WÄRTSILÄ

Improving energy efficiency in the merchant shipping industry

BUSINESS WHITE PAPER

The overall energy efficiency of a vessel is determined by choices made throughout its lifecycle. Improvements in energy efficiency lead to increased profitability, reduced emissions and a more sustainable brand image. When looking for ways to improve the energy efficiency of a vessel, optimising its operation and engine and propulsion systems can offer significant opportunities for savings. Utilisation of the latest digital technologies and data intelligence enable continuous monitoring and optimisation of the operations of the entire fleet.

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Introduction

— Investing in greener solutions is good business.

Merchant shipping is a facilitator for international trade, and closely follows the trends and growth outlook of global trade. Looking back, there's been a dramatic decrease in crude oil prices leading to significant reduction in the operating costs of merchant vessels. The low fuel cost releases the operators from the high operating cost pressure. However, at the same time the continued overcapacity in the existing fleet has driven down freight rates and, consequently, also charter rates, which again has increased the pressure for owners and managers to cut costs.

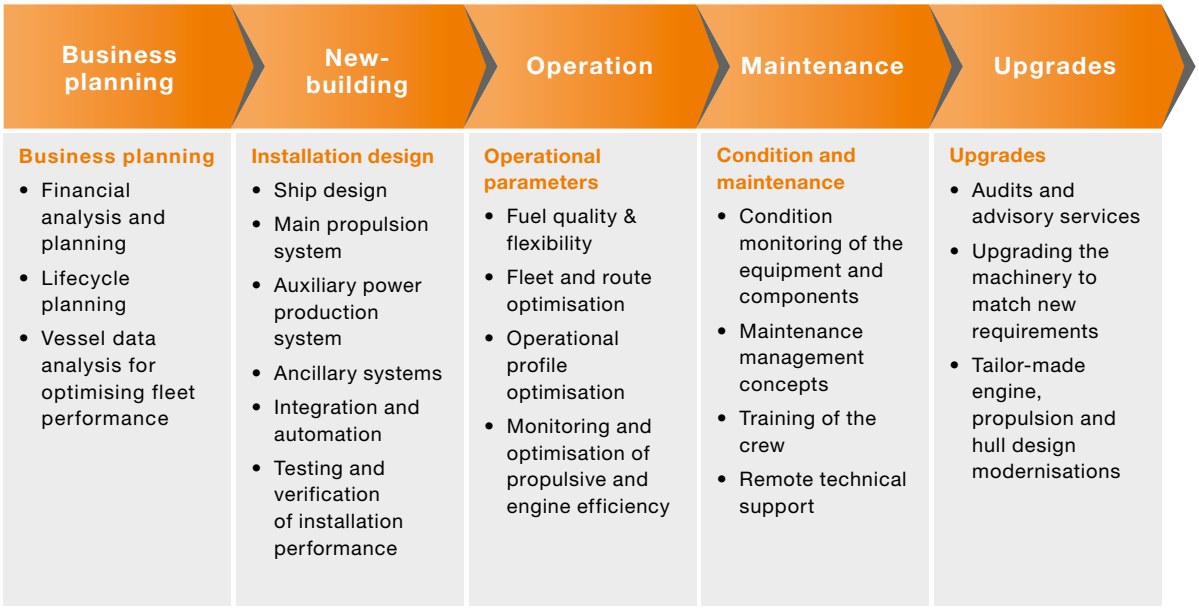
The industry frontrunners are focused on improving safety and energy efficiency, and subsequently minimising their impact on the environment. Environmentally responsible operations are expected by cargo owners. This makes investing in greener solutions good business.

Although the merchant shipping industry has been striving for a green image as well as better fuel efficiency for decades already, recently introduced maritime regulations are driving the whole shipping industry towards significant improvements in vessels' total energy efficiency. In 2013 the IMO introduced Maritime Energy Efficiency Regulations in order to increase the energy efficiency of new ship designs and to create a framework for the management of energy-efficient ship operations for all new and existing ships. For example, the Energy Efficiency Design Index (EEDI) for new builds mandates improvements for hull design and machinery. Likewise, the Ship Energy Efficiency Management Plan (SEEMP) requires ship owners to have a plan for improving the operational energy efficiency of each of the ships in their existing fleet.

The development regarding energy efficiency has been accelerating and older vessels are not nearly as optimal as the latest ones. The development of new ship design is driving towards, for example, modern hull designs, economical coatings and waste heat recovery systems. It is, however, also possible to achieve technically and economically rational improvements to an existing fleet by upgrading the vessels and optimizing its operations and maintenance.

Investing in improved energy efficiency increases profitability and creates a more sustainable brand image. This document provides an overview of energy efficiency improvement areas throughout the lifecycle of a vessel, with a particular focus on operation and maintenance.

Energy efficiency throughout the lifecycle



A vessel's energy efficiency is determined by the total amount of energy it consumes during its entire lifecycle, from the new-build process to the final recycling phase. It is measured in relation to a specific output, e.g. the total energy or fuel consumed per sea mile. An operator wishing to optimise the energy efficiency of the entire fleet, and utilise the synergies between the vessels, should apply a holistic strategy. This is done by implementing comprehensive lifecycle solutions that take into consideration the vessels' entire journey from business planning all the way to the end of its lifecycle. Major improvements to energy efficiency can also be achieved through assessing a specific area and applying a customised solution to it.

Wärtsilä can develop a holistic optimising strategy that covers the entire lifecycle of a fleet, or provide a solution to a specific challenge.

BUSINESS PLANNING

Taking a holistic view on energy efficiency

Improving energy efficiency is among the strategic plans of many shipping companies. Key development areas should be identified and taken into account already in the business planning phase. Comparing performance benefits and lifetime costs of alternative investment opportunities can be a complex task, and decision makers face the challenge of finding technically and economically optimal improvements.

Wärtsilä as an expert partner can provide valuable analysis and consultancy for newbuilding as well as for the current fleet. Here vessel data analysis plays a key role in optimising the performance of the entire fleet. Building investment scenarios and setting smart KPIs to monitor the performance are key steps in this phase.

NEW BUILDING

Increasing energy efficiency by optimal selection and integration of equipment

Ship design is the art of choosing a vessel configuration that matches the intended mission operational profile and trading route, as well as the operator's requirements for performance. Achieving this requires a deep understanding of the vessel type, as well as new technologies and how they integrate into the vessel. A new design will usually offer better energy efficiency than similar older ones due to the optimisation of its hull lines and propulsion configuration for a particular operational profile and lifecycle.

An increasingly important factor in a vessel's energy efficiency is the selection and integration of machinery. On modern vessels that are highly reliant on electrical and automation systems, power capacity and the reliability of these systems are also critical factors for vessel safety.

Electronic and closed-loop-controlled common-rail two-stroke engines with a large stroke-bore ratio, such as the latest Wärtsilä X-generation types (and for some applications their low-pressure dual fuel version), provide excellent fuel efficiency in the entire load range. In combination with latest designs of large, high-efficiency fixed-pitch propellers and the Wärtsilä EnergoProFin propeller cap fins they offer a powerful increase in the overall propulsive efficiency of a new vessel. The option of a waste-heat recovery system provides additional energy to the overall system.

An alternative way of generating electrical power during voyages is utilising a **shaft generator** which is driven by the main propeller shaft of a ship. This usually generates the power at a lower specific fuel consumption than auxiliary diesel generators. For certain vessel types, **hybrid power systems** that combine different power sources with energy storage devices and integrate the latest technology of four-stroke diesel or dual-fuel generating sets, can be the most efficient configuration and provide additional

OPERATION

Continuous performance monitoring for optimal operational energy efficiency

Changes in operating conditions can lead to substantial changes in energy consumption.

Small changes in operating conditions can lead to substantial changes in energy consumption, making it important to continuously monitor and optimise the operations of the entire fleet. It is critical to evaluate existing operational practises, and how they have changed and are expected to change over the years. Furthermore, current operational practices can be reviewed as part of a strategy to identify the best measures to improve operational energy efficiency.

Potential areas of efficiency improvements in ship operations are, for example, time spent in port, economical voyage planning, weather routing and active speed optimisation. Even small speed reductions can reduce energy consumption considerably. Also the choice of fuel matters, since there are big differences in the efficiencies achieved between different fuels. Such a wide range of variables to take into account means that high performance in vessel operations can only be achieved through integrated and truly intelligent solutions.

Increasingly complex systems mean that technical knowledge by maintenance service providers is becoming critical to supplement ship crews' competences. Digital technologies make it possible for service providers to collect and analyse an installation's data and remotely monitor its performance. A system of remote monitoring and support enables immediate identification of operational issues and implementing corrective actions and adjustments.

Wärtsilä Optimised operations is a lifecycle solution that ensures energy efficient operations and that the Ship Energy Efficiency Management Plan (SEEMP) measures are in compliance with MARPOL regulation. The agreement-based service offers real-time monitoring and advisory services that maximise the efficiency of assets. Benefits accrue not only through condition based maintenance but also through operational decisions based on optimised fuel consumption.

A further step towards operational reliability is the **Wärtsilä Guaranteed asset performance** lifecycle solution, which guarantees that the agreed levels of performance will be reached and maintained. The business model is based on actual performance, and success is evaluated in quarterly performance reviews.

The **Wärtsilä Genius services** family of solutions utilises the benefits of real-time data and data analytics to improve the efficiency and predictability of operations. The services are suitable for setting up measuring routines as well as expert analysis of the systems.

MAINTENANCE

Optimised maintenance increases cost predictability

In addition to fuel costs, maintenance costs play an important role in a vessel's total economics. Replacements and maintenance to reduce wear and tear, as well as hull cleaning, propeller polishing, air removal from pipes, and filter cleaning all have a big impact on fuel costs. Maintenance tasks range from relatively easy-to-perform tasks to deep repair and modifications that require highly experienced personnel and may require special tooling.

Smart maintenance planning makes maintenance costs predictable. Furthermore, maintenance scheduled according to predicted needs instead of a fixed maintenance schedule optimises the balance between fuel economy and maintenance costs. Also, spare parts play an important part in optimising the overall efficiency. OEM-quality spare parts comply with the latest specifications and can have up to 50% longer service life compared to non-OEM parts. Combining OEM spare parts with smart maintenance planning can considerably enhance an installation's operation throughout its lifecycle.

The importance of competent personnel is high. In addition to technical and operational measures, awareness and engagement throughout the whole organisation is identified as one of the main success factors. The crew needs to have the right skills and competence level to operate and maintain modern systems and equipment.

Wärtsilä Optimised maintenance is a lifecycle solution that matches maintenance with a vessel's commercial operation and schedule, ensuring maximised uptime and long-term cost predictability. It is based on continuous engine and propulsion condition monitoring, Dynamic maintenance planning and periodical inspections. Predictive maintenance keeps installations running at optimal level.

Wärtsilä Land and Sea Academy provides solutions securing competent personnel for current and future needs. Assessment and a full spectrum of training methods are available, including practical, classroom, blended, on-site and simulated environment. For example, the Engine performance course emphasises the importance of efficient operation and maintenance of main and auxiliary engines as a means of effective energy and resource management.

UPGRADES

Opportunities to incrementally improve energy efficiency
As a result of an overheated ship newbuilding market in container transportation, the industry faced an overcapacity and a large number of laid-up vessels. Frontrunners in the industry promoted the reduction of vessel speeds with the effect that laid-up vessels could again be utilised and total fuel consumption was reduced substantially.

Now slow steaming has become the new industrial reality. Container vessels delivered until approximately 2012 were typically designed for maximum speeds of 24-25 knots and continuous operation between 19-23 knots, whereas the speeds today are in the range of 12-18 knots with a maximum required speed of 20-22 knots. This creates high efficiency optimisation potential for vessels.

Typically the target is to reduce total fuel consumption by a double-digit percentage. Such a reduction requires solutions from technical feasibility and redesign studies to joint innovation and development of solutions. Often this means the full delivery, modification and installation of integrated multi-solution retrofit packages.

— Fuel quality and flow have a significant effect on efficiency.

Advances in propulsion research, and the use of hydrodynamic knowledge and advanced numerical methods such as computational fluid dynamics, have led to more efficient designs for energy-efficient vessels. Wärtsilä offers various **propulsion upgrades**, including energy-saving devices and propeller and related machinery upgrades, offered individually or as a combined package with engine upgrades and hull optimisation.

The availability of **two-stroke engine upgrading solutions** provides several efficiency optimisation options. This can be achieved over the full engine load range or with a focus on new key load ranges. Some examples are the intelligent combustion control system (ICC), automated flexible turbocharger cut-out, new tuning or a de-rating of the main engine. Available as standalone or tailored combined packages, these solutions substantially save fuel costs and offer attractive payback times.

Carrying out complex projects on existing installations requires excellent **project management** capabilities. Wärtsilä Services has professional project managers and project teams with the needed level of competences to run successful projects. Projects are managed on all aspects from feasibility studies, financing solutions, solution proposals, execution planning and implementation to full engineering, procurement and construction (EPC) solutions.

Using data intelligence for improving energy efficiency

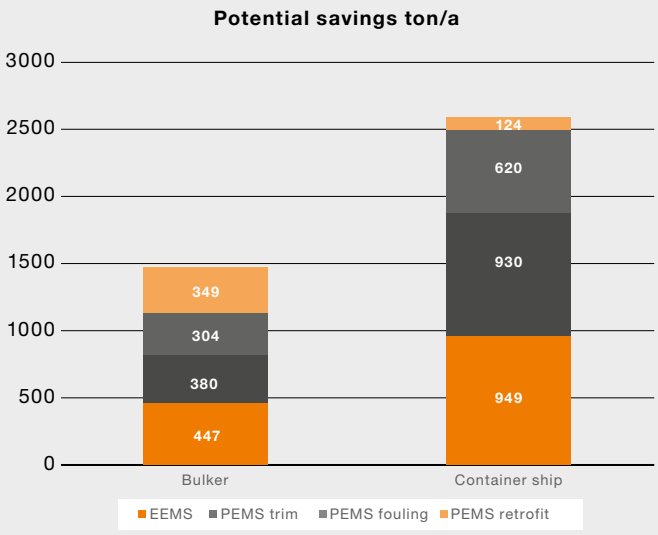
Every ship has different potential for energy savings. Bulker and container ships have different kinds of operation profiles, and typically bulkers use less power for propulsion than container ships. The vast majority of fuel is burned by the main engines and used for the vessel's main propulsion. This makes the main propulsion train the priority when optimising the energy efficiency of any ship.

With the **Wärtsilä Engine efficiency monitoring service** you can minimise fuel consumption and optimise your operational practices. Fuel savings can be achieved by improved operation habits over installed engines, better fuel quality, correctly timed overhaul actions and operational focus on fuel consumption. The service monitors the efficiency of your engines in an ISO standardised way, and supports your overhaul and operational decision making based on actual real-time data. Through advanced follow-up and trend analysis you can improve the management of your power production, and total fuel consumption can be improved.

The **Wärtsilä Propulsive efficiency monitoring service** is a comprehensive high-quality service for any ship with conventional shaft lines. It measures shaft power, thrust and various ship conditions such as different trim, fouling and ambient conditions. It is a self-learning system for all operating conditions that optimises the management of your vessels through continuous validation. The service optimises propeller and total cleaning intervals, as well as the trim of the vessel. This leads to significant fuel savings. The cost savings can validate investments in retrofits such as the addition of nozzles, a new propeller design or an energy efficiency device. These services are available through a service agreement.

In the following example we are able to reach 3-4% savings on fuel consumption by monitoring the fuel consumption trend, drilling into the root causes, and taking corrective actions to ensure the most optimal trim, as well as doing hull and propeller cleaning and repairing activities.

Example of annual fuel savings



Fuel consumption savings breakdown

EEMS	1-3%
PEMS trim	1-2%
PEMS fouling	1-2%
PEMS retrofit	0.2-2%

Total effect calculated with dedicated operation pattern thus:

8.3 % total savings for bulker and 3.6% total savings for container of total fuel consumption.

Source: Wärtsilä

The savings offered by the EEMS solution depicted above derive from improved operation habits, correctly timed overhaul actions, and new training for the crew to concentrate on fuel consumption. Additional savings could be achieved by upgrading engines to operate with higher efficiency in the desired operation area, or some other SFOC improvement package based on EEMS findings.

The calculation of savings through trim management using the Propulsive efficiency monitoring service (PEMS) uses advanced information on trim effects to correct trim to suite various, and changing, operation weather conditions, speed and loading conditions. PEMS fouling refers to correctly timed cleaning actions for the propeller and the hull. Cost benefits can also be achieved through retrofitting the main engine and propellers, and by upgrading them to the latest technologies and matching them with new operational profiles.

Case study:
Container vessel upgrade

A series of very large container vessels, each equipped with Wärtsilä electronic-controlled common-rail RT-flex96C-B two-stroke main engines and fixed-pitch propellers (FPP), achieved considerable savings by adopting a comprehensive approach to improving the overall energy efficiency of the vessels.

CHALLENGE

Built approximately five years ago, these ships were originally designed for high-speed operations, as was the norm at the time. However, the operational reality in container shipping has changed, and container vessels nowadays operate at a much lower speed. The container line operator defined a new long-term operating profile, which reduced the maximum speed of the vessel by 12% and average operating speed by almost 20%. This created the need for substantial adjustment and optimisation of the whole propulsion system and hull line.

SOLUTION

After a deep analysis of the new specified operating profile in a speed and draught matrix, a new bulbous bow design was selected, which optimises hull resistance in the new prioritised operation ranges. This formed the basis for determining the required power at various vessel speeds, and for designing an optimised new propeller. The new five-blade FPPs with larger diameter, but much lower weight, were pre-designed by Wärtsilä using the latest CFD programmes. The new FPP design also incorporated Wärtsilä EnergoProFin (EPF) propeller cap fins. Based on the combined results from the bulbous bow and propeller designs, the Wärtsilä team studied the feasibility of various combinations of upgrading and tuning solutions for the main engines. Finally, the combined integrated effect on fuel consumption per prioritised speed-draught point was calculated.

After joint evaluation of the feasible options, the customer selected the final retrofit project scope. Besides the modification of the bulbous bow, executed by the shipyard, Wärtsilä delivered and installed the new propellers, including EPF, and the full main engine retrofit packages. These consisted of engine de-rating, a permanent plus an automated flexible turbocharger cut-out, FAST fuel injector retrofits, Intelligent Combustion Control and Monitoring, and a special tuning for ultra-low-load operation. The majority of engine modifications were implemented during the vessels' commercial operation prior to the docking, whilst propeller and hull modifications were carried out while docked. After the new propellers were installed, the engines also received an Engine Limiter.

— Savings in fuel consumption from the combined solution were between 10% and 30%.

RESULTS

Significant savings were achieved in total fuel consumption, with the added benefit of a reduced environmental impact. Depending on the operating point, the achieved savings in fuel consumption from the combined solution were between 10% and almost 30%. Calculated for the new planned operating profile, the resulting savings are almost 20% or about six thousand tons per annum. As part of a service agreement, the vessels are also supported by remote monitoring for continuous efficiency, operations and maintenance optimisation.

Wärtsilä believes that regulation and innovation will drive demand for expertise in optimising the lifecycle costs of fleets and the reliability of vessels. Shipping operators benefit from the lower fuel costs we see today. This gives them a unique possibility to invest in energy efficiency and long-term profitability. As the cost of fuel is expected to increase in the future, now is a perfect time to invest in energy efficiency.

Please contact us: www.wartsila.com/services

Ensuring your lifecycle operations

Wärtsilä is an experienced lifecycle solution provider, with a proven track record in operation and maintenance services. Globally, more than 300 ships are covered by Wärtsilä service agreements.

Wärtsilä's extensive global service network and efficient spare parts logistics ensure that you can focus on your core business, resting assured that your maintenance needs can be optimally met, whenever and wherever.

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