FEATURE

Maritime gears up to meet new global challenge

By JOHN PAGNI*

The IMO 0.5 per cent Sulphur fuel limit and the UN body's target of cutting 2008's greenhouse gas emissions (GHG) in half by 2050, will require shipping to take bold decisions on new innovative technologies in order to not only comply, but help by cutting costly fuel bills too.

Transport – shipping in particular – is not known as a cleantech sector nor one to swiftly take up new ideas. But with the clock ticking and the world watching, the time has come to change old habits. The good news is that despite the bad press and general public perception, shipping has been by far the cleanest mode of transport for ages due to economies of scale.

Figures from many sources show clearly that although far from perfect, ships leave other transport modes far behind in efficiency and emissions. While 90 per cent of global international trade is carried on water, it is only responsible for 3 per cent of the planet's greenhouse gases (GHG).

For example, a ship delivering 1000 TEU containers emits the same as 500 trucks or 17 trains. Air transport rates at 435 grams per thousand kilometres (g/tkm), a truck's is 80g/tkm and a cargo ship 7.9. However, the huge box ships now plying the oceans rate just 3g/tkm, according to a 2014 IMO GHG study.

Viking Grace and sail (not in action due to its approaching harbour)

In Australia's case, shipping is responsible — like the rest of the world – for the overwhelming share of its international trade – no great surprise for an island nation. The case for the 0.5 per cent S limit is not only its increase in human and animal health and welfare and their associated costs, but also for the environment too. *(OzStat said it was 85 per cent but that seems too low, as Finland's is 90 per cent and we have the rail option. But he didn't say what that included, so I suspect it covered services too).*

Optimal energy use is crucial in shipping nowadays, with fuel making up 50-60 per cent of a vessel's OPEX – getting the most out of each drop is priority No. 1. A number of firms offer a range of solutions, which makes the final decision on which one(s) to invest in vital – and difficult.

Sails force – wind propulsion returns to merchant shipping

The technology attracting the most interest due to its theoretical and so far, practical evidence, is in fact old. The Flettner rotor (or mechanical) sail – named after its German inventor – was first deployed aboard a ship in 1921, using the Magnus effect .

Put simply, it works by being rotated in windy conditions, then the magic works. Technically, the vertical tube has a thin layer of air around it which creates a perpendicular force powering a vessel forward. For a layman's explanation see: https://www.youtube.com/watch?v=2OSrvzNW9FE for a 'Bend it like Beckham' demo.

The most successful, indeed almost the

only, references are from Norsepower, a Finnish company which is the market leader. "We have modernised entirely this near-century old concept by introducing composite materials and an automation system," says Norspower CEO and partner Tuomas Riski, "we have three customers and many in the pipeline."

The rotor sail's composites consist of carbon and glass fibres for the outer spinning column, which rotates on two bearings with a normal steel column inside. Power to propel it is supplied by a small electric motor. "It can rotate in both directions like a yacht when tacking or jibbing," Riski adds .

Norsepower's first Flettner was on Bore's RoRo *Estraden* in 2014, which was a trial for both companies, with two units installed, but firmed into an order when their efficacy was proven. Another is on the LNG cruise ferry *Viking Grace* (see Shipping Australia - Spring 2012 edition).

Lastly, *Maersk Pelican*, 109,647dwt LR2 (long-range) product tanker that has two 30-metre tall by 5-metre wide sails. Maersk Tankers has said that if the savings are proven – and so far the results are described as promising – then the rotor sails may be put aboard 80 of its large and medium-size product carriers.

Echoing textile sails of yesteryear, mechanical sails allow a vessel to maintain its service speed using less power, thus saving fuel. But what are the financials? Riski reveals each ship set costs €1-2 million (AUD1.6-3.2 million), whether retro or newbuild, and consists of foundations, cables and automation system, plus sail(s).

"Payback in the case of *Estraden* at today's delivery price would be under four years. Currently, typical payback would be three to eight years," says Riski. And for the *Maersk Pelican*, although data is still being gathered and analysed, the technology is working, and in favourable winds the ship clearly goes faster than before, so it attains the same service speed using less power and thus fuel (and ergo less esmissions)."

Riski adds that the largest rotor sails, such as on *Maersk Pelican*, provide up to 3MW-equivalent of power, while using less than 90kW to spin the sails.

Retrofits can be carried out while normal drydocking takes place and the sails can be fitted when the ship is berthed, as happened in the case of *Estraden* and *Maersk Pelican*. "With more sails (per ship) fuel costs can be cut up to 20 per cent. In addition to the wind conditions of the route, it depends on the speed – the faster a ship goes,

The rotor sail spinning like hell at night in favourable conditions

the smaller the percentage savings are, due to the propulsion power requirement."

In March, Norsepower got the first type approval design certificate from DNV GL, based on the classification society's assessment of the rotor sails that were already fitted on *Maersk Pelican*. The

previous month, Norsepower won the 2018 International Quality Innovation Award and last year received the World Wildlife Fund's Climate Solver prize.

Others are entering the market but as yet have more theoretical than practical experience. Airbus-supported Airseas, will try automated kite-like sails in 2020, estimating 20 per cent cuts in fuel burn on the 13 day voyage between France and Alabama. (www.airseas.com)

Spain's bound4blue uses automated 'wingsails' to harness the wind, which are also collapsible and fold up into a deck housing. It claims up to 40 per cent in fuel savings and says it is negotiating with shipowners, as its reference base is just a 40 metre long fishing and 60 metre theatre vessel.

Magnuss of USA claims 50 per cent in the fuel savings bidding war using rotor sails again, but with the innovative tweak that they can be retracted into the ship. "It's just a better mousetrap", quips CEO James Rhodes. Magnuss' target group is Panamax dry bulkers. The idea is that the rotor sails will not get in the way of loading/unloading by crane. The company has yet to get its idea off the ground so to speak, though it has raised capital now to promote its innovation. (http://magnuss.com/news.html)

Hull of a question – answer: bottom bubbles?!

A technology attracting attention due to its simplicity, hull air lubrication is another old idea brought up to date by the wonders of modern engineering and IT.

"Air lubrication dates from the 1850s," says Noah Silberschmidt, CEO Silverstream Technologies, "but we have achieved a very good energy balance, meaning not a lot is spent producing the air that goes into our air release units (ARU), which then spreads it equally in a thin layer across the flat bottom of a vessel.

"Silverstream's air lubrication system (ALS) creates micro-bubbles creating an 'air carpet' along that flat part. This minimises the friction resistance as most of a ship's energy created aboard is lost to various frictions the vessel faces and little actually used in forward propulsion," Silberschmidt explains, so allowing the ship to sail more efficiently while cutting fuel consumptions and emissions. See https://www.silverstream-tech.com/the-technology/

Among those offering ALS to ship owners, the UK-based Silverstream Technologies is the most advanced. The first development was the Mitsubishi Air Lubrication Systems (MALS) in 2012, that has three hull outlets. There were negatives experienced, such as effects on the propeller in bad weather, and air bubble size changes. The last known installations on two passenger ships were for AIDA's Japanese-built cruise ships *AIDAprima* and *AIDAperla*. Although MALS claims CO2 savings of 35 per cent 'with a high-efficiency ship hull', no figures for the *AIDAs* have been made public.

Competing concepts, such as air cavity ships (ACS) and its similar air chamber energy savings (ACES), plus winged air inject pipe (WAIP) were all tried, tested and discontinued for various reasons.

Silverstream System is available for both newbuilds and via retrofitting on all vessel types. Silverstream's reference list demonstrates its ALS saves 5 per cent on a chemical tanker, 6 per cent on cruise ships and 8 per cent on large flat-bottomed tankers – numbers certified by classifications societies (Lloyd's Register, DNV GL) and others (Southampton University, HSVA, Carnival Corporation, Shell).

"Typically, we work with vessels that have a busy operational profile (250 days/year), higher-than-average speed and a large flat bottom. For a tanker, it's 40 per cent of the surface area to 25 per cent for a cruise ship," Silberschmidt outlines, "but cruise ships steam fast and have a high fuel burn."

The numbers translate why more fuel can be saved in percentage terms depending on the flat bottom area size. "We target a two to three-year payback – based on spot prices," Silberschmidt reveals.

"The shortest retrofit installation was during a six-day drydock, but took place in a well-organised yard. Typically, it should be longer, while the ship is having other work done, such a scrubbers or a BWTS fitted, during routine drydocking. On average ten to fifteen ARUs are fitted: we cut out a space, put them in and then paint."

"As they're prefabricated it took three days to put them in and another three to paint."

He is citing Carnival's *Diamond Princess* cruise ship retrofit done by Sembcorp in Singapore. Silverstream's ALS will be fitted into Grimaldi Group's 12-ship hybrid RoR os, on order from Jinling in China. (See Grimaldi Green case study box)

Maintenance is simple. Each compressor supplies two ARUs and is controlled by frequency converters, run automatically by a system made in partnership with Wärtsilä, either in the engine room or wheelhouse, as preferred. The compressors are the same as those in water treatment plants ashore and used to run 24/7/365. Filters and an oil change per vessel suffice, and service costs are low at AUD14,000 once a year.

"It's a stand-alone system or may be fully integrated into the vessel's control system, and is designed to switch on at 11 knots and off at 10 knots, so if a ship is going 10.5 knots when manoeuvring or a pilot is aboard, it is not continually tripping in or out and the crew need not do a thing."

What affect do conditions have? "We can still create the air carpet that sticks to the boundary area in bad weather, but it's more complex as resistances are changing."

Silberschmidt stresses that testing should be transparent and relevant. "In shipping, new technology is usually compared before and after drydocking, when the ship's hull has been cleaned and painted, so measuring a new propeller and/or rudder improvement is difficult."

Silverstream's simplistic approach stretches to bona fide results by turning the system on and off for six hours, when the ship is moving in a straight line at the same speed. "It takes two minutes to see a drop-in shaft power when it's turned on, then ten minutes later the speed increase is noticeable. Lower speeds see a higher increase and vice versa."

So, it is easy to test, despite factors like wind, waves and current that may impact the hull. A side benefit is lessened hull fouling. Though the evidence is subjective and scientifically uncorroborated, Silberschmidt claims that all the vessels using the Silverstream System ALS, ships' management have reported "much less fouling or none at all on the flat bottom."

"Some say periodic propeller cleaning has been cancelled as it was unnecessary, as both that part of the hull and propeller was cleaner than before."

"There has been no growth on the bottom – proven and verified by diver surveys or during compulsory drydocking."

Anti-fouling: foul play or be fair?

Which leads nicely into other hull treatments: preventive anti-fouling paint or regular cleaning by divers, supplemented by more comprehensive blasting during drydocking. The former has a long record, but changes are afoot as new entrants intend to disrupt the market.

Biofouling is as old a problem as water-borne transport. Anti-fouling coatings on ships and boat hulls to prevent what is charmingly called 'colonisation' by various creatures and plants of the sea or biofouling. The worst colonisers being shellfish and barnacles in particular. Although generally small, they can take over a ship's hull to the point where the extra weight, and more importantly, roughness, seriously adds to speed and fuel costs - like snowboarding with rough stones on the snowboard bottom.

Copper sheets were nailed on to wooden hulls in sails days. Metal-based compounds appeared with metal hulls, which kept the offending biofoulers at bay but leached into the water, causing damage to the marine environment in general and ultimately even appearing in human food.

In the 1960s, one predominated: the organotin tributyltin (TBT). This was effectively banned by the International Convention on the Control of Harmful Anti-fouling Systems on Ships that came into force in 2008, as it had proven negative effects on marine life as well as wonderful results.

Swedish scientists took another approach employing Mother Nature. Selektope® was developed by I-Tech of Sweden (aided by AstraZeneca's Gothenburg BioVenture incubator hub) after over a decade of development, finally reaching the market in an anti-fouling coating for ocean-going vessels in 2015. "Selektope deters barnacles from attaching to a hull when used in an anti-fouling coating," defines Catherine Austin, I-Tech's director marketing and communications.

Its pharmacological ingredient is added to marine paints intended for hull coverings. Importantly, Selektope meets the EU Biocide Product Regulation and is approved by leading shipbuilding nations Japan, China and South Korea. It is now in the range of two of the five major marine paint makers: CMP and Hempel. Meanwhile Akzo Nobel is experimenting with ultra-violet LED lights in the hull that has so far been a success.

Selektope says 350 million tonnes of fuel is burnt annually by the global fleet emitting 1.1 billion tonnes of CO_2 and 10 million tonnes of SO_x. Unprotected hulls without an anti-fouling coating could raise a vessel's fuel bill by 40 per cent due to attached marine life causing

Grimaldi goes hybrid for green newbuilds

Probably a sign of the shape of ships to come in employing packages of fuel-saving technologies — or hybrid vessels — is the Italian family-owned shipowner and operator's order for twelve new ro-ro ships from China's Jinling yard.

The ships are notable not only for their size and capacities, but the environmentally friendly features on board. Nine will have 7,800 lane metres that can take a whopping 500 trucks and trailers. The other three are for its Baltic subsidiary, Finnlines are a bit smaller with 5,800 lane metres. The latter trio will be built to the Finnish-Swedish ice class Super 1A, to sail in the winter ice up north.

All twelve will have a 5,600 square metre car deck, plus a weather deck for 300 TEU. And they will continue established Grimaldi policy of using scrubbers to cleanse their exhaust, and using HSFO during sailing. Battery power in port will guarantee its "zero emissions in port" promise. The lithium-ion battery bank, which will be charged during sailing, will provide power for the ship while at berth and manoeuvering.

In addition, there will be a Silverstream ALS fitted, and optimised energy efficiency is ensured by the vessels' hull lines, including the most advanced integrated propeller-rudder system. As well as the shaft generators, one of the hybrid sources will be SOLAR PANELS! 600 Six hundred square metres of them and a first on such a big ship.

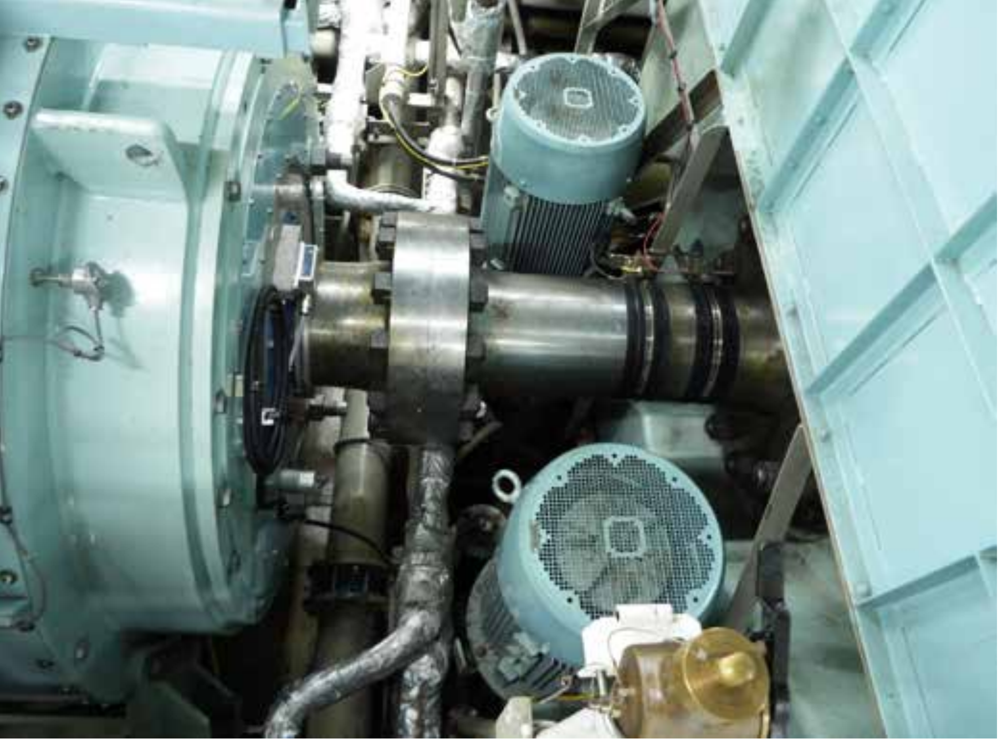
The design of the "Grimaldi Green 5th Generation" (GG5G) was developed by the Grimaldi Group's own Technical and Energy Saving Department, in cooperation with Danish ship designer Knud E. Hansen, incorporating innovative patented or copyrighted equipment.

At a total cost of about €800 million (AUD1.26 billion), each ship will be 17,400dwt/64,000gt, 238 metres long with a 34 metre beam, mixing old and new, or fossil fuel with electric propulsion.

"These vessels will offer us the lowest possible fuel consumption and exhaust emissions, and are in line with our investments in sustainable development. We are proud that these exceptional technologies on board will make the vessels the most innovative and efficient vessels in the world," says Emanuele Grimaldi, Grimaldi Group and Finnlines CEO.

"Reducing fuel consumption and, consequently, cutting harmful emissions are categorical imperatives for our Group", says Grimaldi Group President Gianluca Grimaldi.

"It is the first time in the world that such powerful batteries, equivalent to those equipping 90 Tesla cars, will be installed on ships," continues Grimaldi MD Diego Pacella.



Shows the main engine (right, propulsion shaft and the PTI generator (left)

greater friction called hydrodynamic drag.

"Widely acknowledged fuel savings attributed to anti-fouling coatings is 10 per cent," says Austin. "This is quite a conservative claim, but based on assuming bunker fuel is priced at AUD558/tonne, annual savings would result in 35 million tonnes fuel saved, worth AUD19.5 billion plus 100 million tonnes less of CO2."

The problem is accentuated in 'red zones' such as Asia and Australia, where warm water temperatures pro-activate fouling. Static vessels that are laid up or newbuilds being fitted out are magnets to barnacles, mussels and worms. As Asia ships manufactured goods to the world, and Australia commodities to its manufacturing powerhouses, the problem has grown.

Selektope's minuscule amounts are seen as an ideal solution. Just a few grams per litre are needed to ward off barnacle larvae, with the concentration adjusted according to conditions and ship type and purpose. I-Tech recommends a minimum concentration of 0.1 per cent w/w of paint used.

"When exposed to Selektope, barnacle larvae are repelled from a ship's hull and kept in swimming mode with non-fatal effect. This revolutionary biotech approach to fouling prevention is controlled by the activation of the barnacle larva's octopamine receptor and is completely unique in its application within hull coatings," explains Austin.

"The actual cost of a Selektope paint is dependent on vessel size, trading pattern and activity that will differ for each. Shipowners can expect to pay similar prices for Selektope coatings as for other premium paints on the market," reveals Austin.

Its cost-effectiveness includes reducing hull cleaning frequency and hard scrubbing while improving fuel saving. For paint makers it is flexible and may even be used with copper-based mixes or, better still, replace the metal altogether.

To promote its abilities, an IMO II MR chemical products tanker *Team Calypso* got a free Selektope coating in 2015. The ship has a global trading pattern, 60 per cent average activity rate, 12 knot average speed and sails in biofouling hot spots with a 25°C temperature, with long idle periods of 25 days or more.

"The vertical sides were coated with a premium Selektope® product with a 60 month service life. Diving inspections at 36 months confirmed the hull was completely free from hard fouling with slight slime coverage. The hull had not been cleaned during the 36 months," Austin explains.

"This is proof of what I-Tech's ingredient can offer ship operators: a hull free from barnacles with no abrasive cleaning needed, over 60 months between drydockings," Austin concludes but points out biofouling is increasing as water temperatures rise, so more coatings manufacturers are launching Selektope products.

Nippon Paint recently launched the first biocide-free non-silicone low friction self-polishing copolymer antifouling coating. Nippon Paint Marine director John Drew said, "Typically anti-fouling ships paints have contained some form of biocide: copper, tributyltin, co-biocides. Biocides are today strictly controlled by national and international regulations. With Aquaterras our scientists have achieved a truly effective, long-term antifouling paint without biocides."

Which means regular cleaning by divers could become obsolete or obsolescent at least, with hull maintenance being carried out only during regular drydocking. Commonplace now, its practice has been limited by the after-effect of the toxic waste falling to the sea floor, while uninvited unwanted marine life finds a new home far from its own, causing further damage to the local marine environments.

Norway's ECOsubsea and HullWiper (licenced by K-ROV in Australia) are two that have developed proprietory hull-cleaning equipment that effectively removes detritus and ensures everything is filtered into a waste receptacle for processing on shore. Hull cleaning by divers can cost AUD24-28,000 and may need to be done in several stages according to how big a ship is and its length of stay in port, and is usually done simultaneously with other subsea work.

According to Simon Doran, HullWiper's managing director, costs are LOA dependent. "For a small 120 metre gas vessel (HullWiper is headquartered in Dubai, as it is jointly-owned by GAC and designer Robert Andersen), the rate would be AUD16,670, while for a container or cruise ship with a 400 metre LOA, it would rise up to AUD48,619."

It must be pointed out that most hull cleaning is carried out by scuba divers, but the HullWiper is unusual in that it is an ROV and controlled by a surface operator and possibly represents better value for money, as IT relentlessly replaces people in on-the-spot work.

While prevention may appear to be getting the better of cure in this case, Austin brings hope down to Earth by pointing out that fouling is on the increase as water temperatures rise, due to global warming and increased trading patterns. "This is why coatings makers are launching Selektope products, as this unique anti-fouling delivers the prevention needed."

Hybridisation: the energy efficiency solution – for now

The start of 2019 saw the introduction of the IMO's Data Collection System of vessels fuel consumption for ships of at least 5,000gt, which make up 85 per cent of all ship emissions. This echoes in many respects the EU's Monitoring, Reporting and Verification (MRV) requirement that began a year earlier that concerned energy efficiency and CO2 emitted. Why the IMO is cracking down on all shipping GHGs is possibly explained by Shell, that the world's largest fifteen ships emit as much NOx as all the world's 760 million cars.

The Energy Emission Design Index for newbuilds will enter in phases where energy efficiency must improve over 2014's ships, intially by 30 per cent in 2025. Together with the Ship Energy Efficiency Management Plan for all ships, these will lead to a change in propulsion energy sources from diesel engines to ultimately electric-only, from zero-carbon emission-free fuels or batteries - or something else.

On this voyage to maritime propulsion nirvana, ships will use a variety of energy sources, which is referred to as hybridisation. For instance, to comply with EEDI, a hybrid system can be installed, instead of slowing speed and thus raising its attractiveness.

"The hybridisation of a ship depends on whether it is single or double-screw and what is included in the package," says Mårten Storbacka, WE Tech's CEO. "Our WE-Drive variable frequency drive generator, shaft generator, DC link distribution for heavy bow thrusters, and an energy storage (battery) option too."

Each ship gets a bespoke suite and Storbacka points to Stena Line's eight E-Flex Ro-paxes being built in China, which will be the most fuel-efficient in the world, the Swedish company claims.

"Our E-Flex tailored solution is a shaft generator, driven by the main engine that generates all the electricity needed on-board, without using any fuel to run the auxiliary generators when sailing. This is based on our WE Drive, which allows the main engine to run at variable speed while producing electricity on-board, resulting in tons of fuel savings every day," defines Storbacka.

The two 2600kW shaft generators, together with the WE Drive, generate power for the ship's electrical network in power take out (PTO) mode and also utilises the common DC-link for power distribution in bow thrusters .

As an example of costs and payback, Storbacka quotes a 20,000dwt product tanker burning 15 tons daily, resulting in a payback of one to three years. Project costs per ship span from €700,000 (AUD1 million) to €6 million (AUD9.5 million). Currently WE Tech's business is heavily skewed to newbuilds.

Another reference is a power take in (PTI) mode, with direct drive permanent magnet shaft generator fitted in the propeller shaft line after the main engine, on the world's first LNG dry bulkers for ESL Shipping. "The solution is particularly good for winter conditions to provide an 'ice boost', giving additional torque to the propeller thereby helping the main engine and ensuring effective operation in Ice Class 1A," explains Storbacka .

"The main driver for our business is more efficient engine use already in the design. Another example, is ultra-low steaming with a two-stroke main engine is less efficient than redundant propulsion (or auxiliary propulsion) utilising auxiliary engines and shaft generator in PTI mode. Then again, when deep-sea sailing at service speed the generator on the propeller shaft requires just the main engine, which is highly efficient at design service speed."

"The main engine is obviously bigger and thus has better fuel efficiency than an auxiliary engine, so fuel savings come from using the main engine and employing an auxiliary as little as possible. Fuel savings of 20 per cent are easily achieved," Storbacka sums up.

Danfoss is also heavily involved in this market. It places much on its DC-to-DC converter, which can flatten out voltage (raising or lowering) easily and safely from multiple power sources, including a bi-directional feature for batteries when not suited to the grid converter, adapting a wide voltage range. Ships need flexibility in propulsion as power demand gyrates greatly at sea and when in port. (Presentations at https://www.danfoss.com/en/search/?query=hybridization)

Danfoss foresees other energy storage sources which its converter can manage just as well as batteries, due to its wide voltage window. Though not practical now, they may well be in the future Danfoss thinks, and is prepared for and developing.

On the horizon

There are other technologies and innovations in the pipeline, but for the moment that is where they remain. Nuclear is not considered an option anymore, post-2011 tsunami disaster in Japan, which almost turned into a catastrophe with the Fukushima meltdown.

Apart from naval craft, only four merchant ships have been using atomic power, with the last being *Sevmorput* of Russia, which has by far the longest logbook and is still working after its 1988 maiden voyage. In addition to safety concerns and astronomical costs, there is the problem of how many ports would accept such a vessel.

Hydrogen and fuel cells have been touted as the next big maritime propulsion miracle, for years. But – there's always a but when something seems too good to be true. Hydrogen fuel cells seem ideal: stable (meaning non-vibrating, here), produce DC electricity, have rapidly rising capacity, clean water exhaust, long lifecycle and low maintenance requirements and costs.

But it is now very costly to produce LH2 (liquid hydrogen fuel) and then store at -253°C. Fuel cells are expensive to make, and hydrogen burns in an air mix within a wide range of 4 per cent to 75 per cent - so potentially explosive.

This all leaves shipowners with a complex compendium of technologies and choices, none of which are cheap. But they are mandatory. In this situation only the fittest will survive, and size does not matter – as dinosaurs know. If they were alive – they were large-slow-moving creatures with low intelligence that failed to adapt.

Therefore the effect of AI and IT on shipping has yet to be seen or covered in detail. With growing influences these subjects are so complicated and wide-ranging, they need a separate feature on their own.

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MS Viikki, the world's first LNG-fueled bulk carrier, docked in Helsinki for media and VIP introduction