### Air pollution from Maritime transport

<table>
<thead>
<tr>
<th>Total emissions</th>
<th>Cantidad</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Million ton</td>
</tr>
<tr>
<td>CO2 (trafico internacional)</td>
<td>1,046 (870)</td>
</tr>
<tr>
<td>NOx</td>
<td>20</td>
</tr>
<tr>
<td>SOx</td>
<td>12</td>
</tr>
<tr>
<td>PM</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Presentation of MARPOL Annex VI

MARPOL Annex VI

- Provides regulations for the prevention of air pollution from ships,

- In force since 19 May 2005,

- Applies to all ships of 400 gross tonnage and above and to offshore units built on or after 19 May 2005,

- The compliance of the ship with Annex VI will be marked by the issuance of an IAPP Certificate.
MARPOL Annex VI

► ANNEX VI adopted in 1997
► Entered into force: 19 MAY 2005
► Limits shipboard air pollution, Ozone; Shipboard Incineration, SOx, NOx, PM and VOC
► Annex VI Certificates:
  ► IAPP and EIAPP
► Annex VI (Revised, MEPC 2008)
► Entered into force on 01 JUL 2010
► Strengthen emission limits with ECA etc.
Presentation of MARPOL Annex VI

MARPOL Annex VI covers

- Ozone depleting substances,
- Nitrogen oxide emissions from diesel engines,
- Sulphur oxide emissions from ships,
- Volatile organic compound emissions from tankers,
- Shipboard incineration,
- Fuel oil quality.
Presentation of MARPOL Annex VI

Ozone depleting substances (ODS): Regulation 12

- ODS prohibited on all ships

- ODS are defined in the Montreal Protocol on Substances that deplete the Ozone Layer. The following ODS may be found on board ships:
  - halon 1211, halon 1301, halon 2402
  - CFC-11, CFC-12, CFC-113, CFC-114, CFC-115

- Deliberate emission of ODS during operation, maintenance, repair, etc. are prohibited.

- Hydro fluorocarbons permitted until 1 January 2020.
Presentation of MARPOL Annex VI

**NOx emissions from Diesel engines:** *Regulation 13*

- Applies to all Diesel engines
  - With a power > 130 kW

- Does not apply to the following engines:
  - Emergency diesel engines
  - Engines installed in lifeboats
  - Other engines used solely in case of emergency
Presentation of MARPOL Annex VI

**Shipboard incineration:** *Regulation 16*

- Incinerators installed on board a ship on or after 1 January 2000 are to be type approved in accordance with the provisions of IMO Resolution MEPC.76(40) : Standard Specification for Shipboard Incinerators.

- Operating manual specifying how to operate the incinerator is to be kept onboard.

- Incineration of certain substances is prohibited (cargo residues, PCBs, etc.).

- Personnel responsible for the operation is to be trained.
Presentation of MARPOL Annex VI

Fuel oil quality: *Regulation 18*

- The “appropriate authorities” will have to maintain a register of local fuel oil suppliers.

- Details of fuel oils used onboard shall be recorded by means of a bunker delivery note containing the following information:
  - Name and IMO number of the ship
  - Port
  - Date of commencement of delivery
  - Name, address, and telephone number of marine fuel oil supplier
  - Product name(s)
  - Quantity (metric tons)
  - Density at 15 °C (kg/m3)
  - Sulphur content (% m/m)
  - A declaration signed and certified by the fuel oil supplier’s representative that the fuel oil supplied is in conformity with regulation 14 (1) or (4) (a) related to sulphur content and regulation 18 (1) related to fuel oil elaboration process (see Appendix V)
Fuel oil quality: *Regulation 18 (cont.)*

- Bunker delivery notes are to be kept onboard the ship for a period of 3 years after the fuel oil has been delivered onboard.

- The bunker delivery note shall be accompanied by a representative sample of the fuel oil delivered. The sample is to be kept onboard until the fuel oil is substantially consumed, but in any case for at least 12 months from the time of delivery.

- Guidelines for the sampling are given in Resolution MEPC.96(47).
1 - General

► “NOx” means NO and NO2, which are formed during fuel combustion.

► Only emissions from Diesel engines are considered. NOx emissions from marine diesel engines account for approximately 17% of global NOx emissions produced by fuel combustion.

► Other sources are considerably lower (about 2 g/kWh for boilers and 5 g/kWh for gas turbines vs. 10 to 15 g/kWh for diesel engines).

► NOx has harmful effect on the environment (acidification, formation of ozone, adverse health effects).
NOx emissions are influenced by the combustion process. When the combustion temperature and duration increase, the amount of NOx formed increases. Higher peak pressure and compression ratio result in higher NOx emission levels. NOx-influencing parameters include:

- Injection parameters (timing, nozzle, pump, fuel cam, injection pressure for common rail systems).

- Combustion chamber (cylinder head, piston, cylinder liner, compression ratio, valve timing).

- Charge air system (turbocharger, charge air cooler).
Equipment to reduce NOx emissions:

- Direct water injection
- Charge air humidification
- Emulsified fuel (fuel / water emulsion)
- Exhaust gas recirculation
- Selective catalytic reduction (injection of urea solution)
Emission Control Areas (ECA)

► An Emission Control Area:
  - NOx, SOx and particulate matter, or
  - all three types of emissions.

► Existing ECA and SECA are today:

<table>
<thead>
<tr>
<th>Emission Control Area</th>
<th>Date 1</th>
<th>Date 2</th>
<th>Date 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>North American (SOx, and NOx and PM)</td>
<td>26 Mar 2010</td>
<td>1 Aug 2011</td>
<td>1 Aug 2012</td>
</tr>
<tr>
<td>United States Caribbean Sea ECA (SOx, NOx and PM)</td>
<td>26 Jul 2011</td>
<td>1 Jan 2013</td>
<td>1 Jan 2014</td>
</tr>
</tbody>
</table>
### International Regulations for SOx emissions

<table>
<thead>
<tr>
<th>Regulations</th>
<th>Sulphur Content (in mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2010</td>
</tr>
<tr>
<td>IMO – Global (except for passenger ships)</td>
<td>4.5%</td>
</tr>
<tr>
<td>IMO – ECA – SECA (EU aligned with IMO)</td>
<td>1.5%</td>
</tr>
<tr>
<td>EU ports</td>
<td>0.1%</td>
</tr>
<tr>
<td>California (&lt; 24 nm)</td>
<td>1.5%</td>
</tr>
<tr>
<td></td>
<td>0.5%</td>
</tr>
</tbody>
</table>

- With effect from 18 December, 2012, the EC Sulphur Directive 1999/32/EC is amended by Directive 2012/33/EU in order to align the EC regulations on sulphur content of marine fuels with the IMO regulations.

- The EC regulations are aligned with the revised Annex VI to MARPOL, both inside and outside EU Sox Emission Control Areas (SECA). The 0.50% limit outside EU SECAs will apply in EC waters from 1 January, 2020, regardless of the outcome of the IMO fuel availability review, which is due by 2018.

- Emission abatement methods (e.g. exhaust gas cleaning systems) are permitted for ships of all flags in EC waters as long as they continuously achieve reductions of SOx emissions which are at least equivalent to using compliant marine fuels.
SOx emissions reduction solutions

- Low sulphur fuel oil
- Scrubber Systems
- LNG as fuel
Regulations for NOx emissions

<table>
<thead>
<tr>
<th>Regulations</th>
<th>2000</th>
<th>2011</th>
<th>2021</th>
</tr>
</thead>
<tbody>
<tr>
<td>IMO – outside ECA</td>
<td>Tier I</td>
<td>Tier II</td>
<td></td>
</tr>
<tr>
<td>IMO - ECA</td>
<td>Tier I</td>
<td>Tier II</td>
<td>Tier III</td>
</tr>
</tbody>
</table>

Tier III applies only in ECA (not in SECA) and is not retroactive.

For ships fitted with Nox certified engines, specifically for those using the parameter check method, replacement of Nox critical components must be marked up as required. Record book of Engine parameters must be completed, even for similar changes. The approved Technical File must be on-board for inspection request.

The direct measurement and monitoring method in an alternative way to demonstrate compliance. However, this still requires a technical file.

Ships built before 2000 were initially outside the Nox certification requirement, except where certain replacement engines are installed. The introduction of the « approved method » concept has changed this for engines over 5000 kW and of 90 litre/cylinder or more on ships constructed on or after 1st January 1990 and before 1st January 2000. If an approved method exists, it is required to be fitted within a given time period. Owners of such fleets should remain aware of announcements from IMO.
### Emissions NOx. MARPOL

- **Reglamentaciones para las emisiones de NOx**
  - **power** ≥ 130 kW
  - Entered into force: 1st July 2010

<table>
<thead>
<tr>
<th>Keel laid D *</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1/2000 ≤ D &lt; 1/1/2011</td>
<td>Tier I</td>
</tr>
<tr>
<td>1/1/2011 ≤ D &lt; 1/1/2016</td>
<td>Tier II</td>
</tr>
<tr>
<td>1/1/2016 ≤ D</td>
<td>Tier III in ECA **</td>
</tr>
<tr>
<td>“existing engines” 1/1/1990 ≤ D &lt; 1/1/2000 bore ≥ 90 l &amp; power &gt; 5,000 kW</td>
<td>Tier I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>rpm</th>
<th>N &lt; 130</th>
<th>130 ≤ N &lt; 2000</th>
<th>N ≥ 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tier I</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tier I I Reg. 13(3)(a)</td>
<td>17.0 g/kWh</td>
<td>45 N^{-0.20} g/kWh</td>
<td>9.8 g/kWh</td>
</tr>
<tr>
<td><strong>Tier II</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>~ 80% Tier I</td>
<td>14.4 g/kWh</td>
<td>44 N^{-0.23} g/kWh</td>
<td>7.7 g/kWh</td>
</tr>
<tr>
<td><strong>Tier III</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>~ 20% Tier I</td>
<td>3.4 g/kWh</td>
<td>9 N^{-0.20} g/kWh</td>
<td>2.0 g/kWh</td>
</tr>
</tbody>
</table>
NOx emissions reduction solutions

► LNG as fuel
► Selective Catalytic Reduction (SCR)
► Exhaust gas recirculation (EGR)
Exhaust Gas Recirculation (EGR)

► Principle: a fraction of exhaust is redirected into the engine
► It reduces NOx produced during combustion

► Exhaust in Engine: Challenges
  - Particles and soot can damage turbo and the engine
  - It reduces the efficiency of the intercooler
  - Particles need to be removed
  - Filter is the easiest solution
  - High temperature of exhaust can affect the efficiency
  - Cooler to cool down the exhaust
NOX and SOX abatement

**NOX emissions can be reduced:**
- Selective Catalytic Reduction (SCR)
  (compliant with TIER III, but uses ammonia)
- Water in fuel
- Wet air engine
- Recirculation of exhaust gas (EGR).

**SOX emissions can be reduced:**
- Scrubbers
- Low sulphur fuels
Dual Fuel engines

► GAS FUEL: Cicle OTTO

► LIQUID FUEL: Cicle DIESEL
REGULATION ON CO2 EMISSIONS
Comparing to others

IT IS QUITE GOOD !!!

50g CO₂ /ton/km

>500g CO₂ /ton/km

15g CO₂ /ton/km

5g CO₂ /ton/km
Regulations for CO₂ emissions: EEDI & SEEMP

► IMO developed a tool to measure (compare) energy efficiency of ship designs: the EEDI
  
  - Not perfect (no consideration of seaworthiness and economy of scale of large ships) but usable
  - Progressively applicable to the majority of ship types

► MSC.203(62) – New ch. 4 of MARPOL Annex VI

► EEDI mandatory for “new ship” (reg. 2.23):
  
  - Building contract placed on or after 1 January 2013 or
  - In the absence of a building contract, the keel laid on or after 1 July 2013 or
  - Delivery on or after 1 July 2015

SEEMP mandatory for new and existing ships at first intermediate or renewal survey on or after 1 January 2013
### CO₂ Reduction - Energy Efficiency Design Index (EEDI)

**Reference**

MSC.203(62) – New chapter 4 to MARPOL Annex VI – Reg.19,20,21

**Entry into force**

1 January 2013

**Applicable to**

all new ships ≥ 400gt*

---

The EEDI objective is to stimulate innovation and technical development in order to increase the energy efficiency from the design stage.

The formula is:

\[
\frac{\text{Environmental cost}}{\text{Benefit for society}} = \frac{\text{CO₂ emissions at 75% MCR} + \text{fixed auxiliary power}}{\text{cargo capacity} \times \text{ship speed} \times [\text{correction factors}]} \quad \frac{g[CO₂]}{t \cdot nm} \quad \frac{g[CO₂]}{gt \cdot nm}
\]

- **Capacity:**
  - DWT: Dry cargo ships, Tankers, Gas Tankers
  - GRT: Passenger ships, RO-RO Passenger ships 70% DWT: Container ships

- **Correction Factors:**
  - Sea state dependant
  - For any technical/regulatory capacity limit (Ice class)

- **Ship Speed:**
  - Taken at 75% of MCR

- The CO₂ reduction due to energy recovery systems is taken into account directly in the calculation.

- Auxiliary power calculation refers only to power for propulsion machinery systems & accommodation.

*Except for ships with diesel-electric propulsion, turbine propulsion or hybrid propulsion systems.*
The EEDI of ships is to be calculated according to IMO guidelines:

- Original document: MEPC Circ.1/681
- Calculation guidelines adopted at MEPC 63: Resolution MEPC 213(63)
- Formula:

\[
\text{EEDI} = \left( \prod_{j=1}^{M} f_j \right) \sum_{i=1}^{\text{ME}} P_{\text{ME}(i)} \cdot CF_{\text{ME}(i)} \cdot SFC_{\text{ME}(i)} + \left( P_{\text{AE}} \cdot C_{\text{FAE}} \cdot SFC_{\text{AE}} \right) + \left( \prod_{i=1}^{\text{PTI}} f_{i} \cdot \sum_{i=1}^{\text{eff}} f_{\text{eff}(i)} \cdot P_{\text{AEeff}(i)} \right) C_{\text{FAE}} \cdot SFC_{\text{AE}} - \left( \sum_{i=1}^{\text{eff}} f_{\text{eff}(i)} \cdot P_{\text{eff}(i)} \cdot C_{\text{FAE}} \cdot SFC_{\text{ME}} \right)
\]

- \( f \) Correction factors
- \( CF \) CO₂ emission coefficient
- \( SFC \) Specific fuel consumption
- "AE" Subscripts for auxiliary engines
- "ME" Subscripts for main engine(s)

Ship’s work in normal operating condition
Reference Curves for the Required EEDI

The baselines curves are available in the document MEPC 62/6/4

- Ship tonnage $\geq 400$ gt
- Bulk carriers, gas carriers, oil & chemical tankers, container cargo, refrigerated cargo, OBO's, Ro-Ro
- Calculation based on IHS Fairplay
- Baseline value $= a \times \text{Capacity}^{-c}$
Target Years & Reduction Rates

Draft regulatory text for mandatory EEDI requirements: target years & reduction rates

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>Size</th>
<th>Phase 0 1 Jan 2013 – 31 Dec 2014</th>
<th>Phase 1 1 Jan 2015 – 31 Dec 2019</th>
<th>Phase 2 1 Jan 2020 – 31 Dec 2024</th>
<th>Phase 3 1 Jan 2025 onwards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Carrier</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Gas tanker</td>
<td>10,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>2,000 – 10,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Tanker</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Container ship</td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>10,000 – 15,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
<tr>
<td>General Cargo ships</td>
<td>15,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 – 15,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-15*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Refrigerated cargo carrier</td>
<td>5,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>3,000 – 5,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-15*</td>
<td>0-30*</td>
</tr>
<tr>
<td>Combination carrier</td>
<td>20,000 DWT and above</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>4,000 – 20,000 DWT</td>
<td>n/a</td>
<td>0-10*</td>
<td>0-20*</td>
<td>0-30*</td>
</tr>
</tbody>
</table>

* Factor to be linearly interpolated between two values dependent upon vessel size (the lower value of reduction factor is to be applied to the smaller ship size).
Certification of EEDI - Overview

BV is the contact point in IMO and was in charge of writing the IACS PR 38 on EEDI computation & verification.
SEEMP: Some Possible Measures

Possible measures are quite varied and dependent of the ship type:

- Weather routing
- Optimization of the commercial speed (just in time arrival)
- Slow steaming and super slow steaming
- Optimization of ballast and trim
- Retrofitting of ESDs
- Periodic hull and propeller cleaning
- Other
Energy Efficiency Operation Index (EEOI)

The EEOI objective is to facilitate the quantitative monitoring of energy efficiency and thus it may be used for the monitoring of SEEMP.

The formula is:

\[
\frac{\text{Environmental Cost}}{\text{Benefit for Society}} = \frac{\text{Fuel Consumption} \times \text{CO}_2 \text{Conversion factor}}{\text{Cargo Capacity} \times \text{Distance}} \cdot \frac{\text{gCO}_2}{\text{t-nm}}, \frac{\text{gCO}_2}{\text{teu-nm}}, \frac{\text{gCO}_2}{\text{pas-nm}}
\]

Capacity:
- DWT: Dry cargo ships, Tankers, Gas Tankers
- Passengers: Passenger ships
- TEU: Container ships

- Simple, straightforward calculation
- The EEOI can be calculated for one trip or for a certain period covering several trips (ballast ones included)

Reference:
MEPC 59 – MEPC.1/Circ.684
International Energy Efficiency Certificate (IEEC)

SEEMP Review - International Energy Efficiency Statement of Compliance

- Owner can request BV to carry out a SEEMP review and issue an IEE SoC

- The IEE SoC is an evidence that the SEEMP has been developed taking into account guidelines adopted by the Organization, in compliance with IMO MEPC.203(62) Regulation 22.2.
IMPROVING SHIP EFFICIENCY

BV SEEMP NOTATION & SEECAT
The additional class notation SEEMP is defined in BV NR 586 “SEEMP Additional Class Notation” and deals with the voluntary approval and periodical inspection of the SEEMP.

The notation SEEMP was revised in 2013:

- Two levels: review of initial plan (SEEMP) and review of plan and inspections in service (SEEMP SIS)
- Introduction of SEEMP INST for ships fitted with onboard measuring equipment (FO flowmeters, CO2, navigation info)
# Energy Saving Measures Ranking

<table>
<thead>
<tr>
<th>Letter</th>
<th>Order of magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Saving &gt; 20%</td>
</tr>
<tr>
<td>B</td>
<td>10 &lt; Saving &lt; 20%</td>
</tr>
<tr>
<td>C</td>
<td>5 &lt; Saving &lt; 10%</td>
</tr>
<tr>
<td>D</td>
<td>2.5 &lt; Saving &lt; 5%</td>
</tr>
<tr>
<td>E</td>
<td>1 &lt; Saving &lt; 2.5%</td>
</tr>
<tr>
<td>F</td>
<td>Saving &lt; 1%</td>
</tr>
</tbody>
</table>

## Energy Efficiency improvement measures

<table>
<thead>
<tr>
<th>Energy Efficiency improvement measures</th>
<th>Potential energy saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather routing</td>
<td>D</td>
</tr>
<tr>
<td>Just in time arrival</td>
<td>D</td>
</tr>
<tr>
<td>Speed optimization</td>
<td>D</td>
</tr>
<tr>
<td>Super Slow Steaming</td>
<td>A</td>
</tr>
<tr>
<td>Optimum trim</td>
<td>D</td>
</tr>
<tr>
<td>Optimum ballast condition</td>
<td>D</td>
</tr>
<tr>
<td>Hull coating cleaning</td>
<td>C</td>
</tr>
<tr>
<td>Propeller cleaning and polishing</td>
<td>C+</td>
</tr>
<tr>
<td>Engine auto-tuning</td>
<td>D</td>
</tr>
<tr>
<td>Main engine derating</td>
<td>E</td>
</tr>
<tr>
<td>Main engine variable turbo area</td>
<td>E</td>
</tr>
<tr>
<td>Use of alternative fuels</td>
<td>B</td>
</tr>
<tr>
<td>Waste Heat Recovery System</td>
<td>B-C</td>
</tr>
</tbody>
</table>
Trim Optimization

- Sea State
- Power
- Wind
- Load
- Fuel Efficiency
Electro motors speed variation
Weather & current routing
Granting BV Additional Notation SEEMP

The additional class notation SEEMP is defined in BV NR 586 “SEEMP Additional Class Notation” and deals with the voluntary approval of the SEEMP in a professional approach.

- The Owner provides the SEEMP to BV for initial review and approval, as well as future revisions of the plan.

- BV evaluates the different possible measures initially suggested by the Owner and the order of magnitude of the possible gains by building an energy flow model of the ship with the BV SEECAT simulation tool and using it to simulate the effect of the proposed measures in operating conditions defined by the Owner. BV will also check that the SEEMP is effectively implemented onboard the ships.
It is necessary to adopt an **holistic approach** when improving a ship in operation

Only a specific **energy transfer** equations calculation **tool** can provide a third party **global gain prediction at ship scale**

**Fuel oil consumption can be reduced by:**

- Operational measures
- Improved maintenance measures
- Retrofitting Energy Saving Devices on hull, propeller, machinery
Propeller Optimization

Description: unsteady CFD simulations of a rotating propeller

Outputs of the simulations:
- $K_t$, $K_q$ and efficiency of the propeller in open water
- Estimation of cavitation onset risks

Example of applications:
- Evaluation of propeller performances
- Evaluation Energy Saving Devices close to propeller
Self Propulsion Simulations

Description: unsteady CFD simulations of hull and appendages, including rotating propeller

Outputs of the simulations:
- Propulsive performances of the ship
- Evaluation of hull/propeller/appendages interactions
- Cavitation onset risk, pressure pulses …

Example of applications:
- Hull power optimisation
- Appendages alignment (twisted rudder and shaft brackets …)
- Evaluation of several propellers performances
TRIM OPTIMISATION
Energy Saving Devices (ESD) - Some options

- **Mewis Duct**
  - Improvement of propeller wake field
  - 3-10%

- **CR propeller**
  - Recovering of kinetic energy due to the rotational flow
  - SSPA 5~10%

- **ACS**
  - Reduction in frictional resistance 7-15% depending on ship type
  - 3-10%
  - Improved efficiency 6~12%

- **Loaded tip propeller**
  - Reduction in viscous pressure resistance ~2%

- **Fins in front of prop.**
  - Reduction in viscous pressure resistance ~2%

- **Twisted rudder**
  - Reduction in viscous pressure resistance ~2%
Energy Management

ISO 50001
ISO 50001

Certification Process

- Definition of certification scope
  - Pre-audit (optional)
- Certification audit in 2 stages:
  - Stage 1: readiness review performed to verify that the organization is ready for certification
  - Stage 2: evaluation of implementation, including the effectiveness of the organization’s management system
- A certificate valid for 3 years
- Surveillance audits annually
- Re-certification after 3 years
### Reliance Infrastructure Ltd
Dahanu Thermal Power Station

**Client industry:**
Power generation

<table>
<thead>
<tr>
<th>Examples of Energy Saving projects</th>
<th>Total Annual Savings</th>
<th>Investment</th>
<th>Payback months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation of Turbo wind ventilators</td>
<td>0.44</td>
<td>0.30</td>
<td>8.15</td>
</tr>
<tr>
<td>Reduction of auxiliary power by installing Hi- Chrome liners instead of Manganese liners in Coal mill 1AB</td>
<td>5.786</td>
<td>6.00</td>
<td>12.44</td>
</tr>
<tr>
<td>Auxiliary power reduction by replacement of BFP cartridge.</td>
<td>7</td>
<td>3.50</td>
<td>6</td>
</tr>
</tbody>
</table>

**ISO 50001**

► BV – first society to issue an ISO 50001 Certificate
Any questions?

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