



VCS Methodology

VM0053

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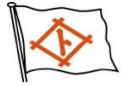
# ALTERNATIVE LOW-CARBON FUELS FOR SHIPPING

Version 1.0

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Sectoral Scope 7: Transport

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# 1 SUMMARY DESCRIPTION

<b>Project Category</b>	Transport
<b>Project Activity Type</b>	Transport fuel efficiency (e.g., fuel switch)
<b>Additionality</b>	Activity method
<b>Crediting Baseline</b>	Performance method
<b>Mitigation Outcome</b>	Reductions

This methodology applies to project activities that involve use of the following alternative low-carbon fuels in ships in place of traditional fossil fuels:

- 1) Green or e-hydrogen
- 2) Green or e-ammonia
- 3) Electrofuels (e-fuels) including e-liquefied natural gas (e-LNG), e-liquefied petroleum gas (e-LPG), e-diesel, and e-methanol

Greenhouse gas (GHG) emission reductions (reductions) are calculated based on the difference between emissions from baseline fossil fuel use and those from the use of alternative low-carbon fuel used in the ship (i.e., project fuels).

# 2 SOURCES

This methodology uses the following module, tools, and other sources:

- *VMD0059 CO<sub>2</sub> Capture from Bioenergy*
- *VT0009 Combined Baseline and Additionality Assessment*
- *VT0011 Electricity System Emission Factors*
- *CDM TOOL15 Upstream Leakage Emissions Associated with Fossil Fuel Use, v02.0*
- International Maritime Organization *Guidelines on Life Cycle GHG Intensity of Marine Fuels*<sup>1</sup>
- Argonne National Laboratory Research & Development GREET Marine Model<sup>2</sup>

<sup>1</sup> 2024 version available at: <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2081/Annex%2010.pdf>

<sup>2</sup> Available at: <https://www.energy.gov/cmei/rd-greet-life-cycle-assessment-model>

## 3 DEFINITIONS

In addition to the definitions set out in the *VCS Program Definitions*, the following definitions apply to this methodology.

### **Alternative low-carbon fuel**

Energy carrier derived from non-fossil sources or from processes that result in significantly lower carbon dioxide emissions per unit of energy output compared to conventional fossil fuels. In the context of this methodology, alternative low-carbon fuels are green and e-hydrogen, green and e-ammonia, and electrofuels.

### **Ammonia<sup>3</sup>**

A colorless, pungent gas composed of nitrogen and hydrogen with the chemical formula  $\text{NH}_3$ . Includes e-ammonia and green ammonia.

### **Diesel fuel<sup>4</sup>**

Combustible liquid used as fuel in diesel engines. Includes heavy fuel oil (HFO), light fuel oil (LFO), marine diesel oil (MDO), marine gas oil (MGO), diesel, and e-diesel. E-diesel is directly mixable with diesel fuels and can be used in diesel engines.

### **Direct air capture**

A process to capture and concentrate carbon dioxide from the atmosphere using various separation methods

### **E-ammonia**

An energy carrier produced with e-hydrogen and nitrogen, resulting in a fuel with an emission factor significantly lower than the global average for produced ammonia

### **E-hydrogen**

An energy carrier produced by electrolysis of water using electricity from the grid or renewable sources, resulting in a fuel with emissions significantly lower than the global average for produced hydrogen

### **Electrofuel (e-fuel)**

A type of alternative low-carbon fuel made by storing renewable electrical energy in the chemical bonds of liquid or gas hydrocarbon fuels. The hydrocarbon is typically produced with green or e-hydrogen and carbon dioxide from direct air capture or biomass feedstocks. E-liquefied natural gas (e-LNG), e-liquefied petroleum gas (e-LPG), e-methanol, and e-diesel are types of e-fuels.

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<sup>3</sup> Adapted from Britannica (2024). "Ammonia." <https://www.britannica.com/science/ammonia>

<sup>4</sup> Adapted from Britannica (2024). "Diesel Fuel." <https://www.britannica.com/technology/diesel-fuel>

**Emissions intensity factor**

The cumulative carbon dioxide emissions associated with the well-to-wake life cycle of a fuel relative to the unit of output (e.g., tonnes of CO<sub>2</sub> emissions per tonne of hydrogen, ammonia, or e-fuel produced)

**Gate-to-tank emissions**

Transport emissions from transporting alternative low-carbon fuel to the usage point

**Green ammonia**

Zero-carbon, renewable energy carrier produced from green hydrogen and nitrogen, produced by liquefaction of air using renewable energy with zero emissions

**Green hydrogen**

Zero-carbon, renewable energy carrier produced by electrolysis of water powered by renewable energy with zero emissions

**Gross tonnage (GT)<sup>5</sup>**

A measure of a ship's overall internal volume, determined by dividing by 100 the contents, in cubic feet, of the vessel's enclosed spaces. Applies to the vessel, not the cargo.

**Hydrogen<sup>6</sup>**

A colorless, odorless, tasteless, flammable gaseous substance with the chemical formula H<sub>2</sub>. Includes green hydrogen and e-hydrogen.

**Liquefied natural gas (LNG)<sup>7</sup>**

Any combustible hydrocarbon or mixture of hydrocarbons consisting primarily of methane (CH<sub>4</sub>) and including other combustible and non-combustible gases in a gaseous state, which is in a liquid state at or near atmospheric pressure at sea level. Includes e-LNG, which is directly mixable with fossil LNG.

**Liquefied petroleum gas (LPG)<sup>8</sup>**

Any of the several liquid mixtures of volatile hydrocarbons like propene, propane, butene, and butane. Includes e-LPG which is directly mixable with fossil LPG.

**Methanol<sup>9</sup>**

An organic chemical compound with the chemical formula CH<sub>3</sub>OH, used as fuel in engines. Includes e-methanol.

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<sup>5</sup> Adapted from IMO (n.d.). "International Convention on Tonnage Measurement of Ships." Available at: <https://www.imo.org/en/about/conventions/pages/international-convention-on-tonnage-measurement-of-ships.aspx>

<sup>6</sup> Adapted from Britannica (2024). "Hydrogen." Available at: <https://www.britannica.com/science/hydrogen>

<sup>7</sup> Adapted from LexisNexis (2024). "LNG Definition." Available at: <https://www.lexisnexis.co.uk/legal/glossary/lng>

<sup>8</sup> Adapted from Britannica (2024). "Liquefied Petroleum Gas." Available at: <https://www.britannica.com/science/liquefied-petroleum-gas>

<sup>9</sup> Adapted from Britannica (2024). "Methanol." Available at: <https://www.britannica.com/science/methanol>

**Tank-to-wake (TTW) emissions**

Total greenhouse gas emissions generated during combustion or use of fuels in vessels from the point of fueling until the fuel is completely consumed. The fuels eligible for use in this methodology do not produce tank-to-wake emissions.

**Well-to-gate emissions**

Emissions from sources related to:

- fuel production, including emissions related to direct air capture, compression, storage, and transport of nitrogen relevant for ammonia
- emissions related to the capture, processing, and transport of biogenic CO<sub>2</sub>, and
- emissions related to direct air capture of CO<sub>2</sub>, where applicable

**Well-to-tank (WTT) emissions**

Total greenhouse gas emissions generated during the extraction, production, processing, transportation, and distribution of fuels and feedstocks up to the point of fueling a vessel

**Well-to-wake (WTW) emissions**

Encompasses all the stages of the fuel life cycle from well-to-gate (i.e., production emissions), gate-to-tank (i.e., transportation emissions), and tank-to-wake (i.e. combustion emissions) and serves as the system boundary for the determination of the emissions intensity of a fuel product.

## 4 APPLICABILITY CONDITIONS

This methodology applies to project activities that involve the use of alternative low-carbon fuels in ships to replace conventional fossil fuels. The fuels replaced may be used for propulsion and/or for other purposes such as on-board power generation. It is globally applicable.

This methodology is applicable under the following conditions:

- 1) The ships involved in the project activities:
  - a) are new or existing and operational including those with modifications to the engine and fuel storage systems necessary to use e-fuels, irrespective of their gross tonnage.
  - b) have mono or multi-fuel engines.
  - c) operate in territorial or high seas in alignment with relevant regulations.

- 2) The engine specific fuel consumption in the baseline ( $SFC_{BL}$ ) and engine specific fuel consumption in project activities ( $SFC_P$ ) are certified according to IMO MARPOL Annex VI Chapter 4.<sup>10</sup>
- 3) The project activity involves use of the following alternative low-carbon fuels as a replacement for the baseline fuel for propulsion and/or onboard power generation:
  - a) Green or e-hydrogen
  - b) Green or e-ammonia
  - c) E-LNG, e-LPG, e-diesel, or e-methanol produced with green or e-hydrogen and captured CO<sub>2</sub> sourced from ambient air or from biomass feedstocks that meet the sustainable sourcing requirements in Appendix 1 in VMD0059 CO<sub>2</sub> Capture from Bioenergy or the VCS tool that supersedes VMD0059.<sup>11</sup>

## 5 PROJECT IMPLEMENTATION

### 5.1 Project Start Date

The project start date must be established in accordance with the applicable versions of the *VCS Standard* and *VCS Program Definitions*.

When determining the project start date, the following types of actions must be considered, as applicable:

- 1) Signing contracts to purchase new ships included in the project that use eligible fuel types
- 2) Signing contracts to purchase equipment or signing service contracts to modify the ships included in the project to enable the use of eligible fuel types
- 3) Signing fuel offtake agreements or otherwise sourcing eligible fuels for use in ships included in the project

### 5.2 Initial Crediting Period Start Date

The initial crediting period start date must be established in accordance with the applicable versions of the *VCS Standard* and *VCS Program Definitions*.

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<sup>10</sup> International Maritime Organization (IMO). 2024. *MARPOL Annex VI: Regulations for the Prevention of Air Pollution from Ships (consolidated version)*. Available at: [https://www.riigiteataja.ee/aktiivisa/2190/3202/4008/MARPOL\\_Annex\\_VI.pdf](https://www.riigiteataja.ee/aktiivisa/2190/3202/4008/MARPOL_Annex_VI.pdf)

<sup>11</sup> Currently in development at time of publication of this methodology

### 5.3 Crediting Period Renewal

Project proponents must renew the project crediting period in accordance with the VCS Program rules.

### 5.4 Methodology Transition

Projects that transition from other methodologies to *VM0053* must apply this methodology in full and follow the VCS Program rules.

## 6 PROJECT BOUNDARY

The spatial extent of the project boundary encompasses the ships using alternative low-carbon fuels in the project. The emissions intensity factors of the fuels consumed in the baseline and project scenario cover the full fuel life cycle.

All emissions associated with the fuels consumed in the baseline and project are considered emitted to the atmosphere at the time of combustion but are included as baseline emission sources, project emission sources, and leakage emission sources in Table 1 for clarity and completeness.

**Table 1. GHG sources and sinks accounted for as baseline, project, and leakage emissions**

Source/Sink	Type	Gas	Included?	Justification/Explanation	
Baseline	Well-to-wake emissions from fuel use	Source	CO <sub>2</sub>	Yes	Main emission source
			CH <sub>4</sub>	Yes	Emission source
			N <sub>2</sub> O	No	De minimis
			Other	No	De minimis
Project	Use of fuels in project	Source	CO <sub>2</sub>	Yes	Main emission source
			CH <sub>4</sub>	Yes	Emission source
			N <sub>2</sub> O	No	De minimis
			Other	No	De minimis
Leakage	Production of fuels used in project	Source	CO <sub>2</sub>	Yes	Main emission source
			CH <sub>4</sub>	Yes	Emission source
			N <sub>2</sub> O	No	De minimis
			Other	No	De minimis
		Source	CO <sub>2</sub>	Yes	Main emission source

Transportation of fuels used in project		CH <sub>4</sub>	Yes	Emission source
		N <sub>2</sub> O	No	De minimis
		Other	No	De minimis
Storage of fuels used in project	Source	CO <sub>2</sub>	Yes	Main emission source
		CH <sub>4</sub>	Yes	Emission source
		N <sub>2</sub> O	No	De minimis
		Other	No	De minimis
Production of components and equipment used to modify or retrofit engine and/or on-board storage systems to use e-fuels	Source	CO <sub>2</sub>	No	De minimis (see Appendix 1 for justification)
		CH <sub>4</sub>	No	Magnitude of leakage emissions is marginal in relation to GHG emission reductions realized through project activities and thus leakage emissions are excluded.
		N <sub>2</sub> O	No	
		Other	No	

## 7 BASELINE SCENARIO

Project proponents must determine the activities and GHG emissions that would have occurred in the absence of the project activity.

### 7.1 Step 1: Identify Alternative Scenarios

Project proponents must assess the following alternative scenarios:

**Baseline scenario B1:** Conventional fossil fuels are used in ships relevant to the project as follows:

- 1) For ships that used LNG prior to implementation of the project activity, LNG
- 2) For all other ship categories, one or a mix of diesel fuels is used (i.e., heavy fuel oil, HFO; light fuel oil, LFO; marine diesel oil, MDO; marine gas oil, MGO), where the specific type or blend does not need to be determined because the most conservative (i.e., lowest) emission factor for diesel is used in quantification.

**Baseline scenario B2:** Biofuels are used in ships relevant to the project as either the component of a fuel blend with fossil fuels or as drop-in replacements.

**Baseline scenario B3:** The proposed project activity occurs without being registered with a GHG program.

## 7.2 Step 2: Check Consistency with Mandatory Applicable Laws and Regulations

Project proponents must use Step 1b of VCS tool *VT0009 Combined Baseline and Additionality Assessment* to identify the alternative scenarios from Section 7.1 that comply with all mandatory applicable legal and regulatory requirements regarding the operation of ships in territorial or high seas. All relevant policies and regulations related to the project activity must be assessed, including those with objectives other than GHG emission reductions and/or carbon dioxide removals (e.g., for air pollution control).

## 7.3 Step 3: Investment Comparison Analysis

Project proponents must use Option 1 in Step 3 of *VT0009* to compare the financial attractiveness of all the alternative scenarios remaining and eliminate all but the least financially attractive scenario.

## 7.4 Step 4: Establish the Baseline Scenario

If B2 or B3 is the only remaining scenario, the project is not eligible under this methodology.

If B1 is the only remaining scenario, B1 is the baseline scenario and is used in Section 8 to assess additionality.

# 8 ADDITIONALITY

This methodology uses an activity method to demonstrate additionality.

### **Step 1: Regulatory Surplus**

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the applicable version of the *VCS Standard*.

Where the project proponent demonstrates regulatory surplus, proceed to Step 2. Otherwise, the project activity is not additional.

### **Step 2: Positive List**

The applicability conditions (Section 4) of this methodology represent the positive list. Project proponents must demonstrate that the project meets all applicability conditions, and in so doing, it is deemed additional.

The positive list was established using the activity penetration method (Option A in the VCS *Methodology Requirements*). The procedure for determining the positive list is included in Appendix 2.

## 9 QUANTIFICATION OF REDUCTIONS AND REMOVALS

### 9.1 Baseline Emissions

Baseline emissions are calculated based on the type, quantity, and emissions intensity factor of the conventional fossil fuels used for shipping, using Equation (1).

$$BE_y = \sum_i BF_{i,y} \times EF_{i,y} \quad (1)$$

Where:

$BE_y$	=	Baseline emissions in year $y$ (t CO <sub>2</sub> e)
$BF_{i,y}$	=	Amount of baseline fossil fuel type $i$ consumed in year $y$ (t)
$EF_{i,y}$	=	Emissions intensity factor of baseline fossil fuel type $i$ in year $y$ from Table 2 (t CO <sub>2</sub> e/t fuel)
$i$	=	Baseline fossil fuel type

The amount of baseline fossil fuel type  $i$  consumed in year  $y$  is calculated as follows:

$$BF_{i,y} = \sum_z PF_{z,y} \times \frac{NCV_z}{NCV_i} \times \frac{SFC_{BL}}{SFC_P} \quad (2)$$

Where:

$BF_{i,y}$	=	Amount of baseline fossil fuel type $i$ consumed in year $y$ (t)
$PF_{z,y}$	=	Amount of project alternative fuel type $z$ consumed in year $y$ (t)
$NCV_z$	=	Net calorific value of project alternative fuel type $z$ (MJ/kg)
$NCV_i$	=	Net calorific value of baseline fossil fuel type $i$ (MJ/kg)
$SFC_{BL}$	=	Specific fuel consumption of engine in baseline prior to conversion or retrofit (g/kWh)
$SFC_P$	=	Specific fuel consumption of engine during project after conversion or retrofit (g/kWh)
$i$	=	Baseline fossil fuel type
$z$	=	Project alternative fuel type

**Table 2. Default emissions intensity factors for baseline fossil fuels ( $EF_{i,y}$ )**

Ship category	Baseline fossil fuel type $i$	$EF_{i,y}$ (t CO <sub>2e</sub> /t fuel)
LNG carriers and gas carriers	Fossil LNG	3.277
All other categories	All diesel fuels (HFO, LFO, MDO, MGO)	3.376

The values in Table 2 represent the most conservative emissions intensity factors of the fuels most likely to be used in the baseline. Refer to Appendix 3 for details on the rationale and process used to determine:

- baseline fuel types for different ship categories.
- emissions intensity factors for the fuels consumed in the baseline.

## 9.2 Project Emissions

Project emissions are based on the type, quantity, and emissions intensity factor of the alternative low-carbon fuels consumed in project activities, using Equation (3).

$$PE_y = \sum_z PF_{z,y} \times EF_{z,y} \quad (3)$$

Where:

$PE_y$	=	Project emissions in year $y$ (t CO <sub>2e</sub> )
$PF_{z,y}$	=	Amount of project alternative fuel type $z$ consumed in year $y$ (t)
$EF_{z,y}$	=	Emissions intensity factor of project alternative fuel type $z$ in year $y$ , determined using one of the options in Section 9.2.1 (t CO <sub>2e</sub> /t fuel)
$z$	=	Project alternative fuel type

### 9.2.1 Alternative Low-Carbon Fuel Emissions Intensity Factors ( $EF_{z,y}$ )

The emissions intensity factor of project fuels must be determined using one of the approaches listed below. For all approaches, project proponents must ensure that:

- 1) no environmental attribute certificates, renewable energy certificates, or other virtual supply scenarios are used in accounting for the emissions associated with the fuel and energy inputs of any stage of the fuel life cycle.
- 2) the emissions intensity for the fuel applies to the engine cycle of ships in the project.
- 3) any software version used to model the emissions intensity factor is unmodified.

**Approach 1:** The emissions intensity factor of the fuel is calculated in accordance with the most recent version of the International Maritime Organization’s *Guidelines on Life Cycle GHG Intensity of Marine Fuels*<sup>12</sup> (IMO Guidelines) for the corresponding fuel type and fuel pathway determined using the process outlined in the guidelines in either:

- Section 9: Default Emission Factors, or
- Section 10: Actual Emission Factors

**Approach 2:** An active emissions intensity factor approved or accepted by a regulatory program in the jurisdiction where the alternative low carbon fuel is produced is used.

**Approach 3:** An actual (i.e., based on user inputs) or default emissions intensity value is determined using the Argonne National Laboratory GREET Model for the corresponding fuel type and fuel pathway.

All inputs to emission intensity calculations and the resulting value must be confirmed by a third party accredited to the following standards by a national accreditation organization recognized by the International Accreditation Forum:

- ISO 17029 – Conformity assessment: General principles and requirements for validation and verification bodies
- ISO 14065 – General principles and requirements for bodies validating and verifying environmental information
- ISO 14066 – Competence requirements for teams validating and verifying environmental information

### 9.3 Leakage Emissions

Emissions from the life cycle stages upstream of the project boundary are considered leakage. These emission sources are accounted for in the emissions intensity factors required for the calculation of baseline emissions and project emissions. As such, no further calculations for leakage are required.

### 9.4 Net Reductions and Removals

Net GHG emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad (4)$$

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<sup>12</sup> The 2024 version is available at: <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/annex/MEPC%2081/Annex%2010.pdf>

Where:

$ER_y$	=	Net GHG emission reductions in year $y$ (t CO <sub>2</sub> e)
$BE_y$	=	Baseline emissions in year $y$ (t CO <sub>2</sub> e)
$PE_y$	=	Project emissions in year $y$ (t CO <sub>2</sub> e)

## 9.5 Uncertainty

The primary source of uncertainty identified for the project activities covered by this methodology is measurement error related to fuel usage. However, it is reasonable to assume that custody transfer meters or fiscal metering will be employed for the measurement of fuels consumed and therefore the uncertainty of measurement error may be considered de minimis.

All other potential sources of uncertainty are either considered de minimis or accounted for in the conservativeness of the default factors. Therefore, the overall uncertainty is estimated to be less than 10% and no discount for uncertainty quantification is required.

# 10 MONITORING

## 10.1 Data and Parameters Available at Validation

<b>Data/Parameter</b>	$EF_{i,y}$
<b>Data unit</b>	t CO <sub>2</sub> e/t fuel
<b>Description</b>	Emissions intensity factor of baseline fossil fuel type $i$ in year $y$
<b>Equations</b>	(1)
<b>Source of data</b>	IMO (2022) and CDM <i>TOOL15</i> , v02.0
<b>Value applied</b>	For LNG and gas carriers: 3.277 For all other ships using diesel fuel types: 3.376
<b>Justification of choice of data or description of measurement methods and procedures applied</b>	<p>Calculation details are provided in Appendix 3.</p> <p>The emissions intensity factor represents the full well-to-wake (WTW) life cycle of the fuel.</p> <p>Values for tank-to-wake (TTW) emissions are as provided and used for reporting GHG emissions from shipping to IMO. Upstream fossil fuel emissions for LNG and diesel are as provided by the CDM.</p> <p>The same TTW values are used in EU Regulation 2016/2071 L 320/3 as default values for emission factors for fuels used onboard, for monitoring, reporting, and verification of CO<sub>2</sub> emissions from maritime transport.</p> <p>A 30% discount for upstream emissions (well-to-tank, WTT) has been applied as required by VCS Program rules.</p>

Purpose of data	Calculation of baseline emissions
Comments	None
Data/Parameter	$NCV_i$ $NCV_z$
Data unit	MJ/kg
Description	<p>Net calorific value of baseline fossil fuel type <math>i</math></p> <p>Net calorific value of project alternative fuel type <math>z</math></p>
Equations	(2)
Source of data	<p><b>Option 1:</b> Base the NCV on fuel supplier specifications or on national or international publications. Option 1 must be used for e-diesel, e-LNG, e-LPG, and e-methanol.</p> <p><b>Option 2:</b> Use IPCC default values for fossil diesel fuels and LPG as provided in Table 1.2, Chapter 1, Volume 2 of the <i>2006 IPCC Guidelines for National Greenhouse Gas Inventories</i>. For ammonia, hydrogen, LNG, and methanol, use default values provided in Table 3 of IRENA (2021). Option 2 must be applied conservatively such that the lower IPCC default values are used for baseline fuels and upper IPCC default values are used for alternative fuels.</p> <p>The production process used does not affect the NCV of hydrogen or ammonia.</p>
Value applied	<p><b>Option 1:</b> Value based on fuel supplier specifications or national or international publications</p> <p><b>Option 2:</b> The following default values:</p> <p>Fossil fuels:</p> <ul style="list-style-type: none"> <li>Gas/diesel oils (includes LFO): 41.4</li> <li>LNG: 46.5</li> <li>HFO/residual fuel oil: 39.8</li> </ul> <p>Alternative fuels:</p> <ul style="list-style-type: none"> <li>Liquid or compressed hydrogen: 120</li> <li>Liquid ammonia: 18.6</li> </ul>
Justification of choice of data or description of measurement methods and procedures applied	The <i>2006 IPCC Guidelines for National Greenhouse Gas Inventories</i> and IRENA publications are internationally recognized.
Purpose of data	Calculation of baseline emissions
Comments	Where the IPCC or IRENA NCVs are updated, the updated values must be used in future monitoring reports.

<b>Data/Parameter</b>	$SFC_{BL}$ $SFC_P$
<b>Data unit</b>	g/kWh
<b>Description</b>	Specific fuel consumption of engine in baseline prior to conversion or retrofit  Specific fuel consumption of engine during project after conversion or retrofit
<b>Equations</b>	(2)
<b>Source of data</b>	Measurements and modeled parameters used during IMO certification process
<b>Value applied</b>	Value determined as part of Attained Energy Efficiency Design Index within the International Energy Efficiency Certificate following IMO regulations on ship energy efficiency regulations (Chapter 4 of MARPOL Annex VI). Smaller ships using this methodology must use the same procedures, as described in Chapter 4 of IMO MARPOL Annex VI. <sup>13</sup>
<b>Justification of choice of data or description of measurement methods and procedures applied</b>	MARPOL is the International Convention for the Prevention of Pollution from Ships, adopted by the International Maritime Organization (IMO). The IMO MARPOL Annex VI Chapter 4 requirements are internationally recognized and longstanding procedures for estimating engine efficiency in marine transport.
<b>Purpose of data</b>	Calculation of baseline emissions
<b>Comments</b>	Ships of 400 gross tonnage (GT) and above are required to report this data to IMO <sup>14</sup> based on a specified protocol; the same data are used by the project.

## 10.2 Data and Parameters Monitored

<b>Data/Parameter</b>	$PF_{z,y}$
<b>Data unit</b>	tonnes
<b>Description</b>	Amount of project alternative fuel type z consumed in year y
<b>Equations</b>	(2), (3)

<sup>13</sup> Available at:

[https://wwwcdn.imo.org/localresources/en/publications/Documents/Supplements/English/OOC664E\\_022019.pdf](https://wwwcdn.imo.org/localresources/en/publications/Documents/Supplements/English/OOC664E_022019.pdf) or <https://doi.org/10.62454/KD664E>

<sup>14</sup> As required by Chapter 4 of MARPOL Annex VI

<b>Source of data</b>	<p>Ship operator, using data supplied to IMO Ship Fuel Consumption Database, which is compulsory for all ships of 5000 GT and above according to international regulations.</p> <p>Smaller ships using this methodology must use the same procedures, as described by IMO Resolution MEPC.278(70) (Adopted on 28 October 2016) Annex III or EU Regulation 2015/757 Annex I Part B.</p>
<b>Description of measurement methods and procedures to be applied</b>	<p>Fuel consumption is determined by one of the following monitoring methods without preference for any of the options:</p> <ul style="list-style-type: none"> <li>• Bunker delivery note (BDN) and periodic stock takes of fuel tanks</li> <li>• Bunker fuel tank monitoring onboard</li> <li>• Flow meters for applicable combustion processes</li> </ul> <p>Measurements must be made in accordance with Part B of Annex I to EU Regulation 2015/757 which details the different measurement methods that may be applied. Fuel consumption must include fuel consumed by main engines, auxiliary engines, gas turbines, boilers, and inert gas generators and fuel consumption within ports at berth, with separation per fuel type.</p>
<b>Frequency of monitoring/recording</b>	Annual
<b>QA/QC procedures to be applied</b>	<p>Data excluding fuel consumption at port is reported to IMO annually and for ships arriving at, within, or departing from ports under the jurisdiction of a Member State of the European Union is also reported to the EU based on EU Commission Delegated Regulation 2016/2071.</p> <p>The quality of data is checked by the IMO and for ships which report data to the EU, the data is verified by an external verifier (Chapter III of EU 2015/757).</p>
<b>Purpose of data</b>	Calculation of baseline and project emissions
<b>Calculation method</b>	N/A
<b>Comments</b>	Ships of 5000 GT and above are required to report this data to IMO based on a specified protocol; the same data are used by the project.

<b>Data/Parameter</b>	$EF_{z,y}$
<b>Data unit</b>	t CO <sub>2</sub> e/t fuel
<b>Description</b>	Emissions intensity factor of project alternative fuel type z in year y
<b>Equations</b>	(3)
<b>Source of data</b>	<p>One of the following:</p> <ol style="list-style-type: none"> <li>1) International Maritime Organization's <i>Guidelines on Life Cycle GHG Intensity of Marine Fuels</i> (IMO Guidelines)</li> </ol>

	2) The regulator in the jurisdiction of fuel production 3) Argonne National Laboratory GREET Model
<b>Description of measurement methods and procedures to be applied</b>	Determined using one of the approaches listed in Section 9.2.1
<b>Frequency of monitoring/recording</b>	Emissions intensity factors are considered valid for the period specified in the approach used or, where no period is specified, three years. Demonstrated with each fuel delivery.
<b>QA/QC procedures to be applied</b>	In accordance with the options and requirements listed in Section 9.2.1
<b>Purpose of data</b>	Calculation of project emissions
<b>Calculation method</b>	N/A
<b>Comments</b>	None

### 10.3 Description of the Monitoring Plan

Project proponents must design and implement a comprehensive and robust monitoring plan to ensure collection of all data and information required for each parameter listed in Sections 10.1 and 10.2.

#### 10.3.1 Regulatory Limits on Carbon Dioxide Emissions

Project proponents must monitor and report any new or amended legal or regulatory framework that has been imposed and directly or indirectly limits GHG emissions from shipping fuels.

Where such new or amended frameworks or requirements are introduced, the project proponent must use the procedures set out in Section 8 to reassess the additionality of the project using a project baseline, based on the situation on the date on which the new framework was introduced.

GHG emission reductions claimed within a potential future emission trading system under the International Convention for the Prevention of Pollution from Ships (MARPOL) and the IMO Net-Zero Framework (for compliance purposes to avoid penalties or as transferable surplus carbon credit units) cannot be claimed by a project using this methodology. Reductions which go beyond those claimed under an IMO framework may generate carbon credits under this methodology.

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# APPENDIX 1: JUSTIFICATION FOR TREATMENT OF LEAKAGE EMISSIONS

Emissions from the production of components and equipment used to modify or retrofit engine and/or on-board storage systems to use e-fuels are considered de minimis (Table 1). The analysis shown in this appendix illustrates that the emissions associated with production of a new storage tank do not exceed 5% of the expected mitigation outcomes for a typical project under this methodology.

The analysis is based on 40 000–80 000 DWT (PANAMAX, ~5000 TEU) container ships using heavy fuel oil in the baseline scenario. This category comprises 1122 ships (IMO 2024). Annual CO<sub>2</sub> emissions per ship are 41 349 t CO<sub>2</sub> and annual distance traveled per ship is 80 880 km (IMO 2024). Hydrogen is selected as the project alternative fuel as it has the lowest energy density of the alternative fuels and therefore provides the most conservative estimate.

**Table 3. Parameters for a container ship heavy fuel oil tank (baseline) and liquid cryogenic hydrogen tank (project)**

Parameter	Heavy fuel oil tank	Hydrogen tank
Tank capacity for equivalent energy <sup>1</sup> (m <sup>3</sup> )	6624	29 526
Steel required for tank <sup>2</sup> (t)	159	7382
Carbon footprint of steel <sup>3</sup> (t CO <sub>2</sub> /t)	1.85	1.85
Tank lifespan <sup>4</sup> (years)	20	
Total tank carbon footprint (t CO <sub>2</sub> )	294	13 656
Annualized tank emissions (t CO <sub>2</sub> /year)	15	683
Additional annual emissions compared to the baseline (t CO <sub>2</sub> /year)		668
Additional emissions as percentage of total operational emissions (%)		<b>1.60</b>

1: Volume comparison based on MGO to H<sub>2</sub> ratio of 1:4.5 (MGO and HFO have comparable energy density). HFO: Tables 2 and 3 in IMO (2024). H<sub>2</sub>: ABS (2020).

2: HFO: Assumptions: Vertical tank 10 000m<sup>3</sup> specifications. H<sub>2</sub>: 0.25 t/m<sup>3</sup> – upper value for 2000 m<sup>3</sup> hydrogen tank specifications; Liquid cryogenic tank selected for long-distance shipping.

3: Sustainable Ships (2022)

4: Assumed to be 20 years based on experience of Iino Kaiun Kaisha, Ltd.

The additional carbon footprint from the larger hydrogen tank (compared to HFO baseline) represents only 1.6% of the ship's annual operational CO<sub>2</sub> emissions. Since hydrogen has the lowest energy density of the alternative fuels, this represents the most conservative (highest impact) scenario. All other alternative fuels would result in a smaller percentage.

# APPENDIX 2: DETERMINING THE POSITIVE LIST

## Option A: Activity Penetration

The project activity has achieved a low level of penetration relative to its maximum adoption potential, calculated as follows:

$$AP_y = \frac{OA_y}{MAP_y} \quad (5)$$

Where:

- $AP_y$  = Activity penetration of the project activity in year  $y$  (%)
- $OA_y$  = Observed adoption of the project activity in year  $y$  (t)
- $MAP_y$  = Maximum adoption potential of the project activity in year  $y$  (t)

The maximum adoption potential is the total adoption of a project activity that could currently be achieved given current resource availability, technological capability, level of service, implementation potential, total demand, market access, and other relevant factors within the methodology's applicable geographically defined market. Maximum adoption potential does not consider market price, cost of adoption, consumer education, cultural or behavioral barriers, or laws, statutes, regulatory frameworks, or policies. The maximum adoption potential for e-fuels is the total current fuel usage. The type of e-fuel that will be primarily used is still uncertain. However, for decarbonization of the maritime sector, the strategy used and the barriers and limitations encountered are not resource-related – renewable energy is available – but price-related (IRENA 2021). The fourth IMO GHG report (IMO 2021) projects that by 2050 the share of alternative fuels will increase to 20–100%.

Activity penetration level of the project activity was 0.3% in 2023 (see demonstration below).

The IMO is the preferred data source as it is the independent specialized agency of the United Nations responsible for regulating shipping.<sup>15</sup> The IMO collects data on all ships of 5000 GT and above and annually publishes the Marine Environment Protection Committee (MEPC) report on energy efficiency of ships. The IMO database is based on ships of 5000 GT and above. However, the results of the positive list may be used by all ships.

The fuel consumed (Table 4) is based on the IMO Ship Fuel Oil Consumption Database in the Global Integrated Shipping Information System (GISIS), in accordance with Regulation 27 of the *2021 Revised MARPOL Annex VI* and the *2022 Guidelines for the Development and Management of the IMO Ship*

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<sup>15</sup> In the future, other databases might become available that track alternative fuels in a more precise manner. Currently IMO does not distinguish pathways for fuel production (e.g., no distinction is made between green and gray hydrogen or methanol, and all alternative fuels are listed under “others”).

*Fuel Oil Consumption Database* (Resolution MEPC.349(78)) and subsequent guidelines and regulations.<sup>16</sup> This database includes fuel type and fuel quantities consumed by all ships of 5000 GT and above worldwide since 2019.

Result:

$$AP_y = \frac{OA_y}{MAP_y} = \frac{547\,253\,t}{211\,137\,491\,t} = 0.26\%$$

The cumulative market share of alternative low-carbon fuels used in the maritime industry plus other alternative fuels not included in this methodology (biofuels, ethane) was 0.26% in 2023 (most recent available data). This is less than the benchmark value of 5%, meaning that each individual alternative low-carbon fuel also has a market penetration rate of less than 5% and is thus additional and included in the positive list. The positive list is based on the market share of alternative low-carbon fuels as defined in Section 3.

The positive list is applicable for the following alternative low-carbon fuels included in this methodology:

- 1) Green and low-carbon hydrogen
- 2) Green and low-carbon ammonia
- 3) e-LNG
- 4) e-LPG
- 5) e-methanol
- 6) e-diesel

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<sup>16</sup> Available at: <https://www.imo.org/en/ourwork/environment/pages/data-collection-system.aspx>

**Table 4. Amount of fuel used per ship category in 2021 (in 1000 units)<sup>17</sup>**

Ship category	MDO, MGO	HFO	LFO	LNG	LPG	Ethanol, methanol, and others*	Total
Bulk carrier	3 933 563	36 888 628	14 035 409	66 123	4959	12 029	<b>54 940 711</b>
Combination carrier	9059	126 412	10 542	0	0	0	<b>146 013</b>
Container ship	4 858 186	43 113 643	10 182 858	468 540	24 054	310 050	<b>58 957 331</b>
Cruise passenger ship	2 285 902	3 543 433	194 485	158 810	0	7486	<b>6 190 116</b>
Gas carrier	640 003	3 523 942	1 276 417	76 887	189 382	52 874	<b>5 759 505</b>
General cargo ship	1 851 243	3 599 374	1 714 282	18 381	0	12 508	<b>7 195 788</b>
LNG carrier	1 063 442	1 822 407	1 015 466	11 530 785	22 346	0	<b>15 454 446</b>
Passenger ship	309 350	629 823	86 126	94 300	0	0	<b>1 119 599</b>
Refrigerated cargo carrier	136 810	662 977	196 482	37 570	0	0	<b>1 033 839</b>
Roll-on roll-off cargo ship	481 424	1 934 183	368 139	25 098	0	0	<b>2 808 844</b>
Roll-on roll-off cargo ship (vehicle carrier)	699 694	3 008 399	2 535 193	39 547	0	41 475	<b>6 324 308</b>
Roll-on roll-off passenger ship	995 028	1 861 592	579 636	130 739	0	6595	<b>3 573 590</b>
Tanker	6 984 682	27 696 693	7 637 017	207 668	1551	100 175	<b>42 627 786</b>
Other	2 351 630	2 030 239	584 122	35 563	0	4061	<b>5 005 615</b>
<b>Total</b>	<b>26 600 016</b>	<b>130 441 745</b>	<b>40 416 174</b>	<b>12 890 011</b>	<b>242 292</b>	<b>547 253</b>	<b>211 137 491</b>

\* Based on the IMO, “other” includes all fuel types other than MDO, MGO, HFO, LFO, LNG, LPG, ethanol, and methanol.

<sup>17</sup> IMO. 2022. *Energy Efficiency of Ships MEPC 79/6/1*, Annex, Table 2

## APPENDIX 3: DETERMINING BASELINE EMISSION FACTORS

This appendix summarizes the procedure used to determine the emissions intensity factors of the baseline fuels (LNG, LPG, and the four diesel fuels HFO, LFO, MDO, and MGO). Table 5 presents the emission factors used to determine the life cycle (WTW) emissions of the baseline fuels.

**Table 5. Emission factors for baseline fuels**

Fuel	Upstream emission factor by energy content <sup>1</sup> (t CO <sub>2</sub> e/TJ)	Net calorific value <sup>2</sup> (TJ/t)	Upstream emission factor by quantity of fuel <sup>3</sup> (WTT) (t CO <sub>2</sub> e/t fuel)	Carbon conversion factor <sup>4</sup> (TTW) (t C/t fuel)	Life cycle emissions factor <sup>5</sup> (WTW) (t CO <sub>2</sub> e/t fuel)
Heavy fuel oil	9.4	0.0398	0.374	3.114	3.376
Liquefied natural gas	16.2	0.0465	0.753	2.750	3.277
Light fuel oil	16.7	0.0414	0.691	3.151	3.635
Marine diesel oil / marine gas oil	9.4	0.0414	0.389	3.206	3.478

1: Table 3 in CDM *TOOL15*

2: Lower limits of 95% confidence intervals, from Table 1.2 in Chapter 1, Volume 2 of IPCC (2006)

3: Calculated by multiplying emission factor (in t CO<sub>2</sub>e/TJ) by the net calorific value (TJ/t)

4: Table 4 in IMO (2022); listed as unitless.

5: Calculated by summing well-to-tank (WTT) emission factors and tank-to-wake (TTW) emission factors after applying an upstream discount factor of 30% to upstream emission factors as required by VCS Program rules

The baseline scenario represents the most widely used conventional fossil fuels for shipping operations globally (identified based on conservativeness<sup>18</sup>) per ship category, that would be replaced by alternative low-carbon fuels included in this methodology. Use of conventional fossil fuels is representative of the activities and GHG emissions that would occur in the absence of the project activity.

<sup>18</sup> The conservativeness of a baseline fuel is determined based on its GHG emission factor value (well-to-wake). A baseline fuel with the lowest GHG emission factor value is the most conservative.

Table 6 presents a breakdown of the use of different fuel types per ship category based on the most recent available International Maritime Organization (IMO) data.

**Table 6. Percentage of fuel type use per ship category in 2023**

Ship category	MDO, MGO, HFO, LFO (%)	LNG (%)	LPG (%)	Others
Bulk carrier	100	0	0	0
Combination carrier	100	0	0	0
Container ship	99	1	0	1
Cruise passenger ship	97	3	0	0
Gas carrier	94	1	3	1
General cargo ship	100	0	0	0
LNG carrier	25	75	0	0
Passenger ship	92	8	0	0
Refrigerated cargo carrier	96	4	0	0
Roll-on roll-off cargo ship	99	1	0	0
Roll-on roll-off cargo ship (vehicle carrier)	99	1	0	1
Roll-on roll-off passenger ship	96	4	0	0
Tanker	99	0	0	0
Other	99	1	0	0
<b>Total</b>	<b>94</b>	<b>6</b>	<b>0</b>	<b>0</b>

Values calculated using the absolute values of fuel use in Annex, Table 2 of IMO (2024).<sup>19</sup> Heavily shaded cells indicate high fuel penetration.

To determine a representative baseline fuel for a particular ship or a fleet of identical ships, project proponents must identify the ship category most relevant to their project from Table 6 and use either of the following as appropriate:

- 1) For LNG carriers and gas carriers, LNG must be used as the baseline fuel.
- 2) For all other ship categories, any of the listed diesel fuels (i.e., HFO, LFO, MDO, MGO) may be used as the baseline fuel. However, to be conservative, the GHG emission reduction calculations must be based on HFO (see Section 9.1), which has the lowest emission factor of the four diesel fuels.

<sup>19</sup> Available at: <https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Reporting%20year%202023.pdf>

# APPENDIX 4: JUSTIFICATION OF COMPATIBILITY WITH TRANSITION TO NET ZERO

The *VCS Methodology Requirements* requires that methodologies ensure that credited project activities are compatible with the transition to net zero GHG emissions, avoid carbon lock-in, and align with host country climate objectives. This appendix assesses this methodology against these criteria.

## **Alignment with Transition to Net Zero**

The project activities in this methodology result in GHG emission reductions through the displacement of conventional fossil fuels in maritime transport, quantified using a WTW approach. The methodology focuses on low carbon fuels and therefore supports decarbonization of the shipping sector. The use of life cycle accounting ensures that reductions reflect full supply-chain impacts, reinforcing alignment with long-term mitigation objectives.

## **Assessment of Carbon Lock-in Risk**

The methodology is designed to support transition away from the use of fossil fuels in the shipping sector and so inherently avoids carbon lock-in and is aligned with long-term decarbonization in the sector.

Further, the use of life cycle emissions accounting ensures that emissions impacts of any upstream or downstream fossil fuel use are captured, supporting a comprehensive evaluation of system-level outcomes.

## **Compatibility with Host Country Net-Zero Objectives**

This methodology is globally applicable. Given the design of the methodology and the activities supported, it is expected to align with net-zero objectives across jurisdictions.

# DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 June 2026	Initial version