

New generation?

Can electric inboard engines fully replace marine diesels for cruising boats? It's complicated, as Jake Kavanagh reports

Just a few years ago there were perhaps half a dozen manufacturers making electric outboards. Now there are nearly 40. We covered that market in detail last month; here we look at the latest tech for inboard electric solutions – and the remaining unsolved issues – for a hybrid or 'electric-only' conversion. There is also the possibility of installing a DIY electric inboard, relatively inexpensively, from equipment used in other sectors. The fork-lift industry, for example, often has a surplus of new and used DC motors that can be easily converted to marine applications.

Apart from the obvious advantages of silent motoring, renewable fuel, minimal servicing and precision control, electric propulsion allows for other possibilities. Very often the boat can be configured around a high-capacity battery bank that not only provides the energy for the motor, but for everything else as well. Plus the extra usable space reclaimed in the engine room, as demonstrated by Mark Johnson on page 48, means a Pogo 30 can hold the same crew and gear as a Pogo 36 – a saving of £50,000 up front!

Several builders now offer new models designed around a renewable energy system. Examples would be the Hanse Emotion with its ingenious rudder-embedded pod drive, the Sunreef Eco catamarans, the Swedish-built Arcona 435Z (Z for zero emissions) and the eye-catching wood/epoxy Spirit 44E.

For the motorboat sector, the use of foils has allowed relatively small electric inboards to greatly increase both speed and range. German-based Torqeedo, for example, has co-operated with Swedish designer Candela to produce a stylish motorboat that has a top speed of 30



The Pogo 30 Zephyr is a successful all electric family cruiser – see page 48 for more detail


knots and a cruising range of 50 nautical miles on a single charge. Meanwhile, smaller electric 'toys' such as personal watercraft, surfboards and even pedal-assisted water bikes can also eke out an impressive range by foiling to minimise the power required.

The two obstacles

However, two big obstacles to marine electric propulsion remain, especially for fast motorboats. The first is cost. The kit is expensive, sometimes double the price of

an equivalent new diesel installation. However, once the initial outlay is covered, there is very little else to fund and so payback begins. Electric motors and batteries – if well looked after – should need almost no servicing or ongoing maintenance for years. Modern lithium-ion chemistries can deep-cycle without damage up to (and even beyond) 2,000 cycles, and brushless DC motors are pretty much sealed for life.

The second obstacle is range. We don't yet have the battery chemistry to match the energy density of a gallon of diesel, which is why many yachtsmen still choose the hybrid route. Most battery banks of a manageable/stowable size can only provide about four hours of electric cruising speed in smooth conditions.

However, with so many recent advances in energy storage, that is also changing. Lithium-sulphur, for example, is now a cheaper and longer-lived 



LEFT Grace or pace? The Candela has a top speed of 30 knots thanks to its Torqeedo motor and retractable foils. **RIGHT** The Spirit 44E is entirely electric. Note the solar panels blended with the lazarette hatch. **CENTRE** Sunreef 80 Eco, bedecked with 34kW (peak) solar panels

Which hybrid?

Hybrid drives, where a combustion engine is part of the drivetrain, fall into two main types: serial and parallel.

Serial hybrids use a quiet-running diesel generator located in another part of the boat which feeds the motor via thick electric cables. This gives much greater flexibility with the accommodation, as the generator can be located almost anywhere. The generator can also be optimised with the correct loading to make it as quiet and fuel-efficient as possible.

The graphic shows a typical Oceanvolt serial hybrid set-up.

Parallel hybrids connect the electric motor directly to the engine, either by an attachment to the prop shaft or by being mounted on – or between – the gearbox. This also allows it to be driven by the diesel engine as a generator and spun up by the prop shaft during a brisk sail. The photo (right) is an example of a



ABOVE Oceanvolt serial hybrid

hybrid from Netherlands-based Combi. You can see the (green) electric motor bolted to the side of the engine block and connected by a belt.



Motor considerations

One of the main advantages of an electric drive is that it doesn't need a gearbox, so virtually any type of electric motor can be coupled directly to a propeller shaft. However, to gain the full advantage of e-propulsion, there are certain factors to consider:

Voltage

The usual voltage for a sailing yacht installation is 48V DC, giving plenty of torque but unlikely to prove lethal if you get a shock from an open circuit. It's easy to step this voltage up or down via inverters or DC converters for 240V mains and 12V appliances on board.

Regeneration

Some DIY-sourced motors, such as from scrapped fork-lift trucks, work

RIGHT An Oceanvolt electric saildrive installed in one hull of an ITA catamaran. Note the cleanliness and accessibility of the installation



fine for propulsion but can't be used for generation. For full regen, you need a motor type that can also operate as a generator, especially if you wish to harness a freewheeling propeller.

Cooling

Electric motors can run hot, which reduces their efficiency. Many have a simple cooling system already installed that will need hooking up to a suitable skin fitting. The saildrive units tend to have all this already built into the leg.

Electric prop

With the torque available usually less than from a diesel, the role of the propeller becomes more critical. Companies such as Darglow, Gori and Bruntons all have feathering propellers that lend themselves ideally to a

RIGHT Brunton's Ecostar propeller

combination of electric drive, motor-sailing or regen. Bruntons' Ecostar has been designed specifically for electric boats. The blades pivot outwards with a variable pitch, automatically adjusting for the forces in play. The Oceanvolt Servoprop does much the same thing, adjusting the pitch in response to the power input and the water speed to give the optimum blade angle. When in regen mode, the blades open in the opposite direction to harvest as much energy as possible, but only when there is sufficient speed to negate the drag.



ABOVE Torqeedo and ZF have come together to form an all-electric 'Deep Blue' saildrive; an advanced version rotates 360° for full joystick docking control



LEFT Italian H2 Boat is trialling a hydrogen fuel cell in a 24ft yacht using a B&G control interface

RIGHT A high-efficiency Lynch electric motor is connected by a belt to the gearbox and will double as a 10kW generator



alternative to the staple lithium-ion, with higher energy densities per kilogram evolving every year. Meanwhile, the inventor of the lithium-ion cell, John Goodenough, has recently announced the lithium-glass battery, which he says will 'finally make electric cars more affordable'. The range is said to be three times greater than existing chemistries, with the ability to fast-charge in minutes.

Meanwhile, the hydrogen fuel cell is seeing rapid development and is already being trialled for leisure marine.

For those not yet ready to invest thousands in the latest batteries, dependable lead-acid (98% recyclable) technology still provides a simple and

relatively inexpensive solution that is mainly being used on the inland waterways. On flat-bottomed narrowboats, for example, the weight is also useful as ballast.

Hybrid or electric-only

For coastal sailors, who don't expect to spend more than two or three hours under power, an electric solution is already proven. The boat can often put some of the charge back while sailing, with renewable power harvested from wind turbines, solar panels and by a free-wheeling 'hydro-regen' propeller.

However, for passage-making to a timetable, such as during the annual summer holiday or a long weekend, a

hybrid is often a better solution. This allows for electric manoeuvring in port, while on a long, windless passage the diesel takes over, with the electric motor becoming generator to recharge the batteries.

However, the hybrid does still present the owner with the need to buy and store fuel and have the engine regularly serviced, with ongoing outlay for labour and consumables. On the plus side, there is no real issue with range (just carry more fuel) and there is no need for a separate generator.

Case histories

We spoke to four owners of production boats who now have electric-only installations. These are still mostly found on fast, lightweight modern designs suited to hydro-regeneration, but improved electric saildrives are encouraging quick conversions

CASE 1: POGO 30 ZEPHYR

As leader of marine innovation for Raymarine, Mark Johnson was well placed to convert his 30ft yacht to a full electric set-up. Power comes from a pair of Torqeedo 48-5000 (48VDC-10kWh) lithium batteries recharged by 1kW of Solbian flexible solar panels. The motor is a 4kW (5.3hp) Torqeedo 4 pod, which can also harvest power when sailing.

The 'sweet spot' for propulsion is 1.5kW which provides 4.5 knots. When sailing fast (seven knots) for three hours, the pod regenerates around 600Wh. The solar array on the boom can be placed horizontally to catch more rays and also act as a sunshade. Energy is also captured by reflection from the water.



ABOVE LEFT The Raymarine Axiom multi-function display (MFD) has been configured as an energy flow meter **RIGHT** Transom-mounted solar panels catch reflected sunlight



Mark's Raymarine Axiom MFD (Multi-Function Display) has been configured to accurately represent the ebb and flow of power. He has used *Zephyr* extensively for family holidays, including several Channel crossings, with the display allowing him to plan 'energy strategies' depending on the

weather. When asked if he is happy with his electric propulsion, Mark replied: "There's no noise or smell; no vibration; it weighs much less than a diesel; and power is instantly available. But I think the single biggest benefit is the space saving because without that you'd really need a 36ft boat for family cruising."

The use of electric propulsion has allowed Mark to use the engine space for the liferaft, with the diesel tank area now a hanging locker. By removing the diesel engine, Mark saved just over 200kg (440lb) in weight and £750 a season in fuel and servicing costs.

Price comparison

The set-up aboard *Zephyr* is more than double the price of a diesel, but servicing and running costs are over 90% cheaper.

Installation costs: retail prices incl VAT	Diesel (€)	10kWh Torqeedo 4FP (€)
Motor, propeller, controls and chargers	10,000	6,000
Batteries (3 x 200Ah AGM) vs (2 x 48-5000 Li-Ion)	1,000	10,000
Solar (2 x boom panel, 1 x transom panel, 3 x Genasun 200)	0	7,000
Digital switching	0	2,000
TOTAL	11,000	25,000

CASE 2: 10M SUSTAINABLE YACHT YA

Conceived in 2010 and designed by naval architect Dick Koopmans, the Dutch-built Ya completed a global circumnavigation between 2016-2018. The mission was to prove that an entirely electric yacht was both practical and enjoyable for blue water cruising. The sail plan is for a yawl, while electric propulsion comes from a pair of e-Tech 7.5kW (10hp) shaft drive inboards. Two small Brunton Ecostar propellers optimise the thrust. Power is generated from an array of solar panels and a masthead-mounted wind turbine.

The boat uses no fossil fuels at all, even for cooking, and has a draught of just 70cm (2.5ft) allowing access to almost anywhere, including shallow inland waterways. She is also designed to sail fast, with 130m² of sail area when the gennaker is flown. She only has three berths, a deliberate move to keep the interior as spacious and comfortable as possible. The full-length windows are a design feature to make her feel more spacious still. The careful generation and management of renewable power allows Ya to have an induction cooker,



ABOVE Ya all-electric blue-water voyager
INSET Twin e-Tech inboard motors power Brunton Ecostar self-pitching propellers

microwave, oven, freezer, fridge and two watermaker systems. There is also inverter power of 230V and 'USB outlets everywhere.' Ya is described by her

enthusiastic owners as 'an energy-neutral demo yacht for everybody who wants to sail sustainably'. You can try her for yourself and book a paying berth on her via the youth sailing website: windseeker.org or via the yacht's own (mostly Dutch language) site at duurzaamjacht.nl



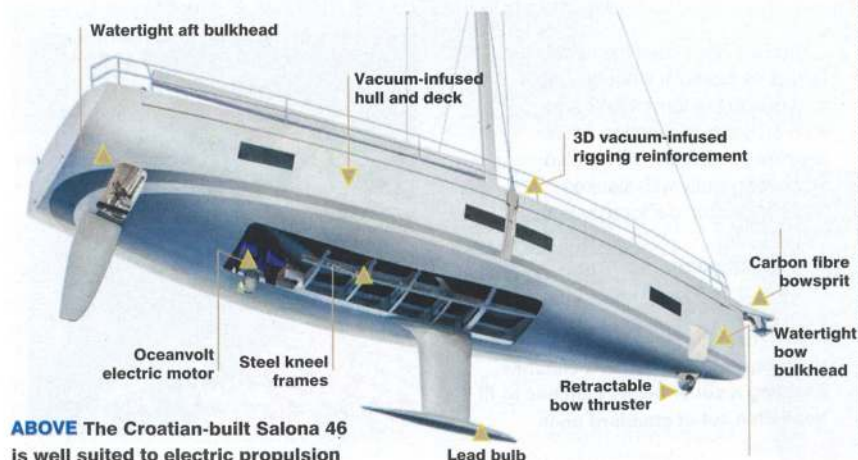
CASE 3: SALONA 46

Graham Balch of Green Yachts commissioned the Croatian-built Salona 46 with twin electric motors and describes the result as 'amazing'. The lithium battery bank packs 30kW and powers twin 10kW (13.4hp) Oceanvolt Servoprop electric saildrive units.

The yacht sails fast, recording 10 knots on a beam reach in 15-20 knots of breeze. This allows for very effective hydro-regeneration from the twin servo-pros, whose blades have been optimised for this purpose. "Manoeuvring in a marina was easy, with no need to use



the wheel," Graham said. "When sailing, we can hydro-regenerate twice as fast. The Salona 46 is such a quick boat, even in quite light winds, so it's ideal for electric motors." The boat can make its maximum of 8.5 knots under power for three hours.



ABOVE The Croatian-built Salona 46 is well suited to electric propulsion

CASE 4: SALTRAM 24 E-VOYAGER

Three Plymouth-based companies, two local universities and a host of OEMs have come together to convert an old workboat into an all-electric 'test bed' passenger ferry. Voyager Marine took the hull of the 1980's-built Saltram 24 Mermaid and stripped it out, replacing the elderly 50hp Ford diesel with a modern (and massively overpowered) 140kW (187hp) Avid electric motor provided by EV Parts UK. The overpowering was deliberate in order to get MCA type approval for the engine and controls, which would then be used in commercial vessels of up to 24m. The battery is a stripped-down and re-purposed 400VDC automotive version from two written-off low-mileage Nissan Leafs, with the lithium-ion cells pared down to 22kWh. The e-Voyager will become the UK's first seagoing all-electric passenger vessel on her route across Plymouth Sound, with recharging available from three 22kWh chargers installed at key locations along the route. A full charge can be achieved in three hours (usually done overnight) with shorter 'top ups' taken between regular passenger runs.

Larger projects are already underway based on the e-Voyager test data.



The motor unit is deliberately overpowered



The e-Voyager project is a test bed

More information:

To find out more about electric propulsion, there is an excellent website at www.plugboats.com

Contacts

Aquawatt - aquawatt.at
Combi - combi-outboards.com
Elco - electromotoryachts.com
e-Tech - starboats.eu
Fischer Panda - fischerpanda.com
Greenstar - greenstarmarine.se
Torqeedo - torqeedo.com
Ocean Volt - oceanvolt.com