energy technologies institute

An ETI Insights report

TARGETING A 30% IMPROVEMENT IN FUEL EFFICIENCY FOR MARINE VESSELS

ETI10 TEN YEARS OF INNOVATION 2007 — 2017

Contents

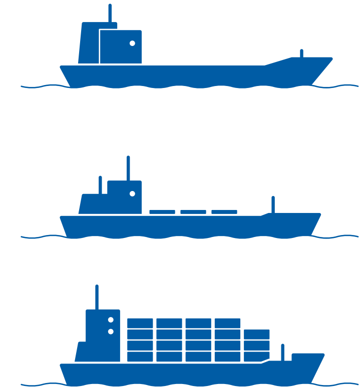
The International Maritime Organisation states that, without intervention, maritime emissions could rise by

50-250%

by 2050 compared to 2011 levels

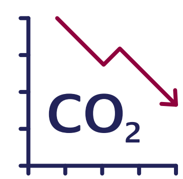
The greatest CO_2 emissions come from three ship types –

tankers, bulk carriers and container ships



TARGETING A 30% IMPROVEMENT IN FUEL EFFICIENCY FOR MARINE VESSELS

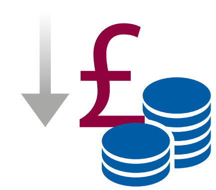
Eliminating fossil fuels for shipping does not appear credible – the best potential to achieve substantial CO_2 reduction in the next few decades is through reducing fuel consumption



The ETI believes

30%

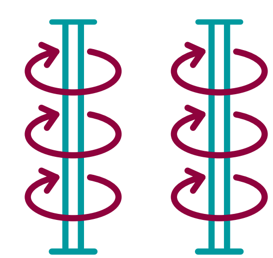
fleet fuel consumption reduction can be achieved by using innovative technologies with an economic payback of around two years



New technology introduction is challenging, costly and risky so **fuel-saving technology** demonstration is needed to give confidence and overcome market barriers

ETI is advancing **marine technology** demonstration in Flettner rotors, high efficiency propulsion systems and waste heat recovery

Flettner rotors



KEY HEADLINES

- Shipping emits substantial amounts of CO_2 which, without significant intervention, will rise as a proportion of our national emissions as we become less carbon dependent in other industry sectors
- Ocean voyaging ships have the biggest impacts on CO_2 emission due to the length and speed of their voyages and the current calculation method[1] underplays the UK's share of international shipping carbon emissions
- There are economic advantages to emitting less carbon (and the economics of such are more cost-effective than some other carbon abatement opportunities in marine and other sectors)
- Using non-fossil fuels such as nuclear or high levels of biomass does not appear credible in the timeframe assessed
- In the medium to long term (to 2050), the best potential to achieve substantial CO_2 reduction is by fuel consumption reduction
- ETI modelling has shown that a 30% fleet fuel consumption reduction can be achieved using innovative technologies with an economic payback period of around two years and a fuel price of $720/Tonne
- For the opportunity to materialise, fuel-saving technology demonstration is needed to give confidence to stakeholders and overcome market barriers

1 Based on marine fuel bunker sales

Introduction to CO_2 Emissions from shipping

Global emissions

The International Maritime Organisation (IMO) third greenhouse gas emission study in 2014 stated "Marine transport emitted 938 million tonnes of CO_2 in 2012, representing 3.1% of the world's total emissions"[2], and that "The total fuel consumption of shipping is dominated by three ship types: oil tankers, container ships and bulk carriers". Consistently for all ship types, the "main engines are the dominant fuel consumers", and in the IMO assessment of future scenarios, they state that, without intervention, maritime emissions could rise by 50–250% by 2050 compared to 2011, illustrated in Figure 1.

In Figure 2 opposite, we see that from 2007 to 2012, international shipping emissions were in relative decline compared to global emissions due to a change in economic activity and the subsequent increasing popularity of "slow-steaming[3]".

The IMO introduced the Energy Efficiency Design Index[4] (EEDI) in 2011. The EEDI sets specific ship-class fuel efficiency targets, and aims to progressively tighten them. The EEDI encourages continued technical progress in the reduction of vessel fuel consumption. The initial CO_2 reduction target level is -10% from the 2011 datum and will be tightened every five years to keep pace with fuel consumption and emissions reduction technology developments. These targets are mandatory for all ships. The intention of EEDI is admirable; however, relying on technical progress to drive commercial deployment and acceptance is unlikely to accelerate CO_2 emissions reductions to meet the IMO or UK government targets. Additional initiatives are needed, and the intention of this programme is to provide the technology, tools and commercial advantages to ship owners, operators and charterers to accelerate compliance with emissions targets.

Figure 1
Expected CO_2 emissions from IMO[2]

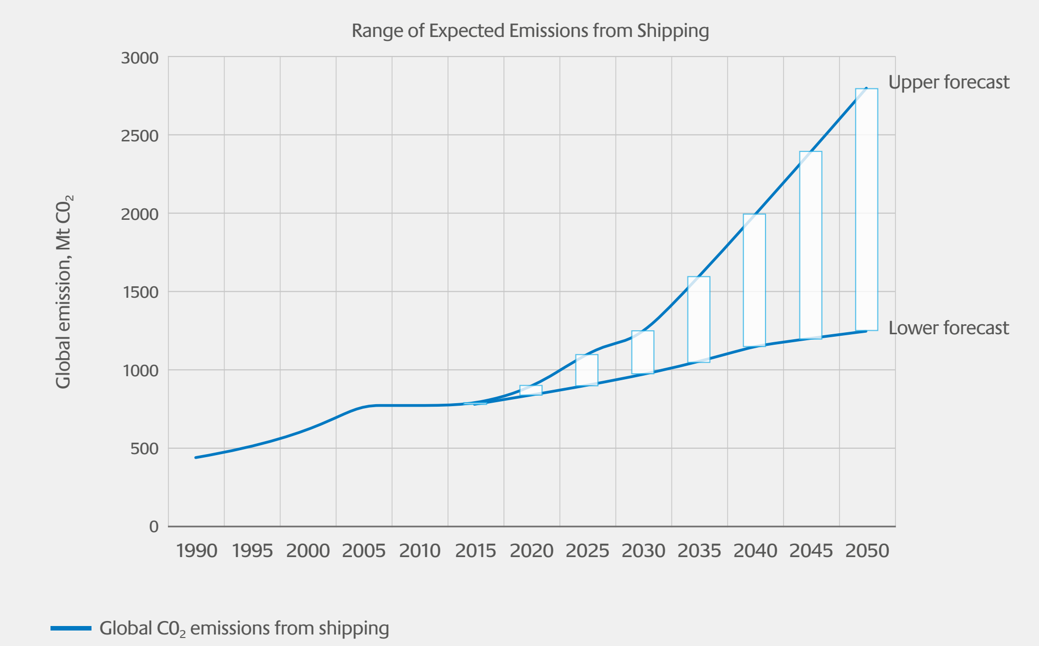
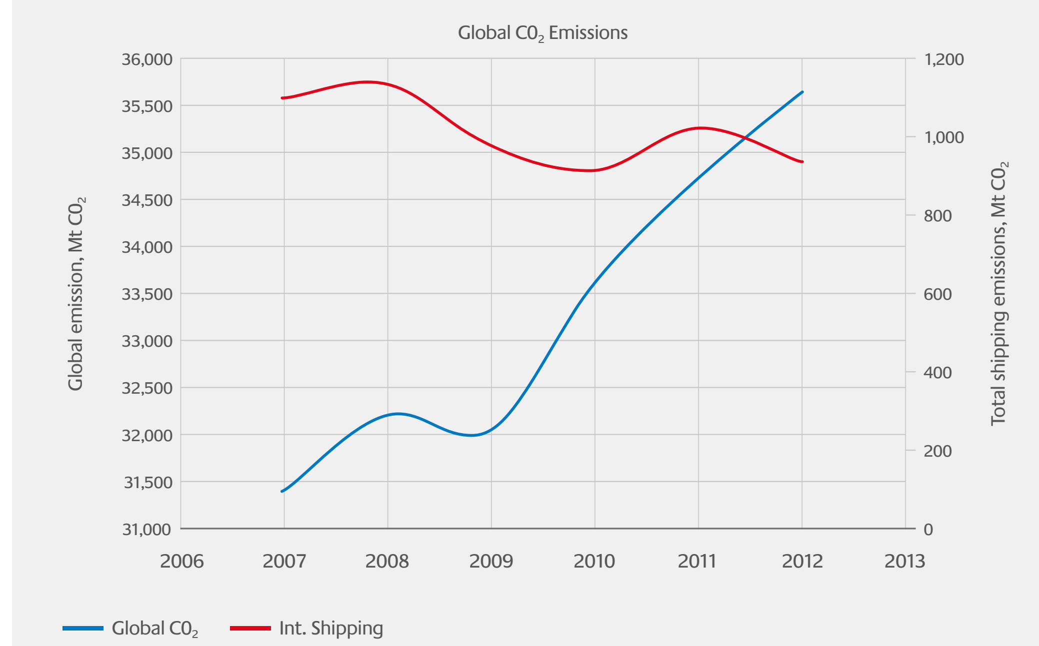


Figure 2
Global CO_2 emissions from IMO 2014 greenhouse gas study



2 http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Greenhouse-Gas-Studies-2014.aspx

3 Slow-steaming is the practice of significantly reduced ship speed for long periods of a voyage. The purpose is to reduce fuel consumption, but can sometimes be used to manage the cargo value.

4 http://www.imo.org/en/MediaCentre/HotTopics/GHG/Pages/default.aspx

Introduction to CO_2 Emissions from shipping

Continued ›

UK Emissions

The UK is committed to reducing its total CO_2 emissions to 80% of 1990 levels by 2050. The contribution of the UK transport sector in 2011 was 120 million tonnes of CO_2 . Of this, heavy duty vehicles (HDV), including land vehicles and marine vessels account for 44 million tonnes, or 8% of the total and shipping is 11 million tonnes or 2%. As the UK economy decarbonises, the relative contribution to total CO_2 emission is likely to rise from 2% to 8%, as shown in Figure 3 below.

The shipping sector is unable to decarbonise in the same way as the energy sector due to technical reasons and high costs. Therefore, the UK needs to reduce HDV emissions to ensure that CO_2 emission reduction obligations are met.

UK shipping emissions have been studied by the Committee on Climate Change (CCC)[5], and UK ports and shipping activity is monitored by the Department for Transport (DfT)[6] and independent organisations such as Lloyds List[7].

Shipping emissions allocation is internationally agreed to be proportional to marine bunker sales, and this method is used by the Department for Transport in their assessments of CO_2 emissions. This report from the CCC shows that the UK fleet contribution is 11 million tonnes of CO_2 ($MtCO_2$) from a total global output of 938$MtCO_2$, or 1.2%. However, this assessment may be unreliable since it depends upon marine bunker sales, which is strongly influenced by ship owner and operator purchasing decisions. An alternative method of estimating CO_2 emissions attributable to UK shipping is used by the CCC, and consists of studying the ship size, engine type and fuel use, voyage length and other parameters. Shipping emissions are considered to be attributable to domestic and international shipping, where international shipping includes that to and from the UK, and domestic is between UK ports. On average there are over 120,000 UK port calls annually, with over 90% of those being to and from Northern Europe and the Atlantic coasts of France, Spain and Portugal. Typical shipping routes are illustrated in Figure 4.

These emissions can be further analysed, and be associated with ship types and voyage type; as shown in Figure 5 below.

Figure 3
Relative UK Shipping CO_2 Emissions versus year

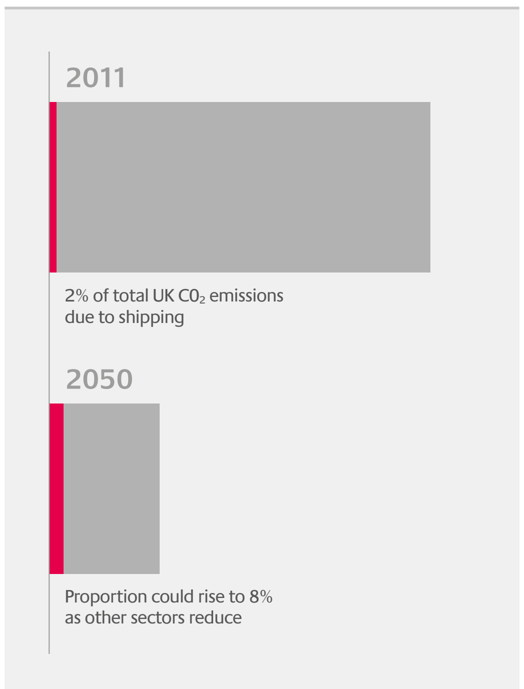
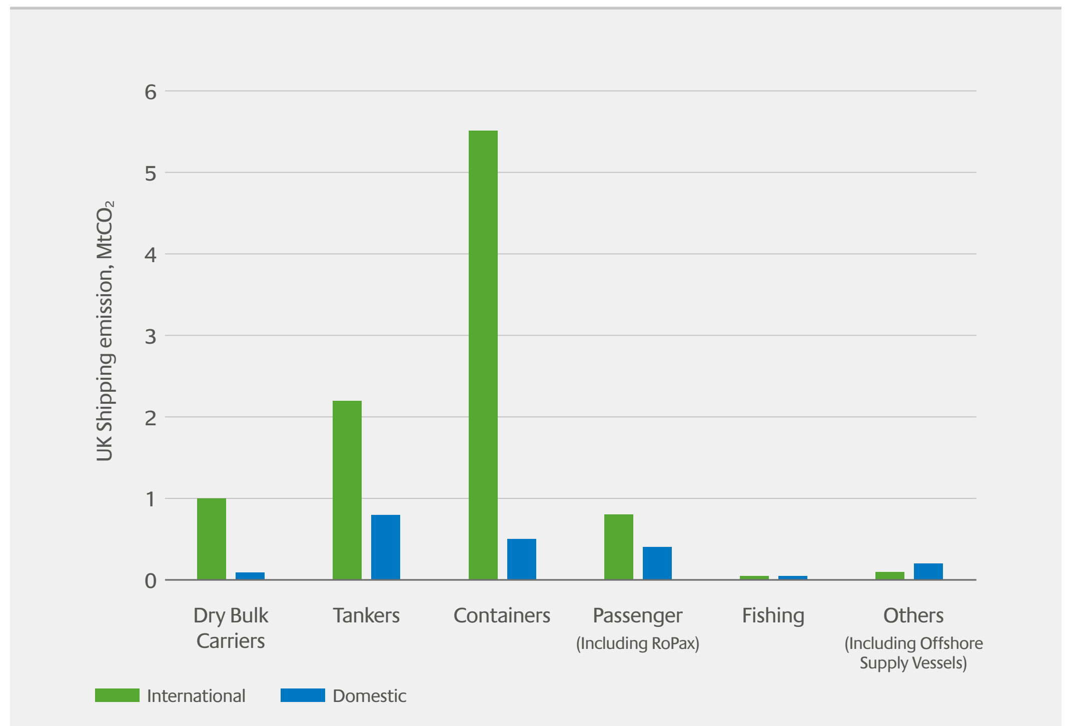


Figure 4
Map illustrating typical shipping routes

Figure 5
UK CO_2 emissions by ship and voyage type



Source: Committee on Climate Change 2015

5 https://www.theccc.org.uk/wp-content/uploads/2015/06/6.737_CCC-BOOK_WEB_030715_RFS.pdf
6 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440269/dft-annual-report-and-accounts-2014-to-2015-_web-version_.pdf
7 https://www.lloydslist.com/

The ETI Heavy Duty Vehicle Marine Programme

- A system engineering, integrated approach to future vessel concepts
- Developing sub-system and component technologies to enable vessels to be up to 30% more efficient

The ETI Heavy Duty Vehicle Marine Programme[8] encourages the development and adoption of technologies to reduce CO_2 emissions, and ensure that UK transport systems are affordable, sustainable and secure.

The programme aims to increase the efficiency of land vehicles and marine vessels by 30% by 2050, by developing and deploying emission-reducing technologies from 2025 onwards. This saving is a meaningful improvement and is achievable by means of commercial and technical innovation, driving accelerated CO_2 emission reductions.

The first part of our marine programme, the concept development project, has completed the creation and integration of a validated, full-scale shipping model that is focused on vessels involved in the UK Fleet activity. This model is central to understanding ship trading, technology and the potential for emissions reductions and fuel consumption improvement.

How will we meet these aims?

- Fuel Consumption Reduction
- Cost advantage, sustainability and commercial acceptance

Ship owners and operators could be incentivised to reduce CO_2 emissions in response to financial policies or trends such as

- Increasing fuel prices
- Increasing fuel quality and thus cost, for example, increasing pressure to use reduced-sulphur fuels
- Potential financial incentives through carbon trading

The HDV programme aims to design, validate and demonstrate commercially and technologically superior marine sub-systems and services to reduce fuel consumption. This will drive market acceptance by virtue of economic advantage and may also improve reliability, safety, and ship performance.

Opportunity Scoping

Our initial activity started in 2013 and closed in summer 2015 with an investment of £2m. This focused on developing a range of highly efficient concept vessels by combining data and modelling techniques from academia with commercial knowledge and technology development expertise from industry. The project was delivered by Rolls-Royce with support from University College London (UCL).

This has leveraged Rolls-Royce technology knowledge at a vessel level and combined it with UCL's capabilities to understand and model the shipping network. It has built upon the Low Carbon Shipping project led by UCL[9] and funded in part by the Engineering and Physical Sciences Research Council (EPSRC).

Due to the uncertainties in modelling, assessment and validation of fuel-saving technologies, we also invested in a parallel project with BMT Defence Services[10]. This project also studied the whole vessel system performance and was designed to challenge assumptions and outcomes of the technology selection process described below.

8 See http://www.eti.co.uk/programme/transport-hdv/
9 http://www.lowcarbonshipping.co.uk/
10 http://www.bmtdsl.co.uk/

The modelling work started with the classification of the UK fleet, which would allow identification of representative vessels and their trading patterns. This is not as obvious as for other HDV vehicles, since the maritime trade is global and highly mobile, making vessel types, sizes and voyages ambiguous.

What is the UK Fleet?

- Types of ships and their characteristics
- Typical mission profiles
- Their CO_2 impacts

The project needed to identify the UK fleet and their typical mission profiles to allow the ship system requirements to be obtained and analysed within the system model. The UK fleet is defined as ships that travel to a UK port, and their emissions are tallied for the incoming voyage only[11]. From this definition, port calls and ships were correlated, and then a set of ship characteristics were obtained. This information allowed the project participants to determine common technology platforms which offer the highest CO_2 reduction opportunities across the five selected ship types (see table 1). These characteristics included deadweight, voyage duration, speed and ship type.

This work showed that the five selected ship classes account for circa 74% of all UK Fleet CO_2 emissions. The range of ship parameters included amongst others:

- 200 to over 200,000 deadweight tonnes
- 2 nautical miles to 10,000 nautical miles voyage length
- maximum rated speeds from 10knots to over 30knots

A study of the 2020 fleet projections allowed the project to develop a clear understanding of the future UK maritime sector, and the technology changes likely to be introduced in that time with or without intervention. The ship selection can be checked against the CO_2 emissions described in Figure 5, page 9. It can be seen that the greatest CO_2 emissions come from three ship types – tankers, bulk carriers and container ships – travelling on international voyages.

The large quantity of UK port visits means that encouraging fuel-saving technologies will have a great effect on the global fleet, since ship owners will not limit their ship operations to the UK only.

11 https://www.theccc.org.uk/publication/review-of-uk-shipping-emissions/

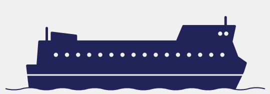
The ETI Heavy Duty Vehicle Marine Programme

Continued ›

The five representative ship types of the UK fleet and their particulars, as used in the ETI analysis in table 1:

Table 1

UK Fleet Ship particulars (2011)

Ship Type		Dead-weight Tonnes[12]	Service Speed, Knots[13]	Main Engine Power kW[14]	Length m	Breadth m	Max Draft, m
	Tanker	10000	14	4000	115	20	11
	Dry Bulk	45000	15	10500	200	30	12
	Container feeder	10000	18	7000	134	22	7
	RoPax[15]	9000	22	20000	170	28	6
	OSV*	3900	15	9000	87	21	8

* Offshore Supply Vessel, a ship that works for oil and gas platforms

12 Deadweight is the measure of the ship's cargo-carrying capacity, gross tonnage is another commonly used measure, and is a function of the ship's volume over its full length, and keel to funnel top

13 A knot is one nautical mile per hour and is approximately equal to 1.15 miles per hour, or 1.94m/s

14 Some ships have significant on-board power generation which may add to the vessel's CO_2 emissions

15 Roll-on/roll-off passenger ferry (e.g. Dover to Calais ferries)

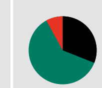
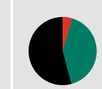
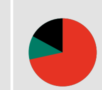
What is the potential prize?

- Lower fuel costs
- The UK Fleet CO_2 emission and fuel consumption is closely related, and varies by ship type and size, voyage profile and ship adherence to best maintenance practise. Table 2 below shows the CO_2 emissions and mission profile for each ship type.
- Technology adoption for other fleets

The UK Fleet CO_2 emission and fuel consumption is closely related, and varies by ship type and size, voyage profile and ship adherence to best maintenance practise. In Table 2 showing the UK fleet emissions and voyage profile below, we show the CO_2 emissions and mission profile for each ship type. The mission profile is described as percentage of the voyage time spent manoeuvring (red), slow-steaming (green) and full-away (black). Manoeuvring is that part of the voyage where the ship speed and direction can change as it enters or leaves port. Full-Away is the time when the ship operates under broadly constant speed, usually near to the nominal maximum speed. Slow-steaming is similar to full-away, but there is a deliberate decision to travel slower than the nominal maximum speed, usually to save fuel.

Table 2

UK fleet emissions and voyage profile (2011)

Ship Type		Global fleet annual CO_2 in Mtonnes	No of ships in the UK fleet	UK fleet annual CO_2 in Mtonnes	gCO_2 per tonne km	Average journey, km	Mission profile
	Tanker	170	530	3.03	8–90	2800	
	Dry Bulk	180	400	1.11	5–65	3000	
	Container feeder	260	780	5.98	15–82	2600	
	RoPax	105	550	1.53	20–150	200	
	OSV	95	390	0.36	–	–	

■ Manoeuvring ■ Slow-steaming ■ Full-away

The ETI Heavy Duty Vehicle Marine Programme

Continued ›

Simulation modelling suggests that by implementing the technologies described in the section "Technology Landscape" and in the assessment work, the 30% UK fleet target for fuel consumption reduction can be met. However, if fuel consumption is reduced, the emissions of other harmful gases may not be reduced by the same ratio, since emissions also depend upon the prime mover combustion efficiency. This means that pollution reduction may not directly correlate with fuel consumption reduction.

Energy use during time-in-port was not included in our project technology selection process since this is highly dependent upon non-technical parameters such as port facilities and working practices, offloading capacities and capabilities, and navigation. However, the use of shore-based power connections have been studied, and there are significant cost savings to be offered by the use of shore power during time-in-port, and may range from £3000 to £1000 per day for our representative ships. These cost savings are due to the operating expenditure reductions.

Technology Introduction Stakeholders

There are diverse stakeholders involved in the selection of marine vessel low-carbon enabling technology, or are involved in setting standards that encourage technology adoption. In Figure 6 (right) is an illustration of the relationships between stakeholders for novel marine technology introduction. Legislative framework and insurance services are influential in setting legal, social and economic targets for technology introduction, with the aims of encouraging safety, benign environmental impacts and commercial advantages. New technology introduction is challenging, costly and risky, with uncertain benefits and detriments. However, if classification societies are involved in new technology introduction from the outset, their influence in de-risking and passing on valuable technical expertise, risk-mitigation and operational experience can be a significant positive influence.

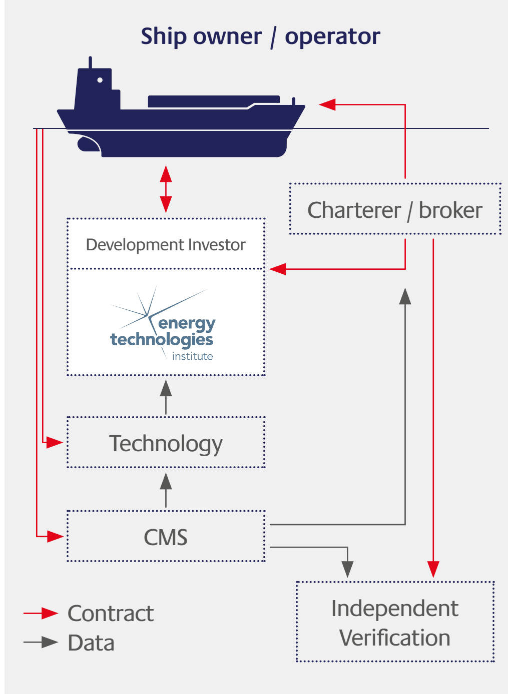
Figure 6

Relationships between project stakeholders

Shipping technology stakeholders

International and National legislation – IMO, UN and WTO, UK MCA*

Local legislation – Health and safety, employment law and staff associations	Insurance services



Ship Owner / Operator
Responsible for installation of technology, performance and its safe operation

Charterer and Ship Brokers
Charter of vessel, staff and services to move goods

Development Investor (eg. ETI)
Finance Capital and installation cost of technology. Recoups investment through fuel saving, split with owner. Trades investment against data generated during trials

Technology Provider
Provides technology and supports owner in terms of installation and operation

Continuous Monitoring System (CMS)
Fitted by owner and forms part of the requirements embodied under the charter

Independent Verification
Contracted by charterer to independently verify the results and values attributed to the technology. May be a classification society

* MCA is the UK's Maritime and Coastal Agency
www.gov.uk/government/organisations/maritime-and-coastguard-agency

The ETI Heavy Duty Vehicle Marine Programme
Continued ›

- A **ship operator** may operate the vessel on behalf of the owner, and could be responsible for variable costs such as fuel consumption, stores, maintenance and repairs. Ship's staff have a significant role in managing fuel consumption improvements since they are directly operating the machinery, navigating and maintaining the vessel.
- The **charterer** is the ship owner's customer, and could buy that service via a ship broker. The charterer seeks reliability, low-cost and low-risk. The charterer is responsible for insuring the cargo.
- The **development investor**, for example, the ETI, finances and manages innovation projects that improve the ship's performance. They might work with ship builders, naval architects, and ship operators to encourage system engineering and suitable installation project management processes are adhered to.
- The **technology provider** works with the stakeholders to deliver a superior vessel fitted with their innovative technology.
- **Continuous Monitoring Systems** are used to observe ships' operating parameters. These systems are essential in validating technology developments, allowing performance data collecting. The system will provide real-world validation that enables financial decisions.
- **Independent Verification Services** are often provided by classification societies or engineering consultancies. They will scrutinise and assess technology impacts allowing the stakeholders to understand the innovation's performance against targets and requirements.

There is no single body responsible for fuel consumption, but there are common groups that are interested in fuel cost reduction, such as legislative bodies, charterers and brokers. The ship charterer is ultimately responsible for charter selection, and the technology applied to deliver that service is only relevant if it has a positive impact. This market is dominated by cost and risk management, meaning that any superior technology must have positive impacts on both cost and risk to be acceptable to all involved parties.

Technology Landscape and Innovation Opportunities

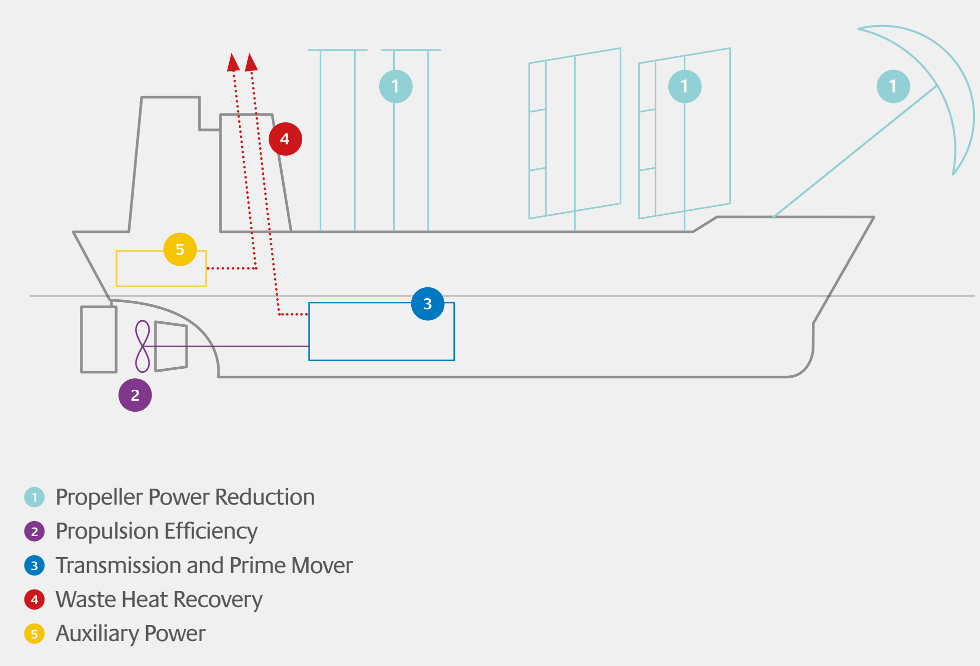
- What possible technologies can make a difference?
- Why aren't they used today?
- How can we get these technologies to market?

The project raised and applied a whole-ship system engineering model to facilitate technology comparisons. The methodology used over 180 variables within the study, and included the following input parameters:

- Ship's particulars
- Fuel cost, type and availability
- Engine and power system topology and performance
- Hull form
- Mission profile
- Sea temperature, weather conditions and sea state
- Degradation and fouling

The ship's power paths considered were propeller power reduction, propulsion efficiency, transmission and prime mover, waste heat recovery and auxiliary power; see Figure 7. A total of 57 technologies were studied in the initial assessment.

Figure 7
System Engineering outline showing the ship's power paths



Each technology was compared with the technical and commercial targets and the most promising technologies studied in greater detail as shown in table 3. Of the identified technologies, some were established technologies from other industries like chemical processes, or aviation, but not yet used in marine applications. Some are specific to marine applications, but are not selected by ship owners due to other reasons. Our intention was to study the reasons for low adoption, then try to overcome them.

The ETI Heavy Duty Vehicle Marine Programme
Continued ›

Table 3
Assessed technologies

Propeller Power Reduction	Propulsion Efficiency
Flettner rotors (FR) A Flettner rotor is a type of wind-assisted propulsion device working on the Magnus principle, redirecting wind to provide thrust	Contra rotating propellers (CRP) Contra rotating propellers are paired propellers sharing the same shaft axis, but rotating contra each other
Kites Kites are wind-assisted propulsion devices that capture thrust	Large area propellers (LAP)* Large area propellers reduce thrust loading and increase propeller efficiency
Micro-bubble drag reduction (MBDR) Micro-bubble power reduction reduced hull drag by air lubrication	Contra rotating, rim drive propellers (CARD) Rim drive propellers are mounted within an outer duct, and are driven from a rotor within the outer duct
Air cavity (AC) Broad, shallow hull recesses used with micro-bubble drag reduction	Post-swirl stator (PSS) Post-swirl stators are static devices that improve flow characteristics before the propeller
Wing sails (WS) Wing sails are rigid wind-assisted propulsion devices that capture wind to provide thrust	Mewis Ducts (MD) Static devices that improve flow around the propeller
	Transom stern flaps (TSF) Fitted to the aftmost part of the transom hull on the waterline for flow improvement
	Surface coatings (SC) Surface coatings are designed to reduce drag
	Kappel/NPT* propellers Improved shape propellers that increase efficiency
	Composite bladed propellers Propellers are made from stiff non-metalic materials to allow blade deflection under load and greater efficiency
	Optimised rudders Optimised rudders improve flow in the propeller wake, increasing efficiency

* Kappel - MAN Diesel and Turbo
* NTP - Stone Marine Propulsion
* LAP with MD and SC is a highly efficient propulsion system (HEPS)

Transmission and prime mover	Waste Heat Recovery	Auxiliary power
Power take off or take in PTO/PTI is an electrical machine and drive that can extract or add power to the ship's main shaft	Organic Rankine Cycle (ORC) Waste heat recovery using (ORC)	Proton exchange fuel cells (PEFC) Low-temperature (>100C) fuel cells using hydrogen
LNG methane fuels LNG/methane fuels emit less CO_2 when burnt	Turbo-generator (TG) Placed in the main engine exhaust stream, TG use the exhaust heat to drive an electrical generator	High-temperature fuel cells (HFC) A fuelled battery without moving parts, operating at high stack temperatures (<400C)
Fuel water emulsification Emulsions are used to improve combustion and thermodynamic efficiency		Dual fuel, HP (DHFP) gas engine Otto cycle engine burning different fuels at high pressure
2-stage turbocharging This is an improved turbocharging system that boosts air flow and pressure		
Electro-turbo compounding A combination of electrical machine and engine supercharger, designed to improve specific fuel consumption and waste energy recovery		
Composite shafting Lightweight main propeller shaft that offers improved dynamic response and lower mass		
Iso engine An improved diesel-type engine using isothermal compression cycle and gives better CO_2 emissions		

The ETI Heavy Duty Vehicle Marine Programme
Continued ›

An assessment of suitability was made for each technology applied to the five representative vessels, and their emissions impact, costs, technology readiness levels, safety and reliability compared. The assessment criteria were weighted to emphasise impact, commercial acceptability, safety and ETI additionality[17]. Using the ship technology model to study the technology impact on a range of real-world ships in a virtual environment, and to assess their compliance with our requirements for realistic fuel consumption reduction. The balance between capital expenditure and operating expenditure was studied to understand the compromises and balances between a lower capital cost product and potentially higher operating costs. This study also included time to market, and cost reduction strategies and projections.

This assessment revealed some strong themes:

- a range of propulsion efficiency improvements can be low-cost
- Wind assistance can make a significant impact
- Waste heat recovery methods are attractive since they are lower cost than wind-assisted propulsion and effective

Although the technologies identified above are generally at TRLs from 4 to 8, we can see that their adoption over the UK fleet might not be straightforward due to their limited effectiveness on some ship classes and mission profiles. Our project studied this within the selection analysis and concluded that their applicability and effect was impactful, as shown in Table 5 below.

The high efficiency propeller (HEPS) can be successfully applied to most ships with good effect, and the waste heat recovery (ORC and TG Set) is applicable to all ships. Flettner Rotors (FR) are also applied to good advantage.

It's also worth noting that the RoPax and OSV ships have the fewest opportunities for improvement.

Table 4
Technology effectiveness and cost

Description	Powerpath	Efficiency improvement (%)	Unit Cost Price (£k/kW)
Propeller Boss cap with Fins	Propulsion Efficiency	5	10
Microbubble Drag Reduction	Propeller Power Reduction	5	75
Mewis Duct	Propulsion Efficiency	7	100
Composite Bladed Propellers	Propulsion Efficiency	6	200
Organic Rankine Cycle	Waste Heat Recovery	10	200
Rim Driven Propeller	Propulsion Efficiency	9	300
Wingsails	Propeller Power Reduction	5	500
Contra Rotating rim driven propellers	Propulsion Efficiency	12	500
Flettner rotors	Propeller Power Reduction	17	800

Table 5
Quantified Vessel Performance versus technology selections

	Optimum Technologies Applied	Fuel Consumption Improvement, %[18]
Tanker	DFHP Gas Engine, MBDR, ORC and TG, HEPS, FR	40
Dry Bulk	MBDR, ORC and TG, HEPS, FR	32
Container feeder	DFHP Gas Engine, MBDR, ORC and TG, HEPS, WS	30
RoPax	DFHP Gas Engine, ORC and TG Set, MBDR, WS	16
OSV	ORC, TG Set, MBDR, WS	13

17 Additionality in this case is defined as the impact that investment from the ETI will have on successful technology development and deployment. This means that developments at high commercial readiness levels are not highly ranked

18 Error or uncertainty is ±5% reduction in fuel consumption per nautical mile

The ETI Heavy Duty Vehicle Marine Programme
Continued ›

Based on system level analysis of ship power paths (see Figure 7 page 17), we have identified credible options to deliver greater than 30% fuel efficiency improvements across the UK fleet.

Of the identified optimum technologies above, micro-bubble drag reduction and DFHP Gas Engine are already being developed into commercially acceptable products by a number of corporations.

The development opportunities that could most benefit from ETI Additionality were judged to be:

- Flettner Rotors
- Waste Heat Recovery
- High Efficiency Propulsion systems

Conclusions and Next Steps

The project has clearly shown that a range of technology developments could deliver 30% fleet fuel consumption reduction and have a positive impact on shipping costs and CO_2 emissions. For the opportunity to materialise, fuel-saving technology demonstration is needed to give confidence to stakeholders and overcome market barriers. This demonstration needs to be carefully executed and measured, with independent verification enabling transparent and valid results assessment.

The ETI is intending to fund the opportunities identified into demonstration projects

FURTHER READING FROM THE AUTHOR

Insights into Floating Wind Technology
www.eti.co.uk/insights/floating-wind-technology

Insights into Tidal Stream Energy
www.eti.co.uk/insights/insights-into-tidal-energy

Insights into Wave Energy
www.eti.co.uk/insights/offshore-renewables-insights-into-wave-and-tidal-energy

ABOUT THE AUTHOR

Stuart Bradley
BSc PhD MIET

Offshore Renewables – Strategy Manager

Area of Expertise: Marine Engineering, Technology Management, Innovation and Manufacturing Engineering

Stuart is a Marine Engineer with over twenty years' experience of designing ship systems and five years of ship operational experience. These systems include cruise liners, military ships (minehunters to aircraft carriers) and boats (motor yachts to submarines). He has helped create innovations employed on a wide range of marine technologies, including propellers, electrical machines, drives and mechanical components. Since 2013 he has also been the ETI's strategy manager for Offshore Renewables managing projects and authoring insight reports into offshore wind and marine energy technologies.

01509 20 20 65
stuart.bradley@eti.co.uk

Energy Technologies Institute
Holywell Building
Holywell Way
Loughborough
LE11 3UZ

01509 202020
www.eti.co.uk
info@eti.co.uk
@the_ETI