

Electric/hybrid propulsion



Powering big changes and opportunities ahead

The term “incremental revolution” couldn’t be more of an oxymoron and yet here we are—with a sputtering paradigm shift in marine propulsion on the horizon. The problem is that electric and hybrid systems have been on the horizon for the better part of multiple decades with no mass market solution in sight just yet. So far, it’s been two steps forward and one step back for this “disruptive technology” that will (eventually) massively change the recreational marine landscape. So how disrupted should NMEA dealers and servicing technicians expect to be and what should they do to prepare for this “climate neutral” propulsion technology and all that it will touch?

The market

To understand where we’re going, we first need to know where we are so a bird’s eye view of the market and some definitions may help. Marine is a niche market. It’s comparatively small with low volumes and limited profitability, it’s slow to adapt with relatively low R&D investments overall, and it’s highly fragmented with dozens of segments that behave differently. It tends to follow the auto market to a degree, so the growth of electric and hybrid cars has helped electric boats get some traction but it’s still a unique animal.

Currently and somewhat counter intuitively, buses in China are leading the shift to CO²-neutral mobility. Clean buses account for 13% of the fleet in a country that struggles with air pollution, but that number is expected to reach 80% within a decade. Additionally, less than 2% of passenger cars worldwide are now electric but with an expected compounded growth rate of 53%; the year 2040 should see that number top 50%. The boating market is in its infancy in this regard with only 1.3% of boats integrating electric or hybrid propulsion. Part of this is due to the unique issues of the marine market. Boats have a different fre-

Moonwave, a Gunboat sailing cat, has a complete Torqeedo system. A 25 kW Saildrive with a folding propeller is at upper right. Designers stress the difference between generation needs for boats vs automobiles. Power requirements aboard boats are greater and more complex, especially if the system is called upon to provide all the electricity for an extended cruise.

quency and variance of use than cars, and many segments (ferries, sailboats, small high-speed planers) where boats are used differently are making it hard to build one solution to fit all applications.

As with any new technology, there's an adoption curve. The early adopters are the technologists, visionaries and tinkerers and they make up only about 15% of the market. In marine, these are distance sailors that need efficient sustainability and autonomy, but they're also ferries and water taxis that operate on bodies of water where internal combustion engines aren't allowed. These early guys are either wealthy techno-curious geeks or those who don't have a choice because they boat in zero emission zones.

Then comes the fattest part of the bell curve—nearly 70% are in the early and late adopters range. That's where the money is made and it can be everything from daysailers and tenders to the boating sweet spot of the 25-75-foot midrange power market. This last segment is still up for grabs and there are numerous manufacturers vying for a chance to own it.

The players

Manufacturers who have dabbled in this market (or in some cases have staked their entire fortunes on it) are many and they range from garage startups to established companies. They each tend to focus on (or own) a part of the solution. By far the one that has done the most in terms of branding is Torqeedo, which is based in Gilching, Germany. They started in the early 2000s with simple outboard technology and have expanded to high-voltage systems for large inboard applications. Another contender is Elco from Athens, NY, which began with small outboards but is also reaching into the coveted inboard market.

Others include the Finnish OceanVolt, Italian Diesel Center, American Electric Yacht, and British Hybrid Marine. California-based Electroprop sells pre-packaged 6 and 21 kW systems that boat builders can drop into their engine rooms. Konrad Bergström, founder of the Swedish headset and speaker company Zound Industries, is planning to raise \$2.8 million in a crowd funding campaign for his venture, X Shore, which builds luxury electric boats. German company Steyr (later purchased by the Chinese) came out of the gate early, winning numerous awards for their diesel-electric solution in 2008. It has since gone into insolvency. Swedish giant Volvo



The 60-foot hybrid catamaran has been completely refitted and her systems upgraded. According to the boat's captain, the project lightened the cat by more than three tons due in large part to the new Deep Blue Hybrid system and components while providing increased reliability, autonomy and performance.

Penta is promising a 2021 introduction of electric motors installed inline between their diesels and IPS pods. Currently, there's a hush-hush project between Volvo and Fountaine Pajot on a Lucia 40 sailing cat.

Engine manufacturer Beta Marine is teaming up with Nigel Calder's 9 kW "alternator on steroids" called Integrel (Intelligent Generation of Electricity) that is marketed by Triskel Marine. This award-winning "advanced generator replacement technology" combines components including a 5-inch touchscreen and a sophisticated black box control unit to optimize diesel engine loads to basically eliminate the need for a standalone genset. In so doing, it uses less space and fuel, and reduces purchase, operating and maintenance costs. It's a game changer that took years to develop and it has gained the attention of some high-profile clients like Gino Morrelli who is looking to add it to his HH Catamaran 66-foot designs.

Of course, it's not all just about engine manufacturers. Lithium-ion battery makers such as Mastervolt and NexGen and monitoring specialists like Victron and Simarine are in the periphery as well. Everyone seems to be working on their part in hopes of gaining an early foothold before the market explodes. In most cases, smaller companies are identifying, seeding and building the market while bigger players wait on the sidelines until there's enough potential profitability to have them swoop in and acquire the startups or bust out with their own modified solutions. Case in point: Torqeedo was acquired by German giant Deutz but to date they've left co-founder

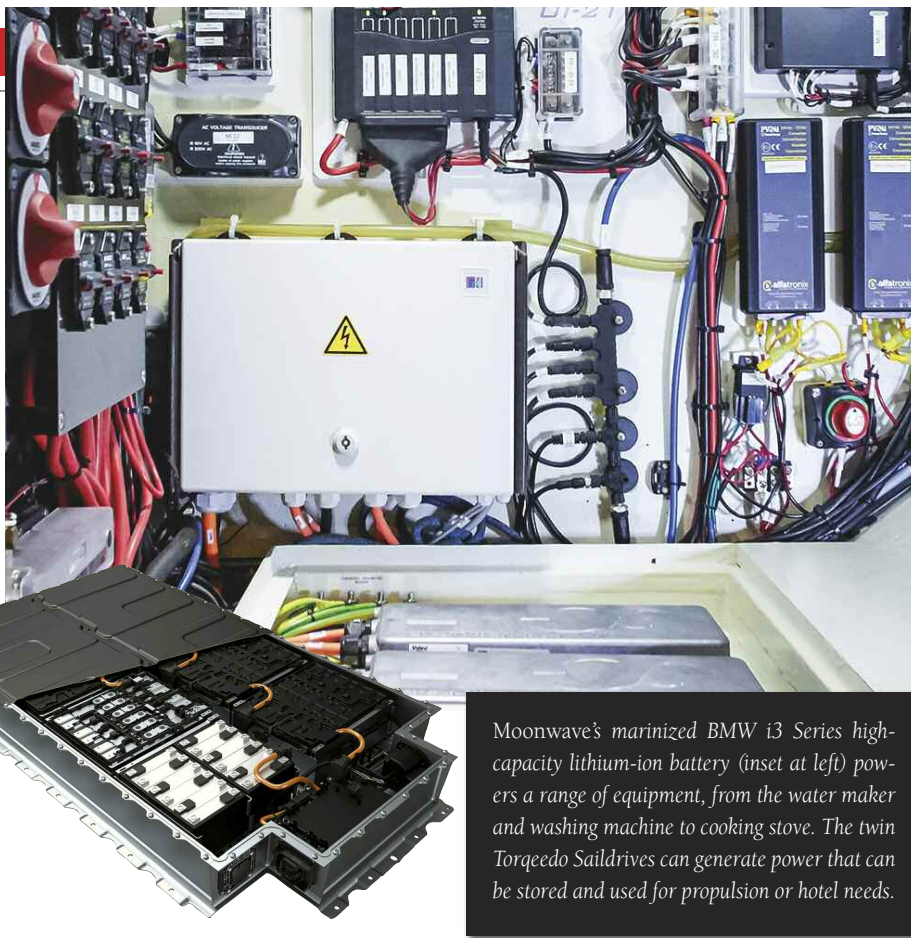
and CEO, Dr. Christoph Ballin, in charge, making Torqeedo a well-funded startup—yet another oxymoron.

The technology

So besides behaving like responsible stewards of our delicate planet, why are so many focused on electric/hybrid conversion? There are numerous benefits to e-propulsion, including that it's quieter, more efficient at lower speeds and less smelly. It's also expected to lower costs of ownership by reducing or eliminating the need for oil and transmission fluid changes, filter and impeller replacements and starter problems. There's less to winterize too. Unlike with diesel or gas engines, electric provides full torque instantly and conversions (which currently make up the lion's share of the market) can use existing drive shafts and components.

Use of brushless permanent magnet electric motors and advances in lithium-ion battery technology have allowed for leaps to be made in the rush to marine electric. Torqeedo teamed with BMW and marinized their i3 and i8 Series auto batteries for use in a variety of boats. For example, with two stacked i3 Series 40 kW batteries and a high-rpm 100 kW Deep Blue inboard motor, a 25-foot Frauscher Mirage 740 Air can reach 25 mph at 2200 rpm and have a 20-mile range. Clearly, electric propulsion is no longer the domain of slow harbor cruisers, tenders and sailboats.

Currently, two approaches are battling it out on the water—serial and parallel hybrids. The serial hybrid system integrates a range-extending generator. The engine drives the



Moonwave's maritized BMW i3 Series high-capacity lithium-ion battery (inset at left) powers a range of equipment, from the water maker and washing machine to cooking stove. The twin Torqeedo Saildrives can generate power that can be stored and used for propulsion or hotel needs.

generator, which powers an electric motor connected to the driveshaft; there is no mechanical connection between the engine and the driveshaft. A parallel system has a direct mechanical connection between the engine and the driveshaft but also drives an additional electric motor that operates as a generator—on the same shaft. Regeneration may be accomplished by a free-spinning propeller, which is easy on a moving sailboat and can be accomplished by using only one engine on a powerboat. Almost all automotive hybrids are parallel systems including the Toyota Prius. Hybrid Marine is offering a third option: a multimode system that combines the best of serial and parallel approaches with an arrangement of clutches and gears.

However, boats aren't cars. Their power generation needs are greater and more complex, especially when the system is expected to provide all electricity for extended living aboard. Gino Morrelli has been monitoring Moonwave, a Gunboat sailing cat that has a complete Torqeedo system installed. "This isn't a Tesla or Prius," he says. "The hotel needs on an autonomous distance cruiser are different than in cars."

Finally, there's the niggling problem of infrastructure, which is the same for automo-

tive: What is the range of these new vessels and where do they recharge? Just like a Tesla that you'd probably not take on a cross-country road trip, a boat needs charging stations that are close together and can "fuel" the vessel quickly. Whoever figures this out and creates and/or owns quick charging stations will make millions.

How to engage with the coming shift

Despite the issues with varying boat needs, evolving technology, inadequate infrastructure and a small but complicated boating market, electric and hybrid propulsion are growing in popularity. Dealers and servicing technicians may get lucky and engage with it in a profitable way at the last minute, but luck comes to those who are prepared so what can you do now to make this transition and grow your business?

Torqeedo's Ballin divides the opportunities into (1) selling electric mobility and (2) installing/servicing:

Selling electric mobility

"Dealers need to understand which segments are suitable for electric and hybrid technology, i.e. in which segments electric and hybrid can catch market share," says Ballin. "They should understand how electric mobility is shaping the industry. Not being in

the know about segments may result in dealers losing their reputation as experts in the eyes of innovative customers."

To provide advice, dealers should understand the basics of electric propulsion—voltages, currents, power ratings, resistances, battery capacities, serial and parallel connections, battery self-discharge and service life—and the dangers of lithium batteries.

Jules Rutstein, President of Consolidated Electronic Distributors in Florida, agrees. He believes it will be helpful to brush up on basic electrical install and load techniques, solar power, new battery technology, high-efficiency motors and the high-voltage control systems supporting these products. He notes that there are synergies because most of the components will still be controlled by NMEA 2000® and the networking and diagnostics will be similar. "Those in the channel need to be expert at electrical systems, power distribution, installation and electricity generation," he says. "They will start getting calls and they need to be prepared with answers. Some of this training can be as easy as catching up with videos on the subject via YouTube."

Ocean racer and two-time solo circumnavigating sailor Bruce Schwab operates Ocean Planet Energy, which does consultative selling of advanced onboard power solutions. They create system diagrams and sell components, differentiating themselves with a unique expertise. "Customers are definitely interested in e-propulsion since there's been a confluence of improved components and evolved battery technology," he says. "It's getting close now."

Schwab doesn't provide service or installation. Instead, he provides detailed plans for overall system requirements so solutions aren't cobbled together. Repowers are his biggest opportunities at the moment. Integration can be intense and detailed so specialized skills are needed. "The first opportunities for dealers are as resellers of equipment where they can take advantage of manufacturer training programs," he says. "And specific expertise in a new trend is a great way to fight box-moving Internet resellers."

Schwab has become a partner in Integrel and has some advice for those who want to get a jump on the evolving technology. "Techs and dealers should get to know (at least) 24V systems and how lithium-ion batteries communicate and are controlled," he adds. "They should also get to know the motor manufac-

turers as well as peripheral system companies. Mostly, they need to figure out what part of the market they want to be in.”

This brings up the question of how distributors will participate in the electric propulsion shift. Peter Braffitt, General Manager of Gemeco Marine Accessories, feels there’s not enough market yet to determine that. “Distributors won’t get involved until manufacturers create enough volume,” he says. “They’ll be late to the table by necessity but once propulsion becomes part of the overall electrical system, everyone will have to engage.”

Installing and servicing

Installation and service of these new systems divide between high- and low-voltage systems (HV and LV). For our purposes, we’re calling anything over 50V high voltage, although technically electricians don’t consider voltage to be high until it reaches 1,000V.

LV installation and service are relatively simple. There should be an understanding of the basics of electrics such as contacts, cables, resistance, waterproofness, databuses and terminals, working with diagnostic tools, etc. “Becoming an LV service dealer for Torqeedo requires having the basics and attending a 3.5-day training course,” says Ballin. “Dealers also need to invest in spares worth around \$2000.”

HV installation and service (like for Torqeedo’s Deep Blue inboard motors) have higher technical requirements. Dealers need to have employees become qualified through education and practice. A degree in electrical engineering is helpful but dealers can also send their employees to classes offered by industry manufacturers or third-party programs like QEST (Qualified Electrical Safety Training). This course (based on NFPA—National Fire Protection Association—70E and OSHA—Occupational Safety and Health Administration) is a nine-hour class for technicians who work with 600V and below. ABYC (American Boat & Yacht Council) also offers basic training, and a Google search will yield other courses. Technicians can also ask one of the key propulsion players for suggestions on other training resources.

Remember that a comprehensive propulsion system is a complex combination of voltages, and techs need expertise across the board. For example, one Torqeedo Deep Blue inboard motor installation may include all of the following:

- 400 VDC for propulsion using automotive battery technology
- 110/240 VAC for hotel loads running on AC
- 24 VDC for onboard electrics
- 12 VDC to “wake up” the larger batteries and generator/range extender
- Bi-directional switching between 24 and 400V networks

The number of servicing dealers in the space is growing albeit slowly. Hybrid Marine is starting to build their service network and Torqeedo has approximately 100 service centers around the globe, which have been slow and expensive to develop. They’re focused on adding only about 10 per year. The challenge and expense of creating a service network have put extra importance on remote service, monitoring, diagnostics and software update capabilities. This may also be a way for dealers and service techs to become involved early on.

What to do now

So when should dealers get engaged in electric mobility? LV training is pretty quick and easy, but HV knowledge takes time and the right personnel. “If existing employees need to be qualified, it makes sense to start the basic HV electric qualification early or you’ll need to hire qualified personnel later and that’s not easy,” says Ballin. “It’s about

preference—going with a small incremental investment now or catching up later with a sizeable effort.”

One thing to get now is HAZMAT certification for dealing with hazardous materials, which is needed to ship lithium batteries. eMarine in Florida, which specializes in power generation products for distance cruisers (solar panels, wind generators, deep cycle batteries, high output alternators, inverters, etc.), also suggests getting on the recommended installers list for any warranty work with manufacturers and staffing up with electrical engineers. Adding personnel who are comfortable with a startup mindset will be helpful too because all new ventures require flexibility and creativity.

Finally, keep in mind that even if some techs don’t choose to pursue expertise in e-propulsion, eventually they may be called to work on a boat that has it. As boat systems become “smart” and more integrated, there will be no way to avoid some of the issues. For example, will there be interference with digital switching or charging systems? What about electronics installations on a boat such as Moonwave whose systems are completely interrelated? Ballin says Torqeedo systems don’t cause problems with either but understanding their interdependence will be required.

Electric and hybrid propulsion are about making mobility lower-carbon quickly and carbon-neutral in the future, which sounds like it’s all about the environment. However that may only be a happy byproduct. The green movement gets a lot of lip service, but it’s energy independence that’s driving the push for electric and hybrid propulsion because the world still works on WIFM (what’s in it for me). So far, electric propulsion has been developing in fits and starts, but one thing is for sure—it’s coming and it will change everything. So, which part of this revolution do you want to take on?



Triskel Marine’s Integrel combines components including a 5-inch touchscreen and a sophisticated black box control unit to optimize diesel engine loads to basically eliminate the need for a standalone genset. Often described as an “alternator on steroids,” Integrel won the DAME Award at METS last year. The company says it uses spare capacity from the existing inboard engine, generating up to 9 kW of electrical power without compromising engine performance.