INTERNATIONAL MARITIME ORGANIZATION

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Agenda item 2

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CONSIDERATION OF THE ENERGY EFFICIENCY DESIGN INDEX FOR NEW SHIPS

Auxiliary engine power on passenger ships and supplementary diesel electric systems

Submitted by Denmark

SUMMARY	
Executive summary:	This document provides proposals to refine the formula for auxiliary power to more comprehensively reflect the auxiliary power consumption on passenger ships and to address supplementary diesel electric propulsion
Strategic direction:	7.3
High-level action:	7.3.1
Planned output:	7.3.1.1. and 7.3.1.3
Action to be taken:	Paragraph 22
Related documents:	GHG WG 1/2/1; MEPC 58/4/10, MEPC 58/4/24 and MEPC 58/23, annex 11

Introduction

1 MEPC 58 approved the use of the draft Interim Guidelines on the method of calculation of the Energy Efficiency Design Index for new ships for calculation and trial purposes with a view to further refinement and improvement, as set out in MEPC 58/23, annex 11.

Objectives

2 The first objective of this document is to refine the formula for auxiliary power to more comprehensively reflect the auxiliary power consumption on passenger ships. The second objective is to provide an explanation of how to include supplementary diesel-electric propulsion power.

Normal maximum sea load – excluding cargo-related auxiliary power

3 The auxiliary engine power P_{AE}, is defined as the required auxiliary engine power to supply normal maximum sea load including necessary power for machinery, systems, equipment and accommodation on board in the condition where the ship is engaged in voyage at the design speed (V_{ref}) under the design loading condition (Capacity). This excludes any auxiliary power needed for thrusters solely used to manouvre in port, cargo gear, cargo pumps, ballast pumps, etc., as well as power to sustain cargo.

4 A generic and simplified marine power plant is illustrated in annex 1.

5 MEPC 58 developed a simple estimate of P_{AE} for cargo ships. For ships with a main engine with a rated installed power (MCR) below 10,000 kW, P_{AE} was expressed as 5% of the main engine MCR. For ships with a main engine with a MCR of 10,000 kW or above, P_{AE} was expressed as 2.5% of the main engine MCR plus a constant hotel load. At MEPC 58 the GHG Working Group, however, identified that one of the remaining tasks to be carried out concerning the new energy efficiency index, is the development of a definition of auxiliary power for passenger ships.

Auxiliary power consumption on passenger ships

6 The concept of a constant hotel load, regardless of the size of the ship is not appropriate for passenger ships, and the formula needs further development to address this. In doing so, it is important to note that on many passenger ships the power required to accommodate the passengers is substantial compared to the propulsion power.

7 As power consumption required for accommodation of passengers contributes a significant part of the total power consumption in passenger ships, it is very important that the energy efficiency design index stimulates reduction of not only the power used for propulsion but also the power used to accommodate the passengers.

8 It is evident that a reduction of the total auxiliary power consumption as a result of higher energy efficiency will result in a lower total installed auxiliary power. Accordingly the total installed auxiliary power should be part of the index formula.

9 Furthermore, it is evident that the power consumption of passenger ships without cabins and restaurants intended for very short voyages differentiates from the power consumption of ships with overnight accommodation for all passengers, large public areas, restaurants, etc., and this should be reflected in the index. Using the gross tonnage as capacity for both passenger ships and ro-ro passenger ships (as proposed in GHG-WG 2/2/6) cater for these concerns as the gross tonnage is a measure of volume and reflects the size of the accommodation including the part used for passengers.

10 The definition of the P_{AE} for cruise ships seems to be complicated. However, normal passenger and ro-ro passenger ships with conventional diesel engine propulsion contribute the major part of the total amount of greenhouse gases from passenger ships compared to passenger ships with full diesel-electric propulsion. Hence, the complexity of determining the contribution from ships with full diesel-electric propulsion must not be a stumbling stone and delay the achievement of the overall objective. Therefore it is proposed to only include passenger and ro-ro passenger ships with conventional diesel engine propulsion in the index as a start and use the necessary time for developing the correct formula for passenger ships with full diesel-electric propulsion.

11 In document GHG WG 1/2/1 (Denmark) on the Energy Efficiency Design Index on new ships, it was proposed to use the total installed auxiliary power as P_{AE}. Based on the discussions at GHG WG 1, several submissions were forwarded to MEPC 58[1] with proposals to use 50% or 75% of the total installed auxiliary power as P_{AE} in order to exclude redundant auxiliary power, etc.

12 Further calculations carried out have shown that a P_{AE} defined as 50% of the rated installed power (MCR) for each auxiliary engine could be a simple and usable solution for the P_{AE} on passenger ships and ro-ro passenger ships with conventional diesel engine propulsion. Hence, it is proposed to proceed with this approach.

13 Accordingly the following baselines for passenger ships and ro-ro passenger ships have been calculated using the following assumptions:

.1 The carbon conversion factor is constant for all engines, i.e. $C_{F,ME} = C_{F,AE} = CF = 3.13$ g CO_2/g Fuel;

.2 The specific fuel consumption is constant for all main engines, i.e. $SFC_{ME} = 190$ g/kWh;

.3 $P_{ME(I)}$ is 75% of the rated installed power (MCR) for each main engine;

.4 The specific fuel consumption is constant for all auxiliary engines, i.e. $SFC_{AE} = 210$ g/kWh;

.5 P_{AE} is set to 50% of the rated installed power (MCR) for each auxiliary engine;

.6 All correction factors f_j, f_i and f_w are set to 1;

.7 None of the ships use waste heat recovery systems, $P_{WHR} = 0$;

.8 None of the ships get any diesel electric propulsion power from auxiliary engines, $P_{PTI} = 0$; and

.9 None of the ships use innovative energy efficient technology, $P_{eff} = 0$.

14 The equation for calculating the average index value is then as follows:

$$Average\ Index\ Value = 3.13 \cdot \frac{190 \cdot \sum_{i=1}^{NME} P_{MEi} + 210 \cdot P_{AE}}{Capacity \cdot V_{ref}}$$

15 The Average Index Values are used as the basis for calculating an exponential regression line. The regression line expresses the baseline value which can then be calculated by using the following formula:

$$Baseline\ value = a \cdot Capacity^{-c}$$

Where a and c are constants deriving from the regression line.

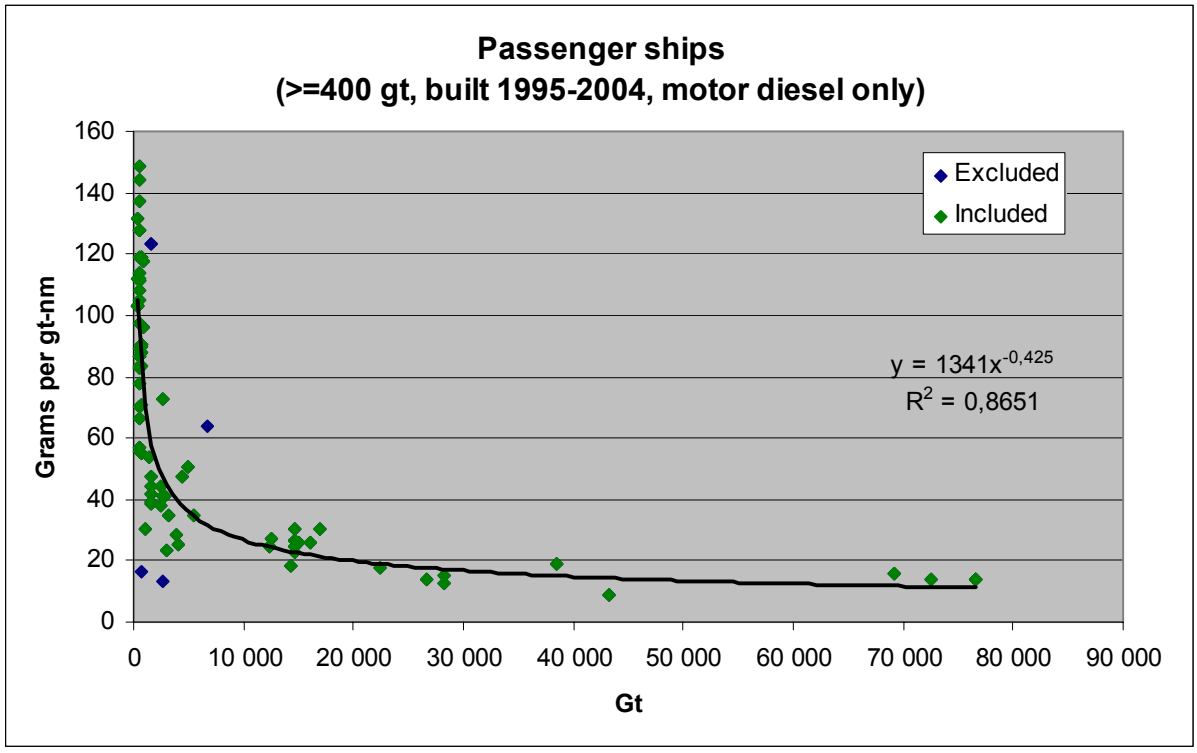
[1] MEPC 58/4/10 submitted by Denmark, MEPC 58/4/14 submitted by Intertanko and MEPC 58/4/30 submitted by IACS.

16 Outliers which are more than two standard deviations from the regression line are removed, and a new regression line is calculated. This ensures that special ships and erroneous data are excluded from the calculation.

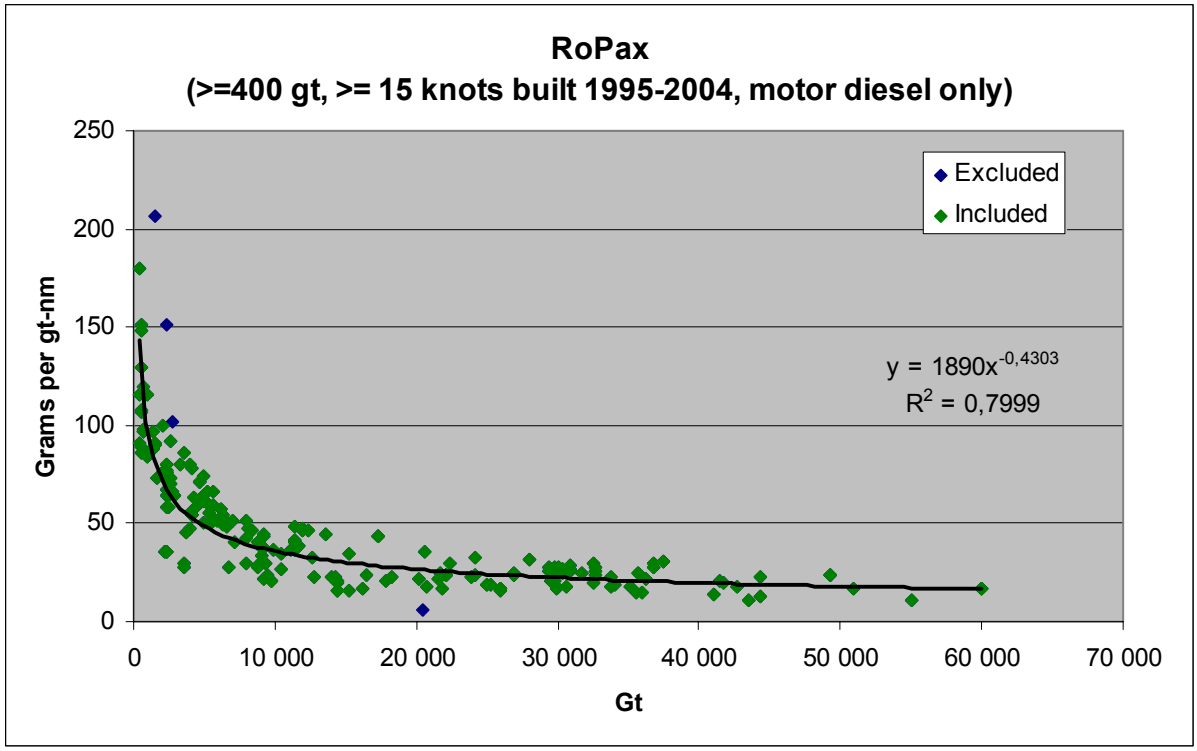
17 The following results, using the mentioned information, definitions and assumptions, are obtained[2]:

Ship type	a	Capacity	c	Number of samples	Excluded	R^2
Passenger ships	1341.0	GT	0.4250	81	5	0.87
Ro-ro passenger ships	1890.0	GT	0.4303	210	4	0.80

Figures showing the recalculated baselines for passenger ships and ro-ro passenger ships are set out below.



2 The baselines were calculated by Det Norske Veritas.



18 According to the above it is proposed that the P_{AE} for passenger ships and ro-ro passenger ships with conventional diesel engine propulsion is defined as 50% of the rated installed power (MCR) for each auxiliary engine.

19 Revised draft Interim Guidelines on the method of calculation of the Energy Efficiency Design Index for new ships are set out in annex 2.

Supplementary diesel electric power systems – shaft motors

20 The design index evaluates the performance of the ship under well-defined conditions characterized by consistent values of power, speed and capacity. MEPC 58 found it appropriate to consider the shaft power P_S which is the actual power linked to the speed – and not only the main engine power P_{ME}. The explanation is that electrical power from the switchboard may be converted using a shaft motor, P_{PTI}.

$$P_S = P_{PTI} + P_{ME}$$

21 The contribution to the index from such shaft motors P_{PTI} should be calculated using the specific fuel oil consumption of the auxiliary engines because they are driven by power produced by auxiliary engines. Similar to the approach applied for ordinary main engines $P_{PTI(i)}$ is 75% of the rated power consumption of shaft motors. It is proposed to divide the rated power consumption by 0.9 to take into account the diesel-electric conversion efficiency.

Action requested of the Intersessional Meeting

22 The Intersessional Meeting is invited to consider the information provided and in particular:

.1 the proposal to only include passenger and ro-ro passenger ships with conventional diesel engine propulsion in the energy efficiency design index as a start and use the necessary time for developing the correct formula for passenger ships with full diesel electric propulsion (paragraph 10);

.2 the proposal for defining the auxiliary power P_{AE} for passenger ships and ro-ro passenger ships with conventional diesel engine propulsion (paragraph 18); and

.3 the proposal to take into account the diesel electric conversion efficiency factor for shaft motors (paragraph 21) and take action as appropriate.

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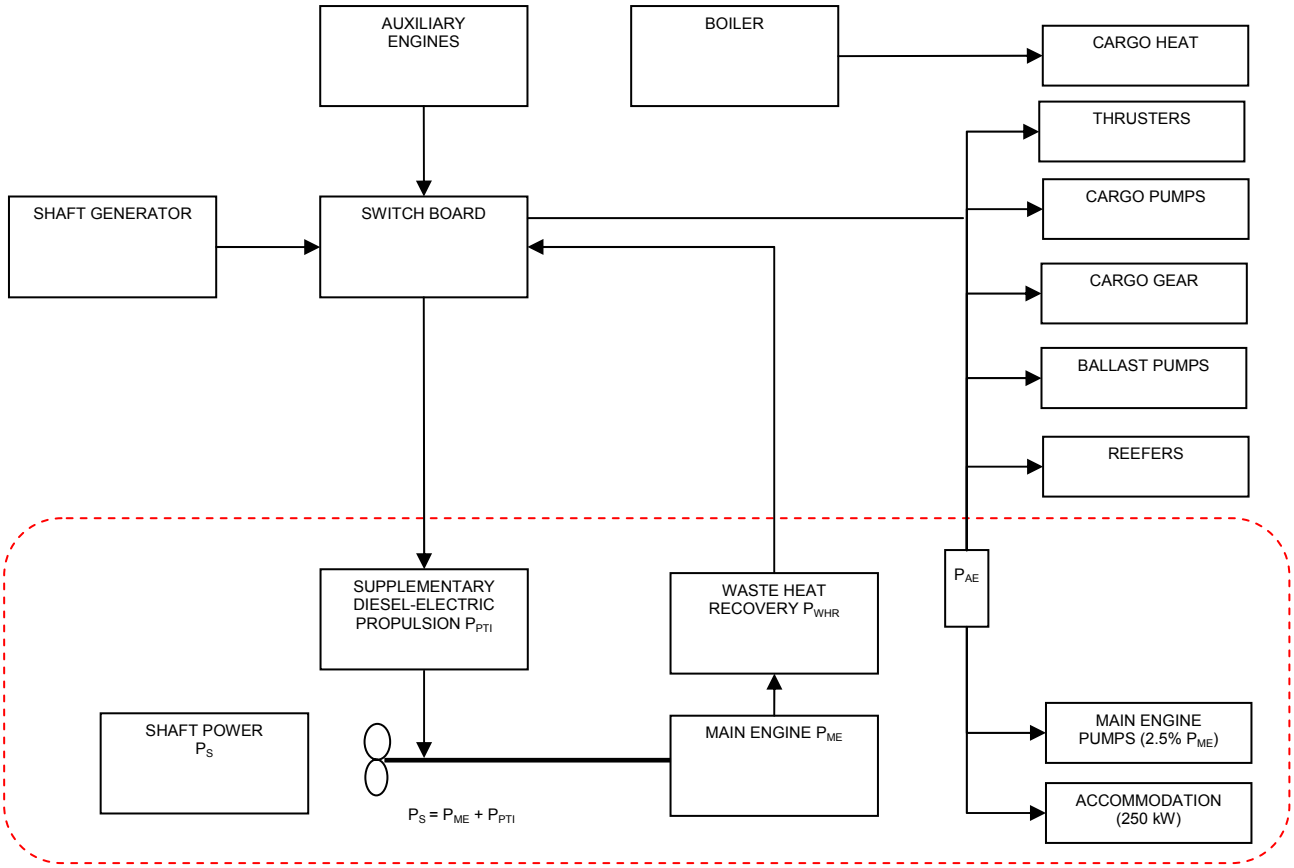
ANNEX 1

A GENERIC AND SIMPLIFIED MARINE POWER PLANT



The power contributions in the dotted box should be considered by the new ship design CO_2 index, and the power contributions outside the dotted box should be excluded. Auxiliary power is generated by the auxiliary engines and may be supplemented via the switchboard by additional power from a shaft generator or from waste heat recovery systems.

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ANNEX 2

DRAFT INTERIM GUIDELINES ON THE METHOD OF CALCULATION OF THE ENERGY EFFICIENCY DESIGN INDEX FOR NEW SHIPS

The attained new ship Energy Efficiency Design Index is a measure of ships CO_2 efficiency and is:

$$\frac{\left(\prod_{j=1}^{M} f_j\right)\left(\sum_{i=1}^{nME} C_{FMEi}\ SFC_{MEi}\ P_{MEi}\right) + P_{AE}C_{FAE}SFC^{*}_{AE} + \left(\sum_{i=1}^{nPTI} P_{PTIi} - \sum_{i=1}^{nWHR} P_{WHRi}\right)C_{FAE}SFC_{AE} - \left(\sum_{i=1}^{neff} f_{eff}\,P_{eff}\,C_{FMEi}SFC_{MEi}\right)}{fi\ Capacity\quad V_{ref}\quad f_W}$$

* If a shaft generator is provided, the Normal Maximum Sea Load can be calculated using SFC_{ME} instead of SFC_{AE}

Where:

1 C_F 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 respectively.

[Refer to the 2006 IPCC Guidelines]

2 V_{ref} is the ship speed, measured in nautical miles per hour (knot), on deep water in the maximum design load condition (Capacity) as defined in paragraph 3 at the output of the engine(s) as defined in paragraph 5 and assuming the weather is calm with no wind and no waves. The maximum design load condition shall be defined by the deepest draught with its associated trim, at which the ship is allowed to operate. This condition is obtained from the stability booklet approved by the Administration.

3 *Capacity* is defined as follows:

.1 For dry cargo carriers, tankers, gas tankers, container ships, ro-ro cargo and passenger ships and general cargo ships, deadweight should be used as *Capacity*.

.2 For passenger ships, gross tonnage in accordance with the International Convention on Tonnage[3] measurement of ships 1969, Annex 1, regulation 3 should be used as *Capacity*.

4 *Deadweight* means the difference in tonnes between the displacement of a ship in water of relative density of 1.025 at the deepest operational draught and the lightweight of the ship.

[3] Displacement can also be used.

5 *P* is the power of the main and auxiliary engines, measured in kW. The subscripts $_{ME}$ and $_{AE}$ refer to main and auxiliary engine, respectively. The summation on *i* is for all engines with the number of main engines (*NME*).

.1 $P_{ME(i)}$ is 75% of the rated installed power (MCR) for each main engine (i);

.2 $P_{PTI(i)}$ is 75% of the rated power consumption of shaft motors divided by 0.9 to take into account the diesel electric conversion efficiency;

.3 P_{WHR} is the rated electrical power generation of waste heat recovery system at $P_{ME(i)}$;

.4 P_{eff} is the main engine power reduction due to innovative energy efficient technology; and

.5 P_{AE} is the required auxiliary engine power to supply normal maximum sea load including necessary power for machinery, systems, equipment and living on board in the condition where the ship engaged in voyage at the speed (V_{ref}) under the design loading condition of *Capacity*.

P_{AE} for cargo ships is defined as:

.1 For cargo ships with a main engine power of 10000 kW or above P_{AE}:

$$P_{AE(MCRME>10000KW)} = \left(0{,}025 \times \sum_{i=1}^{nME} MCR_{MEi}\right) + 250\,;$$

.2 For cargo ships with a main engine power below 10000 kW P_{AE}:

$$P_{AE(MCRME<10000KW)} = 0{,}05 \times \sum_{i=1}^{nME} MCR_{MEi}\,;\ and$$

P_{AE} for passenger ships and Ro-ro passenger ships with conventional diesel engine propulsion is defined as:

.3 $$P_{AE} = 0{,}5 \sum_{i=1}^{nAE} MCR_{AEi}$$

6 $V_{ref,}$ *Capacity*, and *P* should be consistent with each other.

7 *SFC* is the designed specific fuel consumption, measured in g/kWh, of the engines at the power output of *P* determined by paragraph 5. The subscripts $_{MEi}$ and $_{AEi}$ refer to the main and auxiliary engine, including any boilers, respectively. The auxiliary engine Specific Fuel Consumption (SFC_{AE}) is that recorded on the EIAPP Certificate[4] at the engines 50% of P_{AE} MCR power or torque rating.

[4] EIAPP Certificate is the Engine International Air Pollution Prevention Certificate which relates to NO_x emissions.

8 f_j are corrections to account for ship specific-design elements:

The f_j coefficient for ice-classed ships is determined by the standard The f_j "table/curve" which is to be contained in the Guidelines.

9 f_W is a non-dimensional coefficient indicating the decrease of speed in representative sea conditions of wave height, wave frequency and wind speed (e.g., Beaufort Scale 6), and should be determined as follows:

.1 It can be determined by conducting the ship-specific simulation of its performance at representative sea conditions. The simulation methodology should be prescribed in the Guidelines developed by the Organization and the method and outcome for an individual ship shall be verified by the Administration or an organization recognized by the Administration;

.2 In case that the simulation is not conducted, f_W value should be taken from the "standard f_W " table/curve. A "Standard f_W " table/curve, which is to be contained in the Guidelines, is given by ship type (the same ship as the "baseline" below), and expressed in a function of the parameter of *Capacity* (e.g, DWT). The "Standard f_W " table/curve is to be determined by conservative approach, i.e. based on the data of actual speed reduction of as many existing ships as possible under the representative sea conditions; and

.3 f_W should be taken as 1.0 until the Guidelines for the ship-specific simulation (paragraph .1) or f_W table/curve (paragraph .2) becomes available.

10 f_{eff} is the availability factor of any innovative energy efficient technology.

11 f_i is the capacity factor for any technical/regulatory limitation on capacity, and can be assumed one (1.0) if no necessity of the factor is granted.