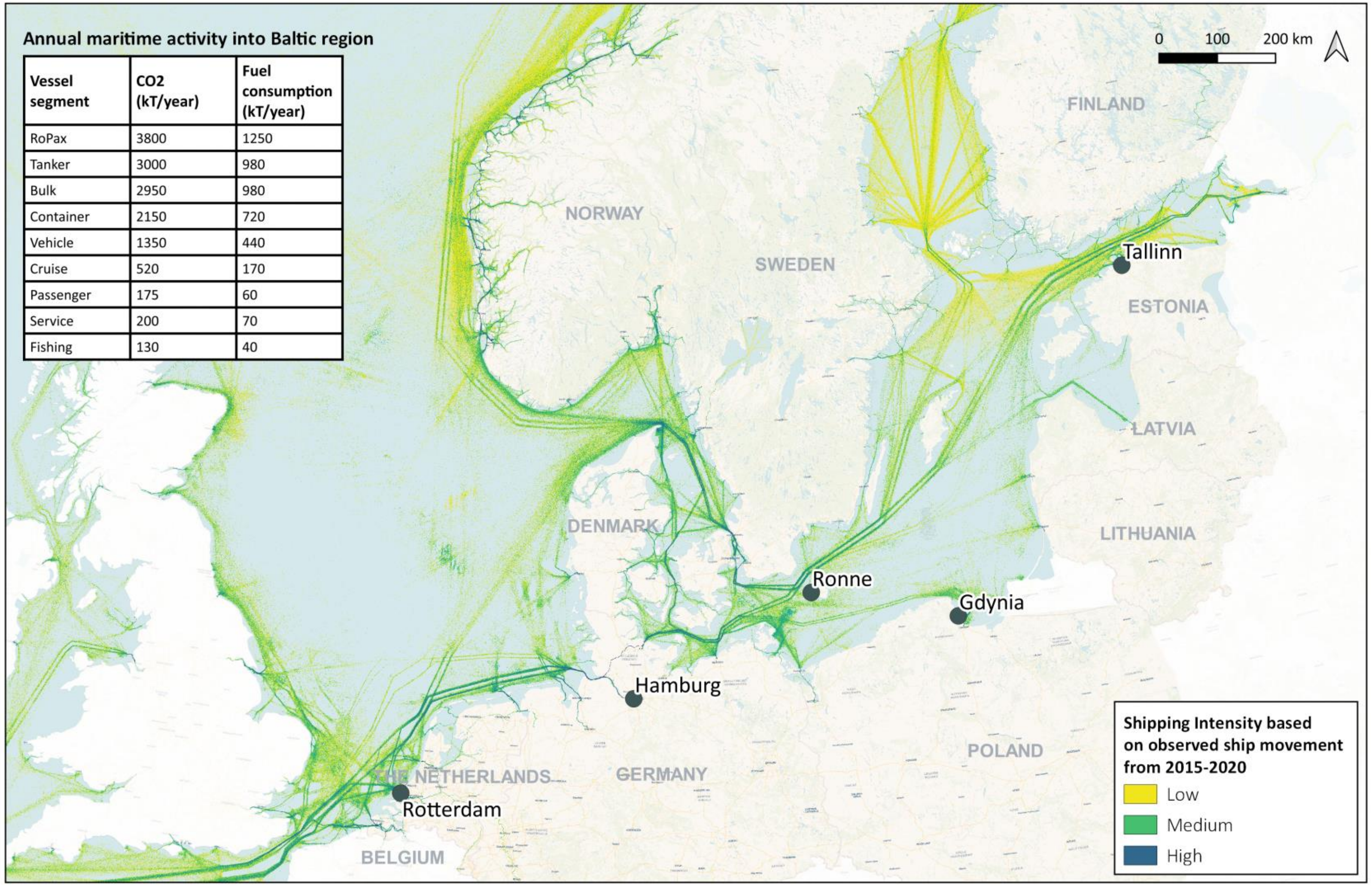
We show the world it is possible

European Green Corridor Network

Overview of Maritime Activity in the Baltic Region



Annual maritime activity into Baltic region

Vessel segment	CO2 (kT/year)	Fuel consumption (kT/year)
RoPax	3800	1250
Tanker	3000	980
Bulk	2950	980
Container	2150	720
Vehicle	1350	440
Cruise	520	170
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Service	200	70
Fishing	130	40

Sources - Ports: World Port Index; Vessel Density - World Bank and IMF; Maritime Activity - Project Partners; Boundaries: EU NUTS; Basemap: OSM
2022 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

PORT GDYNIA | Port of Rotterdam | HPA Hamburg Port Authority | PORT OF TALLINN | PORT OF ROENNE

Agenda

- 10:00 Welcome

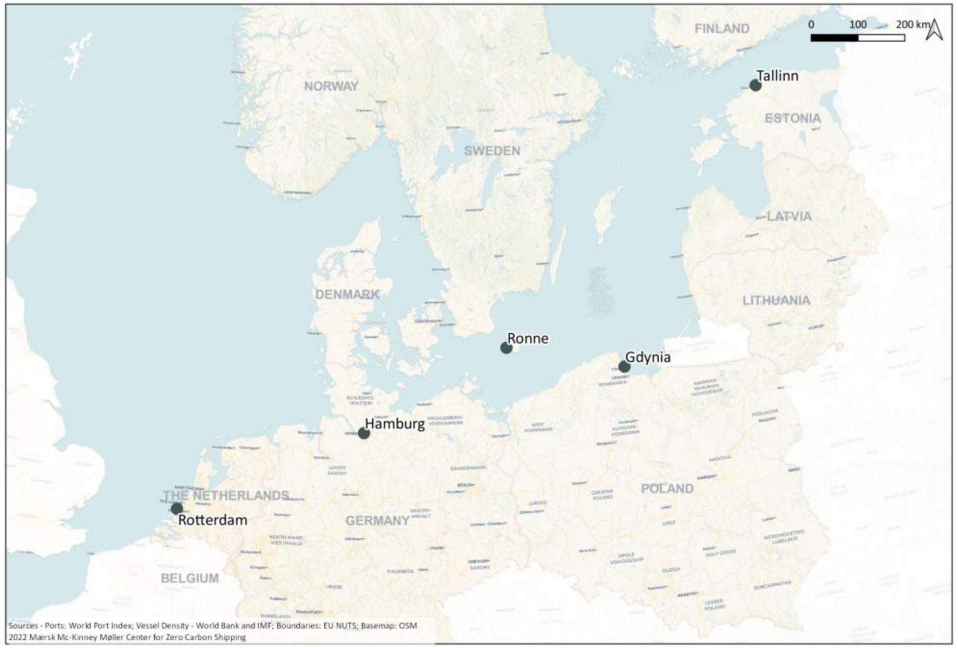
  by Lars Nordahl Lemvigh (CEO Port of Roenne)

- Project presentation
  - Vessels segments operating in the region, fuel demand, and emissions
  - Alternative fuel infrastructure in the region, at ports, producers, suppliers – existing and under development
  - Port Project Partners Activities in region and Readiness
  - Cost of transition
  - Project recommendations
  - Additional in formation on: Stakeholder interviews and feedback, and Funding options
- 12:00 Lunch
- 13:00 Afternoon session
  - Panel sessions
    - Fuel producers and bunkering providers panel
      - Pitch by Panelists (CiP, LiquidWind, Skovgaard Energy)
    - Off-takers panel
      - Pitch by Panelists (Furetank, VTTI)
  - 15:00 - Introduction to Workshop and break-out sessions
  - 15:05 - Coffee break
  - 15:30 - Workshop
    - Workshop: *Progressing from here!*
      - (Moderators: Cees/Roman, Maja/Olga, Hele-Mai/Natalja, Linda/Johan, Michal/Martin)
    - Report from moderator of workshops
  - Summary of the day and closing remarks (17:30)
- 18:30 Networking dinner

Establishing Green Corridors in N. Europe and the Baltic Sea

Vision – "To establish Green Corridors[1] in Northern Europe and the Baltic Sea by mid decade"

Baltic Project Partner Ports



1. Defined by the Getting to Zero Coalition's "The Next Wave" report: Green Corridor Report are shipping route between two major port hubs (including intermediary stopovers) on which the technological, economic, and regulatory feasibility of the operation of zero-emissions ships is catalyzed through public and private actions

Proposed overall objectives:

- Establish infrastructure and value chains for alternative fuels at each participating port by mid-decade, so that calling vessels can bunker these fuels
- Operationalize the full shipping supply chain with vessels sailing on alternative fuels between each participating port by mid-decade thereby realizing the Green Corridors.
- Accelerate development of these Green Corridor routes to full commercial scale implementation by 2030.

Objectives for Phase 1 (Dec-21 to June-22):

- *Identify and establish the foundation for the first Green Corridors between participating ports, first mover vessel segments, operators, and their bunkering needs in combination with a coherent selection of an alternative fuel supply option*

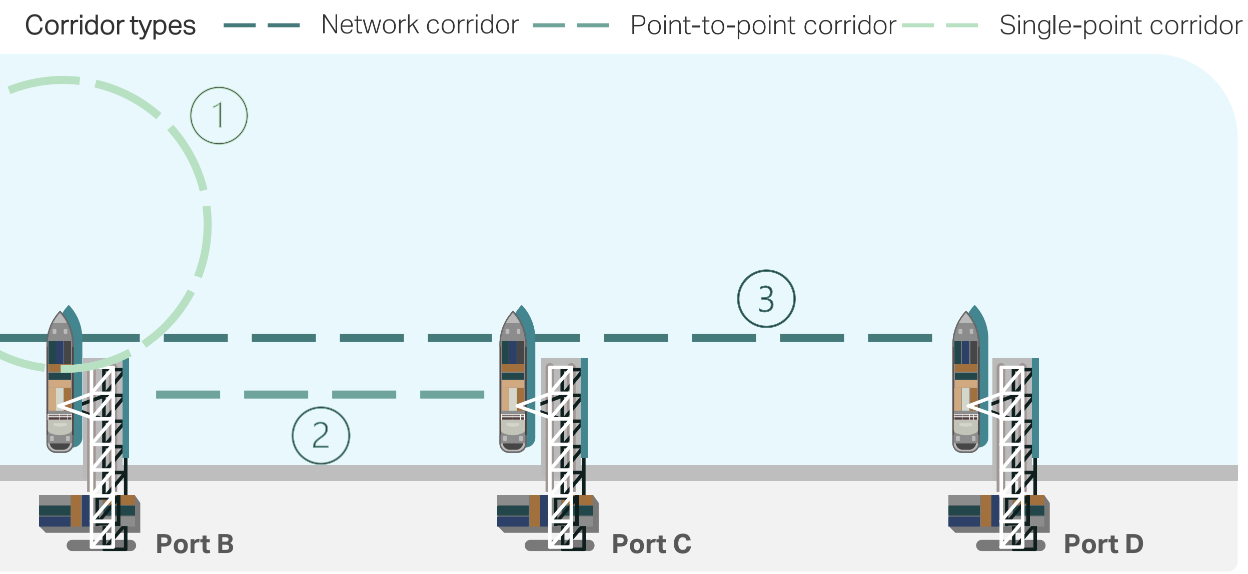
Dissemination for Phase 1 (Aug-22 to Sept-22):

PORT GDYNIA | Port of Rotterdam | HPA Hamburg Port Authority | PORT OF TALLINN | PORT OF ROENNE | Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

What is a Green Corridor

What defines a Green Shipping Corridor?

Main corridor types	Description
1 Single point	Single-point corridors establish zero-emission shipping routes around **a particular location,** i.e., a port hub allowing round-trip bunkering
2 Point to point	Point-to-point corridors are single-route green corridors between **2 ports** Typically, more niche segments or based around a commodity transportation route
3 Network	Network green corridors establish routes between **3 or more ports** where vessels can sail on alternative fuels



Definitions

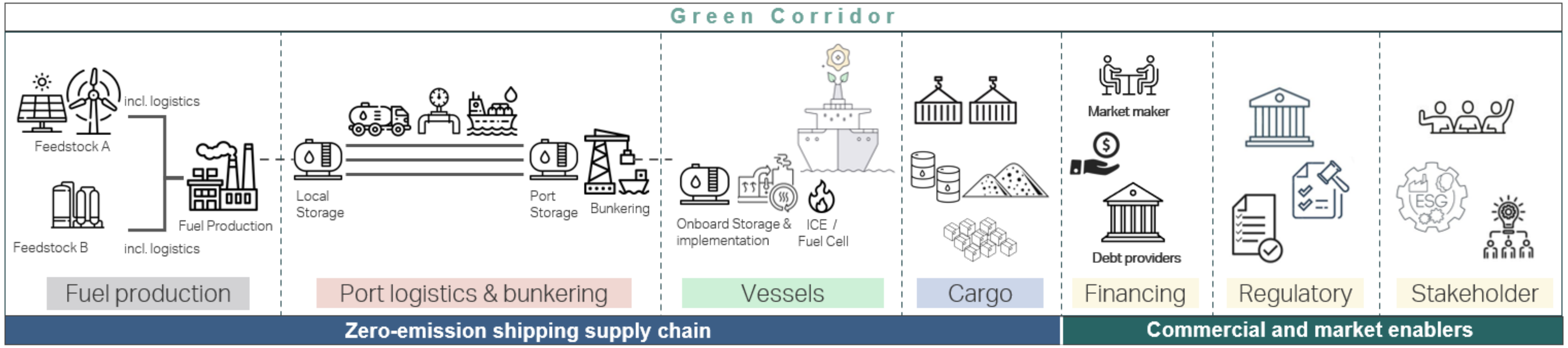
1. **Green Corridors** are shipping route between two major port hubs (including intermediary stopovers) on which the technological, economic, and regulatory feasibility of the operation of zero-emissions ships is catalyzed through public and private actions

2. **Green Corridors** are focused action / intention by a group of companies / countries / institutes, related to the entire **Zero Emission Shipping Value Chain** with the aim to deliver a commercial product/offer throughout the value chain

What is a Green Shipping Corridor?

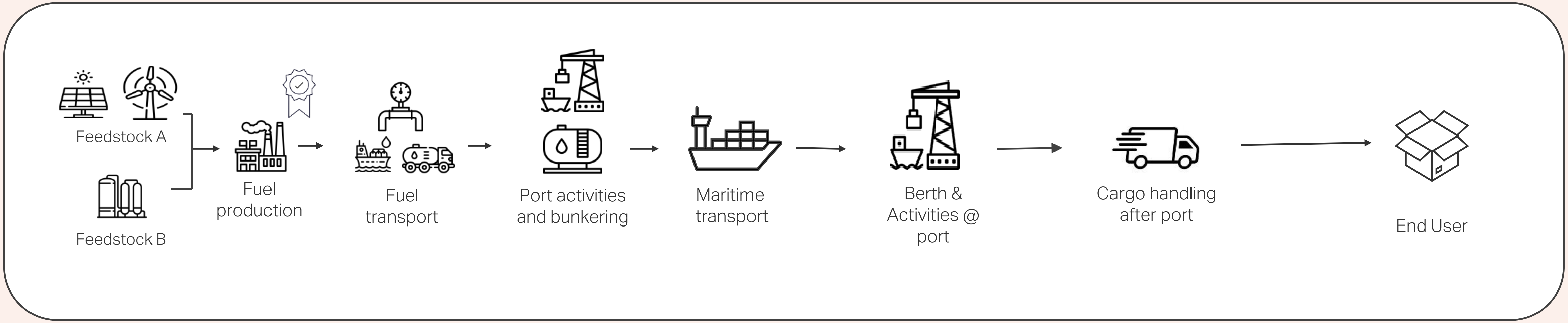
The Getting to Zero Coalition suggested that four critical building blocks need to be in place to establish a green corridor

1. Cross-value-chain collaboration:
   A green corridor requires stakeholders that are committed to decarbonization and are willing to explore new forms of cross-value-chain collaboration to enable zero-emission shipping from both the demand and supply side!
2. A viable fuel pathway:
   Availability of zero-emission fuels, along with bunkering infrastructure to service zero-emission vessels, are essential factors!
3. Customer demand:
   Conditions need to be in place to mobilize demand for green shipping and to scale zero-emission shipping on the corridor!
4. Policy and regulation:
   Policy incentives and regulations will be necessary to narrow the cost gap and expedite safety measures!

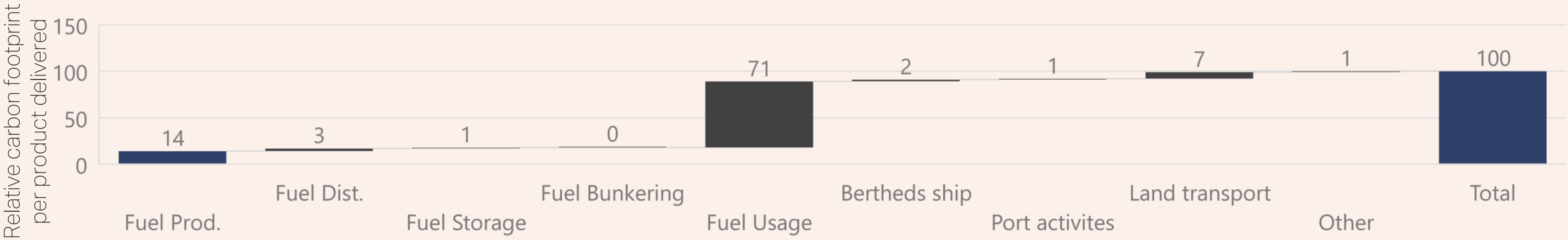


What is a Green Shipping Corridor?

– What has decarbonization potential?



– Where do we see the highest potential for decarbonization?

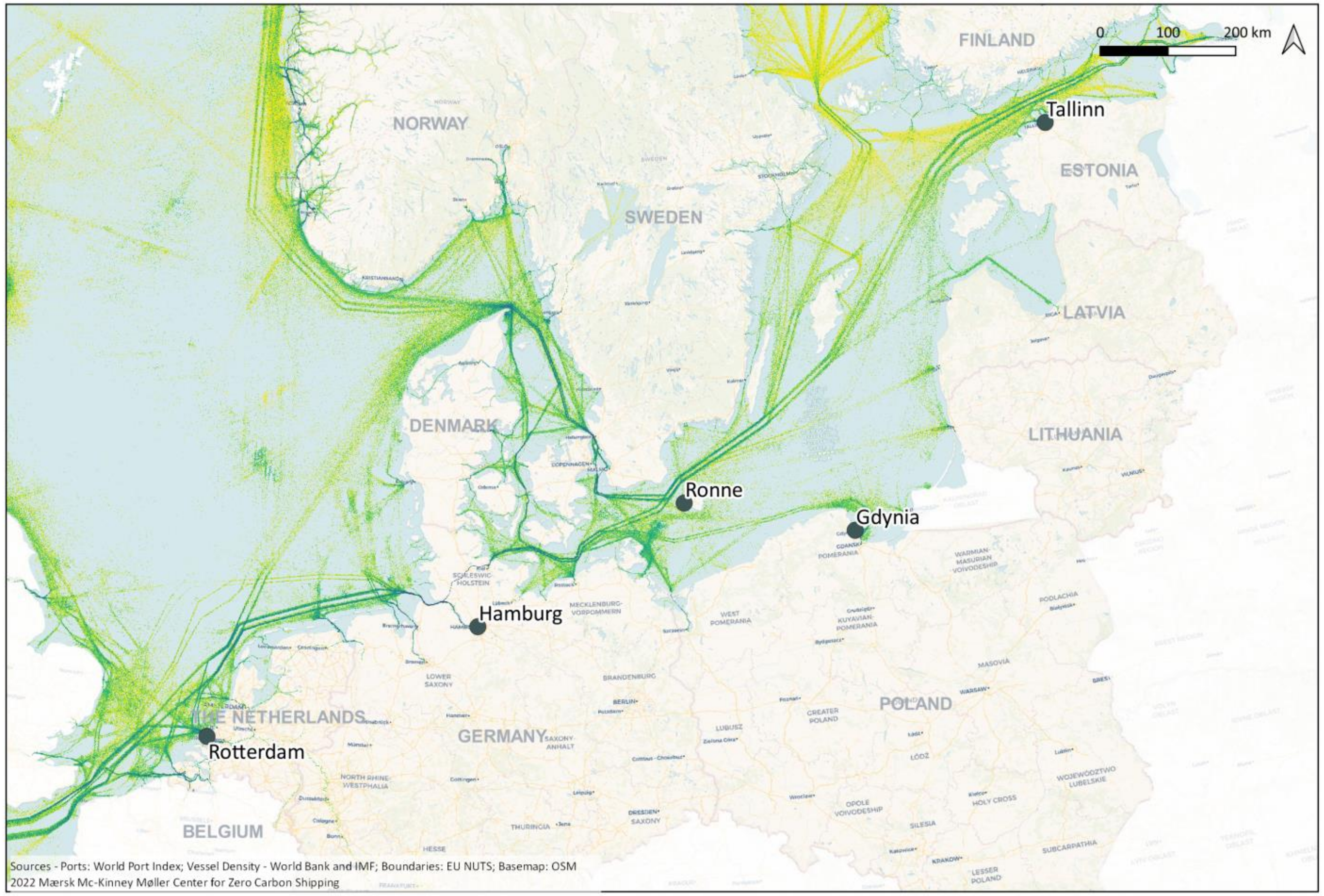


Pre-feasibility study

Pre-feasibility analysis by:

Port Gdynia · Port of Rotterdam · HPA Hamburg Port Authority · Port of Tallinn · Port of Roenne · Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Baltic Project Partner Ports



→ Pre-feasibility has addressed:

- Trade routes
- Vessel segments
- Fuel options and choice
- Port case:
  - Adaption of new fuels
- Stakeholder rounds
- Funding options

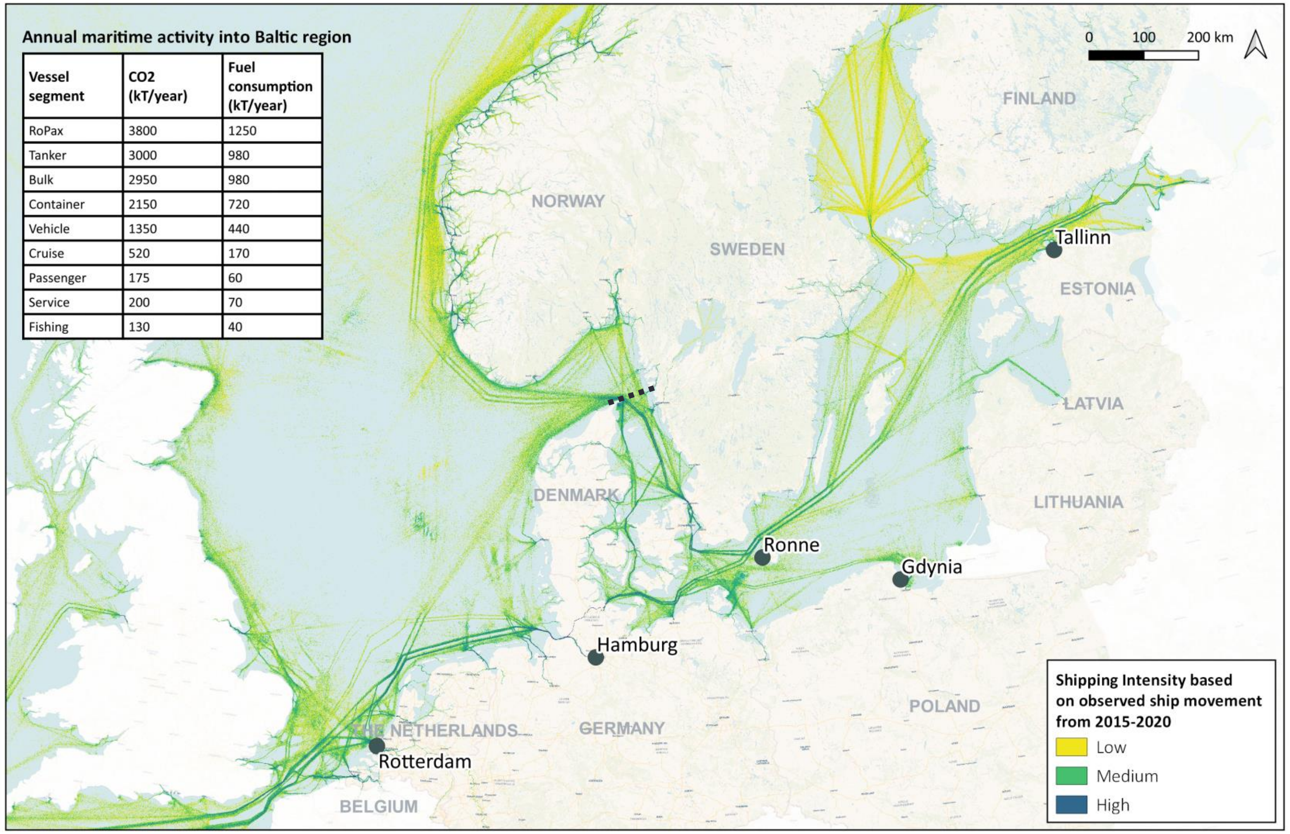
Trade routes & Vessel segments

Trade routes & Vessel segments

There are about 2000 ships in the Baltic marine area at any given moment and about 3500–5500 ships navigate through the Baltic Sea per month[1]

- *More than 50% of the ships are general cargo ships*
- *20% of the ships are tankers carrying over 200 million tons of oil*
- *20% of the ships are bulkers packed with forestry, metal or steel products and mostly stay within the region*
- *15% of the ships are container lines handling around 8 million TEU through the ten largest ports*
- *35% are ferries, vehicle carriers, and passenger ships operating about 50 million passengers – which differs from the global fleet composition!*
- *Remaining segments are: Cruise ships, Service ships, and Fishing vessels*

Overview of Maritime Activity in the Baltic Region



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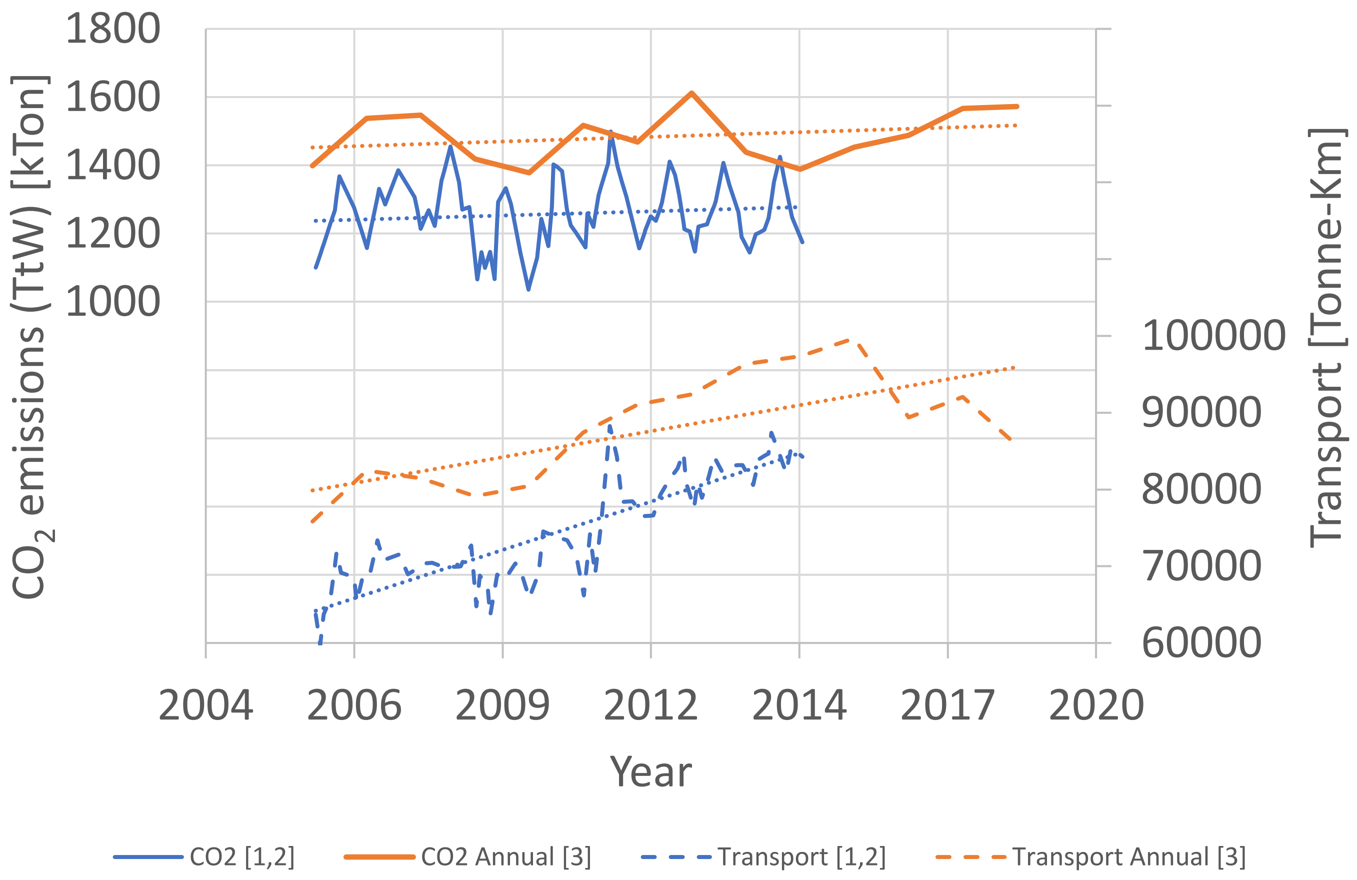
1. Shipping in the Baltic Sea, BalticLINes, 2016, https://vasab.org/wp-content/uploads/2018/06/Baltic-LINes-Shipping_Report-20122016.pdf and references therein
2. View Data | EMODnet Human Activities (emodnet-humanactivities.eu)

Activity levels consistent for decades

Measured in terms of CO_2-emissions and Transport work

Emissions from Shipping in the Baltic Sea, 2006-2014/19 (Reproduction from 1, 2 and 3)



1. Boteler, B., J. Tröltzsch, K. Abhold, M. Lago, T. T. Nguyen, E. Roth, E. Fridell, H. Winnes, E. Ytreberg, M. Quante, V. Matthias, J.-P. Jalkanen, L. Johansson, J. Piotrow, U. Kowalczyk, K. Vahter & U. Raudsepp (2015). SHEBA - Drivers for the shipping sector. SHEBA Project Report
2. Parsmo, R., B. Boteler, J. Troeltzsch, U. Kowalczyk, J. Piotrowicz, J.-P. Jalkanen, L. Johansson, V. Matthias & E. Ytreberg (2016, under review). SHEBA - Sustainable Shipping and Environment of the Baltic Sea Region. SHEBA Project Report
3. Emissions from Baltic Sea shipping in 2006-2019, Jukka-Pekka Jalkanen,, Maritime Working Group, Onlinel, 5 - 8 October 2020,

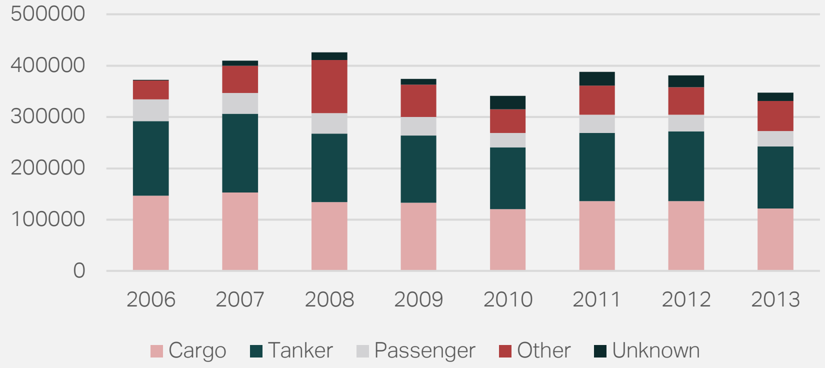
Region activity

Baltic Sea countries (including Russia) controls around 7000 cargo ships with gross tonnage > 1,000, ie.:

- 13% of the world fleet
- 35% of the EU-controlled fleet[1]

The EU-controlled fleet (including Norway) has expanded by more than 70% in the Baltic Sea region in the period 2005 to 2014 (both in GT and DWT) [1]

However, the total number of vessels decreased by 31% for the same period indicating a trend towards larger ship sizes, especially for the cargo transport[2]



Emissions and fuel consumption in the region by segment

Summary of fuel consumption and CO_2 emissions (TtW) for the Baltic Sea fleet during 2018[1]

	RoPax	Tanker	Cargo	Container	Vehicle	Cruise	Passenger	Service	Fishing	Total
Ships (#)	218	1.911	4.011	607	259	94	470	401	801	**8.772**
Fuel Main (kT/yr)	1.053	628	706	495	391	138	29	23	22	**3.485**
Fuel Aux (kT/yr)	182	341	261	273	63	35	21	33	22	**1.231**
Total fuel (kT/yr)	1.235	969	967	768	454	173	50	56	44	**4.716**
CO_2 (kT/yr)	3.754	2.941	2.941	2.337	1.379	526	150	170	134	**14.332**

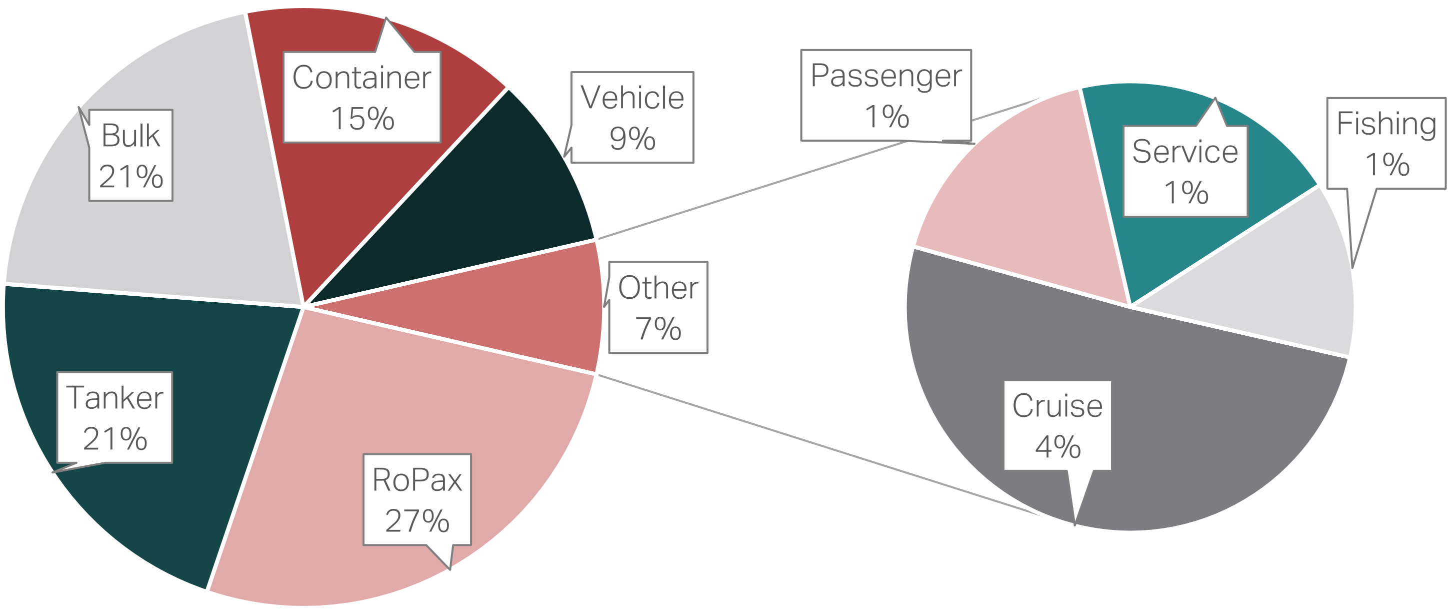
Summary of fuel consumption and CO_2 emissions for the Baltic Sea fleet during 2019[2]

	RoPax	Tanker	Cargo	Container	Vehicle	Cruise	Passenger	Service	Fishing	Total
Ships (#)	211	1.981	4.035	492	264	87	465	388	784	**8.772**
Fuel Main (kT/yr)	1.070	649	720	420	374	130	46	36	21	**3.466**
Fuel Aux (kT/yr)	181	363	274	247	62	39	25	41	21	**1.253**
Total fuel (kT/yr)	1.251	1.012	994	667	436	169	71	77	42	**4.719**
CO_2 (kT/yr)	3.804	3.074	3.021	2.027	1.325	515	217	233	130	**14.346**

1. Emissions from Baltic Sea shipping in 2006-2018, Jukka-Pekka Jalkanen, Lasse Johansson, Maritime Working Group, Lisbon, Portugal, 23-26 September 2019
2. Emissions from Baltic Sea shipping in 2006-2019, Jukka-Pekka Jalkanen,, Maritime Working Group, Onlinel, 5 - 8 October 2020

CO_2-Emissions in the region by segment

Summary of CO_2 emissions (kTon/Year) for the Baltic Sea fleet 2018 - 2019



RoPax

Is the highest emitting segment in the region responsible for more than one quarter of the regional maritime associated emissions. This differs from global shipping, where the primary impact is from cargo vessels[1]

Cargo

The combined cargo ship segments account for more than half of the emissions in the region, these include:

Tankers
These are primarily responsible for carrying oil into and through the region

Bulk
Mainly packed with break bulk (e.g. forestry, metal or steel products). Most of these ships stay inside the Baltic Sea and Northern Europe, and export rates among Baltic States are generally high

Container
The ten largest ports handles around 8 million TEU containers, and has experienced an approximate 3% annual growth

1. Johansson, Jalkanen, and Kukkonen, Global assessment of shipping emissions in 2015 on a high spatial and temporal resolution, Atmospheric Environment, Vol.167, 2017, Pages 403-415,

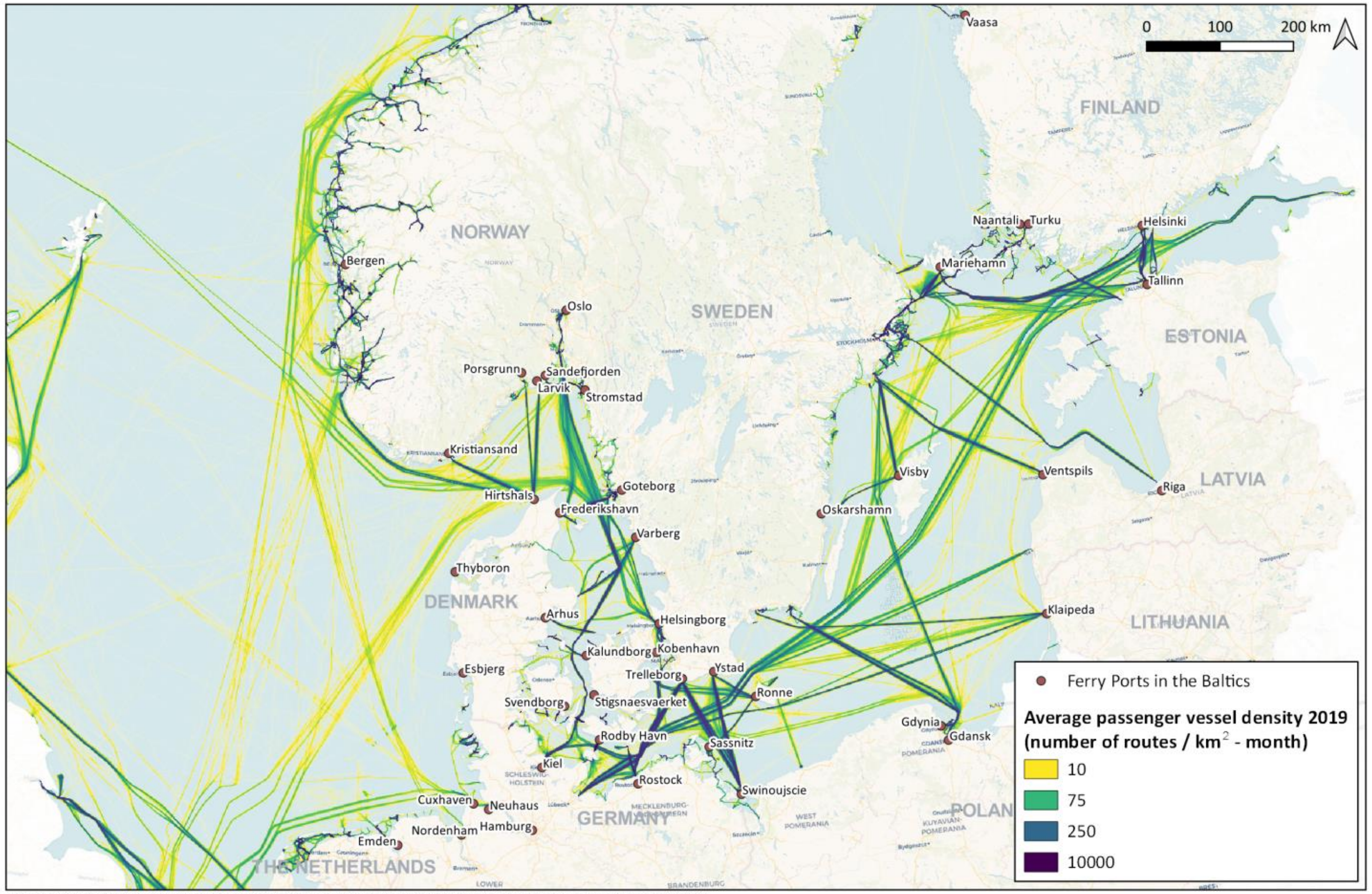
Ferry line operations in the region

Ferries offer an excellent option to build up infrastructure for decarbonized shipping and green corridors in the region

In the region more than 25 ferry lines (RoPax, Passenger and Vehicle carriers) operate a network of point to point routes, and are responsible for more than 5 mTons/Year CO_2

- Ferries carry more than 50 million passengers
- Ferries are essential for inter-regional cargo transport typically in trucks
- Selected ferries are subsidised to ensure domestic connectives
- More than 35% of maritime CO_2 emissions in the region can be eliminated by decarbonizing ferries

Ferry Vessel Traffic in the Baltics



Sources - Vessel Density Data: EMODnet; Passenger Data: Eurostat; Ports: World Port Index; Boundaries: EU NUTS; Basemap: OSM
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View Data | EMODnet Human Activities (emodnet-humanactivities.eu)

Cargo vessel operations in the region

Cargo vessel are instrumental to decarbonized shipping and central to green corridors in the region

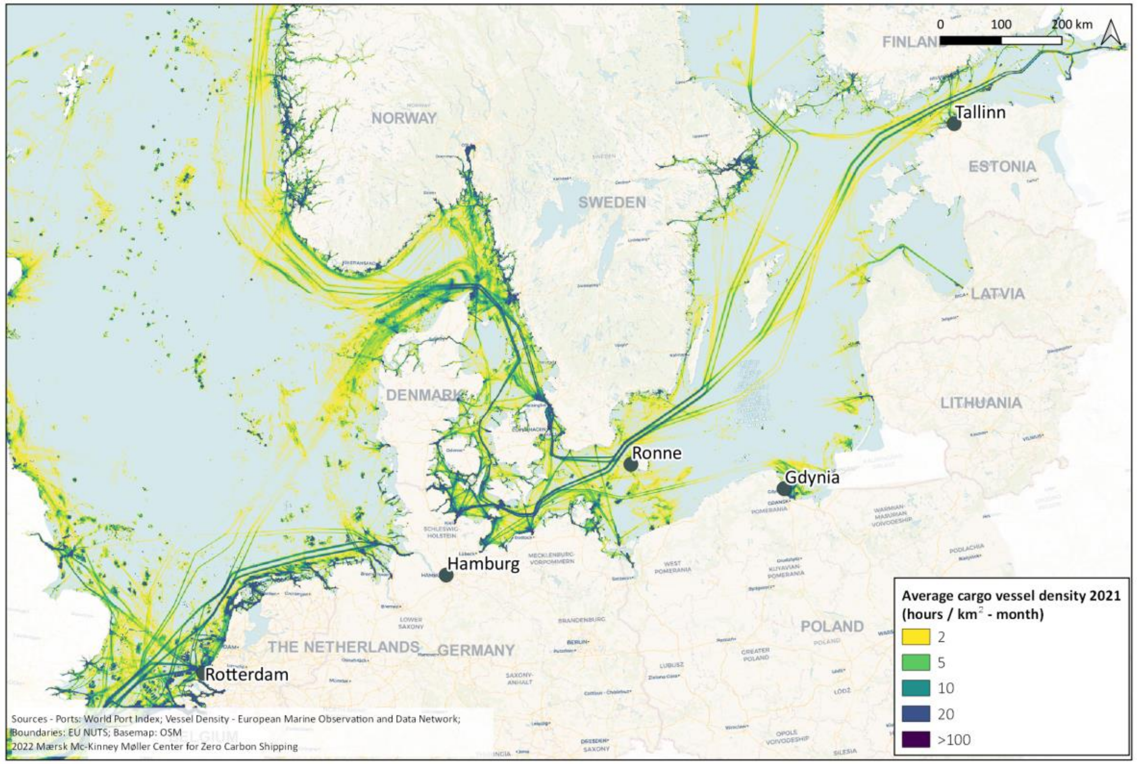
As a combined segment cargo shipping has potential to eliminate up to 8 mTons/year CO_2 emissions in the region on the path of decarbonization!

1. Part of the fleet operates exclusively in the region
2. Part of the fleet operates in line operation between selected ports in the region with fixed cargo transport
3. Selected cargo may have potential to carry a premium on transport cost

When the above three can be met, there is a good potential to pursue a green corridor!

There is a need to determine actual operators!

Cargo Vessel Activity in the Baltic Region

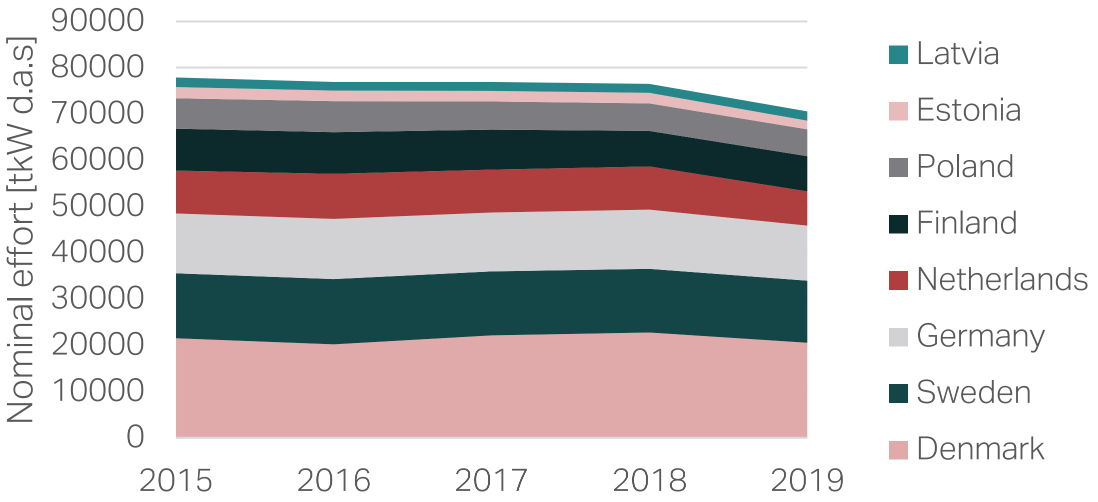


Maritime cargo transport 2021

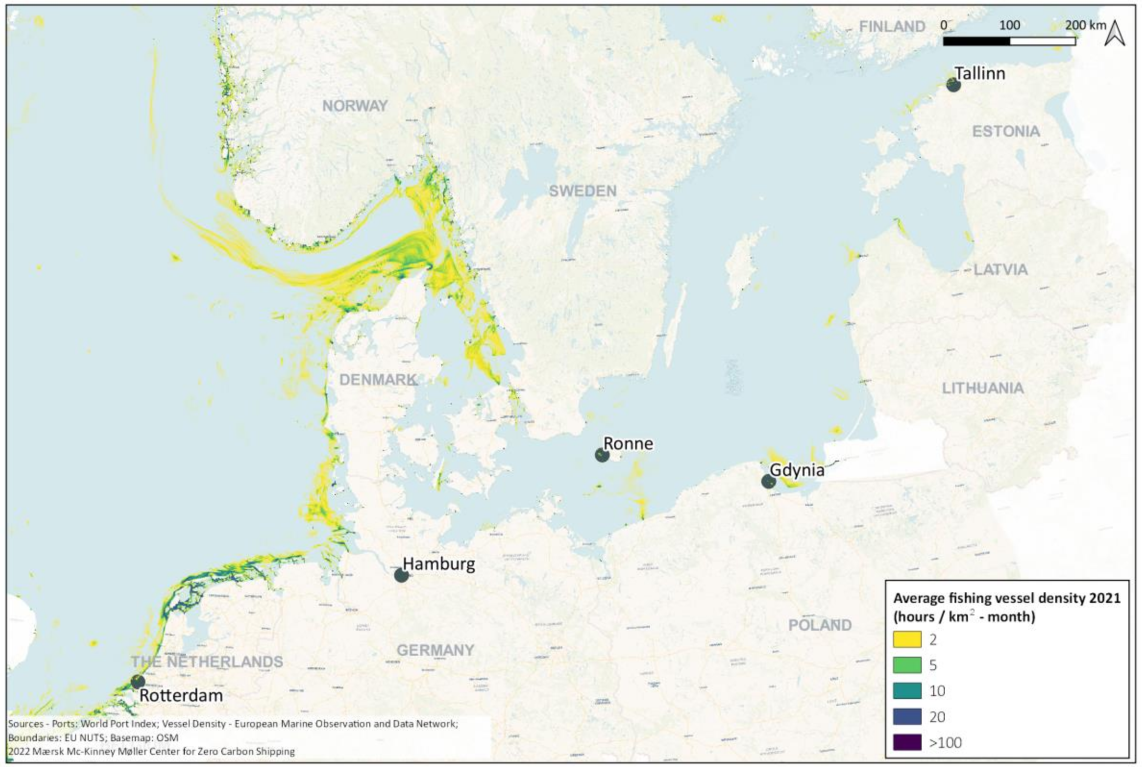
View Data | EMODnet Human Activities (emodnet-humanactivities.eu)

Fishing fleets operation in the region

- The total fishing effort is declining, the CO_2 impact minimal, and the fleet is scattered with operation out of many ports
- The fishing fleet does not appear as an option for the first demonstration of green corridors, but can utilize infrastructure build for other segments



Fishing Vessel Activity in the Baltic Region



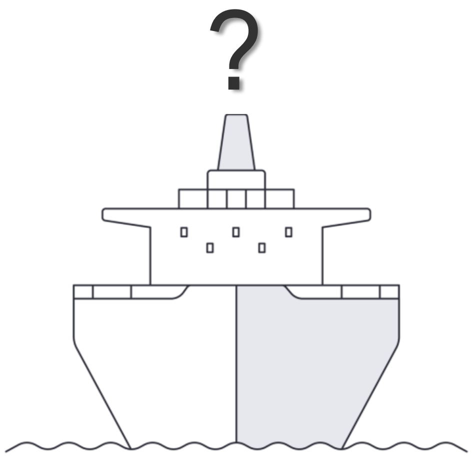
Fishing fleet activity 2021

1. View Data | EMODnet Human Activities (emodnet-humanactivities.eu)
2. ICES (2021): Greater North Sea ecoregion – Fisheries overview. ICES Advice: Fisheries Overviews. Report. ttps://doi.org/10.17895/ices.advice.9099
3. ICES (2021): Baltic Sea Ecoregion - Fisheries overview. ICES Advice: Fisheries Overviews. Report. https://doi.org/10.17895/ices.advice.9139

Fuel option and choice

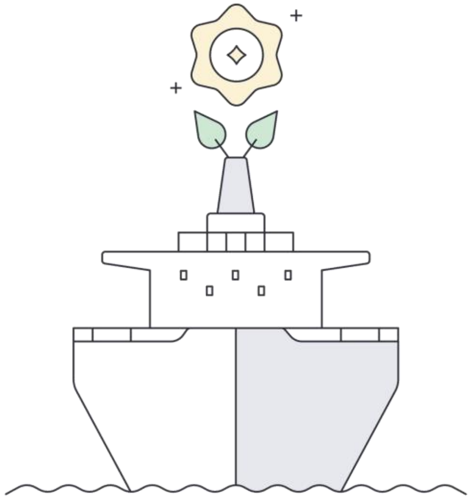
Fuel options and choice

Primary fuel types for first mover shipping segments



Fuel Options

- Biooils
- Methane
- Hydrogen
- Methanol
- Ammonia
- Batteries



Assessments

Technical readiness
Bunkering infrastructure
Use on vessels

Commercial readiness
Foreseen availability within region
Relative cost levels

Societal readiness[1]
Regulatory barriers
Requirements on emissions

1. In contrast to TRL, and CRL; SLR may in many cases have local and regional dependencies and regulations

Fuel Pathway Maturity Map

A simple, overview of readiness across the main alternative fuel pathways

	Feedstock availability	Fuel production	Fuel storage, logistics & bunkering	Onboard energy storage & fuel conversion	Onboard safety & operations	Vessel emissions	Regulation & certification
E-ammonia	Mature	Solutions identified	Major challenges	Major challenges	Major challenges	Major challenges	Major challenges
Blue ammonia	Solutions identified	Solutions identified	Major challenges	Major challenges	Major challenges	Major challenges	Major challenges
E-methanol	Solutions identified	Solutions identified	Solutions identified	Mature	Mature	Mature	Solutions identified
Bio-methanol	Solutions identified	Solutions identified	Solutions identified	Mature	Mature	Mature	Solutions identified
E-methane	Solutions identified	Solutions identified	Mature	Mature	Mature	Solutions identified	Solutions identified
Bio-methane	Solutions identified	Solutions identified	Mature	Mature	Mature	Solutions identified	Solutions identified
Bio-oils	Solutions identified	Major challenges	Solutions identified	Solutions identified	Mature	Solutions identified	Solutions identified

MATURE
Solutions are available, and none or marginal barriers are identified.

SOLUTIONS IDENTIFIED
Solutions exist, but some challenges on e.g. maturity and availability are identified.

MAJOR CHALLENGES
Solutions are not developed, or lack specification.

Fuel Pathways | Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
Please not this does not include commercial feasibility

Technical readiness of primary fuel choice

Technical readiness

Bunkering infrastructure
Use on vessels

Bio-oil

Bunkering infrastructure
Can be bunkered from existing fuel infrastruc., but managing a variety of bio-oil specifications and potential mix of bio-oils can prove to be challenging

Use on vessels
Can be used on most vessels with no or limited modification
Impact of varying fuel properties (e.g. stability, acidity, corrosion) requires attention

CH_4 Methane

Bunkering infrastructure
Can be bunkered using existing LNG infrastruc.
A remaining challenge at terminals and during bunkering is the low boiling point resulting in a latent risk of boil-off.

Use on vessels
Drop-in solution on LNG fuelled vessels
If regulations and safety practices are followed, no obstacles remain regarding safety and onboard operations for major scaling of methane

H_2 Hydrogen

Bunkering infrastructure
No existing bunkering infrastructure
Discussions on infrastructure in Hamburg and Rotterdam

Use on vessels
Only applied for inland barges and range extension
Only 4 stroke engine technology available
On board fuel management and safety to be addressed

CH_3OH Methanol

Bunkering infrastructure
10 known storage terminals in the region
No landbased facilities for fuel bunkering
Ship to ship bunkering possible

Use on vessels
Engines in commercial operation since 2017 and available for certain classes
No expected obstacles regarding onboard fuel safety and operations

NH_3 Ammonia

Bunkering infrastructure
Around 15 existing storage terminals in region[1]
No land based facilities for fuel bunkering,
Ship to ship bunkering possible

Use on vessels
Engine development in progress both for two-stroke and four-stroke solutions, but no commercially available solutions
On board fuel management and safety to be addressed

1. In connection with existing production facilities

Fuel Choice

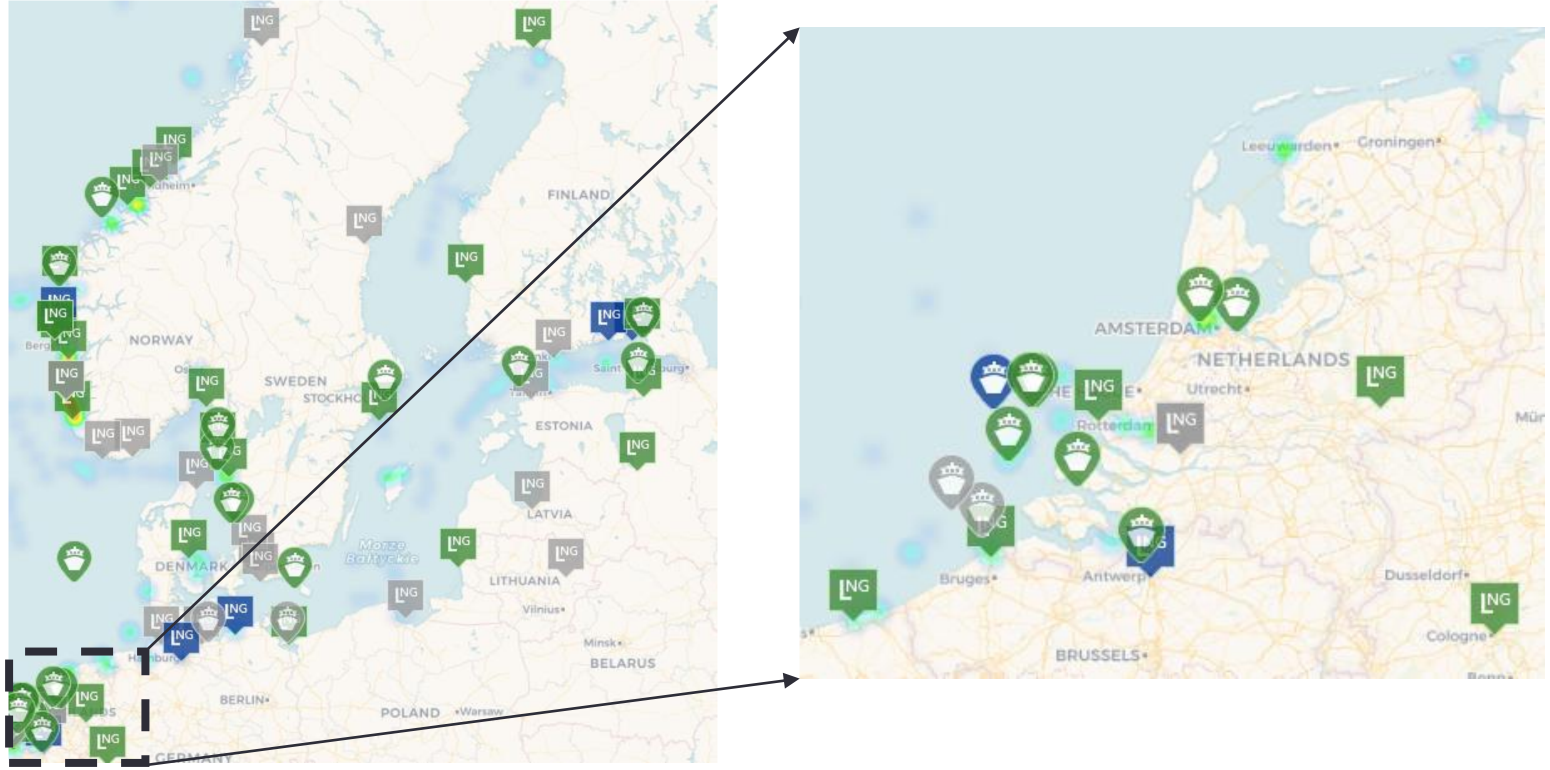
Availability of alternative fuels – Existing and planed port infrastructures

Infrastructure
- In operation
- Decided
- Under discussion

“Bio-Oil”

Can be bunkered from existing infrastructure

LNG



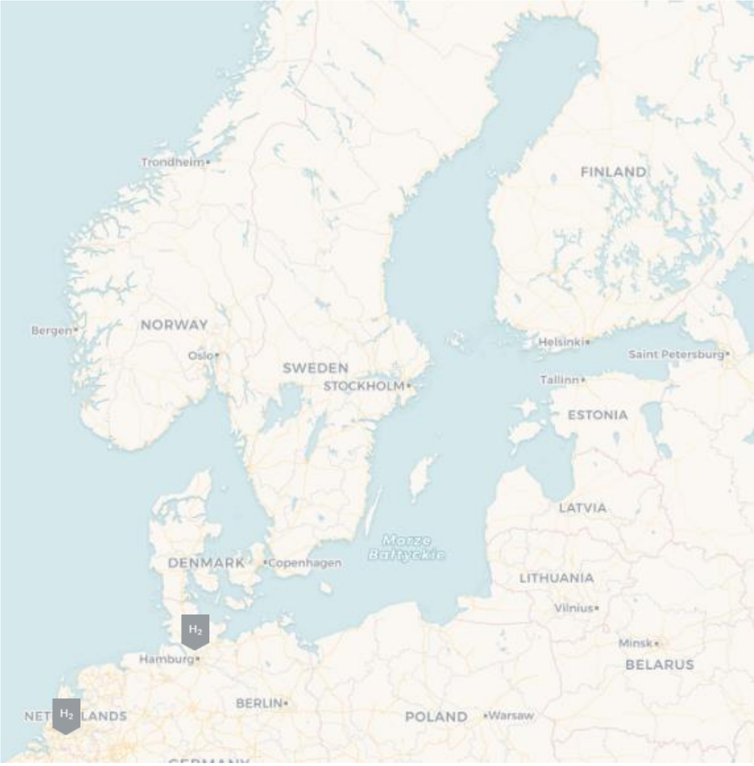
Alternative Fuels Insight (dnv.com)

Fuel Choice

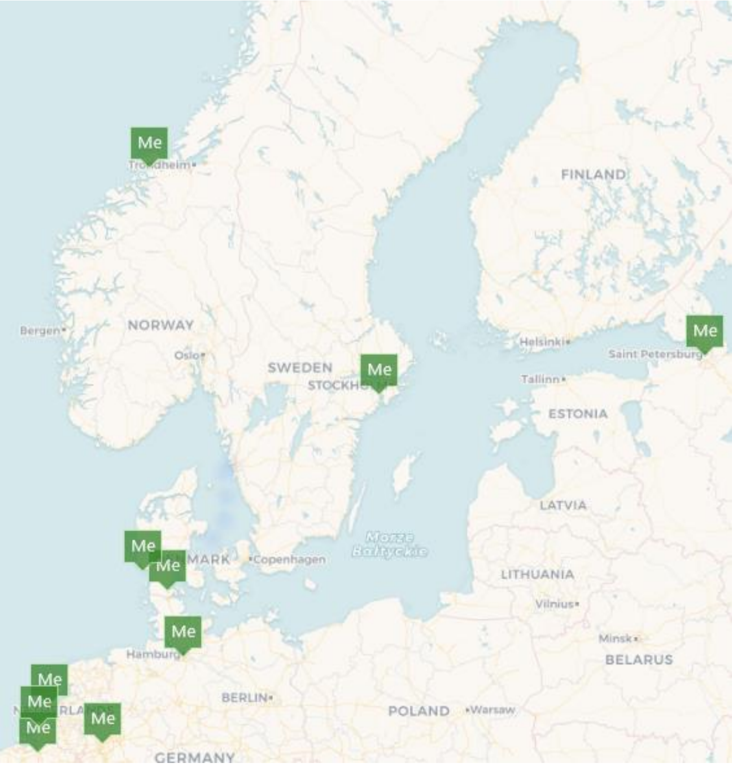
Availability of alternative fuels – Existing and planed port infrastructures

Infrastructure
- In operation
- Decided
- Under discussion

Hydrogen



Methanol



Ammonia

Alternative Fuels Insight (dnv.com)

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Other port infrastructure
Shore power, batteries, …

- Shore power or shore supply is the provision of shoreside electrical power to a ship at berth while its main and auxiliary engines are shut down
- Shore power saves consumption of fuel that would otherwise be used to power vessels while in port, and eliminates the air pollution associated with fuel consumption and reduces noise
- Examples of users are ferries and cruise ships for hotel electric power
- Some port city may have anti-idling laws that require ships to use shore power
- Batteries are seen on ferries with short connections

 Alternative Fuels Insight (dnv.com)

Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Commercial readiness of primary fuel choice

Commercial readiness

Foreseen availability within region
Relative cost levels

Bio-oil

Availability within region

Around 20 existing liquid biofuel facilities exists within the region

Half of these are in commercial production

Relative cost levels[1,2]

2025: 37 – 54 $/GJ
2030: 23 – 26 $/GJ
2035/50: 22-26 $/GJ

CH_4 Methane

Availability within region

>300 biomethane facilities exists within the region for commercial production

Nearly no e-methane

For fuel supply, biogas will most likely be traded through certificates and enter the grid near the production facility

Relative cost levels[1,3]

2025: 52 (23) $/GJ
2030: 44 (21) $/GJ
2035/50: 40/24 (19/16) $/GJ

H_2 Hydrogen

Availability within region

More than 25 projects within region in various stages of development

Many projects are focused on captive use of hydrogen

Projects focused on supplying the maritime industry are limited to few

Relative cost levels[1,4]

2025: 33 $/GJ
2030: 27 $/GJ
2035/50: 26/14 $/GJ

CH_3OH Methanol

Availability within region

Few exiting grey production for traditional applications in chemical industry

Several e-fuel and bio-fuel projects under early development within the region that can lead to production within the decade

Relative cost levels[1, 5]

2025: 67 (35) $/GJ
2030: 54 (30) $/GJ
2035/50: 50/32 (29/27) $/GJ

NH_3 Ammonia

Availability within region

Exiting grey production for traditional applications fertilizer and chemical industry

Several e-fuel projects under early development within the region that can lead to production within the decade

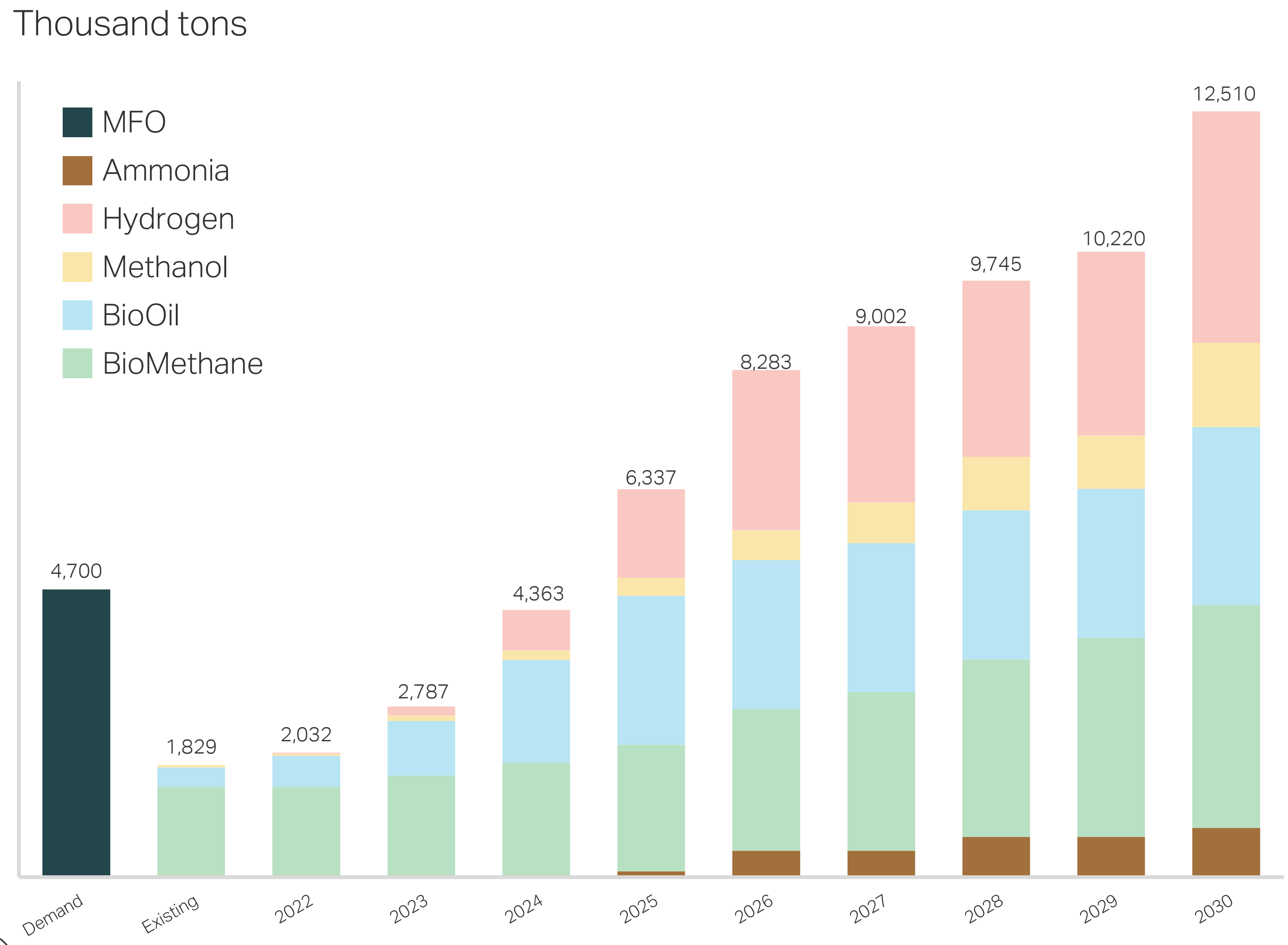
Relative cost levels[1, 6]

2025: 53 (44) $/GJ
2030: 37 (30)$/GJ
2035/50: 35/20 (29/28) $/GJ

1. Datas from MMMCZCS, NavigaTE 2022 estimations
2.Drop-in PyOil BioDiesel - HTL BioDiesel, 3. e-Methane (BioMethane), 4. Compressed green Hydrogen, 5. e-Methanol (BioMethanol), 6. e-Ammonia (Blue Ammonia)

Planned Green Fuel Projects in the region[1]

Cumulative Capacity (kTon MFO equivalent/year)



1. Total cummulative planned production capacity without destingtion of sector availability
2. Gas for Climate Market State and Trends report 2021.

Availability of alternative fuels
Current outlook for alternative fuels suggest that all of these will be available within the region, but at different time horizons.

BioOils
Are already available and are foreseen to be fuel with the largest availability within the region in the coming decade

BioMethane
Will be available. Currently between 0,5 & 25% of national gas consumptions is biomethane, expectations are 10% by 2030, so and average growth of 12% growth per year has been assumed[2]

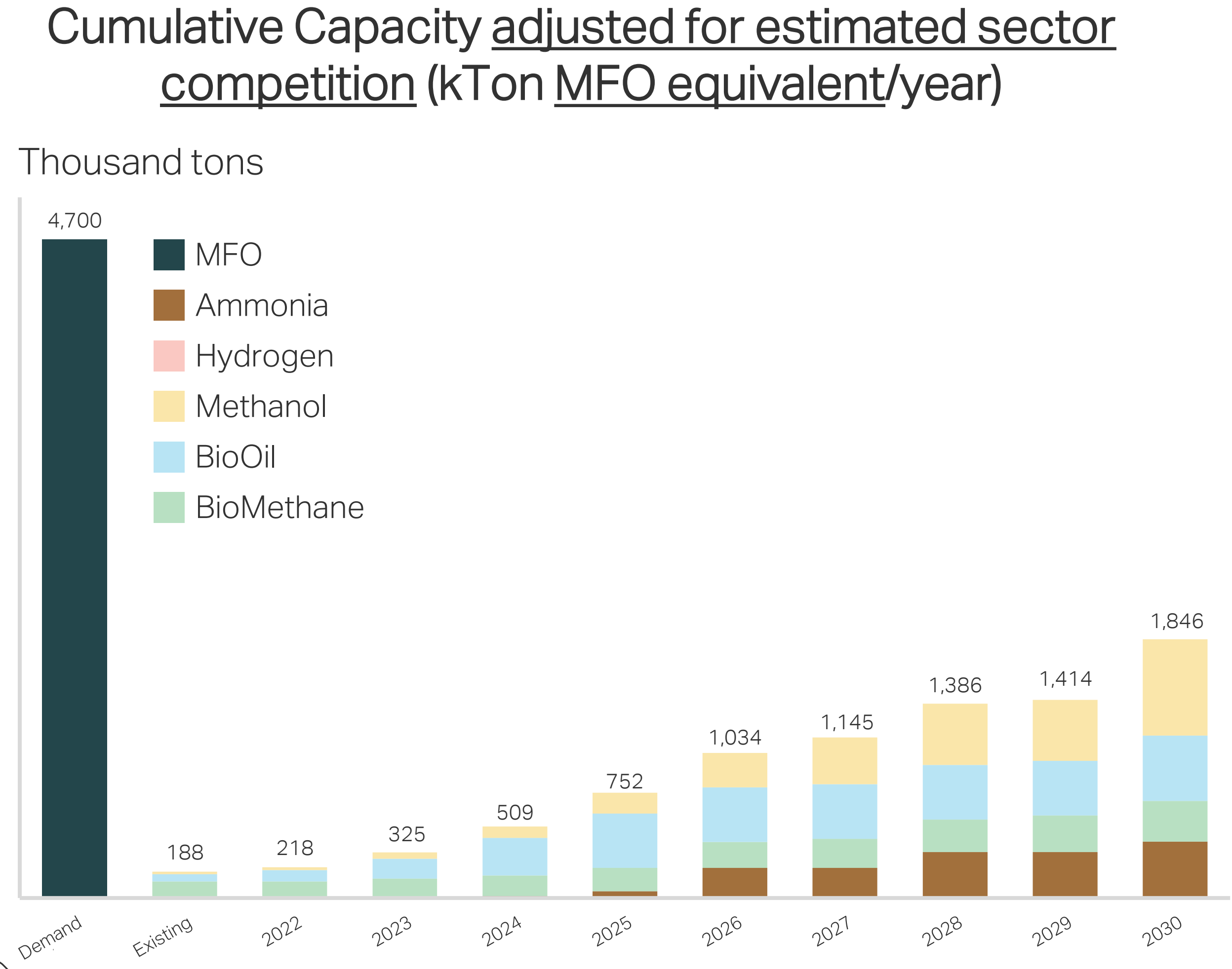
Methanol
Is expected to be available within years, but growth of availability is not seen until end of the decade

Ammonia
Is expected to be available within years, but only limited growth in availability is seen within the decade

Hydrogen
Only anticipated for in-land shipping

Planned Green Fuel Projects in the region

Cumulative Capacity adjusted for estimated sector competition (kTon MFO equivalent/year)



1. MMMCZCS Industry Transition Strategy 2021

Availability of alternative fuels considering sector competition
Several fuels will be demanded by other sectors, such as land transport, aviation, chemical industry, and fertilizers, which will limit the actual availability to shipping

BioOils
According the Industry Transition Strategy[1] from MMMCZCS 16% of the available bio-oils, are estimated to be available for shipping

BioMethane
According to the Industry Transition Strategy[1] from MMMCZCS 8% of the available Biomethane is estimated to be available for shipping

Methanol
Has an existing market in the chemical industry, so it is assumed that only 50% of the installed capacity will be available to shipping

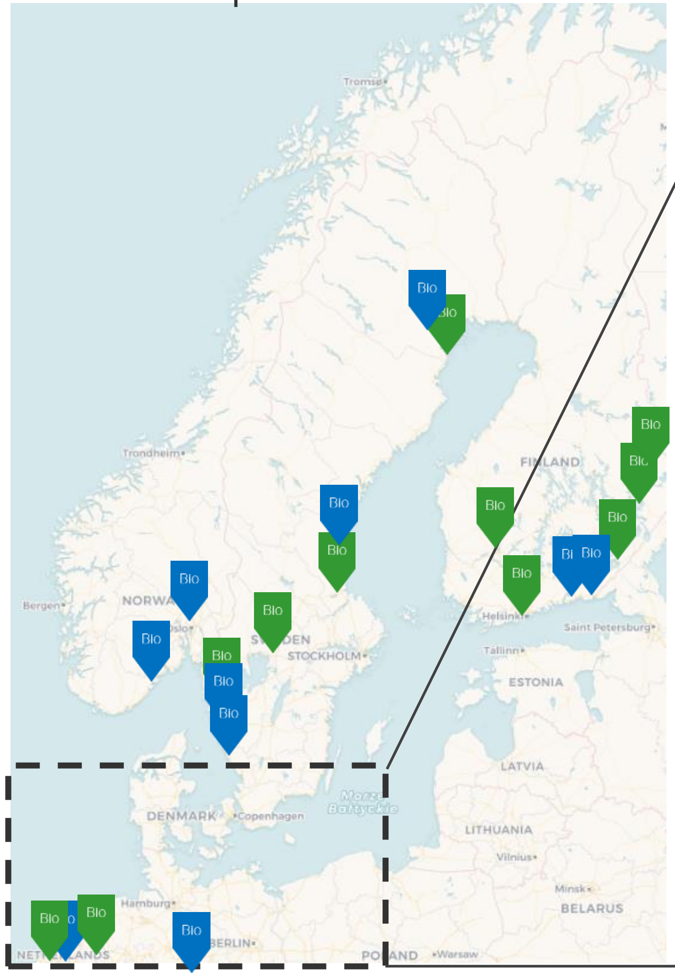
Ammonia
Following the Ukraine/Russia, the European fertilizer industry has been put under pressure due to high gas prices and a stop of import from Ukraine. Thus, significant production can go to fertilizers – 50%

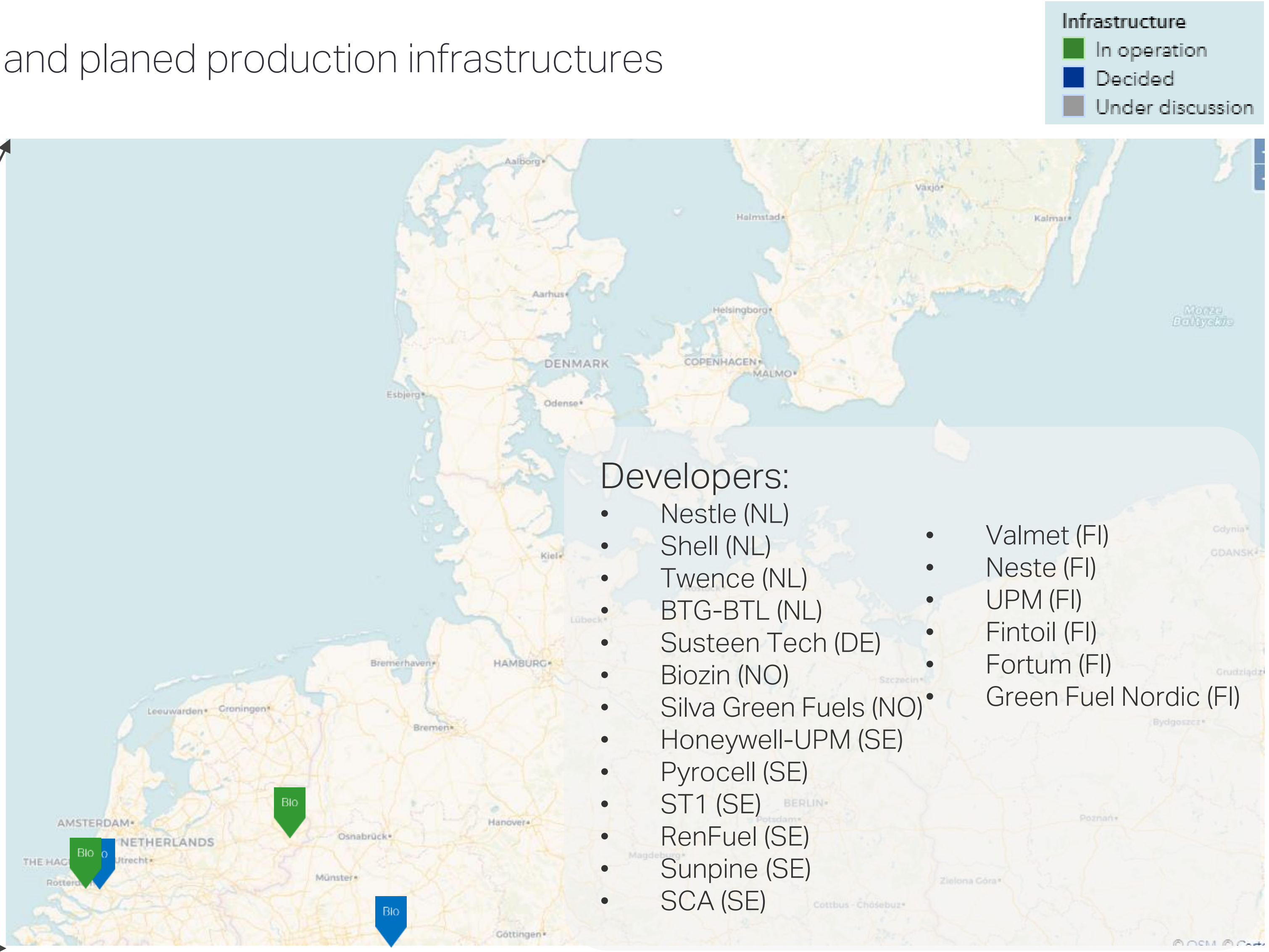
Hydrogen
Only anticipated for in-land shipping, and consequently not part of sea transport

Fuel Choice

Availability of alternative fuels – Existing and planed production infrastructures

Liquid biofuels





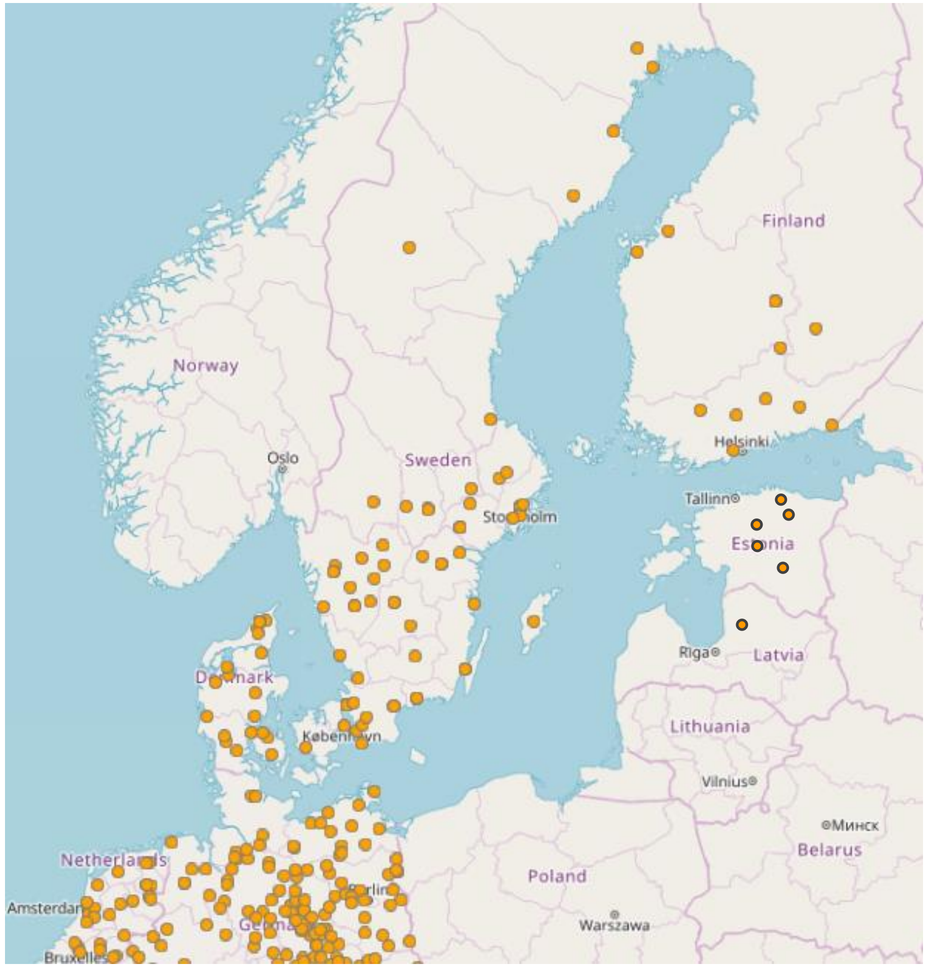
Developers:

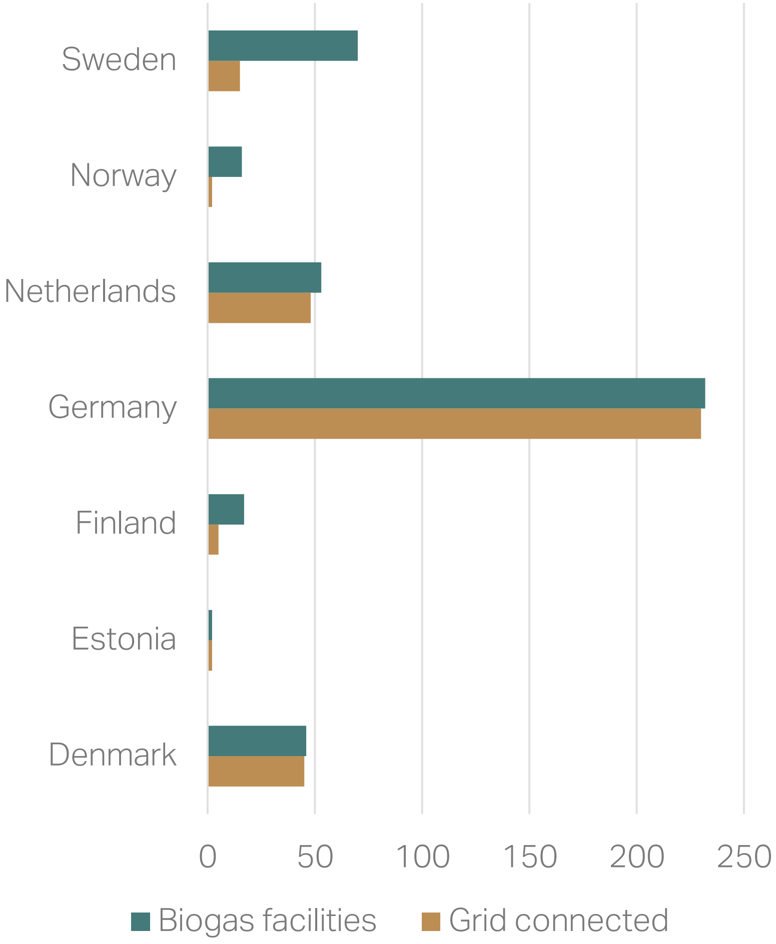
- Nestle (NL)
- Shell (NL)
- Twence (NL)
- BTG-BTL (NL)
- Susteen Tech (DE)
- Biozin (NO)
- Silva Green Fuels (NO)
- Honeywell-UPM (SE)
- Pyrocell (SE)
- ST1 (SE)
- RenFuel (SE)
- Sunpine (SE)
- SCA (SE)
- Valmet (FI)
- Neste (FI)
- UPM (FI)
- Fintoil (FI)
- Fortum (FI)
- Green Fuel Nordic (FI)

Installations | Bioenergy (ieabioenergy.com)

Fuel Choice

Availability of alternative fuels – Existing biomethane production infrastructures





Facts

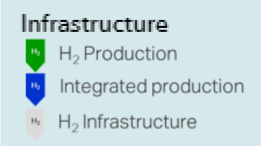
More than 300 biomethane facilities exists within the region

Near all of these are for commercial production

For fuel supply, however, the biomethane will most likely be traded through certificates and enter the grid near the production facility…

However, is this supported by the GHG Protocol when accounting scope 1 emissions by operators???

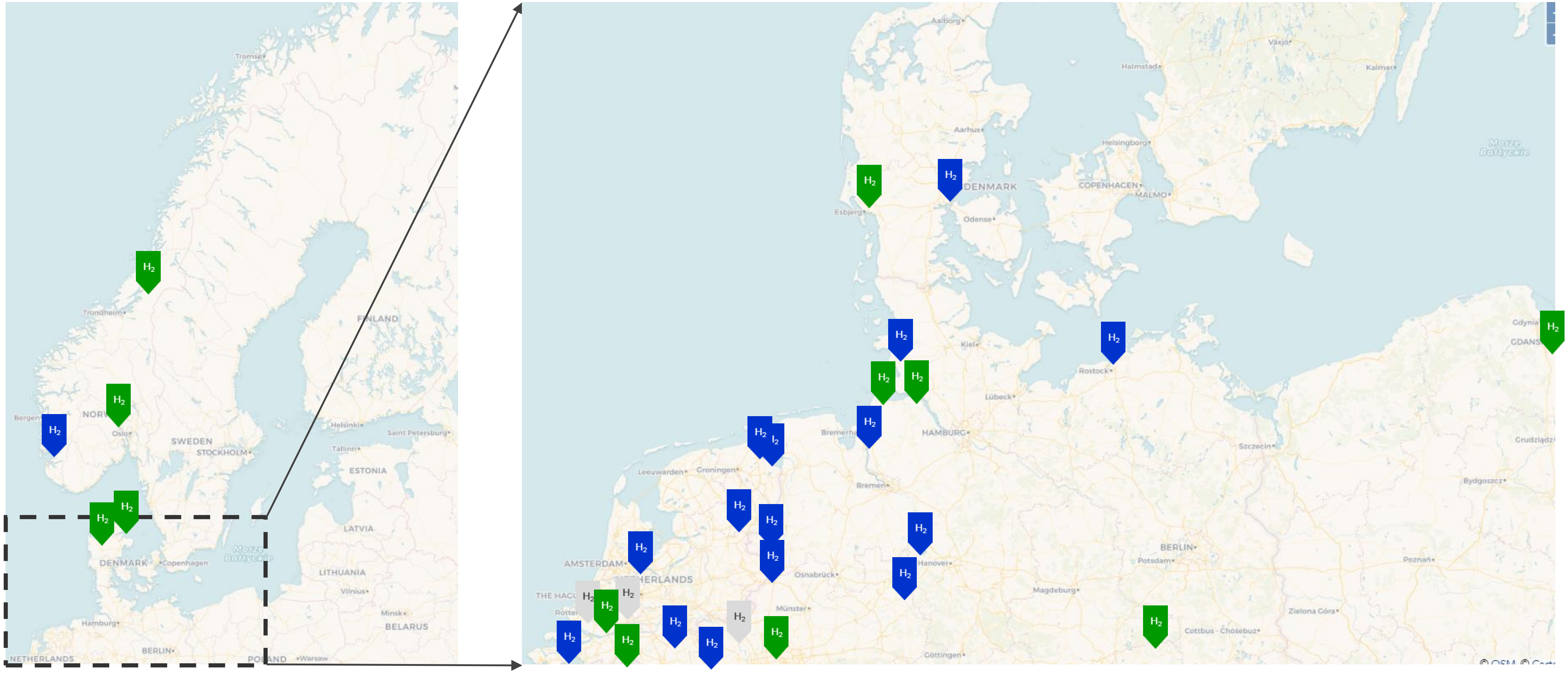
Bio-based industry (europa.eu)
EBA Statistical Report 2021
European Biomethane Map



Fuel Choice

Availability of alternative fuels – Planed production infrastructures

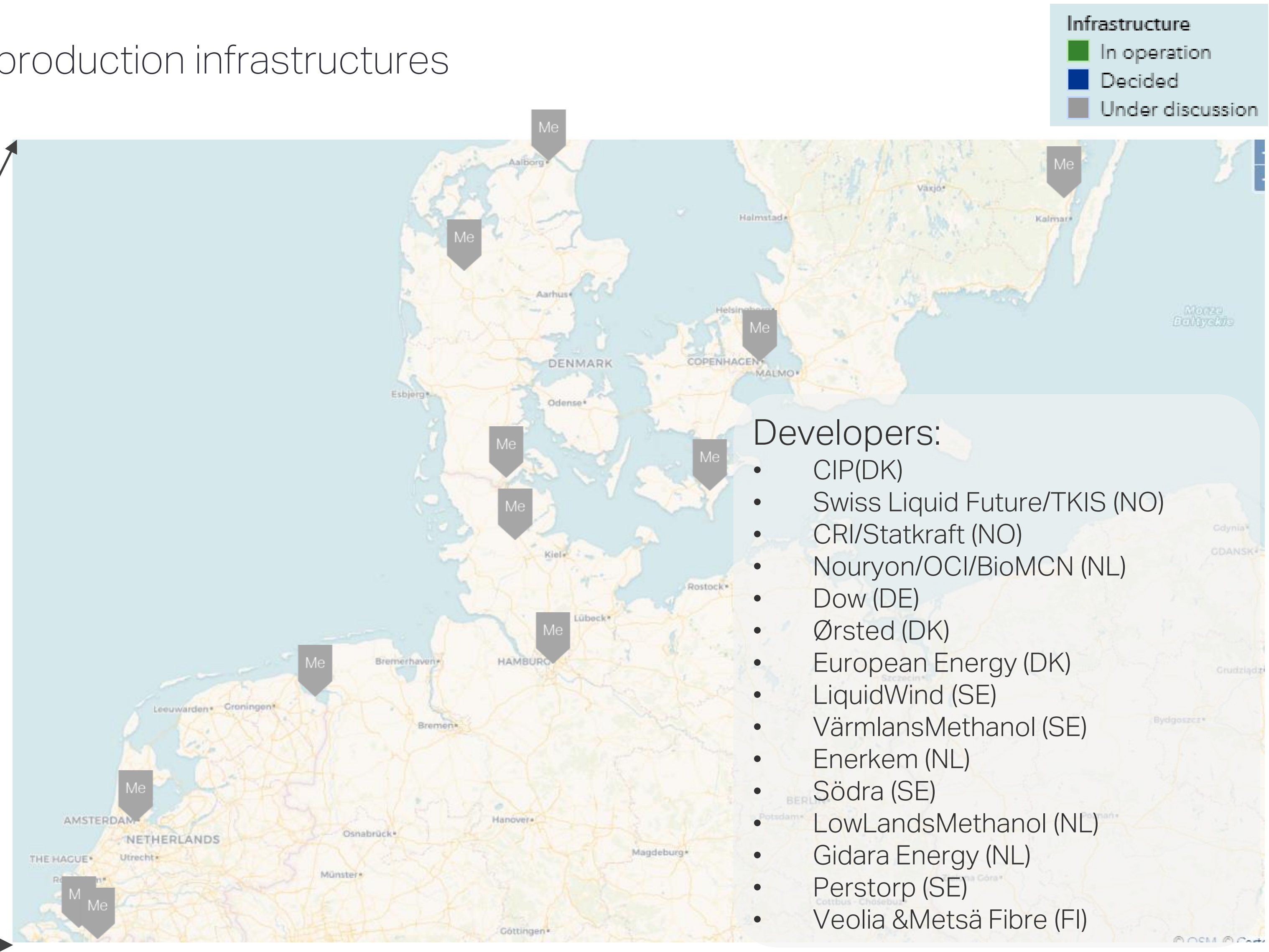
Hydrogen



Fuel Choice

Availability of alternative fuels – Planed production infrastructures

Methanol



Developers:

- CIP(DK)
- Swiss Liquid Future/TKIS (NO)
- CRI/Statkraft (NO)
- Nouryon/OCI/BioMCN (NL)
- Dow (DE)
- Ørsted (DK)
- European Energy (DK)
- LiquidWind (SE)
- VärmlansMethanol (SE)
- Enerkem (NL)
- Södra (SE)
- LowLandsMethanol (NL)
- Gidara Energy (NL)
- Perstorp (SE)
- Veolia &Metsä Fibre (FI)

Fuel Choice

Availability of alternative fuels – Planed production infrastructures

Ammonia

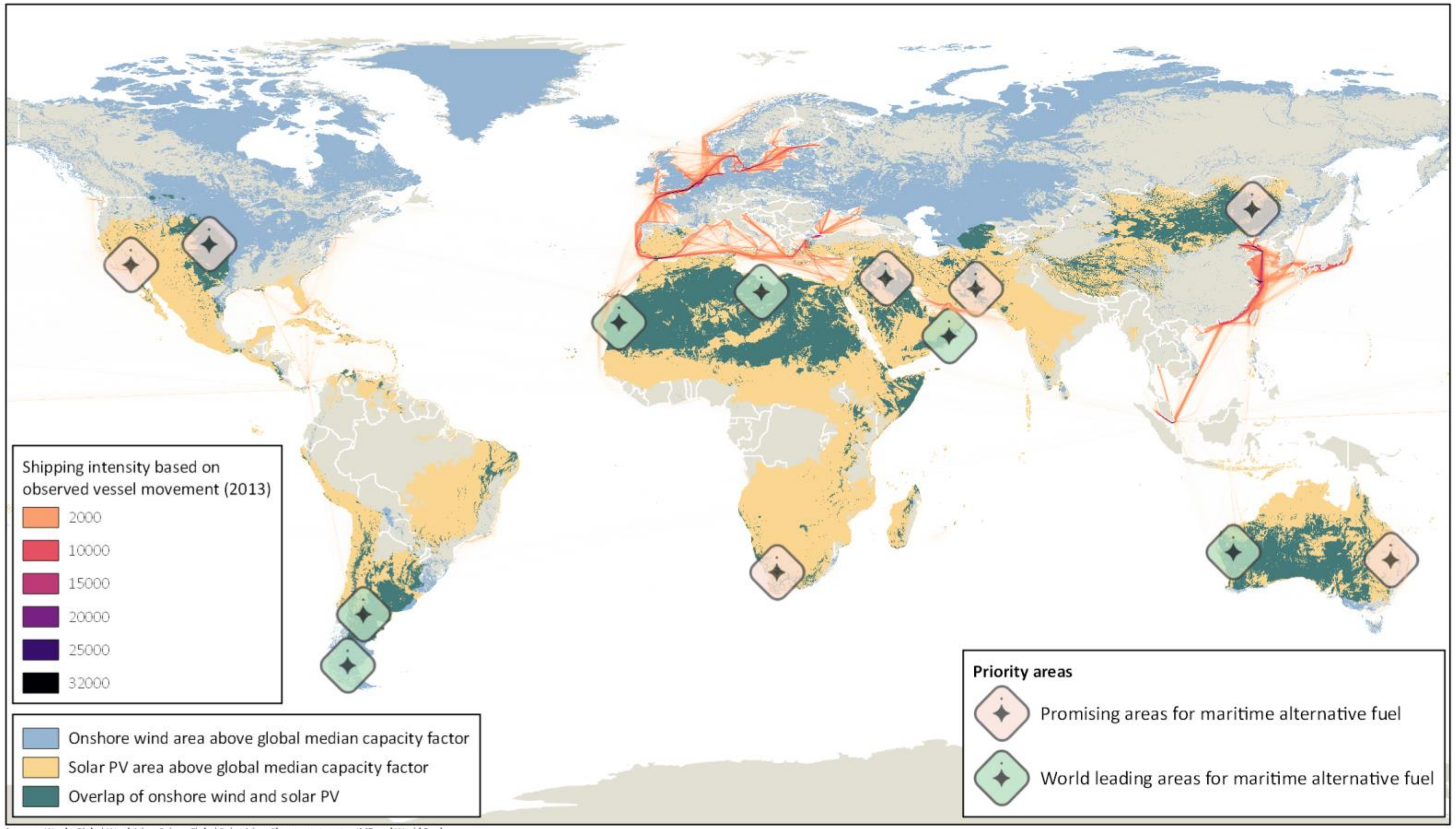
Infrastructure
- In operation
- Decided
- Under discussion

Developers:
- CIP (DK+NO)
- Skovgaard Invest (DK)
- HydrGEN/Aquamarine (DE)
- Yara (NO)
- Yara (NL)
- Proton Ventures (NL)
- Aker/Varanger Kraft (NO)

Fuels supply from outside the region

The global potential for production and supply of alternative fuels is considerable

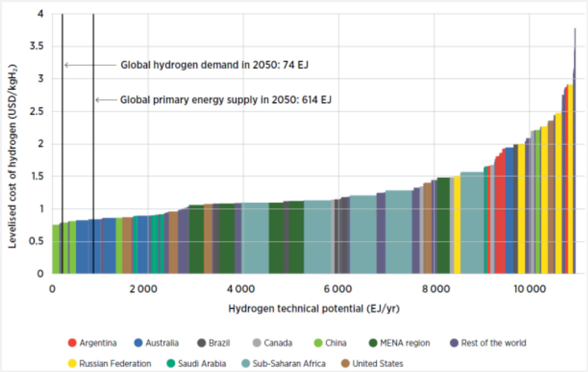
Shipping Intensity and Areas with High Solar and Wind Capacity



Sources: Wind - Global Wind Atlas; Solar - Global Solar Atlas; Shipping intensity - IMF and World Bank
Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Global outlook for alternative fuels

The global potential for production of renewables, hydrogen and derived fuels **exceeds the forecasted demand** by more than one order of magnitute[1]



Epicenters for production lies **outside** the **region**, so as production scales globally, imported fuels will add significantly to the regionally alternative fuel availability and cost of fuels are equally expected to decrease.

1. IRENA (2022), Global hydrogen trade to meet the 1.5°C climate goal: Part III – Green hydrogen cost and potential, International Renewable Energy Agency, Abu Dhabi

Societal readiness of primary fuel choice

Societal readiness

Regulatory barriers
Requirements on emissions

Bio-oil

Regulatory barriers
Standardization is required around bio-oil including rules for emissions for comparable, but not identical, bio-products. Feedstock and process will vary, so development of standards is complex.

GHG impact[1]
Well To Wake emission[2]
2025: 18,6 – 27,8 $kgCO_{2eq}/GJ$
2030: 14,8 – 22,0 $kgCO_{2eq}/GJ$
2035: 7,8 – 9,6 $kgCO_{2eq}/GJ$

Reduction potential
2025: 80 – 71%
2030: 84 – 77%
2035: 92 – 90%

CH_4 Methane

Regulatory barriers
Fugitive emissions needs to be controlled for biomethane, while acceptable CO_2 sources are to be defined for e-methane. Thus, LCA policy needs to be developed

GHG impact[1]
Well To Wake emission[3]
2025: 11,6 (21,0) $kgCO_{2eq}/GJ$
2030: 11,4 (16,9) $kgCO_{2eq}/GJ$
2035: 11,3 (13,9) $kgCO_{2eq}/GJ$

Reduction potential
2025: 88 – 78%
2030: 88 – 82%
2035: 88 – 86%

H_2 Hydrogen

Regulatory barriers
Implementation at scale is difficult since tariffs are under revisions, holding back FID's on H_2 production and derivatives

GHG impact[1]
Well To Wake emission[4]
2025: 1,5 (17,4) $kgCO_{2eq}/GJ$
2030: 1,1 (16,0) $kgCO_{2eq}/GJ$
2035: 0,7 (14,7) $kgCO_{2eq}/GJ$

Reduction potential
2025: 98 – 82%
2030: 99 – 83%
2035: 99 – 85%

CH_3OH Methanol

Regulatory barriers
National support to storage of CO_2, makes production of e-methanol uneconomic and acceptable CO_2 source to be defined. LCA policy needs to be developed

GHG impact[1]
Well To Wake emission[5]
2025: 0,8 (10,4) $kgCO_{2eq}/GJ$
2030: 0,5 (8,4) $kgCO_{2eq}/GJ$
2035: 0,4 (6,6) $kgCO_{2eq}/GJ$

Reduction potential
2025: 99 – 89%
2030: 99 – 91%
2035: 99 – 93%

NH_3 Ammonia

Regulatory barriers
There is no ammonia fuel standard.
Permitting and safe handling in ports is to be defined, and LCA policy needs to be developed.
Public acceptance !

GHG impact[1]
Well To Wake emission[6]
2025: 1,0 (19,3) $kgCO_{2eq}/GJ$
2030: 0,7 (17,8) $kgCO_{2eq}/GJ$
2035: 0,5 (16,5) $kgCO_{2eq}/GJ$

Reduction potential
2025: 99 – 80%
2030: 99 – 81%
2035: 99 – 83%

1. Datas from MMMCZCS, NavigaTE WTW Position Paper
2. HTL – PyOil, 3. e-Methane (BioMethane), 4. e-Hydrogen (Blue Hydrogen), 5. e-Methanol (BioMethanol), 6. e-Ammonia (Blue Ammonia)
3 Relative to LSFO

Project Partner Ports - Activities in region

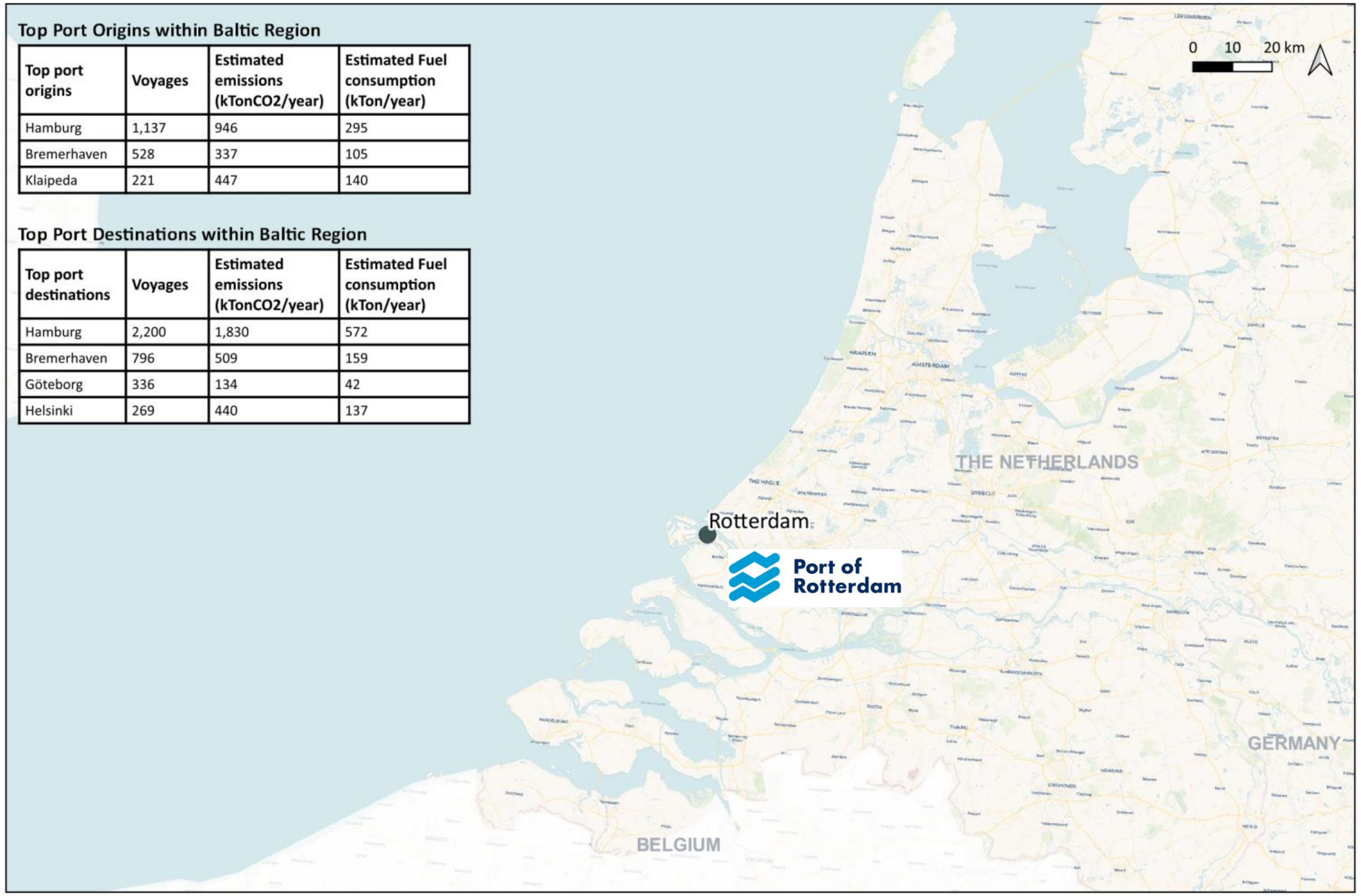
Primary trade routes Port of Rotterdam

– Port of Rotterdam is the most active port in the region across all cargo vessel segments, which also is reflected by the emissions and fuel consumption associated with voyages to and from the port

– The most activities are seen to the upcoast German ports Hamburg and Bremerhaven

– The leg between Port of Rotterdam and Port of Hamburg comes out as the most active voyage in the region!

Rotterdam All Maritime Activity 2021



Top Port Origins within Baltic Region

Top port origins	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Hamburg	1,137	946	295
Bremerhaven	528	337	105
Klaipeda	221	447	140

Top Port Destinations within Baltic Region

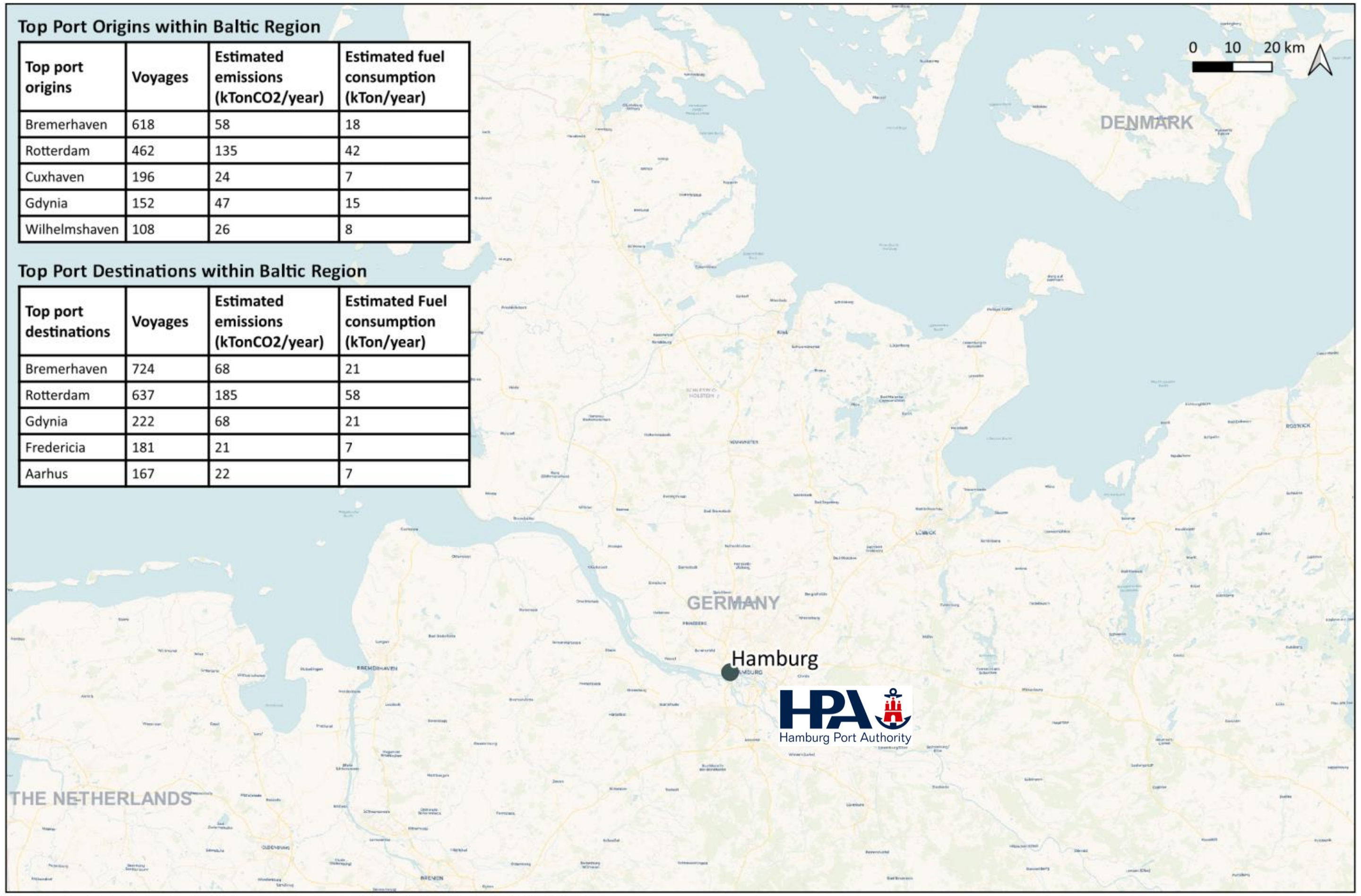
Top port destinations	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Hamburg	2,200	1,830	572
Bremerhaven	796	509	159
Göteborg	336	134	42
Helsinki	269	440	137

Sources: Port data - Partners; Vessel Density - IMF and World Bank; Ports - World Port Index; Basemap from OSM

Primary trade routes Port of Hamburg

- Voyages to and from Bremerhaven and Port of Rotterdam are by far the most active connections for Port of Hamburg in the region
- The connection to Bremerhaven may correlate strongly to the feeder operation into the region
- The feeder fleet is a vessel segment of focus to supply with alternative fuels due to voyages and frequency

Hamburg Bulk, Tanker, and Container Activity 2021



Top Port Origins within Baltic Region

Top port origins	Voyages	Estimated emissions (kTonCO2/year)	Estimated fuel consumption (kTon/year)
Bremerhaven	618	58	18
Rotterdam	462	135	42
Cuxhaven	196	24	7
Gdynia	152	47	15
Wilhelmshaven	108	26	8

Top Port Destinations within Baltic Region

Top port destinations	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Bremerhaven	724	68	21
Rotterdam	637	185	58
Gdynia	222	68	21
Fredericia	181	21	7
Aarhus	167	22	7

Sources: Port data - Partners; Vessel Density - IMF and World Bank; Ports - World Port Index; Basemap from OSM
2022 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Primary trade routes Port of Gdynia

- The Port of Gdynia is a node of the TEN-T Core Network and the entry point of the Baltic-Adriatic Corridor, the extension of which connects Gdynia with Sweden via Gdynia-Karlskrona motorway of the sea

- One of the most active connection in Gdynia is Gdynia-Karlskrona with RoPax

- An alternative fuel supply to the RoPax could be an efficient decarbonization target
  - Subsequently supplying cargo ships...

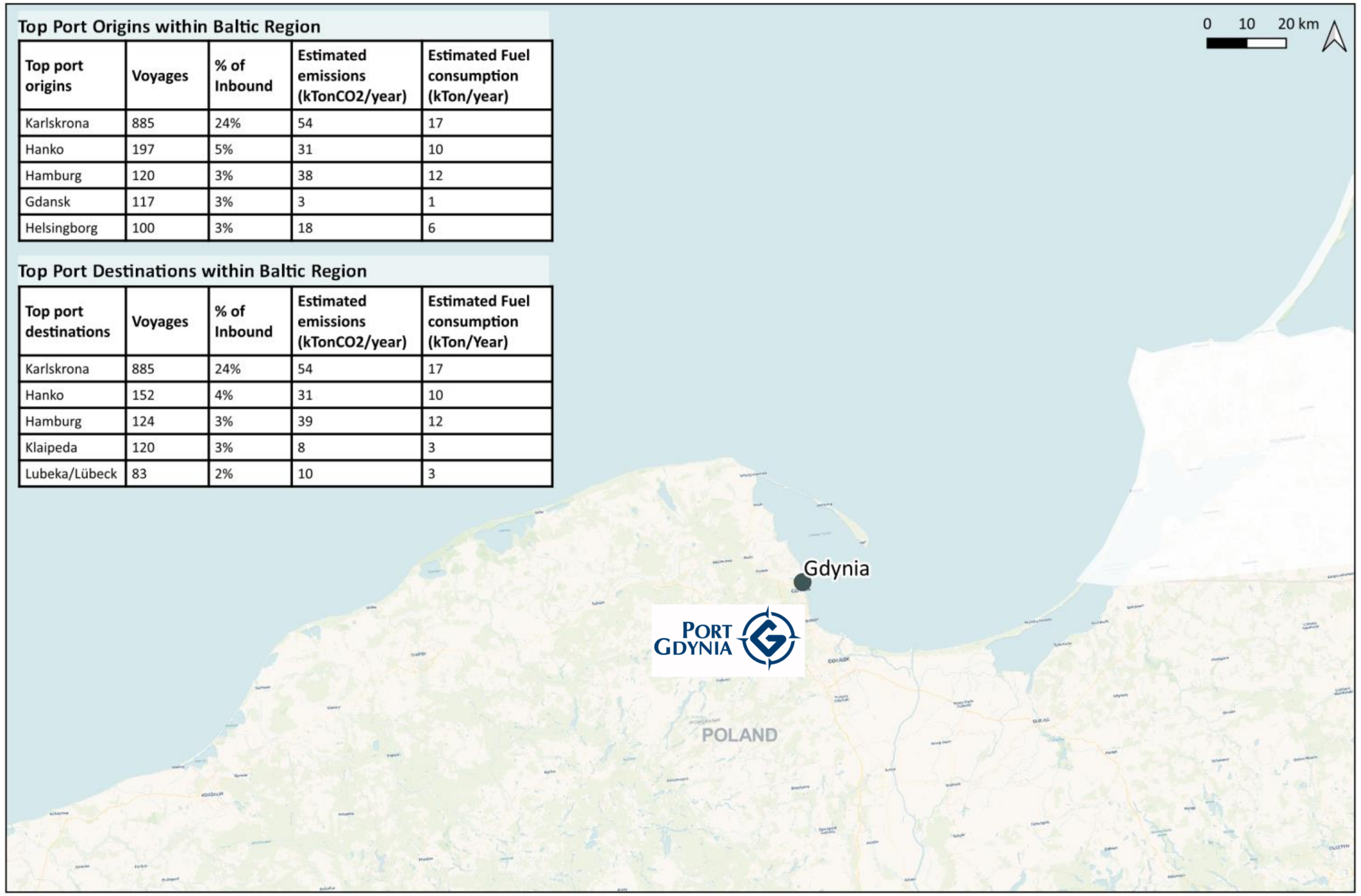
Gdynia RoPax, Bulk, Tanker, and Container Activities 2021

Top Port Origins within Baltic Region

Top port origins	Voyages	% of Inbound	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Karlskrona	885	24%	54	17
Hanko	197	5%	31	10
Hamburg	120	3%	38	12
Gdansk	117	3%	3	1
Helsingborg	100	3%	18	6

Top Port Destinations within Baltic Region

Top port destinations	Voyages	% of Inbound	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/Year)
Karlskrona	885	24%	54	17
Hanko	152	4%	31	10
Hamburg	124	3%	39	12
Klaipeda	120	3%	8	3
Lubeka/Lübeck	83	2%	10	3



Sources: Port data - Partners; Vessel Density - IMF and World Bank; Ports - World Port Index; Basemap from OSM
2022 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Primary trade routes Port of Tallinn

- Estonia is on the European TEN-T North Sea- Baltic corridor and Port of Tallinn is on the core network of the ports in Europe. Located on the east coast of the Baltic Sea, Port of Tallinn is well placed for transhipments between the East and West as well as the North and South.
- The dominating maritime traffic to and from the Port of Tallinn are ferry lines to:
  - Helsinki (FI), Vuossari (FI), Hanko (FI), Kapellskär (SE), and Stockholm (SE)
- An alternative fuel supply to the RoRo, RoPax (inc. domestic), container and cruise fleets could be an efficient decarbonization target.

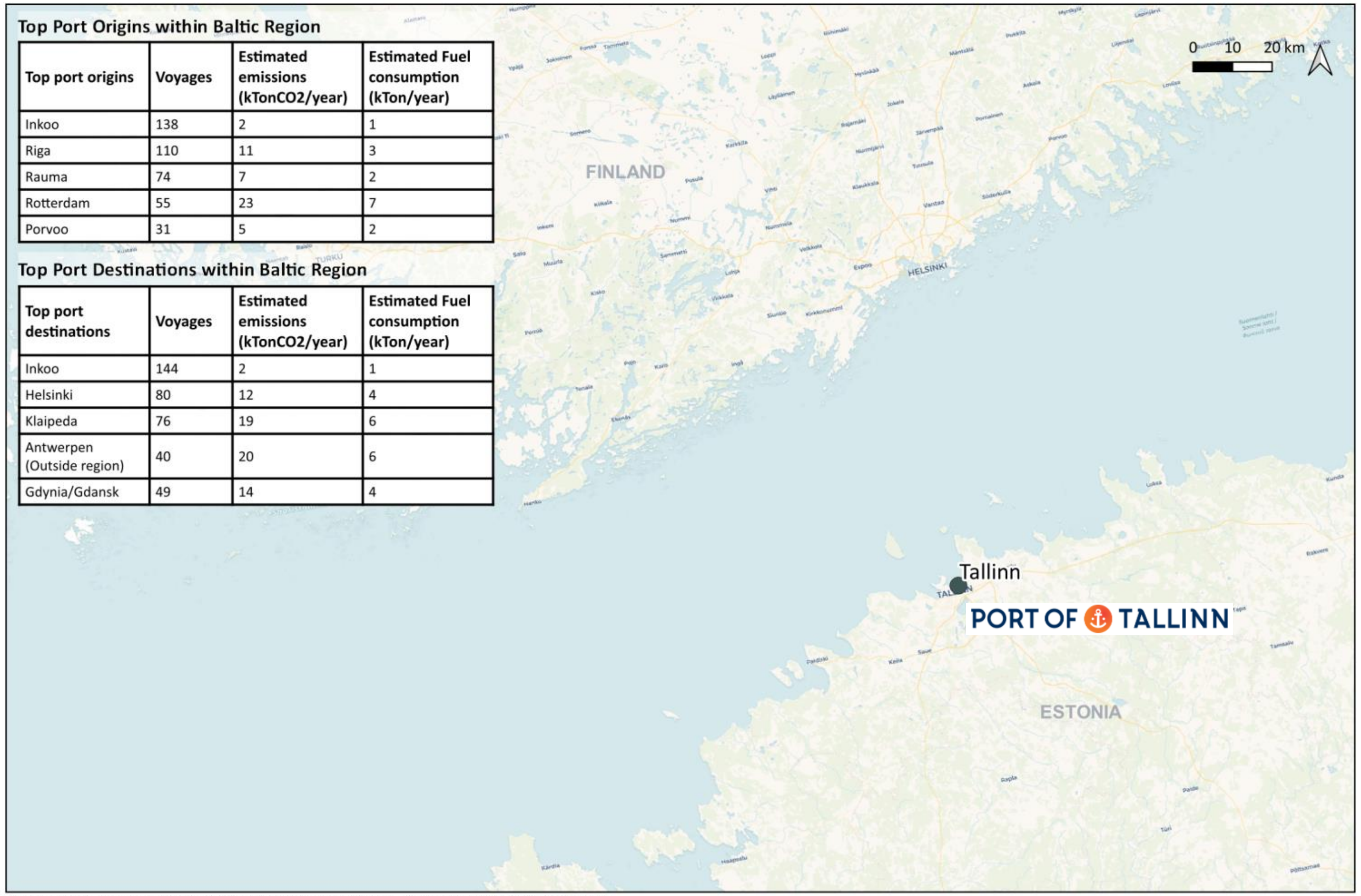
Tallinn Bulk, Tanker, and Container Activity 2021

Top Port Origins within Baltic Region

Top port origins	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Inkoo	138	2	1
Riga	110	11	3
Rauma	74	7	2
Rotterdam	55	23	7
Porvoo	31	5	2

Top Port Destinations within Baltic Region

Top port destinations	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Inkoo	144	2	1
Helsinki	80	12	4
Klaipeda	76	19	6
Antwerpen (Outside region)	40	20	6
Gdynia/Gdansk	49	14	4

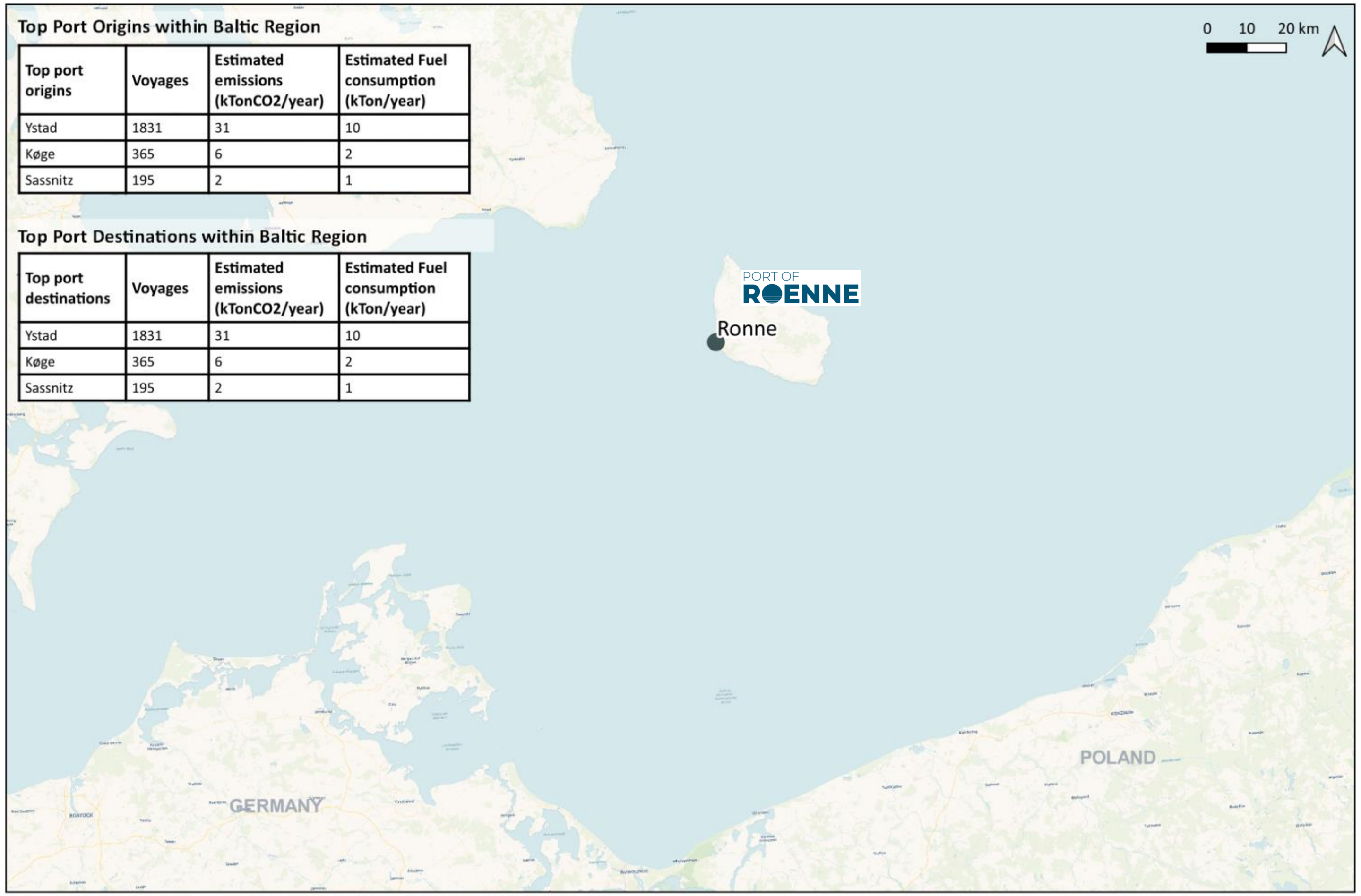


Sources: Port data - Partners; Vessel Density - IMF and World Bank; Ports - World Port Index; Basemap from OSM
2022 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Primary trade routes Port of Roenne

- Port of Roenne is centrally placed in the middle of the entry to the upper Baltic sea
- The dominating maritime traffic to and from the port is ferry lines connect to:
  - Ystad (SE), Koge(DK), and Sassnitz (DE)
- The island depends on ferry connection and has potential for local fuel production, which could be an attractive for target for decarbonization

Rønne Ferry Activity 2021



Top Port Origins within Baltic Region

Top port origins	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Ystad	1831	31	10
Køge	365	6	2
Sassnitz	195	2	1

Top Port Destinations within Baltic Region

Top port destinations	Voyages	Estimated emissions (kTonCO2/year)	Estimated Fuel consumption (kTon/year)
Ystad	1831	31	10
Køge	365	6	2
Sassnitz	195	2	1

Sources: Port data - Partners; Vessel Density - IMF and World Bank; Ports - World Port Index; Basemap from OSM
2022 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping

Port case on:
Adaption of new fuels

Adaption of new fuels in ports

LNG, Methanol, Ammonia, Electric, Nuclear, Autonomous, LOHC, …

Have you ever had the question: “*When are you ready*” ?

- In best practice of industry, and in many reports it is stated:
  - The ports have to take care of….
  - Policy makers and regulatory authorities directing that ports should be ready for at …..

- We need to accelerate all we can do to facilitate a timely energy transition for shipping – This requires ports to be <u>Fuel Ready!!!</u>

Port Readiness Level

An instrument for ports to share their readiness to serve calls, bunkering, service, maintenance etc. of alternative fuelled vessels

How ports and other stakeholders can use port readiness levels to provide transparency and unlock new fuels-related opportunities

- Ports play a crucial role in the adaption - and the pace of alternative fuels deployment
  - To accelerate the energy transition in shipping, ports need to make sure they are ready to handle and/or supply new type of fuels

Port	Bunkering, Call, Service, in-port, anchorage
Readiness	What is your "Ready"?
Level	What is current and future readiness for fuels

- The **Port Readiness Level** offers a simple transparent way to share when a port is ready for what!

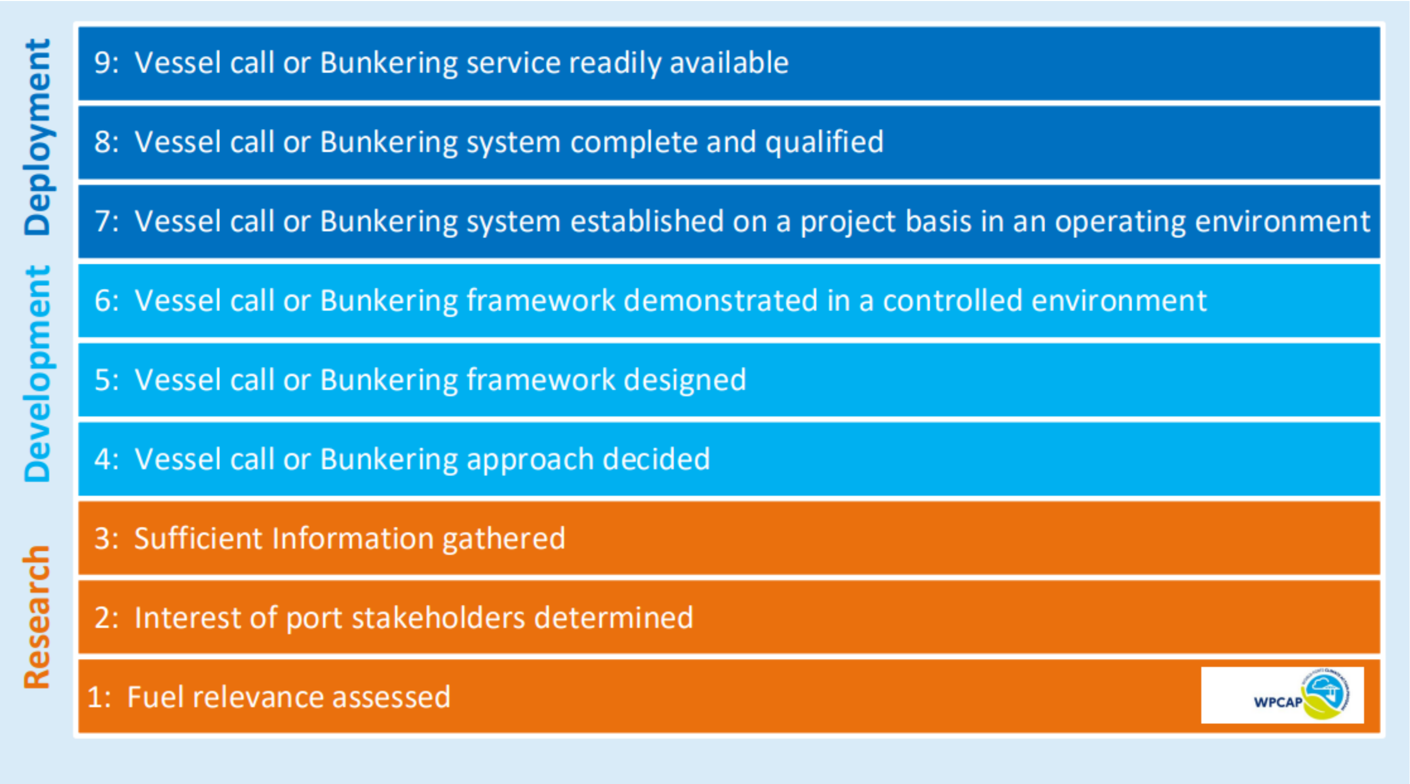
Introduction to Port Readiness Level

What is it and why it is useful?

– Port Readiness Level serves as indicator and guidance tool

It provides/requires:

1. Common language
2. Familiarity - based on TRL format
3. Self-assessments of ports
4. Port ambition
5. Port guidance
6. Expectation management
7. Stakeholder communication
8. Communication instrument



Identification of green corridor opportunity and feasibility

A profile of various ports along a certain route is needed to frame the opportunity and assess the feasibility of a green corridor

PRL provides insights into the current and expected future 'readiness' of ports (both port of call and bunker ports) for alternative fuels.

– Self-assessment by partnering ports

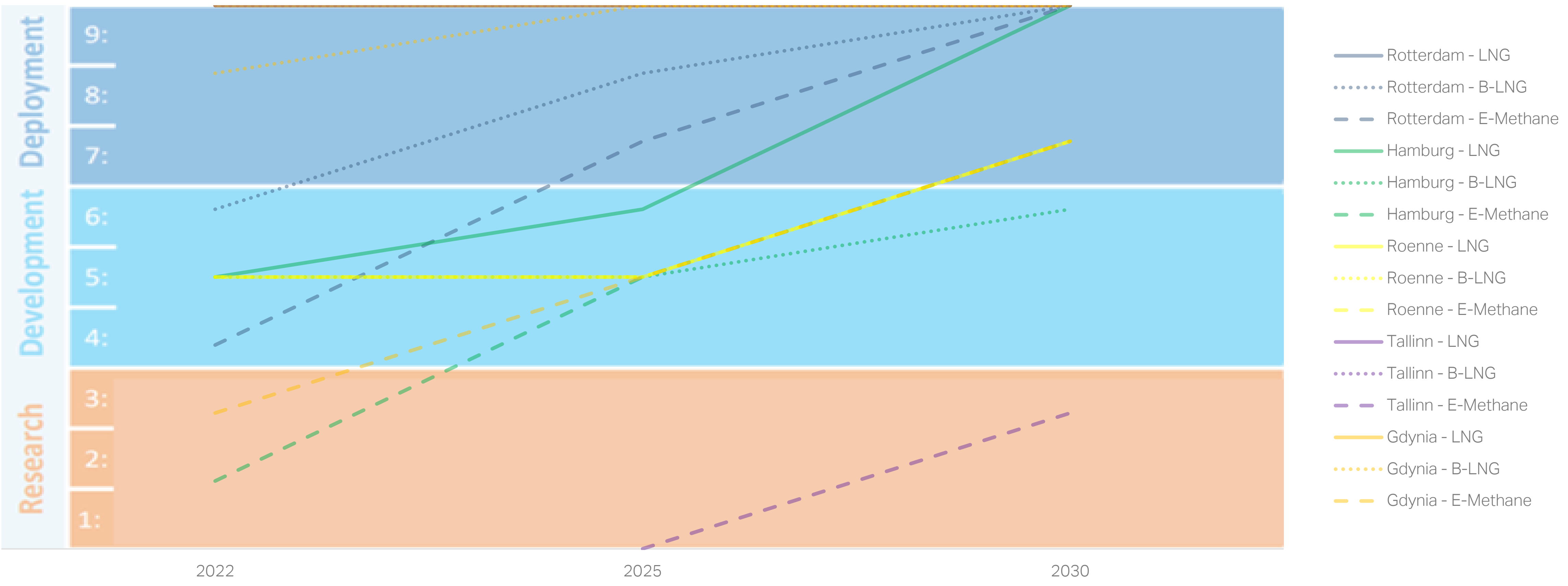
  – Most ports expect to become a bunker port for most alternative fuels

  – LNG, methanol and ammonia are the predominant alternative fuels considered

	Port of Rotterdam	Port of Hamburg	Port of Roenne	Port of Tallinn	Port of Gdynia
LNG	Bunker	Bunker	Bunker	Bunker	Bunker
Bio-LNG	Bunker	Bunker	Bunker	Bunker	Bunker
e-Methane	Bunker	Bunker	Bunker	Bunker	Bunker
Methanol	Bunker	Bunker	Bunker	Bunker	Bunker
Bio-Methanol	Bunker	Bunker	Bunker	Bunker	Bunker
Ammonia	Bunker	Bunker	Bunker	Port of call	Bunker
Hydrogen – pressure	Bunker	Bunker	N/A	Bunker	Bunker
Hydrogen – Liquid	Bunker	Bunker	N/A	Bunker	Port of call
Hydrogen – pressure (inland)	Bunker	Bunker	N/A	N/A	Port of call
Hydorgen – liquid (inland)	Bunker	Bunker	N/A	N/A	Port of call

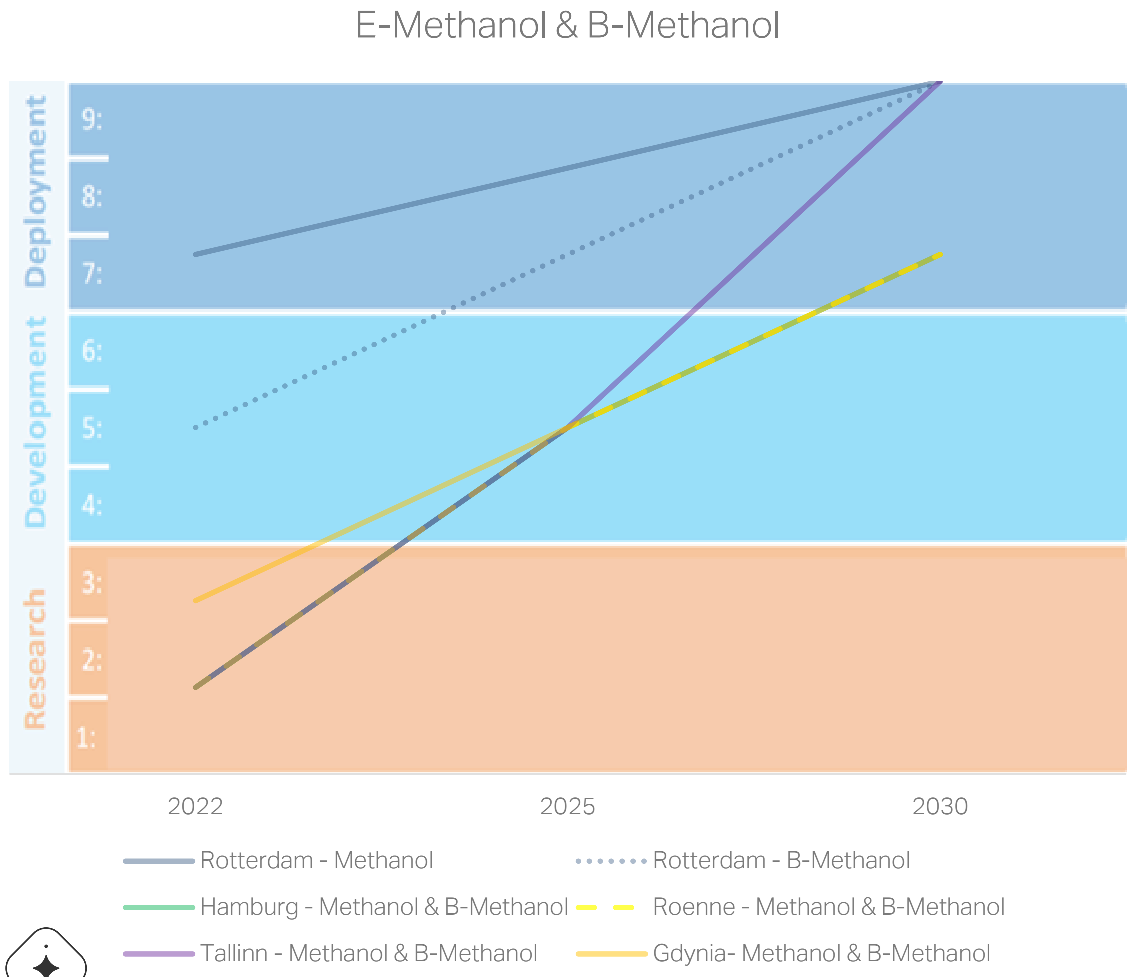
Identification of green corridor opportunity and feasibility

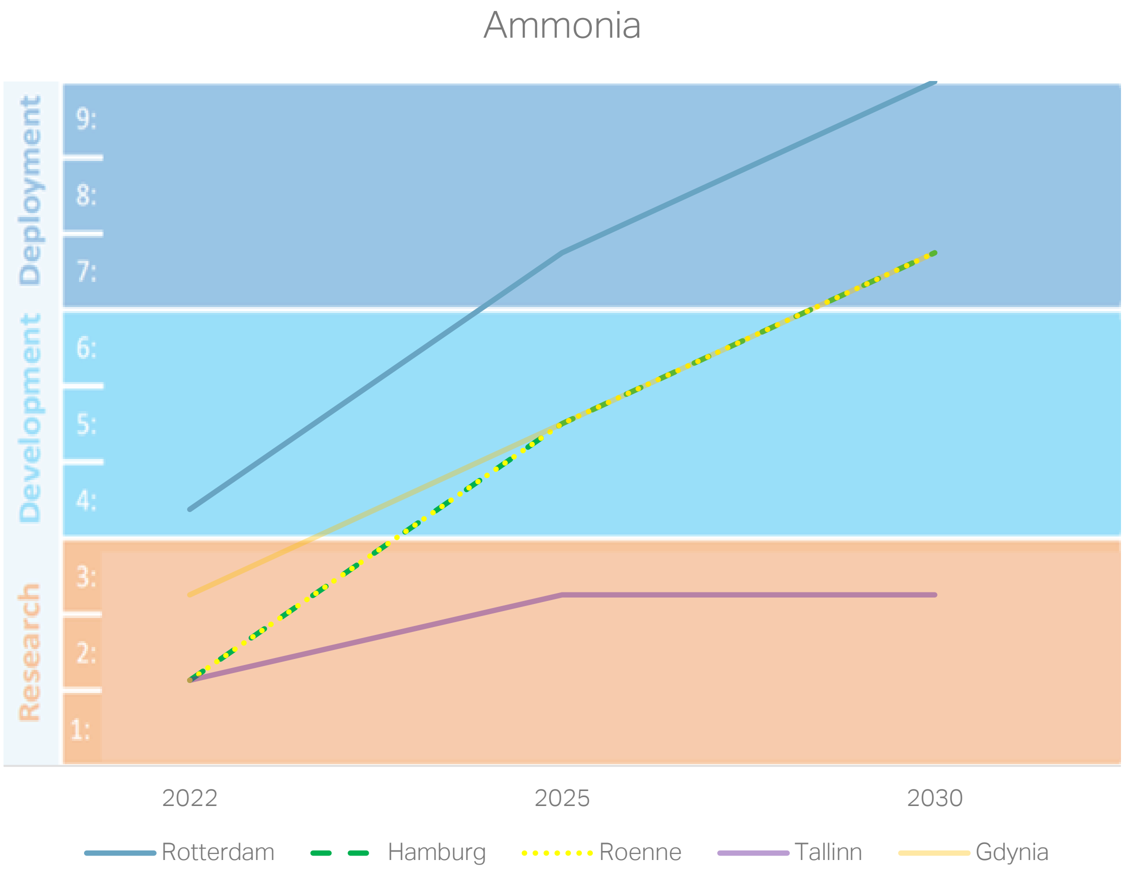
LNG is at most ports already common practice, while Bio-LNG and e-Methane are expected to become more dominant towards mid-decade



Identification of green corridor opportunity and feasibility

Methanol is already quite established in Rotterdam, whilst the other ports are expecting to be ready around 2026
Ammonia bunkering is in all ports in development, and most ports expect to be ready around 2028



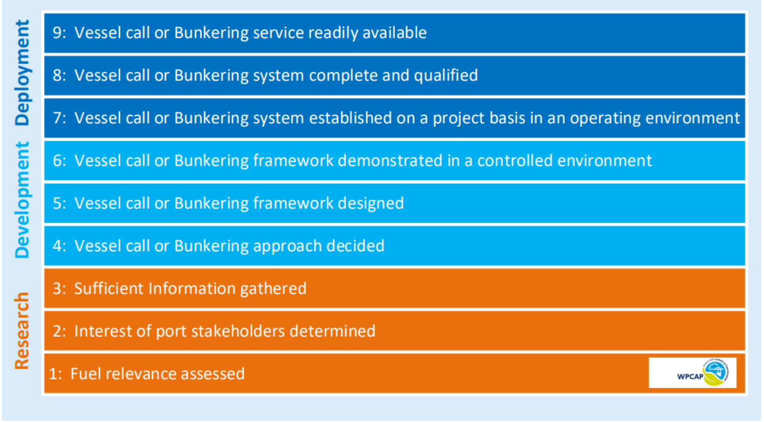


Port Readiness Level

The goal is to publish the PRL Indicator and the guidance ultimo 2022

Current crafting process…

- WPCAP and the IAPH/CMF are developing the topics a port has to consider for each level
- For "Ports of Call" and "Bunkering Ports" topics on:
  - Governance
  - Infrastructure
  - Safety (including a safety framework)
  - Availability
  - Feasibility
  - …are all addressed so: *You can already start now!*



Cost of transition

Incremental fuel cost to enable the transition*

Fuel cost and emission reduction benefits

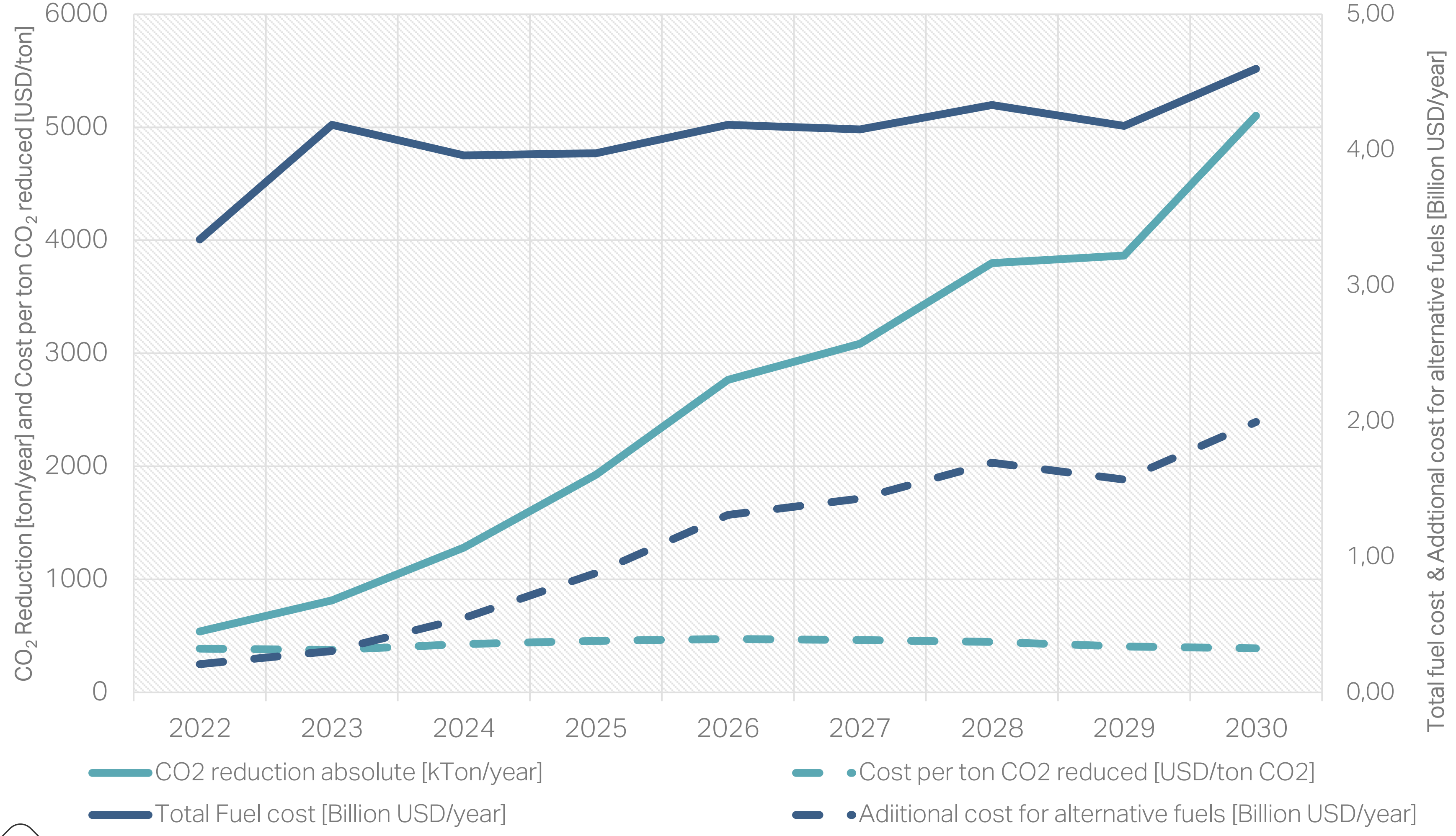
Fuel (2030)	Annual fuel cost [Billion USD/year]	Additional cost[1] [Billion USD/Year]	CO_2 reduction [kton CO_2/year]	Cost per ton CO_2 [USD/ton CO_2]
LSFO	2,6	0	0	0
Biooils[2]	4,6 (5,2)	2,0 (2,6)	11.000 (12.000)	217 (182)
Methane[3]	8,8 (4,2)	6,2 (1,6)	12.600 (11.700)	492 (137)
Hydrogen[4]	5,4	2,8	14.200	197
Methanol[5]	10.8 (6.0)	8.2 (3.4)	14.200 (13.000)	577 (262)
Ammonia[6]	7.4 (6.0)	4,8 (3,4)	14.200 (11.600)	338 (293)

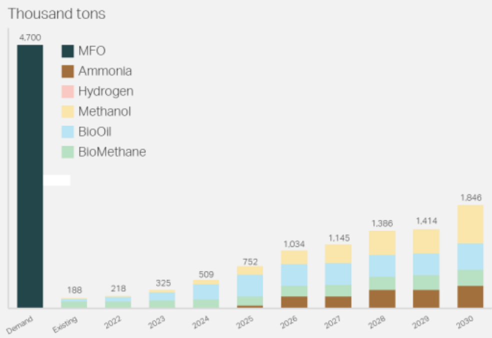
Baseline: Fuel demand: 4.700 kton/year = 200.220.000 GJ/year (MFO eq.) ~ 2,6 billion USD/year (2030 LSFO) – 14.300 kton CO_2/year
Numbers Outside/(Inside) bracket:
1. PyOil (HTL), 2. e-Methane (BioMethane), 3. Compressed green Hydrogen, 5. e-Methanol (BioMethanol), 6. e-Ammonia (Blue Ammonia)

* Excluding all investment cost required in the fuel supply chain and vessels
1 Relavite to LSFO 2030 cost data from NavigaTE 2022

Cost of transition*

Cost of adapting projected and available fuel mix towards 2030, emissions, and cost of emissions reduction





Decarbonization potential & cost

Adapting the fuel scenario above has potential to decarbonize around 1/3 of the maritime sector in the region by 2030 at an additional fuel cost of 2,0 billion USD

- CO_2 emissions can be reduced from: 14.300 to ~9.200 kton/year[1]
- Alternative fuels; e-methanol, biooil, biomethane and e-ammonia has higher cost than LSFO, but the total cost is to a degree counteracted by the cost reduction projected in the forward curve for LSFO cost
- Cost per avoided CO_2 is between 480 and 380 USD/ton from 2024

- Across fleet and excluding all investment cost required in the fuel supply chain and vessels

1. Estimated based on WtW data from NavigaTE well-to-wake Position Paper

Premium cost of services and transport in green corridors

What are the additional cost and saved CO_2 emissions to the customer?

What are the additional cost associated with building a green corridor, how to cover these and who should pay?

Cost of container transport on 1500 TEU vessel on green corridor

Fuel (2025)		LSFO	Bio-Oils	Methanol	Ammonia
Fuel cost [USD/Ton]		660	1775	1340	1000
Vessel rental / Port Costs		-	-	+15%	+15%
Consumption	Sailing [Tons/Day]	40	42	85	90
	Berthing [Tons/Day]	2	2	4	5
Pilot fuel [Bio-Oil]		-	-	5%	5%
Single Allocation cost [USD/TEU]		**194**	**392**	**573**	**483**
CO_2 reduction [WtW]		0	76%	96%	94%
CO_2 per Single Allocation [kg/TEU]		625	149	27	36
Cost of CO_2 reduction [USD/Ton]		-	417	633	491

Based on the data and method by Yisong et al. (2020) the additional cost of container transport cost was estimated for selected fuels for 1500 TEU vessel

Cost Details for Two Vessel Types
Hamburg – Kotka[1]

Vessel Type	900 TEU	1500 TEU
Vessel Cost		
Vessel Rental Cost	6000	7500 USD/Day
Full Voyage Times	7	7 Days
Vessel Cost in Total	42000	52500 USD/Sailing
Fuel Cost		
Fuel Consumption on Sailing	30	40 Ton/Day
Fuel Consumption on Berthing	2	2 Ton/
Sailing Time on Sea	4.5	4.5 Days
Berthing Time in Port	2.5	2.5 Days
Price of Heavy Oil	650	650 USD/Ton
Price of Light Oil	1000	1000 USD/Ton
Fuel Cost in Total	92750	122000 USD/Sailing
Port Cost		
Port Cost of Hamburg	13000	14000 USD
Port Cost of Kiel Canal	15000	16000 USD
Port Cost Kotka	13000	14000 USD
Port Cost in Total	41000	44000 USD
Total Sailing Cost	175750	218500 USD/Sailing
Available Capacity	900	1500 TEU
Capacity utilization	75%	75%
Single Allocation Cost	260	194 USD/TEU

1. Yisong L., Xuefeng W., Hao H., and Hui Z. Research on feeder network design: a case study of feeder service for the port of Kotka, European Transport Research Review (2020) 12:61
2. Methanol case with no additional cost no vessel rental, 20% discount on fuel cost (Methanol and pilot fuel), 50% discount on port costs

Premium cost of services and transport in green corridors

What are the additional cost and saved CO_2 emissions to the customer?

What are the additional cost associated with building a green corridor, how to cover these and who should pay?

Cost of container transport on 1500 TEU vessel on green corridor

Fuel (2025)		LSFO	Methanol	1	2	3	4
Fuel cost [USD/Ton]		660	1340	1070	1070	1070	1070
Vessel rental / Port costs		-	+15%	+15%	Discount	+η	Free SP
Consumption	Sailing [Tons/Day]	40	85	85	85	72	72
	Berthing [Tons/Day]	2	4	4	4	4	0
Pilot fuel [Bio-Oil]		-	5%	5%	5%	5%	5%
Single Allocation cost [USD/TEU]		**194**	**573**	**472**	**446**	**390**	**380**
CO_2 reduction [WtW]		0	96%	95.7%	95,7%	96,2%	97.5%
CO_2 per Single Allocation [kg/TEU]		625	36	27	27	24	16
Cost of CO_2 reduction [USD/Ton]		-	**491**	**465**	**420**	**326**	**305**

Based on the data and method by Yisong et al. (2020) the additional cost of container transport cost was estimated for selected fuels for 1500 TEU vessel

Cases introducing Value chain discounts

1. 20% on fuel
2. 15% on charter and 50% on port costs
3. 15% energy efficiency on vessel
4. Free shore power

1. Yisong L., Xuefeng W., Hao H., and Hui Z. Research on feeder network design: a case study of feeder service for the port of Kotka, European Transport Research Review (2020) 12:61
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Premium cost of services and transport in green corridors

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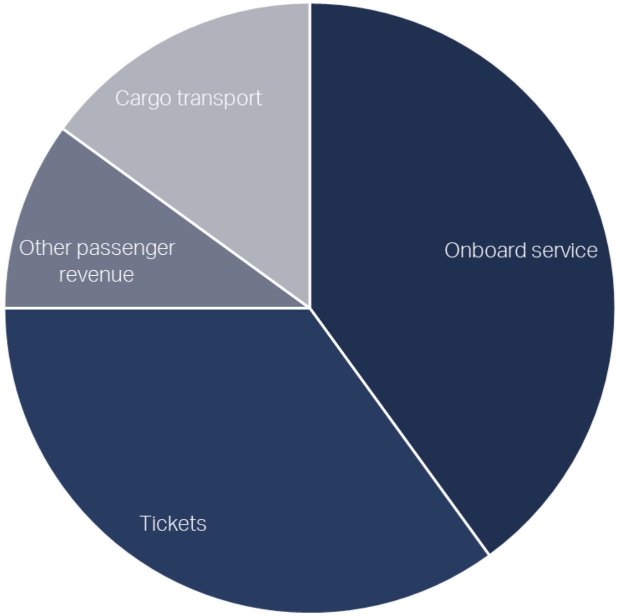
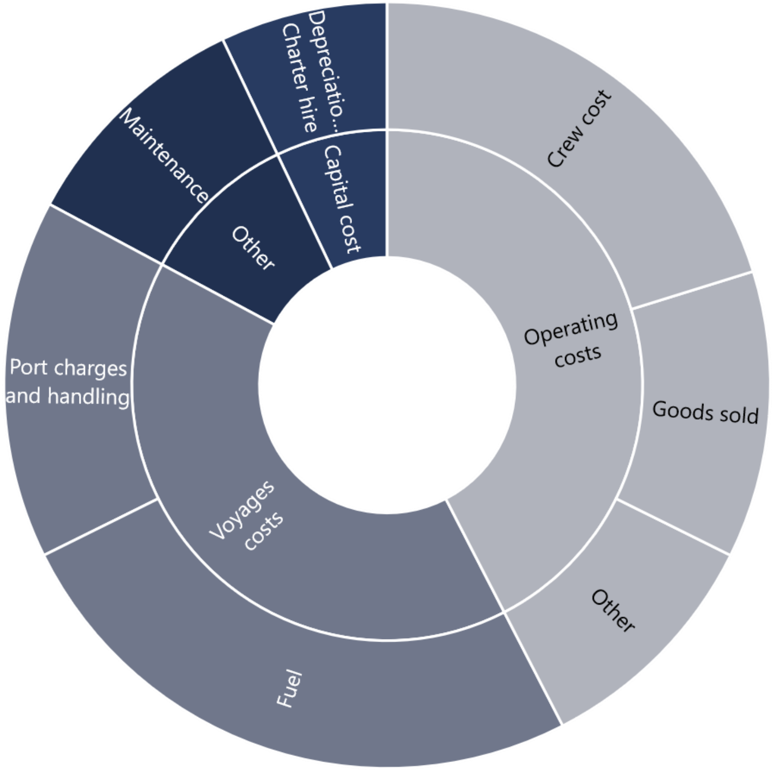
Price of ferry ticket in green corridor…



Revenue streams



Running costs

The revenue stream and running cost of operating and ferry line differs compared to cargo shipping due the combination of passengers' transport, cargo transport and onboard consumptions[1] Cargo transport can be up to 70 – 80% of revenue stream

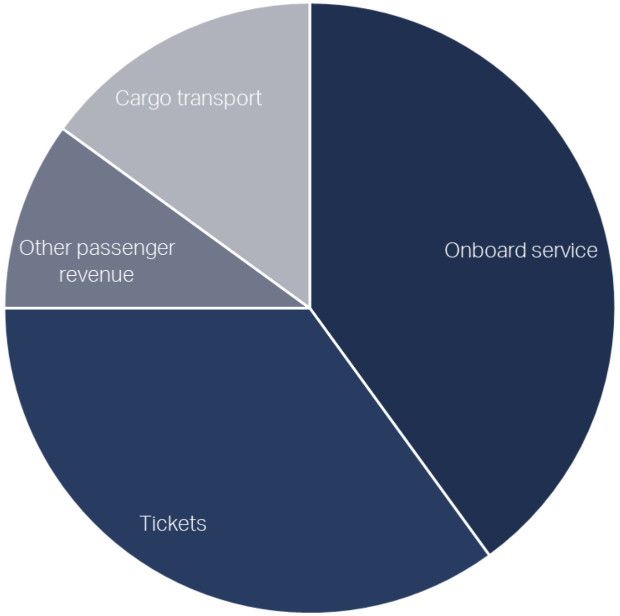
1. I. Urbanyi-popiołek "The Economic Aspects of the Ferry Operator Activity", DOI: 10.18276/epu.2015.119-04
2. Ü. Bilen, H. Kramer, R. Monden, D. Scott, M. Bonazountas, S. Stamatis, V. Palla, A. Yrjänäinen, E. Kahva "Holistic Optimisation of Ship Design and Operation for Life Cycle," HOLISHIP, Horizon 2020 – 689074 (2018)

Premium cost of services and transport in green corridors

What are the additional cost and saved CO_2 emissions to the customer?

What are the additional cost associated with building a green corridor, how to cover these and who should pay?

Price of ferry ticket in green corridor…



Revenue streams

How do ferries pas on the additional cost of green operation ?

Running costs

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Recommendations

Recommendations for next steps

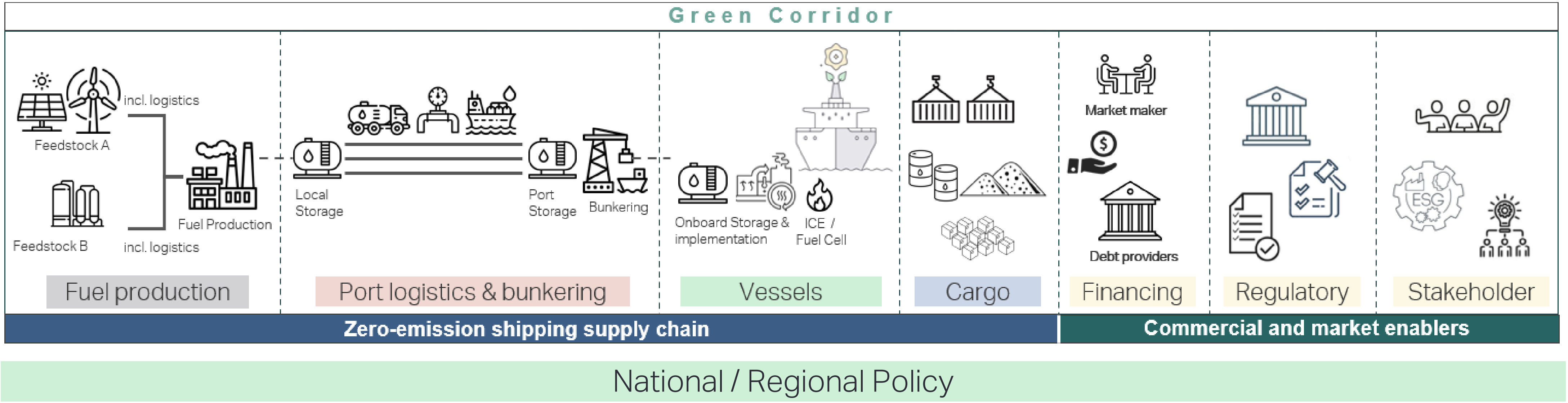
Potential green shipping corridors to be assessed in depth

- **National and interregional ferry lines** (RoPax, RoRo, Vehicle) with potential to operate on biooil, biomethane, methanol, or ammonia !
- **Identifying feeder operator(s)** to decarbonize loops from Rotterdam/Hamburg/Bremerhaven into the Baltic sea, which can tab into fuel infrastructure established for ferries
- Build initial fuel supply, port and bunkering infrastructure for the above at selected locations, which followers can subsequently tab into!
  - "Hot-spots" in the region would be ports with significant ferry and cargo activities
- Develop economic incentive across value chain for first movers to enable the start of a transition!
  - What can each stakeholder do or offer?
  - Determine end customers with a wiliness to pay for green service

Additional information…

Stakeholder rounds

Key stakeholders that form a **Green Shipping Corridor**



Stakeholders
- Project developers
- Renewable energy producers
- Fuel producers
- National policy makers

Stakeholders
- Fuel transporters
- Storage terminals
- Bunker traders
- Bunker vessel operators
- Port Authorities
- Port working groups
- Port organizations (ESPO, IAPH)
- Municipalities
- Local authorities

Stakeholders
- Cargo owners
- Freight forwards
- End customer

Stakeholders
- Private banks
- Public institutions (funding)
- Insurers
- Policy makers

Stakeholders
- Shipping companies
- Class Societies
- Flag states
- IMO
- European Maritime Safety Agency
- Engine supplier / manufacturers

Stakeholder Rounds

Interview rounds creating a multitude of perspective from across the value chain

Energy and Fuel production

CIP Copenhagen Infrastructure Partners, European Energy, Ørsted, Shell, TotalEnergies, bp, Neste, Skovgaard Energy

Fuel supply

Shell, Neste, Mabanaft, TotalEnergies, bp

Bunkering

MES Marine Energy Solutions, Bunker One, Mabanaft, Elenger Marine

Ports

Port of Tallinn, Port of Rotterdam, HPA Hamburg Port Authority, Port of Roenne, Port Gdynia

Vessel owners & operators

Maersk, MSC, CMA CGM, Hapag-Lloyd, Viridis Bulk Carriers, Furetank, Transfennica, Grieg, MPC Container Ships, Tallink, Unifeeder, Molslinjen, Finnlines, Cargill, Stena Line, AIDA

Cargo owners

Cargill

Stakeholder Rounds

Interview focal point

Interview rounds creating a multitude of perspective from across the value chain

Fuel supply

- Project status/maturity, how far has it been developed, is it in Feasibility, or has Pre-FEED or FEED been completed, if not by when?
- The product: What is the product they aim for? Has it been finally decided? What capacity are they aiming for?
- Timeline, What is the outlook for FID? Construction and subsequent start-up and first delivery of product?

Bunkering

- Expectations and indications on fuel demand
- What demand signal for alternative fuels do local bunkering companies get from ship owners
- What are their expectation to deliver alternative fuels ie.
  - What
  - By when…

Vessel owners & operators

- What is the ambition for decarbonization and when
- What will CII and EU Fit for 55 and the ETS mean for your company
- Are there concrete plans for decarbonization
- Do your customers request green transport, is there willingness to pay?
- Is traffic in the area mainly line traffic or tramp service?
- Fuel and bunkering demands

Stakeholder Rounds

Interview rounds creating a multitude of perspective from across the value chain

Energy & Fuels

- Outlook for project and production aggregated in to Fuel options/choice
- Current interest in supply of alternative fuels concerns:
  - LNG and Bio-oils
- Increasing interest in Methanol

Bunkering

- Meets request for bio-oils and methanol
  - Helps that shipping lines have committed to an alternative fuel (e.g. Maersk and CMA to methanol) -> this gives clear demand signal
- Expected more interest in ammonia
- Engages or considers engagement in fuel production

Vessel owners & operators

- Generally ambitions to decarbonize between 2030 and 2050
- In stakeholder group an ambitions to realize several DF methanol (from 2023) and ammonia (from 2025) vessels this decade

Other initiatives in the region

A Nordic Roadmap for the introduction of Sustainable Zero-carbon* fuels

A four year Nordic collaboration *paving the way*

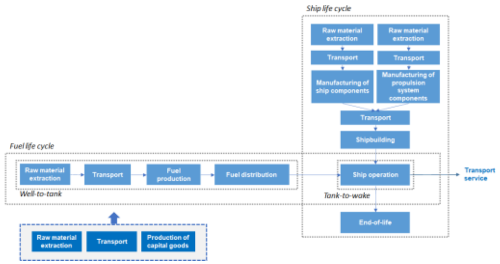
Nordic Council of Ministers

Technical deliveries

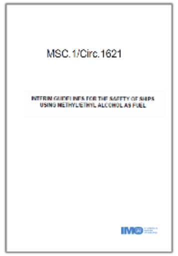
Fuel scorecard

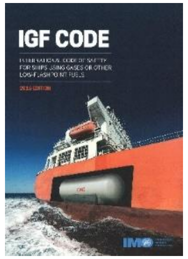
- Identify relevant fuels: Ammonia, Hydrogen, Methanol
- Develop KPIs
- Evaluate KPIs for each fuel

Life-Cycle Assessment

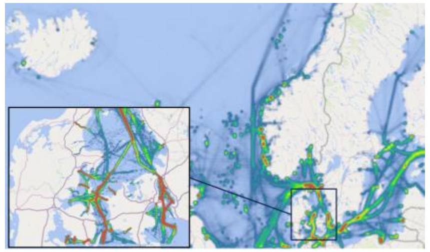


Regulatory framework





Traffic & infrastructure



Co-operation platform

Join us today at: *futurefuelsnordic.com*

Contributing partners:

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

Supporting partners:

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

Goal

Reduce key barriers to implementation and establish a common roadmap for the whole Nordic region and logistics ecosystem towards zero-emission shipping.

Objectives

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

**The term sustainable zero-carbon fuels are used to indicate fuels with potential zero climate impact throughout their lifecycle.*

Funding for further work

EU Funding options
Connecting Europe Facility (CEF)

EU and national funding programs which could support subsequent work on realizing green shipping corridors

- Supports the development of high performing, sustainable and efficiently interconnected trans-European networks divided over 3 pillars: Transport, Energy and Digital
- Duration: 2021-2027
- Targeted phase: Implementation and production
- Challenge: projects must be identified as PCI in order to be eligible for financial support (this list is updated every two years)

- CEF-Energy
  - Budget: €5.84 billion
  - Open call:
    - Energy infrastructure – Projects of Common Interest (PCI's) – Works & Studies
    - Deadline: 1 September 2022
  - Call to monitor:
    - Cross-border renewable projects – call for work and studies (will be published end 2022)

- CEF-Transport
  - Budget: €14.5 billion
  - Open calls:
    - Alternative Fuels Infrastructure Facility (AFIF) – budget call €375 million
    - Aimed at the deployment of alternative fuel supply infrastructure
    - Rolling call, deadlines: 7 June 2022, 10 November 2022, 13 April 2023, 19 September 2023
  - Calls to monitor:
    - General Transport call – budget €7 billion

EU Funding options

The EU Innovation Fund

EU and national funding programs which could support subsequent work on realizing green shipping corridors

- Focuses on highly innovative technologies and big flagship projects with European value added that can bring significant emission reductions. Duration: 2020-2030
- Targeted phase: Demonstration
- Total budget: €25 billion
- Themes: innovative low-carbon technologies and processes in energy-intensive industries, CCU, CCS, innovative renewable energy production, and energy storage

- Small-scale projects:
  - Small-scale: total capital costs < € 7.5M
  - Budget for call 2022: €100M
  - Co-finances up to 60% of the project's capital and operating costs
  - Requirement: capital costs ranging from €2.5M - €7.5M

- Large-scale projects:
  - Large-scale: capital exp. > € 7.5M
  - Budget for call 2022: €1.5 billion
  - Requirement: capital costs above €7.5M

EU Funding options

Horizon Europe: “Climate, Energy and Mobility” relevant

EU and national funding programs which could support subsequent work on realizing green shipping corridors

- Facilitates collaboration and strengthens the impact of research and innovation in developing, supporting and implementing EU policies while tackling global challenges
- Duration: 2021-2027
- Targeted phase: Ideation, research, tests, demonstration
- Total budget: €95.5 billion
- Requirements:
  - Innovative technological developments and must solve an EU problem in climate, energy and/or mobility
  - Large market potential – min 100M EUR in 5 years

- Open call – as part of the Clean Hydrogen Partnership:
  - **Development and demonstration of mobile and stationary compressed hydrogen refueling solutions for application in inland and short-distance maritime operations**
  - Budget call 2022: €7 million, funding rate max 70% (for non-profit legal entities 100%)

Regional options

Interreg South Baltic

- OBJECTIVE: The Interreg South Baltic aims to unlock the potential for green and blue growth through cross-border cooperation between local and regional actors from Denmark, Germany, Lithuania, Poland and Sweden
- TYPE: Grant
- SUM: €78 million, the co-financing rate for Swedish and Danish beneficiaries is up to 75% of ERDF co-financing

Interreg Baltic Sea Region

- OBJECTIVE: Aims to support integrated territorial development in the Baltic Sea region. Projects have to involve at least three different countries from the area.
- TYPE: Grant
- SUM: Project budgets range between €1,5 and 4,5 million for seven or more partners working for two or three years. Co-financing is up to 75% for Scandinavian partners.

National programs

Open calls

EU and national funding programs which could support subsequent work on realizing green shipping corridors

BordstromTech (German Federal Ministry for Transport and Digital Infrastructure)

- Market activation of alternative technologies for the environmentally friendly onboard power supply and mobile shore-side power supply of seagoing and inland navigation vessels
- Deadline: 30 September 2022

Energy Technology and Demonstration

- With support from this programs, you can carry out projects that develop and test a technology, system or method to bring it to market. EUDP can provide grants for the development and / or demonstration of all energy technologies that can contribute to achieving the Danish energy policy goals of a 70% reduction in CO2 equivalent emissions by 2030 and climate neutrality by 2050.
- Targeted phase: R&D and demonstration
- Grants: 0.03 – 15M Euro
- Deadline: open on continuous basis, deadline two times a year March and September

The Danish Maritime Fund

- The purpose of The Maritime Fund is to strengthen and develop the shipping and ship building industries with the aim of creating new jobs and strengthening the companies in the industry.
- Targeted phase: R&D
- Grants: 0.07 – 0.3M Euro
- Deadline: open on continuous basis, deadline four times a year Jan, April, Aug and Oct.