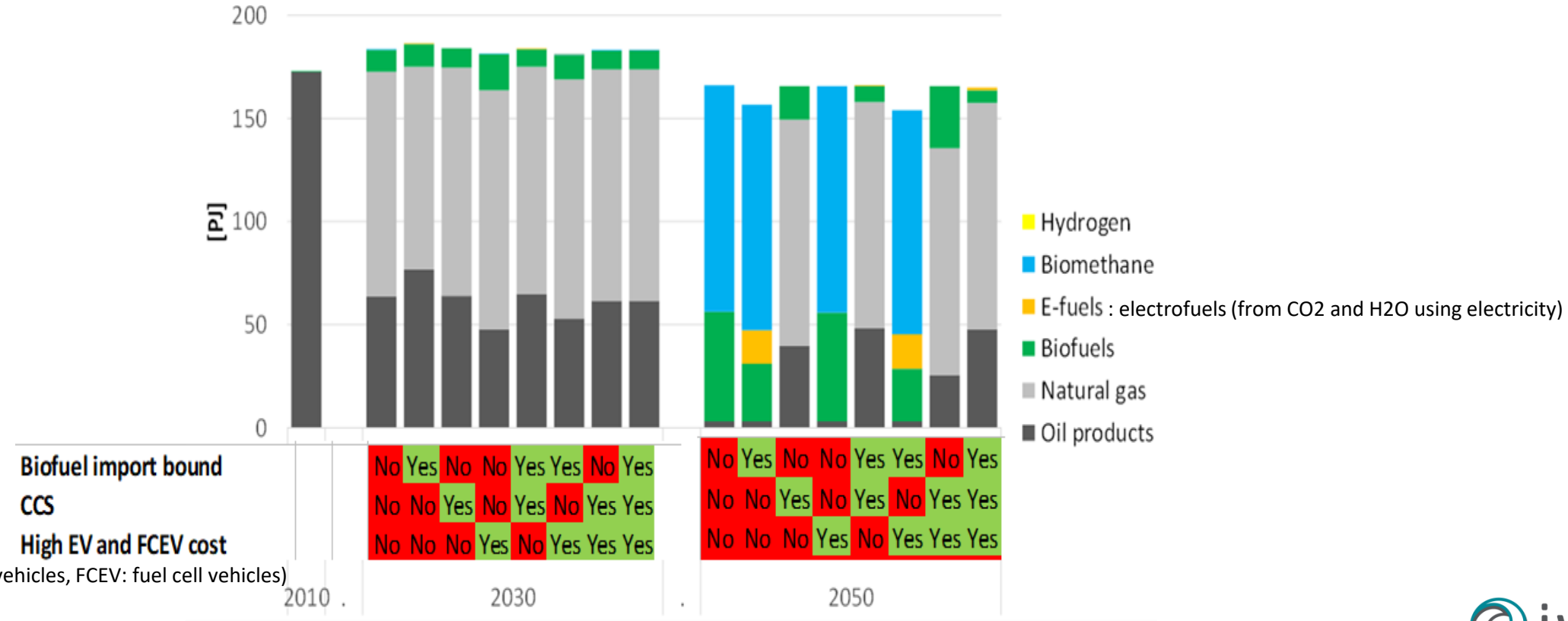
Earlier study: Decarbonizing Nordic Transports – the Role of Different Alternative Transport Fuels

- Scenario cases:
  - Biomass/biofuel limitation
  - Carbon capture and storage (CCS)
  - High cost electric and fuel cell vehicles

Fuel use in Scandinavian shipping sector in 2030 and 2050

No net CO2 emissions by 2050

Biofuels in all cases. No hydrogen. Electrofuels if no CCS and limited biomass

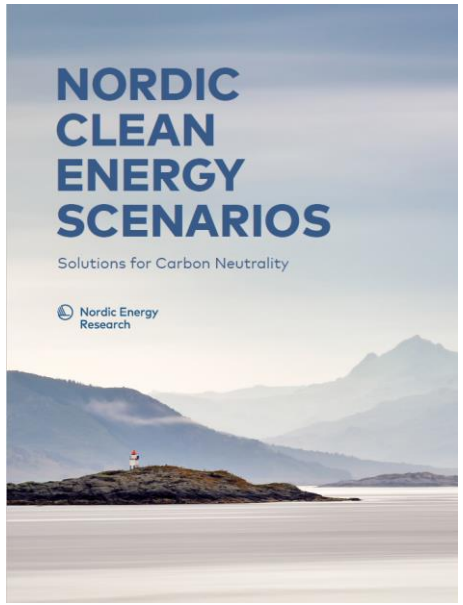


(EV: electric vehicles, FCEV: fuel cell vehicles)

ivl SVENSKA MILJÖINSTITUTET

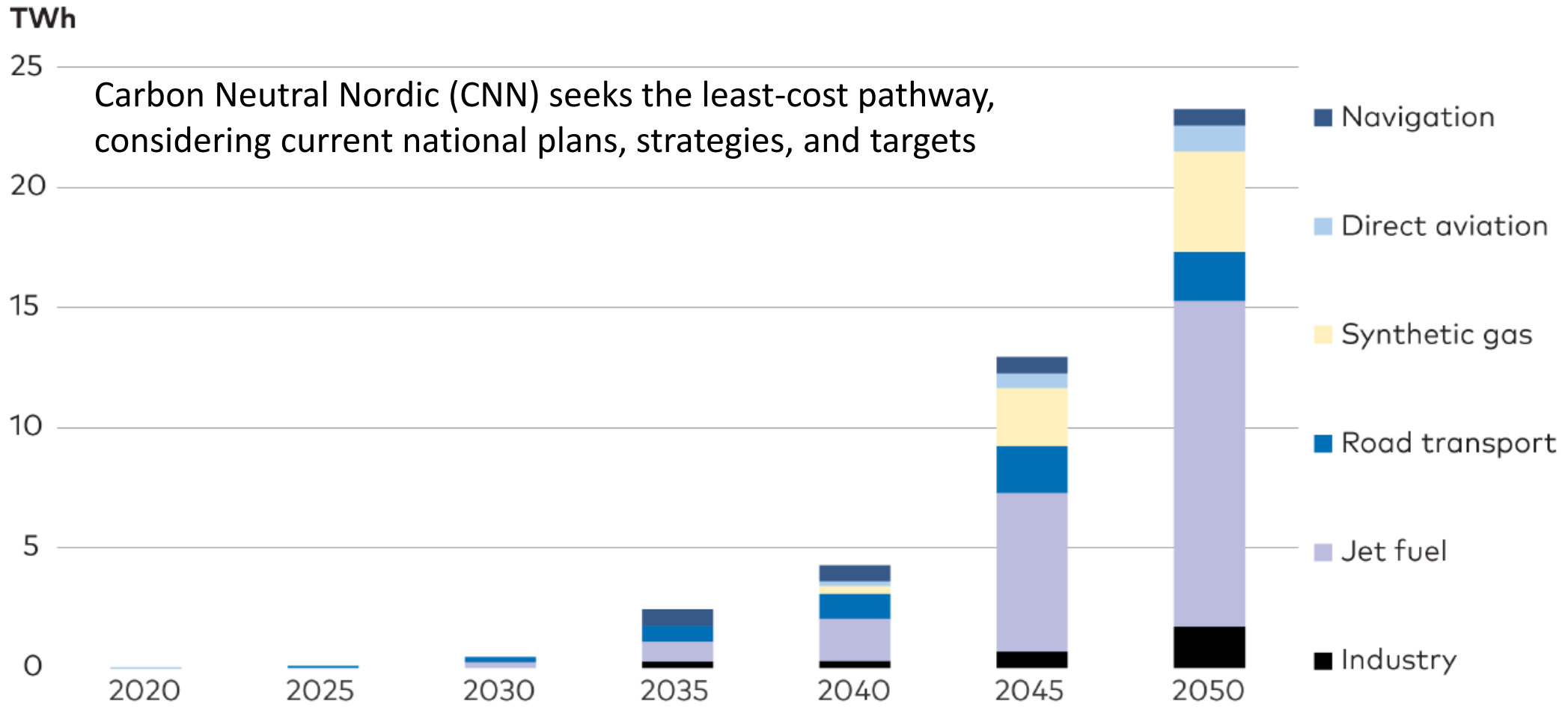
Nordic Clean Energy Scenarios

- Map potential long-term pathways to Nordic carbon neutrality using energy system modelling (Open Nordic Times model)

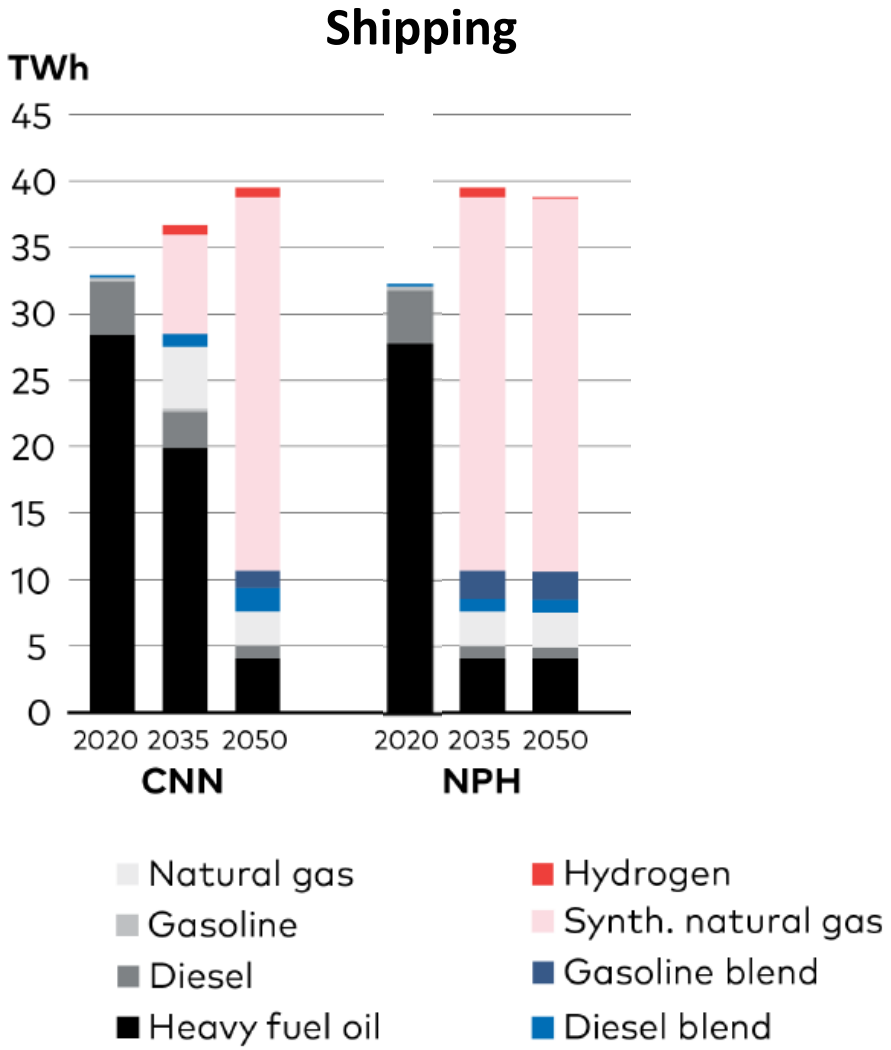


https://www.nordicenergy.org/project/nordic-clean-energy-scenarios-solutions-for-carbon-neutrality/

Hydrogen use in Nordic Clean Energy Scenarios 2020-50 by end-use



Cost-effective fuel choices in Nordic Clean Energy Scenarios 2020-2050 (fuel use)



Shipping: synthetic natural gas (methane) dominate in 2050. Synthetic fuels are based on hydrogen or bioenergy, sometimes combined with CCS

ivl SVENSKA MILJÖINSTITUTET

Findings so far

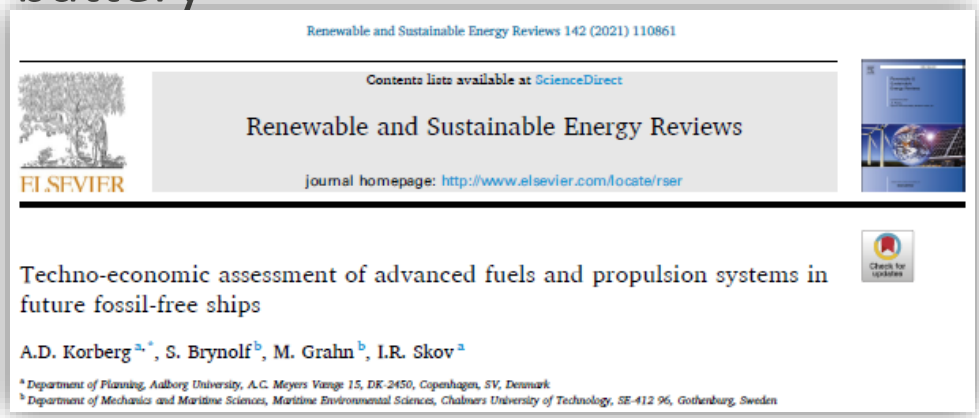
- Fairly low use of hydrogen for shipping, but further assessment needed before firm conclusions can be drawn on the potential role for hydrogen in the Nordics.
- Future role of hydrogen will depend on
  - expansion of low-carbon electricity generation
  - availability of sustainable biofuels
  - development of hydrogen-based solutions
  - hydrogen demand in other sectors
  - cost development of electrified options
  - development of CCS and bio-CCS
  - policies and their design

What about the possible cost for marine hydrogen solutions?

Techno-economic comparison of marine fuel options

- Mobility cost (2030) incl. fuel production and distribution cost + propulsion cost
- Two type vessels: (i) Large ferry: main engine 11MW, 6 hours between ports, (ii) Container ship: main engine 55MW, 240 hours between ports
- Included options: Liquid hydrogen, ammonia, electrofuels (coal-based), combined bio- och electrofuels (all carbon in the biomass used for fuel)
- Internal combustion engines (ICE), fuel cells (FC) and battery-electric propulsion
- Fuel production in Europe 2030

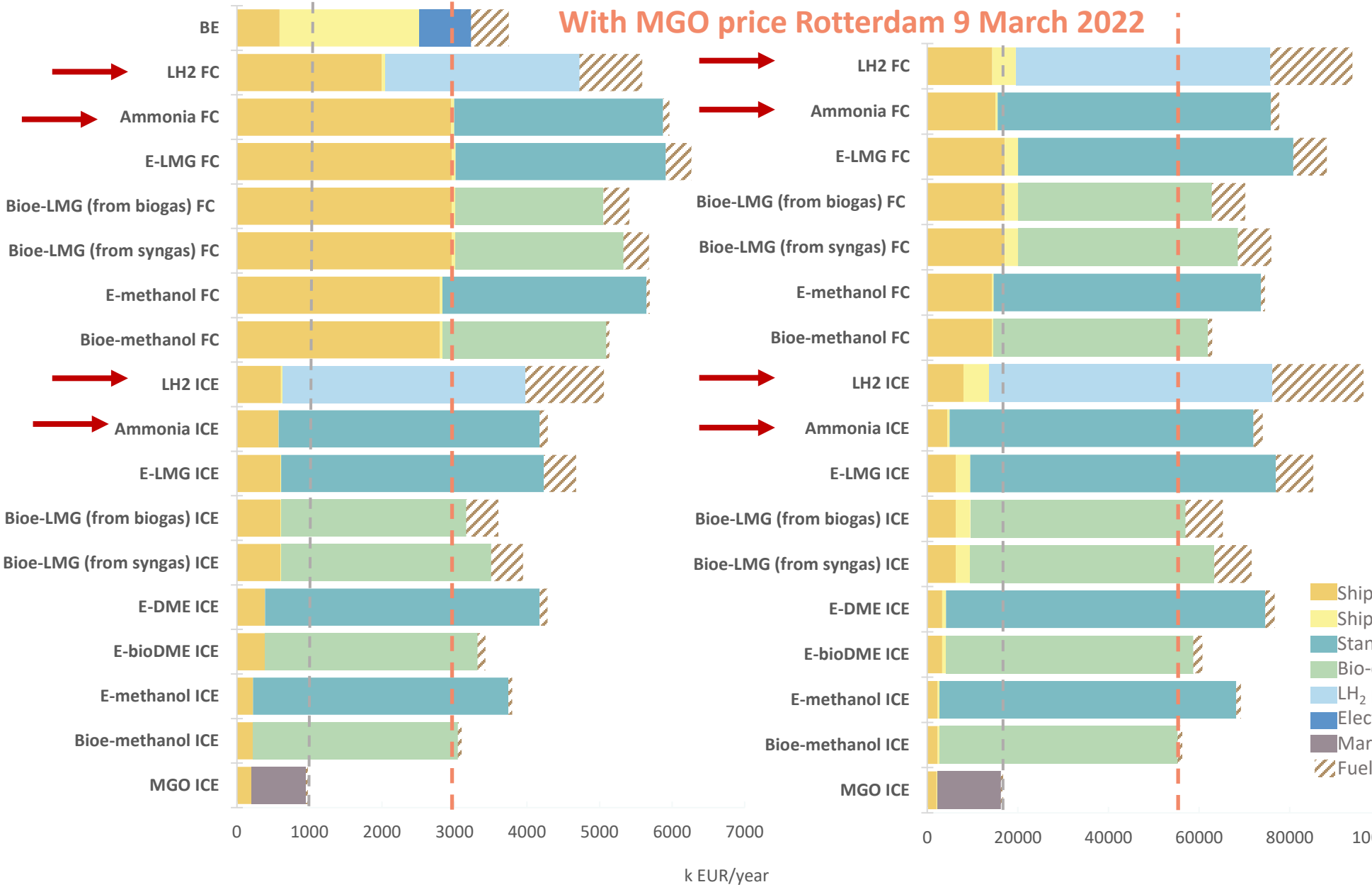
Review of electrofuel feasibility - Prospects for road, ocean, and air transport. *Selma Brynolf, Julia Hansson, James E. Anderson, Iva Ridjan Skov, Timothy J. Wallington, Maria Grahn, Andrei David Korberg, Elin Malmgren and Maria Taljegård. Manuscript submitted to PRGE.*



Large ferry

Container ship

With MGO price Rotterdam 9 March 2022

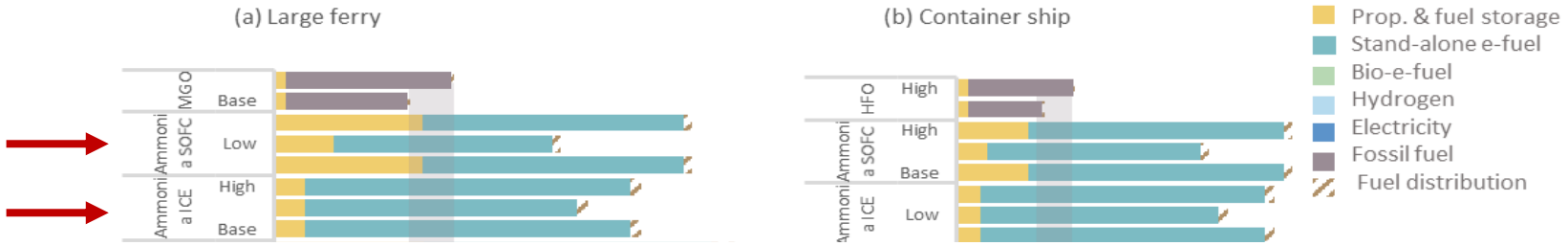


- Least cost H2-NH3: Ammonia ICE for large ferry, Ammonia for container ship
- Bio-e-methanol in ICE lowest cost
- Battery-electric propulsion interesting for the ferry (Stena plan)

CHALMERS

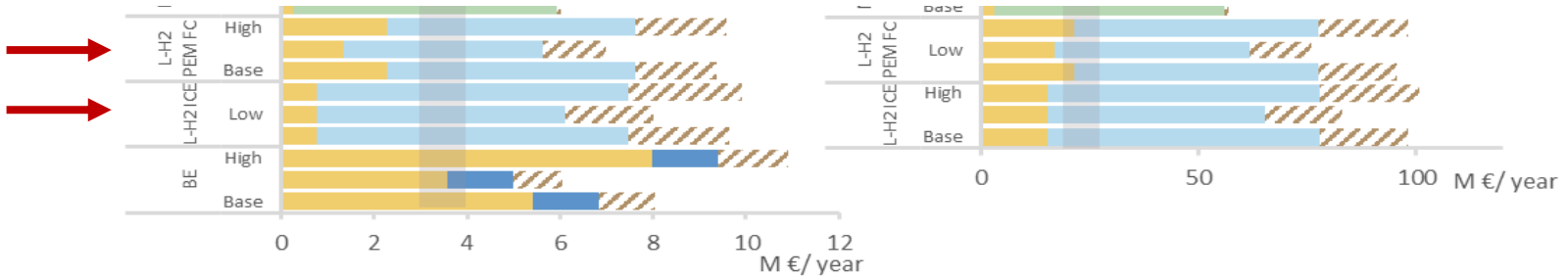
ivl SVENSKA MILJÖINSTITUTET

Uncertainties in cost estimates



Carbon abatement cost

- Estimated carbon abatement cost for liquefied hydrogen corresponds to 230-570 €/tonne CO2 (large ferry). For ammonia 190-600 €/tonne CO2
- Will depend on cost for conventional fuel and GHG emissions
- For large ferries, e-bio-methanol has lowest carbon abatement cost (110-440 €/tonne CO2) and for battery-electric large ferry it is 175-500 €/tonne CO2.



Nordic Roadmap for the introduction of sustainable zero-carbon fuels in shipping

ivl
SVENSKA MILJÖINSTITUTET

Nordic roadmap zero-carbon marine fuels

- To reduce key barriers to implementation and establish a common roadmap for the whole Nordic region and logistics ecosystem towards zero emission shipping.
- Funded by Nordic Council of Ministers (via Norwegian Ministry of Climate and Environment)
- 2022-2025
- Led by DNV. Other partners: Menon, IVL, Chalmers, MAN, Litehauz
- Total budget: 18 million DKK (IVL: 1.95 MDKK)

Tasks

Objective		Task		Task leader/ Contributors:
1	1. The Nordic countries have gained a technical knowledge base and provided a framework for regulatory development of promising alternative fuels.	A	Screening and selection of sustainable zero-carbon fuels	Menon DNV, IVL, Chalmers
		B	Technical and regulatory analyses of selected fuels	DNV MAN
		C	LCA of selected fuels	Chalmers IVL, DNV, MAN

Tasks

Objective		Task		Task leader/ Contributors:
1	1. The Nordic countries have gained a technical knowledge base and provided a framework for regulatory development of promising alternative fuels.	A	Screening and selection of sustainable zero-carbon fuels	Menon DNV, IVL, Chalmers
		B	Technical and regulatory analyses of selected fuels	DNV MAN
		C	LCA of selected fuels	Chalmers IVL, DNV, MAN
2	2. The Nordic countries have established a strategy for infrastructure development and for the use of harbours as green energy hubs.	A	AIS analysis of the Nordic ship traffic and energy use	DNV
		B	Infrastructure and bunkering challenges for selected fuels	Menon Litehauz, IVL, DNV, Chalmers
		C	Develop a Nordic Roadmap for infrastructure development to supply the new fuels	DNV All

Tasks

Objective		Task		Task leader/ Contributors:
3	3. The Nordic countries have established a platform for improved cooperation between Nordic industries and companies, and can promote the high level of competence and competitiveness of Nordic companies and institutions when use of carbon sustainable zero-carbon picks up globally.	A	Establish a platform for cooperation and networking in the Nordic region	DNV All
		B	Piloting of the selected fuels	DNV IVL, Litehauz

Technical tasks provides input to the strategy

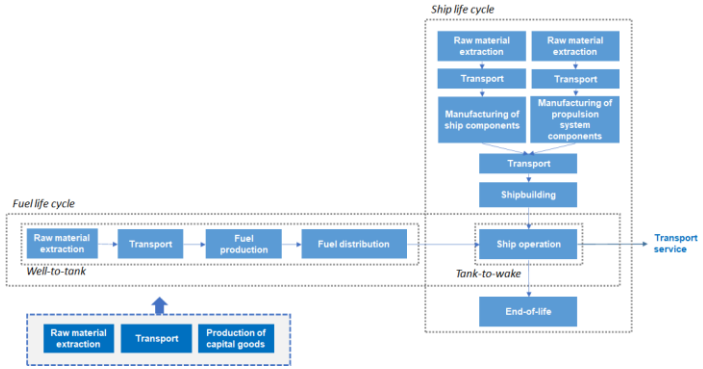
Fuel scorecard

Identify relevant fuels:
Ammonia, Hydrogen, Other

Develop KPIs

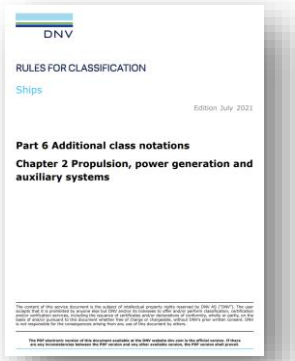
Evaluate KPIs for each fuel

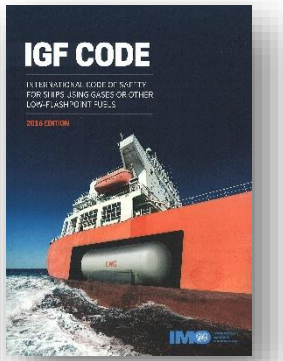
Life-cycle Assessment



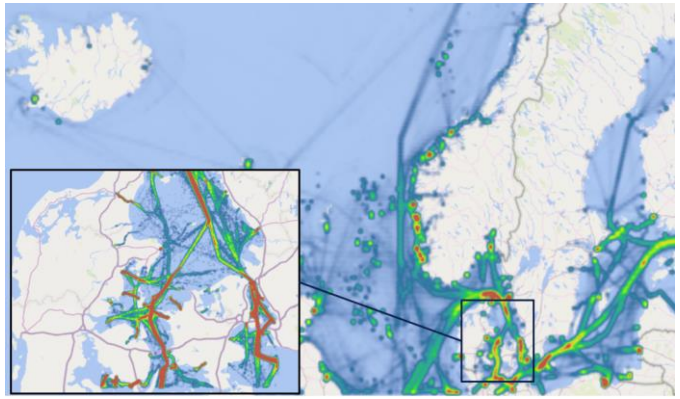
Nordic Roadmap

Regulatory framework





AIS & New infrastructure

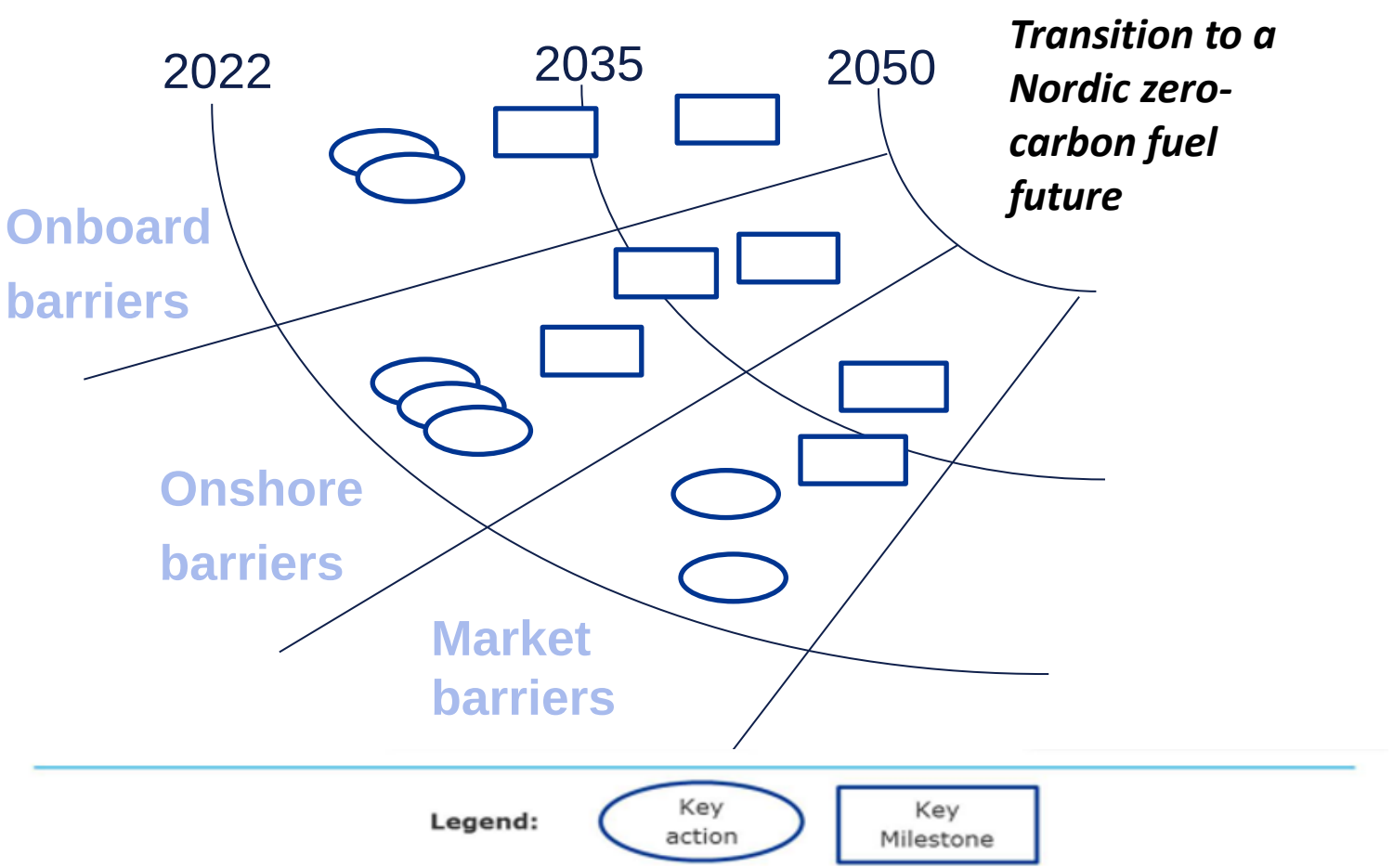


Nordic Roadmap development

The Nordic Roadmap will point towards **concrete actions** along with important **milestones**.

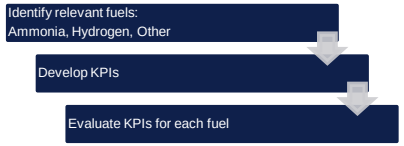
This project will establish **pilot studies** as concrete actions.

Focus on **hydrogen, ammonia and yet undecided fuels**.

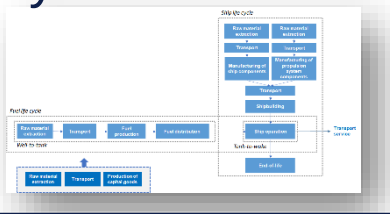


Deliverables
centred around a platform for collaboration

Fuel scorecard



Life-cycle Assessment

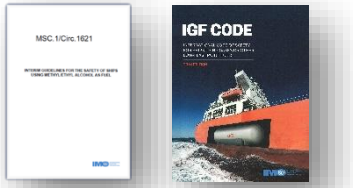


A Nordic Roadmap

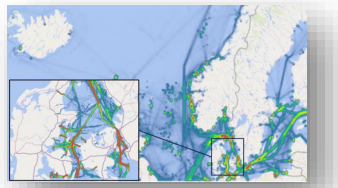
The Nordic Collaboration Platform will establish a Nordic Roadmap to accelerate the fuel transition

The platform will facilitate technical developments, piloting, co-operation and information sharing - means for overcoming barriers

Regulatory framework



AIS & New infrastructure



Thank you!

Contact: julia.hansson@ivl.se, erik.fridell@ivl.se

HOPE project is part of Nordic Maritime Transport and Energy Research Programme

We are very grateful for the funding by Nordic Energy Research, Danish EUDP, Business Finland, Swedish Transport Administration, Norwegian Research Council, Icelandic Research Center and in-kind from participating companies.

ivl SVENSKA MILJÖINSTITUTET