Clean, green marine:
a breakthrough solution for global shipping

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Expleo has developed breakthrough retrofit and new build systems that replace a vessel's internal combustion diesel generators with a closed-loop e-methanol fuel cell solution to deliver up to 100 % reduction in operational greenhouse gas (GHGe), significant savings on fuel and future proofing for alternative fuels.

With around 85 % of the world's vessels being small or medium-sized, and prime targets for conversion to hybrid power, Expleo's solution has the potential to shape the future of the marine industry's Net Zero ambitions.

> **"Not only have we developed a scalable fuel cell/ battery hybrid solution for decarbonising the industry, but one delivering an OPEX saving of circa £1.4m a year per vessel, making a practical business case for green technology investment."**
>
> **Paul Burns,** Chief Engineer – Marine, Expleo

The challenge – and opportunity – for shipping

Cargo shipping releases around

1,000 million tonnes of CO_2

emissions every year, as much as 3% of total global emissions[1]

The shipping industry will need to spend

USD 1–1.4 trillion

or on average between USD 50–70 billion annually for 20 years, to decarbonise in line with International Maritime Organisation (IMO) targets for 2050[2]

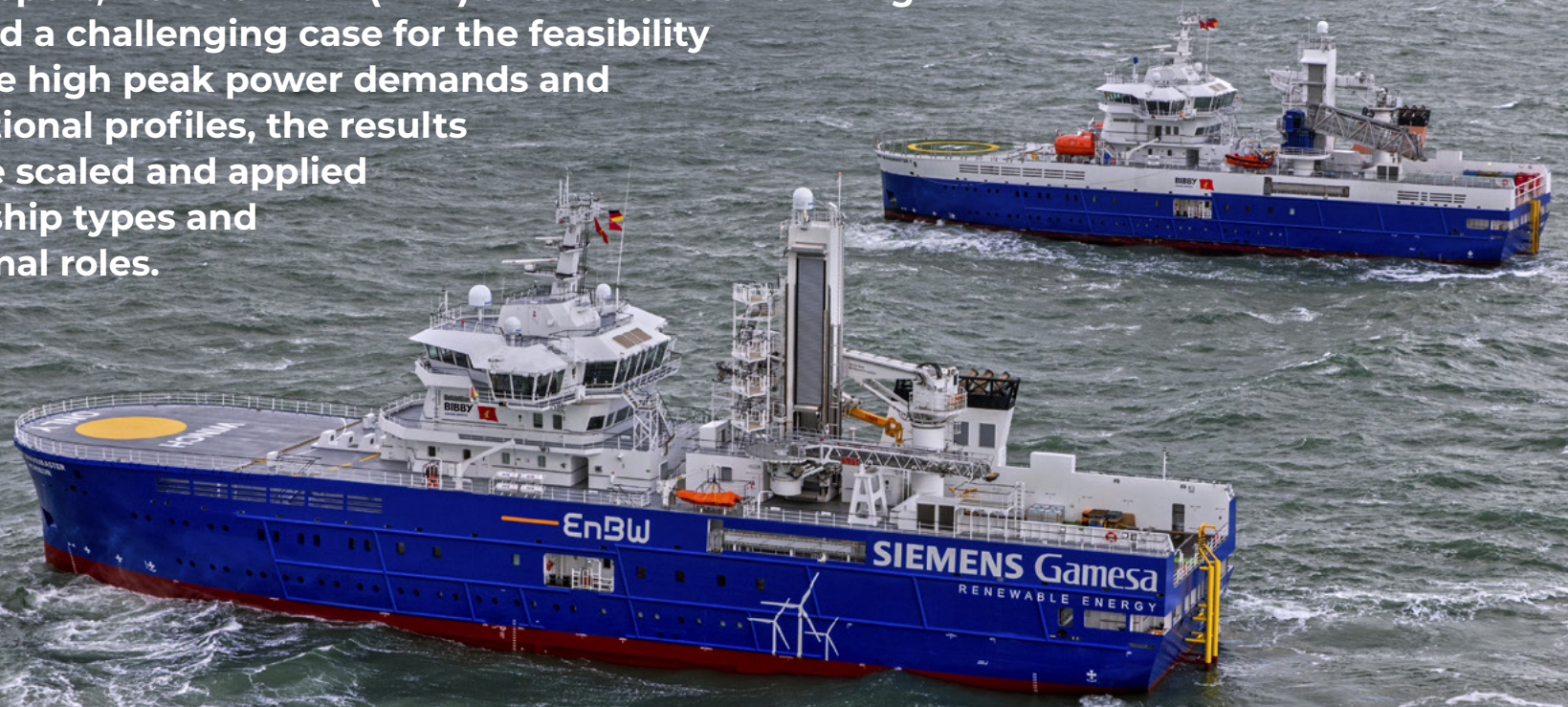
The global market for alternative fuel production technologies could rise to

USD 11–15 billion per year

by 2050, according to research by the UK Government[3]

An industry open to change

In partnership with Bibby Marine, a Liverpool-based SOV owner and operator, Expleo was successful in the UK Government's Clean Maritime Demonstration Competition (CMDC), securing funding for a feasibility study into a low-emission, retrofit solution for short-sea shipping, focused on the Bibby WaveMaster 1 SOV. These vessels perform a multi-operational role including cargo transport, accommodation, engineering support, walk to work (DP2) and materials handling – which presented a challenging case for the feasibility study due to the high peak power demands and complex operational profiles, the results of which can be scaled and applied to many other ship types and varied operational roles.

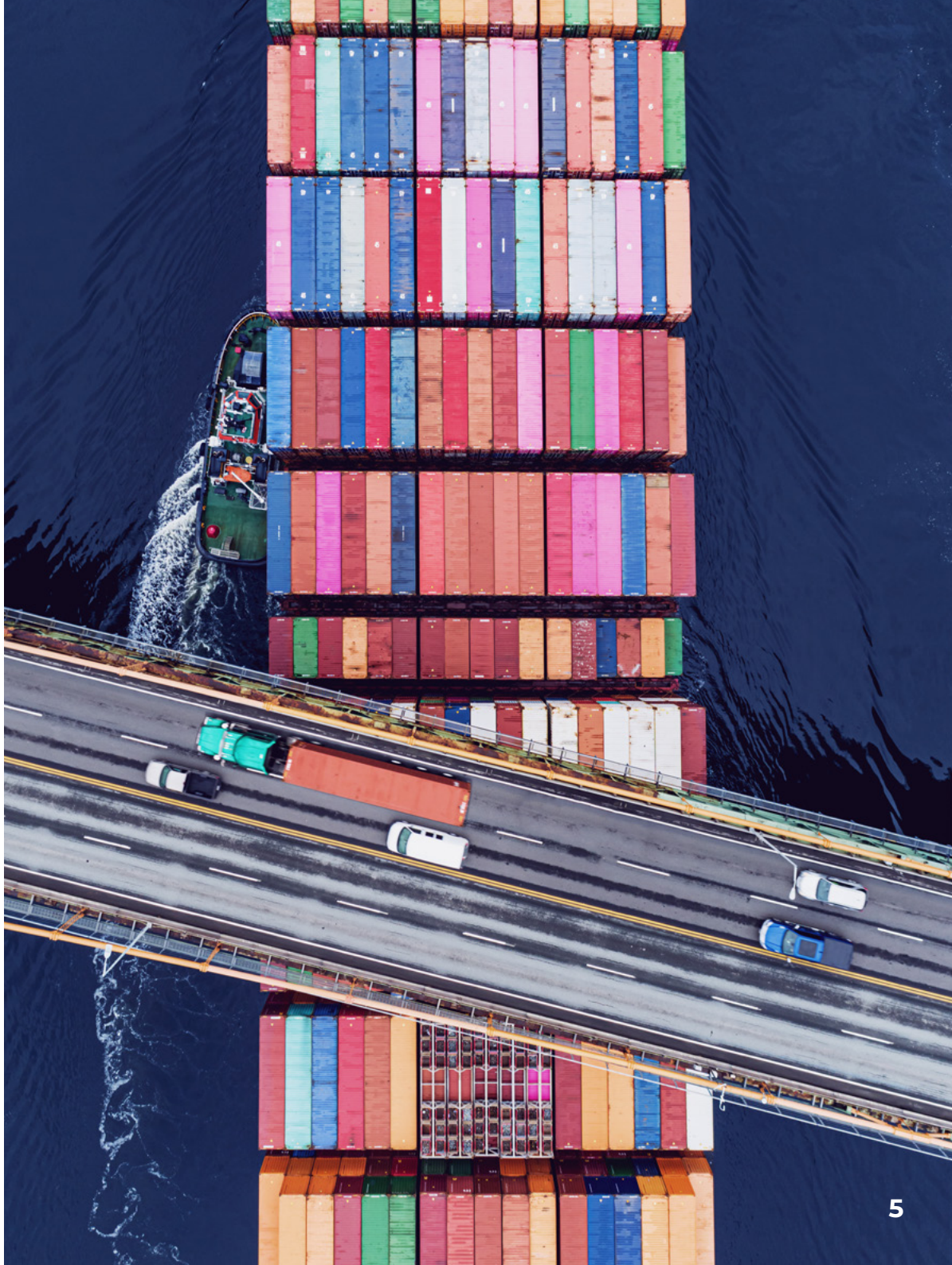


Art of the possible

The WHY for a project like this is simple. In line with International Maritime Organisation (IMO) timelines for reducing carbon emissions in shipping, a sizeable number of the world's 100,000 vessels will need to reduce emissions by 40% by 2030. The UK target is 78% by 2035 and net zero by 2050. Securing long-term finance for a ship that will not meet these targets will become challenging for ship owners. Developing a retrofit solution for the world's existing fleet becomes essential to avoid the early scrapping of many vessels, which need to comply with global regulatory decarbonisation targets. There is also considerable pressure from customers who need to reduce their overall supply chain carbon footprint.

The HOW is more complex. The marine industry is acutely aware that there is no silver bullet for global shipping - there is no one-size-fits-all solution. Vessels will require specifically tailored solutions based on their power requirements and operational profile. In its study, Expleo considered how various technologies and fuel options might work for marine – exploring each technology to a logical conclusion, before proposing a solution.

In parallel to the primary focus of the study, Expleo also considered the availability of fuel at the quayside, or bunker fuel supply, and how to future proof any innovation – mindful that with a vessel's 20+ year lifespan operators want solutions that avoid obsoletion in 10 or even five years' time.



A scalable, global solution

The solution Expleo explored for Wavemaster 1 was to replace one of its prime mover gensets with an SOFC, but in order to achieve 100% of its operational profile, a small percentage of its role would still require use of its diesel gensets. However, for different types and sizes of vessel, a 100% reduction in GHGe is achievable in new build and certain retrofits.

This makes it a truly scalable solution for maritime that has the potential to be applied globally to the world fleet.

> **"Over a 14-day operation the Bibby WaveMaster 1 could see a reduction of up to 92% in GHGe, by replacing a single diesel generator with a 1.6 MW bank of fuel cells."**
>
> **Andrew King,**
> Head of Commercial Marine, Expleo

> **"The scope the team has covered in seven months is phenomenal. Our initial focus was to deliver a solution for in-port hotel loads. Now, we're looking at the potential to help a sizeable portion of the world's shipowners achieve million-pound savings, the introduction of circular fuel ecosystems, and approximately 92% GHG reduction for at-sea vessels. We believe this 'system of systems' provides a potentially scalable solution for the world's shipowners."**
>
> **Jon Wines,** Capability Director – Marine, Expleo

Focusing the lens

#1 Methanol, the practical carrier of hydrogen

Expleo's development team consciously started small by considering how they might solve the problem of powering an SOV while in port. And if a solution could be found, could it be scaled?

In exploring this problem, the Expleo team considered all available options, from a retrofit perspective. The most promising power options assessed were battery, hydrogen, and methanol. When considering the impact on OPEX, CAPEX, weight, volume, and the design constraints dictated by the vessel's existing arrangement - methanol emerged as the most practical fuel.

In addition, alternative technologies were reviewed that would complement the methanol fuel choice, including what might replace the internal combustion engine (ICE) on the SOV. The Expleo team found the answer in a solution first developed in the 19th century: the fuel cell. Recent technological developments have seen a significant increase in fuel cell efficiency approaching 60 %, and up to 90 % by using a waste heat recovery system, when compared to an ICE which achieves around half that return.

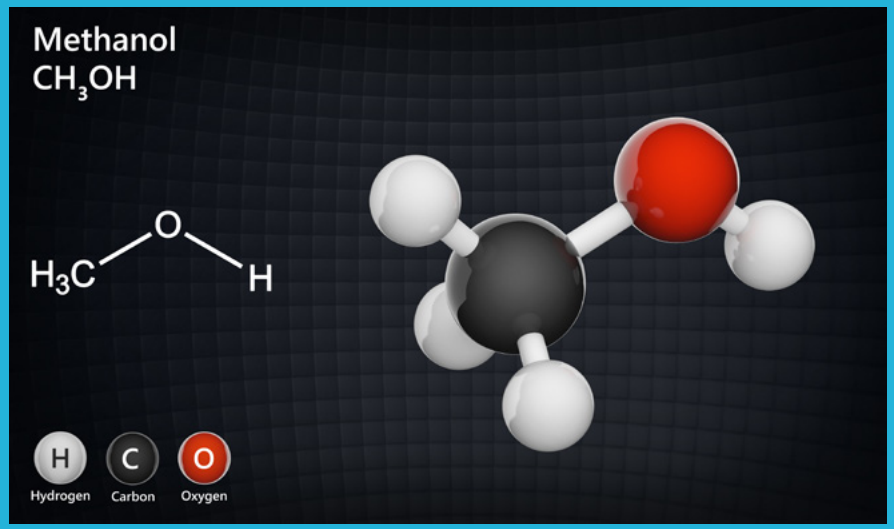
As methanol has less than half the power density of marine gas oil (MGO), it means that a fuel cell solution only requires an additional 30 % volume to maintain the vessel's equivalent operational range, compared to an ICE using MGO, which is essential for retrofit projects where available space on-board is at a premium.

METHANOL AS AN ENERGY CARRIER FOR HYDROGEN

Methanol production could quintuple in the next 30 years

Production of methanol has more than doubled over the last 10 years and could increase fivefold by 2050, according to the International Renewable Energy Agency (IRENA) , provided decarbonised green methanol (also called renewable methanol or e-methanol) becomes cost-effective.

Methanol is currently available in 88 of the top 100 ports in the world and while most of today's methanol is produced from natural gas and coal, future supply will need to come primarily from biomass, solid waste or by synthesising CO_2 and green hydrogen to make e-methanol.



#2 The case for a solid oxide fuel cell (SOFC)

There are several proton exchange membrane (PEM) fuel cells available for marine use, which can be combined with methanol reformers to extract high purity hydrogen (>99.97 %) for the cell. However, SOFC technology offers key benefits over and above PEM for marine applications, as they:

- support the use of multiple fuels including hydrogen, ammonia, methanol and natural gas
- operate at high temperature, supporting internal reforming
- are made from robust steel stacks which are efficient and highly durable

Due to these key benefits, SOFC's are more likely to be the power train of choice for many marine decarbonisation solutions.

As the benefits offered in marine applications were compelling, the Expleo team focused its continued work on exploring SOFC technology in partnership with Ceres Power, a UK SOFC developer, and were able to prove that an existing, single diesel generator set replaced with a 1.2 MW SOFC powered solution would support up to 96 % of WaveMaster 1's current operational profile, both in port and at sea. To further improve the system and reduce operational GHGe, the team adopted a custom carbon capture and storage system into the design, which at 1.6 MW achieves a 92 % reduction.

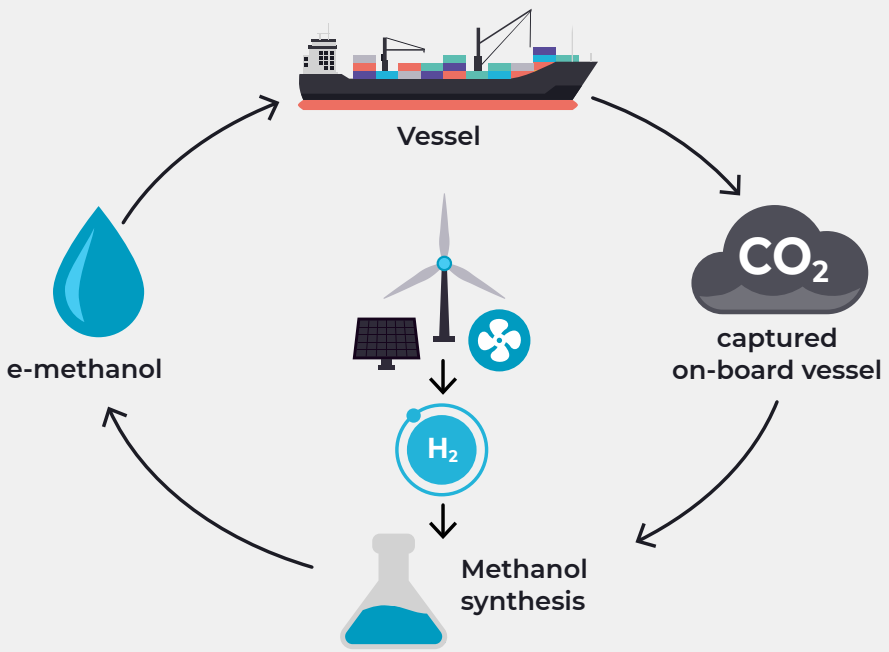
A methanol fuel cell powered solution with carbon capture is a novel alternative to diesel ICE gensets that could be retrofitted into a sizeable portion of the global fleet, and as a genset replacement it can be easily incorporated into new build designs.

#3 Closed-loop, circular fuel production

As a methanol fuelled SOFC exhaust releases a high concentration of CO2 the emissions must be addressed to offer Net Zero benefits. Expleo devised a solution incorporating a novel carbon capture and storage concept, reusing the captured CO2, in the synthesis of e-methanol. As part of Expleo's study it was established that several wind farm operators were exploring the opportunity to generate green hydrogen at sea, using surplus electrical energy. This supply of green hydrogen could then be used to generate e-methanol, in port or at sea.

This creates a closed-loop, circular fuel production solution allowing the marine industry to synthesise its own fuel.

The financial, logistical, environmental and global fuel security benefits are a game changer, removing the need for costly fuel processing and transportation while also tackling emissions, with the potential to significantly contribute towards the creation of 'green shipping corridors' as outlined in the Clydebank declaration.



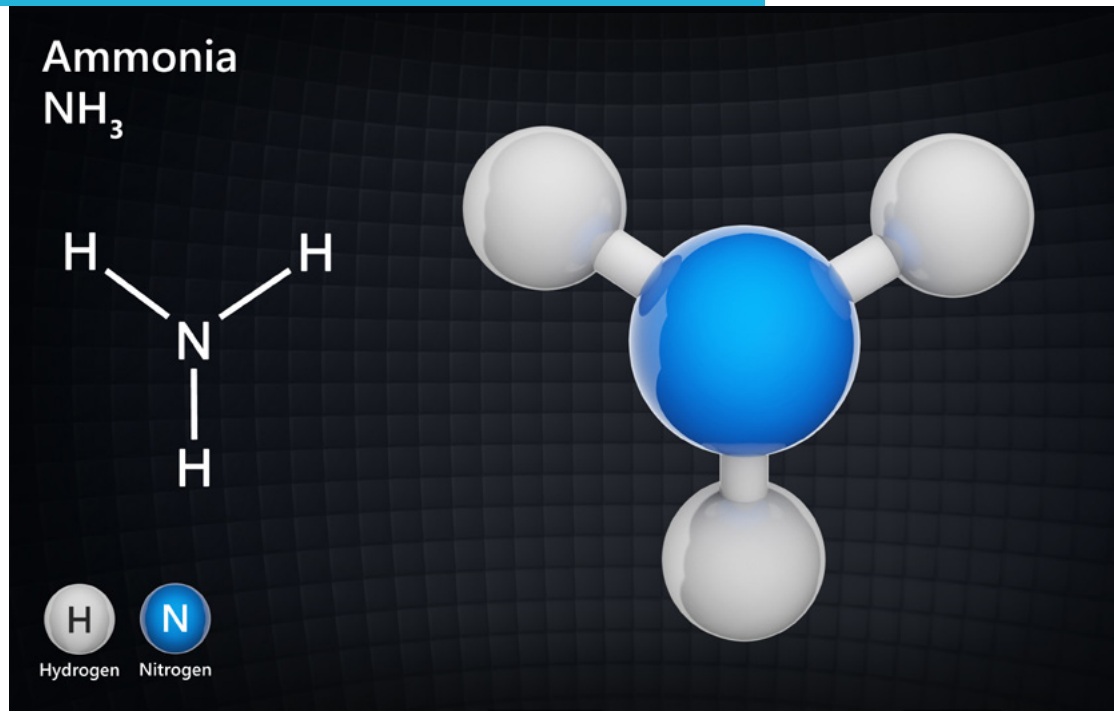
“Imagine if ship owners and operators were self-reliant for fuel, using wind energy to power their ships, as they were before fossil fuels. Challenges around fuel infrastructure remain, as well as carbon capture, but we are confident that this will be overcome in a short timeframe. These are changes that need to happen for the industry to meet the Net Zero challenge in time.”

Malcolm Stein, Systems Engineering Manager – Marine, Expleo

#4 Future proofing for ammonia

In addition to the adoption of SOFC technology and the development of a closed-loop fuel production concept, Expleo has also identified a way to future-proof the solution, by demonstrating that the CO_2 storage system and the SOFC can be easily converted to store and utilise ammonia, where practical.

Ammonia is hazardous and with the current lack of distribution infrastructure for marine use and supply chain challenges it could be another decade before it becomes a feasible mainstream alternative fuel for shipping. However, indications point towards its proliferation in the future.



MAKING THE FINANCIAL CASE

Projected savings of
£1.4m
per annum

Four-year payback
based on projected estimate for retrofit

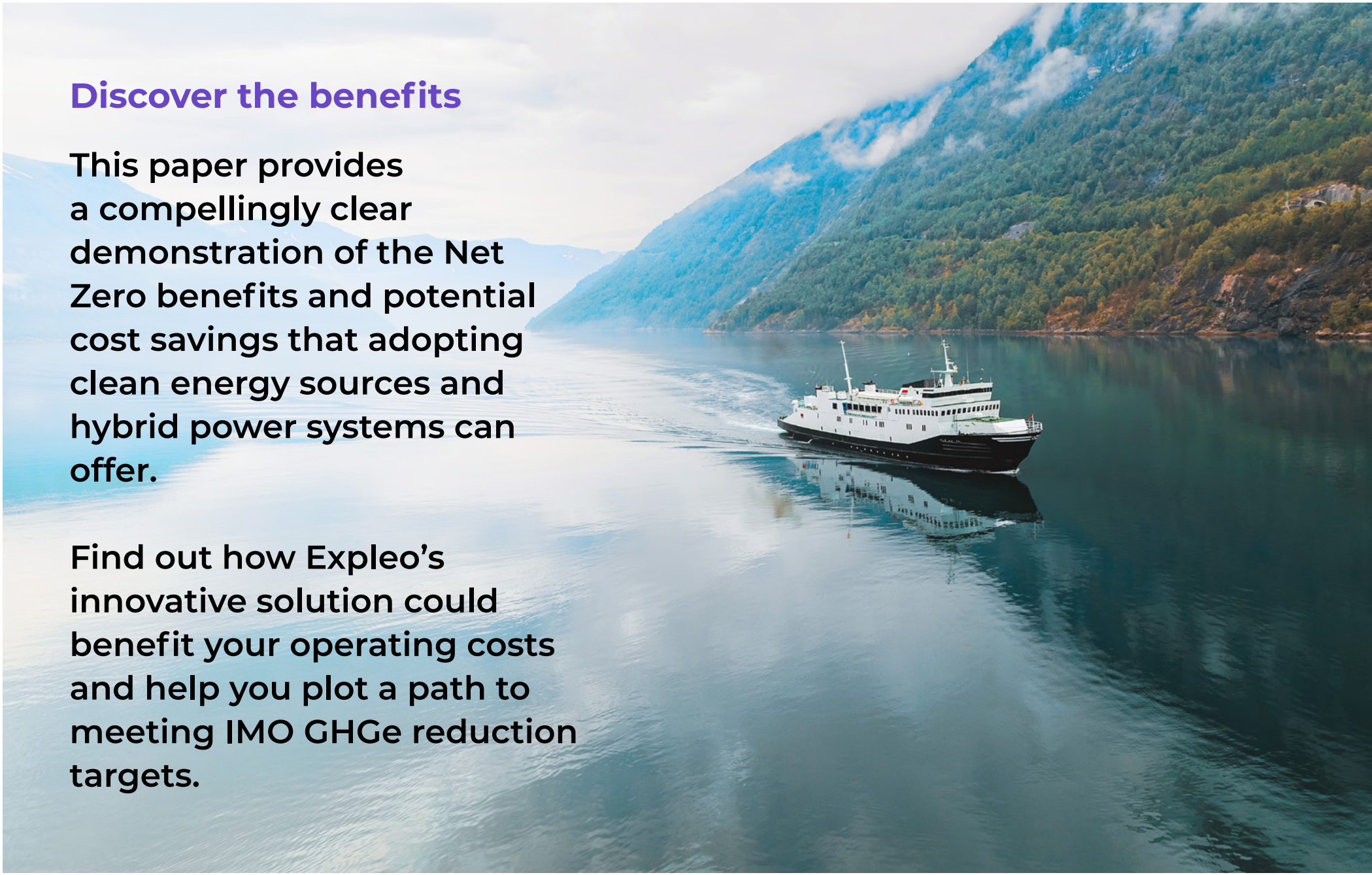
Compared to an existing diesel vessel, projections in the study show that a methanol system will save Bibby WaveMaster 1 operators £1.4m a year per ship. This figure includes fuel cost savings against MGO, the value of captured CO_2 and the cost of the EU Emissions Trading System (ETS). ETS is scheduled for introduction in January 2023 at 25% of the emissions cost at £85 per ton, increasing to 100% by 2026.

Moreover, for ship owners looking to purchase new low GHGe vessels, this solution would demonstrate residual value for financiers, if adopted as a concept design for new builds, rather than a retrofit solution for existing tonnage. This design concept would be applicable to a wide range of vessel types and operational profiles, not just SOVs that formed the focus of the study.

Discover the benefits

This paper provides a compellingly clear demonstration of the Net Zero benefits and potential cost savings that adopting clean energy sources and hybrid power systems can offer.

Find out how Expleo's innovative solution could benefit your operating costs and help you plot a path to meeting IMO GHGe reduction targets.



Clean Marine Demonstration Competition (CMDC)

This project was launched in March 2021, funded by the Department for Transport and delivered in partnership with Innovate UK. As part of the CMDC, the Department allocated more than £23 million to 55 projects supported by 208 organisations from across the UK.

The CMDC was announced as part of the Prime Minister's Ten Point Plan to position the UK at the forefront of clean maritime technologies and reduce emissions from the sector. The CMDC is supporting the research, design, and development of zero emission vessel and infrastructure solutions to enable clean technologies to commercialise and to accelerate the decarbonisation of the maritime sector. The programme is funding projects from across the entire UK, including in Scotland, Wales and Northern Ireland as well as from the South West to the North East of England.

Expleo is proud to be part of a competition that supports UK innovators to achieve net zero. The CMDC funding offers an unparalleled opportunity for Expleo to work with its partners on their journey to net zero, while also developing new skills in-house for the future. Expleo believes that all learnings must be shared with the open market. They must all be transferable and scalable to achieve maximum impact on the net zero challenge.

Expleo has worked with several technology suppliers to complete the design and analysis work, assessing alternative energy technologies – hydrogen, methanol, ammonia, batteries and hybrid solutions – as well as a range of supporting technologies such as reformers, fuel cells and energy reclaim.

The project has included a qualitative design study to determine environmental credentials, technical feasibility, economic viability, regulatory compliance and alignment with industry innovations such as in-field offshore wind farm bunkering facilities. Expleo now plans to take this solution into phase two of the CMDC, working with partners and technology suppliers to develop a demonstrator.

References in this whitepaper

[1] https://www.imo.org/en/OurWork/Environment/Pages/Fourth-IMO-Greenhouse-Gas-Study-2020.aspx

[2] https://www.globalmaritimeforum.org/news/the-scale-of-investment-needed-to-decarbonize-international-shipping

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/815664/clean-maritime-plan.pdf

[4] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2021/Jan/IRENA_Innovation_Renewable_Methanol_2021.pdf

About Expleo

Expleo is a global engineering, technology and consulting service provider that partners with leading organisations to guide them through their business transformation, helping them achieve operational excellence and future-proof their businesses.

Expleo benefits from more than 40 years of experience developing complex products, optimising manufacturing processes, and ensuring the quality of information systems.

Leveraging its deep sector knowledge and wide-ranging expertise in fields including AI engineering, digitalisation, hyper-automation, cybersecurity and data science, the group's mission is to fast-track innovation through each step of the value chain.

As a responsible and diverse organisation, Expleo is committed to doing business with integrity and working towards a more sustainable and secure society.

Expleo boasts an extensive global footprint, powered by 15,000 highly-skilled experts delivering value in 30 countries and generating more than €1 billion in revenue.

For more information, visit expleo.com.

To work with Expleo's development team on this project – or another innovation in the marine industry – contact us today:

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Meet the team

JONATHAN TAYLOR

VP
Marine

Jonathan Taylor began his career with Expleo in 2004 and holds more than 18 years' experience in the marine, nuclear, aerospace and defence sectors. As Vice President of Expleo's global marine business, Jonathan's vision is to lead the division to become an internationally recognised maritime industry solutions provider.

ANDREW KING

Head of Commercial Marine
Marine

A naval architect with 38 years' experience in the ship design and shipbuilding/refit sectors, working for industry leading marine companies. Andrew has extensive experience in the commercial shipping, oil and gas, cruise, super yacht and naval defence (surface and sub-surface) sectors, having worked on a wide range of vessels and project types, encompassing concept design studies, major conversions and new build projects from tugs to aircraft carriers.

JONATHAN WINES

Capability Director
Marine

An engineering leader with more than 22 years' experience working in the aerospace and defence sector for manufacturers, system suppliers and engineering service providers, John's strengths are in leading multi-functional teams to deliver integrated solutions across the life cycle, from new product development to in-service support.

PAUL BURNS

Chief Engineer
Marine

Paul has more than 20 years' experience dedicated to the marine industry. Paul has led numerous defence projects and played a major part in the design and build of several vessels. Paul joined Expleo in 2020 and now holds the position of Chief Engineer for the marine division. His duties include QMS, overall technical governance and capability development.

MALCOLM STEIN

Systems Engineering Manager
Marine

Mal is an experienced engineer, graduating in electronic systems and microcomputer engineering at the University of Glasgow. After working in telecoms and L&D, Mal moved to the marine sector 12 years ago and has recently completed an MBA, specialising in adoption of AI. He joined Expleo in 2021 and is now Systems Engineering Manager on a naval marine project.


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