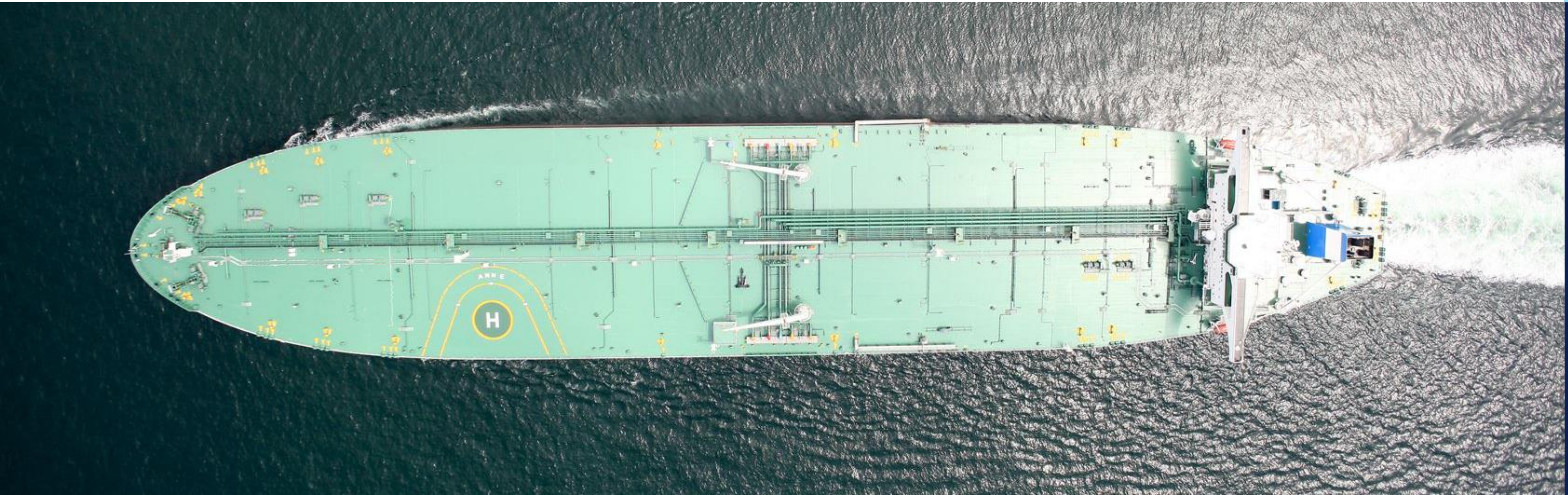
WHEN TRUST MATTERS

Executive summary and documentation

Measurement of Zero-Emission Shipping Mission KPIs

2023-03-08 (Rev 2)

Zero-Emission Shipping Mission



Executive summary and documentation

Measurement of Zero-Emission Shipping Mission KPIs

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DNV Legal Entity	4100 - DNV AS
DNV Reference	2023-0007
Date of Issue:	2023-03-08
Terms and Conditions	DNV standard terms & conditions
DNV distribution	Confidential

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Contents

Abbreviations

AIS	Automatic identification system
CCS	Carbon capture and storage
CO2	Carbon dioxide
DAC	Direct air capture
DCS	Data collection system
EU	European Union
FPSO	Floating Production Storage and Offloading
FSU	Floating Storage Unit
GHG	Greenhouse gas
HFO	Heavy Fuel Oil
HVO	Hydro-treated Vegetable Oil
KPI	Key performance indicator
LCA	Life-cycle assessment

LFO	Light Fuel Oil
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
RED	Renewable Energy Directive
TRL	Technology Readiness Level
TtW	Tank-to-wake
UCO	Used Cooking Oil
WtT	Well-to-tank
WtW	Well-to-wake
ZESM	Zero-Emission Shipping Mission

Definitions used in the report (1)

Term	Description
Well-to-wake zero-emission GHG fuels	Alternative marine fuels with the potential to reduce well-to-wake greenhouse gas emissions by up to 100%. This includes biofuels made from sustainable feedstock (advanced biofuels), electrofuels made from renewable electricity and sustainable carbon, and blue fuels made from reforming of fossil energy with CCS.
Deep-sea vessels	Deep-sea shipping comprises large ocean-going ships, operating intra- and inter-regionally/continental, where a very large share of their energy consumption relates to propulsion of the ship at steady speed over long distances. The ships require fuel that is globally available, and the fuel energy-density is important to maximize the space available for the transport of cargo over long distances. In contrast, vessels in the short-sea segment are typically smaller, with more varied operational profiles and a greater share of their time and energy is spent on purposes other than steady propulsion. In this study we assume that all commercial ships above 10 000 GT, apart from offshore vessels, are deep-sea vessels. In reality, the cut-off between short-sea and deep-sea will depend on ship-type, trade, and operational area. As of December 2022, approximately 35 000 vessels in the world fleet fulfill our definition of deep-sea vessels.
Electrofuels	Electricity-derived alternative fuels, produced via hydrogen from electrolysis of water. Electrofuels have the potential to reduce WtW GHG emissions by up to 100%, provided that electricity needed for production is renewable. For carbon-based electrofuels (e.g. e-methanol), it is also important that carbon feedstock is based on a sustainable CO2 source (e.g. biogenic CO2 or CO2 from DAC).
Biofuel	A liquid or gaseous fuel which is produced from biomass through various alternative processing methods. If sustainable biomass is used for production, with low land-usage change impact, use of biofuels may lead to significant reduction in WtW GHG emissions. Such biofuels are often referred to as advanced biofuels.

Definitions used in the report (2)

Term	Description
Blue fuels	A gaseous or liquid fuel, produced via hydrogen from reformation of fossil energy with CCS. For example, blue hydrogen may be produced from steam reformation of natural gas, resulting in an output stream of CO2 and hydrogen. If the CO2 is captured and stored permanently, the hydrogen product is referred to as blue. Blue hydrogen and blue ammonia are the most commonly mentioned blue fuels.
Vessels capable of operation on well-to-wake zero-emission hydrogen-derived GHG fuels	Vessels that have one or several energy converters onboard, capable of being fuelled by methanol, ammonia, or hydrogen.
Energy converter	Internal combustion engine or fuel cell onboard vessel, converting fuel energy content to electric power, heat or shaft power.
Newbuild well-to-wake zero-emission hydrogen-derived GHG fuel vessel	Vessel capable of running on well-to-wake zero-emission hydrogen-derived GHG fuels from newbuilding stage.
Retrofitted well-to-wake zero-emission hydrogen-derived GHG fuel vessel	Vessel which was not capable of running on well-to-wake zero-emission hydrogen-derived GHG fuels from newbuilding stage, but after a retrofit.
Green shipping corridors	Green shipping corridors are zero emission maritime routes between 2 (or more) ports. Reference is made to the Clydebank declaration*.
Deep-sea green corridors	Green shipping corridors where deep-sea vessels operate.

*https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors

Definitions used in the report (3)

Term	Description
Green shipping corridor initiative	An announced agreement, partnership or initiative to investigate and/or establish a green shipping corridor. Could be either a specific route (port-to-port), a specific region (network), involving specific ports and/or a partnership among defined stakeholders.
Port A and Port B	Port A and Port B refers to the two ports involved in a port-to-port green shipping corridor.
Hydrogen-derived fuels	Hydrogen fuel, or fuels produced using hydrogen as a feedstock. In this report, we only consider the hydrogen-derived fuels hydrogen, methanol and ammonia.
Member countries and organizations	A current member of the ZESM (http://mission-innovation.net/missions/shipping/).
A voyage	Any movement of a ship that originates from or terminates in a port of call. The voyage starts when the ship leaves the port and ends when entering a new or the same port location.

1. **Introduction and Executive summary**
2. Documentation of KPI methodology, results and challenges
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Introduction

Background

The ZESM aims to demonstrate commercially-viable zero-emission ships by 2030, making vessels that operate on zero-emission fuels the natural choice for ship owners when they renew their fleet. In order to achieve this aim, the ZESM has identified six Key Performance Indicators (KPI). A robust methodology, incorporating cutting-edge databases on uptake of alternative fuels in shipping and other tools, is needed to monitor the status and progress of these KPIs.

Objective

The main objective of this study is to provide the Zero Emission Shipping Mission with the status of specified KPIs (KPI number 1 – 4), as of 2022, based on a robust methodology and data-collection. To meet the objective, DNV has utilized our MASTER* model based on automatic identification systems (AIS) data, DNV's Alternative Fuel Insight (AFI) database, and performed a literature review of relevant industry and academic papers. We have also identified important challenges related to measurement of the KPIs, and proposed solutions where possible.

*Mapping of Ship Tracks, Emissions and Reduction potentials

Delivery from this project

- In order to meet the project objective, we have prepared an interactive digital dashboard shared via the DNV Veracity platform, where the data is also stored. The dashboard has been created with the view to make the delivery flexible and future updates more easily.
- The digital dashboard consists of two key elements:
  - PowerBI dashboards for visualizing the status of each KPI (1-4). The dashboards allow filtering, so that the user can focus attention on the most relevant set of results at any given time.
  - Executive summary and documentation outlining methodology for estimating each KPI, results, and uncertainties in estimate. This DNV report includes results for ZESM's KPI 5 & 6, as estimated by the administration.
- The dashboard may be accessed via the following link (provided access has been granted by DNV): https://insight.dnv.com/decarbonisation/Report/Progress-report-on-Zero-Emission-Shipping-Mission-KPIs/Zero-Emission%20Shipping%20Action-Executive-summary

High-level methodology

DNV has applied a three-step approach (shown below) for estimating the current status of KPIs defined by the ZESM alliance. Each step is described below:

Step 1 – Identification of data-sources

Relevant industry literature for each KPI has been identified. DNV has built on its global network of professionals working on topics related to the global energy transition, to make sure that the most relevant data-sources are captured.

Step 2 - Extraction of relevant information

When data-sources has been identified, work is carried out to extract information specifically related to each given KPI (1-4).

Step 3 – Translation of results into KPIs

Based on the results of step 1 and step 2, KPI-status is estimated for KPI 1-4. Uncertainty in each estimate has been discussed.

Results: KPI 1-4

KPI 1: Number of deep-sea vessels applying well-to-wake zero-emission GHG fuels

Number of vessels
0

KPI 2: Number of deep-sea vessels capable of using well-to-wake zero-emission GHG fuels

Number of vessels
76

KPI 3: Number of deep-sea green shipping corridors involving Mission countries and organizations

Number of existing deep-sea green shipping corridors	Number of announced green shipping corridor initiatives
0	19

KPI 4: Number of deep-sea zero-emission maritime research, development, and demonstration/pilot projects

Part A: Projects on ammonia, hydrogen and methanol

Number of vessel projects	Number of bunkering projects
12	16

Part B: Testing, trialling and R&D projects related to use of biofuels

Number of vessel projects	Number of bunkering projects
18	1

Please note that there are uncertainties related to the reported number/status for all KPIs, and several challenges to measure and monitor the KPIs. The methodology applied and the related uncertainties and challenges are further addressed in Section 2 of this report.

KPI 5-6 (delivery from the ZESM administration)

ZERO-EMISSION SHIPPING MISSION

Note: The results shown on this slide is based on work carried out by the ZESM administration

KPI 5: Number of workshops and publications issued by the Mission, as well as engagement of these events or documents, to ensure that the Mission is serving as a thought-leader and disseminating the information to a broad audience.

Number of publications	Number of workshops/events
7	27

KPI 5 measured by: Annual survey counting the number of documents published by the Mission and number of workshops held. In terms of engagement, publication engagement will be tracked by monitoring the number of downloads or unique views of the documents hosted on the Mission webpage. Workshop participation will be tracked by summing the number of attendees to each workshop throughout the year. Baseline values are to be established during the first year, from which out-year goals can be established.

KPI 6: Number of participants (co-leads, core members, supporting members) involved with the Mission and that identifies their affiliation (industry or government), country, and Pillar interests

Number of co-leads	Number of core mission members	Number of mission support members
5	4	6

KPI 6 measured by: Annual survey of all mission participants

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Key challenges identified

Inevitably, the estimation of each KPI status involves a range of uncertainties and challenges, due to the applied methodology and data-sources. The below gives key challenges identified for each KPI (1-4).

KPI	Challenge	
KPI 1: Number of deep-sea vessels applying well-to-wake zero-emission GHG fuels	Lack of data sources	To DNV's knowledge, there are currently no comprehensive public data sources giving the number of vessels applying zero-emission WtW GHG fuels.
	Lack of a standard for assessing WtW GHG emissions for marine fuels	Without an internationally recognized standard for assessing WtW GHG emissions for marine fuels, it is unclear what fuels and production pathways will be considered zero-emission WtW GHG in the future.
KPI 2: Number of deep-sea vessels capable of using well-to-wake zero-emission GHG fuels	Extent of capability of running on methanol, hydrogen, or ammonia	It is important to set criteria for the extent to which a vessel is capable of running on methanol, hydrogen, or ammonia (e.g. should only vessels with hydrogen-derived fuels as main propulsion fuel be included?). This is to avoid giving a too optimistic estimate of the KPI status.
KPI 3: Number of deep-sea green shipping corridors involving Mission countries and organizations	Maturity definitions for green corridors	A distinction should be made between existing and announced green shipping corridors. Most of the mapped green shipping corridor initiatives are at an early stage and still far from realization.
KPI 4: Number of deep-sea zero-emission maritime research, development, and demonstration/pilot projects	Lack of data sources	There is currently no exhaustive list or database of current maritime research, development and pilot projects.
	Definition of "pilot projects"	It is important to have clear and concise definition of "pilot project", in order to avoid a possible overlap with KPI 2 and to capture the most meaningful projects for deep-sea shipping.

Based on our assessment of KPI statuses, we find that KPI 1 & 4 has the greatest potential for improvement in order to more accurately portray the KPI measurement. We believe that the largest uncertainty in KPI measurement is found for KPI 1, due to lack of data.

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Step 2 - Extraction of relevant information

When data-sources has been identified, work is carried out to extract information specifically related to each given KPI (1-4).

Step 3 – Translation of results into KPIs

Based on the results of step 1 and step 2, KPI-status is estimated for KPI 1-4. Uncertainty in each estimate has been discussed.

Methodology per KPI

KPIs	1 Identification of data-sources	2 Extraction of relevant information	3 Translation of results into KPI status
KPI 1: No. of deep-sea vessels applying well-to-wake zero-emission GHG fuels	Aggregated DCS-data Industry literature DNV experts	Aggregated fuel consumption per fuel-type Vessels applying well-to-wake zero emission GHG fuels	No. of deep-sea vessels applying well-to-wake zero GHG fuels on a continuous basis No. of deep-sea vessel equivalents fuelled by fuels with potential to be well-to-wake zero GHG
KPI 2: No. of deep-sea vessels capable of using well-to-wake zero-emission GHG fuels	DNV's AFI platform DNV experts	Uptake of vessels capable of running on methanol, hydrogen, and ammonia	No. of operational deep-sea vessels capable of running on ammonia, methanol, and hydrogen (newbuilds and retrofits) No. of ordered deep-sea vessels capable of running on ammonia, methanol, and hydrogen today (orderbook)
KPI 3: Number of deep-sea green shipping corridors involving Mission countries and organizations	Industry literature AIS-data DNV experts	Key information on existing and announced green shipping corridors AIS-data on vessels transiting between announced green shipping corridor ports	For identified green shipping corridors involving Mission members: i. No. of existing and announced corridors ii. Sailing distance and no. of deep-sea vessels operating on port-to-port corridors
KPI 4: Number of deep-sea zero-emission maritime research, development, and demonstration/pilot projects	Public databases Industry literature DNV experts	Key information on maritime research, development, and demonstration/pilot projects.	No. of deep-sea zero-emission maritime research, development, and demonstration/pilot projects projects involving Mission members related to: - Part A: Methanol, hydrogen, or ammonia as fuels on deep-sea vessels and bunkering. - Part B: Testing, trialling and R&D projects related to use of biofuels

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Results (1) – KPI 1

Step 1 – Identification of data-sources

- To DNV's knowledge, there currently exists no comprehensive data-sources giving the use, or number of ships using verified zero-emission WtW GHG fuels on deep-sea vessels. It is also important to note that there is currently no international standard adopted for assessing WtW GHG emissions for marine fuels.
- Although, many deep-sea vessels reportedly have tested different types of liquid biofuels (e.g. UECC, 2021), and some container shipping companies use liquid biofuel blends on a routine basis (see e.g. (MSC, 2022) and (CMA CGM, 2022)), no deep-sea vessels are identified to use verified WtW zero-emission GHG fuels on a consistent, long-term basis. In this context, we only include deep-sea vessels thought to have most of its energy consumption derived from WtW zero-emission GHG fuels.
- Currently, the most comprehensive set of data available on consumption of marine fuel for shipping, is IMO DCS data. Since 2019, all cargo-ships above 5000 GT have been required to report annual consumption of marine fuels, along with other parameters including sailed distance and hours underway. DCS data is currently not publicly available, however, each year the IMO secretariat publishes a document where aggregated fuel consumption by fuel type is given (IMO 2019;2020;2021). This is relevant for the estimation of KPI 1.

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Results (2) – KPI 1

Step 2 - Extraction of relevant information

There are three key limitations to note when applying aggregated IMO DCS data for the purpose of estimating the status of KPI 1:

- The data only covers fuel consumption by fuel type, with no information on the given fuel's production pathway. For fuel consumption reported as HFO, LFO, MGO/MDO, LNG, ethane, and LPG, we can safely assume that production is based on fossil energy. For other fuel types, on the other hand, such as methanol, this is not so obvious.
- There is no information in the IMO DCS-data on the number of ships applying the different fuel types, only aggregate values of fuel consumption are given.
- IMO (2021) notes that fuels reported as biofuel includes different fuel blends (e.g. B50 and B100), with no distinction made between the different blends.
- DCS-data is applicable for all vessels trading internationally above 5000 GT, with some exceptions (e.g. FPSOs, FSUs, and drilling rigs). In this study, we have defined deep-sea vessels as vessels with gross tonnage above 10 000 GT. As such, some of the fuel consumption reported may apply to vessels engaged in short-sea trades.

Bearing the above data-limitations in mind, IMO (2021) reports aggregated fuel consumption of fuels with potential to reduce WtW GHG emission by up to 100% as shown below.

Fuel type	Aggregated reported fuel consumption (tonnes)
Methanol	13031
Ethanol	4849
Biofuel (reported under Other)	67580

Results (3) – KPI 1

Step 3 - Translation of results into KPI status

- DNV has not identified any deep-sea vessels using 100% verified zero-emission WtW GHG on consistent, long-term basis. As such, the status of KPI 1 is zero vessels. That being said, a not unsubstantial volume of fuels with potential to reduce WtW GHG emissions by up to 100% was reported through the IMO DCS scheme in 2021.
- In order to translate relevant information from step 2 into something tangible for KPI 1, we need to make assumptions related to WtW GHG emissions and share of biofuel (for fuel consumption reported as biofuel). These assumptions are provided per fuel type in the below table.

Fuel type	Assumptions
Other (biofuel)	**WtW GHG emissions** IMO (2021) states that reported biofuel consumption includes HVO, different biofuel blends, and UCO. Although the bulk of worldwide bio-based diesel production is made from conventional feedstocks (IEA, 2022), the most common biofuel-types applied by shipping companies are based on waste sources like used cooking oil (see e.g. MSC (2022); CMA CGM (2022); UECC (2021)). Waste sources such as UCO and animal fats, for the purpose of producing biofuels, is given special treatment by the EU RED II (EU, 2018) as feedstock sources which are not based on food or animal-feed. Challenges with waste-based biofuels is that waste may still have valuable alternative uses and potentially cause displacement emissions when diverted for biofuel production. Nevertheless, UCO sourced domestically can bring high GHG savings compared to fossil fuels, given that the origin of the UCO is scrutinized (Transport & Environment, 2020). For the purpose of estimating the status of KPI 1, we assume that all biofuel consumption reported in DCS has the potential to reach reduce WtW GHG by up to 100%. **Share of biofuel** Data-sources on the most commonly applied biofuel blends are scarce, although Rotterdam (2020) notes that the most common biofuel-blends bunkered in 2019 was between 20 – 30% biofuel. We assume a weighted average biofuel blend of 20% for consumption reported through DCS.

Results (4) – KPI 1

Fuel type	Assumptions
Methanol	**WtW GHG emissions** Only 0.2% of global methanol production is based on renewable sources (i.e. based on sustainable biomass or renewable electricity with sustainable carbon), with the remainder being produced from fossil sources including natural gas and coal (IRENA, 2021). As such, we assume that all reported methanol consumption is fossil-based methanol, and will not qualify as a WtW zero emission fuel for KPI 1.
Ethanol	**WtW GHG emissions** Ethanol production is primarily via fermentation of plants. More specifically, current production is based mostly on conventional biofuel feedstocks such as corn, sugar cane, and cereals (REN21, 2022). The EU RED II sets a cap on biofuels identified to have significant ILUC-risk, including ethanol produced from food and feed crops, as any WtW GHG emissions saving may be negated by GHG emissions associated with ILUC. It should be mentioned that 8% of ethanol production in 2021, was from advanced feedstocks such as lignocellulosic crops (IEA, 2022), with comparatively low ILUC emissions. Nevertheless, for estimating status of KPI 1, we disregard all reported ethanol consumption by IMO DCS.

- When applying an assumed blend-in share of 20% to the reported Other (biofuel) consumption from IMO DCS, we reach a figure of 13 500 tonnes biofuel. This is equivalent to 14 200 tonnes VLSFO-eq., assuming a LHV of 42.7 GJ/tonne for liquid biofuel.
- To put this in perspective (see Appendix A - Ship equivalent fuel consumption and segments), this is equivalent to the annual fuel consumption of one VLCC, or two feeder container vessels. It must, however, be emphasized that this does not mean that any one vessel continuously runs on well-to-wake zero emission fuels.

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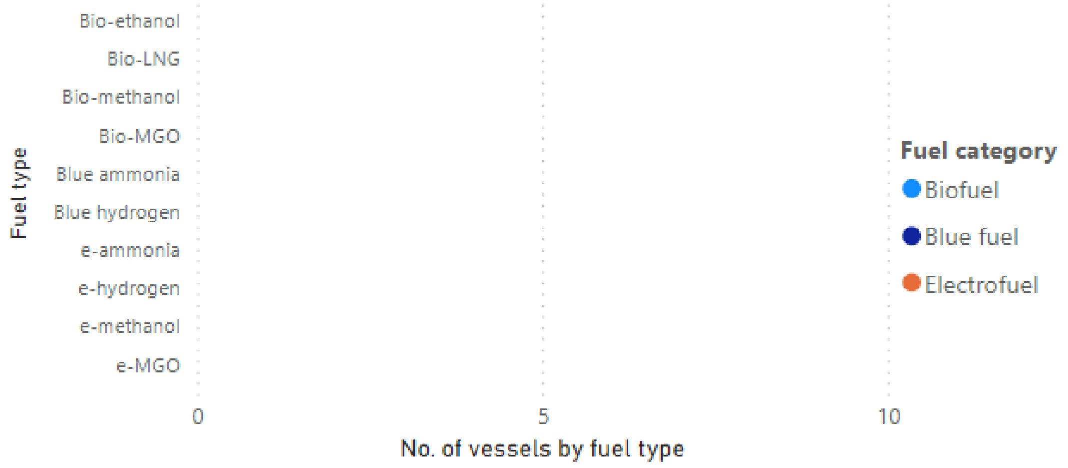
Results for KPI 1 (snapshot of dashboard)

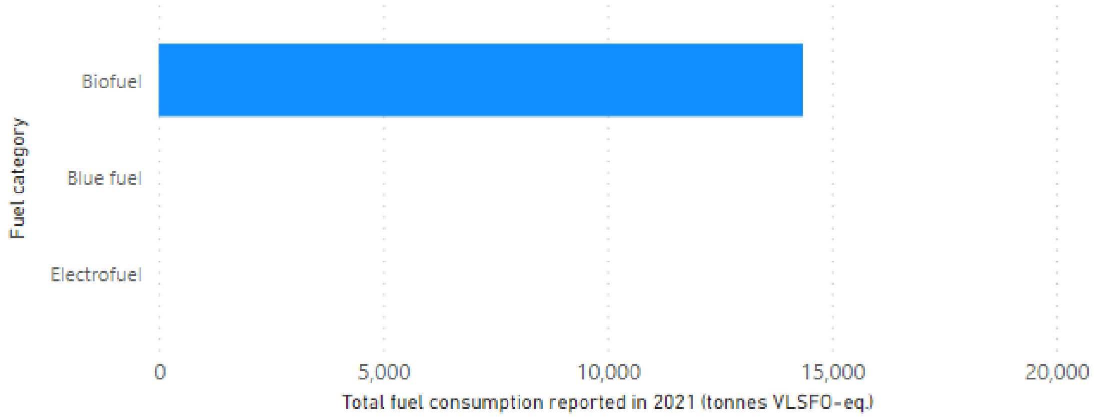


*Number of vessels applying WtW zero-emission GHG fuels on a **consistent, long-term basis.** Vessels applying fuel-blends consisting partially of fossil fuels are not included.*

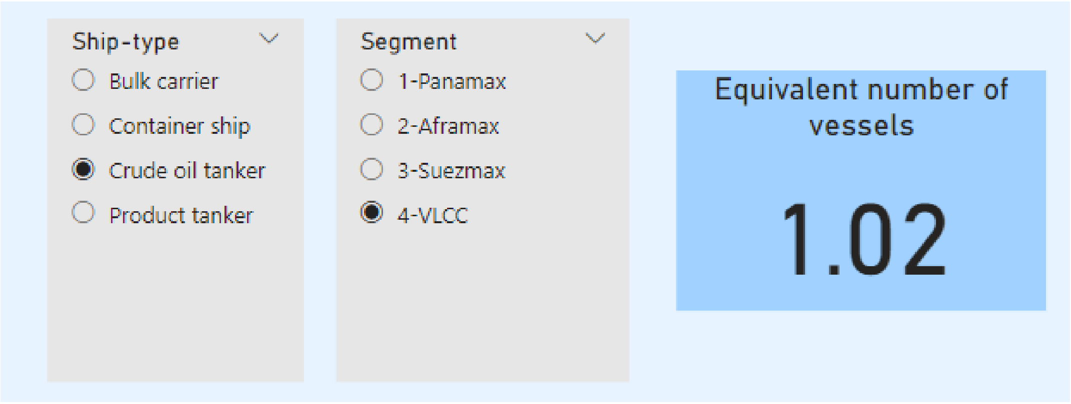
Number of vessels

0

The below total fuel consumption reflects the total amount of fuel with potential to reduce WtW GHG emissions by up to 100% reported in 2021. It includes use of fuel blends.



The below box gives the aggregated WtW zero-emission GHG fuel consumption in terms of the average annual fuel consumption of a typical vessel (to be specified by applying filters).



Challenges and uncertainties (1) – KPI 1

There are significant challenges associated with estimating the status of KPI 1. Some of these are described below.

Lack of data sources

To DNV's knowledge, there are currently no public data sources giving the number of vessels applying zero-emission WtW GHG fuels. Currently, the most comprehensive set of data available on consumption of marine fuels for shipping is IMO DCS data, giving ship-by-ship aggregated annual fuel consumption by fuel-type. However, there are important limitations in its use:

- The database is not available to the public. On an annual basis, the IMO secretary publishes a report aggregated fuel consumption volumes (IMO 2019;2020;2021), but the number of vessels applying specific fuels on a continuous basis is not given in the report.
- DCS-data attributes fuel consumption to different specified fuel-products (e.g. methanol or HFO). The name of the fuel-products are based on fossil fuels, and currently do not take into account fuels produced from non-fossil sources. As a results, biofuel usage is reported in the category "other".
- DCS-data does not accommodate reporting of fuel-blends consisting of fossil fuels and fuels with the potential to each zero WtW GHG emissions.

Criteria for qualifying a vessel as "running on WtW zero-emission GHG fuels"

It is important to have a clear criteria for what constitutes a vessel "running on WtW zero-emission GHG fuel". For example, would an ammonia-fuelled vessel powered by dual fuel internal combustion engines, running on e-ammonia and fossil pilot fuel oil qualify?
Most dual fuel engines rely on a certain share of pilot fuel oil, when operating in alternative fuel mode. Although, in energy terms, the share of pilot fuel oil is typically low (<10%), it cannot be ignored. Technically speaking, the pilot fuel oil could be sourced from biofuels or electrofuels. In addition, some vessels will not exclusively have energy converters capable of running on alternative fuels. For example, some vessels may have a main engine capable of running on methanol, but auxiliary engines and boilers only capable of running on fuel oils. For such vessels, it would be impossible to run 100% on WtW zero-emission GHG methanol.

Challenges and uncertainties (2) – KPI 1

Lack of a standard for assessing WtW GHG emissions for marine fuels

Currently, there is no international standard for assessing WtW GHG emissions for marine fuels. Without such a standard, it is unclear what fuels and production pathways will be considered zero-emission WtW GHG in the future. In this study, we have aligned our definition of zero-emission WtW GHG fuels with the EU's RED II directive, with respect to treatment of biofuels. More specifically, we have only considered biofuels with significant potential to reduce WtW GHG emissions and produced from non-food or animal-feed.

Recommendations – KPI 1

In order to overcome the challenges for KPI 1 described on the previous slide, these are some possible measures that may be taken by the ZESM:

Development of a WtW zero-emission GHG marine fuel database

- A database containing information on the use of WtW zero-emission GHG fuels for deep-sea vessels can be developed. As a minimum, the database will need to be able to capture:
  i. applied fuel-type along with information on fuel production pathway (e.g. ammonia produced via renewable electricity)
  ii. the consistency, timeline, and total fuel consumption of WtW zero-emission GHG fuels on board during the measurement period
- Development of such a data-base from scratch and maintaining it, would be challenging, not least as it requires coordination with numerous stakeholders in the maritime value-chain. One option could be to establish contact-points with major suppliers of zero-emission WtW GHG fuels to the marine industry and ask for regular updates on the volume of fuel delivered to deep-sea vessels, and the number of vessels in question. Parallels can be drawn to DNV's AFI scrubber statistics, where data is continuously updated based on input on the number of scrubbers delivered by scrubber manufacturers.

Application of IMO's LCA guidelines to assess potential of marine fuels to have zero-emissions of WtW GHG

- Life-cycle assessment (LCA) guidelines for all marine fuels, is currently under development by an IMO working group. The first set of guidelines are likely to be adopted at MEPC 80, in June 2023. These guidelines could be applied in order assess the potential of given marine fuels to have zero-emissions WtW of GHGs.
- In the future, DNV expects that IMO will extend the IMO DCS scheme, in order to accommodate collection of information on WtW GHG emissions and WtW zero-emission GHG fuels. This could make it easier to estimate the status of KPI 1 in the future.

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Results (1) – KPI 2

Step 1 – Identification of data-sources

- DNV's Alternative Fuels Insight (AFI) platform is utilized in order measure the status of KPI 2. The Alternative Fuels Insight (AFI) platform provides the shipping industry with an open platform for evaluating the uptake of alternative fuels and technologies, accessible via https://afi.dnv.com/ . The AFI platform compiles data from publicly available information, supplemented with data directly from equipment manufacturers, and other relevant databases. The data source is cross-checked with S&P Global Market Intelligence*.

Step 2 – Extraction of relevant information

- The AFI platform includes data on vessels capable of being fuelled by alternative fuels such as LNG, LPG, hydrogen, ammonia, and methanol, and an overview of vessels fitted with scrubbers and batteries. KPI 2 specifies deep-sea vessels capable of running on well-to-wake zero-emission hydrogen-derived GHG fuels (ammonia, hydrogen, and methanol). As such, we extracted data from the AFI platform on the number of deep-sea vessels capable of operation on ammonia, hydrogen, and methanol. Results are broken down by:
    - Ship-type (e.g. bulk carrier)
    - Operational status (in operation or on order)
    - Type of energy converter (internal combustion engine or fuel cell)
    - Alternative fuel installation implementation stage (newbuild or retrofit)
- "Alternative fuel ready" vessels, i.e. vessels that have made some preparation for future retrofit to a given fuel (e.g. methanol-ready), have not been included in the KPI.

*https://www.spglobal.com/marketintelligence/en/mi/products/sea-web-maritime-reference.html

Results (2) – KPI 2

Step 3 – Translation of results into KPI status

- In order to translate data from the AFI platform into data relevant for KPI 2, we saw a need to distinguish between vessels where methanol, hydrogen, or ammonia is the main fuel for propulsion (primary fuel), or where these fuels are only intended to supply energy for auxiliary purposes (secondary fuel). Apart from this, data from the AFI platform is already to a large extent aligned with KPI 2, and no further processing of data is required.
- As of December 2022, there are a total of 68 deep-sea vessels (in operation or on order) capable of being fuelled by well-to-wake zero-emission hydrogen-derived GHG fuels on a primary fuel basis, and 8 vessels on a secondary fuel basis.

Results for KPI 2 (snapshot of dashboard)

Number of deep-sea vessels capable of running on methanol, hydrogen, and ammonia as primary fuel

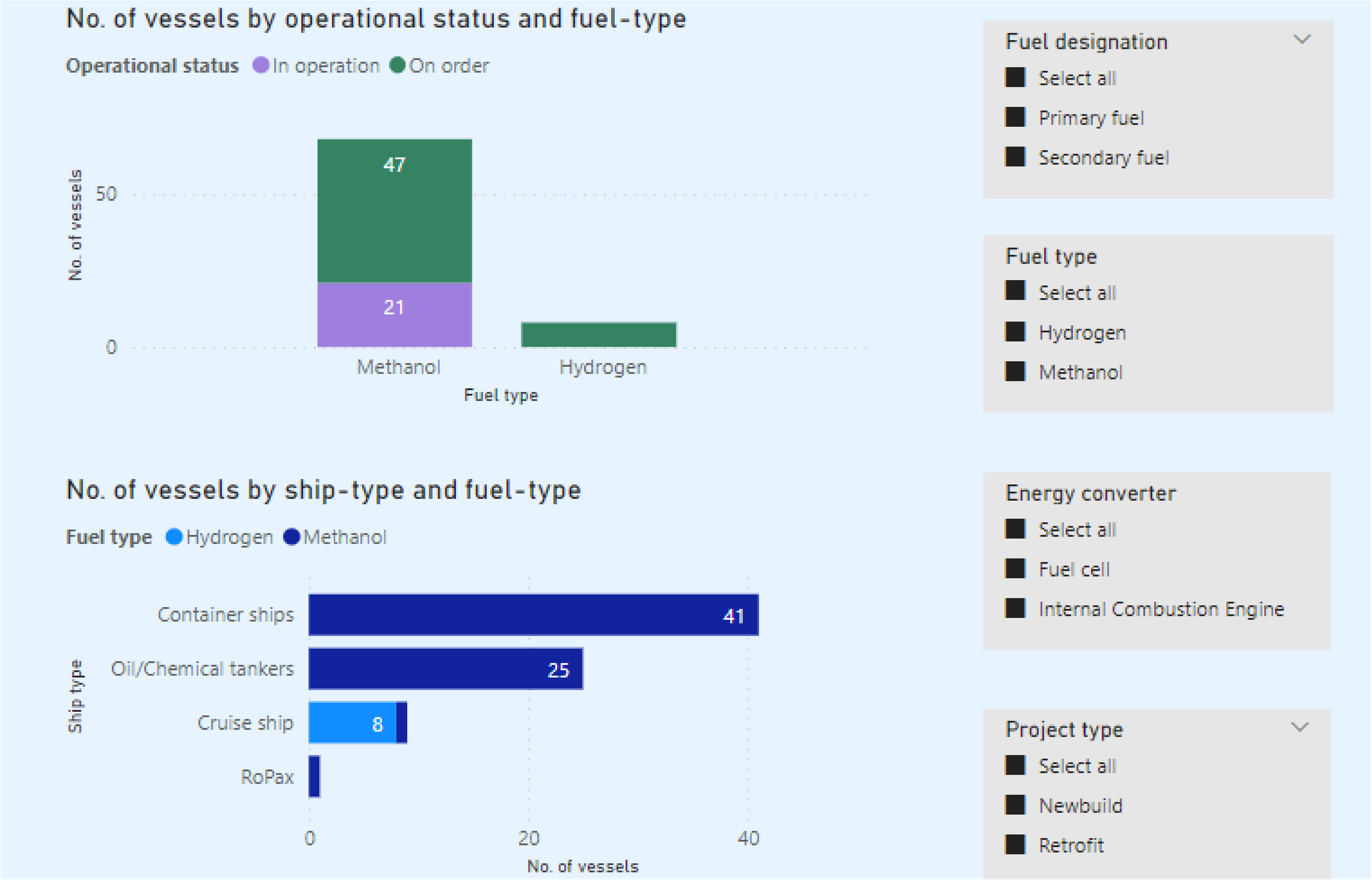
Number of vessels

68

Number of deep-sea vessels capable of running on methanol, hydrogen, and ammonia as primary or secondary fuel

Number of vessels

76



Note: ammonia does not appear in the above statistics, since no deep-sea vessel capable of running on ammonia as primary or secondary fuel was identified.

Challenges and uncertainties – KPI 2

In general, few challenges were found when measuring the status of KPI 2. This is largely due to the existence of a comprehensive database (AFI platform), giving most of the necessary information needed. One challenge that we did find for KPI 2, is that it does not specify the extent to which a vessel is to be capable of running on hydrogen, methanol, or ammonia. If no such distinction is made, a cruise vessel with an oil-fuelled main engine and a hydrogen fuel cell system in place to provide auxiliary power is counted in equal terms as a container vessel with methanol-capable main engine, boilers, and auxiliary engines. In order to address this uncertainty in the KPI status estimation, we applied the terms “primary fuel” and “secondary fuel” (reference to slide 29).

Recommendations – KPI 2

The following recommendations to improve KPI 2 may be considered by the ZESM:

- In order to distinguish between vessels capable of using methanol, hydrogen, or ammonia as main fuel for propulsion, and those that are only capable of using these fuels for supplementary auxiliary power, the wording of the KPI could be amended. One option could be to specify that only vessels equipped with a main engine capable of running on methanol, hydrogen, or ammonia is to be considered in the KPI. In our assessment, we opted to categorize the extent to which a vessel can run on these fuels into “primary fuel” and “secondary fuel”. “Primary fuel”, indicates that a vessel is capable of using methanol, hydrogen, or ammonia as a main fuel for propulsion, while “secondary fuel” indicates that these fuels may only be used for auxiliary power or heat generation (boiler).
- Consider inclusion of vessels capable of running on methane (i.e. bio-LNG, and e-LNG) in KPI 2. Bio-LNG (produced from biomass) and e-LNG (produced from renewable electricity and a sustainable carbon-source) have the potential to reduce WtW GHG emissions by up to 100%, given that challenges such as methane-slip is addressed.

Results (1) – KPI 3

Step 1 – Identification of data-sources

- Green shipping corridors is a concept which aims to kick-start the maritime transition to carbon-neutral fuels. Since the Clydebank declaration in 2021 (UK Gov, 2021), the concept has received increasing interest and attention, recently at the COP 27 climate conference (GSC, 2022). DNV has conducted a literature review, including industry papers and other sources (see e.g. DNV, 2022b; MIZESM, 2022; ABS, 2022; GMF, 2022a; Nordic Roadmap, 2022) to identify planned and existing green shipping corridor initiatives established between, within, or involving Mission countries or organizations.
- AIS data from 2022* has been used to track the voyage of vessels sailing between ports of existing and announced port-to-port green shipping corridors.

Step 2 – Extraction of relevant information

- Key information on existing and announced green shipping corridors involving mission countries is collected. The delivery distinguish between announced/planned and existing/operational green shipping corridor initiatives.
- DNV has utilized the MASTER (Mapping of Ship Tracks, Emissions and Reduction potentials) model which draws on Automatic Identification Systems (AIS) data for vessels, to deduce the sailing distance and the number of vessels transiting each identified planned or existing port-to-port green corridor today. The MASTER model (DNV (2008), Mjelde, Martinsen, & Endresen (2014) and DNV GL (2018)) utilizes data from the AIS system, which provide a detailed and high-resolution overview of all ship movements, where sailing speeds, operating patterns, sailed distances (nautical miles) and time spent in various areas are identifiable for each ship for those ships having the AIS system installed (carriage requirements for shipborne navigational systems and equipment, IMO).

*from 2022-01-01 to 2022-12-15

Results (2) – KPI 3

Step 2 – Extraction of relevant information (cont.)

- The voyage-based model takes the MASTER model results further by to track all voyages carried out by each individual deep-sea vessel (>10 000 GT) in the world fleet. The model checks whenever a vessel has visited one of the corridor ports during the latest year. Further, the model is tracking the vessel movement for the identified corridors from port A to port B. The ports are defined as geographical shapes, and the model uses port stop detection routines to isolate the individual voyage start and end. The time of departure, arrival, voyage speed profile, calculated sailing time and distance, and estimated energy consumption is logged. For the purpose of estimating KPI 3, we applied the number of vessels operating in announced green shipping corridor initiatives.

Step 3 – Translation of results into KPI status

- Based on the literature review, the identified number of i) existing deep-sea green shipping corridors and ii) announced/planned green shipping corridor initiatives is counted. We find that as of end 2022, there are zero existing deep-sea shipping corridors, while there are 24 announced initiatives in total (including short-sea).

- Sailing distances and number of deep-sea vessels operating on i) existing port-to-port green shipping corridors and ii) announced/planned port-to-port green corridor initiatives have been estimated from the voyage-based analysis. The voyage-based analysis also provide additional information on average sailing distance and number of vessels for the identified port-to-port corridors where the ports involved are specified. The number of vessels that transit the route is the AIS-reported number of vessels that have sailed directly from port A to port B on that route during 2022*. Each green corridor route length reported is the median of the reported sailing distance of all vessels sailing on the specific corridor. Number of vessels and sailing distances for green shipping corridors has only been estimated where the ports involved for the specific corridor has been specified. Single port corridors are not accounted in this KPI and may not be as relevant for deep-sea shipping as port-to-port corridors.

*from 2022-01-01 to 2022-12-15

Results (2) – KPI 3

Step 3 – Translation of results into KPI status (cont.)

- In total, as of end-2022, we identified 24 deep-sea green shipping corridors. This includes corridors involving Mission members and corridors involving non-members.
- In the dashboard, we have categorized the green shipping corridor types into three:
  i. Port-to-port corridor: refers to a green shipping corridor initiative where the port in both ends of a port-to-port ship route are specified. The category do also include port-to-region corridors, where the specific port in the region still is unspecified.
  ii. Corridor network: refers to a green shipping corridor initiative involving more than two ports (often undefined). Corridor roundtrips are included in this category.
  iii. Undefined: refers to a green shipping corridor initiative where there still is unclear if there shall be a port-to-port route or a corridor network consisting of several connected routes.
- We have also divided each identified green shipping corridor into maturity phases:
  i. Initiation: 11 of the initiatives remain at an early stage (initiation) where only announcements and initial partnerships are made
  ii. Feasibility: 11 of the 24 mapped corridor initiatives are in a feasibility phase, ranging from pre-feasibility to route-specific feasibility assessment.
  iii. Planning: Only two of the routes (Shanghai-LA and the SILK Alliance) are at the stage where they are developing an implementation plan.
  iv. Operation: None of the mapped corridors are in operation.

Results for KPI 3 (snapshot of dashboard)

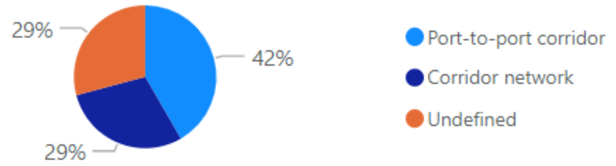
Number of existing deep-sea green shipping corridors

0

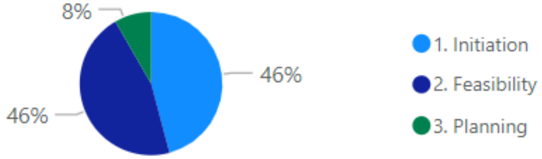
Number of announced green shipping corridor initiatives

24

Corridor type



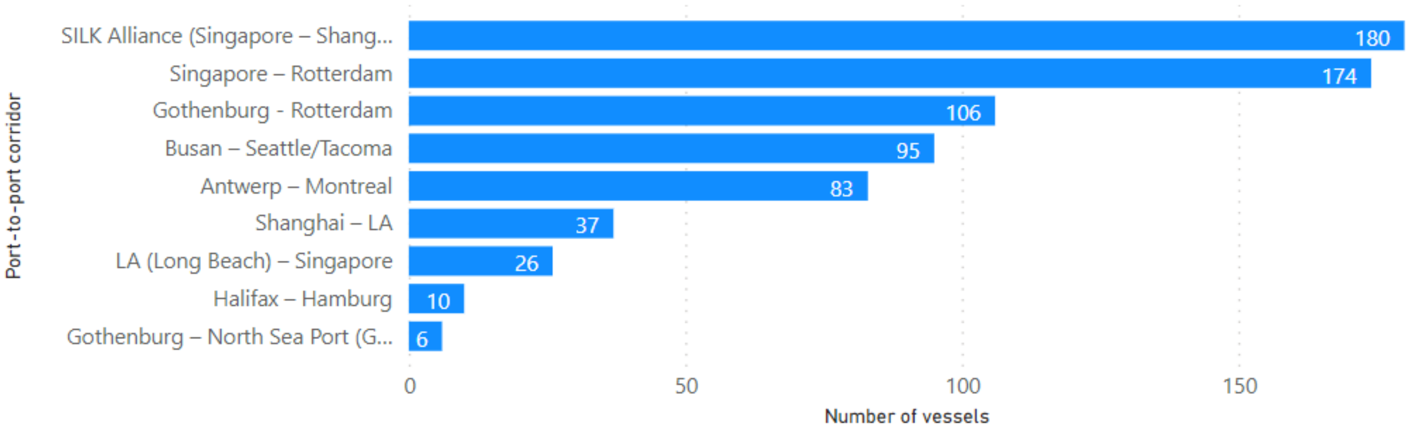
Maturity level



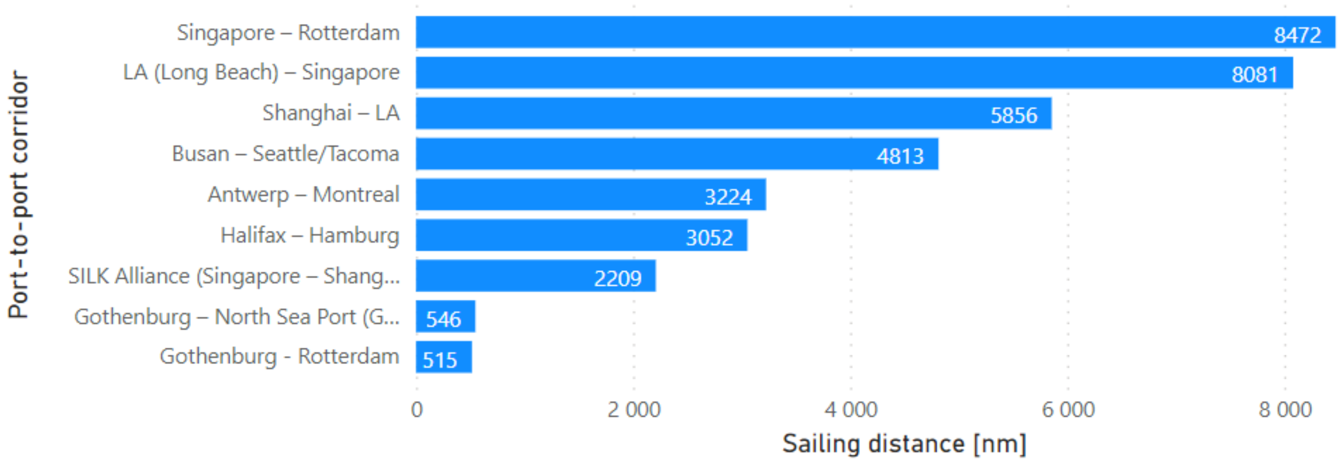
Corridor initiated by Mission Members?

Show Table

Number of vessels per port-to-port deep-sea shipping route (AIS-data from 2021)



Sailing distance per port-to-port deep-sea shipping route



Challenges and uncertainties (1) – KPI 3

The most important challenges and uncertainties identified when estimating the status of KPI 3 are described below.

Inclusion of green shipping corridors outside of members

- KPI 3 monitors the number of deep-sea green shipping corridors. Distinguishing between members and non-members, might be important in order to track the progress made by the Mission on green shipping corridors. In our KPI 3 measurement, DNV has included green shipping corridors involving both members and non-members countries of the Mission, but separate statistics can be made using the dashboard.

Maturity of green shipping corridors

- It is important to have clearly defined maturity levels for green shipping corridors. Moreover, a specific criteria on maturity level should be set, with respect to inclusion of green shipping corridors in the KPI 3 measurement. Most of the mapped green shipping corridor initiatives are at an early stage and still far from realization.
- As the number of announced corridors increases, the discussion on which initiatives to include and what maturity level to consider will gradually occur. As for now, the dashboard includes both existing (none) and announced/planned green shipping corridor initiatives, while only the specific port-to-port corridors are listed with number of vessels and sailing distance.

Definition of deep-sea green shipping corridors

- In-line with the Mission focus on deep-sea, a more concise definition of deep-sea green shipping corridors would be beneficial for estimating KPI 3. The definition should address greenhouse gas emissions with a lifecycle perspective. In the future, we expect there to be an industry standard for green shipping corridors which could be adopted.
- Without a clear definition of zero-emission, the monitoring of KPI 3 could be distorted by the inclusion of corridors that do not meet the definition and associated requirements. More information about the definitions of green shipping corridors found in industry literature, is given in *Appendix B - Green shipping corridor definitions*.

Challenges and uncertainties (2) – KPI 3

Data collection and data gaps

- In general, AIS data have some uncertainties related to the radio signal and the reported data points. This could be due to both technical and human errors. There are uncertainties of activity-based modelling and uncertainties related to the use of AIS data, as discussed by Longva & Sekkesæter (2021) and addressed in the Fourth IMO GHG study (Faber et al., 2020). Similar error sources and quality considerations for AIS data are also reported by the UN Statistics Wiki (2020).
- The voyage-based AIS analysis will only count the number of vessels that are sailing directly from port A to port B. In some cases, for example for the Rotterdam – Singapore corridor, it is likely that several of the vessels that are sailing between the ports have intermediary stopovers, and these vessels will hence be excluded in the reported number. It is also important to note that this is not an average number of vessels, but the actual number of vessels reported by AIS data to sail on the specific corridor during the last operational year*.
- In the voyage-based AIS analysis, defined areas where ports are located (port shapes), are used to identify vessels travelling between green corridor ports. The use of port shapes may lead to inaccuracies, in case the port shapes are specified wrongly. In addition, we see that the use of port shapes may lead to inaccurate results for specific corridors where ships sail through canals or river systems. For example, we see this for the corridor Antwerp – Montreal. Montreal port is located near a river system where the vessels need to sail past Quebec port, in order to get to Montreal port from Antwerp, and vice versa. If a ship is sailing past a port on the way to the end port, the AIS data might report this port as the final stop of the voyage. To give a more realistic number of vessels sailing on the corridor Antwerp – Montreal, the reported number of vessels are based on both the vessels sailing directly Antwerp – Montreal but also the vessels sailing directly Antwerp – Quebec.
- In this delivery, the reported number of vessels is the actual number of AIS-reported vessels sailing (at least once) directly from port A to port B in the corridor during the last operational year. These vessels do not necessarily travel frequently on this route.

*from 2022-01-01 to 2022-12-15

Recommendations – KPI 3

In order to overcome the challenges described on the previous slide, these are some possible measures that may be taken by the ZESM:

- Inclusion of all deep-sea green corridor initiatives in KPI 3, also those not involving Mission members. However, to avoid taking credit for initiatives outside ZESM, it will be important to divide between corridors initiated by Mission countries or organizations and other corridors.
- A clear definition of a deep-sea green shipping corridor, with particular focus on GHG emissions, should be defined. A standardized method for GHG accounting should be applied across different corridors.
- A clear maturity scale for green shipping corridors, to keep track on the status and timeline for the listed green corridor initiatives, would be useful. The defined maturity level should also include aspects related to key decision for the corridor to be realized, such as fuel type, ship segment, and involvement of all necessary stakeholders.
- Each individual green shipping corridor have corridor-specific attributes (see e.g. DNV, 2022b*):* "…including the sailing distance and energy demand of the corridor (fuel feasibility); the number of ports and their location and surroundings (safety zones, supply of fuel, etc.); the number of jurisdictions involved and their willingness and ability to support development (regulations, supporting policies, etc.); the type of ships operating on the corridor (fuel feasibility, regularity, etc.); the nature of the traffic on the corridor (e.g. liner shipping vs. tram shipping), and the composition and maturity of the actor ecosystem (private and public)….". A standardized way of characterizing individual green shipping corridors using attributes reflecting the Mission's focus, is important for benchmarking and comparing corridors with each other.

Results (1) – KPI 4A

Projects on ammonia, hydrogen and methanol

Step 1 – Identification of data-sources

The report "Mapping of Zero Emission Pilots and Demonstration Projects" report (GMF, 2022b) and the NextGEN website (NextGEN, 2022) are employed as main sources of information. Additional sources that have been screened are: Green Shipping Programme (GSP, 2022), Mærsk Mc-Kinney Møller Center for Zero Carbon-Shipping (MMMCZCS, 2022), Green Ship of the Future (GSF, 2022), NCE Maritime CleanTech (NCE MCT, 2022), Ocean Hyway Cluster (OHC, 2022) and the IEA Clean Energy Demonstration Projects Database (IEA CEDPD, 2022).

Step 2 – Extraction of relevant information

In order to identify projects relevant for KPI 4A, we applied an overview of maritime projects reported in NextGEN (2022) and GMF (2022) as a starting point. We have categorized each project into "vessel" and "bunkering", depending on project objective. All bunkering projects reported in NextGEN (2022), are included in KPI 4A. Bearing in mind the Mission's focus on deep-sea shipping, we short-listed relevant projects from the identified data-sources. The projects found to be relevant are characterized by their relatively large scale, and objective of developing zero-emission deep-sea vessels and bunkering solutions. Only projects involving hydrogen-derived fuels (methanol, ammonia, and hydrogen) are considered relevant for KPI 4A, whereas biofuels are considered in KPI 4B. Projects related to making ships ready for conversion to a different fuel-type (e.g. methanol-ready) are not included in KPI 4A.

We have utilized the following project development phases, based on Odenweller (2022), to categorize projects:

1. Concept
2. **Feasibility and design studies**
3. **Financial investment decision**
4. Under Construction
5. Operational

Results (2) – KPI 4A

For the purpose of estimating the status of KPI 4A, we have only included projects considered to be at the stages of *feasibility and design studies* or *financial investment decision* (given in bold above). It is important to note that projects at the development stage of *under construction* and *operational*, are covered by KPI 2. An example of this is the series of methanol-fuelled container vessels ordered by the shipping company Maersk (Maersk, 2022).

Research, development and demonstration/pilots related to production facilities are excluded in this KPI. The justification being that it is not clear in each case if the produced fuel is purely relevant for the maritime market. An increase in green fuel production is certainly a must for achieving the mission pillars. However, as there are a wide range of markets competing for the fuels, there is no good way of ensuring that this measure is a good indicator for where the maritime industry is headed. Therefore, the relevant projects are taken to be vessel and maritime bunkering specific projects. The same deep-sea definition of > 10 000 GT, as in previous KPIs, is also applied here.

Finally, only projects related to mission member countries are included.

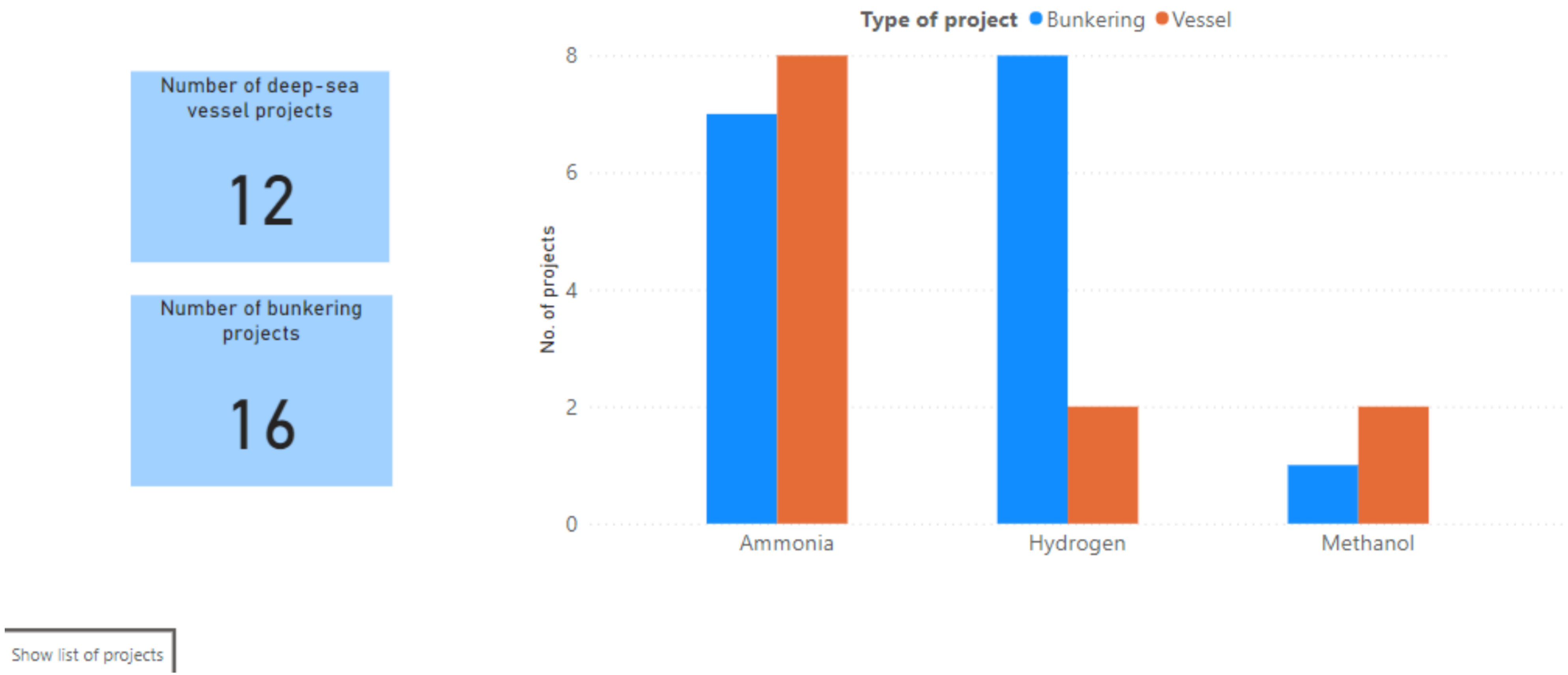
Step 3 - Translation of results into KPI status

Relevant parameters for the monitoring of KPI 4A are as follows:

- No. of deep-sea zero-emission maritime research, development, and demonstration/pilot projects involving implementation of methanol, hydrogen, or ammonia-fueled deep-sea vessels. This is found to be 12 projects.
- No. of projects involving commercial scale ammonia, methanol, and hydrogen bunkering infrastructure. This is found to be 16 projects.

In the dashboard we have visualized the two above parameters. We also give a list with details on each project.

Results KPI 4A (Snapshot of dashboard)



Results (1) – KPI 4B

Testing, trialling and R&D projects related to use of biofuels

Step 1 – Identification of data-sources

Different industry literature sources (ref. slide 42), were reviewed to identify testing, trialling, and R&D projects relating to biofuels. In addition, press releases and media articles (from e.g. https://www.bunkerspot.com/, https://ship.energy/, and https://www.offshore-energy.biz/) were applied.

Step 2 – Extraction of relevant information

The following key boundary conditions were applied when gathering information:

- Only projects between 1. Jan 2022 - 1. March 2023 are included. For an overview of research, trialling, and pilot projects that have found place before 2022, you may refer to studies such as EMSA (2022), IEA (2017), and ECOFYS (2012).
- We have chosen to only include projects where it is specifically mentioned that the use or bunkering of biofuel onboard a vessel is related to **testing, trialling and R&D.** As such, biofuel use in connection with commercial service offerings, e.g. Maersk ECO Delivery (Maersk, 2023) and CMA CGM (2021) has not been accounted. In addition, press releases revolving around purchase of biofuels are not accounted. There are also established suppliers of biofuels to the marine market, such as Neste (2023) and GoodFuels (2023).
- Use of fuel blends consisting of fossil fuels along with a certain share of biofuel were accounted for. The blend percentage in the projects range from 10% to 100%.
- All relevant types of biofuels for maritime applications have been considered, including FAME, HVO, bio-LNG, and bio-methanol.
- Only projects involving deep-sea vessel (>10 000 GT) were included.
- We have only included projects where biofuel was reported to be bunkered in a member nation of ZESM, or where one of the participating stakeholders (e.g. ship owner or charterer), are associated with a member nation.

Results (2) – KPI 4B

Step 3 - Translation of results into KPI status

Given the boundary conditions specified in step 2 (slide 45), we identified 19 projects relating to testing, trialling and R&D projects related to use of biofuels and bunkering within ZESM members. Most projects are related to vessel usage of FAME.

Few bunkering projects were found. A possible explanation for this is that some biofuel-types, can to a large extent use existing infrastructure for bunkering. It should be noted, however, that the projects identified in KPI 4A on methanol bunkering, could be relevant for bio-methanol.

It should be recognized that the number of projects is largely determined by the applied definitions and boundary conditions.

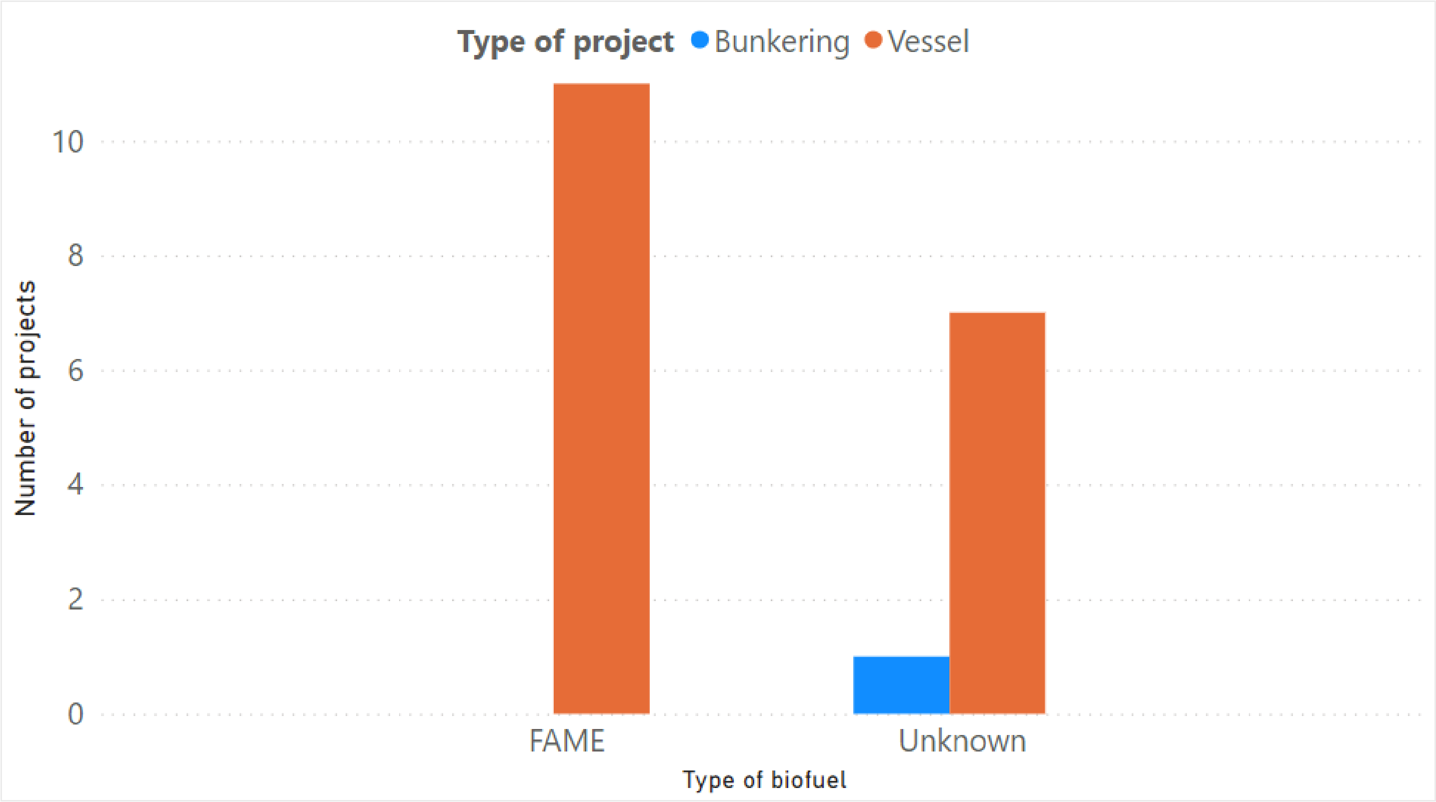
Results KPI 4B (Snapshot of dashboard)

Number of vessel projects

18

Number of bunkering projects

1

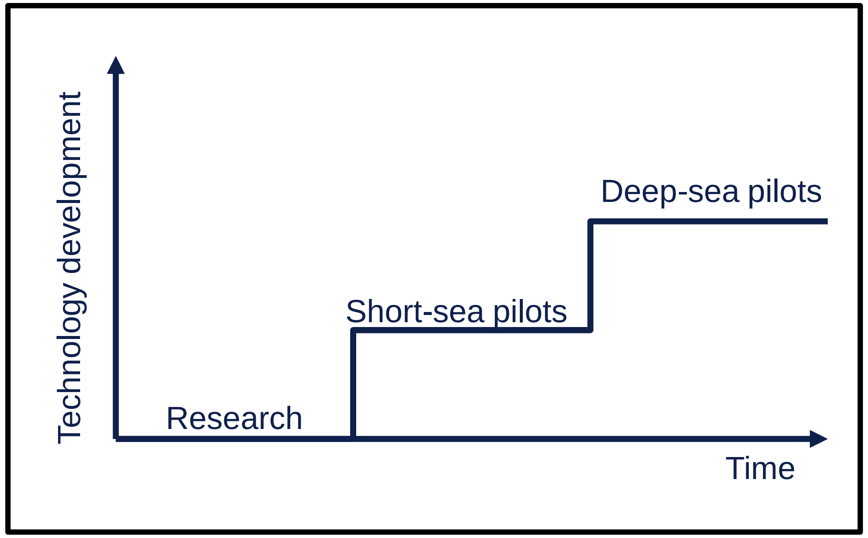


Show list of projects

Challenges and uncertainties (1) – KPI 4

We have identified some key challenges specifically for KPI 4:

- It is important to have a clear distinction between projects to be included in KPI 2 and KPI 4, in order to avoid counting the same projects in both KPIs. In our assessment of KPI 4, we excluded projects considered to be commercial to separate the KPI 2 and KPI 4. At the same time, an argument can be made that even commercial projects could be considered as development within deep-sea decarbonization.
- There is no complete list or database of current maritime research, development and pilot projects. Creating such a database is time consuming and difficult to keep up to date on a frequently basis. Finding relevant information requires a search through a wide range of resources. However, the identified relevant sources provide good input towards making such a database.
- KPI 4 does not distinguish between the size of specific projects, and as a result all projects are weighted equally into the KPI. This is a consequence of having “no. of projects” as a measurement. It is suggested to use funding of projects as a measurement rather than total number of projects. However, this raises the issue of gaining insight in the funding of each project, which increases the amount of data gathering needed to report on the KPI. Often only information about public funding is available. This might misrepresent of the size of the project as private funding may be much larger than the public.



- In many cases, maritime technology development progresses in steps from research, to short-sea pilots and then to deep-sea pilots. The figure on the right illustrates this. As this KPI is aimed on deep-sea, and excludes short-sea one might lose a valuable part of the development chain. An example of a short-sea project that is excluded is a hydrogen ferry pilot of the west coast of Norway (GSP, 2020).

Challenges and uncertainties (2) – KPI 4

- Some of the projects we identified in KPI 4A (step 1) were not included in the KPI measurement, as they involved preparing deep-sea vessels for future conversion to alternative fuels. It is important to distinguish such projects, from projects that focus on deep-sea vessels with the capability of using alternative fuels. Even though a vessel is prepared for a future conversion to an alternative fuel, there is no guarantee that a conversion will take place.
- For KPI 4A, projects relating to bunker vessels will be counted as bunkering projects and not deep-sea vessel projects.
- Some projects list a wide range of participants, representing different countries and companies. From publicly available information, it is sometimes hard to identify the main stakeholders driving a project.

Recommendations – KPI 4

In order to overcome the challenges described on the previous slides, these are some possible measures that may be taken by the ZESM:

- A database, compiling information on relevant deep-sea vessel and bunkering projects could be developed. Active contributions from members of ZESM could help to populate such a database, and provide further insight into current developments.
- Consider extending KPI 4 to capture developments taking place in the short-sea segment. Historically, many vessel technologies have been implemented for short-sea vessels before later implementation on deep-sea vessels (e.g. LNG-fuelled vessels, excl. LNG carriers).

As a possible future add-on, inclusion of more meta-data on each project (e.g. energy-converter for KPI 4A, or biofuel-blend for KPI 4B), could serve to enrich the KPI.

1. Introduction and Executive summary
2. Documentation of KPI methodology, results and challenges
    i. Overall KPI methodology
    ii. KPI results
        a. KPI 1: Number of deep-sea vessels applying well-to-wake zero-emission GHG fuels
        b. KPI 2: Number of deep-sea vessels capable of using well-to-wake zero-emission GHG fuels
        c. KPI 3: Number of deep-sea green shipping corridors involving Mission countries and organizations
        d. KPI 4: Number of deep-sea zero-emission maritime research, development, and demonstration/pilot projects
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Appendix A & B

Appendix A - Ship equivalent fuel consumption and segments

Bulk carrier segment	Size (dwt)	Average annual fuel consumption (tonnes VLSFO-eq.)
Handysize	20000 - 39999	6400
Handymax	40000 - 49999	6500
Supramax	50000 - 59999	8200
Panamax	60000 - 79999	10000
Post-panamax	80000 - 124999	14400
Capesize	125000 - 220000	17100
Very Large Ore Carrier (VLOC)	>220000	14400

Container ship segment	Size (TEU)	Average annual fuel consumption (tonnes VLSFO-eq.)
Feeder	0 - 1999	7300
Feedermax	2000 - 2999	8600
Panamax	3000 - 5099	13200
Post-Panamax	5100 - 9999	22100
New-Panamax	10000 - 14499	26900
ULCV Ultra-large Container Vessel (ULCV)	>14500	23900

Product tanker	Size (dwt)	Average annual fuel consumption (tonnes VLSFO-eq.)
Handysize	20000 - 34999	6800
Medium-range (MR)	35000 - 54999	6900
Long-range 1 (LR1)	55000 - 79999	9000
Long-range 2 (LR2)	80000 - 159999	15400

Crude oil tanker	Size (dwt)	Average annual fuel consumption (tonnes VLSFO-eq.)
Panamax	60000 - 79999	10000
Aframax	80000 - 119999	14100
Suezmax	120000 - 199999	17700
Very Large Crude Carrier (VLCC)	200000 - 319999	14100

Source: DNV, based on 2019 DCS-data

Appendix B - Green shipping corridor definitions

- Global Maritime Forum (2022) have discussed the definition of both “green” and “corridor”, and we suggest to consider these aspects also in the Mission’s definition of a green corridor. Beyond the Clydebank declaration’s definition of green shipping corridors, these are some examples from other industry stakeholders:

  ii. In The Next Wave: Green Corridors - A Special report for the Getting to Zero Coalition (2021), green corridors are referred to *as “specific trade routes between major port hubs where zero-emission solutions have been demonstrated and are supported”* and more specific *“a shipping route between two major port hubs (including intermediary stopovers) on which the technological, economic, and regulatory feasibility of the operation of zero-emissions ships is catalyzed through public and private actions, they offer the opportunity to accelerate progress in tackling the challenges of decarbonizing shipping”.* https://www.globalmaritimeforum.org/content/2021/11/The-Next-Wave-Green-Corridors.pdf

  iii. The U.S. Government have published a framework on green shipping corridors and refers to them as “maritime routes that showcase low- and zero-emission lifecycle fuels and technologies with the ambition to achieve zero greenhouse gas emissions across all aspects of the corridor in support of sector-wide decarbonization no later than 2050.” https://www.state.gov/green-shipping-corridors-framework/

  iv. The Economic and Social Commission for Asia and the Pacific (ESCAP) refers to green shipping corridor as “facilitating early and rapid adoption of fuels and technologies that, on a lifecycle basis, deliver low and zero emission across the maritime sector, placing the sector on a path to full decarbonization.” https://www.unescap.org/sites/default/d8files/event-documents/10_ESCAP_SYK_GreenShippingCorridors.pdf

  v. The American Bureau of Shipping (ABS) defines green shipping corridors as “the geographical connection between two locations (could be specific maritime routes or it could be multiple ports between two regions) and the enabling environment that helps reduce emissions.” https://ww2.eagle.org/content/dam/eagle/publications/whitepapers/Green-Shipping-Corridors.pdf

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