SHIPPING

Electrification of ships starts with river and coastal vessels

For a long time, the global shipping industry was left out of conversations about decarbonisation. But companies are now feeling the pressure of new industry-specific emissions targets – and they're looking to batteries to help them comply, write *Sarah Gibbons*, in London, *Jens Kastner*, in Taipei and *Julian Ryall*, in Tokyo.

Denmark hosts the world's largest electric ferry named *Ellen*
Photo: Mobimar

Shipping was described by environmental campaigners during the negotiation of the Paris Agreement at the COP21 conference in 2015 as the 'elephant in the room'. But today, the industry – which is responsible for around 3% of global carbon dioxide emissions – is beginning to look seriously at electrification. From inland ferries to cargo barges and even cruise ships, modern vessels are increasingly being designed and outfitted with renewable propulsion technologies.

According to the United Nations Conference on Trade and Development (UNCTAD)'s *Review of Maritime Transport 2018*, around 90,000 ships worldwide burn 370mn tonnes of fuel each year, emitting 20mn tonnes of sulphur oxides (SOx) into the air. SOx are known to cause both acid rain and respiratory issues in humans. Meanwhile, the International Maritime Organization (IMO) has said that by 2050 shipping could be responsible for almost 20% of global CO2 emissions if the industry fails to get serious about decarbonisation – thereby threatening global emissions targets.

Since March 2018, the IMO has mandated that the fuel consumption of all ships, and therefore their exhaust emissions, must be logged. From 2020, only fuel containing no more than 0.5% sulphur content may be used in all vessels worldwide. The current limit is seven times that amount. Last year, IMO member states agreed to target a 50% reduction in shipping's total greenhouse gas (GHG) emissions by 2050 when compared to 2008 levels. Electrification is going to be vital in ensuring this target is met.

Key players from the maritime sector have been conferring on the implementation of alternative fuel sources at a recent IMO meeting. The Symposium on IMO 2020 and Alternative Fuels debated potential pathways for decarbonising shipping, as well as discussions around the production, costs and lifecycle GHG emissions of alternative fuels.

EU responds to regulation

The UK government is one key stakeholder with a seat at the table. It has announced that all new ships ordered from 2025 and bound for UK waters must be equipped with zero emission technology, such as batteries or biofuels. A £1mn competition to cut ship emissions was also launched under the July 2019 Clean Maritime Plan. Hybrid ferries already operate between Scottish islands and on cross-Solent journeys to the Isle of Wight.

UK Maritime Minister Nusrat Ghani said government research suggests that the global market for maritime emission reduction technologies could reach $15bn per year by 2050. A Maritime Emissions Regulation Advisory Service (MERAS) will be created by 2020 to provide dedicated support to innovators using zero emission propulsion technologies. Early stage clean maritime research projects will receive government grants.

By all accounts, the global market for electric ship propulsion could be huge, especially as individual countries implement strict emissions regulations of their own. Under Norwegian Maritime Authority regulations, for instance, all new vessels made in Norway and ships (including cruise liners) entering its fjords, must be propelled by electricity.

The country's shipping sector is rapidly responding. Maritime equipment maker Kongsberg is equipping the vessel *Yara*

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Birkeland, which will be the world's first fully electric and autonomous container ship, with batteries ahead of its planned 2020 launch. The company, based in south-eastern Norway, is supplying all key enabling technologies, including sensors and integration required for remote and autonomous ship operations, in addition to the electric drive, battery and propulsion control systems.

The vessel, purpose-built for Oslo-based fertiliser company Yara, is an open top container ship. It will also reduce diesel-powered truck transport of its cargo by some 40,000 journeys per year. Loading and discharging will be undertaken by automatic electric cranes and related equipment. The ship will not have ballast tanks but use its battery pack as permanent ballast. According to Svein Tore Holsether, President and CEO of Yara, the *Yara Birkeland* is 'a game-changer for global maritime transport contributing to meet the UN sustainability goals.'

Neighbouring Denmark is also boosting electric propulsion in ships – hosting the world's largest electric ferry, *Ellen*, which completed its first voyage with passengers in August, sailing between the southern Danish port Fynshav to Soby, on Ærø island. The e-ferry carries 30 vehicles and 200 passengers free from noise, vibrations and diesel fumes, and is powered by a battery with a capacity of 4.3 MWh, according to Swiss battery maker Lechanché, which provided the system.

Over one year, *Ellen* will prevent the release of 2,000 tonnes of CO2, 42 tonnes of nitrogen oxides (NOx), 2.5 tonnes of particulates and 1.4 tonnes of SOx into the atmosphere. The vessel can sail up to 22 nautical miles between charges. Its development was part funded by the European Union, which aims to help develop 100 or more of these e-ferries by 2030.

Back in Norway, the world's first battery-operated vehicle ferry has been operating a regular scheduled service since 2015. The 80 m long *Ampere* sails across the Sognefjord between Lavik and Oppedal, 34 times per day, 6 km at a time. The vessel was developed by Siemens with Norwegian ship builder Fjellstrand.

Lithium-ion batteries are installed in the ship and at both ports and during each ten-minute stop, the ferry's batteries are charged briefly and are then fully charged overnight using electricity from a hydroelectric power plant. Its developers claim its electric propulsion reduced CO2 emissions by 95% and operating costs by 80% compared with a conventional ferry.

Now Fjellstrand is planning to spend €12mn to develop an all-electric high-speed passenger vessel to operate at 25 knots between Stavanger and Hommersåkat on the west coast of Norway, together with Rogaland county municipality and other members of the NCE Maritime CleanTech consortium of ship operators. This collaborative project will also conduct studies for the same type of vessel in London, UK, and the inland waterways of Belgium.

Finnish power giant Wärtsilä, which is delivering all-electric solutions for the ferry, will buy the batteries from a supplier yet to be decided and place them in the hull. As this is a fast ferry, the weight of the battery package will be a challenge rather than a boon, as with the *Yara Birkeland*.

Vessels crossing inland waterways are also good candidates for battery electrification. For instance, a fully electric ferry has been sailing on the River Mosel in Germany since 2018. The *Sankta Maria II* can carry 45 passengers and six cars, with electricity supplied by 15 solar modules and EST-Floattech Green Orca 1050 lithium NMC batteries, with a total installed capacity of 252 kWh, enabling the ferry to sail for 6.5 hours. Electric ferries also sail in Germany on the River Ruhr in Witten.

The *Ellen* electric ferry's battery capacity is 4.3 MWh
Photo: Mobimar

Ambition in Asia

In Asia, the world's first 2,000 tonne all-electric cargo ship has been launched in Guangzhou, China, manufactured by the Guangzhou Shipyard International Company. It uses a lithium battery for its operations in the inland section of the Pearl River – ironically carrying coal for electricity generation. After being charged for two hours, the ship can run 80 km on battery energy of about 2,400 kWh, according to a note from Guangzhou Shipyard International.

Elsewhere in Asia, Japanese ship manufacturers have been developing inshore hybrid-electric and battery-powered vessels, and four of the nation's leading ship designers have recently announced the creation of a consortium with the aim of creating the world's first zero-emission, fully battery-powered tanker.

In August, Nagasaki-based Oshima Shipbuilding Co announced the launch of the 'e-Oshima' ferry, which is powered by a battery delivering propulsion, communication, navigation, lighting and air-conditioning systems aboard the 340-tonne vessel. It uses large-capacity lithium ion storage batteries produced by Japan's GS Yuasa Corp, and has a maximum capacity of 50 passengers and a bus and four

passenger cars.

Meanwhile, a new e5 Lab consortium has been formed with major ambitions. Asahi Tanker Co, Exeno Yamamizu Corp, Mitsui OSK Lines, and Mitsubishi Corp will together develop zero emission, fully electric vessels. Tomoaki Ichida, general manager at Asahi Tanker Co said: 'Our initial aim is to develop and improve batteries for use in marine vehicles, both in terms of their capacity and quality.'

The consortium wants to develop larger energy density systems, giving the batteries a larger capacity while reducing their size and weight and delivering a longer life, according to Ichida. 'Eventually, we want to develop fuel cells that will allow us to store more energy and achieve far longer sailing times and distances with no emissions,' he said.

Early versions of the planned vessels should operate for a maximum of eight hours within Tokyo Bay, while recharging the batteries should take between four and five hours. The consortium expects chosen battery developers to work closely with the shipbuilders to develop a vessel that has the optimum hull design and propulsion systems.

'Our e5 will be designed to increase the capacity of cargo tanks and we are also going to improve the size of accommodation for the ship's crew,' Ichida reported. The use of batteries will also give designers greater flexibility in designing ship interiors, boosting cargo space and crew accommodation. E5 Lab will develop coastal oil tankers, followed by tugs, dry cargo ships and ferries, Ichida said.

South Korea is another Asian innovator in electric shipbuilding. In May 2019 the Busan Port Authority announced that it would commission the construction of a fully electric battery-powered port guide-ship to replace existing port guides using bunker C oil. It will be South Korea's first commercially built electric propulsion vessel, with an estimated price tag of $7mn. The ship will be capable of accommodating more than 60 people, Busan Port Corporation said.

Meanwhile, South Korea's other major port city, Ulsan, will also increase the use of electric propulsion ship technology, with the national budget unveiled in August including an allocation of $2mn to an Ulsan-based ICT Convergence Electric Propulsion Smart Ship Development and Demonstration Project.

The world's first battery-operated vehicle ferry, the *Ampere*, has been operating a regular scheduled service since 2015 in Norway

Photo: Fjellstrand AS

'The shipbuilding and offshore industry, which is one of Ulsan's four strategic industries, is facing a crisis due to the recent limitations of growth engines and strengthened environmental regulations,' Lee Sang-heon, a politician who represents Ulsan in the National Assembly, told Korean-language news outlets. 'It is urgent to secure the technology of smart ships in order to provide an opportunity to overcome this,' he added.

Elsewhere on South Korea's research front, Suwon-based LG Marines (LGM) claims that it has overcome many inherent problems with electric boats, innovating technologies such as cartridge battery system, electricity shock prevention, range management, power management, electric magnetic radiation (EMR) prevention, and mobile artificial intelligence (AI) connections.

Additional avenues

Ultimately, the variety of these electric ship initiatives reflect, said Diane Gilpin, CEO of the UK's Smart Green Shipping Alliance, how 'the global fleet is heterogeneous – multiple different ship types and sizes operating across the world delivering cargoes on different routes at varying speeds.'

But she stressed that for electrification to really reduce carbon emissions, renewables need to predominate as a recharging source. If power is produced by fossil fuels 'then shipping is simply switching its GHG emissions responsibility to a different sector.'

Ironically, given shipping's wind-powered past, she said wind propulsion systems maybe a green part of the industry's future: 'Wind is clean, free and abundantly available at sea. It makes sense to use it direct wherever possible.'

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Auxiliary, wind-powered propulsion technologies, including kites and rotor sails, are currently capturing the interest of ship owners and operators worldwide. There are a handful of so-called rotor ships in operation today – including a tanker owned by Maersk, the world's biggest shipping company. These vessels have large, vertical rotors installed on their decks which utilise the Magnus effect to assist propulsion.

When the wind meets the spinning rotor 'sail', air flow accelerates on one side and decelerates on the other. The changing speed of air flow results in a pressure difference, which creates a lift force. Rotor sails aren't powerful enough to power a ship on their own, but they can reduce fuel consumption, or potentially help to conserve power on a battery-powered vessel. The same applies to experimental, deck-mounted 'kite' designs, which work much like traditional sails.

In the end, shipping will need all of the renewable solutions it can get to reduce its harmful emissions. While batteries will undoubtedly be useful on short-sea routes, there is still much work to be done – especially around weight and range – before they can be installed on giant oceangoing container ships. However, the industry is taking steps in the right direction when it comes to short-sea shipping. It has been a long time coming, but the maritime sector is finally turning away from polluting heavy fuel oil. ●