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

Understanding the barriers for using green hydrogen-based fuels in Nordic shipping with a focus on ferries

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Key messages

- The Nordic Ministers of Environment and Climate have agreed to develop zero-emission ferry routes between the Nordic countries.
- A promising option to consider is the use of green hydrogen and green hydrogen-based fuels.
- Policy interventions would be needed to facilitate the adoption of these fuels and to address the barriers associated with their use.
- Policymakers would need to prioritize addressing the high costs and lack of supply of these fuels, the lack of infrastructure for their use, and the uncertainty and high risks for early adopters.

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Introduction

In May 2022, the Ministers of Environment and Climate from Denmark, Finland, Iceland, Norway, Sweden, Faroe Islands, Greenland, and Åland signed a joint Declaration for the creation of zero-emission ferry routes between the Nordic countries (NORDEN, 2022). The overall aim of the Declaration is to help the Nordic shipping industry accelerate its transition towards new fuels and propulsion technologies that have low emissions throughout their value chain from production to end-use. To support the transition, the Ministers agreed to focus on the ferry segment and to promote the creation of zero-emission ferry routes between Nordic countries. This would allow key stakeholders to gain experience and test new fuels and technologies in pilot projects involving short ferry routes. However, currently only a limited number of fuels and technologies have the potential to deliver zero-emissions throughout their lifecycle, and most are not immediately available for the Nordic context.

Besides battery-electric ferries, a promising option for the ferry segment is the adoption of green hydrogen and green hydrogen-based fuels such as ammonia, methanol, and liquid organic hydrogen carriers (LOHC) (see: DNV, 2022; IRENA, 2021b). Using these fuels could result in significant environmental benefits, mostly from reducing emissions of greenhouse gases (GHG) and air pollutants in different stages of the value chain. These benefits are mainly expected at the production, processing, and end-use of the fuels. While the environmental benefits of transitioning to these fuels are easily identifiable, there are relevant challenges that need to be considered for upscaling their use, including those associated with a higher demand for renewable electricity. Identifying and understanding the barriers can help Nordic policymakers define the actions needed to establish zero-emission ferry routes. Policy makers would also need to consider that policy intervention would be required at different stages of the hydrogen value chain and across several industries.

To help decision makers, this brief identifies and explores the key barriers that need to be prioritized to facilitate the adoption of green hydrogen and green hydrogen-based fuels in zero-emission ferry routes. The insights presented are based on research conducted by the University of Iceland within the HOPE project (Hydrogen fuel cells solutions in shipping in relation to other low carbon options – a Nordic perspective) during the years 2021 and 2022. The research included an extensive analysis of the literature as well as a workshop and interviews with key stakeholders from the Nordic shipping industry and the Nordic hydrogen value chain.

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Green hydrogen-based fuels

A color designation is given to hydrogen based on the way in which it was produced. The color depends on the process, feedstock, and energy sources used to produce it. In the case of green hydrogen, the color means that it was produced by a process called electrolysis using water and renewable electricity. The resulting product (green hydrogen) can then be used directly, or it can undergo additional processes to convert it into another fuel. Depending on the process used, green hydrogen can be converted into ammonia, methanol, or liquid organic hydrogen carriers (LOHC).

Key barriers for the adoption of green hydrogen and green hydrogen-based fuels

A variety of barriers can limit the adoption of green hydrogen and green hydrogen-based fuels for their use in zero-emission ferry routes in the Nordic countries. The main barriers that need to be prioritized are:

- **High comparative costs:** Transitioning from fossil fuels to green hydrogen-based fuels represents significant challenges. Perhaps the most relevant is to make them cost-competitive and attractive for end-users, mainly ferry owners and operators. To do so, two things need to happen: 1) The cost of fossil fuels needs to increase. The current prices of fossil fuels used in shipping, such as heavy fuel oil (HFO), marine diesel oil (MDO), and liquified natural gas (LNG), do not incorporate all the external costs to society from their production and consumption. In the field of environmental economics, these are called negative externalities and include aspects such as the costs associated with air pollution, GHG emissions, oil spills, underwater noise and vibrations, biodiversity loss, among others. 2) The costs of green hydrogen-based fuels need to decline. To do so, costs must be reduced in all stages of the value chain from their production to their delivery and bunkering to the vessels.
- **Lack of supply of green hydrogen:** Besides costs, an immediate techno-economic challenge is the availability and supply of green hydrogen that can be purchased and delivered to Nordic ports. A limiting factor for producing it at a large scale has been the price of renewable electricity, which until recently had been too expensive compared to fossil fuels. However, the price of renewable electricity has declined significantly (mainly from wind and solar) and green hydrogen is now expected to become cost-competitive by 2030 in some regions (see: IRENA, 2021b;

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IRENA, 2022a). While a low price of renewable electricity is fundamental for increasing green hydrogen production, there are other relevant aspects to consider for the Nordic region: 1) Producing green hydrogen requires large amounts of water and renewable electricity[1]. This means that policy makers will need to prioritize the supply of these commodities. While the Nordic countries already have a high supply of renewable electricity in their energy mix (see: IRENA, 2022b), the production of green hydrogen at a large scale would represent a significant extra demand for renewable electricity. This means that investments would be needed to increase the capacity for producing renewable electricity and doing so could take several years in the design, planning, and construction of new infrastructure. Using large quantities of water for industrial use can be limited by its physical availability but also by regulations. For the Nordic countries this could represent a competitive advantage for producing green hydrogen since they have a higher availability of fresh water in comparison to most of the European countries (see: European Commission, 2022). 2) The historical demand for hydrogen in the Nordic region has been mostly limited to the petrochemical industry in small quantities and most of it has been with production and use on-site. As a result, the infrastructure in the Nordic countries for the hydrogen value chain associated with shipping is not readily available which means that new infrastructure would need to be developed to support an increased supply.

- **Lack of infrastructure:** The lack of supply of green hydrogen is in part linked to the lack of infrastructure. While the Nordic ferry segment has been a frontrunner in the use of alternative fuels, mainly through the early adoption of LNG and most recently with battery-electric ferries, its infrastructure is mostly designed for fossil fuels. Three aspects should be taken into consideration: 1) The hydrogen value chain can benefit from some of the existing infrastructure used by other industries. For example, most hydrogen-based fuels can be transported through existing pipelines for natural gas. A starting point would be through blending which means that hydrogen-based fuels are mixed (in a small percentage) with the blend flowing through the pipeline (see: International Energy Agency, 2019). In the Nordic context, the hydrogen value chain could benefit from using existing infrastructure such as the Norwegian oil and gas pipelines. 2) New infrastructure for the hydrogen value chain will, however, also need to be developed. For

[1] Approximately 9 liters of water are needed to produce 1 kg of green hydrogen (International Energy Agency, 2019) and 1.5 MWh of electricity are required to produce 1 MWh of hydrogen (approximately 30 kg of hydrogen) (IRENA, 2021a).

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instance, ports will require on-site or nearby storage and bunkering facilities to attend vessels using green hydrogen-based fuels. 3) New infrastructure the production, transmission, and distribution of renewable electricity will be required. This is particularly relevant considering that green hydrogen-production will compete for the use of renewable electricity with other industries and consumers in the Nordic region such as energy intensive industries (e.g. aluminum smelters and iron production) and in the electrification of transportation systems.

- **Uncertainty and high risk:** The lack of availability and supply of green hydrogen along with the lack of infrastructure means that it cannot be purchased and delivered with the same guarantees as fossil fuels being used today in the Nordic region. This results in a high level of uncertainty for stakeholders and potential users. Another aspect to consider is that green hydrogen and hydrogen-based fuels are still being tested for shipping. This means that these fuels have not reached commercial maturity and therefore early adopters are expected to face high risks, mainly financial and operational, which in turn translate into high initial investments and costs.
- **Additional barriers:** Policy makers should keep in mind that additional barriers will need to be addressed. The three most relevant for the creation of zero-emission ferry routes between Nordic countries are: 1) Lack of knowledge regarding new fuels, their characteristics, and how to operate them safely. This includes the need for trained crew and specialized maintenance staff; 2) Lack of regulations and standards for the adoption of green hydrogen-based fuels for their use in shipping. This includes aspects related to the bunkering and storage of the fuels; 3) Operational challenges, mainly in relation to onshore and on-board storage as well as bunkering.

Conclusions

This policy brief discussed the main barriers that would need to be prioritized to facilitate the adoption of green hydrogen and green hydrogen-based fuels in zero-emission ferry routes between Nordic countries. The insights presented can help policy makers recognize and understand the challenges for establishing zero-emission ferry routes and can help prioritize the actions needed. The findings suggest that policy intervention will be required at different stages of the hydrogen value chain and across different industries. Therefore, a holistic and systemic perspective and a close collaboration between stakeholders will be required to establish zero-emission ferry routes between the Nordic countries. The key aspects to be considered are:

- Addressing the barriers will require close coordination and collaboration between Nordic authorities and stakeholders. An initial step could be the creation of working groups which could begin by defining a clear strategy with specific deliverables. That the barriers may be addressed through European instruments such as the Emissions Trading System (ETS) should be considered.
- Policy makers will need to evaluate the cost-effective potential of each fuel for different ferry routes. They will also need to consider optimal ways for introducing the fuels and identify how and when subsidies and policy intervention will be required in the different stages of the hydrogen value chain. This should be done considering the wider context of the Nordic region and not limited to the routes and fuels. The cost-effective analysis should follow a life-cycle perspective of the fuel from production to end-use. This, among other parameters (e.g. energy security), would help determine to what extent the production of green hydrogen-based fuels should be done within the Nordic region or imported from other regions.
- Policy packages should be prioritized over focalized policies for the establishment of zero-emission ferry routes. This requires a cross-industry and transnational approach in which Nordic collaboration will be essential. The policy packages should consider ways for mitigating risks for early adopters, the establishment of new projects, and the development of infrastructure.

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