DNV AS, Norway

REVISION OF APPRAISAL TOOL

User manual

International Maritime Organization (IMO)

Report No.: 2024-1208, Rev. 5
Document No.: 227711-SA-01 September 2025
Date: 2026-03-05

Project name:	Revision of EET IP and Appraisal Tool	DNV Maritime
Report title:	User manual	DNV AS, Norway
Customer:	International Maritime Organization (IMO)	P.O.Box 300
	4 Albert Embankment	1322 Høvik
	SE1 7SR London	Norway
	United Kingdom	Tel:
Customer contact:	Astrid Dispert	
Date of issue:	2026-03-05	
Project No.:		
Organisation unit:	Shipping Advisory	
Report No.:	2024-1208, Rev. 4	
Document No.:	227711-SA-01 September 2025	

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

Objective:

User manual to of the updated and reviewed version of the Appraisal Tool delivered to IMO by DNV Maritime Advisory in 2016.

Prepared by:	Verified by:	Approved by:
Cathrine Kabbe Consultant	Knut Ljungberg Senior Principal Consultant	Rolf Ole Jensen Head of Section
Harald Stangeland Mundal Benjamin Timerblid Helle Johnsgård Jensen	Gøril Gleditsch Principal Consultant	

DNV Distribution:

☒ OPEN. Unrestricted distribution, internal and external.

☐ INTERNAL use only. Internal DNV document.

☐ CONFIDENTIAL. Distribution within DNV according to applicable contract. *

☐ SECRET. Authorized access only.

*Specify distribution:

Keywords:

IMO, Energy efficiency, Excel tool, MACC, CII, EEXI, EEDI

Remark: DNV Maritime Advisory acts independently and autonomously from other organisational divisions within DNV. DNV Maritime Advisory is in a different reporting line than DNV Classification / Certification units. If applicable, DNV Classification/Certification will independently verify the given statements and therefore may come to other conclusions than Maritime Advisory. This principle is founded on DNV`s management system.

Rev. No.	Date	Reason for Issue	Prepared by	Verified by	Approved by
1	2024-02-13	First issue	Cathrine Kabbe	Knut Ljungberg	Rolf Ole Jensen
2	2024-08-22	Second issue	Cathrine Kabbe	Knut Ljungberg	Rolf Ole Jensen
3	2025-05-16	Third issue	Cathrine Kabbe	Knut Ljungberg	Rolf Ole Jensen
4	2025-09-12	Fourth issue	Cathrine Kabbe	Knut Ljungberg	Rolf Ole Jensen
5	2026-03-05	Fifth issue	Cathrine Kabbe	Knut Ljungberg	Rolf Ole Jensen

Table of contents

1 EXECUTIVE SUMMARY

According to the Fourth IMO GHG Study (1), the GHG emissions of total shipping have increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018. While carbon intensity improved between 2012 and 2018 for international shipping, emissions are projected to rise by 2050 compared to 2008 levels. The maritime industry is expected to undergo a rapid energy and technology transition, significantly impacting costs, asset values, and earning capacity. Additionally, the pressure to reduce GHG emissions is mounting due to upcoming regulations and demands from cargo owners and consumers (3).

In July 2023, the 80th session of IMO's Marine Environment Protection Committee (MEPC 80) completed the first revision of the initial GHG Strategy (5). This revision significantly strengthens the ambitions for international shipping compared to the initial goal of a 50% GHG reduction by 2050. The revised strategy continues with the 2008 baseline but now aims to reduce well-to-wake GHG emissions by 20% by 2030, striving for 30%, then 70% by 2040, striving for 80%, and ultimately achieving net-zero by or around 2050. Additionally, there is a 2030 target to achieve an uptake of zero or near-zero GHG emissions technologies, fuels, and/or energy sources, representing at least 5% of the energy used by international shipping, while striving for 10% (6). The goal of 40% reduction of carbon intensity by 2030 also applies to the revised strategy.

In 2016, when the first version of the Appraisal Tool was published, limited GHG reduction requirements were introduced. The technical design index, Energy Efficiency Design Index (EEDI) for newbuildings built after 2015, and the voluntarily operational index, Energy Efficiency Operating Index (EEOI), recommended as a tool for monitoring fuel consumption and energy efficiency, were adopted. Since the last version was published, new mandatory requirements for short-term GHG reduction have been adopted by IMO. In June 2021, MEPC 76 adopted new mandatory technical and operational measures to reduce the carbon intensity of international shipping, effective from 2023. These measures include Energy Efficiency for Existing Ships (EEXI), Enhanced Ship Energy Efficiency Management Plan (SEEMP) and Carbon Intensity Index (CII) rating scheme. In 2025, the MEPC 83 concluded its first review phase by raising the annual reduction targets from 2% (2023-2026) to 2.625% for 2027-2030.

In 2022, IMO and GreenVoyage2050 wanted to update and review the existing Appraisal Tool developed by DNV in 2016. This tool appraises the technical and operational energy efficiency measures for ships. It is designed to support interested stakeholders in investigating and assessing energy efficiency measures and can serve as an initial screening of applicable and relevant measures for further investigation. It is not intended for decision-making purposes, as this requires a more detailed and case-specific analysis. The tool identifies applicable measures for a chosen ship and compares the cost and benefit of those measures. It allows users to evaluate which measures will have the most effect on energy efficiency and which measures are the most cost-effective. The updated version of the tool aligns the number of measures with those presented in the IMO Energy Efficiency Information Portal (more information here).

The tool calculates the potential effect of different measures have on EEDI and EEXI, depending on the age of the vessel being investigated. The operational measure is CII, where the attained CII before and after applied measures are benchmarked against the vessel type and size's trajectory from IMO required reduction rates. The tool is updated with trajectories reaching decarbonization in 2050. The lines are assumed to be linear from 2030, as guidelines only exist for yearly reduction until 2030. The economic cost of reducing one more tonne of CO_2 is presented with the Marginal Abatement Cost Curves (MACC) for both the EEDI/EEXI and CII. The output of the tool is a list of the available measures for the chosen ship type and size, along with the effect and cost for the different measures.

The tool covers various vessel segments and size categories, as shown in Table 3-1, and the energy efficiency measures outlined in Table 3-2. The vessels are categorized by type and size, representing groups of vessels with technical and operational characteristics.

Additional Green Voyage resources and tools supporting shipping's transition towards a low carbon future can be found on GreenVoyage2050 Website.

2 INTRODUCTION

On behalf of IMO and GreenVoyage 2050 DNV has updated and reviewed the already existing Appraisal Tool delivered to IMO by DNV in 2016. Since the last version, the knowledge and focus on energy efficiency have increased, in addition the IMO has adopted new regulations. The updated version focuses on including these new requirements so the user can benchmark a vessel's performance before and after the implementation of certain measures. The motivation behind this tool is to educate the industry on relevant energy efficiency measures, investigate costs and reduction potential, and general applicability for a given vessel type. This version also includes all the measures described in the Information Portal so the user can select a broad range of both technical and operational measures when investigating the cost and associated fuel savings and performance for a vessel.

The pressure to reduce greenhouse gas emissions is increasing with upcoming regulations and requirements from cargo owners and consumers (3). In addition to the stricter regulations and pressure to reduce emissions, world politics and the energy crisis have resulted in increased energy prices and fuel costs, which make it crucial to have an energy-efficient vessel and operation.

Chapter 3 of this report describes the scope of the project, including a brief description of the model and the general principles and assumptions behind the model. Chapter 4 providing a user manual for the tool including an overview and instructions.

3 PROJECT SCOPE

The following sections outline the scope of work, including a brief description of the model.

3.1 List of ship types

The tool covers the following vessel segments and size categories, shown in Table 3-1. The type and size categorization are in line with the one presented in Table 8 the Fourth IMO GHG Study 2020 (1). The vessel segments used for CII are slightly different from the Fourth Study, with a lower level of granularity, so the user's input will be translated into the CII segments when calculating the CII trajectory. he vessel segments are categorized based on four different metrics: deadweight (DWT), gross tonnage (GT), TEU (Twenty-foot Equivalent Unit), and cbm (cubic merers).. The carbon intensity metric used in the CII scheme depends on the ship segment. The capacity gross tonne distance (cgDIST) is based on gross tonnage as cargo carrying capacity. It applies to cruise passenger ships, vehicle carriers, Ro/Ro cargo ships and Ro/Ro passenger ships. In contrast, the Annual Efficiency Ratio (AER) is based on deadweight and applicable to the remaining ship types. Liquified gas carriers uses cbm (cubic meter) and container TEU as units in the Fourth study but will be using deadweight when calculating AER.

Some of the categories presented in *Table 8 the Fourth IMO GHG Study 2020* has been excluded from the model due to the IMO regulations not being relevant to them, and many of the abatement measures are not relevant. This applies to the Yacht, Service – tug, Miscellaneous – fishing, Offshore, Service – other and Miscellaneous – other.

It is assumed that all short-sea vessels, ferry-pax, ferry-RoPax and cruise ships have 4-stroke engines while the others have 2-stroke engines.

Table 3-1: Vessel segments and size categories included in the tool.

Ship type	DWT size category								
Bulk carrier	0-9,999	10,000-34,999	35,000-59,999	60,000-99,999	100,000-199,999	200,000-+			
Chemical tanker	0-4,999	5000-9,999	10,000-19,999	20,000-39,999	40,000-+				
General cargo	0-4,999	5000-9,999	10,000-19,999	20,000-+					
Refrigerated bulk	0-1,999	2,000-5,999	6,000-9,999	10,000-+					
Oil tanker	0-4,999	5,000-9,999	10,000-19,999	20,000-59,999	60,000-79,999	80,000-119,999	120,000-199,999	200,000-+	
Other liquids tankers	0-999	1,000-1,000-+							
Ro-Ro	0-4,999	5,000-9,999	10,000-14,999	15,000-+					
Ship type	**GT size category**								
Cruise	0-1,999	2,000-9,999	10,000-59,999	60,000-99,999	100,000-149,999	150,000-+			

Ferry-pax only	0-299	300-999	1,000-1,999	2,000-+					
Ferry-RoPax	0-1,999	2,000-4,999	5,000-9,999	10,000-19,999	20,000-+				
Vehicle	0-29,999	30,000-49,999	50,000-+						
Ship type	**TEU size category**								
Container	0-999	1,000-1,999	2,000-2,999	3,000-4,999	5,000-7,999	8,000-11,999	12,000-14,499	14,500-19,999	20,000-+
Ship type	**cbm size category**								
Liquefied gas tanker	0-49,999	50,000-99,999	100,000-199,999	200,000-+					

3.2 List of measures

The Energy Efficiency Appraisal tool includes the measures outlined in the Energy Efficiency Information Portal and can be seen in Table 3-2 below. Detailed descriptions and assumptions related to each measure can be found on the portal. The tool will also provide the user with a brief description of each measure by clicking the "i" box in the "Measure Summary"-sheet.

Table 3-2: List of measures evaluated in the study including whether it is a technical or operational measure.

Technology group	Measure	Technical/ operational
Energy consumers	Energy efficient lighting system	Technical
	Frequency controlled electric motors	Technical
Energy recovery	Fixed sails or wings	Technical
	Kite	Technical
	Solar panels	Technical
	Rotor sails	Technical
Machinery	Auxiliary systems optimization	Technical
	Engine performance optimization (automatic)	Technical
	Engine de-rating	Technical
	Engine performance optimization (manual)	Operational
	Exhaust gas boilers on auxiliary engines	Technical

	Battery hybridization	Technical
	Shaft generator PTO	Technical
	Shore power	Technical
	Improved auxiliary engine load	Operational
	Steam plant operation improvement	Operational
	Waste heat recovery systems	Technical
General technical solutions for operation	Autopilot adjustment and use	Operational
	Combinator optimizing	Operational
	Trim and draft optimization	Operational
	Weather routing	Operational
	Speed management	Operational
Propulsion and hull improvements	Air lubrication	Technical
	Hull performance coating	Technical
	Hull cleaning	Operational
	Hull form optimization	Technical
	Propeller retrofitting	Technical
	Propulsion improving devices (PIDs)	Technical
	Propeller polishing	Operational

3.3 Model description

The model is developed in MS Excel, containing the main modules and information flow outlined in the chart below. The “Start-up” and “Output” are the user interfaces, and the modules within the dashed line are the underlying spreadsheets for input data and calculations. The model description is outlined in Figure 3-1.

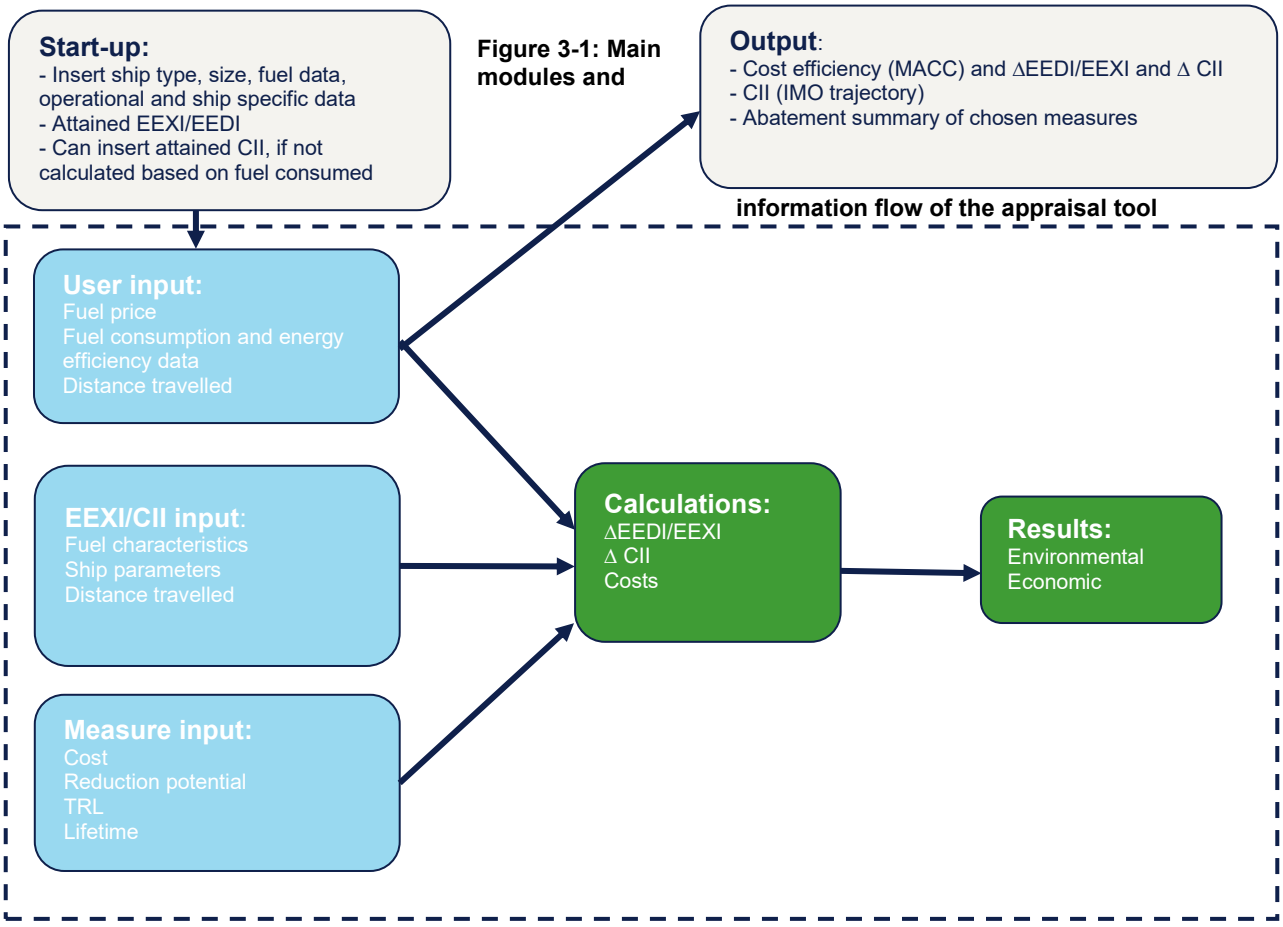


Figure 3-1: Main modules and

Start-up

The user must select the ship type, size, fuel type, fuel consumption, fuel price, year with operational data, and the expected remaining lifetime of the vessel from the date of the analysis. The calculations are done based on a predefined design, the inserted operational data, financial parameters, and a given set of measures. Other measures than the ones displayed can be selected from the dropdown menu in the applicable “measures” cell. In cases where two fuel types are used, they can be entered, and a weighted fuel price will be calculated.

The user can also fill in the "attained CII” if the user has the information available for the specific vessel. In cases where this data is unavailable, the user must insert the distance sailed, and the tool will calculate the CII based on the fuel consumed. Attained EEXI/EEDI from the technical file must be inserted to get information on the cost efficiency of EEXI/EEDI for the chosen measures. The required EEXI/EEDI will be calculated based on the vessel information.

A brief description of each measure is available by clicking the info ("i") cell to the right of the measure name in the "Measure summary" sheet. In addition, the user can adjust financial parameters and the effect of measures in the “measure summary” sheet. This setup allows users with diverse needs for flexibility and complexity to use the tool. The default mode, which includes default values for fuel savings potential and costs, can be used for an initial screening of measures. Adjusting these values allows for sensitivity analysis.

Databases for user, measure, and other input

The tool will contain three databases:

- User input
- EEXI/EEDI/CII input
- Measure input

The user input database will contain data on distance travelled, fuel consumption and other relevant data found in the Fourth IMO GHG Study.

EEX/EEDII/CII input database contains engine data, fuel characteristics and ship parameters for each ship type. This database also contains an abatement control that defines which measures are applicable for the different ship types and if they influence EEXI/EEDI and/or CII.

The measure input database contains information on cost, reduction potential, maturity in terms of TRL and lifetime of different measures. The data sources are DNV R&D projects and experience gained from energy efficiency studies involving 30+ customers operating 1000+ ships.

List of Measures

The Energy Efficiency Appraisal Tool will include all the measures given in the Information Portal (expect from hull retrofitting).

Calculations and results

The following calculations are included in the module:

- Required EEXI and EEDI for the chosen ship type and size.
- CII calculator, calculating initial CII (if attained CII is not inserted) and new CII as a result of the chosen measures. From this result, the user can evaluate which energy efficiency technologies are convenient in each specific case.
- Change in “net” value of combined EEXI/EEDI and CII for each specific energy efficiency measure.
- Cost of the measure(s).

Output

The output of the tool will be the Marginal Abatement Cost Curve (MACC), CII IMO trajectory and a list of the different measures feasible for the chosen ship type, their effect on the combined EEXI/EEDI and CII and the estimated investment cost, operational cost, payback time and yearly savings.

3.3.1 Required EEXI and EEDI calculation

The user must insert the vessel’s attained EEXI/EEDI from the technical file, while the tool estimates the required EEXI based on the reduction factors for the EEXI relative to the EEDI reference line from *MARPOL ANNEX VI, Ch 4 Reg 25 Required EEXI*. The required EEDI is calculated by the EEDI from the reduction factors for the different phases for the EEDI relative to the EEDI reference line from *MARPOL ANNEX VI, Ch 4 Reg 21 Required EEDI*. The EEDI phases are considered by the user’s input of the vessel's building year. The parameters for the determination of reference values for the different ship types is also provided in the Required EEDI regulation.

3.4 Basic assumptions

The following chapter outlines the underlying assumptions and philosophy used in the model.

3.4.1 Purpose and general description of the tool

The purpose of this tool is to compare different energy efficiency measures for a chosen vessel type and size. The user can choose whether the vessel is a newbuilding or an existing vessel. For existing vessels, operational measures could be relevant to investigate but will in most cases experience other costs and reduction numbers due to a different reference situation. The tool identifies measures that are applicable for that ship and compares the cost and benefit of those measures. The tool allows the user to evaluate which measures will have the most significant effect on energy efficiency, and which are the most cost-effective. The objective of this tool is to serve as an indicative assessment of relevant and applicable measures, including associated costs and reduction potential. It is not intended for decision-making purposes, as this would require a more detailed and case-specific analysis.

3.4.2 Measures

The measure input database contains information on cost, reduction potential, maturity in terms of TRL and lifetime of different measures. The data sources are DNV R&D projects and experience gained from energy efficiency studies involving 30+ customers operating 1000+ ships.

3.4.3 Uncertainty

The tool is designed to estimate savings and costs related to each measure, indicating how each contributes to the overall savings and costs. However, it should be noted that significant variations in trade, operational profiles, and other vessel specifics exist within each vessel and size segment. These variations will influence the applicability and effectiveness of the measures. If the user has their own experienced values, the values in the grey columns in "Measure summary" or in each of the tabs for each measure can be overwritten and will then be used in the calculations.

The model applies a representative set of values describing each vessel, its operation, and the cost and effect of the measures. The results should be perceived as indications and guidance rather than exact numbers for a specific vessel and measure. A three-point fuel-saving estimate (“typical,” “low,” and “high”) can be found in the “Measure summary” sheet and the tabs for each measure, reflecting the uncertainty of the fuel savings potential. DNV have collected information from participation in projects, testing of solutions with clients and verification of performance of specific technologies for suppliers. The result of this work is organized in databases and is now included in these tools. The final effect obtained from a specific technology will vary depending on speed, operational profile, and vessel design. Therefore, DNV have used typical values as an initial suggestion. DNV have provided high and low values to indicate that there are uncertainties, but in some cases, a specific technology applied to a vessel may result in savings outside the range of those provided in this tool.

The potential savings for EEXI and EEDI calculations are subject to significant uncertainty, relying on assumptions and limited experience. The impact will vary from vessel to vessel, and accounting for potential interaction effects between devices presents challenges. For this tool, a flat average across all ship types is employed. If the user has experienced numbers, it is highly recommended to update by overwriting the grey columns in the “Measure summary” sheet.

3.4.4 Measure correlation

Investigating and applying multiple measures to the same vessel can potentially lead to a change in the effect of each measure, e.g., applying speed reduction and trim optimization at the same time would likely change the saving potential of one or more measures.

However, the measures proposed in this model are perceived as relatively independent because the uncertainty of the effect of applying several measures to the same vessel would not exceed the uncertainty within each measure category.

Measures incompatible with others will be highlighted in red after running the calculation, e.g., applying "Rotor Sails" and "Kite" to the same vessel. The user must then select different combinations of measures.

4 USER MANUAL

The following chapter includes a user manual for the tool.

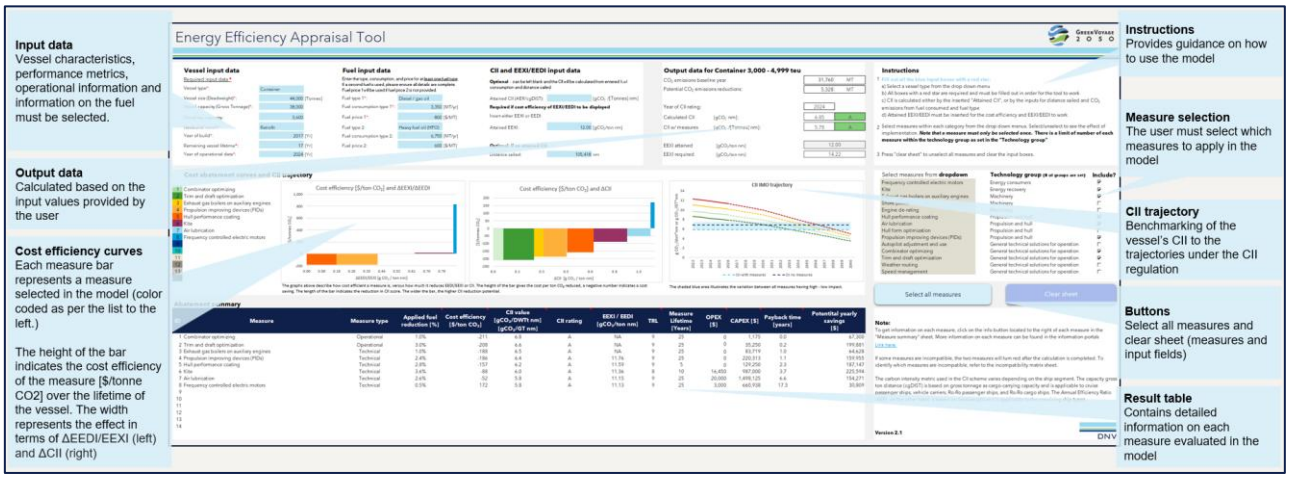
4.1 General requirements

- MS Excel 2007 or newer installed
- General understanding of MS Excel
- Macros enabled (prompted when opening the document)

4.2 Dashboard overview

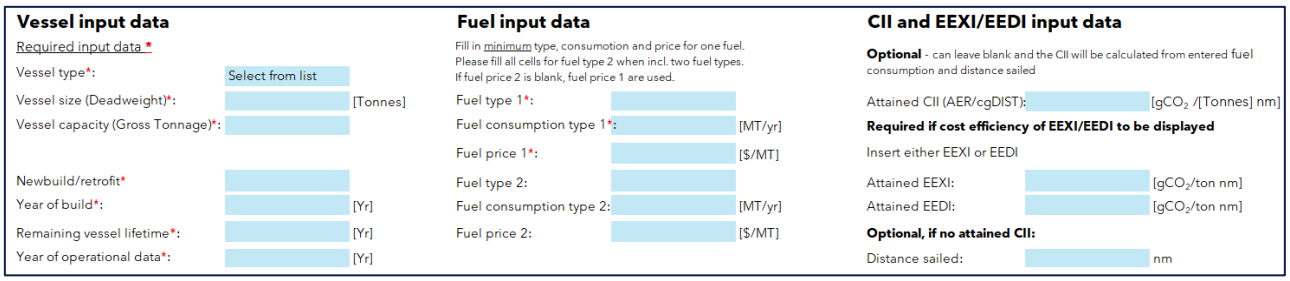
The following sections explain the different objects on the model dashboard and how they should be interpreted.

4.2.1 Dashboard



4.2.2 Input

The input parameters in the model are described in this section. The input cells in the model have a light blue colour, and the required cells have a red star, see the figure below.



4.2.2.1 Vessel input data

All the vessel input data are required fields.

Vessel type

The vessel types can be selected from a pre-defined list and are used to estimate the effect of the selected measures and to identify the correct CII trajectories. The vessel types are:

a. Bulk carrier
b. Chemical tanker
c. Container
d. Cruise
e. Ferry-RoPax
f. Ferry-pax only
g. General cargo
h. Liquefied gas tanker
i. Oil tanker
j. Other liquids tankers
k. Refrigerated bulk
l. Ro-Ro
m. Vehicle

Vessel size

The vessel's size in deadweight tonnes must be entered as an integer.

Vessel capacity

The vessel's capacity in gross tonnes must be entered as an integer.

Vessel teu / cbm capacity

If the selected vessel type is Container or Liquefied gas tanker a new field appears where the user must input "Vessel teu capacity" for Container and "Vessel cbm capacity" for Liquefied gas tanker.

Newbuild/retrofit

The user can select whether the vessel is a newbuild or should be retrofitted with the applied measures from the dropdown menu.

Year of build

The year the vessel was built

Expected vessel lifetime

The remaining expected lifetime of the vessel must be given in years.

Year of operational data

The year the operational data is applied for, and thus the year of the CII requirement values.

4.2.2.2 Fuel input data

Fuel type

The relevant fuel type can be selected from the dropdown menu. The fuel types are:

a. Diesel/gas oil

b. Light fuel oil (LFO)

c. Heavy fuel oil (HFO)

d. LPG Propane

e. LPG Butane

f. Liquefied natural gas (LNG)

g. Methanol

The user can select two fuel types and minimum one of the fields must be chosen. Biofuel is not included in the tool.

Fuel consumption

The fuel consumption in metric tonnes per year must be given as input. Users can enter two fuel types, and the total fuel amount will be calculated in HFO-equivalents, weighted by each fuel's energy density. At least one fuel consumption field is required.

Fuel price

The average fuel price in US dollars for the selected vessel must be provided as input. The user can enter two fuel types, and the weighted fuel price will be used in the calculations. At least one fuel price field is required. If two fuel types are provided but only one fuel price is entered, the specified fuel price will be applied to both types.

4.2.2.3 CII and EEXI/EEDI input data

Attained CII (AER/cgDIST) (optional)

The user can input the most recent AER or cgDIST value. If the value is not given, the model will calculate the CII based on the inserted fuel consumption and distance sailed.

Attained EEXI or EEDI (optional)

To assess the cost efficiency of EEXI or EEDI, the attained EEXI or EEDI value must be provided as an integer. If it is a vessel built before 2015 without major conversions, the EEXI should be applied, and the EEDI will be left blank. The same applies if the attained EEDI is filled out.

Distance sailed (optional)

The user can state the distance sailed in nautical miles for the vessel for the relevant period, e.g., the last calendar year. If the attained CII is not inserted this value is used to calculate the vessel's AER/cgDIST.

4.2.2.4 Example of a filled-out sheet

Vessel input data

Required input data *

Vessel type*:	Container	
Vessel size (Deadweight)*:	44,000	[Tonnes]
Vessel capacity (Gross Tonnage)*:	38,000	
Vessel teu capacity:	3,600	
Newbuild/retrofit*	Retrofit	
Year of build*:	2017	[Yr]
Remaining vessel lifetime*:	17	[Yr]
Year of operational data*:	2024	[Yr]

Fuel input data

Fill in minimum type, consumption and price for one fuel.
Please fill all cells for fuel type 2 when incl. two fuel types.
If fuel price 2 is blank, fuel price 1 are used.

Fuel type 1*:	Diesel / gas oil	
Fuel consumption type 1*	3,350	[MT/yr]
Fuel price 1*:	800	[$/MT]
Fuel type 2:	Heavy fuel oil (HFO)	
Fuel consumption type 2:	6,750	[MT/yr]
Fuel price 2:	600	[$/MT]

CII and EEXI/EEDI input data

Optional - can leave blank and the CII will be calculated from entered fuel consumption and distance sailed

Attained CII (AER/cgDIST):		[gCO_2 /[Tonnes] nm]

Required if cost efficiency of EEXI/EEDI to be displayed

Insert either EEXI or EEDI

Attained EEXI:		[gCO_2/ton nm]
Attained EEDI:		[gCO_2/ton nm]

Optional, if no attained CII:

Distance sailed:	105,418	nm

4.2.2.5 Selection of measures

Measures are selected by choosing options from the dropdown menu in the highlighted area and marking those to be included in the analysis. The number of measures in each Technology group is set to be: 1 *Energy consumer*, 1 E*nergy recovery*, 3 *Machinery*, 4 *Propulsion and hull* and 5 *General technical solutions for operation.*

Select measures from **dropdown**	**Technology group** (# of groups are set)	**Include?**
Energy efficient lighting system	Energy consumers	☑
Kite	Energy recovery	☑
Exhaust gas boilers on auxiliary engines	Machinery	☑
Shore power	Machinery	☐
Dropdown to select measure	Machinery	☐
Hull performance coating	Propulsion and hull	☐
Air lubrication	Propulsion and hull	☑
Hull cleaning	Propulsion and hull	☑
Propulsion improving devices (PIDs)	Propulsion and hull	☑
Autopilot adjustment and use	General technical solutions for operation	☐
Combinator optimizing	General technical solutions for operation	☑
Trim and draft optimization	General technical solutions for operation	☑
Weather routing	General technical solutions for operation	☐
Speed management	General technical solutions for operation	☐

If the measures are incompatible, the following will appear:

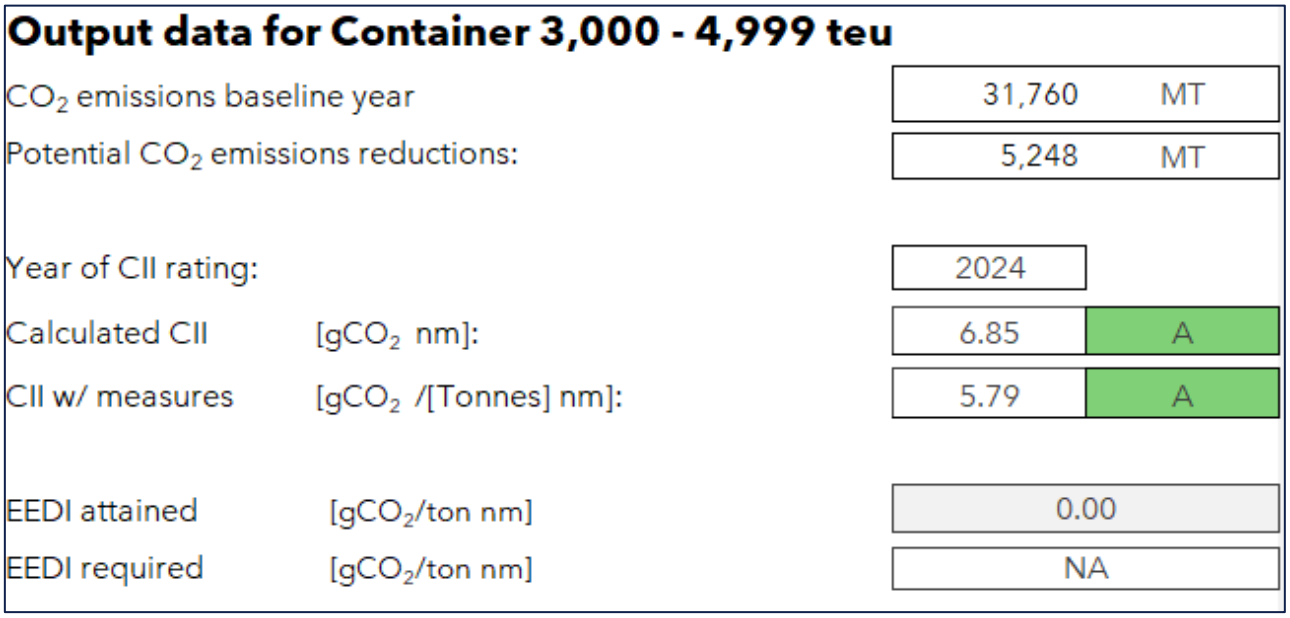
Select measures from **dropdown**	**Technology group** (# of groups are set)	**Include?**	
Energy efficient lighting system	Energy consumers	☑	
Kite	Energy recovery	☑	
Exhaust gas boilers on auxiliary engines	Machinery	☑	
Shore power	Machinery	☑	The measures in red are incompatible with each other. Please check the incompatibility matrix and unselect one of the measures
Engine de-rating	Machinery	☐	
Hull performance coating	Propulsion and hull	☑	
Air lubrication	Propulsion and hull	☑	
Hull cleaning	Propulsion and hull	☑	
Propulsion improving devices (PIDs)	Propulsion and hull	☑	
Autopilot adjustment and use	General technical solutions for operation	☐	
Combinator optimizing	General technical solutions for operation	☑	
Trim and draft optimization	General technical solutions for operation	☑	
Weather routing	General technical solutions for operation	☐	
Speed management	General technical solutions for operation	☐	

If the measures do not apply to retrofitting or newbuilds, the following will appear:

Select measures from **dropdown**	**Technology group** (# of groups are set)	**Include?**	
Energy efficient lighting system	Energy consumers	☑	
Kite	Energy recovery	☑	
Exhaust gas boilers on auxiliary engines	Machinery	☑	
Shore power	Machinery	☐	
Engine de-rating	Machinery	☐	
Hull performance coating	Propulsion and hull	☑	
Air lubrication	Propulsion and hull	☑	
Hull form optimization	Propulsion and hull	☑	One or several of the measures selected (yellow) are not applicable for Retrofit
Propulsion improving devices (PIDs)	Propulsion and hull	☑	
Autopilot adjustment and use	General technical solutions for operation	☐	
Combinator optimizing	General technical solutions for operation	☑	
Trim and draft optimization	General technical solutions for operation	☑	
Weather routing	General technical solutions for operation	☐	
Speed management	General technical solutions for operation	☐	

4.2.3 Output

The tool's output—including output data, cost abatement curves, CII trajectory, and the abatement summary—is detailed in the following sections. The picture below shows the Output data fields for an example vessel.



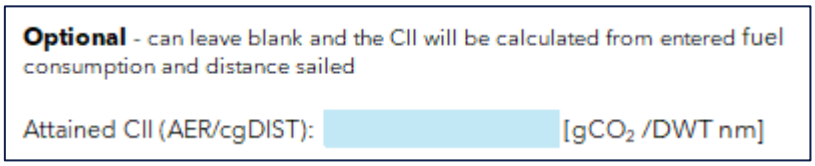
Output data for Container 3,000 - 4,999 teu

CO_2 emissions baseline year		31,760	MT
Potential CO_2 emissions reductions:		5,248	MT
Year of CII rating:		2024	
Calculated CII	[gCO_2 nm]:	6.85	A
CII w/ measures	[gCO_2 /[Tonnes] nm]:	5.79	A
EEDI attained	[gCO_2/ton nm]	0.00	
EEDI required	[gCO_2/ton nm]	NA	

4.2.3.1 CII

As mentioned in section 4.2.2.3, CII values are determined either from attained values or calculated from the inserted distance sailed and fuel consumption. Both methods depend on the vessel-specific input data described in section 4.2.2.3.

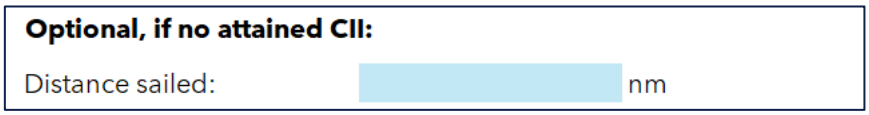
The attained values can either be inserted in the “Attained CII” cell:



Optional - can leave blank and the CII will be calculated from entered fuel consumption and distance sailed

Attained CII (AER/cgDIST): [gCO_2 /DWT nm]

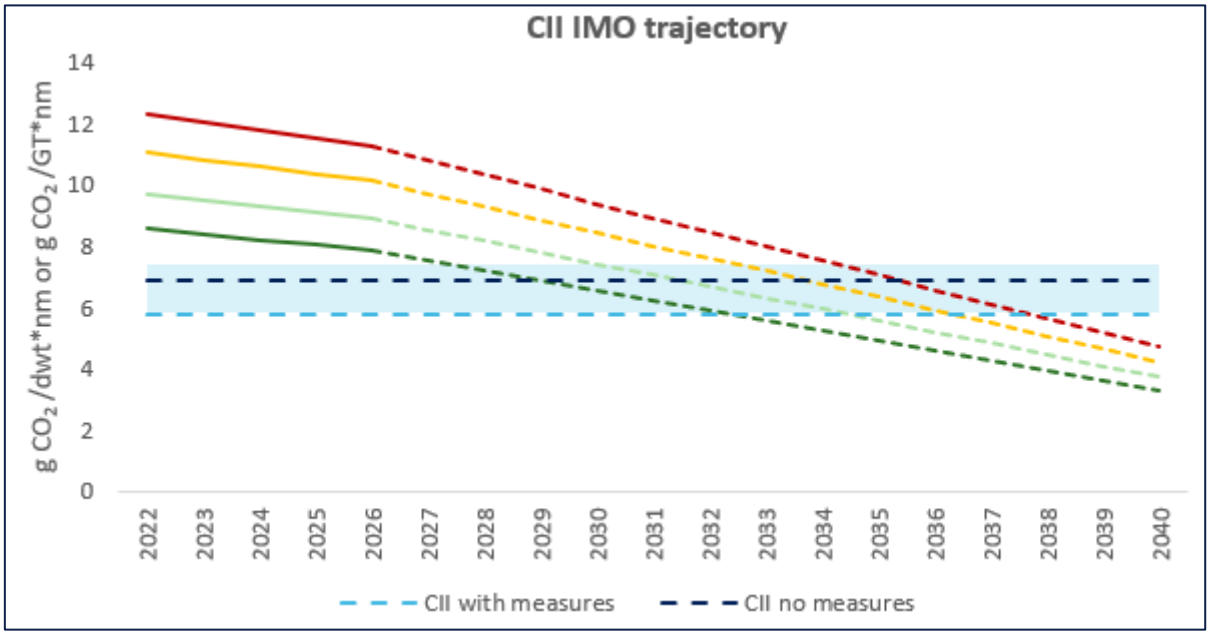
Or by inserting the distance sailed. The CO2 emissions are calculated based on the fuel consumption provided in the “Fuel input data”. Based on these figures, the CII values are calculated. **Note:** CII correction factors are not considered.



Optional, if no attained CII:

Distance sailed: nm

The presentation of the CII trajectory displays both the CII value in the absence of any measures and the CII value incorporating the selected measures (refer to the user instructions for further details). The light blue area represents the uncertainty of the measure reduction potential: high and low impact.



4.2.3.2 EEXI/EEDI

When all fields are completed accurately, the required and attained EEXI values will be displayed in the output data field.

EEDI attained	[gCO_2/ton nm]	5.00
EEDI required	[gCO_2/ton nm]	5.66

4.2.3.3 MACC figures

Marginal abatement cost curves (MACC) present the estimated costs or savings associated with different emission reduction measures, as well as the potential quantity of CO_2 emissions that may be reduced if these measures are implemented. These curves enable easy comparison of the cost-effectiveness and impact of different opportunities in terms of emission reduction.

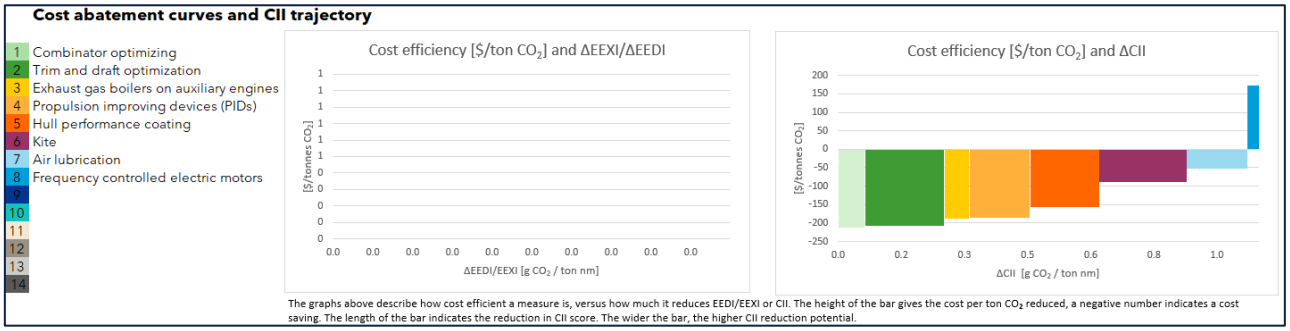
1. **Marginal Abatement Cost Curves (MACC)** = Net Cost of Measure Reduction
   - **Net cost** refers to the total of capital, operational, and maintenance expenses after deducting fuel savings or efficiency gains.
   - **Emissions reduction** is determined by comparing baseline emissions with the anticipated reductions resulting from the measure.
2. **Ranking Measures**: Measures are ranked from lowest to highest MACC, allowing decision-makers to prioritize cost-effective options.
3. **Cumulative Reduction**: The total width of the curve shows the cumulative emissions reduction if all measures are implemented.
4. **Negative Costs**: Some measures may exhibit negative MACCs, indicating that they achieve both cost savings and emission reductions (e.g., fuel-efficient routing)

The annualized net present value (NPV) of each measure is divided by the annual expected CO_2 reduction, resulting in a unit expressed as USD per ton CO_2, which is plotted along the y-axis. Measures with negative values indicate potential savings, while positive values reflect associated costs. The standard discount rate in the NPV calculations is 8%. The fuel consumption baseline is looked up from the input values in the "Dashboard". The MACC tool sorts the selected measures by cost-efficiency, applying them sequentially and recalculating each one's impact based on the cumulative effect of previously implemented measures—ensuring that savings are not double-counted and that only the most effective remaining options are considered.

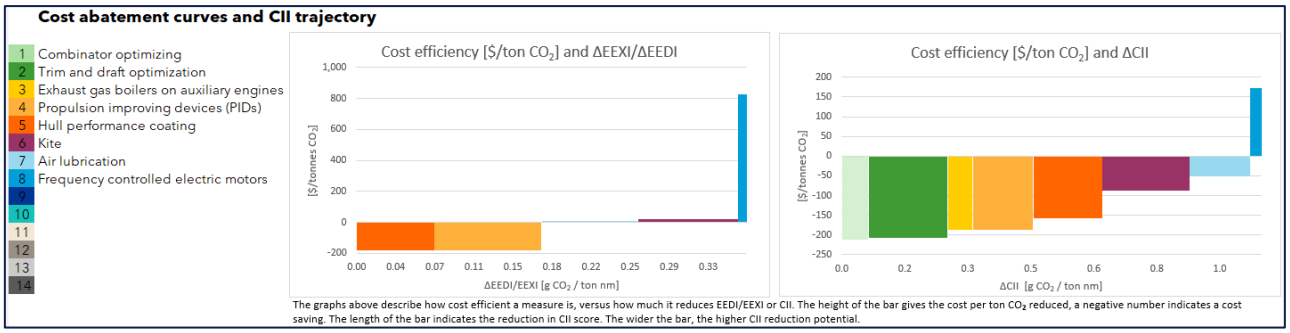
Two graphs are displayed in the dashboard, $\Delta EEDI/EEXI$ and ΔCII. Each bar represents a single measure. The width of the bar indicates the measure's impact on the x-axis metric (ΔEEDI/EEXI or ΔCII), while the height reflects its cost-effectiveness.

In summary, measures that can provide high cost savings and significant annual emission reductions should be prioritized for further investigation. The measures only represent the abatement cost, i.e., the cost per ton of CO_2 reduced, assuming full implementation, and do not reflect the market uptake of each measure.

Curves without an inserted EEXI/EEDI value:



Curves when inserted EEXI/EEDI value:



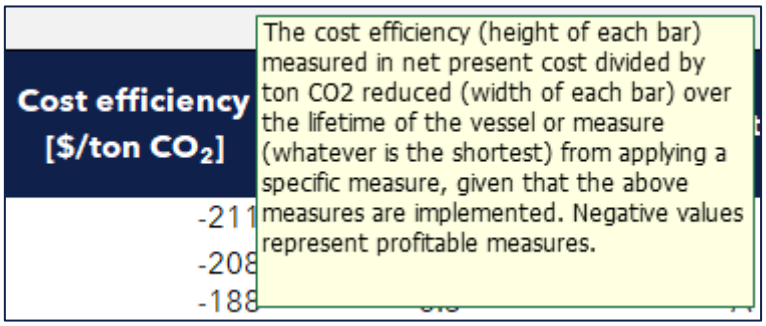
The fuel savings of an operational measure are calculated over its expected duration. If this duration is shorter than the vessel's lifetime, it is assumed that the measure continues in the portfolio and the fuel saving is applied for a new period until the vessel's end of life. The OPEX is an annual cost that occurs every year.

4.2.3.4 Abatement summary

The Abatement summary is a table containing important numbers related to each measure. The summary table provides an overview of the numbers used to make the graphs in the dashboard. The measure summary lists all the measures that have been selected. A brief explanation of all the column entries is provided below:

Abatement summary

ID	Measure	Measure type	Applied fuel reduction [%]	Cost efficiency [$/ton CO_2]	CII value [gCO_2/DWTt nm] [gCO_2/GT nm]	CII rating	EEXI / EEDI [gCO_2/ton nm]	TRL	Measure Lifetime [Years]	OPEX [$]	CAPEX [$]	Payback time [years]	Potentital yearly savings [$]
1	Combinator optimizing	Operational	1.0%	-211	6.8	A	NA	9	25	0	1,175	0.0	67,300
2	Trim and draft optimization	Operational	3.0%	-208	6.6	A	NA	9	25	0	35,250	0.2	199,881
3	Exhaust gas boilers on auxiliary engines	Technical	1.0%	-188	6.5	A	NA	9	25	0	83,719	1.0	64,628
4	Propulsion improving devices (PIDs)	Technical	2.4%	-186	6.4	A	4.90	9	25	0	220,313	1.1	159,955
5	Hull performance coating	Technical	2.8%	-157	6.2	A	4.83	9	5	0	129,250	2.3	187,147
6	Kite	Technical	3.6%	-88	6.0	A	4.73	8	10	16,450	987,000	3.7	225,594
7	Air lubrication	Technical	2.6%	-52	5.8	A	4.65	9	25	20,000	1,498,125	6.6	154,271
8	Frequency controlled electric motors	Technical	0.5%	172	5.8	A	4.64	9	25	3,000	660,938	17.3	30,809
9													
10													
11													
12													
13													
14													



Abatement summary column explanation – from left to right

- **ID:** An ID assigned to the selected measure is displayed. This makes it easier to locate a specific measure in the graphs above.
- **Measure:** A specific title for each measure. Additional information regarding each measure can be found in the information portal (more information here).
- **Measure type**: All measures are categorized as either Technical or Operational.
- **Applied fuel reduction (%):** Each measure has a potential for fuel reduction. The number displayed here is the actual number used in the calculation. The measure with the lowest ID number is applied first before the measure with the second lowinfest is applied – until all selected measures are applied.
  The sequence in which the measures are applied matters. In short, the initial AER value or base number that is used diminishes as more measures are applied, resulting in decreasing effect from each measure applied. So, within each technology group it can be beneficial to select the measure with the highest potential first.
- **Cost efficiency [$/ton CO_2]:** The cost efficiency explains how costs might change with each measure. A negative cost efficiency means a saving is obtained with the measure in question. On the other hand, positive cost efficiency means that there are increased costs related to implementing the measure. The cost efficiency is given in terms of dollars per ton CO_2. To calculate the cost efficiency, the total expected savings/cost related to a measure is divided by the total expected decrease of CO_2 emissions.
- **CII value [gCO_2/dwt nm] or [gCO_2/GT nm]:** The CII-value is calculated using the following formula

$$AER = \frac{\sum_i C_i}{\sum_i dwt\ D_i}$$

  where c_i is the emission of a given transit, dwt is the deadweight of the vessel and D_i is the distance sailed of given transit.
  For calculating CgDist, dwt is replaced with GT in the formula, which gives:

$$AER = \frac{\sum_i C_i}{\sum_i GT\ D_i}$$

- **CII rating:** Once the CII-value (AER or CgDist, depending on vessel type) has been calculated, the value can be translated from a numerical value into a letter score. The possible scores are A, B, C, D and E, with A being

the highest score. The lines are assumed to be linear from 2030, as guidelines only exist for annual reduction targets until 2030. The annual reduction targets have been raised from 2% (2023-2026) to 2.625% for 2027-2030

- **EEXI / EEDI [g CO_2 / ton nm]:** The new EEXI/EEDI value for each measure if the selected measures are applicable for EEXI/EEDI reduction.
- **TRL – Technology Readiness Level:** Each measure is given a score from 1 to 9. High scores reflect a mature technology that is ready to be implemented. A low score indicates that a given measure is currently in trial and is being tested by a few in the industry.
- **Measure lifetime [years]:** Each measure has a life expectancy. Some measures last through the entire lifespan of a vessel with the required maintenance, typically technical measures, while other measures need to be applied with constant intervals e.g., hull cleaning.
- **OPEX [$]:** The Operational Expenditures related to a measure are summarized in the OPEX column. The value is given as a yearly cost.
- **CAPEX [$]**: The Capital Expenditures for a given measure can be viewed in the CAPEX column. The number is given in dollars and as a one-time payment to implement a measure. CAPEX does not include off-hire or dry dock costs, as these will vary depending on the contract and whether the work is part of a regular docking. Therefore, off-hire and dry dock costs are excluded.
- **Payback time [years]:** The payback time is a present value consideration of a given measure. The upfront CAPEX investments are viewed in the potential yearly savings, and the number of years before the investment has paid itself off is calculated.
- **Yearly Savings [$]:** Each measure has a specific fuel reduction associated with it. The yearly savings indicates how much the potential savings from implementing a measure can be. There are uncertainties related to fuel price and actual fuel reduction from implementing a measure. However, the column makes a comparison between the different measures.

4.3 User instructions

The following subsection of chapter 4 is meant to educate the user on how to use the tool correctly, step by step.

1. Select the “Dashboard” tab if you are not already on this page.
2. Select the relevant vessel type from the dropdown menu.
3. Insert the correct vessel size and capacity.
4. Define whether the vessel is a newbuild or retrofit.
5. Insert the building year of the vessel.
6. Define the expected lifetime for the vessel. This is used in cost calculations.
7. Insert the year for which the operational data is applicable. This is used to calculate the score of the CII.
8. Select the fuel type, insert fuel consumption, and fuel price. **Note:** it is possible to select a two fuel types – minimum one is required.
9. If available, insert attained CII. If not available, insert distance sailed. CO2 emissions will be calculated based on inserted fuel consumption.

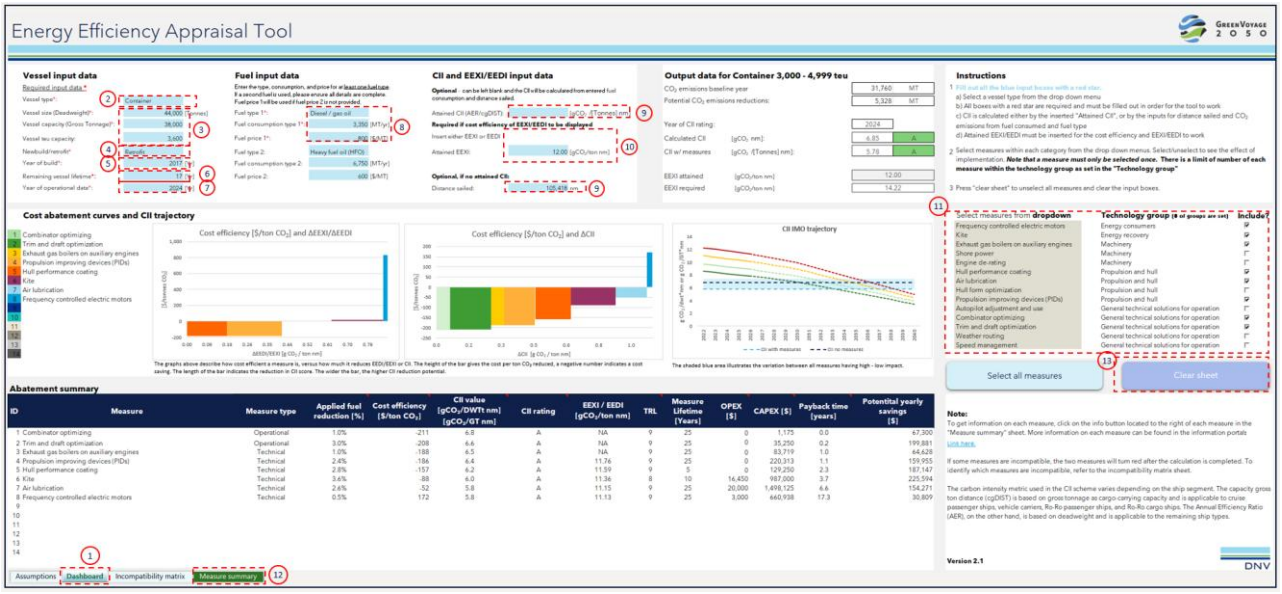
10. If available, insert either attained EEXI or EEDI depending on when the vessel was built or if it has been through major conversions. If EEDI is inserted the EEXI field will blank out as illustrated below. The opposite will occur if EEXI is entered.

11. Select measures from the dropdown menu. Info about each measure can be found in the “Measure summary” sheet in the column with “i” box. You can also select a different measure within the Technology group by choosing from the dropdown menu in the measure cell. The number of measures in each Technology group is set to be: 1 *Energy consumer*, 1 E*nergy recovery*, 3 *Machinery*, 4 *Propulsion and hull* and 5 *General technical solutions for operation.*

12. *Optional: if you want to edit any of the measure values, go to the “Measure summary sheet.” Find the measure you want to edit and change the values in the grey fields.* ***Note: you will now overwrite the original value;*** *to get back to this value, you will need to download the template again or re-enter the original value.*

13. Press clear sheet if the user wants to clear the sheet and unselect all measures.

If any of the selected measures are incompatible, an error message will show up. Change the measure combination until there are no error messages. The measures will turn yellow if they are not applicable for retrofit or newbuild.



5 REFERENCES

/1/ Fourth IMO GHG Study 2020

/2/ Maritime Forecast to 2050 – Energy Transition Outlook 2020, DNV GL, download at eto.dnv.com

/3/ Maritime Forecast to 2050 - Energy Transition Outlook 2021, DNV, download at eto.dnv.com

/4/ Maritime Forecast to 2050 - Energy Transition Outlook 2022, DNV, download at eto.dnv.com

/5/ Adoption of the Initial IMO Strategy on Reduction of GHG Emissions from Ships and Existing IMO Activity Related to Reducing GHG Emissions in the Shipping Sector, Note by the International Maritime Organization to the UNFCCC Talanoa Dialogue.

/6/ Maritime Forecast to 2050 - Energy Transition Outlook 2023, DNV, download at eto.dnv.com

About DNV

DNV is the independent expert in risk management and assurance, operating in more than 100 countries. Through its broad experience and deep expertise DNV advances safety and sustainable performance, sets industry benchmarks, and inspires and invents solutions.

Whether assessing a new ship design, optimizing the performance of a wind farm, analysing sensor data from a gas pipeline or certifying a food company's supply chain, DNV enables its customers and their stakeholders to make critical decisions with confidence.

Driven by its purpose, to safeguard life, property, and the environment, DNV helps tackle the challenges and global transformations facing its customers and the world today and is a trusted voice for many of the world's most successful and forward-thinking companies.