MEDITERRANEAN ACTION PLAN (MAP)
REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE MEDITERRANEAN SEA (REMPEC)

Sixteenth Meeting of the Focal Points of the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC)

Sliema, Malta, 13-15 May 2025

REMPEC/WG.61/INF.17
24 January 2025
Original: English only

Agenda Item 8: Reduction of GHG emissions from ships

Study on the Implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to Reduce GHG Emissions from Shipping in the Mediterranean region

REMPEC
Malta, 2025

Note by the Secretariat

This document presents the Study on the Implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to Reduce GHG Emissions from Shipping in the Mediterranean region.

Background

1 The International Maritime Organisation (IMO), as an international key actor has been working continuously on reducing Greenhouse Gas (GHG) emissions from shipping by adopting GHG strategies and commissioning several studies. In 2021, the Clydebank Declaration was launched, aiming to develop at least six green shipping corridors by 2025 and more by 2030 to accelerate the uptake of alternative fuels. Such green shipping corridors could become key enablers to accelerate the uptake of zero-emission fuels, which could directly contribute to achieving ambitions in the 2023 IMO GHG Strategy that aims for a 5% reduction of zero-emission fuels by 2030 and striving for 10%.

2 At the regional level, the European Union Emissions Trading System (EU ETS) and FuelEU Maritime Initiative were adopted to reduce emissions from international shipping. Other regional initiatives pertaining to the Mediterranean region include the EU Freight Transport Action Plan, Trans-European Transport Network (TEN-T) Corridor Network, Motorways of the Sea, European Green Deal and EU Fit for 55 package, EU Research and Development (R&D) and Innovation Funding Instruments, Sustainable and Smart Mobility Strategy, the Global Gateway Initiative, and the Connecting Europe Facility. In the Nordic countries, the Nordic Roadmap has gathered various stakeholders from the shipping value chain in the region to contribute towards zero-emission shipping.

3 Several countries have developed National Action Plans (NAPs) and policies to decarbonise the shipping industry. These include the major maritime hubs, such as the United States, China, Singapore, and others. Apart from that, several countries, such as Norway, Singapore, The Netherlands, the USA, China, etc., have established programmes related to green shipping and green ports as well as green shipping corridor initiatives. Some green shipping corridor frameworks, e.g., the U.S. and Canada, have been developed and published as well. These frameworks provide a clear direction and message from the Government in supporting the development and implementation of green shipping corridors, where the definitions, steps of planning and implementing green shipping corridors, as well as the potential areas for the deployment of green shipping corridors are elaborated. A similar framework is proposed to be established for the Mediterranean coastal States outlining the key areas of interest in supporting the development and implementation of green shipping corridors and green maritime hubs in the region.

4 In this context, the Secretariat commissioned DNV Maritime Advisory, to prepare a Study on the Implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to Reduce GHG Emissions from Shipping in the Mediterranean region, hereinafter referred to as the Study, in order to support any possible future regulatory or policy action by the Contracting Parties to the Barcelona Convention, in their efforts to mobilise and implement innovative solutions to reduce GHG emissions from ships in selected ports, including through energy efficiency and decarbonisation.

5 The Study was carried out, pursuant to the Programme of Work and Budget for 2024-2025 of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP), adopted by the Twenty-third Ordinary Meeting of the Contracting Parties to the Barcelona Convention and its Protocols (Portorož, Slovenia, 5-8 December 2023).

6 This activity was financed by the voluntary contribution from the Italian Ministry for Environment and Energy Security.

7 The Study is presented in the **Appendix** to the present document.

Action requested by the Meeting

8 **The Meeting is invited to take note** of the information provided in the present document.

Appendix

Study on the Implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to Reduce GHG Emissions from Shipping in the Mediterranean region.

MEDITERRANEAN ACTION PLAN (MAP)
REGIONAL MARINE POLLUTION EMERGENCY RESPONSE CENTRE FOR THE MEDITERRANEAN SEA (REMPEC)

Study on the implementation of possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to reduce GHG emissions from shipping in the Mediterranean region

Final Report

Submitted on: 19th December 2024

Prepared by DNV Maritime Advisory, Singapore

This activity is financed by the voluntary contribution from the Italian Ministry for Environment and Energy Security and is implemented by the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), in cooperation with the International Maritime Organization (IMO).

Study on the implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to reduce GHG emissions from shipping in the Mediterranean region

Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC)

Report no.: DNV10530680, Rev. 2
Date: 2024-12-13

Project name:	REMPEC – Green Shipping Corridors and Green Maritime Hubs	DNV Singapore Pte. Ltd. Maritime Advisory 16 Science Park Dr, Singapore 118227 Tel: +65 6508 3750
Report title:	Study on the implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to reduce GHG emissions from shipping in the Mediterranean region	
Customer:	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC), Sa Maison Hill, Floriana FRN1613, Malta	
Customer contact:	Ivan Sammut	
Date of issue:	2024-12-13	
Project no.:	10530680	
Organization unit:	103959 – Shipping Advisory	
Report no.:	DNV10530680, Rev. 2	

Applicable contract(s) governing the provision of this Report:

Objective:

Prepared by:	Verified by:	Approved by:
Jacob Tam Senior Consultant Maritime Advisory South East Asia Pacific and India	Satinder S Virdi Head of Research and Development Maritime Advisory South East Asia Pacific and India	Lars Holterud Aarsnes Head of Maritime Advisory South East Asia Pacific and India
Chara Georgopoulou Head of Maritime R&D and Advisory Greece	Dorthe Alida Arntzen Slotvik Subject Matter Expert Environment Advisory Oslo, Norway	
Arpit Raj Senior Consultant Maritime Advisory South East Asia Pacific and India	Mohd. Shahrin bin Osman Director, Maritime Decarbonisation and Smart Shipping Centre of Excellence (Singapore/Asia-Pac) Global Business Development Leader, Maritime Advisory	
Malini Mohan Das Consultant Maritime Advisory South East Asia Pacific and India		

Internally in DNV, the information in this document is classified as:

	Can the document be distributed internally within DNV after a specific date? No Yes
☒ Open ☐ DNV Restricted	-- --
☐ DNV Confidential ☐ DNV Secret	☐ ☐

Additional authorized personnel for distribution within DNV:

Keywords

Rev. no.	Date	Reason for issue	Prepared by	Verified by	Approved by
0	2024-10-25	First issue	JACTAM, ARPRAJ, MALIM, CHAGE	SATVIR, DORSLO	LAHOA
1	2024-11-22	Revision	JACTAM, CHAGE	SATVIR, DORSLO, MSBO	LAHOA
2	2024-12-13	Revision	JACTAM	SATVIR	LAHOA

Table of contents

List of Figures

List of Tables

List of Abbreviations

AFIR	Alternative Fuels Infrastructure Regulation
AIS	Automatic Identification System
BMWK	Federal Ministry for Economic Affairs and Climate Action
CapEx	Capital Expenditure
CCfD	Carbon Contracts for Difference
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilization
CEF	Connecting Europe Facility
CEM	Clean Energy Ministerial
CEM-Hubs	Clean Energy Marine Hubs
CEREFE	Renewable Energy and Energy Efficiency Commission
CfD	Contracts for Difference
CII	Carbon Intensity Indicator
coZEV	Cargo Owners for Zero Emission Vessels
CO_2	Carbon Dioxide

COP	Conference of the Parties
CP	Contracting Parties to the Barcelona Convention
EC	European Commission
EEDI	Energy Efficiency Design Index
EEXI	Energy Efficiency Existing Ship Index
EGCS	Exhaust Gas Cleaning Systems
ERTMS	European Rail Traffic Management System
eSAF	electro-Sustainable Aviation Fuel
ETC	Energy Transition Commission
EU	European Union
EU ETS	European Union Emissions Trading System
GCEAF	Global Clean Energy Action Forum
GCMD	Global Centre for Maritime Decarbonisation
GHG	Greenhouse Gas
GMF	Global Maritime Forum
H_2	Hydrogen
HFO	Heavy Fuel Oil
HPC	Hydrogen Production Credit
IAPH	International Association of Ports and Harbors
ICS	International Chamber of Shipping
IGF code	International Code of Safety for Ships using Gases or other Low-flashpoint Fuels
IMO	International Maritime Organisation
IoT	Internet of Things
IRENA	International Renewable Energy Agency
JIT	Just-In-Time
KPI	Key Performance Index
LA	Los Angeles
LCA	Life Cycle Assessment

LCHA	Low-Carbon Hydrogen Agreement
LDCs	Least Developed Countries
LNG	Liquefied Natural Gas
MAP	Mediterranean Action Plan
MARPOL	The International Convention for the Prevention of Pollution from Ships
MBM	Market-Based Measure
MEPC	Marine Environment Protection Committee
MJLHV	Megajoule Lower Heating Value
MoS	Motorways of the Sea
MPAs	Marine Protected Areas
MSP	Maritime Spatial Planning
NAP	National Action Plan
NDC	Nationally Determined Contribution
NEDO	New Energy and Industrial Technology Development Organization
NH_3	Ammonia
NMP	National Mobility Program
OpEx	Operational Expenses
R&D	Research and Development
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
RoI	Return of Investment
RRT	Rail-Road Terminal
SDE++	Stimulation of Sustainable Energy Production and Climate Transition
SIDS	Small Island Developing States
SZEF	Scalable Zero Emission Fuel
SWOT	Strengths, Weaknesses, Opportunities, Threats
TBD	To Be Decided
TEN-T	Trans-European Transport Network

TRL	Technology Readiness Level
UNEP/MAP	United Nations Environment Programme
UNFCCC	UN Climate Change Conference
USA	United States of America
U.S.	United States
UK	United Kingdom

Glossary of Terms

The terms used are defined as indicated in the table below.

Term	Definition/Description
Green shipping corridors	Green shipping corridors are zero-emission maritime routes between 2 (or more) ports. Ref. Clydebank Declaration (United Nations Framework Convention on Climate Change (UNFCCC) COP 26, 2021): https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors
Zero-emission fuels	In this study, the term zero-emission fuels refers to any potential carbon-neutral fuel (e.g., used in a green shipping corridor), such as carbon-neutral methanol, methane, diesel, ammonia and hydrogen, as well as battery-electric propulsion. Carbon-neutral fuels are fuels that have no net GHG emissions. See Intergovernmental Panel on Climate Change (IPCC) definition of carbon-neutral: https://www.ipcc.ch/sr15/chapter/glossary

EXECUTIVE SUMMARY

What we did

DNV was engaged by REMPEC to prepare a Study on the implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to reduce GHG emissions from shipping in the Mediterranean region. The Study will assist the Contracting Parties to the Barcelona Convention and REMPEC, in exploring strategies and measures that could be implemented in the Mediterranean region through the possible establishment of green shipping corridors and green maritime hubs in the area. This Study is an initial evaluation based on literature review, and more detailed and complete assessments should be performed, in collaboration with key stakeholders in the region.

The Study delves into the following key items:

.1 Compilation of policy and regulatory frameworks, international conventions, as well as industry standards related to green shipping corridors and green maritime hubs;

.2 Review of existing literature, reports, and data on green shipping corridors and green maritime hubs globally, particularly in the Mediterranean region;

.3 Best practices and innovative solutions for the implementation of green shipping corridors and maritime hubs emission;

.4 Overview and assessment of the actions, incentive schemes and other relevant mechanisms for the realisation of green shipping corridors and green maritime hubs.

.5 Recommendations with special reference to challenges and opportunities tailored to the Mediterranean context; and

.6 Draft a roadmap and action plan for addressing the identified challenges related to the development of green shipping corridors and green maritime hubs in the Mediterranean region.

What we found

The Study provides information on several international and regional policies, initiatives and frameworks that are already in place to address the needs of decarbonising shipping, as summarised below:

IMO as an international key actor has been working continuously on reducing Greenhouse Gas (GHG) emissions from shipping by adopting GHG strategies and commissioning several studies. In 2021, the Clydebank Declaration was launched, aiming to develop at least six green shipping corridors by 2025 and more by 2030 to accelerate the uptake of alternative fuels. Such green shipping corridors could become key enablers to accelerate the uptake of zero-emission fuels, which could directly contribute to achieving ambitions in the 2023 IMO GHG Strategy that aims for a 5% reduction of zero-emission fuels by 2030 and striving for 10%.

At the regional level, the European Union Emissions Trading System (EU ETS) and FuelEU Maritime Initiative were adopted to reduce emissions from international shipping. Other regional initiatives pertaining to the Mediterranean region include the EU Freight Transport Action Plan, Trans-European Transport Network (TEN-T) Corridor Network, Motorways of the Sea, European Green Deal and EU Fit for 55 package, EU Research and Development (R&D) and Innovation Funding Instruments, Sustainable and Smart Mobility Strategy, the Global Gateway Initiative, and

the Connecting Europe Facility. In the Nordic countries, the Nordic Roadmap has gathered various stakeholders from the shipping value chain in the region to contribute towards zero-emission shipping.

Several countries have developed National Action Plans (NAPs) and policies to decarbonise the shipping industry. These include the major maritime hubs, such as the United States, China, Singapore, and others. Apart from that, several countries, such as Norway, Singapore, The Netherlands, the USA, China, etc., have established programmes related to green shipping and green ports as well as green shipping corridor initiatives.

Some green shipping corridor frameworks, e.g., the U.S. and Canada, have been developed and published as well. These frameworks provide a clear direction and message from the Government in supporting the development and implementation of green shipping corridors, where the definitions, steps of planning and implementing green shipping corridors, as well as the potential areas for the deployment of green shipping corridors are elaborated. A similar framework is proposed to be established for the Mediterranean coastal States outlining the key areas of interest in supporting the development and implementation of green shipping corridors and green maritime hubs in the region.

Several other industry-led frameworks and reports are analysed which can be adopted to initiate and develop green shipping corridors and green maritime hubs. For examples:

.1 The "*Tides of Change: A Framework for Developing Just and Inclusive Maritime Green Corridors*", emphasises the necessary considerations and actions required from companies and governments involved in establishing green shipping corridors around the world;

.2 The "*First Mover Framework*" aims to guide the private and public stakeholders in the supply chain to systematically evaluate decarbonisation strategies for a specific fleet; and

.3 The "*The Next Wave*" study provides a framework evaluating the green shipping corridors assessing the feasibility and impact through various quantitative and qualitative criteria.

The Study cites various green shipping corridors which are either at the planning stage or developing their implementation plans. Since the Clydebank Declaration in 2021, more than 60 green shipping corridor initiatives have been announced. The number of announcements has increased from 21 in 2022 to more than 60 as of November 2024, whereof almost 32 corridors being announced in 2023. Most of the corridors are at the planning stage with feasibility studies and some are developing implementation plans, and none have so far been realised.

Within the Mediterranean context, the studies "*Green Corridors: The Spanish Opportunity*" and "*Green Shipping Corridors in and out of Spain: Assessing Route-based Opportunities*" could be relevant for the planning and implementation of green shipping corridors in the region. Similar to Spain, other Mediterranean coastal States (e.g., Greece, France, Italy, Türkiye, etc.) could leverage their potential to fulfil the four main criteria, i.e., cross-value-chain collaboration, a viable fuel pathway, customer demand, as well as policy and regulation, hence, to identify the opportunities for green shipping corridors in the Mediterranean region. Similar to Spain, Mediterranean coastal States that are EU Member States can leverage EU policy, particularly the EU Fit for 55 package, which includes shipping-specific measures, to support green shipping corridors. Based on the outcomes of the abovementioned studies, an assessment of potential international and regional routes for establishing green shipping corridors could be performed using the methodology described in "*The Next Wave*".

Based on the literature review related to green maritime hubs, the Study highlighted that green shipping corridors will require the supply of green energy at one or both ends or nearby ports, adding a layer of complexity to their implementation. The factors such as volume of traffic, volume of energy used by the traffic and their voyage patterns may be used to assess the feasibility of faster implementation of zero-emission energy hubs (green hubs). Ports with high fuel consumption but simpler voyage structures may have higher feasibility for fast implementation as zero-emission energy hubs (green hubs). Key elements important for the development of green maritime hubs include the twin transition of decarbonisation and digitalisation, a steady supply of green fuels for bunkering, distribution, and storage, utilisation of renewable energy, provision of port electrification and shore power, CO_2 reception and handling facilities, and implementation of safety standards and procedures for safe operations. Key maritime hubs in the Mediterranean region recognized under EU and international regulations including ports in Greece, Spain, Italy, France, Morocco, etc., have been actively taking similar initiatives to become green maritime hubs.

The Study reviews and proposes best practices for the implementation of green shipping corridors and green maritime hubs. These include resolving challenges among stakeholders, promoting collaboration and partnership, harmonising regulations across jurisdictions in alignment with international standards for shipping operations, standardising ship design, shore power and bunkering infrastructure, as well as adopting digital platforms for enhancing performance and efficiency.

The Study identifies and proposes innovative solutions on top of adopting zero-emission fuels, such as the use of energy-efficient technologies to enhance vessel energy efficiency and reduce emissions. Additionally, the Study emphasizes the role of digitalisation in emission tracking and the need for appropriate financial instruments and support mechanisms in realising green shipping corridors.

The Study also highlights four advanced initiatives where implementation plans with actions have been developed that could be used as a reference for any future green shipping corridors and green maritime hubs in the Mediterranean region leveraging upon the respective country's strengths and opportunities. The implementation plans include the key barriers to be resolved with actions needed, and timeline (short and/or long term).

Incentive schemes and support mechanisms, essential for developing green shipping corridors, are also analysed in the Study. These mechanisms or schemes are designed based on several key considerations, including supply and demand, target costs, support mechanisms, processes to determine the level of support, and geographical scope. Mediterranean coastal States could adopt comparable schemes to support the development of green shipping corridors. These schemes could include targeted subsidies for shipbuilding, fuel production, and R&D funding for green technologies, tailored to the specific needs and strengths of each country.

What we recommend

Based on the above findings, the Study proposes key recommendations, as well as suggestions for implementation and a roadmap with an action plan. The key recommendations include:

.1 Establish the baselines (current situation) for the three pillars (i.e., ships, fuels used by the ships, and infrastructure supplying the fuels) and identify first-mover opportunities

.2 Engage relevant stakeholders to identify barriers and actions to overcome barriers

.3 Develop a holistic plan with timelines for all the stakeholders

A draft roadmap with an action plan is shown below. The Study includes the preliminary actions needed from the stakeholders including the Contracting Parties to the Barcelona Convention as well as some examples of actions. More details will be required and will be developed at the later stages when engaging all the stakeholders in the value chain.

ID	Action	Timeline	Contracting Parties to Barcelona	Government and Regulators	Cargo owners	Ship owners and operators	Ports	Fuel producers and distributors
1.	Establish the baselines (current situation) for the three pillars and identify first mover opportunities	2025	R	R	C	C	C	C
2.	Engage relevant stakeholders to identify barriers and actions to overcome barriers	2025	R	R	C	C	C	C
3.	Develop a holistic plan with timelines for all the stakeholders	2026	R	R	R	R	R	R

A policy brief highlighting actionable recommendations for policymakers and industry stakeholders is suggested as below.

*R: Responsible, C: Consult)

ID	Action	Contracting Parties to Barcelona Convention	Government and Regulators	Cargo owners	Ship owners and operators	Ports	Fuel producers and distributors
1.	Mediterranean governments to set up competitive tenders for Mediterranean green shipping corridors	R	R				
2.	Allocate funding to the Mediterranean green shipping corridors	C	R				
3.	Develop a plan for regional integration of fuel production and infrastructure, with development of energy hubs	R	R	C	C	R/C	R/C
4.	Set GHG emission requirements for Mediterranean ship segments	R	R	C	C	C	C

5.	Continue to implement and support the strengthening of EU and IMO GHG regulatory framework	R	R	R	R	R	R
6.	Develop a common approach to implement alternative design approval (as per SOLAS convention) among Mediterranean coastal States	R	R				
7.	Develop a common approach to fuel bunkering and establish common practices for safe and efficient operations with zero-emission fuels	R	R	R/C	C	R/C	C
8.	Develop and submit specific proposals on fuel safety and seafarer training to the IMO to help accelerate the international regulatory development process	R	R	R/C	R	R/C	C
9.	Establish a common approach for how to ensure green fuel quality and certification	R	R	C	C	C	R
10.	Establish Mediterranean support mechanisms accelerating demonstration, commercialization, and deployment of new technologies	R	R	C	R	R	C

1 INTRODUCTION

1.1 Background

The Mediterranean region is confronted with pressing environmental challenges stemming from greenhouse gas (GHG) emissions linked to maritime activities, particularly in coastal and port areas adjacent to urban and industrial centres. The Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) plays a pivotal role in coordinating marine pollution prevention, preparedness, and response efforts, established under the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP/MAP) in partnership with the International Maritime Organization (IMO). REMPEC assists the Contracting Parties to the Barcelona Convention in fulfilling their obligations under the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (the "Barcelona Convention") and the Protocol Concerning Cooperation in Preventing Pollution from Ships and, in Cases of Emergency, Combating Pollution of the Mediterranean Sea (hereinafter "the 2002 Prevention and Emergency Protocol").

In 2018, the IMO adopted the Initial IMO Strategy on Reduction of GHG Emissions from Ships (hereinafter referred to as the Initial IMO GHG Strategy) (IMO, 2018), establishing a framework for the decarbonisation of international shipping. The Initial IMO GHG Strategy provided the IMO Member States with essential tools, objectives, and guiding principles to decarbonise shipping. Since 2000, the IMO has undertaken extensive studies[1] to estimate and project GHG emissions from international shipping, underscoring the importance of data-driven decision-making in developing effective policy frameworks. These studies have informed global discussions on maritime decarbonisation, particularly within the Mediterranean context. By 2020, the IMO reinforced its decarbonisation initiatives through a resolution promoting the development and submission of voluntary National Action Plans (NAPs) focused on GHG emissions reductions from maritime operations. In 2022, the resolution was updated to emphasise green shipping routes and corridors, reflecting an increasing global commitment to sustainable maritime practices. Key areas of focus for these NAPs included optimising energy efficiency, enhancing regional collaboration, and establishing the infrastructure necessary for green shipping.

In 2023, IMO adopted the 2023 IMO Strategy on Reduction of GHG Emissions from Ships (IMO, 2023a) (hereinafter referred to as the 2023 IMO GHG Strategy) marking a critical evolution in the maritime sector's decarbonisation agenda. This strategy updated the Initial IMO GHG Strategy from 2018, introducing a comprehensive vision for emissions reduction for international shipping, detailing candidate measures, implementation timelines, and required actions. It also highlighted the necessity of capacity-building, technical cooperation, and research and development (R&D) to address barriers to decarbonisation.

During COP 23[2] in December 2023, the UNEP/MAP Programme of Work and Budget for 2024-2025 prioritised innovative solutions aimed at diminishing GHG emissions from ships operating in selected Mediterranean ports. This initiative represents a vital stride towards the practical application of the 2023 IMO GHG Strategy in the region.

The Mediterranean region, with its distinct challenges and opportunities, necessitates customised strategies for the effective implementation of the 2023 IMO GHG Strategy by the Contracting Parties to the Barcelona Convention and other relevant stakeholders. The Mediterranean region is

[1] IMO GHG studies, https://www.imo.org/en/OurWork/Environment/Pages/IMO-GHG-studies.aspx
[2] Twenty-third Ordinary Meeting of the Contracting Parties to the Barcelona Convention and its Protocols (Portorož, Slovenia, 5-8 December 2023).

significantly impacted by environmental issues stemming from ship emissions, especially in port areas and coastal regions where harbours are often situated near urban and industrial centres. To address these challenges and their substantial environmental impact, a thorough analysis is required to identify and assess emission control and energy efficiency measures for ships and ports in the region.

The use of green fuels can be one of the strategies to reduce GHG emissions with higher reduction potentials (DNV, 2024a). However, this requires a sufficient number of bunkering hubs for these fuels to be well-distributed along shipping routes. Green shipping corridors, referring to zero-emission maritime routes between two (or more) ports, are increasingly seen as a crucial tool to initiate the transition to zero-emission shipping. Industry reports (UCL Energy Institute, et al., 2024; UMAS & Getting to Zero Coalition, 2021; UMAS & UN Climate Change High Level Champions, 2023) discuss that green shipping corridors can offer the necessary context for testing, demonstration, and large-scale deployment to help achieve at least 5% Scalable Zero Emission Fuel (SZEF) use by 2030, which is in line with the 2023 IMO GHG Strategy of achieving at least 5%, striving for 10% zero and near-zero GHG emission fuel use by 2030. There is a range of public and private corridor initiatives (elaborated in Section 3.2.2), where cross-value chain stakeholders are working on specific shipping routes where zero-emission shipping is planned to be made feasible.

1.2 Motivation and Structure

With this background, DNV has been engaged to provide consultancy to prepare a Study on the implementation of Possible Green Shipping Routes (Corridors) and Maritime Hubs (Green Hubs) to reduce GHG Emissions from Shipping in the Mediterranean region (hereinafter referred to as “the Study”) with a view to assisting REMPEC in exploring strategies and measures that could be implemented in the Mediterranean region through the possible establishment of green shipping corridors and green maritime hubs in the area. This will assist the Contracting Parties to the Barcelona Convention to enhance efficiency, reduce impacts on human and environmental health, and propose potential strategies for the long-term sustainability of the coastal region of the Mediterranean.

In the Study, Chapter 2 outlines the overview of tasks and task limitations aimed at achieving the following objectives:

.1 a compilation of policy and regulatory frameworks related to green shipping corridors and green maritime hubs;

.2 a review of existing literature globally and in the Mediterranean region;

.3 a compilation of best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs emission;

.4 an overview of the actions, regulatory framework, and incentive schemes that may be utilised for measure implementation;

.5 recommendations tailored to the Mediterranean context; and

.6 a roadmap and action plan for addressing the challenges identified, with timelines, milestones, and responsibilities.

Chapter 3 provides an overview of green shipping corridors and green maritime hubs, covering the essential policies and frameworks that support and guide their development. It presents various green shipping corridor plans and initiatives by Governments and industry leaders, highlights best

practices and explores innovative solutions like alternative fuels, digitalisation, etc. Additionally, it discusses incentive schemes, including subsidy schemes and R&D funding, aimed at encouraging the development of green shipping corridors. Overall, the Contracting Parties to the Barcelona Convention will gain an understanding of the multifaceted initiatives revolving around the development of green shipping corridors and green maritime hubs, in their efforts to accelerate the uptake of zero-emission fuels.

Chapter 4 identifies the challenges and opportunities in establishing green shipping corridors and green maritime hubs in the Mediterranean region. Based on the experiences and past learnings as well as challenges and opportunities, the initial recommendations are proposed to address the identified challenges, leveraging upon the identified opportunities.

In Chapter 5, a draft roadmap with initial action plan is developed based on the proposed recommendations.

2 OBJECTIVE, SCOPE OF WORK AND LIMITATIONS

This chapter provides an overview of the tasks and task limitations.

2.1 Task overview

To meet the objective, DNV divides the scope of work into the following two main tasks, with subtasks, as shown in Figure 2-1:

.1 Task 1: Compilation and screening of relevant literature and industry experience.
This task focuses on reviewing green shipping corridor and green maritime hub initiatives globally and in the Mediterranean region as well as the relevant regulations, policies and frameworks. This task also involves the compilation of best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs are determined as well. Reviewing the actions, incentive schemes and other relevant mechanisms for implementation are also part of this task.

.2 Task 2: Recommendations, action plan and roadmap development.
This task involves conducting an analysis with DNV global and local resources to identify the challenges and opportunities in implementing green shipping corridors and green maritime hubs in the region. The identified outcomes are used to develop the recommendations, roadmap and action plan.

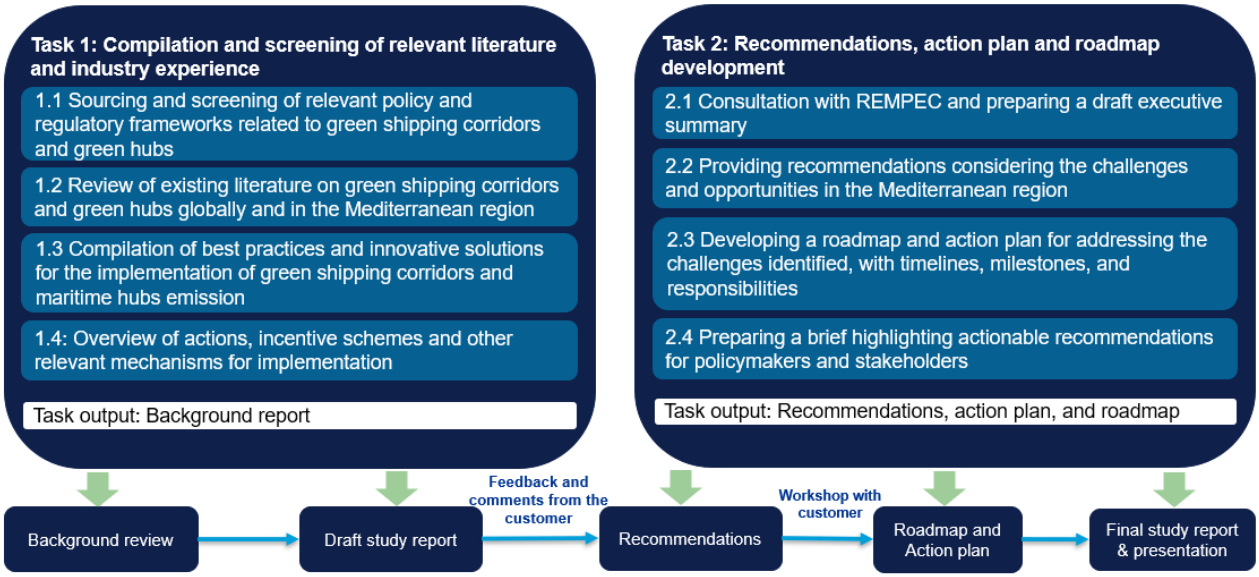

Figure 2-1: Scope of Work

2.2 Task limitations

Limitations of each task in this study are elaborated in Table 2-1.

Table 2-1: Limitations

Tasks	Limitations
Task 1.1: Sourcing and screening of relevant policy and regulatory frameworks related to green shipping corridors and green maritime hubs	This task is limited to a high-level review using available information and it is non-exhaustive.
Task 1.2: Review of existing literature on green shipping corridors and green maritime hubs globally and in the Mediterranean region	This task is limited to a high-level review using available information and it is non-exhaustive. Emphasis is placed on the Mediterranean region and interviews will be conducted on a case-by-case basis, if needed or applicable, to be decided by DNV.
Task 1.3: Compilation of best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs emission	Since most green shipping corridors worldwide are in their initial stages and their effectiveness is difficult to quantify, the expected benefits from selected green corridors currently being initiated/piloted by other countries in other regions will be highlighted, leveraging DNV's domain expertise. Interviews will be conducted on a case-by-case basis, if needed or applicable, to be decided by DNV.
Task 1.4: Review of action, incentive schemes and other relevant mechanisms for implementation	This task is a high-level review of the actions (implementation plans from other initiatives), incentive schemes (information from public domain/DNV's databases) and other relevant mechanisms for implementation.
Task 2.1: Consultation with REMPEC and preparing a draft executive summary	This task is producing a draft executive summary based on the feedback and comments provided by REMPEC on Task 1.
Task 2.2: Providing recommendations considering the challenges and opportunities in the Mediterranean region	This task is conducted based on inputs from DNV's local resources and subject matter experts, inputs from external resources, etc. Interviews will be conducted on a case-by-case basis, if needed or applicable, to be decided by DNV.
Task 2.3: Developing a roadmap and action plan for addressing the challenges identified, with timelines, milestones, and responsibilities	This task is performed with the inputs from Task 2.2, DNV's subject matter experts, and REMPEC through meetings/workshops. Roadmap and action plan is developed based on the identified recommendations.
Task 2.4: Preparing a brief highlighting actionable recommendations for policymakers and stakeholders	This task will be performed using the recommendations, roadmap and action plan from Task 2.3, inputs from DNV's local resources, DNV's subject matter experts, and REMPEC. This brief will be kept concise as part of the final report.

3 COMPILATION AND SCREENING OF RELEVANT LITERATURE AND INDUSTRY EXPERIENCE

This chapter provides an overview of green shipping corridors and green maritime hubs, covering the essential policies and frameworks that support and guide their development. It presents various green shipping corridor plans and initiatives by Governments and industry leaders, highlights best practices and explores innovative solutions like alternative fuels, digitalisation, etc. Emphasis is also placed on the initiatives related to green shipping corridors in the Mediterranean region. Additionally, it discusses incentive schemes, including subsidy schemes and R&D funding, aimed at encouraging the development of green shipping corridors. Overall, the CPs will gain an understanding of the multifaceted initiatives revolving around the development of green shipping corridors and green maritime hubs, in their efforts to accelerate the uptake of zero-emission fuels.

This chapter is mainly divided into two sections, where Section 3.1 Methodology explains the overall methodology adopted to perform a literature review of green shipping corridor developments globally and in the Mediterranean region, while Section 3.2 presents and discusses the overall findings of the relevant green shipping corridor literature and industry experience.

3.1 Methodology

This section explains the methodology adopted to perform a literature review of green shipping corridor developments globally and in the Mediterranean region.

3.1.1 Sourcing and screening of relevant policy and regulatory frameworks related to green shipping corridors and green maritime hubs

.1 A high-level review of existing policy and regulatory frameworks, and/or any relevant industry standards related to green shipping corridors and green maritime hubs is performed leveraging:

.1 Public domain through desktop research, for example, the Global Maritime Forum[3], Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping[4], Mission Innovation[5], etc.;

.1 DNV's databases, for example, DNV's Internal Green Shipping Corridor Database, DNV's AFI, etc;

.2 DNV's domain expertise, for example, Green Shipping Corridors, Decarbonisation, etc.;

.2 Key details of the relevant policies and frameworks are highlighted in Section 3.2.

3.1.2 Review of existing literature on green shipping corridors and green maritime hubs globally and in the Mediterranean region

.1 A high-level review of existing green shipping corridor and green hub initiatives globally was performed and the key details are highlighted, leveraging:

[3] Global Maritime Forum: Green Corridors, https://globalmaritimeforum.org/green-corridors/
[4] Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping: Green Corridors: Feasibility Phase Blueprint, https://www.zerocarbonshipping.com/publications/green-corridors-feasibility-phase-blueprint/
[5] Mission Innovation: Green Shipping Corridor Hub, https://mission-innovation.net/missions/shipping/green-shipping-corridors/

.1 Public domain through desktop research, for example, the Global Maritime Forum, Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, Mission Innovation, etc.;

.2 DNV's databases, for example, DNV's Internal Green Shipping Corridor Database, DNV's AFI, etc;

.3 DNV's domain expertise, for example, Green Shipping Corridors, Decarbonisation, etc;

.2 A review of green shipping corridor and green hub initiatives available in the Mediterranean region is performed, and key details (e.g., current international practices and policies for the implementation of green shipping corridors, etc.) are highlighted.

.3 Discussions with DNV's local resources are conducted to understand further the existing green shipping corridor and green hub initiatives in the Mediterranean region.

3.1.3 Compilation of best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs emission

.1 The best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs are consolidated, based on the results from Sections 3.1.1 and 3.1.2.

.2 Since most green shipping corridors worldwide are in their initial stages and their effectiveness is difficult to quantify, the expected benefits from selected green corridors currently being initiated/piloted by other countries in other regions are highlighted, leveraging DNV's domain expertise.

.3 Discussions with DNV's local resources are conducted to understand better the expected benefits from green shipping corridors and green maritime hubs.

3.1.4 Review of action, incentive schemes and other relevant mechanisms for implementation

.1 A high-level review of the actions (implementation plans from other initiatives), incentive schemes and other relevant mechanisms that may be utilised for measure implementation is performed, leveraging:

.1 Public domain through desktop research, for example, Global Maritime Forum, etc;

.2 DNV's experience in green shipping corridor initiatives and programs, for example, the Green Shipping Programme, the Nordic Roadmap Project, etc.;

.3 DNV's domain expertise, for example, Green Shipping Corridors, Decarbonisation, etc.;

.4 Outcomes from Section 3.1.1

.2 The appropriate plans and incentive schemes for implementation in the Mediterranean region are discussed, based on the above-collected information.

3.2 Findings

This section presents a review of green shipping corridors and green maritime hubs globally and in the Mediterranean region. It is divided into four sections, where Section 3.2.1 reviews plans and initiatives for green shipping corridors and green maritime hubs globally and in the Mediterranean, Section 3.2.2 encompasses the review of relevant policies and frameworks that support and guide the development of green shipping corridors and green maritime hubs, Section 3.2.3 highlights the identified best practices and innovative solutions to initiate and implement green shipping corridors and green maritime hubs, and Section 3.2.4 delves into the identified actions including implementation plans and incentive schemes in the support of establishing green shipping corridors and green maritime hubs.

3.2.1 Relevant policy and regulatory frameworks related to green shipping corridors and green maritime hubs

This section presents the policies and regulations including the frameworks that help and support the development and implementation of green shipping corridors and green maritime hubs.

3.2.1.1 Policies and Regulations

International

To decarbonise shipping, the industry will need to rapidly develop ships using zero-emission fuels, as well as the needed infrastructure to operate these ships. To achieve this, a wide range of policies and regulations, alongside research and development activities, have been initiated across the globe (DNV, 2022b).

IMO has been working continuously to address GHG emissions from ships since the adoption of Conference Resolution 8 on CO_2 emissions from ships in September 1997, in particular, through the adoption of global mandatory technical and operational energy efficiency measures for ships under MARPOL Annex VI. This Resolution was adopted during the 1997 MARPOL Conference and marked a significant step in addressing GHG emissions from the maritime sector.

In April 2018, at the 72nd session of the Marine Environment Protection Committee (MEPC), IMO adopted the Initial IMO GHG Strategy, which defined the objectives, tools, pace of work and guiding principles and as such was the framework for IMO Member States to decarbonise shipping.

In 2020, IMO adopted the Resolution 367(79) to encourage IMO Member States to develop and submit voluntary NAPs to address GHG emissions from ships, which was revised in 2022 to include references to shipping routes to support decarbonisation (Resolution MEPC.367(79)). The latter suggests that NAPs could include but are not limited to:

.1 improving domestic institutional and legislative arrangements for the effective implementation of existing IMO instruments;

.2 developing activities to further enhance the energy efficiency of ships;

.3 initiating research and advancing the uptake of alternative low-carbon and zero carbon fuels;

.4 encouraging the production and distribution of such fuels for shipping;

.5 accelerating port emission reduction activities, consistent with IMO resolution MEPC.366(79);

.6 fostering capacity-building, awareness-raising and regional cooperation;

.7 facilitating the development of infrastructure for green shipping; and

.8 facilitating voluntary cooperation through the whole value chain, including ports, to create favourable conditions to reduce GHG emissions from ships through shipping routes and green maritime hubs consistent with international law, including the multilateral trade regime.

Since 2000, the IMO has commissioned studies to estimate and project GHG emissions from international shipping, supporting evidence-based decision-making. These studies, conducted by reputable research organisations worldwide and overseen by a panel of IMO Member States Governments and the IMO Secretariat, serve as a global benchmark for estimating GHG emissions in the sector.

In 2021, the Clydebank Declaration was launched at the 26th UN Climate Change Conference of the Parties (COP26)[6], where more than 20 countries[7] have committed to develop at least six green shipping corridors between two (or more) ports by 2025 and "many more" by 2030 [8]. Green shipping corridors could become key enablers to accelerate the uptake of zero-emission fuels, and already several plans to develop such corridors have been announced.

The Clydebank Declaration emphasises on aligning international shipping with the Paris Agreement's goal of limiting global warming to below 2°C, while striving for 1.5°C. It acknowledges the Initial IMO GHG Strategy and highlights the urgency of cutting emissions to protect vulnerable countries like the Least Developed Countries (LDCs) and the Small Island Developing States (SIDS). It also stresses the need for synergies between decarbonisation and pollution control under MARPOL and raises concern over rising shipping emissions projected by the IMO and IPCC, urging swift action to reduce them in the coming decades.

The IMO adopted the 2023 IMO GHG Strategy to reduce the GHG emissions of ships, requiring a rapid uptake of zero-emission fuels in the 2030s (IMO, 2023b). The newly introduced intermediate goal of 5% uptake of zero- or near-zero-emission fuels and energy sources by 2030 (and the ambitious 10% stretch goal) within the 2023 IMO GHG Strategy underscores the importance of early action. Rapid scaling of this fuel uptake is needed, and, in this endeavour, green shipping corridors can play an important role.

[6] 26th UN Climate Change Conference of the Parties (COP26): https://www.gov.uk/government/topical-events/cop26

[7] Signatories include Australia, Belgium, Canada, Chile, Costa Rica, Denmark, Fiji, Finland, France, Germany, Ireland, Italy, Japan, Lithuania, Republic of Korea, Republic of the Marshall Islands, Morocco, Netherlands, New Zealand, Norway, Palau, Singapore, Spain, Sweden, The United Arab Emirates, The United Kingdom of Great Britain and Northen Ireland, The United States of America, https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors#signatories

[8] Clydebank Declaration: https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors

As part of the broader strategy to meet the ambitions set out in the 2023 IMO Strategy on Reduction of GHG Emissions from Ships, significant progress was made on mid-term measures for reducing greenhouse gas (GHG) emissions from ships during the 82nd session of the Marine Environment Protection Committee (MEPC) (IMO, 2024). The committee advanced the development of mid-term measures aimed at reducing GHG emissions, which include a technical element (a global marine fuel standard) and an economic element (a maritime GHG emissions pricing mechanism). A draft legal text, referred to as the "IMO net-zero framework," was produced. This text integrates various proposals on the architecture of these mid-term GHG reduction measures from member states and international organizations, setting the stage for further discussions and potential adoption in 2025.

Furthermore, the Clean Energy Marine Hubs (CEM-Hubs) initiative, officially announced in 2022 during the 13th Clean Energy Ministerial (CEM) at the Global Clean Energy Action Forum (GCEAF), sets an important cross-sectoral public-private platform designed to de-risk investments needed to produce and transport low- and zero-emission fuels for the maritime sector. This initiative is a collaboration between various stakeholders consisting of Governments[9], organizations[10] and supporting entities[11].

Regional

At the regional level, the European Union (EU) has also spearheaded regional action for international shipping decarbonisation through the inclusion of shipping in its Emissions Trading System (EU ETS), as part of EU Directive 2003/87/EC establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (European Commission, 2023a), and the adoption of FuelEU Maritime under the EU Regulation 2023/1805 on the use of renewable and low-carbon fuels in maritime transport, and amending Directive 2009/16/EC (European Commission, 2023b). In addition to the EU ETS and FuelEU Maritime, the following policies and initiatives have been influencing the maritime developments in the Mediterranean region:

.1 The EU Freight Transport Action Plan

.2 The TEN-T Corridor Network, with particular focus on the Mediterranean Corridor

.3 The Motorways of the Sea

.4 The European Green Deal and EU Fit for 55 package

.5 The EU R&D and Innovation Funding Instruments

.6 The Sustainable and Smart Mobility Strategy

.7 The Global Gateway Initiative

.8 The Connecting Europe Facility

[9] Governments include Barzil, Canada, Greece, Norway, Panama, Uruguay, and the United Arab Emirates, https://www.cleanenergyministerial.org/initiatives-campaigns/hubs/

[10] Organizations include International Chamber of Shipping (ICS), International Association of Ports and Harbors (IAPH), Clean Energy Ministerial (CEM), https://www.cleanenergyministerial.org/initiatives-campaigns/hubs/

[11] Supporting entities include International Renewable Energy Agency (IRENA) and Global Centre for Maritime Decarbonisation (GCMD), https://www.cleanenergyministerial.org/initiatives-campaigns/hubs/

EU Freight Transport Action Plan, 2012

In 2012[12], the European Commission (EC) called for a drastic reduction of 60% of the transport GHG emissions by 2050, with the goal of limiting climate change at 2ºC, through the so-called EU Freight Transport Action Plan. The latter is a comprehensive strategy designed to enhance the efficiency, sustainability, and competitiveness of freight transport across the EU. The plan focused on improving multimodal logistics, reducing GHG emissions, and promoting digitalisation to create more resilient and sustainable supply chains.

Trans-European Transport Network (TEN-T)

The TEN-T[13] is the EU's flagship initiative for building an integrated, sustainable, and efficient transport network across Europe, linking the continent via road, rail, inland waterways, and maritime routes. The core network must be completed by 2030, while the comprehensive network has a deadline of 2050. The most recent TEN-T policy is based on Regulation (EU) 2024/1679 on Union guidelines for the development of the trans-European transport network and covers requirements for multimodal transport, with focus on rail travel speed, the European Rail Traffic Management System (ERTMS), the airport connectivity, the urban mobility. With regards to maritime and shipping corridors, the following corresponding requirements are highlighted:

.1 Freight terminals: The number and capacity of transhipment terminals will be expanded to meet traffic demands. This includes accommodating 740-meter-long trains, promoting the shift to sustainable transport modes, and boosting Europe's combined transport sector;

.2 Urban mobility: All major cities along the TEN-T network will develop sustainable urban mobility plans to promote zero and low-emission mobility; and

.3 Alternative fuels: The TEN-T is the basis for the deployment of recharging points and refuelling points for alternative fuels, such as hydrogen. It complements the requirements of Alternative Fuels Infrastructure Regulation (AFIR) under the EU Regulation 2023/1804 on the deployment of alternative fuels infrastructure, for urban nodes and terminals.

Four of the nine TEN-T corridors expand, and contain segments or nodes/ports into the Mediterranean Sea, as shown in Figure 3-1:

.1 **The Mediterranean Corridor** is the main east-west axis in the TEN-T Network south of the Alps. It links the Spanish ports of Algeciras, Cartagena, Valencia, Castellȯn, Tarragona and Barcelona with Madrid and along the Mediterranean coastline through southern France – Marseille and Nice until Italy – Genoa and La Spezia. It runs from Marseille towards Lyon across the Alpes and northern Italy via Turin, Milan, Verona, Bologna, Padova, Venice and Trieste. It links also with Ljubljana, Slovenia, and a branch via Rijeka and Zagreb in Croatia, to Budapest in Hungary and to Lviv in Ukraine. The corridor is approximately 3,000-km long. It covers rail and road, airports, ports, freight multimodal terminals, Rail-Road Terminal (RRT)'s and, the Po river inland waterway in northern Italy. Key projects are the gauge change to European standard gauge in Spain, the new high-speed

[12] European Commission, EC. (2012). *Freight Action Plan, EC White paper on transport 2012. EU transport GHG: Routes to 2050.* Brussels: European Commission.

[13] TEN-T: https://transport.ec.europa.eu/transport-themes/infrastructure-and-investment/trans-european-transport-network-ten-t_en

line Montpellier-Perpignan in France, the Lyon in France to Turin in Italy railway base tunnel, the second rail track on the Koper-Divaca line in Slovenia and the overall modernisation of railways infrastructure in the eastern part of the Corridor. The Mediterranean Corridor 5th Work Plan, 2022 [14], describes the recently developed plan for the further upgrade and reinforcement of the corridor infrastructure, including rail, waterborne, short sea shipping, road, and multimodal components. For the Mediterranean maritime routes, the emphasis is placed on optimising port operations, facilitating modal shifts to cleaner transport forms, and integrating new technologies to reduce emissions from shipping. Investments in cleaner fuels, electrification, and digitalisation of logistics are critical to achieving these goals.

.2 The newly created **Baltic Sea – Black Sea – Aegean Sea (BBA) European Transport Corridor (ETC)** links EU Member States from the far north to the far south of Europe with the maritime interfaces of the Baltic Sea, Black Sea and Aegean Sea, which is part of the Mediterranean Sea, through the countries of Ukraine and Moldova. This corridor starts in the north in Finland from its capital Helsinki, passes through Tallinn, Riga, Kaunas and Vilnius, Elk, and connects the ports of Gdansk and Gdynia, passes Krakov, Odessa, Romania, Chisinau, connecting into Hungary up to Timisoara, going south to Sofia and Burgas, passing to the Aegean Sea ports of Thessaloniki and Athens, and finally ending in Cyprus (maritime connection) connecting via the island of Crete to the port of Limassol. The corridor extends in the North from the Polish Baltic Sea ports of Gdańsk and Gdynia as well as Szczecin and Świnoujście and the city of Biała Podlaska through Kłodzko, Kraków and the Katowice region to Brno in the Czech Republic and Bratislava in Slovakia. It stretches further to Vienna in Austria and Budapest in Hungary and its Eastern branch ends in the Slovenian port of Koper and the Croatian ports of Rijeka and Split. The Western branch to Italy connects Bologna and the ports of Trieste, Venice, Ravenna, and Bari.

.3 The new **Western Balkans – Eastern Mediterranean (WBEM) Corridor** links central EU Member States with the ports of the Adriatic and East Mediterranean Sea via the Western Balkans. It runs through eight EU Member States, namely Austria, Slovenia, Croatia, Hungary, Bulgaria, Greece, Cyprus and Italy, as well as other countries, namely Serbia, Bosnia and Herzegovina, Montenegro, Kosovo, Albania and North Macedonia. The corridor connects all capital cities except Vienna and Rome. The WBEM Corridor is multimodal, but it does not include any inland waterways. Cyprus also does not have a railway network. The WBEM European Transport Corridor contains parts of the former Orient/East-Med corridor (in Hungary, Bulgaria, Greece and Cyprus) as well as of the Rail Freight Corridors as described in the previous section. It overlaps in parts with the Mediterranean, the Rhine – Danube, the Baltic Sea – Black Sea – Aegean Sea and the Baltic Sea – Adriatic Sea corridors.

.4 The **Scandinavian-Mediterranean Corridor** represents a crucial north-south axis for the European economy. The corridor extends from the north of Finland, Sweden, and Norway, through Denmark, Germany, and Austria to the Mediterranean coast of Southern Italy and further on by sea to Malta. Major ports and network nodes are Stockholm (Sweden), Helsinki (Finland), Oslo (Norway),

[14] Mediterranean Corridor 5th Work Plan, 2022: https://transport.ec.europa.eu/document/download/1a159cac-63de-41b4-baef-40d00a2405d2_en?filename=5th_workplan_med.pdf

Gothenburg (Sweden) and Copenhagen (Denmark) in the north, while Hamburg, Hannover, Berlin, Leipzig, Frankfurt am Main, Munich and Innsbruck in Gemarny in the centre, and finally Italy's Verona, Bologna, Rome, Naples, La Spezia, Ancona, Livorno, Florence, Cagliari (Sardinia), Bari, Palermo (Sicily) as well as Valetta and Marsaxlokk (both in Malta) in the southern part of the corridor. It comprises rail and road and European Maritime Space sections (e.g. Lübeck/Rostock to Scandinavia or southern Italy/Sicily to Malta) sections as well as 21 airports, 33 ports, 29 rail-road-terminals and 74 urban nodes. The key infrastructure projects on this corridor are the Fehmarn Belt fixed link and the Brenner base tunnel.

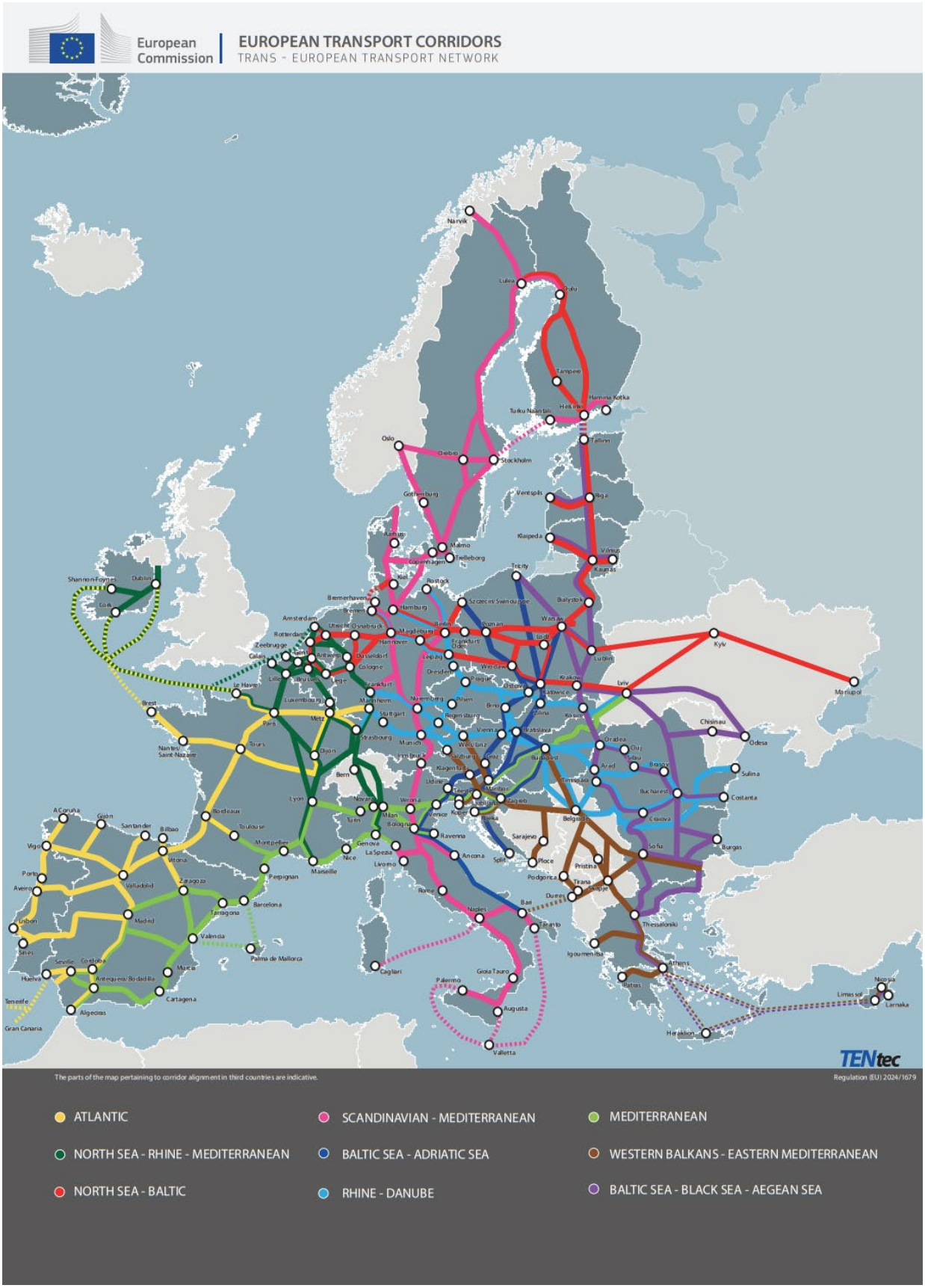

Figure 3-1: The TEN-T corridor network (European Commision, 2024)

Motorways of the Sea (MoS)

Motorways of the Sea (MoS) is a TEN-T initiative aimed at developing sustainable, competitive, and efficient maritime-based logistics corridors. It encourages a shift from road-based transport to sea-based shipping, reducing congestion, especially on land corridors, and lowering CO_2 emissions. In the Mediterranean, the MoS aims to strengthen short-sea shipping by improving port infrastructures and maritime links between North Africa, the Middle East, and Southern Europe. Major ports like Marseille, Valencia, and Piraeus are critical hubs for this initiative. The MoS promotes the use of Liquefied Natural Gas (LNG) and other alternative fuels, which are crucial for reducing the environmental footprint of shipping routes. The EU funds MoS projects through the Connecting Europe Facility (CEF), supporting the development of green maritime technologies, like CO_2 Exhaust Gas Cleaning Systems (EGCS), scrubbers, electric shore-side power, and hybrid propulsion systems.

European Green Deal and EU Fit for 55 package

The European Green Deal is the EU's overarching plan to make Europe the first climate-neutral continent by 2050. The EU Fit for 55 package sets interim targets to reduce GHG emissions by at least 55% by 2030. These policies have a strong focus on decarbonising transport, including maritime shipping. The Mediterranean maritime routes are expected to comply with stricter emissions standards as part of this initiative. The focus is on reducing GHG emissions from maritime transport through various measures, including:

.1 Implementing carbon pricing through the EU ETS for shipping.

.2 Mandating the use of cleaner fuels such as hydrogen, LNG, and ammonia.

.3 Promoting energy efficiency improvements in vessels operating on Mediterranean routes.

.4 Promoting the development of Sustainable Ports: Ports across the Mediterranean are also key targets for sustainability upgrades under the European Green Deal, focusing on electrification (e.g., shore power), renewable energy use, and reducing port-related emissions.

Continuous R&D European Research Innovation and Development Funds

EU has been continuously funding research, development and innovation in the field of maritime transport through dedicated programs along the last decades. It supports projects aimed at developing zero-emission vessels, digital technologies for optimising maritime logistics, and the use of renewable energy in transport. In the previous years, Horizon Europe supports initiatives in the Mediterranean to develop smart ports, improve shipping efficiency, and deploy low-emission maritime solutions. Projects are underway to test alternative fuel vessels and implement digital tools that enhance route efficiency and reduce fuel consumption.

The Sustainable and Smart Mobility Strategy

Launched by the European Commission in 2020, the Sustainable and Smart Mobility Strategy outlines measures for the digitalisation and decarbonisation of all transport modes by 2050. For maritime transport, it calls for zero-emission vessels by 2030 and sustainable port management. With focus on the development of Mediterranean maritime and shipping corridors, the strategy highlights the importance of such corridors as part of the EU’s external connectivity to Mediterranean

coastal States that are not EU Member States. The goal is to encourage collaboration in decarbonising these routes, particularly through the development of sustainable fuels and electrification. In this regard, the strategy covers multimodal hubs, with an emphasis on reducing the carbon footprint of the entire transport chain.

The Global Gateway Initiative

The Global Gateway initiative[15] aligns with green shipping corridors by promoting sustainable infrastructure development in Europe's trade relations, especially in regions like the Mediterranean. Global Gateway was launched in 2021, to boost smart, clean and secure links in digital, energy and transport sectors and to strengthen health, education and research systems across the world. Global Gateway aims to mobilise up to €300 billion in investments through fostering collaborations with Mediterranean coastal States that are not EU Member States to decarbonise trade routes and ensure sustainable practices across borders.

Connecting Europe Facility

Projects funded through the Connecting Europe Facility (CEF) support the development of green shipping routes, port infrastructure improvements, and the adoption of alternative fuels in Mediterranean ports such as Barcelona (Spain), Genoa (Italy), and Piraeus (Greece).

The EU's current policy on green corridors, especially in the Mediterranean region, is focused on reducing emissions through cleaner fuels, sustainable port operations, and the integration of maritime transport with rail and road transport. The region's strategic importance for global trade makes it a priority for these green initiatives, contributing to the overall decarbonisation of European transport by 2050. The following key aspects are covered:

.1 **Decarbonisation**: The action plan aligns with the European Green Deal and aims to reduce freight transport's environmental impact, particularly by shifting freight from road to less polluting modes such as rail and maritime transport.

.2 **Digitalisation and Innovation**: The plan emphasises using digital tools to optimise logistics, streamline border procedures, and improve data sharing, contributing to more efficient freight movement.

.3 **Multimodal Integration**: The EU promotes integrating different transport modes (e.g., sea, rail, road) to reduce congestion, lower emissions, and enhance the flow of goods across borders.

Apart from the EU policies, the Nordic countries[16] are also involved in initiatives towards towards zero-emission shipping, such as the Nordic Roadmap initiative (Future Fuel Nordic, 2024), established in 2021. The Nordic roadmap is centered around the establishment of a Nordic collaboration platform to facilitate knowledge sharing, alongside the launch of pilot projects and studies that will build experience in new fuels and establish green shipping corridors. The collaboration platform is envisaged as a forum where partners can not only share and discuss the progress of the Nordic roadmap, but receive briefings on a new policy, R&D, and other linked programmes, and potentially develop spin-off projects outside. The overall aim is to reduce key

[15] Global Gateway Initiative: https://international-partnerships.ec.europa.eu/policies/global-gateway/global-gateway-overview_en

[16] Nordic countries include Denmark, Norway, Sweden, Finland, Iceland, Faroe Islands, Greenland, and Åland. https://www.norden.org/en/information/facts-about-nordic-countries

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

Summary

Several international and regional policies and initiatives are already in place to address the needs of decarbonising shipping. IMO as an international key actor has been working continuously on reducing GHG emissions from shipping by adopting GHG strategies and commissioning several studies. To accelerate the uptake of alternative fuels, the Clydebank Declaration, which aims to develop at least six green shipping corridors by 2025 and more by 2030, was launched in 2021. Such green shipping corridors could become key enablers to accelerate the uptake of zero-emission fuels, which could directly contribute to achieving ambitions in the 2023 IMO GHG Strategy that aims for a 5% reduction of zero-emission fuels by 2030, and striving for 10%. At the regional level, the EU ETS and FuelEU Maritime Initiative were adopted to reduce emissions from international shipping. Other regional initiatives pertaining to the Mediterranean region include the EU Freight Transport Action Plan, TEN-T Corridor Network, Motorways of the Sea, European Green Deal and EU Fit for 55 package, EU R&D and Innovation Funding Instruments, Sustainable and Smart Mobility Strategy, the Global Gateway Initiative, and the Connecting Europe Facility. In the Nordic countries, the Nordic Roadmap has gathered various stakeholders from the shipping value chain in the region to contribute towards zero-emission shipping.

3.2.1.2 National Policy

At present, green corridor-supporting national policies seek to promote the development of a collection of industry-driven or Government-sponsored projects along prospective routes. This is done to maximise the potential environmental advantages and increase the likelihood of success for upcoming corridors. The efforts for countries to establish green shipping corridors are thus influenced by countries' **Nationally Determined Contributions (NDCs)**[17]**,** which include maritime decarbonisation strategies. It is widely recognised that NAPs may facilitate the implementation of IMO instruments in the national context and support the achievement of international commitments through complementary national action. Many countries are taking actions at the national level to facilitate the reduction of GHG emissions from ships and green shipping, as listed in Table 3-1.

Table 3-1: List of some NAPs submitted to IMO[18]

IMO Member State	National Action Plan (NAP)
Finland	Government resolution on reducing GHG emissions from maritime and inland waterway transport
India	Maritime India Vision 2030
Japan	Roadmap to zero-emission from international shipping
Marshall Islands	Rebbelib 2050: A Catalyst for Change - Marshall Islands National Transport Decarbonisation Framework
Norway	The Government's action plan for green shipping

[17] The Paris Agreement and NDCs: https://unfccc.int/process-and-meetings/the-paris-agreement/nationally-determined-contributions-ndcs

[18] IMO National Action Plans: https://www.imo.org/en/ourwork/environment/pages/relevant-national-action-plans-and-strategies.aspx

Republic of Korea	Toward Green Shipping by 2050
Singapore	Maritime Singapore Decarbonisation blueprint: Working towards 2050
United Kingdom of Great Britain and Northern Ireland (UK)	Clean Maritime Plan: Maritime 2050 Environment Route Map

Apart from the NAPs being developed by various countries, the United States of America (USA) is promoting similar initiatives by legislating **the Clean Shipping Act of 2023**[19]. This Act aims to reduce GHG emissions from the shipping industry to protect the health of port communities and address the environmental injustice impacts of the climate crisis. It would direct the U.S. Environmental Protection Agency (EPA)[20] to set progressively tighter carbon intensity standards for fuels used by ships to reduce GHG emissions by 2040, consistent with the goals of the Paris Agreement to limit warming to 1.5 degrees Celsius. These include setting carbon intensity standards for fuels used by ships that require lifecycle carbon dioxide-equivalent reductions of 20% from 1 January 2027, 45% from 1 January 2030, 80% from 1 January 2035, and 100% from 1 January 2040, as well as, setting requirements to eliminate in-port ship emissions by 2030, where, by 1 January 2030, all ships at-berth or at-anchor in ports in the USA would emit zero GHG emissions and zero air pollutant emissions. Additionally, under **the Inflation Reduction Act (IRA)**[21], the USA is directing substantial funding toward green infrastructure, including port electrification, essential for these corridors.

Likewise**, China's Action Plan for Green Development in the Shipbuilding Industry (2024-2030)**[22] aims to transform the shipbuilding sector into a more sustainable and environmentally friendly industry. By 2025, a preliminary green development system will be established, and by 2030, China's green shipbuilding technology is expected to reach an advanced international level. The plan focuses on using alternative fuels and new energy technologies, reducing pollution and carbon emissions, and improving energy efficiency, with a target to decrease energy consumption per unit output by 13.5% compared to 2020 levels. This initiative is part of China's broader strategy for green and low-carbon development across various industries.

Countries in Europe and the Nordic countries have also taken measures to promote zero-emission vessels and foster green corridors. Norway is leading these initiatives in the North Sea and domestic waters through its **the Nordic Roadmap project (Future Fuel Nordic, 2024)**[23] and **Green Shipping Programme**[24], with more than 60 partners across the Nordic countries. The primary goal is to reduce emissions and foster green competitiveness within the maritime industry. Spearheaded by DNV, the Nordic Roadmap project unites key stakeholders from across the Nordic region to collaboratively plot a course towards the transition to carbon-neutral fuels. As part of this effort, several promising intra-Nordic routes are identified. The project has established two green shipping corridor pilots and is working on ad additional one. In addition to sharing knowledge, the Nordic Roadmap initiative encourages other green shipping corridors and governments to build on insights from previous experiences. In designing its scope, the initiative incorporated learnings generated

[19] The Clean Shipping Act of 2023: https://www.padilla.senate.gov/wp-content/uploads/Clean-Shipping-Act-of-2023.pdf
[20] The Environmental Protection Agency is an independent agency of the United States government tasked with environmental protection matters. https://www.epa.gov/aboutepa/our-mission-and-what-we-do
[21] The Inflation Reduction Act (IRA): https://home.treasury.gov/policy-issues/inflation-reduction-act
[22] Action Plan for Green Development in the Shipbuilding Industry (2024-2030): https://chinawaterrisk.org/regulation/action-plan-for-green-development-in-the-shipbuilding-industry-2024-2030/
[23] Nordic Roadmap: https://www.nordicenergy.org/project/nordic-roadmap-for-the-introduction-of-sustainable-zero-carbon-fuel-in-shipping/
[24] Green Shipping Programme: https://greenshippingprogramme.com/

within the Green Shipping Programme. This resulted in the early involvement of cargo owners and a high degree of fuel specifities in the pilots, both identified as key success factors within Green Shipping Programme. Under this initiative, numerous technical and strategic studies have been and are being performed to reduce key barriers to implementation and establish a common roadmap for the whole Nordic region and logistics ecosystem towards zero-emission shipping.

Singapore, a key maritime hub, offers incentives under its **Green Ship Programme**[25] and **Green Port Programme**[26], supporting the development of sustainable shipping routes throughout the Asia-Pacific. Singapore's **Green Ship Programme**, part of the Maritime Singapore Green Initiative, incentivises shipowners to adopt energy-efficient technologies and reduce carbon emissions. Ships that exceed IMO's Energy Efficiency Design Index (EEDI) requirements receive tax rebates and fee reductions, encouraging the use of greener vessels in Singapore's registry. The **Green Port Programme** focuses on reducing emissions from ships calling at Singapore. Vessels using approved clean fuels like LNG or adopting emission-reduction technology, such as scrubbers, are eligible for port dues concessions. Both programs align with Singapore's commitment to sustainable maritime practices and global decarbonisation goals.

Port-specific initiatives are also playing a central role. The Port of Rotterdam (The Netherlands), Europe's largest port, aims to be carbon-neutral by 2050 and has set up international collaborations to develop and deploy green shipping corridors with other major ports, i.e., Rotterdam – Singapore Green and Digital Shipping Corridor, Rotterdam – Gothenburg Green Shipping Corridor. On the other hand, the Port of Los Angeles and the Port of Shanghai are similarly collaborating to create a trans-Pacific green shipping corridor focused on zero-emission routes, exemplifying global cooperation in maritime decarbonisation. The participants of this partnership will take steps to reduce carbon emissions and harmful pollutant emissions impacting air quality, through methods such as expanding the use of shore power and supporting the development of clean marine fuelling infrastructure. A detailed list of such initiatives can be found in Section 3.2.2.

Summary

Building on international and regional regulations and policies, as well as, being influenced by countries' NDCs, which include maritime decarbonisation strategies, several countries have developed NAPs and policies to decarbonise the shipping industry. These include the major maritime hubs, such as the United States, China, Singapore, and others. Apart from that, several countries have established programmes related to green shipping and green ports (e.g., the Green Shipping Programme in Norway, Green Ship Programme and Green Port Programme in Singapore, etc.) as well as port-specific initiatives (e.g., Rotterdam – Singapore Green and Digital Shipping Corridor, Los Angeles – Shanghai green shipping corridor, etc.).

3.2.1.3 National Framework

The literature review identifies the examples of U.S. and Canadian green shipping corridor frameworks as appropriate to the study objectives which are described further.

The U.S. Green Corridor Framework (U.S. Department of State, 2022) introduces relevant definitions, process steps and building blocks for green corridors. This document is intended to contribute to a common vision of green shipping corridors and advance the effort to establish them across the ocean and along coasts and inland waterways, so that maritime stakeholders may act

[25] Green Ship Programme: https://www.mpa.gov.sg/media-centre/details/no.-7-of-2022---revised-green-ship-programme-under-the-maritime-singapore-green-initiative

[26] Green Port Programme: https://www.mpa.gov.sg/media-centre/details/enhancement-of-the-maritime-singapore-green-initiative-green-port-programme-(gpp)

as a united front to tackle the climate crisis. In the document, it is stated that the United States envisions green shipping corridors as maritime routes that showcase low- and zero-emission lifecycle fuels and technologies with the ambition to achieve zero GHG emissions across all aspects of the corridor in support of sector-wide decarbonisation no later than 2050. The United States is partnering internationally, working on implementation domestically, and investing in the research and development needed to help ensure they have the solutions necessary to meet their commitments. The document highlighted possible components of the green shipping corridor planning process. These could include identifying and convening relevant stakeholders, followed by defining the scope, boundaries, metrics, and framework for analysis. Not limited to that, estimating a baseline emissions inventory for port and/or vessel operations to develop emissions reduction targets, incorporating lifecycle-emissions estimates into equipment, materials, and fuelling infrastructure planning and development decisions, as well as developing an implementation plan with stakeholders and communities to outline a pathway to achieving emissions reductions targets could be part of the planning process. Building on the planning process, there are several building blocks for implementation of green corridors to reach the goal of full decarbonisation. Elements of this implementation process could include, but are not limited to, the deployment and/or operation of:

.1 Alternative refuelling or recharging infrastructure to support zero emissions port and terminal equipment operations;

.2 Support vessels and commercial harbour craft using low- or zero-emission fuels and technologies;

.3 Ocean-going vessels using low- or zero-emission fuels and technologies;

.4 Zero-emissions fuels, bunkering, and refuelling capabilities for vessels including electrification and cold ironing; and

.5 Energy efficiency and operations optimisation activities that lead to reduced overall energy consumption and reduce GHG emissions.

As Canada is a signatory to the Clydebank Declaration, ‘Transport Canada’ has published a “Canadian Green Shipping Corridors Framework” (Government of Canada Transport Canada, 2024) to help guide the development of green shipping corridors and ensure consistent implementation. The framework aligns with other Government priorities, including developing Canada’s Blue Economy Strategy and the Ocean’s Protection Plan. The framework recognises the challenges to Canadian shipping achieving net-zero emissions by not later than 2050 and sets out the Government’s support for scalable solutions that can be implemented in the short term while facilitating a path to net zero. This could include efficiency measures, provision of shore power, as well as alternative zero-emission fuels. Regardless of the measure, the importance of considering the whole lifecycle environmental impacts is reiterated. The framework also identifies the importance of aligning local and national actions with international efforts to ease their implementation, particularly in the case of international corridor partnerships. Finally, it underscores the importance of mobilising a broad range of industry stakeholders in the implementation of green shipping corridors while ensuring the involvement of all implicated parties such as local communities and indigenous groups. The above-mentioned details can be summarised as follows:

.1 A path to net-zero for Canada’s marine transportation sector by 2050;

.2 Reaching net-zero by implementing global commitments at the local level;

.3 Empowering industry to lead the move to net-zero; and

.4 Credibility of success relies on effective measurement and communication of progress.

The framework also outlines the steps for implementing green shipping corridors. It begins with assessing routes to determine the best focus for resources, followed by engaging stakeholders to define the scope, boundaries, metrics, and analysis framework. Next, it involves assessing the feasibility of low-emission technologies, infrastructure, and financing needs. Ensuring sector readiness and setting baselines by incorporating lifecycle emissions estimates into planning and development decisions is crucial, along with establishing a baseline emissions inventory for port and vessel operations. Finally, it concludes with developing an implementation plan in collaboration with stakeholders and local communities to meet emissions reduction targets.

Summary

Both U.S. and Canadian green shipping corridor frameworks provide a clear direction and message from the government in supporting the development and implementation of green shipping corridors. The frameworks in general serve as the common guide for the development and implementation of green shipping corridors for the respective countries, where the definitions, steps of planning and implementing green shipping corridors, as well as the potential areas for the deployment of green shipping corridors can be found in the frameworks. Similar frameworks can be established for the Mediterranean coastal States outlining the key areas of interest in supporting the development and implementation of green shipping corridors in respective countries.

3.2.1.4 Industry Framework

At the industry level, the "Tides of Change: A Framework for Developing Just and Inclusive Maritime Green Corridors" (UN Global Compact, et al., 2023) co-created by the UN Global Compact, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping, and the Sustainable Shipping Initiative, outlines the necessary considerations and actions required from companies and governments involved in establishing green shipping corridors around the world. This document describes what the stakeholders involved in the green corridors project consortia must consider to contribute to a just transition. It is evident that this requires significant collective action, but also that the benefits of this approach will spread far beyond the shipping industry benefiting individuals, communities, and countries. Recommendations made in the report for a just and equitable transition towards net zero include:

.1 Ensuring green corridors leverage wider transition aims regionally/locally including improved access to clean energy, the development of decent, sustainable jobs, a diverse and inclusive workforce and capacity building but also improved air quality and preservation of biodiversity and ecosystems regionally; and

.2 Creating decent, sustainable jobs and workforce up-skilling. In the process of establishing green corridors, stakeholders can test and demonstrate how to conduct inclusive social dialogue with affected groups.

Furthermore, the "First Mover Framework" adopted by the Silk Alliance[27] project in Singapore could be a relevant reference for the implementation of green shipping corridors. This framework aims to guide the private and public stakeholders in the supply chain to systematically evaluate decarbonisation strategies for a specific fleet. The framework is designed with the view that both sides, the fuel supply, and the fleet should work in tandem to support the energy transition along a shipping 'corridor' to ensure its success. The First Mover Framework can be divided into three key parts:

.1 **System thinking stage** (yellow boxes in Figure 3-2): This stage brings together the experiences of all members; and learnings from existing literature and the industry to bolster the Alliance's common understanding of the challenges. Drawing on these collective experiences the members identify the key questions to be addressed in the following stage;

.2 **Foresight stage**: Firstly, key input and scenarios are defined; secondly, a quantitative analysis is undertaken to provide new insights and evidence regarding the costs and benefits of different decarbonisation strategies; and.

.3 **Co-Creation stage**: This final stage aims to create consensus for a common strategy to build an implementation plan through a collective road mapping exercise.

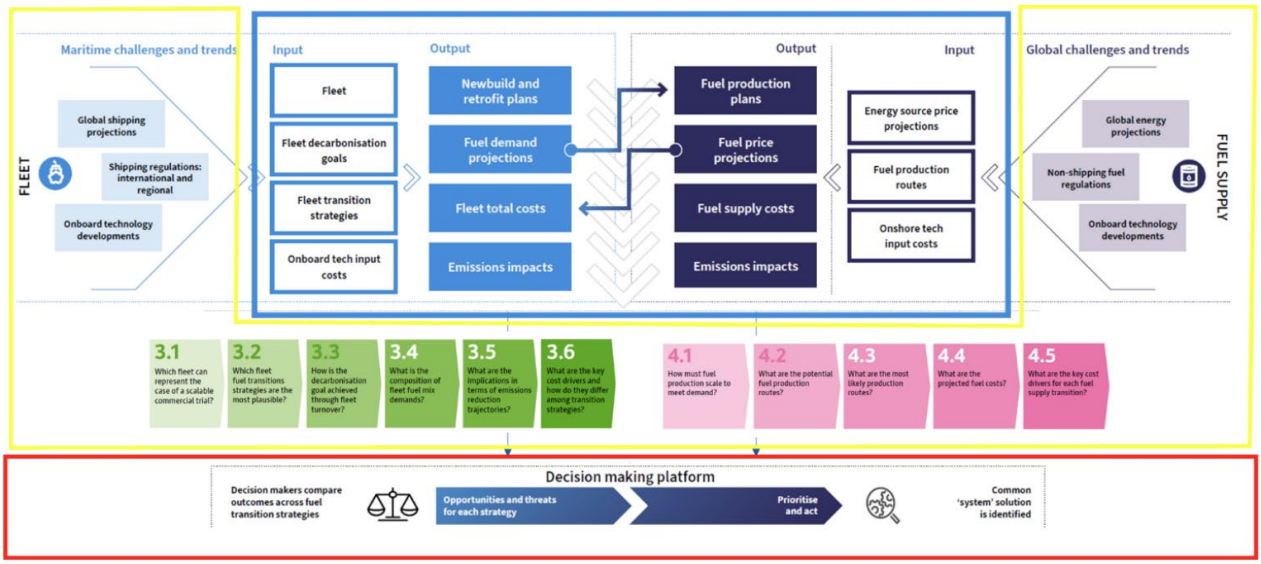

Figure 3-2: A graphical representation of the First Mover Framework taken from the Silk Alliance progress report (Silk Alliance, 2023)

The "The Next Wave" study (Global Maritime Forum, 2021) puts forward an approach to evaluating corridors that assess feasibility and impact through quantitative (emissions reduced, volume of trade, impact on cost of traded goods) and qualitative criteria (stakeholder readiness, policy environment), as shown in Figure 3-3. The impact and feasibility analysis highlighted two routes that were

[27] The Silk Alliance is a Green Corridor Cluster focused on a fleet that predominantly bunkers in Singapore and operates across the Indian and Pacific Oceans comprising stakeholders from across the full value chain including international shipping, shipbuilding, financing and marine fuel supply chains, while also bringing together representatives from both the public and private sector: https://www.thesilkalliance.com/what-is-the-silk-alliance/

particularly interesting for in-depth study, with an additional third corridor that was determined to be interesting enough to feature as a case study, as depicted in Figure 3-4.

High volume routes
Rapid decarbonization routes

	Metric		1 Aus-China iron ore Large volumes, fewer policy enablers	2 Brazil-China iron ore High volume, with higher shipping costs	3 Aus-Japan iron ore Lower volumes with committed stakeholders	4 Transpacific containers Major mainline route	5 Aus-Europe containers Long, high-emission mainline route	6 Transatlantic containers Small volumes, more policy enablers	7 North-South containers Low volumes, limited ability to pass on costs	8 Saudi-India ammonia Potential future fuel, small traded volumes	9 Asia-US automotive Low volume, high value, and carbon intensive	10 Saudi-China methanol Potential future fuel, small traded volumes
IMPACT	**A. Trade and logistics**											
	Share of global trade volume	Basis points	650	195	60	181	210	52	14	2	4	1
	Expected future growth, CAGR 2021-2025	%	4%	3%	3%	2%	3%	3%	8%	5%	2%	6%
	B. Emissions											
	Carbon intensity on route	kgCO2e/tonne cargo	28	48	29	61	93	56	99	104	197	137
	Current carbon emissions on corridor	tonne CO_2e	20,200,000	10,500,000	1,900,000	12,300,000	21,700,000	3,200,000	1,500,000	300,000	900,000	160,000
FEASIBILITY	**C. Value and cost pass-through**											
	Relative price increase of traded good	%	11%	28%	11%	3%	2%	2%	12%	4%	1%	4%
	Scope 3 importance for traded good sector	1=low, 5=high	3	3	3	2	2	4	2	1	3	1
	D. Zero-emission fuel supply											
	Delivered cost of zero-emission fuel in 2025	$/GJ	35	37	35	38	30	40	35	30	38	30
	E. Stakeholder readiness											
	National policies/regulations (net zero, green H2)	1=low, 5=high	2	2	4	1	3	3	4	1	3	1
	Ease of stakeholder environment	1=low, 5=high	2	5	4	1	1	1	2	4	5	4

Figure 3-3: Multi-criteria analysis of 10 potential Green Corridors taken from The Next Wave: Green corridors (Global Maritime Forum, 2021)

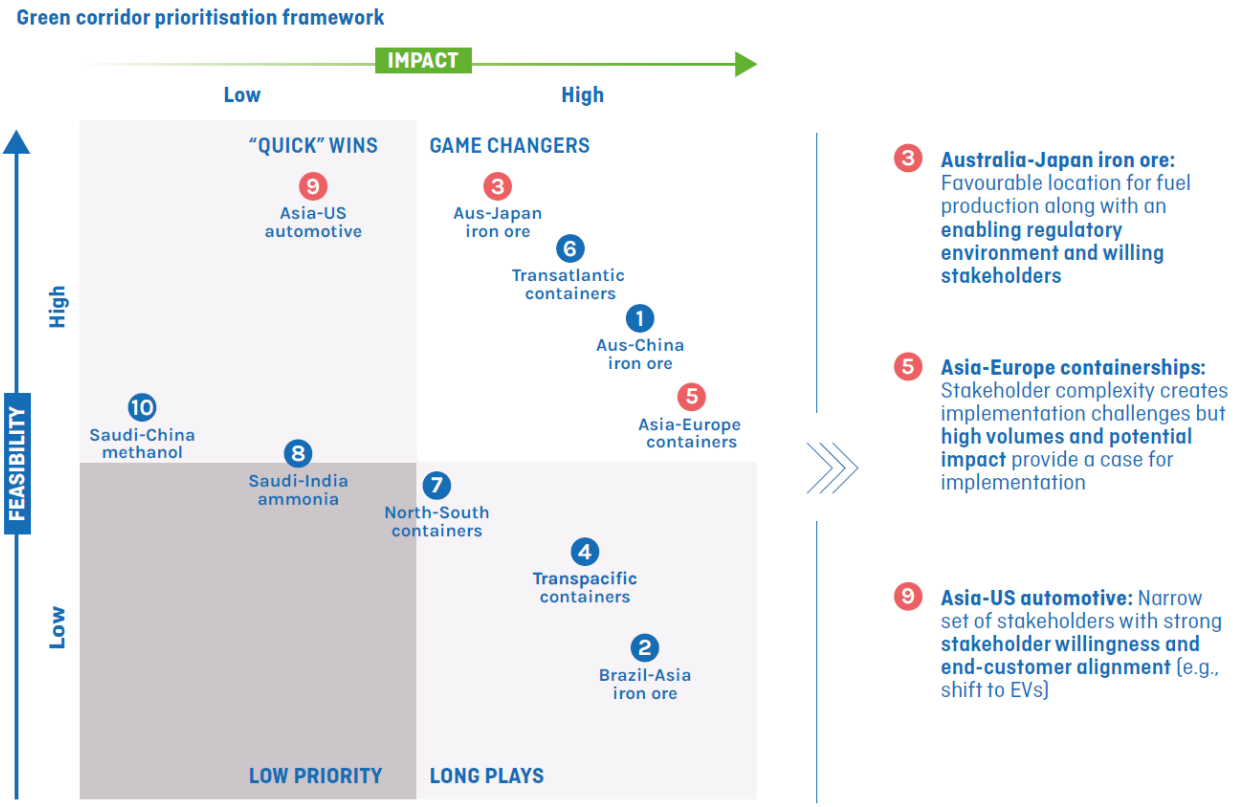

Figure 3-4: Evaluation of three routes based on impact and feasibility parameters using green corridor prioritisation framework taken from The Next Wave: Green corridors (Global Maritime Forum, 2021)

Summary

Several industry-led frameworks and reports can be adopted to initiate and develop green shipping corridors. The "Tides of Change: A Framework for Developing Just and Inclusive Maritime Green Corridors", developed by the UN Global Compact and team, emphasises the necessary considerations and actions required from companies and governments involved in establishing green shipping corridors around the world. Meanwhile, the “First Mover Framework” adopted by the Silk Alliance project aims to guide the private and public stakeholders in the supply chain to systematically evaluate decarbonisation strategies for a specific fleet with the view that both sides, the fuel supply, and the fleet, should work in tandem to support the energy transition along a shipping ‘corridor’ to ensure its success. Furthermore, the “The Next Wave” study that provides a framework evaluating the green shipping corridors and assessing the feasibility and impact through various quantitative and qualitative criteria could serve as one of the initial steps for the planning of green shipping corridors.

3.2.2 Overview of green shipping corridors and green maritime hubs

Since the launch of the Clydebank Declaration in 2021, more than 20 countries have committed to develop at least six green shipping corridors between two (or more) ports by 2025 and more by 2030. Various collaborations and initiatives have been established to initiate the discussion and planning of these green shipping corridors. Apart from that, the CEM-Hub's initiative, established in 2022, provides a public-private platform between energy, maritime, shipping and finance communities. This initiative de-risks investments and transforms the energy-maritime supply chain to play an important role in the development of green shipping corridors.

3.2.2.1 Global green shipping corridor initiatives

Since the Clydebank Declaration in 2021, more than 60 green shipping corridor initiatives have been announced. The number of announcements has increased from 21 in 2022 to more than 60 as of November 2024 (Source: DNV's Internal Green Shipping Corridor Database), whereof almost 32 corridors being announced in 2023. Most of the corridors are at the planning stage with feasibility studies and some are developing implementation plans, six corridors have now moved on from exploration and are preparing for real-world implementation (Global Maritime Forum, 2024), and none have so far been realised. Some zero-emission intra-Nordic voyages have been conducted using biofuels for ships operating in the Baltic Sea, such as the Green Corridor Friday initiative on the Umeå-Vasa corridor[28], and the Turku-Stockholm corridor[29]. Figure 3-5 shows the global distribution of corridor initiatives. Most of the initiatives are either led by Governments committed to the Clydebank Declaration, or ports collaborating and coordinating the transition to supply zero-emission fuels for shipping. Table 3-2 shows the list of global green shipping corridor initiatives as of mid-October 2024.

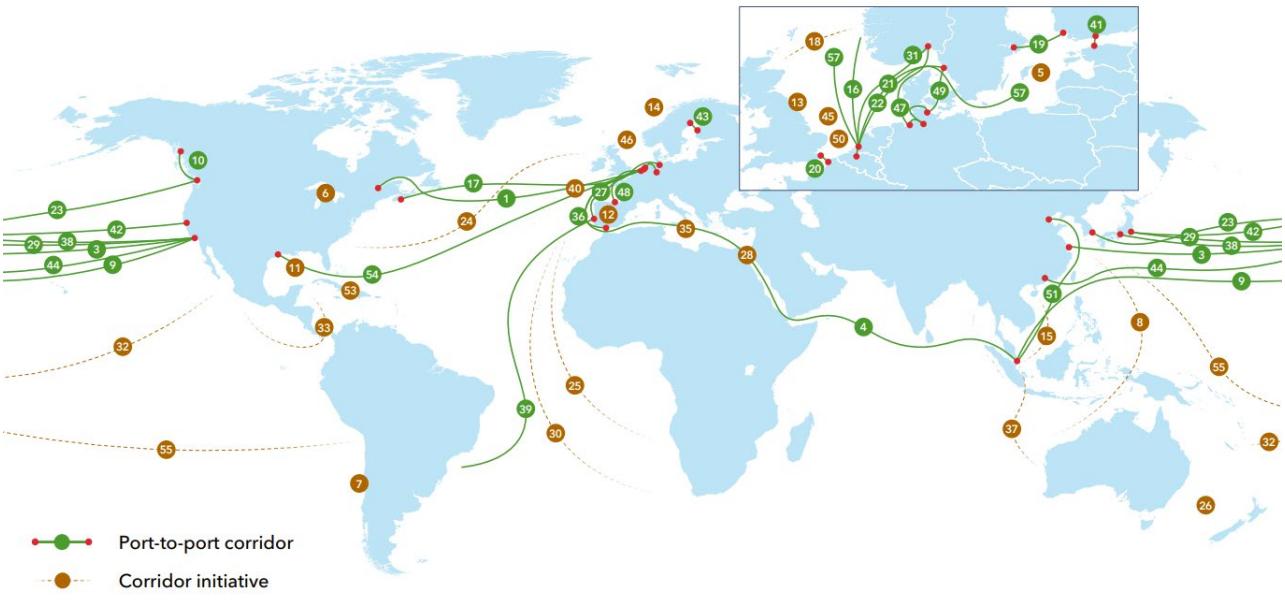

Figure 3-5: Global overview of announced green shipping corridor initiatives. Map showing status as of May 2024. Source: DNV's internal Green Shipping Corridor Database.

[28] Wasaline launches Green Corridor Fridays (October 2023): https://www.wasaline.com/en/portfolio-item/wasaline-green-corridor-fridays/

[29] Viking Line (August 2024), 90 per cent fewer emissions – work on the Baltic Sea's first green corridor culminates in an historic week: https://www.vikingline.com/press-room-old/79BD94FBE3BE4D30/

Table 3-2: List of global green shipping corridor initiatives as of November 2024. Note that initiatives marked with (*) is not shown in the map above (Figure 3-5) and those in **bold** have now moved on from exploration and are preparing for real-world implementation. Source: DNV's internal Green Shipping Corridor Database and Global Maritime Forum (2024).

1 Antwerp – Montreal	23 Busan – Seattle/Tacoma	46 UK – Norway
2 QUAD Shipping Taskforce*	24 US – UK taskforce	47 Oslo Fjord – Northern Germany
3 Shanghai – LA/Long Beach	25 Namibia – EU	48 Bilbao – Amsterdam – Duisport
4 Rotterdam – Singapore	26 Australia – New Zealand	49 Gothenburg – Kiel – Hamburg
5 European Green Corridor Network	27 Sines – Rotterdam	50 UK – Netherlands
6 Great Lakes – St. Lawrence Seaway	28 Suez Canal	51 Singapore – Tianjin (China)
(U.S./Canada)	29 Los Angeles (LA) – Yokohama/Tokyo	52 Denmark – US: Global South corridors*
7 Chilean Green Corridor Network	30 South Africa – Europe Iron Ore	53 Caribbean Green Shipping Corridor
8 Western Australia – East Asia Iron Ore	31 Oslo Fjord – Rotterdam	54 Antwerp-Bruges – Houston
9 LA/Long Beach – Singapore	32 U.S. – Fiji – Pacific blue shipping partnership	**55 Chilean copper to Far East**
10 Pacific Northwest-Alaska	33 U.S. – Panama	56 Canada Green Shipping Corridor Program*
11 Gulf of Mexico	34 G7 Corridors*	57 Rotterdam – Baltic Sea – Scandinavia
12 Green Corridors Spain	35 Mediterranean Corridor	58 Trelleborgs – Lübecks*
13 Clean Tyne Shipping Corridor	36 Rotterdam – Algeciras	59 Bilbao – Portsmouth*
14 Nordic Roadmap	37 Singapore – Australia	60 UK – Irland*
15 The Silk Alliance	38 LA – Nagoya	61 Indiana - Antwerp-Bruges*
16 Rotterdam – West-Coast Norway	39 Sines – Brazil	62 Green Panama Canal*
17 Halifax – Hamburg	40 UK – Spain	63 Norway-Brazil*
18 H2 powered North Sea Crossing	41 Helsinki-Tallinn and Muuga-Vuosaari	64 UK – Denmark*
19 Turku – Stockholm	42 Oakland – Yokohoma	65 New Zealand – Belgium*
20 Dover – Calais/Dunkirk ferry	43 Umeå – Vasa	66 TEN-T Corridor Network*
21 Gothenburg – North Sea Port (Ghent)	44 LA – Guangzhou	**67 Pacific Northwest – South Korea Car Carrier***
22 Gothenburg – Rotterdam	45 UK – Belgium	

3.2.2.2 Green shipping corridor development in the Mediterranean region

The non-exhaustive list of studies related to green shipping corridors in the Mediterranean region is presented in Table 3-3. It shows the high-level information of the studies that could be beneficial for the implementation of green shipping corridors in the region. Selected studies relevant to the objective of the Study are elaborated to draw insights into the possible adoption of similar measures and/or steps for the implementation of green shipping corridors in the Mediterranean region.

Table 3-3: List of studies related to green shipping corridors in the Mediterranean region

Name/Title	Scope and Highlight	References/Links
Green Corridors: The Spanish Opportunity	Spain's Green Corridors assessment urges swift action from stakeholders, focusing on route assessment, stakeholder engagement, feasibility studies, and route mapping for optimal development.	(Aparajit Pandey & Jesse Fahnestock, 2022) Link
Green Shipping Corridors in and out of Spain: Assessing route-based opportunities Produced	The assessment highlighted strong interest in zero-emission fuels at Spanish ports, favourable conditions for hydrogen bunkering, and opportunities in container, ro-ro, and cruise segments. Key trade sectors include food, car manufacturing, and textiles. Promising partnerships are with the UK, Italy, and the U.S.. Next steps involve feasibility studies and engaging policymakers for corridor implementation plans.	(Elena Talalasova, et al., 2023) Link
SuperGreen R&D Project, 7th Framework Programme, 2010 - 2013	From 2010 to 2013, an EU R&D project entitled "Supporting EU's Freight Transport Logistics Action Plan on Green Corridors Issues" (abbreviated name "SuperGreen [30] "), addressed the benchmarking of Green Corridors based on a total picture of key performance criteria, covering environmental, technical, economic, social and spatial planning aspects. The criteria included: - Energy efficiency and consumption, - Service quality, in terms of transport time, reliability, frequency and implementation of ICT measures - Environmental sustainability and emissions - Infrastructure sufficiency, congestion and bottlenecks - Social issues, land use and traffic safety.	Link
SuperGreen Handbook on Green Corridors	The first Handbook on Green Corridors, including maritime segments, and presenting: • What is a transport corridor? • What is a 'green' transport corridor? • Why do we need transport corridors? • How do we develop a green corridor? • How do we manage a green corridor?	(George Panagakos, et al., 2013) Link

[30] 3-year EC Coordinated Action Project (7th Framework Programme)

	• How do we monitor performance? • How can technology help? • Do we need a new approach in doing business? • How do green corridors relate with the TEN-T? • Where can we get more information?	
Assessing the Sustainability Potential of EU Transport Networks	This paper contributed to the research under the superGreen project. The objective is to provide with a multi-modal technology outlook on the applicability of green technologies on the corridors and their potential impact on the Key Performance Indicators (KPIs). This paper presents the SuperGreen approach on the high-level and detailed benchmarking of the green corridors with green technologies.	(Chara Georgopoulou & Nikolaos M.P. Kakalis, 2012) Link
Green technologies and smart ICT for sustainable freight transport	The purpose of this paper is to present the SuperGreen approach on the impact assessment of green technologies and ICTs on existing EU corridors. The current corridor performance, the so-called baseline, is compared to the case that green technologies and ICTs are implemented on the corridors. In the study, **the Mare Nostrum corridor including Mediterranean and Black sea trade routes** is considered. The impacts of green technologies including waste heat recovery systems, exhaust abatement systems and integrated short sea transport were investigated.	(Chara Georgopoulou, et al., 2014) Link
EU TEN-T Mediterranean Corridor	Presented earlier in the text; included here for sake of clarity	Link
EU TEN-T Scandinavian-Mediterranean Corridor	Presented earlier in the text; included here for sake of clarity	Link
EU TEN-T Orient/East-Med Corridor	Presented earlier in the text; included here for sake of clarity	Link
EU TEN-T Baltic Sea – Black Sea – Aegean Sea Corridor	Presented earlier in the text; included here for sake of clarity.	Link

Green Corridors: The Spanish Opportunity (Aparajit Pandey & Jesse Fahnestock, 2022)
This discussion paper has been developed by the Global Maritime Forum (GMF) and the Energy Transition Commission (ETC), in collaboration with the United Kingdom's UNFCCC COP 26 Presidency and the British Embassy in Madrid.
The objective is to explore the concept of green shipping corridor for shipping decarbonisation, building on the GMF and ETC report "The Next Wave", launched in 2021, and applying its insights to Spain, in light of the country signing the Clydebank Declaration for green shipping corridors to support the establishment of such green shipping corridors. The study looks into the four critical building blocks that need to be in place to establish a green shipping corridor in Spain. These include:

.1 **Cross-value-chain collaboration:** A green shipping corridor requires stakeholders who are committed to decarbonisation and are willing to explore new forms of cross-value-chain collaboration to enable zero-emission shipping from both the demand and supply side. Approximately 70% of cargo in Spanish ports consists of liquid bulk (like liquids or gases) and container trade (manufactured goods in containers), both of which offer significant decarbonisation opportunities. Key players in liquid bulk include Fertiberia, Repsol, and Cepsa, while Inditex, Grifols, and CIE Automotive are major in container trade. For the 20% of dry bulk cargo, companies like Acerinox and Ebro Foods are significant. Although few Spanish vessel operators are globally prominent, international companies like Maersk, Höegh Autoliners, Euronav, and Star Bulk are working to decarbonise their fleets. Zero-emission maritime fuels, for instance, from green hydrogen, require substantial infrastructure investment, with Spanish companies like Fertiberia and ArcelorMittal leading the way. Regulatory bodies, including Spain's Ministry of Ecological Transition and the Ministry of Transportation, are essential for establishing green shipping corridors and ensuring safety standards for fuel handling.

.2 **A viable fuel pathway:** The availability of zero-emission fuels and bunkering infrastructure to service zero-emission vessels are essential factors. Spain is poised to become a leading location for green hydrogen production due to its excellent solar and wind resources, strong industrial base, and strategic geographical location. The country aims to produce hydrogen at $1.5 per kilogram, giving it a competitive edge over other producers like Chile, Australia, and Saudi Arabia. The port of Algeciras, a top global bunkering port, underscores Spain's potential in the green fuel market. Green shipping corridors present opportunities for early adopters across the value chain, including distributors and shippers seeking a green premium. The scale of hydrogen production could also foster new industries, such as electrolyser manufacturing, with companies like Iberdrola exploring this potential. Spain's advantages could lead to significant economic benefits.

.3 **Customer demand:** Conditions need to be in place to mobilise demand for green shipping and to scale zero-emission shipping via the corridor. There is a significant cost gap between fossil fuels and zero-emission fuels, which will persist for some time, impacting ship owners and operators since fuel costs already constitute 25-40% of journey expenses. However, the overall cost impact of zero-emission shipping on delivering goods is relatively small, typically under 10% for most traded goods. Many cargo owners, including those in the Cargo Owners for Zero Emission Vessels (coZEV) initiatives[31], aim to fully decarbonise sea freight by

[31] coZEV initiatives: https://www.cozev.org/initiatives

2040, viewing early decarbonisation as a competitive advantage. Green shipping corridors can help by allowing cargo owners to test new business models and spread costs and risks. Spain has significant potential to mobilise demand for zero-emission shipping services, especially for goods that can bear a green premium. Currently, demand for zero-emission hydrogen is fragmented, and individual companies cannot achieve the necessary scale for efficient production. Establishing demand coalitions focused on zero-emission fuel supplies for routes in and out of Spain is essential, supported by a coordinated public-private effort to develop green shipping corridors.

.4 **Policy and regulation:** Policy incentives and regulations will be necessary to narrow the cost gap and expedite safety measures. To fully engage the value chain for green shipping corridors, reducing the cost gap between fossil fuels and zero-emission fuels is crucial. Key policy actions include establishing safe procedures for future fuels, regulating markets with Guarantees of Origin and green fuel certification, incentivising zero-emission fuel use, and reducing production costs. Spanish regulatory bodies can enhance policy impact by prioritising routes, identifying partner countries and ports, and harmonising measures with those at the other end of the corridor. This could involve mutual recognition of standards, port fee exemptions, or shared incentive schemes. Spain can leverage EU policies, particularly the EU Fit for 55 package, to support green shipping corridors. While it's uncertain if these measures will fully drive zero-emission value chains, Spain and its partners should aim to influence policy implementation, such as through revenue recycling to support green shipping corridors in Europe. Figure 3-6 provides an overview of some of the most feasible and impactful options for enabling and stimulating zero-emission shipping via green shipping corridors involving Spain.

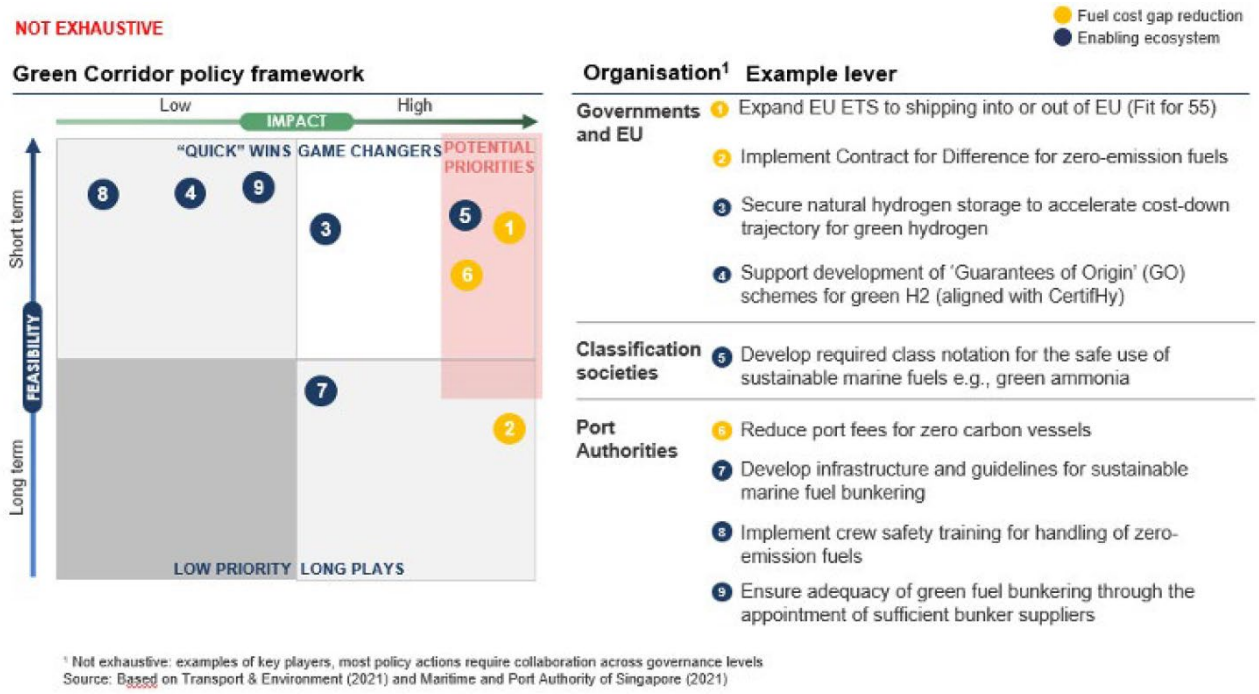

Figure 3-6: Green shipping corridor policy framework for Europe (Aparajit Pandey & Jesse Fahnestock, 2022)

Green shipping corridors in and out of Spain: Assessing route-based opportunities (Elena Talalasova, et al., 2023)

Following the previous study "Green Corridors: The Spanish Opportunity", this study identifies several promising international routes for establishing green shipping corridors in Spain, building on the route assessment methodology described in "The Next Wave". It offers a structured approach to prioritising routes and engaging key stakeholders at all stages of the process.

The underlying logic of the route prioritisation process is that decarbonising a route should significantly contribute to the overall decarbonisation of global shipping while still being comparatively feasible from an implementation standpoint within a reasonable timeframe (Figure 3-7). To arrive at the final list of route-based opportunities, an initial list of route suggestions provided by the ports was refined and ranked based on an assessment of their impact and feasibility against a set of criteria. This was done through an iterative process combining desk research, a survey and two rounds of discussions with stakeholders.

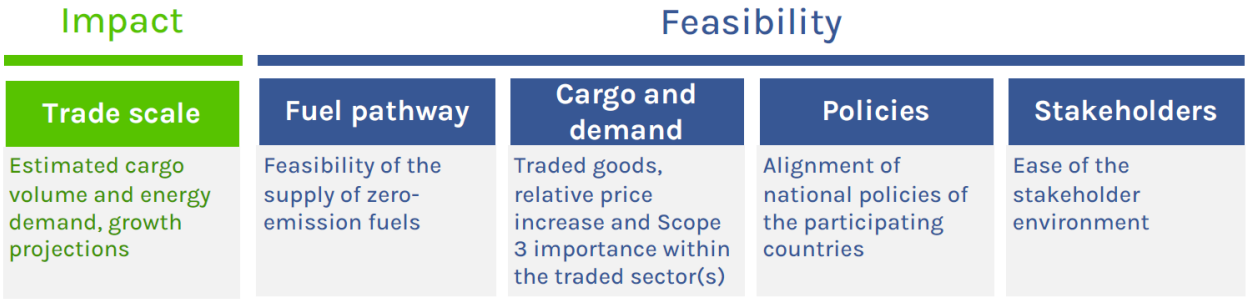

Figure 3-7: Assessment methodology (Elena Talalasova, et al., 2023)

The assessment demonstrated high levels of interest and varying degrees of activity around zero-emission fuels among Spanish ports. An overview of planned green hydrogen projects demonstrated generally favourable conditions for potential bunkering of hydrogen-based zero-emission fuels across the country's major ports.

On the shipping segment side, the results point to opportunities within the container, roll-on/roll-off (ro-ro), and cruise segments. Targeting routes with cargo owners within food and beverage, car manufacturing and textile sectors was recommended due to large volumes, high-value trade and balanced trade flows within these sectors.

Based on the scale of trade, energy demand, dominant trade segments and policy environment, the analysis identified several bilateral partnership opportunities within the European continent and beyond. The UK, Italy and the USA were identified as the most promising partner countries, followed by Türkiye, Morocco, and China. Several short- and deep-sea opportunities for green shipping corridors in Spain are identified, each with their own advantages and drawbacks across the categories of impact and feasibility, as demonstrated in Figure 3-8.

Route	Impact	Feasibility			
		Fuels	Demand and cargo	Policy	Stakeholders
Container; Liverpool - Bilbao					
Container; Valencia –Türkiye					
Container; Valencia, Algeciras – United States East Coast					
Container; Barcelona, Valencia – China					
Ro-ro; Spain – United Kingdom					
General cargo; Valencia – Italy					
Cruise; Barcelona					
Cruise; Spain Atlantic – United Kingdom					

Figure 3-8: Identified routes for green shipping corridors in and out of Spain (Elena Talalasova, et al., 2023)

If stakeholders are interested in the identified opportunities, the next step is to conduct corridor-specific feasibility studies focusing on infrastructure, policy, and financial needs for securing local fuel supply in Spain. Policymakers should be involved in developing implementation plans, as national, bilateral, and regional policies are crucial for success. Additional corridors can be explored by stakeholders using the methodology in the report.

Summary

The two above-mentioned studies could be relevant for the planning and implementation of green shipping corridors in the Mediterranean region. Similar to Spain, other Mediterranean coastal States (e.g., Greece, France, Italy, Türkiye, etc.) could leverage their potential to fulfil the four main criteria, i.e., cross-value-chain collaboration, a viable fuel pathway, customer demand, as well as policy and regulation, hence to identify the opportunities for green shipping corridors in the Mediterranean region. Similar to Spain, Mediterranean coastal States that are EU Member States can leverage EU policy, particularly the EU Fit for 55 package, which includes shipping-specific measures, to support green shipping corridors. Based on the outcomes of the abovementioned studies, an assessment of potential international and regional routes for establishing green shipping corridors could be performed using the methodology described in “The Next Wave”.

3.2.2.3 Green Maritime Hubs

At the intersection of land and sea, ports can play a pivotal role in the decarbonisation of shipping. Ports are a natural hotspot for sector coupling and energy system integration as they host many industry sectors including maritime, oil and gas, cruise-tourism, heavy transport, bulk transfer, manufacturing industries, power generation, electricity grid operators and offshore wind (DNV, 2020). According to the study, “Differentiating on port fees to accelerate the green maritime transition” (Alvar Mjelde, et al., 2019), ports could play a key role in the maritime fuel transition by serving as energy hubs providing both shore-side electricity and infrastructure for storing and

fuelling ships with alternative fuels. They could also play a significant role by investing in digitalisation as well as improving coordination and synchronisation between ship and port to reduce ship energy consumption, emissions and stationary time.

The energy density of zero-emission fuels is lower compared to conventional fuels; hence more frequent bunkering is required. With a wide range of fuel options, ports are challenged to decide on which fuel infrastructure to invest in. However, a hub does not have to be a specific port but could also be an area or smaller region where the same fuel type could serve several vessels. Clustering ports into hubs could ease infrastructure development and a steady fuel supply. The energy hubs could take advantage of nearby wind parks or other installations that provide a steady supply of renewable energy. Another option for bunkering ship fuels is bunker barges, which are mobile and can adapt their availability to the geographical demand of ship traffic.

To identify the potential for being a green maritime hub, and investigate potential demand for future fuels, it is possible to assess the current ship traffic and energy use for ships operating in and out of a specific port or a hub. The hub can be a cluster of ports located in the same geographical area. In the Nordic countries, DNV has performed an Automatic Identification System (AIS) analysis of Nordic ship traffic and energy use, providing information on the energy demand from different ship segments and traffic types, which was used to identify potential Nordic energy hubs (DNV, 2022c). Such analysis can also assess how many ships are involved in routes to and from the ports, the traffic regularity, and how routes or ports may be clustered.

Corridors and hubs – coordinating energy supply

Green shipping corridors will require the supply of green energy at one or both ends or nearby ports, which adds a layer of complexity to their implementation. Large ports with high fuel consumption from numerous visiting ships are promising candidates to become energy hubs, particularly if they can serve as distribution hubs for fuels to surrounding ports. Transforming these large ports into green maritime hubs without emissions will have a significant impact on emission reductions, however, the feasibility of implementing zero-emission solutions might be challenging due to a high number and potentially large variety of actors involved.

While these large ports have a significant impact due to high energy use of activities connected to the ports, their feasibility to be early green maritime hubs can be lower because of the many actors involved and the complexity of voyage patterns for ship traffic connected to the ports. Ports with high fuel consumption but simpler voyage structures, such as those used by fishing or offshore service vessels that frequently return to the same ports, may have higher feasibility for fast implementation as zero-emission energy hubs (green hubs). This is because the number of actors is limited, and their fuel demand is more consistent.

Additionally, ports that are not part of a shipping corridor (or maybe part of a single-port or single-point corridor[32]) or do not have high total fuel consumption can still be suitable for bunkering clean fuels. Small, less central ports serving offshore supply vessels, well boats (for aquaculture), and fishing vessels are good examples of promising local green maritime hubs. These vessels often operate without having to use other ports, reducing the coordination challenges associated with bunkering (Menon, 2022).

[32] Single-port or single-point corridor refers to a corridor that establish zero-emission shipping routes around a particular location, i.e., a port hub allowing round-trip bunkering, https://cms.zerocarbonshipping.com/media/uploads/documents/Project-presentation.pdf

Trends related to the development of green maritime hubs

The trends related to the development of green maritime hubs are often related to the twin transition: Decarbonisation and Digitalisation. The **twin transition** of decarbonisation and digitalisation in maritime ports refers to the simultaneous efforts to reduce carbon emissions and enhance digital capabilities. This dual approach aims to create more sustainable and efficient port operations.

Decarbonisation involves reducing GHG emissions from port activities. Key strategies include:

.1 **Electrification:** Replacing diesel-powered equipment with electric alternatives.

.2 **Renewable Energy:** Utilising solar, wind, and other renewable energy sources to power port operations and produce zero-emission fuels (also partnering up with fuel producers).

.3 **Alternative Fuels:** Adopting cleaner fuels like LNG, hydrogen, and biofuels for ships and port machinery.

.4 **Energy Efficiency:** Implementing measures to reduce energy consumption, such as optimising logistics and improving infrastructure.

It is also important to mention that technologies such as the adoption of energy-saving devices, electrification, carbon capture and storage, and nuclear propulsion can play a role in the decarbonisation of shipping, reducing the need for the supply of zero-emission fuels (green fuels).

Digitalisation involves integrating advanced digital technologies to improve port operations. Key strategies include:

.1 **Automation:** Using automated systems for cargo handling, reducing the need for manual labour and increasing efficiency.

.2 **Internet of Things (IoT) and Sensors:** Deploying IoT devices and sensors to monitor and manage port activities in real time.

.3 **Digital Twins:** Creating virtual replicas of physical port assets to simulate and optimise operations.

.4 **Just-In-Time (JIT) Arrival:** Enabling vessels to optimise their speed during voyages to ensure they arrive just in time for their scheduled berth slot, avoiding congestion, and hence reducing fuel consumption and CO_2 emissions during port calls.

.5 **Data Analytics:** Leveraging big data and analytics to make informed decisions and improve operational efficiency.

A well-planned and coordinated twin transition can provide several benefits for the ports. Decarbonisation efforts lower the carbon footprint of port activities, and the ports can also establish initiatives that encourage shipowners to take extra decarbonisation steps, contributing to global climate goals. Digital technologies that streamline operations can reduce delays and improve throughput, resulting in enhanced efficiency. Standardised emission reporting and data handling can also help with regulatory compliance, preparing the ports to meet the increasingly stringent

environmental regulations and standards. Improved efficiency and reduced energy consumption can lead to significant cost savings over time.

To summarise, some key elements important for the development of green maritime hubs:

.1 **Fuel supply and bunkering:** Providing a steady supply of green fuels, along with the necessary infrastructure for storage and distribution to support the transition to sustainable maritime operations is key for a green maritime hub.

.2 **Renewable Energy:** Solar, wind, and other renewable energy sources should be utilised to power port operations. Ports are working with energy companies and other stakeholders to develop innovative solutions for energy management and emissions reduction.

.3 **Port Electrification and Shore Power:** Ports should be equipped with electric vehicles and equipment to reduce reliance on fossil fuels. Ships that can use electricity directly through shore power and battery storage have significant efficient energy use and emission reductions compared to the significantly more energy-intensive alternative of using electro-fuels, exemplified by green ammonia. Shore power developments and requirements in ports are also emerging.

.4 **CO_2 reception and handling:** A green maritime hub should be able to provide a deposit location for shipowners investing in onboard carbon capture. The global plans for CO_2 storage need to be developed for onboard carbon capture to play an important role in shipping, potentially allowing ships to continue using fossil fuels while decarbonising.

.5 **Digitalisation:** Digital technologies should be utilised to track energy usage, monitor performance, enhance efficiency, and reduce emissions.

.6 **Safety standards and procedures**: Safety standards and procedures for handling operations involving zero-emissions fuels and technologies are required and shall be adhered to ensure safe operations.

Green Hubs in the EU

The concept of EU Green Ports is introduced in the EU Maritime Spatial Planning (MSP) process, with airports and ports being multimodal green hubs for sustainable and smart mobility (European Commission, 2021). MSP is an EU initiative to coordinate a process for cross-sectoral management of maritime spaces, aiming to balance economic, environmental, and social objectives. In MSP, green maritime hubs are strategic areas within coastal and maritime zones that support the EU's sustainability goals, particularly in line with the European Green Deal and Blue Economy[33] initiatives.

The following characteristics describe the concept of EU Green Ports, in accordance with the MSP:

[33] Blue Economy refers to any economic activity relating to oceans and seas. It covers a broad range of established and emerging sectors. In 2021, the European Commission introduced a new approach for a sustainable blue economy in the EU. The new approach aligns marine activities with the goals of the European Green Deal and promotes consistency among blue economy sectors such as aquaculture, fisheries, clean energy, maritime transport, green shipping, shipbuilding and coastal tourism. It also highlights the importance of research, skills, innovation, and cooperation among countries and maritime users. https://oceans-and-fisheries.ec.europa.eu/ocean/blue-economy/sustainable-blue-economy_en

.1 **Sustainable Port Infrastructure:** MSP promotes the development of ports and maritime hubs that integrate sustainable infrastructure, reducing environmental impacts through renewable energy, alternative fuels (e.g., LNG, hydrogen), and emissions-reduction technologies. These ports play a key role in decarbonising the maritime sector.

.2 **Environmental Protection:** Green hubs under MSP are designed to minimise their footprint on marine ecosystems, avoiding critical habitats, and protecting biodiversity. MSP ensures that green maritime hubs do not conflict with Marine Protected Areas (MPAs) or other sensitive environments.

.3 **Integrated Coastal and Maritime Use:** MSP emphasises the efficient use of space within green maritime hubs, ensuring that activities like shipping, offshore renewable energy, and fishing are coordinated. This reduces conflicts between uses and promotes synergies in line with sustainability.

.4 **Resilience to Climate Change:** MSP highlights the need for maritime hubs to be adaptable and resilient to climate change impacts, such as sea-level rise and extreme weather events. This involves strategic planning for coastal protection and sustainable urban development in port areas.

.5 **Circular Economy and Waste Management:** Green maritime hubs foster a circular economy by integrating sustainable waste management practices, promoting recycling, and reducing waste generated by port activities and shipping.

.6 **Innovation and Smart Technologies:** MSP encourages the use of smart maritime technologies in green hubs, such as digitalised logistics, smart grids, and automation, which enhance operational efficiency while reducing environmental impact.

Maritime Hubs in the European and Mediterranean region

The Mediterranean region is home to several key maritime hubs, recognised under EU and international regulations, such as the TEN-T policy and various EU maritime strategies like the Blue Economy and MSP. These hubs are critical for regional and global trade, sustainability, and decarbonisation efforts. Here are some of the most important maritime hubs:

.1 **Port of Piraeus (Greece):** The largest port in Greece and a core TEN-T hub, Piraeus is a key gateway for Europe, Asia, and Africa. It focuses on logistics, shipbuilding, and sustainability through electrification and alternative fuel initiatives.

.2 **Port of Barcelona (Spain):** A strategic TEN-T port, Barcelona leads in green initiatives, including renewable energy use, smart technologies, and emissions reduction. It plays a critical role in Blue Economy projects, contributing to sustainable shipping in the Mediterranean.

.3 **Port of Genoa (Italy):** As a crucial hub in the TEN-T network, Genoa connects the Mediterranean with northern Europe. The port is actively involved in decarbonisation projects, LNG bunkering, and advancing green shipping routes in line with the European Green Deal.

.4 **Port of Marseille-Fos (France):** This major TEN-T node is a leader in sustainability initiatives, including hydrogen and offshore wind projects. Marseille plays a key role in supporting the EU's environmental goals through its focus on green port infrastructure.

.5 **Port of Naples (Italy):** Naples, a core TEN-T port, plays a significant role in Italy's maritime trade. It is expanding its capacity for sustainable shipping by focusing on energy efficiency and renewable energy, making it a key player in the region's green transition.

.6 **Port of Thessaloniki (Greece):** Thessaloniki is a strategic port within the TEN-T network, providing a vital link between the Mediterranean and the Balkans. The port is investing in sustainable technologies and logistics improvements, supporting EU goals for sustainable maritime transport.

.7 **Port of Gibraltar (UK):** Gibraltar, UK, while outside the EU, is a critical hub for maritime traffic in the western Mediterranean and a key bunkering port. It is working on greener refuelling options, such as LNG bunkering, to align with global maritime decarbonisation efforts under the IMO's regulations.

.8 **Port of Valencia (Spain):** Another TEN-T core hub, Valencia is known for its innovation in sustainability, including electrification, renewable energy adoption, and emission reduction programs. It plays a vital role in the Mediterranean Blue Economy strategy[34].

.9 **Tanger Med Port (Morocco):** The port is steadily progressing in cargo volumes, in addition to becoming a clean energy hub as part of its strategy and decarbonisation plan. The port has partnered with the members of the World Bank Group to expand the terminal and strengthen its strategic position as a hub for regional and global trade.

.10 **Port of Algeciras (Spain):** The port is participating in the project for the reduction of the carbon footprint of maritime transport as part of the initiative by the EU's Connecting Europe Facility (CEF) transport aid programme. Under this project, the LNG bunker tanker has carried out 42 bunkering operations in the port, which is part of the 'LNGhive 2' strategy in line with European Directive 94/2014 on alternate fuels to improve air quality at sea and in ports.

.11 **Port Said (Egypt):** A chemicals firm received the first methanol bunkering permit for supply at East and West Port Said. In the meantime, green methanol production in Egypt in collaboration with various agreements signed with giant shipping companies such as Maersk, and an industry consortium consisting of Abu Dhabi Port group, Egyptian partners Transmar, a prominent container shipping line and terminal operator, and Orascom Construction, a globally

[34] This strategy was elaborated in the paper, "Blue economy in the Mediterranean: Case studies, lessons and perspectives". The study assesses and highlights the current weight and various opportunities provided by the blue economy in the Mediterranean in support of sustainable development and to showcase a range of concrete examples and good practices of how blue economy works in the region. https://planbleu.org/sites/default/files/publications/cahier19_en_blue_economy_web.pdf

recognized engineering and construction firm. The project plans to encompass not just the methanol plant itself but also storage and export facilities for the eco-friendly fuel.

As shown in Figure 3-9, almost half of the total number of Bunker vessels for LNG and Methanol are in the European region, as per DNV's 'Alternate Fuel Insights' data.

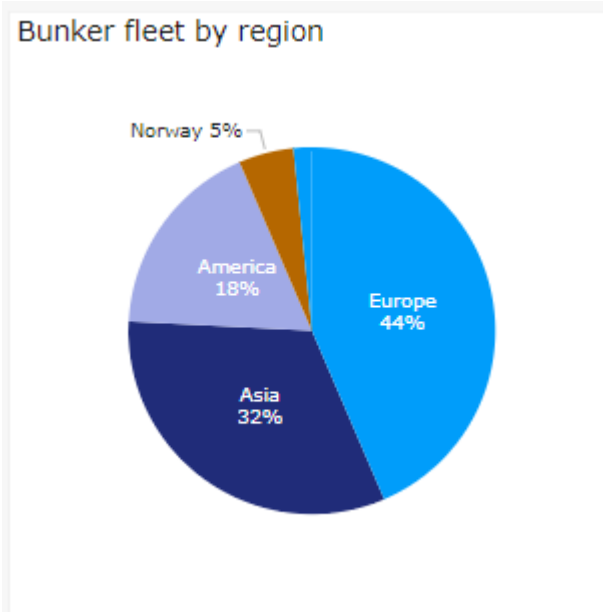

Figure 3-9: Total number of LNG and Methanol bunker vessels in operation in the world. Source: DNV AFI

These hubs are essential in advancing sustainable maritime transport in the Mediterranean, contributing to decarbonisation, and supporting the EU's broader environmental and economic goals in the region. A sizeable number of alternative fuel bunker vessels in Europe is a key enabler in establishing green shipping corridors and green maritime hubs.

Green developments in major shipping hubs

At a more global level, major maritime ports are preparing for the upcoming fuel shift in shipping. Some of the developments in key ports taking action to position themselves as green maritime hubs in the transition towards more sustainable maritime transport are highlighted below. These ports are setting examples for others to follow by integrating sustainable practices and technologies into their operations.

.1 **Port of Singapore:** Singapore is the world's largest bunkering port and a major global hub that is investing in green technologies. The port is working on ammonia, methanol and electrification projects, using LNG as a transition fuel, and implementing digital solutions to optimise operations and reduce emissions. Singapore has engaged in several green and digital shipping corridors, partnering up with ports such as Rotterdam, Los Angeles/Long Beach, Tianjin and Shandong.

.2 **Port of Rotterdam (The Netherlands):** Rotterdam is one of the largest and most advanced ports in Europe. It focuses on reducing emissions using biofuels, hydrogen, and electrification of port operations. The port also has extensive facilities for recycling and waste management. As a partner of the Rotterdam-Singapore Green and Digital Corridor, the port is committed to achieving early commercialisation of sustainable fuels and accelerating the fuel switch.

.3 **Port of Los Angeles (USA):** The Port of Los Angeles (LA) is a leader in sustainability initiatives. It has implemented the Clean Air Action Plan, which includes measures like shore power for ships, electric vehicles, and renewable energy projects. The port is also engaged in several green shipping corridor partnerships with ports of Singapore, Shanghai, Yokohama, Tokyo, Nagoya, Guangzhou, and the QUAD Shipping Taskforce[35].

.4 **Port of Yokohama (Japan):** The Port of Yokohama is developing facilities to store and use green methanol for its shipping fleet. It is also investing in renewable energy sources and digital technologies to enhance efficiency and sustainability. The port is engaged in green shipping corridor initiatives, with ports such as Oakland, LA and Tokyo. The port is also a part of the QUAD Shipping Taskforce.

.5 **Port of Antwerp-Bruges (Belgium):** The Port of Antwerp-Bruges, including the ports of Antwerp and Zeebrugge, has ambitions to be a carbon-neutral port by 2050. The port is investing in hydrogen projects, renewable energy, and carbon capture and storage technologies. The port also promotes sustainable logistics and transportation. The port is involved in several corridor initiatives with the ports of Montreal, Houston and Indiana.

.6 **Port of Gothenburg (Sweden):** Gothenburg is known for its green initiatives, including the use of LNG, shore power, and electric cranes. The port is also involved in various projects to promote biodiversity and reduce environmental impact. The port is part of several corridors linking Scandinavia to continental Europe, such as the Gothenburg-Rotterdam corridor, the Gothenburg-Kiel-Hamburg corridor, and Gothenburg-North Sea Port corridor.

Summary

Green shipping corridors will require the supply of green energy at one or both ends or nearby ports, adding a layer of complexity to their implementation. Large ports with high fuel consumption from numerous visiting ships are promising candidates to become energy hubs, particularly if they can serve as distribution centres for fuels to surrounding ports. While these large ports have a significant impact due to the high energy use of activities connected to them, their feasibility as early green maritime hubs can be lower because of the many actors involved and the complexity of voyage patterns for ship traffic. Ports with high fuel consumption but simpler voyage structures, such as those used by fishing or offshore service vessels that frequently return to the same ports, may have higher feasibility for fast implementation as zero-emission energy hubs (green hubs).

[35] The Quad Shipping Task Force is an initiative launched by the QUAD countries, i.e., Australia, India, Japan, and the U.S., that aims to form a network dedicated to greening and decarbonizing the shipping value chain and establish two or three Quad low-emission or zero-shipping corridors by 2030., https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/24/fact-sheet-quad-leaders-summit/; https://www.mofa.go.jp/files/100347798.pdf

The development of green maritime hubs is often driven by the twin transition of decarbonisation and digitalisation. This refers to the simultaneous efforts to reduce carbon emissions and enhance digital capabilities, aiming to create more sustainable and efficient port operations. Apart from digitalisation, key elements important for the development of green maritime hubs include a steady supply of green fuels for bunkering, distribution, and storage, utilisation of renewable energy, provision of port electrification and shore power, CO2 reception and handling facilities, and implementation of safety standards and procedures for safe operations.

The Mediterranean region is home to several key maritime hubs recognized under EU and international regulations. These include the Ports of Piraeus and Thessaloniki in Greece, the Ports of Barcelona and Valencia in Spain, the Ports of Genoa and Naples in Italy, the Port of Marseille-Fos in France, and the Port of Gibraltar in the UK. Globally, several green developments are underway in major shipping hubs where activities related to green shipping corridors are taking place. These include the Port of Singapore, the Port of Rotterdam in the Netherlands, the Port of Los Angeles in the USA, the Port of Yokohama in Japan, the Port of Antwerp-Bruges in Belgium, and the Port of Gothenburg in Sweden.

3.2.3 Best practices and innovative solutions for the implementation of green shipping corridors and green maritime hubs

Most green shipping corridors are still under development, making it challenging to assess their effectiveness. In previous sections (3.2.1 and 3.2.2), a high-level overview of the frameworks, policies, and key green shipping corridors under development was presented. Building on these foundations, this section highlights the best practices and innovative solutions that are being implemented and planned globally to establish green shipping corridors. These solutions are aligned with the frameworks and studies examined, emphasising how the corridor initiatives are working on practical approaches to accelerate decarbonisation efforts in international shipping.

3.2.3.1 Best Practices

.1 Collaboration and partnership

The core of the green shipping corridor concept is establishing the required level of understanding and agreement among the stakeholders for a specific transport system, such that the cost and risk level associated with using zero-emission fuels become acceptable. This will require innovative ways of collaboration (DNV, 2022b). Green shipping corridors require close cooperation between public and private stakeholders, including port authorities, shipping companies, fuel providers, regulators, and technology developers. Having all necessary stakeholders around the same table facilitates collaboration, early identification of bottlenecks, and a common understanding of each stakeholder's motivation for being in the corridor partnership. Figure 3-10 below provides an analogy of a system of stakeholders involved in a green shipping corridor. In such a system, 'breaking the circuit' at any point will cut the current through all components, and the lights metaphorically go out for all the lightbulbs. In the green corridor value chain, if one stakeholder fails to overcome their barriers and produce a sound business case, the business cases for all stakeholders will fail, and the green shipping corridor will not be established (DNV, 2023b). An example of a green shipping corridor that has explored and implemented this practice is the Rotterdam-Singapore Green and

Digital Shipping Corridor, where, the partners consist of authorities, ports, ship liners, energy companies, universities, etc. (Port of Rotterdam, et al., 2024).

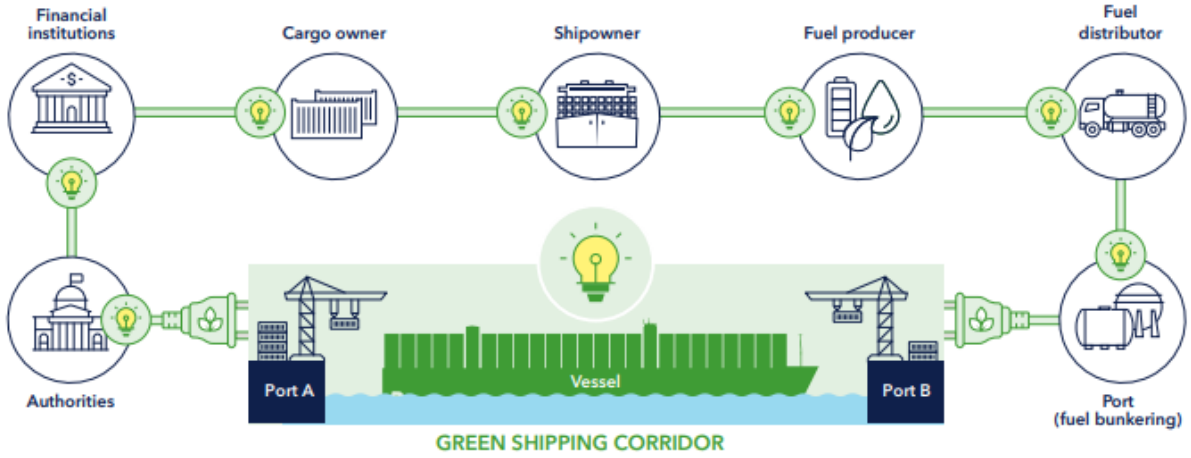

Figure 3-10: Simplified illustration of interconnections between selected stakeholders in a green shipping corridor ecosystem – similar to a series electric circuit, all stakeholders are connected end-to-end, forming a single path for current to flow (DNV, 2023b)

.2 Standardisation & Regulation Alignment

Alignment to International Standards: Harmonisation of regulations across jurisdictions is critical to avoid discrepancies that hinder shipping operations across borders. It is very crucial to have an alignment with IMO's rules and regulations, including the existing measures, e.g., Carbon Intensity Indicator (CII), Energy Efficiency Existing Ship Index (EEXI), etc., as well as the upcoming measures, e.g., IMO mid-term measures, IMO Life Cycle Assessment (LCA) guidelines, Market-Based Measures (MBMs), etc.

Standardised Ship and Shore Infrastructure: To support green shipping corridors and green maritime hubs, ships and ports need standardised bunkering and refuelling infrastructure for alternative fuels like ammonia, methanol, or hydrogen. IMO and port authorities should adopt globally agreed standards for ship and shore infrastructure for safe handling and bunkering.

.3 Infrastructure Development

Alternative Fuel Bunkering: Establishing safe, efficient bunkering facilities for alternative fuels at major ports along these corridors is a priority. Hydrogen, ammonia, biofuels, and synthetic e-fuels [36] require dedicated storage and refuelling stations.

Shore Power Integration: Encouraging ports to provide renewable shore power to vessels during docking reduces emissions. The widespread implementation of shore-side electrification is highly recommended.

.4 Data Collection & Assessment

[36] E-fuels refer to electrofuels produced using renewable electricity based on hydrogen made by hydrolysis, https://www.dnv.com/maritime/publications/maritime-forecast/

Data transparency and sharing protocols ensure that emissions reductions are tracked accurately. This involves adopting digital monitoring systems, automatic identification systems (AIS), and blockchain-based certification for fuel sources. Also, KPIs such as emissions per nautical mile, fuel usage efficiency, and ship lifecycle analyses should be standardised to assess corridor performance. Digital platforms are critical for real-time data capture and emissions reporting.

Summary

The core of the green shipping corridor concept is to establish the necessary understanding and agreement among stakeholders for a specific transport system, making the cost and risk levels associated with using zero-emission fuels acceptable. Green shipping corridors require close collaboration and partnership between public and private stakeholders, including port authorities, shipping companies, fuel providers, regulators, and technology developers. Harmonising regulations across jurisdictions in alignment with international standards for shipping operations, as well as standardising ship design and shore infrastructure, are key to establishing green shipping corridors. Prioritising the development of alternative fuel bunkering and shore power infrastructures is essential to support the establishment of these corridors. Additionally, data collection and assessment through digital platforms are crucial for tracking energy usage, monitoring performance, enhancing efficiency, and reducing emissions.

3.2.3.2 Innovative Solutions

.1 **Alternative Fuels**

Investing in ammonia and hydrogen infrastructure is a critical innovation for long-term sustainability. These fuels are promising for long-range shipping routes due to their low carbon footprint. For a quicker transition, second-generation biofuels and methanol can be integrated into existing engines. The GMF promotes the adoption of scalable biofuel solutions along key trade routes. Several green shipping corridors are fuel-specific, e.g., Australia-Asia Iron Ore on ammonia, Oslo-Rotterdam on hydrogen, while some port-led initiatives adopt a multiple fuel option approach, e.g., Singapore-Rotterdam.

.2 **Decarbonisation and Energy Efficiency Technologies**

In addition to the adoption of alternative fuels, vessel operators can adopt operational and technical measures, e.g., wind-assisted propulsion systems, air lubrication systems, battery hybridisation, etc., to enhance vessel energy efficiency and reduce emissions. Similarly, port operators could adopt appropriate measures, e.g., battery electrification, and fuel cells, etc. for harbour craft and electrification technologies, e.g., electric cargo handling equipment, etc., for port operations.

.3 **Digitalisation**

Digitalisation is the key enabler for decarbonisation, where emissions can be tracked and quantified for optimal management. It enables the seamless sharing of data among various stakeholders, including port authorities, shipping companies, and logistics providers, hence, streamlining operations and reducing

administrative burdens. Some corridors focus not only on green shipping but also on digital shipping, e.g., Rotterdam-Singapore, Singapore-Port of Los Angeles – Port of Long Beach and Singapore-Shandong Green and Digital Shipping Corridors.

.4 **Sourcing for Financial Instruments and Support Mechanisms**

Critical for the realisation of green shipping corridors will be to find ways to share risk and close the significant investment and operational cost gaps. In this regard, early identification and mapping of financial instruments and supporting schemes relevant to the green shipping corridor is critical. A key output is an overview of the relevant supporting schemes in each country involved in the corridor and cost-sharing possibilities among the corridor partners.

Summary

The green shipping corridor initiatives focus on zero-emission fuels, such as ammonia and hydrogen. In addition to these fuels, decarbonisation and energy efficiency technologies—like wind-assisted propulsion systems, air lubrication systems, and battery hybridisation—offer innovative solutions to enhance vessel energy efficiency and reduce emissions. Digitalisation plays a crucial role in enabling decarbonisation by allowing emissions to be tracked and quantified for optimal management. Some corridors aim to integrate both green and digital shipping, emphasizing the importance of decarbonisation and digitalisation. In realizing green shipping corridors, it is critical to find ways to share risks and bridge the significant investment and operational cost gaps. Therefore, appropriate financial instruments and support mechanisms are essential to ensure the successful implementation of green shipping corridors.

3.2.4 Overview of actions, incentive schemes and other relevant mechanisms for the realisation of green shipping corridors and green maritime hubs

While the previous sections covered the policies, frameworks, initiatives, best practices as well as innovative solutions related to green shipping corridors, the emphasis of this section is placed on the actions including the plans developed for implementing the green shipping corridors as well as the incentive schemes that are currently available to support the development of green shipping corridors.

3.2.4.1 Actions (Implementation Plan)

Some of the announced corridor initiatives have already entered the planning stage and started to develop implementation plans with actions. Below is an overview of some public implementation plans:

.1 **Silk Alliance Green Corridor Cluster:** providing an implementation plan for developing green shipping corridors for the members of the Silk Alliance;

.2 **The Next Wave: Green Corridors:** providing suggested implementation plans and roadmaps for the Australia-Japan Iron Ore corridor, the Asia-Europe containership corridor and the Northeast Asia (Japan/Korea) – USA car carriers corridor;

.3 **The Clean Tyne Shipping Corridor:** providing a shipping corridor roadmap intended to stimulate regional stakeholders to work together on their strategies to decarbonise the maritime sector in the northeast, highlighting the key milestones and activities that would enable the supply of a green methanol bunkering hub at the Port of Tyne and the development of the Tyne-Rotterdam corridor; and

.4 **Rotterdam-Singapore Green & Digital Shipping Corridor:** providing some insights into the potential demand for sustainable fuels coming from the partners and the conditions to make this a reality, including the required support and actions.

Silk Alliance Green Corridor Cluster

The Silk Alliance has developed an implementation plan starting from 2023 to 2030, as shown in Figure 3-11. It can be seen that the ultimate goals are to scale ammonia supply for Silk Alliance demand, being delivered to Singapore, and to deploy near zero ammonia vessels on the corridor between 2028 and 2030.

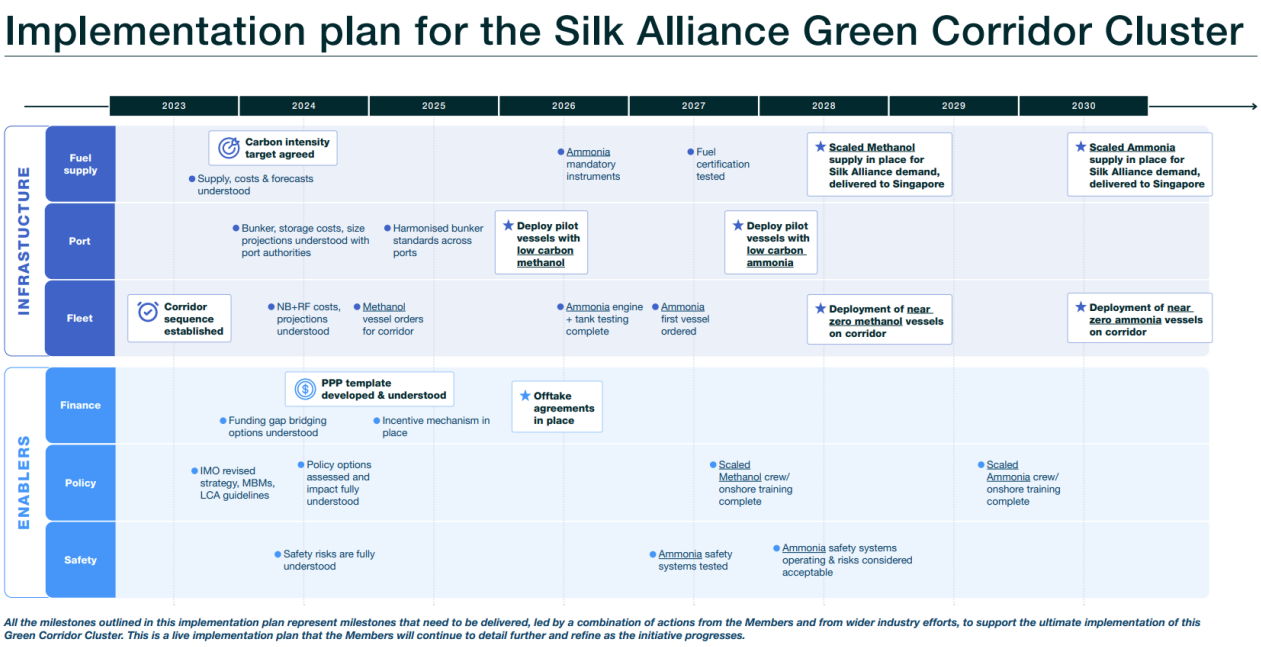

Figure 3-11: Silk Alliance Implementation Plan (Silk Alliance, 2023)

To achieve such goals, key milestones were outlined to be completed as immediate steps, corresponding to three workstreams: 1. Fleet and fuel demand, 2. Fuel supply, and 3. Finance. Three interconnected workstreams were initiated to support the implementation of the Green Corridor Cluster. These workstreams are highly interactive, with tasks in each aiding the progress of the others, as illustrated in Figure 3-12. Initially, the fleet and fuel demand workstream focused on estimating the total demand for the Silk Alliance fleet, based on the Implementation Plan's endorsement. This workstream is linked to the fuel supply workstream, which aims to reach a consensus on fuel carbon intensity levels and fuel cost gap estimations. Both of these workstreams feed into the third workstream on Finance, which seeks to determine the scale of the cost gap and identify mechanisms to bridge this gap across both the fleet and fuel supply.

As work progresses and interactions among these workstreams increase, Silk Alliance members will discuss the way forward, with the ultimate goal of achieving the milestones set out in the Implementation Plan.

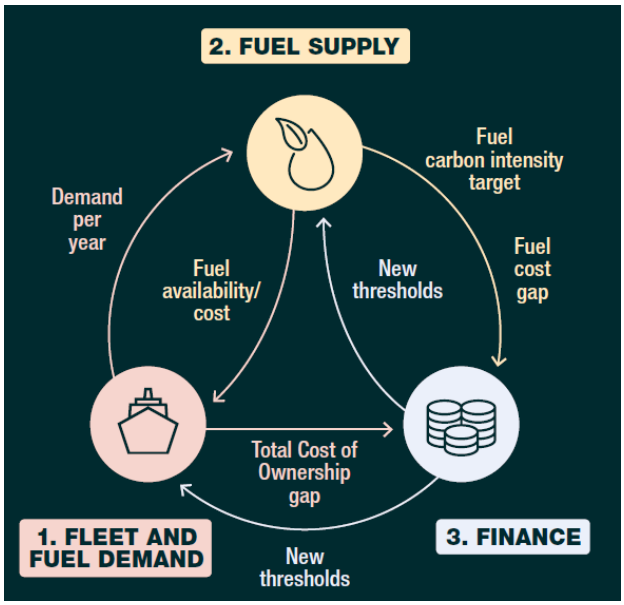

Figure 3-12: Interactions between the three workstreams (Silk Alliance, 2023)

The Next Wave: Green Corridors

Apart from the above-mentioned implementation plans, The Next Wave report (Global Maritime Forum, 2021) provides indicative "Route Maps" for the corridors studied based on input gathered from industry stakeholders (though not from governments or civil society) that could be used as a reference for developing implementation plans. The examples of these roadmaps for the Australia-Japan Iron Ore Corridor, Asia-Europe containership corridor, and Northeast Asia (Japan/Korea) – USA car carriers corridor, are shown below in Figure 3-13, Figure 3-14 and Figure 3-15, respectively.

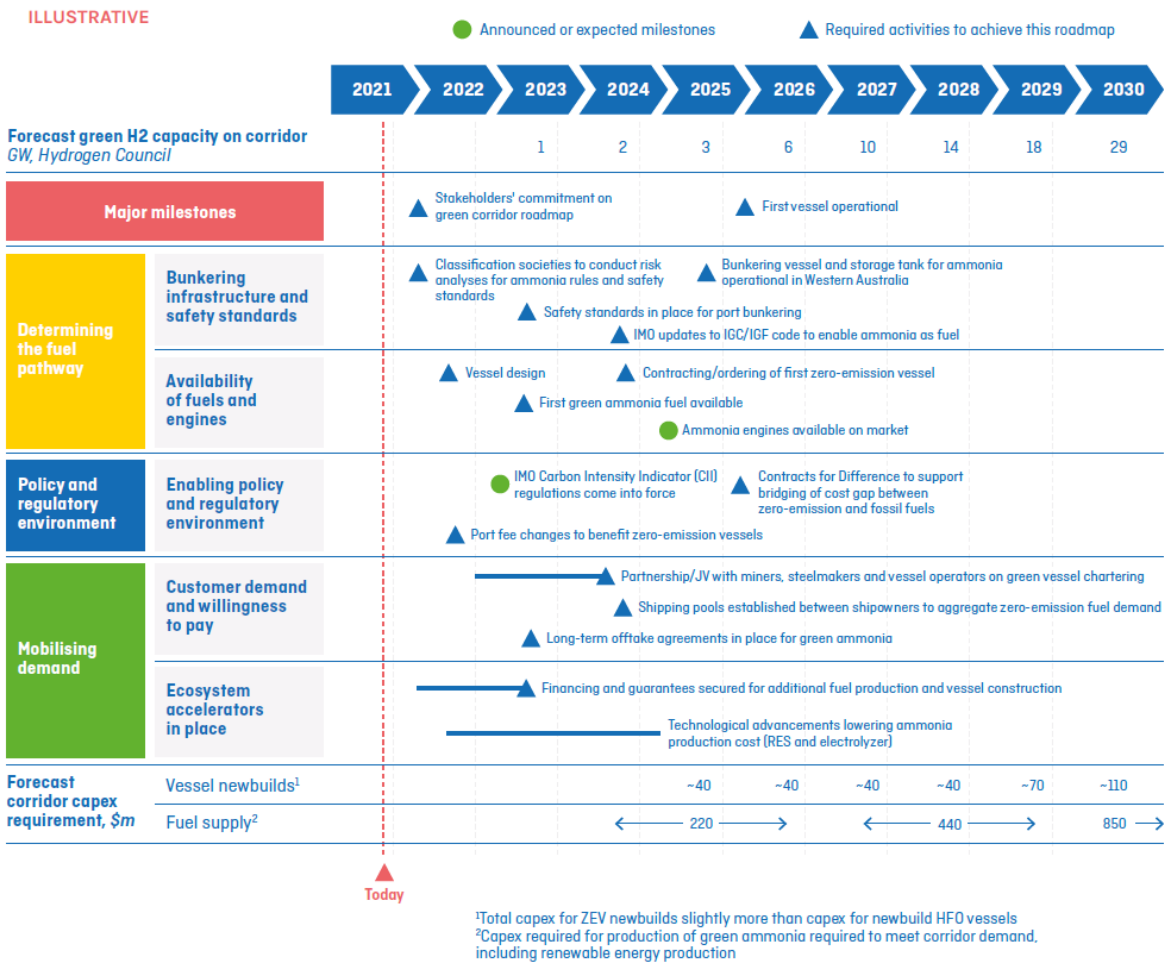

Figure 3-13: A potential credible, ambitious roadmap for decarbonisation of the Australia-Japan Iron Ore Corridor (Global Maritime Forum, 2021)

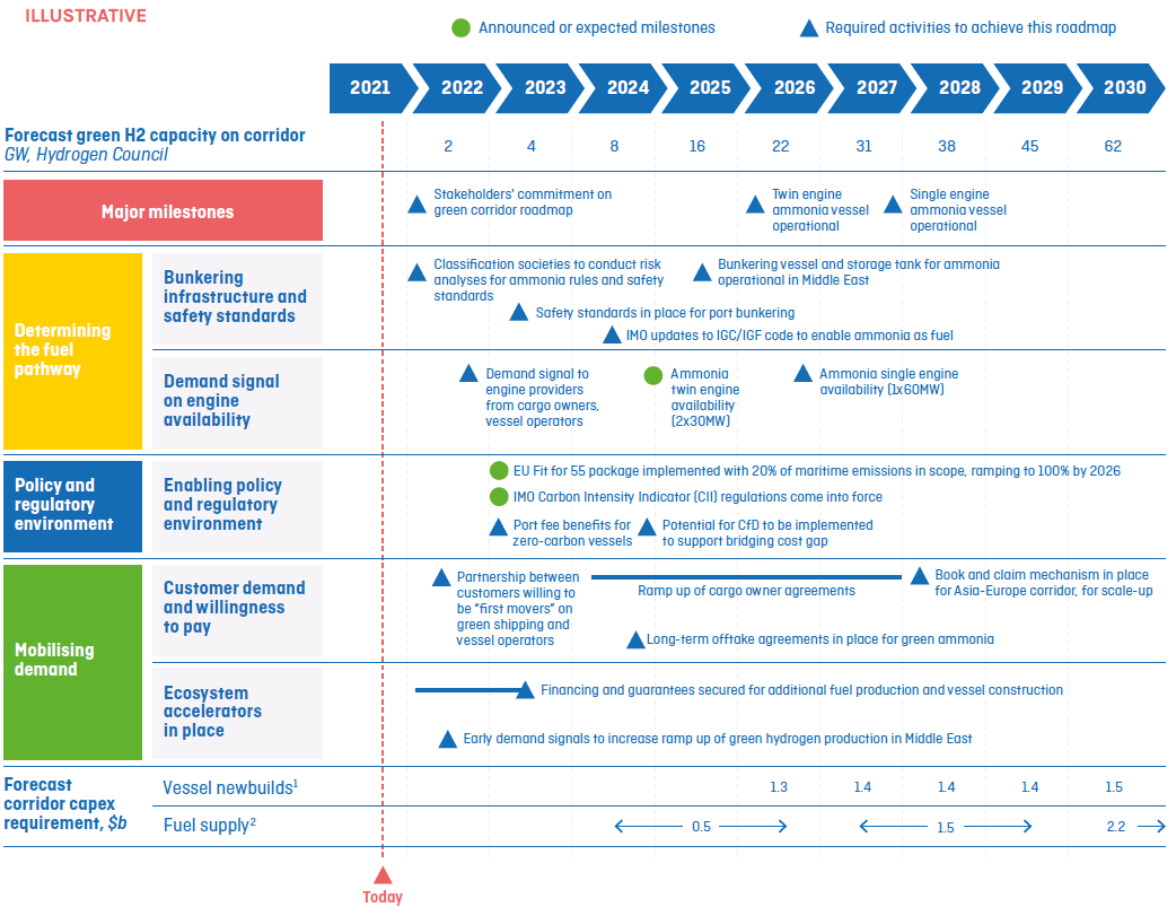

Figure 3-14: A potential credible, ambitious roadmap for decarbonisation of the Asia-Europe containership corridor (Global Maritime Forum, 2021)

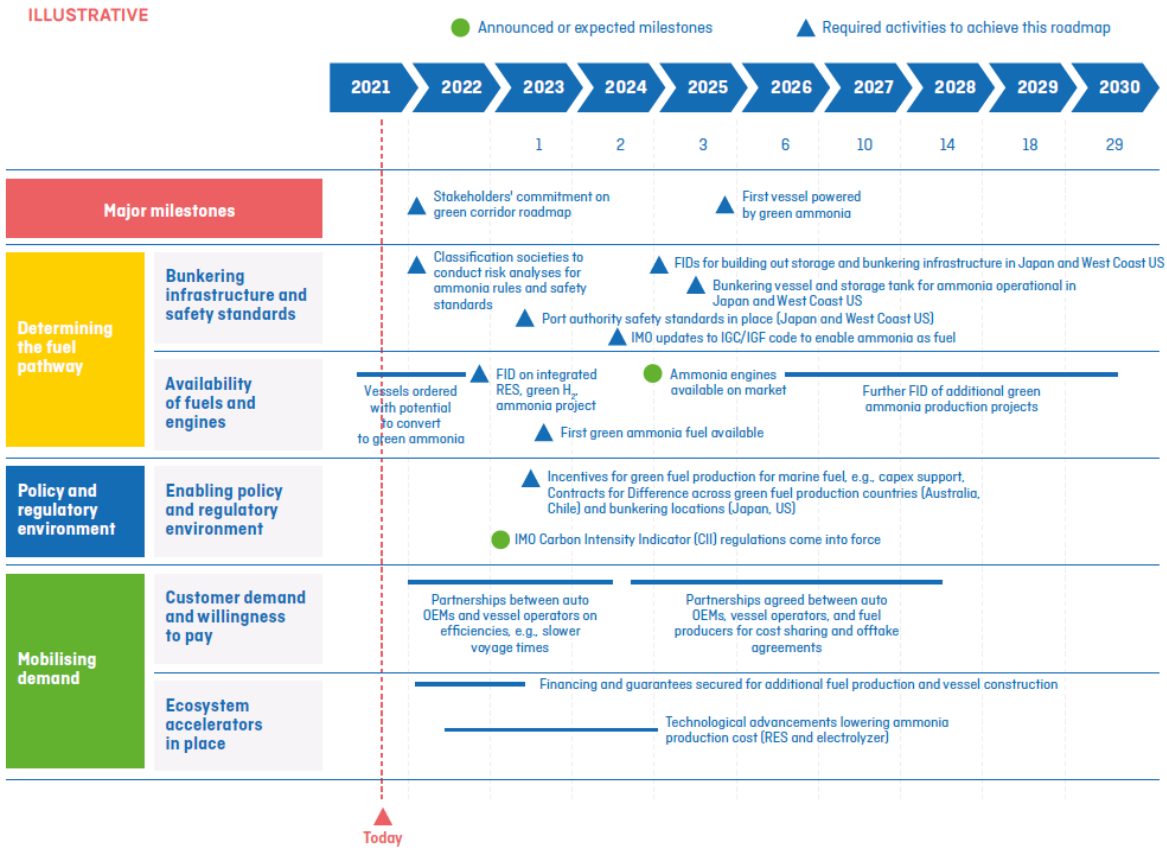

Figure 3-15: A potential credible, ambitious roadmap for decarbonisation of the Northeast Asia (Japan/Korea) – USA car carriers corridor (Global Maritime Forum, 2021)

The Clean Tyne Shipping Corridor

The roadmap covers four topics, i.e., methanol production/supply, vessel decarbonisation pathway, port and bunkering infrastructure and other partners/enablers. The timeline is categorised into short term, mid term, and long term. For each topic, key actions are identified, as shown in Figure 3-16 and Figure 3-17.

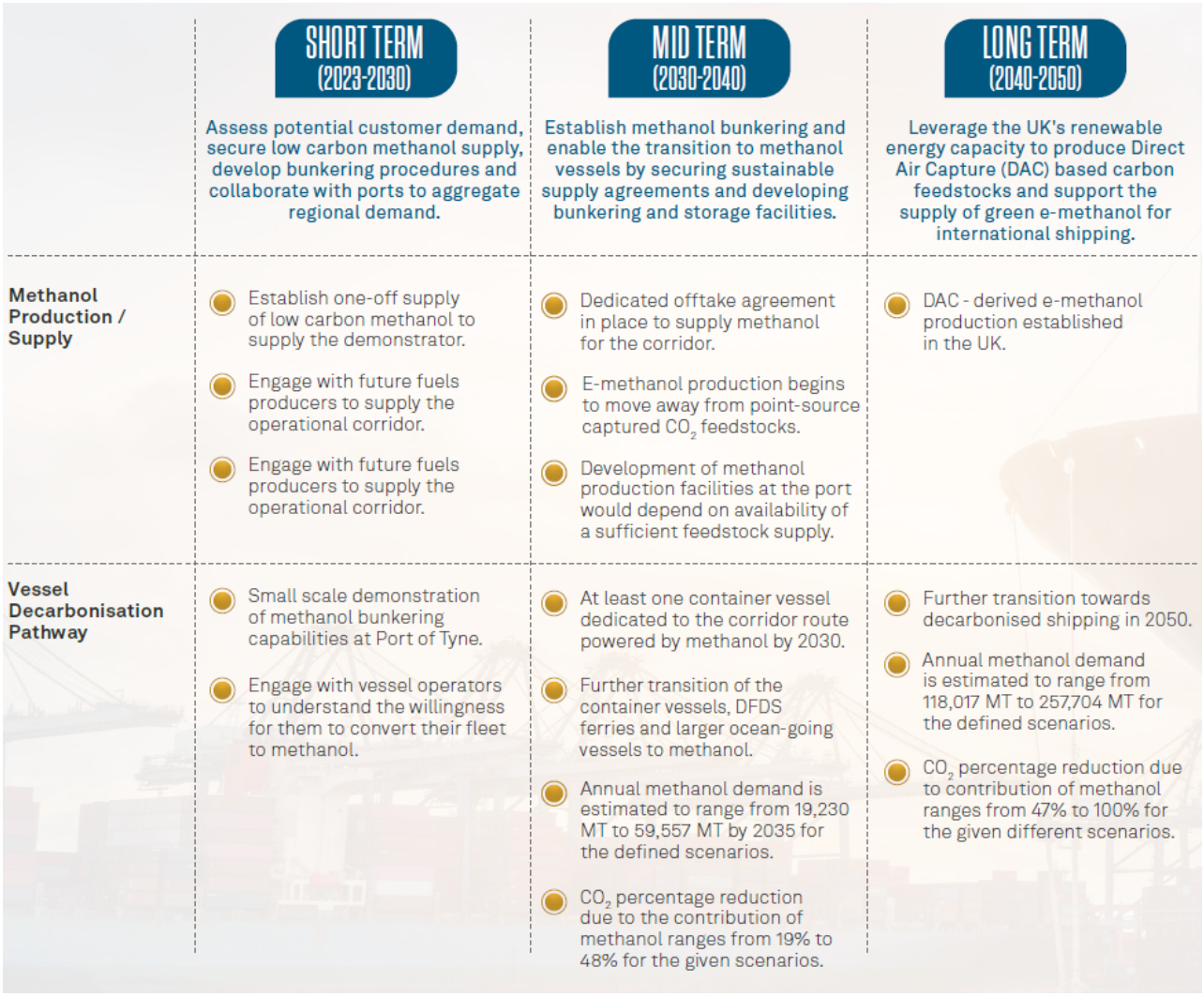

Figure 3-16: Roadmap for Methanol Production/Supply and Vessel Decarbonisation Pathway (Port of Tyne, et al., 2023)

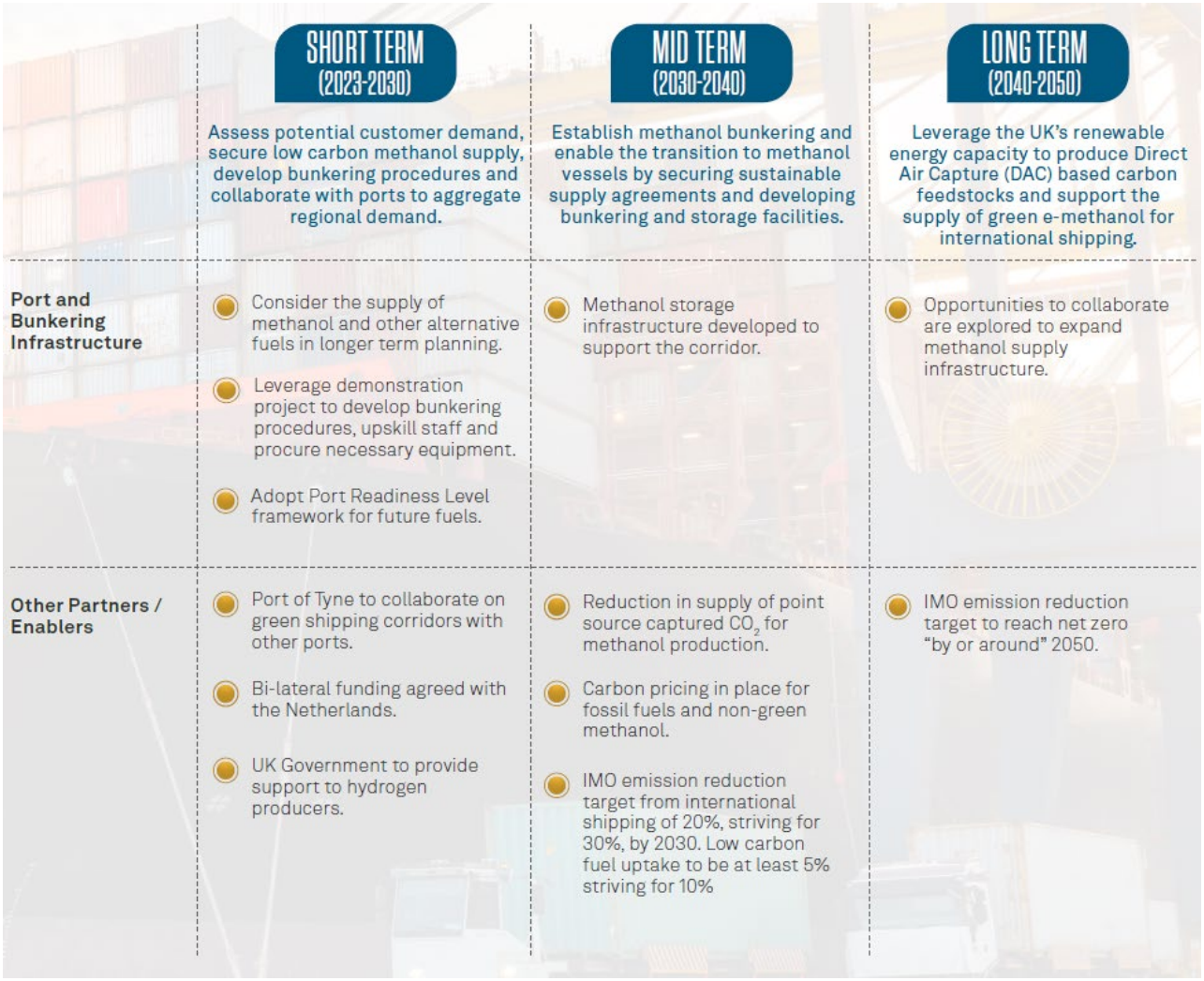

Figure 3-17: Roadmap for Port and Bunkering Infrastructure and Other Partners/Enablers (Port of Tyne, et al., 2023)

Rotterdam-Singapore Green & Digital Shipping Corridor

As seen from Figure 3-18, the required support and green corridor actions are determined based on the identified opportunity as well as complications and challenges. Nevertheless, the timeline is not given for the actions needed as the green corridor is still in the early stages.

Green Corridor calls for timely and dedicated support to scale up sustainable fuel production capacity for shipping in a timely manner, while continuing the joint efforts on improving the availability, affordability and acceptability of sustainable fuels.

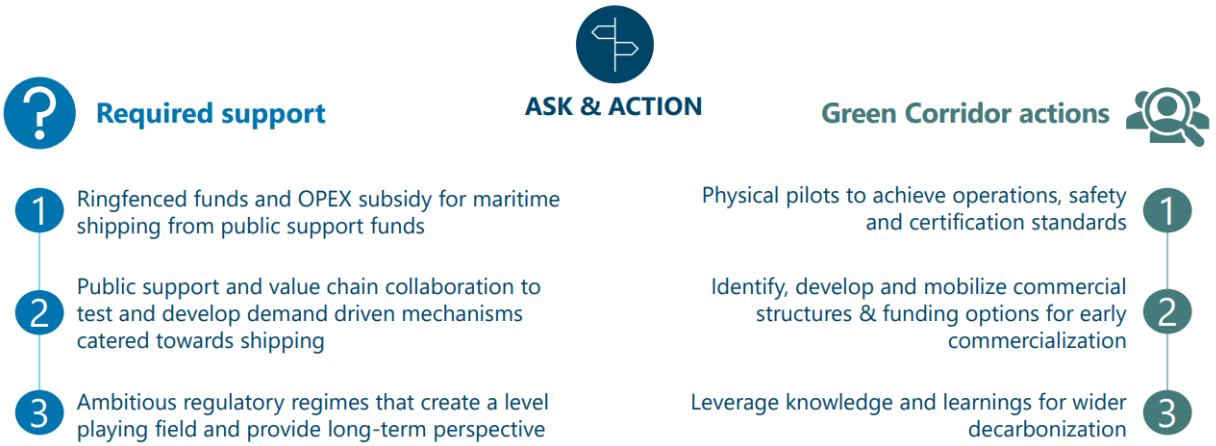

Figure 3-18: Supports and actions needed for the green corridor taken from the report (Port of Rotterdam, et al., 2024)

Summary

From the above-mentioned studies, it can be observed that the key barriers to be resolved with actions needed as part of the milestones in the implementation plan include the availability of zero-emission fuels, maturity of infrastructure and technologies, enabling policies (i.e., regulation and incentives), and partnerships (i.e., demands for fuel). In terms of timeline, achieving a commercial-scale ammonia ecosystem by 2030 is part of the implementation plans for the 'Silk Alliance' and is also suggested in 'The Next Wave' report. On the other hand, the Clean Tyne Shipping Corridor is looking towards the longer term, from 2023 to 2050, with methanol as their fuel choice. The implementation plans developed by the above-mentioned leading corridors could therefore be used as a reference for any future green shipping corridors and green maritime hubs in the Mediterranean region leveraging upon their respective strengths and opportunities.

3.2.4.2 Incentive schemes

Once a significant number of early-stage initiatives have been established, the policy focus should transition towards encouraging private sector investments in these initiatives. As previously mentioned, a key objective at this stage is to reduce the cost gap, which is expected to persist until the underlying technologies reach advanced development levels.

The cost gap's structure varies based on many corridor-specific factors, with a crucial determinant being the types of energy sources used. For scalable zero-emission fuel solutions, particularly relevant for deep-sea shipping, it is widely recognised that the cost of alternative fuel production constitutes the majority of the cost differential.

Therefore, incentive schemes are important. These schemes can help bridge the cost gap by providing financial support and reducing the economic burden on early adopters. Incentives such as subsidies, tax breaks, and grants can stimulate private-sector investment and accelerate the adoption of new technologies. Additionally, incentive schemes can foster innovation by encouraging companies to invest in Research and Development (R&D), ultimately leading to more cost-effective and scalable solutions. Direct subsidisation of international shipping through domestic budgets is a novel and politically challenging concept. Therefore, effective subsidy schemes should consider target recipients, target costs, support mechanisms, and geographic scope as shown in Figure 3-19.

Figure 3-19: Consideration for incentive schemes (Global Maritime Forum & Getting to Zero Coalition, 2023)

Recipients of incentives mainly come from the demand (e.g., shipping) and supply side (e.g., energy producers). Supply-side subsidies target fuel production and can include fuel and vessel subsidies, as well as R&D funding. Demand-side subsidies incentivise the uptake of green fuels among consumers, particularly in hard-to-abate sectors like shipping.

Subsidies can address different **types of costs**. Capital Expenditure (CapEx) subsidies cover the construction of facilities and the purchase of equipment for fuel production. For the shipping sector, CapEx subsidies can support the purchase of zero-emission vessels, helping to bridge the cost gap associated with transitioning to new energy sources. Operational Expenses (OpEx) subsidies, on the other hand, cover the cost of running these facilities, including the transportation of fuel to

consumers. In the context of shipping, OpEx subsidies can support the purchase of zero-emission fuels, ensuring that the operational costs do not become a barrier to adopting greener technologies. Additionally, R&D funding is crucial for the development of enabling technologies and first-of-their-kind vessels, which are essential for the transition to zero-emission shipping.

Support mechanisms include upfront payments, which are grants or investment credits for capital assets or R&D. Fixed price and premium models provide continuous payments linked to production or consumption, including feed-in tariffs and market-maker models. Sliding premium or Contracts for Difference (CfDs) compensate for the difference between a fixed and variable price, with variations like Carbon Contracts for Difference (CCfDs).

Subsidies may target **geographical** (domestic, regional and international) producers, with eligibility often depending on the policy landscape and support prospects.

Table 3-4 features a selection of recently announced, planned or implemented support schemes globally (Global Maritime Forum & Getting to Zero Coalition, 2023). Table 3-5 focuses on subsidies in the hydrogen space, and provide examples of shipping-specific R&D and CapEx subsidies (Global Maritime Forum & Getting to Zero Coalition, 2023).

Table 3-4: Examples of demand- and supply-side subsidies for green hydrogen (including broader schemes supporting the uptake of zero-emission technologies in various sectors) (Global Maritime Forum & Getting to Zero Coalition, 2023)

Country	Name: Support Scheme	Type of Fuels	Funding
EU	European Hydrogen Bank: Fixed premium (EUR per kg H_2) auction determined production subsidy	Renewable hydrogen (RED II)	First auction - $877M for domestic production
Germany	(1) H_2Global Double Auction: Fixed, auction determined prices for producers and consumers (2) CCfDs: Sliding premium (EUR/tCO_2) – difference between the total cost of the climate friendly and traditional production systems, auction-based	(1) Green hydrogen-based ammonia, methanol and electro-Sustainable Aviation Fuel (eSAF) (2) Renewable electricity, EU Taxonomy rules for hydrogen	(1) First auction for producers - $987M, further $3.84B until 2036 (2) Around $50B
The Netherlands	(1) The Netherlands participation in H_2Global: Auction for producers (2) Stimulation of Sustainable Energy Production and Climate Transition (SDE++): Supply side CfD, EUR/kWh basis for all categories except Carbon Capture and Storage (CCS)/ Carbon Capture and Utilization (CCU)	(1) See H_2Global (2) hydrogen by electrolysis	(1) $329M for the first auction (2) €8B for 2023 – for all technologies, total budget around €30B until 2025
Norway	CfDs for hydrogen: Sliding premium	N/A	N/A
UK	Low-Carbon Hydrogen Agreement (LCHA): Sliding	Max 20gCO_2e /Megajoule Lower	N/A

	premium based on the difference between the strike price (production costs + Return of Investment (RoI)) and the higher of (1) sales price and (2) natural gas price.	Heating Value (MJLHV) H_2 on a Well-to-Gate basis	
France	Support for low carbon hydrogen production: Potential CfD covering the difference between grey hydrogen and low-carbon hydrogen. 70% price criteria, 30% non-price criteria	Low-carbon hydrogen, criteria to be announced in consultation	$4.3B
USA	Inflation Reduction Act – (1) Clean Hydrogen Production Credit: Fixed premium in the range $0.6-3/kg H_2 (based on emissions intensity), (2) Clean Energy Investment Credit: administratively set (2) Up to 30% tax reduction, max 6% of value of qualifying capital assets	Max emissions intensity 4 kg /CO_2kg H_2	Around $100B (est.)
Canada	(1) The Clean Hydrogen Investment Tax Credit: 15-40% tax reduction on qualifying capital assets, additional 15% for capital assets for conversion to ammonia (2) Potential CCfD: TBD	Max emissions intensity 4 kg CO_2/kg H_2	(1) $4.17B over 5 years plus additional $8.9B until 2035
Australia	Hydrogen Production Credit (HPC): Premium (per kg H_2) representing the difference between sales price to each offtaker and the cost of production, auction determined HPC value	Green hydrogen compliant with the Australian GO scheme (under development). Blue hydrogen excluded.	$1.33B under Hydrogen Headstart subsidy programme
New Zealand	New Zealand Equitable Transitions Package – Green Hydrogen Consumption Rebate: Sliding premium for industrial users of hydrogen reflecting the difference between the cost of green hydrogen to the consumer and the cost of typical fossil alternative	Green hydrogen	$61M total. $18M for initial four years outlined in 2023 budget
Japan	Subsidy scheme announced in the Revised Hydrogen Strategy: Premium reflecting “all or part of	Threshold of clean hydrogen: 3.4 kg CO_2	Around $50B over 15 years in public

	the difference" between the price of green H_2 (including RoI) and grey H_2"	/kg H_2 on a Well-to-Gate basis. Threshold for ammonia: 0.84 kg CO_2/kg NH3 on a Gate-to-Gate basis	investment for the whole strategy (est.)

Table 3-5: Examples of shipping R&D and CapEx subsidies (Global Maritime Forum & Getting to Zero Coalition, 2023)

Country	Name: Support Scheme	Funding
Norway	(1) Enova: R&D grants for larger ammonia- and hydrogen-powered vessels (2) Enova Hydrogen in vessels and Ammonia in vessels programmes: ship CapEx grant for commercial operation of vessels for up to 80% difference in CapEx and a total of $14M and 1-3 vessels per project by 2026 (both newbuilds and retrofits)	(1) $187M total for 16 ships and hydrogen hubs to date (2) N/A
Germany	Federal Ministry for Economic Affairs and Climate Action (BMWK) support for construction of zero-emission vessels: Grant to promote the construction of zero-emission vessels	$32M per year until 2025
The Netherlands	(1) Sustainable Shipbuilding Subsidy extension 2023: Grant of up to $1.35M per project, retrofits or newbuilds (2) Maritime Masterplan: Grant for development, construction and deployment of 40 demonstration ships by 2030 with focus on hydrogen, methanol, LNG with carbon capture	(1) $2.5M in 2023 (2) $228M awarded from the National Growth Fund for implementation of National Mobility Program (NMP)
UK	(1) Zero Emission Vessel and Infrastructure Competition: R&D grant for development, deployment and operation of solutions within electric vessels and charging infrastructure, shore power, alternative fuels and bunkering. Demonstration in an operational environment for three years to be completed by 2028, up to $25M per project (2) Clean Maritime Demonstration Competition: R&D grant, including demonstration in operational setting, specific provisions for green corridors. Singles out ammonia	(1) $97M (2) $162M across the four competition rounds (since 2021)
EU	(1) Innovation Fund – Shipping: TBD (2) Horizon Europe: R&D grants, 15 relevant projects financed to date	(1) Expected $280-370M per year 2024-2030 (2) N/A
Japan	New Energy and Industrial Technology Development Organization (NEDO) programme – Next-generation Ship Development: Grant, Technology Readiness	$240M total

	Level (TRL) 8+ to 11 for introduction of 10 zero-emission vessels by 2030. Demonstration operation for hydrogen-based vessels completed by 2030, commercial operation of ammonia fuelled vessels by 2028	
South Korea	Shipbuilding support package	$135M in 2023

Summary

Incentive schemes are essential for developing maritime green corridors due to the complex and costly nature of these initiatives, which often require significant financial resources beyond the capabilities of individual companies or stakeholders. Various support mechanisms or subsidy schemes can be employed, ranging from fuel subsidies and vessel subsidies to R&D funding for enabling technologies.

These mechanisms or schemes are designed based on several key considerations, including supply and demand, target costs, support mechanisms, processes to determine the level of support, and geographical scope. For example, Japan and Korea, which are prominent in shipbuilding, have incentive schemes that focus on the introduction of zero-emission vessels. Similarly, Mediterranean coastal States could adopt comparable schemes to support the development of green shipping corridors. These schemes could include targeted subsidies for shipbuilding, fuel production, and R&D funding for green technologies, tailored to the specific needs and strengths of each county. By leveraging these incentives, Mediterranean coastal States can foster innovation and collaboration, driving the transition to sustainable maritime practices.

In essence, incentive schemes enable the maritime industry to overcome financial, technological, and operational barriers to create green shipping corridors, making large-scale decarbonisation achievable and supporting the transition to sustainable, low-emission shipping practices.

4 Recommendations with reference to challenges and opportunities tailored to the Mediterranean context

This chapter presents challenges and opportunities in the Mediterranean region with initial recommendations to address gaps and capitalise on opportunities in the efforts to establish green shipping corridors and green maritime in the region. Notably, this is an initial overview of recommendations based on a high-level literature review and input from DNV subject matter experts and local resources.

4.1 Challenges

The challenges in developing green shipping corridors and green maritime hubs in the Mediterranean region are recognized in the following categories:

.1 Economic challenges

.2 Technological challenges

.3 Regulatory challenges

.4 Political challenges

4.1.1 Economic challenges

Green shipping corridors and the transition to zero-emission shipping need large investments both onboard and onshore, where USD 8 billion (bn) to 28bn is needed annually in additional total investment on ships in a transition phase towards decarbonization in 2050, while about USD 28bn to 90bn per year is needed onshore to scale up production, fuel distribution, and bunkering infrastructure to supply 100% carbon-neutral fuels by 2050 (DNV, 2022a). For green shipping corridors and the first movers, the main issue is the competitive gap that exists between zero-emission fuels and fossil fuels (DNV, 2022b). The maritime fuel costs make up 20-35% of the annual total cost of ownership (Mærsk Mc-Kinney Møller Center, 2021). The price of zero-emission fuels can be more than 3 times the price of conventional fuels in 2030. Such an increase in marine fuel prices will have a significant impact on the short-term economic performance and could possibly increase the total cost of ownership (TOC) by 40-100% depending on ship type and fuel choice (Mærsk Mc-Kinney Møller Center, 2021). Finding ways to share risk and close the significant fuel cost gap is critical for realizing green shipping corridors (DNV, 2023b). The EU's adoption of shipping into the EU ETS, and the IMO's work on market-based instruments, are policies for decreasing the cost gap. However, they are not expected to be sufficient to create price parity with conventional fuels within this decade. Therefore, other cost- and risk-sharing mechanisms, such as CfD (Figure 4-1), will be needed to support first movers developing green shipping corridors. If carbon prices or other measures are insufficient to reduce the price gap, stakeholders could have to pay a green premium for carbon-neutral fuel, a cost which most cargo owners are not expected to wish to cover.

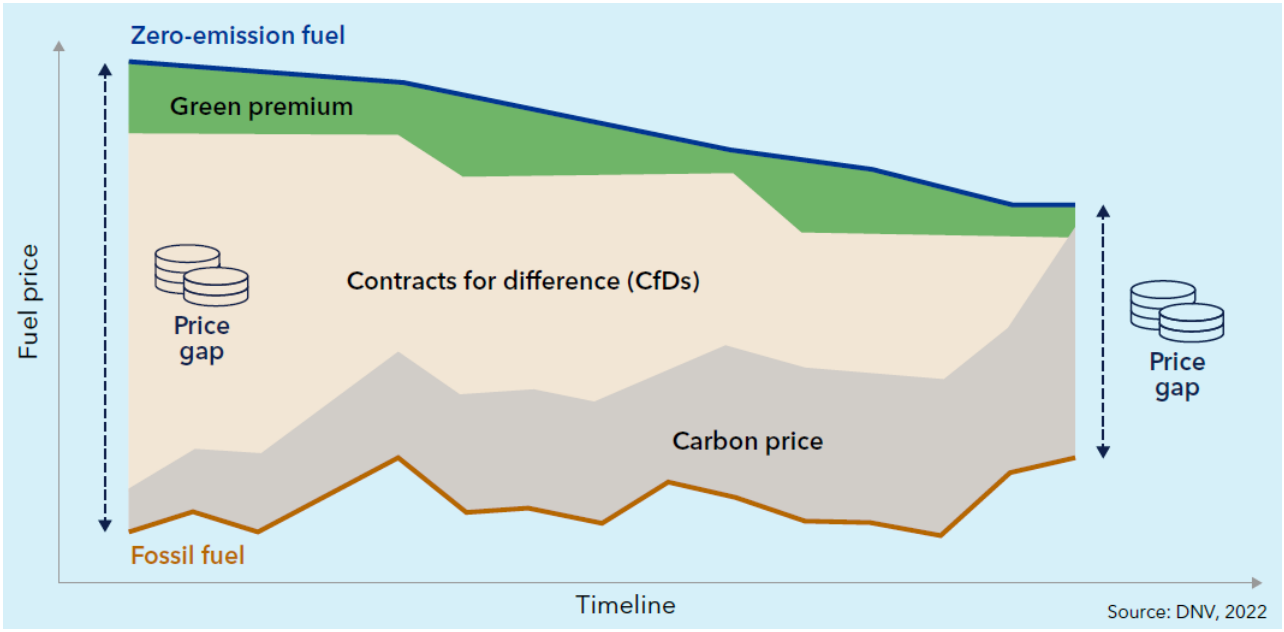

Figure 4-1: Indication of how to close the price gap between carbon-neutral and fossil fuels. Without carbon price and CfDs, the whole price gap will be green premium. (DNV, 2022a, 2023b)

Developing the necessary infrastructure for green shipping corridors is complex and costly. The region lacks uniform well-established processes and methodologies for such projects, making progress difficult. The non-uniform level of GDP across the Mediterranean basin, as well as the low attention to eco-incentives and innovative financing schemes, generate a funding gap in expanding alternative fuel-based solutions (MoS, 13). The region's ports need significant upgrades to handle alternative fuels like hydrogen and ammonia, which are currently much more expensive than conventional fuels (PierNext, 2020). Additionally, the development of necessary bunkering infrastructure, including storage and refuelling stations, is both complex and costly. There is currently no clear commercial incentive for private sector investment in green shipping corridors. In the Mediterranean region, economic incentives are crucial to overcoming the high costs and infrastructure challenges associated with establishing green shipping corridors. Governments are beginning to offer subsidies and grants to support the development of alternative fuel production and distribution networks, as seen in Spain's, Italy's and Greece's initiatives to connect its ports with Europe and beyond (Julian Atchison, 2024). Public-private partnerships are also emerging, pooling resources to share the risks and costs of large-scale investments in green shipping infrastructure. However, the region still faces significant hurdles in implementing these incentives effectively and uniformly across different countries. The fragmentation of financing streams complicates the coordination and implementation of green shipping initiatives.

4.1.2 Technological challenges

The transition from fossil fuels to zero-emission fuels will have to coincide with a corresponding development in onboard fuel technology. From the technological aspect, the current challenge lies in the maturity level of engines operating with zero-emission fuels. Currently, engine makers are working to provide new engines and retrofit packages for operating on alternative fuels. Shipowners are increasingly investing in fuel flexibility – by ordering ships with dual-fuel engines which can run on alternative fuels in addition to conventional fuel oils. Some of the ships in operation are dual-fuel

ready as well as engine makers are also following a strategy of providing future fuel-ready engines for later conversion. Figure 4-2 illustrates the available main engine technologies for the use of alternative fuels available for main ship types and sizes, covering both 2-stroke engines for large ships and 4-stroke technologies used in small to medium-sized ships (and for auxiliary power for all ships). While methane and methanol engines are generally available in a wide power range, the first ammonia engines, which will become available in the next two to three years, are sized for use in large bulk carriers and gas tankers. For hydrogen, development plans for marine engines seem to be aimed at the lower power ranges. It may be expected that technologies and power ranges serving the segments of high demand will be available first, followed by retrofit options and an expansion in product range depending on market development and regulations. LNG-fuelled engines are becoming a mature technology with a global uptake for most ship types, while methanol- fuelled engines have almost reached maturity. No commercial vessels are operating on ammonia as fuel yet, but the first orders for ammonia dual-fuel engines have been signed for delivery from 2025. Engine makers are currently investigating the 2-stroke engine principle. Similarly, no commercial oceangoing ships are operating on hydrogen engines yet, but development is ongoing.

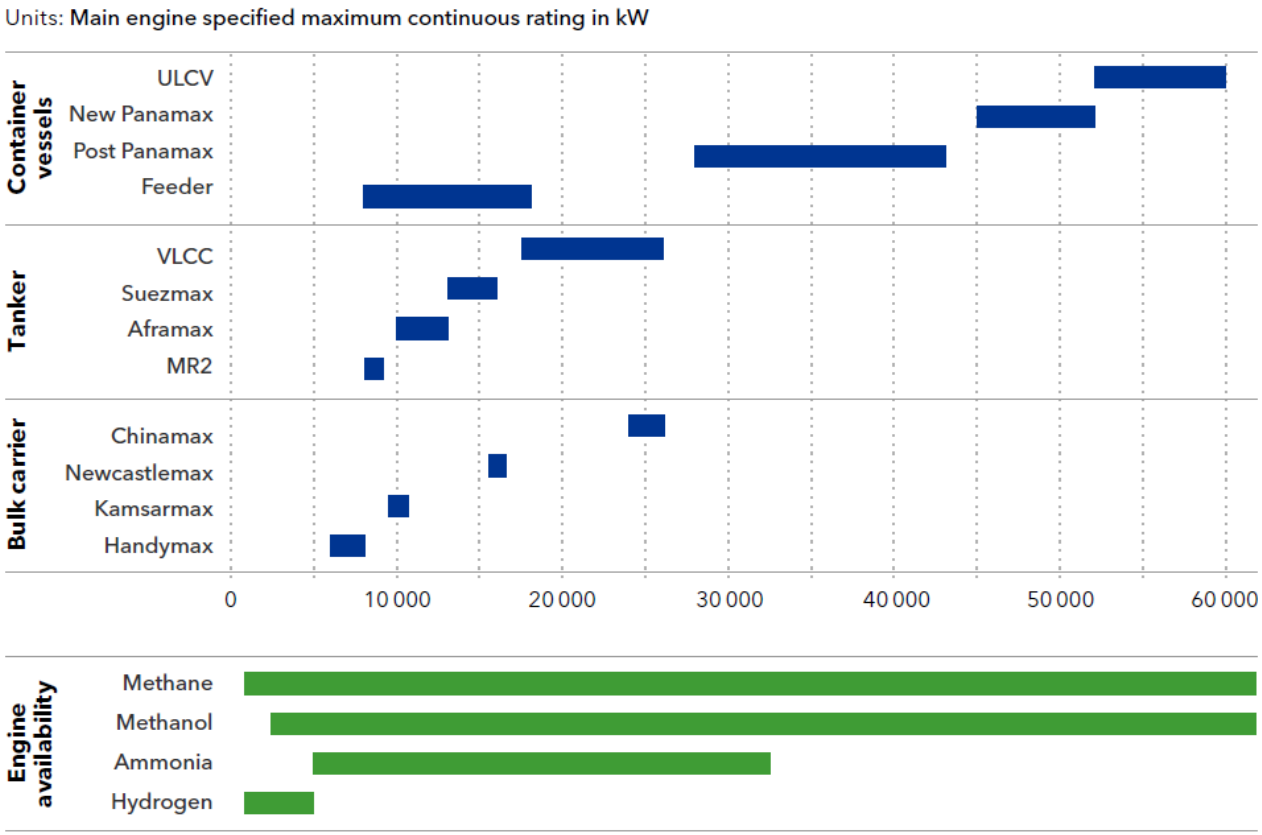

Figure 4-2: Main engine specified maximum continuous rating in kW for typically installed engines as a function of ship size for the largest ship segments: bulk carriers, tankers, and containerships. Compared with available main engines for the use of methanol, methane, ammonia, or hydrogen as fuel (DNV, 2024a).

4.1.3 Regulatory challenges

As with all international shipping, it is a requirement that vessels with alternative fuel are approved by the Flag State and Classification Society according to the applicable IMO Codes and Conventions, national/regional regulations, Class rules and local authority requirements, as applicable and/or guidelines.

IMO provides an international mandatory regulatory framework for alternative fuels through the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) which puts internationally recognized safety standards in place to ensure the safe use of natural gas as a fuel, as depicted in Figure 4-3. However, interim guidelines have been issued by IMO for methanol and neither methanol, ammonia nor hydrogen are currently covered by detailed technical requirements in the IGF Code. The IMO is working on amendments to the IGF Code for methanol, and interim guidelines for hydrogen and ammonia are expected to be finalized and published in early 2025 (Maritime Technologies Forum, 2024).

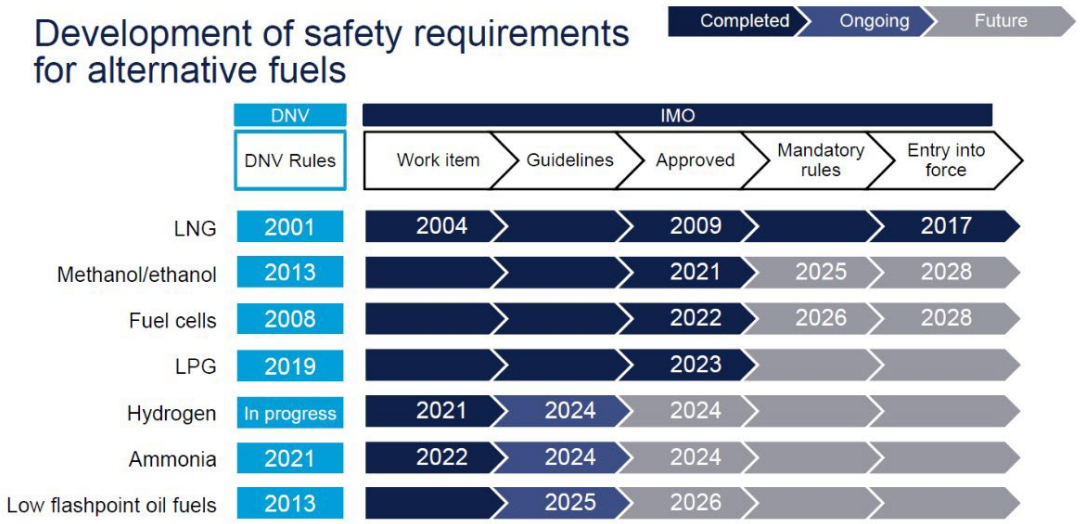

Figure 4-3: Development of safety requirements for alternative fuels. Source: Updated work plan for the development of new alternative fuels under the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF code), CCC 9/WP.3, Annex 3, various IMO documents and DNV estimates. Future dates are indicative.

The scope of the maritime rules and regulations for ships' fuel is generally limited to the installation onboard and stops at the bunkering connection of the ship, while the port and shoreside bunker installation pertain to different regulatory regimes. One challenge in developing green shipping corridors is that the shoreside regulatory framework is local. This implies that there will be differences in the regulations for each new port state and individual ports in the green shipping corridor. The regulations are for instance related to the approval of bunkering infrastructure and handling of dangerous goods and are in addition enforced by multiple agencies. A study by the Maritime & Coastguard Agency identified that 47 pieces of legislation relating to port governance and the handling of hazardous goods within the port environment exist in the UK (Maritime Technologies Forum, 2024). For the stakeholders developing green shipping corridors, this results in a complex regulatory landscape to navigate across different states.

The crew and personnel operating fuel and bunker systems are as crucial as the technical safety barriers. All personnel directly involved in managing the transfer or handling of alternative fuels will require new and updated technical skills to handle alternative fuels and need to be aware of the specific properties and hazards of these fuels. According to the requirements in the IGF Code, the ship owner or operator shall ensure that seafarers on board ships using gases or other low-flashpoint fuels shall have completed training to attain the abilities that are appropriate to the capacity to be filled and duties and responsibilities to be taken up STCW Code Part A / Section AV/3 (IGF Basic and IGF Advanced). Furthermore, the ship owner or operator is responsible for providing appropriate ship and equipment-specific training as specified in regulation I/14 of the STCW Convention. Currently, no IMO model courses or official training from training providers are available for hydrogen, ammonia, and methanol as fuel. As a consequence, it is anticipated that there will be inconsistent implementation of training across different vessels (Maritime Technologies Forum, 2024).

4.1.4 Political challenges

Coordination among countries is essential for establishing green shipping corridors in the Mediterranean region due to the diverse political, economic, and regulatory landscapes. The Mediterranean includes numerous countries with varying levels of commitment and capability to support green shipping initiatives. Effective coordination requires harmonizing regulations, sharing technological advancements, and aligning economic incentives across borders. For instance, the Clydebank Declaration, which several Mediterranean countries have signed, i.e., France, Italy, Spain and Morocco, aims to promote the development of green shipping corridors through international cooperation. However, the region still faces challenges in achieving uniform implementation of these initiatives. The Mediterranean region is geopolitically complex, and collaboration on several matters including sustainable maritime initiatives between EU and non-EU Mediterranean countries can be challenging (Foteini Asderaki, 2021). Despite this, according to a study from the GMF (Elena Talalasova, et al., 2023), based on the scale of trade, energy demand, dominant trade segments and policy environment, the United Kingdom, Italy, and the United States are the most promising partner countries for Spain for the development of green shipping corridors, followed by Turkey, Morocco, and China. Spain's potential partnerships with other Mediterranean and European countries to develop green shipping corridors highlight the potential for regional and international collaboration (Elena Talalasova, et al., 2023). The complexity of aligning policies and investments across multiple jurisdictions remains a significant hurdle due to varying priorities at the national levels. On top of that, the Mediterranean region could also have a potential future challenge due to a gap between an emerging advanced global fleet versus a slow implementation of advanced fuelling facilities in the key ports of the EU TEN-T corridors. For years, the EU has been prioritizing numerous initiatives to bridge this gap, but in the lack of cross-sectoral collaboration and other economic incentives, improvements are still necessary. Furthermore, a gap exists in the transfer of knowledge and paradigms from Deep Sea to Short Sea Shipping between the stakeholders of the region, which is a challenge generated by the inherent differences between the trades. Factors like the uptake of digitalization of administrative processes to facilitate trade on the corridors and the transition to green fuels will emerge as key elements for this necessary knowledge transfer.

4.2 Opportunities

Leveraging on the respective strengths of the Mediterranean coastal States, there are opportunities that could be explored in the support of establishing green shipping corridors and green maritime hubs.

4.2.1 Geographical advantage

The Mediterranean Sea is located at the crossroads of three major maritime passages, namely,

.1 the Strait of Gibraltar, opening into the Atlantic Ocean and the Americas;

.2 the Suez Canal, a main shipping gateway which connects via the Red Sea to Southeast Asia, and;

.3 the Bosporus Strait, leading to the Black Sea and Eastern Europe/Central Asia.

With its strategic location, the Mediterranean hosts an important transit lane and transhipment activities[37] for international shipping. It is also a busy traffic area due to Mediterranean seaborne traffic (movement between a Mediterranean port and a port outside the Mediterranean), and short sea shipping activities (connecting two Mediterranean ports), as shown in Figure 4-4 (Lilia Khodjet, et al., 2021).

In terms of connections with the rest of the world, Europe (European port calls) is by far the main shipping connection for the Mediterranean, receiving about 40-50% of total extra-Mediterranean traffic (from ports outside the Mediterranean) (Jean-François Arvis, et al., 2019). The proportion of intra-Mediterranean traffic in total Mediterranean traffic rose from 49% in 2009 to around 58% in 2016. This increase was attributable to the growth of either trans-shipment or coastal or short-sea shipping (Jean-François Arvis, et al., 2019).

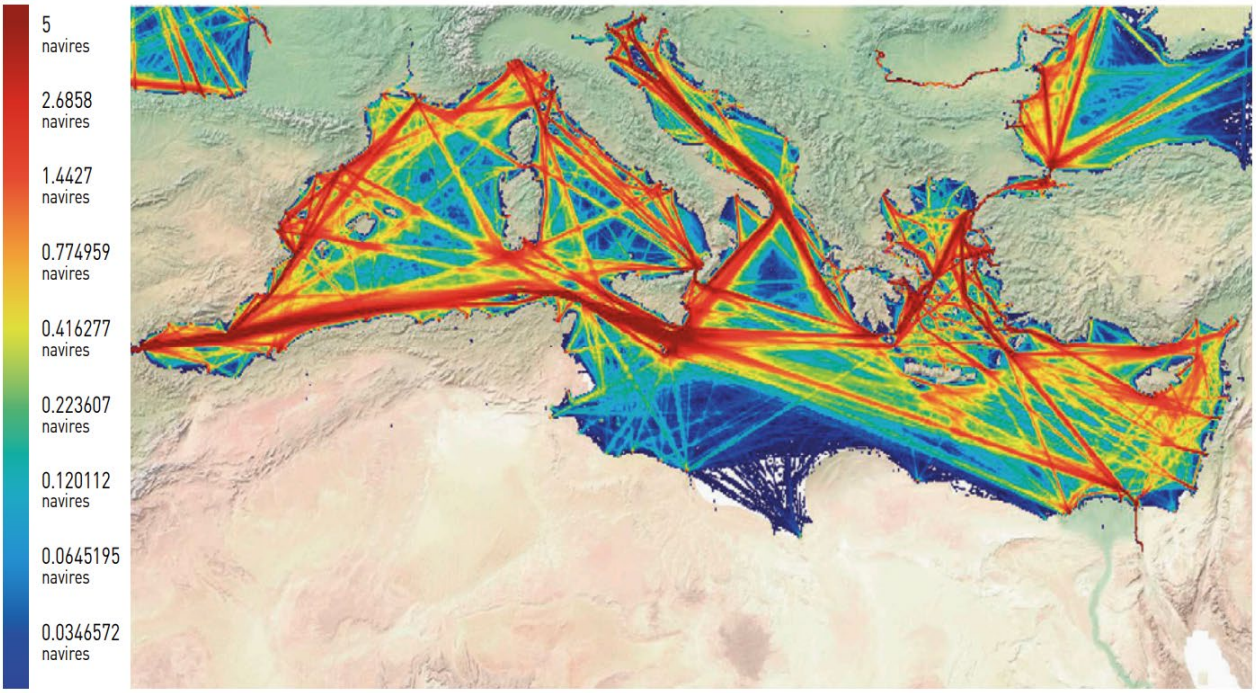

Figure 4-4: Traffic density in the Mediterranean Sea Area (Lilia Khodjet, et al., 2021)

[37] Transshipment is the transfer of goods (containers) from one carrier to another or from one mode to another.

The Mediterranean region has a long-standing, influential position in the global maritime industry, renowned for its advanced ship-owning capabilities and technical expertise. Key countries, including Greece, Cyprus, Italy, and Malta, host a significant portion of the world's commercial fleet, particularly in tankers, dry bulk carriers, and container ships. Greece alone holds one of the largest merchant fleets globally, contributing over 20% of global tonnage. In the region, ship-owning companies are recognized for their advanced technical knowledge and adherence to high safety and environmental standards. Many of these firms leverage sophisticated ship management systems, innovative designs, and eco-efficient technologies, often pioneering initiatives to reduce emissions and fuel consumption. Technical expertise in this region includes state-of-the-art fleet maintenance, digital navigation solutions, and highly skilled crews, making Mediterranean ship owners highly competitive on an international scale. The region's companies also actively engaged in partnerships with leading technology providers and invested in R&D, driving forward-thinking approaches in ship design, operation, and energy management. This advanced status could be a key enabler in establishing green shipping corridors and green maritime hubs.

As listed in Section 3.2.2.3, Greece's Port of Piraeus is one of the busiest in the Mediterranean, acting as a major transhipment hub and a gateway to Europe from the Middle and Far East, due to its strategic geographical position. The Spanish ports, i.e., Port of Barcelona and Port of Valencia stand out as one of the major hubs for transshipment in the region. Similarly, France's Port of Marseille is a significant gateway for trade in the western Mediterranean, benefiting from strong hinterland connections and robust infrastructure. Italy's ports, including Naples, Genoa, and Venice play a crucial role in Mediterranean trade due to the country's central location. These ports are key players in maritime logistics, handling a substantial volume of goods, and are well-integrated into global shipping routes. They are recognised under EU and international regulations, such as the TEN-T policy and are critical for regional and global trade, sustainability, and decarbonisation efforts. In Egypt, the Port of Alexandria is the key port in the country where it handles around three-fourths of the country's maritime trade. Port Said, which is located at the northern entrance of the Suez Canal, is also vital for international trade and serves as a major hub for container shipping. In Morocco, the Port of Tanger Med located near the Strait of Gibraltar, is claimed to be the largest port in the Mediterranean region by container volume, it handles more than 40% of transhipment traffic to the continent (Jassmin Ahdani, 2024). In Türkiye, the Port of Mersin, located on the Mediterranean coast, is one of the largest ports in the country, serving as a major hub for container shipping and bulk cargo. Hence, leveraging upon the above advantages, these maritime hubs could have the potential to transform into green maritime hubs.

4.2.2 Stakeholders ready to promote green shipping corridors and green maritime hubs

Cross-value-chain collaboration is important to make green shipping corridors and green maritime hubs a reality. The possible initiators include cargo owners, ship owners and operators, ports, fuel producers and distributors, as well as regulators and governments, as shown in Figure 4-5. In the Mediterranean region, several key players from the value chain have been working on green shipping initiatives and some are already involved in the initial stage of establishing green shipping corridors and green maritime hubs. Some countries, e.g., Spain, France, Italy and Greece, have developed national energy and climate plans, while some, e.g., Spain, France, Italy and Morocco are also the signatories of the Clydebank Declaration. These directly drive the entire value chain players to work towards common goals. In turn, this could potentially contribute to the development

of green shipping corridors and green maritime hubs. For example, in Spain, the "Green Ports" initiative unites public and private entities, including the Port of Barcelona, to implement shore-to-ship power (cold ironing) and renewable energy solutions, reducing emissions while vessels are docked. In Italy, the "Genoa Blue Agreement" brings together the Port of Genoa, shipping companies, and local governments to voluntarily reduce emissions by limiting vessel speeds and using cleaner fuels near ports. France is pioneering green shipping through the "EcoPorts" partnership at the Port of Marseille, where the port authority collaborates with CMA CGM and other major companies to deploy alternative fuels like LNG and develop hydrogen refuelling infrastructure. In Greece, the Action “Electrification of Eastern Mediterranean Corridor-ELEMED”, co-financed by the Connecting Europe Facility (CEF – managing authority CINEA) of the European Commission, demonstrated the first pilot of Ship-to-Shore Interconnection at the port of Kyllini.

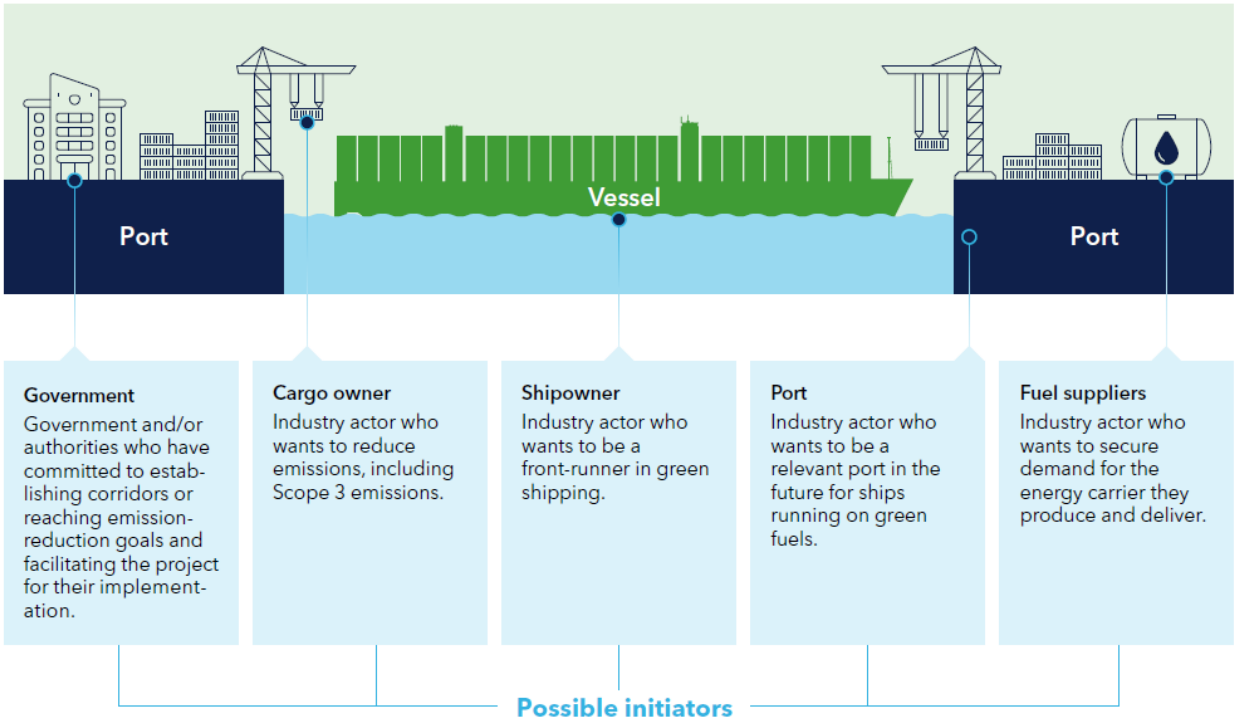

Figure 4-5: Key green shipping corridor value chain possible initiators (DNV, 2023b)

Governments and Regulators: In the Mediterranean region, several key Governments and regulators are driving green initiatives to promote sustainable maritime practices. The EU plays a significant role, with policies such as the EU ETS and the FuelEU Maritime initiative, which set stringent environmental standards for shipping. The United Nations Environment Programme Mediterranean Action Plan (UNEP/MAP) supports the Mediterranean Strategy for Sustainable Development (MSSD), which aims to harmonize economic growth with environmental protection. The Barcelona Convention and its Protocols provide a legal framework for protecting the Mediterranean marine and coastal environment, with initiatives to reduce pollution and promote sustainable development. National regulators in the region are also actively involved, implementing national policies that support the development of renewable energy and green fuels. France’s

Energy Transition for Green Growth Act [38] and National Hydrogen Strategy [39] support the development of renewable energy and hydrogen as clean fuels. Spain's National Integrated Energy and Climate Plan (PNIEC)[40] aims for a 100% renewable electricity system by 2050, promoting biofuels and other renewables in transport. Italy's National Energy and Climate Plan (NECP)[41] includes measures for biofuels, LNG, and hydrogen infrastructure to decarbonize transport. Greece's National Energy and Climate Plan (NECP)[42]focuses on renewable energy and energy efficiency, supporting biofuels and LNG in maritime transport. The abovementioned regional and national initiatives are enablers to establish green shipping corridors and green maritime hubs. Greece has developed a number of presidential decrees to support the implementation of alternative fuels and alternative power sources, e.g. electrification.

Cargo owners: In the Mediterranean region, Spain, France, Italy, Greece, Morocco, Türkiye, and Egypt are some of the key players in maritime trade. In Spain, around 70% of cargo handled in ports is either liquid bulk (e.g., liquid or gas transportation) or container trade (e.g., manufactured goods in intermodal containers)[43]. Key Spanish players that could have the potential to establish green shipping corridors include Fertiberia, Repsol, and Cepsa for liquid bulk, and Inditex, Grifols, and CIE Automotive for container trade. For dry bulk (20% of cargo), firms like Acerinox and Ebro Foods could also play a role. Notably, Cepsa and the Port of Rotterdam Authority have signed a Memorandum of Understanding (MoU) to create the first green hydrogen corridor between southern and northern Europe. This initiative will establish a green hydrogen supply chain connecting the ports of Rotterdam and Algeciras, two of Europe's major ports (Port of Rotterdam, 2022). Furthermore, Inditex, the parent company of brands like Zara and Massimo Dutti, has teamed up with Maersk to cut its global greenhouse gas (GHG) emissions from seaborne logistics by using alternative fuels on all their inbound shipping routes with Maersk (Inditex, 2023). In France, major players that could be potential in developing green shipping corridors are TotalEnergies, Air Liquide, and Rubis Energie for liquid bulk, and ArcelorMittal and LafargeHolcim for dry bulk. TotalEnergies and Rubis Energie are committed to transparent reporting of shipping emissions by joining the Sea Cargo Charter, a global framework for assessing and disclosing the climate alignment of chartering activities of charterers and shipowners (Rubis Energie, 2022; TotalEnergies, 2020). In Italy, Eni, Saipem, and Saras are some of the key players for liquid bulk, while Italcementi and Ilva are for dry bulk. Recently, Eni partnered with Fincantieri and RINA to develop joint projects, in line with the partners' strategies, to decarbonise the maritime sector in the medium to long term with the goal of Net Zero by 2050 (Eni, 2024a). In Greece, major oil refineries like Hellenic Petroleum (ELPE), Motor Oil Hellas, and energy companies like Energean and DESFA are essential to Greece's energy landscape and play a pivotal role in developing infrastructure associated with both domestic and regional fuel supply, as well as the Carbon Capture Utilization and Sequestration (CCUS) value chain. Leading cement producers, such as Titan Cement and LafargeHolcim have a strong presence in the country and contribute to green shipping initiatives. It is worthy to mention that the

[38] France's Energy Transition For Green Growth Act, https://www.ecologie.gouv.fr/sites/default/files/documents/Energy.pdf

[39] France's National Hydrogen Strategy, https://s3.production.france-hydrogene.org.pdf

[40] Spain's National Integrated Energy and Climate Plan (PNIEC), https://www.fieldfisher.com/en, https://www.miteco.gob.es/content/dam/miteco/es/energia/files-1/pniec-2023-2030/PNIEC_2024_240924.pdf

[41] Italy's National Energy and Climate Plan (NECP), https://www.mase.gov.it/comunicati/clima-energia-litalia-ha-inviato-il-pniec-bruxelles, https://energy.ec.europa.eu/system/files/2020-02/it_final_necp_main_en_0.pdf

[42] Greece's National Energy and Climate Plan (NECP), https://energy.ec.europa.eu/system/files/2020-03/el_final_necp_main_en_0.pdf

[43] Data retrieved from Country level - Gross weight of goods handled in main ports, by type of goods, https://ec.europa.eu/eurostat/databrowser/view/mar_mg_am_cwhg/default/table?lang=en

companies have recently attracted funding to invest in critical regional infrastructure on the development of CCUS segments and nodes in Greece (e.g. Titan Cement project, “Ifestos” (TITAN, 2023), at 584 million euro, Motoroil project, “Iris” (Motor Oil, 2023a), at 211.3 million euro, etc.). In Morocco, BB Energy Group is considering investment in solar power, e-mobility infrastructure and green hydrogen and ammonia, contributing to Morocco’s ambition to become one of the world’s largest hydrogen producers (BB Energy, 2023). In Türkiye, ÜPRAŞ is committed to becoming carbon neutral by 2050. They are investing in sustainable aviation fuels, green hydrogen, and zero-carbon electricity. Their strategic transformation plan focuses on creating a balanced and diversified clean energy portfolio. They has also let a contract to Honeywell UOP LLC to deliver alkylation technology for new units to be installed at its four Turkish refineries as part of the operator’s plan to boost production of cleaner gasoline in tow with its broader energy transition goals (Robert Brelsford, 2022). In Algeria, Sonatrach and Sonelgaz, who are the state-owned companies are heavily involved in renewable energy projects, including solar power, wind power, green hydrogen, etc (Energy Intelligence, 2024). All the abovementioned companies are integral to the maritime industry in the Mediterranean region, driving significant volumes of trade and contributing to the region’s economic growth as well as advancing the establishment of green shipping corridors.

Ship owners and operators: As seen from Figure 4-6, 7.7% of the ships in operation (measured in gross tonnage) can now operate on alternative fuels. In the order book, 52.9% of the tonnage can operate on alternative fuels. As of October 2024, there are two retrofit vessels (offshore supply vessel and tugboat) operating using ammonia as fuel with 4-stroke engines, while there are 25 ammonia-fuelled vessels on order, where Belgian shipowner CMB has ordered a series of eight bulk carriers with main engines capable of using ammonia as fuel, as well as the first movers in the ammonia carrier segment like Exmar LPG BV ordering two, and NYK one, mid-size gas carriers capable of burning ammonia as fuel. Following the Norwegian ferry MF Hydra which has been operating on liquefied hydrogen since 2023, the ferry operator Torghatten will take delivery of two 120-metre ferries fuelled by compressed hydrogen in 2025. Dutch logistics solution provider Samskip has ordered two 700 TEU containerships at the Cochin shipyard in India, intending for them to be provided with hydrogen-fuelled fuel cells. There are also numerous hydrogen initiatives for smaller vessels.

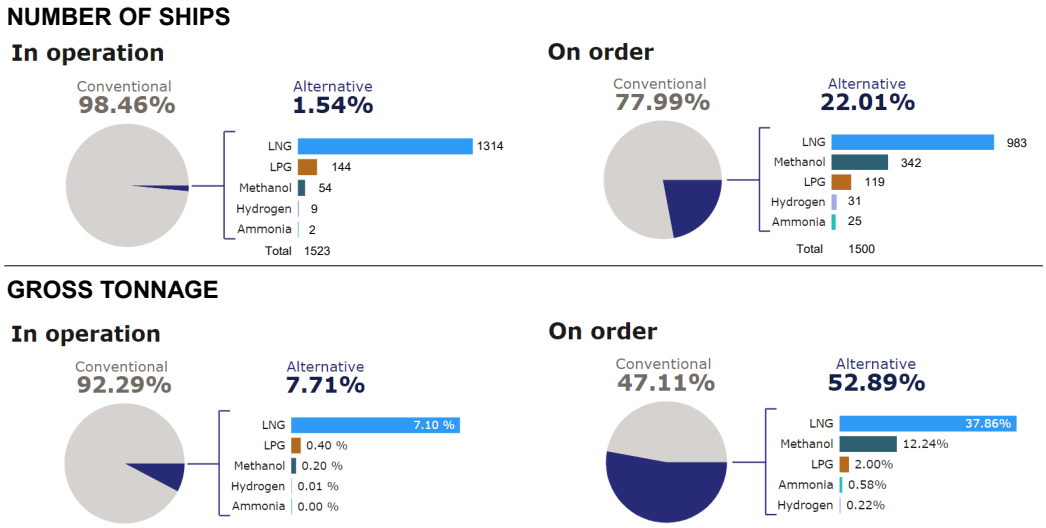

Figure 4-6: Alternative fuel uptake in the world fleet in number of ships (upper) and gross tonnage (lower), as of October 2024. Source: DNV's Alternative Fuels Insight (AFI) Platform

Several international players that service the Mediterranean market have made initial inroads to decarbonise their fleets. First movers include containership giant Maersk, which has already declared that it will have 8 zero-emission vessels operating by the middle of the decade (MAERSK, 2021). In September 2023, a leading French shipping and logistics company, CMA CGM, announced a collaboration with Maersk to accelerate the decarbonization of the shipping industry (CMACGM, 2023). Both companies have set ambitious net-zero targets and are investing extensively in the energy transition for shipping. The Union of Greek Ship Owners, which represents more than 60% of the EU-controlled fleet and more than over 20% of the world DWT capacity, has an influential role in the greening of shipping corridors in the region. The UGS is investing in R&D for alternative cleaner fuels and they support collaboration between the industry and academia. UGS actively backs policies on carbon reduction, by promoting energy efficiency and digitalization of fleets and furthering its reputation as an innovator in global shipping standards. Furthermore, MSC, headquartered in Geneva, Switzerland, and managed in MSC Cyprus, as one of the largest container shipping companies globally, has a strong presence in Mediterranean ports, providing extensive services that connect the region with global trade routes. MSC has set a clear goal of complete net decarbonisation by 2050, without relying on external offsetting. Its focus is on exploring all solutions to accelerate the global energy transition while ensuring that MSC's fleet is ready to adopt zero-carbon fuels as they become available (MSC, 2023). Apart from that, COSCO Shipping, the Chinese state-owned enterprise, has a significant presence in the Mediterranean, particularly through its ownership of the Port of Piraeus in Greece. COSCO Shipping is progressing in the development of 12 of the world's largest methanol dual-fuel container ships and is championing the use of marine biofuels, as part of its commitment to sustainability (COSCO Shipping, 2024). On the other hand, Grimaldi Group, an Italian conglomerate, that specializes in roll-on/roll-off (ro-ro) services and short-sea shipping within the Mediterranean, has been focusing on green shipping technologies, including the use of hybrid and electric propulsion systems for its vessels (Jasmina Ovcina Mandra, 2022). In Egypt, the Maersk group has annonunced its majority ownership in C2X,

a company established to build, own, and operate assets to produce green methanol[44]. The Framework Agreement is deepening the partnership and joint efforts for C2X to establish a strategic project located close to the Suez Canal, in collaboration with the General Authority for Suez Canal Economic Zone (SCZone), the Egyptian New and Renewable Energy Authority (NREA), the Egyptian Electricity Transmission Company (EETC), and the Sovereign Fund of Egypt for Investment and Development (TSFE).The efforts include the establishment of projects for generating green energy from wind and solar sources. With such aligned decarbonisation goals and plans from these companies with the global agenda, establishing green shipping corridors in the region could be technically feasible.

Ports: As highlighted in Section 3.2.2.3, several ports in the Mediterranean region have been exploring and/or offering green initiatives and services. Since Spain, France and Italy are the signatories of the Clydebank Declaration, key ports in respective countries (Spain: Port of Barcelona and Port of Valencia, France: Port of Marseille, Italy: Port of Genoa, Naples and Venice) would be potential in establishing the green shipping corridors. According to GMF research (Elena Talalasova, et al., 2023), Spain is ideally positioned to be a first mover in shipping decarbonisation by building green shipping corridors connecting Spanish ports to Europe and beyond. Findings indicate various deep-sea opportunities in the container segment, such as container trade between China and the ports of Barcelona and Valencia and between US East Coast ports and Valencia and Algeciras. The Port of Algeciras is participating in the project for the reduction of the carbon footprint of maritime transport as part of the initiative by the EU's Connecting Europe Facility (CEF) transport aid programme. Under this project, the LNG bunker tanker has carried out 42 bunkering operations in the port, which is part of the 'LNGhive 2' strategy in line with European Directive 94/2014 on alternate fuels to improve air quality at sea and in ports.[45] Tanger Med Port in Morocco is steadily progressing in cargo volumes, in addition to becoming a clean energy hub as part of its strategy and decarbonisation plan. The port has partnered with the members of the World Bank Group to expand the terminal and strengthen its strategic position as a hub for regional and global trade. **Egypt** is pushing for the initiatives for cleaner maritime operations under shipping industry's ongoing quest for decarbonisation. The country is putting up anew facility to cater to the growing demand for green methanol, as a collaborative project with Abu Dhabi Port group[46]. The move is to offer green fuels for giant containerships transiting Suez canal in future.The development of the green methanol plant in Egypt represents a significant step towards a greener future for the shipping industry. By harnessing renewable energy sources and leveraging existing infrastructure, this project paves the way for cleaner maritime operations and a more sustainable global economy.

Fuel producers and distributors: In the Mediterranean region, several major companies are leading the production of green marine fuels. TotalEnergies in France is a significant player, focusing on biofuels, LNG, and methanol to reduce maritime carbon footprints. For instance, TotalEnergies has completed biofuel bunkering trials at the Port of Le Havre and the Port of Toulon, using blends of marine gas oil (MGO) with sustainable, waste-based bio-components (TotalEnergies, 2023a). Additionally, TotalEnergies is part of a project to produce BioLNG from household waste in the Marseille region, which aims to significantly reduce greenhouse gas emissions from shipping (TotalEnergies, 2021). Spain's Repsol is investing heavily in biofuels and synthetic fuels, aiming to

[44] Maersk's C2X sign with Egypt for developing green methanol: https://www.seatrade-maritime.com/sustainability/maersk-s-c2x-sign-with-egypt-for-developing-green-methanol

[45] 'Levante LNG' transforms Algeciras into a benchmark for the decarbonisation of maritime transport Stefano Campagnolo, project manager at the European: https://en.portnews.ru/news/370770/

[46] Egypt Eyes Green Shipping with AD Ports-Led Methanol Project: https://www.1arabia.com/2024/05/egypt-eyes-green-shipping-with-ad-ports.html

produce advanced biofuels from waste and other sustainable sources. For instance, Repsol has begun large-scale production of renewable fuels at its Cartagena industrial complex, the first plant of its kind in the Iberian Peninsula (Repsol, 2024). Italy's Eni is expanding its portfolio to include biofuels and hydrogen, supporting the maritime sector's transition to sustainable energy. One of the key projects is the conversion of the Livorno refinery into a bio-refinery, which will produce hydrogenated biofuels (HVO) from biogenic feedstocks like vegetable waste and residue (Eni, 2024b). Additionally, Eni is collaborating with Enel to develop green hydrogen projects, using electrolyzers powered by renewable energy to produce hydrogen near its refineries (Eni, 2020). In Greece, Hellenic Petroleum is involved in biofuel production and exploring hydrogen as a marine fuel (IN, 2021), while Motor Oil Hellas is developing LNG bunkering infrastructure and other green fuel options including large-scale green hydrogen projects in Greece (Motor Oil, 2023b). The production of zero-emission fuels is crucial for the development of green shipping corridors. Current advancements and plans by these companies in the region to invest in green fuels show that establishing green shipping corridors in the region could be possible in the near future.

4.2.3 Availability of zero-emission fuels

Some countries in the Mediterranean region have been producing and supplying LNG for marine use and have started moving towards the production and adoption of zero-emissions fuels, e.g., ammonia, hydrogen, etc. For example, in France, CMACGM and TotalEnergies launched Marseilles' inaugural ship-to-containership LNG bunkering operation in the Port of Marseille Fos in 2022 (CMACGM, 2022). This initiative is part of the port's broader strategy to become a major LNG bunkering hub for the Mediterranean region (Port Technology, 2020). In fact, TotalEnergies have also been pioneering new marine fuels including LNG, methanol and ammonia production and bunkering in partnership with various customers and industries (TotalEnergies, 2023b). On the other hand, H2V FOS and the Port of Marseille Fos have also announced the construction of an industrial facility to produce green hydrogen with the aim of decarbonising activities in the Fos industrial port zone (Marseille Fos, 2022). In Spain, the Port of Barcelona has made significant progress in LNG bunkering and the port's Energy Transition Plan specifies that LNG is the cleanest fuel of choice as a preliminary step towards zero-emission fuels, e.g., bio LNG, methanol, ammonia, hydrogen or biofuel, to decarbonise maritime and land transport operating at the port (Port de Barcelona, 2024). The plan also envisages reserving port spaces dedicated to producing green fuels and renewable energies, i.e., the short-term plan is to build a green methanol production plant with priority use as a zero-emissions fuel for ships. In general, Spain has the potential to be among the cheapest production locations in the world and a hub for European production (Aparajit Pandey & Jesse Fahnestock, 2022) as it is blessed with excellent solar and wind resources, as well as a strong industrial base for project development, making it among the most attractive locations in the world for green hydrogen production. Apart from that, Morocco is well-positioned due to its significant investments in solar and wind energy, which can be harnessed to produce green hydrogen (Eleanor Butler, 2024). The government envisages that green hydrogen production will add value to renewable electricity production, in particular its transformation into products with higher energy density. The Moroccan Government within the German Moroccan Energy Partnership (PARMA) signed an active partnership to advance green hydrogen, and is developing a roadmap to 2050 to develop the green industry in Morocco (Giz, 2024). The Moroccan Government and TE H2, a joint venture between TotalEnergies and the EREN Group, along with its partners signed a Preliminary Contract for Land Reservation for the 'Chbika' project, aiming to develop onshore solar and wind

capacities that will power the production of green hydrogen (TotalEnergies, 2024). In Algeria, the Renewable Energy and Energy Efficiency Commission (CEREFE) published the national strategy for hydrogen development in the country in 2024 (SGS, 2024). The strategy highlights the potential Algeria has as a regional and international key supplier for the development of renewable hydrogen, given its abundant renewable solar and wind energies, competitive hydrogen production cost, etc. Certainly, with such developments of near-zero- and zero-emission fuels of alternative fuels, e.g., LNG, methanol, ammonia, and hydrogen, establishing green shipping corridors and green maritime hubs in the Mediterranean region could be feasible.

4.2.4 Alignment of national goals with green shipping corridors and green maritime hubs

Apart from the national policies on the development of renewable energy and green fuels mentioned in Section 4.2.2, the opportunity to mobilise demand for zero-emission shipping services passing through Spain is significant. While not necessarily associated with trade in high value-added consumer goods, seaborne trade passing through Spain includes a significant amount of intermediate and finished goods for which a green premium could be realistic. The Port of Marseille in France is a significant hub for Mediterranean trade, handling goods such as petroleum, chemicals, and foodstuffs. Transitioning to zero-emission vessels can help France meet its climate targets and reduce the environmental impact of its maritime activities. With major ports like Genoa, Venice, and Naples, Italy handles a diverse range of cargo, including machinery, textiles, and food products. Zero-emission shipping can help reduce pollution in these busy ports and support Italy's environmental goals. Morocco is also making strides towards zero-emission shipping. The country is actively working on decarbonizing its transport system, including maritime activities. For instance, Kuehne + Nagel, a global logistics company, is promoting sustainability in sea freight in Morocco by offering carbon-neutral sea freight solutions and collaborating with the Global Maritime Forum's Getting to Zero Coalition. Since the abovementioned Mediterranean countries are the signatories of Clydebank Declaration, implementing green shipping corridors should be part of and/or aligned with their national goals. Apart from those countries who are signatories of the Clydebank Declaration, Türkiye, Egypt and Greece, have been actively involved and/or investing in green fuels and/or renewable energy projects, as part of their national agendas. Croatia and Albania are aligning their national goals to promote greener shipping practices, focusing on reducing maritime pollution and preserving the Adriatic Sea's ecosystem. Croatia is integrating EU environmental directives into its maritime policies, prioritizing the use of alternative fuels, improved port infrastructure, and energy-efficient technologies for vessels, especially in key ports like Rijeka and Split. Croatia is also attracting EU funding for novel ships, such as the ZEAS project on the development of the first demonstration hydrogen-fuelled ferry in the Adriatic Sea (European Commission, 2024a). Albania is also taking steps to reduce emissions in its maritime sector, collaborating with international organizations and neighbouring countries to develop sustainable port facilities in Durres, its main commercial port. Both countries are working to harmonize their environmental regulations with European standards, aiming to foster eco-friendly maritime operations in line with the EU's Green Deal and improve coastal environmental protections across the Adriatic.

4.2.5 EU Policy and Regulations

In the Mediterranean region, several key regulators are driving green initiatives to promote sustainable maritime practices. The EU plays a significant role, in policies and regulations such as the EU ETS and the FuelEU Maritime Regulation, which set stringent environmental standards for

shipping. Those EU Mediterranean coastal states, i.e., France, Italy, Greece, Spain, etc. have an opportunity to leverage European Union (EU) policy in support of developing green shipping corridors and green maritime hubs. One example of opportunities related to the EU regulations under the FuelEU Maritime Regulation is the option to attain compliance across a fleet of ships, even if they belong to different companies. This means that each individual ship does not need to achieve the required fuel GHG intensity but can rely on other vessels to achieve a combined level of fuel GHG intensity which is better than the requirement. A key element in a fleet compliance mechanism is for each ship to calculate a compliance balance which indicates how far the ship is above or below the required GHG fuel intensity (GFI) in terms of absolute GHG emissions, as shown in Figure 4-7. Fleet-level GHG compliance allows for taking full advantage of using alternative fuel technologies. Capital costs can be distributed across a larger GHG emission reduction. Hence, green shipping corridors could help contribute to such a pooling mechanism where fewer green vessels can be pooled along with fossil-fuelled vessels for compliance.

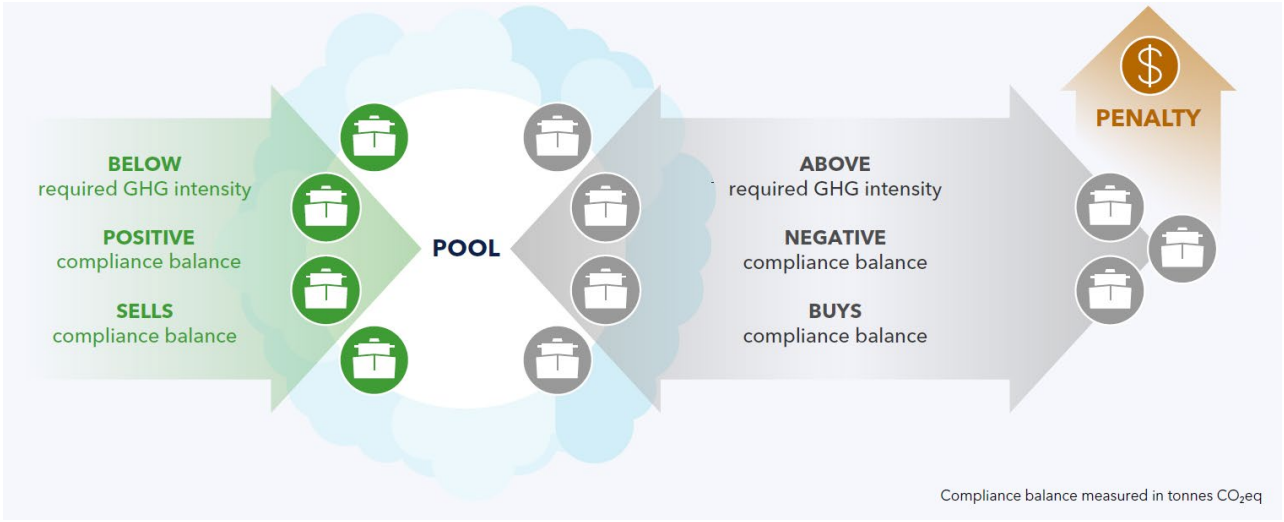

Figure 4-7: Pooling of compliance in the FuelEU Maritime to avoid penalty (DNV, 2024a)

The Alternative Fuels Infrastructure Regulation, part of the EU's Fit for 55 package, also mandates core and comprehensive ports in the TEN-T to install enough onshore power-supply facilities to provide shoreside electricity for at least 90% of the port calls by seagoing passenger and containerships above 5,000 GT every year from 2030 (European Commission, 2024b). The FuelEU Maritime Regulation complements this requirement by mandating zero-emission while at berth (European Commission, 2023b). This means that seagoing passenger and containerships above 5,000 GT must use an onshore power supply or alternative zero-emission technologies[47] from 2030 onwards to meet their electrical power needs when berthed for more than two hours in a TEN-T port. From 2035, this requirement applies to all ports where shore power is available. Support instruments like the Connecting Europe Facility (CEF) provide financing for onshore power supply facilities. Hence, major maritime hubs (e.g., Spain, France, Italy, Greece, etc.) in the Mediterranean region that are the EU Member States could tap into such opportunities to develop port facilities as well as help in establishing green shipping corridors.

[47] Defined as onboard fuel cells with zero-emission fuel, onboard electrical energy storage, or onboard power generation from wind and solar energy.

4.3 Recommendations

The Study delves into existing literature related to conception and development of various green shipping corridors and green maritime hubs around the world. Key insights are gathered which could be useful to develop green shipping corridors in the Mediterranean region. Due to unique nature of the Mediterranean region, the “Intra-Nordic green shipping corridors candidate” (DNV, 2023a) pre-pilot study performed as part of the Nordic Roadmap project could be a useful reference for establishing green shipping corridors in the region.

The following recommendations are made based on the experience gained from the Nordic Roadmap project (Future Fuel Nordic, 2024) and learnings from the GMF Annual Progress Report on Green Shipping Corridors 2024 (Global Maritime Forum, 2024), as well as the initial challenges and opportunities identified.

4.3.1 Establish the baselines (current situation) for the three pillars and identify first mover opportunities

The IMO has adopted the 2023 IMO GHG Strategy to reduce the GHG emissions of ships, requiring 5% uptake of zero- or near-zero-emission fuels and energy sources by 2030 and to reach net-zero by 2050, compared to 2008 levels. Meanwhile, the EU has included shipping in its EU ETS and adopted FuelEU Maritime Regulation as part of the EU Fit for 55 ambition to reduce the EU’s net GHG emissions by at least 55% by 2030, compared to 1990 levels. On top of these ambitions, the Mediterranean region including both EU and non-EU member States should develop a strategic plan for achieving net-zero emissions by 2050. To develop the specific Mediterranean plan, understanding the status and establishing the baselines for the maritime ecosystem are the key initial steps. The maritime ecosystem involving the entire shipping value chain can be categorised into three pillars that are key to maritime decarbonisation. These three pillars are the

.1 Ships operating in the Mediterranean region;

.2 Fuels in use by the ships; and

.3 Infrastructure supplying the fuels.

The baseline (current situation) for each of the abovementioned pillars in the Mediterranean region needs to be established to understand where they are and how far are they away from the international and regional decarbonisation ambitions. As such, data collection and feasibility assessments will be needed. Details such as ship segments, ship traffic in the Mediterranean region, the applicability of potential zero-emission fuels for ships, the geographical distribution of ports as energy hubs, etc., are important in establishing the baselines for the region. With such developed baselines, the potential first movers for green shipping corridors between ports and energy hubs specific to certain ship segments in the Mediterranean region could be identified, e.g., RoPax, feeder containers, etc.

4.3.2 Engage relevant stakeholders to identify barriers and actions to overcome barriers

Based on the key findings in the previous section, the relevant stakeholders under the three pillars including the Contracting Parties to the Barcelona Convention will be engaged to join the discussion on establishing the potential green shipping corridors and green maritime hubs in the region. The identified challenges and opportunities in Sections 4.1 and 4.2 through the literature review can be

used as a basis to initiate discussions with stakeholders. Having all stakeholders around the same table facilitates the identification of actual barriers and respective resolving actions for all the above mentioned three pillars. These barriers can be structured and mapped in a scorecard during the stakeholder workshop, as shown in Figure 4-8.

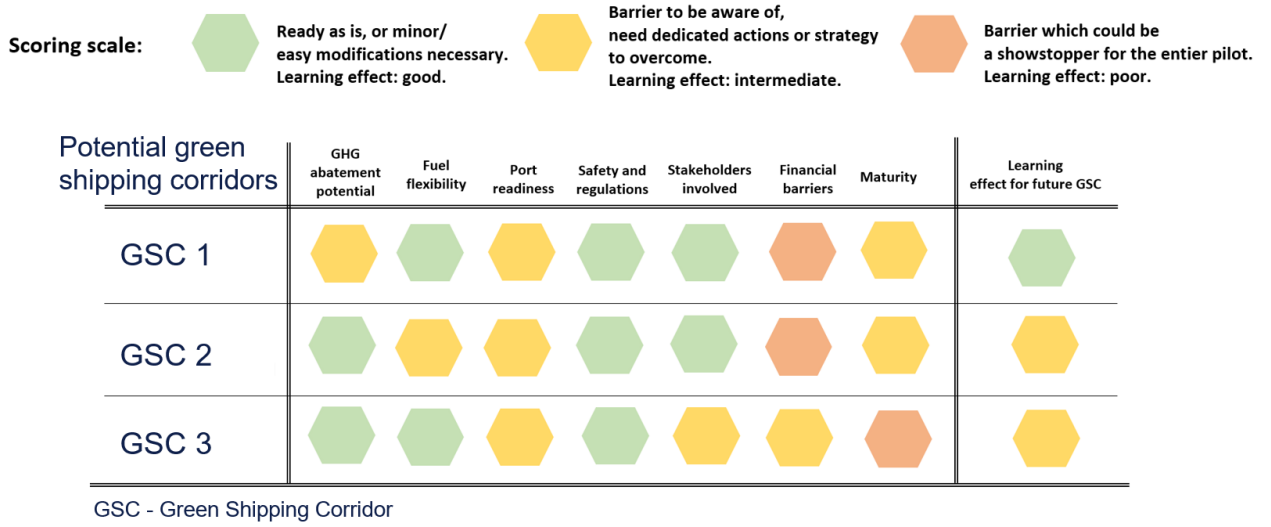

Figure 4-8: Workshop-based mapping of barriers – Example of barrier scorecard (DNV, 2023a)

Based on the learnings from the Nordic Roadmap project (Future Fuel Nordic, 2024), the recent report on Fuel Transition Roadmap for Nordic Shipping (DNV, 2024b) and the annual progress report on green shipping corridors (Global Maritime Forum, 2024), the following initial actions may be used as a guidance to resolve the initial challenges identified:

.1 Economic action: Develop funding, incentives, and pilot schemes for infrastructure development and zero-emission fuel production and adoption[48]

.2 Technological and regulatory actions: Developing zero-emission ship designs, bunkering infrastructure and competency[49]

.3 Political actions: Establishing a green shipping corridor and green maritime hub framework for the Mediterranean region[50]

4.3.2.1 Economic action: Develop funding, incentives, and pilot schemes for infrastructure development and zero-emission fuel production and adoption

For green shipping corridors and the first movers, the main issue is the competitive gap that exists between zero-emission fuels and fossil fuels as well as the high costs for infrastructure development and zero-emission fuel production. The lack of funding and incentives for such developments, which has been one of the key deterring factors, should hence be resolved. As listed in Table 3-4 and Table 3-5 in Section 3.2.4.2, the examples of subsidies for green hydrogen as well as examples of

[48] In the Nordic Roadmap project, the demand and cost of future fuels & fuel availability are cited as the barriers. https://futurefuelsnordic.com/the-nordic-fuel-transition-roadmap/

[49] In the Nordic Roadmap project, the technology and safety are cited as the barriers. https://futurefuelsnordic.com/the-nordic-fuel-transition-roadmap/

[50] In the GMF Annual Progress report on green shipping corridors 2024, the lack of governmental support and national policy incentives to promote adoption of future fuels are cited as the barriers. https://globalmaritimeforum.org/press/green-corridors-grow-by-40-worldwide-but-face-a-feasibility-wall-says-global/

shipping R&D and CapEx subsidies from some countries, e.g., Germany, UK, Australia, Japan, South Korea, etc., can be taken as a reference to develop relevant funding schemes for the Mediterranean coastal States. The Contracting Parties to the Barcelona Convention should propose relevant funding schemes to the Mediterranean coastal States to encourage various stakeholders in the value chain. Furthermore, since there are several funding schemes from the EU for the EU Member States, the Contracting Parties to the Barcelona Convention should also help to facilitate and encourage the development and adoption of similar schemes from the Mediterranean coastal States that are not EU Member States. This could be taken up as a pilot collaborative project between EU and non-EU Member States tapping on the EU funding to promote the development of green shipping corridors beyond the EU boundaries.

4.3.2.2 Technological and regulatory actions: Developing zero-emission ship designs, bunkering infrastructure and competency

To address the technological and regulatory challenges, two key aspects should be resolved: 1. Safety of ship designs and bunkering infrastructure at port adopting zero-emission fuels and technologies, and 2. Ship and shore crew competency in safe handling of ship and port operations using zero-emission fuels and technologies. In order to resolve the abovementioned aspects, it is recommended that the Contracting Parties to Barcelona Convention join forces to take a more active role at IMO and create a regional partnership hub to share best practices and experiences.

The adoption and use of zero-emission fuels require ships which are designed to operate safely. The current IGF Code is mainly centric on LNG as fuel and other fuels are due to be included in the near future. IMO Maritime Safety Committee issued the interim guidelines for ships using methyl/ethyl alcohol as fuel in 2020. Currently, the rules are available for LNG- and methanol-fuelled vessels whereas work for other fuels is progressing steadily but not finalised. Similarly, bunkering infrastructure for these fuels is also developing in a similar way. The Contracting Parties to the Barcelona Convention should monitor and guide the stakeholders so that the use of fuel onboard and bunkering infrastructure can develop in a safe manner, which is essential to developing green shipping corridors and green maritime hubs.

The competent staff on board and ashore is essential to ensure the safe handling of operations in adopting zero-emission fuels. In 2017, the STCW Convention was revised to include competency standards for seafarers sailing on ships subject to the IGF Code. The current IMO Model Courses, related to IGF Code training references mainly LNG as fuel. The competency standards and guidelines for other zero-emission fuels are not developed yet. It would be necessary for the Contracting Parties to the Barcelona Convention to follow up and adopt a similar approach to ensure uniformity in application when competency requirements are being proposed. Similarly, competence for shore workers needs to be standardised as it is necessary to develop bunkering locations which are necessary to develop green shipping corridors and green maritime hubs.

4.3.2.3 Political action: Establishing a green shipping corridor and green maritime hub framework for the Mediterranean region

The USA and Canada published national green shipping corridor frameworks to serve as the common guide for the development and implementation of green shipping corridors. Definitions, steps of planning and implementation, as well as potential areas for deployment, are clearly stated in the frameworks. To initiate the planning and implementation of green shipping corridors and green

maritime hubs in the Mediterranean region, the Contracting Parties to the Barcelona Convention should play a leading role in spearheading the development of such a framework for the Mediterranean region with the participation of all the Mediterranean Costal States. This framework should be used as a guide for the participating states to drive the development of green shipping corridors and green maritime hubs in a common direction.

4.3.3 Develop a holistic plan with timelines for all the stakeholders

After identifying the barriers and agreeable actions by the stakeholders, a holistic plan with timelines should be developed. This plan should detail the actions and milestones for all the stakeholders in the value chain under the three pillars.

5 DRAFT ROADMAP AND ACTION PLAN

Based on the recommendations provided in Section 4.3, the draft roadmap and action plan are drafted, as illustrated in Figure 5-1. The actions for next phase with suggeusted stakeholders' roles are shown in Table 5-1.

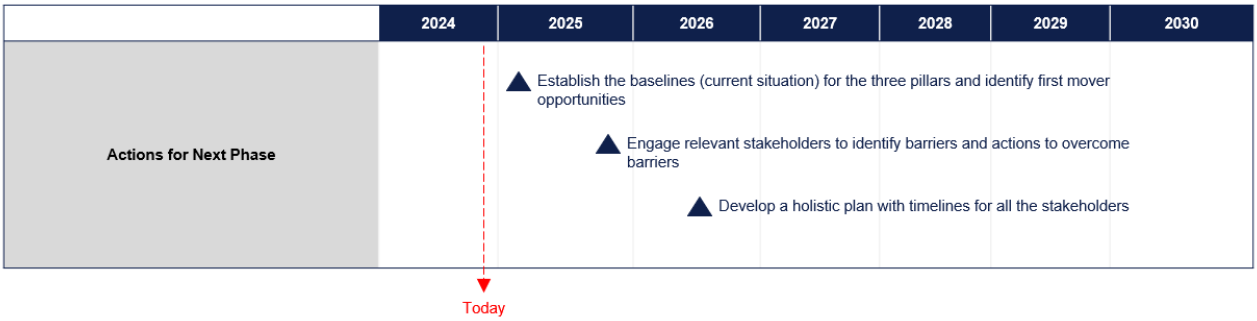

Figure 5-1: Draft roadmap and action plan

Table 5-1: Actions for next phase (*R: Responsible, C: Consult)

ID	Action	Timeline	Contracting Parties to Barcelona	Government and Regulators	Cargo owners	Ship owners and operators	Ports	Fuel producers and distributors
1.	Establish the baselines (current situation) for the three pillars and identify first mover opportunities	2025	R	R	C	C	C	C
2.	Engage relevant stakeholders to identify barriers and actions to overcome barriers	2025	R	R	C	C	C	C
3.	Develop a holistic plan with timelines for all the stakeholders	2026	R	R	R	R	R	R

Note: The stakeholders' roles are only suggestive and may be amended as necessary.

Some examples of recommended actions that may be taken by various stakeholders, such as government and regulators, cargo owners, shipowners and operators, ports, and fuel producers and distributors are shown in Table 5-2. This table may be used as a policy brief highlighting actionable recommendations for policymakers and industry stakeholders.

Table 5-2: Examples of recommended actions (*R: Responsible, C: Consult) (DNV, 2024b)

ID	Action	Contracting Parties to Barcelona Convention	Government and Regulators	Cargo owners	Ship owners and operators	Ports	Fuel producers and distributors
1.	Mediterranean governments to set up competitive tenders for Mediterranean green shipping corridors	R	R				
2.	Allocate funding to the Mediterranean green shipping corridors	C	R				
3.	Develop a plan for regional integration of fuel production and infrastructure, with development of energy hubs	R	R	C	C	R/C	R/C
4.	Set GHG emission requirements for Mediterranean ship segments	R	R	C	C	C	C
5.	Continue to implement and support the strengthening of EU and IMO GHG regulatory framework	R	R	R	R	R	R
6.	Develop a common approach to implement alternative design approval (as per SOLAS convention) among Mediterranean coastal States	R	R				
7.	Develop a common approach to fuel bunkering and establish common practices for safe and efficient operations with zero-emission fuels	R	R	R/C	C	R/C	C
8.	Develop and submit specific proposals on fuel safety and seafarer training to the IMO to help accelerate the international regulatory development process	R	R	R/C	R	R/C	C
9.	Establish a common approach for how to ensure green fuel quality and certification	R	R	C	C	C	R
10.	Establish Mediterranean support mechanisms accelerating demonstration, commercialization, and deployment of new technologies	R	R	C	R	R	C

Note: The stakeholders' roles are only suggestive and may be amended as necessary.

Notably, the Study includes the preliminary actions needed from the stakeholders including the Contracting Parties to the Barcelona Convention as well as some examples of actions. More details will be required and will be developed at the later stages when engaging all the stakeholders in the value chain.

6 REFERENCES

Alvar Mjelde, et al. (2019). Differentiating on port fees to accelerate the green maritime transition. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0025326X19307052

Aparajit Pandey & Jesse Fahnestock. (2022). Green Corridors: The Spanish Opportunity. Retrieved from https://globalmaritimeforum.org/report/green-corridors-the-spanish-opportunity/

BB Energy. (2023). Retrieved from https://www.bbenergy.com/newsroom/news/bb-energy-morocco-expands-its-gas-station-network-with-the-inaugural-opening-of-azzemour-station/#:~:text=The%20group%20is%20currently%20considering,the%20world%27s%20largest%20hydrogen%20producers.

Chara Georgopoulou & Nikolaos M.P. Kakalis. (2012). Assessing the Sustainability Potential of EU Transport Networks. Retrieved from https://api.semanticscholar.org/CorpusID:106926147

Chara Georgopoulou, et al. (2014). Green technologies and smart ICT for sustainable freight transport. Retrieved from https://doi.org/10.1007/978-3-319-01378-7_2

CMACGM. (2022). CMA CGM, a world leader in shipping and logistics, and TotalEnergies have launched Marseilles' inaugural ship-to-containership Liquefied Natural Gas (LNG) bunkering operation in the Port of Marseille Fos, Southern France. Retrieved from https://www.cmacgm-group.com/en/news-media/cma-cgm-and-totalenergies-launch-port-marseille-fos-first-ship-containership-lng

CMACGM. (2023). CMA CGM and Maersk join forces to accelerate the decarbonization of the shipping industry. Retrieved from https://www.cmacgm-group.com/en/news-media/cma-cgm-and-maersk-join-forces-accelerate-decarbonization-shipping-industry

COSCO Shipping. (2024). COSCO SHIPPING Showcases Green Initiatives at the 2nd Shanghai International Carbon Neutrality Expo. Retrieved from https://en.coscoshipping.com/col/col6923/art/2024/art_04c81afc70524a29abf53b571d27b4da.html

DNV. (2020). Ports: green gateways to Europe. Retrieved from https://www.dnv.com/publications/ports-green-gateways-to-europe-179372/

DNV. (2022a). DNV Maritime Forecast to 2050. Retrieved from https://www.dnv.com/publications/maritime-forecast-to-2050-2022-edition-235251/

DNV. (2022b). Insight on Green Shipping Corridors: From policy ambitions to realization. Retrieved from https://futurefuelsnordic.com/insight-on-green-shipping-corridors/

DNV. (2022c). AIS Analysis of Nordic Ship Traffic and Energy Use. Retrieved from https://futurefuelsnordic.com/ais-analysis-of-the-nordic-ship-traffic-and-energy-use/

DNV. (2023a). Intra-Nordic green shipping corridor candidates. Retrieved from https://futurefuelsnordic.com/intra-nordic-green-shipping-corridor-candidates/

DNV. (2023b). DNV Maritime Forecast to 2050. Retrieved from https://www.dnv.com/publications/maritime-forecast-to-2050-edition-2023/

DNV. (2024a). DNV Maritime Forecast to 2050. Retrieved from https://www.dnv.com/maritime/publications/maritime-forecast/

DNV. (2024b). Fuel Transition Roadmap for Nordic Shipping. Retrieved from https://futurefuelsnordic.com/the-fuel-transition-roadmap-for-nordic-shipping/#:~:text=The%20Nordic%20roadmap%20will%20list,and%20major%20actions%20and%20milestones

Eleanor Butler. (2024). Morocco pushes ahead with green hydrogen investment. Retrieved from https://www.euronews.com/business/2024/03/13/morocco-pushes-ahead-with-green-hydrogen-investment

Elena Talalasova, et al. (2023). Green shipping corridors in and out of Spain: Assessing route-based opportunities. Retrieved from https://globalmaritimeforum.org/report/green-shipping-corridors-in-and-out-of-spain-assessing-route-based/

Energy Intelligence. (2024). Algeria's Evolving Energy Strategy. Retrieved from https://www.energyintel.com/00000192-d1e7-de51-a19a-fbf7e35e0000

Eni. (2020). Enel and Eni jointly develop hydrogen projects. Retrieved from https://www.eni.com/en-IT/media/press-release/2020/12/enel-and-eni-jointly-develop-hydrogen-projects.html

Eni. (2024a). Eni, Fincantieri and RINA establish partnership for maritime transport decarbonization. Retrieved from https://www.eni.com/en-IT/media/press-release/2024/03/eni-fincantieri-and-rina-establish-partnership-for-maritime-transport-decarbonization.html

Eni. (2024b). Eni moves ahead with conversion of the Livorno refinery into a bio-refinery. Retrieved from https://www.eni.com/en-IT/media/press-release/2024/01/eni-moves-ahead-with-conversion-of-the-livorno-refinery-into-a-bio-refinery.html

European Commission. (2021). Green airports and ports as multimodal hubs for sustainable and smart mobility. Retrieved from https://maritime-spatial-planning.ec.europa.eu/fundings/green-airports-and-ports-multimodal-hubs-sustainable-and-smart-mobility

European Commission. (2023a). EU Emissions Trading System (EU ETS). Retrieved from https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

European Commission. (2023b). Decarbonising maritime transport – FuelEU Maritime. Retrieved from https://transport.ec.europa.eu/transport-modes/maritime/decarbonising-maritime-transport-fueleu-maritime_en

European Commision. (2024). EUROPEAN TRANSPORT CORRIDORS TRANS - EUROPEAN TRANSPORT NETWORK. Retrieved from https://transport.ec.europa.eu/document/download/3f55bcf7-d2cf-4244-bbf1-fc4f132115ad_en?filename=TEN_T_Schematic_map.pdf

European Commission. (2024a). Ferry demonstrator for the switch to safe use of sustainable climate neutral fuels in Adriatic - Zero Emission Adriatic Ship - ZEAS. Retrieved from https://trimis.ec.europa.eu/project/ferry-demonstrator-switch-safe-use-sustainable-climate-neutral-fuels-adriatic-zero-emission

European Commission. (2024b). Alternative Fuels Infrastructure. Retrieved from https://transport.ec.europa.eu/transport-themes/clean-transport/alternative-fuels-sustainable-mobility-europe/alternative-fuels-infrastructure_en

Foteini Asderaki. (2021). The EU in the Eastern Mediterranean: Multilateral and Bilateral Relations. Retrieved from https://link.springer.com/chapter/10.1007/978-3-030-70554-1_2#citeas

Future Fuel Nordic. (2024). Nordic Roadmap: Future Fuels for Shipping. Retrieved from https://futurefuelsnordic.com/about-us/

George Panagakos, et al. (2013). Green Corridors Handbook Volume II. Retrieved from http://martrans.org/supergreen/docs/public/Handbook-II.pdf

Giz. (2024). German-Moroccan Energy Partnership. Retrieved from https://www.giz.de/en/worldwide/152595.html

Global Maritime Forum. (2021). The Next Wave: Green corridors. Retrieved from https://globalmaritimeforum.org/report/the-next-wave-green-corridors/

Global Maritime Forum & Getting to Zero Coalition. (2023). National and regional policy for green shipping corridors. Retrieved from https://globalmaritimeforum.org/insight/national-and-regional-policy-for-green-shipping-corridors/

Global Maritime Forum. (2024). Annual Progress Report on Green Shipping Corridors. Retrieved from https://globalmaritimeforum.netlify.app/press/green-corridors-grow-by-40-worldwide-but-face-a-feasibility-wall-says-global/

Government of Canada Transport Canada. (2024). Canadian Green Shipping Corridors Framework. Retrieved from https://tc.canada.ca/en/marine-transportation/marine-pollution-environmental-response/green-shipping-corridors/framework

IMO. (2018). 2018 Initial IMO Strategy. Retrieved from https://www.imo.org/en/OurWork/Environment/Pages/Vision-and-level-of-ambition-of-the-Initial-IMO-Strategy.aspx

IMO. (2023a). 2023 IMO Strategy on Reduction of GHG Emissions from Ships. Retrieved from https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx

IMO. (2023b). Revised GHG reduction strategy for global shipping adopted. Retrieved from https://www.imo.org/en/MediaCentre/PressBriefings/pages/Revised-GHG-reduction-strategy-for-global-shipping-adopted-.aspx

IMO. (2024). Marine Environment Protection Committee (MEPC 82), 30 September – 4 October 2024 Retrieved from https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MEPC-82nd-session.aspx

IN. (2021). Hellenic Petroleum – Transformation of production for green fuels. Retrieved from https://www.in.gr/2021/09/23/english-edition/hellenic-petroleum-transformation-production-green-fuels/

Inditex. (2023). Inditex partners with Maersk to reduce its maritime transport emissions. Retrieved from https://www.inditex.com/itxcomweb/en/press/news-detail/4f13a790-d61f-4d0e-b22f-763247177304/inditex-partners-with-maersk-to-reduce-its-maritime-transport-emissions

Jasmina Ovcina Mandra. (2022). Grimaldi investing in 12 new eco-friendly vessels. Retrieved from https://www.offshore-energy.biz/grimaldi-investing-in-12-new-eco-friendly-vessels/

Jassmin Ahdani. (2024). Morocco's Tanger Med breaks into top 20 ports. Retrieved from https://www.theafricareport.com/342633/moroccos-tanger-med-breaks-into-top-20-ports/

Jean-François Arvis, et al. (2019). Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. Retrieved from http://hdl.handle.net/10986/30585

Julian Atchison. (2024). Spanish government launches support scheme for hydrogen valleys. Retrieved from https://ammoniaenergy.org/articles/spanish-government-launches-support-scheme-for-hydrogen-valleys/

Lilia Khodjet, et al. (2021). Maritime Transport in the Mediterranean: Status and Challenges. Retrieved from https://planbleu.org/wp-content/uploads/2021/12/MARITIME_TRANSPORT.pdf

MAERSK. (2021). A.P. Moller - Maersk accelerates fleet decarbonisation with 8 large ocean-going vessels to operate on carbon neutral methanol. Retrieved from https://www.maersk.com/news/articles/2021/08/24/maersk-accelerates-fleet-decarbonisation

Mærsk Mc-Kinney Møller Center. (2021). We show the world it is possible, Industry Transition Strategy. Retrieved from https://cms.zerocarbonshipping.com/media/uploads/documents/MMMCZCS_Industry-Transition-Strategy_Oct_2021.pdf

Maritime Technologies Forum. (2024). Safety considerations for establishing green corridors. Retrieved from https://www.maritimetechnologiesforum.com/documents/2024-mtf-safety-considerations-for-establishing-green-shipping-corridors-report.pdf

Marseille Fos. (2022). H2V FOS and the Port of Marseille Fos Retrieved from https://www.marseille-port.fr/en/projets/h2v-fos-et-le-port-de-marseille-fos

Menon. (2022). Infrastructure and Bunkering Challenges for Zero-carbon Fuels. Retrieved from https://futurefuelsnordic.com/wp-content/uploads/2023/02/Task-2B_final-version-feb-2023.pdf

Motor Oil. (2023a). The Innovation Fund Grant Agreement, for Motor Oil's flagship project IRIS, has been officially signed. Retrieved from https://www.moh.gr/en/news/the-innovation-fund-grant-agreement-for-motor-oils-flagship-project-iris-has-been-officially-signed/

Motor Oil. (2023b). Strategy and Outlook Targets 2030. Retrieved from https://www.moh.gr/wp-content/uploads/2023/11/Strategy-and-Outlook-update-2023-Targets-2023.pdf

MSC. (2023). MSC Reports Progress on Delivering Sustainability Commitments. Retrieved from https://www.msc.com/en/newsroom/news/2023/june/msc-reports-progress-on-delivering-sustainability-commitments

PierNext. (2020). Hydrogen, the fuel of a sustainable Europe arrives to the ports. Retrieved from https://piernext.portdebarcelona.cat/en/environment/hydrogen-the-fuel-of-a-sustainable-europe-arrives-to-the-ports/

Port of Rotterdam, et al. (2024). Demand potential for alternative fuels on the Rotterdam-Singapore Green & Digital Shipping Corridor. Retrieved from https://www.portofrotterdam.com/sites/default/files/2024-09/Rotterdam%20Singapore%20Green%20Corridor%20Fuel%20Demand.pdf

Port de Barcelona. (2024). The Port of Barcelona is making progress towards introducing cleaner fuels for ships. Retrieved from https://www.portdebarcelona.cat/en/communication/news/port-barcelona-making-progress-towards-introducing-cleaner-fuels-ships

Port of Rotterdam. (2022). Cepsa and the port of Rotterdam join up to create the first green hydrogen corridor between the north and south of Europe. Retrieved from https://www.portofrotterdam.com/en/news-and-press-releases/cepsa-and-the-port-of-rotterdam-join-up-to-create-the-first-green-hydrogen

Port of Tyne, et al. (2023). Clean Tyne Shipping Corridor Roadmap. Retrieved from https://cp.catapult.org.uk/report/clean-tyne-shipping-corridor-roadmap/

Port Technology. (2020). https://www.porttechnology.org/news/marseille-fos-looks-to-become-main-mediterranean-lng-bunkering-hub/. Retrieved from https://www.porttechnology.org/news/marseille-fos-looks-to-become-main-mediterranean-lng-bunkering-hub/

Repsol. (2024). Repsol begins large-scale production of renewable fuels in Cartagena, the first plant of its kind in the Iberian Peninsula. Retrieved from https://www.repsol.com/en/press-room/press-releases/2024/repsol-begins-large-scale-production-of-renewable-fuels-in-cartagena-the-first-plant-of-its-kind-in-the-iberian-peninsula/index.cshtml

Robert Brelsford. (2022). Tüpraş adding alkylation capacity to Turkish refineries. Retrieved from https://www.ogj.com/refining-processing/refining/capacities/article/14233583/tupras-adding-alkylation-capacity-to-turkish-refineries

Rubis Energie. (2022). Rubis Energie joins the “Sea Cargo Charter”. Retrieved from https://www.rubisenergie.com/en/rubis-energie-joins-the-sea-cargo-charter/

SGS. (2024). Algeria: National strategy for hydrogen development published. Retrieved from https://inspire.sgs.com/content/101104598/algeria-national-strategy-for-hydrogen-development-published

Silk Alliance. (2023). The Silk Alliance: A progress report. Retrieved from https://www.thesilkalliance.com/wp-content/uploads/LR-Silk-Alliance-Progress-and-Next-Steps-Nov2023.pdf

TITAN. (2023). TITAN Group’s large-scale Carbon Capture project selected by the EU Innovation Fund Retrieved from https://www.titan-cement.com/wp-content/uploads/2023/07/13072023_Titan_Group_large-scale_Carbon.pdf

TotalEnergies. (2020). Total joins the Sea Cargo Charter, as Industry giants commit to transparent reporting of shipping emissions. Retrieved from https://totalenergies.com/media/news/news/total-joins-sea-cargo-charter-industry-giants-commit-transparent-reporting-shipping

TotalEnergies. (2021). Energy transition in shipping: First BioLNG production project at a French port. Retrieved from https://marinefuels.totalenergies.com/news/press-release/energy-transition-shipping-first-biolng-production-project-french-port

TotalEnergies. (2023a). TotalEnergies Marine Fuels completes first biofuel bunkering trials in France. Retrieved from https://marinefuels.totalenergies.com/news/blog/totalenergies-marine-fuels-completes-first-biofuel-bunkering-trials-in-france

TotalEnergies. (2023b). The Roads to Carbon Neutral: Sharing our commitment to maritime decarbonization with CNBC. Retrieved from https://marinefuels.totalenergies.com/news/blog/the-roads-to-carbon-neutral-sharing-our-commitment-to-maritime-decarbonization-with-cnbc

TotalEnergies. (2024). Renewables & Green Hydrogen: TE H2, CIP, and A.P. Møller Capital Partner for a Large-Scale Project in the Kingdom of Morocco. Retrieved from https://totalenergies.com/news/press-releases/renewables-green-hydrogen-te-h2-cip-and-ap-moller-capital-partner-large-scale

U.S. Department of State. (2022). Green Shipping Corridors Framework. Retrieved from https://www.state.gov/green-shipping-corridors-framework/#:~:text=The%20United%20States%20envisions%20green,decarbonization%20no%20later%20than%202050.

UCL Energy Institute, et al. (2024). Climate Action in Shipping - Progress towards Shipping's 2030 Breakthrough. Retrieved from https://globalmaritimeforum.org/report/climate-action-in-shipping-progress-towards-shippings-2030-breakthrough-2024/

UMAS & Getting to Zero Coalition. (2021). A Strategy for the Transition to Zero-Emission Shipping. Retrieved from https://globalmaritimeforum.org/press/shipping-needs-to-take-rapid-action-to-achieve-5-zero-emission-fuel-target/

UMAS & UN Climate Change High Level Champions. (2023). Climate Action in Shipping - Progress towards Shipping's 2030 Breakthrough. Retrieved from https://globalmaritimeforum.org/report/climate-action-in-shipping-progress-towards-shippings-2030-breakthrough/

UN Global Compact, et al. (2023). Tides of Change: A Framework for Developing Just and Inclusive Green Shipping Corridors. Retrieved from https://www.zerocarbonshipping.com/publications/tides-of-change-a-framework-for-developing-just-and-inclusive-green-shipping-corridors/