Technology Innovations for Cost-effective Energy Efficiency Measures

Image Credit: wind-ship.org

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Simple Concept of Energy Efficiency:

Energy efficiency is a very broad term referring to the many different ways we can get the same amount of work (light, heat, motion, etc.) done with less energy. It covers efficient cars on the roads, efficient ships in the waters, improved industrial practices, better building insulation and a host of other technologies. Since saving energy and saving money often amount to the same thing, energy efficiency is highly profitable and great contributor for the climate change issue. Energy efficiency often has multiple positive effects.

For a simple example, an energy saving light gives more amount of light by consuming less amount of electrical energy than a traditional lightbulbs.

- Compared to traditional incandescents, energy-efficient lightbulbs such as halogen incandescents, compact fluorescent lamps (CFLs) and light emitting diodes (LEDs) have the following advantages:
  - Typically use about 25%-80% less energy than traditional incandescents, thus saving the money,
  - Can last 3 to 25 times longer, thus saving the money,
  - 3 to 5 times less energy consumption and Thus saving more energy. So, less fuel consumption and less emissions from power plants.

Source: afdf.com

Energy Efficiency Measures

- The amendments to MARPOL Annex VI Regulations for the prevention of air pollution from ships, add a new chapter 4 to Annex VI on Regulations on energy efficiency for ships to make mandatory the Energy Efficiency Design Index (EEDI) for new ships, and the Shipboard Energy Efficiency Management Plan (SEEMP) for all ships (resolution MEPC.203(62)). Other amendments add new definitions and requirements for survey and certification, including the format for the new International Energy Efficiency Certificate (IEEC).

- In 2011, IMO adopted mandatory technical and operational energy efficiency measures which are expected to significantly reduce the amount of CO_2 emissions from international shipping. These mandatory measures (EEDI/SEEMP) entered into force on *1 January 2013.*

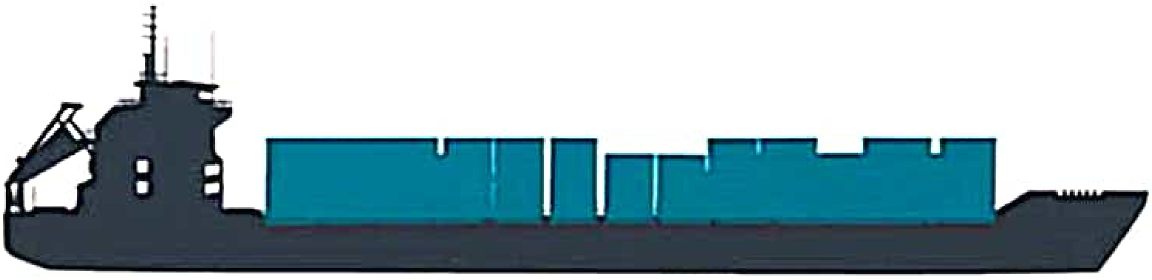
Cost-effectiveness of energy-efficiency measures

Some examples of technology innovations expected to be adopted through effective EEDI and SEEMP implementation include speed reduction, weather routing, use of auxiliary power and a focus on aerodynamics (see Figure 1).

Operational
Weather routing **1-4%**
Autopilot upgrade **1-3%**
Speed reduction **10-30%**

Auxiliary power
Efficient pumps, fans **0-1%**
High efficiency lighting **0-1%**
Solar panel **0-3%**

Aerodynamics
Air lubrication **5-15%**
Wind engine **3-12%**
Kite **2-10%**



Thrust efficiency
Propeller polishing **3-8%**
Propeller upgrade **1-3%**
Prop/rudder retrofit **2-6%**

Engine efficiency
Waste heat recovery **6-8%**
Engine controls **0-1%**
Engine common rail **0-1%**
Engine speed de-rating **10-30%**

Hydrodynamics
Hull cleaning **1-10%**
Hull coating **1-5%**
Water flow optimization **1-4%**

Figure 1 *Potential fuel use and CO_2 reductions from various efficiency approaches for ships (International Council on Clean Transportation (ICCT, July 2013). Long-term potential for increased shipping efficiency through the adoption of industry-leading practices.*

Cost Effective Technology Innovations

- Technologies which are available to significantly improve energy efficiency in the short, medium and long-term include:

1. Ship capacity enhancement

- ➢ Larger ships
- ➢ Purposely designed ships for specific routes/cargo mixers
- ➢ Multi-purpose ships (combination carriers) to avoid ballast (empty) legs
- ➢ Use of light weight construction materials;
- ➢ Zero or minimum ballast configurations;

2. Hull and propeller Designs

- Hull optimisation for less resistance and improved sea margins.
- Advanced underwater hull coatings and monitoring.
- More hydro-dynamically efficient aft-ship, propeller and rudder arrangements.
- Reduced air drag through improved aerodynamics of hull and superstructure.
- Hull air lubrication systems.

4. Engines, waste heat recovery and propulsion system

- More efficient main and auxiliary engines (de-rating, electronic control, longstroke,variable geometry turbocharger, etc.);
- Waste heat recovery and ship's thermal energy integration;
- Fuel cell and hybrid electric technologies

4. Alternative fuels

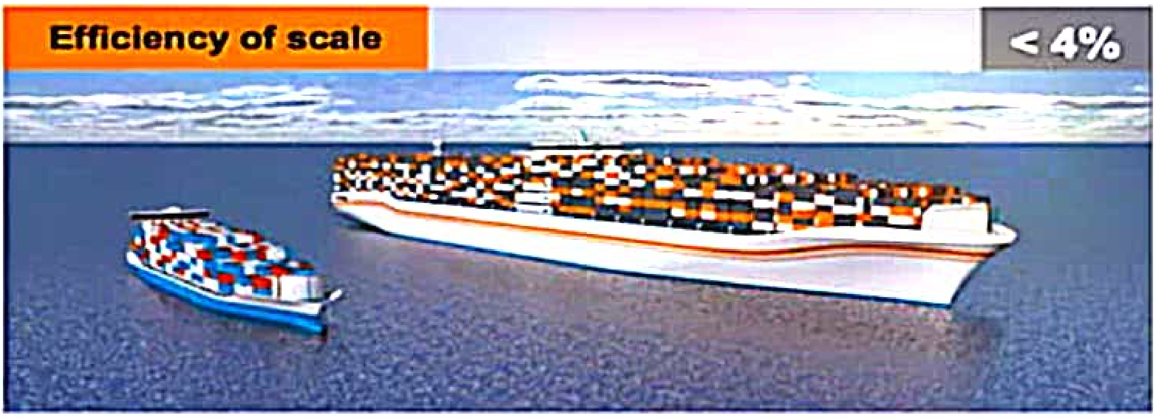
- LNG
- Nuclear

5. Alternative sources of energy

- Solar panels
- Wind power such as kites, sails and flettner rotors

Large Ship's Design

- A larger ship will in most cases offer greater transport efficiency due to efficiency of scale: A larger ship can transport more cargo at the same speed with less power per cargo unit. Limitations may be met in port handling.



Source: Wärtsilä

- Regression analysis of recently built ships show that a 10% larger ship will give about 4-5% higher transport efficiency.

Minimum Ballast Configurations

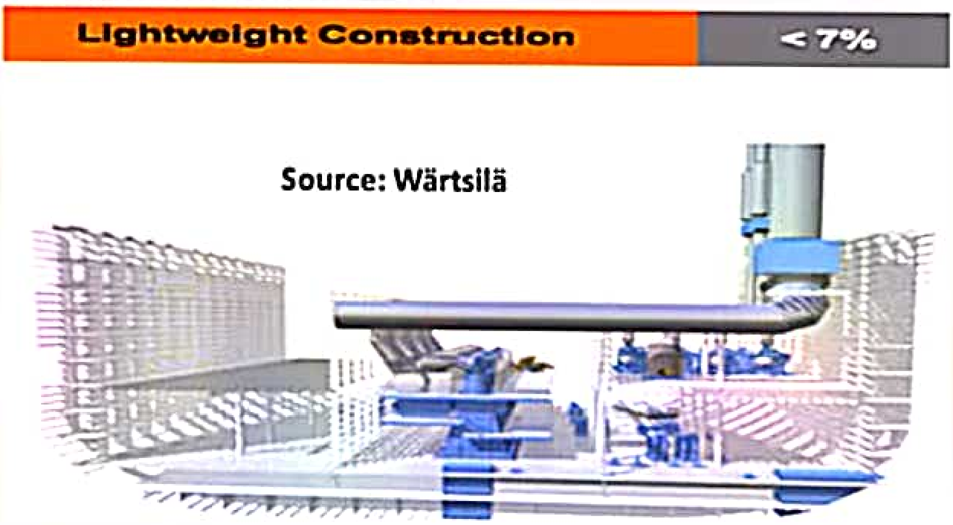
- Minimising the use of ballast results in lighter displacement and thus lower resistance. The resistance is more or less directly proportional to the displacement of the vessel. However there must be enough ballast to immerse the propeller in the water, and provide sufficient stability (safety) and acceptable sea keeping behaviour (slamming).

Source: Wärtsilä

- Removing 3000 tons of permanent ballast from a PCTC and increasing the beam by 0.25 metres to achieve the same stability will reduce the propulsion power demand by 8.5%.

Lightweight Structures

- The use of lightweight structures can reduce the ship weight.
  - In structures that do not contribute to ship global strength, the use of aluminium or some other lightweight material may be an attractive solution.
  - The weight of the steel structure can also be reduced. In a conventional ship, the steel weight can be lowered by 5-20%, depending on the amount of high tensile steel already in use.



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- **A 20% reduction in steel weight will give a reduction of ~9% in propulsion power requirements. However, a 5% saving is more realistic, since high tensile steel has already been used to some extent in many cases.**

Optimum Block Coefficient

- Finding the optimum length and hull fullness ratio (block coefficient, Cb) has a big impact on ship resistance.
- A high L/B ratio means that the ship will have smooth lines and low wave making resistance. On the other hand, increasing the length means a larger wetted surface area, which can have a negative effect on total resistance.
- A too high block coefficient (Cb) makes the hull lines too blunt and leads to increased resistance.

Source: Wärtsilä

- **Adding 10-15% extra length to a typical product tanker can reduce the power demand by more than 10%.**

Interceptor Trim Planes

- The Interceptor is a metal plate that is fitted vertically to the transom of a ship, covering most of the breadth of the transom. This plate bends the flow over the aft-body of the ship downwards, creating a similar lift effect as a conventional trim wedge due to the high pressure area behind the propellers. The interceptor has proved to be more effective than a conventional trim wedge in some cases, but so far it has been used only in cruise vessels and RoRos. An interceptor is cheaper to retrofit than a trim wedge.

Source: Wärtsilä

- **1-5% lower propulsion power demand. Corresponding improvement of up to 4% in total energy demand for a typical ferry.**

Ducktail Waterline extension

- A ducktail is basically a lengthening of the aft ship. It is usually 3-6 meter long. The basic idea is to lengthen the effective waterline and make the wetted transom smaller. This has a positive effect on the resistance of the ship. In some cases the best results are achieved when a ducktail is used together with an interceptor.

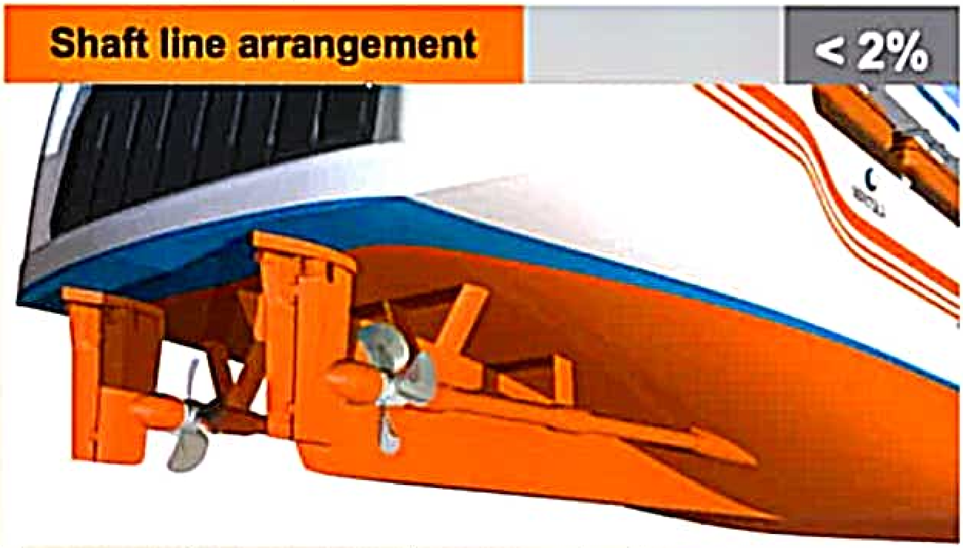
Ducktail waterline extension	< 7%

Source: Wärtsilä

- **4-10% lower propulsion power demand. Corresponding improvement of 3-7% in total energy consumption for a typical ferry**

Shaft Line Arrangement

- The shaft lines should be streamlined. Brackets should have a streamlined shape. Otherwise this increases the resistance and disturbs the flow to the propeller.

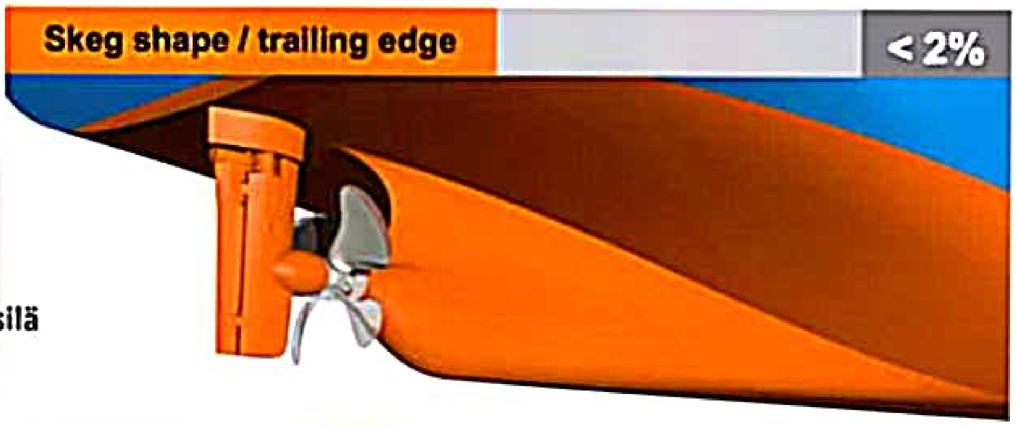


Source: Wärtsilä

- **Up to 3% difference in power demand between poor and good design. A corresponding improvement of up to 2% in total energy consumption for a typical ferry.**

Improved Skeg Shape/trailling Edge

- The skeg should be designed so that it directs the flow evenly to the propeller disk. At lower speeds it is usually beneficial to have more volume on the lower part of the skeg and as little as possible above the propeller shaftline. At the aft end of the skeg the flow should be attached to the skeg, but with as low flow speeds as possible.



Source: Wärtsilä

- **1.5%-2% lower propulsion power demand with good design. A corresponding improvement of up to 2% in total energy consumption for a container vessel.**

Minimizing Resistance of Hull Openings

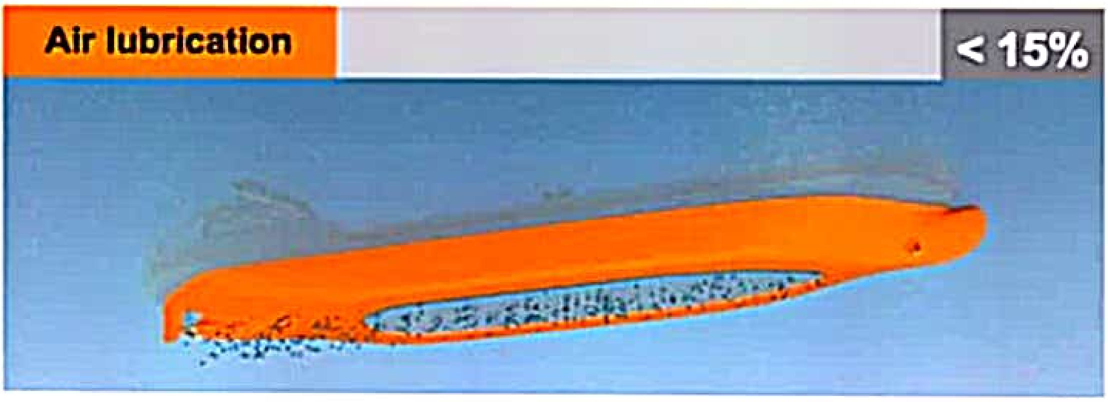
- The water flow disturbance from openings to bow thruster tunnels and sea chests can be high. It is therefore beneficial to install a scallop behind each opening. Alternatively a grid that is perpendicular to the local flow direction can be installed. The location of the opening is also important.

Source: Wärtsilä

- **Designing all openings properly and locating them correctly can give up to 5% lower power demand than with poor designs. For a container vessel, the corresponding improvement in total energy consumption is almost 5%.**

Air Lubrication

- Compressed air is pumped into a recess in the bottom of the ship's hull. The air builds up a carpet that reduces the frictional resistance between the water and the hull surface. This reduces the propulsion power demand. The challenge is to ensure that the air stays below the hull and does not escape. Some pumping power is needed.



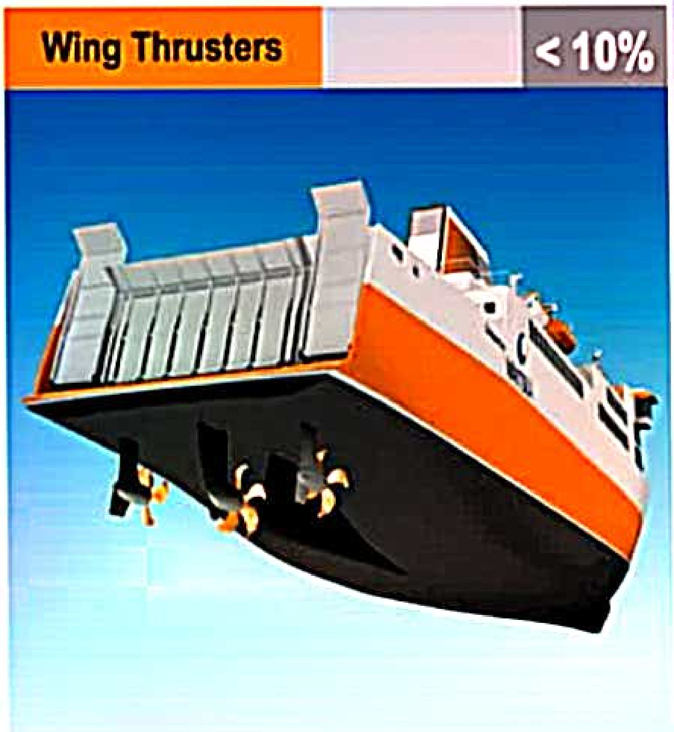
Source: Wärtsilä

- **Saving in fuel consumption:**
  - **Tanker: ~15 %**
  - **Container: ~7.5 %**
  - **PCTC: ~8.5 %**
  - **Ferry: ~3.5%**

Wing Thruster

- Installing wing thrusters on twin screw vessels can achieve significant power savings, obtained mainly due to lower resistance from the hull appendages.
- The propulsion concept compares a centre line propeller and two wing thrusters with a twin shaft line arrangement.

- **Result: Better ship performance in the range of 8% to 10%. More flexibility in the engine arrangement and more competitive ship performance.**



Source: Wärtsilä

Counter Rotating Propellers (CRP)

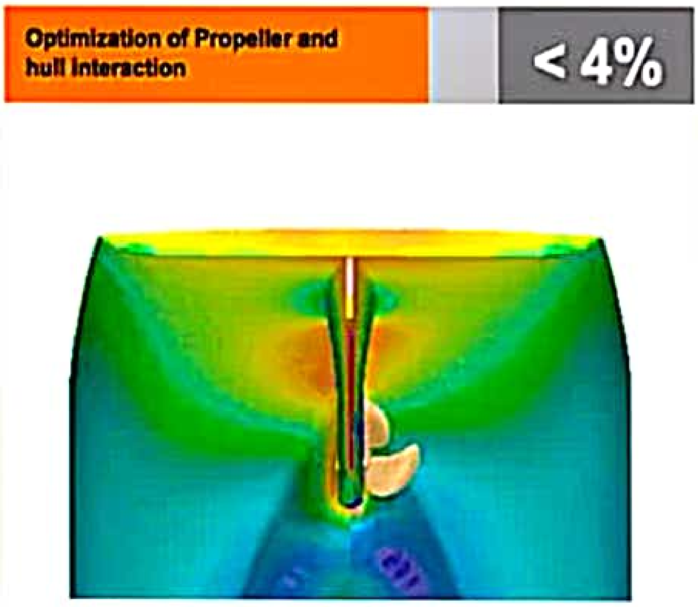
- Counter rotating propellers consist of a pair of propellers behind each other that rotate in opposite directions. The aft propeller recovers some of the rotational energy in the slipstream from the forward propeller. The propeller couple also gives lower propeller loading than for a single propeller resulting in better efficiency.
- CRP propellers can either be mounted on twin coaxial counter rotating shafts or the aft propeller can be located on a steerable propulsor aft of a conventional shaft line.

- **CRP has been documented as the propulsor with one of the highest efficiencies. The power reduction for a single screw vessel is 10% to 15%.**

Optimization of Propeller & Hull Interaction

- The propeller and the ship interact. The acceleration of water due to propeller action can have a negative effect on the resistance of the ship or appendages. This effect can today be predicted and analyzed more accurately using computational techniques.

- **Redesigning the hull, appendages and propeller together will at low cost improve performance by up to 4%.**

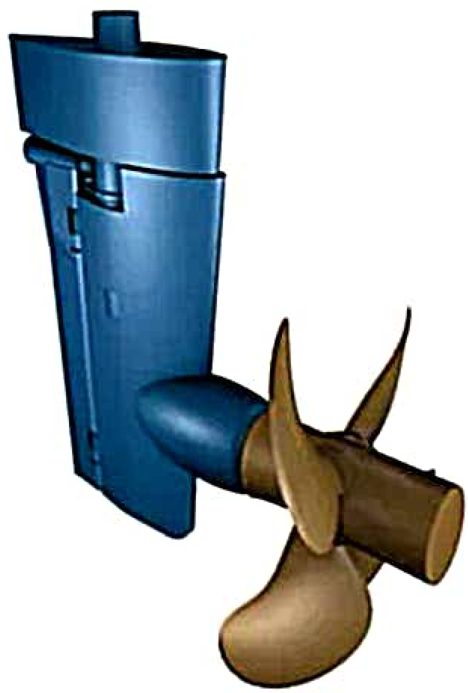


Source: Wärtsilä

Propeller-Rudder Combinations

- The rudder has drag in the order of 5% of ship resistance. This can be reduced by 50% by changing the rudder profile and the propeller. Designing these together with a rudder bulb will give additional benefits.
- **Improved fuel efficiency of 2% to 6%.**

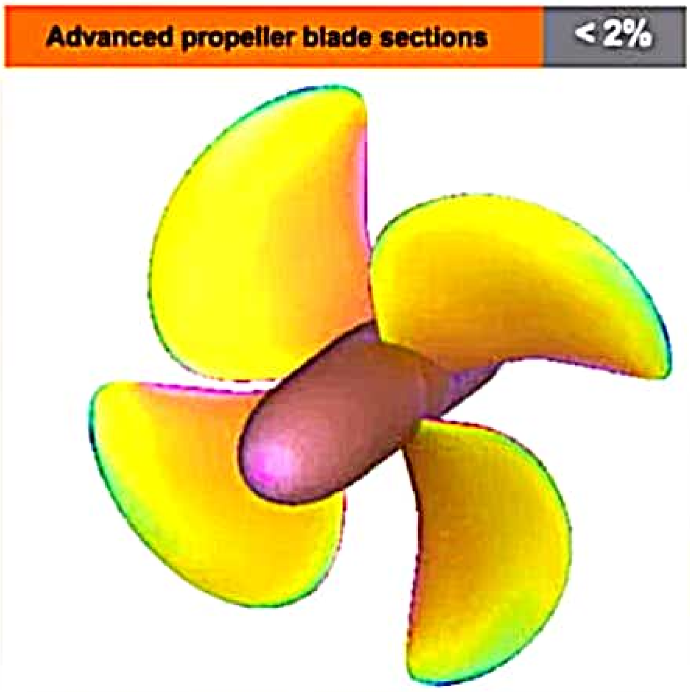
Propeller-rudder combinations	<4%



Source: Wärtsilä

Advanced Propeller Blade Sections

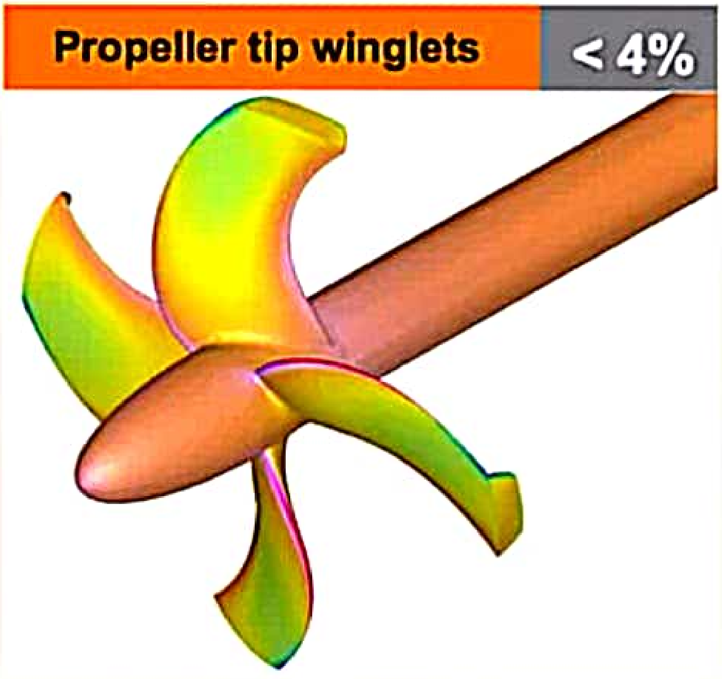
- Advanced blade sections will improve the cavitation performance and frictional resistance of a propeller blade. As a result the propeller is more efficient.
- **Improved propeller efficiency of up to 2%.**



Source: Wärtsilä

Propeller Tip Winglets

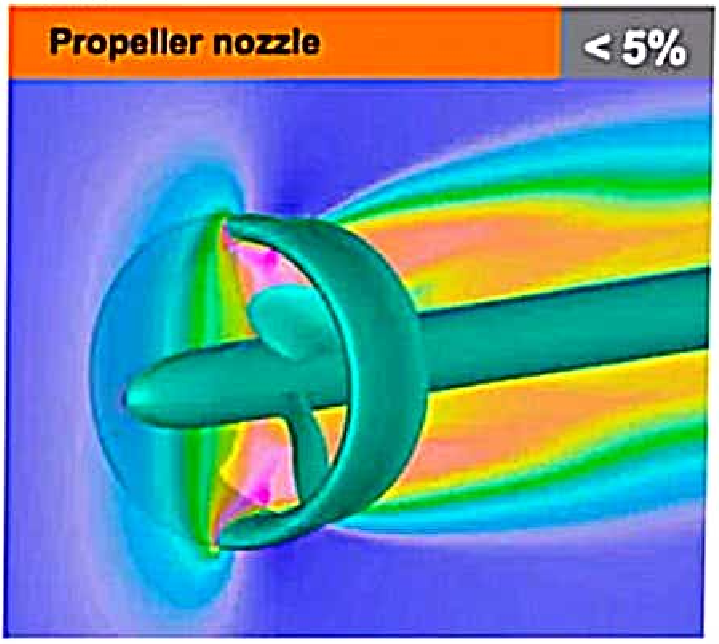
- Winglets are known from the aircraft industry. The design of special tip shapes can now be based on computational fluid dynamic calculations which will improve propeller efficiency.
- **Improved propeller efficiency of up to 4%.**



Source: Wärtsilä

Propeller Nozzle

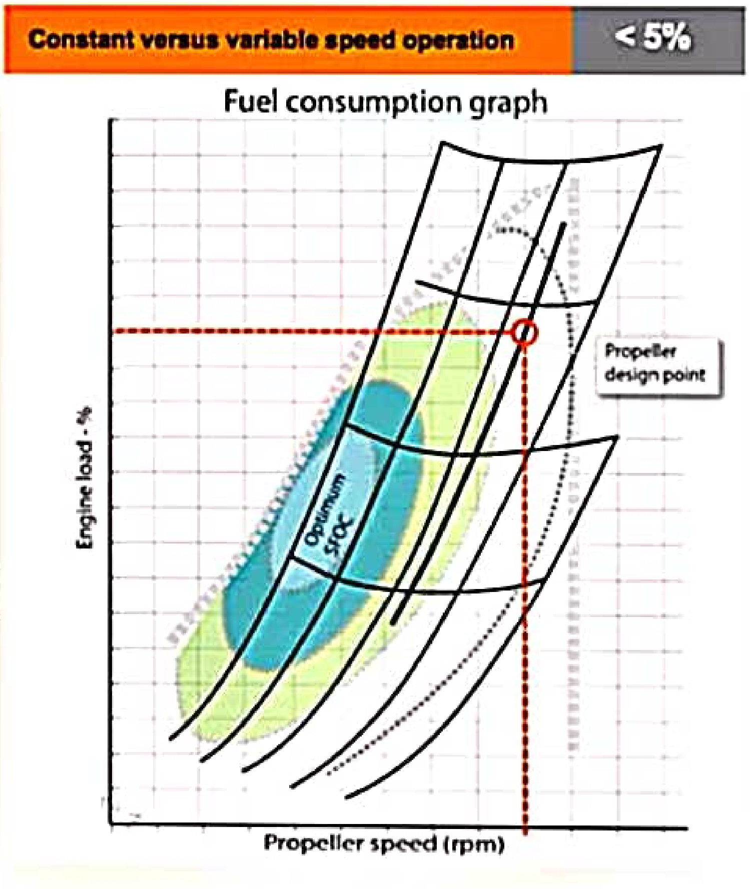
- Installing nozzles shaped like a wing section around a propeller will save fuel for ship speeds of up to 20 knots.
- **Up to 5% power savings compared to a vessel with an open propeller.**



Source: Wärtsilä

Variable Speed Operation

- For controllable pitch propellers, operation at a constant number of revolutions over a wide ship speed reduces efficiency. Reduction of the number of revolutions at reduced ship speed will give fuel savings.
- **Saves 5% fuel, depending on actual operating conditions.**



Source: Wärtsilä

Climate Change Awareness for Ship owners and Managers

- IMO's Second GHG Study (2007) which published in 2009, identified that CO_2 emissions from international shipping accounted for approximately 2.7% of total anthropogenic (caused by human activity) CO_2 emissions in 2007. If no regulatory measures were developed, CO_2 emissions were projected to grow between 200% and 300% by 2050, despite significant market-driven efficiency improvements.
- The adoption by IMO of mandatory reduction measures for all ships from 2013 and onwards will lead to significant emission reductions and also a striking cost saving for the shipping industry. By 2020, up to 200 million tonnes of annual CO_2 reductions are estimated from the introduction of the EEDI for new ships and the SEEMP for all ships in operation, a figure that, by 2030, will increase to 420 million tonnes of CO_2 annually. In other words, the reductions will in 2020 be between 10 and 17%, and by 2030 between 19 and 26% compared with business as usual.

- The reduction measures will also result in a significant saving in fuel costs to the shipping industry, although these savings require deeper investments in more efficient ships and more sophisticated technologies than the business as usual scenario. The annual fuel cost saving estimates states a staggering figure of $20 to 80 billion by 2020, and even more astonishing $90 – 310 billion by 2030.

  So, Ships owners and managers climate change awareness can reduce significant amount of CO2 Emissions by introducing new technology innovations to world fleet and save $20 to 80 billion fuel cost by 2030.

Image Credit:
transitionsoutheast.org.uk

Energy Saving Operation Awareness

- A shipping company, with its human resources department, could create a culture of fuel saving, with an incentive or bonus scheme based on fuel savings. One simple means would be competition between the company's vessels. Training and a measuring system are required so that the crew can see the results and make an impact.

Source: Wärtsilä

- **Historical data as reference. Experience shows that incentives can reduce energy usage by up to 10%.**