Electric Drive Conversion.

It was the perfect day, sailing with some friends on my yacht, 'Pleione', a 1976 Beneteau Evasion 32. We had departed my home port of Votsi, on the Aegean island of Alonissos for a day's sailing, mixed with swimming and snorkelling around the adjacent islands. First stop was the islands called 'The Two Brothers', after a slow sail in light winds and of coarse, wall to wall sunshine, we anchored in a small bay with crystal clear water, everyone dived in to explore the underwater surroundings. From here we motored back between the two islands, the wind having turned from light to zero, for our lunchtime break at the picturesque port of Steni Vala. It was on this leg that the first clue of impending disaster showed itself with the sudden emission of black smoke from the engine exhaust. I immediately eased the throttle and the smoke stopped, I then increased the throttle back again and all was well again. Sometimes things like this happen to a 36 year old Volvo Penta MD3B! At Steni, I thought it prudent to check a few things, oil level, water level etc. All looked OK so I started the engine without problem. Lunch over, we started heading back to Votsi. !0 minutes of motoring and I heard a strange noise from the engine, I stopped it straight away and with some off shore winds we had a good sail back to Votsi. I needed the engine to manoeuvre through the myriad of moored fishing boats in the port so reluctantly started the engine. All seemed OK again, so I thought let us slowly manoeuvre at tick-over speed to get in. But just as I was going to drop the anchor, the engine started to knock loudly and before I could stop it, it stopped itself. I got all the friends off and after goodbyes, rowed back out to Pleione to see what had happened. Result, the engine would turn ¼ of a turn in either direction then metal to metal contact – she had thrown a con rod.

I knew straight away that a re-build and overhaul would be extremely expensive, given the price of Volvo Penta spares. The price of a new Yanmar 30HP would be around €6500, a better option with warranty, but I was having other thoughts, Green thoughts. I have been getting increasingly environmentalist in my old age and considered this would be an ideal time to choose the Green option, an electric drive.

So what does an electric drive give? Obviously no engine exhaust emissions, also no noise, all you here is the swish of the prop through the water.

Pleione sailing off Alonissos

Previously, my first job on getting on board Pleione was to start the engine to warm it up, the electric drive just needs to be turned on and it is ready. When you get to a port or berth, the engine remains running until all is secure; the electric drive is just switched off. On the down side I would have a much limited range under power, with the old engine the 100 litre diesel capacity would give about a 500 nautical mile range, the batteries are good for around 50. But I argued to myself, this is a sailing yacht with an auxiliary engine for manoeuvring in and out of port, what did sailors do before engines? And what is more important, convenience or the planet?

Votsi mooring

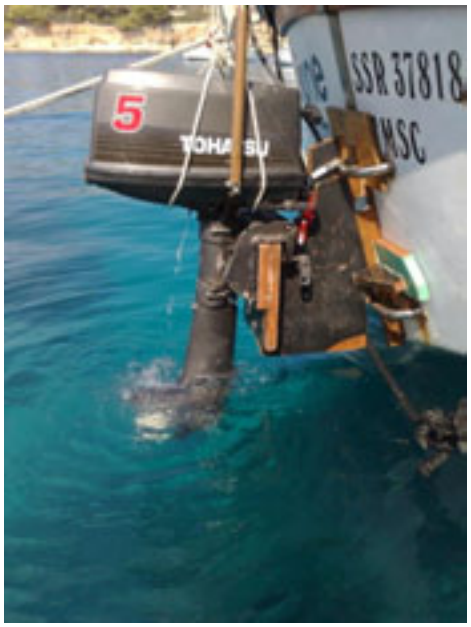
The initial investigation was to see what options were available – Hybrid drives – a good solution using electric but with the advantages of a diesel engine, diesel electric drives – diesel driven generator driving an electric drive or just straight battery / electric.

Volvo Penta MD3B

All showed to be very expensive against the Yanmar, especially the Fischer Panda generator / electric drive. My budget was very limited and it looked like all I could afford was a second hand diesel. In the meantime I busied myself with removing the old engine and cleaning up the engine bay.

Then the second disaster for the year struck with the death of my Mother. All thoughts of the yacht were temporarily put on hold.

On returning from the UK after the funeral, I arranged to get Pleione ashore in our local boatyard (to use the word loosely). This required making a makeshift bracket to mount my 4HP Tomasu outboard for the trip. At 2 knots it took a little longer to get there than usual but we made it. The next problem was getting the yacht onto the rickety trailer used by Mitsu, the boatyard owner. Normally, I align the yacht with the trailer which is run down the slipway and submerged, then drive her on using the engine, using the rudder to keep her aligned. This is not possible with a 4 HP outboard, but we managed it in the end after several attempts, so Pleione was safely ashore.



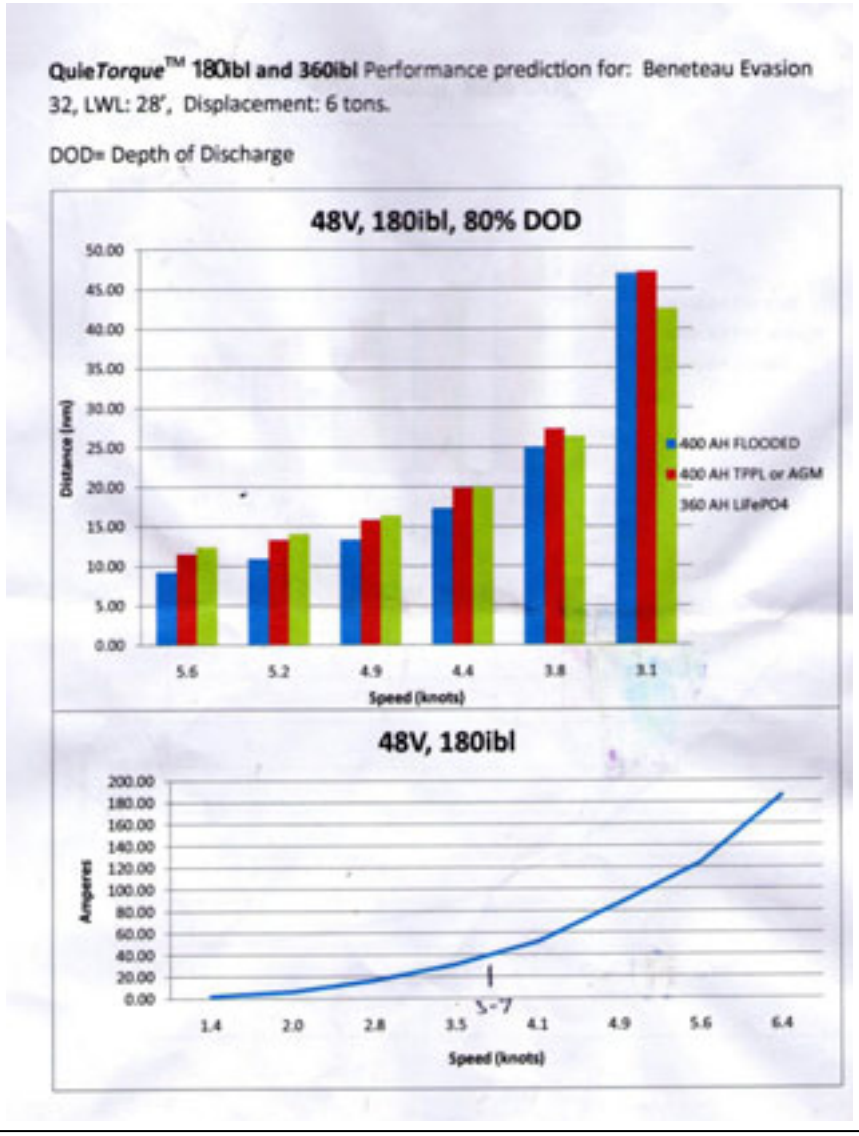
Makeshift engine

On the boat yard trailer

Three months later and with a small inheritance from my late Mother I started looking again, things were still tight, but I felt I should bite the bullet, and my wallet, and go Green.

After much surfing of internet, I discovered Electric Yacht in the USA. They offered a pure electric drive, easy to install and compact. They were also able to supply the system with two quadrants (equivalent to the original Morse controls)as Pleione has two steering positions, one in the cockpit for when steering with the tiller and a second in the deck saloon at the inside wheel steering position. All items were plug and socket making installation easy. When sailing, the back drive of the propeller drives the motor and charges the batteries.

Electric Yacht recommended the Quie Torque 48v 180ibl as the unit best suited for Pleione. This was calculated by them from the information supplied by myself such as waterline length, weight, type of prop etc. The chart shown below shows the performance curves throughout the drive range. As is shown, the distance that can be travelled depends on the speed of the yacht. For instance, at 5.6 knots, using AGM batteries of 400Ah gives a range of only 12Nm, but at 3 knots the range is around 47Nm.



Electric Yacht finally calculate the drive ratio between the motor and the drive shaft to give the best motor speed range for the yacht speed range.

They also supply a drive coupling to suit the existing prop shaft diameter, in Pleione's case this was 30mm.

An energy meter is supplied that give all the information required such as battery state at all times, running current and time to discharge are displayed whilst motoring.

The supplied installation instructions were clear and easy to follow.

The next consideration was the batteries. Pleione has a long full length keel that is very narrow at the bottom. All the standard batteries were too wide to fit. More internet searching found Odyssey Batteries, and in amongst their extensive range I found the PC 1800-FT, a 12v AGM battery 214Ah and only 125mm wide. I could fit four, two side by side, one set behind the other. This meant the batteries would be low and would add ballast, improving Pleione's sailing performance as a bonus. However, I still needed to remove the existing engine cooling seacock as it was in the way of the aft set of batteries, it was no longer required anyway and meant one less hole in the hull.

A personal stipulation was a minimum of 5 hours motoring under power to reach the outer islands on days with no wind. This equated to 8 batteries, so the question was where do I put the other 4? After more investigation I opted to fit two athwart the engine room forward bulkhead, over the top of the four in the bilge, and the final two in the forward cabin locker under the berth, aft end. This I felt would also help to balance the additional weight fore and aft, and keep the weight as close to the centreline and as low as possible.

To charge the batteries I proposed to use solar panels, one thing we do not lack in Greece is sunshine. I had one 55w panel already mounted on a goal post arrangement at the stern, and recently, I had acquired three more from a cottage on the island that had been converted from 12v to mains electricity. Two of the three I had already mounted on the deck saloon roof to increase the capacity of my existing 12v charging system. Next problem was the electric drive, it being 48v. This was going to require a lot of panels, as most available panels are 12v or 24v, certainly the cheaper units. I had already planned to change the Tentex bimini cover for a plywood version to allow more panels to mounted. The three old panels could go onto the deck saloon roof with the forward one slightly covering the sunroof, but three only equals 36v, I needed another 12v unit, and the existing 55w, I wanted for charging the 12v system. I was limited with space on the bimini and there was not enough room to mount the size panels I needed. More internet searching found a Chinese supplier with 20w panels at a very good price. I calculated I could mount a total of 12 - 20w panels and by grouping them I could get one set of four wired in parallel to give the fourth 12v panel, and 2 sets of four wired in series to give two 48v units. This gave a total of three 48v panels with a capacity of around 7amps. This would still take 60 hours of sunshine to re-charge them from flat, at say 8 hours per day (one of the advantages of living in Greece), but this would still take around 8 days.

The next consideration was if I used the battery power during one day and it was going to take approximately 8 days for the batteries to recharge using the sun, what if I wanted to use the yacht before this?

An inboard generator would be the answer as I do not have access to shore power, but once again, diesel generators were not cheap and with a lot of space taken up by the batteries and the electric drive, I could not fit one in. My answer was to use a petrol suitcase generator. It fitted the space, was neat, tidy, quiet and a fraction of the price, after all, it is for back up use only. I chose the Hyundai 3000SI at 30KVA, it having largest output for the price.

So with the generator I required battery chargers, one for 48v, and one for 12v. I spent extra for the 48v as the Victron 48/50 TG unit can be used for direct load meaning in the event of total battery failure, I could power the electric drive directly from the generator via the 48v charger giving a low cost petrol / electric drive. The 50a output should give me approximately 4 knots speed, adequate as a get you home option. I also fitted an optional extra, that is a controller to limit the current when encountering low fuse ratings on some shore supply outlets.

So with all the equipment identified, the space allocated, the 12v and 48v circuits diagrams complete, it was time to start ordering the components.

This is where living on a beautiful Greek island becomes frustrating. It adds both time and cost to every action. We only have an ACS courier on the island, and the post office, where post comes in but takes an age to come out again. Plus the timing was not good with Greece incorporating austerity measures daily, increasing VAT frequently and with items arriving from outside the EU, hefty import tax bills were the order of the day plus all the Greek beaurocracy to further increase the Green cost.

Whilst I waited for the first of the parts to arrive, I started with some preparations. There was a lot of redundant wiring from the original engine installation that needed removing, plus the cooling water heat exchanger. The original exhaust I was going to use for the generator with some adapting.

The two additional batteries to be mounted athwart ships at the forward end of the engine bay needed mounting, as did the two that would go into the forward sail locker under the berth. A problem here was the two batteries would be partly exposed with hatch lid removed. To remedy this, I cut out an offset section out around the hatch, which, when turned through 180 degrees would position the hatch further forward and cover the batteries. Cutting out this section would also facilitate installing the batteries. I manufactured a frame to re-secure the modified hatch section (see photos 1 to 4).

Photo 1

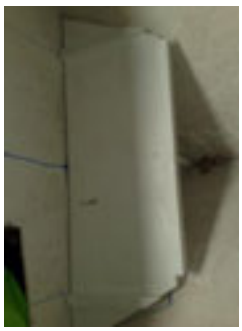
Photo 2

Photo 3

Photo 4

I used 20mm marine ply to manufacture the platform in the bilge to support the lower batteries. This was necessary as there were humps positioned over the keel bolts where they had been fibre glassed over. I was limited for height so I need the platform to fit around these humps so the batteries were just clear. Once in, I used tight fitting tubing to pack the space between the batteries to stop them moving when the yacht was heeled.

Upper battery shelf



Front battery shelf

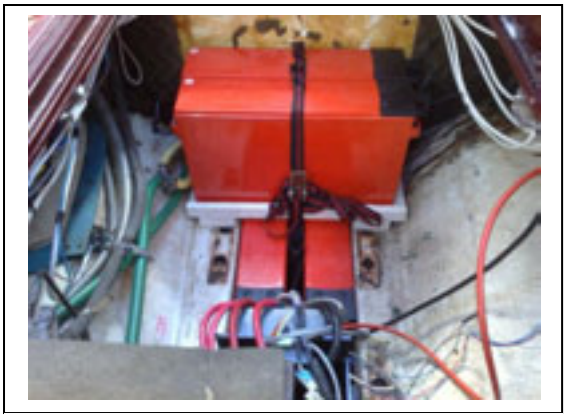
Also manufactured were the shelves to support the engine room batteries and those in the forward cabin. I cut slots in the bulkheads to accept webbing straps to secure the batteries once in position. Lastly, I had to make a platform for the generator that was to fit on the engine bearers between the engine room batteries and the electric drive.

February 2011 saw the arrival of the batteries via our local Kaique (coaster)called the Ioanna Chrisoula. Delivered in a crate weighing 517kg, the first problem was my trailer is only rated at 420Kg. So I needed to remove four of the batteries weighing 60kgs each, and load them into the trailer, then make a second trip for the remaining four plus the crate, helpfully loaded this time using the local forklift truck. On the plus side, our villa is only a 5 minute drive from the port of Patitiri.

I had already worked out how to get the heavy items onboard by doubling up the main boom with two halyards and reversing the main sheet so the pulling end and cam cleat were at deck level. The batteries were duly lift one by one using this method, then man handled by myself and my keen assistant Rodney, to be stowed in their respective locations. We then measured the battery cable lengths and ordered them from our local marine workshop / chandlery to be pre made up with 10mm eye fittings to fit the 3/8 studs of the PC1800 batteries.

Lifting with the boom

Lower batteries on keel



Upper batteries on shelf

Batteries in forward locker

Next to arrive was the drive motor from Electric Drive. Compared to the 200kg for the Volvo Penta engine, this could be lifted by one person. It is supported on slotted angle brackets that fit over studs mounted on the engine bed fixing plates, also slotted. Four holes needed to be drilled for the securing bolts into the original engine bed. After that it was easy to align the drive shaft to the prop shaft using the 25mm / 30mm coupling and tighten everything down, the whole operation taking only 1 ½ hours. With the drive comes a relay and fuse holder. These were mounted on the forward bulkhead of the starboard locker. This was a convenient location close to the electric drive and close to the inboard bulkhead where the main battery isolator was fitted. I did not use the plain on/off isolator supplied by Electric Drive, but instead opted for a 2 battery isolator switch. For this I used battery position one for the 48v batteries and position 2 for the 48v battery charger. This gives the option to either run either purely off the batteries, to use the batteries with the charger on, or to run using the generator and charger only. We mounted the cockpit quadrant where the original Morse control was situated, only needing to add some plywood strips inside as some of the quadrant securing holes aligned with the Morse control aperture. Electric Drive supplied the deck saloon quadrant with a separate key switch (the other unit had the switch incorporated) and a wooden housing made of maple. This was adapted by fitting a base plate enabling the housing to fit utilising the original Morse fixing holes. The respective cables were run following the course of the original Morse cables. When these were removed, I pulled cord through to facilitate running the new cables. Also supplied is an energy meter that scrolls between battery volts and amps used and motor RPM and battery time to discharge. The saloon key switch complete with the Victron current controller were mounted in the original engine switch position.

Electric Drive with cover removed

Cockpit quadrant

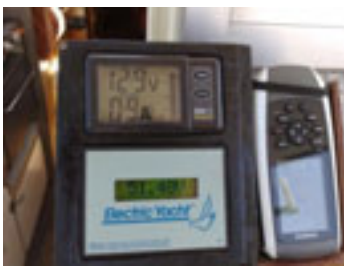
Saloon quadrant and key switch

Fuse and relay

Once supplied, we connected the heavy duty cables to the batteries and other 48v equipment.

To mount the two energy meters, 12v and the Electric Drive unit, I produced a housing made from marine ply. This is mounted on an existing shelf unit on the inside face of the door to the main saloon. As this door is always open, it makes both meters visible to the helm whilst standing at the tiller. In the event of rain, this door is normally shut and the inside steering position utilised thus the meters are out of the rain but still visible to the helmsman although he needs to look behind to see them.

Energy meter housing mounted to existing shelf on saloon door.



12v energy meter at the top, Electric drive meter below

Mains enclosure

12v Battery Charger bottom left
DC-DC Converter bottom right
Existing 1Kw inverter above

48v Solar Controller above,
12v Solar Controller below

Ventilation fan

Additional switch panel on left

The mains electricity panel was now set into the saloon locker end to distribute the power from the generator. The switch panel supplies mains power to the 48v battery charger, the 12v battery charger, an immersion heater fitted to the original calorifier, as no engine heating was now available, and two mains sockets, it also included a shore supply system for charging when shore power was available.

As more equipment arrived, it was mounted and connected. This included a Stirling 30amp 12v battery charger, a DC-DC converter for 48v to 12v to enable the 12v system to be topped up using the 48v batteries, and a 48v solar panel controller to manage the charging of the main batteries. To cool the engine bay with the generator running a forced ventilation fan was fitted and connected to the original tubular ducting discharging outside the hull via a grill. An additional 6 position switch panel was mounted adjacent to the existing unit complete with overloads for the extra controls required such as switching the vent fan on, exhaust cooling water pump, DC-DC converter etc.

The generator was mounted on its platform and connected electrically to the mains panel. I adapted the generator stop circuit so it could be stopped from the new switch panel without having to lift the engine hatch. I originally considered feeding the fuel for the generator direct from the original fuel tank but opted to use the tank purely as storage, decanting the fuel into the generator fuel tank when required. The generator will run for 4 ½ hours on a full tank.

Cooling the exhaust pipe was an interesting problem. I was not sure if it would be required giving the much lower exhaust output of the generator compared to the 36HP diesel. To cover the problem, I inserted a tee connection into the toilet seacock inlet, together with a filter and electric water pump. When turned on, this pumps water via the original engine vent break to a water box into which is mounted a float switch. The float switch controls the level of the cooling water so as to prevent water feeding back into the generator exhaust. The water break prevents water feeding into the system when the pump is stopped, even when the yacht is heeled.

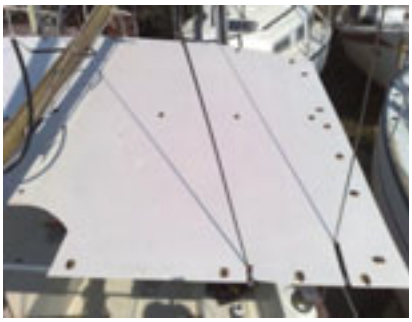
The 48v charger arrived and was mounted under a hinged portion of the deck saloon seating, originally to afford extra access to the engine.

Generator

48v battery charger.

I manufactured the 4mm external ply panel for the bimini on to which the 12 - 20w solar panels were to be secured. This was made in two halves to make it easier to handle. The 20w panels were drilled and bolted together in two 2 x 3 groups, each set of 6 to be mounted either side of the bimini panel. This dramatically increased the weight of the bimini assembly so it was necessary to increase the section of the supporting frame. Once assembled, the panels were inter-connected and finally connected to the solar controller via a waterproof junction box mounted between the panel sets (see photos below).

Finally, I bolted the three existing solar panels together and mounted them to the deck saloon roof using hardwood rails. These were connected to the controller to complete the system.



With all the equipment finally fitted it was time to test run the various systems. First was the main electric drive. I switched the isolator to position 1, operated the cockpit key switch and immediately heard the relay engage. This is normal although it de-energises if the quadrant is not used for 2 minutes, after that it re-energises whenever the quadrant is moved. I slowly incremented the quadrant and after hearing the motor start to hum, the motor turned the propeller shaft. Initially, the speed was high, but I was subsequently informed by Scott of Electric Drive that this was normal with the propeller out of the water. The backup provided by Electric Drive was impeccable, answering all my queries as quick as possible considering the time difference between us, To set the direction, there is a control knob mounted on the drive that allows reversal if necessary. This control also allows the drive to be tuned to the quadrant once the boat is in the water. We then checked operation of the saloon quadrant, although the motor operated, it turned in the wrong direction. To remedy this, we had to turn the saloon quadrant assembly through 180 degrees. Next we checked the priority quadrant. The cockpit unit was chosen as this is where the yacht is controlled most. The priority system is there to prevent someone affecting control of the drive by simultaneously operating the second quadrant. The priority means whilst the cockpit unit is in operation, the saloon unit is disabled. As it happened, they were the wrong way around, but this was easily remedied by swapping the two plug and sockets.

Next was the generator. I had already test started it at home and found onboard with the engine hatch up it was easy to pull start. With the generator running we powered up first the 48v charger, then the 12v charger and finally the immersion element. All functioned as designed.

Powering up the DC-DC converter proved it was possible to charge the 12v system using the 48v.

With the solar controller connected the solar panels all were functioning, charging both for the 48v and the 12v systems.

Last but not least I put the name of the power system on the hull.

The next stage was to launch the yacht and try the systems wet.

To compliment the Green drive system, I purchased a 12v electric outboard motor via Ebay, the outboard is a Bison 55Lb thrust unit running off a 66Ah 12v battery. This gives approximately 30 minuts run time which is more than adequate for the 2 minutes it takes to get from the quay to Pleione's mooring. The battery will either be recharged at home using my mains battery charger or could be connected to the yachts system and be charged from the 55w solar panel. This also eliminates the need for 2T mixture, exhaust emissions and noise of the original Mariner 3.3HP, and the electric unit is considerably lighter.

The final Green addition was an Ultrasonic antifouling system now fitted to avoid the use of toxic antifouling solutions. By transmitting a variety of ultrasonic frequencies though the hull, this inhibits the attachment of barnacles and other marine life that foul a ship's hull. The system consists of a transducer which is bonded to the hull, and a control box to produce the range of frequencies required.

First the hull needed to be thoroughly cleaned and flattened in an area close to the propeller and approximately 300mm from the centreline. This equated to a position under the saloon access stairs but was reasonably accessible with the stairs and access hatch removed. Next, the securing nut must be bonded to the hull with epoxy adhesive. Whilst this was drying, I mounted the control box to the cabinet side below the two solar controllers.

Once the epoxy was set, the transducer is screwed into place with a smear of silicon grease on it's contact surface to ensure good contact with the hull.

The transducer is connected to the control box via a cable with plugs and sockets each end, and the 12v supply was also connected.

On turning the system on, the red and green LED's flashed to show the system was operating, plus you can hear the faint clicking of the pulses.

2nd May 2011, launch day! Myself, and two helpers arrived at the boat yard at 10:30 to find the ancient owner of the yard and his mate still running the trailer under the Pleione. When you are anxious to get going and prove out an 8 month project, they appear to work at a snail's pace, plus it appeared Mitsu had forgotten to pack his brain that morning as they had to do everything twice, so the normal one hour to get a boat into the water dragged out to 2 ½. Eventually, and with not too much of the new antifouling rubbed off the hull, Pleione entered the water for the first time as a Green Powered yacht.

First task was to get her off the trailer, this proved difficult as whilst waiting for the boatyard staff to do their stuff, a light westerly wind had blown up pinning the hull to the trailer so at moderate revs astern, she would not move. With a short burst forward to kick the stern into the wind, then high revs astern, she slowly moved back and we were clear.

At this point, after the stress of getting clear, I suddenly missed something – no engine noise. I knocked her into neutral to do a quick check to make sure all was secure and watertight down below, again, no engine ticking over, this was really alien to me after so many years living with a diesel engine. Happy that all was OK, I slowly incremented the quadrant. With the key switch turned on, the energy display scrolls between motor RPM, motor amps, battery volts and battery hours remaining. We watched the figures slowly increment with each increase of the quadrant until I reach maximum. At this point we were gliding effortlessly along at 5.7 knots, motor RPM 2070, motor amps 207 and hours remaining at 2.6. The design figures from Electric Yacht gave a maximum RPM of 1900 and max amps 160, not too far away after being designed from basic weight and waterline length / beam. The next stage was to adjust a control knob above the motor to tune the motor to the quadrant. This required rotating the knob backwards from maximum until the motor slowed, then back to just return to maximum speed. This control can also be used to limit the amps drawn so I limited the drive to 160 amps as per design. This now gave me 5.5 knots at full throttle.

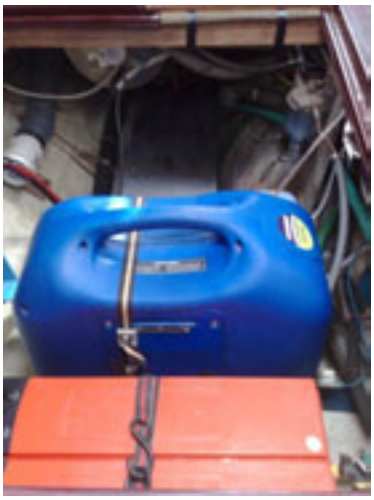
I eased the quadrant back to give us a speed of 4.5 knots, at this speed the amps were down to 60, and the battery time remaining went up to 4.8 hours. So we cruised along with nothing but a hum from the motor for the remaining 45 minutes to get from the boatyard at Bambakies to my mooring in Votsi harbour. Once again as I manoeuvred towards the mooring, going into neutral produced absolute silence. My initial reaction was – "Oh my God, the engine has stopped", but on moving the quadrant again, the reassuring hum from the motor signalled I was still in control. Once secured to the mooring, I checked the 48v energy meter, it showed the volts had dropped from 54v down to 51v, but still showed a 100% as the charge level was still above 48v. This was very encouraging as it indicated the battery system was capable of extended runs, a concern I had worried about all along.

Pleione on the trailer.

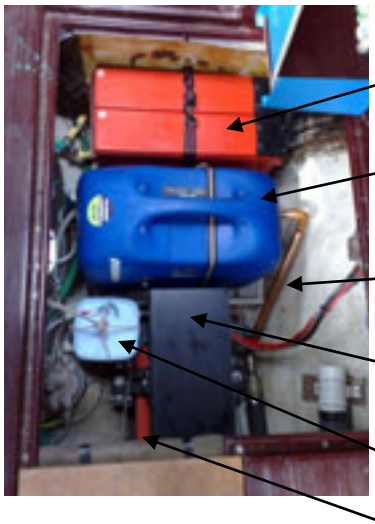
Myself watching Pleione going down the slipway

Almost there, time to board!

With the initial trial over and the electric drive tuned, it was time to fit the Electric Drive motor cover and do the final tidying up jobs.



Electric drive looking aft



Electric drive looking forward

Pleione back on the Votsi mooring

Closer view showing solar panels

The next phase was to take Pleione out to fully evaluate the electric drive / batteries and to ascertain the maximum range under power. I also needed to test the new main and mizzen sails, including any improvement under sail with the added ballast supplied by the lower 4 batteries sat on the keel.

The first item tested was the new electric outboard engine. This was attached to the transom of my Tinker Tramp inflatable. It is lighter than my original 3.3HP, 2T Marina engine, but you also have to carry the battery to power it, so overall, the weight is probably similar. I located the battery on the floor, adjacent to the transom, and the two battery leads were connected using the crocodile clips provided. Performance wise, I estimate that the electric version delivers approximately half the power of the Marina. This equated to 4knots maximum speed in lieu of 8 from the petrol version, but to get from Votsi quay to the mooring took less than 2 minutes so it is adequate. Endurance wise, when run in my test tank, on a setting of 4 (maximum 5), it ran for 30 minutes on a 66Ah battery, more than enough for everyday use. There are 3 red LEDs and 5 green LEDs that indicate battery power, once the last green expires, it is time to row. The lights flash for a time before going out to further indicate battery power remaining. Obviously, battery remaining depends a lot on the throttle setting at the time. I found that if on setting 5, when the last green light went out, reducing to setting 3 brought 3 lights back on. The big difference though is the noise. Even running on maximum 5, there is no noise whatsoever. All you hear is the lap of water under the bow, plus of course, there are absolutely no CO2 emissions.

Sunday 15th May was a perfect day to evaluate the new electric drive and batteries. On a glassy Votsi harbour, myself and two friends silently motored out to Pleione in the Tinker Tramp propelled by the new Bison electric outboard motor. Once onboard, we readied for the trial. This was to be a typical all day trip, visiting two other island and a stop to meet friends at the small fishing port of Steni Vala.

With isolator switched to batteries, I turned the key switch in the cockpit quadrant to hear the relay click on. With the mooring lines cast off, I inched the quadrant forward and silently we ghosted forward and out off the port. First of all, once in clear water, I slowly incremented the speed and we recorded the values from the energy meter for the speed range. These are listed below.

Boat speed (knots)	Motor RPM	Amps	Battery remaining (hours)	Range (NM)
2	650	7	59.6	119
2.5	780	10	38.3	96
3	930	16	26.8	80
3.5	1070	22	18.5	65
4	1200	32	11.9	48
4.5	1370	45	7.9	36
5	1550	72	4.7	23.5
5.7 (max)	1760	116	2.7	15

We settled on to a speed of 4.5 knots as a comfortable speed with sufficient range for our needs. One hour later we silently entered Steni Vala, and got some strange looks from crews on the few yachts moored as we apparently drifted past without an engine or sails. We berthed stern to with several willing hands there to take our lines and to ask what had happened to our engine! We stayed for a hour and a half during which many people wanted to see what was under the floor boards where the engine should be. After coffees and much discussion, we departed Steni Vala and headed for our next stop, the wreck of an old coaster on the rocks in a bay called Vassiliko on the island of Peristera. A slight southerly wind had developed and I longed to get the sails up but evaluating the new drive took precedence. On this leg I first noticed we seemed to be getting more out of the batteries that predicted. After nearly 2 hours motoring, we were still showing 6.2 hours of battery remaining. Giving we started with 6.8, had been motoring for 2 hours, I was expecting more like 4 hours. I know that we were gaining around 6 amps from the solar panels but it still did not add up.

We anchored off of the wreck in 3 meters of crystal clear water, tempting but still very cold at this time of year, so we decided a glass of Retsina and some snacks was a better option than swimming.

30 minutes later we were on our way again, this time around to the west end of the island and into a bay call Peristera bay. Here we made tuna and salad sandwiches and another glass of wine. One of my crew could not resist and went for a swim. She told us it was lovely but I was not convinced myself so stayed dry.

Our last islands were the Two Brothers, we motored between them and then along the south side to a small bay at the west end. On the approach to these islands it occurred to me that 8 months ago in that same area I first got wind of the on coming disaster. We did not anchor here but continued back to Votsi and Pleione's mooring. At 17:30 we slowly motored into the port and once again absolute silence as we coasted to the mooring after a full days motoring with absolute 0 emissions.

So, after a day of motoring around the islands the system was showing 5.1 hours remaining and the batteries were down to 68%, much better than I had expected and with figures I did not confess to understand, but the any error was in the right direction. The next question was how long would it take the solar panels to recharge the batteries back to 100%? I checked the 48v batteries daily and after the fifth day, they were back to 100% again. This is worse case scenario, if I plan my sailing on days with wind, the battery usage will be minimal and re-charge time will be much less, and if I want to go sailing earlier, I can always use the generator to top the batteries at a much quicker rate, although now we are talking emissions again so no thanks.

Was it worth it? Without question! To be able to motor without any emissions and with no more than a hum from the motor, is as pleasurable a sailing. I know that the difference I am making is miniscule, but it is something, and I would urge as many of you as possible to go along this route.

Also, with all the pushes from our respective governments to reduce emissions it would be nice to see some sort of subsidy towards achieving their aims such a reduction in VAT for Green conversions or better, no VAT at all, but somehow I think two glasses of Retsina maybe clouding what I know is virtually an impossibility, but you never know, maybe I will be proved wrong, I sincerely hope so !

The cost of the Green installation, not including my time is shown in the chart below -

Costing sheet for Pleione Electric Drive

Item	Qty	Description	Price £ each	Price € total	Price € each	Price € total	Exchange rate	Delivery	Total	Grand total
1	8	12v Odyssey battery PC 1800-FT		€ -	€ 563.20	€ 4,505.60	1.171	€ 24.95	€ 4,530.55	€ 4,530.55
2	1	Electric Yacht drive system including 2nd quadrant		€ -	€ 4,013.70	€ 4,013.70	1.171	€ 1,311.77	€ 5,325.47	€ 9,856.02
3	1	48vdc battery charger		€ -	€ 1,968.00	€ 1,968.00	1.171	€ 150.00	€ 2,118.00	€ 11,974.02
4	1	Hyundai 3000si petrol generator	£ 498.00	€ 583.16		€ -	1.171	€ 136.53	€ 719.69	€ 12,693.71
5	1	DC-DC converter 48vdc to 13.8vdc		€ -	€ 97.72	€ 97.72	1.171		€ 97.72	€ 12,791.43
6	1	Engine room ventilator fan	£ 30.00	€ 35.13		€ -	1.171		€ 35.13	€ 12,826.56
7	1	Battery monitor 12vdc	£ 95.00	€ 111.25		€ -	1.171		€ 111.25	€ 12,937.80
8	1	12vdc battery charger	£ 252.26	€ 295.40		€ -	1.171	€ 38.91	€ 334.31	€ 13,272.11
9	1	48vdc solar panel controller		€ 102.54		€ -	1.171		€ 102.54	€ 13,374.65
10	1	Battery isolator switch		€ -	€ 82.00	€ 82.00	1.171		€ 82.00	€ 13,456.65
11	1	Immersion heater 1.25Kw, 11"	£ 38.77	€ 45.40		€ -	1.171	€ 11.13	€ 56.53	€ 13,513.18
14	1	Sheet of 20mm marine ply		€ -	€ 95.00	€ 95.00	1.171		€ 95.00	€ 13,608.18
15	1	battery cable 35mm 7.3mm O/D 444/0.30mm dia (per meter)		€ -	€ 202.00	€ 202.00	1.171		€ 202.00	€ 13,810.18
16	1	Battery crimp connector		€ -		€ -	1.171		€ -	€ 13,810.18
17	1	Skylla battery charger controller		€ -	€ 145.14	€ 145.14	1.171	€ 23.50	€ 168.64	€ 13,978.82
18	1	Screws, fixings, clips, trunking etc		€ -	€ 100.00	€ 100.00	1.171		€ 100.00	€ 14,078.82
19	1	6 position switch panel		€ -	€ 45.20	€ 45.20	1.171		€ 45.20	€ 14,124.02
21	1	Main circuit breakers (6) and enclosure		€ -	€ 45.00	€ 45.00	1.171		€ 45.00	€ 14,169.02
23	12	20w solar panel	£ 49.50	€ 695.57		€ -	1.171	€ 276.00	€ 971.57	€ 15,140.59
24	2	Sheet of 5mm external ply		€ -	€ 60.00	€ 120.00	1.171		€ 120.00	€ 15,260.59
25	1	Hard wood lengths for solar panels and handrails		€ -	€ 50.00	€ 50.00	1.171		€ 50.00	€ 15,310.59
26				€ -		€ -	1.171		€ -	€ 15,310.59

3 months on –

With quite a few sailing trips under my belt, was it still worth it? The answer is a resounding YES.

On the positive side, obviously there is no noise, and definitely no emissions, but there is much more. The energy meter constantly feeds information once turned on. Initially, it displays battery state (my fuel gauge), once under way it scrolls through battery voltage and amps being used, motor RPM and battery remaining for the speed set, enabling me to constantly monitor our progress and reserves. Another advantage is when the wind drops and boat speed reduces I can increment the quadrant and we silently speed up motor sailing, but no one on board notices as there is no additional noise. When sailing above 4 knots it is very satisfying to watch the energy meter increment up as the motor charges the batteries, being turned by the 3 blade fixed propeller. Very often on days with wind, I return from the trip with more battery power than when I started. There is no diesel, dirty lub oil, oil / fuel filters, 2t petrol and the bilges are always dry and white. Maintenance is virtually zero, only greasing 2 grease nipples once a year and making sure the battery terminals are clean and greased. Coming into port or quiet bay people are agog, wondering how the boat is moving without any sign of an engine, plus no engine ticking over whilst lines are secured. Going ashore in the dinghy is even quieter, guests often do not realise the tender is moving. To date, I have not needed to start the generator to charge the batteries as generally the batteries are charged within one day via the solar panels anyway, only when I have needed to motor all day does it take up to 4 days. Sailing wise, I find Pleione much stiffer with the batteries low down in the bilge adding ballast and motion through the water is not so lively with the additional weight. The new Kemp main and mizzen sail also have greatly improved sailing performance. Although I have not experienced it yet, when sailing with a very large swell it is possible to set the electric drive to a level that will charge the batteries whilst the yacht surfs down the wave, and then assists the yacht going up the other side automatically with minimal power consumption.

On the negative side the main disadvantage is range, from 500Nm with the original diesel engine and fuel tank to 50Nm at 4 knots is a big drop. Also the electric does not have the same punch as the diesel when fighting a head wind. It has made me use the sails more than I used to (good thing), sailing more to windward where before I would have just started the engine and punched into it. Now I sail up wind with the electric drive giving me additional speed and a higher angle to the wind but with no noise. I no longer get hot water from the calorifier when the diesel engine was running. I have an immersion element now but it requires the generator. I also miss the alternator charging the12v batteries when the diesel was running, the 12v system now relies on a single 55w solar panel for charging. To increase range I generally motor at around 3.5 to 4 knots whereas I used to motor at 5.5 to 6 knots with the diesel. On the aesthetic side, the many solar panels have made the yacht look a little cluttered, and the 3 on the coach roof reduce walking space when handling the main sail. I have noticed a slight reduction in speed under sail, 0.5 to 1 knot. This I put down to the extra weight from all the additional equipment, the engine plus fuel weighed approximately 270Kg whereas the batteries, electric drive, generator and battery chargers weigh around 715Kg, and additional 415Kg. The boat sits approximately 2cm lower in the water from the waterline.

I was moored stern to at the pretty port of Steni Vala with some friends one day. The yacht next to us had it's diesel burbling away the whole time, annoyingly. The owner appeared and apologised to us and said he was charging his batteries – I said, so am I. The interest I have received so far has been fantastic. People are fascinated by the system and it's advantages. Let us hope it moves them in the Green direction too.

With respect to the range, this is only a function of time. For a crew on a long term voyage, waiting 4 days for the batteries to recharge would not be a problem, so the range is infinite, that is until the batteries need replacing after between 10 and 15 years. Even the largest capacity fuel tank will not last that long.

A half way stage would be to fit a Hybrid system, that is an electric motor mounted on a modified diesel engine. The electric can be used for manoeuvring or while the batteries last, then the diesel engine started. This is better than no electric but the temptation is there to use fossil fuel, instead of planning the trip without it.

Mike Holmes is the owner of "Pleione," a 1976 Beneteau Evasion 32, and
writer of the above article. He can be reached via email at pleione99@yahoo.co.uk

More boat specs:
The Evasion 32 is listed on Sailboatdata.com with a LWL of 23.95
feet (7.3m), and a displacement of 12,676 lbs (5750kgs). It is designated a long keeled, deck saloon ketch with twin steering positions, tiller in the cockpit and wheel in the deck saloon.

Electric Yacht Web site: http://www.electricyacht.com
Contacts are:
Scott McMillan, Founder and Chief Engineer: scott@electricyacht.com
Bill Tomlinson, Director of Marketing: bill@electricyacht.com