Climate Action readiness in the Irish fishing fleet

Climate Action technologies and case studies

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Executive Summary

This report explores climate action readiness within the Irish fishing fleet, focusing on technologies and methodologies that have the potential to contribute to energy efficiency and emissions reduction. It provides a comprehensive overview of innovative fuels, propulsion systems, and operational improvements, alongside real-world case studies from Ireland and abroad.

The Irish fleet is structurally diverse, ranging from small inshore vessels to larger offshore vessels, and has an aging profile which is a challenge in adopting modern technologies. This report provides a comprehensive analysis of emerging solutions such as alternative fuels, hybrid propulsion systems, and digital tools, which offer significant potential for reducing carbon footprints. Among the alternative fuels explored, Hydrotreated Vegetable Oil (HVO), methanol, hydrogen, and ammonia emerge as promising options, each with varying degrees of applicability and infrastructure requirements. Battery-hybrid systems are gaining traction, particularly for smaller vessels, while digital innovations such as real-time fuel monitoring and artificial intelligence are enabling more efficient operations.

Despite the potential of these technologies, the report identifies key barriers to their widespread adoption, including high costs, infrastructure limitations, and the need for robust policy incentives. Case studies from Ireland and international contexts demonstrate the feasibility and challenges of these solutions, offering valuable insights for the industry and policy advisors. While the energy transition in the fishing sector is still in its infancy, this report highlights the importance of investing in enabling infrastructure, incentivising adoption, and fostering innovation to accelerate progress. By addressing these challenges, the Irish fishing fleet can position itself as a leader in sustainable and climate-conscious operations, paving the way for achieving Net-Zero emissions.

This document lays the groundwork for future reports addressing the relevance and scalability of these technologies for Ireland's fishing fleet.

Introduction

The prevention of marine and atmospheric pollution by ships is governed by the United Nations through its agency, the International Maritime Organisation (IMO). The shipping industry has committed to reducing Greenhouse Gas (GHG) emissions in line with the Paris Agreement of 2016. This will necessitate the adoption of various Climate Action (CA) technologies and approaches, including the introduction of new fuels, innovative propulsion systems, and greater vessel efficiency. In parallel, the international fishing fleet has embarked on a journey of energy transformation, aiming to achieve Net-Zero emissions by 2050. However, it is important to emphasise that this transition remains in its early stages.

The objective of this report is twofold. Firstly, it seeks to document the range of climate action technologies and approaches currently available to fishing fleets, resulting in a '**climate action menu**' and a list of potential fuels for use in the Irish fishing fleet. Secondly, the report highlights 29 climate action case studies drawn from fishing, aquaculture, and maritime fleets in Ireland and around the world. These case studies, which include both real-world applications and prototypes, will be of particular interest to Ireland's sea fishing, aquaculture, and coastal communities. It should be noted that not all the climate action technologies and case studies are directly relevant to the Irish fishing fleet at present. However, with increasing pressure to decarbonise, these technologies are becoming a regular topic of discussion among vessel owners. The relevance of these technologies, as well as the barriers to adopting new fuels and propulsion systems, will be explored further in a future BIM report.

Background – the Irish fishing fleet

The Irish fishing fleet is highly diverse in terms of vessel length and fishing gear used. The majority of Irish vessels are relatively small and operate in inshore waters.

The fleet is dominated by the polyvalent segment, a diverse category that includes small inshore vessels (such as netters and potters), medium and large offshore vessels targeting *Nephrops*, mixed whitefish, and some pelagic species, including mackerel, herring, and tuna. In addition, the fleet encompasses a range of vessels, from small to large-scale operations, targeting crustaceans to pelagic species.

The average age of Irish fishing vessels is 33 years, which is notably older than the European average. Table 1 shows the current structure of the Irish fishing fleet.

Table 1 The structure of the Irish Fishing Fleet: (Source: Irish Fleet Register, 2024)

Segment	Registered Vessels	Total Gross Tonne	Total kW
Aquaculture	98	4,289	11,843
Beam Trawler	9	943	2,597
Polyvalent [<18m LOA]	1,259	6,735	42,976
Polyvalent [>=18m LOA]	103	19,454	47,459
Polyvalent [Potting]	310	653	8,794
Polyvalent [Scallops >=10m LOA]	3	60	264
RSW Pelagic	23	27,819	47,223
Specific [General]	133	1,302	9,656
Specific [Scallops >=10m LOA]	8	953	2,138
Grand Total	**1,946**	**62,208**	**172,950**

By the end of 2023, 39 vessels, accounting for 6,289 Gross Tonnage (GT) and 15,778 Kilowattts (kW) of engine power were decommissioned, thus adjusting the fleet's composition and efficiency profile in recent times. In 2024, the Irish fishing fleet has a total capacity of 62,208 GT and 172,950 kW.

The fleet is highly diverse with around 80% of vessels under 12-metres in length and typically operating in inshore waters, 90% of the fleet are under 15-metres.

Decarbonising the fishing fleet - a ‘Climate Action Menu’

Several carbon reduction methods are currently available, with some, such as Hydrotreated Vegetable Oil (HVO), already in widespread use in logistics, while others, like hydrogen, are still emerging and in development. The various climate action technologies and approaches summarised below, form a ‘climate action menu’ for the Irish fishing fleet. It is important to note that not all of these measures are directly applicable to every segment of the fleet, given its diverse nature.

The report outlines a range of fuels that feature prominently in the accompanying case studies. These include HVO, methanol, Liquefied Natural Gas (LNG), hydrogen, and ammonia. Electricity and batteries are also highlighted in many case studies, although they are not strictly categorised as fuels. A summary of these case studies is provided in Table 2.

Table 2 Summary list of case studies in this report

Case Study	Description	Technology	Sector
1	VISTools (Belgium)	Digital	Fishing
2	Artificial Intelligence (AI)	AI	Maritime
3	Seacat offshore service vessel (UK)	HVO	Maritime
4	*Stena Germanica* ferry (retrofit) (Sweden)	Methanol	Maritime
5	*Eemsborg* (Netherlands).	Methanol	Concept
6	Methanol powered Tug (Belgium)	Methanol	Tugboat
7	Methanol powered pilot boat (Sweden)	Methanol	Pilot boat
8	Concept: Methanol in fishing (Denmark)	Methanol	Concept
9	Pilot study of ammonia in Norwegian fishing	Ammonia	Trawler pilot
10	*Libas* (Norway)	LNG	Purse seiner
11	Shore power (Ireland)	Shore power	Fishing
12	*Gleoiteog Naomh Fanchea* (Ireland)	Electric outboard	Recreational
13	*Lorna Jane* (Scotland)	Solar electric	Fishing
14	*Hybrid I* (Canada)	Battery hybrid	Fishing
15	*Karoline* (Norway) Battery powered inshore fishing	Battery	Fishing
16	Fuel Cell range extender for small battery vessels	Hydrogen	Service vessel
17	Fuel Cell battery-power (Denmark)	Hydrogen	Fishing
18	Hydrogen One Methanol-to-hydrogen-fuelled tow boat (USA)	Methanol to Hydrogen	Maritime (in build)

Case Study	Description	Technology	Sector
19	*Nobody's Perfect*; Venice tour boat (Italy) Hydrogen electric powered.	Hydrogen fuel cell	Maritime
20	*Veronica* (Ireland)	Hybrid – Diesel Electric	Fishing RSW
21	*Centurión del Atlántico* (South America)	Hybrid retrofit	Fishing
22	*Austral Odyssey* (Australia)	Hybrid – Diesel Electric	Fishing - Toothfish
23	French trawler *Naoned* (France)	Hybrid (Digital)	Fishing (Trawling)
24	*Cygnus Cyclone* (UK). The Parallel Hybrid system	Hybrid	Fishing (Potting)
25	Seiner/crabber *Aksel* Johan (Denmark)	Hybrid	Fishing (Seiner Crabber)
26	BIM diver training vessel (Ireland)	Hybrid	Service
27	Aquaculture feed barge (Ireland)	Hybrid	Aquaculture
28	Wind powered cargo ship (France)	Sail	Maritime
29	Wind Assistance test vessel (Spain)	Sail	Fishing (Experimental)

Fishing vessel efficiency

For a detailed discussion on efficiency in fishing vessels, please see the BIM report on 'Improving Fuel Efficiency on Fishing Vessels' published in 2009. This report outlines many of the efficiency measures that can be implemented in the short term to reduce fuel consumption and therefore increase environmental performance (reduced emissions).

The amount of fuel burned by a vessel is directly proportional to the level of GHG emissions from a fishing vessel. The era of inexpensive fuel and large catches to offset high fuel costs has ended, leaving fishermen prioritising practical methods to reduce fuel consumption across all vessel types. Rising fuel costs, fluctuating fishing opportunities and fish prices, and global pressure to reduce carbon emissions, have severely impacted the profitability of fishing operations. While major investments in new fuel-efficient vessels or alternative fuel sources are often unfeasible due to economic and supply limitations, practical and cost-effective operational adjustments can yield significant benefits.

These include improving engine efficiency through regular maintenance and fuel monitoring, reducing drag caused by hull fouling, and optimising vessel speed for fuel consumption. Basic operational factors such as hull condition, trim, and gear size can also be adjusted to enhance efficiency. Engine efficiency is particularly critical, with the most effective operation achieved at 80-85% of the engine's Maximum Continuous Rating (MCR). Mismanagement, such as using an oversized or overloaded engine, leads to unnecessary fuel consumption and increased costs.

As a consequence, fuel efficient vessels have a lower rate of GHG emissions as they consume relatively less fuel. Some key efficiency measures that reduce fuel consumption are listed below.

Hull resistance and propeller efficiency

New vessels can achieve significant long-term benefits by incorporating early design considerations for hull shape and resistance, dramatically reducing fuel consumption. The Green Trawler project highlighted this potential by tank-testing an existing trawler design, the *Dillon Owen & Ardent*, alongside a new concept Green Trawler at Southampton University. The longer, sleeker hull design of the Green Trawler reduced drag and turbulence, achieving tank-tested fuel savings of over 50% during passage. The profiles of the existing Red Trawler (19.8m) and the Green Trawler design (23.9m) are illustrated in Figure 1.

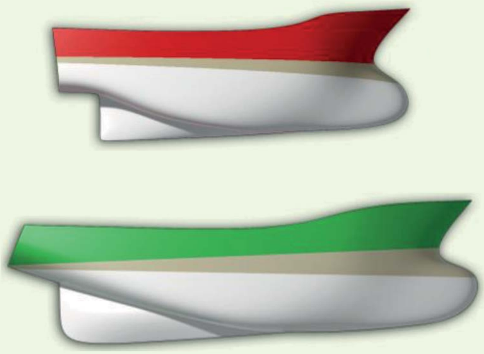


Figure 1 Showing different hull forms for red and green trawlers

Propeller, rudder, and appendage efficiency also play a crucial role in reducing resistance and fuel consumption during passage. Efficiency is particularly significant when trawling at speeds of 3-knots, where water flow to the propeller and the propeller's design have a greater impact. Skippers working with naval architects to fit the best propellers, typically fit one set-up for what they do most i.e., trawling, so this set up may be less efficient when steaming. In Ireland, the number of catamarans in the under-15-metre fleet has been increasing. Many vessel owners have successfully fitted foils at the forward end, which has reduced drag and improved fuel efficiency at service speed, contributing to a corresponding reduction in GHG emissions. Finally, a FAO (fao.org) report has documented the retrofitting of a fishing vessel with a larger-diameter propeller which yielded a 30% reduction in fuel consumption at cruising speed.

Optimisation of Speed, RPM and Pitch

The most fuel-efficient speed for any fishing vessel is its hull speed, irrespective of hull shape. A streamlined hull design allows a vessel to achieve its hull speed more easily and reduces the penalties associated with exceeding it.

Hull speed can be estimated using a simple equation: Hull Speed = 1.1 x √ waterline length (ft). Based on this equation, the hull speeds for various vessel lengths are shown in figures 2 and 3.

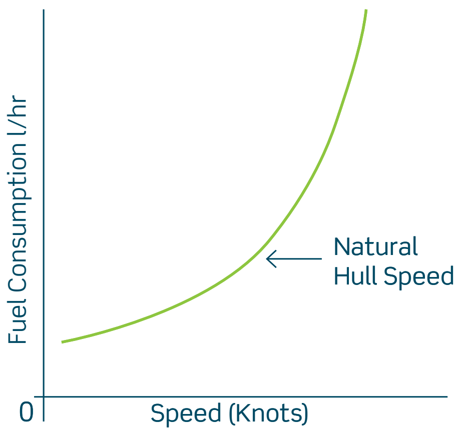


Figure 2 Showing the relationsip of fuel consumption and speed and the concept of hull speed

The curve above shows a typical power/speed curve and how fuel consumption rises steeply once the vessel exceeds her natural hull speed. Carbon emissions can be reduced by keeping the vessel speed below her nominal hull speed.

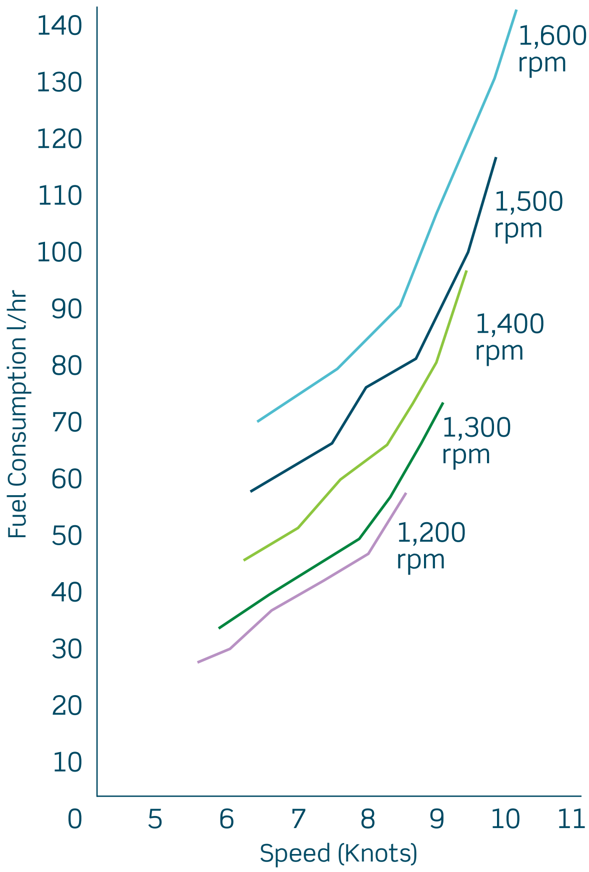


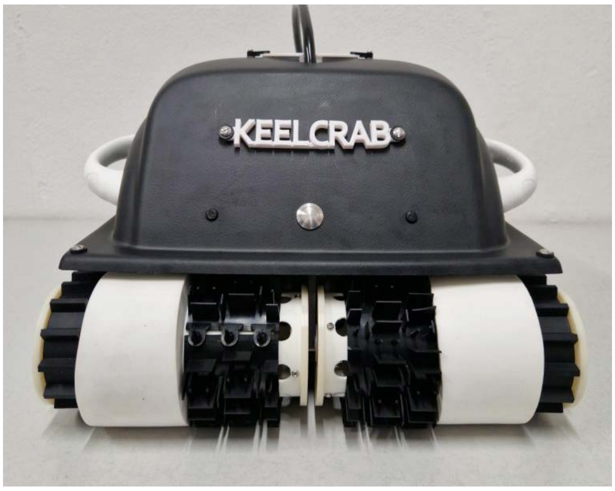
Figure 3 Showing the relationship of fuel consumption and speed and the implications of RPM

The data presented in Figure 3 was collected from two Irish vessels, the *Boy Jason* and *Cisemair*. The hull speed for these vessels is approximately 8.5-knots. During a period of testing, the vessels were equipped with Controllable Pitch Propellers (CPP) and Kort-style nozzles. Fuel consumption and vessel speed were measured with the engine RPM fixed for each curve, while propeller pitch was gradually increased for each data point.

The results clearly demonstrate increased fuel consumption as the vessel reaches its hull speed. The curves illustrate that reducing RPM and increasing propeller pitch can significantly lower fuel consumption for a given vessel speed. By maintaining speeds below the nominal hull speed and optimising RPM and pitch settings, carbon emissions can be substantially reduced. However, this data should be approached with caution, as torque loads increase when RPM is lowered. Engine manufacturers should always be consulted to ensure these adjustments are suitable for individual vessels.

Maintenance

Fuel efficiency can be enhanced, and GHG emissions reduced, through regular drydocking of vessels to maintain a clean hull and undamaged propeller. However, a recent trend has emerged where vessel owners extend the period between drydocking due to costs or limited slot availability. This extended period leads to increased fouling, resulting in greater drag and higher fuel consumption. Expanding the availability of low-cost, fast turnaround drydocking services, where vessels can be lifted, washed, and antifouled with minimal disruption to fishing activity, could serve as an effective GHG emission reduction strategy.



(Photo credit: Keelcrab.com; Hull drone cleaning device)

In-water hull cleaning is another widely used method for both large and small vessels. For example, Greensea IQ, a US-based service provider, employs its EverClean robot to map and routinely clean cruise ship hulls. This reduces fouling, drag, and fuel consumption while lowering carbon emissions. The robot advances at 0.5-metres per pass and records video footage of the cleaned areas. Similarly, the Italian-based company Keelcrab offers a comparable system designed for large yachts and motor vessels. Hull cleaning has consistently proven to be a cost-effective method for reducing fuel consumption and, consequently, carbon emissions.

Engine maintenance also plays a vital role in lowering costs and emissions while ensuring operational efficiency and reliability. In Ireland, larger and more modern fishing vessels consume approximately 180–220 grams of diesel per kilowatt per hour (g/kWh), while older engine models consume significantly more. Properly maintained engines are more fuel-efficient. A common indicator of inefficiency is the presence of dark exhaust smoke, which often signals wasted fuel. Issues such as worn fuel injection equipment, dirty turbochargers or aftercoolers, or worn cylinders can increase fuel consumption by 10–15%, with a corresponding rise in carbon emissions.

Investing in the optimisation of existing vessel components also offers significant potential for improving fuel efficiency. Adjustments such as optimising propeller size and design to match a vessel's operational cycle, altering gearbox ratios, and refining propeller and nozzle designs can yield meaningful improvements. Reducing or eliminating drag caused by appendages for electronic equipment through fairing can further enhance efficiency.

Power generation and storage

The sizing of auxiliary engines significantly impacts carbon emissions, as larger auxiliary engines are less efficient when operating at lower loads. Safety regulations for Irish fishing vessels over 15-metres require two sources of electrical power. Typically, a shaft generator and one generating set are sufficient for the engine room. A shaft generator provides electrical power from the main engine, eliminating the need to run an auxiliary diesel engine. This approach ensures the main engine remains efficiently loaded and avoids the inefficiencies and increased carbon emissions associated with running an auxiliary engine at low load.

Historically, the requirement for constant main engine RPM to drive a shaft generator has reduced efficiency and contributed to higher carbon emissions. To address this, several Irish trawlers have adopted an innovative system involving an engine-driven hydraulic pump that powers a hydraulic motor, which in turn drives an electric alternator. This setup modulates oil flow from the pump to the hydraulic motor, maintaining a constant RPM and frequency despite variations in main engine speed. While this hydraulic drive system has proven successful in achieving overall fuel savings, it does experience some mechanical losses.

Heat Recovery

Accommodation heating in some modern vessels uses underfloor electric heating. However, a more efficient alternative would be to harness waste heat from engine cooling systems and exhausts to heat accommodation and other onboard spaces.

Re-engining

While most of the case studies in this report are concerned with new fuels and propulsion systems, it is important to note that diesel engine replacement can offer very significant cost benefit and emissions improvements. Many manufacturers indicate fuel savings of up to 20% annually upon the installation of a new diesel engine.

Fishing gear with less drag

Gear-related methods for reducing fuel consumption and carbon emissions include improving the detection of catch as it enters the net and reducing netting to lower drag or the weight towed by the vessel during fishing. Trials conducted by BIM demonstrated that using larger mesh sizes in the top sheet of trawls resulted in a 39% reduction in by-catch of undersized whiting, along with a 10% decrease in fuel consumption and a corresponding reduction in carbon emissions. The shift from using single rig in prawn fishing, to twin and quad rigs is another example of how fuel efficiency on a catch per unit effort can be increased. The benefits of using lighter and more selective fishing gear are explored further in various technical reports available at www.bim.ie. Using net designs that reduce drag and fuel consumption, alongside other efficiency measures, can significantly contribute to lowering carbon emissions.

Digital: IT and software systems

CASE STUDY 1 AND 2

The digital revolution, coupled with the advent of Artificial Intelligence (AI), is transforming the maritime sector by improving optimisation and efficiency. Basic digital systems, such as fuel monitoring and reporting, have demonstrated a strong return on investment and play a critical role in reducing fuel consumption and GHG emissions. For example, the Belgian fishing industry has equipped many of its beam trawlers - targeting species such as sole, plaice, squid, and skate—with the *VISTools* software platform. This tool provides real-time data on fishing catch and fuel consumption, enabling vessel operators to monitor the fuel-to-catch ratio and the carbon footprint of fishing trips in real time, as well as over longer periods, including monthly, yearly, and multiyear analyses. Further details on *VISTools* can be found in **Case Study 1** (See case study appendix list at end of this document). Another example of the application of digital technologies in a fishing trawler can be found on the French trawler *Naoned*.

AI is also expected to play a significant role in improving efficiency within the fishing sector. However, its future application remains uncertain, as it represents a substantial departure from traditional systems, which primarily rely on sensor deployment and standard monitoring tools. For instance, **Case Study 2** details how ZeroNorth has developed a fuel model that integrates AI with naval architecture to predict and maintain optimal fuel consumption aboard sea-going vessels. This approach achieves a higher level of accuracy compared to traditional fuel consumption models. More information on this AI-based solution is available at the ZeroNorth case study (2) website. In sea fisheries, a new SINTEF project in Norway is currently deploying catch scanners using AI on fishing vessels with a view to identifying fish species, size and weight. The project is designed to assist skippers with regulatory compliance and to aid stock protection.

For more information on individual case studies, BIM recommend using the case study web links, which can be found in the appendix section at the end of this document.

Alternative fuel 1: Biodiesel and HVO

CASE STUDY 3

Biodiesel is a renewable and biodegradable fuel derived from biological materials such as vegetable oils and animal fats. HVO is an advanced form of biodiesel, initially developed using edible products like vegetable oils and animal fats. The second generation of HVO, now widely available, is produced from energy crops, waste agricultural products, and used cooking oils. HVO serves as a "drop-in" solution for the energy transition, with significant potential for use in the Irish diesel-powered fishing fleet, requiring minimal modifications to engines or fuel handling systems.

The *Emerald Star* recreational fleet in Ireland and offshore vessels in the Offshore Renewable Energy (ORE) industry have already adopted HVO. For instance, the 27-metre *Seacat Enterprise* (**Case Study 3**), operational in various European locations, uses HVO as a partial replacement for diesel, with a blend of 30%. The Port of Dublin has been operating its pilot boat *Dodder* successfully on 100% HVO since 2023. This vessel is powered by two Scania DI16 engines. The port is currently testing two additional pilot boats, the *Liffey* and *Carmac*, on HVO. These vessels, both 15 years old, are propelled by two Caterpillar C12 engines each. Similarly, a newly delivered pilot boat for the Port of Cork, the *Safehaven Interceptor 48*, also operates on HVO and is powered by two Scania DI16 500hp engines.

Engine manufacturers generally support HVO as a suitable fuel, though its energy content (calorific value) is slightly lower than that of diesel, which may require engine adjustments to achieve maximum power output. Insurers are similarly well-disposed toward HVO. Operating a fishing vessel on 100% HVO can result in a significant reduction in carbon emissions. However, challenges related to price and supply security remain. An enterprising vessel owner could make the switch to HVO today and market the vessel's catch as a carbon-neutral product, potentially commanding a premium price. Finally, the Marine Institute in Ireland has successful trialled the use of HVO as an alternative fuel for the Institute's research vessels.

Blue and Green Fuels

The maritime industry's shift towards alternative fuels is increasingly focusing on hydrogen and its derivatives, such as ammonia and methanol. The adoption of these fuels is expected to progress from 'blue' derivatives, produced using carbon capture technologies, to 'green' derivatives, generated from renewable electricity sources. Leading engine manufacturers are investing substantially in research and development to align with the IMO carbon emission regulations. For instance, Wärtsilä, a prominent engine manufacturer, has outlined a roadmap detailing the integration of biofuels and the phased development of blue and green fuels in the energy transition.

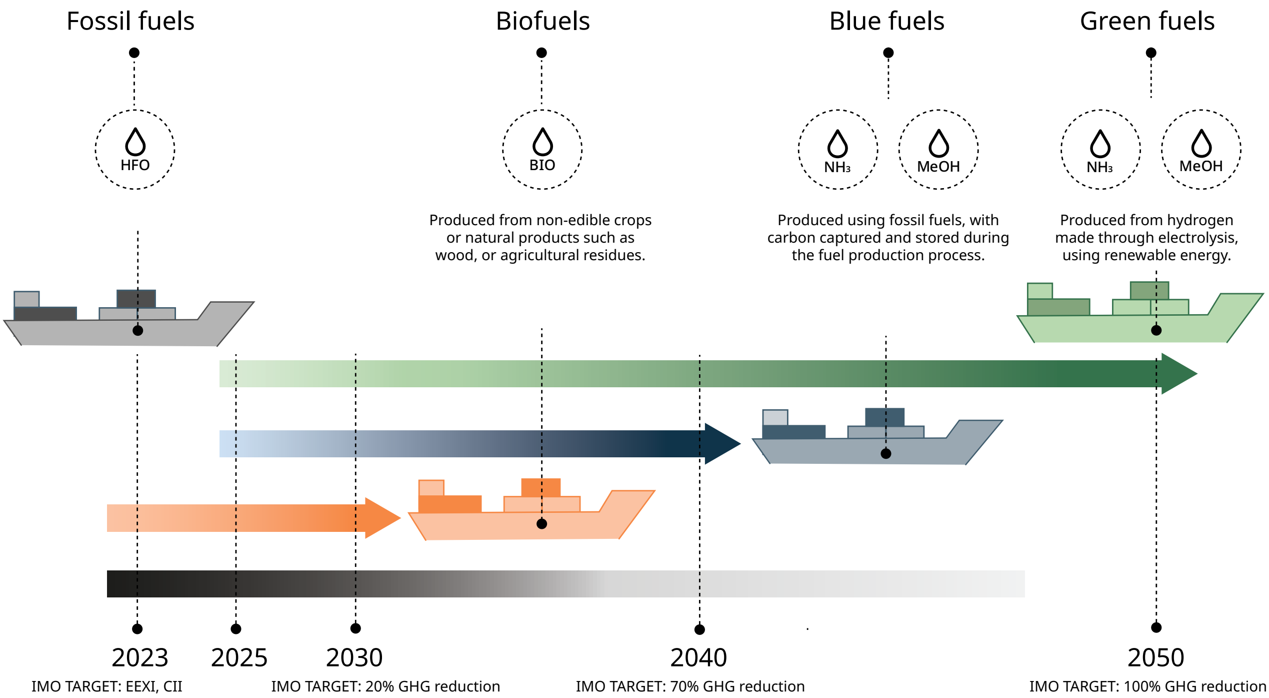


Figure 4 'Sustainable fuels road-map to 2050'. Showing prediction of energy and fuel transition in the global maritime fleet.

(Image credit: Wartsila.com)

The IMO target is to achieve 20% reduction in carbon emissions by 2030, 70% reduction by 2040 and 100% reduction by 2050.

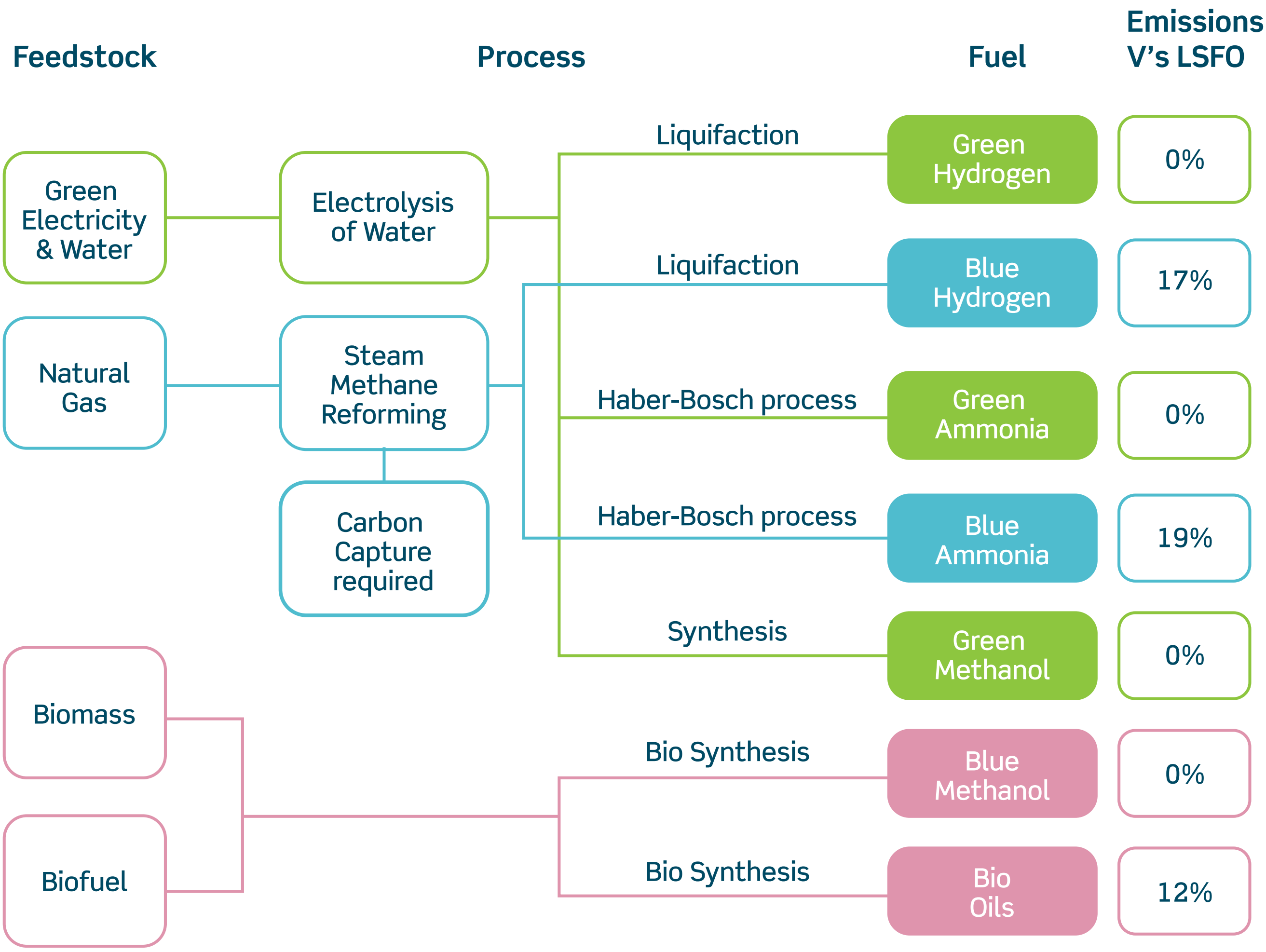


Figure 5 Carbon emissions by fuel source in comparisons with Low Sulfur Fuel Oil (LSFO).

(Source: created by Noel O'Regan of Promara Ltd (2024))

Alternative fuel 2: Hydrogen, Methanol, Ammonia, Liquefied Natural Gas (LNG)

Hydrogen

Hydrogen can be produced from natural gas through the process of Steam Methane Reforming (SMR). In this process, high-temperature steam reacts with natural gas and a catalyst to produce hydrogen, carbon monoxide, and carbon dioxide, resulting in the production of Blue Hydrogen. Another method, electrolysis, uses an electric current to force chemical decomposition, breaking water (H_2O) into hydrogen and oxygen. When the electricity driving this process comes from renewable energy sources, the resulting hydrogen is referred to as Green Hydrogen. For example, the Orkney Islands have adopted an approach combining widespread wind-generated electricity with the production of green hydrogen through the hydrolysis of seawater. Japan is a world leader in hydrogen power development, and has a strategic emphasis on hydrogen as its next-generation energy source.

Hydrogen can be used directly in fuel cells to generate electricity or in internal combustion engines, which are initially started on diesel or HVO before hydrogen is injected into the air intake or cylinders. However, storing hydrogen aboard vessels presents challenges, as it currently requires high-pressure gas cylinders.

Alternative fuels such as methanol and ammonia, which can be derived from hydrogen, offer storage advantages but also introduce unique hazards.

Another project of note is the ZEROKYST project in Norway which is pioneering zero emission solutions for sea fishing and aquaculture vessels, largely based on hydrogen electric systems. The RISE Institute in Sweden has also developed expertise in the use of hydrogen power in maritime applications.

Methanol

CASE STUDY 4

Methanol (CH_3OH), also known as Methyl Alcohol, is a biodegradable alcohol often regarded as a sustainable fuel for maritime applications. Its flashpoint is 11°C, significantly lower than diesel, which has a flashpoint of 60°C. When used aboard a vessel, methanol requires a dedicated tank room connected to the engine room by double-walled pipes, with the entire fuel system constructed from stainless steel to ensure safety and durability.

Methanol is increasingly being adopted in maritime operations, with some installations having been in service for several years. For example, the *Stena Germanica* ferry (**Case Study 4**) was retrofitted in 2015 to use methanol as the primary fuel, to become the world's first passenger vessel fuelled by methanol. The retrofit conducted risk assessments based upon recognised standards (e.g, ISO 31010: Risk management - Risk assessment techniques) and in line with Lloyd's Register's ShipRight procedures and IMO Guidelines on alternative designs and arrangements. Stena has also conducted other retrofits such as on the Stena Superfast VII and Stena Superfast VIII where each vessel has two out of four engines converted for methanol. In all these case studies bunkering, fuel supply, and other systems have been adapted for handling methanol.

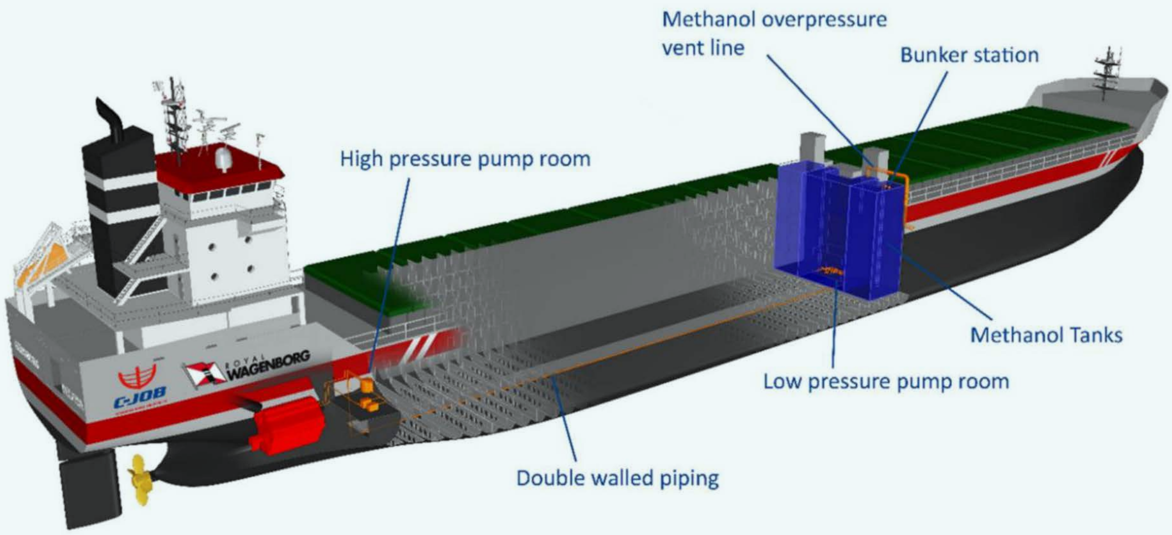
CASE STUDY 5:
Methanol powered *Eemsborg* (Concept vessel, Netherlands)

This case study is based on a 2021 theoretical assessment to evaluate the feasibility of converting various vessel types from diesel to methanol operation. One of the vessels assessed was the Eemsborg, a ship built in 2009, measuring 137-metres in length with a 15.9-metre beam. The vessel is powered by a 4,500 kW Wärtsilä 9L32C main engine and features a conventional propulsion arrangement, including Reduction Gear, Shaft Generator, and Controllable Pitch Propeller.

The proposed concept involves converting the main engine to operate on methanol specifically for use within Emission Control Areas (ECA). To facilitate this, the vessel would require a dedicated Methanol Bunkering System and transfer infrastructure, including a nitrogen blanketing system. Methanol bunker tanks would be installed amidships by converting the existing HFO fuel bunker tanks. This conversion would necessitate the construction of cofferdams forward and aft of the tanks within the two cargo holds.

Additional requirements include a low-pressure pumproom to transfer methanol at low pressure through double-walled pipes to a high-pressure pumproom adjacent to the engine room. From there, pumps would deliver methanol at 450 bar to the buffer tank and then to the main engine. Water would be added to the buffer tank to comply with Tier III emissions regulations, avoiding the need for exhaust gas treatment. The estimated cost for converting the Eemsborg to methanol operation is approximately €3.8 million.

Figure 6 *Eemsborg* hypothetically adapted to run on methanol



(Image credit: marine-service-noord.com)

CASE STUDY 6:
Methanol powered Tug (Belgium)

The *Methatug*, based in Antwerp, is the world's first methanol-powered tug. Measuring 29.5-metres, it delivers 50 tonnes of bollard pull and is powered by two ABC dual-fuel engines retrofitted for methanol use. The vessel carries 12 cubic metres of methanol, sufficient for two weeks of operation.

Each of the two ABC 8DZD MeOH medium-speed engines generates 1,768 kW at 1,000 rpm. Methanol is introduced into the cylinders at low pressure during the downward stroke, and diesel or HVO is injected on the upstroke to initiate combustion.

(Photo credit: Offshore-Energy.biz and Port of Antwerp-Bruges – Tug boat)

CASE STUDY 7:
Methanol powered pilot boat (Sweden)

A 14.4-metre Swedish pilot boat has been converted to operate on a single methanol-fuelled engine. The engine, derived from a Scania model, delivers 415 kW at 2,100 rpm. It uses methanol in combination with an additive to improve ignition, achieving diesel-like performance. The methanol-powered engine is housed in a standard engine room and is supported by a double-skinned fuel tank and double-walled fuel pipes, ensuring safety and reliability during operation.

(Photo credit: Offshore-Energy.biz Pilot boat)

Methanol in Fishing Vessels

Padmos, a prominent shipbuilder, has expressed support for using HVO as a means to reduce carbon emissions in fishing vessels. However, Padmos does not foresee methanol or hydrogen becoming viable fuel options for the fishing industry in the short to medium term (5 to 10 years).

In contrast, the UK's Fisheries Innovation & Sustainability (FIS) group has explored various alternative fuels in their Net-Zero Fishing Vessel Concept Design Project. Their Stage 2 report identified battery electric and methanol technologies as potential options for potting vessels under 10 meters, while methanol and LNG were considered for polyvalent vessels between 15 and 24 meters.

CASE STUDY 8: *Limfjorden*, Methanol

Denmark's Aarhus University has initiated a pilot project to explore the feasibility of converting fishing vessels to methanol fuel. As part of this initiative, the medium-sized vessel *Limfjorden* will have its diesel propulsion system converted to operate exclusively on methanol. A notable challenge with methanol is its lower energy density compared to diesel, necessitating fishing vessels carrying approximately double the fuel volume to achieve the same range. When finished, the *Limfjorden* case study will feature an analysis of green methanol availability and methanol price developments, as well as the cost-effectiveness of the conversion.

In a related development, Caterpillar has signed a Memorandum of Understanding (MoU) with Damen Shipyards to develop dual-fuel 3516E engines capable of operating on both methanol and diesel. These engines are slated for deployment in tugboats by 2026, with broader availability expected thereafter. Mitsubishi is expected to introduce a similar engine size to the market by 2028. Caterpillar aims for a 28-meter tug transiting at 8-knots, requiring 600 kW of propulsion power, to achieve a methanol substitution rate of 70% for diesel.

Ammonia

CASE STUDY 9

Hydrogen can be chemically combined with nitrogen to produce ammonia, often regarded as a practical mechanism for managing hydrogen. Ammonia has a calorific value that is higher than hydrogen and comparable to methanol, making it an attractive alternative fuel. However, converting existing vessels to operate on ammonia poses significant challenges. The fuel system equipment requires a greater degree of separation, and additional space is needed to accommodate ammonia tanks. Despite these challenges, ammonia is considered a significant potential contributor to the long-term development of zero-carbon fuels.

As part of the Norwegian Green Shipping project, a pilot study of ammonia in Norwegian fishing vessels **(Case study 9**) is being conducted by Lerøy Havfisk AS of the Lerøy Seafood Group. The pilot aim is to carry out a study looking at the implementation of dual-fuel ammonia solutions for larger fishing trawlers, addressing technical, risk and cost headings. The study will document the main barriers and enablers for the implementation of ammonia power onboard.

Liquefied Natural Gas (LNG)

LNG is a widely available low-carbon fuel capable of delivering a reduction of up to 21% in GHG emissions compared to Low Sulphur Fuel Oil (LSFO). LNG must be stored aboard vessels at a temperature of -153°C, where it remains a clear, odourless liquid. It is often regarded as a transition fuel in the maritime industry's journey toward decarbonisation. LNG primarily consists of methane (85–95%), but a notable drawback is "methane slip," a feature whereby methane is not fully combusted and is exhausted to the atmosphere.

LNG has a lower energy density, providing just 60% of the energy content of Marine Gas Oil (MGO), which means it requires larger fuel storage capacity aboard vessels. As part of the UK's Net-Zero Fishing Vessel Concept Design Project, a 21-metre trawler powered by LNG was developed as a concept. This design features liquid fuel stored at -153°C in pressurised tanks. For further details on this project, please refer to the FIS/McDuff Ship Design Ltd report here.

CASE STUDY 10: *Libas* Norway (Battery and LNG)

Developed by Salt Ship Design (Norway), *Libas* is an 86m hybrid purse seiner powered by LNG and battery. This pelagic vessel has a MAN Cyro LNG tank, and 500 kWh battery power. Her max speed is 16.5-knots and deadweight is 3,800 tonnes. The RSW hold tanks of 2,800 cum (Cubic metres).

(Photo credit: Salt Ship Design - *Libas*)

Shore power

CASE STUDY 11

Carbon emissions associated with electricity grids continue to decline due to the increasing adoption of renewable energy sources. Some electricity suppliers specialise in providing 100% renewable energy, such as wind and solar power. This electricity is fed into the grid and sold as certified renewable energy, often at a premium price to end users.

Irish skippers should be encouraged to utilise shore power, especially when the cost per kilowatt-hour (kWh) is competitive. Ideally, they would pay a unit rate equivalent to the cost of running a vessel's diesel generator. For reference, the Specific Fuel Consumption (SFC) of a typical harbour generator is approximately 220g/kWh, equating to about a quarter litre of fuel per kWh. If reliable shore power were offered at a rate comparable to one-quarter the cost of a litre of Marine Gas Oil (MGO), participation among fishermen would likely increase. This shift would result in significant carbon reductions and reduced generator maintenance costs for vessels.

Shore power could also be utilised to charge propulsion batteries for smaller vessels. An innovative vessel owner might opt for 100% battery-powered propulsion, sourcing renewable electricity and marketing the vessel's catch as a carbon-neutral product at a premium price. A notable example of shore power adoption can be found in Killybegs, county Donegal. This project, part-funded by the Irish Government and the European Maritime & Fisheries Fund (EMFF), was commissioned in 2020 at a cost of €1.7 million (**Case Study 11**). Prior to this, when fishing vessels were in port, they relied on diesel generators to supply power for prolonged periods. This made for air pollution and noise at the pier. The situation was dramatically improved by the installation of a state-of-the-art shore-to-ship power supply system servicing fishing vessels with mains power, thus leading to a much-reduced carbon emission intensity. Significant investments are being made in shore power internationally and especially in Europe, the USA and Canada.

Battery power

Batteries have long been used at sea as a backup power supply, but the arrival of Lithium-Ion batteries introduced significant weight savings compared to traditional Lead Acid batteries. The subsequent development of Lithium Iron Phosphate (LiFePO4) batteries further improved safety by greatly reducing fire risk. LiFePO4 batteries are preferred by the UK's Maritime and Coastguard Agency (MCA) and other Flag State authorities due to their lower fire risk compared to other battery technologies. Both LiFePO4 and Lithium-Ion battery systems have received Class Approval for use aboard vessels currently in service.

Battery power offers up to 85% efficiency in converting stored electricity into mechanical energy. LiFePO4 batteries are particularly durable, with a predicted lifespan of 3,000 to 5,000 cycles. For a vessel operating 150 days per year, this translates to a battery life of over 20 years. These batteries can be installed below decks in spaces traditionally occupied by engines and fuel tanks. For reference, 100 kWh of LiFePO4 batteries weighs approximately 600 kg, meaning a 500 kWh system would weigh close to 3 tonnes.

The adoption of battery-powered fishing vessels is gaining momentum. While there are currently no registered fishing vessels in Ireland certified for electric propulsion, the Scottish fishing vessel *Lorna Jane* (detailed in case study 13) represents a significant advancement in the use of electric propulsion in licensed fishing operations.

Small vessels

Transitioning the approximately 500 small fishing vessels (< 6- metres) in the Irish fishing fleet from petrol outboards to electric propulsion presents a viable strategy for reducing carbon emissions. Electric outboards, such as the Torqeedo Cruise series, offer suitable alternatives:

- Torqeedo Cruise 6.0 kW: This model delivers 6,000 W of input power, equivalent to a 9.9 hp petrol outboard, and is ideal for boats up to 6 tonnes.
- Torqeedo Cruise 12.0 kW: Providing 12,000 W of input power, comparable to a 25 hp petrol outboard, this motor is suitable for boats up to 12 tonnes.

Both models operate with one or more Power 48-5000 batteries, each offering a capacity of 5.0 kWh and weighing 36.5 kg. It is important to note that the Cruise 12.0 kW motor is limited to 6.0 kW when only one battery is connected.

Adopting electric outboards can significantly reduce carbon emissions and operational costs for small fishing vessels, aligning with broader environmental sustainability goals.

(Image credit: Torqeedo – electric outboards)

Battery location and restraint in a small open boat will be consideration on a case-by-case basis. Charging facilities will need to be in place.

Please see below examples of electrification in small craft.

CASE STUDY 12:
Gleoiteog *Naomh Fanchea* (Kilrush, Ireland)

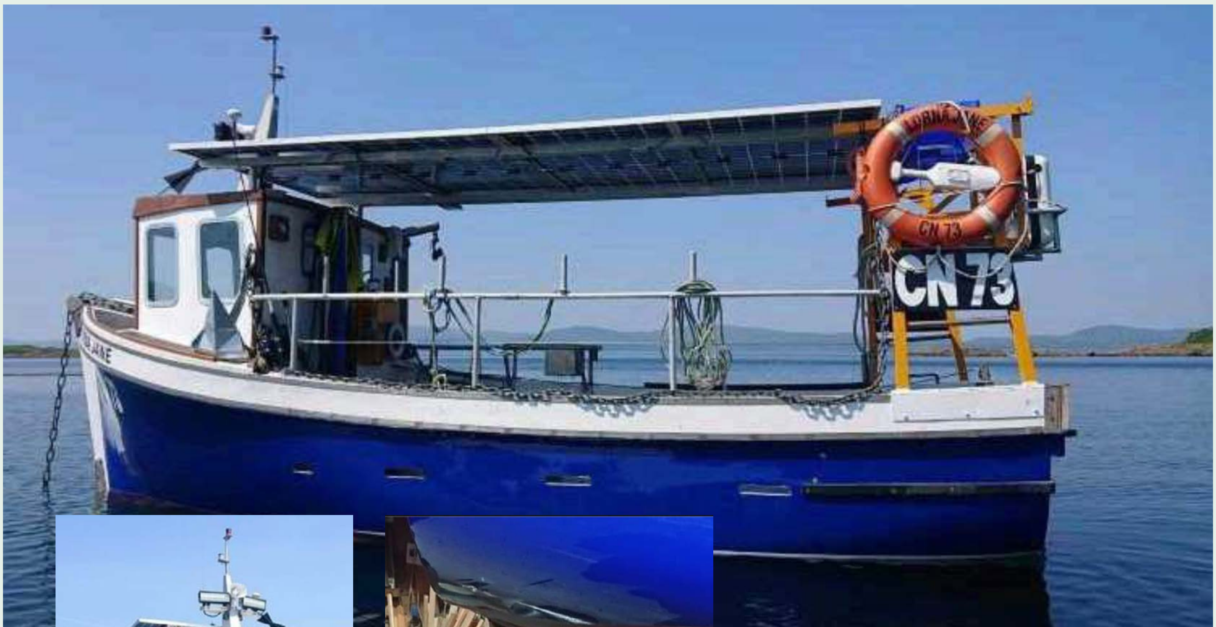
In this case study, a traditional 23ft Gleoiteog style sailing boat was built at Kilrush boatyard and powered by a Torqeedo propulsion pod mounted partially within the foot of the rudder. Power from two Torqeedo Lithium batteries is carried by cables from the transom to the rudder and down through the rudder to the motor. Maximum speed under power is 6.5-knots. Her optimum speed is 4.5-knots at which she can run for 7.5 hours. This is just below her natural hull-speed.

(Photo credits: afloat.ie – Open boat)

CASE STUDY 13:
Lorna Jane (Scotland) Solar

Lorna Jane is a Scottish Cygnus 21 decked potter, and the first electric powered fishing vessel certified by the Maritime and Coastguard Agency (MCA). She is driven by a Fischer Panda 20kW motor mounted externally on a modified rudder shaft for steerage. The motor has been selected at a greater rating than the maximum power available because of its efficiency in converting battery power to propeller thrust. Power is provided by 9kWh Lithium Iron Phosphate (LiFePO4) batteries. Charging is from four bi-facial solar panels and from shore power. The bi-facial panels are arranged overhead the deck and catch the sunshine from above and as reflected from the sea-surface.

The *Lorna Jane* operates for 6–7 hours daily, covering approximately 24 miles. On a calm, sunny day, her maximum steaming range extends to 60 miles, supported by overnight shore power charging and supplemental solar panel input during operation. The vessel's pot hauler is powered by an electric motor, and all other onboard equipment, including navigation systems and even the kettle, are powered by the batteries via an inverter. The total cost of this conversion was 165,000 euro Ex Vat.

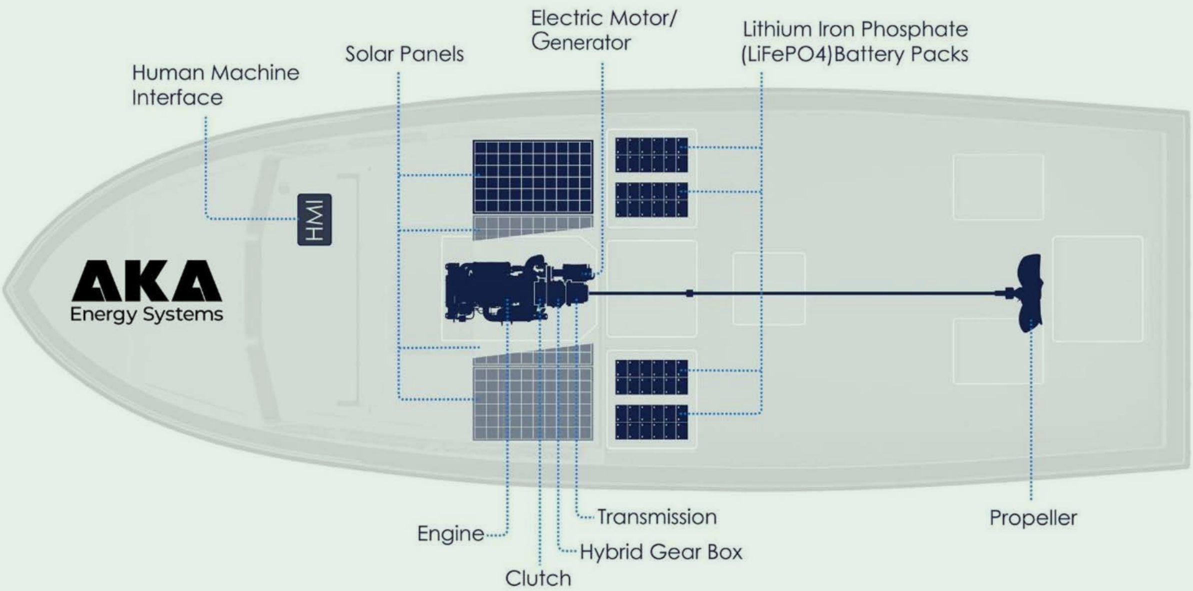


(Photo credit: 'itllneverwork' – *Lorna Jane*)

CASE STUDY 14: "*Hybrid I*" (Canada)

AKA Energy Systems in Canada, have developed the "*Hybrid 1*" battery hybrid potter. The MAN diesel engine drives a reduction gear and shaft drive propeller. The reduction gear is also coupled to an electric motor. The electric motor is powered by LiFePO4 battery banks that are charged by shore power, solar panels and spare capacity output from the main engine while in transit to fishing grounds. The diesel engine can be run on HVO.

(Photo credit: AKA Energy Systems – *Hybrid 1*)



(Image credit: AKA Energy Systems)

CASE STUDY 15: *Karoline* (Norway) Electric

Launched in 2015, The *Karoline* is one of the earliest commercial fishing vessels built to operate on battery power. This 10.99-metre by 4.2-metre vessel features an electric propulsion motor powered by 30 Lithium-Ion batteries with a combined capacity of 196 kWh. A 50 kW genset is used for steaming between port and fishing grounds. Shore power is utilised to recharge the batteries overnight after fishing trips of 8–12 hours.

In 2025, the ZEROKYST project in Norway will deliver *Karoline* 2. This will be a 12.99m battery powered fishing vessel with a 100kW hydrogen fuel cell. The vessel will also have a 129Kw diesel generator for backup purposes.

(Photo Credit: Corvus Energy - *Karoline*)

Battery banks for 'Peak shaving'

Some of the Irish fishing fleet, such as netters and seiners, spend extended hours stopped at sea or dodging around at very slow speed. These vessels could benefit from power storage systems that allow the primary engines to be shut down. A battery bank charged while ashore could provide low-carbon electrical power during these idle periods. Additionally, charging batteries while the vessel is underway could further enhance efficiency. For example, a retractable electric azimuth bow thruster, powered by such a battery bank, could maintain a vessel's heading in adverse weather without requiring an engine to run. It is important to note that many older vessels currently in operation may lack the space to accommodate battery banks, presenting a challenge for retrofitting.

Auxiliary engines do not need to be run at times of low load. A suitable battery bank can provide for periods of low load and provide peak shaving of electrical load when the small auxiliary is under pressure. This allows for the installation of smaller, more efficient generator sets, leading to reduced fuel consumption and lower carbon emissions. Battery banks can be charged either via shore power or by the vessel's auxiliary engines during periods of modest load demand.

Fuel cells

Fuel cells are a logical development as a "range extender" for battery-powered vessels with electric propulsion. Rather than burning hydrogen, fuel cells generate electricity through an electrochemical reaction between hydrogen and oxygen, producing only water and heat as exhaust. Fuel cells are particularly suited for providing power at a steady rate, delivering electricity to a propulsion motor while any excess is directed towards battery charging. Peaks in propeller load that exceed the fuel cell's output are managed by drawing power from the battery bank.

By incorporating fuel cells, the range of zero-emissions operation for battery-powered vessels is significantly extended. A vessel can depart port with fully charged batteries and hydrogen tanks filled, enabling operations with zero carbon emissions and allowing it to land a carbon-neutral catch. Leading suppliers of hydrogen fuel cells include Corvus Energy, Toyota, and Genevos. Fuel cells can be stacked or assembled in banks to increase power output.

A typical fuel cell achieves an efficiency of 50–60% in converting hydrogen fuel into energy. For example, a 60 kW fuel cell operating for eight hours would require approximately five "type 4" carbon fibre hydrogen cylinders, each pressurised to 350 bar and weighing about 100 kg. Alternatively, hydrogen can be stored aboard as a liquid at atmospheric pressure, which requires cryogenic technology to maintain a temperature of -252.8°C.

Further case studies of fuel cell applications are outlined below.

CASE STUDY 16: Fuel Cell range extender for small battery vessels (Netherlands)

(Photo credit: TU Delft and Drechtsteden Economic Development Board – H2C boat)

The Dutch sailing organisation Watersport Verbond has developed the H2C Boat, a greenhouse gas (GHG) emission-free coach boat powered by a hydrogen fuel cell. Propulsion is provided by a Torqeedo Deep Blue electric motor paired with a 40 kWh lithium-ion battery pack, allowing for five hours of operation and speeds exceeding 20-knots. With an additional 51 kWh of hydrogen capacity, the H2C Boat uses a hydrogen fuel cell as a range extender, further enhancing its operational capabilities.

(Photo credit: TU Delft and Drechtsteden Economic Development Board)

CASE STUDY 17:
Fishing vessel with fuel cell/ batteries (Denmark)

The *Skulebas* is equipped with a Pelican Corvus fuel-cell system and a hydrogen storage unit, developed in Norway as part of the H2NOR project. This 35-metre Norwegian fisheries training vessel, built in Denmark in 2023, has a gross tonnage of 482 GT. Propulsion is provided by two 600 kW electric motors driving twin propellers.

Initially, the *Skulebas* was built with diesel generators and a 1,000 kW Orca battery system from Corvus Energy. The battery system is charged via shore power or by the vessel's generator engines, optimising engine loads. In 2024, the vessel's power supply system underwent an upgrade to include a 340 kW Corvus Pelican fuel-cell system. This enhancement will extend the range of zero-emissions operations, enabling the vessel to conduct most of its activities without relying on diesel power.

Corvus Energy states that the Pelican system is designed with inherently gas-safe principles, ensuring that the surrounding machinery spaces remain gas-safe under all operating conditions.

Another hydrogen powered fishing vessel is the *Alba*, which is France's first hydrogen/electric fishing training vessel.

(Photo credit: Corvus Energy - *Skulebas*)

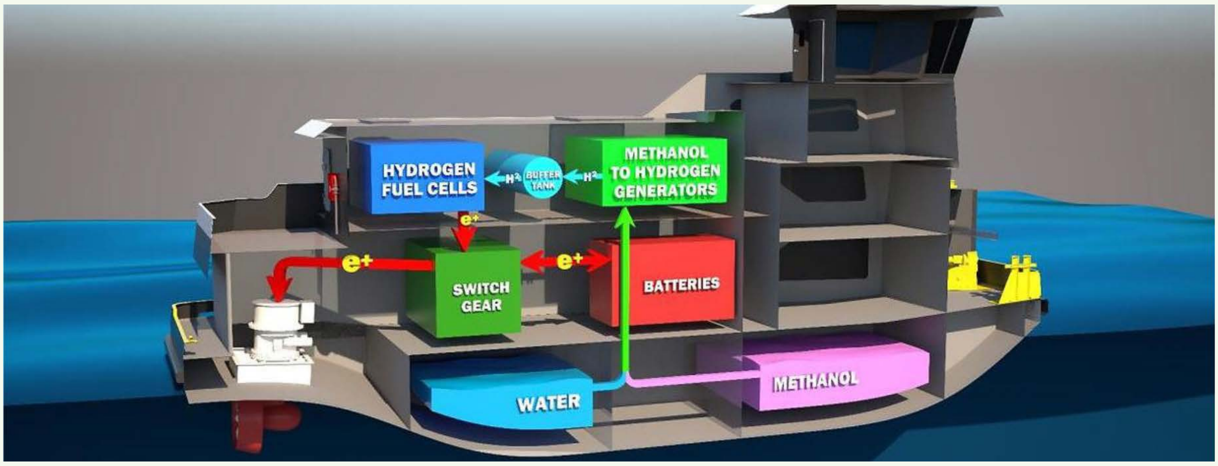
(Image credit: Mauric.com *Alba*)

Case study 18:
HydrogenOne Methanol-to-hydrogen-fuelled towboat (USA)

Hydrogen One is due to enter service in 2025 in the USA. She will be a methanol-to-hydrogen fuelled vessel. The technological innovation is to bunker methanol, which is stored as liquid fuel, and convert the fuel to low pressure hydrogen on-demand using a "Methanol to Hydrogen Reformer" for the Hydrogen Fuel Cells aboard.

(Image credit: Elliott Bay Design Group, USA)

The steady flow of electricity is directed to battery charging or propulsion as required. This case study shows the efficient delivery of hydrogen, in terms of power and space considerations, by using methanol and offers potential for use on fishing vessels.



(Image credit: Elliott Bay Design Group, USA)

CASE STUDY 19:
Nobody's Perfect; Venice tour boat (Italy) Hydrogen

(Image Credit: Offshore Energy.biz Nobodysperfect)

Nobody's Perfect is a 17m timber fishing vessel, originally built in 1978 in Bordeaux, France. She is currently used as a passenger vessel on the Venice Lagoon, Italy. Genevos has been awarded a contract to supply and commission a 40kW Hydrogen Power Module to convert her from diesel to a hydrogen electric power system. The converted vessel is expected to consume an average of 1.5 tonnes of Hydrogen per year.

Hybrid Power; combining technologies

Hybrid propulsion systems utilise two or more energy sources to propel a vessel and can be broadly classified into two main categories: Parallel Hybrid Drive and Series Hybrid Drive.

The Parallel Hybrid Drive employs a conventional configuration where an internal combustion engine is paired with a gearbox-mounted shaft generator. This generator can be switched to operate as a motor, driving the propeller shaft independently of the engine. The battery bank in this setup can be charged via shore power, a fuel cell, or another power source. In addition, if a diesel generator is installed, it can serve as an auxiliary power source to drive the Propulsion Take-In (PTI) in the event of a main engine failure.

CASE STUDY 20: *Veronica* (Ireland) – hybrid (Diesel electric)

Veronica was designed by Salt Ship Design (Norway) and is owned by Irish fishing company Atlantic Dawn. The 64 m vessel has a green battery solution onboard, identical to her sister vessels, the *Leila* and the *Lauren*. This hybrid vessel has a 1,550 m^3 RSW tank capacity and has energy and power management systems (EMS-PMS), hybrid and e-propulsion solutions and energy storage systems. She has a MAN 27/38 main engine and an Alphatronic 3000 propulsion-control system in combination with a Scanvolda single reduction gearbox and a MAN Alpha single ducted propeller. The Alphatronic 3000 propulsion control system offers economical operation with optimised engine loads and thrust control, and a speed pilot-feature with GPS interface for various economy-sailing modes with significant fuel and emission reduction making her (and her sisters) a highly advanced and efficient RSW fishing vessel.

(Photo credit: Atlantic Dawn Ltd *Veronica*)

CASE STUDY 21:
Centurión del Atlántico, Retrofit Hybrid, South America

(Photo credit www.norwegianshipdesign.no *Centurión del Atlántico*)

The 118-metre factory fishing vessel, *Centurión del Atlántico*, has been retrofitted with a new hybrid propulsion with 2-step hybrid gearbox and new propeller. The hybrid system includes a battery system, power electronics and a combined electric propulsion motor / shaft generator. The main engine's exhaust is designed for heat recovery and produces steam for use in the on-board fish factory. The trawling gear has been upgraded to reduce drag and lower fuel consumption. Overall, the retrofit achieves a major carbon footprint reduction.

CASE STUDY 22:
Austral Odyssey (Australia) Hybrid Electric - new build

(Image credit: Austral Fisheries, Australia. *Odyssey*)

The 68.5 m *Austral Odyssey* is being built in Poland and will join the Austral fisheries fleet in early 2026. She has an advanced hybrid propulsion system featuring battery packs, a two-step gear box and large fuel tank capacity to future proof for the potential use of green fuels such as methanol which are less energy dense than diesel. She will be equipped for precise fish traceability, fish processing, freezing and branded packaging aboard. The company has also invested significantly in understanding fish (toothfish) habitats and fish behaviour thus leading to a precise fishing effort. They have adopted a carbon offset policy whereby millions of native Australian trees have been planted to offset carbon emissions from fishing efforts. To this end the Austral fisheries company has been certified as carbon neutral in Australia under the Australian Government Carbon Neutral program.

CASE STUDY 23:
French trawler *Naoned* (France) Hybrid

As part of the HYBA project, a French study is exploring the low-carbon hybridisation of French trawlers. The 23.4-metre *Naoned* (LO-912362), a trawler built by Piriou in 1999 and based in Lorient, has been equipped with a range of sensors and data-gathering equipment to create a "digital twin" of the vessel. This digital twin allows for desk-based simulations of various technologies, enabling assessment before further investment.

The *Naoned* will be retrofitted with a Tier 3 ABC engine, a battery bank, and a Masson hybrid gearbox in a Parallel Hybrid propulsion system. The vessel will be utilised for trawling and seine netting operations, serving as a testbed for low-carbon hybrid technology.

The battery bank will be utilised for peak-load shaving on the main engine and for 100% electric propulsion when the vessel operates in eco-sensitive areas or approaches port. Additionally, the vessel has been equipped with a range of sensors to gather extensive operational data, with the aim of developing a comprehensive digital model for further research and optimisation.

(Photo credit: Coprexma - *Naoned*)

CASE STUDY 24:
Cygnus Cyclone - Hybrid

Marine Industrial Transmissions (MIT) has developed a hybrid propulsion system suitable for 10m–12m Potters. The Parallel Hybrid system can operate as a generator when steaming to the fishing grounds and as a propulsion motor while working gear.

The 210AH Lithium Battery (LiFePO4) can drive the vessel at 3-5 knots for c.2½ hours. The battery can be fully charged in approximately four hours using a 7.5 kW shore power charger, with solar power available as a supplementary charging source. In addition, the main engine can operate on HVO, supporting efforts to achieve zero-carbon fish.

(Photo: Cygnus Cyclone Hybrid)

CASE STUDY 25: Seiner/crabber *Aksel Johan* (Denmark) Hybrid

Vestværftet in Hvide Sande, Denmark, has delivered the *Aksel Johan* to Norway, with high expectations for its overall fuel efficiency. The vessel features battery hybrid propulsion, heat recovery, peak shaving, and load balancing systems. It also incorporates an innovative thermoelectric system that harnesses exhaust gas heat to generate electrical power. All of the vessel's engines are capable of operating on HVO, further enhancing its sustainability profile.

(Photo credit: Hook and Net magazine – *Aksel Johan*)

The *Aksel Johan* measures 40-metres in length, with a beam of 9.2-metres and a gross tonnage of 688 GT. The vessel is powered by a Mitsubishi S6U main engine, delivering 1,100 kW. It features a variable-speed shaft generator with both Power Take-Off (PTO) and Power Take-In (PTI) modes. The vessel is equipped with a 600 kWh Corvus battery bank, which is charged using excess power from the main engine and can be utilised for short-term propulsion duties. The PTI function also serves as a "take-me-home" system, enabling the vessel to operate at six knots using auxiliary power.

In addition, the *Aksel Johan* is fitted with an exhaust boiler that recovers heat from exhaust gases. This heat is used to produce 25 kWh of electricity under normal operating conditions, contributing to the vessel's overall energy efficiency.

CASE STUDY 26:
The BIM diver training vessel (Ireland) Hybrid

The BIM diver training vessel features a hybrid power system designed for inshore operations. The system includes a 72 kWh battery storage capacity, solar generation, and a 20 kVA LPG Combined Heat and Power (CHP) generator. In addition, the system is equipped with a shore power option to charge the battery pack. This hybrid configuration reduces diesel consumption by an impressive 86% during normal operations, significantly enhancing the vessel's energy efficiency and sustainability.

(Photo – BIM diver training vessel)

CASE STUDY 27:
Aquaculture feed barge (Ireland) Hybrid

The Marine Challenge programme implemented a hybrid power system on a commercial salmon feed barge. The system features an 85 kWh battery storage capacity and can supply power in three-phase, single-phase, and 110-volt configurations. It was determined that the hybrid system can meet the energy needs of all onboard equipment, including crane hydraulics. Monitoring and system refinements are conducted monthly to optimise performance.

The hybrid system achieves a monthly reduction in diesel fuel consumption of approximately 3,600 litres, resulting in a corresponding carbon saving of nearly 10,000 kg per month. The vessel's owners, MOWI, have also initiated a HVO trial on the feed barge, which is expected to further reduce emissions to minimal levels.

(Photo credit: MOWI Ireland – feed barge)

Wind/ Sail Power

Wind assistance is currently being trialled and tested on larger commercial vessels as a method to generate forward thrust, thereby reducing the amount of thrust required from the ship's propeller.

CASE STUDY 28: Wind powered cargo ship (France)

The sailing ship *Anemos*, slightly larger than the historic Cutty Sark, recently completed her maiden transatlantic voyage, sailing from Concarneau to New York with 1,000 tonnes of cargo aboard. This newly-built 81-metre steel vessel is the first of eight planned ships. Her owners initially chartered traditional sailing vessels to carry cargo while refining their business model.

(Photo credit: interestingengineering.com *Anemos*)

The *Anemos* is equipped with diesel-electric propulsion, which operates as a hybrid system in conjunction with sails under favourable conditions. According to her owners, the vessel can rely solely on sail power for 95% of her voyages. During strong winds, the propellers are designed to rotate and generate power from the propulsion motors to recharge the ship's battery banks. The vessel can maintain an average speed of 10-knots.

CASE STUDY 29:
Wind Assistance test vessel (Spain)

The International Windship Association (IWAS) set out seven main wind technologies which range from traditional soft sails to their rigid counterpart. The Flettner Rotor or Rotor sail is an electric motor-driven rotating cylinder on a vertical axis that uses the "Magnus Effect" to generate thrust. The most mature 'wind' technology seems to be the "Suction Sail".

(Photo credit: Bound4blue *Balueiro Segundo*)

In 2012 Bound4blue installed its eSAIL system on the 41m / 593GT longline fishing vessel *Balueiro Segundo*. This 12m high rigid sail has an internal suction fan to maintain airflow over the leeward side of the structure. These initial sea trials marked the first real-world application of the eSAIL, which later led to improvements in aerodynamic design, mechanical efficiency, and control systems. These advances have allowed this technology to scale to larger vessels and other segments. However, the implications for on board fishing operations were not addressed during the initial trials. Other wind assistance case studies can be found on the Bound4blue and mauric.com websites.

Summary

This report presents a comprehensive menu of climate action technologies potentially available to the Irish sea fishing fleet. The case studies included offer valuable insights and encouragement for the industry. However, globally the uptake of these technologies remains relatively low, and the energy transition in sea fishing is still in its early stages, with many questions and decisions yet to be addressed.

Despite these challenges, emerging patterns are becoming evident. Improvements in engine efficiency, the adoption of lighter fishing gear, and reducing vessel speeds are key practices increasingly implemented across the fleet. Digital technologies are also gaining traction, offering distinct advantages in fuel savings and return on investment. Methanol frequently appears as a viable alternative fuel, and HVO is beginning to see scaled adoption as a diesel replacement in other sectors. Battery and hybrid power systems are also emerging as significant contributors, particularly for inshore vessels. However, issues such as cost, battery weight, and the availability of enabling infrastructure, such as shore power, remain critical barriers to widespread adoption.

From a long-term perspective, hydrogen emerges as a promising fuel option for new builds and potentially for retrofitting existing vessels. Once hydrogen is generated from renewable energy sources such as wind or solar, it presents enormous potential as a zero-carbon fuel for the future.

For any of these technologies to be adopted at scale in new builds and retrofits, clear strategic direction and a robust policy of incentivisation will be essential to accelerate the energy transition within the fishing industry. So too will the development of a regulatory framework that enables these technologies to be adopted where and when appropriate and this framework should be aligned to IMO guidance and Department of Transport rules.

Please note that BIM do not endorse or promote any particular technology or case study described in this document. These items have been collated for information purposes only.

APPENDIX – Case Study list

Please note that the web links below are working at the time of writing. In the event of a broken link, please try cutting and pasting the URL into your browser or, do a Google search for the case study in question.

Case study	Description	Weblink	Technology	Sector
1	VISTools real time digital monitoring of fuel use and catch and GHG emissions	https://ocean-twin.eu/marketplace/lab/vistools	Digital	Fishing
2	Artificial Intelligence in the maritime fleet	https://safety4sea.com/companies-turn-ai-to-optimize-routes-and-reduce-emissions/	Artificial Intelligence	Maritime
3	Seacat offshore service vessel (27m) (UK)	https://www.4coffshore.com/vessels/vessel-seacat-enterprise-vid2051.html	HVO	Maritime (ORE)
4	Stena Germanica ferry (retrofit) (Sweden)	https://www.lr.org/en/knowledge/research/fuel-for-thought/	Methanol	Maritime
5	Methanol powered Eemsborg (Netherlands)	https://marine-service-noord.com/en/products/alternative-fuels-and-technologies/methanol/case-study-mv-eemsborg/	Methanol	Concept vessel
6	Methanol powered Tug (Belgium)	https://www.offshore-energy.biz/port-of-antwerp-bruges-worlds-first-methanol-powered-tug-launched/	Methanol	Tug boat
7	Methanol powered pilot boat (Sweden)	https://www.offshore-energy.biz/worlds-1st-methanol-powered-pilot-boat-launched/	Methanol	Pilot boat
8	Concept: Methanol in fishing (Denmark)	https://mpe.au.dk/en	Methanol	Fishing (concept)
9	Pilot study of ammonia in Norwegian fishing vessels	https://greenshippingprogramme.com/pilot/ammonia-powered-trawler/	Ammonia	Fishing (trawler pilot study)
10	Libas (Norway) Pelagic fishing vessel	https://www.cemreshipyard.com/en/references/nb0064-libas	LNG and battery	85m purse seiner
11	Shore power Killybegs Ireland.	https://www.seai.ie/case-studies/killybegs-harbour-switch	Shore power	Fishing

Case study	Description	Weblink	Technology	Sector
12	Gleoiteog Naomh Fanchea (Ireland)	https://afloat.ie/power/outboard-engines/electric-outboard-engines/item/48326-electric-power-adds-a-new-element-to-kilrush-built-traditional-galway-bay-gleiteog	Electric outboard	Recreational
13	Lorna Jane (Scotland)	https://itllneverwork.boats/	Solar panels / electric inboard	Fishing
14	"Hybrid I" (Canada)	https://www.aka-group.com/marine-power/hybrid-system-for-fishing-boats/	Battery hybrid / diesel	Fishing
15	Karoline (Norway). Battery powered inshore fishing vessel	https://corvusenergy.com/corvus-energy-powers-the-worlds-first-electric-commercial-fishing-vessel-karoline-designed-and-built-by-selfa-arctic-as/	Battery / shore power	Fishing
16	Fuel Cell range extender for small battery vessels (Netherlands)	https://rina.org.uk/publications/ship-and-boat-international/hydrogen-propulsion-easy-as-h2c-for-dutch-rib/	Hydrogen fuel cell (electric engine)	Service vessel (RIB)
17	Fuel Cell battery-power range-extender for hybrid vessel (Denmark)	https://www.rivieramm.com/news-content-hub/news-content-hub/world-first-fishing-vessel-with-fuel-cell-and-batteries-77951	Hydrogen fuel cell	Fishing
18	Hydrogen One Methanol-to-hydrogen-fuelled towboat (USA)	https://www.rivieramm.com/news-content-hub/news-content-hub/methanol-to-hydrogen-fuelled-towboat-a-clear-path-to-reducing-emissions-80007	Methanol to Hydrogen	Maritime (in build)
19	Nobody's Perfect; Venice tour boat (Italy) Hydrogen electric powered.	https://www.offshore-energy.biz/hydrocell-picks-genevos-fuel-cell-solution-for-first-hydrogen-passenger-vessel-in-venice/	Hydrogen fuel cell	Maritime (formerly fishing)

Case study	Description	Weblink	Technology	Sector
20	Veronica (Ireland) – hybrid	https://www.cemreshipyard.com/en/references/nb0073-veronica	Hybrid	Fishing (RSW)
21	Centurión del Atlántico (South America)	www.norwegianshipdesign.no	Retrofit – Hybrid -	Fishing (Factory ship)
22	Austral Odyssey (Australia) Hybrid	https://mag.hookandnet.com/2023/09/11/2023-09austral-odyssey/content.html	Hybrid new build	Fishing – new build
23	French trawler Naoned (France) Hybrid (diesel and battery bank). Also digital twin	https://www.worldfishing.net/new-horizons/developing-a-digital-profile-for-green-conversion/1496971.article	Hybrid (Digital)	Fishing (Trawling) (Demonstrator project)
24	Cygnus Cyclone The Parallel Hybrid system.	Note: Information on this project is no longer available online.	Hybrid	Fishing (potting)
25	Seiner/crabber Aksel Johan (Denmark)	https://main-hookandnetmag-hookandnet.content.pugpig.com/2024/06/06/2024-06akseljohan/content.html	Hybrid / heat recovery / peak shaving	Fishing (seiner crabber)
26	BIM diver training vessel	www.bim.ie	Hybrid	Service
27	Aquaculture feed barge (Ireland)	www.mowi.com	Hybrid	Aquaculture
28	Wind powered cargo ship (France)	https://interestingengineering.com/photo-story/worlds-largest-sailing-cargo-ship-anemos	Sail, hybrid Propeller generation	Maritime
29	Wind Assistance test vessel (Spain)	https://bound4blue.com/bound4blue-installs-its-esail-system-on-the-fishing-vessel-balueiro-segundo/	Sail	Fishing (experimental)

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