Ship Energy Efficiency Plan

Resolution MEPC.203 (62) – Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (inclusion of Regulations on Energy Efficiency for Ships in MARPOL Annex VI), adopted on 15 July 2011

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Glossary

Term	**Definition**
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
GHG	Greenhouse Gas
IMO	International Maritime Organisation
ISM	International Safety Management (code)
MEPC	Marine Environmental Protection Committee
SEEMP	Ship Energy Efficiency Management Plan
SMS	Safety Management System
ECA	Emission Control Area
IAPP	International Air Polllution Prevention
EIAPP	Engine International Air Pollution Prevention
PM10	Particulate Matter < 10 µm

1. General

The purpose of the Shipboard Energy Efficiency Management Plan (SEEMP) is to establish procedures for MARSIG to improve the energy efficiency of a ship's operation.

MARSIG honours its commitment to protect people and the environment by tracking and analyzing energy consumption on vessels, using lessons learned and best practices, to improve energy efficiency while reducing emissions.

It is MARSIG Shipping Policy that vessels are always operated and marine operations conducted as efficiently as possible, consistent with safe and reliable operations.

Increased energy efficiency remains the cheapest and most abundant form of new energy available today. SEEMP lays the foundation to put processes in place to optimize operational processes and improve profitability through the efficient use of people and assets. It is a resource guide for all personnel to increase energy efficiency in vessel systems and operational processes.

2. Human resources and responsibilities

The master has the overriding authority and ultimate responsibility to decide about procedures and equipment to be used on board and suitable for energy efficient operation. He delegates the organisation and documentation of SEEM to one of his Navigational Officers (see Appendix) who acts as the Energy Efficiency Manager on board.

The fleet management has the final authority to formulate goals and measures for improvement of energy efficiency on board the ship.

The company provides all resources to can implement and maintain the SEEMP:
- The fleet management is responsible to plan on board energy audits
- The technical superintendent is carrying out the energy audit on board
- Fleet management, superintendent and master/chief formulate ship specific measures, control their implementation and documentation
- The fleet management is setting ship specific measures in force
- The Master is responsible for energy efficiency familiarisation on board the ship
- The Chief Engineer and superintendent are responsible for monitoring of ship energy efficiency and documentation

3. SEEMP Documentation and Sources

The SEEMP is written using IMO circular MEPC.1/Circ.683 as guidance. Operational procedures and recommendations are based on:
- IMO Guidance for the development of a SEEMP; MEPC.1/Circ.683
- MEPC Guidelines for voluntary use of the EEOI
- Guidelines for calculation of reference lines for use with the EEDI
- Maritime Industry (Air Pollution from Ships, MARPOL Annex VI and other issues)
- Shipping, World Trade and Reduction of CO2 Emissions, United Nations Framework
- Convention on Climate Change (COP16) – IMO/ MEPC

4. Planning– Appendix 1/2

According MEPC.1 Circ 683 the planning primarily determines both the current status of ship energy usage and the expected improvement of ship energy efficiency.

4.1 Ship specific measures - Appendix 1

The planning has to identify specific measures for the ship to improve energy efficiency. These measures are listed here in 3.1 provide overview of the actions to be taken for ship.

Identified energy-saving measures which have been undertaken and their effectiveness depend on what measures can be useful adopted to further improve the energy efficiency of the ship. Not all measures can be applied every time and to be approved regularly at least annually or in case of change of charterer or trade / trade area.

The company has formulated in Appendix ‘Ship energy efficiency measures’ all measures are in force with:
- Implementation
- Responsibility
- Monitoring
- Evaluation

4.2 Company specific measures - Appendix 2

The ship operation as result of cooperation of many parties like shipowner, operator, charterer, cargo owner, ports, traffic management, yards, supplier etc. is mainly planed in the office with high influence of energy efficiency and liability.

Following aspects to be considered for ship operation:

Voyage Performance / Offshore Operations
- Voyage planning & execution
- Weather routing & sea current
- Speed Management
- Logistic planning
- Chartering/contracts
- Port/harbour operations
- DP operations

Ship Performance
- Hull condition
- Propeller condition
- Trim & draft
- Autopilot & rudder
- Appendages & Technical modifications

Fuel Management
- Pre-bunkering
- During bunkering
- Post-bunkering

Main and AUX engines
- Main Engine efficiency
- Aux Engines efficiency & utilization
- Boilers efficiency & utilization

Consumers
- Thruster operations
- Cargo operations
- Ventilation, HVAC, lights
- Insulation & energy losses
- Water productions
- Incinerator
- Compressors

Management and organisation
- Strategy & tactical plans
- Roles & responsibilities
- Culture & awareness
- Competence & training
- Cooperation & communication
- Performance Management

4.3 Training and familiarization

Each new crew member and office employee has to be familiarized with the energy efficiency system of our company. Depending of rank, responsibility and authority the familiarization is particularly different and included in the familiarization form accordingly.

On board training concerning energy efficiency should comprise at least a bi-annual meeting of entire crew with aim to keep sensibility for this topic on highest level as possible.

Each crew member gets information to can understand specific vessel's operations and interactions with equipment of high potential to waste or save energy.

A key component of vessel familiarization process is a regularly (twice a year or in case of trade change) discussion on energy conversation and consumption.

As part the of initial vessel familiarization, each person should have an understanding of the specific vessel operations and how the crew's interactions with that specific piece of equipment has the potential to waste or save energy.

Very simple good habits can have the potential to save a lot of electricity. For instance, switching lights, television sets, and forced draft fans off have a great potential for saving energy.

A list of energy best practices is developed and handed over during familiarization on what the major onboard consumers are and what can be done to save energy.

4.4 Goal setting

The purpose of goal setting according MEPC.1 Circ 683 is to serve as a signal which involved people should be conscious of, to create a good incentive for proper implementation, and then to increase commitment to the improvement of energy efficiency. Whatever the goal is, the goal should be measurable and easy to understand.

The company will precise goals for each ship separately in intervals not exceeding 12 months as reasonable. Our company energy efficiency policy and goals can be only published by the management by means of formless statement.

Besides natural efforts during daily operation of ship the goal setting will be only used in case of separate, specified third party request concerning energy efficiency improvement (national or charter requirements, etc,)

The goal setting of all ships and evaluation is part of the Management Review.

5. Implementation – Appendix 1/2

The SEEMP describes with App. 1/2 how existing or new measures should be implemented and who the responsible person(s) is.

Record-keeping for measurements and the control for self-evaluation has to be done with the form system of SEEMP. If any identified measure cannot be implemented for any reason(s), the reason(s) should be recorded, too.

The controlling of measures on board is recorded by Form EEM Measures Voyage

The controlling of long term measures planed by company is recorded by Form EEM Measures Long Term.

6. Monitoring / EEOI – Appendix 3

6.1 Monitoring:

- should be binding and equally applicable to all ships
- should be practical, transparent, fraud-free and easy to administer by authority
- should enable compliance to be demonstrated through proper monitoring
- should ensure certainty and predictability

The monitoring of energy efficiency standard in our company is made by EEOI. Consensus is that the EEOI is not mandatory, but recommendatory in nature, and this does not mean that it will not be made mandatory in future.

In order to establish the EEOI, the following procedure to be in force:

1. define the period for which the EEOI is calculated*;
2. define data sources for data collection;
3. collect data;
4. convert data to appropriate format; and
5. calculate EEOI.

Ballast voyages, as well as voyages which are not used for transport of cargo, such as voyage for docking service, to be **also included**.

Voyages for the purpose of securing the safety of a ship or saving life at sea to be **excluded**.

6.2 Key questions

The monitoring of energy efficiency by EEOI has to keep in mind that until now following key questions not yet clear:

- **Baseline:** Transport efficiency potential depends on location of origin and destination, cargo volumes, ability to find return goods, type of goods and more.

- **Allocation:** Distribution of emissions in cases where multiple cargo types are carried (e.g container vessels, etc.).

- **Baseline drift:** Changes in transport demand and fleet size cause changes in relative cargo availability hence efficiency. To be effective, the baseline must be more or less continuously adjusted.

- **Regional impacts:** A side effect of this approach could be that transport cost increase in remote and sparsely populated areas due to the inherent lower efficiency.

- **Ownership and verification:** The CO2 efficiency of a ship depends on its operation which may be controlled by a charterer that is not the ship owner. In this case, if a ship is sold or transferred, who owns the index.

- **Density of the cargo:** Ships can transport weight restricted cargo (high density cargo) or volume restricted cargo. Since the formula is expressed in mass of CO2 per tonne-mile of transport work, the former ship would always have a better index than the latter.

Reasonable other monitoring tools can be only used if confirmed by the management. In such case the concept and method of monitoring to be determined in this SEEMP, too.

7. Self-evaluation and improvement

The evaluation is based on SEEMP form system to be filled during ship's operation and reviewed from ship staff and inspection department in the office. At least once a year the management has to decide what types of measures can/cannot function effectively and how and/or what are the reason(s).

An onboard energy audit is an independent survey and assessment of the overall energy consumption and efficiency of each main electrical consumer.

These surveys and assessments are part of periodical survey by superintendent(s) with focus of energy loss, energy optimizing, energy measures and goal setting and control. The documentation is part of superintendent's report.

The internal verification on board will have at least following items:

- The Energy Management Policy is well implemented
- The crew demonstrates effective onboard implementation of SEEMP
- Voyage management incl. appropriate measurement and reporting requirements.
- Efficient use of energy and vessel optimisation including appropriate measurement and reporting requirements.
- Procedures are in place for measurement and monitoring of overall fuel consumption.
- All fuel is purchased against a defined specification.

8. Energy efficiency design index – EEDI

It is company's policy to use EEDI for technical efficiency interpretation of new buildings. For more details see Appendix 4

9. Reporting

<u>Reporting emissions per voyages</u>

Advantages:

- Ensures all relevant voyages are reported, recorded, inspections can take place and enforcement if necessary.
- Ensures infrequent visitors are included in the scheme.
- Evasion can be identified as it happens as opposed to annual.
- Limits effect of changes or owners/charterers.

Disadvantages:

- Reporting requirements relatively high, especially for vessels with frequent port calls
- Increased burden on crew that already have to verify bunker and stores, deal with customs, immigration, Port State Control, class, Flag, agents and any number of vetting agencies in relatively short period of time
- Potential increase in delays and port congestion – delay in bunkering for inspection.
- Adds a reporting stream – If CO_2 accounts are going to be verified by third party.

Reporting emissions – monthly or in other intervals

Advantages

- Lower Administrative burden for ship, reduced burden on crew for reporting.
- Only monthly (or more) verification of CO2 account by fleet management.

Disadvantages

- Voyage definition, reporting and recording requirements from company might need to be modified during the year.
- Change of charterer/trade etc. can add some complexity account maintained and unique to ship

It is the decision of fleet management for each ship separately which kind of reporting and for how long it has to be used. It is supposed from the captain to be informed from our company accordingly.

Ship Energy Efficiency Plan

Appendix 1

Ship specific measures

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1. Fuel-Efficient Operations

Strategy of SEEMP is to achieve maximum fuel efficiency while maintaining organizational effectiveness. The plan focuses on systems and processes with highest energy conservation potential and implements procedures without placing unnecessary burdens on ship management.

2. Weather Routing System

Vessels using weather routing have demonstrated potential for efficiency saving on specific routes. This allows MARSIG to plan routes, when possible, to take advantage of favourable weather and avoid adverse weather to obtain best performance in speed or fuel consumption.

Our Weather Routing Program consists:
Bridge Weather Routing System: weather infos used to increase efficiency of ship economic.

If installed the Bridge Weather Routing System enables the ship to take strategically and economically sound decisions at voyage planning stage. It provides the ship management with various route options, weather forecast, route optimization, post-voyage analysis, bunker- and route reports. The Weather Routing System also allows the ship to update forecast during voyage, to make adjustments if necessary and to review collected data after voyage.

Were efficient a web-based application will be used to enable shore-side ship operator to monitor vessel performance and in taking decisions.

The Fleet Management System is a web-based application enables users to track vessel's position and see world's weather in surrounding areas. Office staff can also set parameters which can be monitored and alarms can be set such as high fuel consumption or under speed performance.

3. Virtual Arrival, Speed Control and Voyage Planning

Communication and team work between Charterer, Customer, Terminal Operator, and Ship Manager is standard in our company and significant for savings in energy usage.

Further the Speed is "optimised" when ship's estimated arrival is at the same time when the terminal is ready. So far Manager and Charterers agree a speed adjustment.

By maintaining appropriate speed control in voyage planning, all parties involved ensuring that ship arrives at its destination as efficiently as possible.

Best Practices

- Ships are to communicate economy impacts and choices of voyage orders to office and charterer.
- Office / Management are to provide the desired ETA at ports to allow the ship's crew to better manage the speed and fuel consumption of the vessel.
- Operation department / Charterer are to advise each voyage if it is possible to transfer engine slops to slop tanks to avoid diesel consumption in incinerator.

4. Propeller and Hull Inspection

Ship resistance is improved by keeping propeller and hull clean. In general, hull and propeller are cleaned based on condition assessment according class requirements.

Best Practices

- Monitor the propeller ship and overall efficiency of the vessel to look for possible hull fouling signs and schedule cleaning ahead of regularly scheduled cleaning. This performance loss can also be highlighted during the performance trials.

5. Engine Performance Management

Performance of main engine and generators are kept accurate by means of the PMS. The permanent monitoring is part of fuel saving.

Best Practices

- Stop M/E LO + Camshaft LO Pump in port if M/E notice allows. Many terminals require the M/E on short notice so it is not possible all the time, but when possible this should be done. Chief can use his discretion on this best practice.

6. Boiler Performance Management

In case of using boilers on board our PMS has included management of steam / combustion controls and maintenance of burners.

When operating boilers, the engineering staff should survey and optimize original boilers installed onboard to look for inefficiencies.

Significant fuel conservation can be achieved by minimizing overall steam consumption onboard. The correct boiler should be used for the expected demand. When boilers are needed, the operator should ensure that they are not started too far in advance from the time they are needed. Vessels should avoid dumping steam to avoid getting alarms throughout the night. Pipe and valve laggings are to be maintained in good order to minimize thermal losses.

Best Practices

- Use composite boiler – during anchorages and other relevant opportunities;
- Do not start auxiliary boilers too far in advance of intended use;
- Minimize steam dumping when possible;
- Maintain pipe/vale laggings in good order to minimize heat loss;
- Maintain steam traps in good order;
- Use steam tracing judiciously;
- Optimize bunker tank heating;
- Check the O_2 analyzer and the piping system prior to every operation. Most ships do not clean the sensing/sample line and condensation/dirt in the line prevents good flow of sample to the analyzer and hence the O_2 comes down very slowly. This causes a lot of fuel wastage as engineers increase load on the boiler to produce better O_2.

7. Onboard Bunker Management

Managing bunkers is important in improving reliability and reducing the chances of incompatible fuel related incidences. Our crew is familiar with specification of fuel and bunker routines to prevent such incidents.

Before ordering bunkers, each ship should use the bunker worksheet to calculate the expected bunker consumption and verify the amount with the operation department / charterer.

A copy of the final agreed-upon bunker nomination should be sent to CSC Bunkers. As a minimum, vessels should have enough onboard to complete the current voyage maintaining the following:

- HFO - 3 days (maximum consumption)
- MDO – 10 days (minimum generator load)

The ship should consult with the operation department if the above cannot be met.

The decision to carry excess bunkers above the inventory limit is to be justified by economic and operational considerations. Factors that can influence this decision include bunker cost, quality, the absence of firm orders, and other requirements.

Best Practices

- Vessels should carry the most economical amount of bunker in inventory.
- All fuels are purchased on internationally recognized standard known as ISO 8217.
- Every precaution should be made to try to avoid comingling of parcels of fuel. Incompatible fuel is the most common problem with the incompatible fuel leading to clogged filters and in the worst case scenario, engine shut down.
- Fuel should be consumed in a first in, first out fashion. Avoid carrying fuel that is over a few months old. The longer fuel is kept onboard, the longer the solids in the fuel are likely to drop out, and the more potential for reliability problems the ship is likely to face in terms of filter clogging and other problems. Fuel that cannot be used for any reason should be de-bunkered off the ship as soon as possible.

8. Power Generation

The generation and consumption of power onboard represents an opportunity to save fuel and minimize running hours on the power generators. Our crew of ship conscious the high electrical consumers and try to reduce their use as much as possible or operate this equipment when additional generating capacity is required for other uses.

Best Practices

- Minimize use of unnecessary machinery – e.g. deck hydraulic, fire pumps, engine room fan etc.;
- Deck department to communicate better with engine room on ballast and cargo pump usage avoid rolling pumps unnecessarily for long periods;
- Ships to have a meeting to discuss the impacts of running various pieces of machinery and efficient use;
- Maximize D/G load when possible to run on one generator when safe to do so;
- Switch off lights in unused spaces in accommodation;
- Try to minimize use of washing machine and drier with only one or two items;
- Ships to have discussion on judicious use of pump room fans, bosun store fans etc.

9. Bunker Heating

Bunker should be heated in most economical way. The bunker temperature has to be kept in optimize limit for engine consumption and to be limited under safety aspects according Voyage Plan.

In order to reduce fuel consumption and reduce heating costs, a voyage-specific heating procedure should be developed. The following should be considered:

- Vessel tank configuration;
- Number of heating coils and surface area;
- Auxiliary and composite boiler specifications;
- Cloud point, viscosity, and wax content;
- Weather en route including ambient air temperatures;
- Sea water temperatures, wind force, sea and swell;
- Estimated heat loss and drop in temperatures;
- Recommended return condensate temperatures;
- Estimated daily heating hours and consumption.

Best Practices

- Avoid heating during adverse weather period;
- Closely monitor and analyze bunker heating;
- Verify the effectiveness of heating progress;
- Do not heat for short frequent periods;
- Follow the recommended condensate temperature
- Bunker should be heated as economically as possible and planned soon after departure.

10. Draft and Trim Optimization

Operating the vessels at the optimum trim and draft can significantly improve efficiency. Generally all ships create trim table(s) to be able to manage the most fuel efficient draft and trim by keeping all safety and operational requirements.

The resistance of the hull through the water and the overall efficiency of the ship changes with the draft and trim of the vessel. The most optimum draft and trim is dependent on vessel shape, operating speed, and cargo weight. For most vessel it is generally better to sail with minimum draft and slightly trimmed by the bow, to the extent possible.

Tank arrangements, hull girder strength, and minimum propeller immersion often limit the ability of the ship to sail in the most optimum draft and trim.

Trim trials should be performed to test and validate the trim optimization efforts.

The vessel should be familiar with the safe and correct sailing draft and trim of their vessel. A Ballast Exchange plan is to be developed in advance of each voyage and updated as needed. This plan is to show the planned ballast movements during the voyage to keep the ship at or near the optimum trim and draft as fuel oil is consumed.

At no time shall the plan exceed the allowable bending moment and shear force for the hull girder, or allow the propeller immersion to be reduced to the point that the propeller cavitates or causes significant vibrations

11. Accommodation – specific energy conservation

The accommodations can offer a number of energy saving opportunities. Air conditioning is one of the major energy consumers. Windows account for nearly 50% of the heat or heat loss (depending on the season) this in turn places close to 50% of the workload on the air conditioning system or heating system. Untreated windows will allow about 20 times more heat into a space than an equal amount of insulated wall space. Personnel on board can limit the consumption by keeping the blinds closed when sun light is not needed or the space is unoccupied.

Regular inspections of the entire refrigerant systems onboard shall reduce leaks and improve system efficiency.

The use of R22 shall be prohibited from January 1st 2015. New alternatives for refrigeration and air conditioning equipment will have to be sourced after that date.

12. Port

Port congestion has two impacts on CO2 emissions and fuel use.

First, while waiting to enter a congested port, a ship must keep auxiliary engines running to provide power for hostelling and heating or cooling of cargo/fuel.

Second, a ship waiting to enter a port could have sailed slower if been informed about port congestion in advance.

The use of shore side electricity has to be preferred.

13. Ship energy efficiency measures in force

No	Energy Efficiency Measures	Implementation	Responsibility	Monitoring	Evaluation
1	Fuel Efficient Operations				
		Careful planning and execution of voyages	Master / CE	Voyage Plan	M Rev / IA
		Course optimization - Great Circle	Master	Voyage Plan	M Rev / IA
		Current optimization	Master	Voyage Plan	M Rev / IA
		Tides	Master	Voyage Plan	M Rev / IA
2	Weather routeing				
		Potential efficiency savings using routeing tools from existing providers	FM / Master	Voyage Plan	M Rev / IA
		Weather forecast	Master	Daily weather report	M Rev / IA
3	Speed optimisation				
		Optimise speed based on early communication with next port on berth availability	Master / CE	LB entrance	M Rev / IA
		Taking into account engine optimal settings and arrival times/availability of berths at port.	CE	ELB entrance	IA
4	Optimised power				
		Setting constant RPM as efficient	CE	ELB entrance	IA
		Power and light control	CE	ELB entrance	IA
5	Optimised ship handling				
		Optimum trim according trim table - Operating at optimum trim for specified draft and speed	Master / CE	LB entrance	IA
		Minimum treatment plant	Master / CE	LB / ELB entrance	IA
6	Optimum ballast				
		Ballasting for optimum trim and steering conditions	Master / CE	LB / ELB entrance	M Rev / IA
		Ballast free	Master	Stab records	IA
7	Optimum rudder				
		Autopilot settings	Watch Officer	/	
		Reducing distance sailed 'off track' and minimising losses caused by rudder corrections	Watch Officer	/	
8	Improved Cargo Handling				
		Using of dock facilities as possible	Master / CO	/	
		Preventing of stowage failure	CO	/	
9	Bunker Quality				
		Control of delivered bunker quality	CE	Bunker notice	IA
10	Stay in port				
		Use of shore side electricity in ports	CE	ELB entrance	IA
11	Others				

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Appendix 2

Company specific measures

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1. Cooperation between Charterer (Terminal Operator) and Owner

2. Owners and Charterers agree a speed adjustment

3. Propeller/propulsion system upgrades.

4. Retrofit hull improvement.

- Silicon paint.
- Ballast-free ship.
- No foils, flaps or rotors.

5. Main engine retrofit measures.

- Electronically controlled engines.
- Engine performance management
- High efficiency burner

6. Office energy efficiency measures in force / scheduled

No	Energy Efficiency Measures	Implementation	Responsibility	Monitoring	Evaluation
1	Charterer				
		Cooperation between Charterer and Owner	Owner	Charter Party	M Rev
2	Terminal Operator				
		Cooperation between Operator / Terminal / Ship	FM / Master	Voyage Plan	M Rev / IA
3	Speed adjustment				
		Cooperation between Charterer and Owner	Owner	Charter Party	M Rev
4	Retrofit hull improvement				
		Owner - SY	Owner	Yard Plan	Class approv
5	Retrofit ME improvement				
		Owner	Owner / FM	Maintenance	Class approv
6	Other technical modifications				
		??			

7. Goal settings (to be filled by Company, mentioned for all vessels or single ship)

No	Vessel 1	Implementation	Responsibility	Monitoring	Evaluation
1	annual fuel consumption control				
2	EEOI for monitoring energy efficiency				
No	Vessel 2	Implementation	Responsibility	Monitoring	Evaluation
1	annual fuel consumption control				
2	EEOI for monitoring energy efficiency				
No	Vessel XX	Implementation	Responsibility	Monitoring	Evaluation
	.....				

Ship Energy Efficiency Plan

Appendix 3

Monitoring of Energy Efficiency by EEOI

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1. General

In order to establish the EEOI, the following main steps will generally be needed:

1. define the period for which the EEOI is calculated*;
2. define data sources for data collection;
3. collect data;
4. convert data to appropriate format;
5. calculate EEOI;

Ballast voyages, as well as voyages which are not used for transport of cargo, such as voyage for docking service, should also be included. It is company policy that ballast passages part of EEOI calculation according sample calculation 3.

Voyages for the purpose of securing the safety of a ship or saving life at sea should be excluded.

2. Definitions

Fuel consumption: FC, is defined as all fuel consumed at sea and in port or for a voyage or other period in question, by main and auxiliary engines including boilers and incinerators.

Distance sailed means the actual distance sailed in nautical miles (deck log-book data) for the voyage or period in question.

Work done / Cargo includes but not limited to all gas, liquid and solid bulk cargo, general cargo, containerized cargo (including the return of empty units), break bulk, heavy lifts, frozen and chilled goods, timber and forest products,

In general, cargo mass carries or work done is expressed as follows:

1. for dry cargo carriers, liquid tankers, gas tankers, Ro-Ro cargo ships and general cargo ships, metric tonnes (t) of the cargo carried should be used;
2. for containerships carrying solely containers, number of containers (TEU) or metric tons (t) of the total mass of cargo and containers should be used;
3. for ships carrying a combination of containers and other cargoes, a TEU mass of 10 t could be applied for loaded TEUs and 2 t for empty TEUs;

In some particular cases, work done can be expressed to, number of TEUs (empty or full) for containerships

Voyage generally means the period between departures from a port to departure from next port. Alternative definitions of a voyage could also be acceptable.

Conversion from g/tonne - mile to g/tonne - km. The CO2 indicator may be converted from g/tonne - mile to g/tonne - km by multiplication by **0.54.**

3. Formula

Calculation of EEOI:

$$\text{EEOI} = \frac{\sum_j FC_j \times C_{Fj}}{m_{cargo} \times D}$$

Rolling average to be calculated in a suitable time period, for example one year closest to the end of a voyage for that period, or number of voyages, for example six or ten voyages, which are agreed as statistically relevant to the initial averaging period. The Rolling Average EEOI is then calculated for this period or number like.

Calculation of average EEOI:

$$\text{Average EEOI} = \frac{\sum_i \sum_j (FC_{ij} \times C_{Fj})}{\sum_i (m_{cargo,i} \times D_i)}$$

Where:

- j is the fuel type;
- i is the voyage number;
- FCi j is the mass of consumed fuel j at voyage i;
- CFj is the fuel mass to CO2 mass conversion factor for fuel j;
- mcargo is cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships; and
- D is the distance in nautical miles corresponding to the cargo carried or work done.

The unit of EEOI depends on the measurement of cargo carried or work done, e.g., tonnes CO2 / (tonnes • nautical miles), tonnes CO2 / (TEU • nautical miles), tonnes CO2 / (person • nautical miles), etc.

4. Key Question – Ballast passage

Ballast passage of a ship can be factored in during EEOI calculations as follows:

1) by applying ballast displacement in the EEOI formula, which can be difficult in some cases, or
2) by considering ballast passage as an integral part of a cargo voyage.

On the basis of these assumptions, two calculations were conducted. The 1st sample without consideration of ballast and the 2nd calculation was based on the assumption that a ballast passage is a part of a loaded passage.

4. Sample Calculations

4.1 Basic data for model calculation

Fuel mass to CO_2 mass conversion factors (CF) is a non-dimensional conversion factor between fuel consumption and CO_2 emission based on carbon content.

Type of fuel	Reference	Carbon content	*CF* (t-CO2/t-Fuel)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.860	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.850	3.114400

4.2 Sample Calculation 1

Sample including ballast voyage, not considered in calculation.

Voyage or day (i)	Fuel consumption (FC) at sea and in port in tonnes				Voyage or time period data	
	Fuel type (HFO)	Fuel type (LFO)	Fuel type ( )		Cargo (m) (tonnes or units)	Distance (D) (NM)
1	20	5			25,000	300
2	20	5			0	300
3	50	10			25,000	750
4	10	3			15,000	150

$$EEOI = \frac{100 \times 3.114 + 23 \times 3.151}{(25{,}000 \times 300) + (0 \times 300) + (25{,}000 \times 750) + (15{,}000 \times 150)} = 13.47 \times 10^{-6}$$

4.3 Sample Calculation 2

Sample including ballast voyage.

Voyage or day (i)	Fuel consumption (FC) at sea and in port in tonnes				Voyage or time period data	
	Fuel type (HFO)	Fuel type (LFO)	Fuel type ( )		Cargo (m) (tonnes or units)	Distance (D) (NM)
1	20	5			20,000	300
2	20	5			0	297
3	30	10			20,000	500
4	30	10			0	500

Ballast not part of EEOI.

$$EEOI_{AV} = \frac{100 \times 3{,}1144 + 30 \times 3.15104}{0 \times 297 + 20000 \times 300 + 0 \times 500 + 20000 \times 500} = 25.3$$

Ballast part of EEOI.

$$EEOI_{AV} = \frac{100 \times 3{,}1144 + 30 \times 3.15104}{(20000 + 0) \times (300 + 297) + (20000 + 0) \times (500 + 500)} = 18.5$$

Ship Energy Efficiency Plan

Appendix 4

Monitoring of energy efficiency standard - EEDI

REVISION CONTROL

2012/03/01	1st issue	Review by Captain and Superintendent Issued for Approval	ISM	DP	Captain	FM
Date	Revision	Revision Description	Prepared	Checked	Checked	Approved

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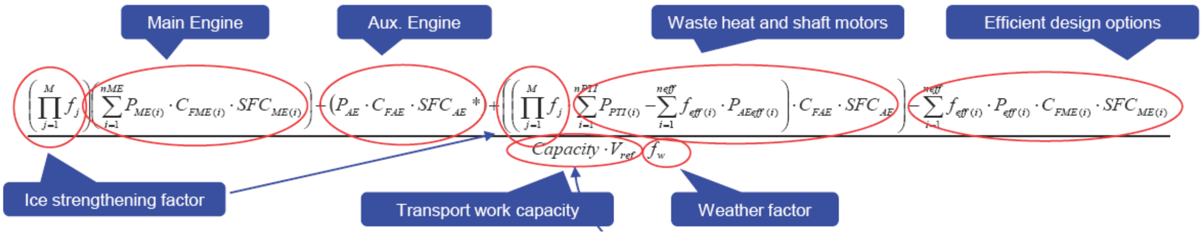
1. General

The EEDI is a metric that reflects the amount of CO_2 emitted per unit of transport work under standardised conditions. Unlike the operational efficiency indicator referred to above, it is a fixed value per ship that does not change with the load factor of a ship, the conditions under which she is operated, maintenance et cetera.

2. Formula



3. Components of formula

-CF

➢ CF is a non-dimensional conversion factor between fuel consumption measured in g and CO_2 emission also measured in g based on carbon content. The subscripts MEi and AEi refer to the main and auxiliary engine(s) respectively. CF corresponds to the fuel used when determining SFC listed in the applicable EIAPP Certificate.

The value of CF is as follows:

Type of fuel	Reference	Carbon content	*CF* ($t\text{-}CO_2/t\text{-}Fuel$)
1. Diesel/Gas Oil	ISO 8217 Grades DMX through DMC	0.875	3.206000
2. Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	0.86	3.151040
3. Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	0.85	3.114400

-Vref

➢ Vref is the ship speed, measured in nautical miles per hour (knot), on deep water in the maximum design load condition.

-Capacity

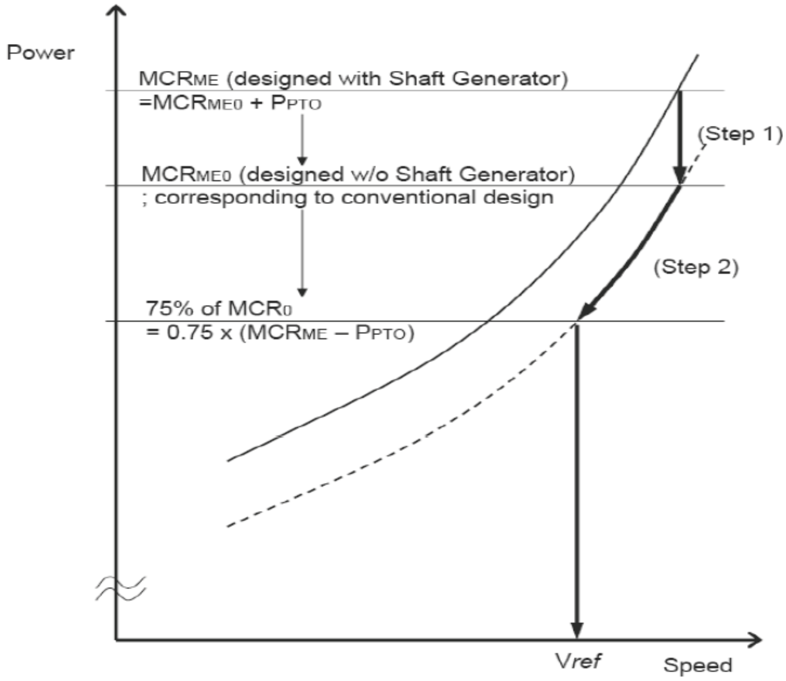
➢ Capacity is deadweight for dry cargo carriers, tankers, gas tankers, containerships, ro-ro cargo and general cargo ships. For containerships, the capacity parameter should be established at 65% of the deadweight.

-Deadweight

➢ Deadweight means the difference in tonnes between the displacement of a ship in water of relative density of 1,025 kg/m3 at the deepest operational draught and the lightweight of the ship.

-P

- P is the power of the main and auxiliary engines, measured in kW. The subscripts ME and AE refer to the main and auxiliary engine(s), respectively.
  - PME(i) is 75% of the rated installed power (MCR) for each main engine (i) after having deducted any installed shaft generator(s): PME(i) = 0,75x (MCR_{Mei} - P_{PTOi})



  - PPTO(i) is 75% output of each shaft generator installed divided by the relevant efficiency of that shaft generator.

  - PPTI(i) is 75% of the rated power consumption of each shaft motor divided by the weighted averaged efficiency of the generator(s).

  - In case of combined PTI/PTO, the normal operational mode at sea will determine which of these to be used in the calculation.

  - Peff(i) is 75% of the main engine power reduction due to innovative mechanical energy efficient technology. Mechanical recovered waste energy directly coupled to shafts need not be measured.

  - PAEeff (i) is the auxiliary power reduction due to innovative electrical energy efficient technology measured at PME(i).

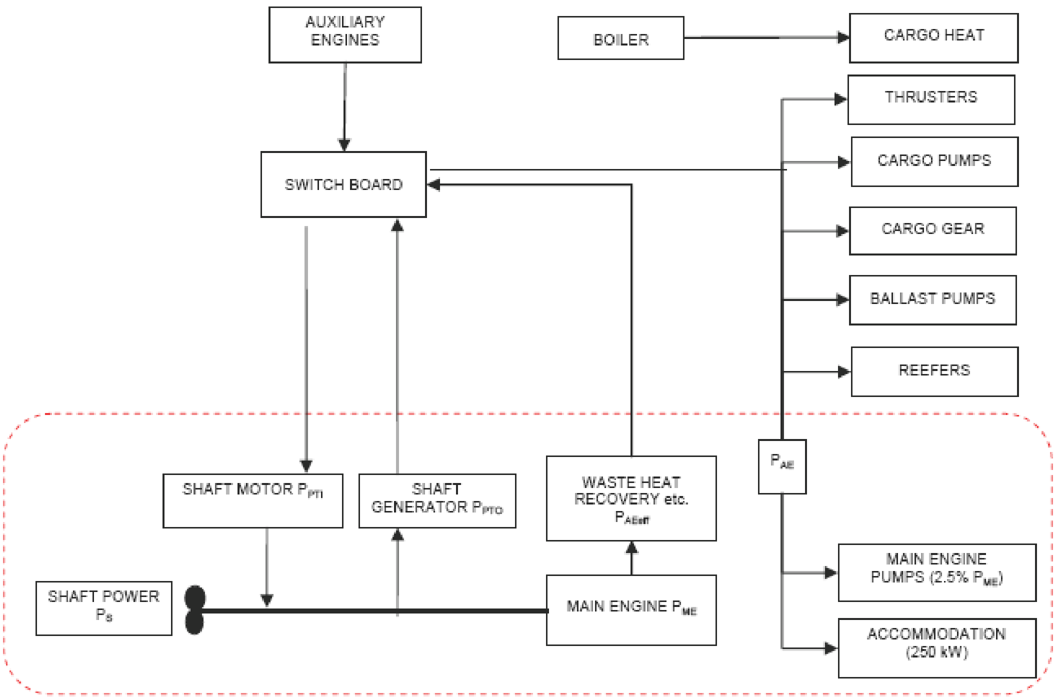
  - PAE is the required auxiliary engine power to supply normal maximum sea load including necessary power for propulsion machinery/systems and accommodation, e.g., main engine pumps, navigational systems and equipment and living on board, but excluding the power not for propulsion machinery/systems, e.g., thrusters, cargo pumps, cargo gear, ballast pumps, maintaining cargo, e.g., reefers and cargo hold fans, in the condition where ship engaged in voyage at speed (Vref) under design loading condition of Capacity.

For cargo ships with engine power of 10000 kW or above, PAE is defined as:

$$P_{AE(MCRME>10000KW)} = \left(0.025 \times \sum_{i=1}^{nME} MCR_{MEi}\right) + 250$$

For cargo ships with a main engine power below 10000 kW, PAE is defined as:

$$P_{AE(MCRME<10000KW)} = 0.05 \times \sum_{i=1}^{nME} MCR_{MEi}$$



-Vref

- ➢ Vref, Capacity and P should be consistent with each other.

-SFC

- ➢ SFC is the certified specific fuel consumption, measured in g/kWh, of the engines. The subscripts ME(i) and AE(i) refer to the main and auxiliary engine(s), respectively. For engines certified to the E2 or E3 duty cycles of the NOx Technical Code 2008, the engine Specific Fuel Consumption (SFCME(i)) is that recorded on the EIAPP Certificate(s) at the engine(s) 75% of MCR power or torque rating. For engines certified to the D2 or C1 duty cycles of the NOx Technical Code 2008, the engine Specific Fuel Consumption (SFCAE(i)) is that recorded on the EIAPP Certificate(s) at the engine(s) 50% of MCR power or torque rating.

-SFCAE

SFCAE is the weighted average among SFC AE(i) of the respective engines i. For those engines which do not have an EIAPP Certificate because its power is below 130 kW, the SFC specified by the manufacturer and endorsed by a competent authority should be used.

-fj

- fj is a correction factor to account for ship specific design elements.

Correction factor for power fj for ice-classed ships

Ship type	f_j	Limits depending on the ice class			
		IC	IB	IA	IA Super
Dry cargo carrier	$\frac{2.150 L_{PP}^{1.58}}{\sum_{i=1}^{nME} P_{iME}}$	$\begin{cases} max\,1.0 \\ min\,0.89 L_{PP}^{0.02} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.78 L_{PP}^{0.04} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.68 L_{PP}^{0.06} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.58 L_{PP}^{0.08} \end{cases}$
General cargo ship	$\frac{0.0450 \cdot L_{PP}^{2.37}}{\sum_{i=1}^{nME} P_{iME}}$	$\begin{cases} max\,1.0 \\ min\,0.85 L_{PP}^{0.03} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.70 L_{PP}^{0.06} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.54 L_{PP}^{0.10} \end{cases}$	$\begin{cases} max\,1.0 \\ min\,0.39 L_{PP}^{0.15} \end{cases}$

-fw

- fw is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed.

-feff(i)

- feff(i) is the availability factor of each innovative energy efficiency technology.

-fi

- fi is the capacity factor for any technical/regulatory limitation on capacity.

Correction factor for fi for ice-classed ships:

Ship type	f_i	Limits depending on the ice class			
		IC	IB	IA	IA Super
Dry cargo carrier	$\frac{0{,}000665 \cdot L_{PP}^{3.44}}{capacity}$	$\begin{cases} max\,1.31 L_{PP}^{-0.05} \\ min\,1.0 \end{cases}$	$\begin{cases} max\,1.54 L_{PP}^{-0.07} \\ min\,1.0 \end{cases}$	$\begin{cases} max\,1.80 L_{PP}^{-0.09} \\ min\,1.0 \end{cases}$	$\begin{cases} max\,2.10 L_{PP}^{-0.11} \\ min\,1.0 \end{cases}$
General cargo ship	$\frac{0{,}000676 \cdot L_{PP}^{3.44}}{capacity}$	1.0	$\begin{cases} max\,1.08 \\ min\,1.0 \end{cases}$	$\begin{cases} max\,1.12 \\ min\,1.0 \end{cases}$	$\begin{cases} max\,1.25 \\ min\,1.0 \end{cases}$
Containership	$\frac{0.1749 \cdot L_{PP}^{2.29}}{capacity}$	1.0	$\begin{cases} max\,1.25 L_{PP}^{-0.04} \\ min\,1.0 \end{cases}$	$\begin{cases} max\,1.60 L_{PP}^{-0.08} \\ min\,1.0 \end{cases}$	$\begin{cases} max\,2.10 L_{PP}^{-0.12} \\ min\,1.0 \end{cases}$

-Lpp

Length between perpendiculars: Lpp means 96 per cent of the total length on a waterline at 85% of the least moulded depth measured from the top of the keel, or the length from the foreside of the stem to the axis of the rudder stock on that waterline, if that were greater.

3. Key questions

From the few available evaluations of the EEDI, it is clear that the EEDI could be a good reflection of the design efficiency of large tankers, bulkers, general cargo and container ships. Smaller ships are often designed for special trades and for them a generalized index may not be a good reflection of the design efficiency (CMTI, 2009)12. Other ship types such as ferries, cruise ships, offshore support vessels, tugs and dredgers are not primarily designed to transport cargo.

Furthermore, it appears that the EEDI is inversely correlated to the size of a ship. Consequently, for small ships a small difference in size corresponds to a large difference in the index value. Therefore, it is difficult if not impossible to establish a baseline for smaller ships.

Ship Energy Efficiency Plan

Appendix 5

Monitoring of Environmental Ship Index - ESI

REVISION CONTROL

2012/03/01	1st issue	Review by Captain and Superintendent Issued for Approval	ISM	DP	Captain	FM
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1. General

The ESI should ideally reflect all relevant emissions to the air that are important from an environmental and health point of view, including CO2, NOx, PM10 and SOx.

The Environmental Ship Index (ESI) identifies seagoing ships that go beyond the current standards in reducing air emissions. Up to now, it was not possible to identify these ships in a general way.

The index is intended to be used by ports to promote clean ships, but can also be used by shippers and ship owners as a promotional instrument.

Finally all stakeholders in maritime transport can use the ESI as a means to improve their environmental performance and as an instrument to reach their sustainability goals.

Environmental Ship Index (ESI) as an instrument to measure a ships air emission performance has following main characteristics:

- It is a voluntary system, helping to improve the environmental performance of maritime shipping.
- ESI is an instrument to distinguish ships in their environmental performance regarding air quality pollutants and CO2.
- The ESI gives points for the performance of ships compared to the current international legislation (mainly IMO).
- ESI only takes the NOx and SOx emissions directly into account and awards documentation and management of the energy efficiency. PM10 is indirectly included because of its strong relationship to SOx.
- ESI can be applied to all types of ships.
- ESI is simple in its approach and presentation.
- ESI is easy to establish and to obtain for every ship.

2. ESI Formula

The overall ESI formula is built up of different parts for NOx, SOx and CO2.

The weight of the ESI_NOx in the overall index is twice the weight of ESI_SOx. This reflects the fact that the average environmental damage from NOx3 in ship air emissions is approximately twice the damage from SOx.

The overall ESI ranges from 0 for a ship that meets the environmental performance regulations in force to 100 for a ship that emits no SOx and NOx and reports or monitors its energy efficiency.
A maximum of 345 sub-points may theoretically be reached since this would result in an ESI score exceeding 100, the ESI score is limited to 100 points.

It is important to know that the index gives a relatively higher weight on emissions at berth and in the ECA, as these have a larger environmental and health impact in and near the ports!

The formula of ESI is:

$$ESI_{overall} = \frac{1}{3.1}\left(2 * ESI\_NO_x + ESI\_SO_x + RR\_CO_2\right)$$

Where:

- ESI_NOx is the environmental ship index for NOx.
- ESI_SOxis the environmental ship index for SOx.
- RR_CO2 is the reward for reporting on ship energy efficiency based on the EEOI
- The ESI_NOx and ESI_SOx both range from 0 to 100.
- The weight of the ESI_NOx in the overall index is twice the weight of ESI_SOx.
- For energy efficiency reporting (RR_CO2) the additional score is 10 points.
- The total amount of points to be scored is 310.

2.1 ESI_NOx

The ESI_NOx indicates the reductions of NOx emissions per unit of power below IMO limit values. It covers all engines and weighs them according to rated power. ESI_NOx can be unequivocally calculated using the EIAPP certificates of the engines on board a ship. Also all relevant data appearing in the EIAPP certificate(s) of the engine(s) on board a ship are used for that purpose and ALL Main and Auxiliary Engines must be included.

ESI_NOx is defined as:

$$ESI\_NO_x = \frac{100}{\sum_{i=1}^{n} P_i} \times \sum_{i=1}^{n} \frac{(NO_x \lim it\_value_i - NO_x rating_i) \times P_i}{NO_x\_\lim it\_value_i}$$

Where:

- Pi is the rated power of engine i.
- NOx rating i is the certificated NOx emissions of engine I in g/kWh.
- NOx_limit_value i is the maximum allowable NOx emissions for an engine with the speed of engine i.
- n number of engines.

2.2 ESI_SOx

The ESI_SOx reflects the reduction in sulphur content of the fuels below the limit values set by IMO and regional authorities.

Three types of fuel are distinguished: fuels typically used at high seas, fuels typically used in ECA's and fuels typically used at berth.

The baselines are based upon IMO limit values and will be tightened in accordance with IMO limits. In addition there is a second baseline for MDO/Gasoil set by the ESI Working Group at 0.5 % sulphur which will be maintained for the next few years.

ESI SOx gives higher weighting to the fuels used in ECAs and at berth, due to its greater impact on the ports and its surrounding areas.

ESI_SOx can be established after inspection of the bunker fuel delivery notes of a ship over the past year.

ESI_SOx is defined as:

$$ESI\_SOx = a\% * 30 + b\% * 35 + c\% * 35$$

Where:

- a = relative reduction of average sulphur of fuel used on high seas - HFO.
- b = relative reduction of average sulphur of fuel used in the ECA'S - MDO/Gasoil.
- c = relative reduction of average sulphur of fuel used at berth - MDO/Gasoil has a sulphur content <= 0.5 %

To establish the ESI SOx for a next period of validity of the system is set up as follows:

- Once a ship has been entered into the database, the first ESI SOx will be established at the first day of the next quarter of the year and will have a validity of half a year.
- Consequently the system establishes the scores on every 1st January, 1st April, 1st July and 1st October for newly entered ships, while for each ship that is already included in the database, the calculation is only performed twice a year.
- For all bunker operations, Bunker Delivery Notes (BDN) shall be issued. At the date of submission of data for ESI, those BDN which have been issued during the two preceding quarters shall be recorded. The data of each BDN such as type of fuel oil, mass and percentage (m/m) of sulphur must be accurately entered into the database.

2.3 RR_CO2 - 10 sub-points bonus for presence of a EEOI

CO2 emissions are not reflected in the index directly. However, where a Ship Energy Efficiency Management Plan (SEEMP) has been developed in accordance with the Guidelines of IMO's MEPC.1/Circ.683, for and is present on the ship, reporting the date of development and originator of the plan is rewarded with a 10 sub-points fixed bonus

2.4 OPS - 35 sub-points bonus for OPS

The question is to get the bonus if there is approved OPS (Onshore Power Supply) installed on board.

This question can only be answered "Yes" where the ship is fitted with an installation that would allow power supply from the shore and capable of taking the vessels full load when carrying out cargo operations etc.

The installation should be approved and certified by a Classification Society. The installation is in addition to a standard shore power breaker for use during repair periods.

When such an installation is fitted the ship board power generators can - and in some ports will - be turned off when the ship is berthed in a port. A positive answer will result in the addition of a fixed bonus of 35 sub-points to the intermediate ESI Score, irrespective of its use in port.

3. MARPOL Annex VI Regulations as ESI Baselines

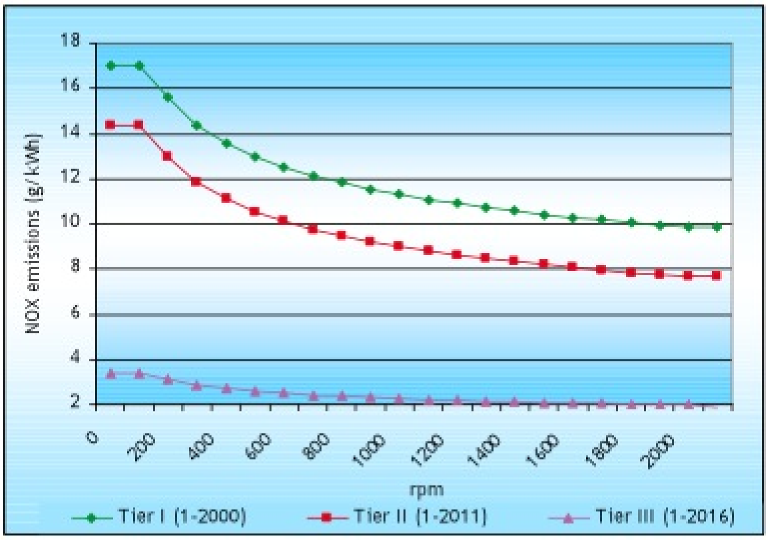
3.1 Nitrogen oxides

MARPOL Annex VI limits the NOx emissions of future marine engines. The figure below depicts the emission limits for current and future Tiers. The limit value depends on the rated engine speed above 130 rpm.

The baseline for calculating the ESI NOx score is Tier I and this approach will be maintained for the next few years.

n	< 130	130 <= n < 2 000	>= 2 000	RPM
Limit Value	17	45*n^-0.2	9.8	g/kWh

Figure: IMO Annex VI NOx Limit Value (g/kWh)



3.2 Sulphur oxides

In the coming years the lower limits for fuel sulphur content from the revised Annex VI to the MARPOL Convention will come into effect, as shown in the Table below.

<table>
<tr><td>Date</td><td>High Sea (HFO)</td><td>SOx ECA (MDO/Gasoil)</td><td></td></tr>
<tr><td>2012</td><td rowspan="2">3.5</td><td>1.0</td><td>% S (m/m)</td></tr>
<tr><td>2015</td><td rowspan="2">0.1</td><td>% S (m/m)</td></tr>
<tr><td>2020*</td><td>0.5</td><td>% S (m/m)</td></tr>
<tr><td colspan="4">* Alternative date is 2025, on basis of 2018 review</td></tr>
</table>

The baselines for ESI SOx are in line with the limit values set by IMO and that determined by the ESI working group.

IMO limit values are in place for fuels that would normally be used at the High Seas and in (S)ECA's and these will be tightened in accordance with IMO regulations.

In addition there is a second baseline for MDO/Gasoil set by the ESI Working Group at 0.5 % sulphur which will be maintained for the next few years.

As shown the limit value of the Sulphur content for Fuel used at the High Seas (HFO) changes to 3.5 % (m/m) on 1 January 2012 and the limit value for Fuel used in SOx ECA (MDO/Gasoil) changes to 0.1 % (m/m) on 1 January 2015.

The base line for calculation of ESI SOx of HFO will consequently change to the same level 3.5 % and will then be used for calculation of ESI SOx scores for bunkering from 1 January 2012 and will therefore only be applied as from 1 October 2012. Similarly, the baseline for calculation of ESI SOx of MDO/Gasoil will change to 0.1 % and will also be applied as from 1 October 2015

4. Data need for ESI calculation

	ESI NOx	**ESI SOx**	**RR_CO2**
Document	**EIAPP certificate**	**Bunker delivery notes over 1 year**	**EEOI reporting or ship energy efficiency management plan**
Data needed	Rated power (kW) and rated engine speed (rpm) ME	Average sulphur content per bunker per kind of fuel (1%)	EEOI reporting or ship energy efficiency management plan
	Rated power (kW) and rated speed (rpm) AE's	Amount of fuel, kind of fuel, bunkered per delivery (ton)	
	Actual Nox emission value (g/kWh)		

5. ESI Calculation sample

The ship in the sample has one main engine and three auxiliary engines. The ship uses HFO and MDO/Gasoil. For the formulas and baselines see 2. ESI Formula, 'MARPOL Annex VI. and ESI Baselines'.

Nitrogen oxides

	Main engine(s)	Auxiliary engine(s)	
NOx Limit Value	17	11.5	g/kWh
NOx Rating (ESI)	15	11	g/kWh
Δ Emission	2	0.5	
Rated Power	9480	970	kW
Number of engines	1	3	

$$ESI\_NO_x = \frac{100}{\sum_{i=1}^{n} P_i} \times \sum_{i=1}^{n} \frac{(NO_x \ limit\_value_i - NO_x rating_i) \times P_i}{NO_x\_limit\_value_i}$$

ESI_NOx = {(17 – 15) x 9480/17 + (11.5 – 11) x 970 x 3/11.5} x (1/9480 + 970 x 3) x 100

ESI_NOx = 1241 x 0.008 = **10.0**

Sulphur oxides

The average sulphur content of the different fuels is extracted from the bunker delivery notes. The average for the respective fuels is the weighted average over all bunkers.

	HFO	MDO/Gasoil	MDO/Gasoil LS	
Baseline	3.5	1.0	0.5	% Sulphur
Actual	2.0	0.6	0.08	% Sulphur

For the different fuels, the relative improvement compared to the baselines is calculated; see also ‘ESI formulas’ and ‘IMO annex regulations and ESI baselines’

$$ESI\_SOx = a\% * 30 + b\% * 35 + c\% * 35$$

ESI_SOx = (3.5 – 2.0)/3.5 x 30 + (1.0 – 0.6)/1.0 x 35 + (0.5 – 0.08)/0.5 x 35

ESI_SOx = 12.9 + 14.0 + 29.4 = **56.3**

ESI Score

For this example the ESI sub- points are as follows leading to an ESI Score of 27.8 points:

$$ESI_{overall} = \frac{1}{3.1}(2 * ESI\_NO_x + ESI\_SO_x + RR\_CO_2)$$

ESI SCORE = (2 x 10.0 + 56.3 + 10.0) / 3.1 = 27.8

The presence on this ship of OPS would result in adding 35 OPS bonus points and the following ESI Score:

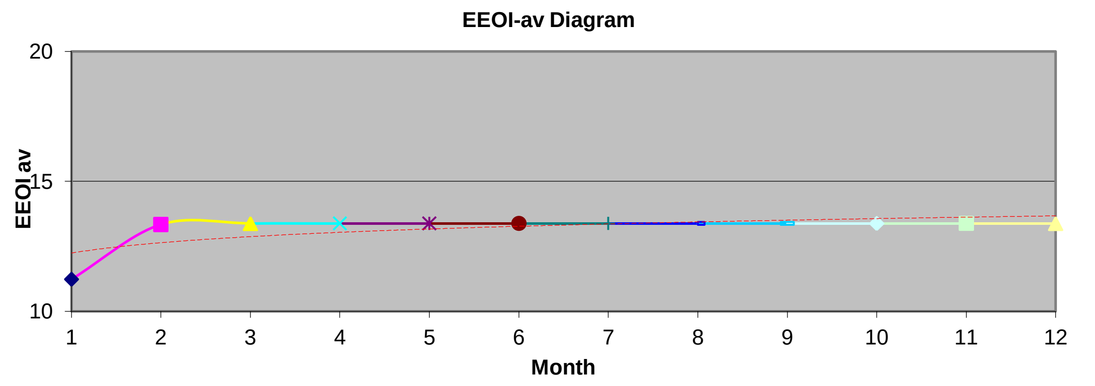
ESI SCORE = (2 x 10.0 + 56.3 + 10.0 + 35.0) / 3.1 = 39.1

When a SEEMP / EEOI is implemented additional 10 bonus points to be added

ESI SCORE = (2 x 10.0 + 56.3 + 10.0 + 35.0 + 10.0) / 3.1 = 42.4

ESI and EEOI Calculation

☐ TEC ☐ Ship



Remarks

bjhlkxjjökjxölk

Signature/Stamp

Vessel:	Date:	Filled by:		Rank:		ESI	28,5

Yearly Summary	Dist. miles	ME KW	Total Run. Hours	Consumption (Tonnes) HFO	MDO	av. SOx HFO	av. SOx MDO	Bunker Emissions (Tonnes) SOx	NOx	CO	Partics	CH4	CO2	SOx gm/kw hour	NOx gm/kw hour	EEOI av
Total year	28142	4500	179799	2375	235	0,39	0,03	99,95	219,24	19,314	19,836	0,00063	8137	0,12	0,27	13,38

Quarterly breakdown	Dist. miles	ME KW	Total Run. Hours	Consumption (Tonnes) HFO	MDO	av. SOx HFO	av. SOx MDO	Bunker Emissions (Tonnes) SOx	NOx	CO	Partics	CH4	CO2	SOx gm/kw hour	NOx gm/kw hour	EEOI av
1st Quarter	28142	4500	179799,0	2375,0	235,0	1,57	0,11	99,95	219,24	19,314	19,836	0,00063	8137	0,12	0,27	13,38
2nd Quarter	0	0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	
3rd Quarter	0	0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	
4th Quarter	0	0	0,0	0,0	0,0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	

Monthly breakdown	Dist. miles	ME KW	Cargo Tonnes	Consumption (Tonnes) HFO	MDO	av. SOx HFO	av. SOx MDO	Bunker Emissions (Tonnes) SOx	NOx	CO	Partics	CH4	CO2	SOx gm/kw hour	NOx gm/kw hour	EEOI av
January	12342	4500	60064	920	67	3,46	0,12	63,85	82,91	7,304	7,501	0,00024	3076	0,24	0,31	11,23
February	15000	4500	107735	1405	168	1,26	0,22	36,10	132,13	11,640	11,955	0,00038	4905	0,07	0,27	13,34
March	800	4500	12000	50	0	0,00	0,00	0,00	4,20	0,370	0,380	0,00001	156	0,00	0,08	13,38
April	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
May	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
June	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
July	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
August	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
September	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
October	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
November	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00
December	0		0	0	0	0,00	0,00	0,00	0,00	0,000	0,000	0,00000	0	0,00	0,00	0,00

EEOI Calculation

The unit of EEOI depends on the measurement of cargo carried or work done, e.g., (tonnes • nautical miles), (TEU • nautical miles), (person • nautical miles), etc

Voy No	Month No	Port of 1st Departure / Date	Port of last Departure / Date	Dist. (Nm)	Cargo / tonnes	# Reefer	# / hrs crane(s)	Bunker received			Bunker remained			Sox of Bunker				
								HFO	LFO	MDO MGO	HFO	LFO	MDO MGO	SOx HFO	Sox LFO	Sox MDO	EEOI Voyage	EEOI Average
										Start	467	0	800					
1	1			3170	29960,0	444	2/23	731,0	8,0		934,0	3,0	800,0	3,50	0,10		8,82	8,82
2	1			3172	0,0			567,0		23,0	1200,0		810,0	3,50		0,20		19,21
3	1			6000	30104,0			555,0		44,0	1400,0		800,0	3,40		0,10	7,04	11,23
4	2			3000	15605,0					35,0	1100,0		823,0			0,20	20,74	12,61
5	2			3000	15605,0			567,0		56,0	1500,0		845,0	3,50		0,20	13,33	12,70
6	2			3000	31045,0					43,0	1100,0		833,0			0,22	15,18	13,20
7	2			3000	15605,0					22,0	900,0		800,0			0,24	16,90	13,54
8	2			3000	29875,0			888,0		100,0	1450,0		888,0	3,50		0,26	12,15	13,34
9	3			800	12000,0						1400,0		888,0				16,22	13,38

ESI Calculation

NOX: 11,1927

SOX: 20,9714

OPS: x

RR-CO2: x

ESI Score: 28,5

ESI_Nox		ME 1	ME 2	AE 1	AE 2	AE 3	Other		
NOx Limit Value	g/kWh	17,00	15,00	11,50	10,00	1,00	1,00	1,00	1,00
NOx Rating (ESI)	g/kWh	15,00	13,00	11,00	9,00				
Δ Emission		2,00	2,00	0,50	1,00	1,00	1,00	1,00	1,00
Rated Power	kW	9480,00	9000,00	970,00	1000,00				
Number of engines		1,00	1,00	3,00	4,00				

ESI_Sox	3308,00	0,17	8,00	0,00	323,00	20,80			
Bunker Notes	HFO	HFO SOx	LFO	LFO SOx	MDO	MDO Sox	HFO Sox act	LFO Sox act	MDO Sox act
Baseline:	mt	**3,50**	mt	**0,10**	mt	**0,50**			
2012/01/12-Bunker Hull	731,00	3,50	8,00	0,10	0,00	0,00	0,00	0,00	
2012/01/30-Bunker HH	567,00	3,50	0,00	0,00	23,00	0,20	0,00		21,00
	555,00	3,40	0,00	0,00	44,00	0,10	0,86		28,00
	0,00	0,00	0,00	0,00	35,00	0,20			21,00
	567,00	3,50	0,00	0,00	56,00	0,20	0,00		21,00
	0,00	0,00	0,00	0,00	43,00	0,22			19,60
	0,00	0,00	0,00	0,00	22,00	0,24			18,20
	888,00	3,50	0,00	0,00	100,00	0,26	0,00		16,80
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			
	0,00	0,00	0,00	0,00	0,00	0,00			