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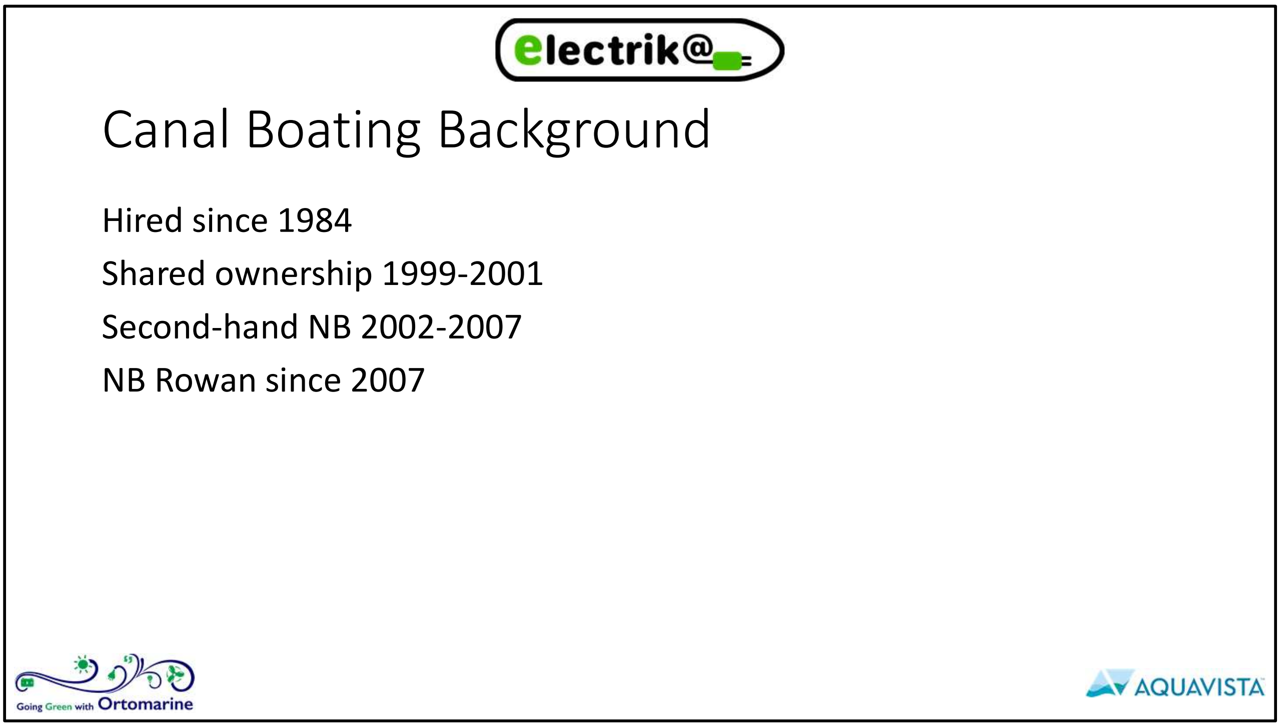
Greening Up - going from Diesel to Electric

Peter McLaren – NB ROWAN

Going Green with Ortomarine

AQUAVISTA

I’m here to tell you how (and why) my narrowboat got converted from diesel drive to electric drive and how it all went. My background is that I was a Weapons Engineering Officer in the Royal Navy, but as I did my electrical engineering degree in the mid-1960s my electrical knowledge is far too old-fashioned to be of any use in considering details of modern electrical systems to drive boats and so I’m not an expert in this field.



I do however have quite a great deal of narrowboating experience. My wife Jacky and I started narrowboating in 1984 when we hired a boat for a long weekend, decided we wanted more of the life and hired with another couple for a trip to London (with 3 children all aged 3). We survived and hired various boats intermittently over the following years. We then owned a share in a boat in 1999-2001 before purchasing our first boat, a second-hand 50 foot Trad-stern which we very much liked. However as often happens after a few years, we thought it would be nice to have a wee bit more space, and would do this and that slightly differently and so we had Rowan built.

NB ROWAN

Rowan is a 57 foot boat completed in late 2007. She is a fairly conventional Trad stern narrowboat, built on a Johnathon Wilson hull and originally fitted with an Isuzu 42 diesel engine, an inverter/charger and the usual equipment for 2+2 cruising – we would typically go for a 6-8 week mid-year cruise plus 1 or 2 early or late weeks. We stay in Stirling in Scotland, and base the boat at Heritage Marina near the south-western end of the Macclesfield Canal.

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NB AMPERE

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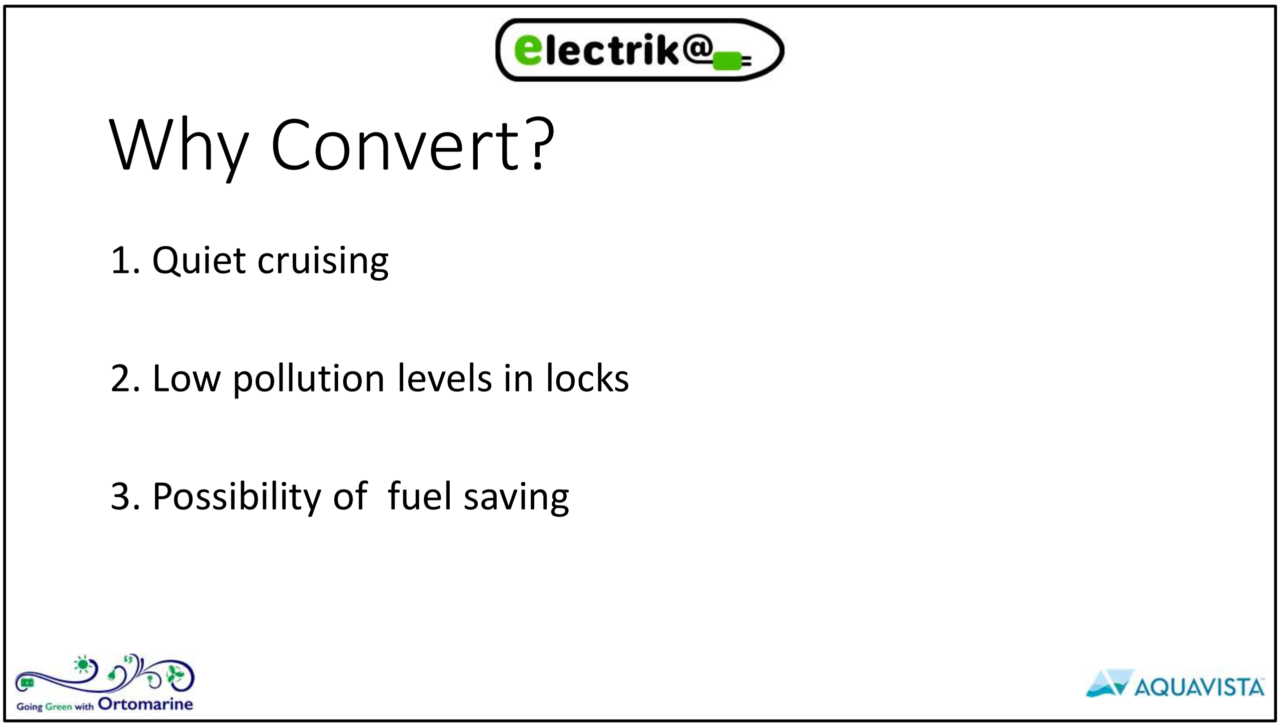
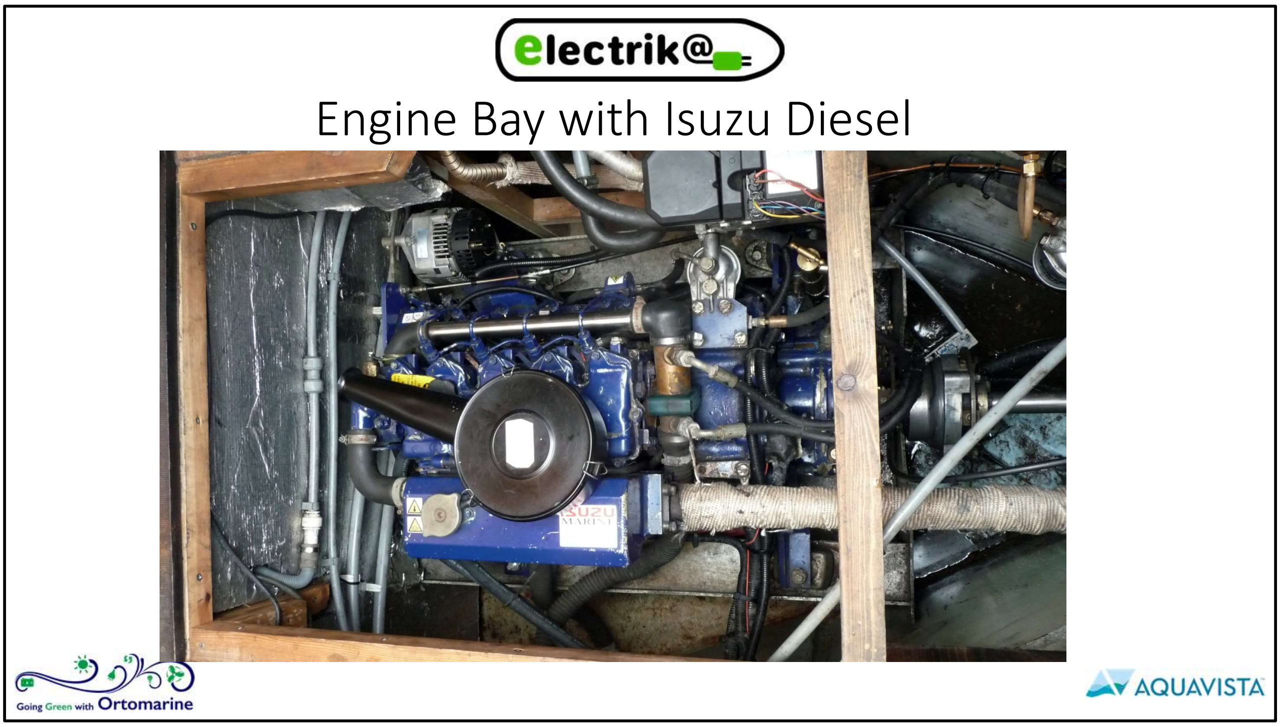
Nearly 10 years ago when electric propulsion was in its infancy I read about NB Ampere in Waterways World and started giving serious consideration to getting electric drive. I got in touch with Malcolm and Barbara Bridge, owners of Ampere, and arranged to meet them to view the boat and discuss their experience. I was also honoured to be permitted to steer her and the quiet way she slipped through the water was beautiful. I wanted to investigate further and did as much research as I could, online and through the Electric Boat Association, and soon started thinking seriously about getting Rowan converted.

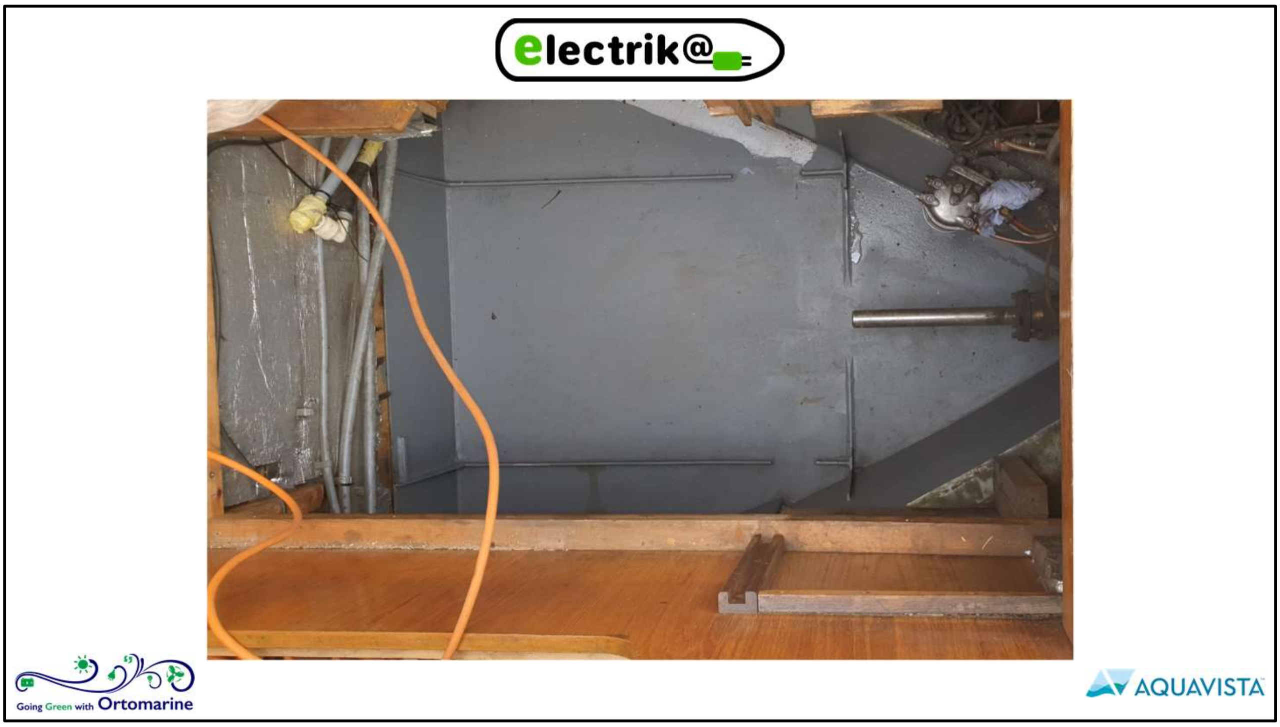


1. Electric drive fitted this bill, and this was my prime motive for converting.
2. Secondly low pollution levels, especially in locks. Measurements have been taken in locks with a diesel-powered boat and have shown that pollution levels of particulates and nitrous oxides can easily exceed all allowable environmental limits by wide margins, Electric drive doesn’t emit any of these toxic substances,
3. Next the possibility of fuel saving. A small generator running on heavy load is more economical in fuel consumption than a large diesel operating on light load.

We had liked our first boat and had based Rowan’s design around it. Rowan was about 10 years old by this stage but still suited us and we knew her ways. A mid-life upgrade could be based around a conversion to electric drive. I made enquiries of a number of boatyards. There was little interest apart from 2 yards,



Phill Abbott and Tim Scoones from Wharf House came up to our base to discuss their proposals and to take some detailed measurements of the engine compartment, seen here. We were starting from the wrong end really in that we had a limited amount of space and were trying to fit all the equipment in, rather than starting with a known amount of equipment and defining how much space was needed. This slide shows the engine in situ and it's obvious that it fully occupied the available space. The distance from the for'd bulkhead to the stern tube is about 4' 6" (1.4 m).



It looks slightly better when the engine has been removed but it hasn't made the space any bigger.

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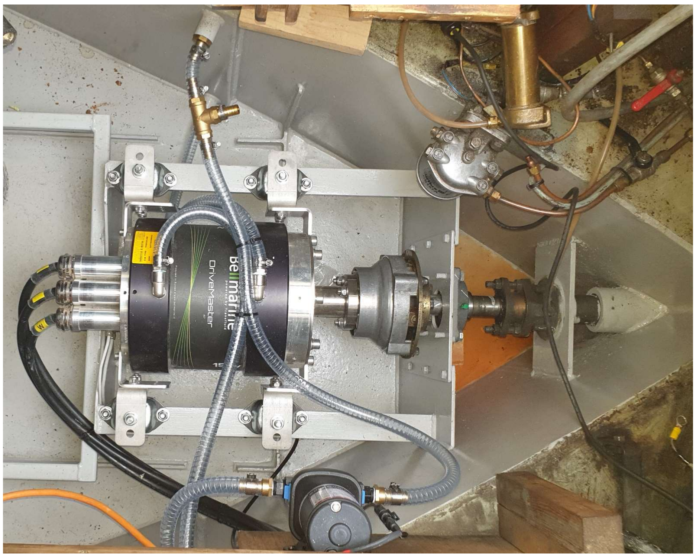
Bell Marine Motor in situ



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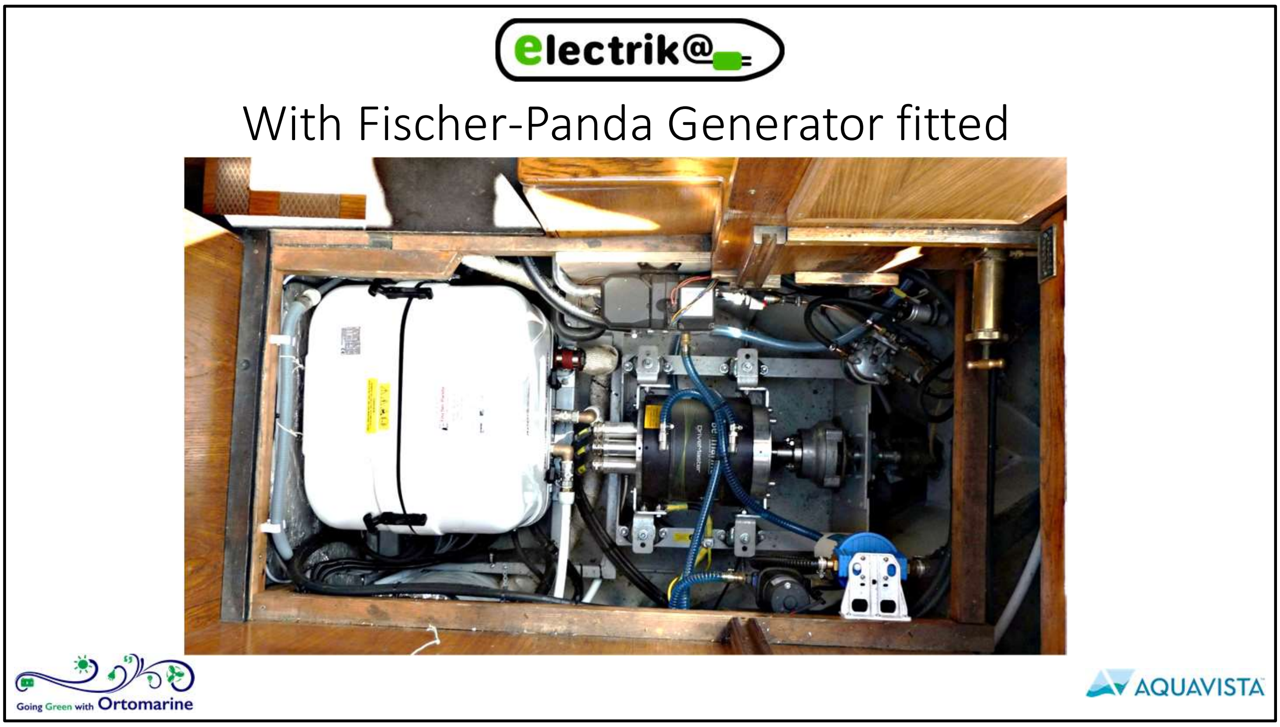
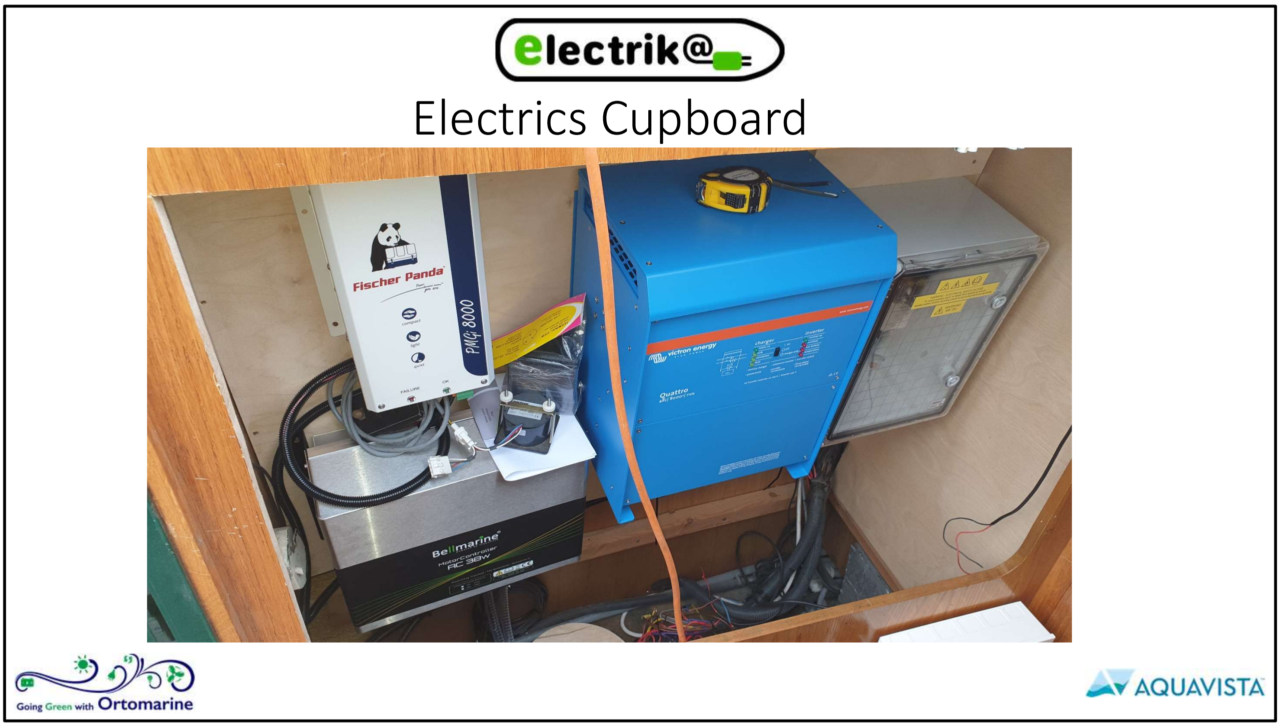
The electric drive system that was to be installed comprised a Bell Marine Drivemaster 48V DC motor, rated at 15kW peak, 10kW continuous. The motor is water cooled and this necessitated the fitting of a second skin cooling tank on the starboard side of the engine space, the original one on the port side being required for the generator.



The generator is a Fischer-Panda 230v AC single phase, rated at 8 kVA peak and 6 kVA continuous, installed in a sound-deadening cocoon. It is seen here installed for'd of the motor. It was a squeeze to fit everything in the available space, for instance there is barely room to get a hand down between the generator and the for'd bulkhead. The generator cooling goes via the hot water calorifier and a second calorifier for the central heating, then to the original skin tank used for the diesel engine. Ampere had a great deal of trouble with a raw water generator cooling system which kept on chewing up water pump impellers due to the gritty nature of canal water. Fortunately I was able to learn from Ampere's experience and ensured that skin cooling was used.



This slide shows the major units in the electrics cupboard. The generator produces an unstabilised 230V approx. 50Hz output via its dedicated inverter designated a PMGi – the large white box upper left. The PMGi output is fed to the Victron Quattro Inverter/Charger (large blue box in the centre) and thence to the AC distribution panel. The Victron also accepts a shore supply and converts the AC from either the generator or shore supply to 48V DC to the battery bank. The PMGi, Victron and the Motor Controller below the PMGi are fitted in the electrics cupboard on the port side above the machinery. Further smaller items were still to be fitted when this photo was taken. All in all there is a great deal of equipment in there and it can give off a great deal of heat. More on this later.

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Batteries

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I haven’t yet mentioned the power source for the electric drive, so here we have 12 Leoch lead-carbon batteries, each 12V 210 Amp-hours, total installed capacity being 30 kW-hours. Nothing interesting to see concerning them and they are all mounted underneath the main double bed.

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Batteries in situ

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Here are the batteries installed under the main bed, 10 athwartships and 2 fore/aft, all around the centreline. The batteries are connected in 3 groups of 4-in-series to provide the 48V for the motor. They are claimed to be good for 2000 cycles to 50% Depth of Discharge, which should certainly be enough to last for the rest of my narrowboating time. 12V domestics are supplied via 2 48V to 12V converters (2 for security of systems) and a stand-alone AC/DC charger supplies the bow thruster battery.

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Motor Control

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Motor Control is simply by switching on with a key and operating a lever throttle for forward and reverse – just like a diesel engine. A red Emergency OFF push is fitted below the control lever. That’s all that is needed.

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Gauges

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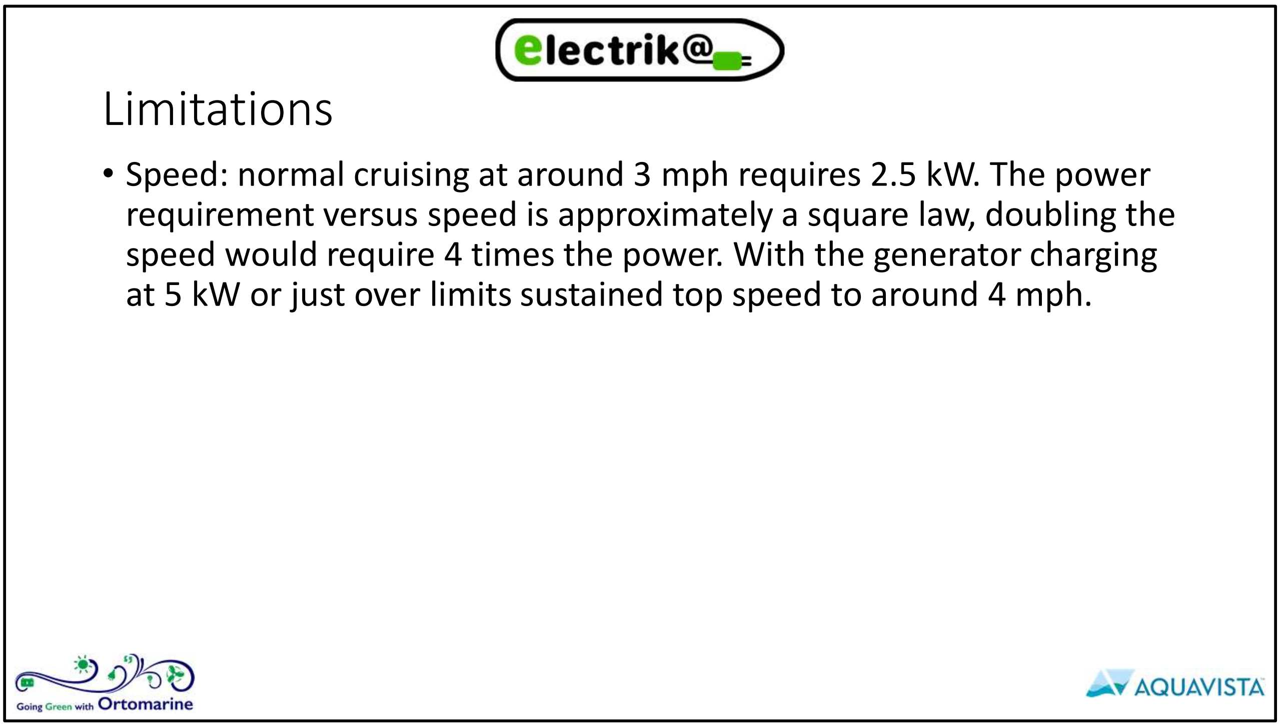
Close-up of the instrumentation. The useful parts are the left and central dials and the battery monitor to the right. The left-hand dial displays motor speed in RPM and the central one is motor current in Amps. Taking battery voltage to be a round 50V it is easy to convert to power being consumed: we find that 50A motor current, equating to 2.5 kW, provides around 550-580 RPM which is a comfortable cruising speed of just over 3 mph. Revs are low compared to a diesel engine because the motor is direct drive whereas diesels have 2-to-1 or 3-to-1 reduction gearboxes and so our 550 revs equate to 1100 under previous diesel drive. Digital readouts of various parameters are below the rotational gauges but these are hard to see from the helm's position. The green trees on the right of the main instrument are an ECO representation and get smaller as power level increases eventually turning red at high powers.

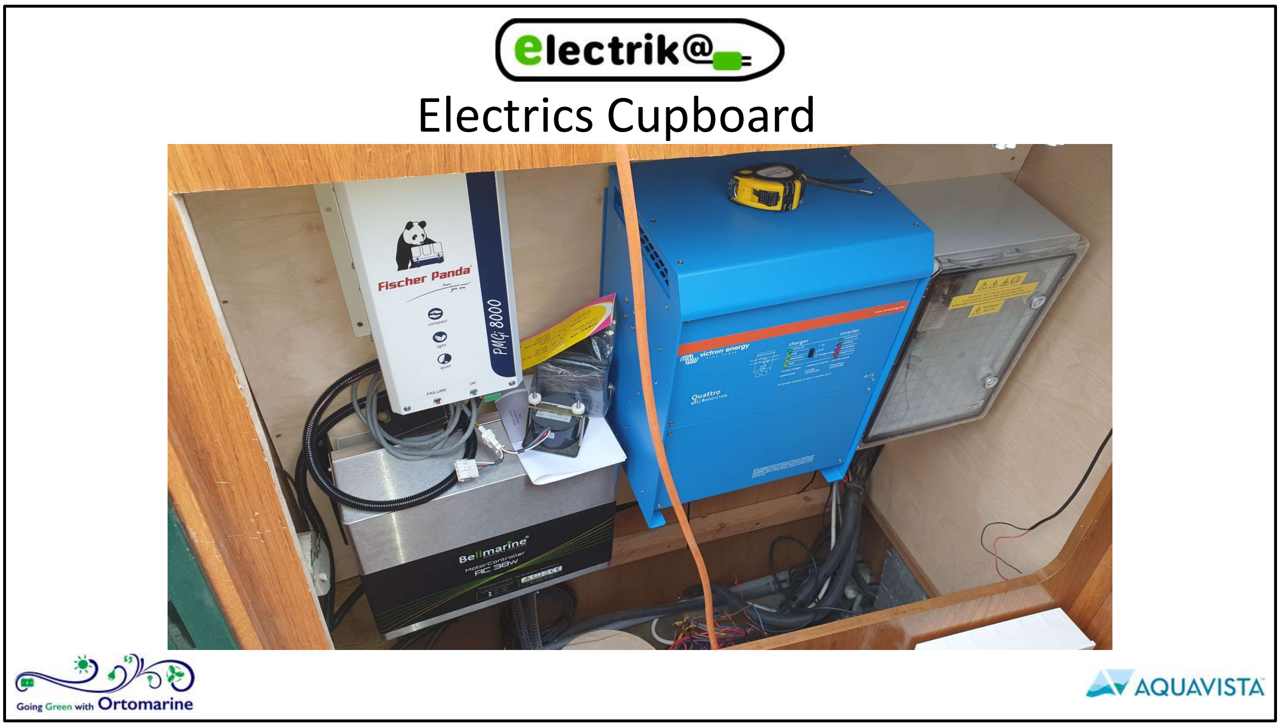
The small gauge to the right is a battery monitor, with 2 very

How has it been?



Speed: I've already said that normal cruising at around 3 mph requires 2.5 kW. The power requirement versus speed is approximately a square law, such that doubling the speed would require 4 times the power. With the generator charging at 5 kW or just over limits sustained top speed to around 4 mph, that is with the motor draw equalling generator output. Any faster and the state of charge of the battery will be decreased. I did wind up the power on 1 occasion and achieved 4.7 mph, an absolute very short-term maximum speed.

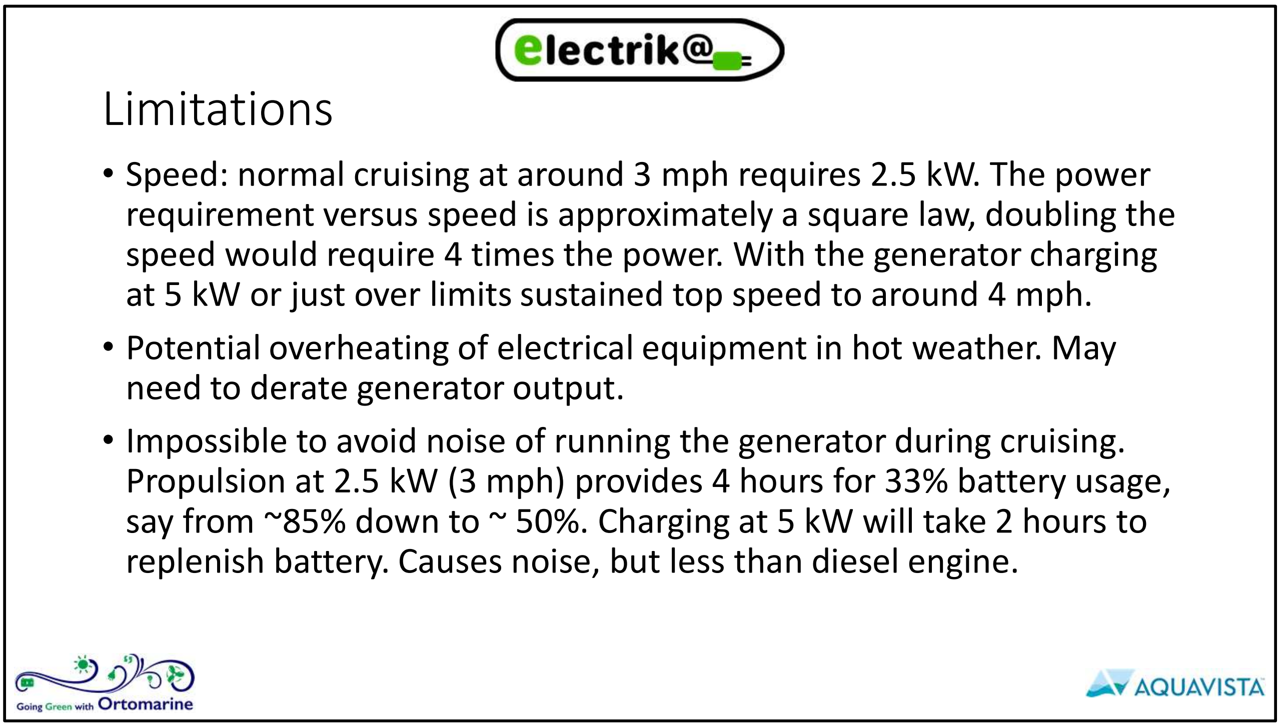
An increase in speed requires an increase in propeller thrust, I'm not sure whether there is anything we can do to get round the limitation in top speed. We just need to be careful about currents on rivers and tidal passages. Fortunately we've already cruised nearly all the rivers and tidal passages on the system, so we don't see this as a problem for us. Changing the propeller size or pitch might be a way of increasing top speed, a subject covered in a separate presentation which deals with this subject.



This is the slide I showed earlier of the major electrical units in their cupboard. The panel with the throttle is fitted on the left hand side of the cupboard and doors close off the rest. When the generator is running a great deal of heat is produced and during our first year's cruising the white PMGi inverter overheated on a hot day even with the cupboard doors open. Result: not possible to charge the battery and we had to hop from marina to marina to recharge from shore supplies for a couple of days to get home. Although the PMGi had been installed in accordance with its specification it clearly needed more cooling. Fischer-Panda repaired it under guarantee and I was advised to fit fans to aid cooling.

I duly fitted 2 thermostatically-controlled computer fans to provide the extra cooling, the inlet vent is just aft of the throttle and the exhaust at foot level. Strangely for electrical equipment, the cooling air inlet is at the top of the unit and the exhaust at the bottom. This works fine provided the ambient temperature isn't too high, and in practice I derate the generator output to 4 kW in hot weather, and keep a careful eye on equipment temperatures.

Potential overheating of electrical equipment can be avoided by derating the generator output which just means spending slightly longer times charging the battery but this is no real problem.



Unless one is going to hop from shore supply to shore supply it will be necessary to charge the batteries with the generator. Propulsion at 2.5 kW (3 mph) provides 4 hours cruising for 33% battery usage, say from ~85% state of charge down to ~50%. Charging at 5 kW, i.e. at twice the cruising discharge rate, would take 2 hours to replenish the battery. The generator exhaust does produce some noise (and pollution) but not nearly as much as the average-sized diesel engine. Our usual routine is to cruise for 3½ - 4 hours during the forenoon and run the generator whilst stopped for lunch, which gives us hot water for dishwashing. Another 2½ - 3 hours cruising in the afternoon and then finish charging the batteries, also providing hot water for showering and more dishwashing. NB Ampere was designed from scratch and the generator is under the long tug deck and can hardly be heard on board. However this option isn’t usually open when converting a boat.

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Meeting original hopes

1. Quiet cruising:

- **YES.** I love the quiet way the boat slips through the water with only a small sound from the propeller wash.

2. Low pollution levels in locks

3. Possibility of fuel saving

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3. Possibility of fuel saving:

- **YES**. With economics of small generator and slightly slower cruising estimated to use on 2/3 of previous fuel, maybe less.

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What might I have done differently?

- Solar Panels ? I had originally thought of getting them fitted, but advice was that they would not contribute worthwhile amount of power, particularly on the northern canals where we are based. Feel they would be useful over winter when boat not used for months. Still possible to retro-fit.

- Wind Power ? Wanted to, but not allowed in my marina!

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The Bottom Line 2020-21 prices

Cost of conversion (parts and labour) including money received for previous Engine and Inverter/Charger: £50,000

Compare with:	Est cost of new build:	£150-200,000
	Less sale of Rowan:	£50,000
Saving of conversion over new build		£100-150,000

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The cost of conversion by Wharf House Narrowboats and allowing for the sale of the previous Engine and Inverter/Charger was £50,000. The further costs for a new build and sale of Rowan are fairly speculative, but I’m content that converting Rowan cost considerably less than selling and purchasing a new-build electrically powered boat.

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