

Environmental Ship Index (ESI) Fundamentals 2017

1. Port's Clean Air and Ship's emissions

Ports are the indispensable key hubs in the global supply chain that enable the uninterrupted flow of world trade providing economic activities and jobs. The ports also have responsibilities in maintaining a clean and healthy environment in the port area.

Clean and efficient land based operations in ports are part of that responsibility but ports also try to improve the performance of ships visiting their ports areas by encouraging them to reduce their air emissions as much as possible.

2. Engines & Fuels

Ships shall comply with MARPOL 73/78 Annex VI. This Annex specifically sets limits on fuel sulfur content limits which reduce emissions of sulfur oxides (SO_x) and sets engine standards for nitrogen oxide (NO_x) emissions from ships exhausts and prohibits deliberate emissions.

The Environmental Ship Index (ESI), established in 2011, is an international program developed through the World Ports Climate Initiative (WPCI) of the International Association of Ports and Harbors (IAPH). IAPH/WPCI seeks international collaboration among ports and shipping lines to further reduce emissions to air and greenhouse gasses and to promote sustainability.

Through ESI, ports and other interested parties promote ships to use cleaner engines and fuels and receive preferential treatment by allowing discounts on port dues, granting bonuses and other benefits commensurate with the level of cleanliness.

In the ESI Program four main groups of emissions are distinguished as follows :

NO _x emissions	mainly dependent on the engine properties;
SO _x emissions	mainly dependent on the fuel's sulphur content;
PM (particulate matter) emissions	related to SO _x emissions and
CO ₂ emissions	mainly dependent on the amount of fuel used.

NO_x, SO_x and PM have a direct effect on the air quality in a port area and they are the main constituents of the formula for calculating the ESI Score (see below).

It has been demonstrated that the "damage potential" of both SO_x and NO_x with respect to negative effects on human health (pulmonary diseases, etc.) and the environment (acidification, etc.) are about equal; however, in combustion processes a double amount of NO_x units is produced. This is reflected in the formula by doubling the result of any reduction of the average NO_x emissions.

CO₂ emission reduction - as a consequence of increased fuel efficiency - results in positive changes in the global air quality (climate issues); its effects are not immediately reflected in the conditions in a port area. The willingness of ship owners to engage in measures to improve fuel efficiency in ships, is considered to be a direct sign of their positive attitude towards taking measures for the environment in general and increasingly this aspect is taken into account in the ESI Score.

CO₂ emission reductions will focus on increasing ship fuel efficiency resulting in reduced consumption and generally less pollution on a per mile basis.

3. ESI Formula

The ESI Score is the sum of points for each of the emission groups NO_x, SO_x and CO₂ (PM is included in the SO_x sub score). In calculating the ESI NO_x and ESI SO_x parts a maximum of 100 sub points may be reached. ESI CO₂ contributes between 5 and 15 points to the ESI Score while the presence of OPS adds another 10 points; please remember that emission of CO₂ is a climate critical component and not of prime importance for clean air in ports.

For a ship that is fitted with an engine or uses a fuel, that is only just in compliance with the mandatory requirements (IMO regulations) for NO_x emissions and sulphur content respectively, both the NO_x and SO_x sub points are set at 0. At the other extreme, where neither NO_x nor SO_x is emitted on board a vessel the score for each is 100 sub points.

SO_x emissions affect ports most when in or near ports; reduction of emissions at the high seas doesn't directly affect ports, but it is included to stimulate ship owners' consciousness about the environment.

As a consequence the maximum of 100 sub points to be gained in this section is divided in maximum 35 sub points for fuel used in port, 35 sub points for fuel used near port or in an ECA and 30 sub points for fuel used at the high seas; in other words 30 sub points for the use of HIGH, 35 sub points for MID and 35 sub points for LOW fuel oils, respectively.

A vessel fitted with an On-shore Power Supply (OPS) installation - independent of its use – adds another 10 points to the ESI Score which is capped at 100 :

$$\text{ESI SCORE} = \text{ESI NO}_x + \text{ESI SO}_x + \text{ESI CO}_2 + \text{OPS (max. 100)}$$

$$\text{ESI NO}_x = X \quad 2 \times \text{NO}_x \text{ sub points divided by } 3$$

$$\text{ESI SO}_x = Y \quad \text{SO}_x \text{ sub points divided by } 3$$

ESI CO₂ : The efficiency of a vessel is calculated over a 3 (three) year period based on the reported totals of fuel consumption and distance sailed in that period (base line period); efficiency over a reporting year i.e. any year in the next three year period is also calculated (reporting period). Change in efficiency between these two periods is calculated and any increase in the reporting period over the base line period is recorded.



Reporting during the 3 year period adds 5 points to the ESI score and any efficiency increase in % in the reporting period is added to the ESI Score as points; the ESI CO₂ is capped at 15 points.

The calculation of efficiency takes place at the date of calculation of the ESI Score for the same period over which the BDNs received have been entered; the half year period over which fuel used and distance sailed are requested coincides with the BDN reporting period.

OPS = **10** if On-shore Power Supply (OPS) installation is fitted .

ESI NO_x, ESI SO_x, ESI CO₂ and OPS points are separate, independent parts of the formula and consequently each of them is calculated independently based on data present; if no data are present for one or more of these parts, that part cannot be calculated which will result in a lower ESI Score.

As an example, it is acceptable that no data are entered on OPS just as it would be OK not to enter any engine data to calculate ESI NO_x sub points. However, where it is decided to include engine data then the data of all engines should be entered and conversely whenever those data are not present in full, no data for the NO_x part of the equation should be entered. Similarly, for the SO_x part and that may be simpler to understand: if entry of all data wouldn't be required, the bunkering(s) with the highest S % could simply be left out or "forgotten", resulting in a high but not really correct ESI SO_x sub score.

Where electrical power is supplied to a ship by a non-ship-fitted power generator its emissions cannot be considered as ship's emissions even if such generators are controlled by the vessel. The ship may however, qualify for the OPS bonus if in compliance with the applicable conditions.

4. Calculating the ESI NO_x score

MARPOL Annex VI requires ships to be installed with engines that meet certain NO_x emission standards. These standards are divided into tiers based on the date of the ship's construction. Tier I engine standards are applicable for ships that are constructed on or after 1 January 2000 through 31 December 2010.

Tier II engine standards are applicable for ships that are constructed on 1 January 2011 or beyond.

The standards are further divided by crankshaft speed of the engine "n", expressed in revolutions/minute "rpm" and set limit values "LV" expressed in g/kWh based on following criteria :

- Tier I Engines where $n < 130$, the LV is 17.0;
Engines where n is within the range of $130 \leq n < 2,000$ the LV is determined by the following equation: $45 * n^{(-0.2)}$;
Engines where n is $\geq 2,000$, the LV is 9.8.



Tier II Engines where $n < 130$, the LV is 14.4;
Engines where n is within the range of $130 \leq n < 2,000$ the LV is determined by the following equation: $44 * n^{(-0.23)}$;
Engines where n is $\geq 2,000$, the LV is 7.7.

From 1 January 2016, Tier III is applicable for ships sailing in an ECA

Tier III Engines where $n < 130$, the LV is 3.4;
Engines where n is within the range of $130 \leq n < 2,000$ the LV is determined by the following equation: $9 * n^{(-0.2)}$;
Engines where n is $\geq 2,000$, the LV is 2.0.

Tier I, Tier II and Tier III ships are issued with an International Air Pollution Prevention (IAPP) Certificate and selected details of this certificate have to be entered in the ESI database. It should be ascertained that the IAPP Certificate is still valid beyond the next calculation date of the ESI Score.

Additionally, for each engine installed ships are issued an Engine International Air Pollution Prevention (EIAPP) Certificate.

This certificate shows the rated power "RP" in kW and the actual NO_x rating "RV" expressed in g/kWh of each engine; it appears in the Certificate as "**Parent Engine(s) Emission Value (g/kWh)**". The former value should be entered in the box "Rated power (kW)" and the latter value should be entered in the box "Actual emission level (g/kWh)".

The limit value "LV" expressed in g/kWh is a function of the RPM and it is automatically calculated by the system based on the RPM entered in the appropriate box; it appears in the Certificate as "**Applicable NO_x Emission Limit (g/kWh), regulation 13.3, 13.4, or 13.5.1**" but doesn't need to be entered.

Having entered these data into the ESI database, the ESI NO_x score can be calculated.

The ESI Working Group has developed the following formula for the ESI NO_x sub points calculation :

ESI NO_x = {100 / (sum of RP of all engines)} * {Sum of (LV – RV) * RP/LV_{eng.1} + (LV – RV) * RP/LV_{eng.2} + (LV – RV) * RP/LV_{eng.3} + (LV – RV) * RP/LV_{eng.4} ...etc. etc.}

$$ESI\ NO_x = \frac{100}{\sum_{i=1}^n RP_i} \times \sum_{i=1}^n \left\{ \frac{(LV_i - RV_i) \times RP_i}{(LV_i)} \right\}$$

The following is an example of a ESI NO_x score calculation for a ship with a main engine and three identical auxiliary engines :

		Main engine(s)	Auxiliary engine(s)	
NO _x Tier I Limit Value	LV	17	11.5	g/kWh
NO _x Rated Value	RV	15	11	g/kWh
	n	130	900	RPM
Rated Power	RP	9480	970	kW
Number of engines	<i>n</i>	1	3	



$$\left\{ \frac{1}{(9480 + 970 \times 3)} \times 100 \right\} \times \left\{ (17 - 15) \times 9480 \times \frac{1}{17} + (11.5 - 11) \times 970 \times \frac{3}{11.5} \right\} = 0.008 \times 1241 = 10.0$$

$$\text{ESI NO}_x = \frac{100}{(1 \times 9480) + (3 \times 970)} \times \left\{ 1 \times \left(\frac{(17 - 15) \times 9480}{17} \right) + 3 \times \left(\frac{(11.5 - 11) \times 970}{11.5} \right) \right\}$$

In calculating the ESI NO_x sub points, Tier I Limit Values are used as a base line regardless of applicable Tier for the ship; for the next few years this approach will be maintained.

Ships that are constructed before 1 January 2000 that have not been issued with an IAPP-certificate and where no engines are fitted with an IEAPP-certificate can nevertheless obtain an ESI NO_x score provided such ships have been issued with an “approved statement” to the effect that engines meet Tier I requirements.

5.1 Calculating the ESI SO_x score

ESI SO_x sub points will be calculated based on the amount and type of sulphur of fuel bunkered based on the following fuel sulphur percentage ranges :

- 0.50 < S % ≤ 3.50 HIGH (previously HFO High sea)
- 0.10 < S % ≤ 0.50 MID (“ HFO LS/MDO ECA)
- 0.00 < S % ≤ 0.10 LOW (“ MDO LS Port)

The ESI Working Group has developed the following formula for the ESI SO_x score calculation :

ESI SO_x = x * 30 + y * 35 + z * 35 where :

- x = the relative reduction of the average sulphur content of HIGH.
- y = the relative reduction of the average sulphur content of MID.
- z = the relative reduction of the average sulphur content of LOW.

For each of the categories HIGH, MID and LOW the average S % (a, b and c respectively) is calculated as a mass weighted average as follows :

HIGH : bunker 200 tons with 3.00 % S, 400 tons with 2.00 % S and 200 tons with 1.50 % S :
(200*3.00 + 400*2.00 + 200*1.50) / (200 + 400 + 200) = **2.125 % S** **a**

MID : bunker 100 tons with 0.49 % S, 50 tons with 0.30 % S :
(100*0.49 + 50*0.30)/(100 + 50) = **0.427 % S** **b**

LOW : bunker 15 tons with 0.01 % S and 25 tons with 0.09 % S :
(15*0.01 + 25*0.09)/(15 + 25) = **0.060 % S** **c**

The following are the baselines for the various fuels :

- 3.50 % S for HIGH (IMO regulation)
- 0.50 % S for MID (ESI Working Group decision)
- 0.10 % S for LOW (IMO regulation)

The relative reductions x, y and z may now be calculated as follows :

- HIGH $x = (3.50 - a \text{ 2.125}) / 3.00 = 0.458,$
- MID $y = (0.50 - b \text{ 0.427}) / 0.40 = 0.183$ and
- LOW $z = (0.10 - c \text{ 0.060}) / 0.10 = 0.400.$

Using the formula $ESI SO_x = x * 30 + y * 35 + z * 35$ calculate the $ESI SO_x$ sub points :

$ESI SO_x = 0.458 \times 30 + 0.183 \times 35 + 0.400 \times 35 = 13.7 + 6.4 + 14.0 = 34.1 (= 11.0 \text{ ESI Points}).$

5.2 Fuel Bonus

To stimulate the use of cleaner fuel, bonuses are included in the $ESI SO_x$ sub points calculation to induce ship owners to bunker fuels with the lowest possible sulphur content:

- Ships that do not bunker fuels higher than 0.50 % sulphur, receive the maximum 30 sub points of the HIGH fuel range provided that fuel of at least one other sulphur content range is bunkered;
- Ships that only bunker fuels with sulphur content less than or equal to 0.10 % sulphur (LOW fuel), receive as a bonus the 30 sub points of the 0.50 - \leq 3.50 % sulphur content (HIGH fuel) range and the 35 sub points of the 0.10 - \leq 0.50 % sulphur content (MID fuel) range;

This is however only applicable for vessels that have sailed in- and outside (S)ECA's during the reporting period; where ships sailed in (S)ECA's only, the 30 sub points for the HIGH fuel range are not added.

The reason for this is that incentives are not provided for mandatory items and in (S)ECA's vessels may only use LOW fuel oil; however, if the vessel did actually sail outside the (S)ECA while continuing to only use LOW fuel oil, the HIGH bonus will be added. In order to prove this, the number of days outside the (S)ECA during the reporting period has to be entered into a box in a section of the data entry page that will open after an appropriate question has been answered positively. Alternatively or additionally ports visited outside the (S)ECA in the reporting period may be entered.

Rewarding the use of cleaner fuel with a bonus is translated into the following rule for calculation : the average sulphur content (a, b and c) for any fuel type that is more polluting and while being allowed to, is not bunkered is set at the lowest level of its range; consequently the full amount of sub-points for any dirtier fuel that is not bunkered is given as a reward.



Take the above example and assume that the ship doesn't bunker any HIGH but only MID and LOW and the above rule would result in

$$\text{ESI SO}_x = 1.00 \times 30 + 0.183 \times 35 + 0.40 \times 35 = 30.0 + 6.4 + 14.0 = 50.4 (= 16.3 \text{ ESI Points}).$$

Further cleaning up and only bunkering LOW would lead to the even higher value of

$$\text{ESI SO}_x = 1.00 \times 30 + 1.00 \times 35 + 0.40 \times 35 = 30.0 + 35.0 + 14.0 = 79.0 (= 25.5 \text{ ESI Points}).$$

Check table for more information.

CATEGORY OF FUELS BUNKERED	HIGH sub-points	MID sub-points	LOW sub-points	RANGE of sub-points
HIGH	max. 30	0	0	0 - 30
MID	bonus 30	max. 35	0	30 - 65
LOW	bonus 30 *	bonus 35	max. 35	65 - 100
HIGH & MID	max. 30	max. 35	0	0 - 65
HIGH & LOW	max. 30	bonus 35	max. 35	35 - 100
MID & LOW	bonus 30	max. 35	max. 35	65 - 100
HIGH & MID & LOW	max. 30	max. 35	max. 35	0 - 100

* only if vessel sailed outside ECA

6. Calculating the ESI CO₂ score

The ESI Working Group has been considering a number of approaches to include an adjustment in the ESI score associated with reductions in Green House Gases, which acknowledges the efforts by industry to reduce emissions of CO₂ through increasing the fuel efficiency of ships. Reducing the amount of fuel used will - by its very nature - lead to less CO₂ generation and hence less pollution on a per mile travelled basis.

Reductions of CO₂ emissions - from improvements in fuel efficiency - will have positive effects on global climate issues. To encourage further improvements and to promote the ship owners' continued positive attitude towards taking measures for the environment in general, CO₂ will be an aspect that will be increasingly taken into account in the ESI score (through the ESI CO₂ score). It is also recognized that the resultant overall reduction of emission of SO_x, NO_x and PM does have a limited effect only on the air quality in and around ports.

The Working Group has studied a number of methods to measure fuel efficiency as they are used by various industry bodies and has reached the conclusion that for the purpose of including improvements in efficiency into ESI, a simple yet efficient method is preferable. The recommended method from the Working Group that meets these requirements of simplicity and efficiency is the recording of fuel amount consumed and distance sailed in a certain period; IMO's MEPC.1/Circ.684 contains pertinent definitions of both these data sets.

Starting 1 July 2013, the ESI website enables a ship owner to enter these two data sets in the database for periods that are similar to the reporting periods for BDNs; upon entering the requested data, a bonus (previously 10 ESI CO₂ sub points) was included in the calculation of the ship's ESI Score.

An important element of this approach is the creation of a base line against which future data on fuel used and distance sailed may be compared to determine any potential improvements in fuel consumption efficiency. It has been decided to use the actual vessel itself to establish the ship's base line. It is acknowledged that this approach would require a fairly extended period of data collection to dampen (off set) variations in seasons, loading conditions, trading patterns, ports visits, etc. in order to establish a ship specific base line. The Working Group is of the opinion that such a period should not be shorter than three years.

The efficiency of a vessel is therefore calculated over a 3 (three) year period based on the reported totals of fuel consumption and distance sailed in that period (base line period); efficiency over a reporting year i.e. any year in the next three year period is also calculated (reporting period). Change in efficiency between these two periods is calculated and any efficiency increase in the reporting period over the base line period is recorded.

Reporting during the 3 year period adds 5 points to the ESI score and any efficiency increase in % in the reporting period over the efficiency of the base line period is added to the ESI Score as points; the ESI CO₂ is capped at 15 points. If no improvement is determined, no action will follow.

The calculation of efficiency takes place at the date of calculation of the ESI Score for the same period over which the BDNs received have been entered; the half year period over which fuel used and distance sailed are requested coincides with the BDN reporting period.

7. Audits

The Terms of Use in section 10.4 outline the procedures for auditing the Ship's Data that have been provided by Data Providers (Ship Owners) and that are used to calculate the ESI Score. The audits may be in the form of administrative checks of data provided and/or on board ship or in office inspections of data provided including documents pertaining thereto.

On request an Incentive Provider (IP) may be granted the right to audit the data that are used to calculate the ESI scores of vessels that are, have been or will be included in the incentive program of that IP. For that purpose the IP may select a person (auditor) with a sound knowledge of and experience at inspections of sea going vessels; after selection the auditor will have to be authorized by the ESI Administrator to perform audits.

An auditor having been advised of his selection by the IP will register as "Auditor" in the ESI data base representing that particular IP. The ESI Administrator, after having ascertained the suitability of the auditor, will activate the auditor and thereafter the appropriate section in the ESI Database may be opened. The name of the auditor will appear in the section "Manage Auditors" of the IP represented.

If an IP would want ship's data to be audited, an auditor may be selected in the section "Manage Auditors"; the ship(s) and the date(s) of calculation of the ESI score that the IP would want to be audited are assigned to that auditor; the period(s) in which the ship(s) may be visited should also be specified: this period cannot exceed 14 consecutive calendar days. The auditor is informed of this assignment; the ESI Administrator is copied.

Only after this assignment, the auditor having logged in can click on "View ships" and will in "Ships available for audit" see the ship(s) assigned to him for inspection. Clicking on the magnifying glass (View Details) will show the data of the vessel available for inspection including three randomly selected BDN's and the total of BDN's registered for the period under review. Clicking on "Download Audit Report" will make the ESI Audit Report available in "pdf" format for printing and storing.

After having stored the completed Audit Report, the auditor should upload this report into the ESI Data base using the function "Upload audit report" in his section of the web site. Ship Owner and ESI Administrator will then be automatically informed of the result of the Audit. The Audit Reports will be available to IP's authorized to view all reports.

The auditor can only pass a vessel if the data that have been reproduced from the database in the downloaded Audit Report, are in complete conformity with the data that are made available to him on board the vessel in certificates, documents, logbooks, etc.

Where a nonconformity however slight, is observed, the vessel will fail the audit. In such cases the ESI Administrator will recalculate the ESI Score of the vessel on the basis of the official certificates, documents, logbooks, etc. made available on board the vessel. Where the recalculated ESI is lower than the ESI Score appearing on the Audit Report, the ESI Administrator will revoke the validity of the ESI Score for the present period. Ship Owner and Incentive Providers are informed of this action. Where the nonconformities concern administrative matters there is no change in ESI Score and no consequences are attached to such fail.