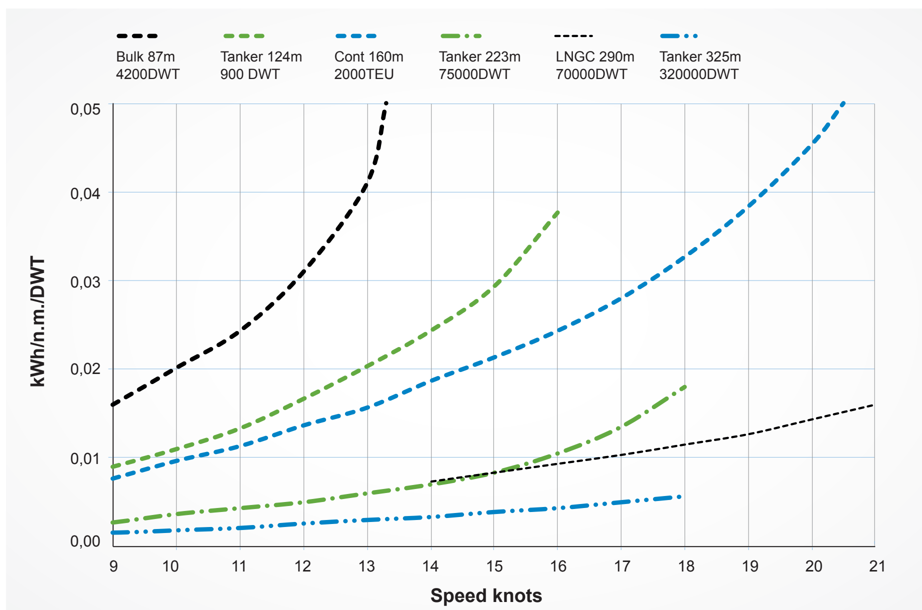
Ways to energy efficiency

Widely used so-called energy efficiency indices and KPIs measure CO_2 emissions and there is indeed a connection between energy and emissions, but the distinction should be made clear. In practice, energy efficiency refers to optimisation in hydrodynamics, technical solutions and operational profiles. The challenges of energy efficiency and reducing emissions have to be approached internationally and the IMO has focused on emissions and energy efficiency for a considerable time. Recently, SSPA Sweden AB performed a study on behalf of the IMO, focusing on the optimisation of energy efficiency as part of the implementation of a Ship Energy Efficiency Management Plan (SEEMP). With decades of in-house experience on ship optimisation and a range of studies related to energy efficiency, SSPA has a vast knowledge of both the technical and operational aspects of energy efficiency, including regulative elements.



Energy consumption per tonne-km for a few examples of ships. Figure: SSPA.

Impacting regulations

Connected to air pollution and a reduction in greenhouse gas emissions, energy efficiency has been an issue within the IMO for a considerable time.

MARPOL Annex VI was adopted in 1997, mainly focusing on air pollution in the form of NOx and SOx emissions, and, with resolution MEPC.203(62) in 2011, the focus was shifted towards CO_2 by a host of technical and operational measures designed to provide an energy efficiency framework for ships. These measures came into force on 1 January 2013 under chapter 4 of the MARPOL Annex VI which made the Energy Efficiency Design Index (EEDI) and SEEMP mandatory elements for all ships. The SEEMP provides a possible approach for monitoring ship and fleet efficiency performance over time.

An upcoming regulation, also focusing on CO_2, is the European Union (EU) MRV Regulation 2015/757 and, as of 1 January 2018, shipping companies will be required to monitor the CO_2 emissions of their vessels per voyage for all voyages conducted into, between and out of EU ports.

Energy efficiency in practice

When discussing energy efficiency, it is all too common for energy and emissions to be confused. For instance, the EEDI and Energy Efficiency Operational Indicator (EEOI) are measures of CO_2 emissions and not measures of energy efficiency. The EEOI, being the suggested KPI in the SEEMP, represents the actual CO_2 emissions per transport work, typically described as grams CO_2 per Ton cargo per nautical mile, of a ship in service whereas improvements to its energy efficiency are often discussed on a much lower level, such as operational speed, propeller efficiency or specific fuel consumption. The different factors also impact upon each other. A technical solution optimised for a specific trade and operational pattern will most probably not be optimal if the trading pattern is changed; for instance, by changing the operational area, speed or cargoes. Education and awareness are a prerequisite for successful work on improved energy efficiency. Of course, this also includes a good understanding of the basic facts.

Technical measures for energy efficiency

Hydrodynamic properties are very important for a vessel's energy efficiency, with two major components being hull optimisation and hull-propeller interaction.

The hull and its main dimensions are optimised to reduce the two main resistance parts, namely the frictional (or viscous) resistance and the wave resistance. In general, it can be said that the energy consumption per transport work is reduced in line with the size of the vessel. This is mainly owing to the wetted area increasing (in principle) with the length squared whereas the cargo capacity increases with the length cubed. Consequently, the power demand grows more slowly than the transport capacity. The figure illustrates the dependency of speed and vessel size with regard to their energy consumption.

With regard to the interaction between the hull and the propeller, a good design can recover some of the losses that the hull and propeller have when operating by themselves, e.g. by placing the propeller aft of the hull in the so-called wake. Further improvements include energy saving devices placed around the propeller, e.g. wings and/or ducts in front of the propeller and twisted rudders. These and other systems are mainly aimed at creating a more uniform flow to the propeller which improve efficiency and to

Optimised vessel design. Photo: SSPA.

Route optimisation. The image (also found on the front) is a photomontage.

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reduce the rotational losses aft of the propeller. Furthermore, Propeller Boss Cap Fins, fitted at the propeller hub, can break up the vortices aft of the propeller, thereby recovering some of the losses.

A slow ship is more energy efficient than a fast one with a speed reduction of 10% typically resulting in a reduction of fuel consumption/per distance of about 20%. The most direct way to reduce the EEOI is therefore to reduce speed. The slow steaming that is widely practised today is therefore a very efficient way of reducing energy consumption. Yet, whether the slow vessel is more efficient when logistic, economic and other factors are also considered remains another issue.

Discussing energy efficiency without taking speed into account, which is essentially what is done in the EEOI and EEDI, is therefore not a complete way of describing the problem and can sometimes result in faulty conclusions. If design efficiency is to be compared, it has to be done by comparing vessels operating at the same speed (or equalising them by using relevant calculation methods).

Operational measures for energy efficiency

Voyage planning and, for liner traffic, adjusting timetables, including keeping speed as low as possible, is an effective measure. However, the way in which charter party terms are stipulated affects a vessel's possibility of optimising its energy consumption. Efforts have been made on contractual regulations on energy efficiency as evidenced by the virtual arrival processes launched by Intertanko and OCIMF and the slow steaming clause by BIMCO aimed at saving fuel through speed reduction. Despite standard clauses being included in charter parties, there are still considerations to be made before all operational aspects are covered. Clauses related to where, when and within which time frame the voyage should be executed need to be taken into account as well as those clauses related to a vessel's performance and guarantees on speed and bunker consumption. In addition, demurrage and dispatch clauses as well as ready berth clauses provide further examples of aggravating factors on contracts for energy efficiency through speed reduction.

Performance monitoring is another measure with possible substantial impact, but this requires thorough follow-up and the ability for it to be adjusted when needed. Optimum speed, load factor and trim also need to be fully understood as properties unique to each ship that will impact upon energy efficiency. This applies to both on-board and operational shore personnel, with ship owners also needing to be included in such discussions since a ship's performance is a vital part in any contractual discussions with charterers.

What can SSPA do for improvements on energy efficiency?

SSPA provides its customers with high-level advice on both operational and technical energy efficiency improvements for new builds as well as for vessels already in operation.

For new vessels, SSPA assists in defining operational profiles at an early stage and sets, for example, capacities, main dimensions and operational speeds. We also assist in hydrodynamics model testing and CFD calculations, which can assist in optimising the hull and propellers by taking a range of cargo conditions, speed profiles and operational areas into account.

Route optimisation is another measure with possible large impact on energy efficiency for new builds as well as existing vessels, where SSPA provides extensive support. Furthermore, for vessels already in operation, technical optimisation could be granted by way of trim and CPP optimisation and the design of energy saving devices. SSPA can also judge and optimise operational efficiency based on operational data and suggest technical and operational improvements. We also assist in optimising vessels for a change in operational profile by a hull and propeller redesign and can offer guidance on optimum settings for propulsive machinery.

KPI .... Key Performance Indicator
CO_2 .... Carbon Dioxide
IMO .... International Maritime Organization
NOx .... Nitrogen Oxides
SEEMP ... Ship Energy Efficiency Management Plan
SOx .... Sulphur Oxides
EEDI .... Energy Efficiency Design Index
EEOI .... Energy Efficiency Operational Indicator
MRV .... Monitoring, Reporting and Verification
OCIMF .... Oil Companies International Marine Forum
CFD .... Computational Fluid Dynamics
CPP .... Controllable Pitch Propeller
BIMCO .... Baltic and International Maritime Council
MEPC .... Marine Environment Protection Committee
MARPOL ..... International Convention for the Prevention of Pollution from Ships
Intertanko ... International Association of Independent Tanker Owners