It was presented the IMO requirement on implementation from January 1st, 2013 the Ship Energy Efficiency Management Plan (SEEMP) and consequences of its utilization. The aim was getting some profits connecting with realization process of that plan. The ship-owners have had to prepare the plan for each ship which was under the IMO regulation mentioned in circular MEPC.213(63) and realization of that plan on each vessel over the 400 GRT. The SEEMP returns the attention to ship-owners on vessel exploitation process, optimization of marine power plants utilization, waste energy recovery etc. The main index is calculated as a result of carbon dioxide emission from marine power systems divided by transport efficiency of vessel. The target of SEEMP utilization is restriction of carbon dioxide emission as greenhouse gas and increasing efficiency of marine transport.

**Keywords:** ship energy efficiency management plan, IMO resolution, environmental protection, IMO MEPC, energy efficiency indexes.

**INITIAL REMARKS**

A Ship Energy Efficiency Management Plan (SEEMP) will form part of Annex VI of MARPOL Convention. The requirement will be applicable to all ships (both new and existing) of 400 gross tonnage or above from January 1st, 2013. Each ship ought to keep a SEEMP onboard. The plan is intended to be a practical tool for helping ship-owners and ship crew manage their environmental performance and the main target is to improve ship operational efficiency. It means to reduce fuel consumption, maintenance costs and emissions, cut total costs. Ship-owners that have successfully implemented the SEEMP will improve their green profile. The expected benefits are:

- fuel savings up to 10–15%,
- improved performance of main and auxiliary engines,
- leadership in friendly processes to environment.

Each company ought to develop their own SEEMP for each vessel in conformity with the Guidance provided in MEPC.213(63). There is a sample template that each SEEMP can be base upon [6]. The SEEMP belongs to the company and next ship-owner ought to develop its own plan for that vessel relates to its energy strategy. The method mentioned in MEPC.213(63) is preferably international standard and there is no need to prepare other monitoring tools
(indexes) like Key Performance Indicator (KPI), Environmental Ship Index (ESI) or Energy Efficiency Operational Index (EEOI) [8, 13]. It is important to review the SEEMP regularly. The feedback after results of each review ought to be a signal to planning phase of improving the SEEMP. The SEEMP should be considered as a “live document” changing with the vessel technical state. Energy Efficiency Methods are not in the same scale suitable for all types of vessels. During usual MARPOL survey (initial, annual etc.) the vessel ought to demonstrate onboard the International Energy Efficiency (IEE) Certificate.

After the MEPC.213(63) regulation the period of vessel search and rescue operations do not need to be used for energy efficiency indexes (this is a special period when the vessel and crew safety is most important) [9].

1. ENERGY EFFICIENCY INDEXES

The most popular index is Energy Efficiency Operational Index (EEOI). This is a tool to evaluate the performance of ships with regards to CO$_2$ emissions. Directly relates the ratio of mass of CO$_2$ discharged by the ship to the transport work [1]. It means compared data from the fuel use and the units of a cargo carried by ship. The equation of EEOI is:

$$EEOI = \frac{\sum_i FC_i \times CF}{\sum_i m_i \times D_i}$$

where:
- $FC_i$ – fuel consumption [g] during i-voyage (1 ton = 10$^6$ g);
- $CF$ – index of CO$_2$ emissions from 1 g fuel depending on the type of fuel;
  - for MDO: $CF = 3.206$ g CO$_2$/g fuel,
  - for HFO: $CF = 3.114$ g CO$_2$/g fuel,
  - for LPG propane $CF = 3.000$ g CO$_2$/g fuel,
  - for LPG butane $CF = 3.030$ g CO$_2$/g fuel,
  - for LNG methane $CF = 2.750$ g CO$_2$/g fuel;
- $m_i$ – mass of the cargo (units depending on the type of vessel) [ton];
- $D_i$ – distance sailed during i-voyage in nautical miles or km.

The result of EEOI has the main unit: g CO$_2$/ton × Nm or g CO$_2$/ton × km.

The EEOI is a primary monitoring tool according to IMO MEPC.213(63) requirement. The energy efficiency of a ship should be monitored quantitatively. This should be done by an established method, preferably by an international standard. The EEOI developed by the Organization is one of the internationally established tools to obtain a quantitative indicator of energy efficiency of a ship and/or fleet in operation, and can be used for this purpose. Therefore, EEOI could be considered as the primary monitoring tool, although other quantitative measures also may be appropriate [6].
If used, it is recommended that the EEOI is calculated in accordance with the Guidelines developed by the Organization (MEPC.1/Circ.684), adjusted, as necessary, to a specific ship and trade [13]. In addition to the EEOI, if convenient and/or beneficial for a ship or a company, other measurement tools can be utilized. In the case where other monitoring tools are used, the concept of the tool and the method of monitoring may be determined at the planning stage [6].

Fuel-efficient operations of vessel which improved the EEOI index are possible by [1, 9, 11, 16]:
- improved voyage planning,
- weather routeing,
- just in time (correction of voyage planning),
- speed optimization (mainly by decreasing the vessel speed as a reference speed),
- optimized shaft power,
- optimized ship handling (optimum trim, optimum ballast),
- optimum propeller and propeller considerations,
- optimum use of rudder and heading control systems (autopilots),
- hull maintenance,
- systems of decreasing ship’s resistance,
- propulsion system maintenance,
- waste heat recovery,
- improved fleet management,
- improved cargo handling,
- energy or power management,
- fuel type,
- optimization of electric energy production and distribution (power management system),
- other measures.

The lower EEOI the more efficient it is. The same dependence is with The Energy Efficiency Design Index (EEDI). The EEDI apply the vessels responsible for the most emissions and when contract is placed on or after January 1st, 2013 or keel-laying occur on or after July 1st, 2013. EEDI benchmarks will be raised successively for new ships built in 2015, 2020 and 2025 will need to meet even higher standards [10]. Under the regulations, vessels are required to meet a minimum energy efficiency requirement. Their EEDI must be equivalent to or less than a value given in equations of MEPC.215(63) [4].

Vessels with diesel-electric, gas turbine or hybrid propulsion don’t need an EEDI. Some other vessels like ro-ro, ro-pax, cruise and offshore vessels are exempt (up to January 1st, 2015 in phase 0) [7].

The verified EEDI shall be part of the supplement of the International Energy Efficiency (IEE) Certificate for new ships. The EEDI verification process is conducted in two stages. In the first stage, the preliminary value of EEDI is determined using basic design parameters, towing tank results and additional
calculations required by classification society carried through the survey. In the second stage, the final value of EEDI is determined based on the parameters of the installed engine(s) and EIAPP Certificate(s), Technical NOx file(s), document specific fuel consumption at 75% of MCR power of main engine(s) and results of the sea trial and required additional information [7]. An overview of the verification process is given in Fig. 1.

![EEDI verification process](image)

Fig. 1. EEDI verification process [7]

The EEDI ought to be changed respectively to the ice classed vessel using ice class factors and capacity correlation factors [7]. The next one is determination of correction factors for Ship Specific Voluntary Enhancement which increases safety and fatigue life of ship’s structure, e.g. additional corrosion allowance. The determination of correction factors are more depending on the vessel’s type [3–5, 7].

For containerships the Estimated Index Value (EIV) is used. The formula of EIV is given by equation:

\[
ESTIMATED INDEX VALUE = 3.1144 \times \frac{190 \sum_{i=1}^{n} P_{MEi} + 215 P_{AE}}{70\%DWT \times V_{ref}}
\] (2)

where:
- \(P_{MEi}\) – power of “i” main engine number,
- \(P_{AE}\) – power of auxiliary engines,
- \(DWT\) – deadweight of the vessel;
- \(V_{ref}\) – reference vessel speed.
An example of comparison between EIV and required reference line value for containerships built in years 1998–2010 is given in Fig. 2. The differences sometimes amount to about eight times. The EIV depends on many factors: year of vessel built, type of ice-class vessel, sailing area, type of main engine, number of cooled containers (electric energy consumption) etc. How will change real emissions due to the EEDI requirement for new vessels after January 1st, 2015 etc. [10]?

It is necessary to check all the IMO requirements during the process for estimating the SEEMP. The better way is using the classification society regulations [7] for help which are compatible with the IMO regulations [3–6, 10–15].

2. SHIP ENERGY EFFICIENCY MANAGEMENT PLAN AND ITS UTILIZATION

The company provides all resources to 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 familiarization on board the ship,
- the Chief Engineer and superintendent are responsible for monitoring of ship energy efficiency and documentation [6, 17].
A model of marine power plant used for calculating the EEOI is given in Fig. 3 as a parameter for evaluating the SEEMP [2, 3, 9, 15].

![Diagram of marine power plant](image)

**Fig. 3.** A generic and simplified marine power plant for calculating EEOI [3]

EEOI depends on many factors having a considerable influence on comparing and analysis possibility. The numerous factors are: weather, currents, wave heights, wind direction and force, geographical area, type of trade, type of ship, voyage length, vessel speed etc.

**FINAL REMARKS**

The SEEMP ought to be prepared by ship-owners due to IMO requirements from January 1st, 2013 for all mentioned types of vessels and ought to be onboard.
1. The main monitoring index for evaluating process of SEEMP is the EEOI.
2. The ship-owners are forced by IMO and classification societies for preparing the SEEMP. The SEEMP and other indexes help the ship-owners for providing their own energy strategy.
3. The SEEMP may show how energy efficient the vessel power plant is and how the SEEMP changes during exploitation.
4. The target of introducing the SEEMP was to minimize the greenhouse and other pollutant gases emissions from marine power plants.
5. The SEEMP ought to be as “live plan”. It is expected to expand on other types of vessels and to decrease the expected level of EEOI in the future.
6. It is possible that in near future the records of EEOI level may be a document for additional environmental taxes, especially in situations when the EEOI level would be increased over the calculated (expected) level for that type of vessel.
7. The simple way for improving the EEOI is decreasing the vessel exploitation speed to reference speed.
8. The important problem to solve for ship-owners is how to fulfill the increased requirements in the future.

REFERENCES

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5. Guideline MEPC.214(63) EEDI Verification.
6. Guideline MEPC.213(63) SEEMP.
10. MEPC.1/Circ796 and MEPC.1/Circ.815
11. MEPC Circ.681 EEDI Calculation.
12. MEPC Circ. 682, EEDI Verification.
13. MEPC Circ. 684 EEOI.
14. MEPC Circ. 683 SEEMP.
UWAGI PO WPROWADZENIU OKRĘTOWEGO PLANU ZARZĄDZANIA EFEKTYWNOŚCIĄ ENERGETYCZNĄ

Streszczenie


Słowa kluczowe: okrętowy plan zarządzania sprawnością energetyczną SEEMP, rezolucje Międzynarodowej Organizacji Morskiej IMO, Komitet Ochrony Środowiska IMO, ochrona środowiska, wskaźniki efektywności energetycznej statku.