



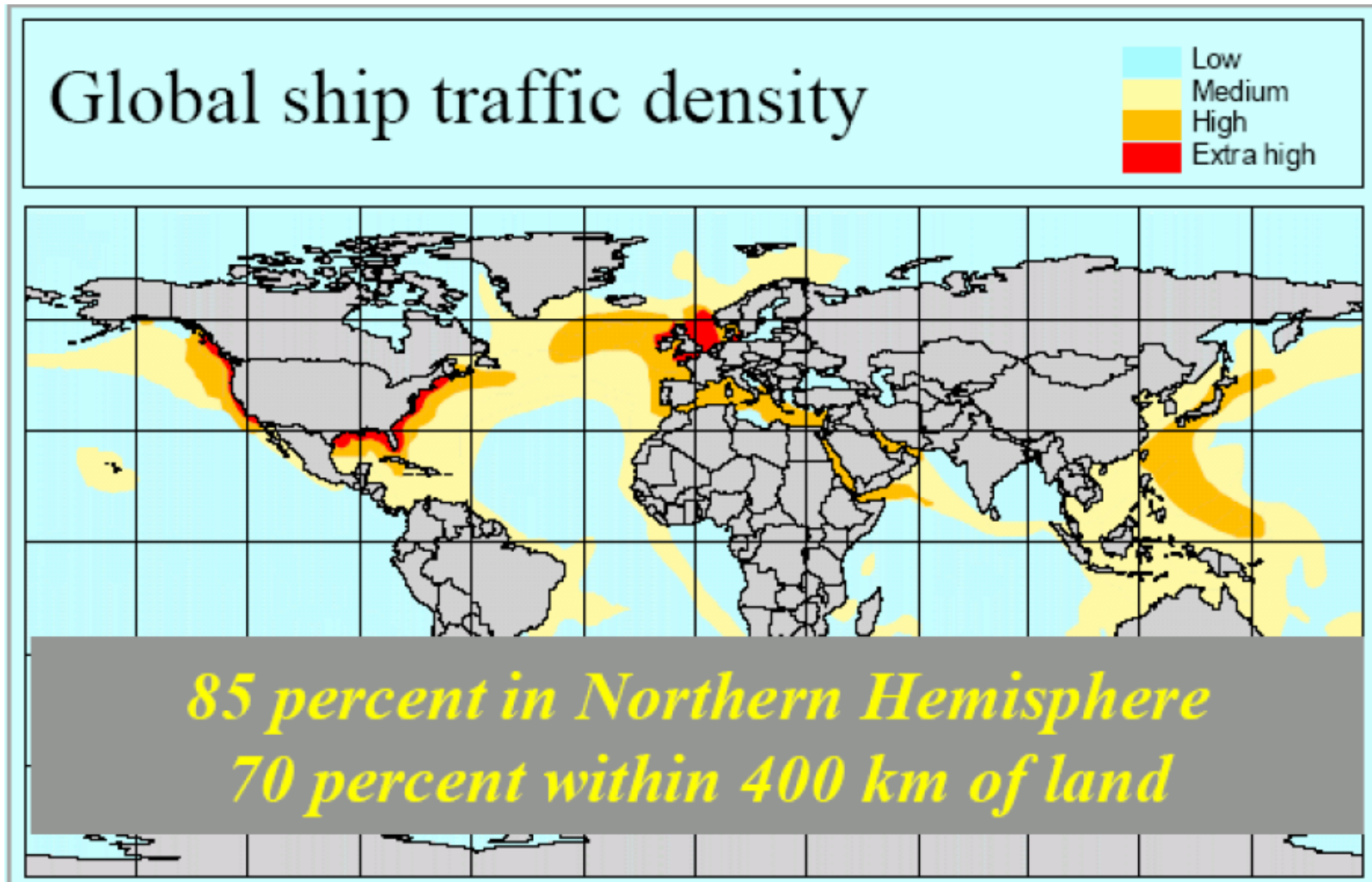
Climate Change Regulations

Consequences for Ship Design in a Rapidly Changing Environment

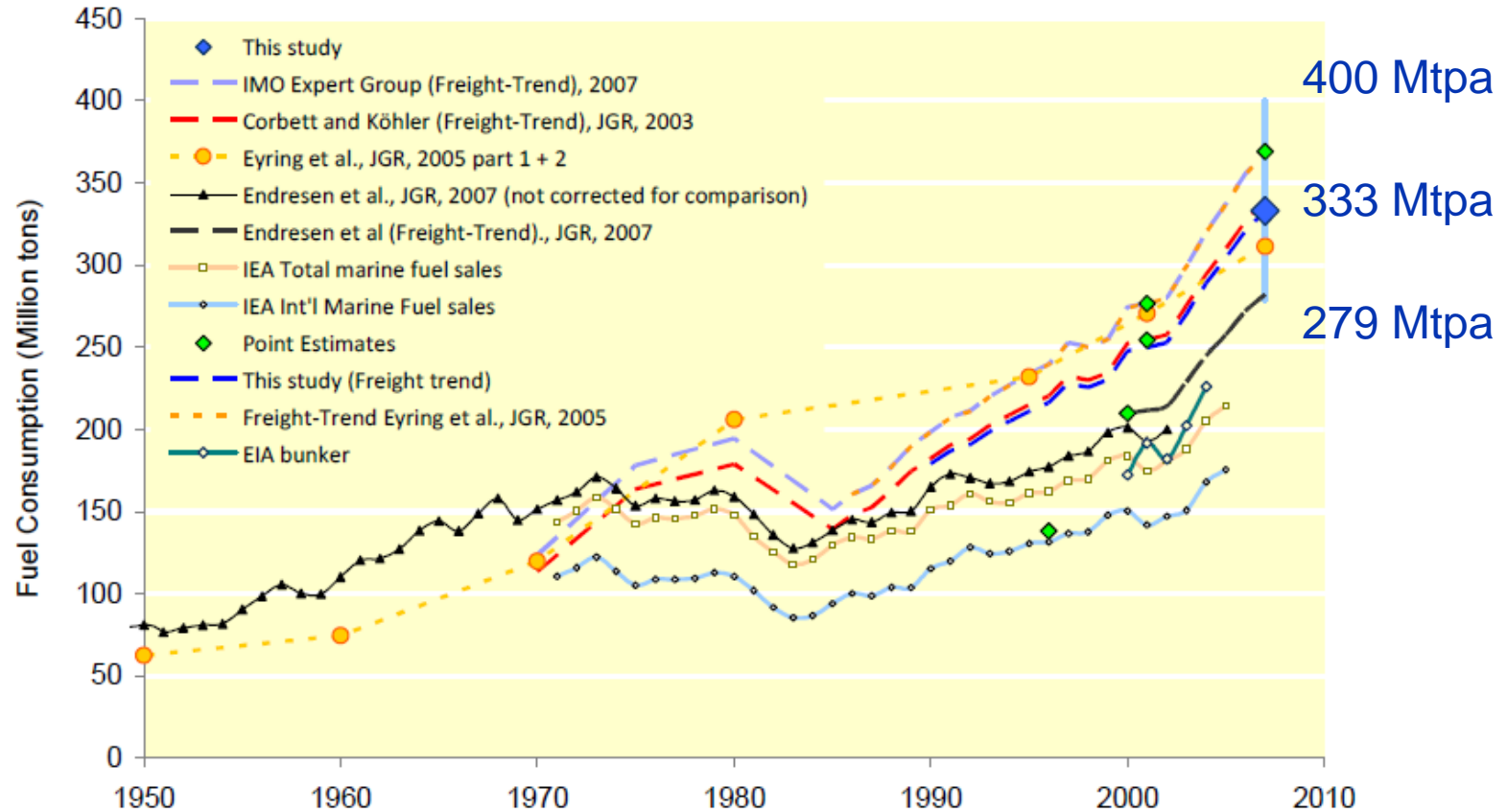
D. Braxton Scherz with Eirik Nyhus and Tore Longva

6 January 2010

Shipboard Emissions - A Global Concern



Consensus Worldwide Bunker Estimate



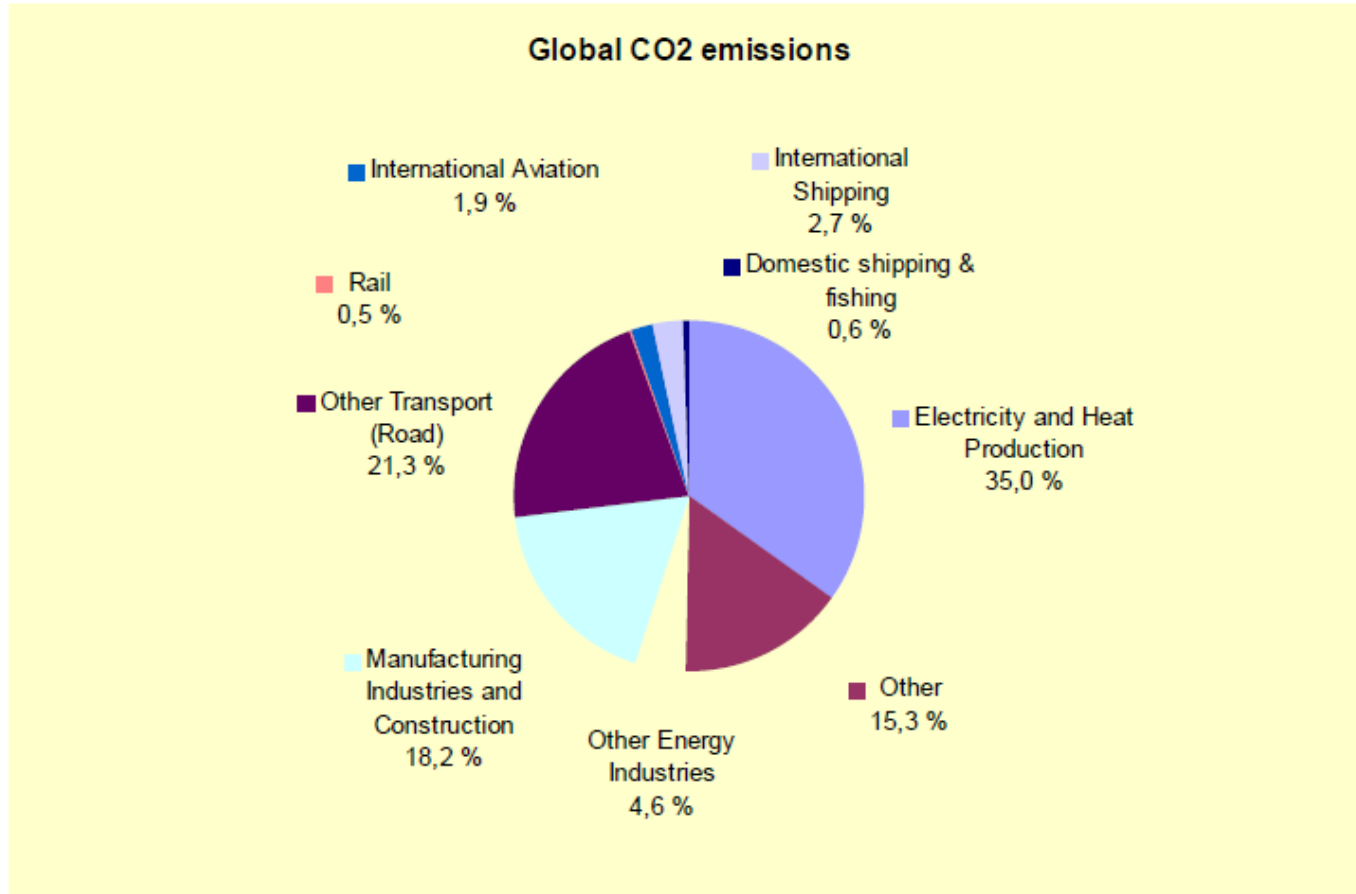
870 Mtpa – Estimated CO₂ Released to Atmosphere (2007)

Ocean Transport is Favored on a ton-mile Basis

- Estimated Carbon Released – lb/ton-mile
 - Air Cargo – 1.78
 - Truck – 0.37
 - Train – 0.23
 - Sea Freight – 0.09
- Ships Represent the most Carbon Efficient Method of Transport

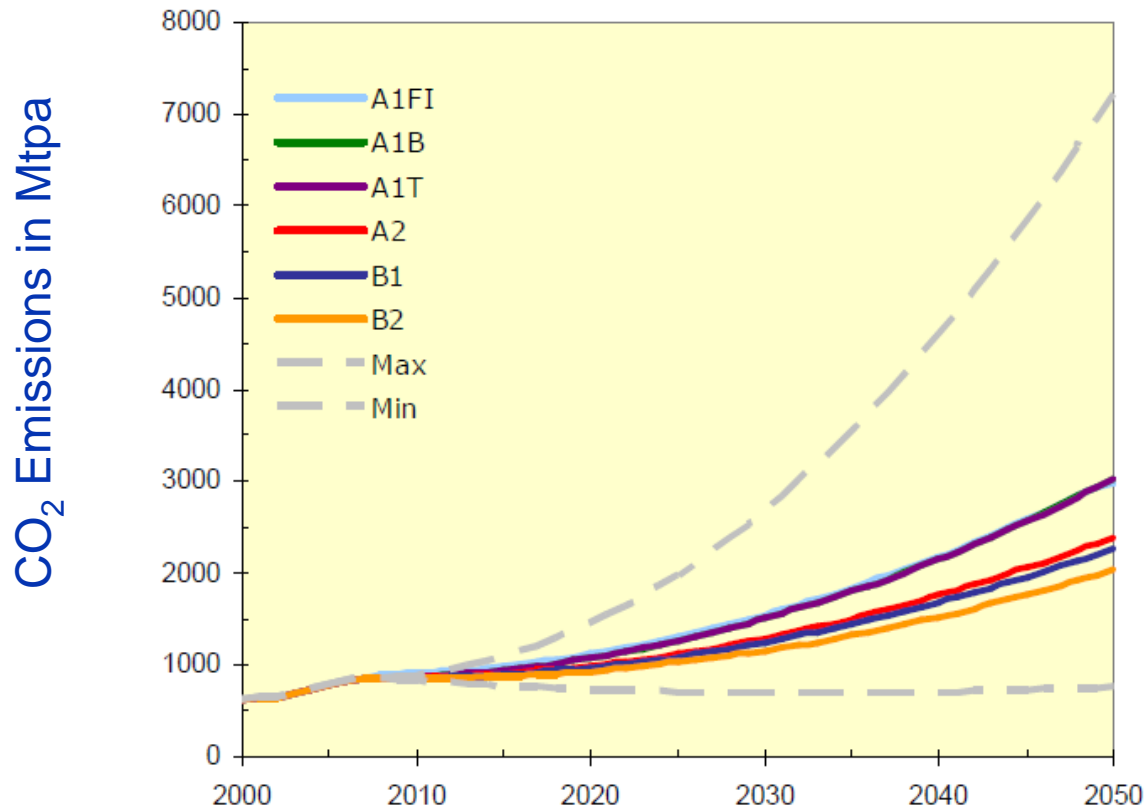


Ships CO₂ Emission – About 3% of Total Transport



Ships CO₂ Emission – 14% to 19% Overall by 2050

IPCC (Intergovernmental Panel on Climate Change) Scenarios



Emission estimates without mitigating actions

Pollution Prevention – Historical Summary

- The IMO (a technical organization) established by the U.N in 1948 to improve safety at Sea
- SOLAS 1960 was the first convention adopted and amended throughout the years as required.
- MARPOL 1973 (the International Convention for Prevention of Pollution from Ships), modified in 1978 to prevent & regulate overboard pollution from ships
- The IMO established the Marine Environmental Protection Committee (MEPC) in 1973 to coordinate environmental activities

MEPC – Moving IMO in a “Green” Direction

- MARPOL - Annex VI (Sept 1997) *Prevention of Air Pollution from Ships* in force May 2005
- A three tier approach to NOx and Sox reduction
- Adopted in MEPC58 October 2008.
- EU Directive EC 2005/33
 - Ships to reduce sulfur in liquid fuels to 0.1% (from 1.5% in 2005) inside Environmental Containment Areas (ECA)

Proposed ECA for North American Coastal Waters



Adopted in MEPC 60 with planned enforcement - August 2012

IMO Framework 2008 – MEPC Impacts Shipbuilders

- Effective Reduction of Total GHG
- Binding & equally applicable to all flag States
- Cost effective with minimum competitive distortion
- Sustainable w/o penalizing global trade or growth
- A goal-based rather than methods- based approach
- Supports R&D/technical innovation - all shipping sectors
- Promotes technology re. energy efficiency
- Practical, transparent, and fraud-free

Four Key Proposals to Address CO2 Emissions

- Market Based Instruments – carbon trading fuel taxes
- Voluntary (maybe mandatory) Ship Energy Efficiency Management Plan (SEEMP)
- Voluntary revised Energy Efficient Operator Indicator EEOI
- New mandatory Energy Efficiency Design Index EEDI
 - EEDI is proposal with **largest impact** on ship design and ship building

Energy Efficiency Design Index – EEDI

“Interim Guidelines on the Method of Calculation of the Energy Efficiency Design Index for New Ships”, (MEPC.1/Circ.681)”,


$$\text{Attained design CO}_2 \text{ index} = \frac{\text{Environmental cost}}{\text{Benefit for society}}$$

Calculated as: grams CO₂ / capacity * nm

“Interim Guidelines for Voluntary Verification of the Energy Efficiency Design Index” (MEPC.1/Circ.682)”

INTERNATIONAL MARITIME ORGANIZATION
4 ALBERT EMBANKMENT
LONDON SE1 7SR

Telephone: 020 7735 7611
Fax: 020 7587 3210



E


Ref. T5/1.01 MEPC.1/Circ.681
17 August 2009

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

1 The Marine Environment Protection Committee, at its fifty-ninth session (13 to 17 July 2009), recognized the need to develop an energy efficiency design index for new ships in order to stimulate innovation and technical development of all elements influencing the energy efficiency of a ship from its design phase. The Committee, being mindful that the applicability of the EEDI formula to all categories of ships and the feasibility and applicability of the technical parameters (i.e. f_{eff} and f_w) in the EEDI formula need to be further refined to improve the method of calculation of the EEDI; agreed to circulate the Interim Guidelines on the method of calculation of the energy efficiency design index for new ships, as set out in the annex.

INTERNATIONAL MARITIME ORGANIZATION
4 ALBERT EMBANKMENT
LONDON SE1 7SR

Telephone: 020 7735 7611
Fax: 020 7587 3210



E

Ref. T5/1.01 MEPC.1/Circ.682
17 August 2009

INTERIM GUIDELINES FOR VOLUNTARY VERIFICATION OF THE ENERGY EFFICIENCY DESIGN INDEX

1 The Marine Environment Protection Committee, at its fifty-ninth session (13 to 17 July 2009), recognizing the need to develop a method for voluntary verification of the energy efficiency design index for new ships in order to promote uniform use of the Interim Guidelines on the method of calculation of the energy efficiency design index for new ships (MEPC.1/Circ.681), agreed to circulate the Interim Guidelines on voluntary verification of the energy efficiency design index, as set out in the annex.

The Evolution of an Index

- Japan: MEPC 57/4/12

$$\frac{C_F \cdot SFC \cdot P}{Capacity \cdot V_{ref}}$$

- Denmark: GHG-WG 1/2/1

$$\frac{\prod_{j=1}^M f_j \sum_{i=1}^{NME} C_{FMEi} SFC_{MEi} P_{MEi} + \prod_{k=1}^L f_k \sum_{i=1}^{NAE} C_{FAEi} SFC_{AEi} P_{AEi}}{Capacity \cdot V_{ref}}$$

- MEPC 58/4

$$\frac{\left(\prod_{j=1}^M f_j \right) \left(\sum_{i=1}^{NME} C_{FMEi} SFC_{MEi} P_{MEi} \right) + \left(\prod_{k=1}^L f_k \right) \left(\sum_{i=1}^{NAE} C_{FAEi} SFC_{AEi} P_{AEi} \right)}{Capacity \times V_{ref} \times f_w}$$

- USA: MEPC 58/4/35

$$\frac{\left(\sum_{i=1}^{NME} C_{FMEi} SFC_{MEi} P_{MEi} \right) + \left(\sum_{i=1}^{NAE} C_{FAEi} SFC_{AEi} P_{AEi} \right) - \left(\sum_{eff=1}^{Neff} f_{eff} C_{F_{eff}} SFC_{eff} P_{eff} \right)}{Capacity \times V_{ref} \times f_w}$$

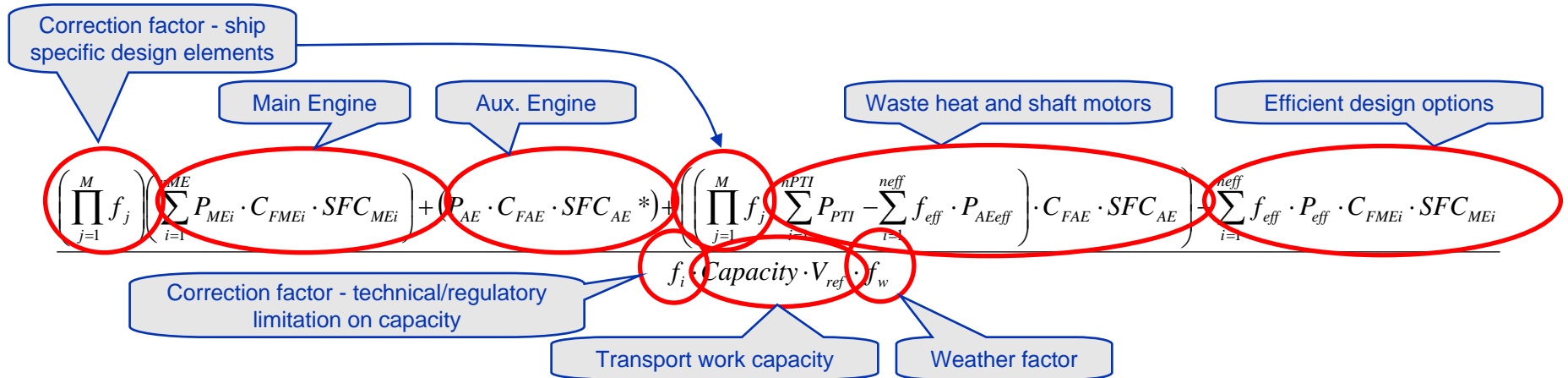
- MEPC 58/23

$$\frac{\left(\prod_{j=1}^M f_j \right) \left(\sum_{i=1}^{nME} C_{FMEi} SFC_{MEi} P_{MEi} \right) + P_{AE} C_{FAE} SFC_{AE}^* + \left(\sum_{i=1}^{nPTI} P_{PTI} - \sum_{i=1}^{nWHR} P_{WHRi} \right) C_{FAE} SFC_{AE} - \left(\sum_{i=1}^{neff} f_{eff} P_{eff} C_{FMEi} SFC_{MEi} \right)}{f_i \cdot Capacity \cdot V_{ref} \cdot f_w}$$

- MEPC.1/Circ.681

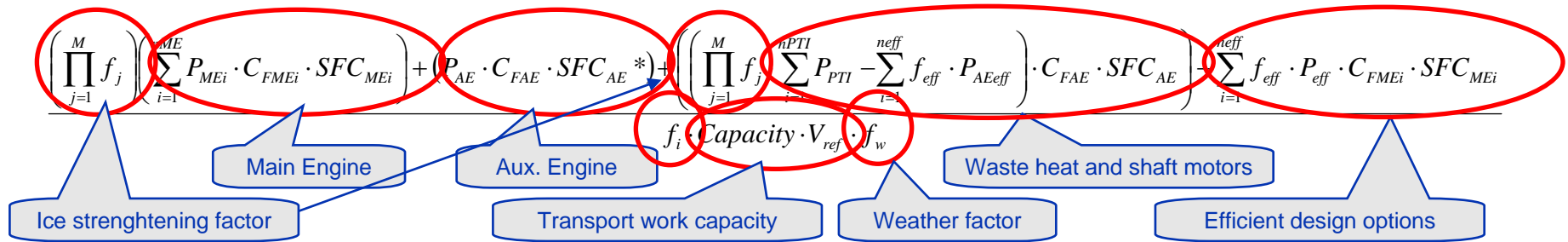
$$\frac{\left(\prod_{j=1}^M f_j \right) \left(\sum_{i=1}^{nME} P_{MEi} \cdot C_{FMEi} \cdot SFC_{MEi} \right) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE}^*) + \left(\left(\prod_{j=1}^M f_j \cdot \sum_{i=1}^{nPTI} P_{PTI} - \sum_{i=1}^{neff} f_{eff} \cdot P_{AE_{eff}} \right) \cdot C_{FAE} \cdot SFC_{AE} \right) - \sum_{i=1}^{neff} f_{eff} \cdot P_{eff} \cdot C_{FMEi} \cdot SFC_{MEi}}{f_i \cdot Capacity \cdot V_{ref} \cdot f_w}$$

Present EEDI formulation



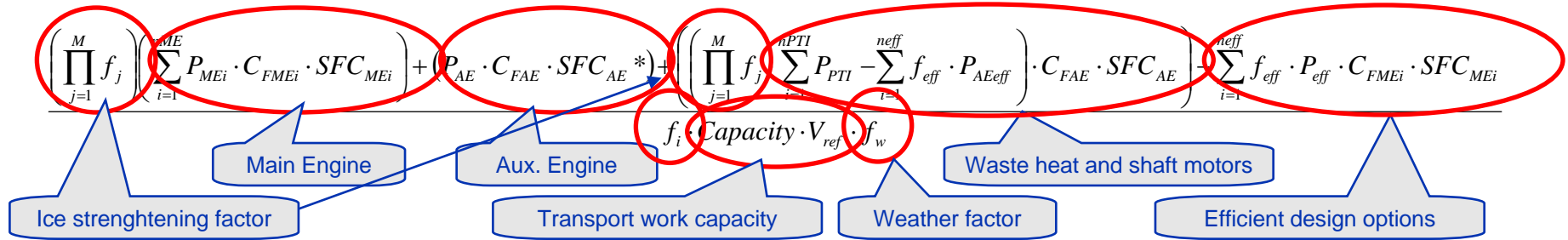
- The basic principle retained but complexity increased
- Correction factors for ice strengthening added (f_i for capacity & f_j for power)
- The aux engine power on diesel-electric systems to be further explored
- No guidelines on weather factor f_w at present
- No discussion regarding application and requirements

Ongoing Development of Formula in MEPC



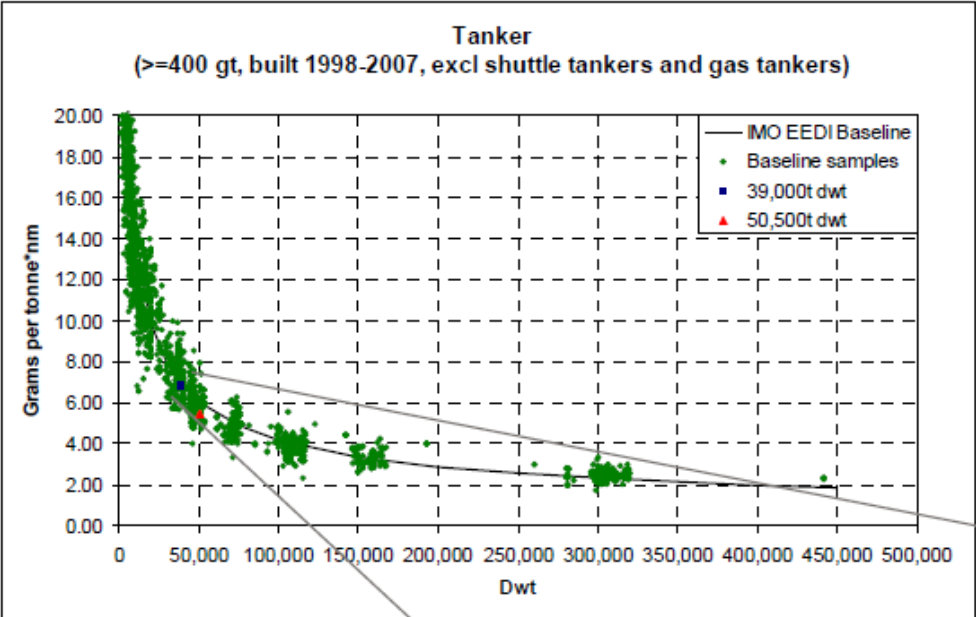
- $P_{ME(i)}$ is 75 % of the MCR for each main engine deducted any shaft generators (P_{PTO})
- SFC is the certified specific fuel consumption taken from the EIAPP certificate at 75 % load (ME, E2 or E3 cycles) or 50% (AUX, D1 or C1 cycles)
- P_{AE} is the required auxilliary power to supply normal max. sea load (...) and is a function of the total MCR of main engines
 - $MCR > 10000 \text{ kW} \rightarrow P_{AE} = 2,5\% \cdot MCR + 250$
 - $MCR < 10000 \text{ kW} \rightarrow P_{AE} = 5\% \cdot MCR$
 - If this value is significantly different from the total power used and normal seagoing P_{AE} can be estimated using the electric power table
- P_{AEeff} is the AUX power reduction due to innovative electrical energy efficient technology (...)
- P_{PTO} is 75 % of the output of each shaft generator divided by the relevant efficiency

Ongoing Development of Formula in MEPC

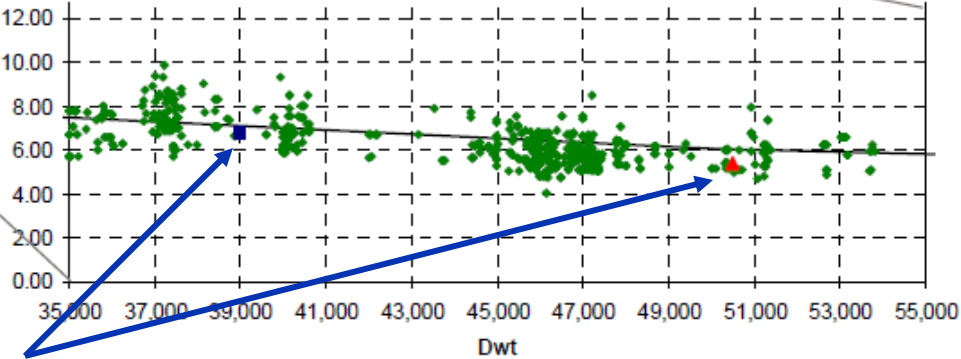


- P_{PTI} is 75 % of the rated power consumption of each shaft motor divided by the relevant efficiency
- P_{eff} is the ME power reduction due to innovative mechanical energy efficient technology
- f_{eff} is the availability factor for each innovative energy efficient technology (i.e. 1 for waste heat)
- f_w is a non-dimensional coefficient determining the decrease of speed in representative sea conditions (BS 6)
 - Can be determined through simulation or standard tables, but will remain 1 until guidelines become available
- f_j is a correction factor to account for ships specific design elements (such as ice strenghtening)
- V_{ref} is the ship speed on deep water in maximum design load condition (deepest operational draft as defined in stability booklet) in calm weather
- f_i is the capacity factor for any technical/regulatory limitation on capacity (...) (such as ice strenghtening)

Establishing the EEDI Base Line



Baselines are derived by taking a ten-year sample of data from Lloyd's Register Fairplay database, filter for data entry errors, and apply the EEDI formula with all correction factors set to 1.0.



Below EEDI baseline

(baseline still under review)

EEDI - Some Concerns...

- Safety issues
 - Redundant propulsion power
 - Ice strengthening
- Improvement potential
 - Speed reduction may be the only option
 - Fixed engine load

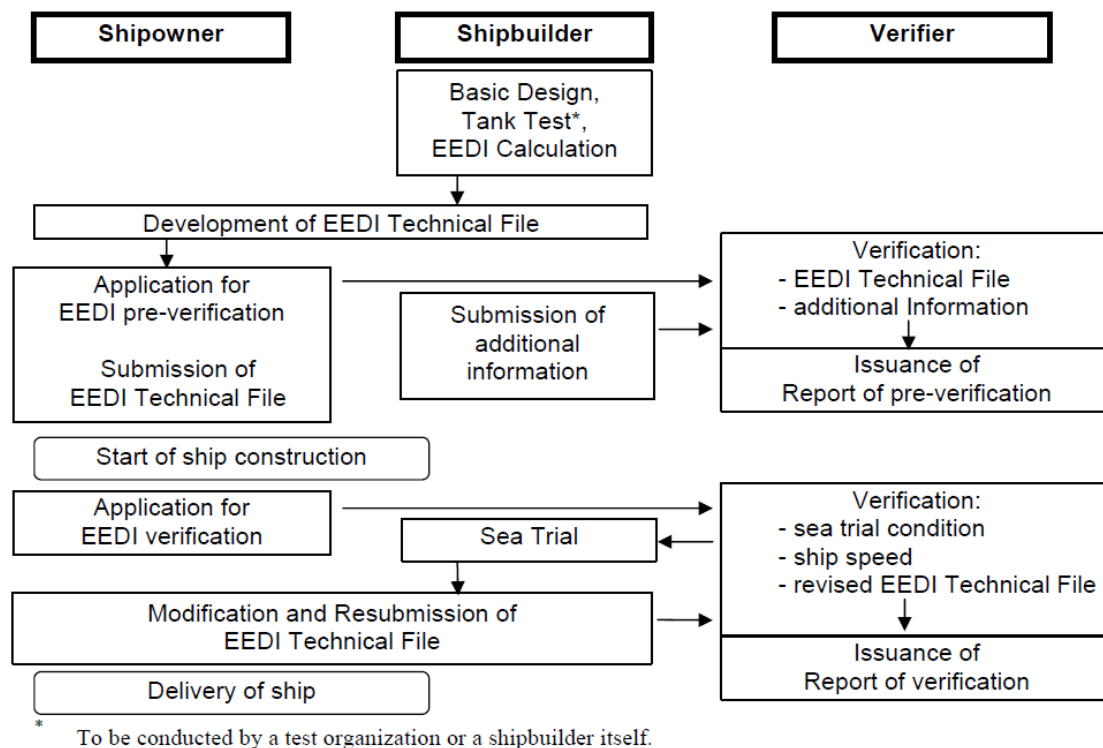
EEDI - Some Concerns...

- Verification problems
 - Load balance (for diesel-electric propulsion)
 - Rating of waste heat recovery systems
 - Innovative technology
 - Speed-power relation

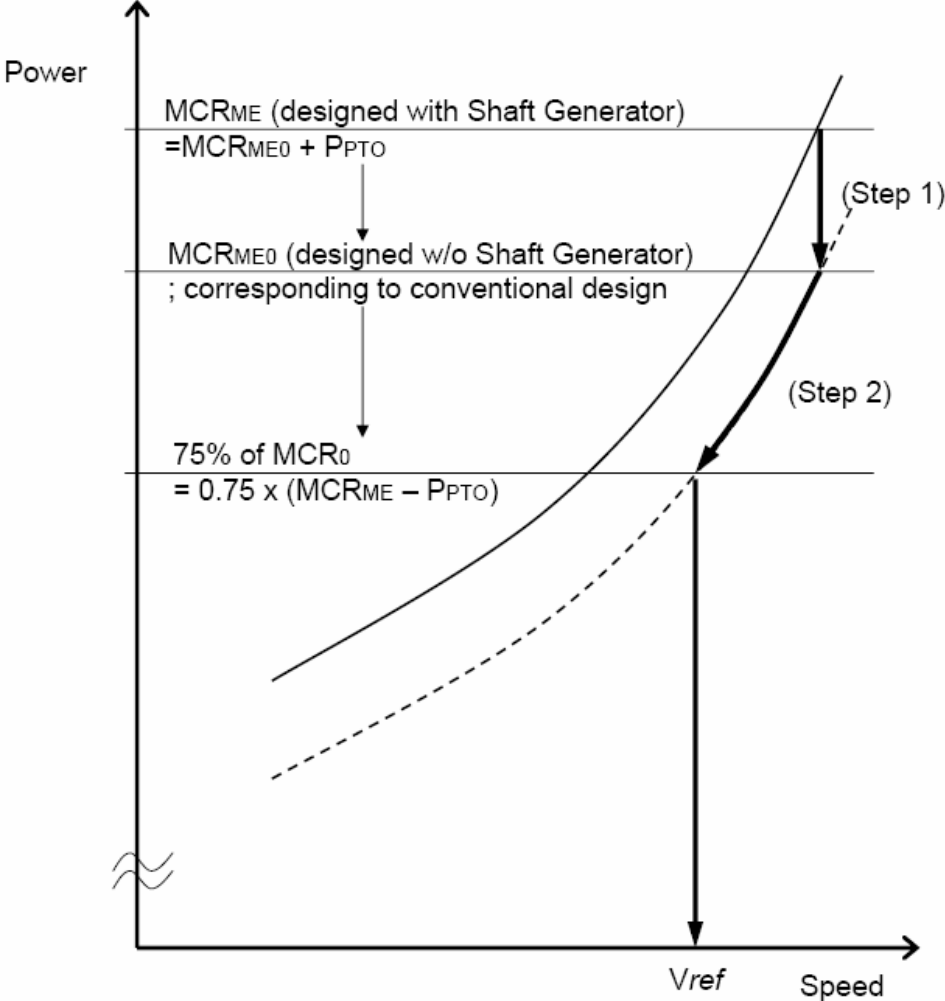
- Baseline
 - Difficult to obtain data to create precise baseline
 - Introduction of CSR

EEDI - Verification in Two stages

- Preliminary verification at the design stage
- Final verification at the sea trial
 - But what happens if the ship is not approved at sea trial?



EEDI - Consistency of Speed and Power



EEDI - Ship Types Included and Definitions

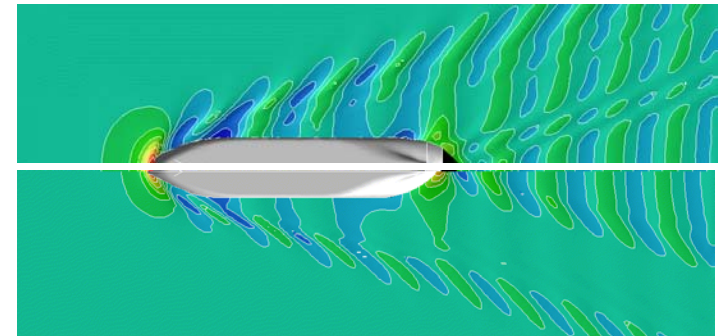
Ship type	Definition	Capacity
Passenger ship	A ship which carries more than 12 passengers as defined in SOLAS chapter 1, regulation 2	GT
Dry cargo carrier	A ship which is constructed generally with single deck, topside tanks and hopper tanks in cargo spaces, and it is intended primarily to carry dry cargo in bulk, and includes such types as ore carriers and combination carriers, as defined in SOLAS chapter IX, regulation 1	DWT
Gas tanker	A gas carrier as defined in SOLAS chapter II-1, regulation 3	DWT
Tanker	An oil tanker as defined in MARPOL Annex I, regulation 1 or chemical tanker and a NLS tanker as defined in MARPOL Annex II, regulation 1	DWT
Containership	A ship designed exclusively for the carriage of containers in holds and on deck	65%*DWT
Ro-ro cargo ship: Vehicle carrier	A multi deck ro-ro cargo ship designed for the carriage of empty cars and trucks	DWT
Ro-ro cargo ship: Volume carrier	A ro-ro cargo ship, with a deadweight per lanemetre less than 4* tons/m, designed for the carriage of cargo transportation units	DWT
Ro-ro cargo ship: Weight carrier	A ro-ro cargo ship, with a deadweight per lanemetre of 4* tons/m or above, designed for the carriage of cargo transportation units	DWT
General cargo ship	A ship with a multi-deck or single-deck hull designed primarily for the carriage of general cargo	DWT
Ro-ro passenger ship	A passenger ship as defined in SOLAS chapter II-1, Part A, regulation 2.23	GT

EEDI – What's Next?

Reduce installed power while achieving the same speed w/o compromising safety!

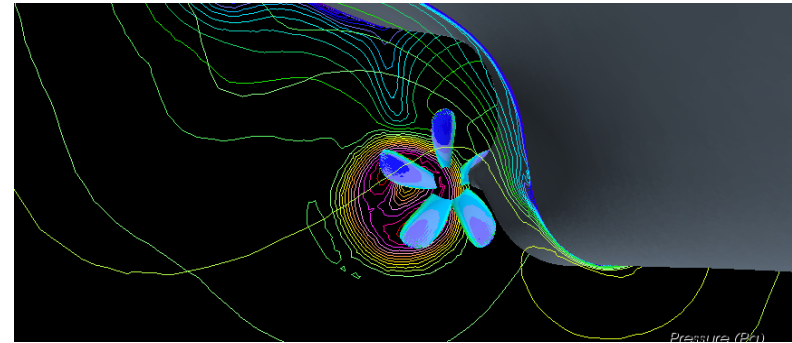
Detailed assessment of the EEDI

- Including all factors in the formula (waste heat recovery systems, ice class, etc..)
 - Benchmark against a smaller number of vessels with more ship specific data available
-
- Hull design
 - Global hull form optimization for fuel efficiency
 - Bow design for an effective combination of drafts and speeds rather than one optimum point



EEDI – What's Next?

- Hull and propeller interaction
 - Optimize hull, propeller & rudder efficiencies based on numerical simulations using CFD codes
 - Avoid sub-optimal solutions and assess the total performance of ship including all interaction effects
 - Identify possible gains from different energy efficiency devices such as wake improving appendages, vortex generators and energy recovering systems
 - Check for allowable noise and hull vibrations for the optimized system
- Fuel efficiency improvement of ship systems
 - Detailed review of ship specification focusing on the ship systems and energy consumers (pumps, fans, HVAC systems, etc...)
- Added resistance in waves – sea margin
 - Investigate ways to reduce the applied sea margin by better estimating speed loss in waves



EEDI – Earliest Possible Timeline

- MEPC 59 - July 2009
 - EEDI formula finalized and agreed as voluntary measure
- MEPC 61 – October 2010
 - EEDI approved as mandatory measure, including application issues (scope of application, requirement levels, verification issues, non-compliance consequences, entry into force date, etc.)
 - Diesel electric ships possibly included
- MEPC 62 – July 2011
 - Decision of MEPC 61 adopted
- Entry into force – assuming Marpol Annex VI is used as legal instrument; somewhere between 2013 – 2018 depending on ratification process



The Future - Port or Starboard?



- COP 15 called for further regulatory progress
- Market-based instruments will be established, either internationally or regionally between 2013 – 2014
- Mandatory regulations are expected to have **medium to long term** impact
- New regulations will drive technological innovation
- It's important to get the right regulations

Safeguarding Life, Property and the Environment

www.dnv.com



MANAGING RISK