THE HYBRID REVOLUTION

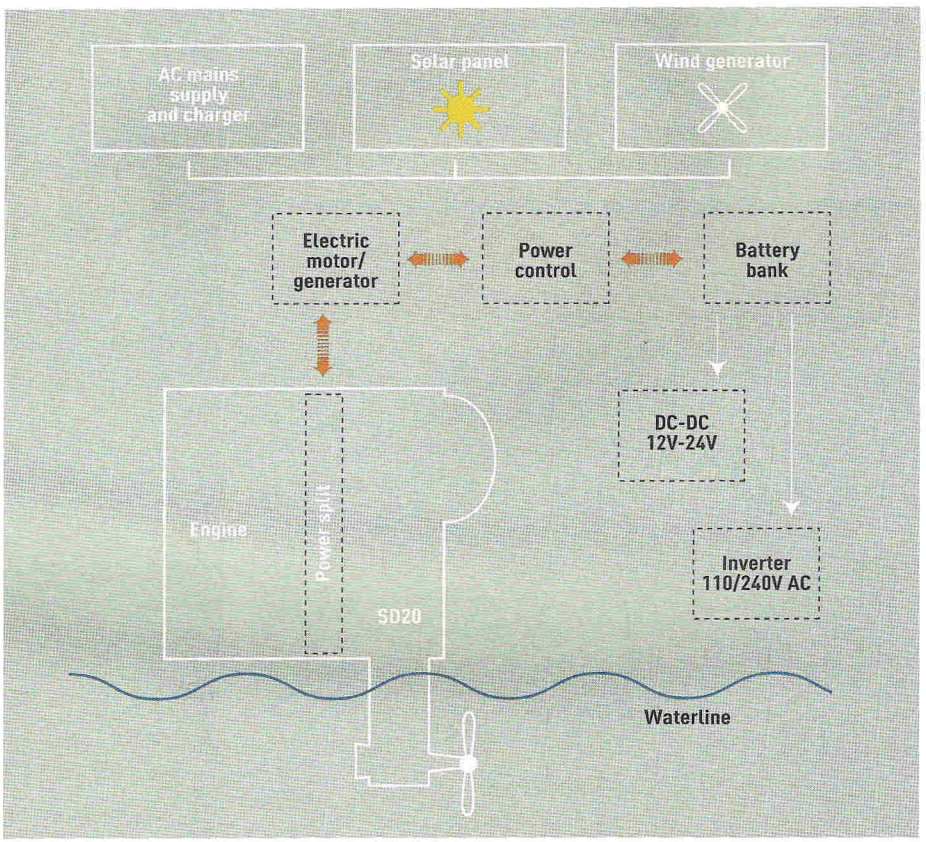
GREEN SENSE

In a knock-on from the automotive industry, the diesel-electric hybrid is gaining favour, not just because it's fashionable, but because advances in technology mean it has a lot to offer **JAKE KAVANAGH**

Silent, emission-free and easy to use, electric propulsion has a lot going for it. But until recently, concerns over low power, short range and the need for a bank of heavy batteries have limited the options. Happily, all that is changing.

Huge leaps in technology have led to more powerful electric motors, vastly improved batteries and some very sophisticated control systems. There have also been some encouraging advances in fuel cell design and renewable power generation. But perhaps the most exciting development for the marine industry — especially for production boatbuilders — is the emergence of the diesel-electric hybrid. This was first used in early submarines, but is now being harnessed to make leisure boats greener and more fuel-efficient, yet still able to generate plentiful electrical power.

"We're suddenly getting a lot of enquiries from production boatbuilders and designers," says Mark Tilley, sales director of UK-based Hybrid Marine. "We've just come back from Germany where we've been in talks with HanseYachts. But we've also had discussions with Island Packet, Discovery, Northshore, Premier (Moody) and Bavaria.



ABOVE **Hybrid Marine's 10kW electric motor is coupled to a sophisticated power management system, so it also acts as a generator when running. This provides a steady 5kW of power**

SIX YEARS IN DEVELOPMENT

Hybrid Marine's managing director, Graeme Hawksley, has spent the last six years developing a viable diesel-electric hybrid aimed mainly at the yachting market. It uses a 10kW (13hp) electric motor piggy-backed onto a conventional diesel shaft-drive, but after a collaboration with Yanmar-specialist EP Barrus, they have just launched a prototype SD20 saildrive.

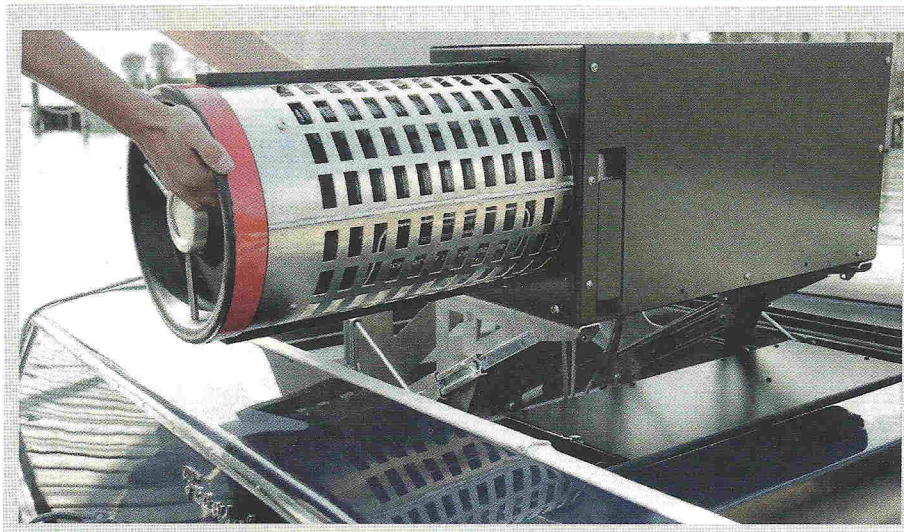
"Thanks to the automotive market, the public are now far more aware of what a hybrid can do," says Tilley, "but in a boat there are yet more applications. Our 10kW electric motor is coupled to a very sophisticated power management system, so it also acts as a generator when the diesel engine is running. This provides a steady 5kW of power. When used for propulsion, it can silently push a typical 14m (45.9ft) yacht along at 6kt, for over an hour in average weather conditions, on a bank of four 100Ah batteries."

In stronger weather the skipper can revert to the diesel engine, which is more efficient at higher loads.

"When sailing in a stiff breeze, the motor becomes a shaft-driven generator, powered by the free-wheeling propeller," Tilley explains. "This produces up to 1kW of DC current so it would be possible to generate enough power during a day's sail to motor electrically in and out of harbour, and still have plenty left for domestics."

Needless to say, this is capturing the boating public's imagination and — with a price tag starting at around £5,000 (€5,649) for a retro-fitted system — it is also very affordable, especially when compared to the cost of a stand-

Combining tradition with innovation



ABOVE **Frauscher Bootswerf has launched an all-electric boat powered by a hydrogen fuel cell**

Austria-based Frauscher Bootswerf introduced the first-ever production serial hybrid to the world at the St Francis yacht club in San Francisco on May 16, 2008. The company placed a single Steyr hybrid diesel in one of its sleek 757 St Tropez day boats and showed it off to an admiring American press. Since then, Frauscher has decided to take the lead again, this time with an all-electric boat powered by a hydrogen fuel cell.

"Our main target is to combine tradition with innovation," says sales director Stefan Frauscher. "You will find a lot of retro-styling in our boats, but also the latest technology. In Europe, we are the largest yard producing electric boats — from small, slower ones up to boats that can run at 17kt for an hour on a single charge.

"Now we have come up with a serial hydrocell boat. It's not fast — about 5kt or so — but our main focus with this project will be to work with partners to create a recharging infrastructure. This will allow customers to cruise around the Austrian lakes on purely electric power, but with the option to recharge the batteries or fuel cell from a number of locations. "For a private buyer, it may be a little too early to buy this type of boat for general use, but we want to prove that we are not too far away. Even if we don't sell many of these boats in the next three years, we strongly believe that working with new technologies is very important for us."

ABOVE **Frauscher's 606 Riviera**

Fuel cell technology, where hydrogen and oxygen are used to create electricity, is also enjoying rapid development with several types of cell now commercially available. However, they still need fuel in the form of a hydrocarbon (typically methanol or propane) and outputs are still fairly limited compared to the amount that can be produced by a diesel hybrid.

alone diesel generator. Better still, there are no seacocks to fit, no exhausts and no extra fuel required. Maintenance of the electical items is also virtually nil.

Hybrid Marine's main market at the moment is on the inland waterways of the UK where canal boaters find the electric propulsion ideal for their type of boating, especially when negotiating flights of locks or long tunnels. The system can also supply them with all the power they need when cruising or moored up. It also appeals to boaters with a strong social conscience. Electric cruising preserves the peace, allowing them to get closer to nature. This means that hybrid applications appeal to groups such as environmentalists.

Such has been the demand for the new system that the UK engine manufacturer Beta Marine has taken on the rights to factory-fit Hybrid Marine systems on their new engines.

"We are now on the cusp of rolling out a production hybrid saildrive," Tilley explains. "The prototype works fine. We just need enough finance to go into full production. We're firmly convinced the new saildrive will become a sought after option on new-builds. It effectively provides electric and diesel propulsion, regeneration, and a powerful diesel generator all in one compact package. The premium is not much more than a stand-alone genset."

A similar system has already been developed by Dutch electric specialists Bellman with its Aquapella drive, but this is mainly targeted at inland motorboats, especially excursion boats. The Aquapella has been designed for quick and easy installation on any engine up to 40hp, with a choice of 3kW, 6kW or 7.2kW drives. Recharging is from the main engine.

'PANCAKE' STYLE

Both companies have been able to take advantage of the 'pancake' style of electric motor first developed by the UK's Dr Cedric Lynch. These flattened high-torque motors are ideally suited for parallel hybrids because they are highly efficient but take up little space.

"There isn't much point in going above a 10kW 48V motor," says Tilley. "The currents get too much for DC. However, the amount of horsepower required to drive even quite a large hull in calm conditions is fairly small. Our system is optimised so the diesel engine delivers power at the middle and top end of demand, and the electric motor provides the medium to low speed requirements. This also gets the most efficiency out of the system, as diesels work best when working hard."

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For boats that require more power, both Bellmann and Hybrid Marine can couple a second motor to the gearbox.

"Batteries can only accept a certain amount of charge at a certain rate otherwise they cook, so we have developed sophisticated electronics to manage the recharging. We also have a software-controlled clutch to protect the batteries and motor generator unit. Despite their complexity, the control systems must be simple to use. This has taken up most of the research time and budget of around £350,000 (€396,160). We have our own modelling software which uses a boat's design data (even down to the sail area and size of rigging) to make absolutely sure we have the perfect match of power generation, propulsion, battery banks and prop size."

Unlike a parallel hybrid — which is easy to retro-fit onto an existing gearbox — the serial hybrid is

more complex. In this case, the electric motor is in line with the propeller shaft, and therefore becomes part of it.

First to market with a full production model has been German company Steyr Motors, which has worked closely with another pioneer, Frauscher Bootswerf of Austria, a yard renowned for its futuristic runabouts and long history of electric boating.

EXPLOITING A GAP IN THE MARKET

The Steyr DEHS hybrid was launched at the Düsseldorf show in January 2008 and immediately won several awards for innovation. As with many great ideas it was developed after a customer enquiry. Realising there was a gap in the market, Steyr produced a permanent magnet electric motor to sit between the bellhousing and gearbox of its lightweight, low-emission range of marine diesels. This means the DEHS hybrid unit can be used in four modes; as a generator, a starter motor, an electric drive and as an electric booster. The latter allows the hybrid to give a 10kW burst of power to complement the main engine at peak demand such as when lifting a boat quickly onto the plane. For electric cruising the motor provides a steady 7kW, providing 5kt. As a generator it can provides a more than ample 4.5kW.

"We are receiving enquiries from all over the world," Steyr's marketing manager Hubert Boxleitner enthuses. "We are the only company to offer this production system. We are even getting enquiries from Dubai where they have a number of environmentally sensitive lagoons. The commercial sector is also good for us with enquiries from water taxis throughout Europe, but my personal opinion is that the yacht sector will show the greatest growth."

Similar to the Hybrid Marine arrangement, the DEHS can also regenerate from a free-wheeling prop shaft. However, the power management software for each unit needs to be calibrated for the individual yacht.

The Steyr DEHS uses a 48V system and its neat design adds a mere 100mm (4in) to the length of the engine. It's not very heavy, either, weighing in at just 75kg (165.4lb). Unlike the parallel hybrid, though, the retrofit options are limited and the motor unit itself is far more costly, adding around £9,500 (€10,752) to the base price of an already high-value engine.

Even so, the biofuel-ready Steyr hybrid is still proving popular.

"It's highly fashionable to be green, especially in the US," Boxleitner says. "People are downsizing and buying more fuel-efficient cars. They

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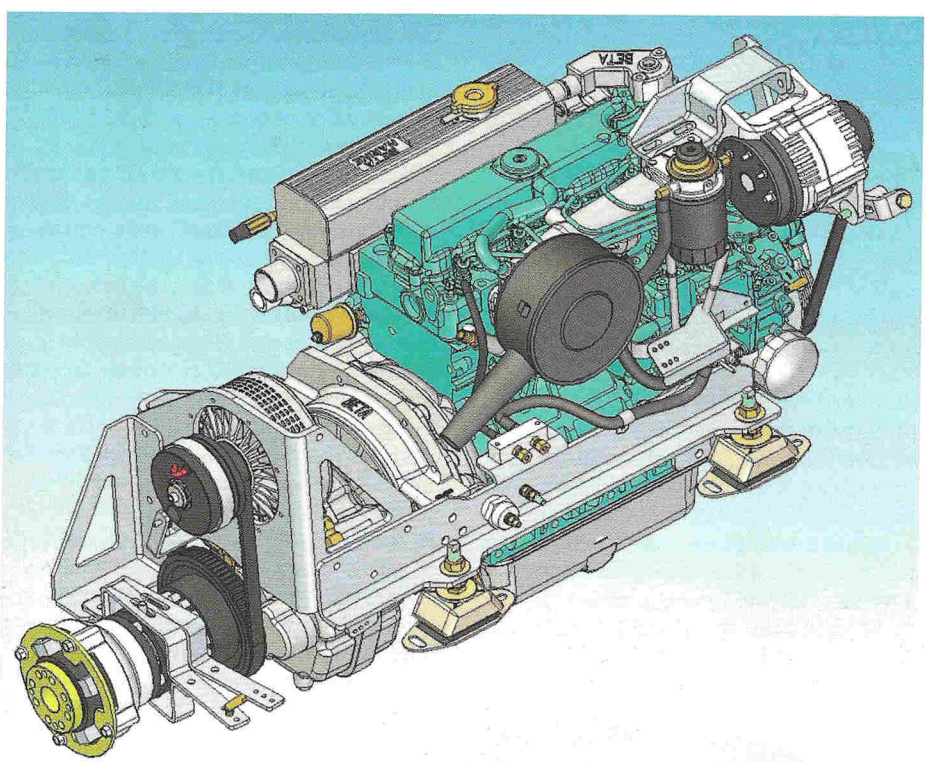


ABOVE **The Beta Hybrid is offered as a factory-fit installation**

Battery banks

Hybrids are pretty punishing on lead-acid batteries, so a certain type is needed to cope with the deep level discharge and recharge cycles. As the battery bank will form a large part of the cost of a hybrid, a long lifespan is also desirable.

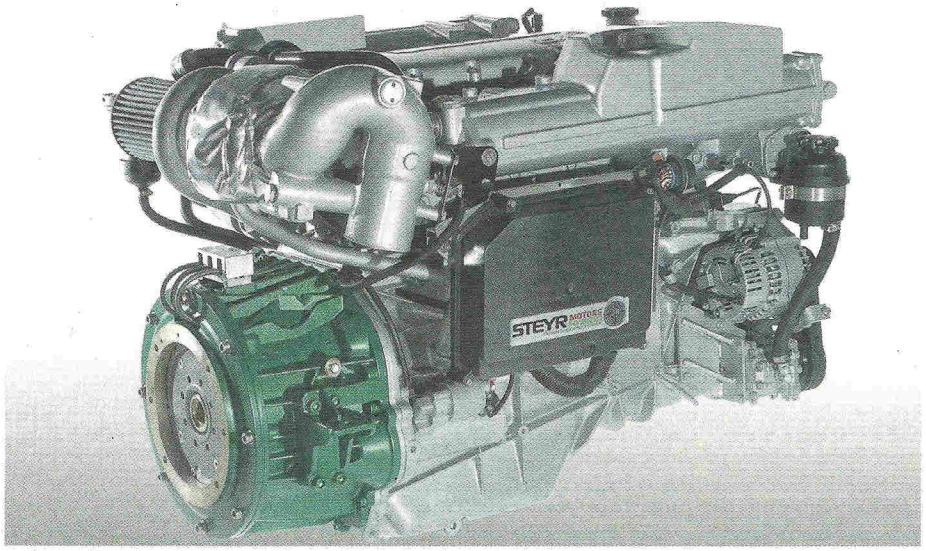
ABOVE **Mastervolt's 24V Lithium-ion battery is light and compact**

One of the drawbacks for automotive hybrids is the challenge of carrying the weight of the batteries, but in a boat this ballast can be advantageous. However, recent advances in battery technology are helping to bring down the weight, although not necessarily the cost.

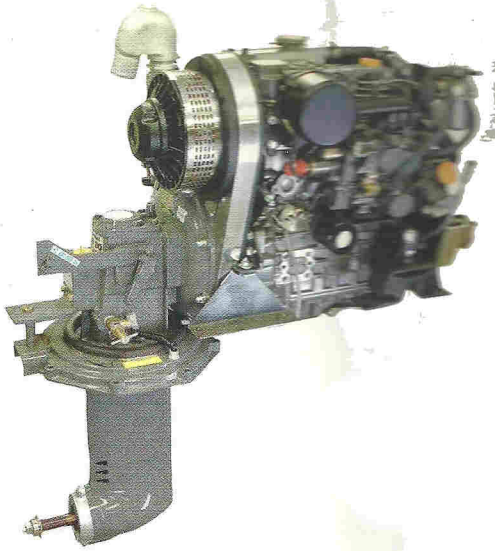
"Efficient batteries are fundamental to a good hybrid system," Tilley confirms. "We tend to use deep cycle traction batteries, but are also looking at Odyssey PC2250 cells as they use thin-plate technology which gives a much larger surface area of lead. They are a military grade AGM, and a little heavy, but with four of these in series you can get a 50/50 diesel/electric cruising regime. They also recharge 15 times quicker than conventional batteries."

Barry Fower, MD of Fischer Panda UK, finds that most deep cycling tractor-type batteries work well with a hybrid, preferring AGM, Gel or NiCad varieties. Good battery management, with carefully balanced charging, is vital for keeping the bank in good condition.

Probably the most groundbreaking advance in battery development has been with Lithium-ion, pioneered for marine applications by Dutch-based Mastervolt. Its 24V Lithium-ion batteries are expensive (five times the price of AGM) but are 70 per cent lighter and more compact than lead acid batteries. With an impressive 'depth of discharge' (DOD) factor, they are perfect for a hybrid set-up. Compared with an equivalent 800Ah bank of conventional lead acid batteries, Lithium-ion is 600kg lighter, and can be discharged to 80 per cent of its capacity, as opposed to just 50 per cent for lead acid. They also have a lifespan of around three times longer and can be orientated in any position aboard.



ABOVE **The Steyr DEHS hybrid was launched at Düsseldorf 2008 and has won several awards for innovation**



ABOVE **The SD20 saildrive based on a Yanmar engine**

want boating to be environmentally friendly too. We're developing a larger unit to get faster speeds from the electrics, especially for the commercial market. The demand is really booming."

The diesel-electric hybrid has still to reach the masses, but the progress being made by pioneering companies is attracting buyers. Other diesel electric systems are available. They use a remote generator to provide current to a purely electric propulsion system. The benefit of this arrangement is that a compact diesel generator can be sited almost anywhere in the boat, saving both weight and fuel. It also opens up a great deal of flexibility to the designer and builder alike. The motors can also be housed in watertight directional pods under the boat, a highly efficient system used on a grand scale by cruise ships. The Fischer Panda DE Whisperprop is a perfect example of a smaller set-up for leisure craft.

With concern for the environment now very fashionable, boat buyers are actively seeking out hybrid options. The ability to make your own power while sailing, and to cruise silently while still having the option to run power-hungry AC systems, is very appealing. With a hybrid saildrive poised to enter the market, forward-looking boatbuilders will be able to take full advantage of this facility as an inexpensive option.

Don't just rely on the conscientious environmentalist or the fashionable baby boomer for future custom, though. All it will take is a massive surge in the price of oil and the hybrid could quickly become an essential installation for all discerning boat owners.

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