SIGTTO

Society of International Gas Tanker & Terminal Operators Ltd

Measurement and Reporting of CO_2 Emissions from Gas Carriers

First Edition

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The Society of International Gas Tanker and Terminal Operators (SIGTTO) *is a non-profit making organisation dedicated to protect and promote the mutual interests of its members in matters related to the safe and reliable operation of gas tankers and terminals within a sound environment. The Society was founded in 1979 and was granted consultative status at the International Maritime Organization in November 1983.*

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Introduction and Scope

1. Introduction and Scope

1.1 Introduction

SIGTTO continues to actively encourage continuous improvement to reduce the environmental impact of liquefied gas shipping. This document is one of a series of documents specific to environmental protection matters that are aligned with, and support, the International Maritime Organization's (IMO's) environmental goals on the reduction of greenhouse gas (GHG) emissions.

This document provides high-level guidance to assist the gas shipping industry in its efforts to reduce carbon dioxide (CO_2) emissions and meet the targets set out in the initial IMO GHG Strategy,[1] including the implementation of its short-term measures for the reduction of GHG.

This document provides recommendations for the measurement and reporting of CO_2 emissions from gas carriers. It identifies sources of CO_2 emissions, measurement methodologies and regulatory requirements to support standardised measurement and reporting.

Reporting standards set by the IMO and the European Union (EU) are explained, including the IMO Data Collection System (DCS) and Carbon Intensity Indicator (CII), and EU Monitoring, Reporting and Verification (MRV).

[1] IMO – Resolution MEPC.304(72) – Initial IMO Strategy on Reduction of GHG Emissions from Ships

1.2 Scope

The guidance in this document covers CO_2 emissions from gas carriers and does not consider other GHGs. A gas carrier in this context is any ship built in accordance with the IGC Code.[2] Floating units, such as floating storage units (FSUs) and floating storage and regasification units (FSRUs), which retain their classification as gas carriers, are also considered in scope when operating as ships.

This document focuses on CO_2 emissions from hydrocarbon combustion as part of normal ship operations. This document is not applicable to monitoring of gas carrier CO_2 emissions when CO_2 is carried as a cargo.

The level of technical detail in this document assumes that the reader is familiar with the operation of liquefied gas carriers. Not all concepts are simplified or explained at an introductory level.

[2] IMO – International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

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Measurement of CO_2 Emissions

2. Measurement of CO_2 Emissions

This document focuses on CO_2 emitted from gas carriers during normal operations. Typical sources of CO_2 from gas carriers for propulsion, power generation and cargo operations include:

- Main engines
- auxiliary engines
- main boilers
- auxiliary boilers
- gas combustion unit (GCU)
- inert gas generator.

There are two main methods used by the industry for measuring CO_2 emissions on ships:

1. Measuring fuel consumption and calculating the CO_2 produced during combustion using a carbon emission factor[3] in the following formula:

   fuel consumption × *emission factor* = CO_2

2. Direct CO_2 emissions measurement.

Measurement of CO_2 emissions on board a ship can be considered an emerging technology, so this topic is not discussed in detail. This document focuses on measuring fuel consumption and calculating the CO_2 produced during combustion.

2.1 Fuel Consumption Measurement

The following methods for monitoring fuel consumption are generally used on liquefied gas carriers:

- Bunker delivery notes (BDNs)
- calculating from bunker fuel oil tank measurements
- flow meters to measure fuel consumption on board
- calculating fuel consumption from cargo tank measurement (when cargo is used as a fuel).

The choice of measurement method should be based on the type of ship and fuel used, considering the practicalities of application and accuracy. A combination of methods may be used and this section provides an overview of how they are carried out.

[3] As defined in IMO – Resolution MEPC.308(73) – 2018 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships

2.1.1 Using bunker delivery notes

This method uses BDNs to determine the total annual quantity of fuel used. BDNs are required by *The International Convention for the Prevention of Pollution from Ships* (MARPOL)[4] for fuel[5] delivered to and used on board a ship for combustion purposes. BDNs are required to be retained on board for three years after the fuel has been delivered.

In this method, annual fuel consumption is the total mass of fuel used by the ship during the year, as reflected in the BDNs, plus the amount of fuel left over from the last year, minus any fuel offloaded and minus the amount of fuel carried over to the next calendar year.

Fuel tank readings may use methods such as automated systems, soundings and dip tapes. The method used should be specified in the Data Collection Plan.[6] Tank readings should be taken at the ports of departure and arrival.

Any supplemental data used for reducing the difference in bunker quantity should be supported with documentary evidence.

2.1.2 Bunker fuel tank monitoring on board

This method uses daily fuel consumption data to determine annual fuel consumption. Tank readings are usually carried out daily when the ship is at sea and each time the ship is bunkering or de-bunkering. Appropriate tank measurement methods should be used, such as automated systems, soundings and dip tapes.

A summary of monitoring data, containing records of measured fuel consumption, should be available on board.

2.1.3 Using flow meters

In this method, flow meters measuring fuel flows are used to determine the annual total fuel consumption. They should be located so that daily fuel consumption data can be collected from all relevant fuel consuming processes on board.

Any consumer not monitored with a flow meter should be clearly identified and an alternative fuel consumption measurement method should be in place. Alternative methods, such as manual tank readings, should also be used if any flow meters break down.

The means of calibration of the flow meters should be specified, and calibration and maintenance records should be available on board.

2.1.4 Gauging the cargo at loading and discharge

Ships that are permitted to use part of their liquefied gas cargo as a fuel can determine the quantity used by comparing the difference between cargo levels at the start and the completion of the voyage.

Cargo calculations are carried out both before and after every cargo transfer operation, so accurate figures are readily available to determine the amount consumed as a fuel. If cargo is consumed as a fuel during cargo transfer operations, this may be calculated using certified flow meters.

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[4] The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, Ch III, Reg 18

[5] MARPOL refers to "Fuel Oil", defined in Annex VI, Ch 1, Reg 2.9 as "any fuel delivered to and intended for combustion purposes for propulsion or operation on board a ship, including gas, distillate and residual fuels."

[6] Part of the Ship Energy Efficiency Management Plan (SEEMP)

3

Reporting Standards for CO_2 Emissions

3 Reporting Standards for CO_2 Emissions

Reporting standards for CO_2 emissions from international shipping are set by the International Maritime Organization (IMO) and the European Union (EU). There are two types of energy efficiency calculation within the regulations:

1. Technical efficiency: a single design-based calculation of the potential efficiency of the ship.
2. Operational efficiency: the actual efficiency the ship achieves in service, calculated on an ongoing basis.

This document focuses on operational efficiency, but a summary of technical efficiency measures is included for completeness.

It is worth noting that the initial IMO energy efficiency regulations for the Energy Efficiency Design Index (EEDI) included *gas carriers*, which were defined as cargo ships constructed or adapted and used for the carriage in bulk of any liquefied gas, but excluded ships with "non-conventional propulsion", such as diesel-electric propulsion, turbine propulsion or hybrid propulsion systems.

An amendment to these regulations introduced requirements for LNG carriers with "conventional or non-conventional propulsion". It also introduced a new definition for *LNG carrier* and modified the definition of *gas carrier* in MARPOL:[7]

- *Gas carrier*: a cargo ship, other than an LNG carrier, constructed or adapted and used for the carriage in bulk of any liquefied gas
- *LNG carrier*: a cargo ship constructed or adapted and used for the carriage in bulk of liquefied natural gas.

The EU makes the same distinction between LNG carriers and gas carriers as the IMO.

3.1 IMO Standards

IMO regulations for energy efficiency are given in MARPOL Annex VI. They cover technical efficiency and operational efficiency.

3.1.1 Technical efficiency

Energy Efficiency Design Index (EEDI)

The EEDI is a measure of the technical efficiency of a ship, based on installed power, ship capacity and speed, expressed as gCO_2/tonne-mile.

When it was first introduced by Resolution MEPC.203(62),[8] it was applicable to most ship types delivered on or after 1 July 2015, including gas carriers, but it explicitly did not apply to ships with diesel-electric, turbine or hybrid propulsion. The regulations were amended by Resolution MEPC.251(66)[9] to include LNG carriers, including those with non-conventional propulsion, delivered on or after 1 September 2019.

[7] The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, Ch 1, Reg 2.2

[8] IMO – Resolution MEPC.203(62) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – (Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI)

[9] IMO – Resolution MEPC.251(66) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – Amendments to MARPOL Annex VI and the NOx Technical Code 2008

The EEDI requires new ships to have an improved technical efficiency over three phases, starting from a baseline set out in the regulations. The baseline was calculated using a simplified EEDI formula and data from existing ships.

Table 1 shows the current dates and CO_2 reduction factors for gas carriers and LNG carriers. These dates are periodically reviewed and the IMO is considering a Phase 4 to further improve the technical efficiency of ships.

	Phase 1: 1 Jan 2015 to 31 Dec 2019	Phase 2: 1 Jan 2020 to 31 Mar 2022	Phase 3: 1 Apr 2022 onwards
LNG carriers (10k DWT[10] and above)[11]	10%	20%	30%
Large gas carriers (15k DWT and above)			
	Phase 1: 1 Jan 2015 to 31 Dec 2019	**Phase 2: 1 Jan 2020 to 31 Dec 2024**	**Phase 3: 1 Jan 2025 onwards**
Gas carriers (10k DWT and above but less than 15k DWT)	10%	20%	30%
Gas carriers (2k DWT and above but less than 10k DWT)	0–10%[12]	0–20%[12]	0–30%[12]

Table 1: EEDI phase dates and CO_2 reduction factors

Energy Efficiency Existing Ship Index (EEXI)

The EEXI applies the EEDI to existing ships, with additional guidance to aid application. It applies to the same ships as the EEDI and uses the same baselines. The reduction factors are aligned with Phase 3 of the EEDI for LNG carriers and larger gas carriers (15k DWT and above) and Phase 2 for smaller gas carriers (less than 15k DWT).

Verification that a ship's attained EEXI is in accordance with the requirements should take place at the first annual, intermediate or renewal survey after 1 January 2023. Ships that do not meet the EEXI targets can improve efficiency through retrofits and upgrades in technology. They can also reduce emissions by limiting engine or shaft power.

3.1.2 Operational efficiency

IMO Data Collection System (DCS)

The IMO DCS provides a high-level summary of fuel consumption of ships, based on annual reporting since 2019. It was adopted and incorporated into MARPOL Annex VI in 2016[13] and the main requirements are laid out in Regulation 22A.

[10] Deadweight tonnage

[11] Phase 1 for LNG carriers began on 1 September 2015

[12] Reduction factor to be linearly interpolated between the two values, depending on ship size

[13] Through IMO – Resolution MEPC.278(70) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – Amendments to MARPOL Annex VI (Data collection system for fuel oil consumption of ships)

These reporting requirements are applicable to all gas carriers and LNG carriers of 5,000 gross tonnage (GT) and above.

The procedures to collect the data required by Regulation 22A should form Part II of a ship's Ship Energy Efficiency Management Plan (SEEMP).[14] The SEEMP must contain a description of the methodology that will be used to collect the data and the process used to report the data, which must be approved by the Flag State. The data collected should be reported each year as follows:

1. Ships submit the data within three months after the calendar year end to the relevant Flag State, or any organisation duly authorised by it, by 31 March at the latest.
2. A Statement of Compliance (SoC) is issued by the Flag State within two months of receiving the data, by 31 May at the latest.
3. The data will be submitted to the IMO by the Flag State within one month of issuing the SoC.

In general, for conventional fuels, ie distillate or residual, the bunker delivery note (BDN) method of data collection is recommended and readily verifiable. For ships that use liquefied gas cargo as a fuel, the method of gauging the cargo at loading and discharge is recommended. The gas cargo quantity used will need to be converted into a mass for reporting.

Table 2 gives a summary of the key parameters that should be reported. Further information and a standardised data reporting format can be found in the IMO SEEMP guidelines.[15]

Parameter	Measurement	Notes
Cargo	Deadweight tonnage (DWT)	Actual cargo transported is not recorded and ship DWT is used instead
Technical efficiency	EEDI, expressed as gCO_2/tonne-mile	Can be recorded as 'not applicable'. No estimated value is used
Ship type	'Gas Carrier' or 'LNG Carrier'	Reported as per definitions under MARPOL Annex VI, Ch 1, Reg 2.2
Fuel oil consumption	Fuel oil by type in metric tonnes. The carbon factors used are from the EEDI guidelines	Gas is included in the definition of *fuel oil* in this context. If non-standard fuels are used, the fuel oil supplier should provide a carbon factor for the respective product, supported by documentary evidence
Distance travelled	Over-ground in nautical miles	Distance should be recorded in the logbook in accordance with SOLAS[16] Regulation V/28.13. Distance travelled while the ship is underway under its own propulsion should be included in the aggregated data of distance travelled for the calendar year
Hours underway	Hours	This should be an aggregated duration while the ship is underway under its own propulsion

Table 2: Key parameters to be reported to the IMO DCS

[14] Guidelines on the development of the SEEMP can be found in IMO – Resolution MEPC.282(70) – 2016 Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP)

[15] A list of the data to be reported can be found in Annex IX of MARPOL Annex VI

[16] The International Convention for the Safety of Life at Sea

The IMO Carbon Intensity Indicator (CII)

The IMO CII was adopted and incorporated into MARPOL Annex VI in 2021 and is a mandatory requirement for all gas carriers and LNG carriers of 5,000 GT and above.

Building on the DCS, the CII requires continual improvement in the carbon intensity of a ship, as measured against a ship type benchmark. The required reductions in carbon intensity increase over time, aiming to at least meet the IMO GHG strategy reduction targets in 2030. The CII reductions are set relative to the 2019 reference line, as shown in Table 3.

Year	Reduction factor relative to 2019
2023	5%
2024	7%
2025	9%
2026	11%
2027–2030	Yet to be decided

Table 3: CII reduction factors

The CII is calculated on an annual basis by dividing the *carbon emitted* (annual fuel consumption multiplied by the carbon factor) by the *work done* (distance travelled multiplied by actual cargo carried (delivered) or, as a proxy, ship capacity). The carbon factor is taken from the DCS and it uses the same parameters as the DCS.

IMO Energy Efficiency Operational Indicator (EEOI)

These voluntary guidelines were introduced in 2009 and cover the CO_2 emitted per transport work metric, leaving the choice of period to the operator.[17] Although similar to the CII, the EEOI has the significant difference of only using actual cargo carried rather than permitting the use of a proxy (ie ship DWT). While not mandatory, the CII guidelines encourage the use of the EEOI for trial purposes.

The EEOI collects data on fuel consumed per voyage, distance travelled and actual cargo carried. It introduces the concept of rolling average data but does not specify the number of voyages or period to be used.

3.2 EU Monitoring, Reporting and Verification

3.2.1 Technical efficiency

EU Monitoring, Reporting and Verification (MRV)[18] requires the EEDI of a ship to be reported but does not have its own technical efficiency measure. If the EEDI is unavailable, an estimated index value (EIV) should be derived and reported using the same formula used to develop the EEDI baselines.

[17] IMO – MEPC.1/Circ 684 – Guidelines for Voluntary use of the Ship Energy Efficiency Operational Indicator (EEOI)

[18] Since leaving the EU, the UK has introduced The Merchant Shipping (Monitoring, Reporting and Verification of Carbon Dioxide Emissions) (Amendment) (EU Exit) Regulations 2018, which is aligned with the EU MRV scheme

3.2.2 Operational efficiency

The EU MRV regulations[19] require more detailed monitoring of CO_2 emissions than the IMO DCS and CII. They require reporting of actual CO_2 emissions, actual cargo transported, and time at sea and in port for every voyage and port call.

These regulations apply to all gas carriers of 5,000 GT and above calling at EU Member State ports. The EU MRV makes the same distinction between LNG carrier and gas carrier as MARPOL Annex VI.

An approved monitoring plan is required and the data collected is reported per calendar year, with data first reported in 2018. Data should be reported each year as follows:

1. The ship should submit a verified emissions report to the European Commission (EC) and relevant Flag State by 30 April of each year.
2. By 30 June, the ship should carry a valid Document of Compliance relating to the relevant reporting period.
3. Ship emissions reports are made publicly available, through the EU THETIS MRV platform, on 30 June each year.

The EU MRV regulations allow the use of any of the measurement methods covered in Chapter 2 of this document. In general, for conventional fuels (ie distillate or residual) the BDN method, with bunker tanker monitoring, is recommended and readily verifiable.

It is recommended that ships that use liquefied gas cargo as a fuel use the method of gauging the cargo at loading and discharge. The quantity used needs to be converted into a mass for reporting.

The following should be reported on a *per voyage basis*:

- Port of departure and port of arrival, including the date and hour of departure and arrival
- quantity (in metric tonnes) and emission factor (consistent with EEDI guidelines) of each type of fuel consumed
- quantity of CO_2 emitted
- actual distance travelled over-ground in nautical miles
- time spent at sea, in hours (excluding anchoring)
- quantity of cargo delivered, in mass for *gas carriers*, and volume for *LNG carriers*
- transport work, as gCO_2/tonne-mile or gCO_2/m^3-mile.

On an *annual basis*, the following should be reported:

- Quantity and emission factor of each type of fuel consumed in total
- total aggregated CO_2 emitted, within the scope of the EU MRV regulation
- aggregated CO_2 emissions from all voyages between ports under a Member State's jurisdiction
- aggregated CO_2 emissions from all voyages that departed from ports under a Member State's jurisdiction
- aggregated CO_2 emissions from all voyages that arrived at ports under a Member State's jurisdiction
- CO_2 emissions that occurred within ports under a Member State's jurisdiction at berth

[19] Regulation (EU) 2015/757 of the European Parliament and of the Council on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC

- total distance travelled
- total time spent at sea
- total transport work
- average energy efficiency.

When reporting the ship particulars, the EEDI is required. If the EEDI is unavailable, an estimated index value (EIV) should be derived and reported using the same formula used to develop the EEDI baselines.

Annexes

Annex 1 – Glossary of Terms and Abbreviations

BDN Bunker Delivery Note

CII Carbon Intensity Indicator

CO_2 Carbon Dioxide

DCS Data Collection System

DWT Deadweight Tonnage

EC European Commission

EEDI Energy Efficiency Design Index

EEOI Energy Efficiency Operational Indicator

EEXI Energy Efficiency Existing Ship Index

EIV Estimated Index Value

EU European Union

FSRU Floating Storage and Regasification Unit

FSU Floating Storage Unit

Gas Carrier (as defined in MARPOL Annex VI) A cargo ship, other than an LNG carrier, constructed or adapted and used for the carriage in bulk of any liquefied gas

GCU Gas Combustion Unit

GHG Greenhouse Gas

GT Gross Tonnage

IMO International Maritime Organization

LNG Carrier (as defined in MARPOL Annex VI) A cargo ship constructed or adapted and used for the carriage in bulk of liquefied natural gas

MARPOL The International Convention for the Prevention of Pollution from Ships

MRV Monitoring, Reporting and Verification

SEEMP Ship Energy Efficiency Management Plan

SoC Statement of Compliance

Annex 2 – Reference List

- IMO – Resolution MEPC.304(72) – Initial IMO Strategy on Reduction of GHG Emissions from Ships
- IMO – International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
- IMO – Resolution MEPC.308(73) – 2018 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships
- The International Convention for the Prevention of Pollution from Ships (MARPOL)
- IMO – Resolution MEPC.203(62) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – (Inclusion of regulations on energy efficiency for ships in MARPOL Annex VI)
- IMO – Resolution MEPC.251(66) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – Amendments to MARPOL Annex VI and the NOx Technical Code 2008
- IMO – Resolution MEPC.278(70) – Amendments to the Annex of the Protocol of 1997 to Amend the International Convention for the Prevention of Pollution from Ships, 1973, as Modified by the Protocol of 1978 Relating Thereto – Amendments to MARPOL Annex VI (Data collection system for fuel oil consumption of ships)
- IMO – Resolution MEPC.282(70) – 2016 Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP)
- The International Convention for the Safety of Life at Sea (SOLAS)
- IMO – MEPC.1/Circ 684 – Guidelines for Voluntary use of the Ship Energy Efficiency Operational Indicator (EEOI)
- UK – The Merchant Shipping (Monitoring, Reporting and Verification of Carbon Dioxide Emissions) (Amendment) (EU Exit) Regulations 2018
- Regulation (EU) 2015/757 of the European Parliament and of the Council on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC

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