



# Green Ship of the Future

2,500 TEU Regional ECOFeeder



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# INTRODUCTION

The Regional ECOFeeder design provides an immediate 30% CO<sub>2</sub> reduction compared to the average feeder fleet. This is obtained by applying significant changes to the overall design, by including the most energy efficient technology available and by reducing turn-around time in port terminals.

The ECOFeeder design is a result of collaboration between OMT and technology suppliers, ensuring optimal interaction between the applied technologies to obtain maximum energy efficiency. The feeder segment is dominated by an aging fleet, ready for gradual renewal. If the renewal is carried out responsibly, significant amounts of both fuel and emissions can be saved over the coming years.

If the reductions from shipping are to be consistent with the overall ambitions of the Paris Agreement and in accordance with that, reduce to zero during the second half of the 21st century, with a net emission peak in 2025, energy efficient technology cannot stand alone. Additional measures have to be taken including the appliance of fossil free fuels. However, with an immediate 30% CO<sub>2</sub> reduction, the partners behind the Regional ECOFeeder demonstrate that a large proportion of the necessary emission reductions from shipping can be obtained today by simply applying the available technology, while we, at the same time, continue the search for next generation fuels for the maritime industry.

The successful project is a result of input and willingness to share knowledge from all participating partners. The Regional ECOFeeder is a collaboration between:

- AAB
- Alfa Laval
- Bureau Veritas
- Corvus Energy
- Danfoss VLT Drivers
- Danish Maritime
- DNV GL
- DTU Mechanical Engineering
- HOK Marineconsult
- Lloyd's Register
- MAN Diesel & Turbo
- Odense Maritime Technology
- Rolls Royce Marine
- Silverstream Technologies
- VP Solutions

A collaborative process is dependent on facilitation and resources. The Regional ECOFeeder project was made possible by the financial contribution from the Danish Maritime Fund. The Danish Maritime Fund was founded in 2005 and the objective of the foundation is to support initiatives that develop the Danish maritime industry.



# BACKGROUND

From an environmental perspective, the feeder segment deserves special attention due to its main operation, and contribution to air pollution in coastal zones. In 2005, 35% of Sulphur deposition in coastal areas originated from international shipping and exceeded 0.2 g/m<sup>2</sup>/year, with maximum values up to 0.5—1.0 g/m. In addition, 20% of nitrogen deposition in coastal areas are from ships (Main Report Shipping, 2013). A reduction of emissions will consequently contribute to improved air quality for the population in these areas.

## A high quality and sustainable feedership design with optimal energy efficiency

The objective of this process has been to develop a truly innovative, low emission regional feedership that meets demands for optimal energy efficiency and compliance

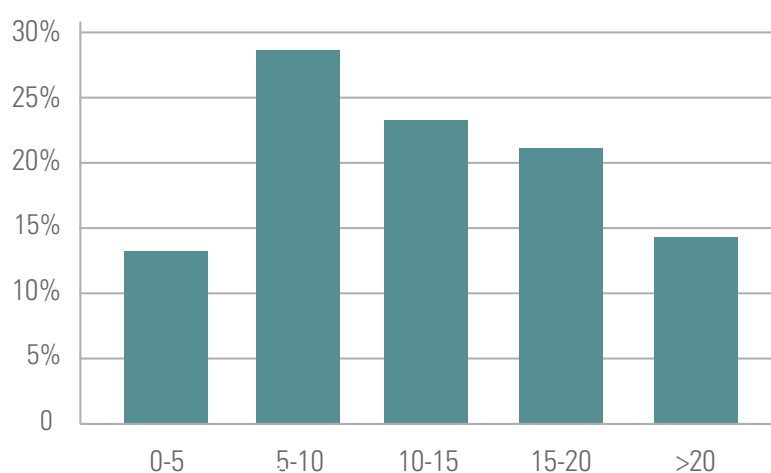
with global regulations. The design includes innovative options that result in at least 30% reduction of CO<sub>2</sub> per transported container compared to world fleet average, Sulphur 2020 compliance (0.5% S), NOx Tier III compliance, as well as reduced PM (particulate matter) and BC (black carbon) footprint. Furthermore, the aim has been to reduce the cost per TEU per nautical mile compared to current levels in terms of operational and manning.

## The current global feeder fleet

The current global feeder fleet between 1,000-3,000 TEU consists of 1,861 vessels. More than 50% of this fleet is older than 10 years, leaving considerable room for technology and operational improvement.

*Source: Clarksons World Fleet Register, March 2017*

**1,000-3,000 TEU age distribution**





# DESIGN OVERVIEW

The ECOFeeder has been designed and optimised for low emissions per container slot. This has been achieved by optimising intake and by reducing turn-around time in terminals.

The ECOFeeder has been designed using the 'open-top' concept, where containers are stowed as close as possible in open cargo holds with cell guides, readily accessible for easy loading and unloading of containers. The cell guides provides the most compact container stowage, as well as the fastest and most reliable sea fastening. The high side-structures protects for green water, ensures sufficient flooding angles and provides good structural support to the stack-cells and to the hull girder strength.

In order to optimise the access to containers, the conventional tall accommodation block with navigation bridge has been replaced by an accommodation and ship control area above the engine room and aft mooring deck, which allows stowage of containers above.

In order to ensure safe navigation and look-out, the vessel is operated by a 'virtual bridge' at the ship's control centre (SCC), which combines the navigation bridge, ship control room and engine control room. The virtual bridge is connected with video (CCTV) and sensor signals from the forward part of the vessel, using latest technology. For safe navigation in ports, approaches and sheltered waters, a small auxiliary wheelhouse is located in the upper part of the bow.

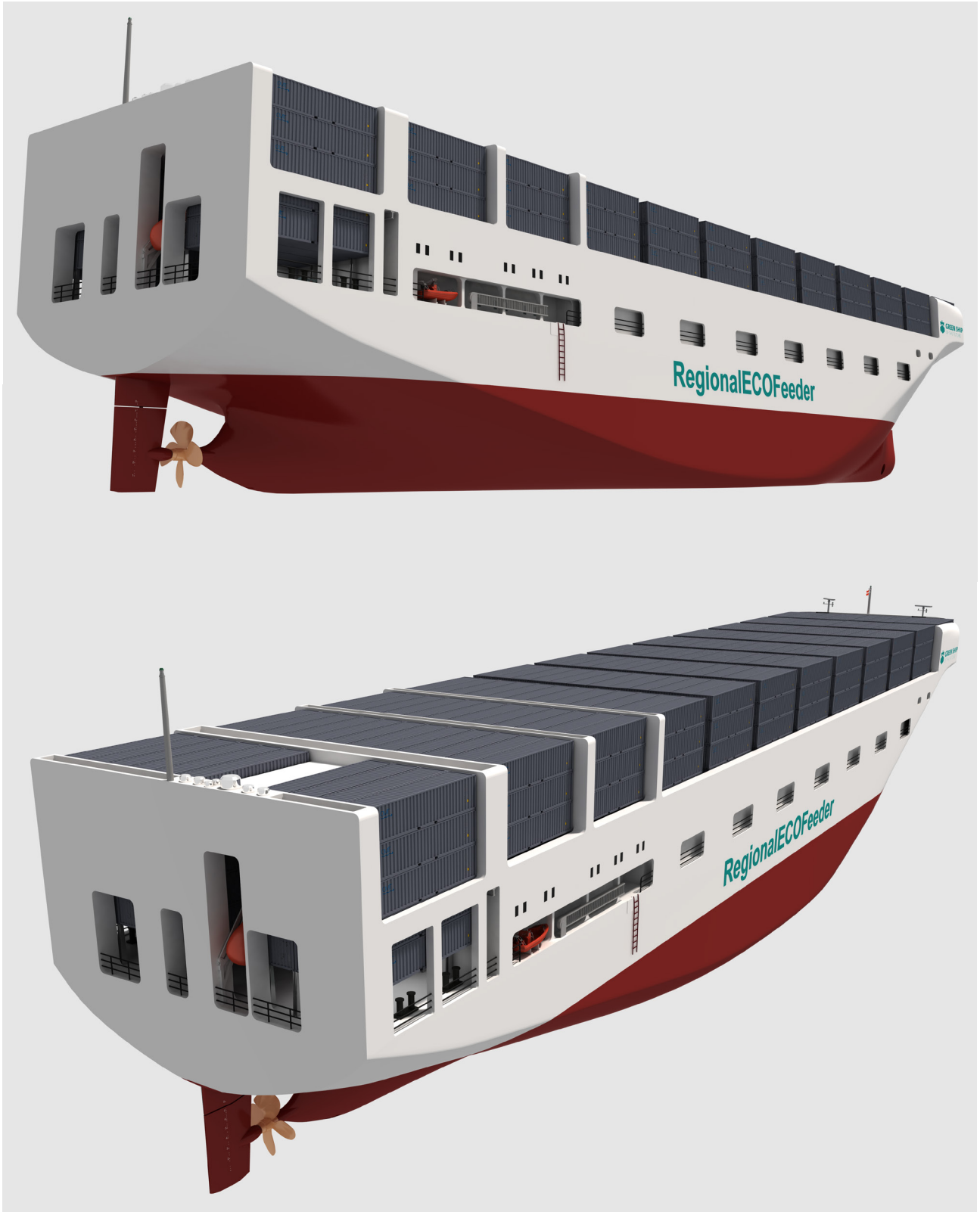
Various propulsion concepts have been evaluated, considering a typical operational profile for feeder vessels

of this size. The ship is propelled by a single large CP-propeller (Kappel design), direct coupled to a two-stroke dual-fuel marine diesel engine, which provides lowest SFOC and efficient operability in terminals. The engine is suitable for both heavy fuel oil, low-sulphur fuel oil, marine gas oil or LNG.

The auxiliary power is generated by a highly efficient in-line shaft-generator with variable frequency, which is backed up by two diesel generators. A battery pack is included in order to reduce generator load peaks and to provide power to the bow thruster during manoeuvring.

# DESIGN PRESENTATION





# DESIGN DESCRIPTION

## Concept

The concept of the ECOFeeder is to provide the basic functionality of a container carrier in the simplest and most compact way. This calls for a box shaped design with containers stowed as close as possible in cell guides, permanently open at the top, readily accessible for loading/unloading, and with a minimum of obstructions to the movements of the container cranes. In order to save cost and space, the ship's crew should be reduced. Most of the vessel's features are a result of these simple guidelines.

The box shape is a consequence of maximum capacity for a given size of the vessel, i.e. min. initial cost. The cell guides provide the most compact container stowage, as well as the fastest and most reliable sea fastening. The high coamings/side-structures serves the following purposes:

- To ensure flooding angle is large enough to allow the hatch covers to be omitted
- To support the top of the stack-cells
- To provide necessary hull girder strength without excessive scantlings

The conventional accommodation block has been replaced by a smaller accommodation, low enough to allow stowage of containers above. The reduced crew size results from systematic planning and optimization of all tasks onboard, using the 'safe manning' software. The lack of a tall accommodation block requires bridge visibility via closed circuit television (CCTV). This system makes it possible to locate the wheelhouse on upper deck level in the forward part of the accommodation block, as part of the ship's control center (SCC) in combination with the engine control room, deck office, captain's office

and chief engineers' office. For use during navigation in ports, approaches and sheltered waters, a small auxiliary wheelhouse is located in the upper part of the bow.

## Mast and funnels

To give unobstructed crane access within the full cargo area, the foremast, radars and other antennas are located on top of the auxiliary wheelhouse, forward of the cargo area. Likewise, the funnel and aft mast is located in the aft stack-cell, aft of the cargo area. In the aft-most container bay, two rows have been omitted, in order to accommodate the engine room casing and the free-fall lifeboat. The casing can be extended as necessary by removing further container rows, if scrubbers or other large equipment needs to be installed.

## Propulsion concept

The ship is propelled by a single large controllable pitch (CP) propeller, direct coupled to a two-stroke dual-fuel marine diesel engine. The engine may in principle run on heavy fuel oil, low-sulphur fuel oil, marine gas oil or LNG.

## Generator concept

Power is generated by an in-line shaft-generator, backed up by two diesel gen-sets. A battery pack is included in order to reduce generator load peaks.

## Fuel tanks

The oil fuel tanks are located forward of the engine room and below the chain lockers. Both locations are outside useful cargo space. LNG is carried in four cylindrical tanks located above the accommodation. This space could otherwise have been used for containers. Larger LNG tanks may be adopted at the cost of more container slots.

## Access

Access from shore to ship is via conventional accommodation ladders on upper deck (P & S). The pilot

ladders are also located on the upper deck. Access from the aft end / accommodation area to the cargo and bow area can be via partly open side passages at upper deck level (P & S), through the engineering passageway below deck (P & S) and via the passage through the holds at A-deck level (P & S).

### **Accommodation block**

The common rooms are located on the upper deck level, above the engine room, below bays 10 and 11. These rooms include the following:

- Ships control center (SCC)
- Mess and dayroom
- Provision and galley
- Deck store
- Change room
- A/C room
- Laundry/drying room
- Gymnasium
- Electrical equipment room
- Gas fuel room
- Suez room
- Hospital
- Fire control station (FCS)

Air intakes, out-door swimming pool, public toilets, corridors and stairways to the cabins (above) and the engine room (below) are located at upper deck as well.

The crew cabins are located along the ships side at A-deck level, with five cabins in each side. The cabins occupy the outboard two rows in each side, leaving the remaining eight rows for cargo or LNG-fuel tanks.

### **Stores, provision and spares handling**

A monorail crane is located at the aft end of the accommodation block for stores, provision and spares handling. It is able to reach over the ship's sides and serve the engine room hatch, deck store, paint store, emergency diesel generator room and provision room.

### **Mooring**

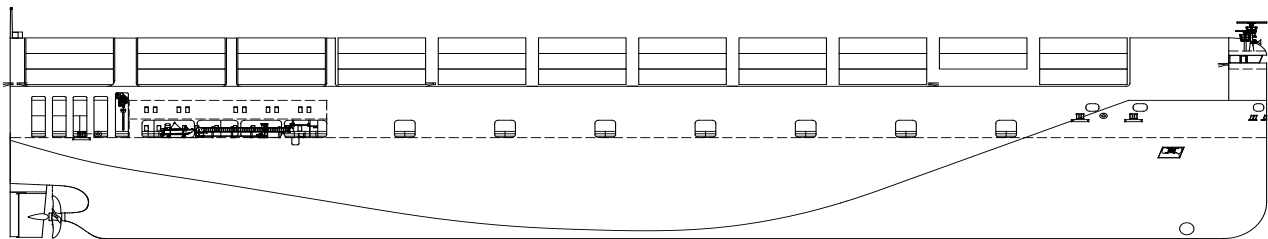
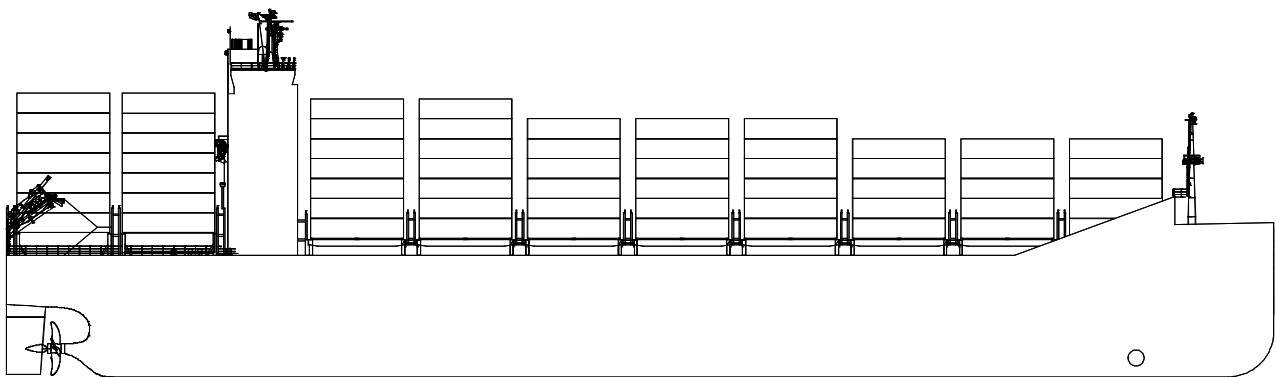
The vessel has a conventional mooring arrangement, with five winches at upper deck level aft and five winches (incl. windlasses) in the focsle deck forward (A-deck level). In order to optimize vessel operability even further, automatic mooring using e.g. vacuum mooring devices could be considered.

### **Energy saving devices**

As part of the concept, various energy saving devices have been selected as options. These devices include:

- Air lubrication system
- Twisted leading edge rudder
- Rudder bulb
- Kappel Propeller
- Shaft generator
- Waste heat recovery (WHR) based on organic rankine cycle (ORC)

# GENERAL PARTICULARS



	Reference vessel Upper	ECOFeeder Lower
Length (Loa)	166.7 m	175.0 m
Beam (B)	27.7 m	32.5 m
Draft scantling	10.0 m	10.0 m
Positions	1,938 TEU	2,422 TEU
Speed (scantling incl. 15% SM)	18.3 kn	17.9 kn
Main engine	MAN 5S60ME-C8	MAN 7S60ME-C10.5-GI
SMCR	11,000 kW	10,500 kW



# EMISSION REDUCTIONS

The emission reductions of the ECOFeeder have been estimated for two typical feeder schedules in Northern Europe.

The Blue feeder schedule illustrates a typical feeder schedule between Netherlands, UK and Scandinavian countries, without transit of the Kiel Canal.

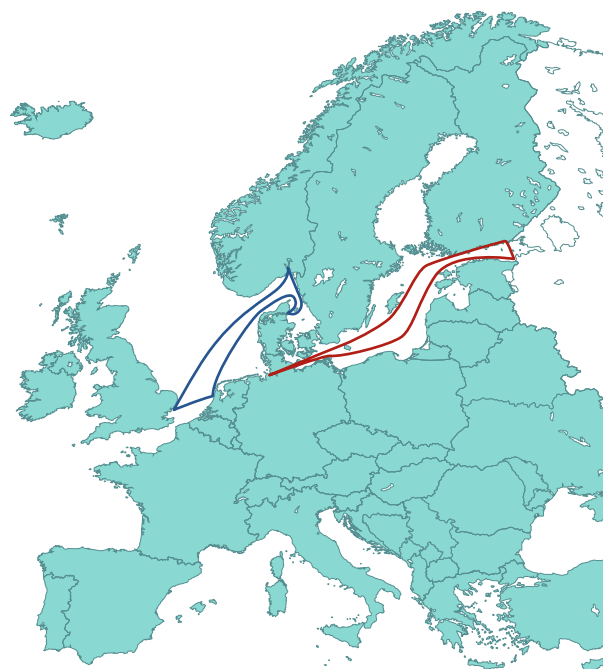
The Red schedule illustrates a typical schedule between Hamburg and Baltic countries, with transit through the Kiel Canal.

For the two typical feeder roundtrip schedules, the IMO Energy Efficiency Operational Indicator (EEOI) is estimated as follows for the ECOFeeder relative to the typical reference vessel (based on MGO):

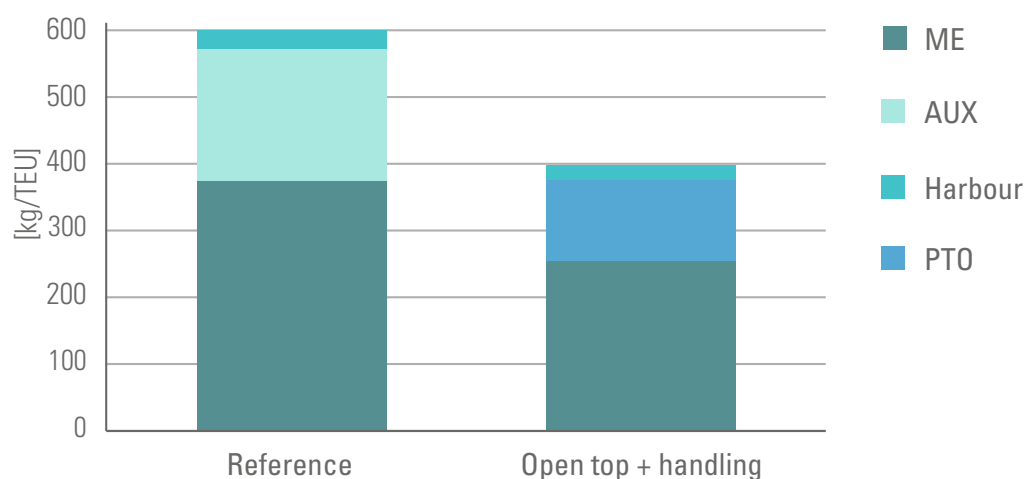
- Blue: 35% reduction
- Red: 30% reduction

The lower reduction potential for the Red schedule is due to draft and deadweight restrictions through the Kiel Canal.

The reductions are achieved partly by increased intake and partly by the energy saving technologies applied as described on page 13-14.



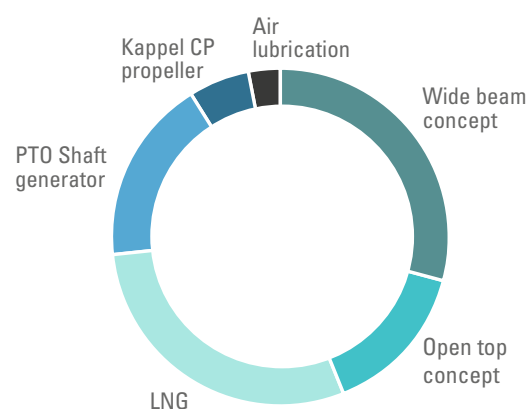
**Round trip – Red schedule**  
**CO<sub>2</sub> emission per TEU transported**



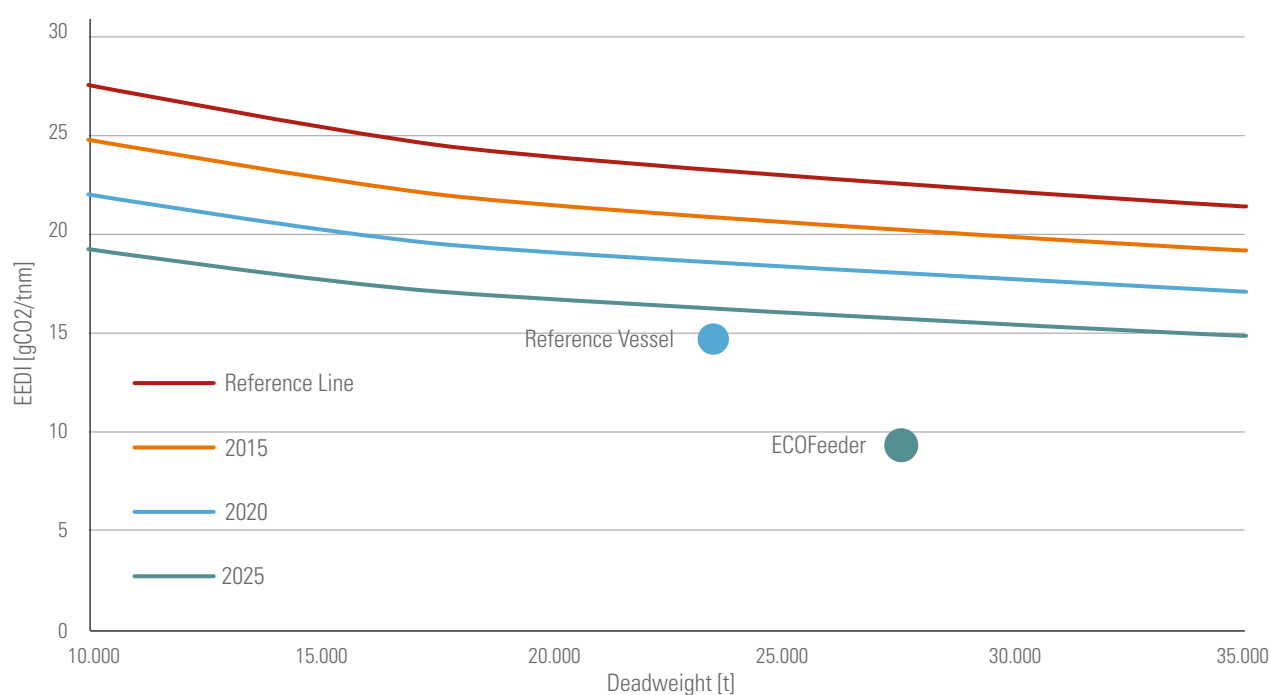
The IMO Energy Efficiency Design Index (EEDI) of the ECOFeeder is significantly reduced compared to both the IMO baseline and reference design.

For the ECOFeeder with LNG propulsion, almost 40% EEDI reduction is achieved compared to the IMO baseline. When comparing the ECOFeeder with the reference vessel, the EEDI is reduced by approximately 30%.

The relative contribution to the lower EEDI by the various technologies is illustrated in the pie chart:



	EEDI 2015 [gCO <sub>2</sub> /tnm]	EEDI (HFO) [gCO <sub>2</sub> /tnm]	EEDI (LNG) [gCO <sub>2</sub> /tnm]	Below 2025 [%]
Reference	16.13	14.58	-	9.6
ECO Feeder	15.62	-	9.25	40.8



# APPLIED TECHNOLOGY AND DESIGN

The technology and design applied to the ECOFeeder have been chosen to reach the greatest impact on energy efficiency and innovation.

## **Widebeam for improved container intake**

The design is based on a wide-beam design. By increasing the beam of the vessel, the nominal intake is significantly improved. Higher stability reduces the need for ballast water and thereby the payload for nominal containers is increased. The beam of the vessel is maximised to 32.5 m for passage of the Kiel Canal, which improves the nominal intake by more than 10% compared to a typical containership of the same length. The propulsion power increases by increasing the beam, yet considering the operational speeds of the vessel design, the net fuel reduction per transported container is still positive. In addition to the increased beam, the vessel is designed with slim ballast water tanks. In this way the container positions below are maximised, which also improves the nominal intake due to lower vertical centre of gravity.

## **Open top for easy loading and lashing**

Feeder vessels spend up to 50% of their time in harbour. In order to optimise cargo handling and reduce time in terminals, an open top concept has been applied for easy loading and lashing of containers. The vessel has five open cargo holds with cell guides to 13<sup>th</sup> tier and semi-automatic stack splitters at 10<sup>th</sup> tier of containers. In this way 20 or 40 feet containers may be loaded to 13 tier of containers without hatches and without lashing. This application reduces harbour turn-around time by up to 2 hours per port call.

## **Camera bridge lookout for simplified arrangement**

The vessel has a new and innovative arrangement of the deck house. The traditional bridge lookout for officers

on the bridge deck has been replaced by cameras and sensors in the front and on aft and side of the vessel. In this way the look-out is managed by the officers on duty in the control room, arranged in a lower and optimised deck house arrangement on the aft of the vessel. In this way container positions are increased by around 100 TEU and the arrangement of the accommodation is optimised due to less stairways. Currently, lookout by means of cameras and sensors are not allowed by SOLAS and flag states. However, considering the on-going discussions of autonomous vessels, lookout and control of vessels by means of cameras and sensors may be allowed in the future.

## **LNG fuelled propulsion for reduced emissions**

The vessel is designed with LNG powering based on 2-stroke dual fuel engines. With LNG powering, the direct CO<sub>2</sub> emissions are reduced by approximately 20% per transported container and Sulphur emissions are almost eliminated. NOx Tier III requirements are met by EGR NOx abatement system. The vessel has four cylindrical C-type tanks with total capacity of 1,300 m<sup>3</sup>, which provides endurance of around 15 days or around 5,000 nm.

## **Shaft generator solution for improved fuel efficiency of auxiliary power**

The power for auxiliary system and reefer containers is approximately 10-15% of the total installed power. Considering the 20% higher energy efficiency of 2-stroke engines compared to 4-stroke engines, auxiliary power is provided by a 2,000 kw PTO shaft generator producing electric power for the auxiliary systems and reefer containers. Compared with typical electric power generator systems with separate 4-stroke auxiliary engines, the estimated overall energy efficiency is around 6% higher for a roundtrip.

**CP-propeller with Kappel propeller blades**

The vessel is propelled by a CP-propeller with high efficiency Kappel propeller blades. The CP-propeller solution offers better propeller efficiency and is comparable with a fixed pitch (FP) propeller. In addition, the solution offers greater load flexibility in combination with shaft generator and significantly better maneuvering characteristics, which are very important for container feeder vessels with many terminal calls.

**Organic rankine cycle**

The Organic rankine cycle (ORC) unit considered for the ECOFeeder is designed for electricity production by utilizing exhaust gas heat. The use of low-sulphur (<0.1 %) fuel enables cooling of the exhaust gases without issues of sulphuric acid formation on the boiler tubes. The ORC unit is designed based on the assumption that no service steam is required for HFO preheating, etc. due to the use of low-sulphur fuel. Space heating demands are covered by heat from the HT cooling water. For ISO conditions, fuel savings of 3.3 % compared to the fuel energy used in the main engine can be obtained. For winter conditions fuel savings of 2.3 % can be obtained. By including scavenge air and EGR cooler heat, the fuel saving potential will increase.

**Battery**

The vessel design includes a 1 MWh battery package for optimisation of auxiliary engine load. With the battery package, the engine load on the auxiliaries are continuously optimised for optimum specific fuel consumption, and in harbour mode the electric bow thruster is effectively powered by the battery package. Overall the battery package reduces power consumption by estimated 1-2%. As a surplus, the number of required auxiliary engines are reduced by one auxiliary genset.

**Air lubrication saves propulsion power**

Air lubrication is a technology that improves a ship's efficiency and reduces energy losses. By reducing the resistance between the ship's hull and seawater using micro bubbles, the air bubble distribution across the hull surface reduces the resistance working on the ship's hull, creating energy-saving effects. With the hull design of the ECOFeeder, it is estimated that CO<sub>2</sub> emissions are reduced by around 6% at speeds above 15 knots.

**Other technologies reduce energy consumption and CO<sub>2</sub> emissions**

In addition to the above-mentioned technologies and solutions selected for the ECOFeeder, the design includes frequency control of pumps and fans, which are already widely accepted by the industry. In addition, the vessel may be supplied with necessary equipment for cold ironing in ports, should this be available at the terminals.

These technologies are not considered when calculating the reduction potential in terms of energy and CO<sub>2</sub> emissions in this project. However, it is proven that by including frequency control of selected pumps and fans, relatively large electric power savings can be obtained.

# PROCESS AND COLLABORATION

The ECOFeeder was part of the Green Ship of the Future (GSF) project portfolio in 2016. Cross industry collaboration between partners is a key element in all GSF projects in order to enhance knowledge sharing, co-creation and innovation.

## Process

To create the ECOFeeder, OMT defined the project's main objectives in terms of emission targets, but left the identification of solutions to the partners in order to create space for maximum creativity. The suggested technologies were assessed in combination with other technologies, in order to develop and evaluate on the complete system entities, rather than the individual solution. Through three phases, the partners ideated, shared knowledge and evaluated the suggested solutions in order to reach the project's main objective and emission targets.

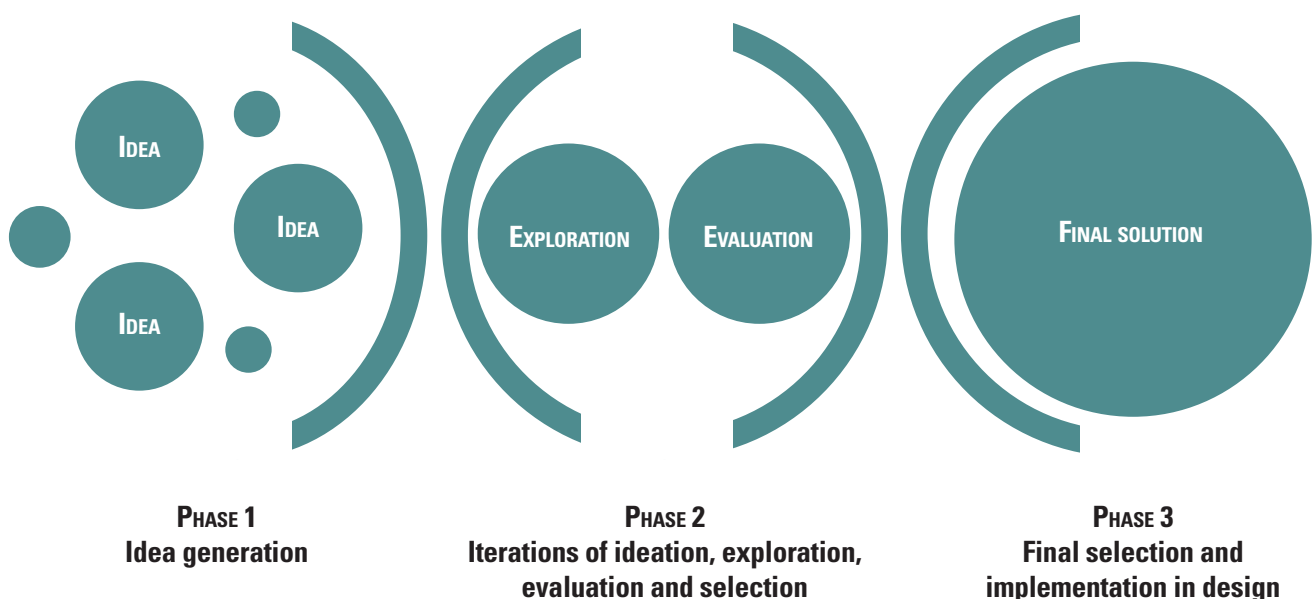
Phase 1 included a kick-off workshop at which the project idea and scope was presented by OMT. Led by a facilitator, the participants were asked to ideate on

solutions that would help reach the emission targets. A professional facilitator ensured a smooth process in which the participants and project owner OMT could concentrate on applying their professional competences, experience and ideas. The participants were divided into ship systems in correspondence with their core competences and came up with more than 20 initial ideas for emission reducing technology.

In phase 2 the partners refined the ideas by carrying out several iterations of ideation, exploration, evaluation and selection, until the most suitable and energy efficient combination of technologies was identified.

In phase 3 OMT produced a design optimized to include the chosen technology.

Throughout all phases, the contribution to emission reductions for all identified technologies and design solutions were evaluated.



# PARTNERS



Move Forward with Confidence



## ABB

ABB is a global leader in power and automation technologies. We are shaping the world through innovations and pioneering technologies. As a leading supplier of electrical propulsion systems for the global marine industry, ABB is helping ship owners answer mounting pressures to increase fuel economy and reduce their fleet's environmental impact. ABB offers integrated marine solutions for optimal reliability, flexibility and energy efficiency.

ABB's electric power plant with shaft generator solution gives environmentally neutral and cost effective electric power to onboard services when required, and utilizes excess electric power to boost the propulsion system when available.

Highly innovative solutions improving the efficiency while lowering the environmental impact is the very core of what we do at ABB. One of our unique products is OCTOPUS software system, which supports the operators optimizing the route and the energy efficiency on board. We work continuously with our partners to research and develop tomorrow's power solutions for marine applications.

[www.abb.com/marine](http://www.abb.com/marine)

## Alfa Laval

Alfa Laval Aalborg is the world's market leading supplier of marine boilers and delivers its boiler and heat exchanger concepts to all corners of the world and for all commercial ship types including Floating Production Systems.

From dry dock to harbour to open sea, Alfa Laval is at your service. No other supplier offers such a wide range of proven equipment, covering most critical operations on

board. Nor will you find greater competence in merging equipment into optimized applications and innovative solutions to your challenges. Our decades of work with shipyards, ship owners and ship operators are vital in this respect. Meeting the future is impossible without a true understanding of where things stand today – an understanding we've earned through a century of marine service.

[www.alfalaval.com](http://www.alfalaval.com)

## Bureau Veritas

Established in 1828 Bureau Veritas is one of the World's leading societies within marine classification and certification services. Bureau Veritas has been involved in every major innovation in LNG since maritime transportation began in the late 1950s. In 1962 Bureau Veritas published the first specific class Rules for LNG carriers and classified the first experimental LNG Carrier. Furthermore, in 2006, Bureau Veritas classified the first ever dual-fuel LNG Carrier. Bureau Veritas presence has been evident every step of the way.

[www.veristar.com](http://www.veristar.com)

## Corvus Energy

Corvus Energy provides purpose-engineered energy storage solutions for marine, oil & gas and port applications. Corvus Energy has the largest installed base of ESSs with the largest number of projects completed in the maritime industry. More than 90% of large commercial hybrid vessels utilize a Corvus ESS. Custom developed mechanical and electrical design combined with state-of-the-art battery management systems, provides Corvus Energy's customers with not only lower maintenance costs but also reduced fuel consumption, and emissions.





A Corvus ESS assists with regulatory compliance and emission control area (ECA) limits and provides immediate benefits with a rapid return on investment.

Using a customer's load profile and other requirements, Corvus engineers design an Energy Storage System (ESS) tailored to the customer application without the expense of custom/bespoke engineering. The only purpose designed industrial lithium-ion battery system.

[www.corvusenergy.com](http://www.corvusenergy.com)

### **Danfoss VLT Drives**

Danfoss Drives is your partner in frequency converters. Danfoss Drives is unique in that it is 100% focused on developing, manufacturing and supplying AC drives. Our portfolio of high-quality, application-optimized products maximizes process performance, saves the most energy and minimizes emissions.

Our portfolio includes VLT® and VACON® drives – top performers in the marine and offshore industry – that are designed and built to provide maximum uptime and efficiency and robust performance. These are critical factors in the marine business where repair and maintenance must be kept to a minimum. Our drives have the highest number of class type approvals from nine authorities. This gives you the best possible choice when selecting drives for your marine application.

Our robust and versatile drives are perfectly suited to marine and offshore applications where vibration, temperature, redundancy and noise levels place high demands on processes. They can be found in all areas of a ship, from the keel to the topside, from the engine room to the cargo deck, in cabins, and in shore-supply and harbor processes.

[www.drives.danfoss.dk](http://www.drives.danfoss.dk)

### **Danish Maritime**

As an industry association, Danish Maritime is the meeting place for Danish producers of maritime equipment and ships. The association initiates cooperation between its member businesses in a variety of areas including research, development and innovation, and it promotes favourable conditions for the Danish maritime industry. It is a centre of knowledge, furnishing its members, public authorities and the media with the latest relevant information on the maritime sector.

The Danish maritime industry is famous for its green and sustainable products and its innovative technological solutions. The industry is dynamic and international, and it comprises a large number of skills within specialized businesses such as shipyards, maritime suppliers and consultants. Danish maritime manufacturers offer very environmentally and climate friendly solutions, and in many cases the products and solutions do not only meet with the applied legislation; often they are even a step ahead to be ready for future demands. It is important to have high standards in environmental and climate issues. However, it is also important that the rules and legislation that apply are the same for everyone, as the maritime industry is global and compete globally. Danish Maritime is aiming for high international standards – i.e. by participating as a delegate at IMO meetings. As the Trade Organisation for the maritime industry, Danish Maritime establishes connections between business, authorities and others at the highest levels.

[www.danskemaritime.dk](http://www.danskemaritime.dk)

### **DNV GL**

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to



advance the safety and sustainability of their business. Operating in more than 100 countries, our professionals are dedicated to helping our customers in the maritime, oil & gas, energy and other industries to make the world safer, smarter and greener.

DNV GL is the world's leading classification society and a recognized advisor for the maritime industry. We enhance safety, quality, energy efficiency and environmental performance of the global shipping industry – across all vessel types and offshore structures. We invest heavily in research and development to find solutions, together with the industry, that address strategic, operational or regulatory challenges.

[www.dnvgl.com](http://www.dnvgl.com)

### DTU Mechanical Engineering

At the Section of Thermal Energy at DTU Mechanical Engineering we are working with various projects and technologies within green energy and energy optimization. In the maritime field the research is focused on two-stroke diesel engines and technologies for recovery of waste heat. In relation to the ECOFeeder project, our contribution was related to the organic Rankine cycle technology with which we have several years of experience through numerical simulations, experimental investigations in our lab, and operational experience from testing the 125 kW organic Rankine cycle system on Arnold Maersk. The organic Rankine cycle technology enables conversion of waste heat, e.g. jacket cooling water heat, scavenge air heat and exhaust gas heat to electricity whereby a reduction in fuel consumption can be achieved.

Maritime projects at the Section of Thermal Energy are primarily focused on developing shipping in a green direction. We provide knowledge via collaboration with

the maritime industry through commissioned research (consultancy work), research projects and student projects.

[www.tes.mek.dtu.dk](http://www.tes.mek.dtu.dk)

[www.pilotORC.mek.dtu.dk](http://www.pilotORC.mek.dtu.dk)

[www.thermcyc.mek.dtu.dk](http://www.thermcyc.mek.dtu.dk)

### HOK Marineconsult

HOK Marineconsult ApS is a small one-man owned company, whose main activities are different feasibility studies on energy demand and exhaust gas emissions for various ship types, such as container ships, bulk carriers, tankers and Ro-Ro ships. These studies are carried out with generic computer based ship models, where all the different specific ship design parameters can be changed systematically in order to find the most optimum solution for a given project. Besides these activities the company also carries out different specialized naval architectural investigations such as ship propulsion and manoeuvrability studies.

### Lloyd's Register

Lloyd's Register works around the world to assess and certify ships, systems and facilities to help improve quality and increase safety. We work with ship yards, owners and operators to provide innovative, value-added solutions that help improve performance and protect the environment throughout the design, construction, operation and decommissioning of ships.

New fuels, new engines and new designs are becoming available for the existing fleet. The difficulty for shipowners, builders, equipment makers and financiers is not only what technology to support but when to invest. Whatever technology or solution our clients are exploring



## MAN Diesel & Turbo

for their fleet, LR can help assess it, understand it and make it safe.

LR's range of environmental products and services helps ship operators not only meet legislative requirements but also implement best practice solutions for managing environmental risks. Besides undertaking ship energy audits, and providing fuel technology services, we help operators to implement ISO 14001 certification. We can help operators to develop a safe, practical strategy to reduce the risks associated with ballast water management and to comply with national and IMO regulations. By undertaking a gap analysis (HEGA), we can help implement best practice for managing the human element.

Our overall vision is to continuously improve in helping our clients ensure supply chains are safe, responsible and sustainable.

[www.lr.org](http://www.lr.org)

## MAN Diesel & Turbo

MAN Diesel & Turbo SE, based in Augsburg, Germany, is the world's leading provider of large-bore diesel and gas engines and turbomachinery. The company employs around 15,000 staff at more than 100 international sites, primarily in Germany, Denmark, France, Switzerland, the Czech Republic, India and China. The company's product portfolio includes two-stroke and four-stroke engines for marine and stationary applications, turbochargers and propellers.

The range of services and supplies is rounded off by complete solutions like ship-propulsion systems. Customers receive worldwide after-sales services marketed under the MAN PrimeServ brand.



In light of the importance of emissions in modern-day shipping, MAN Diesel & Turbo has developed a multi-pronged strategy to maintain as green a profile as possible. The strategy covers the development of environmentally friendly engines, green retrofits to existing engines, secondary measures (EGR and SCR) to eliminate NOx emissions, the development of ultra-efficient propeller technology, and cooperation with business and academic partners.

[www.marine.man.eu](http://www.marine.man.eu)

## Odense Maritime Technology

We are leading designers, production engineers and project managers for the maritime industry. Our maritime solutions are based on a close partnership with the client throughout each project and, as most of us are former Odense Steel Shipyard employees, solid experience from shipbuilding.

To optimise the clients' desired results, we work closely with strategic partners and outsource around the globe, and we approach each project with unique end-to-end value chain capabilities and disciplines as well as experience and know-how.

We offer total solutions as well as defined partial solutions to meet your fundamental requirements. We deliver integrated solutions for shipbuilding, shipyards, brokering and marketing.

Our technical solutions are based on extensive research and development gained over the last ninety-four years.

The continuous refinement of innovation and leading edge technology has resulted in the highest quality as well as high economic and operational output.

OMT designs incorporate retrofit options to save energy,



**Rolls-Royce**

regenerate heat loss and lower the CO<sub>2</sub> emissions.

Our ship designs are well recognised for their advanced technology, seaworthiness, use of excellent environmental solutions and operating performance.

Our proven products are state of the art, energy-efficient and prepared for expected future regulatory and environmental requirements.

[www.odensemarmarine.com](http://www.odensemarmarine.com)

### **Rolls Royce Marine**

Rolls-Royce is a global leader in integrated marine power and propulsion systems. Our product range and vessel design capabilities enable us to bring the right products together when integrating sophisticated systems into complex ships.

We offer the world's largest portfolio of marine products and systems from a single supplier, ranging from gas turbines and diesel & gas engines, through to propellers, thrusters, water jets, deck machinery, automation and control systems.

Our world is changing, populations are increasing. We need more power but not at any cost to society. The world needs better power.

As a leading power systems provider we have a fundamental role in meeting the environmental and societal opportunities and challenges that the world faces.

Sustainability is inherent to our strategy. Our vision is to provide better power for a changing world. We will deliver better power for our customers, use innovation to secure a better future, and build on today's achievements to develop a better business, ready for the opportunities ahead.

[www.rolls-royce.com](http://www.rolls-royce.com)

### **Silverstream Technologies**

Silverstream Technologies B.V. has pioneered air lubrication within shipping for over ten years, and has invested significantly in the research and development, and testing of air lubrication for ships. The Silverstream® System reduces frictional resistance between the water and the hull surface, dramatically reducing fuel consumption and associated emissions. The Silverstream® System is unique in that it is the only proven air lubrication technology that can be retrofitted in between 5 and 14 days, as well as being applicable for newbuildings. It lasts the lifetime of the ship, is complementary and can be used in conjunction with other clean technologies, and return on investment is typically between 2 and 5 years.

The Silverstream® System is a unique system that reduces frictional resistance between the water and the hull surface, dramatically reducing fuel consumption and associated emissions.

We believe that the increasing pressure on and regulation of international shipping to become constantly more efficient (and, therefore, greener in terms of reduced CO<sub>2</sub> emissions), goes hand in hand with a series of new technologies offered to the market. To achieve these new, ambitious goals set by IMO we believe several technologies will come into play and that Silverstream Technologies' air lubrication system will be an important part of that mix.

[www.silverstream-tech.com](http://www.silverstream-tech.com)

SILVERSTREAM  
TECHNOLOGIES



### VP Solutions

VPS offers cost efficient performance management solutions for analysis of performance data. Our business idea is to convert performance data into decision support using data collection processes that are already implemented within ship owners or ship operators. Such data can be either classic noon reporting formats or autolog data if such data exist. VPS service supports optimization of fuel consumption for fleets of vessels within owners, operators and ship management companies.

Based on operational data for ships VPS determines operational profile of vessels for optimization of hull lines for an operational profile. Benchmarking of designs against similar vessels of same class to ensure vessel is efficient for its class.

VPS help operators, ship managers and ship owners to improve the transport efficiency by providing services to monitor and improve the fuel efficiency of fleets of vessels and thereby also reducing the environmental footprint. This is done by offering performance management services supplemented by ship benchmarking services. Performance management is an excellent platform to learn about real ship operation in order to improve new ship designs for the future, i.e. close the feedback to newbuilding design.

[www.vpsolutions.dk](http://www.vpsolutions.dk)

### Green Ship of the Future

Green Ship of the Future is a public private partnership for innovation and demonstration of technologies and methods that makes shipping more environmentally friendly. Through collaborative innovation, forces are joined to explore, develop and demonstrate ambitious

green solutions for the shipping industry and for shipping. The core activity of GSF is the development of environmental and energy efficiency projects in relation to ships and the shipping industry.

Regional ECOFeeder was part of the GSF project portfolio in 2016.

[www.greenship.org](http://www.greenship.org)



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**Also, a very special thanks to all the participating partners for good and constructive collaboration.**



OMT →

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[greenship.org](http://greenship.org)



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