APRIL 2024

electric & hybrid

marine technology international

ELECTRIC & HYBRID MARINE EXPO EUROPE 2024

- Technology preview
- Conference highlights
- Speaker spotlights

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Power & control

Why vessel electrification and autonomous technologies should be working in harmony

Electrifying superyachts

How are latest propulsion advances impacting the design of high-performance, highly luxurious vessels?

Hydrogen vessel roundup

Examining some of the most exciting new vessel designs bringing fuel cell technology to the waterways

Battery chemistries

Selecting, designing – and protecting – energy storage systems for the harsh conditions experienced on the water

Battery developments | Hybrid systems | Fuel cells | Electric motors | Charging technologies

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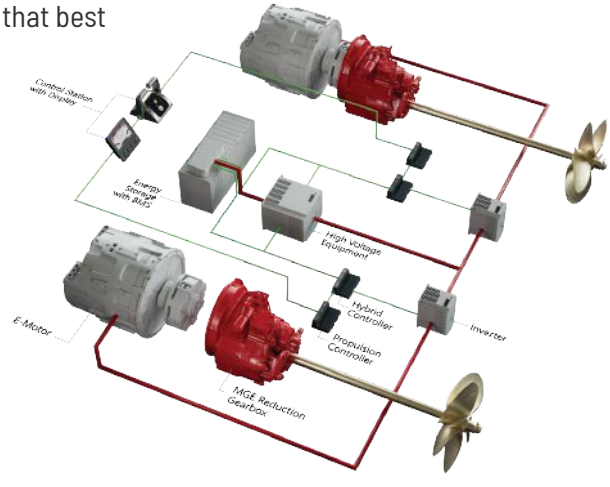

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electric & hybrid marine EXPO EUROPE

48: Electric & Hybrid Marine Expo Europe 2024
A preview of this year's industry-leading expo and conference, set to take place in Amsterdam on June 18, 19 & 20

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EDITOR'S NOTE

One of the best things about working on a technology magazine is that you get a front-row seat for the emergence of new paradigms and shifts in attitude. Nowhere is this more true than with electrification. Back when I worked on *E&H Marine*'s sister publication (which covers the automotive sector) it was always fascinating to chart, from one issue to the next, how ideas and technologies were taking root and finding purchase out in the world. The concept vehicle you'd write about in one issue would be the inspiration for a new series announcement a year later, and then you'd find yourself driving the press car a couple of years further on, getting hands-on with technology you'd heard engineers speculate about at a motor show four years earlier.

It's a similar story with *E&H Marine* – though, I'm sad to say, fewer press vessels are getting dropped off at our office than I might like. I can remember the first time I heard engineers and naval architects talking about boats powered by hydrogen, how superyachts of the future could look fundamentally different when they were no longer constrained by huge diesel engines, and how wake boats could enjoy new levels of performance if they could manage to fit sufficient energy storage on board. A few years later and these kinds of conversations are being had in light of actual, real-world applications that are on the water right now.

So it's particularly exciting to see that a technological progression from the automotive sector is being mirrored in the maritime sector once again. Autonomous operation is a huge subject – and one that comes with its own set of associated technological challenges – but I'm very happy that we've had a chance to explore it more in this issue. Turn to page 34 for Alex Grant's excellent exploration of the ways in which the technological spheres of electrification and autonomy can – and indeed should – overlap with increasing complexity. It's a subject I fully expect us to delve into much more in the future, and I can't wait to see lots of today's ideas become tomorrow's vessels. Enjoy the issue.

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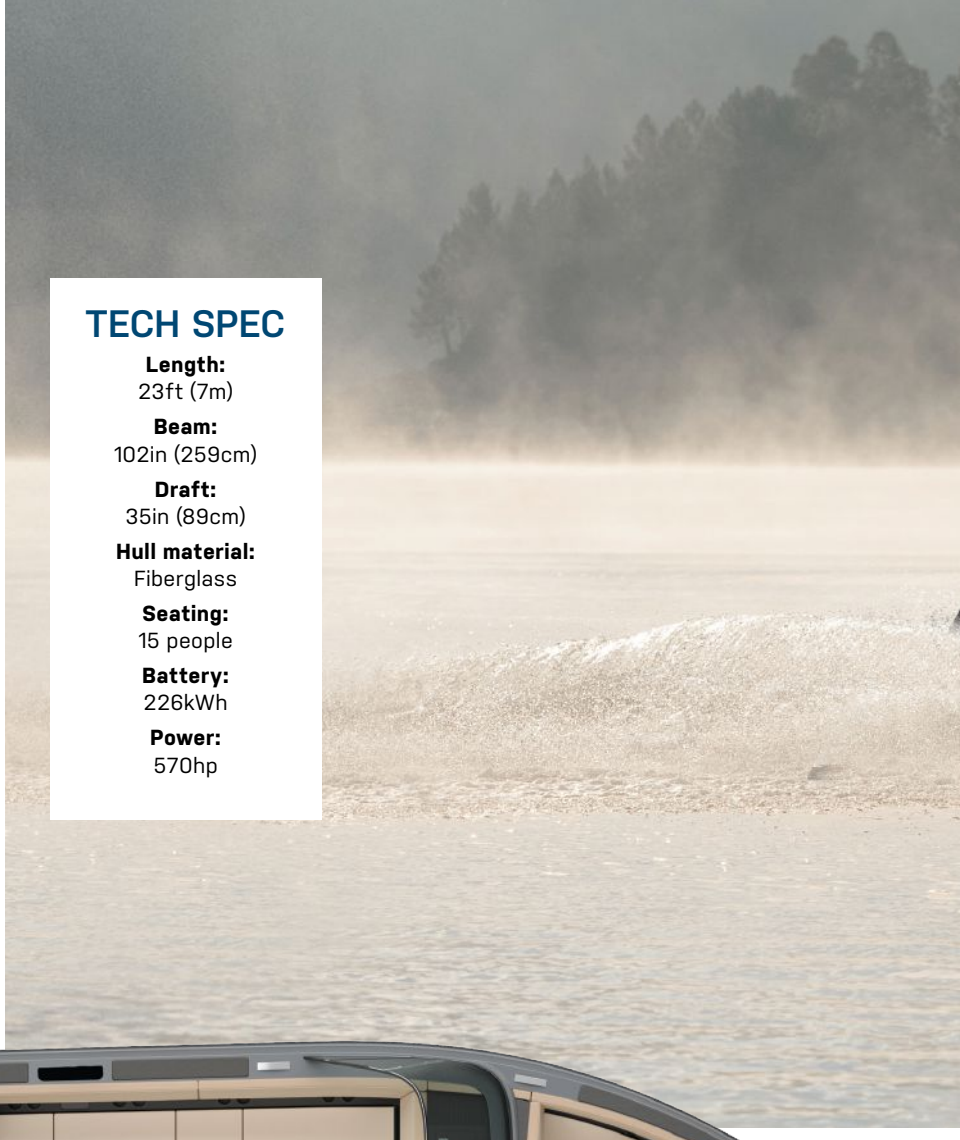
Wake-up

call

E&H Marine meets the team working on the Arc Sport, the second vessel from the LA-based electric boat developer

WORDS: **MATT ROSS** AND **RICHARD GOODING**



TECH SPEC

Length:
23ft (7m)

Beam:
102in (259cm)

Draft:
35in (89cm)

Hull material:
Fiberglass

Seating:
15 people

Battery:
226kWh

Power:
570hp

The Arc Boat Company, founded in 2021, is headquartered in Los Angeles, California, where it designs, manufactures and distributes its vessels. Headed up by chief technical officer Ryan Cook, a former Space X engineer, and chief executive officer Mitch Lee, a mechanical and software engineer, Arc has launched the Arc One, a limited-edition, pure-electric luxury cruising craft. Now, it's the turn of the more mass-market Arc Sport.

The Arc Sport is an all-electric high-performance wake boat. The 7m craft has a dry weight of 3,130kg, and when combined with a computer-controlled ballast gives a total displacement figure of 4,082kg. Cook and Lee both previously worked at Boeing, so the Arc Sport makes use of aerospace design and manufacturing practices. The glass-fiber hull features a 226kWh battery built into the structure of the boat itself, and the company designs its battery packs, thermal control systems and software in-house. The battery has an 'active usage time' of four to six hours (including towing), and lower-speed cruises should see 24 hours of range. Plug in the Sport to charge overnight on a Level 2 connection, and Arc says there will be a full battery by morning. According to the company's tech specs, the Sport boasts a power output of 570hp.

Mass appeal

"The Arc Sport brings cutting-edge EV technology and modern design to the wake boat space," says Arc head of product Ted Herringshaw. "We think this will appeal to a broad range of boaters: watersports fans, families young and old, tech enthusiasts getting into boating for the first time, and so on. Anyone who wants to have fun on the water without the gas-related headaches should check it out.

"Typical recreational outings also lend themselves well to charging, because they usually start and end from the same location and then sit unused overnight. All of this adds up to a simpler, more enjoyable experience."

"By bringing critical powertrain components in-house, we can better design for the customer's needs in the first place, and then react more quickly if a customer is ever having an issue"

Ted Herringshaw, head of product, Arc Boat Company

Electric origins

Arc boats are engineered to be electric from the very beginning which, Herringshaw explains, "removes a lot of the most troublesome parts of the boat, like fuel gauges and gaskets, and frees up more storage space for the customer. Going electric also means adding a large battery pack to the vessel. In the case of wake sports, that weight happens to be a key ingredient to producing a great wave behind the boat."

In-house expertise

Arc designs many of the drivetrain systems in-house, which enables the team to tailor the system to specific customer experience.

"By bringing critical powertrain components in-house, we can better design for the customer's needs in the first place, and then react more quickly if a customer is ever having an issue," says Herringshaw.

Home base

In 2023, Arc secured a 14,000m² factory in Los Angeles to increase production and meet growing levels of demand.

"The new HQ has been a huge win for the company's growth," says Herringshaw. "The whole team is now under one roof, which further accelerates our speed of learning and iteration. We have aggressive internal production targets to channel that speed as we scale."

> "Typical recreational outings also lend themselves well to charging, [as] they usually start and end from the same location and then sit unused overnight"
>
> Ted Herringshaw, head of product, Arc Boat Company

Keeping in control

An auto-retract hardtop tower allows for an adjustable tow point and cabin closure, to enable a more comfortable ride; bow and stern thrusters make the Arc Sport highly maneuverable. Over-the-air (OTA) software updates give the craft new capabilities and features.

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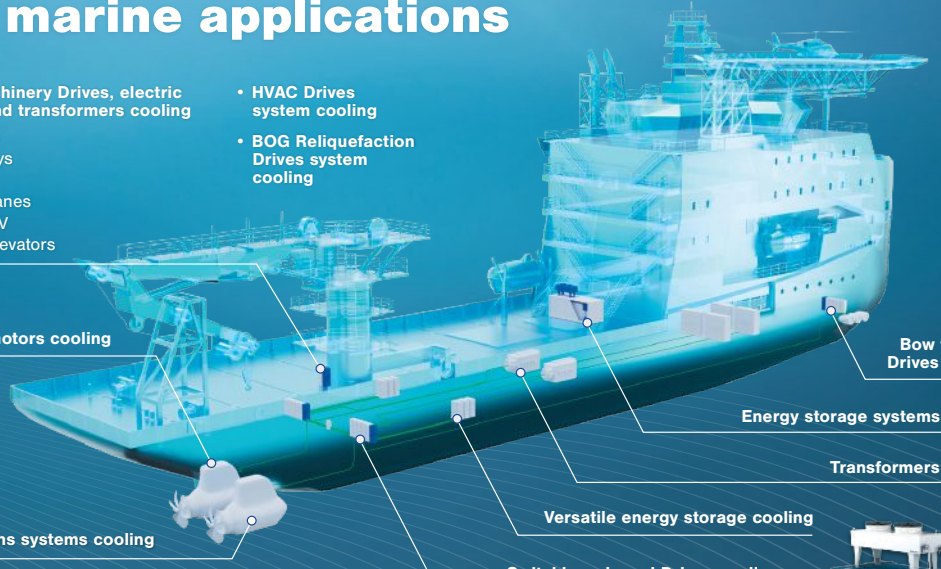

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Pleasure seekers

E&H Marine rounds up some of the latest pleasure craft that mix high-tech propulsion systems with high levels of onboard luxury

WORDS: **RICHARD GOODING**

FRAUSCHER X PORSCHE
850 FANTOM AIR

Co-developed by Frauscher Shipyard and Porsche, the Frauscher x Porsche 850 Fantom Air features the electric powertrain technology of the new Porsche Macan SUV. The synchronous electric motor and 100kWh lithium-ion battery are installed under the rear lounge area of the 8.6m day cruiser; the battery is suspended in the boat's support frame by wire rope mounts. A shaft transmits the electric motor's 400kW of power to the Z-drive, which can be directly controlled in a similar way to an outboard motor with a shaft and screw. Silicon carbide semiconductor material helps optimize efficiency.

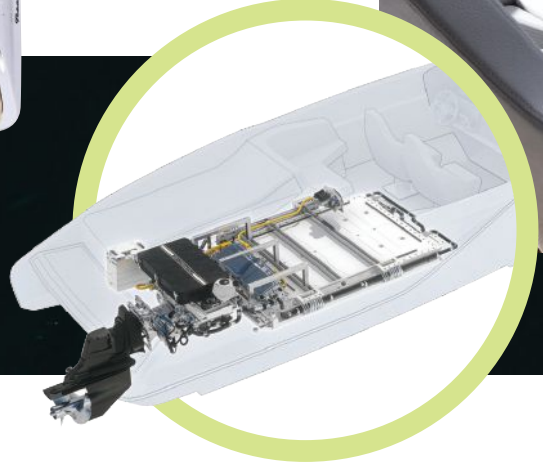
Association with Porsche suggests performance, and the 850 Fantom Air features four 'driving' modes: Docking, Range, Sport and Sport Plus. These alter the throttle response curve and allow differing speed limits.

Optimal cruising speed is 22kts, at which speed the boat's battery charge lasts around an hour. Sport Plus mode liberates a 46kts top speed. A mix of slow and fast speeds is claimed to give a sailing time of around two to three hours before recharging. With 800V charging technology borrowed from Porsche's electric cars, the Frauscher x Porsche craft charges at speeds over 250kW DC, and a 10-80% refill takes around 30 minutes. An 11kW AC onboard charger is standard.

The 850 Fantom Air is based on Frauscher's 858 Fantom Air day cruiser, and looks very similar to that vessel. A Studio F A Porsche-designed helmstand adds a sportier twist, with a high-gloss black instrument panel housed behind a frameless, tinted acrylic glass windshield. A Porsche steering wheel and two front seats embossed with the company's crest reinforce the association with the German sports car manufacturer, and the vessel has accommodation for nine people. There is a swimming platform and two sunbeds at the rear, and a pair of upholstered benches at the front. An exclusive first edition of 25 units will be delivered in 2024.

The Fantom Air uses components of the Premium Platform Electric (PPE) on which the Macan is based

Vessels from the limited first-edition run of 25 boats will start from €561,700 (US$600,110). The Fantom Air will be constructed at the Frauscher Shipyard in Ohlsdorf, Austria



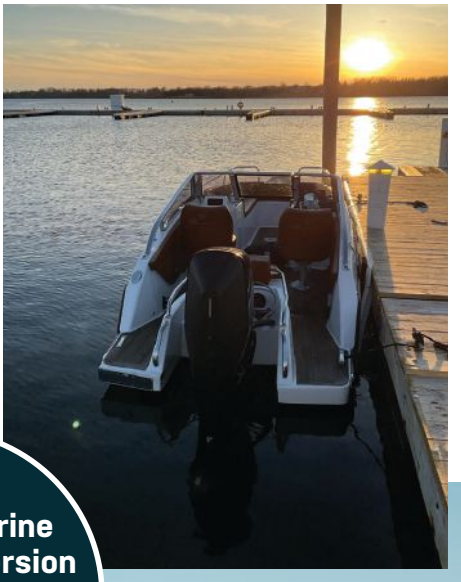
The Fantom Air's permanently excited synchronous electric motor has a limited peak power output of 400kW

MAGONIS
WAVE E-550 FLUX MARINE

Spanish luxury electric leisure vessel manufacturer Magonis Boats has teamed up with US electric outboard motor manufacturer Flux Marine to build a version of its Wave e-550 pleasure craft for North America. Fitted with a 40kW Flux Marine motor integrated into the glass-fiber and GRP-hulled cruiser, a useful 55kW boost gets the boat to planing speeds in just a few seconds, before power drops to give an official range of 29 nautical miles at cruising speeds. The Flux Marine motor makes the US version of the e-550 Wave the most powerful yet, sitting above the 35kW craft with Magonis's own Mag Power powertrain.

Once the 28.65kWh lithium ($LiFeMnPO_4$) battery is depleted, the boat can be charged using a 6.6kW charger compatible with standard 125V/250V 50A AC outlets usually found in marinas or at home. Custom user interfaces on a dedicated Garmin touchscreen are carried over from the regular Magonis Wave e-550 craft and provide real-time system data of speed and charge levels, as well as navigation tools.

First launched in 2021, the Magonis Wave e-550 is a 5.5m, four- to six-person all-electric leisure craft with a top speed of 22kts. Usually powered by a choice of Torqeedo electric motors or Magonis's own electric drive unit, the Wave e-550, with a dry weight of 435kg, is claimed to be the lightest boat in its category. The company's proprietary ECU records data in real time so owners can view information – such as trip visualizations, distance traveled, speed monitoring and autonomy – on the boat's own app. High-end optional features of the Wave e-550 include two 200W Fusion Signature speakers, an integrated wireless smartphone charger, up to six USB charging ports, a sun lounge and a deck shower. Swim decks and full-teak decking are standard.



The Magonis Wave e-550 is equipped with custom user interfaces on a dedicated Garmin screen. The interface provides real-time system data, including speed and level of charge

The Flux Marine powertrain version is available to customers in North America

The fully electric E-GT model weighs in at 5.8 tons, while the diesel-electric E-GTR is a little heavier at 6.2 tons

MAYLA GT

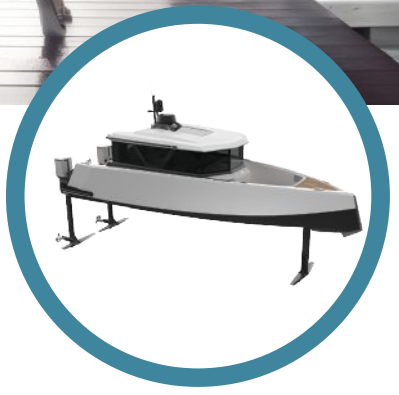
German boat builder Mayla unveiled its GT at boot Düsseldorf in January 2024, claiming that the vessel pays tribute to the speedboats of the 1970s and 1980s. Unashamedly a luxury sports boat, as its name suggests, the Mayla GT has prodigious levels of performance. The electric Mayla E-GT has a pair of 820kW electric engines that give the 13.5m craft a top speed of over 50kts, with a cruising speed of 25kts. The Mayla E-GTR electric-diesel hybrid marries the same electric engines with a 298kW diesel unit, which lifts cruising speed to 30-40kts, with a higher top speed of over 60kts. The boat's structure is designed to withstand speeds of around 100kts – the top speed of the powerful 2,311kW gas-engined GTR-R version.

The hull is made from pre-preg carbon fiber, and has been developed by Swedish engineering office Petestep. The deep-V monohull design features twin transversal steps and patented Petestep deflectors to provide optimized hydro- and aerodynamic benefits. More commonly a feature of offshore racing powerboats, the transversal steps introduce bubbles of air under the hull, pushing top speeds higher. The deflectors redirect spray under the hull to produce greater lift than with a more traditional spray rail. This is said to reduce energy use by up to 35%, and to lower 'slamming' by 50%, resulting in a more stable and quiet ride experience. Mayla's founders, Christopher Gelsdorf and Olivier Arnault, have both worked for premium automotive manufacturers, and the build precision and quality standards match those of the car industry.

Up to eight passengers can bask in the sleek Mayla GT's luxury. Standard features include a double bed, WC, separate shower and a premium audio system. There are sliding sun loungers and shock-damping drivers' seats on deck, and a garage at the stern has room for a jet ski, plus an electric door that becomes a beach club platform at water level.

Mayla sources high-tech carbon laminate from the UAE for the boat structure

Mayla estimates that its use of tunnel prop drive technology increases performance and acceleration by over 10%



Navier's vision of the marine sector's future involves small, high-speed, more frequent waterborne transportation

NAVIER
N30

Due to the enhanced efficiencies and comfort benefits offered over conventional craft, hydrofoil technology is enjoying a resurgence, particularly in the pleasure vessel sector. Notable entrants include Candela with its C-8, but Californian company Navier is also employing hydrofoils on its 9m N30 carbon-fiber craft. Powered by a pair of 90kW electric motors, the N30 is lifted 1.2m above the water's surface when the foils are deployed. The technology is controlled by aerospace-derived flight control. The startup's founders include MIT, Berkeley and CMU alumni with aerospace, autonomy, maritime and robotics experience.

The company's first vessels were developed in partnership with The America's Cup and Lyman-Morse boatyard in Maine. The Navier vessel has a take-off speed of 16kts, topping out at 30kts. Cruising speed is 20kts, with a claimed range from the larger of two battery packs of up to 75 nautical miles. The base N30's smaller battery offers up to 45 nautical miles of sailing distance. The batteries are charged via a 240V overnight shore power connection or, on top-spec models, by a 30-minute DC fast-charging option.

The craft is available in three styles – Open, Hard Top and Cabin – and in Base, Standard and Premium specifications. The smaller battery is only offered in Base specification.

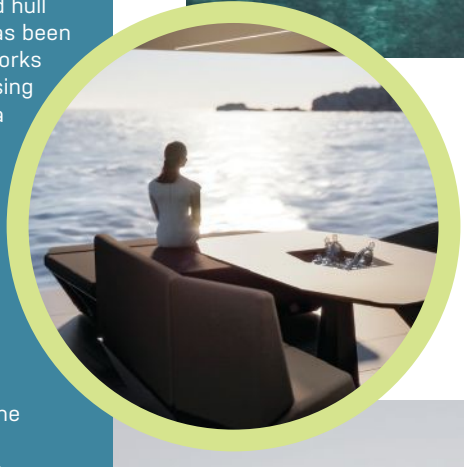
Navier expects future software updates to enable full self-driving capability

The flight control system scans the surrounding sea at various points hundreds of times per second

TYDE OPEN

With the first vessel launch due in January 2025, German luxury boat maker Tyde is plotting an electric course with its foiling luxury yacht named the Open. The 14.7m craft is billed as 'the largest foiling motor yacht on Earth', and promises up to eight passengers a truly luxurious, yet sustainable, sailing experience. As with Tyde's other yacht, the Icon – of which the second hull will be ready in autumn 2024 – the Open has been designed in collaboration with the Designworks innovation hub, a BMW Group subsidiary, using 400kWh of BMW i3 batteries that feature a nine-year capacity warranty.

Employing a pair of 100kW Torqeedo Electric Blue motors – Tyde co-founder and managing director Christoph Ballin used to head up the electric boating mobility company – the Tyde Open has an estimated top speed of 30kts, with a range of 50 nautical miles at a 25kts fast cruise. Active hydrofoil technology helps extend the yacht's battery range through the non-generation of waves or drag, and the company's tandem foiling system features computer-controlled foils and rudders. Tyde claims hydrofoiling achieves 80% energy savings through drag reduction, and the day craft's full-surface solar roof is further proof of the firm's commitment to cleaner yachting technology. Using three-phase charging technology, recharging the Open's batteries to 50% capacity is said to take around two hours.



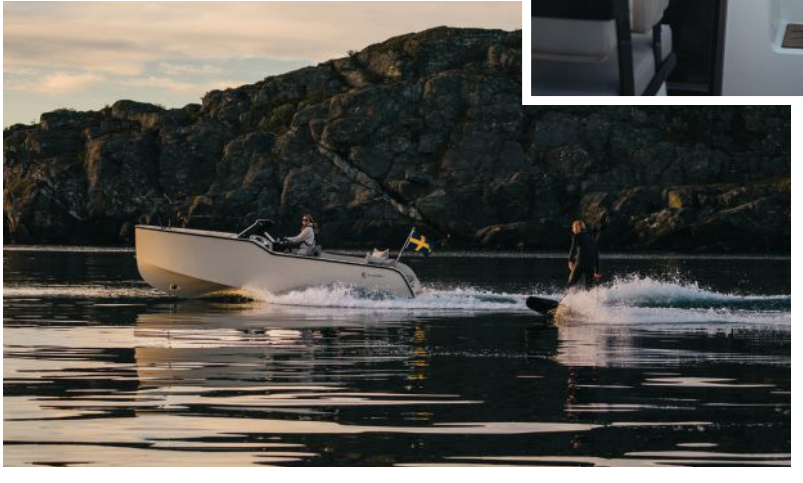
The tandem foiling system on a Tyde is rooted in America's Cup DNA and has evolved into high-efficiency computer-managed foils and rudders

X SHORE 1

Swedish electric boat manufacturer X Shore first set sail into zero-emissions boating with the Eelex 8000 in 2020, but now the 8m-long craft has been joined by the 6.5m X Shore 1. The electric day cruiser is available in Open or Top (fitted with a cockpit tent and a retractable sun roof – full exterior enclosure is also possible) configurations, and with a choice of Utility, Performance or Premium specifications. Powered by a Bosch Engineering 125kW electric motor and a single 63kWh Kreisel KBP63 lithium-ion battery, the X Shore 1 has a top speed of 30kts and a cruising speed of 20kts.

The X Shore 1's weight has been kept down to 1,700kg by use of a glass- and carbon-fiber pre-preg hull, designed for low resistance and maximum efficiency. At lower speeds, the range is 50 nautical miles, while at faster cruising speeds X Shore claims a weather-dependent distance of around 20 nautical miles. When connected to a 45kW fast charger, the battery can be 80% charged in 50 minutes. This increases to three hours when plugged into a 22kW three-phase connection.

The X Shore 1's hull has been optimized for low resistance and maximum hull efficiency



The X Shore 1 enjoys similar performance to the X Shore Eelex 8000 thanks to its 125kW electric motor

Jamie Marley

There is a widely appreciated barrier to the greater uptake of electric vessels: the cost. Builds will never be as cheap as we want, but with the energy storage solution in some cases making up to three-quarters of the total propulsion system cost, there's always going to be a particular focus on the battery cost element of every electric/hybrid project.

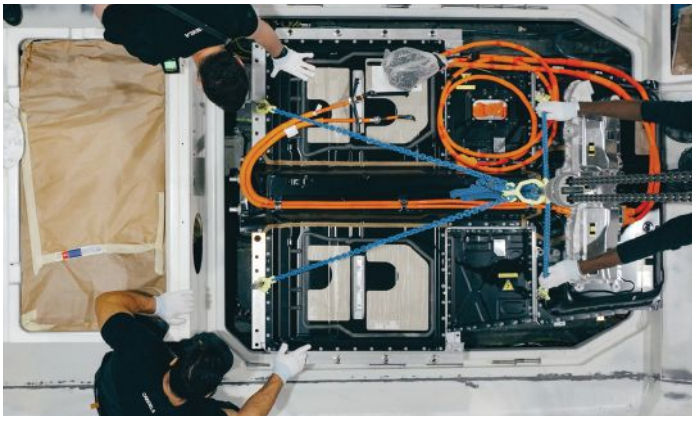
The cost of lithium batteries has dramatically decreased over the last 10 years, and with global demand from the automotive sector, predictions suggest battery cost will continue to drop as manufacturers ramp up production - great news for e-mobility on the water!

But in the wake of the automotive EV boom, used EV batteries can find themselves homeless, even though they are in a great state of health. Around the world, the batteries removed from EVs that are being dismantled prematurely are filling up shelves at specialist companies, awaiting sale. Some never find a second life and must be properly disposed of.

Fortunately, there is a growing number of businesses emerging, filtering out select EV battery packs for applications such as home energy storage, grid batteries, generator replacement, EV conversions and so on.

Most EV battery packs can be safely opened and dismantled down to module level and, in some cases, cell level. This enables savvy businesses to repurpose them into just about any application with a demand. Modern EV batteries also boast some of the best energy densities - the likes of which the marine sector only sees on the horizon.

I have been a keen user, beneficiary and advocate of repurposing these batteries - but the marine industry is yet to widely exploit this supply of second-life, high-quality, low-cost batteries. Rehousing repurposed EV batteries in a marine environment is certainly within our capabilities, and greater challenges can be imagined: getting the necessary approvals and sorting in terms of class type certification, for example.



Candela boats sport Polestar batteries – could a lower-price option, featuring second-life energy storage, represent a viable solution for the future?

Another important consideration is lifecycle analysis and the carbon debt inherited by the new vessels' manufacturing processes. Batteries need to be used across their lifetime to ensure all the energy used to manufacture them does not go to waste.

So, in the case of recreational electric vessels, they see little use and struggle not to increase their carbon debt. Install second-life lithium batteries, however, and we take one more step to clearing up any thoughts that zero-emission vessels might be bad for the planet.

Global demand for lithium batteries is ever increasing, and it's fair to say raw materials have become a sought-after (hopefully not fought-after) commodity. Essential, established industries often get first dibs on raw materials or the finished product. At present, demand from marine applications is low, but embracing repurposed batteries (on the way toward mainstream adoption) is an opportunity for the marine industry to further decarbonize, benefiting from an alternative battery supply solution and remaining competitive.

The EU Battery Regulation entered into force in August 2023, with a digital battery passport becoming mandatory from February 2027. This will enable all batteries to be tracked from assembly to recycling, and further pressure industries to make full use of them.

The electric and hybrid marine industry has already seen vessels benefiting from new EV battery packs, such as Torqeedo's BMW i3 battery used in its Deep Blue systems, Candela's use of the Polestar 2 battery and the Frauscher x Porsche 850 Fantom Air using the auto maker's 100kWh battery. Could the next step be for these vessel manufacturers to offer a lower-cost, second-life battery option?

Jamie Marley works as a consultant and futurist, and has more than 25 years of experience designing and installing marine electrical systems in vessels. His expertise and knowledge of the marine e-mobility transition and technology landscape keep him at the forefront of the issues explored by the industry

California has long been synonymous with hydrogen fuel cell road vehicles, having played host to multiple fleet trials from the likes of Toyota and Hyundai. Beginning this summer, it will also have North America's first fuel cell ferry when the Sea Change enters service on a tourist route along the San Francisco waterfront between Pier 41 and the Ferry Building.

The project has been five years in the making - not just because of Covid-19 but also thanks to the lengthy commissioning and US Coast Guard permitting process. "That takes longer than anyone expects it to," says shipowner Pace Ralli, CEO of Switch Maritime. "It's the first time this technology has been in operation so we're learning a lot as we go and fine-tuning complex systems. We're getting through those commissioning steps and it's looking very good."

The 75-passenger Sea Change will work for San Francisco Bay Ferry, the public transit system that is administered by the Water Emergency Transportation Authority (WETA). An initial six months on the short-hop route promises high traffic and maximum visibility for the new vessel, but with a range of up to 300 nautical miles (556km), other routes are a possibility for the future. Having established a regulatory framework for hydrogen powertrain and storage systems with the US Coast Guard, Switch believes the door is also open for larger ferry designs capable of operating at higher speeds on longer routes.

Powertrain integration

On board the 70ft (21.3m) catamaran are two 300kW BAE Systems electric motors powered by 360kW of Hydrogenics PEM fuel cells (three racks of 120kW) and 100kWh of Xalt lithium-ion batteries - all off-the-shelf, proven components, according to Ralli, but

Change in the tide

Hydrogen power comes to the dock of the Bay this summer in the form of Sea Change, a new fuel cell ferry

WORDS: **GRAHAM HEEPS**

ones that have not been integrated in an application like this before.

"Hydrogenics is owned by Cummins," Ralli notes, "which is great because you want to see some of the big, incumbent players [in the industry] that can provide similar support as they do for diesel.

"Getting all those systems to work together is a large part of the commissioning process," he expands. "You put it all together with an assumption of how things are going to work and learn from there, but we are getting the power that we expected.

"The technology that we have on board is already five years old, because that's when we started the project and ordered the equipment, so a huge learning is how quickly this technology evolves. With today's technology we could probably fit fuel cell towers with four or five times the power in the same amount of space that we have now. That's a massive advantage as we move into our next designs and builds. We're currently working on 150-passenger and 300-passenger designs."

Ralli expects Sea Change to use 25-50kg of hydrogen per day. On the top deck, the vessel has 242kg of H_2 stored in gaseous form at 250 bar. It's currently sourced from the same distributor that serves local automotive gas stations, but Switch Maritime has a green hydrogen project in development. Alongside building zero-emission vessels, enabling the fuel supply chain is part of its business model for helping to accelerate their adoption by existing operators.

"If we have three or four ferries operating in the Bay, then we should have enough demand to be producing our own," says Ralli. "We have a project underway to produce hydrogen with electrolysis using renewable power, right at where we homeport the ferries, but it's going to take a few years to get it built."

He adds that getting the fuel bunkering permitted was another learning point during the commissioning period.

"The Coast Guard and the fire department used to show up, but they don't show up anymore," he observes. "It's not dissimilar to how you would fuel a bus, just more volume. Another big learning during the commissioning period has been working with the operator. Many operators in the US don't have a lot of experience with electrical propulsion systems, so there's a learning curve there as well."

> "We have a project underway to produce hydrogen with electrolysis using renewable power"
>
> Pace Ralli, CEO, Switch Maritime

Future fleet

Ralli says that for the future, Switch will continue in its role as a shipowner: financing the build of new vessels, leading construction and then bareboat leasing or chartering them to operators. In late 2023, it raised US$10m to grow its fleet in a Series A round led by Nexus Development Capital. For now, Ralli's attention is squarely on ensuring the first vessel operates smoothly and reliably. Assuming that happens, he's sure there will be more to come.

"Our first customer, and many of the other expected customers for zero-emission vessels in the US, will want bigger and faster [ships], so that's where we will have to go," he concludes. "We're working on that currently and, if all the factors come together, we will be excited to announce construction of our second vessel, hopefully later this year."

Further fuel for thought

E&H Marine rounds up some of the other exciting hydrogen projects in the pipeline

OceansLab during offshore sea trials, November 2023

Pure Vida Images

OceansLab readies hydrogen fuel cell for 2024 racing season

The OceansLab racing yacht was undergoing a winter refit at the time of writing, following the 60ft (18.28m) IMOCA's (International Monohull Open Class Association) first offshore sea trials at the end of 2023. The boat is being readied for the 2024 racing season, including control system optimization work on its hydrogen-electric energy system.

Supplied by Electric & Hybrid Marine Expo exhibitor Genevos, the 15kW hydrogen power module (HPM) installation is thought to make OceansLab the world's first zero-emission racing boat to feature a hydrogen-electric energy system. In December 2023, Lloyd's Register granted approval in principle (AiP) to the IMOCA hydrogen-powered installation, while in January this year Genevos signed an MoU with ACUA Ocean to develop uncrewed surface vessels (USVs) that integrate hydrogen marine fuel cells.

The company is commercializing 40kW, 80kW and 250kW HPMs. According to Genevos, they can be connected in parallel to achieve higher power and can be applied for hotel loads and/or full-H_2 power propulsion. Multiple modules provide redundancy if one is under maintenance.

The technology can be applied to a diverse range of vessels. Multiple confidential projects are underway, including for high-speed foiling motorboats, service and fishing vessels, work boats, USVs, superyachts and offshore platforms. In the meantime, OceansLab's 2024 race program includes two solo transatlantic races, The Transat CIC and the New York-Vendée, with a further ambition to start the 2024 Vendée Globe as the only non-fossil-fuel-powered IMOCA vessel.

"Our first offshore mileage was sailed in November and the strong winds provided a significant test for OceansLab," said the boat's skipper and Genevos CTO, Phil Sharp. "Being at the start line of the Vendée Globe is a clear aim. In addition to our sporting objectives to enter the race with a competitive package, we have a strong environmental objective to be the first zero-emission IMOCA to complete the race."

Hull rendering of Zero Emission Ships Project's hydrogen-fueled, electric-propulsion ship

Yanmar to develop hydrogen engines for Japanese shipping

As an intermediate step in the transition to zero emissions, Yanmar Power Technology (YPT) is prioritizing development of a pilot ignition six-cylinder that uses HVO as a pilot fuel to co-combust with H_2. Onshore testing is scheduled to start this year. The Nippon Foundation, Japan's largest philanthropic foundation, is targeting this blended engine technology for the main propulsion units of inland vessels. In 2026, it is planning demonstration voyages with a vessel powered by two of YPT's pilot ignition engines.

Around the same time, YPT plans to conduct onshore verification tests of a second project: a spark ignition, hydrogen-only engine. This four-stroke, high-speed engine is being developed for power generation in Japanese coastal vessels as part of the Nippon Foundation's Zero Emission Ships Project. YPT is collaborating on the creation of a hydrogen-engine-compatible, hybrid electric propulsion vessel (pictured) that combines hydrogen engine generators with batteries. A container-unit-type hydrogen power generation system would be situated on the vessel's upper deck.

Shipping company Uyeno Transtech – another of the six Zero Emission Ships consortium members – will be responsible for the vessel's development and construction. The project is accelerating the development of hydrogen-fueled ships to achieve carbon neutrality in Japan's coastal shipping sector by 2050.

Yanmar

Hydrogen-powered cargo vessel ready for Rhine operations

A new hydrogen-powered vessel, the H_2 Barge 2, is entering service to ship goods on the Rhine between Rotterdam, the Netherlands and Duisburg, Germany. The barge is the result of a collaboration between Future Proof Shipping (FPS – a zero-emission shipowner), the EU-funded Flagships project and the Interreg-funded ZEM Ports NS project.

The retrofitted vessel is the first of two hydrogen-fueled demonstrators in the Flagships project. The second is the new-build Zulu 06, a commercial cargo transportation vessel that is scheduled to ply the river Seine in Paris from late 2024.

H_2 Barge 2 is also the second of 10 zero-emission inland and short-sea vessels planned by FPS. First built in 1993 and formerly known as FPS Waal and Fenny 1, the 360ft-long (109.8m) vessel has been retrofitted with six 200kW FCwave fuel cells from Ballard Power Systems. The fuel cells, hydrogen storage, IP67-rated 10kWh battery pack and electric drivetrain are all installed below deck, with the previous fossil fuel tanks and drivetrain having been removed. The conversion work was carried out at Holland Shipyards Group (HSG) in Werkendam, the Netherlands, during 2023.

The vessel was undergoing trials at the time of writing and is expected to be in operation by the time of *E&H Marine*'s publication. With a capacity of 190 TEU, it is expected to save 3,000 tons of CO_2 annually when sailing the Rhine. Its creators note that 80% of all Rhine cargo flows between Rotterdam and Duisburg, so H_2 Barge 2's arrival is a promising development for the switch to zero-emission transportation on this busy river.

The vessel was built as a conventionally powered container ship, and was stripped of its IC engines and fuel tanks in 2023 at Holland Shipyards in Werkendam in the Netherlands

Japan's first biofuel hydrogen tourist ship enters operation

Japan's first hybrid passenger ship to use hydrogen and biodiesel entered service in Fukuoka Prefecture in April 2024. Built at the Hongawara shipyard for the Motena-Sea line (an operating consortium that includes Hongawara and Tokyo-Mitsui O.S.K. Lines – MOL), the Hanaria is said to reduce CO_2 emissions by 53-100% compared with conventional fossil fuel vessels through an innovative propulsion system that incorporates hydrogen fuel cells, lithium-ion batteries and biodiesel-fueled combustion engines.

Hanaria is 33m long, 10m wide and weighs around 248 tons. The 100-passenger catamaran draws 1.4m of water and has a sailing speed of about 10.5kts. It is being used for tourist trips in the Kanmon Straits, the stretch of water separating the Japanese islands of Honshu and Kyushu, operating from the city of Kitakyushu.

Meanwhile MOL is also part of a consortium that has conducted a risk assessment of a hydrogen-powered multipurpose vessel. AiP has been granted by ClassNK for a parcel layout concept that puts the H_2 tank on the vessel's rear deck. It's said to be the world's first AiP certification for a ship equipped with a low-speed, two-stroke hydrogen engine as the main propulsion unit.

Two years of demonstration operations are expected to begin in 2027 as part of a project that has attracted government funding through the Green Innovation funding program of Japan's New Energy and Industrial Technology Development Organization (NEDO). Japan Engine Corporation's (J-ENG) large, low-speed two-stroke hydrogen-fueled engine and Kawasaki's marine hydrogen fuel tank and fuel supply system (MHFS) will be installed in the vessel by 2026. MOL and MOL Drybulk will own and operate the vessel, which will be developed and built by Onomichi Dockyard.

The proposed hydrogen-fueled multipurpose vessel has a deadweight of 17,500 metric tons

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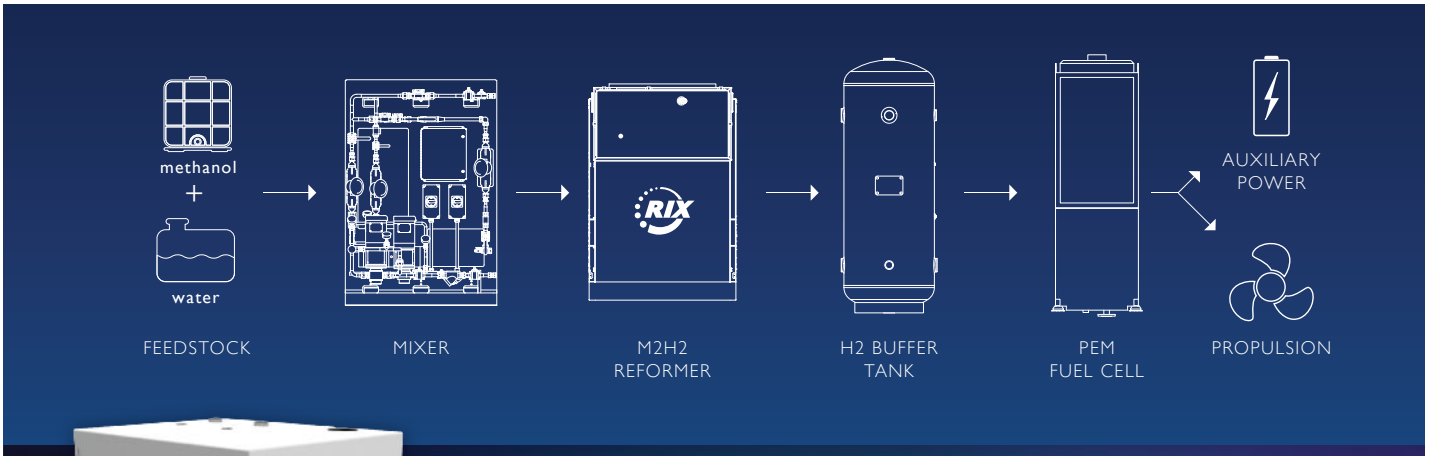

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Tough cells

E&H Marine discovers the role of existing and emerging chemistries in the ruggedization process for battery systems expected to perform safely on the water

WORDS: **RICHARD GOODING**

As the marine sector pushes ahead with electrification, system demands are becoming ever more complex. Increasing power density requirements are only one factor that a vessel operator needs to consider when specifying batteries as part of an electrified powertrain.

"The most suitable battery chemistry is driven by several factors: actual application, capex/opex - investment and operational costs, and the onboard location and installation," says Arjen Zijlmans, project manager at C-Job Naval Architects. "In terms of the operating profile, batteries have different applications, such as spinning reserve, peak shaving and energy harvesting, as well as being the main energy source."

With regard to investment and operational costs, Zijlmans says, a maritime battery energy storage application must respond to the specific energy and power demands, so the lifecycle expectations need to be considered.

"To arrive at an optimum package, a well-engineered system with a detailed operational profile needs to be made up front," he comments, adding that there is no one type that suits all situations.

The duty cycle of a particular vessel plays a role in determining the technologies used. Jaap de Jonge, director at JR E-Yachts, refers to the automotive industry, where an EV may have a 300kW motor and a 60kWh battery, resulting in a battery-to-motor ratio of 5:1. An electrified leisure or fast sailing craft may have a similar specification, but because of the varied

Main and right: EST-Floattech systems will carefully consider system requirements when determining the best battery chemistry and specification

environmental conditions, could be at full throttle for 10-20 minutes, running batteries hot.

"I believe the battery should be at least two times the power of the motor," de Jonge says. "We try to stay at 0.5C – the ratio between the power of the motor and the battery size. At cell level, 1kWh and 1kW usage is a ratio of 1C. That's mostly the maximum discharge a cell can do continuously," he adds.

"The duty cycle is absolutely the priority, because if you don't know how much energy you need to use, you can't move on from that," says Eugene Bari, CEO at marine propulsion and energy storage specialist Ecomar Propulsion. "The duty cycle dictates that energy, and that dictates the vessel. This dictates the choice of batteries, the form factor and everything else. The really big thing is the marine environment is not an automotive environment. While energy density is important, the continuous power delivery far outweighs everything else."

Best fit

Diederick Stam, technical director at energy storage system supplier EST-Floattech, says preliminary conversations with the customer partly dictate the chemistry used on board. "For each application we make calculations based on the load balance we receive from the customer," he explains. "We look into what's the best fit for the types of cells being put into the modules, either high power oriented or high energy oriented."

Zijlmans adds, "Currently, most battery systems are based on lithium-ion – nickel manganese cobalt oxide (NMC) – and lithium iron phosphate (LFP) technology, particularly for costs and specifications." Both of these chemistries have their pros and cons.

Gijs Wolbert, co-founder of Dutch battery manufacturer Ionbase (whose batteries use LFP) says the chemistry has a major role to play over the next decade.

"LFP will remain very hard to beat for several years," he says. "Performance is increasing every year, and although LFP batteries do have a slight trade-off in weight, this is usually not an issue aboard vessels. A niche exists for NMC batteries offering higher energy and power densities than LFP – with a marine-grade battery pack energy density of around 150Wh/kg versus 110Wh/kg for LFP – but they cannot match LFP for safety. NMC should only be chosen when weight plays a very critical role," Wolbert adds.

Lithium titanium oxide (LTO) – and other chemistries – is also deemed to be secure, and this is favored by battery system supplier Echandia in its heavy-duty applications.

"LTO has been misjudged as heavy, with less energy density than competing chemistries," says Magnus Eriksson, Echandia's founder and chief strategy officer. "However, in a complete system it makes up for its lower energy density per kilogram."

One benefit of LTO is its ability to discharge more of its available energy over greater periods of time, resulting in less need for oversizing, reducing the size and weight of an ESS. Capable of recovering up to 90% of its capacity after 20,000 charge/discharge cycles, LTO uses lithium titanium oxide rather than graphite as an anode material.

Above: An Echandia LTO rack in the workshop

Right: EST-Floattech's modular battery system is designed for container spaces

"LTO has been misjudged as heavy, with less energy density than competing chemistries. However, in a complete system it makes up for its lower energy density per kilogram"

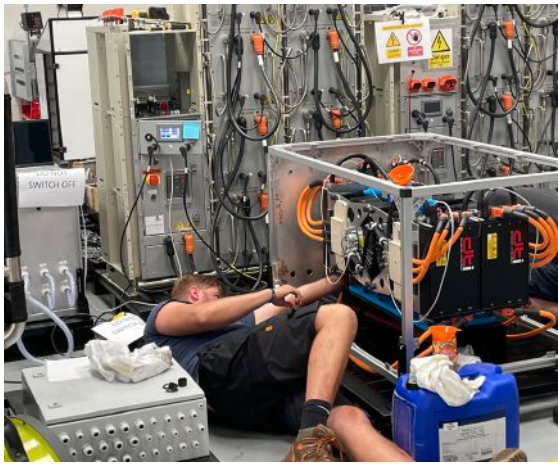
Magnus Eriksson, founder and chief strategy officer, Echandia

Right: Ecomar determines the duty cycle for a vessel, which then determines the various choices in terms of battery type, form factor and so on

"A major problem for Li-ion batteries, and a cause of undetectable internal short circuits, is dendrite build-up," says Eriksson. "LTO anode material doesn't use carbon, so there is no issue." This build-up causes cells to degrade more quickly and, as the dendrite level grows, the separator material between the anode and cathode can be pierced, causing a short circuit.

"To optimize a storage system, the actual required voltage to supply the ship's installed system could lead to a certain amount of required modules," Zijlmans says. "It is also favorable to bring the power source as close to the consumers as possible. For new-builds, this is a major part of the design process; for retrofits, it can be more challenging."

Bari believes battery form factor is also important. "A typical ship has a deep keel and a flat deck, and a cubic form doesn't fit easily into that," he says, adding that bigger, vertically racked systems create a second set of problems. "Unlike land-based vehicles, a ship has buckling loads. It moves in every dimensional orientation, transferring loads into the frame holding the battery cells and modules. The modules are fairly robust, but if a battery box weighing 300-400kg moves through 30° or 40° arcs in every direction, that's a lot of stress. How the ship is put together has to change because it needs to rigidly hold that."



Modular battery design and installation can help with safety.

"A commercial vessel has different compartments in case it has a collision and its hull cracks open," explains de Jonge. "Even with one compartment damaged, it can remain afloat. The same approach can be taken with battery packs." Packs can be split over different compartments that can be flooded, and if one battery set is discarded, another is still available.

"The only way to make a battery system truly safe is by having as few single points of failure as possible," says Wolbert. "Marine battery systems should be modular and able to continue operation after several components have failed."

"Battery spaces can be very odd shapes, and a modular system is easier to install," explains Stam. EST-Floattech's modular system is optimized for container solutions. "We have string controllers, and a system controller that consolidates a group of strings toward the system integrator that will be handled as a single battery bank through the system controller," he says.

Bari says that although chemistry changes have brought diminishing costs, as well as increasing energy densities and battery capabilities, it is battery management systems that have seen the biggest advances.

"The biggest sea change was the BMS," he states. "Cell-to-cell transmission, thermal

Ionbase batteries use lithium iron phosphate. Co-founder Gijs Wolbert (pictured on the right, alongside founder Bram ter Meulen) believes this chemistry has a major role to play in the marine sector

"We try to stay at 0.5C – the ratio between the power of the motor and the battery size"

Jaap de Jonge, director, JR E-Yachts

runaway and current surges, all these have to be managed through the BMS, which has to be really well versed and capable of going down to cell level."

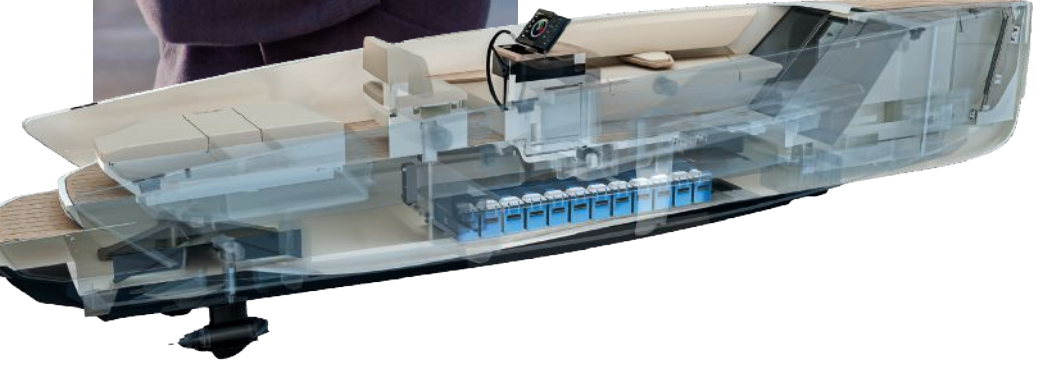
Shock and vibration assistance

The combination of battery chemistry and the unique marine environment have a bearing on the ruggedization requirements needed.

"Shock and vibration resistance is vital," states Wolbert. "Typically, batteries are installed in dry areas, but marine batteries should be waterproof. We only produce IP67-rated batteries."

However, installing batteries in an enclosed compartment means that in the event of thermal runaway, the enclosure can be flooded.

"Water is pumped in or the vessel is sunk," says de Jonge, adding that the design of the craft must be optimized for this eventuality.



"If a hull is designed well, especially for commercial vessels, a large pump is needed with an overflow that only floods the battery room so the vessel stays afloat. Only the batteries will be destroyed."

Stam explains, "The battery room needs to fulfill agreed safety requirements. There should be a fixed firefighting system, and temperature, ventilation and cooling control. We use a passive safety system. If a cell goes into thermal runaway, if you don't do anything it will be contained into one module. But at other indicated times of danger, such as a fire near the battery room, water cooling works very well. If you want to control the temperature inside the room, a water mist or a sprinkler system will help cool down the battery space and the batteries."

In most cases, battery safety testing is primarily carried out at the supplier level, with little need to retest once integrated on board.

"Testing programs have been developed, determined and recorded by the International Electrotechnical Commission and are the same across industries," says Zijlmans. Test standard IEC 62619:2022, for example, consists of at least six cell-level and four system-level evaluations.

As in other industries embracing electrification, battery selection is key to the success of current - and future - marine systems. Throw in the added complexities of marine environments and complex safety considerations and it makes for a challenging proposition - but one that the industry's leading minds are keen to address.

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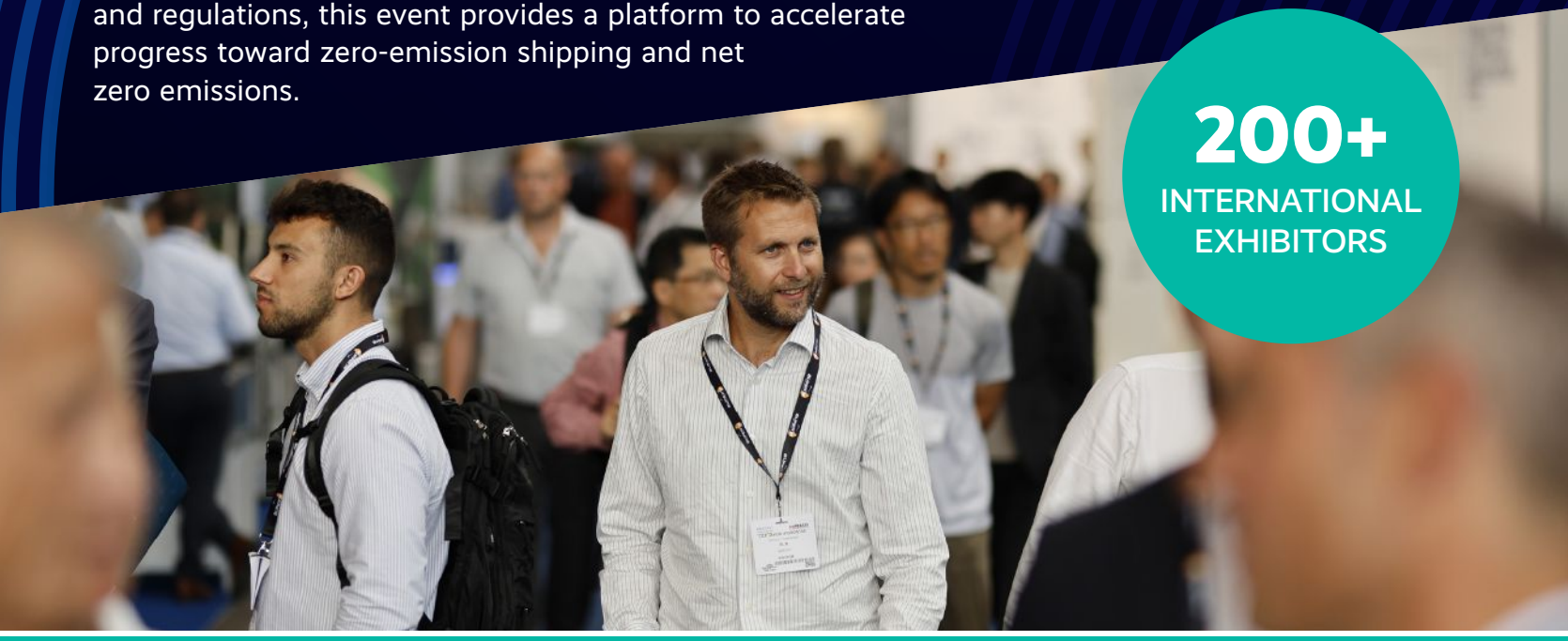

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Taking the helm

Accelerated by technological developments and economies of scale from other markets, autonomous operation could provide the key to more cost-effective electric vessels

WORDS: **ALEX GRANT**

From the factories of the Industrial Revolution to the data centers powering cutting-edge artificial intelligence, few concepts have transformed modern society quite like automation – and transportation is next in line. Unmanned vehicles promise safer, less energy-intensive and more cost-effective transportation, and automation could become an important technology for a maritime sector that's under growing pressure to find alternatives to fossil fuels.

The experts at Norwegian ferry developer Hyke believe that, as has often been the case for roadgoing vehicles, urban areas will be an important early market for both technologies. The company's battery-electric shuttle concept is designed to reduce on-land congestion by providing a cost-effective transit solution for inner-city waterways. It features a shallow hull to improve efficiency, standardized parts for easier mass production and a sensor suite enabling partial or full automation with the flexibility to adjust those operations after deployment.

"Electrification in the maritime sector is vital for everything we do," comments Ola Hjukse, Hyke's chief product officer. "The combination of an electrified powerplant and flexible automation system allows you to learn the best way of using a vessel and to implement those lessons directly. You don't have to design yourself into an operational envelope."

Both technologies are becoming more affordable. Hyke uses batteries from trucks, adapts automotive-grade sensors for marine applications, and uses the open-source Robot Operating System 2 (ROS 2) software as a foundation for autonomous operation. Hjukse believes the early business case for electrification is enhanced by automating outdated and labor-intensive processes, such as docking. The shuttle has a 7kW rooftop solar array and intelligent docking system with wireless charging, which combine to extend the run time without requiring larger, heavier and more expensive batteries.

"I don't think it's an accident that the increased level of electrification in the maritime market trails the automotive industry by a couple of years," he says. "[With automation] we are trying to ride on the coat-tails of the automotive industry and use, as much as possible, lessons learned because the volume is so much greater. If all shipping industries [install] sensors on board the vessels, it will take years to catch up with the data that the automotive industries have already captured. We are trying to learn from that as much as possible."

Kongsberg Maritime's SVP of remote and autonomous solutions, Pål Andrè Eriksen,

> "The combination of an electrified powerplant and flexible automation system allows you to learn the best way of using a vessel"
>
> Ola Hjukse, chief product officer, Hyke

Main: Hyke builds autonomous vessel control technology into its vessels, enabling development, validation and approval of autonomous operations

Right: The Hyke shuttle concept has an energy consumption of 10-12kWh/hour at 6kts, a max speed of 15kts and a battery capacity that can be specified between 95kWh and 285kWh

Redesigned ports

Unmanned vessels could require a rethink of landside infrastructure as well as the ships themselves. Zulu Associates' Antoon Van Coillie (left) says ports will need to have either onshore crews who can moor ships, or magnetic or suction-based machines that can do so, and automating that process requires an exchange of information.

"Instead of the human in the port giving instructions to the person responsible for the vessel, vessels will need to speak directly to the lock and get information without human intervention. The port of the future would be created for that," he says. "In a big port, you would know all the ships' routes and waypoints and as an operator you would know the situation at 12 o'clock tomorrow, identify a dangerous position and intervene."

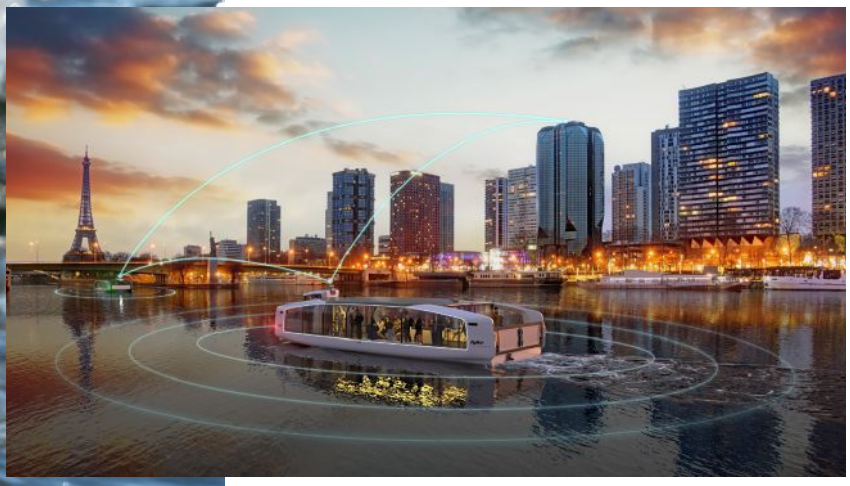
With no standards in place for those interactions, Hyke provides standardized jetties to enable easier deployment. These are equipped with an intelligent docking system, wireless charging and an optional backup battery to reduce the need for grid connection upgrades.

The company's Ola Hjukse explains, "We designed our jetties with the primary goal that it should be easy not only for a human to dock here but also for our computer."

forecasts similar early use cases. The company provides a full suite of propulsion, energy storage and bridge systems, which can be combined into automated functions – a process made easier for customers by sourcing them from a single supplier, he says. Applications span a wide variety of vessels, including battery-powered ferries in Oslo that have completed more than 10,000 automated docking and transit maneuvers.

"There have been significant advances in the deployment of remote and autonomous technologies across several sectors in the past decade. What's common across all sectors, including shipping, is that this technology is being used to solve specific problems – it is not just autonomy for autonomy's sake. Technology is being added incrementally," he explains.

"In the car industry, systems such as automatic braking, parking assist and satellite navigation now come as standard. In a similar way, Kongsberg Maritime sees systems such as collision avoidance or auto-docking becoming standard items on certain vessel types in the next decade."



Getting connected

Connectivity is a bottleneck for open ocean use, which means early adopters are mostly coastal or on inland waterways. The technology has automated two electric barges for Norwegian grocery distributor ASKO and the MV Yara Birkeland, a container ship used to carry fertilizer, all of which are shifting cargo volumes away from trucks. These use cases are an important opportunity to gather data, verifying the technology and informing regulations before fully autonomous vessels begin commercial operation in the longer term. They will also help to build trust, Eriksen says, which is important as full efficiencies will be

New skills

Shipping is facing a prolonged global shortfall in seafarers, reaching 9% of the global pool in 2023 according to consultancy Drewry. The deficit, it says, is a legacy of Covid-19 disrupting training and leaving crews stranded. It is not expected to improve by 2028.

Kongsberg Marine's Pål Andrè Eriksen believes automation and remote operation could help to close that gap. New technology would, he says, enable individuals to control multiple vessels and move some traditionally seafaring roles on land, making them accessible to those who don't want to spend long periods away from home.

The UK's South Hampshire College Group is hoping to help students access those jobs, purchasing a digital training vessel (DTV) using Robosys Voyager AI. This can be remotely controlled either within line of sight or from the classroom, providing hands-on experience of using USVs as career opportunities grow in offshore wind farms, hydrography, defense and marine sciences. Robosys has similar partnerships underway in the USA.

"The traditional jobs are going because digitalization and electrification are allowing more opportunity in the marketplace and more mobile working. You could be a USV pilot and do a six-hour shift, go home for 12 hours, pick up the kids from school, have Sunday lunch and then go back for your next shift. You don't even need an airplane ticket to get there," explains Robosys's Nigel Lee.

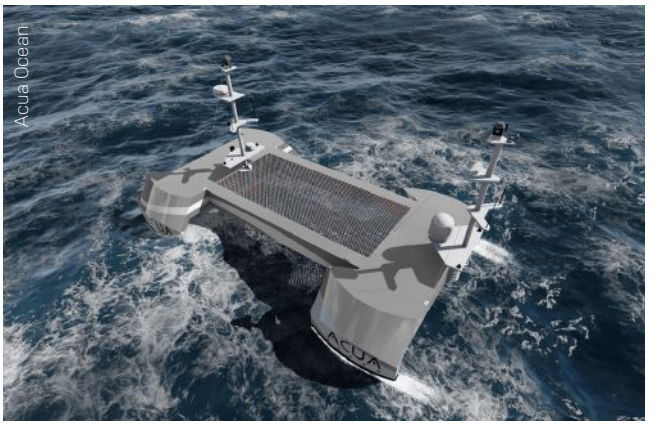
unlocked by designing vessels without human crews in mind.

"Remote and autonomous systems can help manage fuel and energy use, making smart decisions to optimize the voyage - for example, acceleration, slow steaming, route selection," Eriksen says. "Future unmanned ships would also be much simpler in design, with fewer costly subsystems to support a crew - this reduces the weight of a ship and the amount of energy required, and could also increase cargo capacity."

Wärtsilä has commercialized 360° situational awareness solutions, and managing director Torsten Bussow sees automation as a next step from today's unmanned engine rooms.

"The business case for autonomous vessels is the ability to undertake commercial operations with fewer crew, reducing labor costs. Electric propulsion is a key way to reduce maintenance efforts and enable operating vessels efficiently and safely without requiring a large crew presence," he says, noting one limiting factor.

"The use of electrification systems does naturally restrict the types of vessels that can adopt [autonomous] technology. For instance, smaller vessels and those traveling shorter and more predictable distances, such as those operating on inland waterways, short sea shipping or ferries, as frequent docking enables charging of batteries."



In the UK, Robosys is reporting growing demand for its AI-supported sensor-agnostic software platform, particularly for military and surveying operations. Chief strategy officer Nigel Lee cites improved availability of digital electric powertrains and communications infrastructure such as Starlink as enablers, with growing demand for solutions that meet NCA and IMO requirements for mission continuity and cybersecurity.

The company's system provides collision avoidance - explaining actions to human supervisors - or lock-on to objects for search and rescue, and will either continue to the next waypoint or return to base if it loses comms. It's used by Acua Ocean's hydrogen-powered survey platform, which can spend between 40 and 60 days at sea between short changeovers, maximizing its uptime.

Customers are finding other efficiencies, too.

"Over the last five to eight years, people have been experimenting with ones and twos. Now they're saying they want our software to automate a fleet of unmanned surface vessels (USVs). They want one operator here to log in to a USV, come off watch then log in six hours later to a USV over there. The business model is expanding," says Lee.

"A lot of customers are looking at USVs as a Service - particularly surveying - deploying them and not getting them back for several weeks. During that time, they've been tasked in support of two or three end users."

Antoon Van Coillie, CEO of Zulu Associates, believes automation provides the improvements in operational efficiency needed to offset higher energy storage costs for hydrogen or battery-electric ships compared with their fossil fuel counterparts. The technology would ensure vessels follow set routes without deviation, enable them to operate 24 hours a day, and could provide more accurate scheduling for cargo. In turn, it could maximize profits for operators, all while improving working conditions for seafarers.

Top: Acua Ocean designs, develops and deploys hydrogen-powered autonomous surface ships

Above: The MV Yara Birkeland will reduce diesel-powered truck haulage by 40,000 journeys a year

Left: Kongsberg Maritime's Pål Andrè Eriksen

Above and right: The impact of autonomous technology will also be felt in harbors and ports, and will likely lead to changes in the infrastructure used to moor, charge, service and supply vessels

"Electric propulsion is a key way to reduce maintenance efforts and enable operating vessels efficiently and safely without requiring a large crew presence"

Torsten Bussow, managing director, Wärtsilä

Rough seas ahead

However, there are bottlenecks to overcome.

"Whether you're talking inland shipping or open sea, the regulators such as CCNR and IMO are really falling behind," says Van Coillie. "There's a lot of change already, and indeed openness to approach change at both institutions, but I think it should go much faster. We don't have enough seafarers. Being a seafarer is a tough and socially difficult job. Why do we need to put people in those jobs, when we could have machines do the job?" he asks.

"There are also people with legacy assets and a resistance from the guys in the ports, saying they will never load or unload an autonomous ship. Those are the two main obstacles."

The company is developing two autonomous vessels: the X-Barge, a 1,500-ton deadweight low-to-zero-emission dry bulk container barge for inland routes, is undergoing final construction design; Zulu Mass, a crewless zero-emission short sea vessel with a 200-container (TEU) capacity, extends the concept further, testing solutions including wind blades, wave foil propulsion and containerized batteries.

Unmanned vessels also reduce inefficiencies within traditional crews, which tend to have spikes of activity within a journey, Van Coillie says. Predictive maintenance and redundancy within the powertrain would reduce the need to have engineers on board to fix minor faults, while larger issues with crewed vessels usually require offboard assistance anyway. Those engineering jobs can be undertaken in port, creating new roles on shore.

"What is important for people to realize is that, because of digitalization, we should not automate what humans do," he concludes. "We have to reinvent the types of vessels and all the systems around them. We need to reinvent how we do shipping."

E&H Marine discovers how the high-performance – and high-luxury – superyacht sector is embracing electrification technology

WORDS: **RICHARD GOODING**

CLEAN

LIVING

As well as enhancing a vessel's environmental credentials, the use of zero-emissions propulsion can improve the owner and operator experience, and in the case of superyachts, add to the sense of luxury.

One clear benefit of electrification is the reduction in noise and vibration when batteries are used instead of generators.

"When generators are required, they can be used in conjunction with the batteries to reduce the number of generators needed at any one time," explains Jim Mair, technical director at Arksen. Smaller generators can also be used, with vessels propelled silently in electric mode for short periods. A reduction in fuel consumption overall and at efficient cruising speeds due to reduced generator running hours is welcome. The Arksen 85 is powered by a Praxis Automation diesel-electric serial hybrid system and Mair says electrification enables the futureproofing of vessel drivetrain and power systems. "Batteries are installed in a way that allows for straightforward replacement as technology progresses and energy density improves," he explains.

Luciano Cardini, chief technical officer at Wider Yachts, agrees.

"The powertrain system as a whole is modular, in the sense that the individual macro components (batteries, generators, electric motors) can be updated independently of each other," he explains. "Serial yacht architecture can be constantly updated with the latest technology, significantly slowing 'technological aging'."

The first unit of the 28m WiderCat 92 composite catamaran was completed in January 2024, featuring a pair of electric motors delivering 500kW each to the thrusters, with two 349kW variable-speed generators for electrical energy production.

Electrification also gives luxury superyachts the opportunity to employ a number of other sustainable technologies.

"When you look at the operational window of a standard yacht, [there are periods when] it's not

Superyachts such as the Cosmopolitan 85 tend to have different use profiles from vessels in other sectors – and this must be considered when specifying any electrified propulsion system

The Moonflower 72, a 72m steel and aluminum superyacht joint project designed in conjunction with Nauta Design, uses Wider Yachts' hybrid propulsion system with two 1,860kW variable-speed generators and a 1MW sodium nickel battery bank

used – it's not always embarking on non-stop journeys like a commercial craft," explains Iván Salas Jefferson, naval architect and managing partner at Cosmopolitan Yachts. Luxury craft mostly sit at anchor or in a marina, and Jefferson welcomes this chance to streamline power consumption.

"We see it as a huge opportunity to embrace electrification, and specifically solar energy. From the consumption charts and load balances we see, most of this comes from the use of generators, air-conditioning and onboard systems. When you compare the consumption – the hotel load with the available power you can get from solar, for example – it makes sense," he says, adding that electrification also makes sense for shorter trips, or to improve efficiency and redundancy on longer trips.

"By separating the propulsion function from power generation, the serial diesel-electric hybrid system allows the thermal engines to operate at optimal RPM, resulting in higher efficiency and reduced fuel consumption for a given power output," says Andrea Micheli, chief commercial officer at Southern Wind. The company builds yachts fitted with a diesel-electric serial hybrid propulsion system designed in collaboration with BAE Systems. Christened HybriGen, the system has zero-emissions capability and a hydrogeneration mode to recharge the lithium-ion energy storage when under sail – up to 35kW can be regenerated at speeds of up to 16kts.

The Arksen 85 uses a diesel-electric serial hybrid system supplied by Praxis Automation. The fully integrated platform has three 200kW variable-speed generators that provide power to two 250kW electric motors and two 80kW lithium battery banks, connected to a twin-screw, fixed-pitch propulsion setup

Alessandro Rossi, chief technical officer at Azimut|Benetti Group, sees improved efficiency as a key highlight.

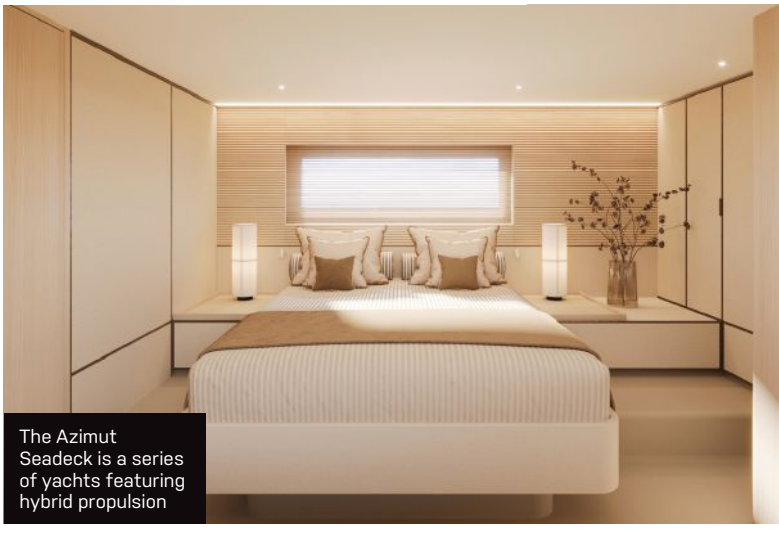
"Electrification facilitates higher levels of efficiency and safety, thanks to the redundancy in the power and propulsion sources," he reports. "The electric motors can provide additional power to the main engines as boosters for acceleration, or fast-charge the battery packs, supporting the hotel mode at anchor. These features reduce the operational hours of endothermic engines, enabling the extension of scheduled maintenance periods."

Rossi also believes hybrid systems and advanced battery technology offer yachts an opportunity to significantly downsize generators, and even make them superfluous.

"At the same time, the adoption of electric grids enables the transition from traditional hydraulic systems to electric drives and actuators for many auxiliary components such as stabilizers, thrusters and actuators, which are notably smaller and lighter. This can result in more spacious and comfortable living areas for passengers," he says.

"Engines can be shut down temporarily depending on the battery size, and the engines can be loaded on the most efficient points"

Giedo Loeff, head of research and development, Feadship



The Azimut Seadeck is a series of yachts featuring hybrid propulsion

Increased comfort

This additional comfort is a big draw in all sectors – but is of particular relevance to the superyacht industry.

"By managing loads and excitation of the gensets, as well as reducing local emissions to a minimum, the main advantage is the increased comfort," says Giedo Loeff, head of research and development at Dutch vessel building company Feadship. "Engines can be shut down temporarily depending on the battery size, and the engines can be loaded on the most efficient points. In the transition to fuel cells and dual-fuel engines, load responses of power systems decrease. Therefore, a PMS and DC grid will enable ideal use of fuel and management of the lifetime of the power system components."

"The biggest benefit is the added comfort for guests on board," agrees Peter Van Der Zanden, general manager of design and development at Heesen Yachts, whose 2017 vessel, Home, was the world's first fast displacement hull form (FDHF, which enables yachts to save up to 30% in fuel consumption) with hybrid propulsion. "When the yacht is being powered by diesel-electric, you can cruise almost silently at a speed of up to 12kts. A yacht can leave a marina early in the morning and cruise to another destination without guests being woken or disturbed," he adds.

Heesen is continuing to see a demand, and will deliver its third FDHF hybrid model, the 50m Project Orion, in Q2 2025. Heesen's drivetrain doesn't employ battery power, but consists of two diesel engines, a pair of diesel generators and two electric motors that operate separately or together in various combinations thanks to power management software. Similar to Loeff, Van Der Zanden points to drivetrain lifetime improvements with electrification, saying, "A lower workload for the traditional engines results in increased longevity for the entire propulsion system."

Green spaces

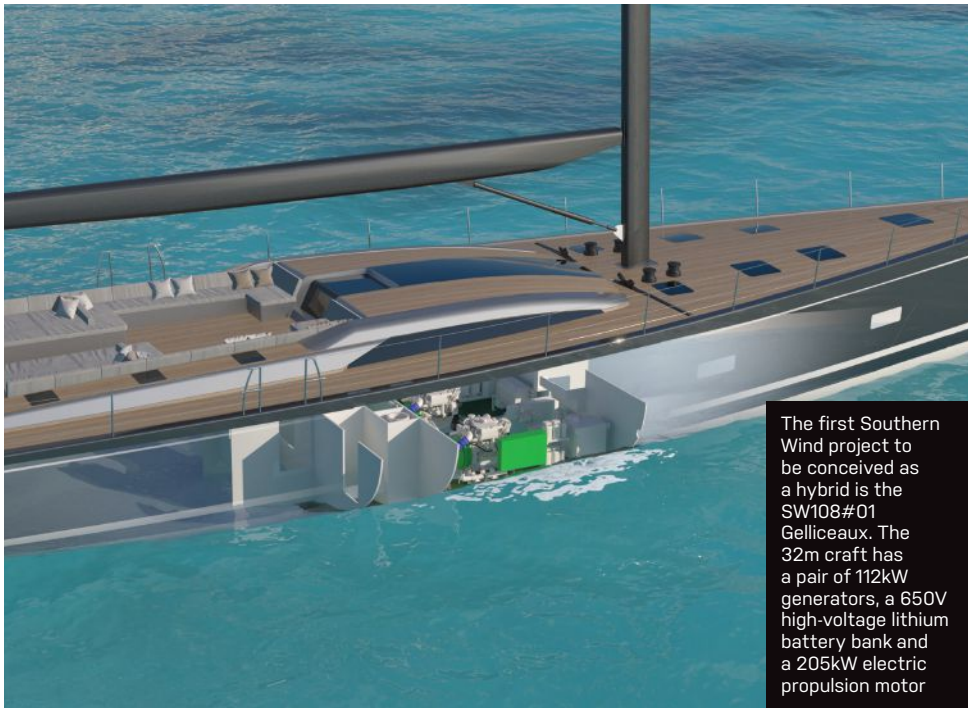
Through the packaging benefits offered by an electrified powertrain, land-based electric vehicles often feature improved cabin and stowage space, and this flexibility is also afforded on board a luxury vessel.

"Electrified drivetrains give the designer more flexibility in terms of where generators, batteries and key infrastructure are positioned on board, relative to the actual propulsor," says Mair. "For example, if a client wanted a particular piece of equipment in the engine room of an Arksen 85, we could rearrange the positioning of the generators to an extent to accommodate this, as they are not mechanically connected to the drivetrain as with a conventional shaft-driven vessel," he adds.

"Electric drives provide inherent flexibility, a great advantage in superyacht design," agrees Loeff. "We can keep all power systems on the tank deck, with accommodation on the lower deck, from bow to transom."

"Aside from components, we also rethink the way [an electrified] boat is used"

Yann Dabbadie, technical manager, Southern Wind



The first Southern Wind project to be conceived as a hybrid is the SW108#01 Gelliceaux. The 32m craft has a pair of 112kW generators, a 650V high-voltage lithium battery bank and a 205kW electric propulsion motor

"High-performing, compact electric motors allow freedom from endothermic engines and their auxiliary systems," Cardini adds. "The technical rooms can be distributed in strategic areas of the vessel. This allows the designer freedom to choose the most optimal layout."

Jefferson agrees there is more design flexibility with electrified propulsion: "It definitely gives you more flexibility on the operational side, because you have four different systems to move the boat, especially on a catamaran - two main engines, two e-motors, two small generators and a battery bank. There is a lot of redundancy, which makes sense with long-range operations or standalone time.

"Styling also needs to be considered," he adds. "Integrating solar panels was a challenge visually, and you have to optimize for different operational ranges, so pushing toward electrification does have a big impact. Our lift flybridge roof allowed us to optimize the solar power generation when the flybridge was not in use."

New approaches

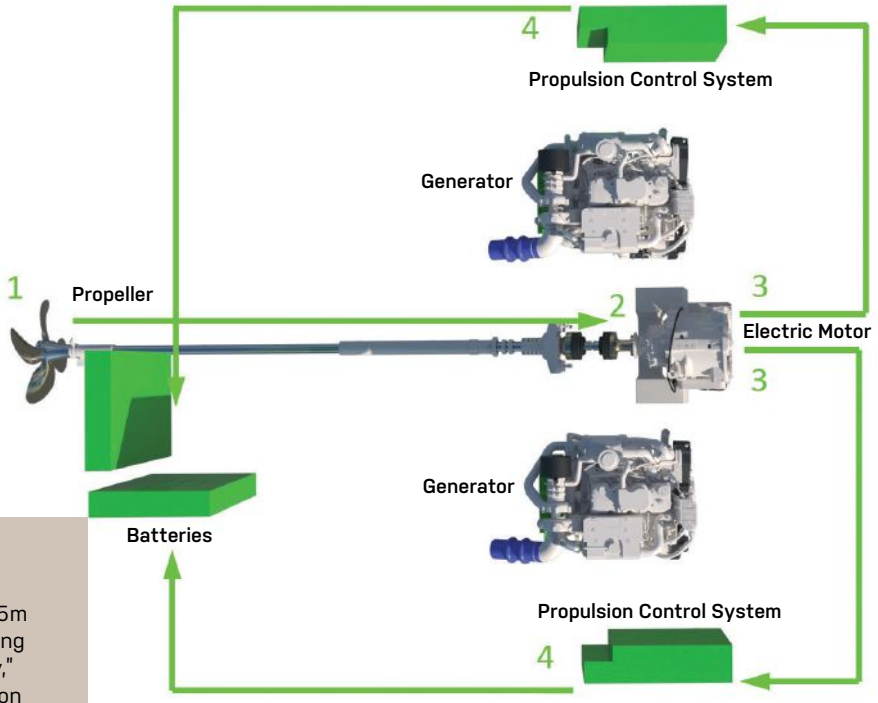
Designing a superyacht around an electrified propulsion unit does require a different perspective from more conventional craft (see *Different by design*, opposite), explains Yann Dabbadie, technical manager at Southern Wind.

"A diesel-electric propulsion system is approached completely differently from a standard diesel system. We have high-voltage cables, a glycol cooling system and a CANbus system for information and control," Dabbadie says, adding that this mostly impacts engine room design. "We have to go into finer details for equipment placement and installation. Aside

The WiderCat 92 is equipped with a serial hybrid propulsion system, and is capable of running in zero-emission mode

Below: The engine room aboard the Gelliceaux

Right: The vessel's propulsion system schematic



Different by design

When compared with a pure diesel drivetrain, electric and hybrid propulsion units require certain special design requirements to harness the efficiency and other benefits on offer.

"A high-power system is associated with considerable electrical components and cabling," Feadship's Giedo Loeff explains. "Bearing in mind superyachts are only outclassed in terms of compactness by naval subs, this is a hell of a job."

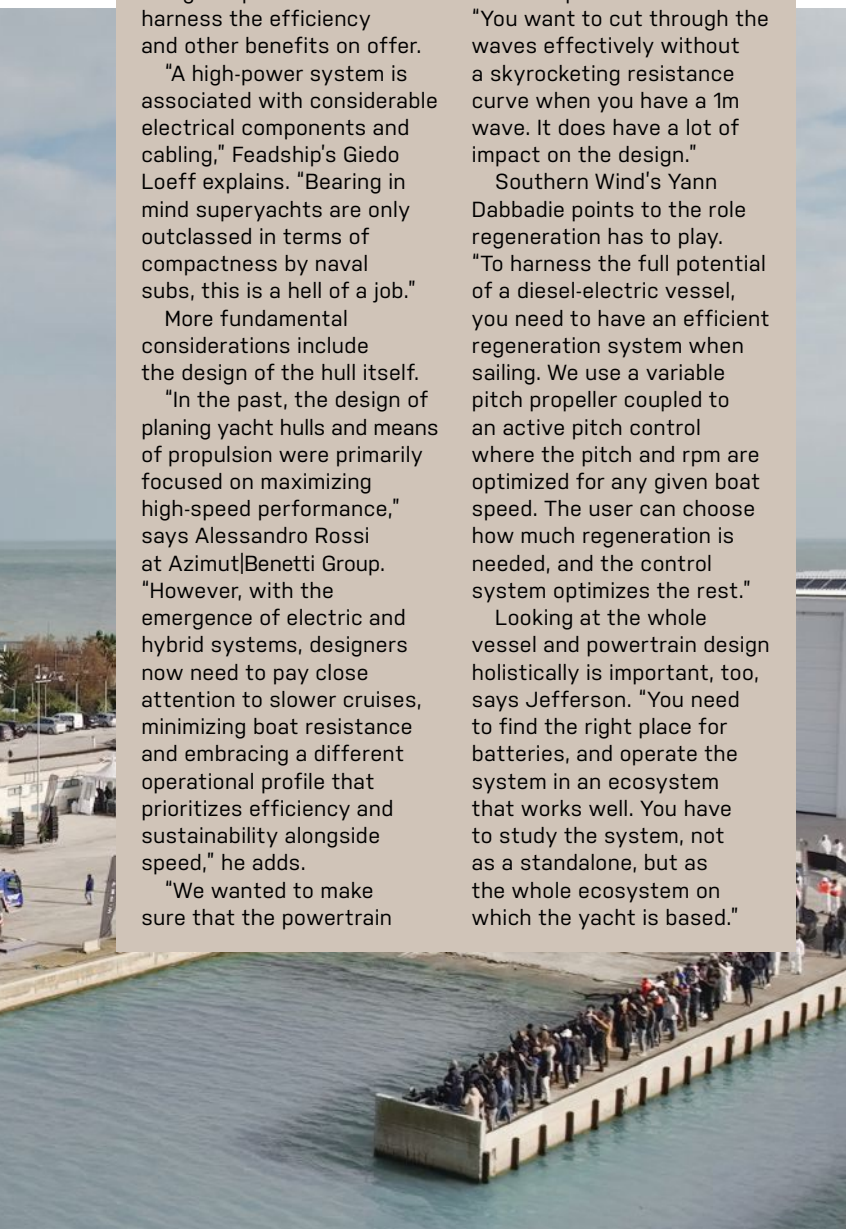
More fundamental considerations include the design of the hull itself.

"In the past, the design of planing yacht hulls and means of propulsion were primarily focused on maximizing high-speed performance," says Alessandro Rossi at Azimut|Benetti Group. "However, with the emergence of electric and hybrid systems, designers now need to pay close attention to slower cruises, minimizing boat resistance and embracing a different operational profile that prioritizes efficiency and sustainability alongside speed," he adds.

"We wanted to make sure that the powertrain functions well within 1.5m waves without increasing resistance significantly," says Iván Salas Jefferson at Cosmopolitan Yachts. "You want to cut through the waves effectively without a skyrocketing resistance curve when you have a 1m wave. It does have a lot of impact on the design."

Southern Wind's Yann Dabbadie points to the role regeneration has to play. "To harness the full potential of a diesel-electric vessel, you need to have an efficient regeneration system when sailing. We use a variable pitch propeller coupled to an active pitch control where the pitch and rpm are optimized for any given boat speed. The user can choose how much regeneration is needed, and the control system optimizes the rest."

Looking at the whole vessel and powertrain design holistically is important, too, says Jefferson. "You need to find the right place for batteries, and operate the system in an ecosystem that works well. You have to study the system, not as a standalone, but as the whole ecosystem on which the yacht is based."



from components, we also rethink the way the boat is used. Being able to have an intuitive boat to use makes for a more enjoyable experience, allowing the user to use the system's full potential, regenerating electricity as the yacht is sailing."

"Hydrogeneration will cut the number of engine hours dramatically during any crossing," adds Micheli.

For the future, Cardini says, Wider Yachts is keenly following developments in the production of increasingly safe and efficient batteries: "These use innovative automotive-derived chemistries that allow extremely reduced charging times together with the use of latest-generation electrified docks with CCS sockets."

Rossi says the Azimut|Benetti Group's forthcoming R&D activities will focus on leveraging AI to oversee the electrical loads, with a primary goal of augmenting the efficiency of managing its vessels' electrical requirements: "Our aim is to develop AI solutions that can proficiently and dynamically balance power demands, prioritize energy usage and optimize resource allocation on board."

Feadship's R&D activities concern transferring the step toward fuel flexibility (paraffins and alcohols) and the associated engine and fuel cell concepts to projects under development.

"Further R&D will be linked to the actual introduction of these systems, their evolution in cooperation with suppliers, the exploration of full DC systems, and anticipating the next generation of batteries," Loeff says. "Where will technology development take us? Inherently safe 1,000Wh/l batteries, viable shore power charge networks pushed by FuelEU legislation? Life remains interesting."

June 18, 19 & 20, 2024 // Amsterdam // Netherlands

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Check out the next 10 pages for a taste of what the expo has in store...

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Nominations have now closed, and our independent, international judging panel – boasting some of the world's leading marine journalists, industry experts and academics – are voting for their winners, which will be announced on Day 1 of the expo. The ceremony starts at 17:00, Tuesday, June 18. Don't miss it!

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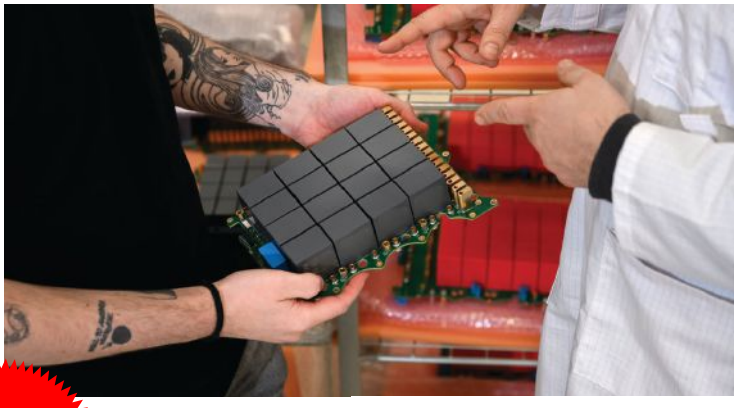
Galvanic isolated DC-DC converters



The marine industry's latest technologies for electrical architectures are based on the integration of high-power DC electrical components. When using DC energy sources such as hydrogen fuel cells and batteries, voltage levels are a significant challenge. However, galvanic isolation is equally critical. This is due to concerns regarding current leakage and safety protocols, requiring the complete electrical segregation of power sources and actuators to prevent system damage. The importance of isolation is magnified when multiple fuel cells are configured in parallel to scale power levels beyond megawatts.

Addressing these challenges, BrightLoop is pioneering the development of proprietary high-frequency, low-loss transformers. The company will tell visitors to its booth how these offer comprehensive galvanic isolation while delivering outstanding performance across DC and AC applications. Operating at frequencies exceeding 300kHz, they achieve a power density of 20kW/kg with more than 97% efficiency.

Proprietary low-loss transformers

BrightLoop
Booth 5110

DC grid-to-inlet charging system

Cavotec will introduce a turnkey DC grid-to-inlet charging system at Electric & Hybrid Marine Expo.

In an effort to decarbonize vessels and industrial vehicles globally, the system integrates a high-power electronic module with Cavotec's Megawatt Charging System (MCS) and an MCS inlet. For enhanced versatility, an optional battery storage module is available to manage energy peaks or supplement limited grid capacity.

Aligned with MCS standards defined by the CharIN taskforce to ensure universal compatibility, Cavotec's MCS facilitates fast-charging across a spectrum of heavy-duty vehicles, from construction machinery to e-ferries.

With three defined power levels – 350kW (level 1), 1MW (level 2) and 3MW (level 3) – Cavotec's compact MCS connector enables manual connection with smaller copper conductors and high-power pins, while meeting stringent thermal charging requirements. Modular and scalable, the system offers manual and automated inlet connection options, accommodating higher power ratings and multiple outlets for simultaneous vessel and vehicle charging.

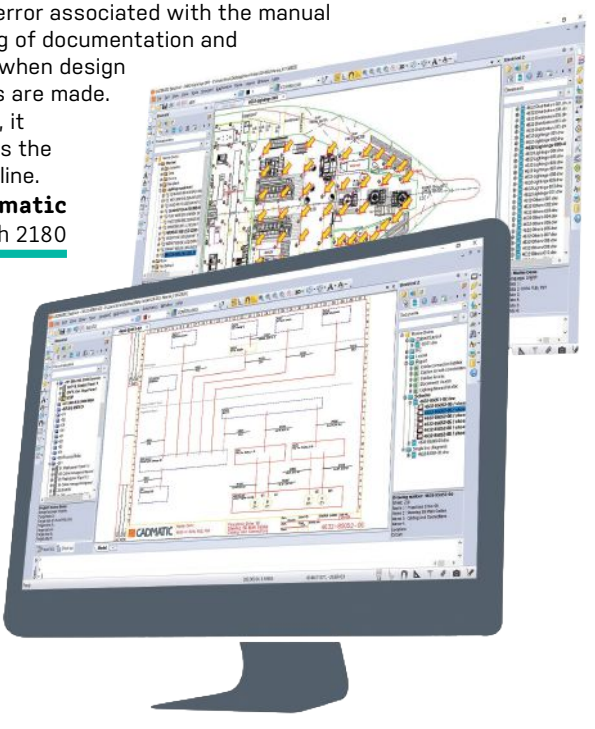
Cavotec
Booth 1238

Integrating electrical design with 3D modeling

Electrical documents such as schematics, diagrams, arrangement drawings, electrical equipment, switchboards and cabinets can all be linked to the 3D model. There is also scope to link manufacturing information, supplier data and PLM/PDM/ERP data. With this approach, the project documents and information are always up to date and synchronized with 3D models, which eliminates the need for time-consuming, error-prone manual checks.

Cadmatic Electrical will be at the show to talk to visitors about how an integrated approach ensures that the design project remains under control without any last-minute surprises and delays. It also improves quality by eliminating human error associated with the manual updating of documentation and models when design changes are made. In short, it improves the bottom line.

Cadmatic
Booth 2180

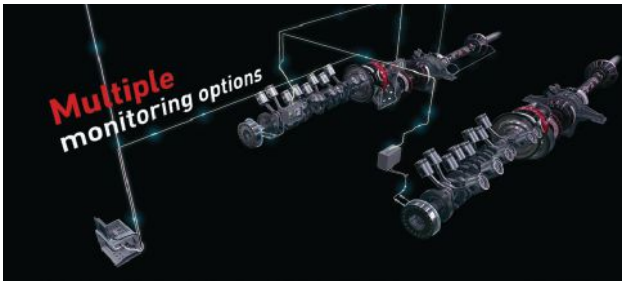


Multiproduct monitoring

Geislinger Digital Solutions' two core units, the Geislinger Analytics Platform (GAP) and the Geislinger Monitoring System Mk6 (GMS Mk6), work together to provide continuous measurement of dynamic system behavior and a cloud-based data push. This enables features such as trend analysis, AI-powered anomaly detection, rapid troubleshooting, data analysis, reporting and predictive maintenance.

The GMS Mk6, which will be on display at the company's booth, now offers product monitoring and can handle up to four products in any combination. The intuitive user interface allows easy switching between the individual drive components via the operating panel or the Geislinger Analytics Platform.

Monitoring a drivetrain with Geislinger Digital Solutions ensures maximum safety, prevents downtime, mitigates overall operational risk and provides a solid foundation for fuel savings and, ultimately, a reduction in CO_2 emissions, helping to futureproof vessels and fleets.



Geislinger
Booth 1315

Inboard electric propulsion system

NT Systems offers turnkey electric propulsion systems designed for commercial and leisure applications, with a power range from 40kW to 450kW. The systems require minimal maintenance and can be installed on various drive units.

This year, the company will showcase the most powerful inboard model within the C-Series offering. One of the standout features of this series is its high power-to-weight ratio. The system measures 900mm in length, weighs 226kg and delivers 450kW of output power in a single integrated plug-and-play unit.

In addition, the company will reveal an upgraded model of a side-mount throttle lever with a trim option. The simple, ergonomic lever includes all essential functions such as maneuvering mode and an interlock mechanism.

NT Systems
Booth 6110

Speaker spotlight

WÄRTSILÄ

Uwe Heine, chief technologist, Wärtsilä Marine, Germany

SESSION: Alternative fuels and energy sources for marine propulsion

PRESENTATION: How does hybridization support the adoption of new fuels?

New fuels, such as ammonia and methanol, are on the rise but will cost more and require specialized storage and delivery systems while having a lower power density than traditional fuel. This presentation will explain how hybridization supports the transition to future fuels, including improving load management and efficiency to save fuel.

Please visit the website for more information and speaker details

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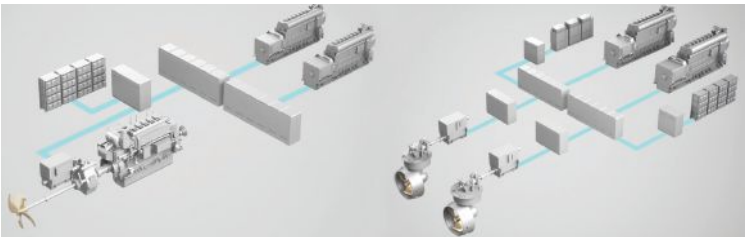
Sustainable propulsion solutions

HD Hyundai (HD KSOE) will present eco-friendly propulsion solutions including mechanical propulsion, hybrid propulsion, electric propulsion and pure-electric propulsion (without ICE) at the expo.

Mechanical propulsion using environmentally friendly fuels such as methanol and ammonia improves the efficiency and performance of maritime transportation to comply with increasingly stringent environmental regulations.

Hybrid propulsion combines electric and mechanical technologies to optimize fuel efficiency and reduce emissions while providing operational versatility. Using a gear-connected shaft generator/motor, this propulsion offers flexible solutions for various operating conditions.



Electric propulsion using onboard power sources (engines, batteries, fuel cells, etc) offers advantages such as high fuel efficiency, responsiveness and zero emissions.

Pure-electric propulsion is powered only by batteries and fuel cells. Engines are no longer required for electric vessels, and combining other energy sources offers added flexibility.

HD Hyundai
Booth 6060

Autonomous Ship Expo exhibitor

Radar technology for situational awareness

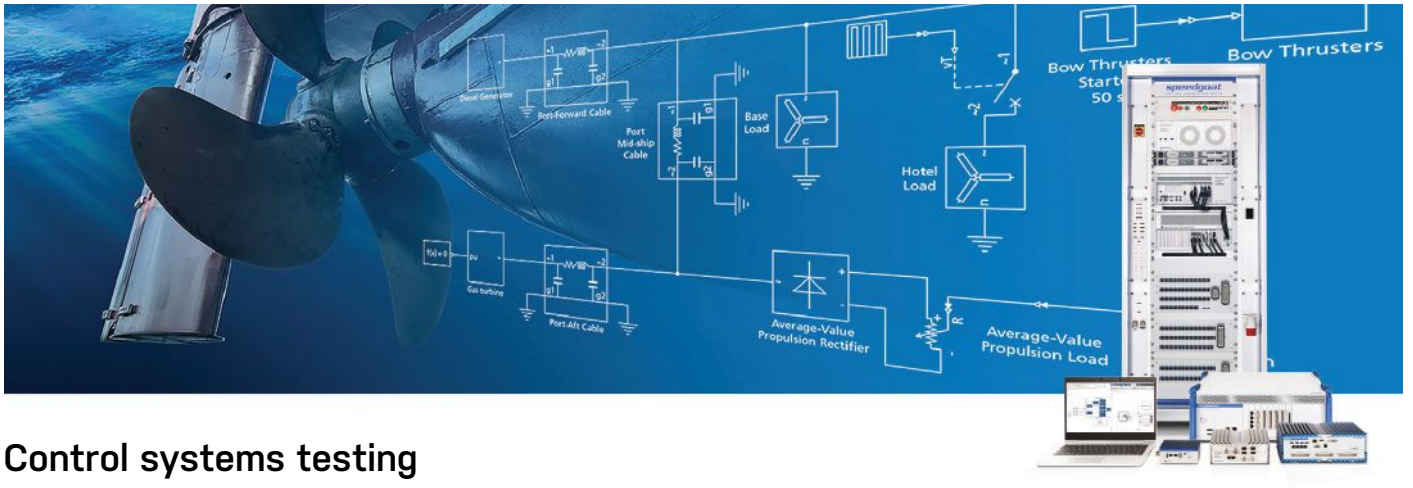
Powered by millimeter-wave FMCW 76-77GHz (W-band) radar technology, the RAS6 from Navtech Radar offers unparalleled situational awareness – detecting small targets such as buoys and kayaks – to enable safe navigation even in the harshest weather conditions. Real-world trials have demonstrated its superior performance across marine applications. With a 4Hz refresh rate, 1,000m detection range and centimeter-level resolution, RAS6 ensures fast, reliable detection of all risks when navigating in congested waters. Furthermore, with 360° views and versatile output options, it simplifies integration. RAS6 fills the blind spot that often plagues X-band radars, providing unmatched detection for short-range targets and ensuring safety in challenging environments. Find out more at Navtech Radar's booth in the Autonomous Ship Zone.

Navtech Radar
Booth 1408

Hydrogen on demand

Aiming to streamline the energy transition, RIX has pioneered a simplified solution for emission-free marine operations. Its M_2H_2 reformers produce fuel cell-ready, 99.97% pure hydrogen on demand, obviating the need for complex hydrogen storage and transportation. Now configurable with PEM fuel cells, this new integrated design improves energy efficiency and makes implementation easier. With a modular, scalable design, systems integrate into existing shipboard infrastructures with minimal retrofitting. The integrated solution is self-contained. It is built and tested as a packaged unit, eliminating the need for onboard qualification testing or verification. Tapping into safe, stable methanol as a feed source eliminates the complexities of transporting and storing hydrogen and takes advantage of the wide availability of portside methanol to meet environmental mandates.

RIX Industries
Booth 8080

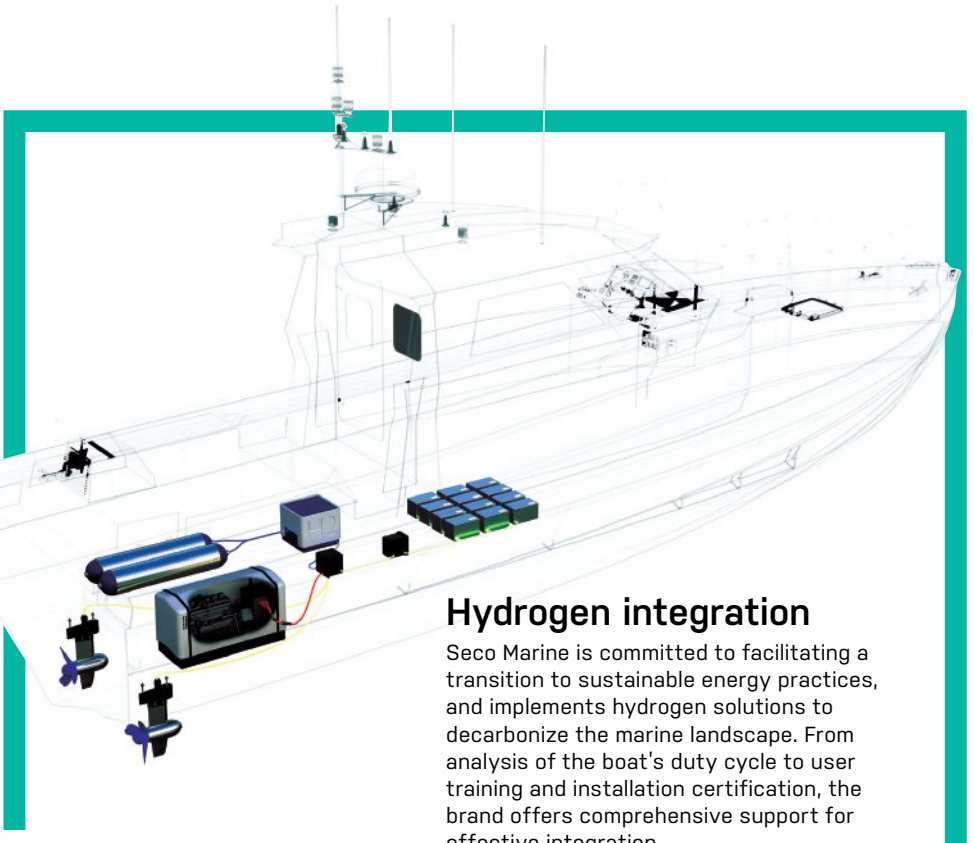


Control systems testing

Electric and hybrid shipboard systems typically include integrated power systems connecting power sources, loads, energy storage systems and electric propulsion. Speedgoat and MathWorks have designed a solution to enable the development and testing of the controls of these integrated components. Engineers can start with a model-based design of their shipboard power systems and controls in Simulink, and prototype their control designs on a Speedgoat real-time test system. They can stay in the same environment and test their embedded controllers using an automated hardware-in-the-loop (HIL) testing solution. Various operational scenarios can be tested, such as energy management strategy, stability of the onboard power distribution system, virtual commissioning and software interoperability between various components of the power management system.

Visit Speedgoat's booth to see a shipboard energy management system (EMS) demo showcasing the testing of EMS controls, and another demo showcasing the design and testing of motor controls.

Speedgoat
Booth 4000



Hydrogen integration

Seco Marine is committed to facilitating a transition to sustainable energy practices, and implements hydrogen solutions to decarbonize the marine landscape. From analysis of the boat's duty cycle to user training and installation certification, the brand offers comprehensive support for effective integration.

At the expo, Seco will be on hand to talk about its solutions for all types of technology: hydrogen propulsion systems, hybrid systems and all-electric systems. Its approach, based on compliance with safety standards in line with class organizations, enables it to offer systems that are state of the art in terms of reliability and operating safety.

Seco Marine
Booth 3200

Comprehensive system toolkit

Torqeedo's range of components includes electric motors, batteries, chargers, throttles, controls, displays, interfaces and onboard renewables that are fully integrated into the company's holistic propulsion and energy management infrastructure. On display at the expo will be inboards, outboards and steerable thrusters up to 100kW, plus the new Deep Blue Battery 80.

Torqeedo's customized solutions team has almost two decades of experience and can optimize the entire electrification process, from the planning phase with individual design consulting through installation to commissioning, all backed by a global service and support network.

Torqeedo
Booth 7040

Battery emulation and testing

Battery and fuel cell emulation and battery testing play a crucial role in the development, testing and optimization of electrical installations in the hybrid marine industry.

TTMS will be showing its wide range of bidirectional DC power supplies used for emulation, with voltage levels from 10V to 2,250V and power levels from kW to MW+. This is combined with supporting software and includes protection from overvoltage, undervoltage, overcurrent, overpower and overtemperature.

TTMS
Booth 2055

Speaker spotlight

SEACHANGE

James Morfee, principal systems engineer, Seachange New Zealand

SESSION: Developments in hydrofoiling propulsion

PRESENTATION: Real-world performance of electric hydrofoiling vessels in commercial operations

This is a case study of an innovative, fully electric hydrofoiling vessel that can revolutionize commercial maritime operations including ferries, water taxis and tourism. A technical description of a fully hydrofoiling system will be presented, focusing on its significant reduction in water resistance and energy efficiency over traditional vessels. Real-world performance data will be discussed alongside case studies of example routes. Conceptual designs and performance of larger vessels will also be presented.

Please visit the website for more information and speaker details

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Ramping up battery production

AYK Energy is set to unveil ambitious expansion plans at Electric & Hybrid Marine Expo Europe. AYK founder Chris Kruger, one of the earliest pioneers of marine battery technology, believes that 2024 will be the company's breakthrough year. As well as revealing more about plans to build the US's biggest marine battery gigafactory in Oak Ridge, Tennessee, AYK will showcase a new lighter battery range.

The new plant and battery cater to surging demand for AYK's marine energy storage solutions. Kruger reports that sales are projected to reach 100MWh in 2024, making AYK one of the fastest-growing marine battery companies in the world.

Kruger says the new range will feature a lighter aluminum box, replacing steel, and new cell tech, ramping up energy density by as much as 30%.

AYK's new gigafactory will complement its 5,000m² factory in Zhuhai, China, which opened in 2023. Kruger says the China plant has a production capacity of 300MWh a year, with the ability to expand to 1GWh. Oak Ridge will follow a similar model.

AYK Energy
Booth 7050

Lithium-ion battery solutions

Esco Power will display its lithium-ion battery solutions for use in battery-powered vessels, offshore platforms and hybrid applications, as well as its onboard energy solutions, from cell to pack, designed to meet the needs of customers' applications.

The company's modular DNV battery pack is designed to meet the highest safety and certification requirements. Built for scalability, the modular battery packs can be connected in series or parallel to offer versatility across a range of applications needing robust, safe, high-performing lithium-ion batteries. Advantages of the Esco Power battery pack include there being one product family for all applications; worldwide approvals and certification of safety standards; no development costs and fast time-to-market; 15-215kWh power sizing; quick charging capability; smart battery management system; high discharge performance; proven cost-efficiency per kWh; worldwide delivery capability; high security and safety standards; and product interfaces for maximum versatility.

Esco Power
Booth 9110

Q&A: Mathilde Gombeaud, managing director, BlueNav

Q What are you hoping to talk to visitors about at Electric & Hybrid Marine Expo Europe 2024?

A Our aim is to engage visitors in discussions about the importance of mindset evolution in the electrification journey. We'll highlight how hybridization addresses user concerns like range anxiety and access to charging points while preparing both the market and user behavior for full electric mobility. We want to emphasize how this approach enables boaters to enjoy the benefits of electric propulsion, enhancing their user experience and facilitating acceptance of future navigation changes.

Q Can you share a little about what you'll be talking about at the conference?

A We'll delve deeper into our vision for electrification and the necessity for human awareness and behavioral change alongside technological advancements. We'll discuss how our approach aligns with current trends in the marine sector and how it positions BlueNav as a leader in driving the electrification transition.

Q What are the main trends affecting the marine electrification sector at the moment? How is BlueNav staying at the forefront of those?

A The dominant trends in the marine electrification sector right now include technological innovation, regulatory frameworks favoring cleaner technologies, a rising demand for sustainability, and of course advancements in battery technology, expansion of charging infrastructure and collaboration among industry stakeholders.

Innovation remains key, with the integration of various advanced technologies such as digital connectivity and autonomous navigation enhancing safety and user experience while opening new avenues for market growth.

We understand that for electrification to succeed, user acceptance is paramount. That's why we're dedicated to innovative solutions – such as converting boats to hybrid electric – that not only push the boundaries of technology but also prioritize seamless integration and intuitive user interfaces.

From advanced hybrid electric systems to cutting-edge digital connectivity, every aspect of our solutions is designed with the user in mind, ensuring a smooth transition to electric propulsion and an unparalleled boating experience.

BlueNav
Booth 1118

Electric outboard motor

At this year's expo, Volta Future will present a revolutionary e-outboard with 222kW (300hp) continuous power and 790Nm. The next-gen e-outboard is called iWOP, which stands for invisible waterline outboard power-drive.

The housing of the iWOP is more compact than classic outboard housings and contains two specially developed, high-performance electric motors together with a directly cooled double-inverter. Unlike other outboards on the market, the iWOP can be mounted not only on boats with a transom (outboard) but also on boats with (normally) inboards instead of the sterndrive, enabling a bathing platform instead of an engine housing.

The electric motors are linked by a carbon belt drive, leading to a high-performance propulsion system with great compactness and efficiency.

Due to the frameless integration and the unique dynamic pressure technology, no impeller or additional cooling pump is needed.

The iWOP will be available in two versions – iWOP-dual (two electric motors) and iWOP-single (one electric motor) – to provide a power range of 66-222kW with identical, compact size.

Volta Future
Booth 4040

Lithium batteries for marine applications

Keheng has 16 years of experience in the research and development of lithium batteries.

The company's slogan – 'Tailored for you with unchanging quality' – reflects Keheng's dedication to providing lithium battery solutions tailored to customers' individual needs.

The latest marine battery design will be on show at the expo in Amsterdam and features an IP67 waterproof rating and an integrated fire suppression system, enhancing safety during transportation and ensuring stable and reliable performance even in extreme conditions.

Keheng New Energy Technology (Dongguan)
Booth 5170

Speaker spotlight

Shell Marine

Kaushik Jadhao, port electrification manager, Shell Marine, Netherlands

SESSION: Developments in fueling and charging infrastructure

PRESENTATION: Port electrification – MW MCS charger for the Port of Amsterdam

This presentation will describe the installation of the world's first dual-purpose MW charger with MCS connector in Amsterdam at the end of Q1 2024. This is a game-changer for inland shipping as the technology provides fast on-the-go charging capabilities. It will also provide additional flexibility for the battery-swapping barges. With its dual purpose, it will also serve as a high-use charger for terminals along the inland waterways that serve customers from both modes.

Please visit the website for more information and speaker details

Register for your conference place **NOW!**

Liquid cooling in marine battery systems

For many years, Leclanché has been implementing liquid cooling in its marine lithium-ion battery systems, including the previous-generation MRS-2 and the more recent Navius MRS-3 marine rack system, which it will be showing at Electric & Hybrid Marine Expo.

Liquid cooling in marine Li-ion battery systems offers several advantages. First, it helps maintain optimal operating temperatures, which is crucial for the efficiency and longevity of the batteries. By dissipating heat efficiently, liquid cooling prevents overheating that can lead to performance degradation and even safety hazards. Moreover, by regulating temperatures, liquid cooling can enable faster charging rates and more consistent performance, enhancing the overall reliability of the battery system. Additionally, in marine environments where space is often limited, liquid cooling systems can be designed to be compact, lightweight and modular, minimizing the impact on vessel design while maximizing battery capacity. Overall, liquid cooling contributes to safer, more efficient, longer-lasting Li-ion battery systems in marine applications.

Leclanché
Booth 3090

Register for your free exhibition entry pass online **NOW!**

Next-gen hydrogen fuel cell power systems

End-to-end solution

The Genevos Gen-II hydrogen power modules offer improved power density and a lower price per kilowatt, making hydrogen power solutions accessible across the maritime sector.

The Gen-II modules feature optimization of the HPM-40kW and the launch of the all-new HPM-250kW, a stackable and 1,500kW containerized solution for energy-intensive vessels. The innovations are in full compliance with the latest maritime offshore commercial regulations for type approval.

The HPMs feature in the Complete H_2-Pack, which offers an end-to-end solution for onboarding hydrogen power. Services include design engineering, power management, commissioning, optimization and maintenance.

Genevos will showcase its Gen-II 40kW hydrogen power module at this year's show.

Genevos
Booth 3150

Autonomous Ship Conference and Expo are co-located with Electric & Hybrid Marine Expo Europe.

Autonomous Ship Conference (rates apply) offers instant access to the latest insights, lessons and case studies from real-world applications that enable varying degrees of automation – from anti-collision assistance to fully autonomous operation – across the ship and cargo handling sectors. Panel discussions and workshops provide extensive networking opportunities with those leading progress in this exciting sector.

Key speakers at the conference include **Andre Burgess**, assured autonomy program lead, National Physical Laboratory, UK; **Tom Eystø**, CEO, Massterly, Norway; **Ilia Maslov**, technical advisor – digital and smart ships, Bureau Veritas Marine & Offshore, France; **Koki Asari**, general manager, Japan Space Systems, General Incorporated Foundation, Japan; **Zakirul Bhuiyan**, director, Warsash MASS Research Centre, UK; and **Sinikka Hartonen**, secretary general at One Sea Association, Finland.

Autonomous Ship Expo showcases the latest developments in autonomous navigation technology and automated onboard systems, conveniently bringing together providers and purchasers of sensor technology, e-navigation systems, automation software and maritime remote-control technology. Exhibitors at the free-to-attend exhibition include **Samsung Heavy Industries**, **Marine AI**, **Nortek**, **Navtech Radar**, **Maritime Robotics** and **L3Harris**.

More info here: www.autonomousshipexpo.com/index.php

Hybrid propulsion systems

Transfluid, established in 1957, celebrates a significant milestone at the expo this year: the 10th anniversary of its first hybrid system installation on a vessel.

The Transfluid range of products includes complete, adaptable solutions that are rigorously tested, certified and mass-produced. They offer an eco-friendly and efficient alternative to conventional methods of propulsion. The hybrid systems are used in various vessel types, including taxi boats, pilot boats, patrol vessels and passenger ships. This underscores the flexibility of the systems to meet the demands of leisure and professional navigation.

Transfluid
Booth 3020

Solid-state batteries

EPTechnologies will be exhibiting its solid-state batteries, which, unlike traditional lithium-ion batteries, do not use liquid electrolytes. This fundamental difference enhances safety, cycle life and overall performance. They can be overcharged, heated to extreme values and even punctured with a projectile with no ill effects.

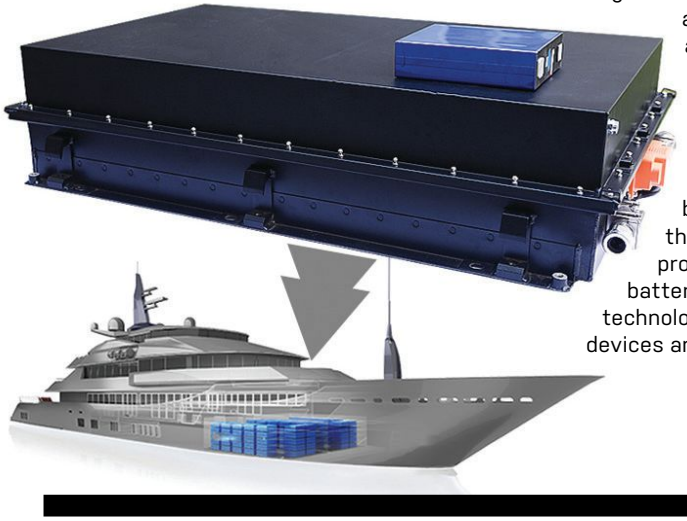
This opens new possibilities for applications. For instance, EPTechnologies can develop batteries equipped with a hardware override switch to bypass all electronic control systems if necessary. Overcharge, over-discharge, short circuits and similar issues have minimal impact other than reducing battery life.

This technology also extends the usable cycle life to over 10,000 cycles, making batteries more environmentally friendly and cost-effective. Prolonging the lifespan of materials and increasing the return on investment offers ecological and economic benefits.

EPTechnologies
Booth 6020

Lithium battery technologies

The CTS 153.6V 206Ah lithium iron phosphate battery module supports multiple packs in series and parallel to achieve more capacity.



Hunan will talk expo visitors through its customized solutions according to different vehicle requirements. This battery product is designed to offer high safety, long lifetime and strong environmental adaptability, covering electric boats, electric vehicles, heavy-duty trucks, street-sweeping vehicles, electric city buses and more.

Lithium battery innovation brings more possibilities for the development of many projects. Hunan's lithium-ion batteries feature advanced technology designed to power devices and equipment for longer.

Hunan CTS Technology
Booth 1426

Speaker spotlight

SEAQ by VARD

Håvard Vollset Lien, VP research and innovation, Vard Group, Norway
Øystein Longva, CTO, Vard Electro, Norway

SESSION: Charging at sea

PRESENTATION: Charging battery-powered vessels at sea

In March 2024, an innovative battery charging solution for offshore use on board vessels working in offshore wind farms was tested in full scale in the North Sea by the Rem Power SOV, demonstrating that it is fully feasible to charge large battery-powered vessels in an open-water environment. This presentation will present the findings and experiences from the tests, the challenges and how they were solved, as well as the supporting activities of the project.

Please visit the website for more information and speaker details

Register for your conference place **NOW!**

Autonomous Ship Expo exhibitor

Forward-looking sonar

At Autonomous Ship Expo 2024, Wavefront Systems will feature its new Vigilant 600 forward-looking sonar (FLS). Complementing the company's Vigilant 1000 and 1500 systems, it allows autonomous surface and subsurface vessels to transform their underwater situational information. The provision of real-time navigational and obstacle avoidance data to onboard or remotely controlled systems enables safer operations in unfamiliar or dynamic environments by dramatically reducing the risk of collisions or grounding.

Patented technology capable of depth-finding at ranges ahead of the vessel in excess of 20 times the prevailing water depth, combined with real-time data on poorly charted seabed features and water column obstacles, enables reactive navigational autonomy.

Wavefront Systems
Booth 1406

New electric outboard motor series

The ePropulsion X Series (12-40kW) is a zero-emission electric propulsion system with what the company describes as an industry-leading powertrain efficiency of 88.2%. Weighing up to 36% less than traditional motors, the X Series has a compact, fully integrated design. All motors within this series unify electric steering, power trim/tilt, the electric control unit and the controller within a single assembly, simplifying installation and optimizing onboard space.

The X Series features the ePropulsion Smart System Architecture (eSSA), the modular architecture of which ensures simple system configuration and supports the integration of renewable energy systems.

The X Series is also integrated with ePropulsion's Connectivity Service to enhance communication between boat owners, fleet managers and their vessels, and provides cloud-based connectivity without extra hardware.

Fully compliant with the latest IEC standards, the X Series is IP67 waterproof and built to yield a minimum service life of 5,000 hours. The motors are fully compatible with existing ePropulsion accessories.

ePropulsion
Booth 1110

Powerful electric motors and alternators

Almott is a technology company that develops and manufactures brushless electric machines with a wide range of voltages, power and rotational speeds for a variety of applications. It has several registered patents. Its new design of coil stator unit is designed to enable users to achieve small sizes and large currents, and its rotary synchronous motors are characterized by low inertia. Its AC motors are made using PIN technology and offer power ranging from 1kW to 230kW. The quality management system at Almott is certified according to ISO 9001:2015.

Almott says it constantly invests in its team, products, systems, equipment and facilities so that it can offer innovative, high-quality, tailor-made motors and generators with the best price/quality ratio. Find out more at its booth in Amsterdam.

Almott
Booth 4140

Turnkey, fully autonomous electric USV fleet

Zero USV, a collaboration between the founders of Marine AI and MSubs, has launched the world's first fully autonomous USV fleet for long-term lease or charter. The first vessels will be available this autumn.

With a twin electric drive for optimum redundancy and a hybrid powertrain for resilience and efficiency, Oceanus12 is a 12m, fully autonomous turnkey package. It uses a suite of marine sensors that feed into Marine AI's Guardian AI autonomy software for real-time processing and analysis and, ultimately, COLREG-compliant vessel control and navigation.

It is designed as a versatile platform with a wide range of applications. These include geophysical surveying and mapping, offshore oil and gas exploration, renewables exploration and maintenance, border control, fisheries science and defense.

Two vessels are in production, with eight planned for 2025. Charter will be available in the UK, North America, Canada and Australia as Zero USV rolls out its USVs with global partners. Find out more at Marine AI's booth.

Marine AI
Booth 1400

Fuel cell stacks, systems and solutions

EHG will showcase its 250kW fuel cell system, which has recently received approval in principle from DNV, with type certification targeted by the end of the year.

Advantages of EHG fuel cell technology include high power density, design flexibility, higher efficiency levels and lower costs.

The 250kW system is designed for marine applications and can be integrated into modular, turnkey, containerized solutions for different fuels, up to multi-megawatt power ratings.

EH Group
Booth 5120

Don't miss the Electric & Hybrid Marine Conference!

The world's only conference dedicated to the electrification and hybridization of marine vessels, along with associated supporting infrastructure for ports, charging, fueling and energy supply, will take place alongside the expo. The three-day conference is a must for anyone requiring or developing the latest and next-generation electric and hybrid propulsion technologies or state-of-the-art charging systems

Companies presenting will include:

WÄRTSILÄ
Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
mtu A Rolls-Royce solution
GE
SEACHANGE
BMT
VARD a Fincantieri company
RICARDO
HD HYUNDAI EUROPE R&D CENTER
DNV
GLAS OCEAN ELECTRIC
Shell Marine
RSP engines off, shore power on

Major themes of the conference

- Keynote: The challenges to shipowners in the decarbonization process, and the responsibilities of equipment manufacturers
- Integration challenges
- Battery safety
- Developments in hydrofoiling propulsion
- Alternative fuels and energy sources
- Fueling and charging infrastructure
- Vessel and project case studies

Book your DELEGATE PASS for the 2024 conference online today!

www.ElectricandHybridMarineWorldExpo.com

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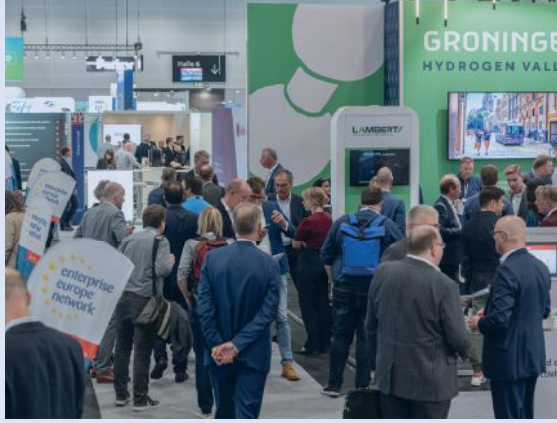

2023 WINNER
Multi-Award Winning Show

Hydrogen Technology Expo Europe is the must-attend conference and exhibition that is exclusively dedicated to discussing advanced technologies for the hydrogen and fuel cell industry. The event will bring together the entire hydrogen value chain to focus on developing solutions and innovations for low-carbon hydrogen production, efficient storage and distribution as well as applications in a variety of stationary and mobile applications.

More than 300 international speakers and over 15,000 attendees will come together to discuss, and see, the latest technologies and engineering solutions, advanced materials, manufacturing equipment, infrastructure, as well as test and evaluation tools and services to finally commercialize hydrogen as a mainstream provider of clean, renewable energy. PLUS – see more than 700 exhibiting companies in the main exhibition hall.

FREE TO ATTEND

REGISTER NOW

A system **perspective**

Consulting a trusted solutions provider ensures the appropriate system meets vessel-specific requirements

WORDS: **MIKE GEE**

The emergence of hybrid and electric marine propulsion systems has represented a significant leap in sustainability and efficiency. As vessel operators seek to reduce emissions and operating costs while complying with stringent environmental regulations, selecting the right propulsion system for a vessel depends on careful consideration of various factors and components. While it may be tempting to identify a one-size-fits-all solution, it's better to consult a trusted provider that can offer insights into the critical factors influencing system integration.

Defining the components

Hybrid and electric propulsion systems comprise a complex network of components, each contributing to the system's functionality and performance in unique ways. The heart of any hybrid or electric system is its power source, which stores and/or delivers energy to drive the vessel's propulsion system. Options including batteries, fuel cells, ICE generators, diesel engines and even wind and solar are all viable. The selection of an appropriate power solution depends on factors such as vessel type and use profile (for example, range), weight and space constraints, regulations, safety considerations, redundancy and maintenance requirements, cost, available infrastructure (including charging and fuel availability) and environmental impact (such as emissions, noise). Furthermore, considerations within each option are influenced by available and emerging technologies (including matters of energy density, battery chemistry, battery charge and discharge rates and alternative fuels).

Electric motors serve as the workhorses of hybrid and electric propulsion systems, translating electrical energy into mechanical power to drive the vessel. There are many options including brushless DC motors (permanent magnet), DC motors and induction motors. What's more, there are selections to be made within each motor type (such as radial versus axial versus transverse flux). Control of the motor is provided by inverters or a variable-frequency drive (VFD). Selection depends on the type of motor being used, the source voltage, the vessel power architecture and cooling, among other considerations. Additionally, factors such as cooling methods, voltage compatibility and weight and size constraints must be carefully evaluated to ensure optimal performance and longevity.

Efficient power distribution and management systems are essential to optimize energy use and ensure seamless operation of the propulsion system. Advanced control algorithms, integrated with sophisticated sensors and monitoring devices, enable real-time adjustments to power flow, maximizing efficiency and minimizing waste. Additionally, intelligent power management systems facilitate seamless transitions between different power sources, such as batteries, generators and engines, based on operational demands, physical location and environmental conditions.

Supplementary components such as generators, and various power electronics such as inverters, converters and chargers (rectifiers), complement the primary propulsion system, providing backup power,

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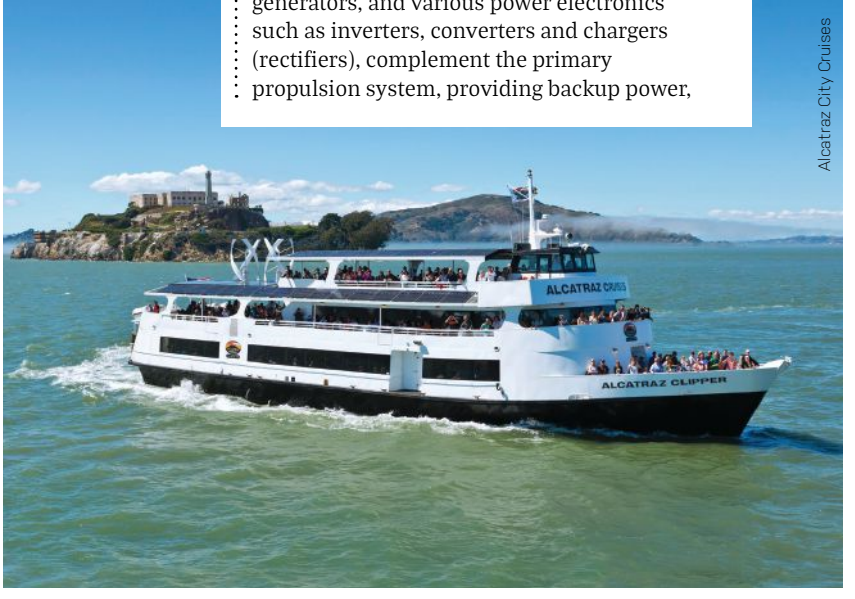
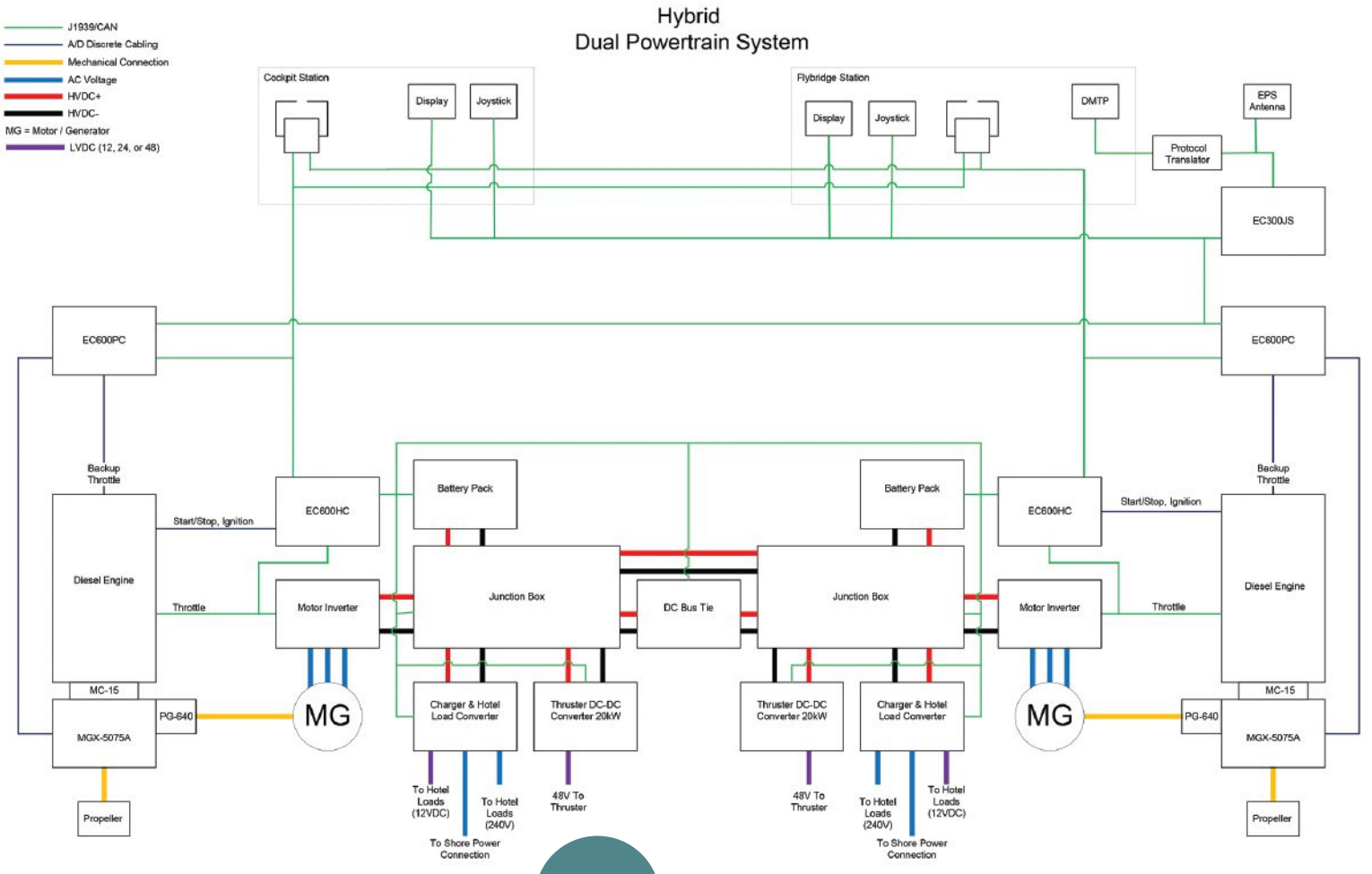
1. Electric and hybrid vessels bring a whole host of considerations but in passenger vessels such as the Alcatraz Clipper operated by Alcatraz Cruises, shipbuilders and operators still prioritize safety, reliability, comfort and maneuverability



Alcatraz City Cruises



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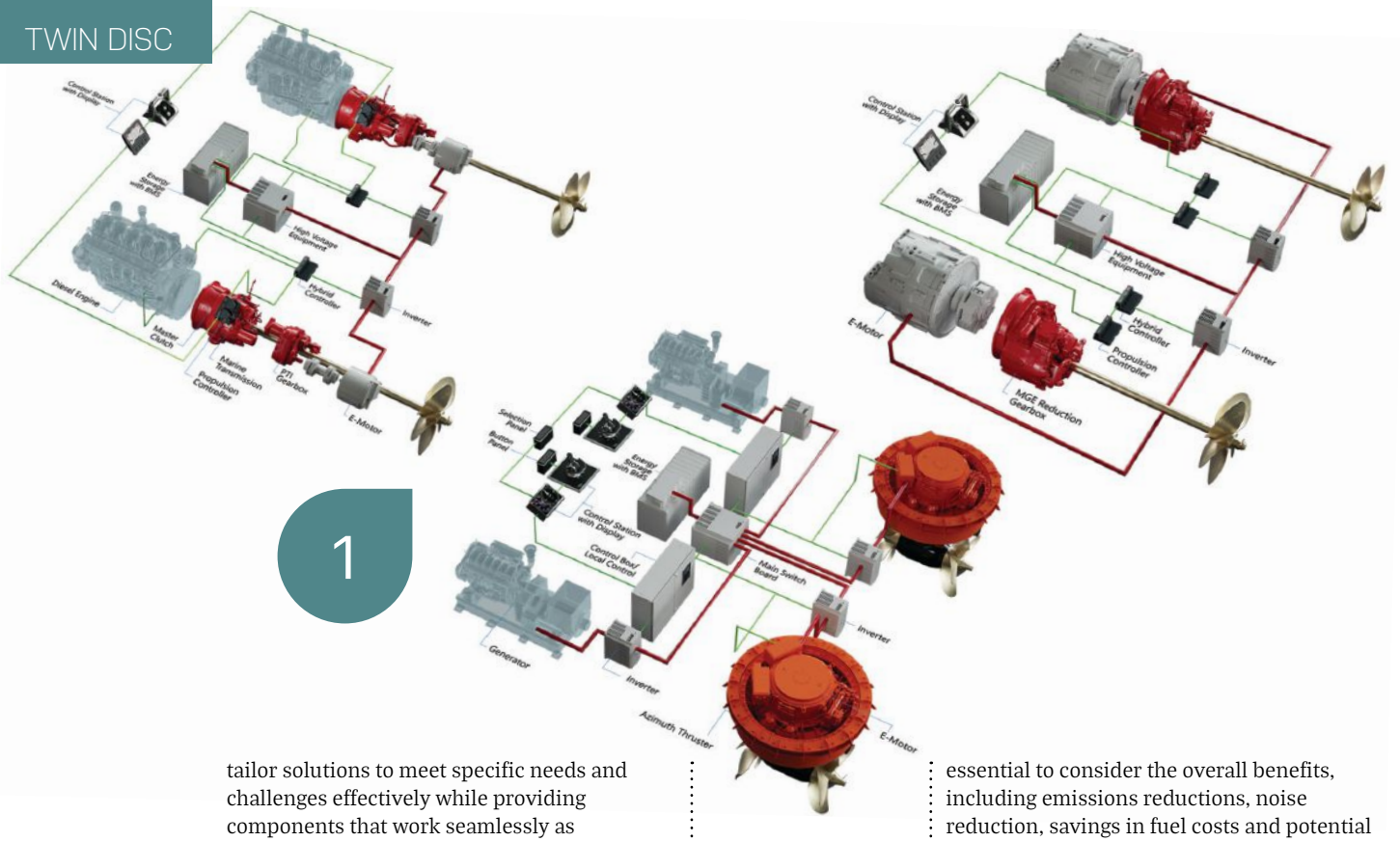
2. This hybrid dual powertrain system architecture gives a representation of the complex network of components that go into a hybrid system. Each part of the system contributes to the functionality, so it is important to consult a trusted provider that can offer insights into the critical factors influencing system integration

charging capability and sources for house loads. In addition to being a primary power source, generators powered by diesel or alternative fuels can provide power for auxiliary systems and recharge batteries as needed. Inverters and chargers, meanwhile, convert DC power from batteries into AC power for onboard equipment and systems, and convert AC shore power to DC for charging batteries. Converters change voltage levels as appropriate to ensure motor and battery compatibility, and can provide DC power for low-voltage house loads or traditional 12/24V DC battery charging. Proper selection ensures seamless integration with existing vessel infrastructure.

Control systems play a crucial role in monitoring and regulating the performance of the propulsion system. Integrated with user-friendly interfaces and intuitive software, modern control systems enable operators to monitor key parameters such as battery state of charge, component health and propulsion status in real time. Additionally, advanced diagnostic features and predictive maintenance algorithms can help identify potential issues before they escalate, ensuring maximum uptime and reliability. The properly engineered control system ensures that the myriad of components all communicate seamlessly to provide a single, easy-to-use operator interface.

Important considerations

The selection of a hybrid or electric propulsion system requires careful consideration of various factors, each influencing the system's performance, cost and environmental impact. To ensure seamless integration of a hybrid or electric propulsion system into a vessel, stakeholders must provide comprehensive information to system designers and engineers. A detailed project narrative provides essential context and insights into the vessel type, hull design, drivetrain configuration, intended use, operational requirements and performance expectations. By understanding the project's scope and objectives, system designers can



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tailor solutions to meet specific needs and challenges effectively while providing components that work seamlessly as a single system.

Understanding the vessel's power and energy requirements at various speeds, operating conditions and use profiles is also critical for selecting the appropriate propulsion components and configurations. Factors such as operating range, speed profile, thrust requirements, propulsion efficiency, auxiliary loads and maneuverability dictate the type of power source, the size and capacity of energy storage systems, and the selection of complementary components such as motors and generators. Considerations such as power regeneration (even from auxiliary onboard systems), shore power capability and alternative fuel availability can also influence vessel efficiency and overall operating costs over the system's lifespan, and therefore must be carefully evaluated to achieve optimal performance and fuel savings.

Finally, analyzing the vessel's duty cycle or operation profile, including operating hours, power demand profiles and energy consumption patterns, provides valuable data for sizing onboard energy storage systems and auxiliary power sources. By matching system capacity to actual use patterns, designers can optimize energy management strategies and maximize operational efficiency.

Although the benefits of hybrid and electric propulsion systems are evident, the initial investment can be substantial. Beyond the up-front costs of equipment and installation, factors such as maintenance, training and infrastructure upgrades must be factored into the total cost of ownership. However, it's essential to consider the overall benefits, including emissions reductions, noise reduction, savings in fuel costs and potential incentives or rebates available for adopting eco-friendly technologies. This is especially true in regions with emissions standards and environmental regulations, which play a significant role in shaping the adoption of hybrid and electric propulsion systems.

1. There is no one-size-fits-all solution for implementing an electric or hybrid system. Factors such as vessel type, hull design, drivetrain configuration, intended use, operational requirements as well as performance expectations dictate whether a fully electric, serial hybrid or parallel hybrid solution is right for a vessel

A trusted supplier

The adoption of hybrid and electric propulsion systems represents a transformative shift in the marine industry, driven by the need to reduce emissions, enhance efficiency and comply with evolving regulatory standards. However, despite these new waves of considerations, shipbuilders and operators still prioritize safety, reliability, efficiency, maneuverability, system redundancy and comfort. By partnering with trusted suppliers and leveraging innovative solutions, stakeholders can address these needs while reducing environmental impact and operating costs.

As a leading provider of hybrid and electric propulsion solutions, Twin Disc offers comprehensive expertise and support throughout the system integration process. From initial consultation and design to final commissioning and after-sales support, Twin Disc's team of experts collaborates closely with customers to identify the right system for their vessels and applications. With the support of trusted partners like Twin Disc empowering customers to confidently navigate the transition to sustainable propulsion, seamless system integration and optimal performance are within reach.

Twin Disc
To find out more, scan the QR code or visit:
www.twindisc.com

Understanding **hydrogeneration**

Exploring the feasibility of using hydrogeneration in sailing superyachts, harnessing energy from water flow

WORDS: **KATARZYNA KARASIŃSKA**

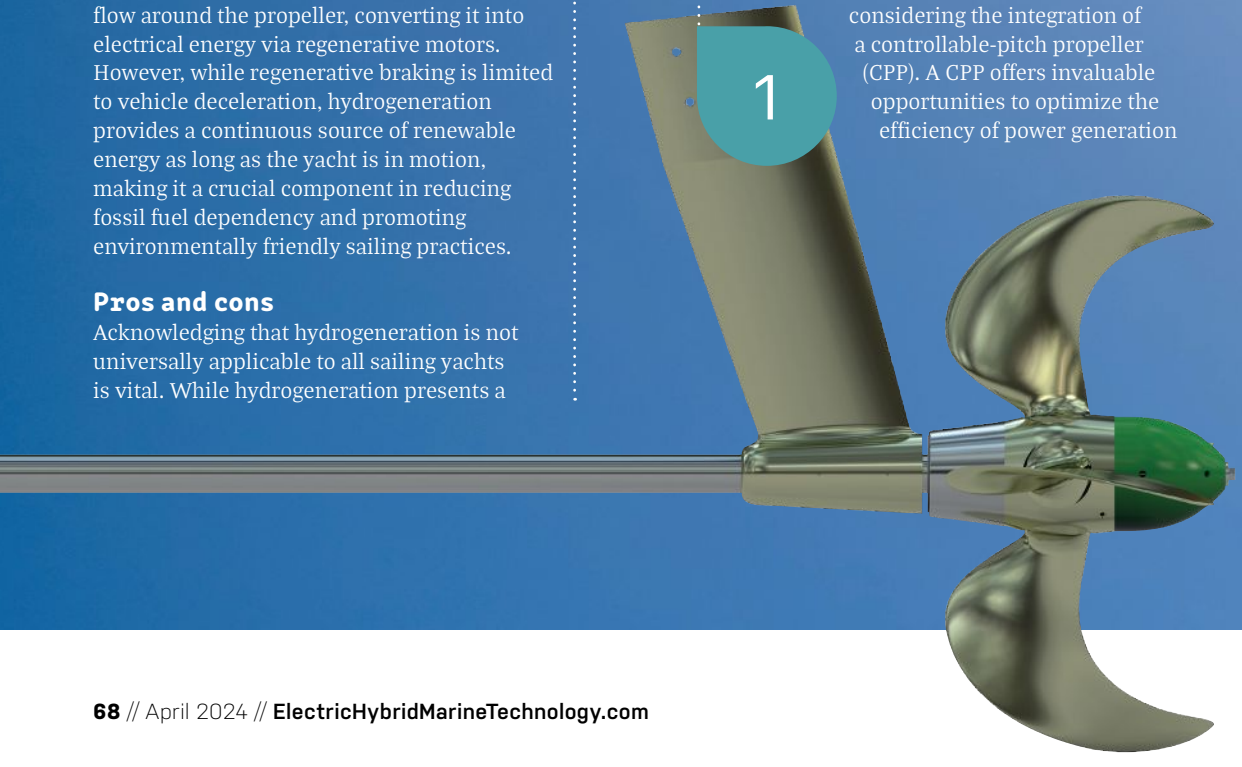
Sailing vessels have long relied on the power of the wind to navigate the open seas, harnessing its force to propel them forward. In today's era of technological advancement and environmental awareness, sailors seek to minimize their ecological footprint by reducing their reliance on fossil fuels. Hydrogeneration is emerging as a vital tool in this endeavor, offering a sustainable alternative to traditional propulsion methods and enabling sailing yachts to generate their own electricity while underway.

Much like regenerative braking in electric vehicles, hydrogeneration in sailing yachts harnesses kinetic energy to replenish energy reserves. In EVs, regenerative braking converts the kinetic energy produced during deceleration back into electrical energy, which is then stored in the vehicle's battery for later use. Similarly, hydrogeneration on sailing yachts captures the kinetic energy of water flow around the propeller, converting it into electrical energy via regenerative motors. However, while regenerative braking is limited to vehicle deceleration, hydrogeneration provides a continuous source of renewable energy as long as the yacht is in motion, making it a crucial component in reducing fossil fuel dependency and promoting environmentally friendly sailing practices.

Pros and cons

Acknowledging that hydrogeneration is not universally applicable to all sailing yachts is vital. While hydrogeneration presents a sustainable avenue for generating electricity, it is not without its challenges. A significant consideration is the additional drag introduced by the propellers during the hydrogeneration process, which affects yacht speed and can slightly affect maneuverability. The responsibility of deciding when and how much power to regenerate can be entrusted to a sophisticated electric propulsion management system. Such a system would autonomously regulate the hydrogeneration process, dynamically adjusting power generation levels based on real-time data such as sailing conditions, energy demands and vessel performance. By delegating this responsibility to advanced technology, sailing yachts can effectively harness the benefits of hydrogeneration while optimizing performance and efficiently helping sailors.

When aiming for effective hydrogeneration, it is worth considering the integration of a controllable-pitch propeller (CPP). A CPP offers invaluable opportunities to optimize the efficiency of power generation



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autonomously. Through the propulsion management system, the blade pitch adjustment is dynamically regulated based on prevailing conditions such as wind speed and water currents. This automated adjustment ensures precise control over the propulsion system, enabling the vessel to adapt seamlessly to varying environmental factors. By optimizing speed and minimizing drag characteristics, the CPP enhances the effectiveness of the hydrogeneration process. With the propulsion management system at the helm, CPP-equipped vessels can efficiently increase electricity production and store a larger amount of power in the battery bank. Thus, the seamless integration of CPP technology not only maximizes energy capture but also streamlines operations, contributing to a sustainable and reliable power supply for sailing yachts.

Exploring real-world application

An Ampros case study of the integration of hydrogeneration with controllable-pitch propellers in a new design for a 93ft (28.3m) sailing performance multihull vessel showcases the potential of hydrogeneration. Integrating hydrogeneration can also be extrapolated to other multihulls with similar performance characteristics.

The Ampros study used CFD software to calculate the desired hydrogeneration power and empirical equations. It was assumed that the boat will be equipped with a 26in (660mm) propeller with two 120kW permanent magnet electric motors. Based on previous studies, overall system efficiency (including propeller, electric motors and mechanical losses) was assumed to be 23%.

Yacht design follows an iterative process grounded in trial and error. Often termed a design spiral, it entails revisiting issues in a predetermined sequence, with each cycle edging closer to an optimal solution. Therefore, for a well-designed electric yacht, it is essential to introduce electric propulsion from the earliest-possible stage of the design.

Once the crucial parameters for optimal performance were established, the Ampros team finalized the high-performance hull design. The model, along with all pertinent data, was integrated into CFD software to compute yacht speed under various sea conditions, typically around 4-5 on the Beaufort scale. Through testing, assuming propeller performance and analyzing water flow cross-sections at predetermined speeds, generated power was assessed. The findings revealed a direct correlation between propeller size and power output; however, larger propellers also increased drag, thereby reducing yacht speed. Striking a balance is imperative when selecting the optimal propeller for peak performance.

1. A CPP propeller for higher performance achievements. Pictured here is the Servogear Ecoflow

2. The yacht design process, often termed a design spiral, enables designers to continually refine and improve their initial ideas through successive cycles of feedback and adjustment

The graphs in Figure 1 illustrate yacht speed (in knots) represented in blue, and hydrogeneration (in kW) in green over a duration of approximately two hours. By comparing the two graphs, it's evident that power regeneration occurs while the yacht is under sail. On average, hydrogeneration reaches 35kW when the yacht is sailing at 16kts. Calculations indicate that employing a 26in-diameter (660mm) propeller results in a loss of approximately 2-3kts when in hydrogeneration mode.

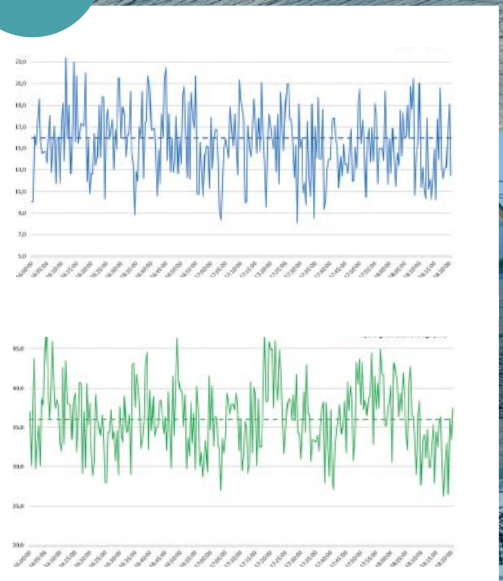
Furthermore, it's essential to recognize that the power harnessed by sailing yachts is predominantly derived from wind energy, constrained by sail area and efficiency. Considering these factors, it is possible to ascertain the available energy at a system's disposal, allocating some for yacht propulsion and the remainder for hydrogeneration. This intricate interplay of forces underscores the fundamental principles of physics at play.

Examining the data

In this case, the CPP and hydrogeneration implementation significantly improves the yacht's performance and fuel efficiency (compared with the use of a fixed-pitch propeller). The ability to adjust propeller pitch enables precise control over thrust and speed, which also results in smoother sailing. Moreover, the reduced noise and vibration levels associated with CPPs contribute to enhanced onboard comfort for passengers and crew, further improving the overall sailing experience. The design is very promising, exceeding the expectations of the yacht owner.

However, CPP systems remain costly and are typically only found in larger vessels due to their complex design and higher initial investment. Although they offer superior control and efficiency, the expense of installing CPP systems may not be appropriate for smaller yachts.

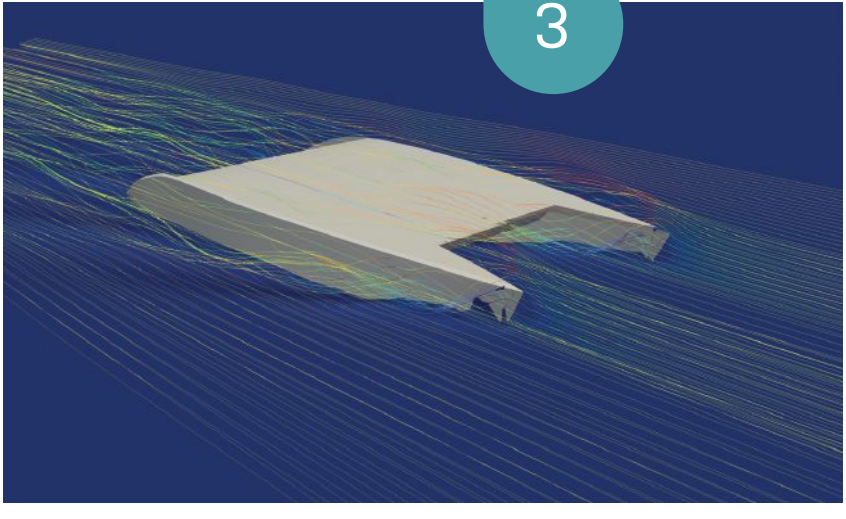
1



2

1. Yacht speed and hydrogeneration for the case study vessel
2. Ideally, the electric drive is considered at the very beginning of the project's design spiral to allow space for an adequately secured electric system and extra weight
3. CFD simulation of the water flow

3



For prospective clients seeking a sailing yacht design that stands the test of time, hydrogeneration is the ultimate solution. As battery and electric motor technologies continue to evolve at a rapid pace, investing in hydrogeneration ensures that a vessel remains at the forefront of sustainability and performance.

Hydrogeneration is leading the way for greener maritime practices. By improving technology, educating sailors and soliciting support from governments, it will be possible to make hydrogeneration more accessible and widely used. Collaboration within the industry will also speed up progress.

In summary, hydrogeneration presents a sustainable solution for maritime activities, merging environmental responsibility with technological advancement. By tapping into the natural energy of the sea, sailors pave the way for a greener, more sustainable future on the water.

Ampros

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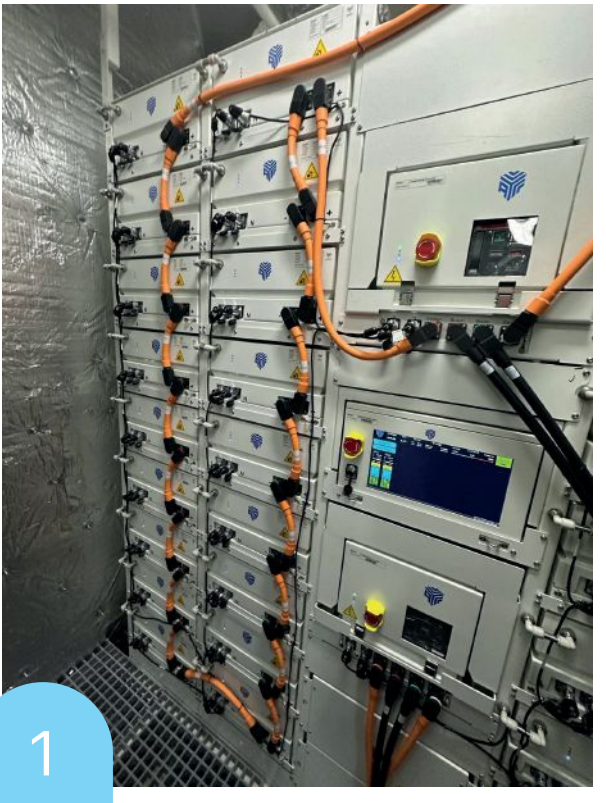
Expanding marine **battery production**

New supplier reveals plans to build the USA's biggest marine battery factory

WORDS: **BEN PINNINGTON**



1. AYK batteries aboard the H_2 Barge 2
2. Chris Kruger founded AYK Energy in 2018 with a goal to produce a low-cost battery that offered superior performance and safety while exceeding class and industry standards

1

The founder of marine battery innovator AYK Energy says 2024 is set to be a breakthrough year for the company. Chris Kruger, an electrical engineer and early pioneer of marine battery technology, explains that this year will see AYK not only unveil new innovations and battery ranges but also reveal plans to build the biggest marine battery manufacturing plant in the USA. AYK's gigafactory is set to be built at the Manhattan Project's famous Oak Ridge K-25 site - now part of the East Tennessee Technology Park. The new-build project will complement AYK's 5,000m² factory in Zhuhai, China, which opened in 2023. The China plant has a production capacity of 300MWh a year (with the ability to expand to 1GWh a year) and Oak Ridge will follow a similar model. Kruger says the China factory is "humming" with production as the company manages a surge in demand from a maritime industry hungry to decarbonize.

As a measure of growth, Kruger says AYK Energy expects orders to exceed 100MW in 2024, tripling its 2023 sales.

"We are disrupting the market with our vision of a safe, low-cost and highly innovative range of batteries," he explains.

Shaking up the market

Ed Carney, a former seafarer and now AYK's sales director, believes the company can provide the market with better prices and certainty than many of the established players.

"AYK is now winning and critically delivering the 5MWh and 10MWh+ systems," he says. "Starting out, we were already more competitive on price and delivery. However, we still had to prove ourselves as a new entrant into the market. Last year we were positioning ourselves to win the bigger battery projects like the 5MWh and above systems, competing with established players who were, and remain, more expensive and are using older technology. The market is seeing AYK's value, due to our range of battery technologies and our proven delivery track record. AYK is now a leading player in the maritime battery market."

According to Kruger, the new USA factory stands to benefit from Oak Ridge's free trade zone status, enabling AYK to serve not only the burgeoning USA market for ferries, tug boats and workboats but also the international market, with no duties on exports. The plant project is being led by Carney, a native New Yorker who now lives in Tennessee. The company is already working with local stakeholders and trade unions on the project and is aiming to employ up to 150 skilled workers supported by an apprenticeship program to train young people in an industry of the future.

"We are massively excited by the US market for coastal, inland marine and Great Lakes vessels," says Kruger. "There is a growing rumble of demand in the USA that is only getting louder. Our concept is for the Oak Ridge factory to serve that demand, especially for the high-speed ferries, hybrid vessels and specialized craft needed for the offshore

2

3. The zero-emission H_2 Barge 2 was handed over in 2024

4. AYK Energy's factory in China is designed to scale up production to suit demands for the company's batteries. The new US facility will follow a similar model

5. The opening of the AYK Energy factory in Zhuhai, China

4

wind energy industry. We've proved what we can do in the short sea inland marine industry by supplying one of the most high-profile electric projects in Europe, with the delivery of the H_2 Barge 2 hydrogen-powered container vessel. Now we take another step into the USA Jones Act market."

AYK attended the handover of the H_2 Barge 2 to Future Proof Shipping at Holland Shipyards Group (HSG) in Werkendam earlier in 2024. The zero-emission barge is seen as a trailblazer for the marine industry, and features two high-density AYK DNV-approved Aries 88 lithium batteries. The 125Wh/kg batteries were installed as part of a complete retrofit at HSG that saw the vessel's diesel engine replaced with a propulsion system consisting of PEM fuel cells, hydrogen storage, AYK's battery packs and an electric drivetrain.

Following the retrofit, the vessel has a cargo capacity of 190 TEU and will operate on the busy Rotterdam-Duisburg route along the Rhine.

"The battery system on this vessel is easy to install, built to exceed class requirements, with a higher density than many other batteries on the market," says Kruger. "AYK is one of the few battery manufacturers to exclusively use lithium iron phosphate (LFP) and we have developed a system where the LFP chemistry is safer, with greater energy density than nickel manganese cobalt (NMC)."

According to Kruger, NMC has been the most commonly used battery chemistry because of its supposed greater density – but can be more dangerous and costly than LFP. AYK, Kruger believes, is now showing that LFP can outperform NMC and deliver greater energy density, higher safety and better value.

Lightweight batteries

Another development for 2024 will see AYK launch its first aluminum-enclosure battery, complementing its steel battery range (where weight is not critical). The aluminum battery is targeted at the fast ferry market where lighter weight is required. The battery will feature a new cell produced by AYK's partner, EVE, a combination that will enable up to 30% weight savings.

"This aluminum-enclosure battery with the new cell technology is a game-changer," believes Kruger. "No other manufacturer has this technology or engineering relationship with EVE. The battery will drive down cost and ramp up power for high-speed catamaran ferries worldwide. We are already selling these batteries and are close to type approval.

"We made a conscious decision to establish ourselves in China. Now we have access to the latest technological innovations and we are close to our supply chain, which allows for constant advancement of our product range," he adds. "This supply chain is enabling us to grow and innovate LFP batteries much faster. We are now taking this know-how to the global market, supplying a very wide range of vessels from superyachts to ferries to tug boats."

Kruger sees the US factory as the company's "boldest move yet" and one that will enable the company to drive decarbonization more quickly and affordably.

"Throughout time, the key to the electric industry – from the days of the current wars between Edison, Westinghouse and Tesla – has been to democratize its use," he says. "At AYK, we believe that with our knowledge, supply chain and LFP technology, we can play a decisive role in bringing marine batteries to a much bigger mass market than ever before. We have a dream that marine batteries will become not just a luxury or a novelty but a low-cost, easy-to-use necessity for all vessel operators serious about decarbonization."

5

AYK Energy
To find out more, scan the QR code or visit:
www.aykenergy.com

PM machine **benefits for vessels**

Direct-drive electric propulsion can add multiple benefits to vessel operation

WORDS: **JUSSI PURANEN**

Permanent magnet (PM) machines have now almost completely replaced conventional electric machine types in big wind turbines. Today, this same shift is happening in various marine applications, such as shaft generator systems.

In PM machines (PMM), no external energy is needed for the production of the magnetic field, which always means better efficiency than in conventional machines. In marine applications, this translates into reduced fuel consumption by the ICE, as well as lower emissions, making it easier to meet new IMO emission regulations.

Typically, PM machines have 2-4% higher efficiency than conventional electrically excited synchronous generators when used in direct-drive, in-line shaft generators. This difference alone can result in fuel savings of several million US dollars during the lifetime of the vessel. Exact figures depend on the vessel size, operating profile and type of the main engine. Due to these savings, PM shaft generators are quickly becoming a standard choice in large oceangoing vessels.

In addition to higher efficiency, PM technology offers further benefits over conventional machines, such as compactness, mechanical simplicity and the minimal need for maintenance.

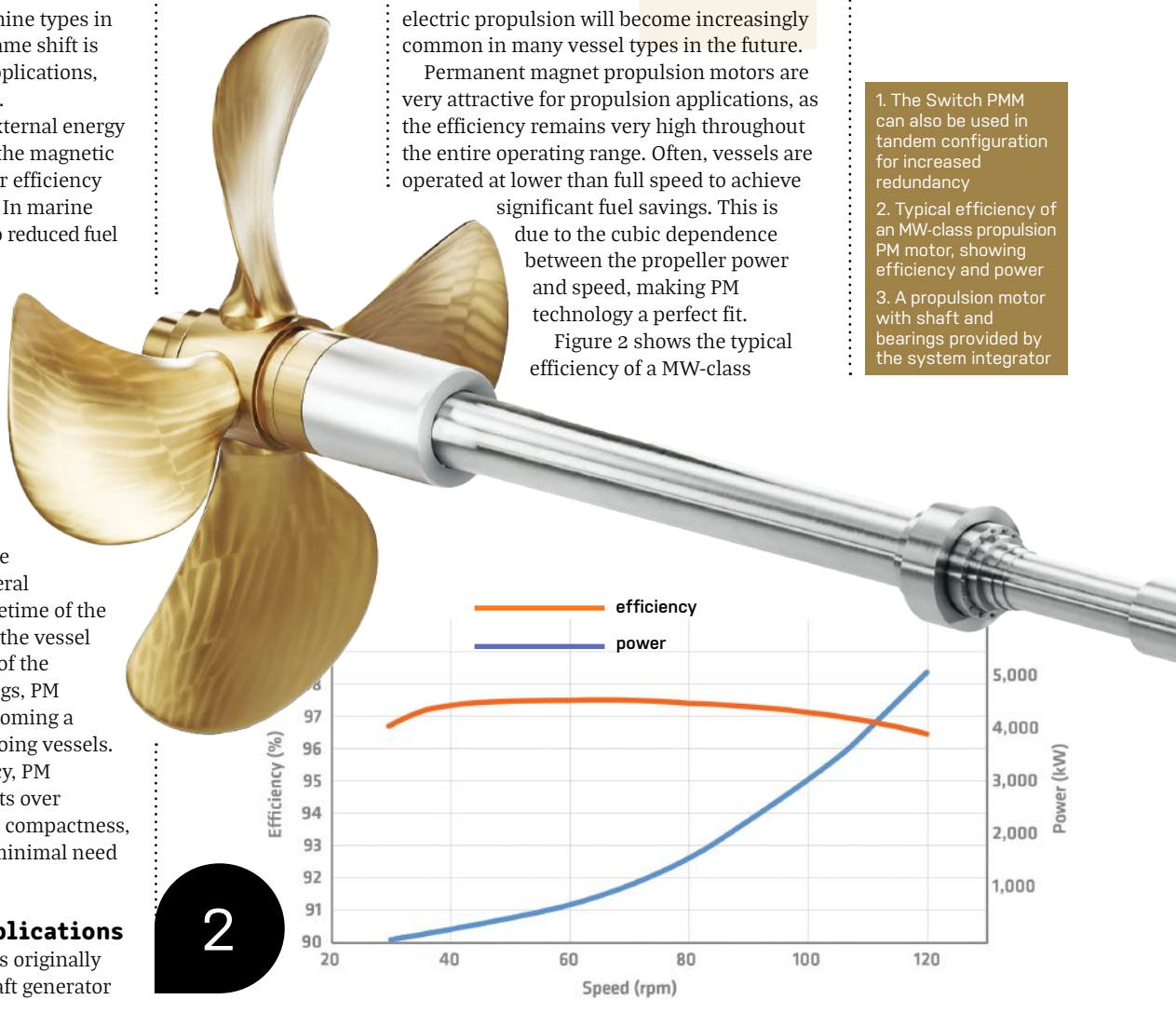
Electric propulsion applications

Even though this technology was originally developed by The Switch for shaft generator systems, it can be applied to direct-drive electric propulsion as well, offering the same benefits.

While the cruise industry has already shifted to electric propulsion, other types of large oceangoing vessels still use conventional diesel-mechanical propulsion, where the propeller is driven by a large combustion engine. However, due to electrification and the need for adding various kinds of power sources to a vessel's system – such as batteries and fuel cells – the team at The Switch believes that electric propulsion will become increasingly common in many vessel types in the future.

Permanent magnet propulsion motors are very attractive for propulsion applications, as the efficiency remains very high throughout the entire operating range. Often, vessels are operated at lower than full speed to achieve significant fuel savings. This is due to the cubic dependence between the propeller power and speed, making PM technology a perfect fit.

Figure 2 shows the typical efficiency of a MW-class



1. The Switch PMM can also be used in tandem configuration for increased redundancy
2. Typical efficiency of an MW-class propulsion PM motor, showing efficiency and power
3. A propulsion motor with shaft and bearings provided by the system integrator

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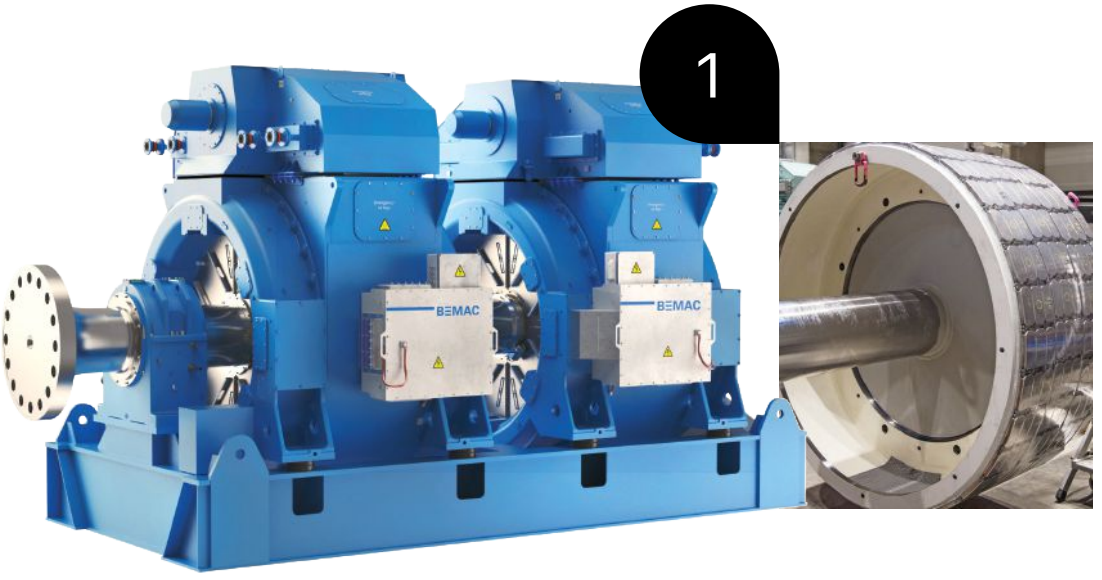


propulsion PM motor rated at 5MW/120rpm along the propeller curve, where high efficiency throughout the operating range is clearly visible.

Permanent magnet motors are also very quiet. This is becoming increasingly important due to environmental concerns, particularly regarding structure-borne noise emitted by the vessel.

Systems already in use

The Switch's first direct-drive propulsion motors are already operating on board the MV Nukumi, operated by Canada Steamship Lines. The vessel uses DC power distribution, which enables variable-speed operation for gensets without making the overall system any more complex than a conventional electric propulsion setup with AC distribution. This enables optimization of genset speed with regard to fuel consumption, depending on the vessel speed and onboard power consumption. Using DC power distribution also makes it easy to connect various power sources, such as batteries and fuel cells, in the future, making the vessel more futureproof.

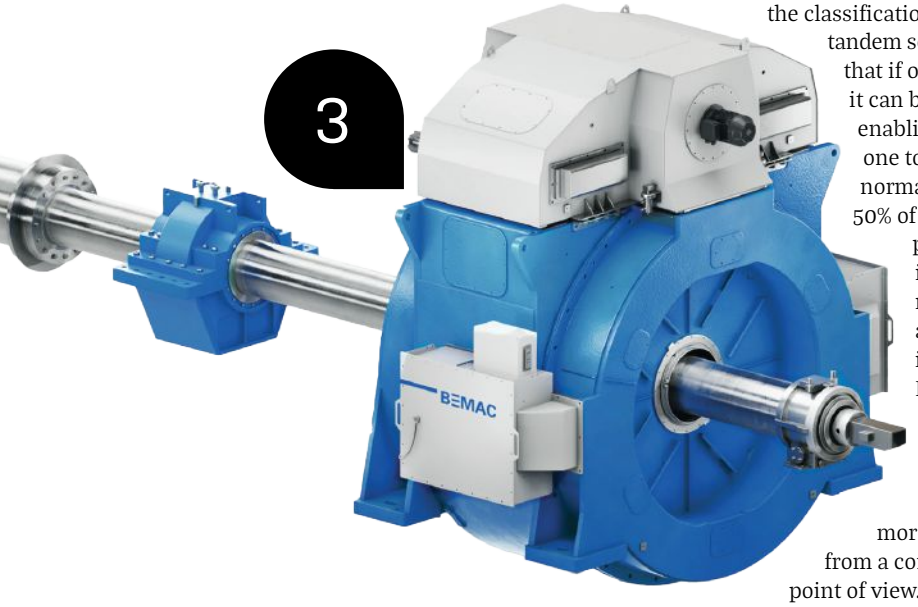
Flexible concepts

Direct-drive propulsion motors come in various configurations.

Sometimes, shafting and all needed bearings are provided by the system integrator, thereby making the whole setup simpler mechanically. However, careful coordination is needed between the motor supplier and system integrator regarding all interfaces and mechanical calculations for the propulsion line. This concept is shown in Figure 3.

In a conventional concept, the propulsion motor has its own bearings and shaft, and the connection to the propulsion shaft is made via a separate coupling. For increased redundancy, the motors can also be delivered in a tandem setup. This is critical in vessels with only one propeller, as failure in any component can result in complete loss of propulsion. This concept and PM rotor are shown in Figure 1.

The Switch machines are always designed with functionality that enables the rotor to be mechanically decoupled from the propulsion shaft within the time limits defined by the classification society. In a tandem setup, this means that if one motor fails, it can be decoupled, enabling the second one to operate normally, providing 50% of propulsion power – which is still enough to move the vessel at about 80% of its full speed. Machines can also be specified with dual-winding designs, offering more redundancy from a converter failure point of view.



Reliability and efficiency

Vessels with permanent magnet propulsion motors and variable-speed gensets have greatly reduced fuel consumption, leading to lower operating costs and decreased emissions. In addition, more space is left for cargo, as gensets with a propulsion motor take less space in the engine room than the big two-stroke engine used in conventional designs. The absence of a two-stroke engine also means quieter operation, which is becoming an increasingly important aspect to consider. In the most critical cases, where the vessel needs to fulfill silent notation by class, structure-borne noise can be even further minimized by adding resilient mountings and using a sine filter between the motor and the frequency converter.

In addition, a direct-drive PM machine is very simple mechanically. This results in increased reliability as there are fewer wearing parts than in conventional electric motor designs. So far, marine machines from The Switch have racked up several million cumulative operating hours without any failures that would have led to vessel downtime. Although the bulk of these hours are from shaft generator applications, most of the design for propulsion is still the same.

In conclusion, it can be stated that a direct-drive permanent magnet motor combined with DC power distribution represents a more economical and environmentally conscious choice for marine systems than conventional diesel-mechanical propulsion.

The Switch
To find out more, scan the QR code or visit:
www.theswitch.com

Electrifying **short-sea shipping**

Could this marine segment be the next candidate for zero-emission shipping?

WORDS: **SVEINUNG ØDEGÅRD**

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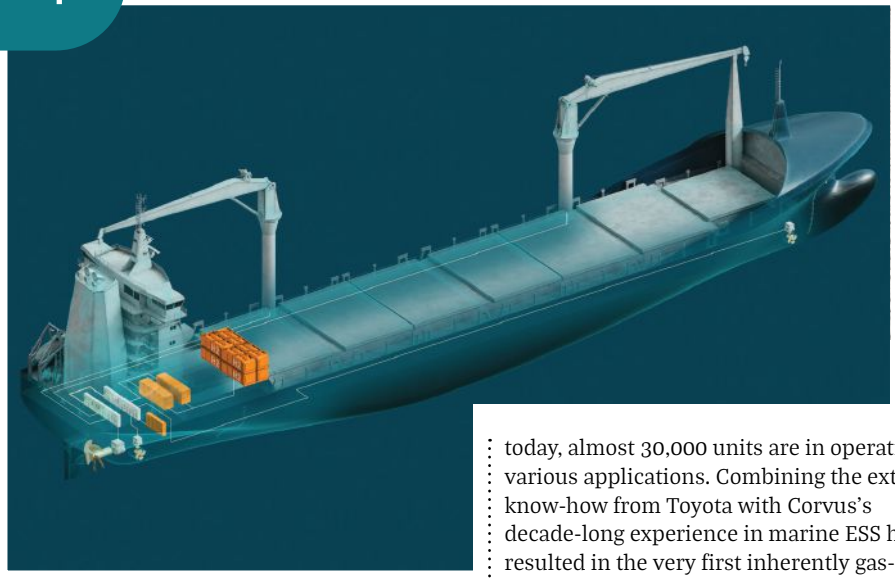


The energy transition in maritime continues to accelerate as the focus on green shipping spreads. Since the launch of Ampere, the world's most famous all-electric ferry in 2015, zero-emission marine vessels have proved reliable and cost-efficient for a range of vessel types.

Corvus Energy battery systems power more than 100 all-electric vessels around the world. Vessels that can operate using battery only include ferries, tugs, harbor cruise vessels, passenger vessels and even bunker vessels. New vessel types will be added going forward.

Shipping is considered a hard-to-decarbonize sector as there is no one-size-fits-all solution. The long-term decarbonization options such as ammonia and other clean fuels are not yet commercialized at a scale needed for widespread use. Furthermore, opinions across the industry contain more politics and open-ended questions than real answers.

Using known technology

By starting with what we know and the technology that is ready for use, we will be able to speed up innovation as we can leverage existing competence and collaborate with existing value chains. We know that batteries work well and will play a pivotal role in decarbonization going forward. However, despite improvements in energy density, volume and charging infrastructure, this will not take us all the way.

So, what other options do we have? It is imperative to remember that hydrogen fuel cell technology is not a new invention. It is a proven technology that has been used for decades in many industrial applications.

Using it on board maritime applications is simply a matter of adding the required safety level to existing technology and fine-tuning the system integration. Fuel cells also exceed the combustion engine in efficiency. Today's commercial fuel cells are in the mid to upper 50% efficiency range, a number that combustion engines struggle to achieve with new and alternative (bio)fuel types. The remaining losses are heat, allowing vessels to increase efficiency even further by having waste heat recovery systems. Hydrogen fuel cells and batteries are also partners in power – and the reason why, in 2021, Corvus formed a partnership with Toyota, a world leader in fuel cell technology. Toyota's hydrogen fuel cell development began in the 1990s and, as of today, almost 30,000 units are in operation in various applications. Combining the extensive know-how from Toyota with Corvus's decade-long experience in marine ESS has resulted in the very first inherently gas-safe marine fuel cell – the Pelican FC – a system that offers huge flexibility in terms of positioning on board a vessel without any additional safety measures. Corvus has also invested heavily in the technology on board to provide shipowners with a completely safe solution, along with supporting systems to optimize the use and lifetime of the systems.

Short-sea shipping

Considering this, and the way forward, short-sea shipping stands out as the next segment suitable for zero-emission operations.

"Short-sea shipping has predictable routes where we can provide the needed fuel and bunkering options," explains Sveinung Ødegård, senior VP of business development, fuel cell technologies at Corvus. "With voyages

1. Using hydrogen on container vessels can help decarbonize a significant sector
2. Short-sea shipping is a segment with usage characteristics that would support zero-emission power
3. An onboard fuel cell room outfitted with Corvus Energy technologies

being limited to less than four or five days between ports, these vessels can reach emission-free operations with direct hydrogen brought on board. For these sailing routes, the space challenge for hydrogen storage is worth looking at. It is less space efficient than fossil fuels, but green corridors and refueling plans for each voyage can level out the disadvantage.

"Another reason short-sea shipping should consider direct hydrogen is the lack of alternative biofuels for all industries," he continues. "The maritime industry alone, representing only 3% of the global energy consumption, would need 30-40% of the estimated total biofuel mass available in 2030. As ammonia and e-methanol are favored for larger vessels, it does make sense for the entire industry to focus on hydrogen for short-sea shipping."

By using batteries in combination with hydrogen and fuel cells, thousands of new vessels can be zero-emission.

Feasible routes

A short-sea vessel will cover the distance from Bergen in Norway to Rotterdam in the Netherlands in less than 40 hours with a speed of 15kts. Assuming a total power demand of 1,800kW (2,445hp), the energy consumption would be 72MWh, equal to 4,250kg (six 40ft containers of compressed hydrogen) with a fuel cell efficiency in the 50% range. Cost and availability will decide if this is a business case, but the technology is ready to be used.

2

3

For shorter routes, the combination of ESS and fuel cell becomes increasingly beneficial. Batteries will constantly optimize the overall electrical system to ensure the best efficiency of the fuel cells, but they can also eliminate a certain amount of H_2 consumption by taking full charge from shore before leaving and returning discharged to the next port.

Fuel cell technologies have the potential to improve in the same way that batteries have done with regard to energy and efficiency and for different use cases.

Ambitious H_2 supply goals

Direct hydrogen avoids the additional losses that occur in the generation of ammonia and e-methanol. It can be produced locally when the cost of energy is beneficial, and it is part of the new total energy plans worldwide. With strong support from governments, ambitious goals have been announced in the USA, Japan and Europe to establish infrastructure in ports.

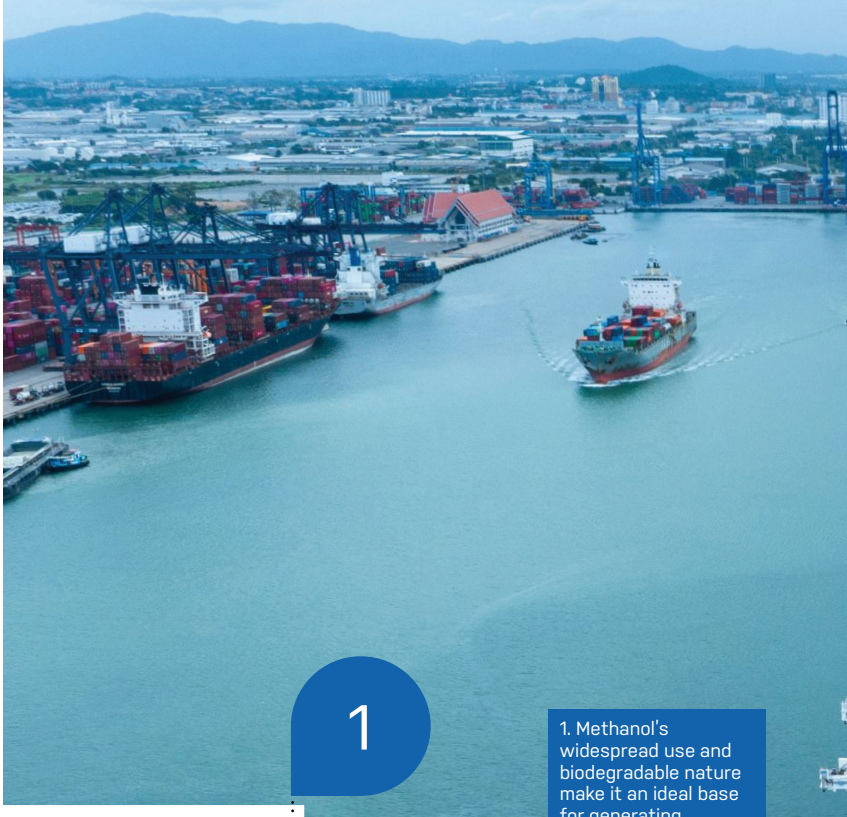
As production scales up and economies of scale drive costs down - coupled with regulatory mechanisms such as the EU ETS and FuelEU Maritime - the Corvus team believes hydrogen is poised to become increasingly cost-competitive going forward.

Corvus Energy
To find out more, scan the QR code or visit:
www.corvusenergy.com

On-demand, **on-vessel hydrogen**

Hydrogen generation on board a vessel offers an attractive decarbonization strategy

WORDS: **BRYAN REID**



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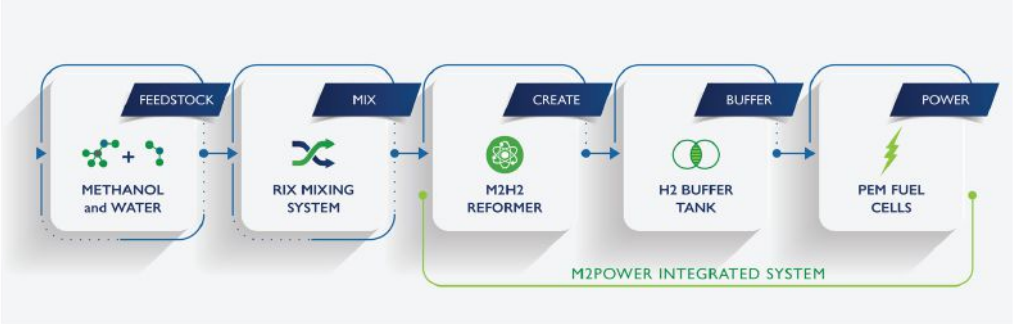
1. Methanol's widespread use and biodegradable nature make it an ideal base for generating high-purity hydrogen-on-demand through methanol reforming, eliminating complex hydrogen storage solutions and reducing environmental impact



The adoption of hydrogen as a sustainable fuel source is a promising solution for cleaner energy in maritime applications. However, the critical question still remains: What will encourage ship operators to integrate hydrogen-fuel-based energy sources efficiently and safely, and how do shipbuilders balance the risks of adopting available technologies now against waiting for even greener alternatives?

Hydrogen-on-demand systems offer a way to address these concerns pragmatically, recognizing the need for a forward-thinking approach to any emissions-reduction solution. The shift toward sustainable fuels requires a more comprehensive strategy than just committing to the choice of fuel – this is where hydrogen-on-demand leverages existing methanol infrastructure to ease the transition, simplify complexities and offer immediate benefits. Its flexibility may be the answer to the confusion in the marketplace that is creating a culture of reluctance – challenging shipbuilders and maritime professionals to adopt decarbonization strategies.

Accessible and streamlined

Traditional hydrogen storage methods pose significant challenges, including the need for high-pressure storage for gaseous hydrogen or cryogenic systems for safely managing liquid hydrogen. Hydrogen-on-demand circumvents these hurdles by using methanol as a hydrogen carrier, significantly reducing the burden of costly, complex storage and transportation protocols. This is enabled by methanol-to-hydrogen (M2H2) technology – readily deployable systems that generate high-purity hydrogen on demand from a feedstock mixture of methanol (62%) and water (38%) through the proven methanol reforming process.

2

Methanol serves as an ideal hydrogen carrier and feed source, given its role as a substance familiar to and manageable within the maritime sector. Low-risk and cost-effective methanol offers global availability, low toxicity and ease of handling. In addition, the costly footprint of cryogenic or high-pressure hydrogen storage is eliminated and safety is improved. Once hydrogen is consumed by a fuel cell, the only additional output is pure water, which can be recirculated back to the M2H2 feedstock mixing system in a true closed-loop manner.

Streamlining operations

When the M2H2 reformer system is integrated with PEM fuel cells, ship operators can fulfill their power needs without the environmental impact of current fuels such as diesel and kerosene. Until recently, M2H2 and PEM technologies have typically occupied different rooms on board vessels. However, a more modular design

2. The ability to generate hydrogen on board will have an enormous impact on new vessel design

3. On-demand generation technology can also impact requirements for hydrogen infrastructure in ports and harbors

3

approach has streamlined their configuration with a combined, integrated approach to further reduce cost and complexity and enable ease of integration.

M2H2 systems and accompanying PEM fuel cells can be strategically co-located, creating a more integrated 'black box' solution that maintains a smaller footprint at a lower cost – minimizing hydrogen runs and reducing the need for inerting systems. Because there are no complex layouts or extensive space requirements, a compact, integrated M2H2-PEM power system can be more effectively placed for ease of accessibility, keeping service and maintenance tasks straightforward and manageable. The self-contained nature of this solution ensures it is built and tested as a packaged unit – as a result, onboard qualification testing or verification is unnecessary.

Sailing to net zero

The journey to net zero emissions in maritime shipping necessitates moving beyond conventional hydrogen storage methods. Critically, the transition to cleaner propulsion does not have to wait for the availability of green methanol – although it is becoming more widely available. With M2H2 technology, shipping operators can begin making significant strides toward their decarbonization targets today, using any type of methanol and simply shifting to greener methanol options when they become available.

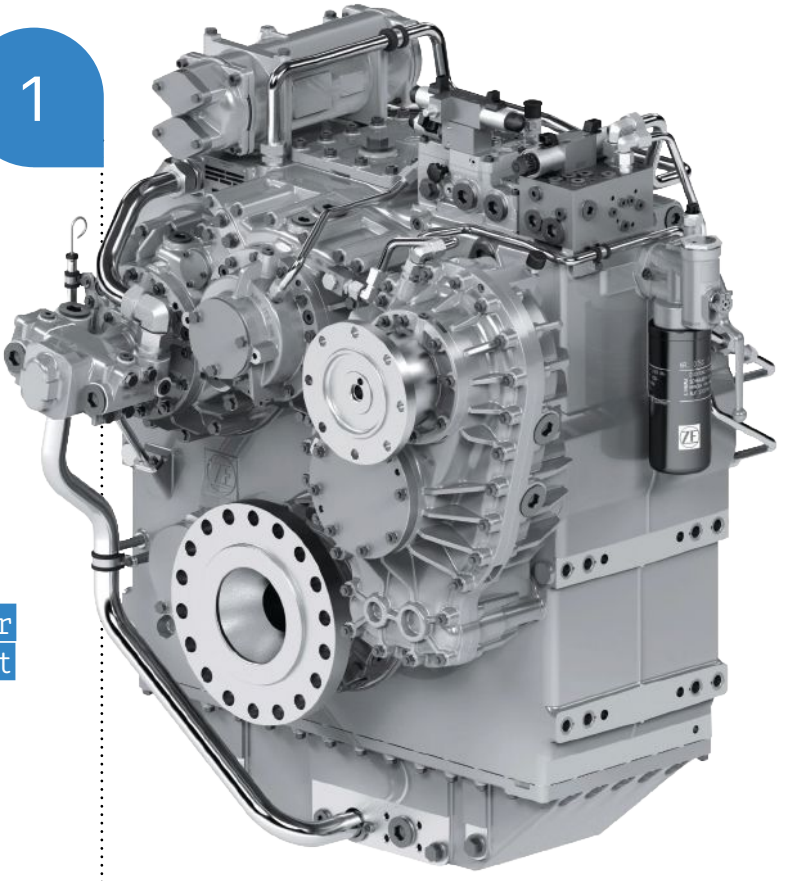
With mandates on the horizon, the maritime industry is facing an inflection point. Hydrogen-on-demand, combined with PEM fuel cells as an integrated package, is ready to make a difference. It's practical, proven technology that offers an immediate pathway to a cleaner, more sustainable future.

Rix Industries
To find out more, scan the QR code or visit: **www.rixindustries.com**

Optimized **propulsion**

ADS van Stigt's Jordi van Pelt, sales engineer for industry and offshore, and business development manager Sander Snoek discuss how optimized ship propulsion systems can reduce greenhouse gas emissions in the maritime industry

INTERVIEW: **ELIZABETH BAKER**



How can ship propulsion systems be optimized to reduce emissions and improve efficiency?

Optimization can be achieved by equipping a reverse gear with a power take-off (PTO) and having it drive an electronically controlled generator. While this isn't a new technique, the need to think about emissions – alongside engine load, installing fewer kW, fewer engines running on board and control technology getting better – calls for this important stepping stone to reduce emissions per ton/km. It's a technique that is retrofittable.

1. ZF W5355 PT transmission
2. Jordi van Pelt (left) and Sander Snoek with a Katsa 2L550
3. Masson Top PTO on a MM W4400
4. Masson MM W4400 NC (non-clutchable) transmission with an asynchronous electric motor
5. ZF ATL 6000 WM thruster including a standard asynchronous motor

By optimizing a ship's hull and supporting with wind power, less power is needed for propulsion. As a result, a small internal combustion engine with the addition of an electric motor will suffice. A hybrid reversing gear is a wonderful solution here because it enables users to sail on a small generator set – and thus prepare for a future power source and renewable energy – while still being able to move forward with reliable, proven technology.

Often, two-thirds of the power is sufficient for most of the voyage and one-third is enough when calling at ports or locks. When 100% is needed, 100% is available in boost mode. At ADS van Stigt we see the above as an interim solution; thinking about how it can be done and what is needed gives a lot of insight and therefore net savings or a suitable solution.

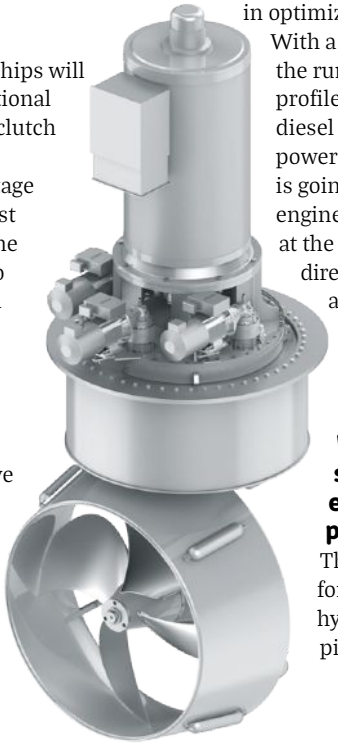
If we want to go even further and fully prepare for the future with renewable energy, a PTI gearbox still seems a great solution where the combustion engine will use alternative fuels and may need support from an electric motor powered by a fuel cell or battery pack through the PTI.

It is also conceivable to switch to a 100% electric drive. An electric motor is mounted directly on the thruster, with the elimination of the upper gearbox resulting in an efficiency improvement; this is called an L-drive. A compact electric motor provides many advantages for the ship designer.

5

There will be a need for more ships with various DP notations in the coming years. With an electrically driven thruster, the DP plot can be executed well, and, in favorable conditions, emissions can be significantly reduced.

Besides the thruster, many ships will continue to sail with a conventional driveline where the reversing clutch is replaced by a non-switching reduction gearbox. The advantage of this solution is that the thrust is neatly accommodated and the reduction will make it easier to choose an electric motor. Then efficiency is improved by increasing the size of the propeller diameter and thus reducing the propeller speed. The overall weight will also be more favorable, which will have an immediate positive impact on the ship design; less weight also means ultimately fewer emissions per ton/km. Here we can go with a single e-motor-driven gearbox or



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– in case it is needed due to redundancy – with a twin e-motor-driven gearbox.

What maritime propulsion technology trends are emerging?

For a lot of vessels, high speed is a key factor in their success. But speed normally costs a lot in energy and emissions, so to improve the environmental footprint the designers are always looking for weight-reducing solutions. We see a trend toward replacing steel shafts with Geislinger carbon shafts. The big advantage is that the flanges and the misalignment couplings are all made from carbon, so the weight reduction is impressive.

How can hybrid propulsion systems contribute to reducing greenhouse gas emissions in the maritime industry?

Reducing emissions starts with reducing the energy needed to propel a vessel. A big saving can be found in the hull design but also in optimizing the propulsion installation. With a hybrid driveline, you can match the running engines with the sailing profile. Downstream or on canals, one diesel engine can generate the electric power for two shaft lines. If the vessel is going upstream, the bigger diesel engine is used to drive the propeller at the highest efficiency possible in direct drive. The hybrid configuration also makes it easier to sail with zero emissions by installing a reasonably sized battery pack or fuel cell.

What role do PTO systems play in enhancing ship propulsion efficiency?

The PTO has been on gearboxes for a long time, mainly to drive hydraulic pumps but also for fixed-pitch propellers. We see more and more applications where an extra PTO is added to the reversing gearbox to drive a shaft generator as well. The advantage is that the main engine – which is running anyway – can also drive the generator for the so-called hotel consumption. The generator set can be switched off, so fewer engines are running and the engine that is running is doing that on a better specific fuel consumption. With a frequency drive, a stable power grid is also created when the engine RPM changes for nautical reasons.

What role do electric motors play in enhancing ship propulsion efficiency?

The electric motor gives design freedom for the hydrodynamic ship designer to optimize the hull but also to prepare the vessel for future fuels. By installing an electric motor on a ZF thruster, the thruster room can be very short and compact, and the power source can be installed in the optimal location on the vessel. This power source can be a couple of regular diesel-driven gensets or a combination of batteries and fuel cells.

How are advances in deck equipment, such as winches and tensioners, reducing energy consumption and emissions in maritime operations?

For certain types of vessel, the deck equipment is a key feature that operates continuously. Because of this, these applications can account for a large part of the overall energy consumption of the vessel, so optimization makes sense. Traditionally, applications like winches and tensioners are hydraulically driven, but we see a trend of electrification here too, to reduce the overall system losses. Depending on the available space and the specifications of the client, we can electrify the application in-house for our products. With our strategic stock of gear sizes, gear types, available reductions and input adapters if needed, an efficient solution can be created quickly.

ADS van Stigt
To find out more, scan the QR code or visit:
www.vanstigt.com

Variable-speed **generators**

1

Head of hybrid electric and alternative fuels Donald Williams explains how a leading supplier utilizes its expertise in the marine sector

INTERVIEW: **MATT ROSS**

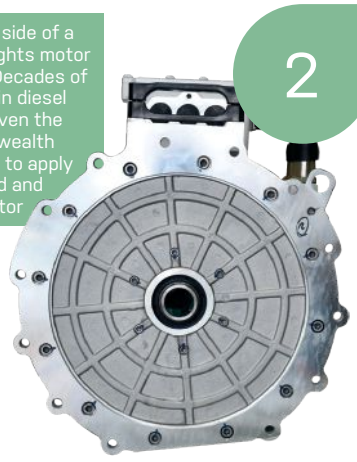
1. A variable speed M944DVS in a sound enclosure. Northern Lights has developed competencies across a range of technology segments relevant to the maritime sector

How has Northern Lights adapted in view of the move toward electrification?

Northern Lights was a very early participant in the move toward hybrid electric, having partnered with the Norwalk Maritime Academy to build the first hybrid electric research vessel in North America, which was completed in 2015 and has been successfully operating ever since. At the time, we partnered with BAE and integrated its electric motor generator and controls into our generator.

In which key areas can Northern Lights leverage its expertise?

We have been a leader in the development of diesel generators in marine for over half a century, so the move to hybrid electric is a natural progression. We also develop and supply chiller systems to the industry, which will play a critical role in providing temperature stability to ESS and motor/generator systems and electronics. We already have a wide array of variable-speed generators, chillers and motor-generator systems and drives that we are offering to the market.



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2. The back side of a Northern Lights motor generator. Decades of experience in diesel units has given the company a wealth of expertise to apply to the hybrid and electric sector

What makes NL's variable-speed generators suitable for use in electric/hybrid systems?

They are designed to be compact and lightweight, which we accomplish with state-of-the-art permanent magnet generators that are generally lighter and smaller than conventional asynchronous systems. We also design them with incorporated converters that allow our systems to output high-voltage DC power that can be directly connected to the existing DC bus. We pride ourselves on delivering reliable and long-lasting systems that are easy to service and operate.

Northern Lights has a long history of delivering compact, reliable, low-noise power generation systems. We deliver this with an extensive footprint of distributors and dealers that span the globe in over 60 countries.

Can you give us a breakdown of NL's hybrid propulsion offerings and what types of applications they are suited for?

We offer a wide array of variable-speed and fixed-speed generators for hybrid applications capable of providing high-voltage AC and DC current. These systems provide power from 35kW to 1,000kW.

We also provide a wide array of direct-compression-based chillers available in fixed-speed, staged and variable-speed configurations.

In addition, we've partnered with a leader in the supply of ESS to provide water-cooled, class-certified battery banks.

We are also able to supply permanent magnet motors for propulsion and auxiliary applications used in the marine environment, including powering hydraulic systems.

And finally, we have partnered with a leader in the area of hybrid electric controls in order to supply turnkey hybrid electric systems to our clients.

Our products are designed to meet the requirements of the pleasure craft, yachting and workboat sectors, which require hybrid systems in the range of 35kW to 2MW.

Is NL working on any specific areas of R&D?

Northern Lights has filed a family of patents and recently secured a patent assignment that is sure to differentiate our hybrid generator from those of the competition.

We are working to bring this novel product to the market soon. Besides that, we have products available that can run on renewable and biodiesels and on dual-fuel diesel and hydrogen. We will continue to develop cutting-edge technologies and test them thoroughly in order to continue to lead the market.

Northern Lights

To find out more, scan the QR code or visit:

www.northern-lights.com

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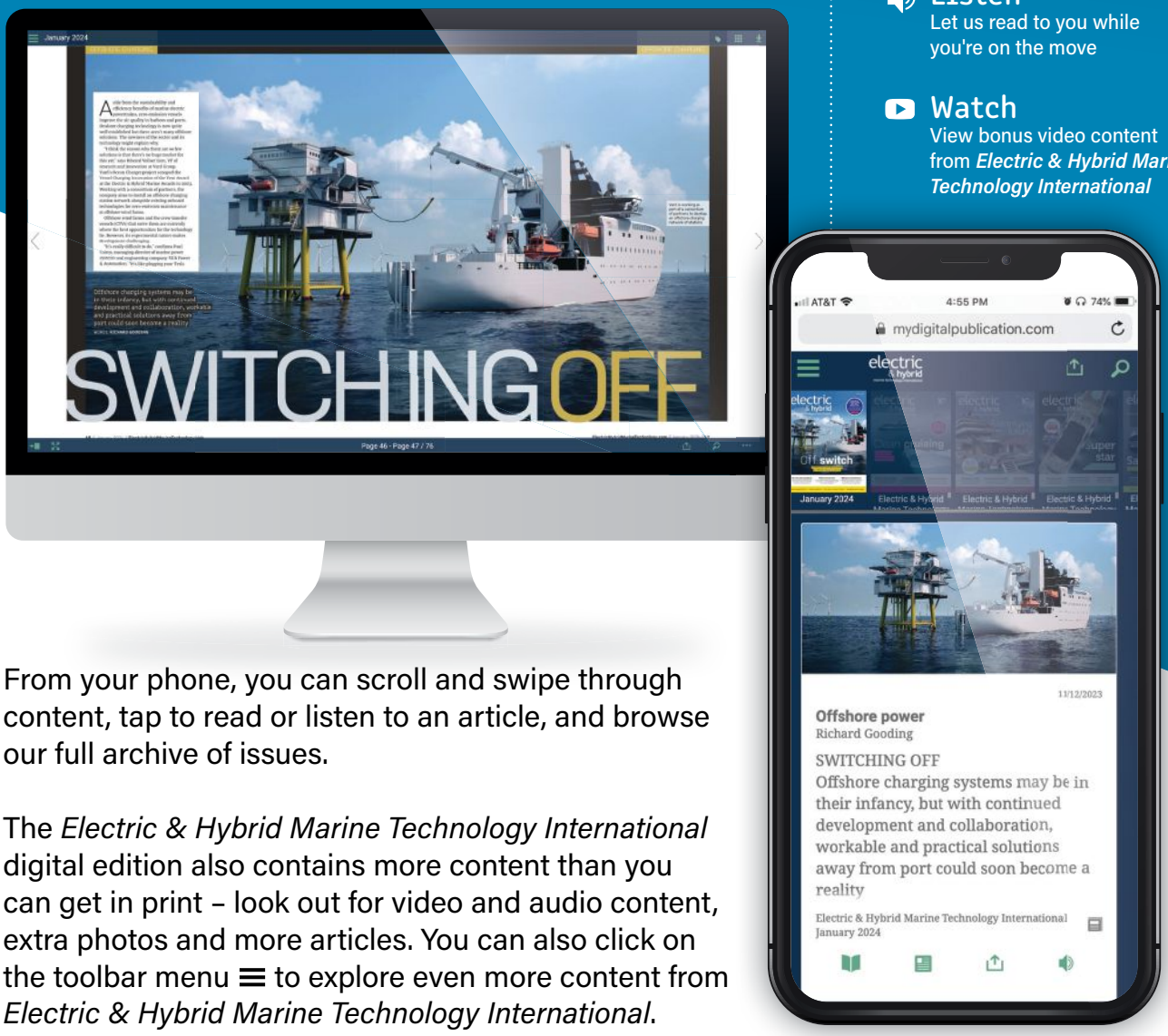

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www.electrichybridmarinetechnology.com/online-magazines

Hydrogen power for offshore vessels

Utilizing fuel cells to reduce the environmental impact of commercial operations

WORDS: **PHIL SHARP**

Offshore workboats, service vessels and fishing vessels make a significant contribution to the footprint of the maritime sector, as they often undertake long offshore operations coupled with high power demand.

With strong advances in emissions regulations over the last 12 months, as well as growing environmental pressure to reduce underwater noise to protect marine life, fuel cells will play a crucial long-term role in the maritime sector's race to net zero.

Hydrogen has been identified as a key fuel to decarbonize commercial vessels where high energy storage and high range are required, while avoiding weight increase, which penalizes the performance and energy efficiency of the vessel.

With several new large-scale green hydrogen production projects now underway, and many more in the pipeline, availability of this sustainable fuel is forecast to increase sharply from 2025, offering access particularly around ports where hydrogen and hydrogen-based e-fuels will be produced, exported or imported.

To make clean hydrogen propulsion accessible to commercial and leisure craft, Genevos has been pioneering marinized hydrogen power systems, with 40kW and 80kW modular fuel cell solutions now in service in recently launched motor vessels.

High-power fuel cell solutions

A recent development has focused on a next-generation 250kW fuel cell system – the Genevos HPM-250 – designed as a modular or containerized solution for vessels of typically over 1MW propulsion, which is of particular interest to the next generation of short sea vessels.

For longer-range, deep sea applications, the Genevos HPM-250 is compatible with methanol and other e-fuel reformers that can output purified hydrogen gas. It reduces opex by enabling power conversion at higher efficiencies than combustion, in addition to eliminating vibration and associated noise.

Decarbonizing commercial vessels

As a confirmed supplier for several short sea and offshore vessels in the fishing, workboat and crew transfer vessel (CTV) segments, Genevos is playing a key role in demonstrating how marine fuel cells can significantly reduce the impact of commercial operations across the maritime sector.

These flagship projects (among other first movers in the leisure market, including high-speed foiling vessels and motorboats) have enabled Genevos to develop significant know-how in onboarding hydrogen power across a broad range of applications through primary, hybrid or auxiliary integration.

Unlike automotive hydrogen vehicles, the application of hydrogen to the broad maritime sector is relatively new – despite having existed in submarine applications for several decades. This emerging maritime market is continually developing through the support of specialist classification companies and flagship projects. Strict standards and procedures are now established, enabling Genevos to advance with type approval certification for its range of products – a requirement for many commercial maritime flag states.

Turnkey systems for vessel classification, along with key design features including practicality, reliability and serviceability, provide a drop-in solution for decarbonizing vessels, and represent a step forward in achieving a sustainable maritime future.

At this year's Electric & Hybrid Marine Expo Europe, Genevos will showcase its new Gen-II HPM and announce pioneering projects that are taking action in the race to net zero.

A 2MW marine fuel cell system featuring the Genevos HPM-250

Genevos
To find out more, scan the QR code or visit:
www.genevos.com

FROM THE PUBLISHER OF ELECTRIC & HYBRID MARINE TECHNOLOGY INTERNATIONAL

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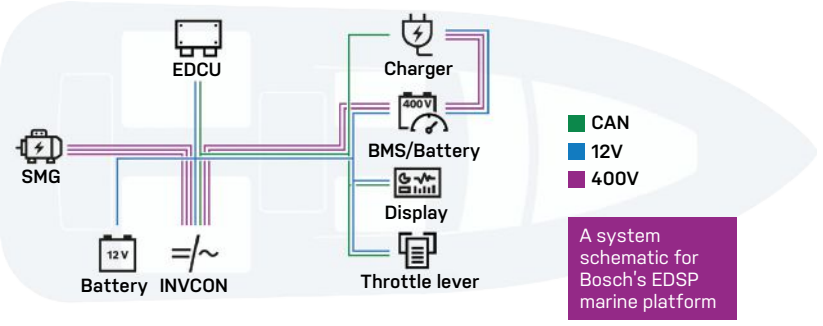
Electrifying **boat drives**



A system schematic for Bosch's EDSP marine platform

An electric drive system and associated components offer a simple solution to electrify vessel propulsion

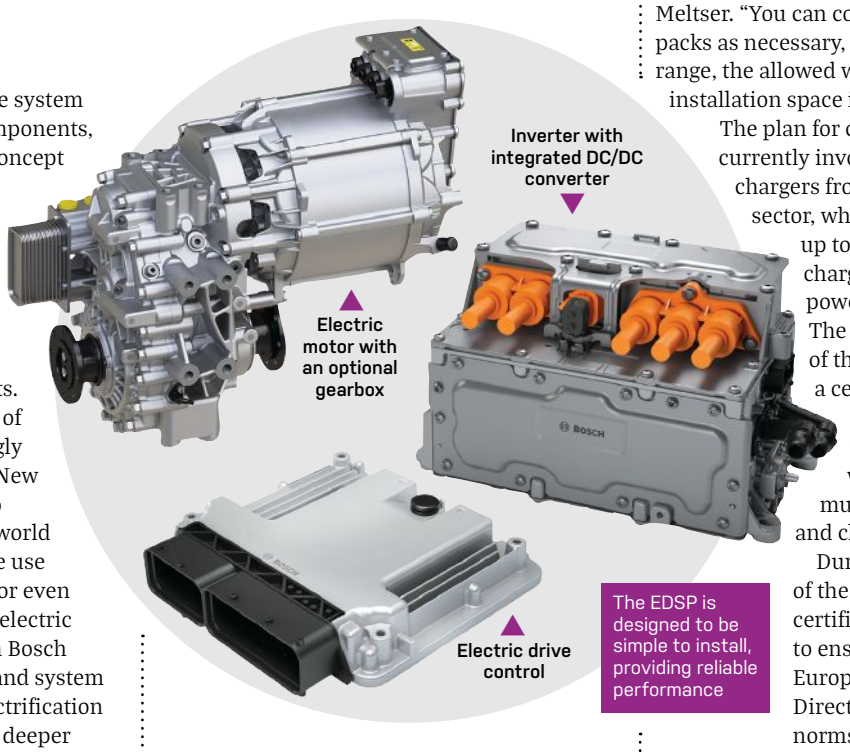
WORDS: **RICHARD BACKHAUS**

By developing an electric drive system platform including drive components, Bosch Engineering offers a concept that enables recreational and commercial boats to be equipped with electric drives quickly and safely. In one system solution, the platform combines Bosch electric motors, inverters and transmissions with all other relevant electrification components.

Sustainability and conservation of resources are becoming increasingly important in the maritime sector. New environmental laws will come into force in many regions around the world in the coming years, promoting the use of alternative powertrain systems or even banning ICEs altogether. With the electric drive system platform (EDSP) from Bosch Engineering, boat manufacturers and system integrators can implement the electrification of boat drives quickly and without deeper development efforts.

"The EDSP is designed for recreational and commercial boats and combines all drive components, as well as components such as high-voltage batteries, chargers and wiring diagrams into a single system solution," says Valentin Meltser, product manager for electric boat drives at Bosch Engineering. "In addition, users receive comprehensive information and tools to integrate the high-voltage drive system into the overall concept of the boat as quickly and efficiently as possible. This includes a system guideline, standardized control unit software, and all-round support during integration and commissioning."

The electric motors, inverters and transmissions were developed by Bosch. The components are based on technologies with a strong track record in the automotive sector and have been used for years in a wide variety of off-highway applications. Their compact size makes them easy to integrate even where space is limited. The electric EDSP drive motors are available in 90kW and 140kW power levels. The 400V permanent magnet synchronous machine is characterized by its high power density and excellent efficiency. The inverter is equipped with a high-performance DC-DC converter to supply the 12V devices. The transmissions feature an impressively high efficiency level and operate quietly with low maintenance.



The EDSP is designed to be simple to install, providing reliable performance

Flexible integration

All of Bosch's EDSP components are extremely reliable and robust. The standardized EDSP software provides specifications for smooth and efficient integration into the drive system. Various battery types can be used, depending on the boat type and customer requirements.

"The typical capacity of a high-voltage battery pack is around 40kWh," explains Meltser. "You can combine as many battery packs as necessary, depending on the required range, the allowed weight and how much installation space is available."

The plan for charging the EDSP currently involves using onboard chargers from the automotive sector, which enable AC charging up to 22kW. If needed, DC charging systems with higher power can also be installed. The electronic control unit of the EDSP system offers a certified NMEA 2000 interface, which provides compatibility with standard marine multifunction displays and chart plotters.

During development of the EDSP, an independent certification body verified it to ensure compliance with the European Recreational Craft Directive as well as relevant norms and standards.

Finally, the design of the various system components that round off the drive as a whole reflects the issues of functional safety and cybersecurity. This applies primarily to the EDSP software, yet also to the wiring of the power and communication networks, the cooling system and other parts of the EDSP's design. The EDSP system guidelines make it easier for customers to address these important aspects. On request, Bosch Engineering also helps customers with customized system developments so that they can adapt the drive to the individual requirements of the application.

Bosch Engineering
To find out more, scan the QR code or visit:
www.bosch-engineering.com

Shiptec

High-performance energy storage

Optimizing battery solutions for an array of marine propulsion applications

WORDS: **FREDERIQUE HOPPE**

1

1. The Octopus Series battery system with Lite modules on board the EMS Rutli of SGV, integrated by Shiptec. The 1929 vessel is being refitted with zero-emission propulsion systems

2. EST-Floattech's containerized energy storage solution on board Kotug's all-electric E-Pusher 1

The electrification of shipping has great social importance. As the amount of goods transported by water will increase significantly in the coming years, the EU is aiming for a 50% increase in transportation via inland waterways and shorter sea routes by 2050 compared with 2015. A volume growth of over 200% is expected for international shipping between 2023 and 2050. Currently, only 1% of the global fleet is electrified, and the sector has a long way to go to achieve net zero by 2050. This makes the pursuit of sustainable solutions of utmost importance.

There are several options in the market, one of which is EST-Floattech's Octopus series. These high-performance modules offer efficiency, reliability and zero-emission voyages. The Octopus series is available in High Power, High Energy and Lite versions. Vessels that need large-scale systems or don't have a dedicated battery room have the option to look at a containerized solution that, like the entire Octopus series, can be customized to the required energy needs.

Kotug International

2

The High Energy modules prioritize maximum energy storage capacity, making them ideal for applications requiring prolonged operation without recharging. On the other hand, the Lite modules strike a balance between energy density and weight, making them suitable for vessels where space and weight constraints are critical factors. This modular system can be seamlessly installed within vessel compartments, optimizing the use of space and ensuring compatibility with diverse vessel configurations.

The deployment of the containerized solution (2MWh) with the Octopus series battery system on board the Kotug E-Pusher 1 exemplifies the transformative impact of this technology in real-world scenarios. As a fully electric, modular and emissions-free pusher tug designed for efficient operations, the E-Pusher 1 relies on the containerized solution to provide all the energy required. By incorporating the Octopus series, the vessel's performance is enhanced while its environmental footprint is reduced.

System controller

Beyond the immediate benefits of reduced emissions and operational costs, this technology paves the way for broader transformations in the shipping industry. When looking at larger systems, there is the option to add the System Controller, which eases the system integration of up to 10 parallel strings, and up to 1.8MWh per system controller. It collects and summarizes data for the customer's power management system - an advantage when looking to easily integrate a large battery system on board and gather data about its performance. From offshore vessels to ferries, the possibilities for integrating EST-Floattech's battery system in maritime applications are extensive.

This battery system offers a blend of high performance, versatility and robustness. EST-Floattech sees the maritime industry embracing the need for decarbonization and operational efficiency, and this battery system supports that change.

EST-Floattech
To find out more, scan the QR code or visit:
www.est-floattech.com

Cooling fuel **cell systems**

1. Bowman's titanium heat exchanger technology is being used for the cooling system aboard the hydrogen hydrofoil

1

A record-breaking hydrogen boat design relies on efficient cooling technology

WORDS: **TONY CARTER**

This summer, in July 2024, a team of students from TU Delft University hope to make history by completing the first emission-free crossing of the North Sea.

Although it sounds simple, the challenge is actually quite daunting – to travel over 400km (216 nautical miles), non-stop from the Netherlands to England, in a boat powered solely by hydrogen.

To achieve this, the TU Delft Hydro Motion team has assembled 23 students who are designing, developing and manufacturing the hydrogen-powered hydrofoil boat. The plan is to 'fly' the hydrofoil-equipped vessel across the North Sea in one day, to demonstrate how hydrogen offers the marine industry an emission-free fuel alternative that could also be ideal for traveling longer distances.

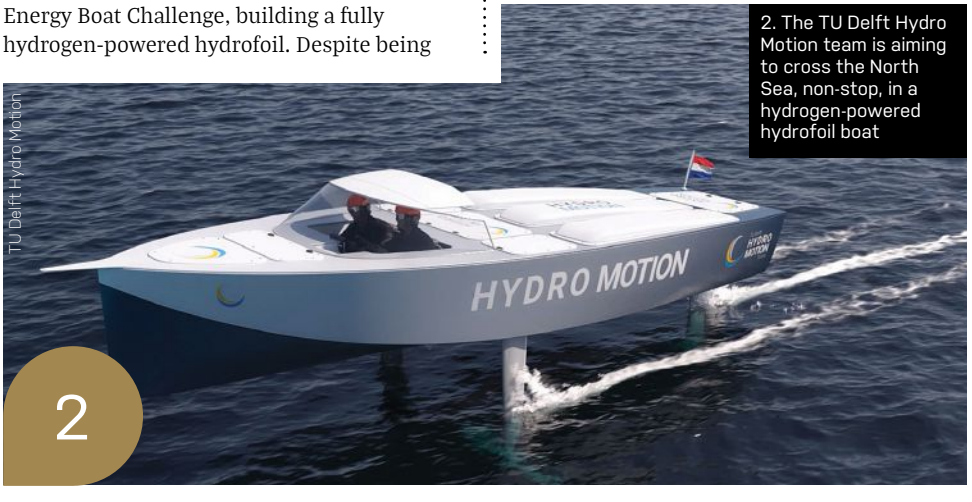
The Hydro Motion team is certainly no stranger to zero-emission marine propulsion. Over the past decade the team has built groundbreaking boat designs to push the envelope of marine technology.

In 2023, the team entered the Monaco Energy Boat Challenge, building a fully hydrogen-powered hydrofoil. Despite being the only student team in the event, it beat off challenges from commercial companies to be crowned world champion.

However, this latest challenge will push the team much further. While speed and agility played a major role in the 2023 World Championship, crossing the North Sea will require a focus on endurance, with robustness and reliability key design considerations for the new boat.

The design will be much larger than in previous years, enabling the hydrofoils to be placed further apart. This wider wingspan will contribute to the stability of the vessel as it hovers above the higher waves that will be encountered in the North Sea (compared with the Mediterranean in Monaco).

The boat will carry three hydrogen tanks, holding a total of 25kg, which will be converted into water via a single fuel cell, generating the electric energy required to power the boat across the North Sea, and eliminating any need to refuel.



TU Delft Hydro Motion

2. The TU Delft Hydro Motion team is aiming to cross the North Sea, non-stop, in a hydrogen-powered hydrofoil boat

2

Keeping cool

Cooling a hydrogen propulsion system is a major consideration for any boat builder. In the Hydro Motion boat, four Bowman heat exchangers, supplied by Koninklijke Van Twist (Bowman's Netherlands distributor), are being used exclusively for the entire cooling system.

Struts underneath the boat will draw seawater into the open-loop cooling circuit, which will then be pumped through the Bowman heat exchangers to cool the closed-loop cooling circuits.

These include the fuel cell and its accompanying converter and compressor, the motor and motor controller, plus the BrightLoop DC-DC converter, using demineralized water as the cooling medium.

The compact design and excellent thermal transfer performance of the Bowman units makes them ideal for hydrogen fuel cell propulsion, where space is often limited. They also proved to be the ideal cooling solution in 2023 when the Hydro Motion team won the Monaco Energy Boat Challenge.

"We wish the TU Delft Hydro Motion team every success in their latest challenge to show that hydrogen fuel really can go the distance in the marine industry," says Bowman sales manager Tony Carter. "We have enjoyed a successful association with the team over many years, and look forward to welcoming them to the UK when they arrive in London later this year."

EJ Bowman
To find out more, scan the QR code or visit: **www.ej-bowman.com**

The eSOV project will demonstrate the feasibility of clean ships in terms of both performance and investment

Bibby Marine
To find out more, scan the QR code or visit:
www.bibbymarine.com

Zero-emission **SOV project**

A leading SOV owner and operator is looking to a fully electric future

WORDS: **KATHRYN DOYLE**

With more than 200 years' experience in the marine sector, Bibby Marine – a subsidiary of Bibby Line Group – is one of the UK's oldest family-owned businesses. Bibby Marine owns and operates the Bibby WaveMaster fleet of walk-to-work (W2W) service operation vessels (SOV), which offer transportation and accommodation for offshore energy workers in remote locations.

Since its inception in 1807, Bibby has been at the forefront of energy transitions. The company is committed to driving innovation in the maritime sector, and was the first UK maritime company to sign up to the Science Based Targets initiative (SBTi). This commitment to innovation and sustainability has driven Bibby Marine on its 'roadmap to green'. This long-term approach began in 2019 with the WaveMaster Zero C project, which aimed to determine the alternative fuel best suited to the next generation of SOVs and similarly sized vessels. This was followed by an award from the Clean Maritime Demonstration Competition for a feasibility study that looked at two vessel solutions – a short-term low-emissions conversion and a long-term zero-emissions new-build. A second award from this competition recognized Bibby Marine's continued research into the use of electric batteries to power vessels, and how they are charged on and offshore.

Next-generation vessel design

This research has led Bibby Marine and a consortium of partners to their latest project – the zero-emission, electric service operation vessel (eSOV). In 2023, Bibby Marine was awarded funding from the Zero-Emission Vessel Infrastructure (ZEVI) competition, which kick-started the project to build this next-generation clean vessel.

Electrification has the potential to be a game-changer for the marine sector, and Bibby Marine is proud to play its part in the drive toward decarbonization. Each fossil-fueled SOV emits more than 7,000 tons of CO_2 every year, and there are around 30 SOVs in operation in Europe alone, which equates to more than 210,000 tons of CO_2 emitted. There will be an estimated 300 vessels of this kind needed in Europe by 2050.

The eSOV design principles present an opportunity to operate a vessel using battery power 100% of the time, which, with clean offshore charging, would equate to true net zero operations. While offshore charging infrastructure develops, this technology will facilitate a 50% reduction in marine gas oil (MGO) fuel consumption and associated emissions. The project has the potential to save each of Bibby Marine's clients more than £1m (US$1.25m) a year in fuel costs (even with only a 50% reduction in fuel consumption). Once operating fully electrically, the savings could reach up to double that per year.

The fuel consumption of the eSOV will average three tons per day, which is approximately 50% less than conventional SOVs. These figures support Bibby Marine's objective to be the UK's cleanest SOV operator.

The vessel will feature battery packs with more than 20MWh with two operational modes: offshore charging available/not available. The vessel will have methanol/MGO dual-fuel hybrid engines for backup along with associated shore charging facilities.

With 85 cabins, powerful dynamic positioning capability, a 3D crane, 30m W2W integrated gangway, 450m² deck space, options on side-loading cargo doors and helideck, and digitalization, the vessel will service the needs of the offshore energy industry while delivering a sustainable and cost-effective solution.

"The delivery of this vessel has the potential to be a game-changer for our industry by accelerating our path to net zero, as well as showcasing marine innovation at its finest," says Bibby Marine's deputy project director, Enora Pichon. "The aim of the project is to demonstrate that clean ships can be built at the same total cost of ownership as a fossil-fuel-burning vessel."

Marine motor expertise

Arnold Magnetic Technologies
To find out more, scan the QR code or visit: **www.arnoldmagnetics.com**

High-performance materials – and the expertise to utilize them – are key to successful marine propulsion projects

WORDS: **RYAN HALVERSON**

Arnold Magnetic Technologies is able to offer its expertise to a wide range of marine motor applications, at whatever stage best suits the project

Today's boat engines, gallon for gallon, emit more pollutants than vehicles on the road. As a result, the US Environmental Protection Agency introduced requirements for catalytic converters on inboard and stern-drive boats beginning in 2011. Many manufacturers of personal watercraft initially switched to outboard propulsion and are now looking to electric motors as the next step.

Converting a boat from gasoline to electric is not as straightforward as dropping in a battery and motor from a car, though. Since boat drag increases with speed, the energy to move a boat through water is far greater than that required for an equivalent electric vehicle.

Arnold offers Arnon silicon steel, laminated magnets and carbon-fiber windings for electric motors that require higher efficiencies. Arnold's non-grain-oriented electrical steel (NGOES) is optimized by thickness and finish. Arnon silicon steel is frequently used for laminations in high-speed, high-efficiency motors and generators. Whereas common laminations use thicknesses between 0.356mm and 0.813mm, Arnon 5 and Arnon 7 are thinner – at 0.127mm and 0.178mm respectively.

Arnon electrical steel has been shown to be particularly advantageous for higher-frequency motors and generators above 400Hz. In these designs, the thinner material offsets the less efficient effects of increased eddy currents and subsequent heat build-up. Using thin laminations of Arnon produces a more efficient unit and frees up design constraints by making it possible to fully enclose the motor without external cooling, for example.

Arnold's Wraptite composite sleeves offer a superior design alternative to metallic solutions, particularly in applications that require high rotational speed or the containment of high centrifugal forces – such as high-speed motors and generators. Wraptite has a low density and high strength-to-weight ratio, as well as greater containment stresses for sleeves of the same thickness, leading to increased rotor speeds. Reduction or elimination of eddy currents in the containment sleeves reduces heat generation and improves efficiency.

Wraptite composite materials include carbon fiber, Zylon fiber and glass fiber composites using a range of epoxy, cyanate ester and BMI-based (bismaleimide) resin systems. The material can operate at temperatures up to 170°C.

When entering a partnership, the first step is to decide what the end goal is, and how best to accomplish it. Perhaps a world-class supplier is struggling with pricing, quality or delivery from its existing supply chain. In that case, Arnold can be an alternative source for either an individual motor component or the complete motor system, having complete control over the supply chain. For example, Arnold sources SmCo (samarium cobalt) magnets from its plant in Switzerland, where all pressing and sintering is done in-house, coupled with a partnership with a rare earth mine to ensure the supply of quality raw materials.

Developing a marine electric motor takes specialized expertise in electric motor design. Arnold can collaborate at whatever step of the process makes the most sense. It offers everything from specialist information on permanent magnet technology, to sourcing components from an extensive selection of Arnold-operated global resources, all the way up to a complete motor design. Arnold provides quick-turn design, rapid prototyping and testing, using one of its technology centers around the world.

2

Responsible **sea exploration**

Hybridized drive solutions can play a key role in protecting marine environments

WORDS: **FEDERICA PAVESI**

Equipped with a Transfluid HM3350 150kW hybrid propulsion system and powered by a powerful Baudouin 6M26.3 diesel engine, a new hybrid oceanographic vessel can sail at a maximum speed of 15kts and a cruising speed of 12kts. This combination of technologies enables the vessel to maximize operational efficiency while minimizing environmental impact.

The vessel is dedicated to underwater natural research, committed to understanding and conserving marine ecosystems. With a maximum capacity of 12 crew members, it focuses on exploring sensitive areas such as the Cíes Islands in Spain. During research expeditions, there are zero emissions and low noise levels are maintained to preserve the tranquility of natural environments, guaranteeing that work does not negatively affect the surrounding environment.

1

1. Hybrid operation can be a key enabler for oceanographic research vessels
2. Transfluid's HM3350 150kW hybrid system is supported by a diesel engine

Company ethos

Eco-sustainability is at the core of Transfluid's mission. Every aspect of operations is designed to minimize environmental impact, contributing to the conservation of our precious seas. Furthermore, thanks to the efficiency of the company's hybrid propulsion systems, Transfluid can optimize fuel consumption, ensuring significant long-term energy savings.

With over 9,700km of coastline between Spain and Portugal, the Iberian Peninsula offers a rich market for sustainable maritime solutions. Increasing focus on sustainable tourism, coupled with governmental support and European environmental strategies for port vessels, creates a favorable environment for the adoption of innovative technologies like Transfluid's systems.

With this project, Transfluid is committed to leading the charge toward more sustainable, efficient and safe maritime navigation. Through research, innovation and steadfast commitment to environmental protection, the company aims to contribute to the preservation of our seas, rivers and lakes.

Transfluid
To find out more, scan the QR code or visit:
www.transfluid.eu

Specifying **cooling systems**

A number of key factors must be considered when determining cooling requirements

WORDS: **HEIKKI MUSTONEN**

Water is an excellent medium to remove heat from components such as power electronics and batteries. Too often water or liquid cooling is, however, claimed to be unreliable or complicated. That doesn't need to be the case when certain basic matters have been properly considered during product engineering, manufacturing and commissioning, and in everyday use. The focus here is the coolant.

The coolant to be used will be specified by the power electronics equipment supplier. Ethylene glycol and propylene glycol can be used as coolants. However, they alone do not have especially good corrosion resistance properties. Therefore, it is necessary to add a corrosion inhibitor to the coolant. Some heat transfer fluids already contain inhibitors. Typically, a glycol-based coolant with a concentration between 20% and 30% offers adequate corrosion resistance while minimizing the reduction of cooling capacity caused by glycol.

If an outdoor-installed water-to-air heat exchanger is part of the cooling circuit, the glycol concentration will be chosen according to the ambient outdoor temperature.

Avoiding galvanic corrosion

All metals have a galvanic potential. When there is a connection between two metals that have a different galvanic potential, a galvanic circuit is formed and galvanic corrosion may take place. The cooling liquid acts as a connector between the metals. Galvanic corrosion can be minimized by using non-conductive materials between metals (such as plastic or rubber) and thus disconnecting the galvanic circuit. The recommendation is to use stainless steel and high-grade aluminum (6000-series) and avoid copper and carbon steel-based materials. If, however, copper materials are used, then aluminum should not be used.

There are two types of cooling circuit: open and closed systems. An open system isn't pressurized and allows free contact with air, while in a closed system the piping is completely airtight and the pipelines are pressurized. Closed-type cooling systems are the most efficient way to prevent oxygen diffusion in the coolant and to reduce the risk of electrochemical corrosion.

Above: Adwatec cooling unit designs have a sight glass for easy coolant level observation

Left: Visual coolant level indication ensuring sufficient water volume in coolant

The importance of cleanliness

During the manufacturing and installation process, anything can and will happen. Metal and other particles may end up in the power electronics piping, cold plates and cooling system. It is vital to ensure that the system is clean, which can be achieved through flushing. Also, later during operation (when following maintenance instructions and renewing the coolant), system flushing is important to remove particles that may have appeared in the system.

Small particles cause wear and tear in the cooling system components and may lead to galvanic corrosion. They can also block tiny cooling channels in cooling elements, leading to heat problems.

Some cooling units have an inspection window through which the quality of the coolant can be checked.

Often the equipment will not be installed and commissioned immediately after manufacturing, but rather stored for later use. The wrong coolant inside the cooling unit, or no coolant at all, can cause severe damage. In these circumstances, it is important to ensure that the equipment is stored according to the manufacturer's instructions.

Adwatec
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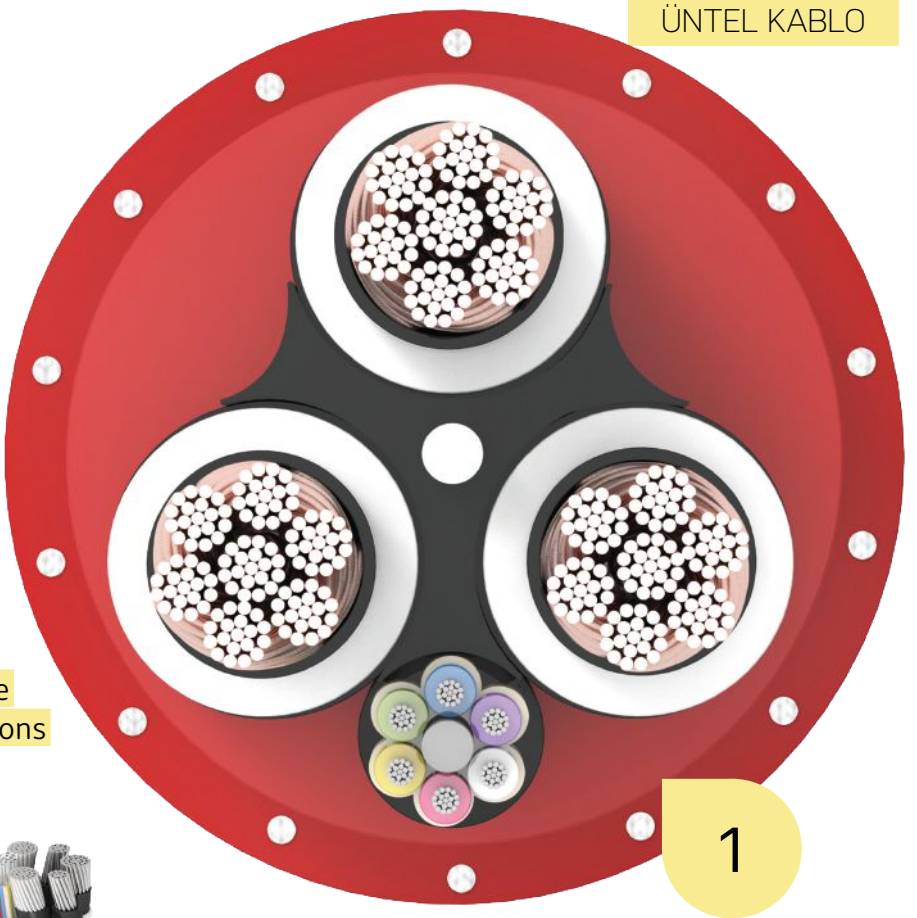
Shoreside **power cables**



1

A portfolio of low- and medium-voltage cables is ideal for harbor power solutions

WORDS: **ONUR SERHAT GÜNAN**

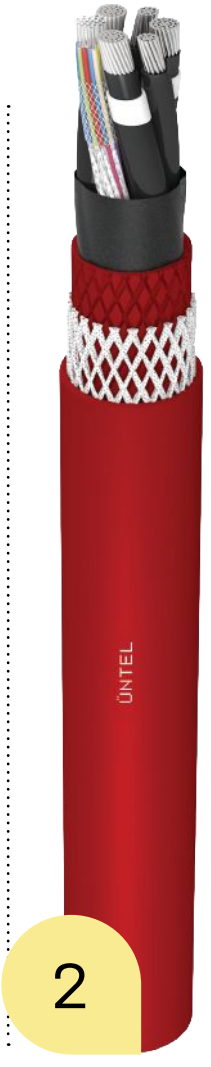
Environmental issues remain a concern – everything from air pollution, global warming and climate change, to greenhouse gas emissions, overpopulation and clean water. With growing levels of environmental awareness, people are becoming more considerate of their behaviors in a bid to reduce damage to the environment.

Ships are among the largest contributors to air pollution as they consume heavy bunker fuels and diesel oils. When ships berth in harbors, they don't need energy for propulsion but still require large amounts of energy to power systems such as heating, cooling, lighting, control systems and other functions. So, they run their generators while berthed instead of using shoreside power supplies. This creates high levels of pollutants and noise. Because of this, port authorities and shipping companies are under pressure to reduce their air pollution levels and create more environmentally friendly solutions in ports.

Getting connected

Üntel Kablo offers various low-voltage and medium-voltage cable solutions.

To reduce the pollutants and environmental impact, ships are increasingly required to turn off their engines or inboard generators while at berth and use shoreside power instead. A growing number of ports and marinas have now installed these energy supply systems and charging stations, offering smart solutions for the shipping and yachting industries. Furthermore, more new-build ships are now equipped with shore power plugs. These systems can be installed on all type of vessels, and on ships of all ages.



2

As every port has a different layout and applications, Üntel Kablo offers a broad range of low- and medium-voltage cable solutions for shore-to-ship power systems, also available with fiber-optic composites for data transmission. Üntel's shore-to-ship power cables meet the requirements for flexibility and durability against stresses experienced during mobile use and the movements typical of ship conditions.

Shore-to-ship cables can be exposed to seawater, moisture, UV and other outside influences, so are generally designed with rubber or polyurethane (PUR) sheathings according to expected environmental conditions. Üntel's shore power supply cables have the advantage of a smaller bending radius and high levels of flexibility. They can be plugged directly into transformers or used with cable reels according to the length required.

Üntel Kablo exports cables to more than 100 countries on six continents, with 60% of its manufacturing dedicated to an array of different industries, and 40% dedicated to maritime. The company has more than 300 international certificates for its 24,000-strong cable product range.

1. Üntel Kablo offers cables suited for a range of low- and medium-voltage applications

2. Cables are designed to survive tough marine environments, as well as being flexible enough to suit the system design requirements found aboard modern vessels

Üntel Kablo

To find out more, scan the QR code or visit: **www.untel.com.tr**

Compact **battery systems**

Piriou shipyard

1

A new marine battery design is impressing in real-world applications

WORDS: **ANDREAS LINGNER**

Germany-based Lehmann Marine, a leading provider of maritime battery systems, has set another milestone in the emission-free maritime energy supply sector. The company's latest product, the Cube battery system, has become a bestseller, despite only entering the market in 2023. The Cube is based on its established sister product, COBRA (compact battery rack).

Key to the success of the Cube system is its well-thought-out concept, which is entirely designed and manufactured in Germany. The Cube system's modular and flexible design makes it possible to easily adapt the batteries to the individual needs of different ships. This flexibility in configuration, combined with easy maintenance (thanks to small and easily accessible battery modules) offers customers unprecedented efficiency and reliability.

Another key advantage is enhanced safety due to the use of lithium iron phosphate (LFP) cells. LFP batteries are much safer than traditional nickel-manganese-cobalt (NMC) batteries, even in extreme situations where thermal runaway can occur, as LFP batteries are not prone to fires. In a thermal runaway, only gas is released and vented outside. This feature makes Lehmann Marine's LFP battery solutions more environmentally friendly and significantly safer for use on board ships.

Lehmann Marine is a leading developer of LFP-based battery systems for use in the shipping sector, thanks to the success of its COBRA and Cube systems. Customers trust the company's German-made products for their quality and reliability, and value the compact system design, which has a high energy density and can outperform most NMC systems.

2

1. The world's first hydrogen dredger, Hydromer
2. Lehmann Marine's Cube battery system

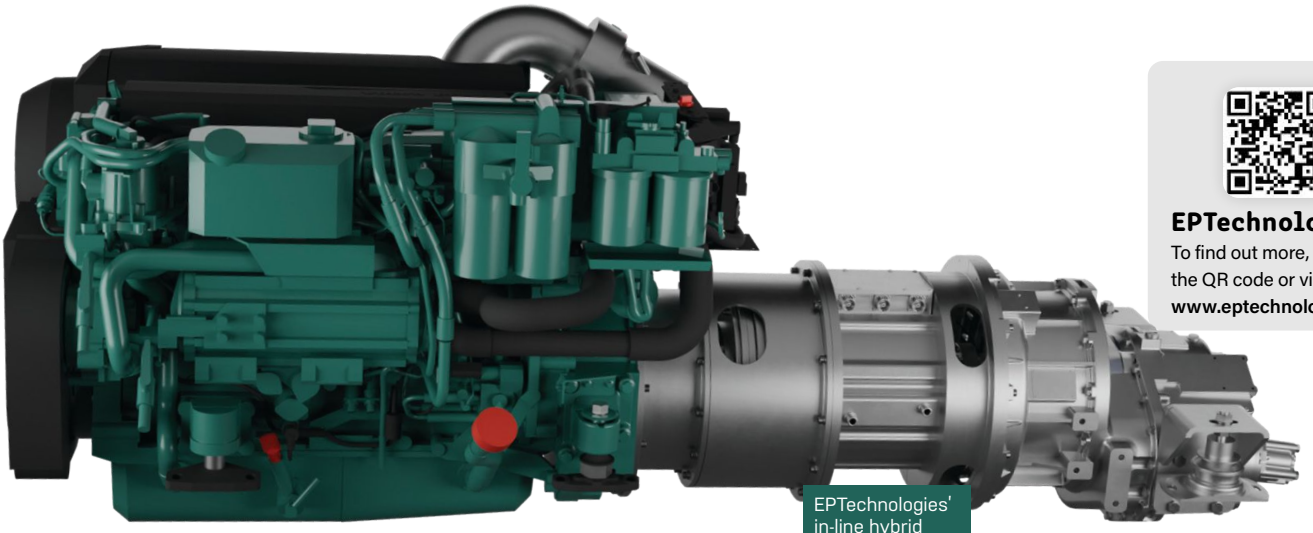
Proven examples

COBRA has been successfully implemented in multiple projects. Among these are the Chicago workboat built by Hitzler Werft for Hamburg Port Authority, and the world's first hydrogen dredger vessel, Hydromer, built by Piriou. COBRA enables the Chicago to operate in battery mode for up to two hours without any emissions or noise, reaching a speed of up to 6kts in the port of Hamburg.

Cube is proving to be highly popular with customers due to its flexible and compact design. The new battery system was first presented at Electric & Hybrid Marine Expo Europe in 2023. The first vessels equipped with 700kWh and 450kWh Cube systems have recently begun operations. Lehmann Marine has recently been contracted to supply Cube batteries for two newly constructed ferries by Ampereship shipyard. Additionally, Lehmann has received fresh orders from Norwegian system integrator Elmarin to provide six battery systems with a total capacity of 6.6MWh for a series of new fish farm service vessels.

These and other projects demonstrate the versatility and performance of COBRA and Cube. Through successful implementation in various ships of different sizes and areas of application, these battery systems have established themselves as safe and efficient solutions for the maritime industry. Lehmann Marine is dedicated to developing and manufacturing cutting-edge battery systems for shipping and is committed to contributing to emission-free shipping with enthusiasm and dedication. With several projects and customer inquiries already in progress, Lehmann Marine is poised to remain at the forefront of this field in the future.

Lehmann Marine
To find out more, scan the QR code or visit:
www.lehmann-marine.com



EPTechnologies' in-line hybrid system is compatible with a wide range of propulsion types

EPTechnologies
To find out more, scan the QR code or visit:
www.eptechnologies.dk

In-line **hybrid drive**

A parallel hybrid propulsion system is suited to a range of vessels

WORDS: **MARCO OTTIKER**

The in-line hybrid system from EPTechnologies is an innovative parallel hybrid propulsion system designed for power vessels ranging from 7m up to 50m superyachts.

The system is tailored to accommodate electric power requirements from 20kW to 600kW, complemented by an ICE motor of up to 1,700hp.

With the EPT design, the PM motor shaft aligns directly with the output shaft of the combustion engine and the marine gear, enabling direct propulsion of the propeller shaft from the diesel engine, the e-motor or a combination in diesel-electric boost mode. Furthermore, the design can seamlessly transition to generator mode while driving with the diesel engine engaged.

The system includes intelligent software that continuously monitors the spare capacity of the diesel engine, ensuring sufficient reserve power for acceleration or boosts when needed. Additional benefits include the ability to use main engines as generators, decreasing the number of ICEs required on board (typically from four to two). This reduction simplifies operations and lowers maintenance costs.

EPT's first vessel using this system has been operational for more than two years. It features a setup including two 1,200hp diesel engines in-line with a 360kW e-motor on each side. The system operates without any issues and has undergone rigorous testing to ensure smooth performance.

The EPT system is compatible with all propulsion systems, including waterjets, Z-drives and standard shaft propeller propulsion. Its versatility extends to integration with all brands of diesel engines and gearboxes, facilitated by the use of standard SAE flanges.

Despite its compact size, the system maintains a low weight even at higher power ratings, using advanced, lightweight and robust components.

Paired with the lightest marine batteries available in today's market (5.3kg per kWh), EPT's integrated solution ensures customers benefit from a well-harmonized and engineered system.

Model	E-power	Diesel power	Boost power	SAE type
EPT 6000	up to 600kW	max. 1,700hp	2,500hp	1
EPT 4000	up to 600kW	max. 1,000hp	2,500hp	1 to 4
EPT 2000	up to 180kW	max. 800hp	1,040hp	2 to 4
EPT 1000	up to 180kW	max. 800hp	1,040hp	2 to 4

The hybrid system can deliver power requirements to suit a variety of vessel types

A typical case study

It's an overnight dockage in a lively marina. The crew wakes up early in the morning and silently navigates the boat in e-mode to a serene bay eight nautical miles away. As there is no noise or vibration, the guests continue to sleep, and wake up to breakfast with a view and the opportunity for a peaceful swim. The guests then wish to swiftly move to a location 30 nautical miles away. The diesel motors are activated for a comfortable 30kts cruise, simultaneously charging the batteries.

Arriving at the new bay with fully charged batteries, the guests can enjoy amenities such as air-conditioning throughout the night without the need for a generator. Opting to stay another night in the beautiful location, the crew uses the powerful main engines to fast-charge the batteries while the guests explore the nearby beach.

Throughout the experience, the guests enjoy a noise-free environment; fuel efficiency (with engines running at optimal settings) is maximized; and comfort and speed are maintained during transitions.

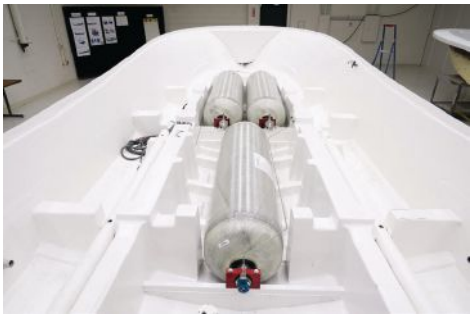
For those seeking even greater eco-friendliness, the addition of solar panels and efficient air-conditioning systems directly powered by high-voltage batteries can also be considered.

Getting **out there**

Yamaha unveiled a hydrogen outboard motor at the 2024 Miami International Boat Show

Yamaha has developed a hydrogen fuel system in collaboration with Roush and Regulator Marine, unveiling a new hydrogen outboard at February's Miami International Boat Show. Roush worked on the fuel system to power the new outboard, while Regulator Marine helped build a boat suitable for testing the prototype outboard. The trio has plans to test the prototype for viability on the water in the summer of 2024.

"Yamaha is exploring all possibilities to achieve carbon neutrality," said Ben Speciale, president of the Yamaha US Marine Business Unit. "We've made commitments for our operations to be carbon neutral by 2035 and our products to become carbon neutral by 2050. That goal within the marine market can only be reached through an approach that leverages multiple solutions. We believe hydrogen is a viable method of achieving these goals."



Matt Van Benschoten, Roush's vice president of advanced engineering, added, "When you look at Roush's history with hydrogen, it ranges from land-speed-record vehicles to spacecraft. A lot of that knowledge we've acquired over the years we are now applying directly to this Yamaha project. We are the fuel systems integrator, responsible for fuel systems designs, all of the specifications development, physical integration and safety system analysis, as well as testing and development. Yamaha is trying to determine if hydrogen can successfully be used in this market, and I think we will find out the answer is yes."

Regulator Marine built a hull based on its 26XO and modified to accommodate the hydrogen tanks to power the new outboard.

"Innovation starts by asking questions," said Joan Maxwell, president of Regulator Marine. "It creates a little angst but at the end of the day, good stuff comes out of innovation. In the future, as we design boats, if this proves what we think it will, it could be very possible that we will be designing hulls around these hydrogen fuel tanks."

The hydrogen outboard is designed for recreational boats, and includes a prototype fuel system

In other sustainable propulsion news, Yamaha recently announced plans to acquire all shares of the electric outboard company Torqeedo, and is also continuing to promote the use of sustainable-fuel IC outboard engines as another alternative.

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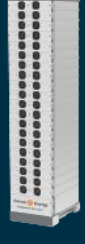

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