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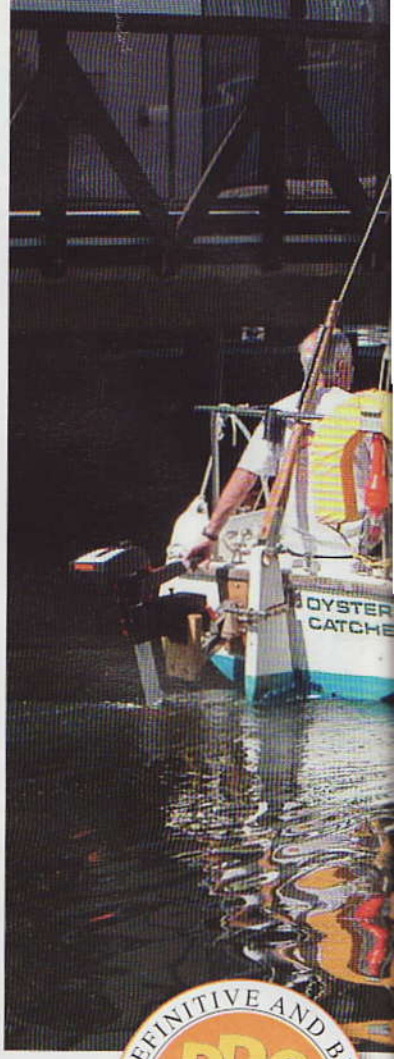


TORQEEDO 801
SHORT SHAFT

MOTORGUIDE
FW54HT
SHORT SHAFT

MINN KOTA
RIPTIDE 80/T
LONG SHAFT

Electric outboards may be 'greener' than petrol ones, but are they a proper, viable alternative? Pat Manley and John Abecasis put three through their paces to find out. Read on for their verdict...

Electric motors are quiet and produce no pollution at the point of use – though this doesn't mean, as is often claimed, they are pollution-free. The electricity to run them has to be generated somewhere and unless renewable energy is used to produce it, creating electricity causes pollution. Certainly an electric outboard is very eco-friendly to those close by. Two-stroke petrol outboards on the other hand, are generally noisy and smelly, and while 4-stroke engines have better green credentials, they still aren't perfect.

In the past, electric outboards have come under the generic term of trolling motors: that is they are used at very low speed for fishing, mainly on inland waters. But can some of the bigger electric outboards be used as an auxillary on a small sailing boat?

Which engine?

To find an engine suitable for your boat the first port of call should be to the manufacturer's website to find their application guide. We didn't have much problem finding the engine model number to suit, but electrical consumption was a different matter – only one manufacturer gave estimated maximum speed and range.

In calm conditions, at less than 'hull speed', the power required to propel an easily-driven hull is much less than you might think. For instance, a 6.4m (21ft), one-ton boat theoretically needs only about half a horsepower to propel it at 4 knots. However, once you take the efficiency of the engine, drive and propeller into account, you'll need a rated power of quadruple this figure.

Achilles heel

An electric outboard needs to be connected to a storage battery, but these are heavy and take time to recharge: it's not like going to a fuelling station and filling up a can with petrol. And here lies the electric motor's Achilles heel. How long will the battery last and how long will it take to recharge?

A motor producing ½hp (375W) consumes just over 30A at 12V. A 100Ah battery will last about three hours from full charge until it's flat, or just one-and-a-half hours to 50% of charge – about 6NM at 4 knots. A mains battery charger will recharge the battery overnight.

Well, that's what the theory says. But how do they perform?

How we tested them

We tested the engines in real boats at real speeds by asking importers of electric outboards to supply a motor suitable for a 6.4m (21ft) Westerly Jouster, a one-ton yacht that would normally have a petrol outboard as an auxillary. As a comparison the motors would also be used to power a 3.1m (10ft) Zodiac inflatable, so we could form a judgement about their usefulness as a propulsion unit for a tender.

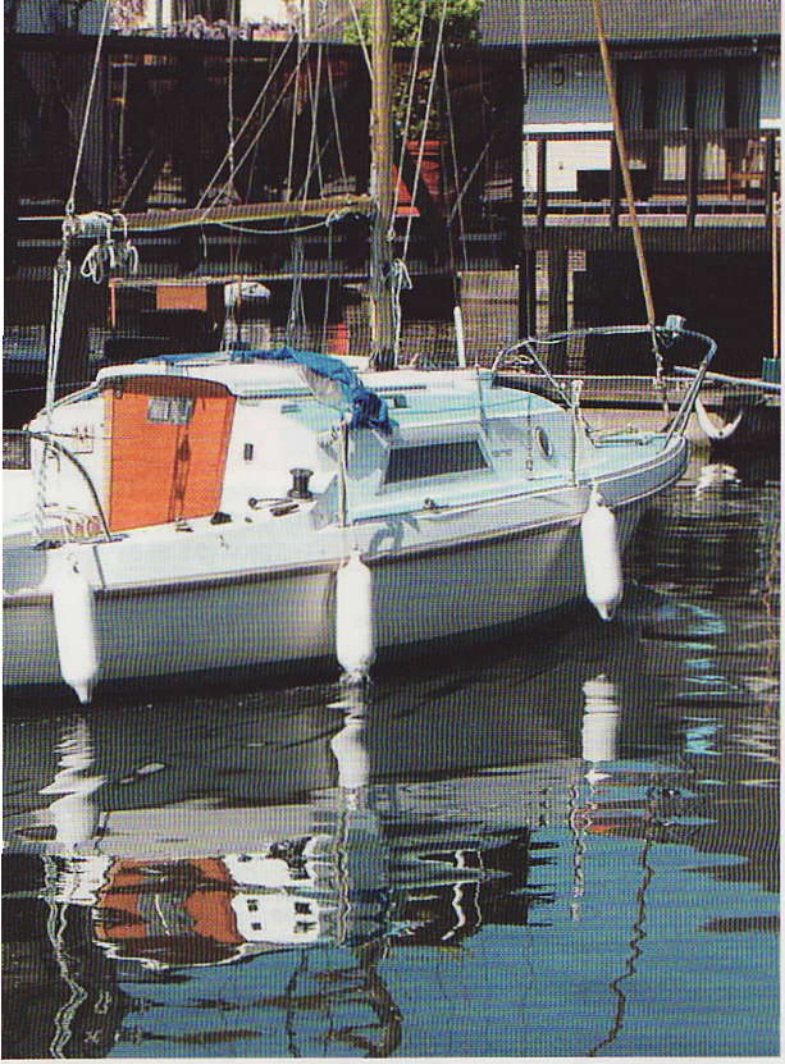
Each motor was run at full power while the current flowing from the battery, its voltage and the steady boat speed were measured. This was repeated at different boat speeds so that range and endurance could be estimated. We were unable to measure the input current on the Torqeedo's integral battery, but knowing the input and output power, we found that this matched the drag curve of the Jouster exactly. Endurance and range were measured for this motor.

We used one or two 112Ah 12V Rolls wet lead-acid batteries, as appropriate, for the Minn Kota and MotorGuide motors. The Torqeedo used its own integral Lithium Manganese 10Ah battery.

THE TESTERS

Pat Manley is a regular PBO contributor, the author of *Simple Boat Maintenance* and a former pilot who now runs mobile diesel engine courses.

John Abecasis is a master mariner and sailed his own Contest 46 back to the UK from Singapore. He now owns a Moody Eclipse 33.



Electric versus petrol

Petrol for your outboard is almost always easily obtainable as you cruise, wherever you happen to be in the world. For a 2hp outboard, there's about 15-20 miles worth of fuel in a 4.5lt can, which when full weighs about 5kg.

A single 110Ah lead acid battery is much the same size as a can of petrol, but weighs about 26kg – and you may need two or three of these depending on the motor used. With a comparable cruising speed to the petrol engine you could expect a range of about four to six miles from your electric motor. Unfortunately you can't top the battery up on the way, so unless you carry a spare, range is a very limiting factor with an electric outboard.

A single 12V, 110Ah lead acid battery would take around 10 hours to fully charge from 50% capacity using a mains charger drawing around 10A DC. This would not be practical using wind or solar power on a cruising boat, as is sometimes claimed, especially as you would have to keep the boat's service batteries charged up as well – creating an even bigger problem. You'll need shore power for this.

TYPES OF MOTOR

Electric outboards work in one of three different ways, having both advantages and disadvantages in price, weight and performance.

DIRECT CURRENT (DC)
The motor is supplied with DC current from the battery via a variable or stepped resistor that alters the voltage according to the power output required. This is an inefficient way of regulating the power output, though, because energy is wasted within the resistor.

This waste of power in the resistor showed up in our test because the maximum range of the motor varied little no matter how much the power was increased – at full throttle or just pottering along, the distance covered was virtually the same.

PULSE WIDTH MODULATION (PWM) Pulse width modulation controls a DC motor much more efficiently. The full DC voltage is switched on and off for varying periods of time. Full power is developed with the voltage switched on all the time, less power is developed by varying the pulse width (time the pulse is switched on). No power is wasted in resistors and the pulse width is managed by a microprocessor, giving increased range as the power is reduced.

ALTERNATING CURRENT (AC) An AC supply is provided electronically from the battery's DC output. Motors can be smaller and can produce higher torque (turning power) at low speed. They are very efficient but are more expensive. In our tests we found that the AC motor was at least twice as efficient as a DC motor, giving much greater range for a given battery size.

CHOOSING A BATTERY

Broadly speaking, there are three main types of battery suitable for powering an electric outboard motor:

WET LEAD-ACID
The cheapest type of battery to buy, it should not be discharged below 50% state of charge if it is to achieve more than a year's life. True maintenance-free types are more expensive but are less likely to result in any spilled electrolyte.

ABSORBED GLASS MAT (AGM)
Far more robust, these batteries are both more expensive and more able to withstand repeated charge/discharge cycles, though preferably to not below 40% state of charge. Absorbed Glass Mat batteries are leak-proof and can be installed at any angle.

LITHIUM MANGANESE
An advanced form of rechargeable 'dry' cell. They can be discharged fully, withstanding as many as 1,000 charge/discharge cycles – but they're expensive. Because of their ability to be completely discharged, you only need half the capacity of a lead-acid battery to get the same sort of performance. They consequently have a much lower weight.

ELECTRIC v PETROL COMPARISON

	Capacity	Size (mm)	Weight	Battery cost	Cost of two batteries	Maximum Endurance	Range @ 2.5 knots	Cost of recharging	Cost per mile
						(Minn Kota on Jouster)	(Minn Kota on Jouster)		
Rolls battery	112Ah	318 x 171 x 241	26.8kg	£105.49	£210.98	10 hours	4.5NM	£0.25	£0.06
Delphi battery	110Ah	330 x 175 x 240	26.9kg	£88.11	£176.22	10 hours	4.5NM	£0.25	£0.06
						(Torqeedo on Jouster)	(Torqeedo on Jouster)		
Torqeedo battery	10Ah	300 x 200 x 108	3.5kg	£339	n/a	6 hours	5.2NM	£0.10	£0.02
Torqeedo + Rolls batteries	112Ah	318 x 171 x 241	26.8kg	£105.49	£210.98	32 hours	20.5NM	£0.25	£0.01
					(+ cost of battery				
					lead £129)				
						(petrol outboard on Jouster)	(petrol outboard on Jouster)		
Petrol (used in 2hp outboard)	4.5lt	260 x 190 x 200	5kg	n/a	n/a	5 hours	15NM	£4.50	£0.30

The outboards we tested

Minn Kota Riptide 80/T long shaft

PRICE: £699 (saltwater Riptide range from £299 to £749)

CLAIMED THRUST: 36KG (80LB)

The saltwater range of Minn Kota engines comprises five models: from the smallest at 18kg (40lb) thrust to the largest at 46kg (101lb) thrust. The motor tested was the second largest in the range at 36kg (80lb) thrust and needed 24V to run it. With a 'composite' leg, the motor was easy to carry – but you needed to remember to pick up the shaft fairly close to the propeller/motor end as the electric motor was much heavier than the tiller/electronics. The tiller friction, leg length stop and the clamps were easy to use, and attaching the motor to the transom presented no problems. The tiller could be swivelled upwards and the leg could be lifted to nearly horizontal with plenty of stops to allow accurate adjustment to the rake of the transom. The throttle was continuously variable in both ahead and astern. The motor was a pleasure to use and propelled our Jouster at a maximum of 3.5 knots in zero wind and calm sea. Tilting the motor was hampered by the stern rail on the Jouster and we needed to adjust the immersion depth and outboard bracket precisely to get the prop clear of the water. Despite the added weight of needing two batteries, it propelled the Zodiac at a maximum of 3.6 knots.

▲ Minn Kota: easy to carry and a pleasure to use

MANUFACTURER: Minn Kota, www.minnkotamotors.com
UK SUPPLIER: Johnson Outdoors, tel: 01493 745192, www.johnsonoutdoors.co.uk

MotorGuide FW54HT short shaft

PRICE: £279 (fresh water range from £149 to £499, saltwater range POA)

CLAIMED THRUST: 24.5KG (54LB)

The MotorGuide salt water range (built by Mercury/Mariner) comprises two models of 21kg (46lb) and 24.5kg (54lb) thrust – but is not currently available in the UK. EP Barrus therefore supplied the 24.5kg (54lb) thrust fresh water model which ran on 12V and had a stainless steel leg. It was lighter than the Minn Kota and balanced closer to the middle of the leg. Again, adjustment and fitting was very easy and although the tiller didn't swivel upwards, it did have an extension to bring it nearer to hand. The 'throttle' had five forward speeds and two astern – this was a straight DC motor without Pulse Width Modulation. Also like the Minn Kota, tilting the motor was hampered by the Jouster's stern rail, but with practice you could find the right position. A simple friction clamp controlled the leg length. The motor was a pleasure to use and achieved 2.4 knots at full power in the Jouster – pretty much what we expected considering it was only half the power of the Minn Kota. Needing only one 12V battery in the Zodiac made the inflatable very manoeuvrable and achieved a creditable top speed of 3.3 knots.

▲ MotorGuide: featuring a straight DC motor

MANUFACTURER: MotorGuide, www.motorguide.com
UK SUPPLIER: EP Barrus, tel: 01869 363636, www.barrus.co.uk

Torqeedo 801 short shaft

PRICE: £1,049 (£619 without battery. Torqeedo range from £619 to £1,349)

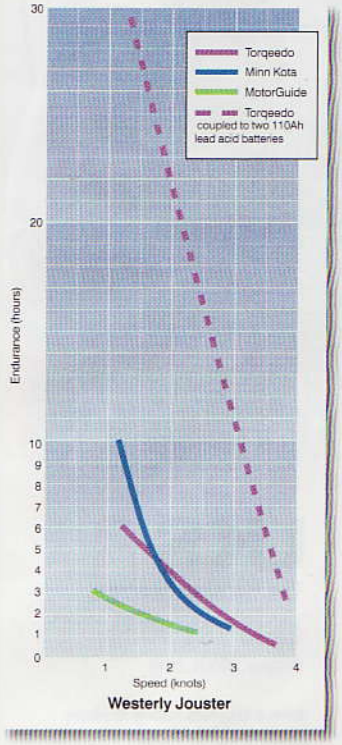
CLAIMED THRUST: 33KG (72.6LB)

This motor was something completely different. The extruded anodised aluminium alloy leg folded into three parts, the plastic tiller and the plastic mounting bracket could be removed and the whole thing could be stowed in a bag for transportation. When assembled it was light and well balanced, and the integral Lithium Manganese battery didn't need to be fitted until the motor was in place on the transom. Weighing only 3.5kg (7.7lb) the battery could be safely fully discharged, but had a capacity of only 10Ah. A spare integral battery costs £339, but an optional cable to connect to a remote lead-acid battery – instead of the integral one – is available at £129, allowing a significant increase in range and endurance.
There was a series of LEDs to indicate the battery's state of charge and a 'key' to isolate it. There was also a safety lock to prevent the battery detaching in use.
Despite its smaller size and lighter weight, this was easily the most powerful motor on test. In addition to the full variable speed range in forward and reverse, the 'throttle' had three 'extra' stops: maximum power with a five minute limit; exactly one hour's endurance until the battery was flat; and max range on remaining battery power.
The unit gave a max speed of 3.8 knots on the Jouster and 4.3 knots on the Zodiac.

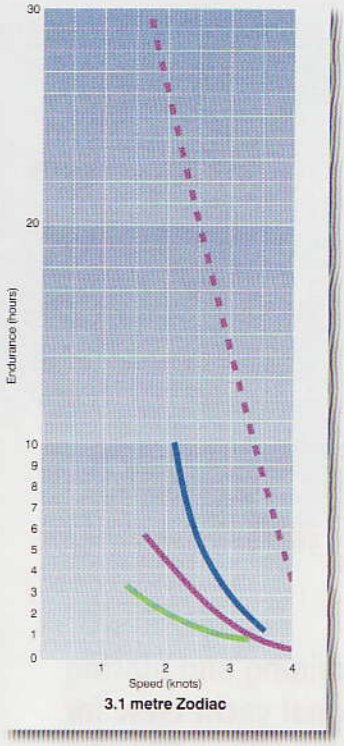
▲ Easily the most powerful motor on test

MANUFACTURER: Torqeedo www.torqeedo.com
UK SUPPLIER: C Quip tel: 01489 577257 www.cquip.com

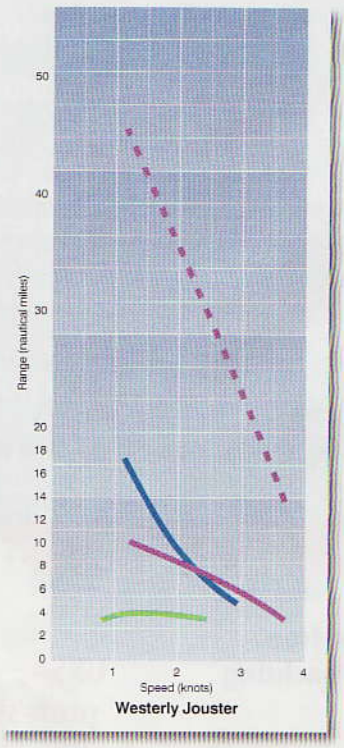
THE FINDINGS – SPEED, RANGE AND ENDURANCE



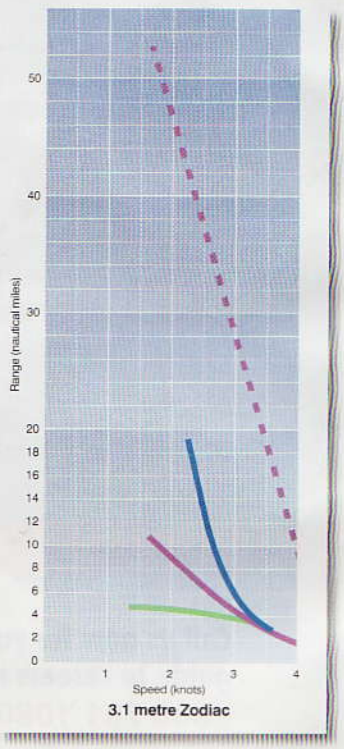
Westerly Jouster



3.1 metre Zodiac



Westerly Jouster



3.1 metre Zodiac

The two DC electric outboards were virtually silent, but the Torqeedo was a bit noisier, sounding rather like a sewing machine, though even at maximum power the noise was quite acceptable.

The lack of fuss and ease of control for all these electric outboards was outstanding, and the prospect of tenders in the future being propelled electrically around the anchorage, instead of noisily with petrol engines, was one we longed for.

We compared the measured input power of the outboards with the horsepower required to propel the Jouster. At maximum power, the Minn Kota was 16% efficient, the MotorGuide 12% and the Torqeedo 44%. As a comparison, a small petrol outboard is less than 10% efficient – less than all three.

Another method of judging the relative efficiency is to measure the distance you can get out of a specific battery size. Yachtsmen normally judge battery size by its capacity in Ah, but this is no good if the batteries are of different voltage. So we used 'Watt hours' (Wh) – equated as V x Ah – as a measure of capacity. A 12V 110Ah battery, then, has 660Wh of available capacity (at 50% depth of discharge) and two 12V 110Ah batteries in series giving 24V equals 1,320Wh. Using this measure at 2 knots speed, the Torqeedo was about four times as efficient as the other two motors, giving two miles for every 100Wh, compared with only half a mile for the others.

CONCLUSIONS

Although its maximum suggested displacement was 1.8 tons, in practice we found the MotorGuide 54 too small for the one-ton Jouster. Its non-PWM DC motor put it at a disadvantage, with short range even at low speed. It was light and easy to use, though, and we suspect that a bigger, PWM MotorGuide (two models are available, starting from £399) would have a similar performance to the Minn Kota.

The Minn Kota 80/T showed how much more suitable a PWM DC motor is to propel a small yacht or dinghy, achieving a 12 mile range, albeit at a leisurely 1.2 knots from two 110Ah batteries. It was also easy and pleasant to use.

The Torqeedo, with its AC motor, was a completely different kettle of fish! Taking a fresh look at outboard electric propulsion, it was simple to use, lightweight and very efficient. However, as we've said, it was a little noisier and a lot more expensive than the DC motors. But whereas the others are very able trolling motors the Torqeedo is a viable electric outboard, especially as its 10Ah battery could be recharged from the boat's inverter in about 10 hours, drawing only around 2-4A – a practical proposition using wind or solar power.

So to sum up, if you can live with the much reduced range and endurance of an electric outboard, it really has to be the way to go. However, if you can't re-charge your batteries easily, then you'll just have to put up with the noise and hassle of a petrol outboard for a while longer.

▲ **The Torqeedo 801 short shaft electric outboard is unlike anything else: able to be dismantled, very light and efficient, it is a viable alternative to petrol outboards**

THANKS TO: Barden Energy for the supply of the Rolls wet lead-acid batteries, tel: 01489 570770, www.barden-uk.com
And also Carlton Douglas for the loan of his Westerly Jouster *Oyster Catcher* as a test bed