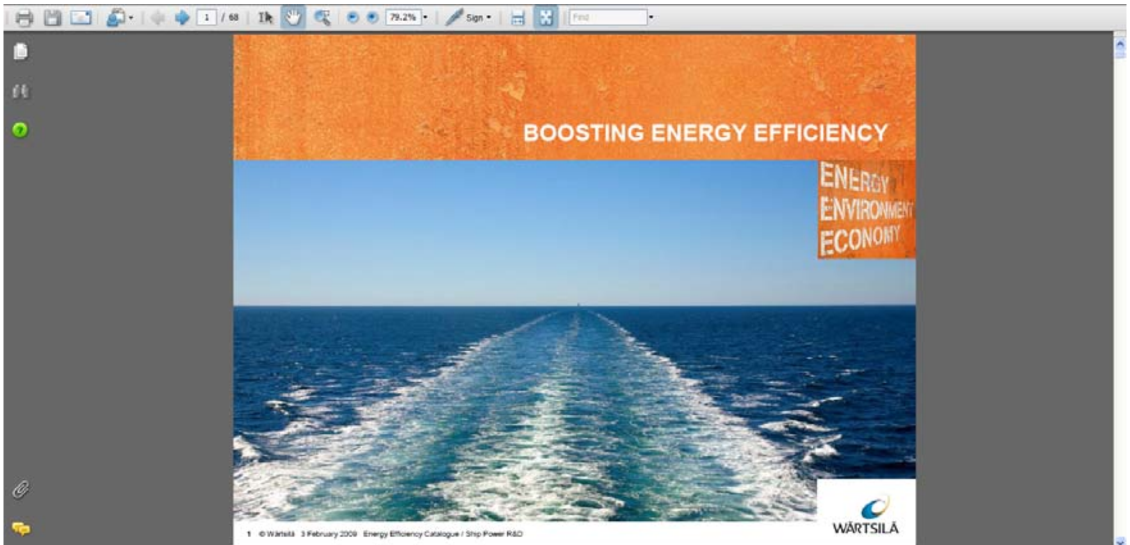
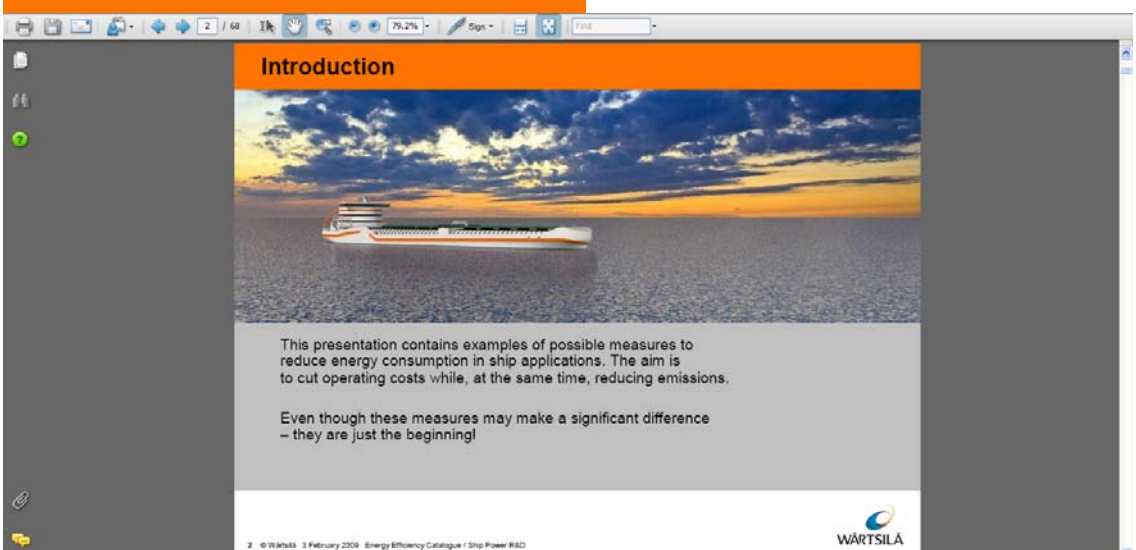
Percentage Reduction in Fuel Consumption & related GHG emissions



MACHINERY



Diesel electric machinery

< 20%

Installing electric drives will have a greater impact on operation especially where changes in operation and load profiles are part of normal operation. Other important areas are processes where speed regulation can be utilised.

Installing electric propulsion gives the following main benefits:

- reduced installed power (typical >10%)
- flexible arrangement (more cargo area)
- are flexible and efficient operation
- excellent redundancy

The savings can be as much as a 20-30% reduction in fuel consumption when DP is part of the operation.

For other vessel operational profiles fuel savings typically 5-8%.

CODED machinery

< 4%

Combined diesel-electric and diesel-mechanical machinery can improve the total efficiency in ships with an operational profile containing modes with varying loads. The electric power plant will bring benefits at part load, were the engine load is optimised by selecting the right number of engines in use. At higher loads, the mechanical part will offer lower transmission losses than a fully electric machinery.

Total energy consumption for a offshore support vessel with CODED machinery is reduced by 4% compared to a diesel-electric machinery.

Low loss concept for electric network

< 2%

Low Loss Concept (LLC) is a patented power distribution system that reduces the number of rectifier transformers from one for each power drive to one bus-bar transformer for each installation. This reduces the distribution losses, increases the energy availability and saves space and installation costs.

Gets rid of bulky transformers.

Transmission losses reduced by 15-20%.

Variable speed electric power generation

< 3%

The system uses generating sets operating in a variable rpm mode.
The rpm is always adjusted for maximum efficiency regardless of the system load.

The electrical system is based on DC distribution and frequency controlled consumers.

Reduces number of generating sets by 25%.

Optimised fuel consumption, saving 5-10%.

Fuel type – LNG | < 4%

Switching to LNG fuel reduces energy consumption because of the lower demand for ship electricity and heating. The biggest savings come from not having to separate and heat HFO. LNG cold (-162 °C) can be utilised in cooling the ship's HVAC to save AC-compressor power.

Saving in total energy < 4 % for a typical ferry. In 22 kn cruise mode, the difference in electrical load is approx. 380 kW. This has a major impact on emissions.

Waste heat recovery | < 10%

Waste heat recovery (WHR) recovers the thermal energy from the exhaust gas and converts it into electrical energy. Residual heat can further be used for ship onboard services. The system can consist of a boiler, a power turbine and a steam turbine with alternator. Redesigning the ship layout can efficiently accommodate the boilers on the ship.

Exhaust waste heat recovery can provide up to 15% of the engine power. The potential with new designs is up to 20%.

Energy saving lighting | < 1%

Using lighting that is more electricity and heat efficient where possible and optimizing the use of lighting reduces the demand for electricity and air conditioning. This results in a lower hotel load and hence reduced auxiliary power demand.

Fuel consumption saving: Ferry: ~1%

Power management

< 5%

Correct timing for changing the number of generating sets is critical factor in fuel consumption in diesel electric and auxiliary power installations. An efficient power management system is the best way to improve the system performance.

Running extensively at low load can easily increase the SFOC by 5-10%.

Low load increases the risk of turbine fouling with a further impact on fuel consumption.

Solar power

< 4%

Solar panels installed on a ship's deck can generate electricity for use in an electric propulsion engine or auxiliary ship systems. Heat for various ship systems can also be generated with the solar panels.

Depending on the available deck space, solar panels can give the following reductions in total fuel consumption:

Tanker:	~ 3.5%
PCTC:	~ 2.5%
Ferry:	~ 1%

Cooling water pumps, speed control

< 1%

Pumps are major energy consumers and the engine cooling water system contains a considerable number of pumps. In many installations a large amount of extra water is circulated in the cooling water circuit. Operating the pumps at variable speed would optimise the flow according to the actual need.

Pump energy saving (LT only) case studies:

- Cruise ships (DE)	20-84%
- Ferry	20-30%
- AHTS	8-95%

Automation < 10%

An Integrated Automation System (IAS) or Alarm and Monitoring System (AMS) includes functionality for advanced automatic monitoring and control of both efficiency and operational performance.

The system integrates all vessel monitoring parameters and controls all processes onboard, so as to operate the vessel at the lowest cost and with the best fuel performance.

Power drives distribute and regulate the optimum power needed for propeller thrust in any operational condition.

Engine optimisation control, power generation & distribution optimisation, thrust control and ballast optimisation give 5-10% savings in fuel consumption.

Advanced power management < 5%

Power management based on intelligent control principles to monitor and control the overall efficiency and availability of the power system onboard. In efficiency mode, the system will automatically run the system with the best energy cost.

Reduces operational fuel costs by 5% and minimises maintenance.

PROPULSION

Wing Thrusters

< 10%

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.

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

CRP propulsion

< 12%

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.

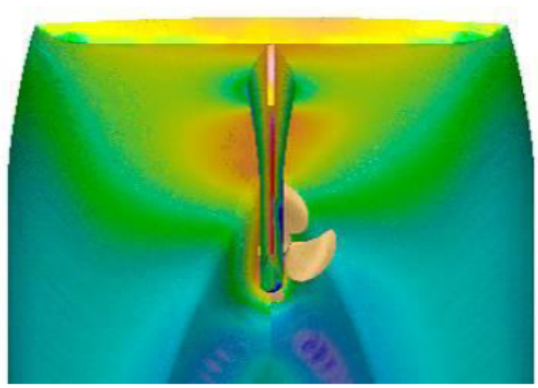
CRP has been documented as the propulsor with one of the highest efficiencies. The power reduction for a single screw vessel is 10% to 15%.

Optimisation of Propeller and hull interaction

< 4%

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 analysed more accurately using computational techniques.

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



Propeller-rudder combinations

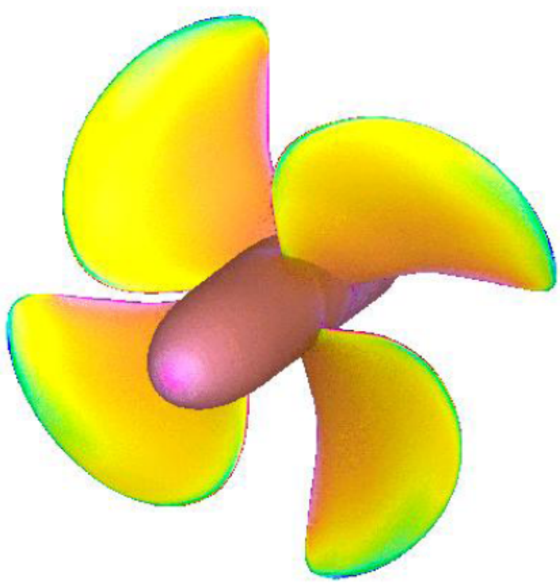
< 4%

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. This system is called the Energopac® system.

Improved fuel efficiency of 2% to 6%.

Advanced propeller blade sections

< 2%

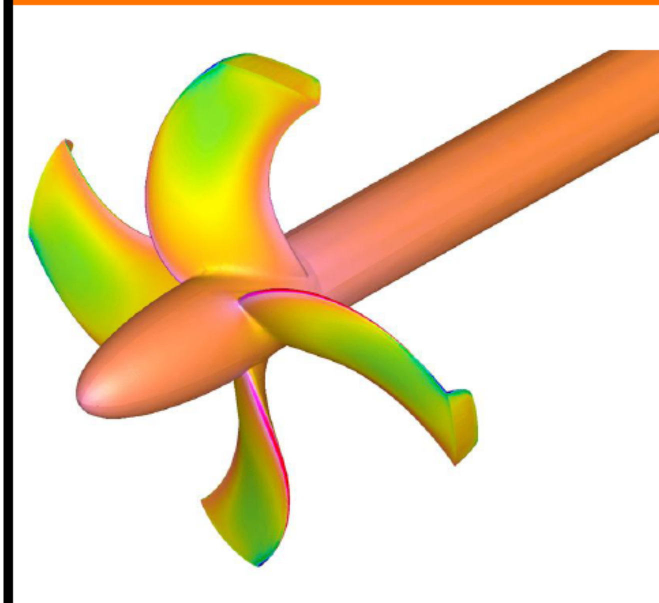


Advanced blade sections will improve the cavitation performance and frictional resistance of a propeller blade.
As a result the propeller is more efficient.

Improved propeller efficiency of up to 2%.

Propeller tip winglets

< 4%



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.

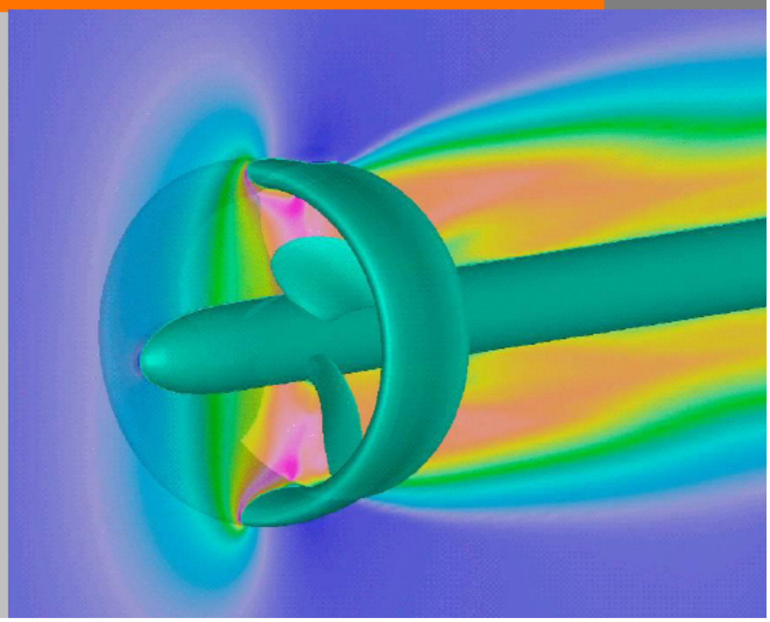
Improved propeller efficiency of up to 4%.

Propeller nozzle

< 5%

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.

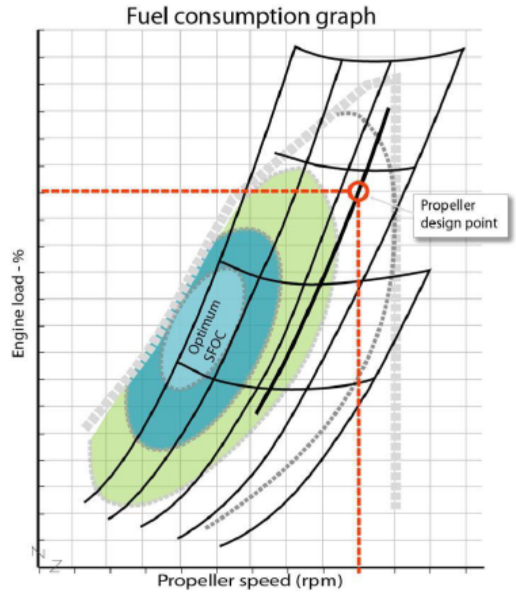


Constant versus variable speed operation

< 5%

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.



Wind power – sails and kites

< 20%

Wing-shaped sails installed on the deck or a kite attached to the bow of the ship use wind energy for added forward thrust. Static sails made of composite material and fabric sails are possible.

Fuel consumption savings:

Tanker	~ 21%
PCTC	~20%
Ferry	~8.5%

Wind power – Flettner rotor

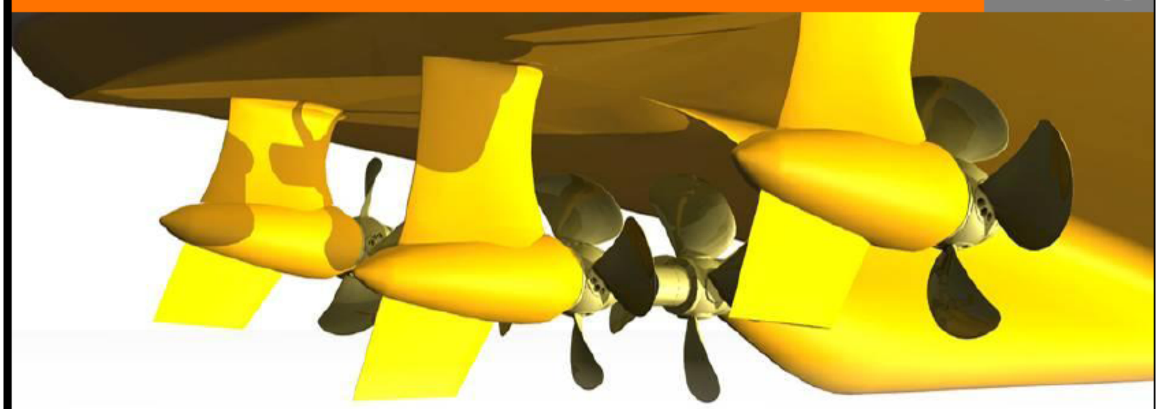
< 30%

Spinning vertical rotors installed on the ship convert wind power into thrust in the perpendicular direction of the wind, utilising the Magnus effect. This means that in side wind conditions the ship will benefit from the added thrust.

Less propulsion power is required, resulting in lower fuel consumption.

Pulling thruster

< 10%

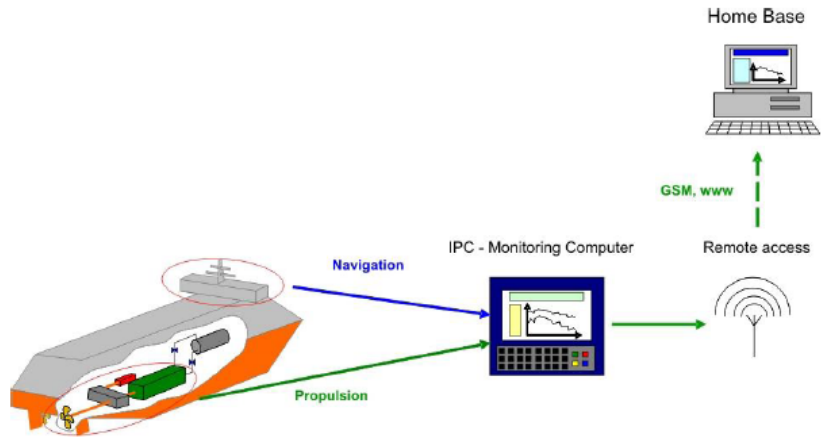


Steerable thrusters with a pulling propeller can give clear power savings. The pulling thrusters can be combined in different setups. They can be favourably combined with a centre shaft on the centre line skeg in either a CRP or a Wing Thruster configuration. Even a combination of both options can give great benefits. The lower power demand arises from less appendage resistance than a twin shaft solution and the high propulsion efficiencies of the propulsors with a clean waterflow inflow.

The propulsion power demand at the propellers can be reduced by up to 15% with pulling thrusters in advanced setups.

Propeller efficiency measurement

< 2%



Measure performance data on board to save fuel. The measurements taken will include propeller performance data such as speed through the water, propeller torque and propeller thrust.

Accurate measurement of propeller data will enable fuel savings in operation. Experience shows that this can reduce fuel consumption by as much as 4%.

SHIP DESIGN

Efficiency of scale

< 4%

A larger ship will in most cases offer greater transport efficiency – "Efficiency of Scale" effect. A larger ship can transport more cargo at the same speed with less power per cargo unit. Limitations may be met in port handling.

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

Reduce ballast

< 7%

Minimising the use of ballast (and other unnecessary weight) 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).

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%.

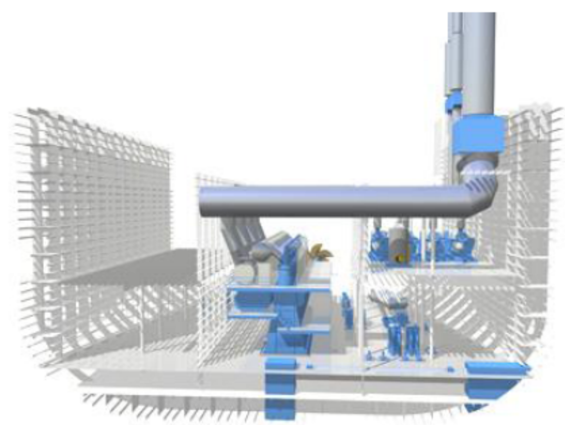
Lightweight construction

< 7%

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.

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.

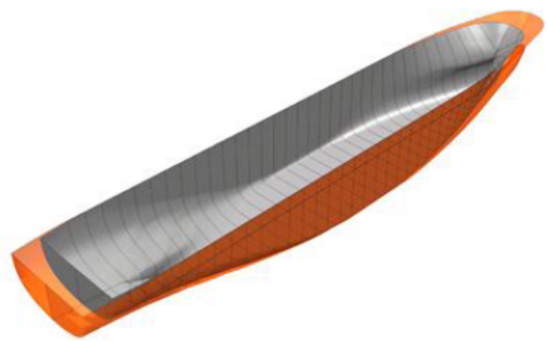


Optimum main dimensions

< 9%

Finding the optimum length and hull fullness ratio (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.

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

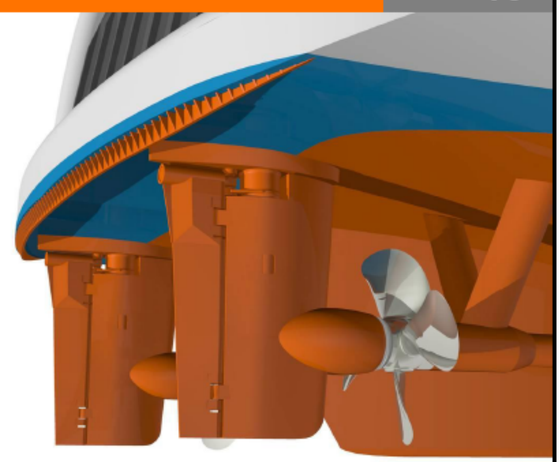


Interceptor trim planes

< 4%

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.

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



Ducktail waterline extension

< 7%

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.

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

Skeg shape / trailing edge

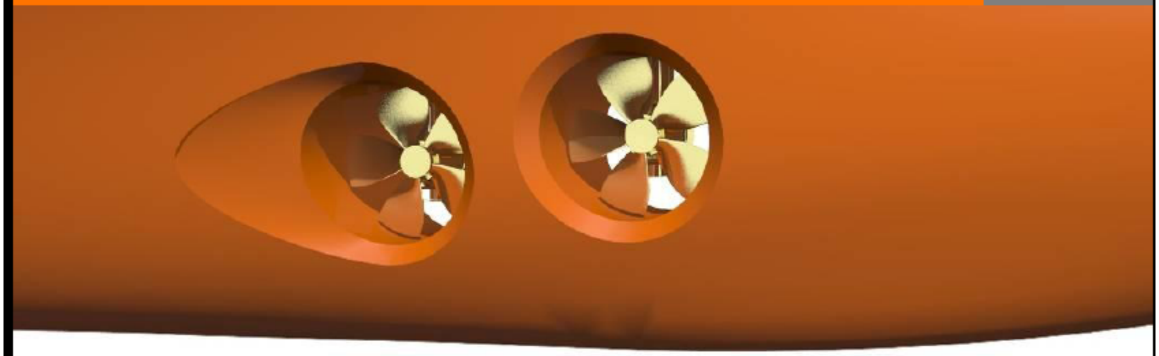
< 2%

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.

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.

Minimising resistance of hull openings

< 5%



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.

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

< 15%

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.

Saving in fuel consumption:

Tanker:	~15 %
Container:	~7.5 %
PCTC:	~8.5 %
Ferry:	~3.5%

Tailoring machinery concept for operation

< 35%

This OSV design combines the best of two worlds. The low resistance and high propulsion efficiency of a single skeg hull form is combined with the manoeuvring performance of steerable thrusters. Singe screw propulsion is used for free running while retractable thrusters are used in DP mode when excellent manoeuvring is needed.

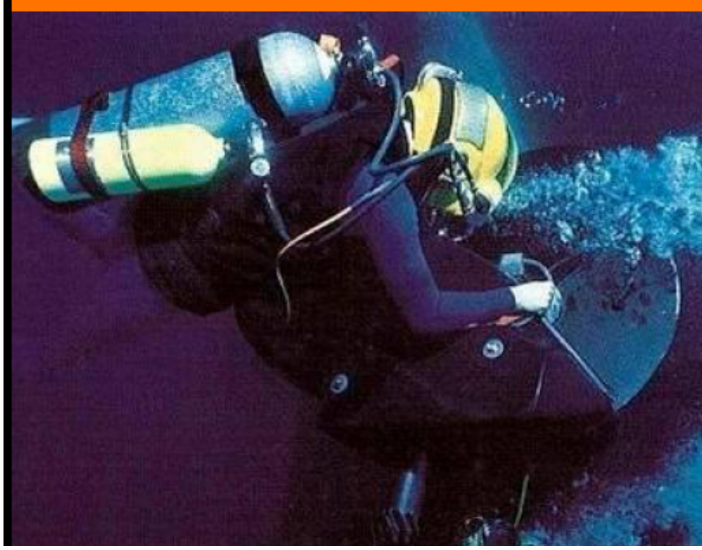
The machinery also combines mechanical propulsion in free running mode with electric drive in DP mode. Low transmission losses with mechanical drive. Electric propulsion in DP mode for optimum engine load and variable speed FP propellers give the best efficiency.

Diesel-electric machinery and twin steerable thrusters reduce the annual fuel consumption of a typical supply vessel by 35% compared to a conventional vessel.

OPERATION & MAINTENANCE

Propeller surface finish/polishing

< 10%



Regular in-service polishing is required to reduce surface roughness on caused by propellers of every material organic growth and fouling. This can be done without disrupting service operation by using divers.

Up to 10% improvement in service propeller efficiency compared to a fouled propeller.

Hull surface – Hull coating

< 5%

Modern hull coatings have a smoother and harder surface finish, resulting in reduced friction. Since typically some 50-80% of resistance is friction, better coatings can result in lower total resistance.

A modern coating also results in less fouling, so with a hard surface the benefit is even greater when compared to some older paints towards the end of the docking period.

Saving in fuel consumption after 48 months compared to a conventional hull coating:

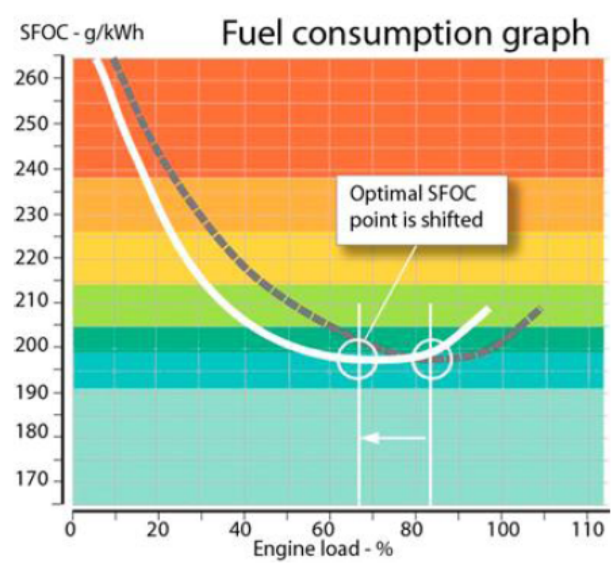
Tanker:	~ 9%
Container:	~ 9%
PCTC:	~ 5%
Ferry:	~ 3%
OSV:	~ 0.6%

Part load operation optimisation

< 4%

Engines are usually optimised at high loads. In real life most of them are used on part loads. New matching that takes into account real operation profiles can significantly improve overall operational efficiency.

New engine matching means different TC tuning, fuel injection advance, cam profiles, etc.



Ship speed reduction

< 23%

Reducing the ship speed an effective way to cut energy consumption. Propulsion power vs. ship speed is a third power curve (according to the theory) so significant reductions can be achieved. It should be noted that for lower speeds the amount of transported cargo / time period is also lower. The energy saving calculated here is for an equal distance travelled.

Reduction in ship speed vs. saving in total energy consumption:

- 0.5 kn	-->	- 7% energy
- 1.0 kn	-->	- 11% energy
- 2.0 kn	-->	- 17% energy
- 3.0 kn	-->	- 23% energy

Voyage planning – weather routing

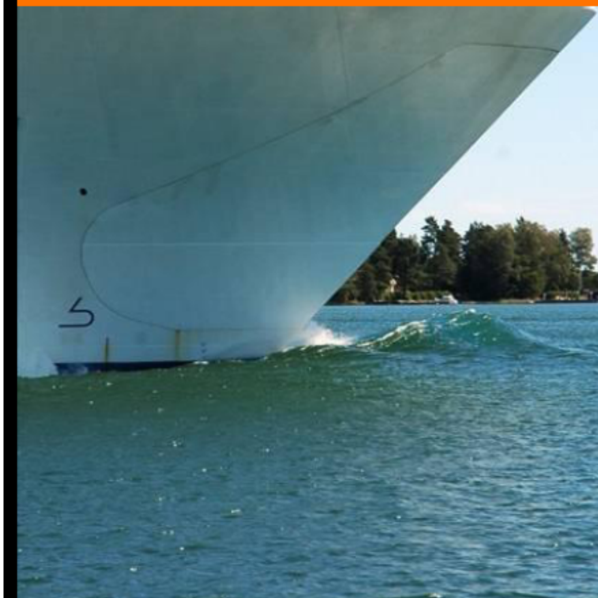
< 10%

The purpose of weather routing is to find the optimum route for long distance voyages, where the shortest route is not always the fastest. The basic idea is to use updated weather forecast data and choose the optimal route through calm areas or areas that have the most downwind tracks. The best systems also take into account the currents, and try to take maximum advantage of these. This track information can be imported to the navigation system.

Shorter passages, less fuel.

Vessel trim

< 5%



The optimum trim can often be as much as 15-20% lower than the worst trim condition at the same draught and speed. As the optimum trim is hull form dependent and for each hull form it depends on the speed and draught, no general conclusions can be made. However by logging the required power in various conditions over a long time period it is possible to find the optimum trim for each draught and speed.
Or this can be determined fairly quickly using CFD or model tests. However it should be noted that correcting the trim by taking ballast will result in higher consumption (increased displacement). If possible the optimum trim should be achieved either by repositioning the cargo or rearranging the bunkers.

Optimal vessel trim reduces the required power.

Autopilot adjustments

< 4%

Poor directional stability causes yaw motion and thus increases fuel consumption. Autopilot has a big influence on the course keeping ability. The best autopilots today are self tuning, adaptive autopilots.
Finding the correct autopilot parameters suitable for the current route and operation area will significantly reduce the use of the rudder and therefore reduce the drag.

Finding the correct parameters or preventing unneccessary use of the rudder gives an anticipated benefit of 1-5%.

Energy saving operation awareness

< 10%

A shipping company, with its human resources department, could create a culture of fuel saving, with an incentive or bonus schemebased 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.

Historical data as reference.

Experience shows that incentives can reduce energy usage by up to 10%.

Condition Based Maintenance (CBM)

< 5%

In a CBM system all maintenance action is based on the latest, relevant information received through communication with the actual equipment and on evaluation of this information by experts.

The main benefits are: lower fuel consumption, lower emissions, longer interval between overhauls, and higher reliability.

Correctly timed service will ensure optimum engine performance and improve consumption by up to 5%.

Hull cleaning

< 3%

Algae growing on the hull increases ship resistance. Frequent cleaning of the hull can reduce the drag and minimise total fuel consumption.

Reduced fuel consumption:

Tanker:	~ 3%
Container:	~ 2%
PCTC:	~ 2%
Ferry:	~ 2%
OSV:	~ 0.6%