Supercharge showcase

Commuting between Stockholm and the Solna Strand, the E/S Movitz is a technological showpiece of advanced efficient marine propulsion and fast charging engineering solutions, helping to dramatically lower urban emissions as well as providing commuters with a smoother and quieter way to travel

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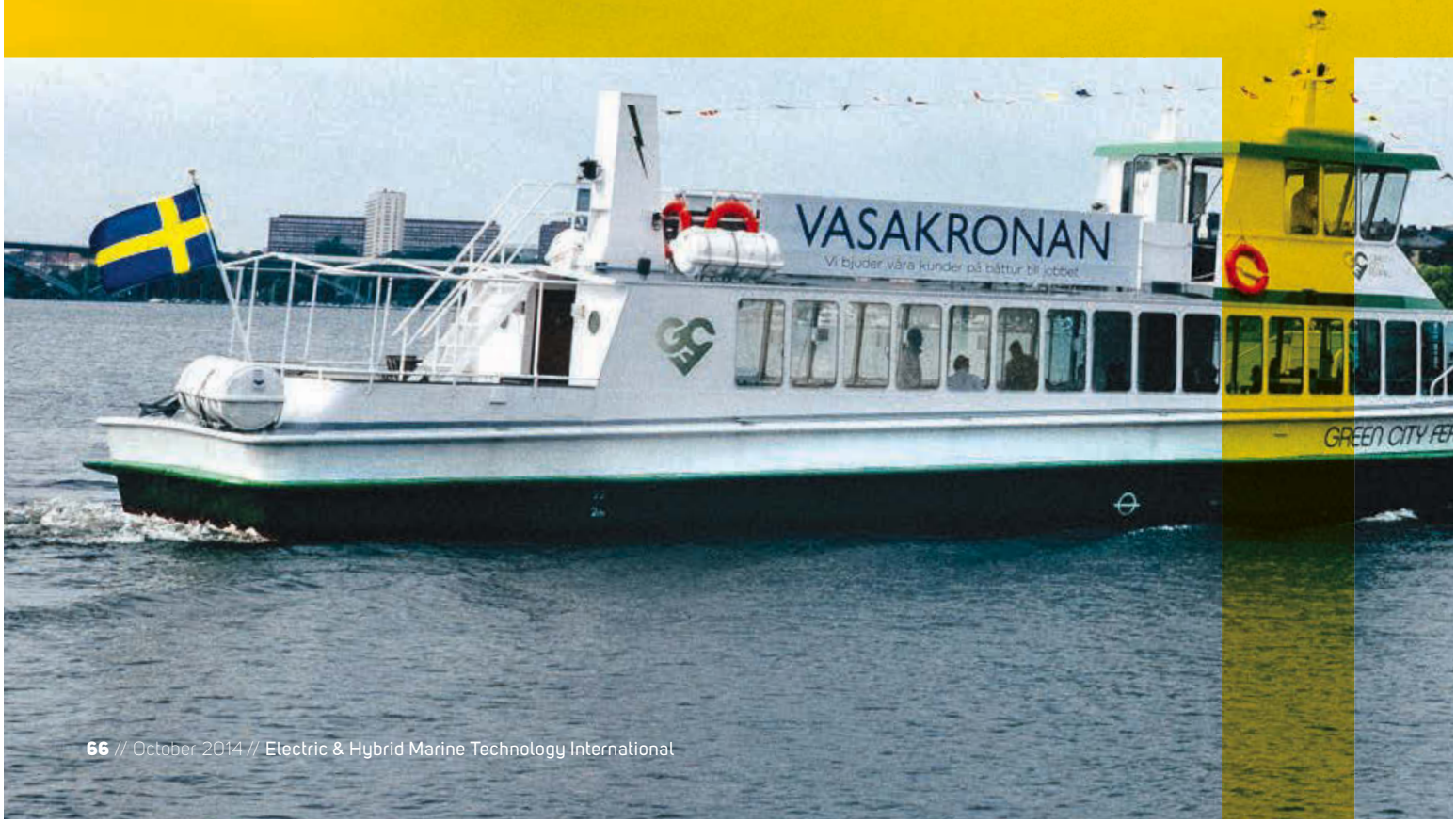

Engineers at Stockholm-based Echandia Marine have pioneered a superfast charging solution for commuter passenger ferries in the 100 to 150 pax range. Unlike competitor systems, the Echandia technology specifically addresses what a high-tech, battery-powered, all-electric drive system can do for the operator rather than what operators have to do to adapt their services to suit an all-electric, limited-range, slow-charge drive system. And if that's not impressive enough, the Echandia team has also developed a pod unit that offers a standard of maneuverability that can eliminate the need for a bow thruster.

The company's first fully functional commercial system is installed on E/S Movitz, a 98-passenger vessel operated by Stockholm-based Green City Ferries on a 50-minute service between the center of Stockholm, and the bustling suburb of Solna Strand.

"Our idea was to create a technical platform that would offer unprecedented efficiency for the operator, a vastly improved environmental footprint for the city and a smooth, quiet ride for passengers," explains Magnus Eriksson, founder of Echandia Marine.

"It was clear from the outset that we would have to charge the batteries extremely quickly so we began looking for a supplier that could provide us with the battery technology we needed to allow us to achieve our targets during a short stop at the end destination." This was no mean feat as the team had set a goal of a maximum of 10 minutes' charging for one hour of operation.

Perfect partner

The solution that Eriksson and his team sought proved to be available close to home, and in 2011, an agreement was reached with Sweden-based Nilar, which could provide precisely the kind of batteries Echandia required for this project.

Nilar was founded in 2000 by Lars Fredriksson and Neil Puester, who both have long track records in the design and development of cutting-edge battery technology. The company has two R&D facilities – one in the USA and the other at its headquarters and main manufacturing facility in Gävle, Sweden.

"It has been quite a journey for us," comments Nilar's marketing director, Marcus Wigren. "We started off developing small scale batteries for power tools and wheelchairs and can now provide off-the-shelf and bespoke high-power, bipolar batteries and associated management systems for a multitude of fixed and mobile applications."

Wigren says that it has always been a challenge for battery developers to create a stable, efficient and safe bipolar design. He adds, "What we have managed to do is optimize the parameters of our stacks, making

The E/S Movitz in action. It takes only 10 minutes for the Movitz's Nilar battery pack to be sufficiently charged for the vessel to transport some 98 passengers on its inner-city route

them highly efficient through decreased resistance and more stable pressure within the cell, which has enabled us to work with higher input and output currents."

Such an advanced design also means that the use of active materials – cobalt coated nickel hydroxide and metal hydride – has been greatly increased, enabling more efficiency in the charging and power provision phases.

"Use is currently above 98% of the theoretical capacity," Wigren confirms. "It means that we are able to exploit a larger amount of the total available discharge capability than has previously been possible."

However, bipolar batteries have traditionally faced a problem that other manufacturers are still struggling to address: "These types of batteries have a tendency to dry out, which means that their efficiency is reduced over time," outlines Wigren. Nilar's solution was to focus on developing a special kind of seal that has hydrophobic properties and incorporates a gas channel that encases each cell.

"By using a multifunctional seal design, we have been able to solve this issue and greatly reduce the complexity of the battery, which means that the manufacturing process could also be simplified." This means a more rational use of space and fewer parts, leading to a smaller, more efficient and lighter stack.

The Movitz project

E/S Movitz uses a Nilar bipolar nickel metal hydride battery installation of 180kWh, which is sufficient for two hours of operation. Charging is done though a 600kW connection every time the ship returns to its end stop. Two gensets have been installed on the vessel as a backup and to guarantee trouble-free winter time operations.

angles up to 180° are also possible. We have therefore been able to completely do away with the need for a bow thruster while still being able to turn the vessel on the spot. Also, the pods can be positioned so that they clear broken ice from a channel while the vessel is moving through the water in the winter months."

Ten-minute charging

The E/S Movitz is charged using electricity sourced from wind energy at its final stop, where a supercharging installation of 600kW is on the quayside. Currently, the connection has to be made by hand, but in the near future a fully automated unit based on a simple but ingenious design will replace this setup.

"You have to remember that a ship moves with the water and even though docking solutions are available that minimize vertical motion, there will always be some movement. Therefore we are currently testing an

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> Magnus Eriksson, founder, Echandia Marine

"One problem we have is that during the winter ice forms on Stockholm's Lake Mälaren where the Movitz operates," Eriksson comments. "So to ensure that the batteries always have a direct source of power and to maintain a regular schedule, we installed two small diesel gensets. However, we are currently investigating other forms of sustainable, onboard power sources to replace them."

In practice this means that in places that receive a lot of sun, solar panels can be installed to provide onboard charging, and as the development of fuel cells moves forward, that technology can also be an alternative solution. Ultimately, with battery developments moving as fast as they currently are, Eriksson envisages that in the future back-up systems will become redundant altogether.

Powering E/S Movitz are two 125kW pods. They are mounted at the stern at a depth of 1.5m and can be operated independently or in tandem. The propulsion motors are a permanent magnet type and are cooled directly by the surrounding sea water.

"All the work that went into developing our pods has been focused on efficiency. Everything has been optimized to ensure that the system is as simple, reliable and robust as possible. On E/S Movitz our steering management system allows the pods to be turned up to 30° in either direction, which has proved to be the most efficient angle for this vessel, although

automated connection that provides a constant contact," explains Eriksson. "We need to ensure that the auto-charging unit is robust, efficient and safe. So far tests have proved that we can achieve this and we are now entering a phase where we are finalizing the production drawings for this installation."

Costs and gains

So what is the cost of going electric? According to Echandia Marine's CEO, Joachim Skoogberg, the numbers play out irrespective of whether one is discussing newbuilds or refits.

"The cost of an installation is obviously dependent on the operational profile you are planning for," he says. "In a newbuild, you can simply design engine room space as required and install all the main technical components, such as batteries, inverters and management systems, before laying the deck and building the passenger space. Costs for construction are higher than for a traditional diesel powered vessel due to the batteries.

"In a refit, other parameters come into play in that you first need to remove the old engine and associated components, which is time consuming and requires large openings to be made in the hull and/or floor sections of the ship. Once this has been done, the installation of an electric drivetrain goes relatively fast."

Echandia claims that it is possible to charge a vessel, such as the E/S Movitz, for 10 minutes and then operate it for an hour, and while that seems relatively simple in theory, how does it play out in practice? "Let's take a look at the thinking behind this, using as an example the conversion of a sightseeing boat from diesel to supercharged electric propulsion, incorporating a combination of Echandia and Nilar technology," says Skoogberg.

"In this calculation, we have used a standard 25m long, 30 ton fiberglass mono-hull sightseeing boat configured to carry 100 passengers on a one-hour journey. On average, the boat will use 30kW power. Given that a one-hour journey means that 30kWh of energy will be consumed, if you want to charge 30kWh in 10 minutes you will need 180kW of power. In this instance, the battery pack needs to be bigger than the average consumption so a 50kWh battery pack would be sufficient to maintain a regular service.

"In essence, running costs in terms of energy are comparable between electric power and conventional, subsidized diesel, is we include the depreciation of the batteries over their lifetime. Based on a European average price for diesel of €1/liter (US$1.2), the 10 liters of diesel used during a round-trip will cost approximately €10. Maintenance costs will be around €2 per running hour and total operational costs for a diesel driven boat add up to €12 per running hour."

In contrast, Skoogberg says that an electric vessel has virtually no maintenance costs but does have capital costs. "A 50kWh battery pack today costs €60 and lasts for five years. With an annual depreciation of €12 euros for 1.5 operational hours, the capital cost of running the ship comes out at €8 per hour. At present, 30kWh of electricity costs €4, so it all adds up to €12 per running hour. If your total investment is €150, less the price of the batteries, you are looking at a total investment in new equipment of around €90. Given a 10-year depreciation timeframe, the capital costs for the equipment are just €6 an hour. This calculation can similarly be applied to commuter vessels.

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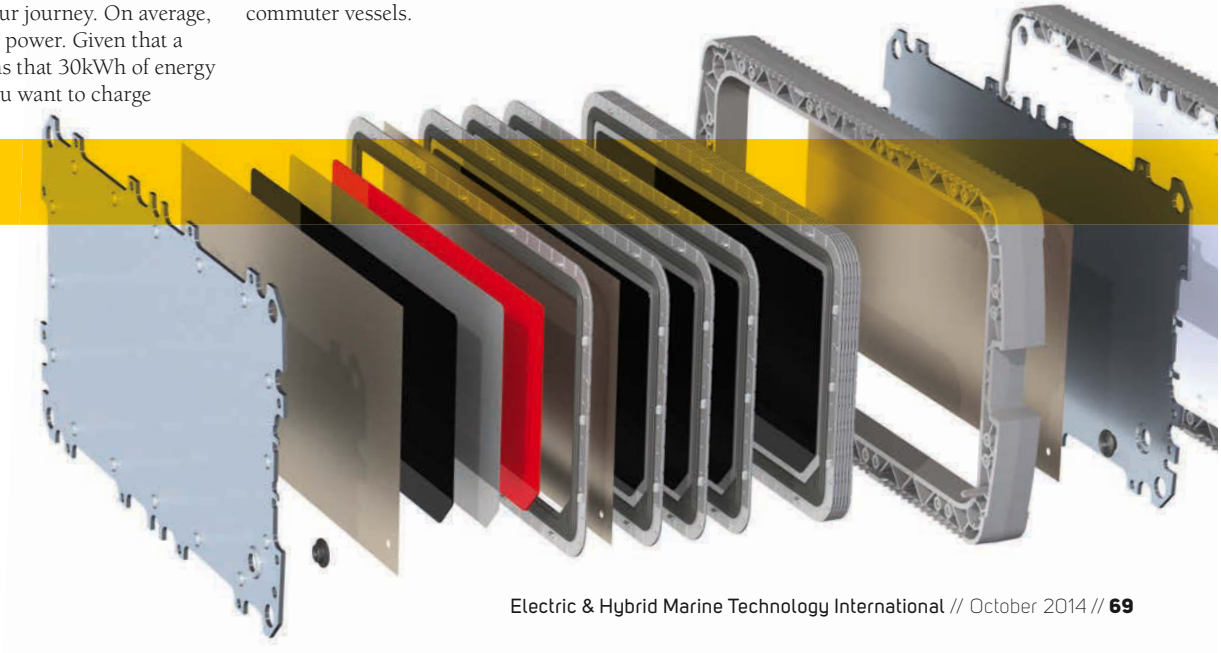
Advantages all round

Skoogberg's numbers seem to add up, but what about the regular day-to-day operations? For passenger services the advantages of electric power are not only many but easily overlooked: no noise, no smell and no vibrations make for a more comfortable ride. For the environment, the fact that there are no emissions of CO_2, NOx or particles means that a green transportation solution for inner-city waterway services has become a reality. And maintenance costs are almost zero, which helps operators' bottom lines.

"We believe that electric power is future proof," adds Skoogberg, referring to the political decisions that ultimately affect whether vessels will be operated as part of a city's publicly funded commuter infrastructure.

"Once an electrically powered ferry in commercial traffic has proved that the technology is viable, and once the passengers have experienced the difference between electric and diesel powered commuting, politicians will have a hard time pulling the plug on future investments of this kind."



Top left: Advanced Nilar bipolar nickel metal hydride battery technology rated at 180kWh, which is sufficient for two hours of full operation, has been developed for E/S Movitz

Left: System charging of the E/S Movitz vessel is conducted though a 600kW connection

Right: Lightweight Nilar battery modules exposed