PHASE II - NORDIC PILOT PROJECT FOR THE ESTABLISHMENT OF GREEN SHIPPING CORRIDORS

Funding opportunities for Nordic green shipping corridors

Nordic Council of Ministers

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This report provides an overview of the additional cost of green shipping corridors and identifies existing government funding and financing opportunities for Nordic green shipping corridors to support first movers.

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EXECUTIVE SUMMARY

To ensure realization of the first Nordic green shipping corridors, it will be critical to find ways to close the significant cost gap between zero-emission fuels and conventional fuels. This report provides an overview of the additional cost of green shipping corridors and identifies existing government funding and financing opportunities for Nordic green shipping corridors to support first movers – including national, Nordic, and EU public funding programmes providing opportunities for grants, loans, and guarantees. Based on this, we provide a high-level assessment of funding and financing opportunity gaps for Nordic green shipping corridors, using the established database.

Findings

1) Shifting from conventional fuels to zero-emission fuels for ships operating on a specific corridor will have considerable costs, including the cost of building (or converting) and operating zero-emission vessels, as well as the cost of establishing or converting bunkering infrastructure for zero-emission fuels. Our illustrative case studies of the vessels-specific costs for two Nordic corridors show that there will be a significant cost difference between conventional operational and zero-emission operation for the same vessel over the modelling period (2025 to 2040). However, the cost difference decreases slightly over time mainly due to the increased stringency of existing GHG regulations.

2) We have mapped 24 national and cross-Nordic public entities in the *Nordic Corridor Funding Database* that are potentially relevant for green shipping corridors in the Nordic region. Together, these entities govern around 60 programmes and instruments that could be relevant for the corridor value chain. Several funding opportunities relevant for green shipping corridors are also available at the EU level. There is large variation in the organizational setup of funding mechanisms in the different Nordic countries, as well as in the available funding volumes. The funding volume available in the EU programmes is often in another order of magnitude compared to national and cross-Nordic programmes.

3) Based on our high-level assessment we find that most of the current funding opportunities in the Nordics target technology development and building of vessels and onshore infrastructure, and there are few opportunities related to fuel cost in the operational phase of green shipping corridors. The presence of opportunities does not guarantee that the necessary funding and required volumes will be secured for specific projects. Funding needs vary significantly from corridor to corridor, depending on the selected fuel strategy, the corridor characteristics, and the actors' financial capabilities and access to private financing.

Recommendations

- To reach the political ambition of early realisation of green shipping corridors, there is a need for more specific and coordinated funding opportunities for all parts of the corridor value chain and development stages. This includes opportunities that will support the reduction of fuel costs in the operational phase.
- Funding a green shipping corridor will likely require several funding sources across the value chain and across borders. The *Nordic Corridor Funding Database*, supporting stakeholders with identifying existing public funding and financing opportunities, should be maintained over time and further developed in line with changing needs. Applicants should enter into early dialogue with the various funding entities to put together the funding puzzle. Further, seeking the right partnerships and utilizing experience within the partnership will increase the probability of success in securing funding. Private financing should also be an important part of the overall funding plan for a green shipping corridor, as corridors will not be realized with public funding and financing alone.
- Beyond government funding and financing mechanisms, there are several other interrelated ways to reduce the cost difference in the short term to support the first Nordic green shipping corridors, including energy efficiency measures, income from sales of green transportation, and regulatory flexibility mechanisms. These options should be combined, ensuring cost- and risk sharing between stakeholders. Other novel mechanisms may also be relevant, such as sustainability-linked loans and bonds and other forms of private financing.

1 INTRODUCTION

At COP 26 in 2021, more than 20 countries (including the Nordic countries) signed the *Clydebank Declaration*, committing to develop at least six green shipping corridors - defined as zero-emission routes between two or more ports - by 2025 and "many more" by 2030.[1] Green shipping corridors can become important enablers for accelerating the global uptake of zero-emission fuels, as they can address a series of barriers at a small scale.[2] More than 60 green shipping corridor initiatives have so far been announced globally, yet most are still in the early planning phase.[3]

To kick-start the follow-up of the political initiatives, the Nordic Council of Ministers awarded in 2022 a Phase I project on establishing Nordic green shipping corridors which developed a shortlist of six intra-Nordic green shipping corridors which could potentially be realized in 2025, or towards 2030.[4] Based on workshops with relevant stakeholders, the additional cost of using zero-emission fuels compared with conventional fuels was identified as the most critical barrier for the realization of green shipping corridors in the Nordics. In 2024, the Nordic Council of Ministers awarded a Phase II project to map existing public funding and financing opportunities in the Nordic countries and assess how they can support the realization of the first Nordic green shipping corridors.[i]

This report identifies existing government funding and financing opportunities in individual Nordic countries, cross-Nordic and in the EU, and identifies opportunity gaps. The report is structured as follows (Figure 1-1):

- Chapter 2 presents an overview of the additional cost of green shipping corridors compared to conventional routes.
- Chapter 3 presents an overview of public funding and financing opportunities for green shipping corridors for Nordic maritime stakeholders in a newly established *Nordic Corridor Funding Database*.
- Chapter 4 presents a high-level assessment of funding and financing opportunity gaps for Nordic green shipping corridors, using the established database.

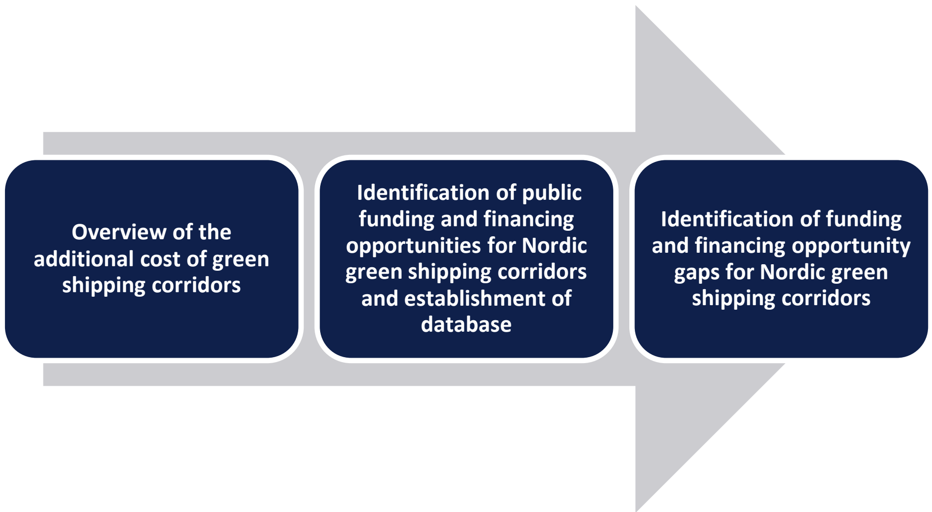


Figure 1-1: The approach used to identify and assess funding and financing opportunity gaps in this study.

This work was carried out in collaboration with the *Nordic Roadmap for Future Fuels* project (2022-2025), coordinated by DNV and funded by the Nordic Council of Ministers.[5] This cross-Nordic collaborative project with more than 70 partners from the maritime fuel value chain aims to reduce key barriers hindering the uptake of zero-emission fuels in Nordic shipping. Recently, the project delivered the *Fuel Transition Roadmap for Nordic Shipping*, detailing 20 actions for overcoming the key barriers.[6] Four of these actions specifically relate to the financing of the first green shipping corridors (see Actions 1-4[6]), covering both investment and operational costs in the value chain.

[i] The Phase II project on establishing Nordic green shipping corridors includes two reports. The other report, titled "Potential green shipping corridors between the Nordic region and neighbouring countries", assesses potential corridors between the Nordics and other non-Nordic neighbouring countries in Europe, with focus on Germany, the Netherlands, and the United Kingdom.

2 THE ADDITIONAL COST OF GREEN SHIPPING CORRIDORS

In this chapter, we outline the additional cost of green shipping corridors. Shifting from conventional fuels to zero-emission fuels for ships operating on a specific port-to-port corridor will have considerable costs, including the cost of building (or converting) and operating zero-emission vessels, as well as the cost of establishing or converting bunkering infrastructure for zero-emission fuels.

The costs of a specific green shipping corridor will depend on the selected fuel pathway (including fuel converter), as well as corridor characteristics, such as route length (sailing distance), ship segment and size, ship speed, transport demand (cargo and passenger volumes), and port readiness level[7] for the specific fuel. The costs will also depend on whether the shift to zero-emission fuels on a corridor requires a newbuild or conversion of an existing ship, or whether zero-emission fuels can be used as a drop-in. There is limited literature on green corridor specific costs, but recent deep-sea and short-sea studies indicate that fuel cost has the largest impact on the life cycle cost and represents the largest share of the cost difference, although for short-sea routes the added cost of novel zero-emission propulsion technologies constitute an important cost element.[8,9,10] For example, the additional cost for zero-emission fuels ranges from three to four times the cost of conventional fuels.[11,12] This has a significant impact on the overall cost of initial corridors, presenting a significant challenge for realizing the first Nordic corridors.

The additional capital expenditure (CAPEX) for a newbuild zero-emission vessel is also significant, and will vary with the selected fuel technology, ship type, and size.[13,14] The additional costs of alternative fuel technologies constitute a larger part of the total cost for simpler ships, such as cargo ships, compared to more advanced ships, such as passenger and offshore ships, where the proportion of the total cost related to propulsion is low. It is difficult to estimate these additional investment costs on a general basis. Experience data does not exist, except for LNG and methanol fuel technologies. An analysis of 2023 and 2024 data for container ships (dual fuel combustion engines) shows that for methanol the additional costs range from 9% (vessels with about 22,000 – 24,000 TEU capacity) to almost 20% (vessels with about 9,000 TEU capacity).[15] The corresponding numbers for container ships with LNG fuel technologies are 12% and 27%. From a literature review, we find some unit costs for engines, tank systems, etc.,[16,17] but the total investment cost will only be known when ships with these technologies are built. However, using unit cost data, the added cost is expected to be highest for liquefied hydrogen, followed by LNG, ammonia, and methanol. For more novel technologies, such as fuel cells, the additional cost will be significantly higher.

In addition to vessel-specific costs, establishing a green shipping corridor requires substantial onshore investments and developments. The cost of establishing bunkering infrastructure (e.g., ship-to-ship, truck-to-ship, or port-to-ship) to support corridors varies depending on fuel type and existing infrastructure and terminals. While biodiesel and methane can benefit from the existing bunkering infrastructure, methanol, ammonia, and hydrogen will need new bunkering infrastructure to be built. The already existing terminal infrastructure for methanol and ammonia could be a starting point for a distribution network for the use of ammonia and methanol as fuels for shipping, bringing down the ‘last-mile’ distribution cost. However, there is limited literature on the cost of constructing alternative fuel bunkering infrastructure. Pre-feasibility studies conducted by the Getting to Zero Coalition estimated that if one bunker vessel and one onshore tank facility is required per port in a green shipping corridor, this could add around 5% to the cost of fuel.[18] Furthermore, the cost of bunkering per tonne is expected to significantly decrease over time. However, truck-to-ship bunkering is expected to be used for the first zero-emission vessels operating on the initial Nordic green shipping corridors, while the required fuel volumes are limited.

As the vessel-specific costs constitute a large part of the total cost for the port-to-port green shipping corridors, we present two illustrative Nordic case studies below to indicate the cost difference between conventional (baseline) vessels and zero-emission vessels. These case studies are inspired by real-life projects but use input from DNV databases for the modelling. This high-level analysis shows that neither of the assessed zero-emission vessels are competitive by 2040 compared to the baseline vessels - a huge challenge for ship owners who will not be able to operate with red numbers for 16 years.

2.1 Illustrative case studies: Vessel-specific cost assessment

To illustrate the vessel-specific cost difference between current operation and potential near-term zero-emission operation, we present cases studies on two potential Nordic corridors. As illustrated in Figure 2-1, the two case corridors are:

1. The Umeå – Vaasa RoPax Ferry Route
2. The Gothenburg – Frederikshavn RoPax Ferry Route

The case study corridors are selected based on their stakeholder maturity level and motivation, with possibilities for early realization. We highlight that the case studies are conducted only to illustrate the cost difference on specific routes in the period 2025 to 2040, examining how the cost difference evolves over time. Below, we first describe our approach to assessing the vessel-specific costs, before presenting the case studies.

Figure 2-1: The two corridors selected for the case studies.

2.1.1 Case study approach

For each case, we assess the cost difference from 2025 to 2040 between operating a baseline vessel and a zero-emission vessel. An existing vessel is used in each case, exploring two different fuel strategies. The fuel strategy of the baseline vessels in both cases is to operate on fossil fuels, blending in biofuel over the period to be compliant with FuelEU Maritime. For the zero-emission vessels, the fuel strategy is to use zero-emission fuels over the period. The baseline and zero-emission vessels are selected based on ongoing initiatives on the routes, focusing on options available for early realization.

We have selected a fifteen-year horizon to illustrate how the cost difference could evolve with today's regulatory requirements and our assumptions on fuel prices and EU ETS allowances prices. However, we stress that our simplified modelling does not include potential market developments and regulatory updates in this period, which will likely impact the cost picture. In the two cases, the identified cost difference could be reduced with more stringent GHG regulations including higher emissions pricing, and/or with support mechanisms such as investment support for fuel production, investment support for technologies onboard vessels, as well as a time-limited support mechanism for fuel expenses during the operational phase.

To assess the cost difference in each case, we calculate and compare the annual cost and total cost for the baseline and zero-emission vessel from 2025 to 2040, including the following costs associated with owning and operating the vessel over the period:

- CAPEX (EUR): Additional capital expenditure for retrofit of existing vessel to make it able to operate on alternative fuels, including loan costs (only relevant for Case 2).
- FUELEX (EUR/year): Fuel expenditure during the operational phase of the vessel, including costs related to consumption of fuel and electricity. Both cases include expenditure for electricity related to shore power, while Case 1 also includes charging of batteries for hybrid propulsion.
- GHGEX (EUR/year): Greenhouse gas (GHG) expenditure, covering EU emission allowances.
- OPEX (EUR/year): Other operational expenditure, such as maintenance, crewing, spare parts, etc.

A high-level cost estimation tool is used for the cost modelling in the two cases. In Appendix C, we describe the simplified cost model with its inputs, equations, and outputs. The cost modelling is made without the inclusion of any additional funding or financial support. In Appendix D, we provide corridor-specific input data, including vessel data, assumed fuel and EUA[ii] prices, and assumed fuel GHG intensities.

For each case below, we outline the corridor evaluated, the fuel strategies investigated for the case vessels, and the main case assumptions, and present key results.

2.1.2 Case 1: Umeå – Vaasa RoPax ferry route

Today, Wasaline transports passengers and cargo daily between Umeå in Sweden and Vaasa in Finland. The journey takes 3.5-4 hours with the RoPax ferry Aurora Botnia, with a sailing distance of 53 nautical miles (nm). The RoPax ferry was delivered in 2021 and has a passenger capacity of 935 passengers and a cargo capacity of 1,500 lane meters for trucks and cars. The ferry has a hybrid propulsion system with batteries and dual-fuel LNG engines, with LNG as the main fuel, but it can also use bio-LNG.[19]

CASE DESCRIPTION AND ASSUMPTIONS

In this case, we use the RoPax ferry Aurora Botnia, described above, as the case vessel. The intention with Case 1 is to estimate the additional cost over the period 2025 to 2040 of shifting from LNG to bio-LNG. This shift will not involve any major technical adaptations that will require additional CAPEX. The case vessel has approximately 1,160 roundtrips per year, with an average transit speed of around 17 knots. The annual fuel consumption and electricity consumption of operating the case vessel daily on the Umeå-Vaasa route has been provided by Wasaline (see Appendix D). All other data, including cost data, has been provided by DNV.

In this case we compare:

A. **Baseline vessel –** operates on a combination of fossil LNG, MGO, and batteries (hybrid) from 2025 to 2040 (see Appendix D.1). The vessel also uses shore power in port. The vessel's FuelEU Maritime compliance strategy is to increasingly blend bio-LNG into the fuel mix to remain compliant over the modelling period.
B. **Zero-emission vessel –** operates on a combination of bio-LNG and batteries from 2025 to 2040 and uses shore power in port.

[ii] DNV: EU ETS – Emissions Trading System – what are EUAs? https://www.dnv.com/maritime/insights/topics/eu-emissions-trading-system/eu-allowances/

ESTIMATED VESSEL-SPECIFIC COST GAP

Figure 2-2 shows the total cost for the modelling period (2025-2040) for the baseline vessel and the zero-emission vessel, which is estimated to be around 153 MEUR and 174 MEUR, respectively (including total OPEX, FUELEX, and GHGEX). This results in a total cost difference of 21 MEUR, mainly due to the higher FUELEX of bio-LNG and that the baseline vessel will have higher GHGEX.[iii] Without GHGEX, the cost difference would be significantly higher. The OPEX is estimated to be the same for both vessels (78 MEUR).

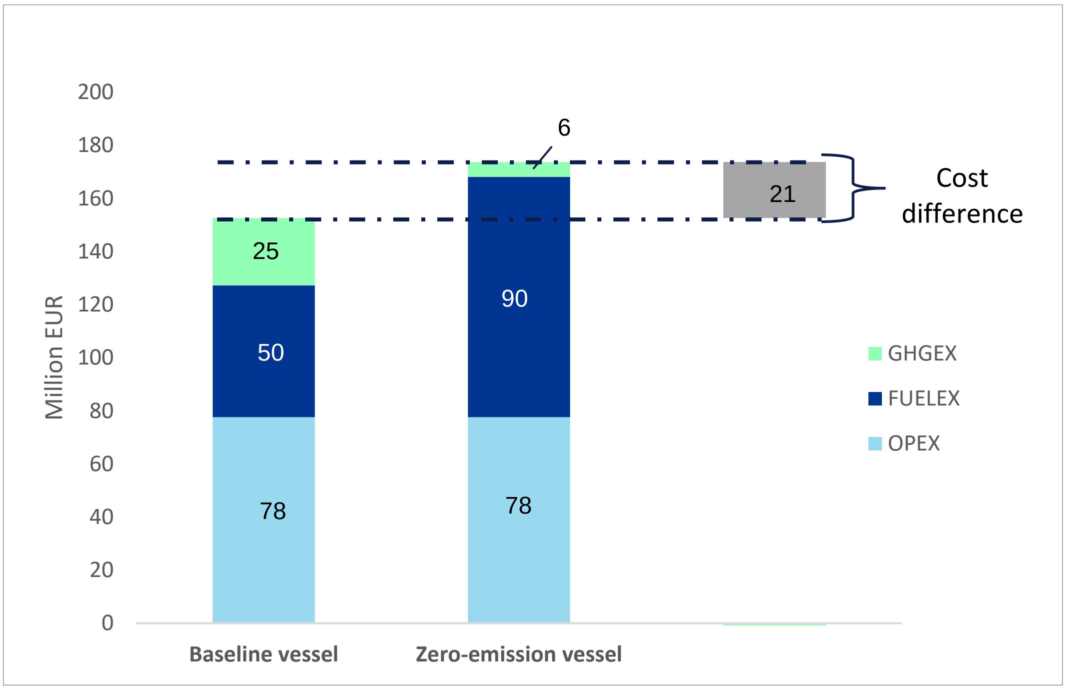


Figure 2-2: The total cost for the modelling period (2025-2040) for case vessels on the Umeå-Vaasa corridor.

Figure 2-3 shows the relative annual cost difference for the zero-emission vessel compared to the baseline vessel. The zero-emission vessel will not be economically competitive with the baseline vessel over the modelling period, as a significant cost difference appears in all years. The annual cost difference is 29% in 2025, gradually decreasing to 4% in 2040 under the assumptions of this study. The modelled cost difference decreases over time mainly due to increasing GHGEX and FUELEX for the baseline vessel, as more and more bio-LNG is blended in to comply with the FuelEU Maritime regulation (see Appendix C for the development of the fuel mix for the baseline vessel).

[iii] It should be noted that the main contributor to the Tank-to-Wake GHG emissions for bio-LNG is CH_4, in addition to a small contribution from N_2O. The GHG intensity factors used in this study are based on default values given in Annex II of the FuelEU Maritime Regulation.

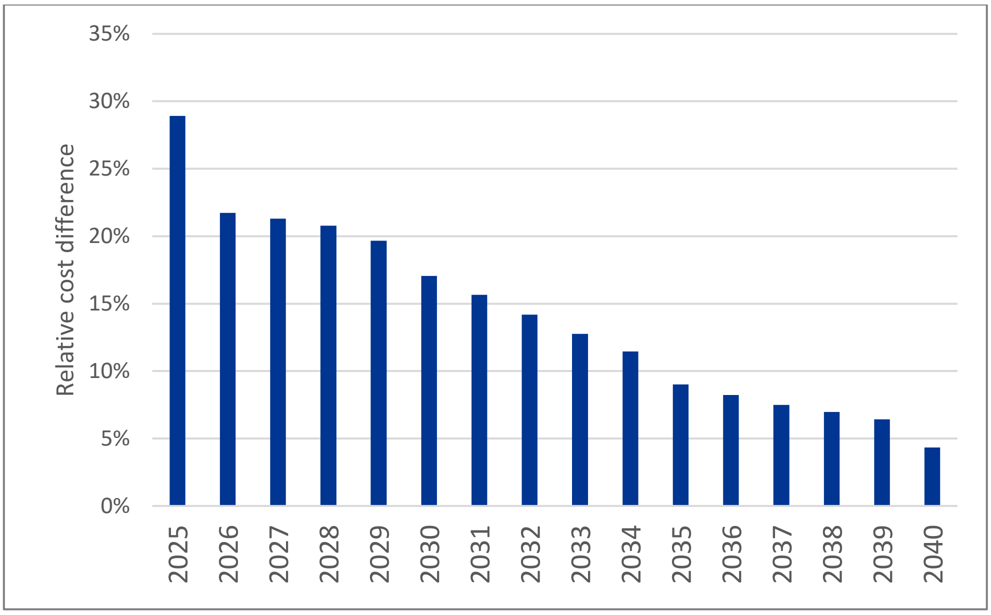


Figure 2-3: Annual cost difference for the modelling period (2025-2040) for the case vessels on the Umeå – Vaasa corridor. The cost difference indicates the additional cost of the zero-emission vessel relative to the baseline vessel.

The corridor partnership on the Umeå-Vaasa route has already come a long way in the early planning and demonstration phase towards becoming a green corridor – also testing operation on bio-LNG during "Green Corridor Fridays" in the autumn of 2023.[20] A unique collaboration platform has been established between the two ports, the two cities, and the vessel operating on the route. A low-hanging first step for the corridor is transitioning to bio-LNG, but other zero-emission fuel options could be relevant in the longer term, such as methanol, hydrogen, and ammonia, with each option involving different costs.

2.1.3 Case 2: Gothenburg – Frederikshavn RoPax ferry route

Today, Stena Line operates two RoPax ferries (Stena Danica and Stena Jutlandica) between Gothenburg and Frederikshavn. The journey takes 3.5-4 hours, with a sailing distance of around 50 nautical miles (nm). This RoPax ferry was built in 1996, with accommodation for around 1,700 passengers and a cargo capacity of 2,100 lane meters for trucks and cars. The ferry currently runs on MGO.

CASE DESCRIPTION AND ASSUMPTIONS

In this case, we use the RoPax ferry Stena Jutlandica, described above, as the case vessel. The intention with this case is to estimate the additional cost over the period 2025 to 2040 of shifting from MGO to e-methanol. The case vessel has approximately 1,300 roundtrips per year, with an average speed of around 15-16 knots. The annual fuel consumption of operating the case vessel daily on the Gothenburg - Frederikshavn route and the cost of retrofitting to e-methanol have been provided by Stena Line and IVL (see Appendix D). All other data, including cost data, have been provided by DNV.

In this case we compare:

- **A.** **Baseline vessel –** operates on fossil MGO from 2025 to 2040 (see Appendix D.1). The vessel's FuelEU Maritime compliance strategy is to increasingly blend biodiesel into the fuel mix to remain compliant over the modelling period. It assumed that blending in biodiesel does not require additional CAPEX.
- **B.** **Zero-emission vessel –** operates on e-methanol from 2025 to 2040. Additional CAPEX is needed to retrofit the existing vessel to make it able to operate on methanol.[iv]

[iv] In this case, we assume that 100% of the CAPEX of retrofitting the zero-emission vessel is financed by an instalment loan, with a down-payment period of 16 years and an interest rate of 5%.

ESTIMATED VESSEL-SPECIFIC COST GAP

Figure 2-4 shows the total cost for the modelling period (2025-2040) for the baseline vessel and the zero-emission vessel, which is estimated to be 311 MEUR and 464 MEUR, respectively. This results in a total cost difference of 153 MEUR, mainly due to the higher FUELEX of e-methanol and the CAPEX of the retrofitting (including cost of capital), and that the baseline vessel will have higher GHGEX. Without GHGEX, the cost difference would be significantly higher. The OPEX is estimated to be the same for both vessels (78 MEUR).

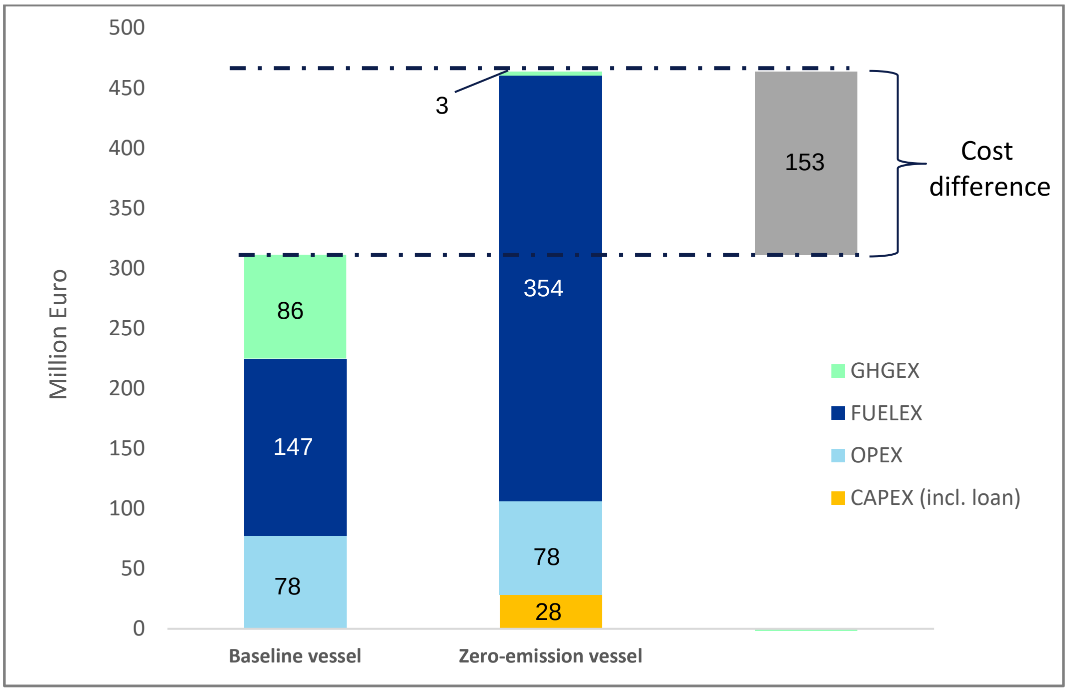


Figure 2-4: Total cost for the modelling period (2025-2040) for case vessels on the Gothenburg-Frederikshavn corridor.

Figure 2-5 shows the relative annual cost difference for the zero-emission vessel compared to the baseline vessel. The zero-emission vessel will not be economically competitive with the baseline vessel over the modelling period, as a significant cost difference appears in all years. The annual cost difference is 114% in 2025 and gradually decreases to 27% in 2040. The modelled cost difference decreases over time mainly due to increasing GHGEX and FUELEX for the baseline vessel, as more and more biodiesel is blended in to comply with the FuelEU Maritime regulation.

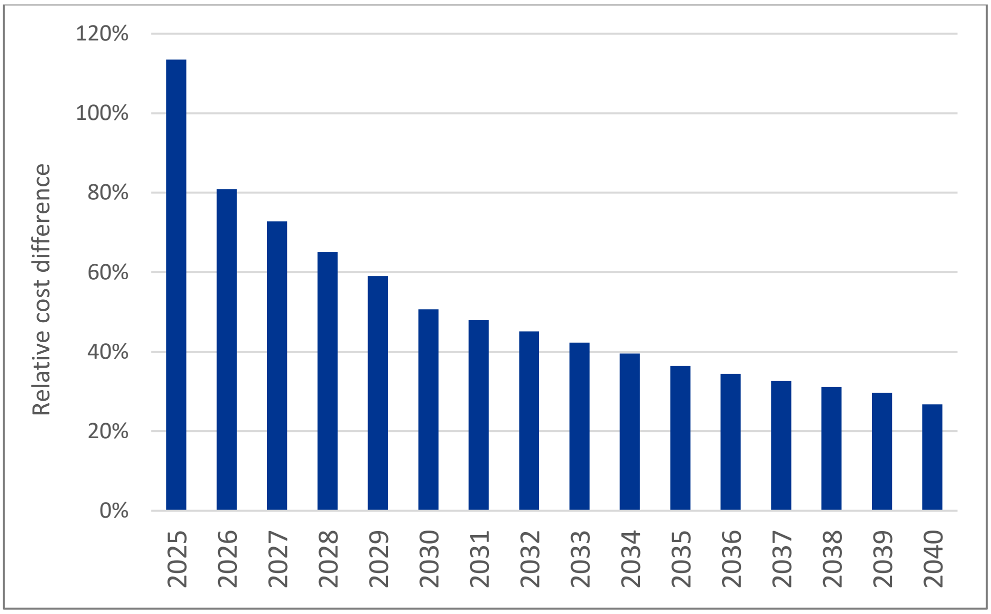


Figure 2-5: Annual cost difference for the modelling period (2025-2040) for the case vessels on the Gothenburg-Frederikshavn corridor. The cost difference indicates the additional cost of the zero-emission vessel relative to the baseline vessel.

In this case study, the only assessed zero-emission option for the route is e-methanol. A Nordic Roadmap pilot study report for this route will be published in 2025, including an analysis and comparison of additional zero-emission fuel options.[21]

This case study illustrates that shifting from conventional fuels to an expensive e-methanol that requires a costly conversion (retrofit) will result in a considerable cost difference (annually and total). It is noted that the case ship is quite old, and this study has not made any considerations regarding remaining lifetime, or the technical feasibility of retrofitting.

3 PUBLIC FUNDING AND FINANCING OPPORTUNITIES FOR NORDIC GREEN SHIPPING CORRIDORS

Public funding and financing will be critical to support the realization of the first Nordic green shipping corridors, before increasingly stringent GHG regulations will support the uptake and production of zero-emission fuels. To build corridor-specific business cases for first movers, it will be important for stakeholders to better understand the various cost elements across the green shipping corridor value chain, which public support mechanisms are available, and which part of the value chain they target. In this chapter, we present the *Nordic Corridor Funding Database,* which gives an overview of existing public funding and financing opportunities relevant for Nordic green shipping corridors and their stakeholders. This includes national, Nordic, and EU funding programmes.[v]

Chapter 3.1 first presents an overview of how data has been collected and the structure of the database, before Chapter 3.2 provides an overview of identified opportunities. Chapter 3.3 then discusses how applicants can succeed in a shifting landscape of funding opportunities.

3.1 Overview of the Nordic Corridor Funding Database

3.1.1 Data collection

Input to the database has been collected by identifying a wide range of funding and financing opportunities in each Nordic country, as well as cross-Nordic and EU opportunities. The focus has been on potential public funding and financing opportunities for realization of the first green shipping corridors, targeting the port-to-port value chain, including fuel production, and the corridor development stages from piloting to realizing. We specifically cover *Technology Readiness Level* (TRL) 6 and above, excluding research activities. Further, we only focus on government grants and loans (including guarantees). Based on these selection criteria, we have collected information on funding opportunities through:

- Input from contributing partners and pilot projects in the Nordic Roadmap project[5]
- Review of relevant websites, reports[22], and articles describing the various Nordic, cross-Nordic, and EU funding opportunities and Nordic maritime projects which have received funding.
- Consultation through written communication, phone calls, and meetings with different funding agencies (e.g., Danish Energy Agency, Business Finland, Swedish Transport Administration, The Research Council of Norway, Innovation Norway, ENOVA, Nordic Energy Research, Nordic Innovation).
- Existing funding opportunity portals, including:
  - The EU's Ship Financing Portal[23]
  - Zero Emission Shipping Mission: Mapping Global Financial Support Opportunities for Zero-Emission and Energy-Efficient Ships, including excel sheet with funding opportunities[24]
  - The EU radar developed by the Green Shipping Programme[25]

As funding opportunities and mechanisms in the Nordics and in the EU are under continuous development, it is acknowledged that the mapping carried out in this report might not represent a complete picture of available opportunities.

[v] The Nordic Corridor Funding Database was first presented at the Nordic Roadmap Conference in Copenhagen 3 December 2024: https://futurefuelsnordic.com/presentations-from-the-high-level-conference-december-3-copenhagen/

3.1.2 Selected data structure

The *Nordic Corridor Funding Database* is structured as shown in Figure 3-1, using an Excel format. The information is structured by country/region, funding entity, funding instrument, and value chain component.

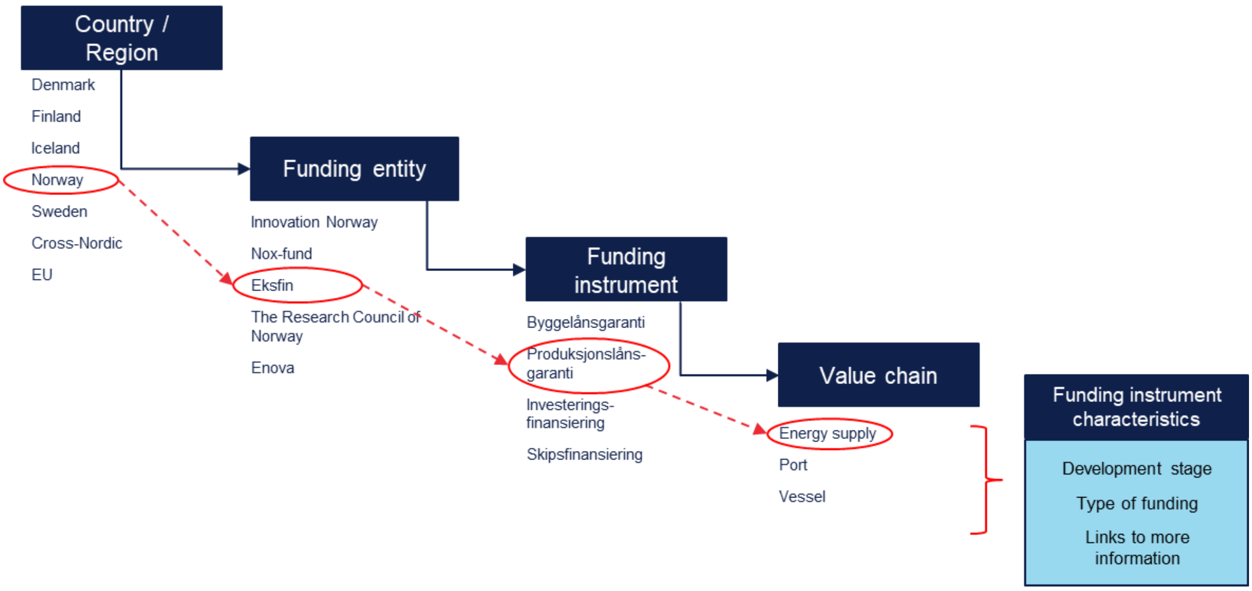


Figure 3-1: Illustration of the selected database structure of public funding opportunities for Nordic maritime stakeholders, exemplified through a hypothetical case.

In the Excel database, each record includes information on these four attributes, in addition to key characteristics as illustrated in the right-hand box in Figure 3-1 (development stage, type of funding, and links to more information about the opportunity). Table 3-1 shows two examples of records in the database. The full list is included in Appendix A.

Table 3-1: Examples of information compilation in the Excel database, including column explanations.

Country/ region	Funding entity	Funding instrument	Value chain coverage	Development stage	Type of funding	Link to more information
EU	EU Commission	Interreg Baltic Sea	All	Development, Execution	Grant	[Interreg Baltic Sea Region Programme 2021-2027 - European Commission (europa.eu)]
Norway	Enova	Program – «Hydrogen i fartøy»	Vessel	Execution	Grant	[Hydrogen i fartøy | Enova]
...	...	...	...	...	...	...

Column explanations:

- *Country/region: The country/region providing the funding opportunity*

- *Funding entity: The government entity providing the funding*
- *Funding instrument: Name of the specific funding instrument/programme*
- *Value chain coverage:* ***Energy supply*** *(fuel production, fuel transport, transmission grids etc.),* ***Port*** *(bunkering/charging, storage, other) and* ***Vessel*** *(onboard technology and systems).*
- *Development stage: TRL levels 6-9, Development (technology development of value chain), Execution (building of infrastructure and vessel), Operation.*
- *Type of funding: Grants and loans/guarantees.*
- *Link to more information: Links to relevant websites describing the funding instrument in more detail.*

3.1.3 Using the database from different user perspectives

Applying the filter function in Excel allows users to effectively identify relevant funding and financing opportunities together with more information about the opportunities. There are various user perspectives when screening opportunities, including the “stakeholder perspective”, reflecting a specific stakeholder in a certain country, and the “green corridor perspective”, reflecting the need for an overall overview across borders and the value chain. Depending on the case specific user needs, the selected data structure allows for flexible and effective filtering of relevant data:

- **Country/region**: A Nordic green shipping corridor involves two or more countries. Hence, there might be different national funding and financing opportunities for the same corridor, and filtering on relevant countries is therefore useful. Users can select the countries involved in the corridor. Please note that some funding programmes focus on national projects, while other programmes also support project partners in other countries (e.g. EU programmes). Applicants should contact the relevant programmes for details.

- **Value chain coverage**: It varies if and how the different funding schemes are limited to certain parts of the green corridor value chain. Specifying the value chain component(s) provides a more targeted search for a specific stakeholder. The database is structured along the following value chain components: Energy supply (fuel production, fuel transport, transmission grids etc.), Port (bunkering/charging, storage, other) and Vessel (onboard technology and systems). Users can select one value chain component or select all the components.

- **Project development stages**: The various funding opportunities could have different restrictions when it comes to what kind of project/technology development stage that is eligible for funding. Such restrictions could be governed by state aid rules and how the various governments have arranged the different funding schemes. Defining the project/technology development stage that needs funding is therefore relevant and the database sorts among the following phases from TRL level 6 and beyond; Development, Execution and Operation. Users can select the different phases.

- **Type of funding**: There are various funding and financing opportunities that could be relevant for a green corridor (e.g., loans, grants, equity, bonds), and the need for financing a green corridor would probably require a set of these alternatives. Being able to sort among various mechanisms could be helpful when developing a financing plan for a corridor. This study focuses on opportunities for public grants and loans/guarantees.

3.2 Identified opportunities

There are several opportunities for public funding for maritime stakeholders within the Nordic countries, across the Nordic countries and in the EU (see Figure 3-2). The number of public funding entities and how these are set up to govern public funding varies between the Nordic countries. In total, 24 national and cross-Nordic public entities have been identified. Together, these entities govern around 60 programs and instruments that could be relevant for the green shipping corridor value chain. Several funding opportunities relevant for green shipping corridors are also available through the EU commission. The identified opportunities are presented in the database overview in Appendix A.

In the following, we elaborate on the similarities and differences between how public funding is organized in the various Nordic countries, and the volume of available funding.

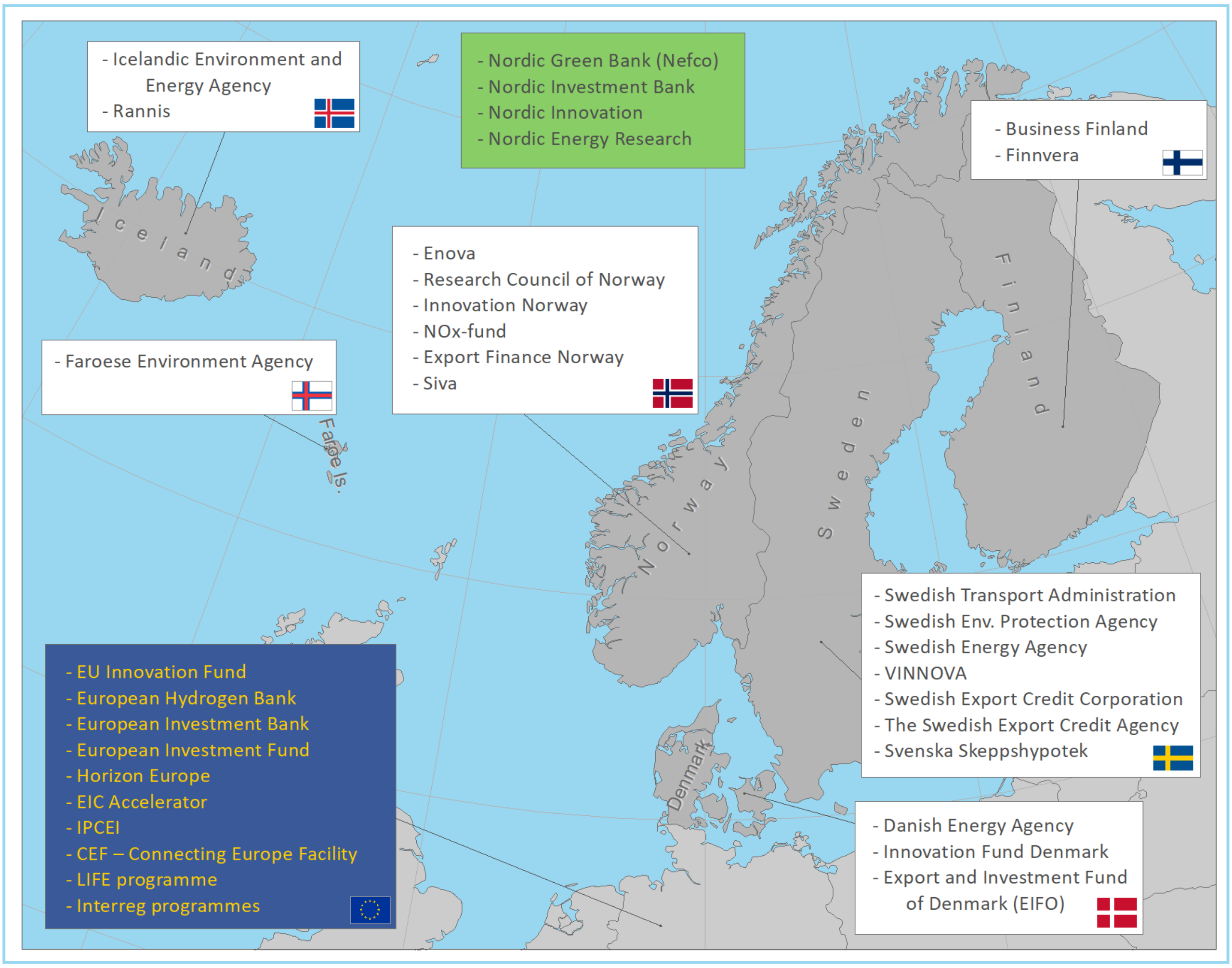


Figure 3-2: Funding entities relevant for the Nordic green shipping corridor value chain, including national entities, cross-Nordic entities (green box) and main EU funding instruments (blue box).

3.2.1 National opportunities

In Finland, funding schemes and instruments providing grants are governed by one funding entity, Business Finland, whereas Finnvera supports the execution stage by providing financing opportunities through loans and guarantees. Grants are available through various generic programs covering the value chain for a green shipping corridor. The programme "Innovation aid for shipbuilding" is, however, dedicated for shipbuilding. One example of a project that has received funding from Business Finland is the Decatrip-project[53] which received funding of 1.6 MEUR to establish a green corridor on the 10-hour ferry crossing between Turku (Finland) and Stockholm (Sweden), via the Åland Islands. Finnvera offers both domestic and export loans, together with guarantees, for energy supply investments. This includes domestic loans for investments in port infrastructure and guarantees related to vessel building.

In Norway, public funding through grants is allocated through various entities with different objectives. For example, the Research Council of Norway (RCN) targets research and early phase development, Enova focuses on industry and demonstration and realization of technology, and Innovation Norway focuses on market entry and export opportunities. The various funding entities also collaborate on different funding programs, such as Pilot-E (Enova, RCN, and Innovation Norway) and Grønn Platform (RCN, Innovation Norway, and Siva). Enova is the main entity when it comes to the final stages of development and investment support for building of vessels and production facilities for fuel, through dedicated programs for hydrogen and ammonia. For example, Enova recently granted more than 940 MNOK to 9 new zero-emission vessels (2 hydrogen vessels and 7 ammonia vessels).[26] Enova has also recently announced that it is granting 777 MNOK in support to build five hydrogen production plants along the Norwegian coast.[27] Further, investments related to charging infrastructure in ports are available, and a programme supporting ammonia bunkering is under development.

Another instrument to mention in Norway is the public-private environmental agreement on NOx reduction where the Business Sector' NOx fund has provided investment support to many relevant projects, including a range of ferry electrification projects in Norway. Since 2008, the NOx-fund has allocated over 15 billion NOK in investment support for the implementation of emission-reducing technologies (both NOx and GHG), with more than half of this funding directed towards the shipping industry. The NOx fund has also coordinated with Enova to ensure sufficient total funding for many projects, for instance Berge Rederi's zero-emission project utilizing batteries, rotor sails, and shore power for emission-free operation of a 13,000 DWT ship between Elnesvågen and Brønnøy. Enova and the NOx fund supported the project with 120 MNOK and 150 MNOK, respectively. Export Finance Norway provides financing opportunities through loans and guarantees, for example through the Construction loan guarantee, which is a dedicated programme aimed to secure competitive financing for costs related to the construction of vessels.

In Denmark, the relevant opportunities involving grants are governed by Innovation Fund Denmark, focusing on the early stages of development, and by the Danish Energy Agency through the Energy Technology Development and Demonstration Programme (EUDP), which covers the TRL levels 4-8.[28] One example of a highly relevant programme for a green shipping corridor is Innovation Fund Denmark's Missiongreenfuels[29], where part of the vision is to contribute substantially to decarbonization of the transport, aviation, and shipping sectors. A relevant example of a project that has received public funding in Denmark is a project carried out by MHO-Co[30] aiming to test fuel cells and new battery technology onboard the shipping company's advanced hybrid vessels. This project received 2.15 MEUR in funding from the EUDP program. Compared to Norway, Sweden, and Finland, there are relatively few public programs relevant for green shipping corridors in Denmark. However, the role of private funds is important in Denmark with the likes of the Danish Maritime Fund and the A.P. Møller fund contributing with substantial amounts of funding for the shipping sector. Public loans and guarantees are available through the Export and Investment Fund of Denmark (EIFO).

In Sweden**,** the governance of the different funding opportunities has been placed under different governmental agencies; Swedish Transport Administration, Swedish Energy Agency, Swedish Environmental Protection Agency, and Vinnova. Various programs are relevant for a green shipping corridor, either through dedicated programs like Vinnova's programme "Sustainable ports", or through generic programs like the Swedish Energy Agency's "Industriklivet", which could be relevant for development of fuel production. It should also be mentioned that the Swedish Transport Administration has dedicated funding available for the shipping sector. This funding is available through their own research and innovation portfolio for the maritime sector and parts of the funding is channelled to the industry through the Swedish Maritime Competence Centre, Lighthouse.[31] An example of how public funding in Sweden has supported the development of green ship concepts is the support given to Wallenius Marine from the Swedish Transport Administration to develop a concept with a wind-assisted propulsion system. Over a period of 4 years (2019-2023), Wallenius Marine received in total of 27 MSEK in funding and today the concept is commercialised by Oceanbird – a joint venture between Alfa Laval and Wallenius. Public loans and guarantees are also available through the Swedish Export Credit Corporation, the Swedish Export Credit Corporation, and Svenska Skeppshypotek.

In Iceland, both Rannis and the Icelandic Environment and Energy Agency have programs that could be relevant for a green shipping corridor. Rannis is typically focused on the early research stages, but activities in the later development stages for technologies could also receive funding through their Technology Development Fund. The Climate and Energy Fund is a programme within the Environment and Energy Agency which could provide investment support in the execution stage of the green corridor project.

To complete the picture for the Nordics, it should also be mentioned that even though the **Faroe Islands** does not provide any public funds for the maritime value chain, they are actively involved in projects related to decarbonising the maritime sector in a Nordic context.[32]

As briefly mentioned above, and reflected through the project examples, the amount of public funding available through grants varies between the different Nordic countries. Norway has provided a larger volume of funding to support zero-emission shipping compared to other Nordic countries. In 2024 alone, the Norwegian government provided around 3.2 billion NOK in funding through Enova, for development of vessels (ammonia, hydrogen, electrification), hydrogen production facilities for maritime applications, and charging infrastructure. It should, however, be noted that when discussing the volume of national funding it is also important to consider how the different countries allocate available funding between national programs and international partnerships, for example the Clean Energy Transition Partnership (CETP).[33] Such a mapping has not been carried out in this study.

3.2.2 Cross-Nordic opportunities

There are also cross-Nordic opportunities for Nordic green shipping corridors through Nordic Energy Research (NER), Nordic Innovation Fund (NIF), Nordic Investment Bank (NIB), and the Nordic Environment Finance Corporation (NEFCO). As an example, through current programs like the Nordic Maritime Transport and Energy Research Programme and Grand Solutions, NER supports relevant projects with joint funding made available from Nordic countries participating in the different calls. Also, the programme Green Transition of the Transport Sector that was run from 2021-2024 should be mentioned. In these programs, Nordic industry and Nordic governmental agencies collaborate to close knowledge gaps and develop projects relevant for green shipping and green shipping corridors. For larger financing needs, NIB can provide loans and guarantees to private and public limited companies, governments, municipalities, and financial institutions. One relevant example is NIB's co-financing of Norled's investments in low-carbon ferries and express boats with a loan of around 43 MEUR.[58]

3.2.3 EU opportunities

As described above, there are many funding opportunities within national programmes in the Nordics and through cross-Nordic collaborations. However, the amount of funding volume available in EU programs are often in another order of magnitude, and there are several EU funding opportunities which could support the realization of Nordic green shipping corridors. This is illustrated for the period 2020-2024, where EU funding for waterborne transport decarbonization research projects is reported to be nearly €1 billion.[34]

The InvestEU Programme was launched in 2021 with the objective of supporting sustainable investment, innovation, and job creation in Europe.[35] Through the programme, the EU Commission provides a budget guarantee up to 26.2 billion EUR with the aim of mobilizing more than 372 billion EUR of public and private investment. The guarantee is implemented through implementing parties such as the European Investment Bank (EIB), the European Investment Fund (EIF), and the Nordic Investment Bank (NIB).

When it comes to funding through grants, opportunities within the **EU Innovation Fund** and **Horizon Europe** should be explored. A relevant example of a project funded through the EU Innovation Fund is the eMETHANOLxWSolution project by Tarntank Ship management, receiving around 2.8 MEUR in funding to demonstrate an innovative combination of foldable suction sails and a dual-fuel engine. For development of infrastructure, for example in ports, the funding instrument **Connecting Europe Facility** (CEF) is relevant.[36] A current call under CEF for Transport includes support to electricity supply as well as ammonia and methanol bunkering facilities in ports, and has a total budget of 1 billion EUR. **The EU Hydrogen Bank** was established as a financing instrument to accelerate the development of a full hydrogen value chain in Europe and is currently the only instrument directly addressing the cost gap related to fuel price. Through auctions, producers of renewable hydrogen can apply for a fixed premium in €/kg. In the second auction, opened on 3 December 2024, a dedicated budget of 200 MEUR has been allocated to projects supplying hydrogen to offtakers in the maritime sector.

There are several other EU instruments and programs which are relevant for a green shipping corridor, as presented in the database overview in Appendix A. It should be noted that not all opportunities in the EU are available for all Nordic countries. For instance, Norway is currently not part of the CEF instrument and Norwegian stakeholders are therefore not eligible to apply for funding.

The EU funding opportunities are often subject to shared management, meaning that a national authority manages the instrument together with the EU Commission. How this is managed varies from country to country. Even though the available volume of funding is much higher in the EU than in the national funding programs, the application process often requires a significantly higher effort and could be difficult to maneuver for smaller companies not experienced in such processes. A recent study carried out on behalf of DG Move also points to the complexity of application processes towards opportunities in the EU as a barrier, especially for small actors.[37] For a stakeholder or project applying for funding, it will be important to identify the national entity responsible for managing EU funding instruments and enter into dialogue to explore opportunities.

3.3 How to succeed in a shifting landscape of funding opportunities

The realization of a green shipping corridor is a complex matter which requires involvement and financing from a series of stakeholders in the green corridor ecosystem. The complexity increases if there are several countries involved and many stakeholders with different perspectives and funding needs. Today, funding opportunities in the Nordic countries focus, however, mainly on individual projects covering one part of the value chain. The landscape of funding opportunities also shifts from year to year, adjusting to political ambitions and the following state budgets. An opportunity which is relevant one year might not be available the next year, due to changes in priorities and budgets.

There are, however, some recent developments in how funding schemes are structured in the Nordic countries which are of high relevance from a green corridor perspective, potentially simplifying the application process and providing a higher volume of funding:

- **Instruments are increasingly developed to target realisation of value chains**: Some instruments and programs are developed with an acknowledgement of the importance of bringing the value chain together. One example is the Nordic Energy Research call “Nordic Hydrogen Valleys as Energy Hubs” which aimed to demonstrate solutions for hydrogen as a zero-emission energy carrier, targeting the entire hydrogen value chain.[38] Another similar example is Clean Hydrogen Partnership’s commitment to and support for creating Hydrogen Valleys.[39] There are also examples of programmes which have tried to address the “chicken or egg” problem, like the Enova programmes on hydrogen production for maritime transport and use of hydrogen in vessels, where funds are allocated both to make fuel available and to build vessels that will use the fuel.

- **Collaboration between funding entities**: Funding opportunities developed in collaboration between different national authorities are also of interest for green corridors. The overall objective of these collaborations is often to accelerate development of new environmentally friendly technology. In Norway, the Pilot-E program[40] is such an example where different funding entities (Enova, The Research Council of Norway, Innovation Norway), usually funding different development stages, join forces to ease the access of funding for projects that involve technology development from early phase to demonstration and market entry. The Green Platform initiative is another example established by the Norwegian government to stimulate larger and more rapid investments from companies in green sustainable solutions and products.[41]

- **Collaboration across borders**: Through Nordic Energy Research, the Nordic countries collaborate and contribute with funding through selected calls. Participating countries can vary between different calls and years. As an example, in the first period of the Nordic Maritime Transport and Energy Research Programme (2021-2023), all the Nordic countries participated in the call, resulting in a total budget of 30 MNOK. In the second period (2024 – 2027), only

Sweden and Iceland participated in the call, with a total budget of around 16 MNOK. In such joint calls, the various partners usually need to apply for funding through their respective national funding agency, and the terms of funding could vary from country to country.

3.3.1 Checklist for green shipping corridor funding applicants

To successfully convert an opportunity into actual funding requires an in-depth understanding of the funding instrument itself and how the funding fits into the overall picture of financing the whole corridor. Identifying relevant funding opportunities is only the first step in the process of securing funding for a green shipping corridor. The *Nordic Corridor Funding Database* could be a starting point for screening potential funding opportunities to start putting together the funding “puzzle”. It is important to note that some funding opportunities are highly competitive with a low success rate.

We propose the following **“check list”** when applying for public funding:

- ✓ **Early identification of opportunities**: When entering the development stage of a green corridor project, it is important to keep in mind that relevant funding opportunities will have different application deadlines and allocation dates. Hence, it is important to do an early mapping of opportunities to ensure alignment with the project timeline and the need for funding.
- ✓ **Early dialogue with the funding agency**: Even though a lot of useful information is available on the website of the responsible funding agency, contacting the funding agency in the early planning phase is important to increase the probability of success. Early dialogue with the funding agency ensures a more targeted and efficient process, as possible limitations and opportunities related to the funding instruments in question are clarified, including the geographical coverage.
- ✓ **Use nominated National Contact Points (NCP):** For some European funding instruments, for example Horizon Europe and Interreg, each country has nominated National Contact Points (NCP) to provide guidance, practical information, and assistance on all aspects related to funding applications. These persons have extensive experience in navigating the European funding system and should be contacted when considering to apply for EU funding. For funding instruments which are not set up with an NCP network, it is important to contact the relevant national authorities who manage the funding instrument together with the EU. Some countries also have funding available for developing the funding application, for example the *PES Horizon Europe - Support for Project Establishment and Positioning* instrument in Norway.
- ✓ **Seek partnership and “harvest” from experienced partners:** Applying for funding in the EU system often requires collaboration between partners in different countries within EU/EEA. The application process itself is often very comprehensive and having experience from previous work on applications towards EU is highly beneficial. Hence, building strong partnerships is critical to succeed. A place to start could be the Green Shipping Corridor Matchmaker provided by Mission Innovation.[42]
- ✓ **Combine different funding sources**: Funding a green shipping corridor could be regarded as a puzzle of funding sources, involving different public funding schemes across both the value chain and across borders. Another aspect that is important to consider when managing a complex funding “puzzle”, is to ensure that the public funding received for a project, and distributed among partners, does not come into conflict with the State aid rules. Different calls could have different limitations when it comes to the share of costs eligible for funding. Close dialogue with the funding agency could therefore be vital to provide the necessary information to ensure compliance with State aid rules.

In Appendix B, we provide examples of relevant projects which have received public funding.

4 HIGH-LEVEL ASSESSMENT OF FUNDING AND FINANCING OPPORTUNITIES

The need for funding evolves as a green shipping corridor project moves across the different stages of development. A green shipping corridor will in most cases require coordinated and timely funding for all parts of the port-to-port value chain.

In this chapter we present a high-level assessment of funding and financing opportunity gaps for Nordic green shipping corridors, using the established database. We assess generic corridors between Sweden – Finland and Denmark – Norway, as these countries have the most identified intra-Nordic corridor connections.[43] As many funding and financing programs target specific fuels, this high-level screening covers a range of zero-emission opportunities (e.g. methanol, ammonia, and hydrogen, methane, and battery hybridization).

4.1 Assessment approach using traffic lights

We assess the funding and financing opportunities for each corridor value chain component (*Energy supply*, *Port,* and *Vessel*) and corridor development stage: *Development* (technology development of value chain), *Execution* (building of infrastructure and vessel), and *Operation*.

The following colour category (traffic light) system has been applied to screen available funding and financing opportunities:

- **Green category**: Funding and financing opportunities are available in the respective country and/or through cross-Nordic collaboration and/or EU, through dedicated programs for the maritime sector.
- **Yellow category**: Funding and financing opportunities are available in the respective country and/or through cross-Nordic collaboration and/or EU, however only through generic programs.
- **Red category**: Funding and financing opportunities are not available in the respective country and/or through cross-Nordic collaboration and/or EU.

Describing a funding opportunity as “available” means that it is possible to apply for funding from an established funding instrument. However, most funding schemes for grants are based on competition between applicants and may cover several sectors/areas. Hence, a green or yellow category does not imply that funding automatically is available for a specific value chain component at the indicated development stage. Further, a green or yellow category does not imply that available opportunities cover the full funding needs of a specific project, which vary considerably for different corridors.

We stress that different funding programs vary considerably in funding volume. For example, programmes vary between providing a few million in grants to several hundred million Euros (with EU and Enova programmes as leading grant providers). It should also be mentioned that the different opportunities address very different needs in financing a green corridor. Public funding in form of a grant could cover parts of the additional costs related to an investment, whereas a guarantee could be critical for financing the project by enabling the possibility of a private loan. The funding availability may also vary with fuel type and therefore the colours in the figure do not necessarily apply to all fuel options.

4.2 Screening results

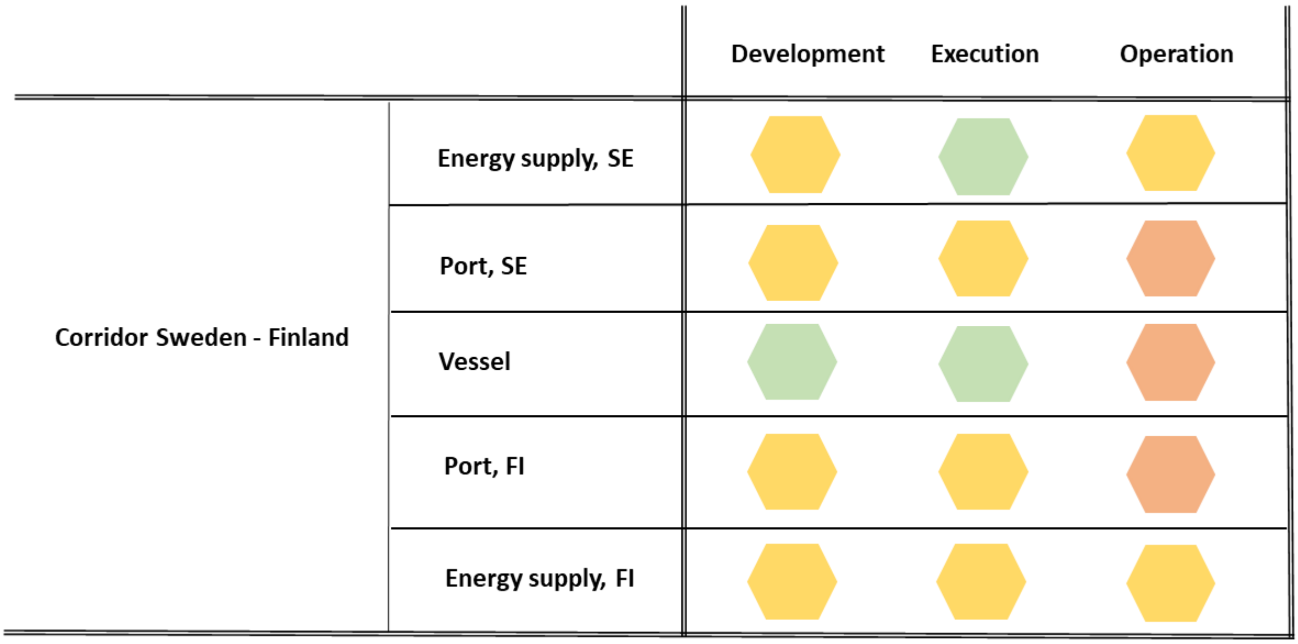
The tables below present the results of the high-level assessment of existing public support mechanisms for two generic Nordic green shipping corridors; Sweden – Finland and Norway – Denmark.

Sweden – Finland

Table 4-1 shows the results of the high-level assessment for a corridor between Sweden and Finland:

- In the **development stage**, there are mainly general funding programs available where allocation of funding depends on being successful in the competition with applications from other sectors. In Finland, the Ship Finance programme has dedicated funding for the development of ship technology, through Business Finland. In Sweden, the Swedish Transport Administration, has funding programmes dedicated for ship technology development within their own R&I portfolio and through the Swedish Maritime Competence Centre - Lighthouse.
- In the **execution phase**, public finance institutions like Swedish Export Credit Corporation offer loans aimed directly towards the shipping sector and towards production of alternative fuel, whereas in Finland the public funding entity Finnvera offers guarantees for domestic shipowners related to shipbuilding activities.
- There are no direct public funding opportunities for the **operation phase**, except for the EU Hydrogen Bank, where producers of renewable hydrogen can apply for a fixed premium in €/kg. Support to fuel suppliers through CAPEX funding is also an indirect support to FUELEX in the operation phase.
- Looking at the value chain, there are more funding opportunities for vessels than for other corridor components. This is mainly due to the dedicated instruments towards the shipping sector found in Finnvera, Svenska Skeppshypotek, and Swedish Export Credit Corporation. The instruments involve opportunities for loans and guarantees, both for export purposes and for domestic shipowners for shipbuilding investments.

Table 4-1: High-level screening of existing available public funding and financing opportunities for Nordic green shipping corridors between Sweden and Finland.

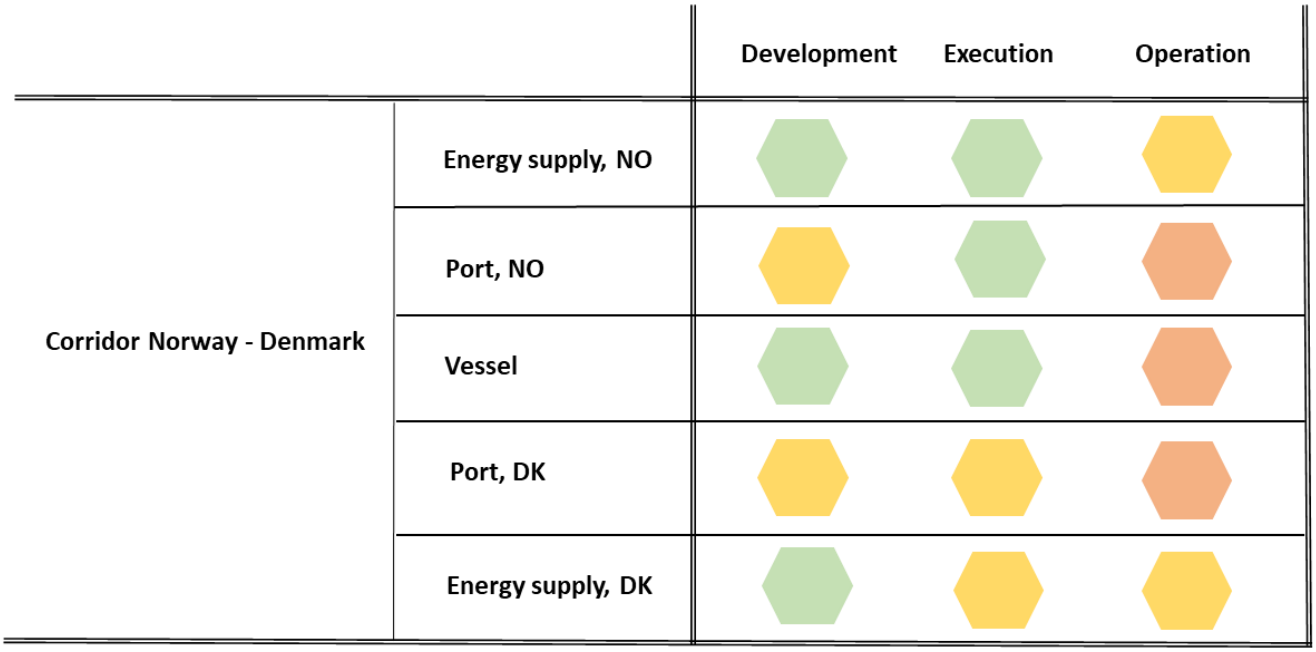


Norway – Denmark

Table 4-2 shows the results of the high-level assessment for a corridor between Norway and Denmark:

- For the **development phase,** the picture varies along the value chain between the two countries. When it comes to energy supply both countries have programs dedicated to support development of alternative fuels. In Denmark, the MissionGreenFuel partnership within Innovation Fund Denmark has allocated a budget of 280 MDKK for the development of green fuels for aviation, road transport, and shipping. In Norway, through Enova's program "Teknologi for bærekraftige energibærere", suppliers of bio- or hydrogen-based fuels can apply for funding to develop the technology further. When it comes to development of vessels, Norway has some funding available through dedicated programs for the shipping sector at the Research Council of Norway (for example the last call for 2024 had a total budget of 125 MNOK) and Enova's program "Banebrytende maritim teknologi".
- In the **execution phase**, Norway offers dedicated programmes along the whole value chain through various ENOVA programs. In Denmark, there are opportunities for financing through EIFO's general programs. Other funds, like the Norwegian NOx fund (public-private agreement) and the Danish Maritime Fund (private), could also be important opportunities when it comes to financing of vessels. We note that some funding programmes have geographical boundary conditions.
- There are no direct public funding opportunities for the **operation phase**, except for the EU Hydrogen Bank, where producers of renewable hydrogen can apply for a fixed premium in €/kg. Support to fuel suppliers through CAPEX funding is also an indirect support to FUELEX in the operation phase.
- Looking at the value chain, there are more funding opportunities for vessels than for other corridor components. This is mainly due to the funding schemes in Norway where Enova has dedicated calls for investment support related to use of ammonia and hydrogen in vessels, as well as infrastructure. Furthermore, Eksfin has dedicated instruments for the shipping sector. In Denmark, only private funds, such as the Danish Maritime Fund, are dedicated to supporting investments in vessels.

Table 4-2: High-level screening of existing available public funding opportunities for Nordic green shipping corridors between Norway and Denmark.



4.3 Discussion

As shown in this high-level screening, most current funding and financing opportunities target technology development and building of vessels and onshore infrastructure, and there are limited direct funding opportunities for the operational phase of green shipping corridors. The only identified direct funding opportunity for the operational phase is specific hydrogen-related funding through the EU Hydrogen Bank. These findings are also supported by other recent work.[44] However, there are funding opportunities for production of zero-emission fuels, such as hydrogen, which will contribute to reducing FUELEX.

We would like to highlight that although a combination of value chain component and development stage may be "green" in our high-level screening, the available funding may not be sufficient to catalyse investments in a specific green corridor project. Further, as highlighted in Chapter 3, applicants will also usually compete for funding. In other words, the presence of opportunities does not guarantee that the necessary funding and required volumes will be secured for specific projects. The fundings needs will vary significantly from corridor to corridor, depending on the selected fuel strategy, the corridor characteristics, and the actors' financial capabilities and access to private financing.

As shown in Chapter 2, the cost difference between operating on zero-emission fuels and conventional fuels will remain significant in the next years (it will, however, reduce over time as GHG regulations become more stringent). This is supported by other studies addressing the cost aspects of green shipping corridors.[45,46] A possible way to support stakeholders with the additional fuel costs in the short term could be to establish a time-limited FUELEX support mechanism. This could, for example, be in the form of contracts for difference or other kinds of support.

Beyond government funding and financing mechanisms in the beginning of the maritime fuel transition, there are several other interrelated ways to reduce costs for the initial Nordic green corridors in the short term. Here we specifically discuss energy efficiency, sales of green transportation, regulatory flexibility mechanisms, and differentiation of port fees.

- **More energy efficient zero-emission vessels:** Applying operational and technical energy efficiency measures, including speed reduction, will lower fuel consumption and thus FUELEX. In addition, utilizing shore power and battery-electric propulsion, as well as installing wind-assisted propulsion systems[47], will significantly reduce fuel consumption, while adding CAPEX and OPEX.
- **Income from sales of green transportation:** Zero-emission vessels could potentially secure additional income which can help reduce the cost difference. For example, there are several commercial initiatives and ship types that voluntarily use biofuels.[48] Some RoPax services already provide the option of paying a premium on ticket prices to enable use of biofuels, as recently mapped in a DNV study.[49] For container shipping, ZEMBA is an example of a buyers' group that is willing to pay a premium for zero-emission transportation.[50] ZEMBA has finalized a tender process which will see 20,000 tonnes of bio-LNG bunkered in the period 2025–2026[51], and has also announced the first commercial deployment of e-fuels in its next tender in 2025.[52]
- **Income from regulatory flexibility mechanisms:** The flexibility mechanisms under the FuelEU Maritime Regulation could also support with reducing costs. For example, a vessel that performs better than the baseline could gain income from selling surplus units. Further, if the zero-emission vessel enters a pool, this could help with reducing total FUELEX for the fleet and could also recuperate the added cost of newbuilds capable of running on zero-emission fuels. Similar flexibility mechanisms may be included in the IMO mid-term measures that will be adopted later this year.
- **Differentiation of port fees:** Ports could also have a role in reducing the cost difference by reducing port fees for zero-emission ships and/or increasing fees for fossil ships.

These options should be combined to reduce the additional cost of initial green shipping corridors, ensuring cost- and risk sharing between stakeholders. However, other novel mechanisms may also be relevant, such as new ways of sharing costs and risks in the value chain, as well as private financing mechanisms such as sustainability-linked loans and bonds.

APPENDIX

Appendix A: Nordic Corridor Funding Database

Region / Country	Funding entity/agency	Funding Instrument	Value chain coverage	Development stage[vi]	Type of funding	Link
Nordic Region	Nordic Green Bank (Nefco)	Financial support from Nopef	All	D,E	Loan	https://www.nefco.int/financing/companies/nopef/
	Nordic Green Bank (Nefco)	Fast-track loans	All	D,E	Loan	https://www.nefco.int/financing/companies/fast-track-loans/
	Nordic Green Bank (Nefco)	Loans and equity	All	D,E	Loan	https://www.nefco.int/financing/companies/loans-and-equity/
	Nordic Investment Bank	Sustainability Linked Investment Loans	All	E	Loan	https://www.nib.int/what-we-offer/loans
	Nordic Investment Bank	Green Investment Loans	All	E	Loan	https://www.nib.int/what-we-offer/loans
	Nordic Investment Bank	Productivity Investment Loans	All	E	Loan	https://www.nib.int/what-we-offer/loans
	Nordic Investment Bank	InvestEU loans	All	E	Loan	https://www.nib.int/what-we-offer/what-we-finance/nib-and-investeu
	Nordic Innovation	No particular instrument	All	D	Grant	https://www.nordicinnovation.org/programs
	Nordic Energy Research	Nordic Grand Solution	All	D	Grant	https://www.nordicenergy.org/programme/nordic-grand-solutions-programme/
	Nordic Energy Research	Nordic Maritime Transport and Energy Research Programme	Port, Vessel	D	Grant	https://www.nordicenergy.org/programme/nordic-maritime-transport-and-energy-research-programme/
EU	The European Commission	European Hydrogen Bank	Energy supply	O	Subsidy	https://energy.ec.europa.eu/topics/energy-systems-integration/hydrogen/european-hydrogen-bank_en
	The European Commission	EU Innovation fund	All	D,E	Grant	https://climate.ec.europa.eu/eu-action/eu-funding-climate-action/innovation-fund_en
	The European Commission	European Investment Fund	All	D,E	Guarantee	https://www.eif.org/index.htm
	The European Commission	European Investment Bank	All	D,E	Loan	https://www.eib.org/en/index
	The European Commission	Horizon Europe	All	D	Grant	https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en
	The European Commission	EIC Accelerator	All	D,E	Grant	https://eic.ec.europa.eu/eic-funding-opportunities/eic-accelerator_en
	The European Commission	IPCEI	All	D,E	Grant	https://competition-policy.ec.europa.eu/state-aid/ipcei_en
	The European Commission	CEF - Connecting Europe Facility	Energy supply, Port	E	Grant	https://cinea.ec.europa.eu/programmes/connecting-europe-facility_en
	The European Commission	LIFE programme	Energy supply	D	Grant	https://cinea.ec.europa.eu/programmes/life/clean-energy-transition_en

[vi] Development stages: Development (D), Execution (E), Operation (O)

	The European Commission	Interreg Aurora	All	D,E	Grant	https://www.interregaurora.eu/
	The European Commission	Interreg Øresund-Kattegat-Skagerak	All	D,E	Grant	https://interreg.eu/programme/interreg-sweden-denmark-norway/
	The European Commission	Interreg North Sea Region	All	D,E	Grant	https://northsearegion.eu/
	The European Commission	Interreg Northern Periphery and Arctic	All	D,E	Grant	https://www.interreg-npa.eu/
	The European Commission	Interreg Baltic sea	All	D,E	Grant	https://transport.ec.europa.eu/transport-modes/maritime/ship-financing-portal/interreg-baltic-sea-region-programme-2021-2027_en
	European Space Agency	Maritime decarbonisation: Ports Decarbonisation	Port	D	Grant	https://business.esa.int/funding/call-for-proposals-non-competitive/maritime-decarbonisation-ports-decarbonisation
Denmark	Export and Investment Fund of Denmark (EIFO)	Various	All	E	Loan, Guarantee	https://www.eifo.dk/en/apply/how-to-apply/
	Innovation Fund Denmark	Grand solution	All	D	Grant	https://innovationsfonden.dk/en/p/grand-solutions
	Innovation Fund Denmark	Mission Green fuels	Energy supply	D	Grant	https://missiongreenfuels.dk/
	Danish Energy Agency	EUDP	All	D	Grant	https://eudp.dk/en
Finland	Business Finland	Innovation aid for shipbuilding	Vessel	D,E	Grant	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/innovation-aid-for-shipbuilding
	Finnvera	Domestic loans	Energy supply, Port	E	Loan	https://www.finnvera.fi/eng/financing/loans
	Finnvera	Export loans	Energy supply	E	Loan	https://www.finnvera.fi/eng/financing/loans
	Finnvera	Finance guarantee	All	E	Guarantee	https://www.finnvera.fi/eng/financing/export-credit-guarantees/finance-guarantee
	Finnvera	Ship Guarantee (domestic companies)	Vessel	E	Guarantee	https://www.finnvera.fi/eng/financing/guarantees/ship-guarantee
	Business Finland	Co-research	All	D,E	Grant	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/cooperation-between-companies-and-research-organizations/co-research
	Business Finland	Funding for leading companies and ecosystems	All	D,E	Grant	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/funding-for-leading-companies-and-ecosystems
	Business Finland	Research to business	All	D,E	Grant	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/cooperation-between-companies-and-research-organizations/research-to-business

	Business Finland	Co-innovation	All	D,E	Grant	https://www.businessfinland.fi/en/for-finnish-customers/services/funding/cooperation-between-companies-and-research-organizations/co-innovation
Iceland	Rannis	Technology Development Fund	All	D	Grant	https://en.rannis.is/funding/research/technology-development-fund/
	Umhverfis og orkustofnun/Icelandic Environment and Energy Agency	Climate and Energy Fund	All	E	Grant	https://orkustofnun.is/en/energy_transition/energy_fund
Norway	Enova	Program "Hydrogen production for maritime transport"	Energy supply	E	Grant	https://www.enova.no/bedrift/industri-og-anlegg/hydrogenproduksjon-til-maritim-transport-2027/
	Enova	Bunkringsanlegg for amoniakk	Port	E	Grant	https://info.enova.no/hydrogenverdikjeder
	Enova	Ladeanlegg for fartøy	Port	E	Grant	https://www.enova.no/bedrift/sjotransport/ladeanlegg-for-fartoy/
	Enova	Program "Hydrogen use in vessels"	Vessel	E	Grant	https://www.enova.no/bedrift/sjotransport/hydrogen-i-fartoy/
	Enova	Program "Ammonia use in vessels"	Vessel	E	Grant	https://www.enova.no/bedrift/sjotransport/ammoniakk-i-fartoy/
	Enova	Program "Batteries in zero-emission ships"	Vessel	E	Grant	https://www.enova.no/bedrift/sjotransport/batteri-i-nullutslippsskip/
	Enova	Banebrytende maritim teknologi	Port, Vessel	D	Grant	https://www.enova.no/bedrift/sjotransport/banebrytende-maritim-teknologi/
	Enova	Teknologi for bærekraftige energibærere	Energy supply	D,E	Grant	https://www.enova.no/bedrift/industri-og-anlegg/teknologi-for-barekraftige-energibarere/
	The Research Council of Norway	Pilot-E	All	D	Grant	https://www.forskningsradet.no/utlysninger/2024/pilot-e/
	NOx Fund (public-private agreement)	NOx-fund	Energy supply, Port, Vessel	E	Grant	https://www.noxfondet.no/en/apply-for-support/
	The Research Council of Norway	Innovation project for Industry	All	D	Grant	https://www.forskningsradet.no/utlysninger/2024/innovasjonsprosjekt-i-naringslivet-2024/
	Export Finance Norway (Eksfin)	Byggelånsgaranti	Vessel	E	Loan, Guarantees	https://www.eksfin.no/no/byggelansgaranti/
	Export Finance Norway (Eksfin)	Leverandørkreditt garanti	All	E	Guarantee	https://www.eksfin.no/no/produkter/leverandorkredittgaranti/
	Export Finance Norway (Eksfin)	Investeringsfinansiering	All	E	Loan, Guarantees	https://www.eksfin.no/no/produkter/investeringsfinansiering
	Export Finance Norway (Eksfin)	Produksjonslånsgaranti	All	E	Loan, Guarantees	https://www.eksfin.no/no/produkter/produksjonslansgaranti/
	Export Finance Norway (Eksfin)	Skipsfinansiering	Vessel	E	Loan, Guarantees	https://www.eksfin.no/no/produkter/skipsfinansiering/

	Innovation Norway	Innovasjonskontrakter	All	D	Grant	https://www.innovasjonnorge.no/tjeneste/tilskudd-til-innovasjonskontrakter
	Innovation Norway	Grønt vekstlån	All	D,E	Loan	https://www.innovasjonnorge.no/tjeneste/gront-risikolan
	Innovation Norway	Innovasjonslån	All	D,E	Loan	https://www.innovasjonnorge.no/tjeneste/innovasjonslan
	Innovation Norway	Risikolåneordning for lav- og nullutslippsskip	Vessel	E	Loan	https://www.innovasjonnorge.no/tjeneste/risikolaneordning-for-lav-og-nullutslippsskip
	Innovation Norway	Lavrisikolån	All	E	Loan	https://www.innovasjonnorge.no/tjeneste/lavrisikolan
	Innovation Norway	Grønn industrifinansiering	Energy supply	E	Loan	https://www.innovasjonnorge.no/artikkel/gronn-industrifinansiering-en-mulighet-for-store-prosjekter
	Innovation Norway	Grønn plattform	All	D	Grant	https://www.innovasjonnorge.no/tjeneste/gronn-plattform
	Innovation Norway	Tilskudd til miljøteknologi	All	D	Grant	https://www.innovasjonnorge.no/tjeneste/tilskudd-til-miljoteknologi
Sweden	Swedish Export Credit Corporation	SEK Green Loans	All	E	Loan	https://www.sek.se/en/product/green-loans/
	Swedish Export Credit Corporation	Shipping	All	E	Loan	https://www.sek.se/en/shipping/
	The Swedish Export Credit Agency	Grön kredittgaranti	All	E	Guarantee	https://www.ekn.se/
	Svenska Skeppshypotek	Loans	Vessel	E	Loan	https://www.svenskaskeppshypotek.se/en/
	Swedish Transport Administration	Hållbar sjöfart - Lighthouse	Port, Vessel	D	Grant	https://lighthouse.nu/sv/verksamhet/hallbar-sjoefart
	Swedish Transport Administration	Sjöfartsportföljen	Port, Vessel	D	Grant	https://fudinfo.trafikverket.se/fudinfoexternwebb/pages/UoVisaNy.aspx?id=119
	Swedish Environmental Protection Agency	Klimatklivet	All	E	Grant	https://www.naturvardsverket.se/bidrag/klimatklivet/
	Swedish Energy Agency	Industriklivet	Energy supply	D	Grant	https://www.energimyndigheten.se/forskning-och-innovation/forskning/industri/industriklivet/
	Swedish Energy Agency	Pilot- och demonstrationsprojekt	All	D	Grant	https://www.energimyndigheten.se/forskning-och-innovation/affarsideer-test-och-internationalisering/pilot-och-demonstrationsprojekt/
	VINNOVA	Sustainable Ports - System demonstrator	Port	D	Grant	https://www.vinnova.se/en/calls-for-proposals/systemdemonstratorer-mobilitet-other/sustainable-port-system-demonstrator/
	VINNOVA	General programs	All	D	Grant	https://www.vinnova.se/en/apply-for-funding/find-the-right-funding/
	Swedish Energy Agency	Hållbara transportsystemer	All	D	Grant	https://www.energimyndigheten.se/forskning-och-innovation/forskning/transporter/hallbara-transportsystem/
	Swedish Energy Agency	Framtidens elsystem	Energy supply, Port	D	Grant	https://www.energimyndigheten.se/forskning-och-innovation/forskning/elsystem/framtidens-elsystem/

Appendix B: Examples of projects which have received public funding

Table B-1 lists examples of green projects which have received public funding across the Nordic countries and the EU. In Table B-2, we have included examples of national projects in the Nordics which have received public funding.

Table B-1: Examples of relevant projects which have received public funding across Nordic countries and the EU.

Project	Key info
Decatrip received funding from Business Finland[53]: The objective of the project was to establish a green corridor on the 10-hour ferry crossing between Turku (Finland) and Stockholm (Sweden), via the Åland Islands.	- Location: Sweden/Finland/Åland - Amount of grant: 1.6 MEUR - Time period: 2022-2024
Tarntank Ship management received support from the EU Innovation Fund[54]: The objective of the eMETHANOLxWSolution project is to demonstrate an innovative combination of foldable suction sails and a dual-fuel engine.	- Location: Sweden/Finland - Amount of grant: 2.76 MEUR - Time period: 2023-2026
ForSea Ferries received funding from Innovation and Networks Executive Agency (INEA – CEF funds)[55]: Development of two battery-powered ferries (Aurora and Tycho Brahe) operating between Helsingør (Denmark) and Helsingborg (Sweden).	- Location: Denmark/Sweden - Amount of grant: 12 MEUR - Time period: 2015-2018
H2AMN - Nordic consortium received funding from Nordic Energy Research[56]: The H2AMN project addresses how ports, surrounding areas, and actors will be able to scale up hydrogen-based fuels in the Nordic region and transition to become fossil-free energy hubs.	- Location: Nordic - Time period: 2023-2026

Table B-2: Examples of national projects in the Nordic countries which have received public funding.

Project	Key info
ASKO Maritime received funding from Enova[57]: Development of all-electric propulsion system in two new identical container ships (ro/ro ships), as well as battery charging infrastructure.	- Location: Norway - Amount of grant: approx. 18 MEUR - Time period: 2023
Norled received loan from Nordic Investment Bank[58]: The loan has been provided for the co-financing of Norled's investments in low-carbon ferries and express boats, which can include electric and e-hydrogen vessels and related land-based infrastructure in Norway during 2024-2030.	- Location: Norway - Amount: 43.4 MEUR - Time period: 2024
MHO operations received funding from Danish Energy Agency through EUDP[59]: The objective of the project is to test fuel cells and new battery technology on the shipping company's advanced hybrid vessels.	- Location: Denmark - Amount of grant: 2.15 MEUR - Time period: 2021-2024
Swedish Transport Administration has supported Wallenius Marine[60]: Development of a wind-driven ship concept which aimed to result in a ship design on TRL 6, or a proof-of-concept. Today commercialised by Oceanbird – a joint venture between Alfa Laval and Wallenius.	- Location: Sweden - Amount of grant: 27 MSEK - Time period: 2019-2023
The Swedish Energy Agency has supported Gotland Tech Development[61], which is the development company of Gotlandsbolaget: Several parallel research and development projects to enable the ferries in the Gotland traffic to be powered with renewable hydrogen in the future. The support received was for the initial project which has been continued in several additional R&D projects.	- Location: Sweden - Amount of grant: 3 MSEK - Time period: 2022-2023

Appendix C: The Maritime Investment Tool

A customized version of the Maritime Investment Tool is used in the case modelling, for estimating the cost cap. This Appendix explains the case methodology and main assumptions.

Case methodology

The vessel-specific cost gap assessment (annual and total cost) is based on the following three steps for the cases:

- **Step 1** – Calculate the cost for the baseline vessel from 2025 to 2040, taking into account ship characteristics, low-GHG fuel demand, and regulatory developments.
- **Step 2** – Calculate the cost for the zero-emission vessel from 2025 to 2040, taking into account ship characteristics, zero-emission fuel demand, and regulatory developments.
- **Step 3** – Calculate the cost difference between the baseline vessel and the zero-emission vessel.

Table C-1 provides a high-level model description. The input data used in the case modelling is presented in Appendix D.

Table C-1: Model description of the Maritime Investment Tool.

Yearly cost *C* for vessel *i* (baseline or zero-emission) in year *n*:	Explanation
$$C_{i,n} = C_{CAPEX} + C_{OPEX,n} + C_{FUELEX,n} + C_{GHGEX,n} + C_{loan,n} \quad (1)$$	The annualized cost estimates: Calculating the total annual cost for each case vessel by summing up the different cost element: *CAPEX* – Additional capital expenditure for retrofitting an existing vessel *OPEX* – Manning, insurance, crew, other operational costs *FUELEX* – Fuel costs of the selected fuel types, also including cost of electricity *GHGEX* – EU ETS cost related to emitting CO_2, CH_2, and N_2O *Loan* – Loan expenditures including interests and installments over the downpayment period.
$$TC_i = \sum_{n=0}^{N} C_{i,n} \quad (2)$$	Calculating the total cost for each case vessel over the modelling period of n years.
Relative cost in year n:	
$$\Delta C_n = C_{zero-emissision,n} - C_{baseline,n} \quad (3)$$	Cost difference: Based on the annualized cost estimates using equation (1) for each case vessel, the model calculates the relative cost differences per year.
Units for each variable used	
C_{CAPEX} – *Additional investment cost for retrofitting an existing vessel* $(MUSD)$ C_{OPEX} – *Other operational costs* $(\frac{MUSD}{year})$ C_{FUELEX} – *Cost of fuel* $(\frac{MUSD}{year})$ C_{GHGX} – *Cost of* $CO_{2eq.}(\frac{MUSD}{year})$ C_{loan} – *The cost of the loan from the investment cost* $(\frac{MUSD}{year})$ TC_i – *Total cost over the modelling period* $(MUSD)$ ΔC_n – *The cost gap between the two fuel strategies in year n* $(\frac{MUSD}{year})$	

Assumptions for the baseline vessel and the zero-emission vessel in the case modelling

In the following we highlight key assumptions used in the case modelling.

- **Baseline vessel:** In case studies where an already existing vessel is operating today, it is assumed that the vessel currently operating on the route will continue to operate throughout the modelling period (2025-2040) with no additional CAPEX. The baseline vessel uses fossil fuels and complies with FuelEU Maritime requirements by blending in just enough biofuels. The FuelEU requirements start with a 2% reduction (relative to average GHG intensity in 2020) from 2025 to 2029, 6% reduction from 2030 to 2034, and accelerate from 2035 to reach an 80% reduction by 2050. The baseline vessel complies with EU ETS by paying the allowance cost for the vessel's TtW GHG emissions (for more information on the emission factors used, see Appendix D.3).

- **Zero-emission vessel:** It is assumed that the vessel is operating on zero-emission fuels throughout the modelling period (2025-2040). The zero-emission vessel will also have some TtW GHG emissions which must be covered by the EU ETS allowance cost (see Appendix D.3 for more information on the emission factors used). Depending on the corridor case, a zero-emission fuel strategy is selected, either with:
    - 100% operations on biofuels, assuming the vessel currently operating on the route can be used and that no additional CAPEX is required, or;
    - 100% operations on electro-fuels, assuming a CAPEX for a retrofit.

Simplifications

The simplifications made in the case modelling include:

- Limitations in number of fuel options to be compared for each vessel (including no pilot fuel). The case studies are also limited to one pre-selected compliance strategy to comply with the FuelEU Maritime regulations.
- The model uses the average fuel consumption as input (tonnes/day) and does not account for the vessels' operational profile. In addition, the OPEX is assumed to be constant. Further, the model does not take into account the loss of passenger or cargo-carrying capacity.
- The model only considers costs related to the new EU regulations, and does not include pooling or other flexibility mechanisms. Income from sales of green transportation (to cover/share green premiums) is not included.

Uncertainties

Using a simplified methodology, as explained above, introduces uncertainties. Regarding input data, there are significant uncertainties related to future fuel prices and EU ETS allowance cost.

Appendix D: Case modelling – inputs and outputs

This Appendix provides the input data and outputs for the case modelling, including vessel data, modelled energy consumption (and fuel mix), fuel prices, and EU emission allowances.

D.1 Vessel data and modelled energy consumption

Case 1

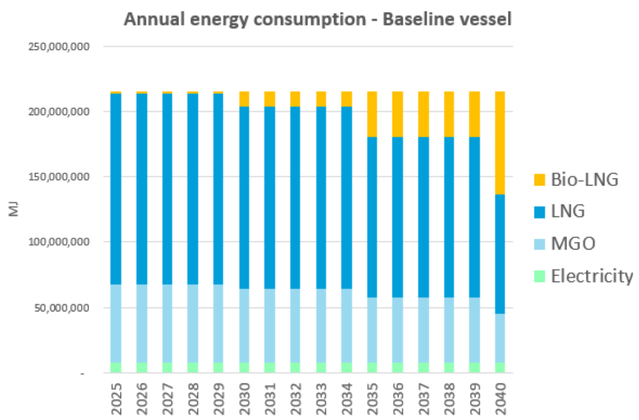
The data presented in the table below was received from Wasaline in November 2024. The input on fuel consumption for Aurora Botnia was used as baseline for the modelling.

Table D-1.1: Input data for Case 1: Umeå – Vasa corridor

Baseline vessel (hybrid) and zero-emission vessel	
Vessel name	Aurora Botnia
Entrance into service	2021
Vessel size	24,036 GT / 7,264 DWT
CAPEX – Baseline vessel CAPEX – Zero-emission vessel	Existing vessel No additional CAPEX
OPEX -both vessels*	5 million USD/year
Fuel types – Baseline vessel Fuel types – Zero-emission vessel	LNG, MGO, OPS, BESS** Bio-LNG, OPS, BESS
Baseline vessel (Aurora Botnia 2023 estimates): Fuel consumption - LNG Fuel consumption – MGO/MDO	 ~ 3,000 tonnes/year – 147,300,000 MJ/year ~ 1,400 tonnes/year – 59,780,000 MJ/year
Zero-emission vessel: Fuel consumption – Bio-LNG	 4,200 tonnes/year – 207,080,000 MJ/year
Annual electricity consumption	2,200,000 kWh/year – 7,920,000 MJ/year

**The OPEX is based on data from previous DNV projects, for similar ship type.*

***OPS – Onshore power supply, BESS – Battery Energy Storage System.*



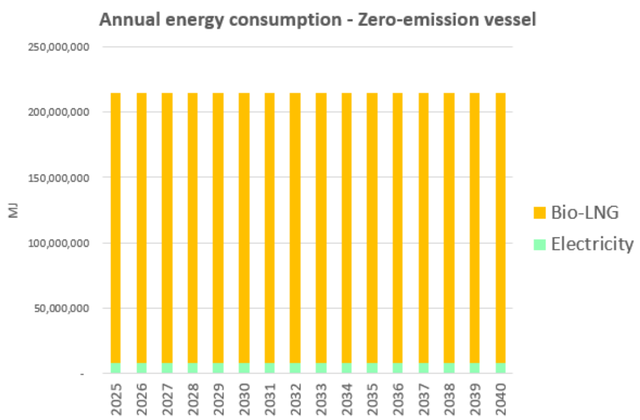


Figure D-1.1: Modelled energy consumption for the baseline vessel and the zero-emission vessel for the Umeå-Vaasa corridor, showing the combination of the selected fuels used in the case.

Case 2

The data presented in the table below was received from IVL in December 2024. The input on fuel consumption for Stena Jutlandica was used as baseline for the modelling.

Table D-1.2: Input data for Case 2: Gothenburg – Frederikshavn corridor

Baseline vessel and zero-emission vessel	
Vessel name	Stena Jutlandica
Entrance into service	1996
Vessel size	29,691 GT
CAPEX – Baseline vessel CAPEX – Zero-emission vessel	Existing vessel Additional ~20 million EUR
OPEX -both vessels*	5 million USD/year
Fuel types – Baseline vessel Fuel type – Zero-emission vessel	MGO/MDO, biodiesel e-methanol
Baseline vessel (Stena Jutlandica 2023 estimates): Fuel consumption – MGO/MDO	 12,090 tonnes/year – 516,243,000 MJ/year
Zero-emission vessel: Fuel consumption fuel type – e-methanol	 25,942 tonnes/year – 516,243,000 MJ/year
Annual electricity consumption	3,650,000 kWh/year – 13,140,000 MJ/year

**The OPEX is based on data from previous DNV projects, similar ship type.*

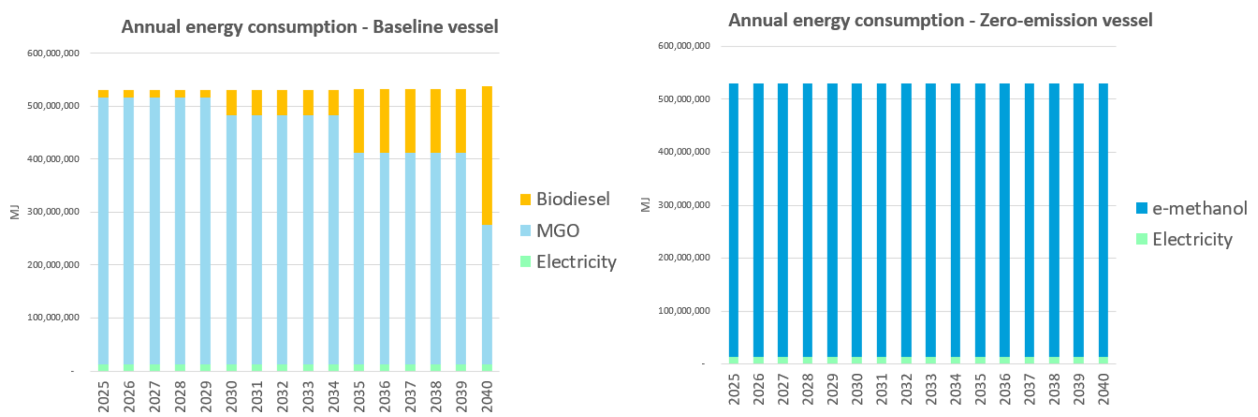


Figure D-1.2: Modelled energy consumption for the baseline vessel and the zero-emission vessel for the Gothenburg - Frederikshavn corridor, showing the combination of the selected fuels used in the case.

D.2 Assumed fuel prices and EU Allowances (EUAs)

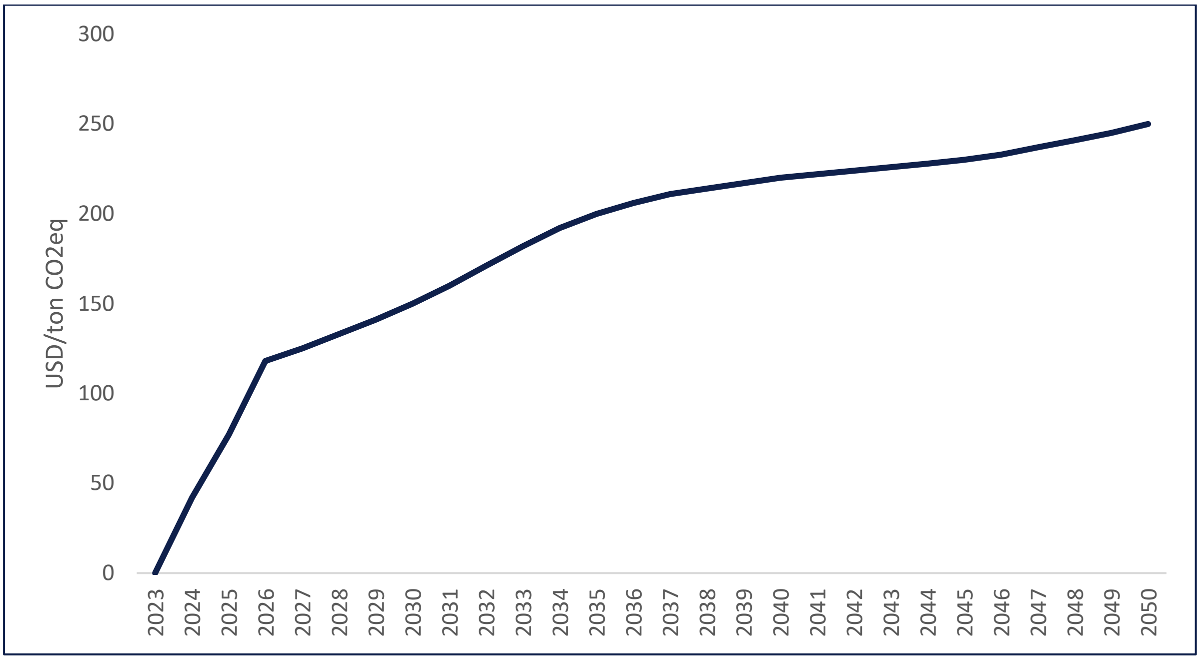


Figure D-2.1: The assumed development of EU Allowances from 2023-2050 (EU ETS, tank-to-wake GHG emission cost). Source: DNV's Energy Transition Outlook, 2023 edition. Data from 2025 to 2040 is used in the case modelling.

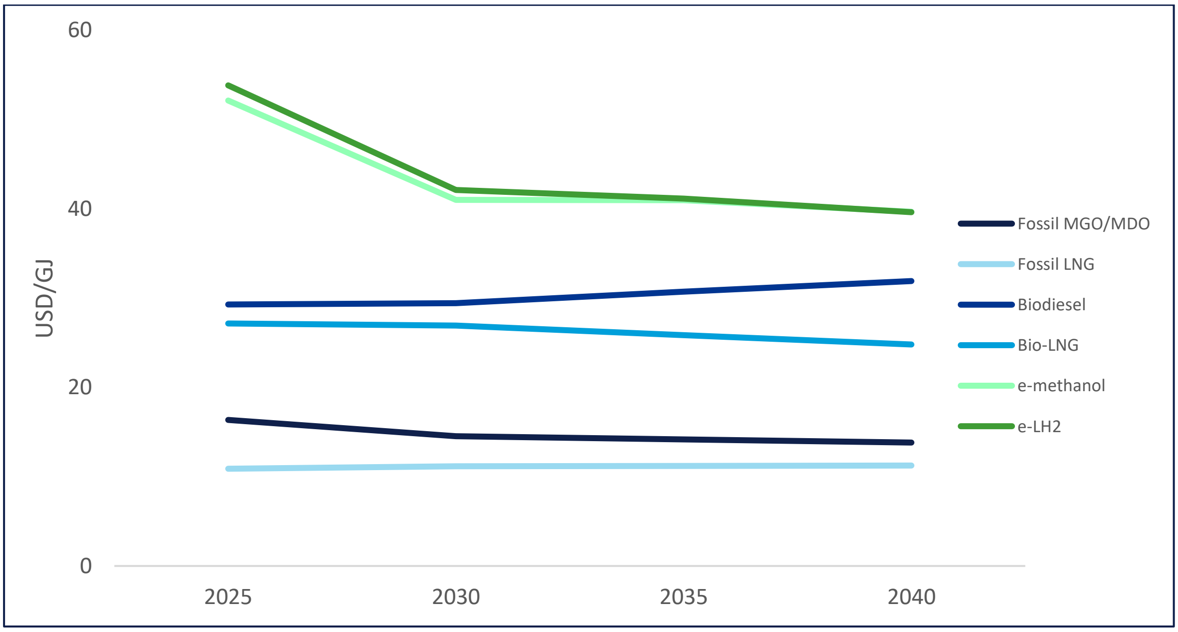


Figure D-2.2: The assumed future fuel prices used in the case modelling, based on DNV's Marine Fuel Price Mapper. Source: DNV's Maritime Forecast to 2050, 2023 edition.

In the cost calculations, an exchange rate 0.97 EUR/USD is applied to convert USD to EUR.

D.3 GHG intensity

Table D-3.1: GHG intensity assumptions for each fuel type considered.

Fuel type	Fuel class	Lower calorific value (MJ/g)	Well-to-wake GHG intensity (gCO_2eq/MJ)*	EU ETS Tank-to-wake GHG intensity** (gCO_2eq/MJ)
MGO (diesel)	Fossil	0.0427	90.77	76.23
	Biofuel	0.044	34.15	1.12
LNG; Otto	Fossil	0.0491	89.20	72.53
LNG (90% GHG saving); Otto	Biofuel	0.0491	19.31	10.28
LH_2 (fuel cell)	e-fuel	0.12	9.40	0
Methanol (90% GHG savings)	e-fuel	0.0199	9.40	2.47

* The well-to-wake GHG intensity factors are based on default values given in the FuelEU Maritime Regulation, see Annex II in Regulation 2023/1805[vii].

** The tank-to-wake GHG intensity factors are based on default values given in Annex I in Regulation (EU) 2015/757[viii], and includes CO_2, CH_4, and N_2O emissions for the fossil fuels and CH_4 and N_2O emissions for the biofuels and e-fuels.

[vii] FuelEU Maritime: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32023R1805

[viii] Regulation (EU) 2015/757: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02015R0757-20240101

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[12] MMMCZCS (2021), Industry Transition Strategy, see figure on page 15: "Fuel represents ~20-35% of total annual costs with almost the entire industry consumption being fossil-based", https://cms.zerocarbonshipping.com/media/uploads/documents/MMMCZCS_Industry-Transition-Strategy_Oct_2021.pdf

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Whether assessing a new ship design, optimizing the performance of a wind farm, analyzing sensor data from a gas pipeline or certifying a food company’s supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

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