Maritime transport greenhouse gas data collection and management

MRV Procedures

Final report
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By: Cathrine Sachweh, Julia Larkin, Rob Winkel, Jasper Deman (Ecofys)
Bryan McEwen (SNC Lavalin)
Chris Peddie-Burch, Grant Turtle, Kevin Williams (SFW)

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Reviewer: Alyssa Gilbert

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Disclaimer

This document has been prepared as part of technical support provided for the implementation of the proposed MRV of CO₂ emissions and other relevant information in maritime transport (COM (2013) 480). This document should be regarded as work in progress. This document reflects the contractor's current understanding and incorporates the data available at the time of writing. The views expressed in this document represent only the views of the authors and not necessarily those of the European Commission.
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Glossary

Definitions

Port  A coastal location with at least one marine terminal (berth). A port is a "port of call" according to Art. 3 of the proposed EU MRV Regulation: "a port where a ship stops to load or unload cargo or to embark or disembark passengers, excluding stops for the sole purpose of refuelling, obtaining fresh supplies and/or relieving the crew".

Time of arrival  The moment that the ship is alongside at berth (First Line Ashore) for the first time at the port of destination. In line with Art. 3 of the proposed EU MRV Regulation, a ship is only considered to arrive at a port if it stops there to (un)loads cargo or (dis)embarks passengers. A ship is not considered to arrive if it stops at a location for the sole purpose of refuelling, obtaining fresh supplies and/or relieving the crew. If a ship first goes to anchor in the port while awaiting a berth, time of arrival is considered the moment the ship drops anchor.

Time of departure  The moment that the ship leaves its final berth (Last Line Gone) to leave the port of origin. Departure in a port is always preceded by arrival at the same port. If a ship goes to anchor at the port once leaving its final berth and before leaving the port itself, time of departure is considered the moment the ship raises anchor to leave.

Voyage  The movement of a ship from one port to another or from one port and returning. Trips within the same port are not considered voyages. Ballast trips are included.

Time at sea  The time between departure and arrival.

Time in port  The time between arrival and departure.

Emissions  The release of CO$_2$ into the atmosphere by ships.

Tonnes of CO$_2$  Metric tonnes of CO$_2$.

Emission factor  The average emission rate of a greenhouse gas relative to the activity data of a source stream assuming complete oxidation for combustion and complete conversion for all other chemical reactions.

Other relevant information  Information related to the consumption of fuels, transport work and energy efficiency of ships which allow for analysing emission trends and assessing ships' performances.
Reporting period: One calendar year during which emissions have to be monitored and reported. All voyages that begin within the calendar year are included.

Company: The owner or operator of a ship as or any other person, such as the manager or the bareboat charterer, who has assumed the responsibility from the ship-owner for its operations.

Gross tonnage (GT): The metric gross tonnage calculated in accordance with the tonnage measurement regulations contained in Annex 1 to the International Convention on Tonnage Measurement of Ships, 1969.

Verifier: A legal entity carrying out verification activities that is accredited by a national accreditation body pursuant to Regulation (EC) No 765/2008 of the European Parliament and of the Council and this Regulation.

Acronyms:
- AR: Accreditation Regulation No. 765/2008 (EC)
- AER: Annual Emission Report
- AVR: Accreditation and Verification Regulation No. 600/2012 (EC)
- BDN: Bunker delivery note
- BOG: Boil off gas
- CCPS: Carbon Positive Program for Ships
- CO₂: Carbon dioxide
- CSI: Clean Shipping Index
- DWT: Deadweight tonnage
- EC: European Commission
- ECA: Emission control areas
- EEOI: Energy Efficiency Operational Indicator
- EEOI_DWT: Nominal EEOI using DWT as the measure of “cargo”
- EEDI: Energy Efficiency Design Index
- EOP: End of Passage
- ESI: Environmental Ship Index
- EVDI: Existing Vessel Design Index
- FAOP: Full Away On Passage
- FORS: Fuel Oil Reduction Strategy
- GT: Gross tonnage
- HFO: Heavy fuel oil
- ISPI: Individual Ship Performance Indicator
- IT: Information technology
- MOEPS: Operational Environmental Performance System
- MP: Monitoring Plan
- MRV: Monitoring, reporting and verification
- MRR: Monitoring and Reporting Regulation No. 601/2012 (EC)
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS</td>
<td>European Union Member States</td>
</tr>
<tr>
<td>MVEP</td>
<td>Marine Vessel Environmental Performance</td>
</tr>
<tr>
<td>Nm</td>
<td>Nautical-mile</td>
</tr>
<tr>
<td>NOx</td>
<td>Nitric oxides</td>
</tr>
<tr>
<td>LFO</td>
<td>Light fuel oil</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquefied natural gas</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied petroleum gas</td>
</tr>
<tr>
<td>MS</td>
<td>EU Member State</td>
</tr>
<tr>
<td>NAP</td>
<td>National Accreditation Body</td>
</tr>
<tr>
<td>Ro-Ro</td>
<td>&quot;Roll on/roll off&quot; or wheeled cargo</td>
</tr>
<tr>
<td>SEEMP</td>
<td>Ship Energy Efficiency Management Plan</td>
</tr>
<tr>
<td>SOLAS</td>
<td>Safety of Life at Sea</td>
</tr>
<tr>
<td>SOx</td>
<td>Sulphur oxides</td>
</tr>
<tr>
<td>TEU</td>
<td>Twenty-Foot Equivalent, a unit of cargo capacity</td>
</tr>
<tr>
<td>TJ</td>
<td>Terajoule</td>
</tr>
<tr>
<td>VR</td>
<td>Verification Report</td>
</tr>
</tbody>
</table>

**Organisations**

- BSR: Business for Social Responsibility
- CCWG: Clean Cargo Working Group
- CSI: Clean Shipping Index
- CSC: Clean Shipping Coalition
- DNV GL: Det Norske Veritas & Germanischer Lloyd merged entity
- EA: European co-operation for Accreditation
- ECSA: European Community Shipowners' Associations
- EMSA: European Maritime Safety Association
- EU: European Union
- IACS: International Association of Classification Societies
- IMarEST: Institute of Marine Engineering, Science and Technology
- IMO: International Maritime Organisation
- MARPOL: International Convention for the Prevention of Pollution from Ships
- MEPC: Marine Environment Protection Committee (of the International Maritime Organisation)
- WPCI: World Ports Climate Initiative
- WWF: World Wildlife Fund
1 Introduction

1.1 Background

Shipping is a large and growing source of the greenhouse gas emissions that are causing climate change.¹ The European Union (EU) wants a global approach taken to reducing emissions from international shipping. As a first step towards cutting emissions, the European Commission has proposed that owners of large ships using EU ports should report their verified emissions as well as other relevant data from 2018. The proposed EU MRV Regulation² would create an EU-wide legal framework for collecting and publishing verified annual data on CO₂ emissions from all large ships (over 5,000 gross tons) that use EU ports, irrespective of where the ships are registered.

Ship owners would have to monitor and report the verified amount of CO₂ emitted by their large ships on voyages to, from and between EU ports. Owners would also be required to provide certain other information, such as data to determine the ships’ energy efficiency. A document of compliance issued by an independent verifier would have to be carried on board ships and would be subject to inspection by Member State (MS) authorities.

The notion of a ship monitoring, reporting and verification (MRV) program is not new, as shippers track vessel criteria that relates to safety as well as environmental and financial performance. As such, vessel fuel consumption, as a key operational expense, is tracked to varying degree by all shipping companies. A move to a broader MRV program that includes many shippers and types/sizes of vessels requires greater attention towards data availability and accuracy as well as monitoring approaches that do not place a large burden on smaller shippers. To the degree possible, these issues are addressed in this study through identification of the accepted fuel monitoring approaches, emissions calculations and alternative methods that may be employed under certain conditions.

Tracking vessel performance is an important and desired feature of ship MRV programs, regardless of whether efficiency goals are expressed. A great deal of discussion and evaluation has occurred with the topic of ship indexing, especially within the International Maritime Organisation (IMO). Use of an operational indicator within a ship MRV program requires additional data collection activities over monitoring of fuel consumption alone.

1.2 Objectives

This study aims to support the implementation of the proposed EU MRV Regulation for the monitoring of CO₂ emissions from maritime transport as well as information related to energy efficiency.

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¹ In 2010, the total CO₂ emissions related to European maritime transport activities (including intra EU routes, incoming voyages to the EU and outgoing voyages from the EU) were estimated to be of the order of 180 Mt CO₂. (Explanatory memorandum to Commissions proposal on MRV for maritime shipping (COM (2013) 480))

The objectives of this study were to develop:

1. Detailed procedures for monitoring and reporting of CO₂ emissions as well as information related to energy efficiency.
2. A set of clear rules that will enable accredited verifiers to effectively verify data reported by maritime parties.
3. Criteria under the existing accreditation framework to ensure that only verifiers who can demonstrate a high degree of competence, independence and impartiality are eligible to act as verifiers.
4. The design of the IT system for exchanging relevant data as well as the functional specifications of that system.

This report addresses the first three objectives.

1.3 Outline

The outline of this report is as follows:

- Section 1 provides an introduction, including background and objective of this study
- Section 2 describes the approach and methods used to meet the objectives of this study
- Section 3 lists monitoring and reporting obligations under the proposed EU MRV Regulation and provides a simplified overview of roles and responsibilities
- Section 4 describes existing MRV programs and tools for emissions from ships
- Section 5 describes measurement techniques for fuel and emissions based on a literature survey
- Section 6 describes what information is currently collected on board ships, logged on the ship itself and/or sent to the ship owner
- Section 7 and 8 describe monitoring approaches for fuel consumption, emissions and other relevant information
- Section 9 describes the verification approach for the assessment of the Monitoring Plan and the Annual Emission Report, addressing fuel consumption, emissions and other relevant information
- Section 10 describes the accreditation approach
- Section 11 provides relevant references
- Annex A contains the stakeholder survey questions
2 Methodology

The methodology to achieve the objectives of this study consisted of six tasks:

1. Development of a monitoring approach
2. Development of detailed MRV procedures
3. Formulating requirements and specifications for registers and databases
4. Formulating requirements for verifiers
5. Electronic data interchange
6. Stakeholder consultation

Information has been collected from publicly available sources and directly from relevant organisations through informal consultation, interviews and a survey. Additional consultation may be undertaken. This report documents the outcomes for the first four points. Stakeholder feedback is incorporated into the relevant section, as appropriate.
3 Fundamental monitoring and reporting obligations of proposed EU MRV Regulation

This chapter provides a brief summary of monitoring and reporting obligations and the associated procedures that are laid down in the proposed EU MRV Regulation\(^3\). More details and interpretations are available in the “General Description of the Proposed EU MRV Regulation on MRV of CO\(_2\) emissions from maritime transport”\(^4\) and in the proposed Regulation itself.

3.1 Data to monitor

The proposed EU MRV Regulation requires companies to monitor fuel consumption and CO\(_2\) emissions for all of the significant sources on board ships, including all engines, boilers, and inert gas generators. These measures are to be monitored for each individual voyage arriving to and departing from a port under a Member State’s jurisdiction, separated to the period at-sea and in-port and separated to the period inside and outside emission control areas. Other relevant information needs to be monitored as well for analysing emission trends and assessing ships’ performances.

The required fields to be monitored on a per-voyage basis are as follows:

- Port of departure and port of arrival
- Date/time of departure and arrival
- Fuel consumption for each fuel type, differentiated by fuel consumed at-sea and in EU ports
- Emission factor of each fuel consumed
- CO\(_2\) emitted
- Distance travelled
- Time spent at sea
- Cargo carried
- Transport work (distance multiplied by cargo carried).

Companies may also monitor information relating to the ship’s ice class and to navigation through ice, where applicable.

The current draft of proposed EU MRV Regulation states that shipping companies are exempted from the obligation to monitor the information referred to above on a per-voyage basis, if:

(a) all the ship’s voyages during the reporting period either start or end at a port under the jurisdiction of a Member State; and
(b) the ship, according to its schedule, performs more than 300 voyages during the reporting period.


\(^4\) The General Description has been developed as part of this study
For each ship and for each calendar year, the proposed EU MRV Regulation requires companies to monitor the following parameters:

- Total amount and emission factor for each type of fuel consumed
- Total CO\(_2\) emitted
- Aggregated CO\(_2\) emissions from all voyages between ports under a Member State's jurisdiction
- Aggregated CO\(_2\) emissions from all voyages which departed from ports under a Member State's jurisdiction
- Aggregated CO\(_2\) emissions from all voyages to ports under a Member State's jurisdiction
- CO\(_2\) emissions which occurred within ports under a Member State's jurisdiction at berth
- Total distance travelled
- Total time spent at sea
- Total transport work (distance multiplied by cargo carried)
- Average energy efficiency, expressed by using at least four indicators: fuel consumption per distance, the fuel consumption per transport work, the CO\(_2\) emissions per distance and the CO\(_2\) emissions per transport work.

Companies may monitor information relating to the ship's ice class and to navigation through ice, where applicable.

Companies may also monitor fuel consumed and CO\(_2\) emitted differentiating on the basis of other criteria defined in the monitoring plan (see Section 3.2.1: Monitoring Plan).

### 3.2 Data to report

The proposed EU MRV Regulation requires companies to submit to the Commission and to the authorities of the flag States concerned, an emissions report concerning the emissions and other relevant information during the entire reporting period for each ship under their responsibility. A "reporting period" means one calendar year during which emissions have to be monitored and reported. For voyages starting and ending under two different calendar years, the monitoring and reporting data shall be accounted under the first calendar year concerned.

#### 3.2.1 Monitoring Plan

To start, all data that will be monitored will need to be listed and the collection approach described in the Monitoring Plan (MP). This plan is prepared by companies before the start of the reporting period and describes in detail the chosen monitoring methodology (see chapters 7 and 8), data sources and relevant procedures. As the MP describes the procedures that companies will follow to gather and store relevant data consistently over each monitoring period, the MP should serve as an internal manual for the monitoring process.

Typically, the MP includes activities of the operator that relate to the data collection, sampling of fuels and description of calculations and formulae to be used. It should also contain the roles and responsibilities of each staff involved in the process and the procedures on data storing, quality management and how identified risks will be addressed.
A MP should typically be completed by staff involved and/or responsible of the monitoring processes as this will allow providing a high level of detail. When preparing the MP, the person preparing it should bear in mind that the MP will serve multiple purposes. It is the methodology for determining annual emissions and will be used by the company internally. Also, it provides a reference for the verifier when verifying the reported annual emissions. Upon initial submission, the verifier will assess whether the monitoring plan is in line with the requirements laid out in the proposed EU MRV Regulation, as outlined in section 3.3. Therefore, keeping the MP as simple as possible will help to facilitate not only the monitoring but also the reporting and verification processes for all involved.

A template for monitoring plans should be developed covering all the defined requirements. The template should contain automated checks, such as restrictions to the values that can be entered in certain fields. It should have functions that blank out any section that is not applicable for a specific approach. Such functions in the template will improve consistency of data and simplify how to fill in the MPs for operators. An implementing act should make the use of this template obligatory in all MS in order to ensure a high degree of harmonisation of monitoring.

Expected elements of a monitoring plan include:

- Ship type, name, IMO identification number, port of registry or home port and name of the ship owner.
- Company name, address, telephone and e-mail details for a contact person. Description of all emission sources and fuel types used on board of the ship.
- Description of procedures, systems and responsibilities used to update the completeness of the list of emission sources over the monitoring year.
- Description of the procedures used to monitor the completeness of the list of voyages.
- Description of the procedures for monitoring fuel consumption of the ship, including:
  - The chosen method for calculating the fuel consumption of each emission source including a description of the measurement equipment used, as applicable;
  - Procedures for the measurement of fuel uplifts and fuel in tanks, a description of the measuring instruments involved and the procedures for recording, retrieving, transmitting and storing information regarding measurements, as applicable;
  - The chosen method for the determination of fuel density and/or fuel volume correction, where applicable;
  - A procedure to ensure that the total uncertainty of fuel measurements is consistent with the requirements of this Regulation, where possible referring to national laws, clauses in customer contracts or fuel supplier accuracy standards;
  - As relevant and appropriate:
    - In case of LNG tankers, description of how BOG consumption is determined.
    - List of single emission factors used for each fuel type or in the case of alternative fuels, the methodologies for determining the emission factors, including the methodology for sampling, methods of analysis, a description of the laboratories used;
    - Description of how emissions from use of biofuel are determined and subtracted, where applicable.
- Description of the procedures used for determining activity data per voyage, including:
  - The procedures, responsibilities and data sources for determining and recording the distance per voyage made;
The procedures, responsibilities, formulae and data sources for determining and recording the cargo carried and the number of passengers as applicable;

The procedures, responsibilities, formulae and data sources for determining and recording the time spent at sea between the port of departure and the port of arrival.

- Description of the method to be used to determine surrogate data for closing data gaps.
- A revision record sheet to record all the details of the revision history to the Monitoring Plan.

### 3.2.2 Annual Emission Report

As discussed above, companies will have to prepare a report on its emissions at the end of a reporting period. This annual emissions report (AER) needs to be complemented with relevant documentation on the sources of the provided data. Section 7.7 provides more detail on the data that needs to be provided in this report. The report, together with the additional documentation, will be assessed by an independent verifier. The MP described above is one of the key documents used in the verification process of the reported emissions as the report will be compared to the outlined procedures and data sources described in the plan.

An emission report should include the following information for each ship:

- Data identifying the ship and the company, including:
  - Name of the ship
  - IMO identification number
  - Port of registry or home port
  - The ice class of the ship, if included in the monitoring plan
  - Technical efficiency of the ship (the Energy Efficiency Design Index (EEDI) or the Estimated Index Value (EIV) in accordance with IMO Resolution MEPC.215 (63), where applicable)
  - Name of the ship owner
  - Address of the ship owner and his principal place of business
  - Name of the company (if not the ship owner)
  - Address of the company (if not the ship owner) and his principal place of business
  - Address, telephone and e-mail details for a contact person

- The identity of the verifier having assessed the emission report.
- Information on the monitoring method used and the related level of uncertainty
- The results from annual monitoring of the parameters (see section 3.1)
3.2.3 List of documents

Table 1. List of documents and timetable

<table>
<thead>
<tr>
<th>Document</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring Plan</td>
<td>By 31 August 2017, or two month after falling into the scope of the proposed EU MRV Regulation</td>
</tr>
<tr>
<td>Modified Monitoring Plan</td>
<td>At any time modifications are required due to reasons listed in Table 11.</td>
</tr>
<tr>
<td>Emission report</td>
<td>By 30 April each year from 2019 on</td>
</tr>
<tr>
<td>Copies of bunkering documents (Bunker Delivering Notes, BDN summaries) covering monitoring period</td>
<td>Together with the emission report, if relevant</td>
</tr>
<tr>
<td>Copies of relevant extracts of Oil Record book covering monitoring period</td>
<td>Together with the emission report, if relevant</td>
</tr>
<tr>
<td>Per ship a document detailing each voyage, with sailed distance, port calls, cargo transported, type and mass of fuel consumed for main engine, auxiliary engines, boilers and other consumption.</td>
<td>Together with the emission report</td>
</tr>
<tr>
<td>Copy of log books containing other relevant information covering monitoring period, e.g. distances travelled</td>
<td>Together with the emission report</td>
</tr>
</tbody>
</table>

3.3 Procedures, roles and responsibilities

The steps of the MRV process as well as roles and responsibilities defined in the proposed MRV system are illustrated by Figure 1. As the figure shows, the Monitoring Plans as well as the CO₂ emissions and other relevant information monitored and reported will be verified by independent accredited verifiers. The verifier needs to be accredited. Accreditation is a continuous approach to assess the competence of the verifier organisation, with the objective to ensure the verifier is sufficiently competent to carry out the activities required. (See Section 10: Accreditation approach)
### Figure 1. Steps, roles and responsibilities in the proposed MRV system.

Source: Legislative proposal to establish an EU system for monitoring, reporting and verifying (MRV) emissions from large ships using EU ports (EU). No 525/2013

<table>
<thead>
<tr>
<th>Process</th>
<th>Entity in charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drafting of a monitoring plan (MP)</td>
<td>Company</td>
</tr>
<tr>
<td>Assessment of the monitoring plan</td>
<td>Verifier</td>
</tr>
<tr>
<td>Is the monitoring plan in line with the regulation?</td>
<td>Verifier</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Monitoring of CO₂ and climate relevant information</td>
<td>Company</td>
</tr>
<tr>
<td>Reporting of annual CO₂ and climate relevant information</td>
<td>Company</td>
</tr>
<tr>
<td>Is the emission report in line with the regulation and the MP?</td>
<td>Verifier</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Company</td>
</tr>
<tr>
<td>Revision of the emission report</td>
<td></td>
</tr>
<tr>
<td>Submission of verified emission report to Commission &amp; flag state</td>
<td>Company</td>
</tr>
<tr>
<td>Has the emission report been submitted?</td>
<td>Verifier</td>
</tr>
<tr>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Verifier</td>
</tr>
<tr>
<td>Issuance of a document of compliance</td>
<td></td>
</tr>
</tbody>
</table>
4 Existing MRV programs and tools

Ship monitoring, reporting and verification (MRV) programs are not new, in principle. Shippers track vessel criteria that relates to safety as well as environmental and financial performance. As such, vessel fuel consumption, as a key operational expense, is tracked to varying degree by all shipping companies. In addition, a number of programs already exist that aim to monitor emissions and efficiency. The design aspects of these existing MRV Programs and lessons-learned during their design and operation could be useful when defining the implementation of the proposed MRV system for ships. Therefore this chapter discusses several existing MRV programs (section 4.1) and compares those with the proposed EU MRV (section 4.2).

4.1 Overview

This section describes several existing marine MRV programs: public programs with a central authority, private programs run by a consulting group and internal programs run by a shipping company. The goal of assessing and comparing these existing marine MRV programs is to collect detailed input and best practices, supporting the implementation of the proposed EU MRV system.

Most of these programs include use of a CO$_2$ indicator, including those evaluated in detail in section 4.2. The information on the different programs has been compiled using publicly available information and information requested from programs by means of a survey (FRAM, Clean Cargo Working Group) and interviews (Norden). Survey questions can be found in Annex A, and answers from two parties are in Annex B. It should be noted that some of the programs assessed provide an extensive amount of publicly available information, where other programs either do not disclose detailed information or the information is simply not present in the first place. The GL Environmental Passport and the Carbon Positive Programme for Ships have for example not been included in the detailed comparison with the EU MRV system, due to the lack of detailed information available.

4.1.1 Clean Cargo Working Group (CCWG)

The CCWG is a global business-to-business initiative made up of leading cargo carriers and their customers, dedicated to environmental performance improvement in marine container transport through measurement, evaluation, and reporting.

The CCWG runs a voluntary MRV program for CO$_2$ emissions from global containerized shipping. CCWG has developed the CCWG CO$_2$ methodology on how to standardise, report and calculate CO$_2$ emissions. The CCWG measures CO$_2$ emissions by first calculating emission factors (emissions per unit of cargo capacity) which are then used to calculate CO$_2$ emissions for both carriers and shipping customers. Clean Cargo carriers report on the following data for each vessel annually (BSR, 2012):

- Nominal capacity in 20-foot equivalent container units (TEUs)
- Number of reefer plugs (plugs for refrigerator containers)
- Distance sailed
- Fuel consumed (HFO and MDO/MGO reported separately)
- Timeframe of data.
The Clean Cargo Performance Metrics Tool uses this information and the IMO emission factor for HFO of 3114.4g CO$_2$ per kg fuel to calculate vessel CO$_2$ emissions per capacity and distance sailed:

\[
\text{Total kg fuel consumed for containers, multiplied by 3114.4g CO}_2/\text{kg fuel, divided by the product of [maximum nominal TEU capacity * total distance sailed]}
\]

Currently, reporting occurs through use of MS Excel worksheets although a database is expected to be developed in 2014. The program has been consistently reporting CO$_2$ emissions since 2009 and the organization itself has existed for over 10 years. An averaged CO$_2$ metric is reported separately for 24 identified trade lanes.


4.1.2 Norden’s Masters Operational Environmental Performance System (MOEPS)

Shipping company Norden operates a software/server based Monitoring and Reporting system called Masters Operational Environmental Performance System (MOEPS). MOEPS is a comprehensive communication tool, where almost all information is integrated for the benefit of the primary users, being the ships Master and the vessel operator. The focus of MOEPS is to optimize Fuel consumption and to ensure primary users focus their time on non-administrative tasks. It generates input to “Right Steaming” and monitors adherence to speed and consumption instructions.

Ships upload all relevant operational data daily, including fuel consumption, position and speed via email or broadband. Figure 2 displays the information exchange of the MOEPS system.

MOEPS was implemented in Q4 of 2009.

Source(s):
- Masters Operational Environmental Performance System (MOEPS);
  http://www.ds-norden.com/CSR/
4.1.3 FRAM program

The FRAM program in Norway is a voluntary vessel reporting initiative that was initiated by several organizations including the World Wildlife Fund (WWF), BW Gas, Grieg Star Shipping, Welhelmsen ASA, Solvang Shipping, Klaveness, DNV and the Norwegian Shipping Association. Since inception approximately a year and a half ago FRAM has received government funding to further develop the program and additional shippers have been invited to join. Program reporting includes fuel consumption and absolute CO\textsubscript{2} emissions, including two measures for efficiency: mass of CO\textsubscript{2} per unit of work performed (i.e. transport efficiency) and per nautical mile sailed (i.e. vessel efficiency). Verification of reports is included, following ISO 14064 guidelines (although self-verification is permitted during year 1).

Source(s):
- [http://www.theframproject.org](http://www.theframproject.org)

4.1.4 French Transport Code

As of 1 October 2013, all organisations providing transport services in France are required by law\textsuperscript{5} to inform their clients of the carbon footprint of their journeys. The Regulation applies to transport services for passengers, goods or moving purposes, carried out using one or several means of transport, departing from or travelling to a location in France, with the exception of transport services

\textsuperscript{5} Article 14 of French Decree 2011-1336, mandates carbon reporting for passenger and freight transport services in line with article L1431-3 of the French Transport Code, and follows the publication of emissions factors in April 2012.
organised by public or private persons on their own behalf. The Regulation includes shipping by sea. Different methods with an increasing level of precision are described for estimating emissions for a service (MEDDTL, 2012):

- **Level 1**: emissions are determined using parameters published by the ministry of transport: a default emission factor (e.g. tCO$_2$/tonne-km) for a particular ship type is multiplied by the amount of payload carried and distance travelled for a particular service (e.g. transporting 20 containers from Le Havre to Tokyo).

- **Level 2**: emissions are determined using average value of the whole activity of the transport operator. This approach is only described for regular seagoing service transporting road vehicles. For such services the trip distance is assumed to be rather constant: the average emissions per unit of cargo per voyage (e.g. tCO$_2$/tonne-voyage) is first calculated. That emission factor is then multiplied by the amount of cargo carried for a particular service (e.g. a 35 ton truck).

- **Level 3**: emissions are determined using average value based on each specific activity of the transport operator. An annual average emission factor (e.g. tCO$_2$/tonne-km) is first calculated based on annual fuel consumption per type, emission factor per fuel type (tCO$_2$/kg fuel), cargo carried and distance travelled. That emission factor is then multiplied by the amount of payload carried and distance travelled for a particular service.

- **Level 4**: emissions are determined based on data issued by real time operating reports. This method is not specified explicitly for shipping by sea. It would consist of calculating the emissions for a specific voyage based on actual fuel consumption on that voyage.

Depending on the type of payload, the unit of payload can be tonne, TEU or passenger. Distance can be the actual distance travelled or a standard distance between two ports. The Regulation stipulates that the breakdown of emissions over goods and passengers must take place according to the number of decks.


### 4.1.5 Germanischer Lloyd - Environmental Passport

The "Environmental Passport – Operation" service from GL certifies a ship's emission inventory for a one-year reporting period (GL, 2013). The following parameters are recorded for every voyage leg for the determination of a ship's CO$_2$ emissions:

- **Total fuel consumption** (i.e. main engine[s], auxiliary engine[s], boiler[s]) including the respective fuel type.
- **Time and geographical position for start and completion of each fuel change over beginning as well as end of voyage legs.**
- **Amount of transported cargo in the appropriate unit depending on ship type and purpose, (e.g. cargo mass, lane meters, pax, TEU, volume).**
- **Distance sailed.**

Emission data is accumulated during voyages and consolidated over the reporting period. The data is verified by GL. Procedures and related requirements are documented in the GL Environmental Service System guidelines (GL, 2012). GL's *Environmental Passport – Operation* summarises emissions to water and air based on predefined categories including CO$_2$, SO$_x$, NO$_x$ and refrigerant releases emitted to air, ballast water, garbage and bilge water into the sea. The *Environmental Passport – Operation* service...
Operation covers the respective vessel’s worldwide operation and also includes computation of the IMO Energy Efficiency Operational Indicator (EEOI).

Sources:

### 4.1.6 Carbon Positive Programme for Ships (CPPS)

Carbon Positive developed a commercial MRV system applicable to all vessels. The MRV system assists the operator to monitor its fuel consumption and manage its carbon emissions. The Member feeds on a daily basis the (member-only) online platform according to the procedure described in the Monitoring Plan. The Data entry is automated minimizing administrative effort. The system also monitors all energy efficiency data. An emission report can be issued automatically any time the Member requests it. Carbon Positive also offers review and an optional third-party verification.

The MRV system follows a set of official international guidelines and requirements such as: the IMO’s guidelines for monitoring of carbon emissions, the Intergovernmental Panel on Climate Change (IPCC) guidelines for monitoring and reporting of GHG and the verification requirements of the ISO 14064.


### 4.1.7 Danish Ship Owners’ Association – Calculation tool

The Danish Ship Owners’ Association provides a freely accessible Calculation tool for assessment of ships’ energy consumption and flue gas emissions, including CO₂ (EEDI). The tool is intended for ship owners, naval architects and others in the industry and may be used for analysing CO₂- and other emissions from ships. The tool is made in three versions: for container ships, for bulk carriers and for tankers and can be used for existing ships as well as newly build ships.

The model will return an approximate figure for CO₂ emissions, energy consumption as well as other emission products, upon entering a ship’s payload capacity, rate of utilization and speed. The calculation can be tailored by inputting a number of parameters, such as engine- and fuel types and employment of various technical measures for reduction of flue gas emissions, primarily NOₓ and SOₓ.

As such the tool allows for occasional monitoring of a ship’s emissions and does not serve the purpose of continuous monitoring of fuel consumption and emissions.

4.1.8 Clean Shipping Index – Calculation tool

The Clean Shipping Index is a business to business tool for cargo owners to select clean ships and quality ship operators. Transport buyers use it to calculate and minimize their environmental footprint. Ship-owners present the environmental profile of their fleet to a network of 32 customers who consider this in procurement situations. The aim is a market demand for clean ships. CSI is driven by a non-profit organization.

The Clean Shipping Index consists of a questionnaire on environmental performance of ships, going beyond existing rules and regulations and covering existing ships of ten different types. The Index is focused on the vessels’ operational impact on the environment and scoring is obtained in five different areas: SOx and PM emissions, NOx emissions, CO2 emissions, chemicals, water and waste control. The information is filled in on a “ship to ship” basis, but the scoring is added to a total carrier score. A ranking is done based on the scoring. The information is collected in the Clean Shipping Index Database. The members of the Clean Shipping Network, a network of cargo owning companies, have access to this database. The Clean Shipping Index has developed a verification protocol for classification societies to get accredited to and carry out verification to the Clean Shipping Index.

In order to rank a ship’s efficiency, ship-owners are required to provide calculated CO2 emissions over a calendar year. Two options are accepted. Ship-owners report data according to MEPCs Energy Efficiency Operational Indicator (EEOI), or for container vessels there is an additional option to report data according to the Clean Cargo Working Group (BSR) calculation formula. Basic information for carrying out these calculations is the cargo carried, the distance travelled, and the fuel consumption.

Ranking is done comparing to a reference vessel of the same type. The EEOI for the reference ship is obtained in two steps. First the Energy Efficiency Design Index (EEDI) is calculated. This is done based on the methods outlined by the Greenhouse Gas Working Group of IMO. In a recent MEPC resolution, baselines are defined for the most common ship types of the world, expressing ideal technical circumstances but not including operational features. The baselines are presented as functions between deadweight (dwt) and emitted grams CO2 per tonne-nm. The EEDI thus provides average fuel consumption for a specific ship (type and size) that carries a cargo corresponding to the dwt.

In the second step, operational factors are accounted for. This means that average load factors and payload factors are taken into account. The load factors (ratio of actual load to maximum load on mass basis) assumed for the reference ships are taken according to the Second IMO GHG study.6

Using the EEDI baseline functions and considering load factors and payload factors, the calculation for an operational reference value will generally look like this:

\[ \text{EEOI}_{\text{ref}} = \frac{\text{EEDI}}{(\text{load factor} \times \text{payload ratio})}. \]

The actual calculated EEOI for the vessel is compared with the calculated \( \text{EEOI}_{\text{ref}} \) for the vessel. The score is determined depending on how much, above or below the reference the actual EEOI is.

6 IMO, 2009
Reporting has been done since 2007, and occurs through a web-based database. Over 2000 vessels are included in the database, belonging to 48 ship-owners.


### 4.1.9 Environmental Ship Index

The Environmental Ship Index (ESI) is a voluntary initiative by the World Ports Climate Initiative (WPCI). It gives a numerical representation of the environmental performance of ships regarding air pollutants and CO₂. The overall ESI formula is built up of different parts for NOₓ, SOₓ and CO₂; additionally a bonus is awarded for the presence of an approved OPS (Onshore Power Supply). The score for CO₂ is calculated with the EEOI data provided.7

Source: [http://www.environmentalshipindex.org](http://www.environmentalshipindex.org)

### 4.1.10 Marine Vessel Environmental Performance (MVEP) – Calculation tool

The Marine Vessel Environmental Performance (MVEP) assessment estimates the impact of a marine vessel’s design and operations on the marine environment by collecting vessel data and performing emission-specific calculations. The program includes a vessel indicator score that incorporates ten air and effluent emissions impact categories including air (CO₂, SOₓ, NOₓ, PM and VOC), spread of invasive species, wastewater and solid waste. Next to a report a spreadsheet tool includes survey entry forms, embedded calculation formulas, and performance summaries. The outputs are given in quantitative units. A one year period is suggested for normalization of data, although a shorter period can be used. Vessel comparisons will be facilitated in the future as the program matures.8


## 4.2 Comparison to the proposed EU MRV Regulation

Table 2 provides an overview of the detailed design aspects of the different maritime MRV programmes described in Section 4.2. To allow comparison, details of the proposed EU MRV system have also been included. The GL Environmental Passport and the Carbon Positive Programme for Ships are not included, due to the lack of detailed information available. Furthermore, the calculation tools (e.g. Danish Ship Owners’, Clean Shipping Index and MVEP) are not considered for comparison either, as they do not intend to be a MRV system.

The overview shows that:

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7Based on material available at: http://esi.wpci.nl/Public/Home

8 Marine Vessel Environmental Performance (MVEP) Assessment Methodology – Ship Survey and Impact Calculations. Prepared for the California Maritime Academy, Vallejo, California. 31 October 2012, Rev. B.
• None of the programs requires monitoring of fuel consumption per voyage. An exception is the GL Environmental Service System, which is not shown in the table. CCWG, Norden and FRAM all have a global scope and do not require monitoring on a per voyage basis. The French program does require emissions reporting on a per-voyage basis and covers only voyages to and from France. That program does, however, not require monitoring of per voyage fuel use, but uses default or annual average factors.
• Like the proposed EU MRV Regulation, all programs request information on the distance travelled.
• Not all programs request reporting of cargo. CCWG requests cargo capacity. Norden and the French initiative do use details of cargo, but these are not made public. FRAM requests cargo, but companies can choose to report transport work instead. This is similar to the proposed EU MRV Regulation, which does require the monitoring, but not the reporting of cargo information.
• Similar to the proposed EU MRV Regulation, all programs make use, or will make use of digital calculation or reporting tools.

It can be concluded that the only program that has experience with per-voyage monitoring of fuel consumption, which could provide useful experience for the EU MRV program, is the GL Environmental Service System. While monitoring and reporting distance is common in all systems, limited experience seems to be available on monitoring information on cargo. In general, it is difficult to learn from any of the existing programs without having detailed guidelines available, such as for the GL Environmental Passport and the Carbon Positive Programme for Ships.
<table>
<thead>
<tr>
<th>Program Element</th>
<th>Proposed EU MRV</th>
<th>CCWG</th>
<th>CSI</th>
<th>Norden MOEPS</th>
<th>FRAM</th>
<th>French transport code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of program</strong></td>
<td>Proposed mandatory system</td>
<td>Voluntary program for container shipping by consultancy company</td>
<td>Voluntary program for all main types of vessels by non-profit association of cargo owners</td>
<td>Company system</td>
<td>Norwegian voluntary program</td>
<td>Mandatory regulation</td>
</tr>
<tr>
<td><strong>Start of program</strong></td>
<td>Start of monitoring in 2018 (proposed)</td>
<td>2003</td>
<td>2007</td>
<td>Implemented 2009</td>
<td>Pilot in 2013</td>
<td>2013</td>
</tr>
<tr>
<td><strong>Ship threshold</strong></td>
<td>Ships above 5,000 gross tonnage (GT)(^2) which account for around 55% of the number of ships calling into Union ports</td>
<td>Container vessels greater than 400 gross tonnage (GT)</td>
<td>All main types of cargo vessels</td>
<td>The entire fleet of Norden is involved (approx. 250 ships)</td>
<td>No requirements for inclusion</td>
<td>All, no threshold for inclusion</td>
</tr>
<tr>
<td><strong>Number of ship owners and/or ships involved</strong></td>
<td>N/a</td>
<td>16 ship owners and more than 2,300 ships (2013)</td>
<td>48 shipowners, over 2000 ships (2014)</td>
<td>Norden’s fleet: about 250 ships (80% dry cargo; 20% tank cargo)</td>
<td>4 ship owners and 108 ships involved</td>
<td>No information available</td>
</tr>
<tr>
<td><strong>Reporting Entity</strong></td>
<td>Shipping Company</td>
<td>Container operators/shipping companies</td>
<td>Shipping company</td>
<td>Ships</td>
<td>Vessel operators, independent of whether technical management is in-house or outsourced</td>
<td>Transport service provider</td>
</tr>
<tr>
<td>Program Element</td>
<td>Proposed EU MRV</td>
<td>CCWG</td>
<td>CSI</td>
<td>Norden MOEPS</td>
<td>FRAM</td>
<td>French transport code</td>
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</tr>
<tr>
<td><strong>Fuels included</strong></td>
<td>All fuel burned in all engines, generators and boilers</td>
<td>All fuel burned in all engines and boilers (main engine, auxiliary engines and boilers)*</td>
<td>All fuels</td>
<td>All fuels</td>
<td>All fuels (LNG, LPG (butane), LPG (propane). No distinction between main vs. auxiliary engines or boilers.</td>
<td>All fuels</td>
</tr>
<tr>
<td><strong>Geographical Scope</strong></td>
<td>Voyages arriving to and departing from a port under a Member State's jurisdiction</td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>Global</td>
<td>All transport, departing from or travelling to a location in France</td>
</tr>
<tr>
<td><strong>Temporal Scope</strong></td>
<td>Monitoring per voyage and year, reporting per year</td>
<td>Annual</td>
<td>Annual</td>
<td>Daily reporting by ships of fuel use, Norden publishes results annually</td>
<td>&quot;Flexible&quot;, allowing participants to report at different time intervals and using different granularities.</td>
<td>Per transport service</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Per ship</td>
<td>Per ship, trade-lane and fleet including all vessels operated by the company (incl. owned and charter vessels) except from short term charter vessel below 6 months</td>
<td>Per shipping company, ship, trade-lane and fleet including all vessels operated by the company</td>
<td>Per ship</td>
<td>Per ship</td>
<td>Per transport service</td>
</tr>
<tr>
<td>Program Element</td>
<td>Proposed EU MRV</td>
<td>CCWG</td>
<td>CSI</td>
<td>Norden MOEPS</td>
<td>FRAM</td>
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</tr>
<tr>
<td><strong>Fuel Measurement Techniques</strong></td>
<td>1) BDN and periodic tank measurements, 2) Fuel tank monitoring on board 3) Fuel flow meters, and 4) Direct measurement of exhaust CO₂.</td>
<td>2) Fuel tank monitoring on board 3) Fuel flow meters</td>
<td>1) BDN</td>
<td>2) Fuel tank monitoring on board 3) Fuel flow meters</td>
<td>2) Fuel tank monitoring on board 3) Fuel flow meters, and 4) Direct measurement of exhaust CO₂.</td>
<td>Not specified</td>
</tr>
<tr>
<td><strong>Reported Air Contaminants</strong></td>
<td>CO₂</td>
<td>CO₂</td>
<td>CO₂, SOₓ and NOₓ</td>
<td>Ships report fuel consumption. This is later converted to GHG emissions*</td>
<td>CO₂</td>
<td>CO₂, including upstream emission</td>
</tr>
<tr>
<td><strong>Supporting Data required</strong></td>
<td>Distance travelled, Time spent at sea, Cargo carried (no reporting requirement), Transport work, Efficiency</td>
<td>Fuel burned, distance, nominal vessel capacity, # of reefer plugs; Vessel utilization is expected to be included in 2013/2014</td>
<td>Fuel burned, distance travelled, cargo carried</td>
<td>Speed, location, weather conditions, engine details such as engine load and fuel consumption, details on cargo</td>
<td>Fuel consumption, Distance sailed, cargo, transport work (as an alternative to reporting cargo carried)</td>
<td>Cargo and distance</td>
</tr>
<tr>
<td>Program Element</td>
<td>Proposed EU MRV</td>
<td>CCWG</td>
<td>CSI</td>
<td>Norden MOEPS</td>
<td>FRAM</td>
<td>French transport code</td>
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<td>--------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Efficiency metric used** | 1) fuel consumption per distance  
2) fuel consumption per transport work  
3) CO₂ emissions per distance  
4) CO₂ emissions per transport work | CO₂/TEU km \(^{(2)}\)          | gCO₂/tonne-nm                | EEOI (gCO₂/tonne-nm)  \(^{(3)}\) | Avg. CO₂/unit of payload. km is calculated depending on level of precision chosen |
<p>| <strong>Reporting method</strong> | To be developed electronic templates                                            | MS Excel worksheets; database is expected to be developed in 2014. | Online database with online guidance               | Digital information system | Online form, CSV file. Data warehouse integration expected | Digital calculation help available. Reporting to beneficiary of transport service in any format |
| <strong>Verification requirement</strong> | Third-party verification by accredited verifier                                | The CCWG CO₂ verification guideline developed by CCWG and class society (e.g. Lloyds register, DNV, GL etc.) | Third party verification by CSI – accredited verifiers | DNV conduct annual verification of emissions. Data samples in on-board engine log book and oil journals are compared to data in the system | Self-verification scheme based on ISO 14064 | Possibility of certifying the compliance of the method implemented by an accredited body. Procedures yet to be specified. |</p>
<table>
<thead>
<tr>
<th>Program Element</th>
<th>Proposed EU MRV</th>
<th>CCWG</th>
<th>CSI</th>
<th>Norden MOEPS</th>
<th>FRAM</th>
<th>French transport code</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Used guidelines and standards</strong></td>
<td>Based on existing MRV framework and yet to be developed guidelines that take into account industry practices and standards.</td>
<td>The CCWG CO₂ methodology is to the extent possible aligned with/based on the GHG Protocol scope 3 supply chain guideline, the European EN 16258 standard and IMOs EEOI guidelines, but is tailor made for container shipping.</td>
<td>IMO EEOI guideline</td>
<td>Detailed introduction guide on how to install the system and to get started.</td>
<td>MRV guidelines issued by FRAM; No international standards that are directly used in the FRAM project specifically. The FRAM project uses the conversion factors from IMO Circular MEPC.Circ.684.</td>
<td>Methodology guide (MEDDTL, 2012)</td>
</tr>
</tbody>
</table>

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1. The rules apply to all types of ships except: warships, naval auxiliaries, fish catching or processing ships, wooden ships of a primitive build, ships not propelled by mechanical means and government ships used for non-commercial purposes.
2. TEU stands for Twenty-Foot Equivalent: a unit of cargo capacity used to describe the capacity of container ships and container terminals. It is based on the volume of a 20-foot-long (6.1 m) intermodal container.
3. Energy Efficiency Operational Indicator (EEOI) defined by IMO. See section 5 for more explanation of the EEOI and other ship indices.
4. Chapter 5 discusses fuel measurement techniques in detail.
5 Fuel and emissions measurement techniques

The proposed EU MRV Regulation requires measurements of fuels and emissions. This section therefore describes different fuel measurement options and shipper experiences based on a literature survey (section 5.1) and draws relevant conclusions for the implementation of the proposed EU MRV Regulation (section 5.2).

5.1 Overview of techniques

Fuel consumption on board ships can be measured in one of three different ways:
1. Bunker delivery note (BDN) and periodic fuel tank measurements
2. Active fuel tank monitoring on board (tank soundings)
3. Fuel flow metering

A fourth option has also been identified, which is to directly measure CO₂ emissions in the exhaust stream. CO₂ monitoring systems are currently not common on board vessels, whereas fuel tank monitoring and fuel flow metering commonly occurs with a variety of different methods and instruments.

A recent evaluation of the possible MRV fuel monitoring approaches has been conducted by the Institute of Marine Engineering, Science and Technology (IMarEST, 2012). While the study does not recommend a preferred monitoring approach it does identify key issues that must be considered with each of the three potential fuel monitoring approaches. These are summarized here:

- The BDN approach would require measurement of fuel at the beginning of the period, fuel deliveries (BDN) and measurement of fuel at the end of the period. Measurements would be based on fuel tank readings achieved with dip tapes, soundings or automated means, which would be subject to vessel conditions such as trim/heel, weather conditions and calibration of the measurement system. Accuracy of the BDN note also warrants attention as it would be determined through a monitoring system of the fuel provider. Finally, sludge and water may be removed from the fuel during on-board treatment before combustion, which could necessitate use of a correction factor in the fuel monitoring calculations.

- Active fuel tank monitoring on board ships requires tank readings for all fuel tanks, taken at defined times or geographical locations. This approach is subject to all of the issues identified in the BDN approach, excluding accuracy of the BDN itself. Additional information will be needed to determine emissions: if the amount of fuel in the tank is measured as volume, fuel density information and/or volume correction factors are necessary to calculate the corresponding mass. Information about the fuel type is needed to select the right emission factor. The BDN will in many cases be the best source to obtain density and fuel type.

- Fuel flow metering requires the existence of meters in the fuel supply lines to engines and boilers. While newer ships often have such metering, installation of flow meters on existing ships is not noted as a common practice.
• Accuracy and consistency of fuel flow metering varies by system type as well as calibration and maintenance activities. A clear advantage to use of fuel flow metering is that fuel treatment (removal of water and sludge) is accounted for without the need for corrective factors. Difficulties with this method include a need for regular system calibration. In addition, IMarEST notes that a backup monitoring approach would have to be identified in the event that a vessel’s fuel metering system was to fail. As with the previous approaches, information on fuel type and density (in case of volumetric measurements) will need to be known to calculate emissions from fuel consumption. The BDN will in many cases be the best source for these data.

An additional study on the topic was completed by CE Delft following the IMarEST work. This study is generally consistent with the IMarEST study and explores several issues in greater detail, notably accuracy and cost associated with the available monitoring approaches. The attributes of each potential monitoring approach (including direct emissions monitoring), as determined by CE Delft, are summarized in Table 3.

### Table 3. Comparison of Potential MRV Fuel Monitoring Methods (summarized from CE Delft)

<table>
<thead>
<tr>
<th>Fuel Monitoring System</th>
<th>Estimated Uncertainty</th>
<th>Associated Cost</th>
<th>Potential MRV Limitations</th>
<th>Associated Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDN and periodic stock uptakes</td>
<td>1 – 5%</td>
<td>Reporting and verification costs may be relatively high</td>
<td>Useful for time-based policy measures but not route-based policy measures</td>
<td>May need to involve a third party (BDN supplier) for verification</td>
</tr>
<tr>
<td>Tank Soundings</td>
<td>Manually: limited to very inaccurate</td>
<td>Cost for one sounding est. 1,000 – 1,300 USD if not automated. Additional cost for regular calibration</td>
<td>Useful for time-based policy measures and route-based policy measures</td>
<td>Tank monitoring devices need to be regularly calibrated</td>
</tr>
<tr>
<td>Fuel Flow Metering</td>
<td>0.1 – 3.0%, depending on technology</td>
<td>Install costs can be high for pre-existing vessels. Reporting costs relatively low</td>
<td>Useful for time-based policy measures and route-based policy measures</td>
<td>Not all relevant flows may be monitored</td>
</tr>
<tr>
<td>Emissions Measurement</td>
<td>0 – 2%</td>
<td>Install costs can be very high for pre-existing vessels. Reporting costs relatively low</td>
<td>Useful for time-based policy measures and route-based policy measures</td>
<td>Emissions monitoring devices need to be regularly calibrated</td>
</tr>
</tbody>
</table>

The cost noted in Table 3 for additional tank soundings (if not automated) is somewhat unclear as these measurements are taken daily on board ships as part of the crew’s regular activities. However, CE Delft does not identify how this cost estimate was determined.
This issue is explored in more detail in Chapter 6 (data availability for ships). Similar to the IMarEST study, the CE Delft study does not recommend one monitoring approach over others. However, several points are made that imply the BDN/periodic stock uptakes approach may be problematic, including:

- Disputes over quantity of fuel is common between bunkerers and ship operators
- Reliability of BDNs has been questioned by industry representatives
- Conscientious verification of fuel use reported would call for complicated cross-checks with bunker fuel suppliers
- Approach would not support fuel use reporting over specific routes

5.2 Relevance for EU MRV

While no definitive study can be found that documents ship fuel monitoring and associated issues for global shipping, fuel consumption measurements can be practically made for the majority of ships over 5,000 GT, regardless of installed tank or flow measurement devices. This statement is supported by the fact that fuel information that is regularly passed between the vessel owner and operator. Several recent publications support a similar viewpoint, including a recent impact assessment completed for the Commission (Ricardo-AEA, 2013).

Regarding the different methods to monitor fuel:

- The use of bunker notes and periodic tank measurements to measure vessel fuel consumption could cause difficulty for data verification.
- The uncertainty for the monitoring should be based on the results of the recently prepared IMarEST study (±5%). However, over longer periods one would expect that the total error in reported fuel consumption would be much less than this value in most cases (e.g., assuming no systematic bias). It remains to be seen if different levels are needed for different monitoring methodologies, since the uncertainty level varies for the different monitoring approaches.
- For those vessels that do not have automatic tank measurement capabilities (e.g., electronic gauges) a degree of flexibility may be required in the proposed EU MRV Regulation to facilitate periods of time when fuel tank soundings simply cannot be done in a safe or accurate manner. This will depend on the data resolution requirements of the MRV program.
- Fuel flow metering has been identified to have the highest potential accuracy of the possible monitoring approaches (CE Delft, 2013).
- Direct emission monitoring is not currently possible with the vast majority of the existing international fleet. In addition, direct monitoring provides a measure of emissions and not fuel consumption directly (e.g., a calculation is required to obtain fuel consumption from this information). Finally, any ship with the capacity for emissions monitoring likely has sophisticated fuel monitoring capabilities. For these reasons, options fuel tank monitoring and fuel flow measurements should likely be the preferred fuel monitoring approaches in a broad

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9 IMarEST, 2012.
ship MRV program, with direct monitoring identified as a complementary measure that may be used in addition to the fuel data (e.g., in lieu of fuel-based CO₂ calculations).

Some uncertainty still exists in terms of the capacity of operators of different types of ships to accurately monitor fuel consumption. For smaller and older ships that may be used for coastal work, the administrative burden would likely be greater than for larger, modern ships.

Vessels that consume fuels other than diesel would have to have unique provisions for monitoring fuel consumption. However, no reason has been identified why fuel monitoring and CO₂ calculations with a reasonable level of uncertainty would not be possible for those vessels. Challenges that may have existed in the past for uniquely different vessel classes such as LNG or LPG tankers for issues such as combustion of boil off gases have now been studied to a reasonable level of detail. Further attention will nevertheless be required for the use of non-diesel fuels.

Historically, there likely has been a bias towards under-estimation of fuel volumes simply because having excess fuel (rather than the converse) is a much safer position to be in. The existence of a formal monitoring program would likely change this behaviour to some degree.
6 Data availability on board ships

To see how the EU MRV system could benefit from existing practices, this chapter describes what information is currently collected on board ships, logged on the ship itself and/or sent to the ship owner.

The information in this chapter relates to typical practices for the majority of ocean going vessels\textsuperscript{10}. There is additional information that may be communicated that relates to specific ship types and cargoes, including cargo heating systems, inert gas systems (tankers), refrigeration systems (containerships, other) and large/fast ballast systems for containerships and very large vessels.

6.1 Overview

This section provides an overview of relevant information available on board a ship.

6.1.1 Bunker Delivery Notes (BDN) and representative fuel sample

IMO regulation (MARPOL annex VI, Clause 18) requires all vessels above 400 GT to keep a record of the fuel oil that they bunker by means of a bunker delivery note (BDN). The form of the bunker delivery note is described in appendix V to annex VI of MARPOL. The BDN is issued by the bunker fuel supplier.

At a minimum, the BDN contains the following information:

- name and IMO number of receiving ship;
- port;
- date of commencement of delivery;
- name, address and telephone number of marine fuel oil supplier;
- product name(s);
- quantity (metric tons);
- density at 15°C (kg/m\textsuperscript{3}) (test method ISO 3675);
- sulphur content (% m/m) (test method ISO 8754); and
- a declaration signed and certified by the fuel oil supplier’s representative that the fuel oil supplied conforms with MARPOL annex VI regulations 14 (paragraphs 1 and 4) and 18 (paragraph 3).

It is important to note that the BDN does not include carbon content of the fuel, nor do typical fuel analyses conducted for shippers. This means that independent determination of fuel-based CO\textsubscript{2} emission factors can be difficult to achieve. A relevant discussion on the topic is available (MEPC 60/WP.6, 22 March 2010). The BDNs have to be kept on-board for a period of not less than three years.

\textsuperscript{10}SNC relies on Captain John Swann for this operational information. John has over 50 years of experience at sea and in the maritime industry.
following the delivery. The BDN must be accompanied by a representative sample of fuel oil sealed and signed by the supplier (see Section 9: Verification approaches)

**6.1.2 Operational logs**

Several sources of information relevant to fuel use and emissions are kept on board ships, including (GL, 2013):

- **The Deck Log** (required under SOLAS 74, Reg. II and III)\(^{11}\) provides relevant information on cargo and its storage (including type and tonnage), ship position and sailing distance.
  - It contains information related to cargo and its storage.
  - Ship position and sailing distance are also recorded.

- **The Engine Room Log** is a track record of all ship machinery parameters, performance, maintenance, and malfunctions. It will contain distance of travel information and speed to support efficiency calculations (propeller slip), as well as documentation of the drafts, trim and ballast conditions.
  - It includes parameters like engine parameters, performance, and maintenance.
  - Distance of travel and speed are essential for efficiency calculations.

- **The Oil Record Book** (or Oil Transfer Log) is required under MARPOL 73/78 Annex I for all vessels with a capacity over 400 GT. In this log, the ship will record all oil or sludge transfers and discharges within the vessel. In particular, part H of the Oil Record Book contains details on the bunkering of fuel. Part 2 contains details on cargo/ballast operations for oil tankers.
  - It covers oil or sludge transfers and discharges.
  - Particular details on bunkering are documented in part H.

- **The Cargo Record Book**, required under MARPOL 73/78 Annex II, is required for vessels carrying noxious liquid substances in bulk
  - It applies to vessels carrying noxious liquid substances.

- **Fuel Oil Changeover Procedure and Log-Book**, required under MARPOL Annex VI, are required for vessels that use separate fuels when entering or leaving ECAs. These are all cargo vessels of 400 GT and greater as well as all passenger ships, platforms and drilling rigs. The log needs to contain:
  - Volume of low sulphur fuel oils in each tank
  - Date, time and position of vessel when change over took place. (Before entering Emission Control Areas)
  - Date, time and position of vessel when change over took place. (After leaving Emission Control Areas).

**6.1.3 Voyage Abstract and Port Abstract**

In addition to the operational logs, two abstracts are typically required to be prepared and submitted to the ship owner as part of the Charter requirement. A Charter is a contract that is required to hire or lease a ship and this agreement can be for one voyage (Voyage Charter) or for a stipulated period of time (Time Charter or Bareboat Charter, although other terms may also be used in the industry). These abstracts are the Voyage Abstract and the Port Abstract.

The Voyage Abstract and Port Abstract include summaries of specific information that is required to be logged on the ship each watch (e.g., 4 hour period), including the following engine and fuel related criteria:

- Fuel lever settings
- Engine rpm (average)

- Engine load (average)
- Fuel flow meter readings and pressure
- Engine fuel consumption
- Engine cylinder temperatures
- Fuel oil inlet temperatures
- Sea water inlet/outlet temperatures
- Lube oil temperatures and pressures
- Piston & jacket cooler temperatures and pressures
- Exhaust gas temperatures
- Additional information, if turbochargers are fitted.

Additional information may also be collected, such as feed line pressures, as well as data for generators and transfer pumps. The engine/fuel data is collected for each tank, including information on the service tank as well as the settling tank (which is used to allow fuel impurities to be removed from the fuel flow). These readings tend to be taken near the end of a watch (shift).

The Voyage Abstract provides a summary of this information from the Full Away On Passage (FAOP) to the End Of Passage (EOP), which in general constitutes the period the ship is at sea. The Port Abstract covers from the EOP to the FAOP (and as such tends to focus on the period(s) at berth and anchor). The Abstracts are therefore a very useful source of information on engines, fuel consumption and vessel performance.

The Voyage and Port Abstracts also contain information crucial to the performance of the ship, including:
- Propeller slip and efficiency (from engine distance – calculated from rpm and propeller pitch, versus travel distance)
- Machinery failures
- Maintenance activities (planned and unplanned)
- Prevailing weather conditions
- Slow steaming practices
- Deviations from course (intended or required due to weather or emergency purposes).

### 6.2 Relevance for EU MRV

A great deal of information is logged on a regular basis as part of the Charter agreement between ship owner and charterer and in the required operational logs. This includes the fields that have been directly identified for the EEOI, namely fuel consumption (all fuels), sailing distance and cargo. Additional fields that relate to vessel performance/efficiency are also available, notably weather conditions, course, course adjustment, maintenance, ballast. These data could be used in the verification of a vessel MRV program and are available for the majority of ships.

It is meaningful to note that shipping companies have responded well to studies involving the calculation of EEOI, showing that the data is available for the main ocean going vessel ship classes.
It is likely that most shipping companies now collect sufficient data to allow calculation of EEOI as well as EEOI subdivisions and variants. Some ship classes (including coastal shippers) may nevertheless not have an equivalent ability to obtain and provide such information without excessive costs or difficulties.
This chapter describes monitoring approaches for fuel consumption and emissions for the implementation of the proposed EU MRV Regulation. It starts by listing monitoring obligation (Section 7.1) and describes emission sources (Section 7.2). Section 7.3 provides relevant definitions and conventions used in the remainder of the chapter. Subsequent sections describe monitoring approaches for:

- Fuel consumption (Section 7.4)
- Emissions factors (Section 7.5)
- CO₂ emissions (Section 7.6)

Section 7.7 describes the aggregation required for obtaining annual data, while Section 7.8 provides recommendations for provisions relevant to monitoring approaches for fuel consumption to be introduced through a delegated act.

### 7.1 Monitoring and obligations

According to the proposed EU MRV Regulation, companies will be required to monitor the following parameters:

a) amount and emission factor for each type of fuel consumed in total  
b) total aggregated CO₂ emitted under points (d), (e) and (f)  
c) aggregated CO₂ emissions from all voyages between ports under a Member State’s jurisdiction  
d) aggregated CO₂ emissions from all voyages which departed from ports under a Member State’s jurisdiction  
e) aggregated CO₂ emissions from all voyages to ports under a Member State’s jurisdiction  
f) CO₂ emissions which occurred within ports under a Member State’s jurisdiction at berth  
g) total distance travelled  
h) total time spent at sea  
i) total transport work  
j) average energy efficiency.

The proposed EU MRV Regulation requires companies to specify in the Monitoring Plan how these approaches will be implemented and also to include the results from annual monitoring in their annual emissions reports. The monitoring obligations listed above do not include the monitoring obligations for other relevant information, which are described in detail in Section 8.

A complete overview of monitoring obligations can be found in Section 3.1. In the following subsections further elaborations and explanations are provided on the requirements which are stipulated in the proposed EU MRV Regulation.
7.2 Emission sources

Emission sources aboard ships include the following:

- Main engine(s)
- Auxiliary engine(s)
- Boiler(s)
- Inert gas generator(s)
- Gas turbine(s)

CO₂ emissions from fuel used in all these sources are covered by the proposed EU MRV Regulation.

7.3 Definitions

This section uses the following definitions and conventions:

- A **port** is defined to be a coastal location with at least one marine terminal (berth). A port is a “port of call” according to Art. 3 of the proposed EU MRV Regulation: “a port where a ship stops to load or unload cargo or to embark or disembark passengers, excluding stops for the sole purpose of refuelling, obtaining fresh supplies and/or relieving the crew”

- The **time of arrival** is defined as the moment that the ship is alongside at berth (First Line Ashore) for the first time at the port of destination. In line with Art. 3 of the proposed EU MRV Regulation, a ship is only considered to arrive at a port if it stops there to (un)loads cargo or (dis)embarks passengers. A ship is not considered to arrive if it stops at a location for the sole purpose of refuelling, obtaining fresh supplies and/or relieving the crew. In the event that a ship goes to anchor at the port of arrival before reaching a berth, the time of arrival becomes the moment the ship drops anchor.

- The **time of departure** is defined as the moment that the ship leaves its final berth (Last Line Gone) to leave the port of origin. Departure in a port is always preceded by arrival at the same port. If a ship goes to anchor at the port once leaving its final berth and before leaving the port itself, time of departure is considered the moment the ship raises anchor to leave.

- A **voyage** as per the draft Regulation is defined to be any movement of a ship that originates from, or terminates in a port of call, whether it is from one port to another or from one port and returning. Trips within the same port are not considered voyages. Ballast trips are included.

- **Time at sea** is the time between departure and arrival.

- **Time in port** is the time between arrival and departure.

For certain techniques of tank measurements, accuracy is highest when made at berth, in calm waters. Defining the voyage to start and end at berth therefore leads to higher accuracy of such measurements.
7.4 Fuel Consumption

Fuel consumption is to be monitored while at sea and in port from all ship sources with one of four different methods noted below. The company may choose which of the four monitoring methods (or combination of methods) will be used, depending on availability (Section 7.4.1). The Commission may consider allowing that an alternative method to these four may be used when LNG Boil Off Gas (BOG) is used to fuel the ship (Section 7.4.2). In all cases, fuel consumption is to be measured on a per-voyage basis, with fuel type and emission factor specified.

For fuel measured in volumetric units, the company shall convert that amount from volume to mass by using density values (Section 7.4.3). For monitoring methods A and B discussed below, the period fuel consumption (in tonnes) must be corrected to remove mass associated with impurities, e.g. water (Section 7.4.4).

7.4.1 Monitoring methods

The company may choose which of the following four monitoring methods will be used (or used in combination), depending on availability of monitoring technologies.

**Method A: BDN (Bunker Delivery Notes) and daily fuel tank readings**

This method is a mass balance approach based on the quantity and type of fuel as defined on the BDN combined with daily stock-takes of fuel tanks based on tank readings. The fuel consumed over a period is the fuel at the beginning of the period, plus deliveries, minus fuel available at the end of the period and de-bunkered fuel between the beginning of the period and the end of the period (de-bunkering is not expected to be a common practice but is included for completeness).

This approach takes advantage of the daily fuel consumption reports that are regularly produced aboard ships. It uses tank tables relevant to each fuel tank to determine the volume at the time of the fuel tank reading, accounting for trim and heel. Fuel tank readings shall be carried out by appropriate methods such as automated systems, soundings and dip tapes. If automated systems are used, regular calibration should be performed.

The BDN can be used to determine properties of fuel in the tank(s): density (Section 7.4.3), impurities (Section 7.4.4) and emission factor (Section 7.5)

In this approach the tank readings shall occur:

- Before and after debunkering
- Departure and arrival to port (at berth location, or, if necessary, anchor).

For each tank, the period fuel consumption should be calculated as follows:

\[ FQ_N = T_N + R_N - T_{N+1} - D_N \] (3)
Where:

- \( FQ_N \) is the fuel consumed in tonnes (or m\(^3\)) for period “N”
- \( T_N \) is the total amount of fuel in the tank in tonnes (or m\(^3\)) at the start of period “N”, following fuel uptake (if applicable)
- \( T_{-N+1} \) is the total amount of fuel in the tank in tonnes (or m\(^3\)) at the end of period “N”
- \( R_N \) is the fuel uptake in tonnes (or m\(^3\)) during period “N” (if applicable)
- \( D_N \) is the fuel debunkering in tonnes (or m\(^3\)) during period “N” (if applicable)

Equation (3) is used for each unique fuel type used on a particular voyage. Periodic stock-takes are to be taken:

- Upon departure from and arrival to port (at berth location, or, if necessary, anchor); to facilitate separate reporting of emissions at sea and at port
  - Vessels that use a single type of fuel need to make fuel measurements directly upon arrival and just before departure.
  - In case a ship switches to a low-sulphur fuel directly after arrival, the measurement of the conventional fuels that were used while at sea may be taken at any time after arrival.
  - Also in case a ship uses a low-sulphur fuel inside an ECA and conventional fuels outside an ECA more flexibility exists. After arrival at or before departure from a port within an ECA, the measurements of conventional fuels may be taken at any time while at berth. The measurements of low-sulphur fuel should in this case however still be made directly upon arrival and just before departure.

As needed, the company shall convert fuel measures from volume to mass by using actual density values (see Section 7.4.3). The fuel measures (in tonnes) must be corrected to remove mass associated with impurities in the fuel (e.g. water) (see Section 7.4.4).

**Method B: Fuel tank monitoring on board**

This method is a mass balance approach based on periodic stock-takes of fuel tanks from tank readings. The fuel consumed over a period is the fuel at the beginning of the period, plus deliveries, minus fuel available at the end of the period and de-bunkered fuel between the beginning of the period and the end of the period.

The periodic stock-take of fuel tanks on-board is based on fuel tank readings, similar to Method A. However, more frequent stock-takes of tanks would be expected (e.g., before and after bunkering). It uses tank tables relevant to each fuel tank to determine the volume at the time of the fuel tank reading, accounting for trim and heel. Fuel tank readings shall be carried out by appropriate methods such as automated systems, soundings and dip tapes. If automated systems are used, regular calibration should be performed.

For each tank, the period fuel consumption should be calculated using equation (3).

The BDN can be used to determine properties of fuel in the tank(s): density (Section 7.4.3), impurities (Section 7.4.4) and emission factor (Section 7.5).
• Periodic stock-takes are to be taken: Upon departure from and arrival to port (at berth location, or, if necessary, anchor); to facilitate separate reporting of emissions at sea and at port:
  o Vessels that use a single type of fuel need to make fuel measurements directly upon arrival and just before departure.
  o In case a ship switches to a low-sulphur fuel directly after arrival, the measurement of the conventional fuels that were used while at sea may be taken at any time after arrival.
  o Also in case a ship uses a low-sulphur fuel inside an ECA and conventional fuels outside an ECA more flexibility exists. After arrival at or before departure from a port within an ECA, the measurements of conventional fuels may be taken at any time while at berth. The measurements of low-sulphur fuel should in this case however still be made directly upon arrival and just before departure.

As needed, the company shall convert fuel measures from volume to mass by using actual density values (see Section 7.4.3). The fuel measures (in tonnes) must be corrected to remove mass associated with impurities in the fuel (e.g. water) (see Section 7.4.4).

**Method C: Flow meters for applicable combustion processes**

This method is based on the type and quality of fuel as defined by the BDN (or independent fuel analyses) combined with measured fuel flows on-board. The data from all flow meters linked to the identified emission sources relevant to the proposed EU MRV Regulation are combined to determine fuel consumption for a specific period.

Method C can be used in combination with one or more of the other allowable fuel monitoring approaches (A, B or D) if flow meters are not used for every relevant emission source.

With flow meters, the fuel flow is typically measured directly by volume, velocity or mass or indirectly by pressure or other parameter. Accuracy may be improved over Methods A and B since the actual fuel consumed by the relevant sources is measured\(^\text{12}\), as long as the monitoring equipment is appropriately calibrated. For this reason, correction of the fuel consumption amounts for impurities (Section 7.4.3) is not required. However, any flow meters that directly or indirectly provide a measure of the fuel volume consumed will require a conversion from fuel volume to fuel mass, which requires the fuel density and temperature values (Section 7.4.3). It is understood that these conversions may be completed in the flow meter software internally (for newer flow meters) or may be completed externally through user calculation.

The monitoring of all outward flows from the fuel storage tanks may indicate different values of fuel consumption compared to the monitoring of inward flows at the engines. For this reason, a metering flow diagram should be accessible in the monitoring plan for ease of verification. The location of flow meters must be shown in the flow diagram which is part of the monitoring plan.

To use this method, the company must ensure that the measurement equipment is suitable for the environment in which it is to be used, and regularly maintained and calibrated as described in the equipment documentation. A backup plan must be identified (e.g., use of Method A or B), should one or more flow meters fail during a voyage.

**Method D: Direct emissions measurement**

This method is based on the determination of CO\(_2\) emission flows in exhaust gas stacks by multiplying the CO\(_2\) concentration of the exhaust gas with the exhaust gas flow. These data are collected by permanently installed continuous emissions monitoring systems (CEMSs) for CO\(_2\). The data from all CEMSs linked to identified emission sources relevant to the EU proposal are combined to determine fuel consumption for a specific period.

Method D can be used in combination with one or more of the other allowable fuel monitoring approaches (A, B or C) if CEMSs are not used for every relevant emission source.

This method may be used while in port or at sea and must include all exhaust gas flows for the identified source. For ships on which reporting is based on this method, the fuel consumption shall be calculated using the measured CO\(_2\) emissions and the applicable emission factor of the relevant fuels (see Section 7.5).

In order to be able to differentiate the fuel consumed at-sea and in EU ports and inside and outside of ECAs, data should be recorded whenever a change in status occurs (port, at-sea, at-sea in ECA), at the minimum.

Similar to direct emissions measurement for stationary sources, the operator shall consider all relevant aspects of the continuous measurement system, including the location of the equipment, calibration, measurement, quality assurance and quality control. Application of EN 14181 ("Stationary source emissions – Quality assurance of automated measuring systems") is considered appropriate for the main engines at a minimum, which are similar to the engines used in certain power stations. EN 14181 requires the following quality assurance levels (QALs) and annual surveillance test (AST):

- **QAL 1**: Testing whether the continuous emissions monitoring system (CEMS) is meeting the specified requirements.
- **QAL 2**: Calibration and validation of the CEMS by an accredited laboratory.
- **QAL 3**: Ongoing quality assurance during operation.
- **AST**: Annual surveillance test using standard reference methods

QAL 2 and AST are to be performed by an accredited laboratory\(^{13}\). Stack CO\(_2\) emissions can be measured to an expected volumetric (ppm) accuracy of ±2\% \(^{14}\). Together with temperature, pressure

---

\(^{13}\) Accreditation in accordance with EN ISO/IEC 17025 is considered appropriate. Other accreditation standards may also be acceptable, if identified.

\(^{14}\) CTE, 2011
and volume (can be measured with an accuracy of ±0.3%), the CO₂ mass flow can be calculated. The specified performance requirements for the ship CEMs should be clearly identified by the company and should be set to achieve an overall accuracy in voyage CO₂ reporting of ± 5% or better (e.g., at least as accurate as the expected upper accuracy level of Methods A and B).

The company must ensure that a backup plan is identified (e.g., use of Method A or B) should the equipment fail during a voyage.

7.4.2 LNG tankers

The Commission may consider modifying measuring method B of the EU MRV Regulation to state that LNG tankers may use BOG as a fuel source for some if not all of the ship fuel requirements. In these cases, the amount of LNG fuel consumed should be determined from the total cargo mass loss over the voyage. This can be achieved by referencing the Custody Transfer System records for the LNG cargo following loading and at the completion of cargo transfer. The uncertainty of this measurement is estimated to be 0.49%\(^\text{15}\). For these cases, the company will have to determine the fraction of total BOG consumed at-sea and in-port for the voyage.

A potential method to calculate BOG consumption in port is shown below:

\[
F_{Q_{\text{port}}} = F_{Q_{\text{tot}}} \cdot \left( \frac{P_{\text{aux}} L_{\text{aux}} t_{\text{port}}}{P_{\text{main}} L_{\text{main}} t_{\text{at-sea}} + P_{\text{aux}} L_{\text{aux}} t_{\text{at-sea}}} \right)
\]  

Where:
- \(F_{Q_{\text{port}}}\) is the fuel quantity consumed in port (tonnes)
- \(F_{Q_{\text{tot}}}\) is the total quantity of BOG consumed over the entire voyage (at-sea and in port, tonnes)
- \(P_{\text{main}}\) is the maximum power rating of the main engine(s) (kW)
- \(L_{\text{main}}\) is the average load on the main engine(s) during voyage (fraction of maximum power rating, unitless)
- \(t_{\text{at-sea}}\) is the time spent at sea for the voyage (hours)
- \(P_{\text{aux}}\) is the maximum power rating of the auxiliary engine(s) used at berth (kW)
- \(L_{\text{aux}}\) is the average load on the auxiliary engine(s) used at berth (fraction of maximum power rating, unitless)
- \(t_{\text{port}}\) is the time spent at berth for the voyage (hours)

Equation (4) assumes that the vessel main engines are not used at berth. Turning off the main engines while in port continues as a majority practice. In the case of diesel-electric ships, where the main engine also provides electrical energy to the ship, it is unlikely that all main engines are turned off. If the vessel main engine(s) are/is used at berth an alternative calculation (similar to equation [4] but including main engine[s]) in the numerator could be identified and used instead.

\(^{15}\) Noted in MEPC 59-4-10 (Society of International Gas Tanker and Terminal Operators), which references the LNG Custody Transfer Handbook 2nd Edition, GIIGNL.
Alternatively, it is noted that the specific fuel consumption rate for the vessel engine(s), if available, could be used for the calculation of BOG used in port, where the fuel consumption rate is fairly constant: the auxiliary load is much less dynamic than fuel consumption from the main engines for propelling the ship.

7.4.3 Conversion of volumetric measurements to mass

For fuel measured in volumetric units, the company shall convert that amount from volume to mass by using the density measurement for the fuel. To complete the calculation, the volume and density values must be for the same temperature. Two methods can be used:

i) The density measurement is specific to 15°C (e.g., from the BDN). The volume measurement should therefore be corrected to 15°C before the conversion to mass occurs. One potential method of correction is to use volume correction factors (VCFs) from the American Society for Testing and Materials (ASTM) D1250. Equation (5) shows the expected calculation.

\[
M = V_T \cdot VCF \cdot \rho_{15C} \left( \frac{\text{tonnes}}{\text{m}^3} \right)
\]  

(5)

Where:

\( M \) is the mass of fuel, expressed in tonnes

\( V_T \) is volume of fuel at ambient temperature \( T \), expressed in m\(^3\)

\( VCF \) is the volume correction factor (unitless) at temperature \( T \), from ASTM D1250, specific to the fuel type

\( \rho_{15C} \) is density of fuel at 15°C, expressed in tonnes/m\(^3\)

ii) The density measurement is corrected to the temperature of the fuel. Equation (6) shows the expected calculation for the density correction.

\[
\rho_T = \rho_{15C} \cdot \left[ 1 - (T - 15) \cdot 0.00064 \right]
\]

(6)

Where:

\( \rho_T \) is density of fuel at temperature \( T \), expressed in tonnes/m\(^3\)

\( \rho_{15C} \) is density of fuel at 15°C, expressed in tonnes/m\(^3\)

\( T \) is the ambient temperature (temperature of fuel in tank)

The corrected fuel density is then multiplied by the actual fuel volume to yield fuel mass.

Determination of density of a fuel sample

The company shall determine the density for each fuel sample taken on board by using one of three approaches:

a) Measured by fuel supplier at fuel uplift and recorded on the fuel invoice or BDN,
b) Independent lab analysis of fuel sample, or
c) On board marine fuel density meter.\textsuperscript{16}

The density values obtained via the approaches listed above should be defined at $15^\circ C$. The company shall use the most accurate approach that is technically feasible at reasonable costs. Actual densities are in principle are always considered to be available from the fuel supplier.

**Averaging densities of different fuel samples**

A tank is not always empty before new fuel is added. The fuel in a tank is therefore a mixture of different samples and its density is dependent on all these samples. Since most operators segregate bunkers to separate tanks, calculating the actual density of a fuel mixture is not required in most cases and the density of the dominant fuel source in the tank can be used.

In the event that fuel types with significantly different densities are mixed in a tank (a difference greater than 3% is considered significant), the company shall determine the weighted average density of the different fuel samples in each tank. To accomplish this, the amount of fuel that is added to the tank, the density of that fuel and the total amount of fuel in the tank determined directly after fuel has been added should be used (see Table 4), unless a density analysis of the mixed fuel sample is available.

**Table 4. Tank log for determination of density of fuel in tank**

<table>
<thead>
<tr>
<th>Period</th>
<th>Fuel type added</th>
<th>Density\textsuperscript{1} (kg/litre)</th>
<th>Fuel added to tank\textsuperscript{2} (kg)</th>
<th>Fuel in tank after adding fuel\textsuperscript{3} (kg)</th>
<th>Density of fuel in tank (kg/litre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMA</td>
<td>886</td>
<td>700</td>
<td>890</td>
<td>850</td>
</tr>
<tr>
<td>1</td>
<td>Input</td>
<td>Input</td>
<td>Input</td>
<td>Input</td>
<td>Calculated</td>
</tr>
<tr>
<td>2</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

\textsuperscript{1} All density values should be defined at the same standard temperature

\textsuperscript{2} The amount of fuel added is to be obtained from the BDN (method A) or through the difference between the amount of fuel in the tank before and after adding removing fuel (method B). For method C, either approach may be used.

\textsuperscript{3} To be determined using measurement of the amount of fuel in the tank after adding fuel or calculated as the sum of the amount of fuel in the tank before adding fuel (obtained through measurement) and the amount of fuel added.

For the example shown in Table 4, calculation of the resultant density would be as follows:

\[
D_w = \left(\frac{X_{\text{add}}}{X_{\text{total}}} \right) \cdot D_{\text{add}} + \left(\frac{X_{\text{exist}}}{X_{\text{total}}} \right) \cdot D_{\text{exist}} \tag{7}
\]

\textsuperscript{16} See for example, http://www.kittiwake.com/density-meter.
Where:

- $D_w$ is the weighted average density of fuel in the tank after additions in tonnes/m$^3$
- $D_{add}$ is the density of the fuel added to the tank, in tonnes/m$^3$
- $T_{add}$ is the amount of fuel added to the tank in tonnes
- $T_{total}$ is the total amount of fuel in the tank after addition, in tonnes
- $T_{exist}$ is the existing amount of fuel in the tank before addition, in tonnes
- $D_{exist}$ is the density of the existing fuel in the tank before addition, in tonnes/m$^3$

### 7.4.4 Correction for impurities

For fuel monitoring methods A and B, the amounts of fuel must be corrected for mass associated with impurities, especially water. Other impurities, such as ash and metals, are anticipated to be too minor to have a significant impact on emissions for these purposes. This correction will not be necessary for fuel monitoring methods C and D. Impurities content can be established from independent fuel analyses (if available) following the ISO 8217 Standard. As shown in Table 5, ISO 8217 specifies the maximum impurities content for four different grades of distillate and six different grades of residual fuels, where water is of particular relevance for the proposed EU MRV regulation.

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Max. water content (% by vol)</th>
<th>Max ash level (% by mass)</th>
<th>Max Al + Si (mg/kg)</th>
<th>Total aged sediment (% by mass)</th>
<th>Max Vanadium (mg/kg)</th>
<th>Max density @ 15 °C (kg/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMX</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>DMA</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>890</td>
</tr>
<tr>
<td>DMZ</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>890</td>
</tr>
<tr>
<td>DMB</td>
<td>0.3</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>900</td>
</tr>
<tr>
<td>RMA</td>
<td>0.30</td>
<td>0.040</td>
<td>25</td>
<td>0.10</td>
<td>50</td>
<td>920</td>
</tr>
<tr>
<td>RMB</td>
<td>0.50</td>
<td>0.070</td>
<td>40</td>
<td>0.10</td>
<td>150</td>
<td>960</td>
</tr>
<tr>
<td>RMD</td>
<td>0.50</td>
<td>0.070</td>
<td>40</td>
<td>0.10</td>
<td>150</td>
<td>975</td>
</tr>
<tr>
<td>RME</td>
<td>0.50</td>
<td>0.070</td>
<td>50</td>
<td>0.10</td>
<td>150</td>
<td>991</td>
</tr>
<tr>
<td>RMG</td>
<td>0.50</td>
<td>0.100</td>
<td>60</td>
<td>0.10</td>
<td>350</td>
<td>991</td>
</tr>
<tr>
<td>RMK</td>
<td>0.50</td>
<td>0.150</td>
<td>60</td>
<td>0.10</td>
<td>450</td>
<td>1010</td>
</tr>
</tbody>
</table>

The amount of fuel is corrected by multiplying the amount of fuel (in tonnes), by the determined correction factor (CF):

$$ CF = \frac{(100 - W(\%)) - A(\%)}{100} $$  \hspace{1cm} (8)

Where:

- $W(\%)$ is the amount water content of fuel, expressed in percent by mass
$A(\%)$ is the amount of other inert material in the fuel such as ash and metals, expressed in percent by mass (expected to be too insignificant to affect emissions for these purposes). The water content of fuel may be available from the BDN. In the event that total ash and metals content ("$A$") of the fuel is not available (e.g., no fuel analysis is available) it should be considered as zero. This assumption, if necessary, would lead to conservative estimates of corrected fuel consumption with acceptable accuracy. In the event that total water content is not available, the maximum water content values in Table 5 should be used, for those fuel types noted. For all other fuel types (heavy and intermediate fuel oils) a value of 1% should be used.

The potential error in the correction factor when complete fuel analysis data is not available is expected to be quite low. For example, the correction factor for RMK fuel assuming the maximum allowable impurities content from ISO 8217:2010 can be calculated as follows:

With impurities data available: 
$$CF = \left( 100 - \left( 0.5 \cdot \left( \frac{999}{1010} \right) \right) - \left( 0.15 + 0.10 \right) + \left( \frac{60 + 450}{1,000,000} \right) \right) / 100 \quad (9)$$

Without impurities data available: 
$$CF = \left( 100 - \left( 0.005 \cdot \left( \frac{999}{1010} \right) \right) - 0 \right) / 100 \quad (10)$$

As shown above, the water content, expressed in Table 5 by % by volume, is corrected to % by mass using the densities of water (999 kg/m$^3$ at 15°C) and fuel at 15°C. With the impurities data available the correction factor is 0.993 and without is 0.995.

When adding fuel to a tank, the correction factor associated with the largest volume of fuel should be applied (e.g., a weighted average correction factor is not necessary).

It is understood that some shippers may use soundings or other measurements of the sludge tank to determine the amount of impurities removed from the fuel. This approach may also be used if documented in the monitoring plan.

### 7.5 Emission factors

This section discusses different ways to determine emission factors. The default method, which is expected to be used in most cases, applies emission factors published in IMO MEPC.1/Circ.684. Corrections for the use of biomass need to be made, where applicable. If a tank contains different fuel samples (types) with different emission factors, a weighted averaging of emission factors is required.

**Emission factors in EU MRV Regulation**

Default emission factors in the proposed EU MRV Regulation are based on the latest available IPCC values.$^{17}$ For stationary installations, the physical quantity of fuel (e.g. tonne) is first converted to an

---

amount energy using the net calorific value (NCV) of the fuel (e.g. TJ/tonne). The resulting amount of energy is then converted to emissions using emission factors specified as an amount of emissions per unit of energy (e.g. tCO₂/TJ).

Table 6 shows the emission factors as emissions per unit of fuels using NCVs and emission factors from the EU MR Regulation for those fuels that are listed under the section "water-born navigation" in the most recent IPCC guidelines (2006 IPCC Guidelines for National Greenhouse Gas Inventories).

Table 6. Calculation of CO₂ emission factors for fuels listed under section "Water-born navigation" in 2006 IPCC Guidelines for National Greenhouse Gas Inventories; emission factor (tCO₂/TJ) and Net calorific value taken from EU MRV Regulation

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Emission factor (tCO₂/TJ)</th>
<th>Net calorific value (TJ/kt-fuel)</th>
<th>Emission factor (tCO₂/t-fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>69.3</td>
<td>44.3</td>
<td>3.070</td>
</tr>
<tr>
<td>Other Kerosene</td>
<td>71.9</td>
<td>43.8</td>
<td>3.149</td>
</tr>
<tr>
<td>Gas/Diesel Oil</td>
<td>74.1</td>
<td>43.0</td>
<td>3.186</td>
</tr>
<tr>
<td>Residual Fuel Oil</td>
<td>77.4</td>
<td>40.4</td>
<td>3.127</td>
</tr>
<tr>
<td>Liquefied Petroleum Gases</td>
<td>63.1</td>
<td>47.3</td>
<td>2.985</td>
</tr>
<tr>
<td>Other oils</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refinery Gas</td>
<td>57.6</td>
<td>49.5</td>
<td>2.851</td>
</tr>
<tr>
<td>Paraffin Waxes</td>
<td>73.3</td>
<td>40.2</td>
<td>2.947</td>
</tr>
<tr>
<td>White Spirit &amp; SBP</td>
<td>73.3</td>
<td>40.2</td>
<td>2.947</td>
</tr>
<tr>
<td>Other Petroleum Products</td>
<td>73.3</td>
<td>40.2</td>
<td>2.947</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>56.1</td>
<td>48.0</td>
<td>2.693</td>
</tr>
</tbody>
</table>

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories mention that for water born navigation, CO₂ emission factors for fuels are generally well determined as they are primarily dependent on the carbon content of the fuel. For example, the default uncertainty value for diesel fuel is about ±1.5 percent and for residual fuel oil ±3 percent.

**Emission factors by IMO**

IMO presented CO₂ emission factors expressed in emissions per quantity of fuel in MEPC.1/Circ.684. (see Table 7). These emission factors constitute the default set of factors to be used in the proposed EU MRV Regulation.

Table 7. Marine Fuels and Default Emission Factors (from MEPC.1/Circ.684)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Reference</th>
<th>Emission Factor (tCO₂/t-fuel)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Fuel Oil (HFO)</td>
<td>ISO 8217 Grades RME through RMK</td>
<td>3.114</td>
</tr>
<tr>
<td>Light Fuel Oil (LFO)</td>
<td>ISO 8217 Grades RMA through RMD</td>
<td>3.151</td>
</tr>
<tr>
<td>Diesel/Gasoil</td>
<td>ISO 8217 Grades DMX through DMC</td>
<td>3.206</td>
</tr>
<tr>
<td>Liquefied petroleum gas (LPG)</td>
<td>Propane</td>
<td>3.000</td>
</tr>
<tr>
<td>Liquefied petroleum gas (LPG)</td>
<td>Butane</td>
<td>3.030</td>
</tr>
<tr>
<td>Liquefied Natural Gas (LNG)</td>
<td>Methane (BOG)</td>
<td>2.750</td>
</tr>
</tbody>
</table>

**Actual emission factors**

In the case of alternative fuels not identified in Table 7, or in the case the company seeks improved accuracy, it may choose to use emission factors that have been determined through sample
analysis, either by the company or by the fuel supplier. In both cases, the company needs to record
the methodology for sampling, methods of analysis, and a description of the laboratories used (with
confirmed ISO 17025 accreditation where relevant). It should be noted that there is no obligation for
the company to develop specific emission factors for the conventional fuels purchased.

**Correction for use of biofuels**

Where biofuels are used, the emission factor is determined from the preliminary emission factor based
on fossil fuel only and the biomass fraction of the fuel as follows\(^\text{18}\):

\[
EF = EF_{pre} \cdot (1 - BF)
\]

Where:
- \(EF\) is the emission factor, expressed in tCO\(_2\)/tonne fuel
- \(EF_{pre}\) is the preliminary emission factor for the base fossil fuels, expressed in tCO\(_2\)/tonne fuel
- \(BF\) is the dimensionless mass-fraction of carbon contained in the fuel that is considered biomass

Note that equation (11) assumes that the emission factor of biomass is zero. Consistent with the MRR,
in order for biofuels to be zero-rated (i.e. for applying an emission factor of zero), the biofuel must
satisfy the sustainability criteria defined by the RES Directive\(^\text{19}\). Guidance document No. 3 (Biomass
issues in the EU ETS) describes in detail how those sustainability criteria apply, and under which
conditions purchase records may be used for obtaining the required information.

**Averaging emission factors from different fuel samples**

In the event that a tank contains different samples of fuel with different associated emission factors, a
weighted average emission factor should be determined. Weighted average emission factors of the
fuel in the tank should be monitored by extending the use of Table 6. It is expected that this
calculation would only be required when mixing fuels of different types or when the company uses
biomass.

### 7.6 CO\(_2\) emissions

CO\(_2\) emissions are determined for each period by multiplying the amount of each fuel consumed
(methods A, B and C in Section 7.4) by the applicable CO\(_2\) emission factors (see Section 7.5). A period
is defined as the time at sea during a voyage to and/or from an EU port, the time at sea within an ECA
during a voyage to and/or from and EU port, or the time while in an EU port.

\[
EM_n = \sum_i (FQ_{i,n} \cdot EF_{i,n})
\]
Where:

\( EM_n \) is the amount of emissions for the period \( n \), expressed in tCO₂

\( i \) is the index for fuel tanks on board the ship

\( FQ_{i,n} \) is the quantity of fuel consumed from tank \( i \) during period \( n \), expressed in tonnes

\( EF_{i,n} \) is the CO₂ emission factor of the fuel tank \( i \) during period \( n \), expressed in tCO₂/tonne fuel

In case the company monitors CO₂ directly (method D in Section 7.4), it should determine the emissions by adding all measured CO₂ source streams.

### 7.7 Annual aggregates to be reported

Annual totals are required to be reported for each ship:

- Total amount and emission factor for each type of fuel consumed in total and differentiated concerning fuel used inside and outside emission control areas
- Total CO₂ emitted
- Aggregated CO₂ emissions from all voyages between ports under a Member State’s jurisdiction
- Aggregated CO₂ emissions from all voyages which departed from ports under a Member State’s jurisdiction
- Aggregated CO₂ emissions from all voyages to ports under a Member State’s jurisdiction
- CO₂ emissions which occurred within ports under a Member State’s jurisdiction.

Totals are defined as the sum of values for different voyages. The amount of fuel consumed of each type and corresponding emission factor differentiated concerning fuel used inside and outside emission control areas can be obtained through tank monitoring of fuel consumption and properties (e.g. Table 4).

### 7.8 Recommendations

It is noted that there are different methods and many different technologies used for monitoring fuel consumption aboard ships. Some of these require external conversion calculations while others leverage internal conversions by monitoring gauge software.

It is therefore very difficult to specify a set of requirements that would fully encompass all of the specific technologies used for monitoring methods A, B, C and D. For these reasons, guidance provided to shippers should remain at a higher level to maintain a level of flexibility.

Regarding monitoring approaches for fuel consumption and emissions, further technical rules may:

- Elaborate on the four different methods to monitor fuel consumption (diesel), as well as LNG boil off gas consumption
- Define how the amounts of fuel are to be converted from volumetric units to mass units
- Define how the amounts of fuel are to be corrected for impurities, where relevant
- Define when simplified approaches can be used and what these are, and finally
- How annual aggregates are to be reported.

Furthermore, technical rules should reflect the fact that some shippers may require use of more than one of the acceptable fuel monitoring methods. For example, a ship may use flow meters or CEMS for some, but not all of the emission sources, requiring a combination of fuel monitoring methods. In addition, it should be required in the monitoring plan to have a backup fuel monitoring approach identified in the event of equipment failure or malfunction.

A recommended template for Monitoring Plans should provide sections for each of the requirements. An automated system, which blanks out certain sections which are not applicable if specific methods are chosen, should be implemented in this template to facilitate the completion of the Monitoring Plan.
This chapter describes monitoring approaches for other relevant information for the implementation of the proposed EU MRV Regulation. It starts by listing monitoring obligation (Section 8.1). Subsequent sections describe monitoring approaches for:

- Port of departure and port of arrival (Section 8.2)
- Date and time of arrival and departure (Section 8.3)
- Distance sailed (Section 8.4)
- Cargo (Section 8.5)
- Time spent at sea (Section 8.6)
- Transport work (Section 8.7)

Section 8.8 describes approach to calculating energy consumption and Section 8.9 elaborates on the collection of data that will need to be reported.

8.1 Monitoring and obligations

As mentioned in Section 3, apart from fuel use and emissions, companies are required to monitor the following parameters on a per-voyage basis:

- Port of departure and port of arrival
- Date/time of departure and arrival
- Distance travelled
- Time spent at sea
- Cargo carried
- Transport work (distance multiplied by cargo carried)

In addition, for each ship and for each calendar year, the proposed EU MRV Regulation requires the company to monitor the following parameters:

- Total distance travelled
- Total time spent at sea
- Total transport work (distance multiplied by cargo carried)
- Average energy efficiency, expressed by using at least four indicators:
  - EEOI (tCO₂/tonne-nm)
  - Energy efficiency per distance (TJ/nm)
  - Energy efficiency per transport work (TJ/tonne-nm)
  - CO₂ efficiency per distance (tCO₂/nm)
Companies are required to include the results from annual monitoring in their annual emissions reports. A complete overview of monitoring obligations, including fuel use and emissions, can be found in Section 3.1.

Time spent in port does not need to be monitored nor reported explicitly. Determining time spent at port would however be possible for companies since they are required to monitor time of arrival and departure.

8.2 Port of departure and port of arrival

Companies are required to record the port of departure and arrival for voyages to and from EU ports. To facilitate annual aggregation, companies are advised to explicitly specify whether the voyage is between EU ports, from a non-EU port to an EU port or from an EU port to a non-EU port.

Recording needs to be based on existing logs, e.g. the Deck Log and/or the Official Ship Log. The name of the port shall be provided in the local language using Latin alphabet.

Although not required by the proposed EU MRV Regulation, companies might be advised to also record ports of arrival and departure for voyages between non-EU ports in the log used for the purpose of monitoring for the EU MRV system. This will assist the company and verifier when checking completeness of reporting.

8.3 Date and time of departure and arrival

Companies are required to record the date and time of departure and arrival for voyages to and from EU ports.

For the purpose of the EU MRV system, the time of departure is defined as the moment that the ship leaves berth (Last Line Gone) or leaves anchor in port, whichever occurs last at the port of origin. The time of arrival is defined as the moment that the ship is alongside at berth (First Line Ashore) or drops anchor in port (if applicable), whichever occurs first at the port of destination. The date and hour of departure and arrival shall be considered using Greenwich Mean Time (GMT).

In the event that a ship stops at more than one berth location at a port, the first berth it stops at (First Line Ashore) shall be used for time of arrival. Similarly, the last berth a ship leaves from within a port (Last Line Gone) shall be used for time of departure.

The company needs to be able to substantiate the time and date of departure and arrival using data reported in the Deck Log and/or the Official Ship Log.
Although not required by the proposed EU MRV Regulation, companies are advised to record these data also for voyages between non-EU ports in the log used for the purpose of monitoring for the EU MRV system. This will assist the company and verifier when checking completeness of reporting.

8.4 Distance sailed

Companies are required to monitor the distance sailed on voyages to and from EU ports. Distance sailed is the actual distance sailed in nautical miles from the time and place of departure to the time and place of arrival at the destination port and shall exclude anchoring. The date and hour of departure and arrival shall be considered using Greenwich Mean Time (GMT).

The distance travelled can be the distance of the most direct route between the port of departure and the port of arrival or the real distance travelled. In the event of the use of the distance of the most direct route between the port of departure and the port of arrival, conservative correction factor should be taken into account to ensure that the distance travelled is not significantly underestimated. The monitoring plan shall specify which distance calculation is used and, if necessary, the correction factor used. The distance travelled shall be expressed in nautical-miles.

The actual distance is the length of the track that the ship follows according to its course over ground. It is the actual path followed by the vessel from A to B relative to the seabed. It is to be obtained through regular positioning of the ship. The actual distance should not be determined as the shortest distance between the port of departure and the port of arrival.

8.5 Cargo

Companies are required to monitor the amount of cargo carried on each voyage. Cargo includes, but is not limited to: all gas, liquid and solid bulk cargo, general cargo, containerized cargo (including the return of empty units), break bulk, heavy lifts, frozen and chilled goods, timber and forest products, cargo carried on freight vehicles, cars and freight (MEPC.1/Circ.684).

For all ship classes except Passenger Vessels, cargo can be monitored in tonnes or standard cubic meters. As noted in Table 8, cargo in tonnes can be determined through a conversion from volume (tankers) or by assuming a representative mass for cargo (Ro-Ro) or passengers (General Cargo). While containerships may use a representative mass for loaded and empty containers, actual cargo tonnage should be used where possible. Specifically, the proposed EU MRV Regulation states:

- For passenger ships, the number of passengers shall be used to express cargo carried. For all other categories of ships, the amount of cargo carried shall be expressed either as metric tonnes or as standard cubic meters of cargo, as appropriate.

- For ro-ro ships, cargo carried shall be defined as the number of cargo units (trucks, cars, etc.) or lane-meters multiplied by default values for their weight.
• For container vessels, cargo carried shall be defined as the total weight in tons of the cargo or, failing that, the amount of TEUs multiplied by default values for their weight.

### Table 8. Cargo measures used by each ship type (based on 2009 Guidelines for voluntary use of ship energy efficiency operational indicator (EEOI) MEPC.1/Circ.684, and other IMO MEPC documents)

<table>
<thead>
<tr>
<th>Ship Class</th>
<th>Primary Cargo Measure</th>
<th>Derived Cargo Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto Carrier</td>
<td>cars or occupied lane metres</td>
<td>tonnes</td>
</tr>
<tr>
<td>Rail Carrier</td>
<td>rail cars or occupied lane metres</td>
<td>tonnes</td>
</tr>
<tr>
<td>LNG Tanker</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>LPG Tanker</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>Chemical Tanker</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>Crude Oil Tanker</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>Product Tanker</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>Tanker - Other Liquids</td>
<td>m³ or tonnes</td>
<td>tonnes</td>
</tr>
<tr>
<td>Bulk Dry</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>Bulk Dry / Oil</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>Self-Discharging Bulk Dry</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>Other Bulk Dry</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>General Cargo</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>Passenger / General Cargo</td>
<td>tonnes and passengers</td>
<td>tonnes*</td>
</tr>
<tr>
<td>Container</td>
<td>TEU</td>
<td>tonnes**</td>
</tr>
<tr>
<td>Refrigerated Cargo</td>
<td>tonnes</td>
<td>-</td>
</tr>
<tr>
<td>Ro-Ro Cargo</td>
<td>One or more of: number of railway cars, number of freight vehicles, lane metres or tonnes</td>
<td>tonnes***</td>
</tr>
<tr>
<td>Passenger / Ro-Ro Cargo</td>
<td>tonnes and passengers</td>
<td>tonnes</td>
</tr>
<tr>
<td>Passenger Ship</td>
<td>passengers</td>
<td>-</td>
</tr>
<tr>
<td>Other Dry Cargo</td>
<td>tonnes</td>
<td>-</td>
</tr>
</tbody>
</table>

* in the absence of data, a default mass per passenger can be estimated at 85 kg
** in the absence of data, mass of a loaded container can be estimated at 10 tonnes, and empty container at 2 tonnes
***a reasonable conversion scheme should be identified and used in this case to express cargo in tonnes

The IMO’s requirements (SOLAS Convention) for weighing containers are scheduled for 2016 and are expected to provide shipping companies a more accurate basis for monitoring and reporting actual cargo.

### 8.6 Time spent at sea

Time at sea should be reported in hours as the difference between the time of voyage start and voyage end. Any anchoring periods that may be used at a port should not be included.
8.7 Transport work

Transport work should be determined for each voyage as shown in equation 14.

\[
Transport \ work = m_{\text{cargo}} \cdot D
\]  

(14)

Where:

- \(m_{\text{cargo}}\) is the mass of cargo (or number of cars, passengers) as defined in accordance with section 8.5
- \(D\) is the distance sailed (nm) as defined in accordance with section 8.4

Depending on the type of vessel, transport work will be expressed in tonne-nm, car-nm or passenger-nm.

8.8 Energy consumption

Energy consumption is calculated by multiplying the total fuel consumption (for each fuel type) by the applicable energy conversion factor. These energy conversion factors are identified in section 8.5, Table 7.

8.9 Data collection

Table 9 provides a sample data collection form for a tanker that consumes two different types of fuel. Two separate voyages are indicated (for the reporting year), showing the necessary data fields required to be monitored to meet the annual reporting requirements. The bottom of the table shows the annual data that would be submitted for the vessel. For simplicity, all voyages are assumed to occur within the Member State’s jurisdiction (e.g., port arrival and port departure). In practice, the port of departure and port of arrival fields would have to be assessed to identify the emissions that would be reported for each of the required measures.
Table 9. Sample Voyage Data Collection Form

<table>
<thead>
<tr>
<th>Voyage #</th>
<th>Port</th>
<th>Departure</th>
<th>Port Arrival</th>
<th>Mode</th>
<th>Departure date/time</th>
<th>Arrival date/time</th>
<th>Elapsed time (h)</th>
<th>Type</th>
<th>Grade</th>
<th>Amount (t)</th>
<th>EF (t CO₂/Fuel)</th>
<th>Distance (nm)</th>
<th>Primary Cargo (m³)</th>
<th>Derived Cargo (t)</th>
<th>Total Fuel (TJ)</th>
<th>Total CO₂ (t)</th>
<th>Work (millions of tonne-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A</td>
<td>B</td>
<td>At-sea</td>
<td>04-14 11:30</td>
<td>04-16 15:20</td>
<td>53:50</td>
<td>HFO</td>
<td>RMD</td>
<td>300.0</td>
<td>3.151</td>
<td>713.0</td>
<td>55,560</td>
<td>50,000</td>
<td>14.634</td>
<td>1,073.5</td>
<td>35.65</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>A</td>
<td>B</td>
<td>In-port</td>
<td>04-16 15:20</td>
<td>04-17 23:40</td>
<td>32:20</td>
<td>Dies</td>
<td>DMC</td>
<td>23.0</td>
<td>3.206</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>1.014</td>
<td>73.7</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>D</td>
<td>At-sea</td>
<td>06-14 09:30</td>
<td>06-15 20:30</td>
<td>35:00</td>
<td>HFO</td>
<td>RMD</td>
<td>250.0</td>
<td>3.151</td>
<td>642.0</td>
<td>53,333</td>
<td>48,000</td>
<td>12.269</td>
<td>900.0</td>
<td>30.82</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>C</td>
<td>D</td>
<td>In-port</td>
<td>06-15 20:30</td>
<td>06-17 21:15</td>
<td>48:45</td>
<td>Dies</td>
<td>DMC</td>
<td>28.5</td>
<td>3.206</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>1.257</td>
<td>91.4</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

1. EF = emission factor, determined for each sample of fuel.

2. Primary cargo in this case is assumed to be measured in m³. An average density of 900 kg/m³ was assumed in each case for the derived cargo measure in tonnes. The total fuel measure (TJ) was calculated using the default conversion factors shown in Table 8.
### Voyage Identification

<table>
<thead>
<tr>
<th>Voyage #</th>
<th>Port Departure</th>
<th>Port Arrival</th>
<th>Mode</th>
<th>Departure</th>
<th>Arrival</th>
<th>Elapsed time</th>
<th>Type</th>
<th>Grade</th>
<th>Additional Voyage Data</th>
</tr>
</thead>
</table>

#### Annual Reported Values

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount (tonnes)</th>
<th>Type</th>
<th>CO₂ factor (t CO₂/t fuel)</th>
<th>Distance (km)</th>
<th>Primary cargo (m³)</th>
<th>Derived cargo (tonnes)</th>
<th>Total Fuel (TJ)</th>
<th>Total CO₂ (tonnes)</th>
<th>Work (millions of tonne-km)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Fuel and annual emission factor (tonnes)</td>
<td>550</td>
<td>RMD</td>
<td>3.151</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Fuel (tonnes) and annual emission factor</td>
<td>127</td>
<td>DMC</td>
<td>3.206</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual CO₂ (tonnes)</td>
<td>2,139</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual CO₂: voyages between ports in (a) Member State’s jurisdiction (tonnes)</td>
<td>2,139</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual CO₂: voyages departed from ports under a Member State’s jurisdiction</td>
<td>2,139</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual CO₂: voyages to ports under a Member State’s jurisdiction</td>
<td>2,139</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual CO₂: berth emissions within ports under a Member State’s jurisdiction</td>
<td>165</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual distance travelled (nm)</td>
<td>1,355</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total time at-sea (hours)</td>
<td>88:50</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total transport work (tonne-km)</td>
<td>66.47</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average energy efficiency – EEOI (gCO₂/tonne-nm)</td>
<td>32.17</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average energy efficiency - tCO₂/nm</td>
<td>1.58</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average energy efficiency - TJ/nm</td>
<td>0.0215</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average energy efficiency - TJ/million tonne-nm</td>
<td>0.40</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For simplicity, all voyages were assumed to occur within the Member State’s jurisdiction*
9 Verification approaches

This section describes appropriate verification approaches, supporting the implementation of the proposed EU MRV Regulation. It is divided into two main parts, the first outlining the assessment of the Monitoring Plan (MP) and the second defining the verification of the emission report. The latter part is again subdivided into general verification requirements and specific approaches for verifying fuel consumption and emissions information, and other relevant information in line with the monitoring requirements presented in Sections 7 and 8.

Both the methodology used for monitoring and the information reported by the company will be verified by independent accredited verifiers. First, verifiers will need to assess the appropriateness of the monitoring methodology chosen by the companies through reviewing and assessing the MP. This should typically take place before the start of the reporting period. The second step of the verification process is the verification of the reported emissions at the end of each reporting period.

The verifier shall identify potential risks related to the monitoring and reporting process by comparing reported fuel consumption, emissions data and other relevant information with estimated data based on ship tracking data and characteristics. The verifier shall also assess the reliability, credibility and accuracy of the monitoring systems and of the reported data.

The process of verification for installations and aircraft operators in the EU Emissions Trading Scheme is prescribed by the Accreditation and Verification Regulation (AVR). In contrast the maritime sector is new to MRV and maritime specific requirements for verification need to be developed, as necessary. The following paragraphs lay down the approaches for the elements subject to verification.

9.1 Assessment of the Monitoring Plan

The proposed EU MRV Regulation defines specific rules concerning the content and submission of the Monitoring Plan. Principally, the Monitoring Plan shall consist of a complete and transparent documentation of the monitoring methodology of a specific ship. It shall be the responsibility of the verifier to assess whether the MP of the company is in conformity with the requirements of the proposed EU MRV Regulation. Due to their role as independent assessors, verifiers will not be in the position to recommend which monitoring methodology to use. Before the actual monitoring takes place, a verifier needs to assess the conformity of the plan and request modifications to it if non-conformities are identified. The assessed MP will serve as a basis for the verification as the Annual Emission Report (AER) will be compared to it.

9.1.1 Detailed assessment approach

First, the verifier will need to check completeness of the MP, i.e. that each of the mandatory items is provided. In case a previous version of the plan exists, a consistency check between the latest and the current version needs to be done. In case deviations between the two versions are found, the reasons for these deviations need to be assessed.
Next, each mandatory element in the plan will be assessed in light of the requirements of the proposed EU MRV Regulation (Articles 6 and 7). Table 10 describes the recommended assessment approach for each element in the MP.

**Table 10. Elements of the Monitoring Plan and the approach for assessment**

<table>
<thead>
<tr>
<th>Elements of the Monitoring Plan</th>
<th>Assessment approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company name, address, telephone, fax and e-mail details for a contact person.</td>
<td>Check information on company website.</td>
</tr>
<tr>
<td>Ship type, name, IMO identification number, port of registry or home port and name of the ship owner.</td>
<td>Compare with public shipping registers, e.g. Ship IMO Numbers database (<a href="http://www.imonumber.com">www.imonumber.com</a>) or World Shipping register (<a href="http://www.world-ships.com">www.world-ships.com</a>).</td>
</tr>
<tr>
<td>Description of all emission sources and fuel types used on board of the ship.</td>
<td>Check whether all emission sources are mentioned, e.g. main engines, auxiliary engines, boilers, inert gas generators and incinerators. Check that all fuel types are being described.</td>
</tr>
<tr>
<td>Description of procedures, systems and responsibilities used to update the completeness of the list of emission sources over the monitoring year.</td>
<td>Check whether the described elements will lead to the required updates of the emission sources.</td>
</tr>
<tr>
<td>Description of the procedures used to monitor the completeness of the list of voyages</td>
<td>Check whether this procedure will ensure that the list of voyages will be complete.</td>
</tr>
<tr>
<td>Description of the procedures for monitoring fuel consumption of the ship, including:</td>
<td>(i) Check whether the chosen method(s) for calculating fuel consumption is in line with the method A to D as described in Appendix I of the proposed Regulation.</td>
</tr>
<tr>
<td>(i) the primary method A to D for calculating the fuel consumption of each emission source including a description of the measurement equipment used, as applicable;</td>
<td>(ii) Check plausibility of procedures for fuel uplift, whether the described measuring equipment will deliver the required parameter.</td>
</tr>
<tr>
<td>(ii) procedures for the measurement of fuel uplifts and fuel in tanks, a description of the measuring instruments involved and the procedures for recording, retrieving, transmitting and storing information regarding measurements, as applicable;</td>
<td>(iii) Check whether determination approach of fuel density and/or volume correction is the most accurate one and whether temperature is properly accounted for. If it is not, check whether reasons for using less accurate measures are justified.</td>
</tr>
<tr>
<td>(iii) the chosen method for the determination of fuel density and/or volume correction, where applicable;</td>
<td>(iv) Cross check consistency of procedure with requirement in the Regulation, and where referred to whether consistent with national law, customer contracts or fuel supplier accuracy standards.</td>
</tr>
<tr>
<td>(iv) a procedure to ensure that the total uncertainty of fuel measurements is consistent with the requirements of this Regulation, where possible referring to national laws, clauses in customer contracts or fuel supplier accuracy standards;</td>
<td></td>
</tr>
<tr>
<td>(v) a backup monitoring plan (if methods C and/or D are employed)</td>
<td></td>
</tr>
<tr>
<td>Elements of the Monitoring Plan</td>
<td>Assessment approach</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>List of single emission factors used for each fuel type or in the case of alternative fuels, the methodologies for determining the emission factors, including the methodology for sampling, methods of analysis, a description of the laboratories used</td>
<td>Check that an emission factor for each identified fuel type is listed. Check whether all information sources provided are complete and comprehensible. In case alternative fuels are used, check the methodology for determining the emission factors and whether the methodology for sampling, methods of analysis, and a description of the laboratories are provided. Check whether laboratories used have ISO 17025 accreditation, as required when using monitoring Method D.</td>
</tr>
<tr>
<td>Where applicable, description of how emissions from use of biofuel are determined and subtracted.</td>
<td>If applicable, check whether description is provided and what methodology is used to determine the emissions from biofuels.</td>
</tr>
<tr>
<td>Description of the procedures used for determining activity data per voyage, including: (i) the procedures, responsibilities and data sources for determining and recording the distance per voyage made; (ii) the procedures, responsibilities, formulae and data sources for determining and recording the cargo carried and the number of passengers as applicable; (iii) the procedures, responsibilities, formulae and data sources for determining and recording the time spent at sea between the port of departure and the port of arrival; (iv) the procedures used to justify a simplified approach (if used)</td>
<td>Check whether the described procedures under (i) to (iii) will lead to accurate activity data per voyage. Check whether all information sources provided are complete and comprehensible.</td>
</tr>
<tr>
<td>Description of the method to be used to determine surrogate data for closing data gaps</td>
<td>Check source of surrogate data and whether proposed method is appropriate to close data gaps.</td>
</tr>
<tr>
<td>Revision record sheet, recording the details of the revision history.</td>
<td>Check the version history log of the Monitoring Plan.</td>
</tr>
<tr>
<td>If applicable, information on the ice class of the ship, and/or the procedures, responsibilities, formulae and data sources for determining and recording the cargo carried and distance travelled and the time spent at sea when navigating through ice.</td>
<td>Check whether the described procedures responsibilities, formulae and data sources will lead to accurate activity data when navigating through ice. Check whether all information sources provided are complete and comprehensible.</td>
</tr>
<tr>
<td>Companies shall use standardised Monitoring Plans based on templates</td>
<td>Check whether the template used is in line with the technical requirements established in the implementing act (not required if the template provided by the Commission is used).</td>
</tr>
</tbody>
</table>

In practice, a MP could contain additional elements that are also advisable to assess, assuming that the required competences are available at the verifier.
9.1.2 Modifications of the Monitoring Plan and re-assessment

The proposed EU MRV Regulation requires that companies themselves make efforts in identifying improvements to their monitoring methodology and check regularly, and at least on an annual basis, whether it reflects the actual functioning of the ship. This requires that Monitoring Plans can be updated at any time and that updates are duly recorded.

Companies shall notify any proposals for modification of the Monitoring Plan to the verifiers without undue delay. Any significant modification of the Monitoring Plan shall be subject to a re-assessment by the verifier. Five main reasons have been identified for making modifications to the Monitoring Plan in line with the proposed EU MRV Regulation. While any modification to the Monitoring Plan will need to be communicated to the verifier, some require a re-assessment by the verifier to confirm that modifications are in line with the requirements. The cases in which modifications are required are listed in Table 11 below and the required re-assessment approaches are elaborated on.

<table>
<thead>
<tr>
<th>Modifications of the Monitoring Plan</th>
<th>Re-assessment approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of company</td>
<td>If only the company owning the ship changes, no immediate assessment by the verifier is required. This information will be verified in the context of the verification report of the next reporting period.</td>
</tr>
<tr>
<td>Occurrence of new emissions due to new emission sources or due to new fuels not yet contained in the approved Monitoring Plan</td>
<td>This type of modification requires an assessment by the verifier, which includes checks on the completeness of all emission sources and fuel types and whether the required descriptions are provided.</td>
</tr>
<tr>
<td>Changes in availability of data that may affect the accuracy in the determination of emissions, due to for example new measurement instruments types, sampling or analysis methods.</td>
<td>In its assessment the verifier should check how the changes affect accuracy of the emissions determination. In case these lead to less accuracy a revision will be required by the company.</td>
</tr>
<tr>
<td>Incorrect data being used in applied monitoring methodology</td>
<td>Assessment required, which includes a comparison of the previous Monitoring Plan and determining whether the new data provided are correct.</td>
</tr>
<tr>
<td>Changes requested by verifier since Monitoring Plan was not in compliance with the proposed EU MRV Regulation</td>
<td>Changes required by the verifiers will require another assessment of the relevant sections of the Monitoring Plan in order to ensure that the Monitoring Plan has been modified appropriately.</td>
</tr>
</tbody>
</table>

The Commission might want to revisit the requirements for assessment of modified MPs and to include in a delegated act the requirement to also assess modifications based on non-conformities identified by verifiers.

9.1.3 Assessment timeline

According to the proposed EU MRV Regulation, companies need to submit a monitoring plan by 31 August 2017 to verifiers for their assessment. The assessment will need to be finalised, including any potential revisions by the company due to identified nonconformities in the initial version, before 1 January 2018 in order to allow companies to start monitoring their emissions according to this assessed monitoring plan.
In order to ensure that verifiers are able to perform the required assessments in time, a delegated act to the proposed EU MRV Regulation, or related guidance document, could contain a recommendation to companies to contract their verifiers in due time, e.g. by 31 May 2017, or at least three months before the deadline to submit a monitoring plan to verifiers for ships falling under the scope of the regulation thereafter. Allowing three months between contract signing and start of the assessment of the monitoring plan should enable verifiers to appropriately prepare contracted assessments and allocate sufficient time and resources to each monitoring plan based on complexity of the monitoring methodology. Recommending this timeline will also help verifiers as they will be able to refer to the regulation when contacting potential clients.

However, such a delegated act should also take account of cases where deadlines will not be met, either on the side of the company and/or the verifier. There are at least four scenarios in which a verifier cannot finalise its assessment before 1 January 2018:

a. Company fails to contract verifier in time, e.g. not by 31 May 2017, which may not allow the verifier to complete the assessment of the monitoring plan before 1 January 2018.

b. Company fails to address nonconformities that the verifier identified during its assessment in time, which in turn means the verifier does not finalise its assessment before 1 January 2018.

c. Verifier underestimates the time required to assess monitoring plans, e.g. due to underestimating the complexity of the monitoring methodology or inadequate planning.

d. A ship falling under the scope of this Regulation only shortly before the reporting deadline might need to submit its MP for assessment at the same time the verification needs to start.

For these cases, a delegated act should stipulate that in case a monitoring plan has not been assessed by the deadline, companies should nevertheless apply the chosen monitoring methodology by 1 January 2018. If the monitoring plan is required to be amended due to findings by the verifier, then the emissions for the period over which the outdated monitoring plan was applied will need to be conservatively estimated by the contracted verifier based on the best available information and data for the respective reporting period. If the monitoring plan is found to be appropriate or only minor items (not affecting the emissions figure) need to be corrected, no estimation of emissions is required and the reporting and verification can proceed according to the assessed monitoring plan.

The delegated act should define verifiers’ pre-contractual obligations both in regards to the assessment task and to verification, e.g. undertaking a review of the information provided by the company to assess the complexity of the monitoring plan and to allocate time to the assessment accordingly. Also, it should enable verifiers to charge for extra time required in general (analogue to article 9.2 of the AVR) and for determination of the emissions figure specifically.

### 9.2 Verification process

The verification process has five major stages:

1. Pre-contractual phase
2. Pre-verification phase, after contract
3. Risk analysis
4. Verification process
5. Draft verification report, highlighting findings to the operator
6. Assessing materiality of any identified and unresolved misstatements and/or non-conformities
7. Final verification report for submission
First, the pre-contractual phase before the verifier and the client enter into a contractual agreement. During this stage, verifiers will need to assess whether they can perform the required verification service for the specific client. It entails a number of checks, which verifiers will commonly undertake in order to assure that they can act as an independent party and includes specifically checking for conflicts of interest, eligibility and impartiality. Furthermore, at this stage, verifiers will need to assess the amount of time they will need for the specific task, i.e. explore the complexity of the requested verification service. If the pre-contractual assessments resulted in the verifier finding that it can provide the relevant service, both verifier and client can enter a contractual agreement.

The second stage begins with the signing of a contract, and is the pre-verification phase with two primary tasks: strategic analysis and risk analysis. The strategic analysis shall cover all relevant activities of the operator and aims at enabling the verifier to understand the company’s activities. At this stage, the verifier will need to understand in much more depth than at the pre-contractual stage what the level of complexity and scope of the verification activity is. The outcome of the strategic analysis is the basis for the risk analysis.

“Risk” in context of verifications is the probability of misstatements and whether these misstatements (omissions, misrepresentations or errors) are likely to have a material effect on reported annual emissions. Determining what issues are material will typically depend on a number of aspects, such as whether the issue directly affects the quantity or characteristics of fuels, e.g. impurities or which source stream, such as main or auxiliary engine or boiler, is affected.

Verifiers should be required to carry out a risk analysis, by examining how high the risk of misstatements is (the risk being expressed in low, medium and high) for data flows provided in the MP and identifying potential reasons for misstatements. The outcome of this process will determine how the verification plan will be set up, which typically entails a verification programme, i.e. the verifiers plan on how he will go about the verification activities, including a plan to test procedures and sampling plan for data verification.

The actual verification stage, which is the third stage of the overall process, then starts with a process analysis in which the verifier first gathers all relevant information it needs to express a verification opinion with reasonable assurance. Once this information is available it will test the reported data and check that the monitoring methodology has been applied in accordance to the assessed monitoring plan. Testing the data contains consistency checks, i.e. cross checking that for one factor the same number is being used across all documents and calculations or that the information and calculation is consistent with other available information. Verifiers will need to validate through plausibility checks that data gathered through the monitoring systems are being correctly entered into the calculation of annual emissions. The verifier shall compile all documentary evidence and justification of all these checks and other activities carried out for the verification in the internal verification documentation.

Any outcomes from the process analysis will be reflected in a draft verification report. Non-conformities and misstatements detected will need to be communicated to the client in due time in order to allow for them to be corrected before finalisation of the verification process.
Companies will need to submit a revised annual emission report, which the verifier will use to assess whether the identified non-conformities and/or misstatements have been appropriately addressed by the company. If the verifier finds that they have not been appropriately resolved and, based on the verifiers risk assessment, that they individually or combined, lead to material misstatements, i.e. affect reported emissions beyond an acceptable level, the verifier shall issue a verification report stating that the emission report does not comply with the requirements of the proposed EU MRV Regulation. If the verifier finds with reasonable assurance that the revised annual emission reports is free from material misstatements it will issue a verification report stating that the annual emission report is satisfactory. See Section 9.7 for more details on the issued report.

The last stage is the finalisation of the verification report, which summarises the findings.

Assessments of the MP and verifications of annual emission reports can be undertaken by different verifiers. Similarly, companies can contract different verifiers for each verification period. In order to ensure that verifiers can make most efficient use of already available information companies will be responsible of providing the new verifier with all relevant information from the assessment of the MP, e.g. at least the assessed MP, and from previous verifications, e.g. at least the verification reports but possibly also non confidential communication between the company and the old verifier.

The delegated act should provide the following clarification and guidance in order to provide verifiers with sufficient understanding of the proposed EU MRV Regulation requirements and basis to form their verification opinion:

a) Detailed guidance on the risk assessment: providing more details on how this assessment should be done, how it can be used to determine the need of site visits (see Section 9.5) and clarifying that in case the verifiers changes a new risk assessment is required from the new verifier.

b) Elaboration on the concept of materiality using the existing guidance ‘AVR Explanatory Guidance (EGD I)’ and defining the acceptable level of materiality to be within the range of 2-5%.

c) Guidance on time allocation for each of the verification steps, outlining the various factors influencing and determining the amount of time required. This guidance note should be based on the existing AVR Key guidance note No. II.12 \(^{20}\) and address how the complexity of different vessel types and the location of relevant information and data (i.e. available in the company’s office or on-board the ship) influences the required time.

d) The necessity for verifiers to compile and maintain an internal verification documentation containing documentary evidence and justification of the checks performed and activities carried out for the verification.

The following two sections describe the verification approaches specific to the maritime sector that should be applied during the process analysis in step 4 above.

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9.3 Verification of fuel consumption and reported emissions

The following subsections outline the verifiers’ approaches to verify the reported emissions after each reporting period.

9.3.1 Overview of verification documents

This paragraph provides an overview of the documents related to fuel consumption and emissions that need to be sent to the verifier by the company. Table 12 describes the various documents that are subject to verification. An indicative timing is provided per document type.

<table>
<thead>
<tr>
<th>Document</th>
<th>Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring Plan</td>
<td>By 31 August 2017, or two months after falling into the scope of the proposed EU MRV Regulation</td>
</tr>
<tr>
<td>Modified Monitoring Plan</td>
<td>At any time modifications are required due to reasons listed in Table 11</td>
</tr>
<tr>
<td>Emission report</td>
<td>By 30 April each year from 2019 on</td>
</tr>
<tr>
<td>Copies of bunkering documents (Bunker Delivering Notes, BDN summaries) covering monitoring period</td>
<td>Together with the emission report, if relevant</td>
</tr>
<tr>
<td>Copies of relevant extracts of Oil Record book (e.g. scans of relevant extracts) covering monitoring period</td>
<td>Together with the emission report, if relevant</td>
</tr>
<tr>
<td>Per ship, a document detailing each voyage, with sailed distance, port calls and cargo transported, type and mass of fuel consumed for main engine, auxiliary engines, boilers and other consumption.</td>
<td>Together with the emission report</td>
</tr>
<tr>
<td>Copy of log books containing other relevant information covering monitoring period, e.g. distances travelled</td>
<td>Together with the emission report, as relevant</td>
</tr>
<tr>
<td>Fuel invoices</td>
<td>Upon request by the verifier</td>
</tr>
<tr>
<td>Copies of information received through Weather Routing Systems</td>
<td>Upon request by the verifier</td>
</tr>
</tbody>
</table>

The delegated act to the draft EU MRV regulation should clarify that verifiers can require shipping companies to provide additional documentation upon request, if deemed necessary by the verifier.

9.3.2 Verify Fuel Consumption

The approach for verifying the reported fuel consumption is subject to the monitoring method used by the company for a particular ship. For each monitoring method this paragraph lists the elements that need to be verified and how this could be done. Since fuel consumption is to be measured on a per voyage basis, the verification should also take place on a per voyage level. The tables have been based on information from CE Delft (2013) and Ecofys knowledge.
## Method A: Bunker Fuel Delivery Note (BDN) and periodic stock-takes of fuel tanks

<table>
<thead>
<tr>
<th>Elements to be verified</th>
<th>Procedure(s) on how to do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are all BDNs that a ship has received presented?</td>
<td>Cross-check the information on the BDNs with other data on fuel consumption registered on-board (e.g. in the oil record book or the engine log book)</td>
</tr>
<tr>
<td>Has a ship received BDNs for all its bunkering operations?</td>
<td>Apply plausibility checks using on-board data (e.g. data on distances covered and by applying an average emission factor) or by comparing the fuel consumption of the ship under consideration with the fuel consumption of comparable ships.</td>
</tr>
</tbody>
</table>
| Have fuel tank readings been carried out by appropriate methods such as automated systems, soundings and dip tapes? | • Cross check the methods used with what is documented in the Monitoring Plan.  
• Check whether tank tables exist for tanks subject to manual soundings  
• Check on-board whether all relevant tanks with monitoring devices have such devices in working order, with a history of maintenance. |
| If automated systems are used for fuel tank reading, have they been calibrated?         | • Check calibration certificates for each of the automated systems being installed on the respective ship that have been used for fuel tank reading. |
Method B: Fuel tank monitoring on board

<table>
<thead>
<tr>
<th>Elements to be verified</th>
<th>Procedure(s) on how to do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have fuel tank readings been carried out by appropriate methods such as automated systems, soundings and dip tapes?</td>
<td>• Cross check the methods used with what is documented in the Monitoring Plan.</td>
</tr>
<tr>
<td></td>
<td>• Check whether tank tables exist for tanks subject to manual soundings.</td>
</tr>
<tr>
<td></td>
<td>• Check on-board whether all relevant tanks with monitoring devices have such devices in working order, with a history of maintenance.</td>
</tr>
<tr>
<td>If automated systems are used for fuel tank reading, have they been calibrated?</td>
<td>• Check calibration certificates for each of the automated systems being installed on the respective ship that have been used for fuel tank readings.</td>
</tr>
<tr>
<td>Have all tanks been monitored sufficiently often?</td>
<td>• Cross-check tank monitoring with logs on-board (e.g. bunker delivery notes, oil record book or engine log book)</td>
</tr>
<tr>
<td></td>
<td>• Apply plausibility checks: either by again using on-board data (e.g. data on distances covered and by applying an average emission factor) or by comparing the fuel consumption of the ship under consideration with the fuel consumption of comparable ships.</td>
</tr>
<tr>
<td>Have all tanks been correctly monitored?</td>
<td>Check on-board whether the tank monitoring devices work correctly on each tank.</td>
</tr>
<tr>
<td>Has the data monitored been correctly documented?</td>
<td>Check the on-board documentation process, e.g. is it being automated or based on manual reading.</td>
</tr>
<tr>
<td>Has the documented data been correctly reported?</td>
<td>Cross-check reported data with documented data on-board.</td>
</tr>
</tbody>
</table>

---

21 This method assumes that only automated systems are being used, since the uncertainty of manual methods will not deliver the required level of uncertainty.
## Method C: Flow meters for applicable combustion processes

<table>
<thead>
<tr>
<th>Elements to be verified</th>
<th>Procedure(s) on how to do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have sufficient flow meters been installed on-board to capture the relevant fuel consumption?</td>
<td>Check whether flow meters are installed on all relevant flows.</td>
</tr>
<tr>
<td>Is a flow metering diagram included?</td>
<td>A diagram should be present to identify the relative location of each flow meter with respect to the emissions source.</td>
</tr>
<tr>
<td>Have the flow meters been continuously working?</td>
<td>Check whether the flow calculation unit has constantly received data from the flow meters.</td>
</tr>
<tr>
<td>Did the flow meters work properly while in operation?</td>
<td>Compare data stored in the flow calculation unit with the reported data.</td>
</tr>
<tr>
<td>Has the data monitored been correctly documented (i.e. the flow calculation unit has worked properly)?</td>
<td>Compare data stored in the flow calculation unit with the reported data.</td>
</tr>
<tr>
<td>Has the documented data been correctly reported?</td>
<td>• Cross-check reported data with other data on fuel consumption (e.g. bunker delivery notes, oil record book or engine log book).</td>
</tr>
<tr>
<td></td>
<td>• Apply plausibility checks: either by using on-board data (e.g. data on distances covered and applying an average emission factor) or comparing fuel consumption of the ship with fuel consumption of comparable ships.</td>
</tr>
<tr>
<td>Have the flow meters been appropriately calibrated?</td>
<td>• Check calibration certificates for each of the flow meters installed on the respective ship that have been used for combustion processes.</td>
</tr>
</tbody>
</table>
Method D: Direct emissions measurements

<table>
<thead>
<tr>
<th>Elements to be verified</th>
<th>Procedure(s) on how to do this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have sufficient direct emissions measurement devices been installed to measure all ( \text{CO}_2 ) emissions for the claimed sources?</td>
<td>Check whether the relevant exhaust gas stacks are equipped with direct emissions measurement devices.</td>
</tr>
<tr>
<td>Are relevant sources on board that are not subject to continuous emissions measurement appropriately addressed through application of method A, B or C?</td>
<td>Check elements to be verified against verification approaches for the other measurement methods.</td>
</tr>
<tr>
<td>Have all the direct emissions measurement devices been continuously working?</td>
<td>Check whether the emission calculation unit has constantly received data from the emissions measurement devices.</td>
</tr>
<tr>
<td>Did the direct emissions measurement devices work properly while in operation?</td>
<td>Check if emissions monitoring devices are regularly and correctly calibrated (calibration dates should be recorded) and have all required certificates.</td>
</tr>
<tr>
<td>Have the emissions monitored been correctly documented (i.e. the emission calculation unit has worked properly)?</td>
<td>Compare the data stored in the emission calculation unit with the documented data.</td>
</tr>
<tr>
<td>Have the documented emissions been correctly converted into the fuel consumption being reported?</td>
<td>Check if the applicable emission factors were used for the relevant fuels.</td>
</tr>
</tbody>
</table>
| Has the calculated fuel consumption been correctly reported?                             | • Cross-check the reported data with other data on fuel consumption on-board (e.g. bunker delivery notes, oil record book or engine log book).  
  • Apply plausibility check: either by again using on-board data (e.g. data on distances covered and by applying an average emission factor) or by comparing the fuel consumption of the ship under consideration with the fuel consumption of comparable ships. |

In case of a large number of voyages, the verifier may choose to verify based upon a sampling plan. The verifier must conduct a risk assessment to determine whether sampling is appropriate. The verifier will also need to ensure that the sample selected for verification is representative of the overall number of voyages.

A delegated act to the proposed EU MRV Regulation should outline the possibility of using sampling for verifying very large number of voyages and should be accompanied with guidance notes on both sampling and risk analysis analogue to the AVR “Key guidance note II.2 on risk analysis” and “Key guidance note II.4 on sampling”.

9.3.2.1 Verify fuel density and/or volume correction

The verifier shall check if the method used by the company to convert fuel measured in volumetric units corresponds to the method described in the Monitoring Plan of the company. The verifier shall also check if the company applied the applicable density value correctly in all cases. For determining the density value, in principle the best available data shall be used by the company. In this respect, using on-board measurement systems is considered most accurate and consistent, followed by fuel
sample tests and thereafter the density measured by the fuel supplier at fuel uplift, being recorded on the fuel invoice or BDN. If actual density values are not available, verifiers should confirm that the approach used to specify fuel density is reasonable and relates to defensible data.

9.3.2.2 Verify correction for temperature

In case density factors have been corrected for temperature, the verifier shall check the validity of the data source of the density-temperature correlation tables being used by the company. Moreover, the verifier shall check if the company is able to provide supporting evidence that the temperature is measured at the same time when a fuel measurement took place.

9.3.2.3 Verify averaging densities of different fuel samples

The verifier shall check whether the company applied an accurate determination of density for different fuel samples. The company shall provide a tank log for determination of density of fuel to the verifier, demonstrating that the appropriate calculation method has been applied each time fuel has been added to the tank(s).

9.3.2.4 Verify correction for impurities

For monitoring methods A and B only, the verifier shall check if the method used by the company to determine the correction factor for impurities is reasonable (e.g., if defaults used are appropriate). As a common sense check, the verifier may wish to check whether the values for water are within the expected maximum impurities content of fuels as specified in the ISO 8217: 2012 Standard. Other impurities, such as ash and metals, are expected to be too insignificant for these purposes.

9.3.2.5 Verify the fuel consumed at sea and in EU ports

The reported fuel consumed at sea and in EU ports shall be verified by cross-checking the date and time of the fuel measurement, e.g. upon arrival and departure, with the available data from log books.

**Fuel consumed at sea**
Reported fuel consumed at sea for a specific voyage shall be verified by comparing the date and time of the measurement upon departure in port A and arrival in port B, with the available data from log books.

**Fuel consumed in EU port**
Reported fuel consumed in a port shall be verified by comparing the date and time of the measurement upon arrival in port A and departure from port A, with the available data from log books.

9.3.2.6 Verify emission factors

The verifier shall check for each fuel reported for ship propulsion and operation whether the emission factor used by the company corresponds with the approved CO₂ emission factor for the respective fuel type. The default emission factors shall be based on the latest available IMO-supported values. Alternatively, a company may have used the actual emission factor that has been determined through sample analysis. In this case the verifier shall check the methodology for sampling and analysis, and if applicable the accreditation of the laboratory used.
In the case of alternative fuels for which no standard factor is available, the company may have used another valid CO₂ emission factor. In this case the verifier shall check if the emission factor is accompanied with the methodologies for determining the CO₂ emission factor, including the methodology for sampling, methods of analysis, and a description of the laboratories used (with confirmed ISO 17025 accreditation where relevant) are to be recorded.

9.3.2.7 Verify emission factors for Biofuels

Where biofuels are used, the verifier shall check if the calculation to determine the emission factor used by the company is correct. In the situation that a company rates emission factor of the biofuel(s) used as “zero”, the verifier shall check if they satisfy the sustainability criteria defined by the RES Directive. Purchase records may be requested for to obtain the required information.

9.3.2.8 Verify CO₂ emissions

For companies using fuel monitoring Methods A, B and C, the verifier shall check the calculation of CO₂ emissions for a particular voyage to and/or from an EU port, the time at sea within an ECA during a voyage to and/or from an EU port, or the time while in an EU port. As such the verifier checks the plausibility of the fuel consumed (cross checking with the distance covered) and whether the emission factor used corresponds with the approved CO₂ emission factor for the respective fuel type.

For companies using fuel monitoring Method D, the verifier checks if the CO₂ emissions from the relevant source streams have been added up correctly.

The verifier can perform the following overall plausibility checks to identify possible misstatements in the reported CO₂ emissions for a particular voyage:

- Compare performance (tCO₂/tonne-nm, or other) of different voyages and check for outliers;
- Use benchmark performance (tCO₂/tonne-nm, or other) and calculate what the expected CO₂ emissions would be and compare this with the actuals.

9.3.2.9 Verify annual aggregates of fuel and CO₂ emissions

The verifier needs to check whether the aggregation of data from different voyages has been done correctly, whether all relevant voyages have been taken into account. The verifier may also apply additional plausibility checks on the annual aggregates.

9.4 Verification approaches for other relevant information

9.4.1 Verification elements

Apart from fuel use and emissions, verifiers shall check the following elements on a per-voyage basis:

- Port of departure and port of arrival
- Date/time of departure and arrival
- Distance travelled
- Time spent at sea
- Cargo carried
- Transport work
In addition, for each ship and for each calendar year, the verifier shall check the following parameters:

- Total distance travelled
- Total time spent at sea
- Total transport work
- Average energy efficiency

The remaining paragraphs of this chapter describe procedure(s) on how to verify each of the elements above.

9.4.2 Verify port of departure and port of arrival

The verifier shall check whether the company reported all voyages between EU ports, from a non-EU port to an EU port, or from an EU port to a non-EU port. The verifier can check this by looking at the ship Deck Log and/or Voyage Abstracts. Next, the verifier shall check whether fuel consumption and CO$_2$ emissions have been reported for all these voyages.

9.4.3 Verify date and hour of departure and arrival

The date and hour of departure and arrival shall be reported by the company using Greenwich Mean Time (GMT). The verifier shall check the date and hour of departure and arrival by looking at the ship Deck Log and/or Voyage Abstracts, and compare this information with the information in the submitted emission report.

9.4.4 Verify distance sailed

The verifier shall check whether the method used corresponds with the method in the Monitoring Plan of the company.

Actual distance should be consistent with the sailing distance recorded in the ship Deck Log. The verifier can check if the reported real distance sailed between ports does deviate unreasonably from the distance of most direct route. In case unreasonable deviations are found, the verifier should request copies of information provided to the shipping company by Weather Routing Systems, to cross-check whether these explain the deviations. The verifier needs to check that distances are expressed in nautical-miles (nm).

In the event that the company reported the distance of the most direct route between the port of departure and the port of arrival, the verifier shall check if the company applied a conservative correction factor to ensure that the distance travelled is not significantly underestimated. The correction factor could be checked against the factor stated in the Monitoring Plan.

9.4.5 Verify cargo and its measures

In all cases the verifier will check the reported cargo against the log books. In the event that the company had to make an estimate of the cargo carried the verifier will check if the company followed “conservative” assumptions in order to avoid over-estimation of amounts of cargo carried. The verifier shall check whether the correct “primary” cargo measures were used for each ship type, and where applicable the correct “derived” cargo measures.
The IMO’s anticipated upcoming requirements for weighing containers will provide verifiers with higher certainty over the reported amount of actual cargo and is hence are expected to enable a better verification of this aspect in the future.

9.4.6 Verify time spent at sea

The verifier shall check if the reported time spent at sea is defined in hours, as being the difference between the time of voyage start and voyage end. The verifier shall cross-check the reported time with the available data from log books. Any anchoring time at or near a port should have been excluded from the reported time spent at sea. The verifier may ask for supporting evidence.

9.4.7 Verify transport work

Transport work shall be verified by checking if the correct parameters (distance travelled and amount of cargo carried) have been multiplied for the respective company and year.

This can possibly be done by cross checking with the transport work reported in the annual report of the shipping company.

9.4.8 Verify average energy efficiency

The verifier shall check at least each of the four underlying indicators that determine the average energy efficiency of a company:

- Fuel consumption per distance = total annual fuel consumption / total distance travelled
- Fuel consumption per transport work = total annual fuel consumption / total transport work
- \( \text{CO}_2 \) emissions per distance = total annual \( \text{CO}_2 \) emissions / total distance travelled
- \( \text{CO}_2 \) emissions per transport work = total annual \( \text{CO}_2 \) emissions / total transport work

In principle, the verifier makes a cross check of the unit values in the above formulas against the values reported separately as part of the annually reporting under the MRV system.

9.5 Site visits

As part of the verification process a verifier may find it necessary to conduct site visits. Such a site visit should include, at a minimum, the visiting of the shipping company’s office. It may also include visiting the respective ship. Site visits serve to confirm that an emissions report is free from any material misstatements.

An office audit with the shipping company should take place as a means to verify the reported fuel consumption and \( \text{CO}_2 \) emissions. It allows the verifier to study the information systems from the vessels and how it is received and processed at the office. In addition, spot checks on sample values from reported fuel consumption and \( \text{CO}_2 \) shall be carried out by the verifier.

The key activities to be undertaken during a site visit should be:\(^{22}\)

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\(^{22}\) The activities described here are based on similar activities outlined in the AVR Key guidance note No. II.5 on Site visits concerning installations [http://ec.europa.eu/clima/policies/ets/monitoring/docs/kgn_5_site_visits_en.pdf](http://ec.europa.eu/clima/policies/ets/monitoring/docs/kgn_5_site_visits_en.pdf)
• interviewing staff involved in the processes subject to monitoring;
• reviewing documents that are not required to be submitted with the emissions report, but are required to be retained by the company in the context of the proposed EU MRV Regulation;
• assessing companies’ procedures in practice;
• checking data flow and assessing the completeness of emission sources and fuel types;
• actual testing of the control activities and assessing the application of procedures mentioned in the assessed Monitoring Plan;
• obtaining physical evidence through assessment of measurement equipment, monitoring systems and processes.

In order to keep verification costs and efforts at a reasonable level the frequency of site visits should be kept at a minimum, especially on board ships, and be determined based on a risk assessment. A risk assessment needs to be done at the ship level. In the risk assessment the verifier should consider which methodology is chosen, for example in cases where on board monitoring equipment is being used, visits of the ship will be more important. If a verifier needs to go on board, a more detailed planning of the verification will be required to minimize unnecessary travel for the verifier. For some issues, scans, diagrams, photos or other information transmitted electronically, could be sufficient.

In its risk assessment undertaken at pre-verification stage, the verifiers should assess for each identified risk how it can detect these potential misstatements through its verification procedures and should determine how much of that risk can be reduced through undertaking an on-site visit. Since many of the records are captured and kept at the offices of companies the number of sources for misstatements or errors occurring on board of the ship should be limited to specific conditions on the ship, such as:
- meters placed at wrong location (or assumed to be at a wrong location);
- technology installed but not running;
- measuring equipment not properly calibrated;
- staff not following the monitoring procedures.

Assessing the quality of the data management system will typically help to determine whether on-board visits will bring additional value to assessing data in the office of the shipping company.

A site visit should however be mandatory for either the assessment of the MP or the verification of the first emissions report prepared by a company, and for a verification of an emission report prepared after the Monitoring Plan has been subject to significant modifications.

The outcome of the site visit of a first verification should provide a basis for assigning risks and impacts to the potential sources of errors and misstatements and should therefore facilitate determining the frequency of future site visits.

In case of low risk of misstatements with low impact on reported emissions, site visits up to every five years could be proposed.

In the delegated act, the EC should clarify how the risk assessment can be used to determine the need and frequency to do site visits, in particular the need to go on-board the ships.
9.6 Uncertainty assessment

In order to assess the quality of the reported data and the reliability of the measurements that generate the data, verifiers will need to assess the uncertainty around the different types of data. The uncertainty in this context is, given a specific level of assurance, the range within which the actual value of reported measurements is expected to lie.

Two concepts influence uncertainty of measured data. On the one hand, accuracy describes how close measured values are to the actual value. For example, if measurements of the same quantity are taken several times they can be considered accurate if they always deviate from the actual value by the same nominal value. On the other hand, precision tells how close results of measurements of the same quantity under the same conditions are to each other, i.e. the standard deviation of the average.

An uncertainty assessment should reveal to the verifier the interval, i.e. a measured average plus/minus the uncertainty, within which the true value is likely to be found.

9.6.1 Uncertainty around different fuel monitoring methods

Given the different natures of the four methods of monitoring fuel consumption (Methods A-D), different levels of uncertainty assessments might need to be considered for each method. For Method A, the basis for verification is data provided by the BDNs, rather than measurements. Therefore the requirement to do an uncertainty assessment could be omitted since BDNs, as legal documents, already provide the uncertainty related to the amount of fuel, which requires no verification by a third party.

Yet for Methods B, C and D uncertainty assessments will be critical. For example regarding Method B, it will be important for the verifier to check the accuracy of the fuel tank reading, which happens either manually or through automated systems on-board of the ship. Similarly for Method C, verifiers will need to check whether flow meters are calibrated appropriately and installed in the right positions in order to determine accuracy of the reported measurements. Since Method D is currently not being used and is also in the mid-term future not expected to be employed widely, experience needs to be gained around the accuracy and precision of direct emission measurements. Undertaking uncertainty assessments will therefore be crucial.

The EC should confirm in the delegated act the level of uncertainty allowed which will serve as a guide to the verifier on the level of detail they will need to go into. As described in Section 5, the estimated uncertainty associated with the four monitoring methods differs, which indicates that different levels of acceptable uncertainty might need to be considered. The defined level will also directly impact what will be allowed under the different methods. For example, if an acceptable uncertainty level of ±5% was chosen based upon the IMarEST study\textsuperscript{23} this would mean only automated systems would be allowed for Method B. Manual soundings would not qualify due to their higher uncertainty (see Table 3).

\textsuperscript{23} IMarEST, 2012.
9.6.2 Uncertainty around other relevant information

Similarly, the EC should clarify in the delegated act which other relevant information should be subject to an uncertainty assessment and what level of uncertainty to apply. While not having an impact on reported CO\textsubscript{2} emissions, data on distance travelled, cargo carried and transport work have a direct impact on measuring efficiency. It therefore needs to be clarified to what level of detail is required from verifiers in his/her uncertainty assessment of the other relevant elements to assure that information regarding efficiency is accurate, reliable and credible.

9.7 Verification report

While the verification typically takes place after the reporting period, after annual emissions reports have been prepared and before the reporting deadline of 30 April, many activities can take place in the interim, allowing for more efficient preparation of the verification report. For example, verifiers can start their pre-verification activities and gather and assess information that is not subject to changes during the reporting year, e.g. procedures on quality management and control.

Starting the verification process early will also allow companies more time to address any non-conformity, identified by verifiers. Any non-conformity found by the verifier will need to be communicated to the company allowing it to make appropriate amendments to the annual emissions reports or even the monitoring plan if necessary, which would then need to be reviewed again by the verifier. In the verification report, the verifier will summarize their findings, commenting on both those that have been addressed and those that remain unaddressed.

A verification report should typically include:

1. The following general information:
   a. Basic information on the company
   b. Information on the emissions from the relevant reporting year
   c. Confirmation of key relevant requirements being met by the annual emissions report
   d. Information on performed site visits
   e. Verification team
   f. Verification opinion, limited to three options:
      i. verified as satisfactory, confirming compliance with the Regulation’s requirements
      ii. verified as non-satisfactory, the report is not in conformity with the Regulation's requirements
      iii. not verified

2. Report on findings:
   a. Non-conformities, both with monitoring plan and with Regulation's requirements
   b. Misstatements, those that have been addressed during verifications and those that have not
   c. Recommendations
   d. Data gaps

3. Summary of the verifier’s basis of work, i.e. reflecting on the various regulations and standards that apply

4. Summarising any changes during the reporting year, incl. changes to the monitoring plan or activity data

In order to assure harmonised reporting of verification reports, a template should be provided and its use be made obligatory through a delegated act to the proposed EU MRV Regulation.
In case a verification report concludes with a satisfactory verification opinion, i.e. confirming companies’ compliance with the Regulation requirements for the relevant reporting period, a document of compliance shall be issued to the shipping company by the verifier. Such a document should include at least the following information:

a. Identity of the ship (same information as provided in the MP)

b. Name, address and principle place of business of owner of the ship

c. Identity of verifier

d. Date of issue of the document of compliance with clear reference to the relevant reporting period and validity in line with the Regulation

This compliance document must then be kept on-board and shown to port officers checking compliance when entering an EU port.

The Commission should consider developing a template for the document of compliance and guidance directed at port officials on checking the authenticity of the compliance documents. As time at port is a serious issue, especially for container ships and ferries, port officers will need a practical and efficient process.
10 Accreditation approach

10.1 Introduction

According to the proposed EU MRV Regulation verifiers should be independent and competent legal entities and should be accredited by national accreditation bodies (NAB) established pursuant to Regulation (EC) No 765/2008 of the European Parliament and of the Council setting out harmonised requirements for accreditation. Verifiers have to be accredited for the activity to be undertaken by the time they issue a verification report.

While the accreditation organisation and process is well defined in the harmonised standard EN ISO/IEC 17011 and in the Accreditation Regulation (AR)\(^2\) some sector specific requirements for the accreditation of verifiers are needed in order to facilitate the implementation of the proposed MRV system for CO\(_2\) emissions from maritime transport. Many of these requirements and processes can be based on the AVR and further explanation be developed along the lines of the AVR’s accompanying guidance documents.

In the following sections of this chapter the existing accreditation organisation and processes are described, highlighting where specific requirements would need to be defined through a dedicated delegated act on accreditation following the regulation on MRV for CO\(_2\) emissions from maritime transport.

10.2 Accreditation organisation

The AR establishes the legal framework for accreditation in Europe promoting a uniformly rigorous approach to accreditation across Member States, while ensuring a high degree of quality by defining the set of knowledge and competences that need to be demonstrated by NABs. Each Member State (MS) has to appoint one single NAB for verification of CO\(_2\) emissions from maritime transport. For cases where a MS finds it is not economically meaningful or sustainable to appoint their own NAB, or verifiers do not have access to a NAB in their MS that can provide an accreditation certificate for verification of CO\(_2\) emissions from maritime transport, the AR provides for cross-border accreditation so that MS and verifiers established in these MS can have recourse to a NAB of another MS. While only NABs in the EU are anticipated to be authorised to accredit verifiers, non-EU verifiers can obtain accreditation through the NAB of the MS where they have offices, for example.

Each NAB has to undergo a peer evaluation as a means to examine their compliance with the relevant regulations and standards. It is the European co-operation for accreditation (EA) that defines the rules and organises this peer evaluation. The EA is the body recognised under the AR to contribute to the development, maintenance and implementation of accreditation in the EU. Each NAB needs to be a member of the EA.

\(^2\)Regulation No. 765/2008 (EC)
10.3 Competence of NAB

In line with what the AVR is requiring for accreditation for the EU ETS, a delegated act following the EU MRV Regulation should provide defined requirements in regards to the competence of NABs. More specifically, in order to be competent to provide accreditation to verifiers for MRV of CO₂ emissions from maritime transport specifically, the NABs should meet the following two main sector specific requirements in addition to general provisions applying to the accreditation process of any verification service undertaken within the EU:

   e) have knowledge of the regulation on MRV of CO₂ emissions from maritime transport, relevant standards and other relevant legislation as well as applicable guidelines published by the Commission
   f) have knowledge of auditing the relevant data and information and the related verification activities referred to in Sections 9 and 9.4 above.

The knowledge required above is specific to the maritime sector or to MRV of emissions and therefore might require NABs to obtain additional training or access to external experts that have the knowledge and experience working with these data and information. Guidance should be provided along the lines of the AVR Key guidance note no. II.9 on specific competences of the different members of an assessment team.²⁵

The delegated act to the proposed EU MRV regulation needs to explicitly include the above listed requirements to ensure that NABs will take the necessary steps to build up the relevant expertise and require that these competences are part of the peer evaluation amongst NABs governed by the EA.

10.4 Competence of verifiers

The verifier applying for accreditation needs to prove the competence of its staff. Competence in this context means the ability to apply knowledge and skills to carry out the verification of the monitoring and reporting of data on CO₂ emissions from maritime transport. This implies that competence cannot be demonstrated simply through presenting qualifications and trainings of relevant staff but that competences rather need to be validated through actual processes.

The general requirements of each member of the verification team include that each individual understands her or his role within the team and the processes and has the relevant language skills for undertaking the relevant task.

In addition, the delegated act related to the proposed EU MRV Regulation will need to stipulate the different competencies for each role within the verification process. The roles that should be represented within the verification team are:

   - A lead auditor
   - Auditor(s)
   - Technical experts
   - Auditor undertaking site visits (particularly on-board visits)

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²⁵ Guidance Document "The AVR - Relation between the AVR and EN ISO/IEC 17011", AVR Key guidance note no. II.9, Version of 19 September 2012
²⁶ Niels-Christian Dalstrup, Convener EA CC EU ETS Network Group, European co-operation for Accreditation was consulted on these findings and recommendations through an email exchange on 10th April 2014.
A verification team can consist of one member if this person meets all relevant requirements. However, the delegated act should stipulate that, in any case, an independent reviewer needs to be assigned, who is not part of the verification team, as this enhances the quality of the verification process.

The delegated act will need to specify the requirements for each of these roles, specifically technical competence to perform verifications need to be defined along the lines of the verification procedures outlined in Sections 10 and 11. However, additional guidance should be provided by the Commission specifying what these sets of competences, specific to the maritime shipping sector entail. The AVR Key guidance note no. II.7 on verifiers’ competence\(^\text{27}\) provides a very good basis for this by giving example of the relevant technical understanding. The following examples for sector specific technical competence and understanding are based on the MP assessment approaches outlined in Table 10 and verification approaches described in sections 9.3 and 9.4 above, and could be listed in an additional guidance document:

- How to assess a BDN
- How to read operational logs, voyage abstract and port abstract, ship Deck Log
- Understanding the emissions sources and benchmark performance (tCO\(_2\)/tonne-nm)
- Requirements for using simplified approach
- Being able to verify how fuel’s carbon content has been determined
- Methods A to D to determine fuel consumption
- Emission factors for standard fuels, biomass and LNG BOG
- Bunkering systems, maintenance of metering equipment
- How to determine cargo
- How to determine the fuel density
- How the efficiency metric works
- Safety and security aspects when doing on-board visits

This list of competences should be reviewed once the final list of MP and verification requirements has been determined.

Verifiers will be obliged to establish a competence process based on these requirements and provide relevant documentation with its accreditation application. Additionally, the verifier is required to establish, document, implement and maintain a quality management system set up in such a way that it is capable of supporting and demonstrating consistent achievement of the requirements in the regulation on MRV of CO\(_2\) emissions from maritime transport and the related delegated act and EN ISO 14065.

During the assessment for accreditation and the reassessment, NABs will have the opportunity to evaluate both the competence process and management system and to check whether it is implemented effectively by comparing the competence process as reported by the verifier with what it is witnessing during on-site visits. Providing the suggested additional guidance on the competence requirements will support the NABs in assessing verifiers’ competence in a harmonised manner.

In addition to these occasions for examining verifiers’ competence, a regular surveillance, as well as extraordinary assessments will be necessary to assure that verifiers continuously follow the defined procedures and comply with the proposed EU MRV Regulation and the related delegated act. These measures are described in more detail in Section 10.6.

\(^{27}\) [http://ec.europa.eu/clima/policies/ets/monitoring/docs/kgn_7_competence_en.pdf](http://ec.europa.eu/clima/policies/ets/monitoring/docs/kgn_7_competence_en.pdf)
10.5 Accreditation process

The AR provides harmonised requirements, which the NABs need to apply when preparing an assessment of an applicant verifier, undertaking the assessment and when taking the decision over whether an accreditation certificate is being issued.

The AVR goes one step further and details the responsibilities of all relevant parties in the compliance cycle of the EU ETS and specifies competence requirements for each party to fulfil. Along these lines the requirements and processes of an accreditation system specific to the proposed EU MRV Regulation should be defined in a delegated act, which should follow the process of ISO 14065.

While there are four different monitoring methods, and many different vessel types to be verified, the accreditation should encompass all variations, and not be split into different technical scopes, as the technical competencies that verifiers have to show will be largely the same. Also, verifiers will have to have the same skills for assessing MPs and for verifying AERs, which calls for accrediting verifiers for both activities at the same time. The following section describes an appropriate accreditation process in more detail.

10.5.1 Accreditation application

Any legal entity that is able to demonstrate through the accreditation process that it is capable of and competent to undertake verification of CO₂ emissions data in the maritime sector (i.e. meeting the requirements outlined in Section 10.4) may apply for accreditation in line with minimum requirements of the AR, of the MRV regulation and of its related delegated act. It is suggested that the accreditation will be granted for the whole maritime sector, which shall be considered as one scope of accreditation. The request for accreditation should contain at least the following information, in addition to information required by the AVR:

- General features of the verifier, including corporate entity, name, address(es), legal status and human and technical resources;
- General information concerning the verifier, including its activities, its relationship(s) in a larger corporate entity if relevant, and addresses of all its physical locations to be covered by the accreditation;
- A written commitment to fulfil the requirements of the regulation on MRV of CO₂ emissions from maritime transport and the related delegated act, including EN ISO 14065 and other requirements, that the NAB imposes on verifiers²⁸.

Additional information can be requested by the NAB.

In the following step, the application is to be reviewed by the NAB on whether the applicant verifier should be assessed.

²⁸ http://ec.europa.eu/clima/policies/ets/monitoring/docs/exp_guidance_1_en.pdf
10.5.2 Assessment of the applicant verifier

If the application satisfies the above listed requirements, an assessment takes place, which the NAB has to prepare appropriately. When preparing, the NAB must consider the complexity of the processes and systems that will be assessed.

The assessment itself will include at least a review of the provided documentation, on-site visits to the applicant verifier, and witness activities for the applicant verifier to demonstrate the performance quality and competence of a representative share of its staff that will be involved in the verification activities in the maritime sector. The NAB will communicate its findings and point out identified non-conformities in its assessment report to the applicant entity, which will have the opportunity to respond and to make relevant corrections.

The NAB evaluates whether the identified non-conformities have been appropriately addressed through a review of the received responses and corrective actions taken, which might also involve a request for prove of implementation of the corrective actions. The NAB then decides whether it issues an accreditation certificate or not.

The validity of the accreditation certificate should be limited to a certain number of years to assure that verifiers undergo reassessment of their activities in regular intervals. This interval should be set in a way to, on the one hand, avoid a too heavy burden on the verifiers, while ensuring that scrutiny is put on verifiers’ continued quality maintenance. A validity of a maximum of five years, in line with the maximum validity of accreditation certificates for EU ETS scopes, should be an appropriate length.

A reassessment of an accredited verifier will become necessary before the expiry of the accreditation certificate. This process will involve the same steps as the initial accreditation assessment.

The delegated act related to the proposed EU MRV Regulation should outline in detail these steps and make reference to the harmonised requirements as provided by the AR.

The delegated act should be accompanied by a detailed guidance document, provided by the Commission, along the lines of the AVR Explanatory Guidance to facilitate better understanding of the verification requirements and their harmonised application.

10.6 Surveillance and extraordinary assessments

MS play a less significant role in the compliance cycle than within the EU ETS through their Competent Authorities (CA), who are reviewing (at least a share) of verification reports and annual emission reports, and are expected to undertake inspections of companies. These reviews are intended to detect any non-conformity on the side of the verifiers. These findings are communicated to the relevant NAB, i.e. the NAB that has accredited the verifier detected as being non-compliant, which is then responsible to follow-up on the issue and take appropriate actions.

With this layer of scrutiny missing, surveillance of verifiers and extraordinary assessments by the NAB play even more important roles. Yet, the AVR provides a good process for the surveillance.

29 http://ec.europa.eu/clima/policies/ets/monitoring/docs/exp_guidance_1_en.pdf
which should be reflected in the delegated act related to the proposed EU MRV Regulation. The NAB should be required to undertake annual surveillance of each verifier that it has accredited. The first surveillance after accreditation is to take place no later than after 12 months.

Surveillance should at least involve an on-site visit of the verifier and a witness activity of the performance and competence of a representative share of the relevant staff.

The outcome of the surveillance should determine whether the continuation of the accreditation can be confirmed or not. In case the outcome is that continuation of the accreditation should not be confirmed the NAB should start a process through which it can take measures such as suspending or withdrawing the accreditation.

In the context of cross-border accreditation a NAB in charge of the verifier can request another NAB to undertake surveillance of the verifier’s activity in another MS on its behalf, as outlined in the EA’s paper ‘EA Cross Frontier Policy for Cooperation between EA Members (EA -2/13)’.31

10.7 Settlement of disputes between companies and verifiers

Due to the absence of a designated national authorities overlooking the MRV compliance cycle for maritime transport, the delegated act should clearly state that the formal responsibility to settle disputes between a company and its verifier lies with the NAB that has accredited this verifier. However, a recommendation should be given that any dispute should first be attempted to be settled through other available means, such as internal procedures of verifiers. However, if these are considered to be insufficient, complaints by companies concerning the process a verifier followed should be submitted to the NAB that has accredited the verifier. The NAB is the most appropriate body to judge whether such a process-related complaint is justified or not, since it has in depth knowledge about the verifier’s internal procedures and standards. The NAB would review how the verifier has followed the relevant procedures, using information such as the internal verification documentation. If the verifier is found to be non-compliant, the NAB would request the verifier to address the issue and inform the shipping company of the outcome.

More specifically, the NAB should then first decide on the validity of the complaint. If it is found to be valid it should provide the verifier the opportunity to provide its view on the issue. Following an assessment of the issues, appropriate actions to be taken can entail to a) start an extraordinary assessment of the verifier (e.g. if the complaints are found to be justified), b) to refer the company to a court to settle the dispute (e.g. if the dispute is concerning contractual agreements) or c) to back the verifier’s position towards the company if it is found that the verifier has acted according to its responsibilities. Both the complaint and the actions taken should be recorded.

10.8 Exchange of information

The delegated act related to the proposed EU MRV Regulation will need to outline information exchange procedures in addition to the procedures prescribed in the AR. These should be aimed at effective communication between all bodies involved in the accreditation process enabling each body to fulfil its roles.

30 Regulation No. 600/2012 (EC), Articles 49 and 51
One set of communication exchanges should empower the EA to fulfil their role in overseeing the peer evaluation process.

Another provision should require the NABs to communicate regularly with each other and potentially the EC on new accreditations and measures taken to suspend or withdraw accreditation from verifiers found to be non-compliant. This information also needs to be made public in order to keep companies informed on the accreditation status of each verifier.

Cross-border accreditation also requires that NABs communicate with each other if surveillance activities should be undertaken by a NAB different to the NAB that has accredited the verifier subject to surveillance and to inform on the outcomes thereof.

Defining these exchange procedures will also enhance the transparency of the accreditation process and by this increase confidence in the system.
11 References

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12 Annex A: Survey questions

Request for input to support the implementation of the proposed EU MRV system for maritime shipping

Dear Sir/Madam,

The European Commission proposed a Regulation for the monitoring, reporting and verification (MRV) of CO₂ emissions and other relevant information of maritime shipping. Our consortium of Ecofys, Intesca-Inarsa and SFW has been assigned to provide technical support for the implementation of an EU MRV system for emissions from ships. Our work will result in:

- Detailed procedures for monitoring and reporting of CO₂ emissions as well as information related to energy efficiency.
- A set of clear rules that will enable accredited verifiers to effectively verify data reported by maritime parties.
- Criteria under the existing accreditation framework to ensure that only verifiers who can demonstrate a high degree of competence, independence and impartiality are eligible to act as verifiers.
- The design of the IT system for exchanging relevant data as well as the functional specifications of that system.

To make best use of existing industry standards and practices, we are reaching out to industry experts and request them for their input on these matters. The list of questions below serves to collect that input. We kindly ask you to provide your answers.

Thank you very much for your time and efforts. Please do not hesitate to contact us in case you have any questions or comments regarding our request.

Kind regards,

Paul Blinde (p.blinde@ecofys.com)
Bryan McEwen (Bryan.McEwen@snclavalin.com)

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For more information, please refer to: http://ec.europa.eu/clima/policies/transport/shipping/index_en.htm
Questions

1. In simple terms, what are the goals of the program?
Answer:...

2. Please identify who is responsible for reporting to the program (e.g., shipping company representative, charterer, etc.).
Answer:...

3. What fuels (marine diesel, LNG, etc.) are supported in the program?
Answer:...

4. What is the geographical scope of the reporting (e.g., all voyages, only voyages to or from Europe, etc.)?
Answer:...

5. What is the temporal scope of reporting (e.g., per voyage, per month, annual)?
Answer:...

6. What is the resolution of reporting (e.g., per ship, per commodity, per fleet)?
Answer:...

7. What fuel data is required to be reported?
   a. Please specify if any distinction is required for fuel consumed in main vs. auxiliary engines or boilers.
Answer:...

   b. Please identify the fuel measurement options that are permitted in the program (bunker notes, flow meter etc.).
Answer:...
8. What emissions data is required to be reported?
   a. Please specify all air contaminants included (e.g., CO₂, CH₄ etc.)

   Answer:....

   b. Please specify which emission factors (for CO₂, CH₄ etc.) are required to be used, if any (please identify the source of the factors)?

   Answer:....

9. What supporting data is required to be reported?
   a. Voyage data such as cargo, distance, weather conditions, etc.

   Answer:....

   b. Calculated metrics, such as efficiency, EEOI, etc.

   Answer:....

10. Are any national or international standards used in the program (for example, ship classification)? Please identify these if used.

   Answer:....

11. Does the program use any other established program or program element (for example IMO SEEMP)? Please explain

   Answer:....

12. Requirements for inclusion
   a. Is there a minimum requirement for vessels to be included to the program? Please explain if so.

   Answer:....

   b. Is there a minimum requirement for shipping companies to be included to the program? Please explain if so.

   Answer:....

13. What data is expected to be kept by members to support the reporting (e.g., for verification purposes)

   Answer:....
14. Please describe any formal verification procedures (including frequency of verification) if included in the program

Answer:....

15. In what format are data being reported (e.g., standardised electronic form?). Please attach the form if one is being used

Answer:....

16. What are/were the main challenges in developing/implementing your program? Please share any “lessons learned” if you are able.

Answer:....

17. Please provide any relevant information regarding your monitoring and reporting system that is not already being addressed above

Answer:....