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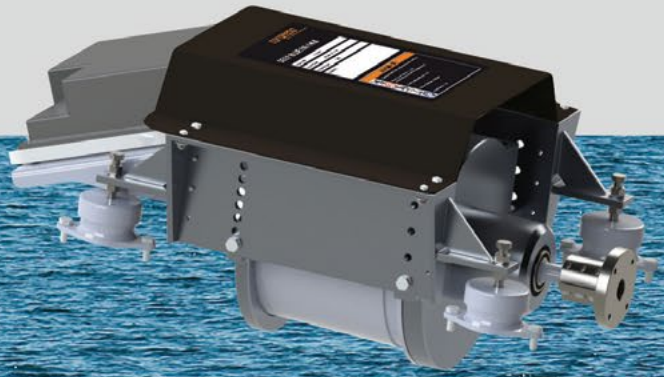

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ELECTRIC BOATS INTERACTIVE

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Contributions from readers are welcome although we cannot be held responsible for any damage or loss which may occur to material provided. Items of interest include letters, reports of rallies, events, cruises, articles and advice on building and running electric boats and on items of equipment. We also welcome manufacturers' reports on new equipment and boats.

Copy Deadlines

Material to be considered for inclusion in Electric Boats interactive should be sent to the editor (preferably by email) by the following dates:

Spring	31 January
Summer	30 April
Winter	30 September

ELECTRIC BOATS INTERACTIVE

Volume 2
Number 1
Summer 2020

"Madness is contagious"

CATCH 22 *Joseph Heller*

I hope that by the time most people are reading this digital magazine some sanity has been restored to the UK economy in general and the leisure boat industry in particular.
Sailing the world's oceans is one way of escaping the madness (unless you are on a cruise ship) and *Energy Observer*, the feature boat in this issue, is completely energy self sufficient and well suited to the present conditions. On their global voyage they have seen more than most the plastic flotsam polluting the seas and oceans. In my first editorial for the Electric Boat magazine in Spring 2013 I said that this vast expanse of plastic waste was growing at an alarming rate. Today micro plastic has been found in all surface water on the planet and, while statistics need to be treated with the utmost caution, it has been reported that we are all ingesting a credit card size amount of plastic a week. Whether or not there is any scientific evidence to support this statistic, there is empirical evidence that 100 gms of farmed edible mussels contains on average 70 particles of plastic. If you follow the red dot link to a river in Bosnia it is not difficult to believe the statistic that 80% of the plastic enters the world's oceans from around 1,000 rivers.

Before it entered the river every piece of plastic will have at some stage been in a human hand and until people change their chuck away mentality it is left to others to try and clean up.
On page 29 we feature the efforts of Ocean Cleanup's solar powered *Interceptor* and on page 11 the Torqeedo powered *Waste Cleaner 66*.
Solar technology is developing at an ever increasing rate (page 20) and the cost of solar power is falling to levels exceeding all forecasts and potentially world changingly cheap.
The production of 'green' hydrogen by electrolysis is one way of storing renewable energy and fuel cell technology is also developing rapidly (pages 8,16).
In the current madness people are blowing up 5G telecommunication masts for reasons best known to themselves. Which is a shame because 5G is a sea change in digital evolution powering the 'Internet of Things' (page 19) and giving everybody instant access (page 34) to a knowledge base that is not only an antidote to ignorance and misinformation, but essential for scientific research and solutions based on evidence.

Don Wright

Cover: The Energy Observer

Published by Futuremode Limited

CONTENTS

Summer 2020

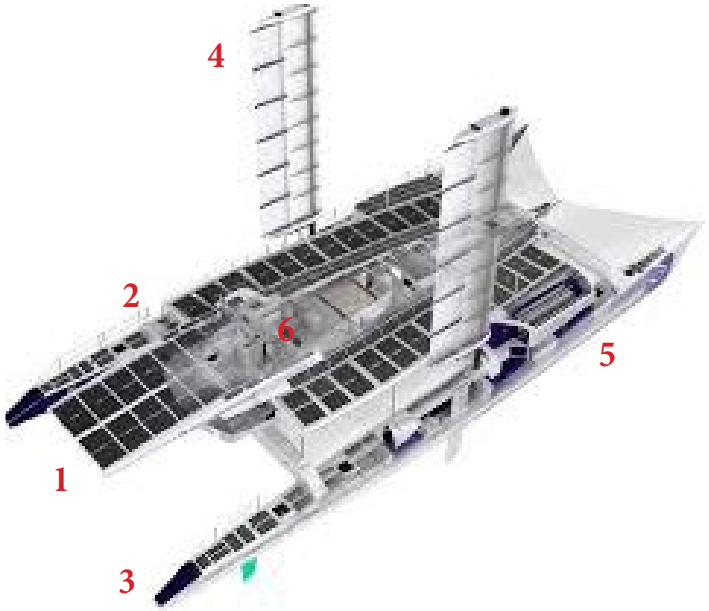
Electric Catamaran

Designed by the naval architect Nigel Irens *Energy Observer* is a maxi catamaran built in Canada in 1983 for open sea sailing races and was the first boat to sail 500 miles in 24 hours. Originally 24.38 meters long, it has been lengthened four times and today measures 30.5 meters long by 12.80 meters wide. After an outstanding racing career under the names of Formula TAG, Tag Heuer, Enza New Zealand, Royal & SunAlliance, Team Legato, or Daedalus, at a cost of around US$6m the boat was transformed by a team of engineers designers and naval architects into a floating laboratory for testing and proving renewable and emission free energy production in extreme environments.

Solar power is the boat's primary source of energy but the boat was designed to demonstrate the effectiveness of hydrogen as a renewable fuel. *Energy Observer* produces and stores its own hydrogen and is the first autonomous hydrogen vessel operating through a mix of renewable energies. The various components of the renewable energy system are looked at in more detail on pages 8 and 9.

After being fitted out with its state of art energy systems and travelling at 8-10kts *Energy Observer* set out to visit 50 countries and 101 ports over a six year period after leaving its home port of Saint-Malo in 2017. It is a sponsored funded project which is reported to cost around US$5m a year. The boat's voyage plan is to call at a variety of port cities around the world which are engaged in energy transition projects, centres of political importance, hosting large international maritime trade events or places in need of support for ecological protection.

At the end of its third year of navigation to its voyage and having sailed 18,000 nautical miles since leaving Saint-Malo, *Energy Observer* arrived in London on the final leg of its 2019 tour of Northern Europe which included travelling 5700 km from Saint-Petersburg to Spitsbergen in the Arctic reliant totally on its renewable energy systems. London is the 47th stopover of the *Energy Observer* world tour and the boat was moored close to Tower Bridge in St. Katharine Docks, where its travelling exhibition was open to the public. London is home to the headquarters of the International Maritime Organization (IMO). It is estimated that shipping is responsible for 5% of greenhouse gasses, a figure that is set to double by the year 2050, and the IMO is under pressure to implement regulations to reduce the shipping sector's CO2 emissions.



Proof of Concept

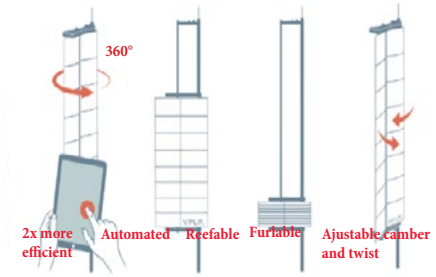
Energy Observer **was conceived as an experimental laboratory looking to prove that hydrogen can be the answer to the problems of intermittent sources of renewable energy. The key components of the boat are:**

1. **Solar Panels**
2. **Batteries**
3. **Electric Motors**
4. **Wing Sails**
5. **Hydrogen Production**
6. **Energy Management System**

Solar panels are the primary source of energy for the boat. At the start of the world tour the hulls, nacelle and wings of the catamaran and were covered with 141m2 of cells which were connected with 6.2 km of Prysmian cables, used in the aerospace industry. All the panels were independently connected so that the if one fails the rest continue to operate which is why there's so much cable and why areospace cable was used to reduce weight. After the optimal sunshine enjoyed in the Mediterranean, the photovoltaic panel surface was increased by 27 m2 to a total surface area of 168 m2 in anticipation of travelling in the Northern hemisphere. For much more on *Energy Observer's* solar power see page 16

Batteries A 112kWh lithium-ion battery bank powers the 400 volt electric motors. The system was carefully optimised being only 2.5 times the capacity of the battery used for an electric car like the Renault Zoe. Another set of 18 kWh batteries powers the 24-volt low-voltage domestic system including electronic navigation, on-board computers, lighting, comfort, and security. Great care was taken to ensure the two networks did not interfere with each other and the designers had to add several power converters to even the supply of electricity from the solar panels and other sources of renewable energy. All wiring was designed to maximise space and reduce line power loss.

Electric Motors two Phase Automation 42 kW motors, one in each hull, provide a total of 115 horsepower with a 97% efficiency rating. The motors are also regenerative and can each produce up to 4kWh. Another advantage of electric motors is their silence which not only benefits the crews' onboard comfort. In Greece acoustic engineers from the Archipelago Association scanned the submarine noise frequencies of the boat's motors and recorded them to be under 1 kHz, which is much less than the 3 kHz thought by scientists to be the tolerance threshold for disturbing sealife. And considerably less than the thousands of diesel engines that cross the Aegean Sea.



Wing Sails are essentially aircraft wings turned upright providing horizontal 'lift' (instead of vertical) and in the America's Cup their aerodynamic efficiency has proved to be superior to traditional sails. French industrial group CNIM has been working with naval architects VPLP Designs to bring the technology to commercial shipping and VPLP has developed an automated and reefable rigging system. *Energy Observer* has two VPLP 31.5 m² Oceanwings®, rising 12m/40ft on each hull significantly improving the boat's energy efficiency by either assisting the electric motors in maintaining speed or by allowing the motors to reverse and act as hydro generators while under sail alone.

Hydrogen

"I believe that water will one day be used as a fuel"....Jules Verne 1874.

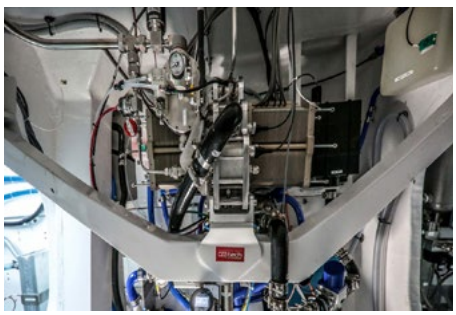
Although hydrogen's density is very low, which means that it must be compressed or liquefied, it has an exceptional energy properties:
1kg of hydrogen releases:
- 4.1x more energy than 1kg of coal
- 2.8x more than 1kg of gasoline
- 2.4x more than 1kg of natural gas

On board weight is a critical factor in *Energy Observer's* design. The battery bank weighs 1,400 kg for 112 kWh, whereas the hydrogen storage and fuel cell together weigh a total of 1,700 kg for 1,000 kWh.

Electrolysis decomposes water molecules (H2O) into hydrogen (H2) and oxygen (O2) gas. The Proton Exchange Membrane (PEM) electrolyser, was installed to support because of its compact design and flexible hydrogen production capability. These electrolysers are able to operate on a wide range of energy inputs, and are able to supply gas on demand. The device can produce up to 4 Nm3 per hour of pure hydrogen, and consumes 3.66 L of deionised water per hour. In 2018, the electrolyser operated for a total of 1,469 hours and produced a total of 488 kg of hydrogen.

Compression Hydrogen is an extremely light gas which occupies a substantial volume under atmospheric pressure conditions. As a result, storing it requires high levels of pressure. The Energy Observer tanks store hydrogen at 350 bars, which is the current standard for buses. The *Energy Observer* compressor operated for 1,469 hours for the first level at 180 bars and 1,105 hours for the second level at 350 bars. The levels of compression in the H2 production supply demanded a lot attention from the crew during the first 16 months at sea with a number of problems with the electroylser membranes.

Storage Eight carbon fibre tanks with a capacity of 332 L store a total of 62kg of hydrogen, which provides the same energy as 230L of fuel. The global net energy stored is 1 MWh. The engineers decided to distribute the tanks in external well decks on each wing which required complex calculations for the weight distribution and tank support design. Because high-pressure hydrogen is an inflammable gas, the danger of storing it has been an obstacle to developing its use in the past. But current storage methods have proven to be very safe, with industrial use going back over 20 years.



Fuel Cell The fuel cell is the centrepiece of the hydrogen chain. The initial system on Energy Observer was tailor-made by CEA-Liten engineers and was designed to provide 20 kW of pure electric power. There are several different technologies for fuel cells. The most widespread used in vehicles is called PEM (proton exchange membrane), because it is compact, reliable, and is the technology used on Energy Observer.
In 2018, the Energy Observer fuel cell operated for 371 hours. During navigation, average daily use was 6 to 7 hours with 48% power output.

Energy Management

The Energy Management System (EMS) is the brain of the vessel's energy supply. Combining multiple intermittent renewable energy sources and storage is one thing. Optimising their use to propel the boat and ensure the crew's comfort is another. This is where the EMS comes in. It is a set of automated procedures which command and coordinate all the systems, and is driven by the human pilots using an on-board computer. Rockwell, American leader in industrial automation and partner in the Energy Observer project, contributed their experience and many software solutions. Three main power modes are configured in the Energy Observer:

- In normal navigation, solar or wind electricity directly power propulsion.
- The lithium-ion batteries take over if there is a momentary drop in production, for example in cloudy weather.
- For longer interruptions, at night for example, the fuel cell takes over, and prolongs autonomy by converting hydrogen reserves into electricity.

On the other hand, strategies are also programmed to recharge batteries and resupply hydrogen stocks whenever possible, to ensure theses reserves are not depleted. For example, when battery life descends below 30%, the majority of the electricity production is used to recharge it. When battery life is over 90%, or the boat is stationary, the energy is used to restore the hydrogen reserves. The pilots can automatically vary the power of the motor, and hence the speed of the boat, to preserve stable charge levels.
All these decisions can now be managed almost instantly, either by the system, or by the pilots who can take over at any time. Thanks to dedicated software comprising 21 SFCs connected to 200 alarms, 12 analogue and 13 digital actuators, 1,050 elements of data can be uploaded by the internal digital network in real time. Apart from ensuring comfortable navigation for the crew, this data is also a new knowledge base for developing routing software using renewable energy sources. And of course, this data can be recovered remotely for preventive maintenance of the whole system.
In 2019 the team had an EMS engineer on board but for 2020 one of the objectives is to do without an engineer, so that any professional sailor can manage and navigate the boat autonomously. Given the performance, safety and low costs, this is an essential condition for the widespread use of hydrogen in maritime transport. And this will give Energy Observer engineers time to develop other innovations.

Olympics 2020 In 2019, the on-board technologies more than proved their effectiveness: over 8,000 nautical miles, 16 stopovers and 11 countries, navigating a passage from Antwerp to London, with an historic stopover in Spitsbergen, the epicentre for climate change. In 2020 *Energy Observer* will cover more miles in one year than since being launched, and first leg of 2020 will see the boat journey to Tokyo, during the Olympic Games where for the first time in history the Olympic flame will be fuelled by hydrogen. The boat has had a fourth refit and new technological features have been installed including a new fuel cell system and new solar panels (see pages 16 and 18).

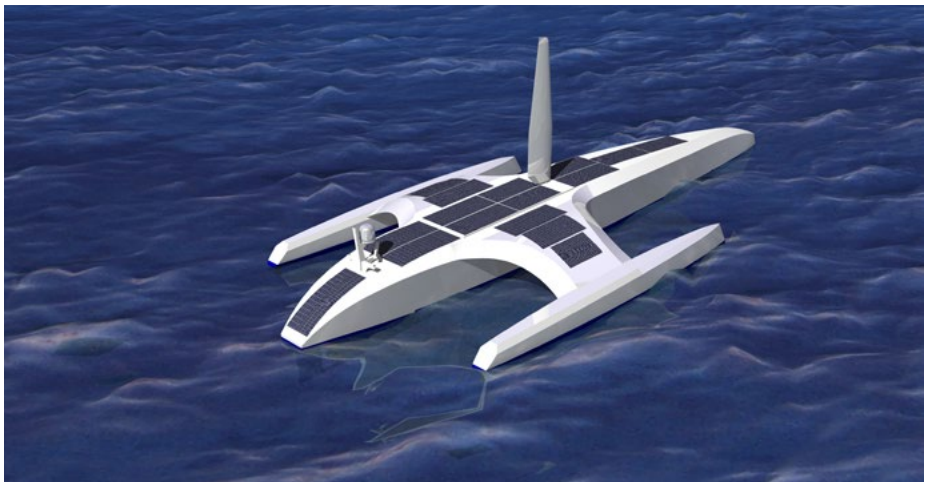
In Brief

Underwater Robot

The Canal & River Trust is using an underwater remotely operated robot to upgrade Carr Mill Reservoir on the outskirts of St Helens, Merseyside. Costing just over £1 million, the work will be delivered in two phases and is due to be completed by the end of 2020. Employing the robot means water levels will only need to be slightly lowered without the need to drain the entire reservoir. Originally a mill pond powering Carr's Corn Mill, the lake was hugely expanded in the 1750s to provide water for the Sankey Canal about a mile away. This is no longer navigable but the reservoir has now become a popular venue for angling and water sports, as well as a great habitat for wildlife.

HS2 Campaign

Following the Government's announcement that HS2 will now go ahead, the IWA is continuing its decade-long campaign to protect the waterways from the worst effects of its construction and operation and have achieved several changes to the project since 2010, but current plans mean noise impacts will affect many waterways and there will be damaging effects to some canal restoration schemes. The IWA had a major victory in 2014 when it persuaded the Government to change the route of the Handsacre Link spur near Lichfield to avoid two crossings of the Trent & Mersey Canal which would have seriously damaged the environment, tranquillity and heritage of the canal around Woodend Lock above Fradley Junction. Working in conjunction with Lichfield & Hatherton Canals Restoration Trust, Lichfield Cruising Club and Canal & River Trust, the IWA also secured assurances that HS2 will build a canal diversion and fund a replacement moorings basin at Cappers Lane in Lichfield when the bridge there is demolished for an HS2 viaduct.

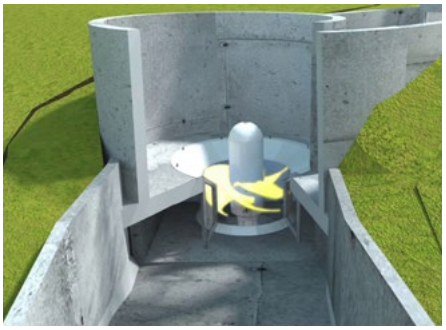


Fischer Panda on board Mayflower

Fischer Panda UK will supply, install and commission a complete electric propulsion system for the innovative Mayflower Auton Ship (MAS) project for an unmanned Atlantic crossing, scheduled for September 2020.
The voyage, from Plymouth, UK to Plymouth, Massachusetts, is to celebrate the 400th anniversary of the voyage of the pilgrim fathers. Equipped with advanced research sensors and IBM's latest AI, Power servers and edge technologies, the 15m trimaran is expected to make the crossing in approximately 12 days at speeds up to 20 knots, a huge advance on the original Mayflower's 60 days at 2.5 knots. The autonomous boat will be powered by a Fischer Panda fully-electric propulsion system primarily charged by wind and solar energy. The Fischer Panda equipment will comprise:
Two 48V DC generators – a 22kW Fischer Panda AGT 22000 and a 4kW Fischer Panda AGT 4000. Both generators are in 'PVM' format, with a dry exhaust which removes the need for a raw water intake, a potential source of leakage or corrosion.
Two 48V Fischer Panda 20kW 600rpm Easybox shaft motors.
A Mastervolt Mass Combi 48/3500-50 Inverter and Charger, supported by a battery management system for control and monitoring.
A 38.4kWh battery bank consisting of eight of the new Mastervolt MLi Ultra 5500 Lithium Ion batteries, providing 800Ah at 48V.

Micro Hydro

Turbulent water turbines are designed to generate power from small rivers and watercourses without needing a large height difference, and give reliable power in remote locations
Due to the combination of height difference and flow of the site, the Turbulent vortex turbine can produce an average of 13 kW of power, more than enough energy to power lights, fans, laptops and kitchen appliances. All their Turbulent water turbine materials can be transported to site by a simple pickup truck and can be built to fit into the natural landscape. No dams or major height differences need to be created, just a small canal to divert some of the water flow.



Torqeedo powers clean up

Torqeedo has supplied the electric drive for the *Waste Cleaner 66*, an all electric boat built to clean pollution from inland waterways and harbours The vessel will be powered by a 25 kW Deep Blue engine and a 40 kWh battery power system which will give the boat at a cleaning speed of two knots sufficient for up to eight hours of operation. The six meter long aluminium ship uses a patented technology to hold up to 700 kilograms of solid waste and 1,000 litres of liquid waste, including hydrocarbons. According to the manufacturer, the cleaning system automatically separates water and hydrocarbons to prevent emulsification. The boat was designed

for use in inland waters, harbours and coastal waters and can also be used in areas with jetties and narrow bends, where access is naturally difficult. The boat can pick up garbage both when stationary and while travelling forwards or backwards, and can easily be moved to new locations by road transport.

Electric Lifesaver

U-Safe is a battery powered remote controlled lifesaving buoy. It is propelled by electric turbines that take in water and fire it out of the back with sufficient power not only to reach the victim but also to bring them to safety

Derek Gowling Pat and Paul Wagstaffe pay tribute to the work of Derek Gowling who died last year. When Derek joined The Inland Waterways Amenity Advisory Council (IWAAC) as Policy Manager his skill in research and expertise in clear, succinct and readable written words led to major changes in Central and Local Government attitudes towards, and respect for, the UK Inland Waterways. His work contributed significantly to the progress made in waterways restoration and improvement and helped unlock considerable millions of £'s of UK Lottery and European Funding grants.

Publications with a major input from Derek included :- Britain's Inland Waterways: an undervalued asset IWAAC 1997 Waterway restoration priorities IWAAC 1998 ; A second waterway age IWAAC 2001; leading to the Government's milestone new Policy Document: Waterways for tomorrow 2001

In Brief

Boat Talks

The IWA has launched a new regular programme of waterway webinars for members with speakers covering topic areas including IWA campaign successes, waterways heritage, and IWA canal adoption schemes. The webinars kicked off with the National Chairman Paul Rodgers giving a presentation on the IWA being more relevant than ever and were followed by talks on: Transforming the Northampton Arm by Geoff Wood; Bringing Waterways to the attention of Government by Alison Smedley: Changing the face of the Ashton Canal by Maarja Kaaristo; and Protecting our Waterways Heritage by Amy Tillson,

Boat Numbers

The Canal & River Trust's annual national boat count shows that licence compliance on its waterways remains high with 96.2% of boaters holding a valid licence (2019: 96.4%). This is the fourth highest compliance figure in the last 10 years and is the eleventh successive year with evasion below 5%. The national boat count sees the Trust's teams physically recording boats on every stretch of waterway to check if they are correctly licensed. The COVID-19 restrictions meant they were unable to access some marinas and stretches of canal, while flooding and high-water levels have also prevented access to some rivers to obtain sightings. This will likely explain a reduction in the overall number of boats sighted on the waterways this year with 33,672 boats sighted across England & Wales, down 1,568 boats on 2018/19. The numbers of boats sighted on waters where Trust licences are required also reduced by 323 to 31,110. In comparison, the Trust's licence system showed that 34,435 boats held valid licences at 31 March 2020, a slight uplift on the previous year (31 March 2019: 34,367).

Boat Shows

If you're looking for a show with absolutely everything water-based all under one enormous roof, then boot Düsseldorf is that show making a great start to the new decade with a huge selection of products and services on show from more than 1,900 exhibitors in the 17 halls packed into 220,000 square metres of exhibition space. Nineteen themed areas covered everything from boats and superyachts, to water sports, fishing, engines, equipment, services and much more.

plugboats.com

Jeff Butler Editor of Plugboats - the international on line electric boats journal - has made a quick guide to all the electric boat exhibitors and has kindly allowed EBi to use copy and pictures.

The DutchCraft 25, an 8 metre carbon fibre tender, was one of the new electric boats making their debut at Dusseldorf. DutchCraft is the sister company of Zeelander Yachts, which builds luxury yachts, and the DC25 was designed not only to serve as a tender but also to be all-electric from the start, unlike some boats where the buyers pick a propulsion system after the boat is built. The 100 kW motor in the DC25 can be paired with battery packs of 79kWh to 127kWh capacity, giving cruising time of 75 minutes at 32 knots and at the other end of the speed/autonomy range, 6 hours at 6 kts.

The eLimo Q-Yachts premiered its new electric boat the eLimo, which is a commercial adaptation of the Q30 electric day cruiser conceived of by Q-Yachts founder Janne Kjellman. The battery powered twin 10 kilowatt motors have the option of extra capacity supplied by hydrogen fuel cells. The eLimo, and water-taxis in general, are used very differently from recreational boats, and this battery or battery and fuel cell capability makes an electric water limousine commercially viable for the broadest range of operators. Travelling at 8 knots and fully loaded with 8 passengers the eLimo can make 3 hours of trips on a 30 kWh battery.

The SAY 29E powered by a 360 kiloWatt electric motor set the record for the world's fastest production e-boat clocking 50kts (93kph) on Lake Zell in Austria in 2018. Manufactured by SAY Carbon the carbon fibre hull of the SAY 29 weighs only 400 kilograms which is astoundingly light and an ideally suited to electric propulsion. The carbon fibre construction also enables the design of a very distinctive and efficient wavecutter bow with side wings to give stability and precise handling. The drive train and batteries of the SAY 29E are provided by Kreisel Electric, one of the most innovative electric propulsion companies.

The Eelord 6000 After the success of its first boat the Eelord 8000 which featured at the Dusseldorf show in 2019 Swedish company X Shore unveiled its second electric boat at thus year's show. The Eelord 6000 is a smaller version of the Eelord 8000 and both boats have a 225kW electric motor powering a Volvo Penta DuoProp sterndrive. There are two battery options available: a 90kWh and 120kWh. Batteries are Lithium-Ion and can be charged through 360V or 220V. Depending on the power source charging time from full discharge to full charge is about 8 hours. (For further information on X Shore boats see page 28)

The E32 chaseboat built by the Domani shipyard in Belgium made its debuts at Boot Dusseldorf 2020. Chaseboats have evolved from yacht tenders and follow superyachts to their destination. The E32 can go for 100 nautical miles on a single charge and silently cruise at a speed of 8 knots for up to 12 hours. The boat has an axial flux motor, sometimes referred to as 'pancake' motors, because the rotor is a thick plate, or disc, rather than a cylinder as in a radial flux motor. The motor is rated at 50kW continuous power and there are three lithium battery configurations available: 37.5kW, 56kW and 75kW

Boat Shows

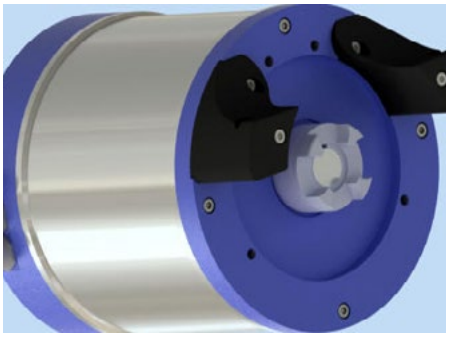
More than 250,000 watersports fans from 106 countries made their way to Düsseldorf for boot 2020. Over 24% came from outside Germany. These visitors' home countries were mainly the Netherlands, Belgium, Great Britain, Switzerland, Italy, France and, from overseas, the USA and Canada.

SolarImpact made its debut at last years show with the headline 'This yacht could sail around the world using only the sun'. Featuring again at this year's show the most noticeable change is the outward appearance. The new design, by Roland Friedberger, revises the original concept to give the boat a more conventional look. The technical specifications virtually identical to what they were a year ago: 24metres long, 11 metre beam, 2 X 500kW electric motors, with an 800kW battery pack,
(For further information on SolarImpact see page 21)

Electric Stern Drives

Two new electric sterndrive (inboard-outboard) motors designed for MerCruisers were at the show exhibited by German company AQAForce and the Danish company EPTechnologies. The motors are not associated with MerCruiser, but have been fitted with brackets and mounts to make it easy to connect to the popular sterndrives. The motor specifications are quite similar, as both have to fit into existing spaces and be compatible with the MerCruiser.

AQAForce GmbH based in Schleswig Holstein build light and powerful boat drives. Their 5200rpms motor is a 150kW BLDC (Brushless DC) unit operating off 336 Volts and 397 continuous amps. It weighs 112kg and is cooled by an ultraquiet seawater system developed by AQAForce Founder Klaus Lehmann. The power source is an 84kWh lithium-ion battery module weighing 440kg also developed by Lehmann.



EPTechnologies based in Sondenborg Denmark specialise in marine propulsion and offer a complete in house design from batteries to controllers and drives. The company was founded six years ago by Kasper Falkenberg, who has been working electric propulsion for over 18 years. The EPT motor is a 145 kW motor operating at 5200rpms with a 400V system and 94 kWh flexible box design 620kg battery module.

Malcolm and Barbara Bridge were already experienced narrowboaters when they took delivery of their all electric boat at the Crick Boat Show in 2015 where *Ampere* was voted one of the shows favourite boats on display. Since then *Ampere* has travelled extensively and in the second of a series on electric narrowboating Malcolm gives his personal assessment of the relevant technologies.

Electric narrowboating

As previously I should emphasis that these are my personal views on the present state of the technologies relevant to the design of an electric narrowboat, based on my involvement in the design and construction of all-electric narrowboat *Ampère* over the period 2011-15 and its subsequent use, totalling about 3,000 miles of cruising.

Batteries

After choosing the system voltage the next job is to work out the battery capacity. Unless you are happy to risk losing the peaceful cruising you were seeking by running your generator while doing so you will need to provide for at least one full day's use. If you have the space, providing for two, or more, days has the advantage that you may be able to make a useful cost saving by charging at your home mooring instead of using your generator. Depending on the price at which diesel can be bought, the marginal cost of power from a generator is likely to be about 50% more than a typical domestic tariff, though hot water and, maybe, space heating should be available as by-products. For the purpose of calculation, 3kW for however many hours you expect to cruise each day (or 2, or 3) will probably be close enough for canal use, though you should use a higher figure if you expect to cruise faster frequently (on a river, for example) as power required rises rapidly with speed. If using a higher figure don't forget that, unlike a diesel, an electric-drive uses no power while waiting for, and in, locks so, for typical one lock per mile canal use, power will only be used for about two thirds of the time. Multiplying your answer by 1,000 and dividing by the battery voltage then gives your usage in Ah. For example, 3kW for a 6 hour day is 18kWh, which translates to 375 Ah at 48V. For an all-electric boat the domestic use (typically 30 to 50% of this) then needs to be added, giving about 500 Ah. You then need to decide between various options.

2V traction cells are probably the best lead-acid option as they are the cheapest, have greater tolerance of deep discharge than most and are catered for by standard chargers.

AGM and gel batteries are sealed for life, don't gas during charging so can be installed more-or-less anywhere, and are also catered for by standard chargers, though their maximum charging rates may not be fast enough to allow a large, heavily discharged bank to be fully recharged in an acceptable time. Lead-acid batteries exhibit what are termed 'memory' effects. This means that if they are not fully charged (floated) often enough they stop accepting a full charge, thereby progressively reducing their maximum capacity. Some say floating is necessary every cycle, others that every 10th is sufficient. This need to charge fully is where the efficiency of an electrical system can be compromised as the final 1% of charging a large battery bank can take 4-5 hours, during which time the generator may be doing little more than warming the canal. Floating only every 7-10 days and running high power appliances (oven, hob, washer, etc) to use surplus power while in the later stages of charging makes it less wasteful, though a hook-up is best as the charger then takes only what it needs. Although lead-acid batteries will tolerate occasional deeper discharge it is best not to take them below 50% too often so you need to double those figures to 750 (or 1,000) to ensure that you don't. They will also lose capacity slowly over time so it is best to add another 25% initially, taking you to a minimum 900 (or 1,250)Ah so that you will still have sufficient capacity in a few years' time (ten if you're lucky). You can get away with a smaller battery bank by running the generator while cruising but, as mentioned above, may then lose the quiet cruising you were seeking. Also, while some generators are designed to have dry exhausts and are suitable for running while cruising, many of the more compact ones come equipped with wet ones and are less so. We have certainly found that running ours while cruising results in drawing more debris into the raw water strainers than running it when moored. Debris is less of a problem on wider waters.

Lithium batteries are technically the best. They can be discharged more-or-less completely without suffering damage and don't exhibit 'memory' effects, meaning that there is no need for inefficient, full charging cycles. However, even allowing for the smaller battery banks needed, at the time of writing new lithium batteries cost around 3 times as much as traction cells for comparable usable capacity. Finally, it is worth noting that reconfigured, second-hand, electric car batteries are now becoming available at prices which aren't all that much higher than sealed lead-acid.

I will be looking at generators in the next **Electric Boats** *interactive*

Clubs and Associations

As Edward Hawthorne's book (serialised on page 31) reveals boats powered by electric motors were on canals and rivers long before the internal combustion engine took over propulsion and the resurgent interest in electric boats is reflected in the clubs and associations that can be found all over the world.

www.electricboatasssociation.org

The UK Electric Boat Association was formed in 1982 and is an international, not-for-profit membership organisation of individuals and businesses promoting electric boating.
The EBA has appointed a new General Secretary, Tim Knox MD of Mothership Marine, builders of the electric narrowboat *Shine*. The EBA now has a new logo and a revamped website. The website includes an archive of all the Association's past magazines starting in June 1990. These have all been digitised and are available to be downloaded as PDFs

www.eba.gr

The Electric Boat Association of Greece is a non profit organisation founded in 2016 to promote the development of Electric Boating and to serve the needs of all who have an interest in electric boating.
The Association's website has a current news blog that is regularly updated and has recently featured a new award: The Gustave Trouvé Awards for excellence in electric boats and boating. The "Gusssies" will recognise the individuals and companies responsible for exceptional design and innovation in the field of electric marine propulsion.

www.electricboatasssociation.ca

The Electric Boat Association of Canada is a not for profit Canadian corporation and was formed by a group of boating enthusiasts concerned about the use of fossil fuels for transportation and excited about the possibilities of boats and ships powered by electricity.
Their website has a Canada e-boat news feed from Plugboats.com and the latest post features the Canadian Electric Boat Company which has recently expanded the company's line of all electric boats with the introduction of a new 29ft speedboat the 290 Phoenix

www.seff.nu

The Frisian Electric & Hybrid Boating Association (SEFF) was founded to promote electric and hybrid boating in the Netherlands Frisian province.
Their website has a news and press release section. SEFF conducted a survey at BOOT Holland 2020 asking approximately 80 visitors about their opinions regarding electric and fossil fuel free sailing. The survey indicated that the majority of visitors to BOOT have sailed electrically or fossil-free and that more than half are sailing or want to do so electrically or fossil-free.

www.electricboats.org

The Electric Boat Association of America was formed in 1992 with the objective of being:
an educational arm and information source for electric powered boating issues, and a representative of electric boaters in matters of environmental protections and regulations; a planning and organizing agency for meetings, exhibitions and competitions;
a clearing house for ideas and information on electric boat products and services, and a link with similar international associations in the promotion of electric boating.

www.bateau-electrique.com

The French Electric Boat Association was created in 1994 in Bordeaux by partners from different professional backgrounds - academics, researchers, engineers and industrialists - to develop the image and market of the electric boat in France as well as abroad.
As well as a news section on their website The AFBE also produces an email newsletter covering news from their members and the latest edition features Brittany which is looking for boat rental companies to move to electric on the river Vilaine.

Fuel Cells

According to Kevin Desmond's excellent book on the History of Electric Boats and Ships the UK's first fuel cell boat was the *Ross Barlow* a 52ft narrowboat conversion in 2007 by Birmingham University's Protium Project team. The following year the University set up the UK's first hydrogen filling station and in 2010 the *Ross Barlow* made a 65 mile journey by canal from Birmingham to Chester to attend a waterways festival.

The first recorded experiment to mix hydrogen and oxygen in a test tube was undertaken by Joseph Priestly in Birmingham in 1781 and the result was water. Reversing the process produces hydrogen and oxygen. In 2005 the International Energy Agency made a grant of £150,000 to the Department of Metallurgy and Materials at the University of Birmingham, and the Swiss Federal Laboratories for Materials Science and Technology (EMP), for a two year prototype research project titled the Protium Project which was described as:

A canal boat, the Ross Barlow, powered by a combination of a metal hydride solid state hydrogen store, a proton exchange membrane fuel cell, a lead acid battery stack and a NdFeB permanent magnet electric motor. The solid state store contains 133kg of powdered Ti-V-Mn-Fe alloy which when fully charged stores around 2.5kg of hydrogen. The solid state store will be examined for evidence of degradation. The project also aims to develop (possibly in conjunction with other hydrogen transport projects) a local scale hydrogen infrastructure. The display area of the Ross Barlow will be used to exhibit a range of fuel cell and energy efficient devices.

The project coordinator was Professor Rex Harris at the University of Birmingham and the canal boat was named after one of his post graduate students who had been working on the project and who had died in a hang gliding accident.

The narrow boat was converted by members of the Birmingham University Protium team and the main cabin was opened out into a walkthrough area to display equipment. The boat's diesel engine was replaced by a 48v high torque permanent magnet electric motor and battery bank. Steerage was converted to a joy stick system which could also be operated remotely by Wifi.

The hydrogen store linked to a proton exchange membrane (PEM) was installed in the bow and is visible to passengers. The metal hydride storage system was developed with EMP and enables large quantities of hydrogen to be reversible stored at room temperature and at a safe pressure of around 10 bar (150 psi). Hydrogen is absorbed into a metal lattice at a higher pressure and then released at a lower pressure. The storage capacity of the Ross Barlow system is equal to that of four standard high pressure 200 bar cylinders. The metal hydride powder weighs 130kg and the weight of the cylinders is easily accommodated in a canal boat.

Whatever happened to the *Ross Barlow* - if you know, let me know - *editorelectricboat @gmail.com*

Toyota Maritime Fuel Cell

Toyota has been involved with *Energy Observer* project from the start, because of hydrogen being at the very heart of the design and has worked closely with the boats engineers to install Toyota's leading fuel cell technology. Toyota Technical Center Europe has developed a compact fuel cell system suitable for marine applications. It will deliver more power and efficiency, but also high reliability when crossing the Atlantic and Pacific Ocean this year. The R&D team in Europe managed the design and component production within 7 months, followed by the build and installation of the fuel cell, which demonstrates the adaptability of the Toyota fuel cell technology to a variety of applications. The Toyota fuel cell system has already proven its benefits for many years in the Toyota Mirai car, but more recently also in other applications such as buses and trucks.

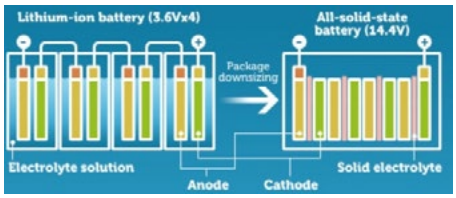
Battery on float

The Port of Amsterdam and renewable energy solutions provider Skoon Energy have launched a floating battery service to provide mobile stored power to river cruise vessels at the port and inner city of Amsterdam. The battery has been placed on a barge, allowing it to deliver electricity to any location close to the water. Among the battery's uses will be the supply of power to river cruisers which peaks in April and May, with current grid connections unable to provide enough capacity to meet the increased demand. This requires the vessels to run diesel generators while moored, creating noise pollution and harmful emissions in the centre of Amsterdam. The battery will provide a silent supply of energy, generated by renewable energy sources.

'We have started this project with Skoon, as it is in line with our ambition of creating partnerships that will help us become a zero-emission port,' said Koen Overtoom, CEO of the Port of Amsterdam. "Together with Skoon and Zoev City, the floating battery will also be deployed in the city centre of Amsterdam, when it is not needed to deliver power to river cruisers.'

Samsung Solid State

Samsung has announced that its research divisions have developed a new type of solid-state battery with improved life and safety compared to current designs. Solid-state batteries are seen as the next major step in performance for electric cars as they can deliver greater range and safety over current liquid-type batteries like lithium-ion units. But while the technology isn't new, solid-state batteries remain difficult to manufacture on a mass scale. They also don't have the longevity required for automotive where frequent charging at high energy rates is common. One problem in the area of longevity is the growth of crystals on the lithium anodes of solid-state batteries during charging, which reduces battery lifespan and also causes them to overheat. To address this, Samsung's researchers developed a prototype battery featuring a silver-carbon (Ag-C) composite layer as the anode. They found that this resulted in not only improved life and safety but also more capacity.



Battery Tech

Glass

A patent application for a new battery that uses glass as a key component has been submitted by a team headed by John Goodenough, the part winner of the 2019 Nobel Prize in Chemistry for his work as co-inventor of the lithium-ion battery. The research team say that by 'spiking' glass with either sodium or lithium to form an electrode within the battery the new battery technology provides three times the energy storage capacity of comparable lithium-ion batteries. It is also neither volatile nor flammable, and does not display issues of lithium dendrite growth that plagues li-ion batteries, which can cause short-circuits and present safety hazards. Early research also suggests the battery could have thousands of charge and discharge cycles, more than the average 1,000-2,000 cycles achievable in typical nickel-manganese-cobalt or lithium iron phosphate batteries.

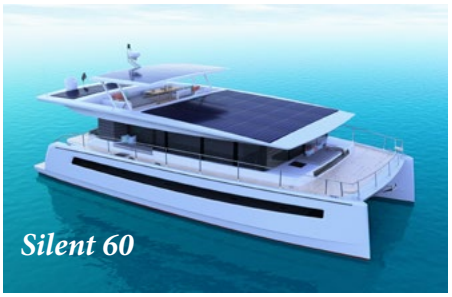
Pouches

General Motors has created a new electric vehicle battery called Ultium. The new battery cells, are soft, flat pouches. Usually, these sorts of pouch cells have to be lined up in horizontal rows with the pouches standing on edge like books in a bookshelf. The Ultium cells can be used that way or they can be stacked up vertically with the pouches laying on their sides. This gives car designers more flexibility because it allows the battery pack, which is made up of lots of these cells, to have a greater variety of shapes. The Ultium battery cell uses a minimal amount of cobalt, an expensive ingredient for electric vehicle batteries, and that factor, combined with continuing manufacturing improvements, will drive prices down, to below $100 per kilowatt hour. Batteries make up a very large part of an electric vehicle's cost and $100 per kilowatt hour is often cited by analysts as the threshold that will enable electric cars to become truly cost competitive with petroleum powered vehicles.

Solar Boats and Boating

Silent Yachts

Heike and Michael Köhler have received several awards for their development of boat alternative energy production and consumption and their success in implementing the results into luxury yachts. Today they build high-end yachts in different sizes and layouts using the Silent System to provide and manage solar energy for propulsion, and onboard living.



After five years and 15,000 NM of sailing on a test catamaran Heike and Michael Köhlert launched *Solarwave 46* in 2009 as proof of concept of the first ocean-going yacht that powered the propulsion as well as all household appliances exclusively by solar. *Solarwave46* then undertook a five year sea trial. Now with their unique expertise, their Mallorca based Silent-Yachts brand has collaborated with Italian and German designers and naval architects to design and construct four full production solar-electric yacht models, namely the *Silent 44, Silent 55*, *Silent 60*, and the *Silent 80*

Silent 44
Length overall: 13,40 m (44‘)
Beam overall: 7,2 m (23.6‘)
Draft: 0,75 m (2.5‘)
Light displacement (EC): 11 tons
Water: 500 – 1.000 L
Waste-Water: 1 x 250 L
Fuel: 250 – 500 L
Solar Panels: 9 kWp
E-Motors: 2 x 30 kW / 2 x 80 kW
Generator: 22 kW / 100 kW
Battery Capacity: 120 kWh
Cruising Speed: 6 – 8 kt / 6 – 10 kt
Top Speed: approx. 12 kt / 15 kt
CE Certification: CE-A

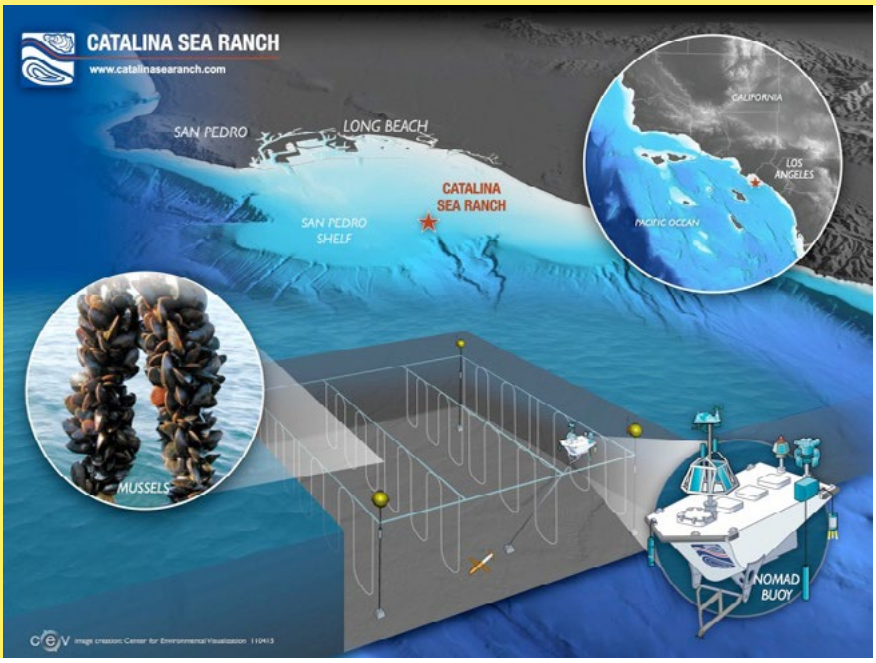
Silent 55
Length overall: 16,70 m (54.8‘)
Beam overall: 8,46 m (27.7‘)
Draft: 1,20 m (3.9‘)
Light displacement: 19 tons
Water: 500 – 1.000 L
Waste-Water: 2 x 500 L
Fuel: 500 – 1.600 L
Solar Panels: 10 kWp
E-Motors: 2 x 30 kW / 2 x 250 kW
Generator: 22 kW / 100 kW
Battery Capacity: 140 kWh
Cruising Speed: 6 – 8 kt / 12 – 15 kt
Top Speed: approx. 12 kt / 20 kt
CE Certification: CE-A
Range: Trans-Ocean

Silent 60
Length overall: 17,99 m (59.0 ‘)
Beam overall: 8,99 m (29,5 ‘)
Draft: 0,93 m (3.0 ‘)
Light displacement: 25 tons
Water: 1.000 L
Waste-water: 2 x 500 L
Fuel: 600 – 1600 L
Solar Panels: 17 kWp
E-Motors: 2 x 30 kW / 2 x 250 kW
Generator: 22 kW / 100 kW
Battery capacity: 70 – 210 kWh
Cruising Speed: 6 – 8 kt / 12 – 15 kt
Top Speed: 12 kt / 20 kt
Certification: CE-A
Range: Trans-Ocean

Silent 80
Length overall: 24,30 m (79,8‘)
Beam overall: 10,95 m (35,8‘)
Draft: 1.25 m (4.1')
Light displacement: 55 tons
Water: 1.000 L
Waste-water: 4 x 500 L
Fuel: 3.000 L
Solar Panels: 26 kWp
E-Motors: 2 x 135 / 2 x 250 kW
Generator: 100 kW / 2 x 130 kW
Battery capacity: 240 kW
Cruising Speed: 6 – 8 kt / 12 – 14 kts
Top Speed: approx. 10 kts / 16 kts
Certification: CE-A
Range: Trans-Ocean

Solar Boats and Boating

Ocean Internet of Things powered by solar panels



The Internet of Things (IoT) is the latest jargon for the interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data. And this technology has now been extended to the worlds oceans Kyocera's solar panels, tested for long-term deployment in marine and coastal areas, are now powering an innovative Ocean Internet of Things remote data monitoring platform off the coast of Huntington Beach, California.

Developed by eMarine Systems for the 100-acre Catalina Sea Ranch, the new NOMAD sea buoy is able to take the 'pulse' of a specific area in the ocean. Gaining worldwide attention, the buoy features IoT sensors that transmit a variety of marine data in real-time to the wireless cloud, providing government agencies, the scientific community and research institutions a web-based analysis of the ocean.

A Sea-Bird MicroCAT sensor on the buoy monitors water temperature, salinity, dissolved oxygen, phytoplankton density and sensor depth. Real-time cameras mounted to the mast provide security for the aquaculture ranch, and the buoy's internal battery voltage and processor temperature are remotely monitored to help ensure optimal performance.

In the future, the buoy will measure pH levels and pings from acoustic tags placed on marine mammals by researchers. It will also feature additional above- and below-water live camera feeds.

The buoy is an aluminum boat 10 feet wide and 20 feet long with equipment and batteries below deck. Four Kyocera 145W solar panels and a vertical axis wind turbine (VAWT) are supported by solar charge controllers and a battery monitor, which network together to provide power for the buoy's remote monitoring capability.

Kyocera's entire line of photovoltaic (PV) solar modules has passed the Salt Mist Corrosion Test, IEC 61701: Severity Level 6 and Severity 1, administered by TÜV Rheinland. Successfully passing this independent, third-party testing indicates that Kyocera's solar modules — built upon four decades of continuous solar R&D — can perform with optimal output even in severe conditions including harsh marine, coastal, and agricultural environments. Kyocera's modules also exceeded the criteria for the industry-standard Ammonia Test, IEC 62716: ed 1.0, which makes them optimal for installation near livestock, greenhouses, and other environments subjected to fertilizer, ammonia, and dust. 'We selected Kyocera's solar panels because they're known for long-term reliability and quality,' said Bob Everhard, Sales Manager, eMarine Systems. 'Knowing the panels have proven to withstand even the harshest coastal conditions ensures this innovative marine IoT solution will provide uninterrupted transmission of compelling data from the sea without costly and time-consuming maintenance issues.'

Kyocera has more than 40 years of expertise producing PV solar panels that are widely known for durability and reliability and are made to withstand harsh conditions in both aquaculture and agriculture environments.

Solar Boats and Boating

Flatpack Solar Catamaran

SolarCat solar-electric catamarans are manufactured in a small, rural town in Northern California by a family-owned business with over 30 years experience in the marine industry. The catamarans have high-efficiency solar panels that charge the boat's batteries and power

its electric motors. The 2-person pontoon boat has a spacious, reclining seating area with sunshade. Storage compartment in the pontoons provide a dry, safe place to store personal items and can be used as a cool box for food water and other drinks. Piloting the mini catamaran is very easy and requires no experience. Simply push two switches located on the armrest to move forward, backward, left, right or in a smooth 360°. When returning to the beach or shore side, the boat can be driven onto the shore and the handles on the front of the pontoons enable the boat to be pulled on land. The motors and propellers are recessed in the pontoons so there is no risk of damage.

The SolarCat is shipped unassembled in two boxes. Detailed assembly instructions complete with photos are provided. Assembly takes approximately 4 hours, and requires no advanced technical skill.

The SolarCat kit comes with a 12 month warranty and includes:

(2) Electric motors: 12v
(2) Solar panels: 200 watts
(2) Batteries: Lithium-Ion: 12v, 50ah
(1) Onboard Battery Charger
(1) LED display showing battery charge level
Aluminum frame, high-density pontoons

Solar Tech

World record

Scientists at the National Renewable Energy Laboratory (NREL) in the US have set a new world record in solar energy conversion efficiency, producing a 'six-junction' solar cell, that used 140 layers of semiconductor materials to achieve a conversion rate of 47.1 per cent. The researchers believe the new technique could provide a pathway for producing solar cells with even higher efficiencies that are ideally suited for use in concentrated solar power devices.

The six-junction solar cell, combining sandwiching multiple layers of materials that were fine-tuned to convert different portions of the light spectrum into electricity. A single junction solar cell faces a fundamental conversion efficiency limit of around 30 per cent, known as the Shockley–Queisser limit.

While the layered solar cell design will almost certainly be cost prohibitive to produce at commercial scale compared to conventional silicon cells, it may find use in more niche applications. Usually the super high-efficiency solar cells are limited for use in spacecraft and satellites, where performance, space and weight are a premium. However, cells with such high conversion efficiencies could used in concentrated solar plants. Rather than building a full solar farm of panels, as is currently done with commercially available solar cells, the ability to use a smaller number of the super cells paired with cheaper mirrors that concentrate the highlight could produce cost-competitive solar power. Using a mirror to focus the light down to a point requires much less semiconductor material and an additional advantage is that the efficiency goes up as the light is concentrated.

The US researchers were optimistic that producing a solar cell with greater than 50 per cent efficiency would be achievable.

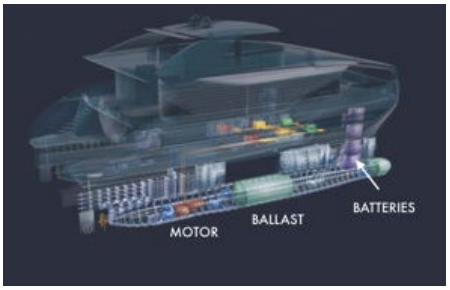
Solar Boats and Boating

SWATH Solar Impact

Solar Impact is a 78ft ocean-going solar-powered motor yacht based on an aluminium SWATH (Small Waterplane Area Twin Hull) hull.

The SWATH design comprises two torpedo-shaped tube which travel a few feet under the water, based on the idea that a boat sways and pitches because it floats on top of the water and feels the full effect of the surface waves going up and down and sideways. But if the flotation elements of the boat are where there are no waves, the effect of water motion on the boat is reduced. The accommodation is raised above the waterline on slender blades to minimise drag and frontal area. The battery configuration is housed in these pillars with the motors placed in the pontoons.

The boat's power comes from twin 500kW electric motors fed by an 800kWh battery pack which is kept topped by 300m2 of solar cells mounted on the coachroof, hard top and folding wings. A pair of exceptionally compact 70kVA rotary-engined diesel generators help extend the range during cloudy conditions. Soar Impact has a top speed of 20kts for short periods and can cruise at lower speeds on battery power for 10 hours. In calm sunny conditions it can cruise indefinitely at 5 knots.



SolarImpact has a fully digital helm

making piloting easy with monitoring system that analyzes data constantly, including weather forecasts, to determine the most efficient use of motors and batteries.

There is an open-plan saloon and galley on the main deck, a master suite forward, four twin or double cabins below, each with ensuite bathrooms, and small cabin for crew.

Specification

Length overall	23,95 m
Beam max	11,90 m
Draft	2,35 m
Displacement	93 tons
Engine Power	2 x 500 kW
Battery Power	800 kWh
Range (ECO)	430km *(V=5 Kn ~ 232 sm)*
Range Extender	2 x 65 kW
Maximum speed	up to 20 kn
Water capacity	1000 l

Solar Tech

Solar sails

French sailmaker Alain Janet, the founder of Solar Cloth System, has been developing a system for generating electrical power from thin photovoltaic films laminated onto modern sail fabrics. Sails offer the largest available surfaces on a sailboat which makes them the most logical place to collect solar power. But water, UV, salt, high-pressure seawater, flogging, folding, being stepped on, are amongst many reasons why generating electricity inside a laminate or on a woven sail is not the easiest thing to do and efficiency, durability and safety are serious issues.

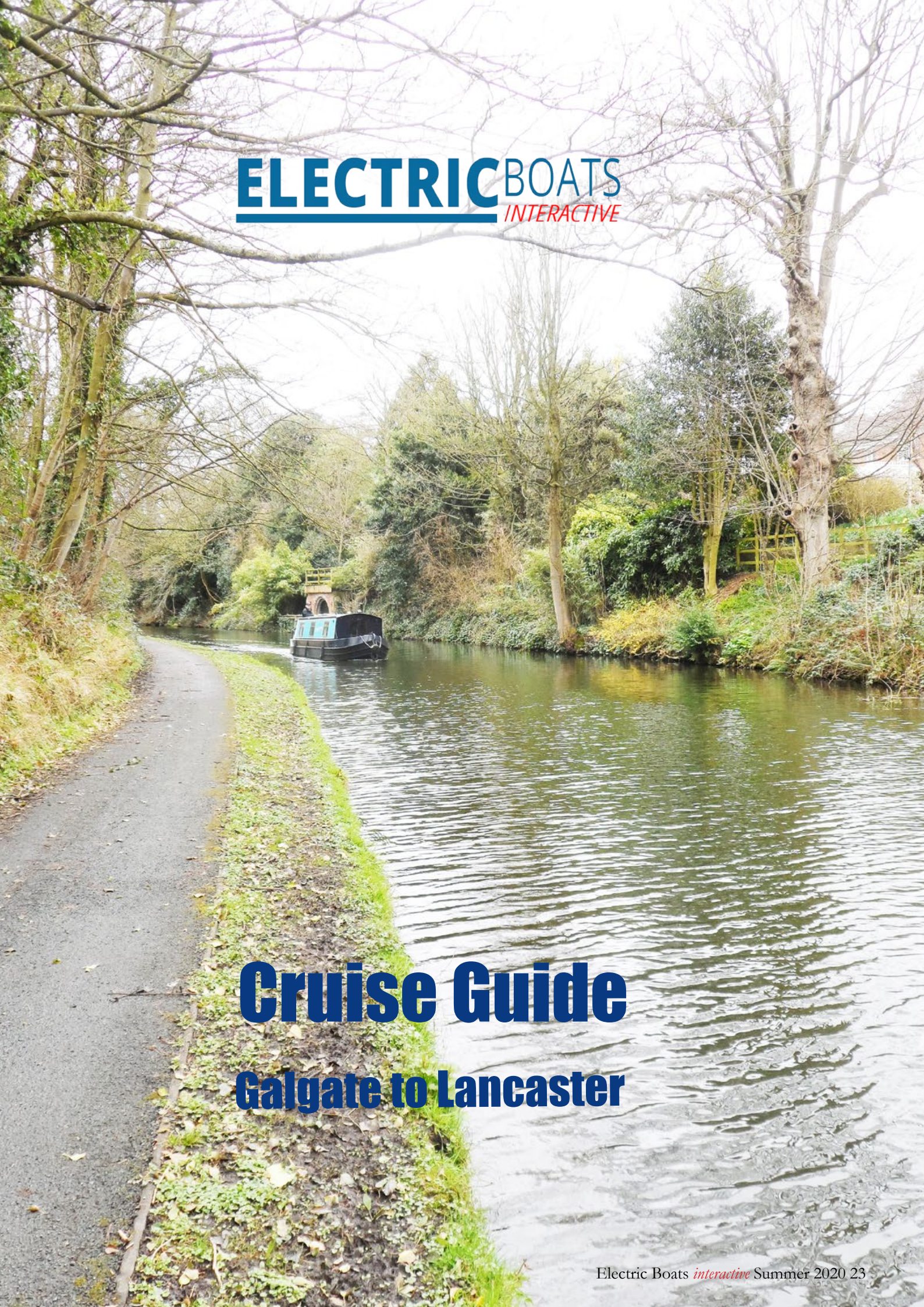
However, over the past decade UK Sailmakers has been developing the 'titanium' sailmaking process, using relatively less resin, dry continuous yarns and moving away from infrared 'cooking' pads to a wider 13m oven for better heat and humidity control. This sail making process was the basis for Solar Cloth Systems experimenting with two types of thin solar cells for their 'Power Sails' system. Both films are cooked at a pressure in their oven during the lamination process. There is still a lot more work to do. Highly conductive carbon yarns had to be replaced with black aramid, diodes had to be incorporated to prevent unwanted polarity switching between the two sides of the sail, circuit breakers had to be fitted to the tack, and the best way to bring electricity down to the photovoltaic regulator inside the cabin had to be identified. Every industrial country is developing new thin film prototypes, many of which will become commercially available in the next few years.

To qualify as a thin solar film for sailmaking, the film should be 65µ-150µ thick giving the finished solar film+sail material a thickness of 0.5-0.75mm, with a weight of 200-400g/m2 after full encapsulation into a sail laminate or bonded over a woven material like Dacron.

Interactive Red Dots

Click on the Dot

Be taken to another world



Cruise Guide

Galgate to Lancaster

Cruise Guide


Galgate Marina

The Lancaster Canal runs for 42 miles without any locks from Preston to Tewitfield on the fringe of the Lake District. Originally it extended to Kendal but the M6 construction cut it off in several places. It was not connected to the main UK canal network until the opening of the Ribble Link in 2002 and it is still a very quiet canal. Our cruise covers approximately 4.5 miles of this peaceful waterway from the canal marina at Galgate to the centre of Lancaster. For the most part of this cruise we pass through a very rural landscape but when the canal was built at the end of the 18th century its purpose was to serve the industries of its time and, in common with all other UK canals, evidence of its industrial heritage can still be found today.

Galgate to Lancaster

Our cruise starts at Galgate a small village on the main A6 just south of Lancaster University and at one time the centre of a thriving silk industry. At the back of the village up the hill by the church the silk mill was converted from a water-powered corn mill in 1792. Although not canal side the proposed Lancaster Canal may have influenced the new business owners to set up their new venture.

It is thought to have been the first mechanical silk spinning mill in the country. It was also the last mill in England to spin silk and at the date of its closure in 1971 had 85 employees. It has now been converted again, this time into student accommodation and on the ground floor the Silk Mill cafe. Galgate is in the parish of Ellel and as we leave Galgate Marina we catch a glimpse through the tree of the new village hall which opened in 2012.

Cruise Location


Galgate Marina Slipway

Heading northwards we soon pass a modern milestone indicating that it is four miles to Lancaster. The canal now goes through an undulating green countryside marked only by eighteenth century stone humpback bridges and aquaducts crossing streams. We travel through an unusually long wooded cutting crossing the aquaduct at Burrow Heights just

2.0 miles

Galgate

Deep Cutting Bridge

Canal side Lancaster

Bridge 92

Bridge 94

before reaching Burrow Beck Bridge (bridge 92). Deep Cutting Bridge (bridge 94) which has been reinforced to carry the Ashton B road marks the end of the cutting and the start of the outskirts to Lancaster. As we approach Haaverbreaks Bridge (bridge 95) we pass the sign and entrance lane off Adcliffe Road to Fairfield Nature Reserve. The Reserve is an area of different habitats with accessible paths to woodland, meadow, hedgerow and wetland with a wide variety of native wildlife, trees and flowers. It is home to, and visited by at different times, over 30 species of bird. There are extensive views across fields towards Lancaster Castle.

The canal's rural landscape is now increasingly taken over by suburban housing, some with boat houses taking advantage of their canal side as the canal heads for the centre of Lancaster passing under bridge 97 which carries the West Coast Railway line into the city station. The canal passes the Waterwitch pub situated on the old Chancellors wharf just before Penny Street bridge, number 99, which is at the end of King Street, Lancaster's main street leading to the Castle. Reflecting Lancaster's industrial heritage the city's canal side buildings include a number of restored mills converted into apartments as well as new build town houses in the style of canal side warehousing.

Info

Launching

Galgate Marina
Main Road
Galgate Lancaster
LA2 0LG
T: 01524 751491
www.bwml.co.uk/galgate-marina

Licences

Short term licences can be obtained from the Canal and River Trust Boat Licensing Team. There is a 25% discount for electric propulsion.
T: 0303 040 4040
Mon to Fri, 8am to 6pm.
Email: customer.services@canalrivertrust.org.uk
www.canalrivertrust.org.uk/licensing

Pubs

The Waterwitch
Towpath
Adcliffe Road
Lancaster
LA1 1SU
Tel: 01524 63828
Real ales
Wifi
Restaurant
www.thewaterwitch.co.uk

The Ring O'Bells
52 King Street
Lancaster
LA1 1RE
Tel: 01524 61777
Real ales
Beer garden
Wifi

The Three Mariners
Bridge Lane
Lancaster
LA1 1EE
Tel: 01524 388957
Real ales
Restaurant
Wifi
www.thethreemarinerslancaster.co.uk

Tourist Information

The Storey
Meeting House Lane
Lancaster
LA1 1TH.
T: 01524 582394
www.visitlancaster.org.uk

Lancaster

The city's name was first recorded in the Domesday Book in 1086 as Loncastre, where 'Lon' refers to the River Lune, and 'castre', from the Old English cæster and Latin castrum for 'fort', refers to the Roman fort which was built by the end of the 1st century AD on the hill where Lancaster Castle now stands. The topography of a defensive and commanding position overlooking a navigable river fits well with other Roman forts in the UK. Roman baths were discovered in 1812 and can be seen near the junction of Bridge Lane and Church Street. Little is known about Lancaster between the end of Roman rule in Britain in the early 5th century and the Norman Conquest in the late 11th century. Archaeological evidence suggests there was a monastery on or near the site of today's Lancaster Priory by the 8th or 9th centuries. Lancaster Castle, partly built in the 13th century was enlarged by Elizabeth I. In the 19th century, the port became one of the busiest in the UK until the river silted up. Lancaster Maritime Museum now occupies two historic buildings on St. George's Quay, the city's main 18th century harbour. The 1764 Custom House contains displays on the history of the Port of Lancaster and the local fishing industry, with a gallery for exhibitions. In the adjacent warehouse are displays on the Lancaster Canal and the ecology of Morecambe Bay.

The Waterwitch is an award winning cask ale pub converted from canal side stables and is a five-minute walk from the historic city centre. It is run by a small independent team which looks to use local products in the restaurant and source most of the cask ales from breweries less than 50 miles away.

EBi International

X Shore

Sweden

Having made a fortune in premium headphones and speakers, the Swedish tech millionaire Konrad Bergström was inspired by Tesla to create an all-electric boat brand offering performance, range and style.

Tesla of the seas

The Tesla business model meant creating an electric boat that is better than fossil fuel boats, that focuses on range and performance, and that starts with low volume, top-end boats before going down market with higher volume production. Konrad Bergström's stated aim is that every boat in the X Shore range must be capable of 40 knots, be able to run for two hours at 25 knots and have a range of 100nm at 10-12 knots.

However matching the performance and range of a fossil fuel sports boat using electric power proved no easy task. Water is 784 times denser than air and takes a lot more energy than rolling a car along a flat road. X Shore decided to design a new electric boat but not having the resources to develop its own electric motor and battery pack, looked to improve other areas of the boat's design.

The initial hull design featured a relatively conventional twin-stepped hull but after 3,000 hours of testing at Rolls-Royce's marine engineering facility it was found that a single, much deeper 37cm step could reduce drag by up to 30%. The step effectively it splits the planing surface into two distinct sections fore and aft with clear air between them, allowing it to plane at speeds as low as 8-10 knots. In displacement mode, it's less efficient than a round bilge design but that was an acceptable compromise.

The design features a tall bow for a dry ride matched with a modular cockpit for flexible seating options. The helm station features a rotary dial instead of a throttle lever, the seats are mounted on sliding rails and the steering uses fly-by-wire technology. Front and

rear bow thrusters make light work of manoeuvres. After the successful reception of its first boat, the Eeelex 8000, X Shore launched its second model, the Eelord 6000, at the 2020 BOOT Düsseldorf show. Both boats have a 225kW electric motor driving a Volvo Penta DuoProp stern drive. There are two battery options available: a 90kWh and 120kWh. Batteries are Lithium-Ion and can be charged through 360V or 220V.

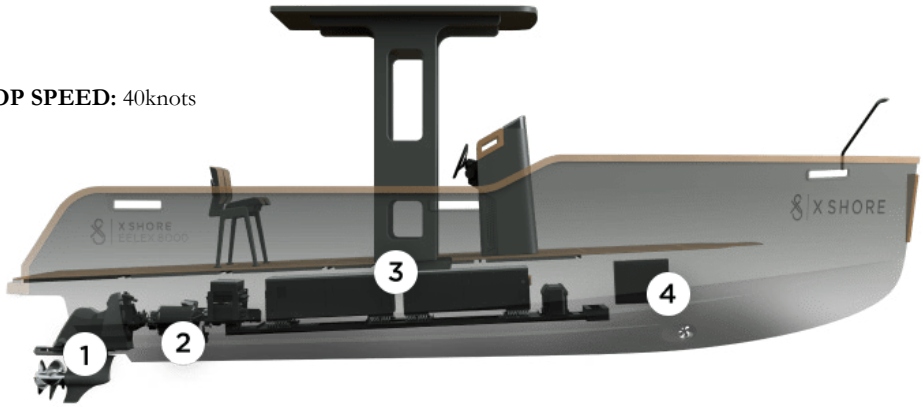
Xshore has won a number of awards for its innovative boats and design, the latest being the Peoples' Choice Award in the Swedish Design Festival.

Eelex 8000

REACH: 70 Nautical miles **CHARGE:** 8 hours **TOP SPEED:** 40knots

Technical specifications

Length: 8.0 m
Width 2.5 m
Weight 2600 kg
Draft 0.8 m
Battery capacity 120 kWh
Sterndrive Volvo Penta Dual Prop Sterndrive
Maximum Engine Output 220 KW
Charging 8h on 360V/24h on 220V
Supercharge 1h
Cruising Speed 24 knots
Top Speed Up to 40 knots
Max Range 100NM in lower speeds



1 Volvo Penta Duo Prop Stern Drive
2 225 kW engine
3 120 kWh (2x60kWh) water cooled lithium ION batteries
4 Electronic fuse box

EBi International

Plastic Interceptor *Netherlands*

Rivers are the main source of ocean plastic pollution and research has indicated that 1,000 rivers are responsible for roughly 80% of the pollution. Boylan Slat the dutch co- founder of Ocean Cleanup has come up with a way to stop plastic pollution at the source. The *Interceptor* uses floating barriers to catch waste and guide it towards an opening. The current then moves the debris onto a conveyor belt, which extracts it from the water and delivers it to a barge type processing plant. The autonomous *Interceptor* is 100 percent solar powered and uses onboard lithium-ion batteries that enable it to operate day and night without any noise or exhaust fumes. Its barriers cover only half of the river so it will not interfere with other vessels or impede the movement of wildlife. The *Interceptor* has been designed for mass production and can be applied virtually anywhere in the world. Ocean cleanup has already installed two interceptor systems in Malaysia, and Indonesia. A third interceptor will soon be deployed in the Mekong Delta in Vietnam, and a fourth is headed for Santo Domingo in the Dominican Republic. Thailand has signed up to deploy an interceptor near Bangkok, and Ocean Cleanup is in talks with LA county in the USA.

Plastic Printed Boat *United States*

The USA University of Maine has printed a boat, the *3Dirigo*, designed on a large-format polymer 3D printer developed by the University's Advanced Structures and Composites Center. The boat is 7.62 meters long and weighs 2.2 tons. It was manufactured in just 72 hours from a mixture of plastic and wood cellulose. The project teams were awarded three world records: the largest 3D printer, the largest printed solid part, and the largest 3D printed boat. Additive manufacturing is a promising development for the marine industry where large-format 3D printing could create structures in one go and avoid assembly or post processing steps that are expensive and time-consuming.

Eco Recreation *India*

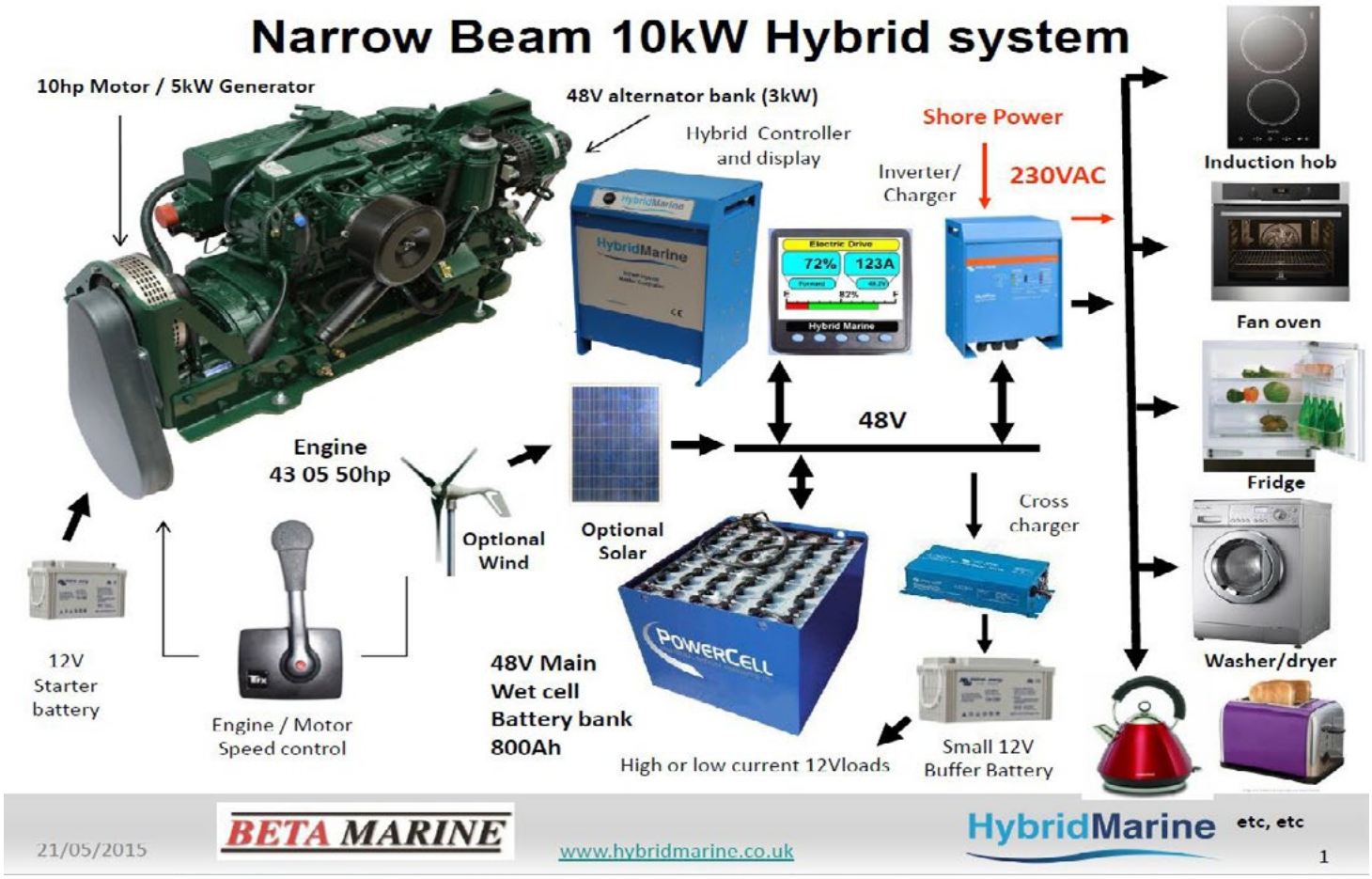
Dolphin Eco Recreation based in Rajasthan, India, is a Torqeedo distributor, and manufacturer of eco boats.

Solar Shikara Boat

Length: 24 ft
Width: 6 ft including stabilizers
Material: Fibreglass- Sandwich Construction with positive buoyancy incorporated in hull & stabilizers
Capacity: 4+1 person
Dry weight 250 kg.
2x 100 watt Solar battery system integrated with heavy duty 12V Electric Outboard Motor.
2x 10 watt Solar system for music & lights
Cushion Seats & curtains
Auxiliary Battery Onboard with Switchover & Shore based charger

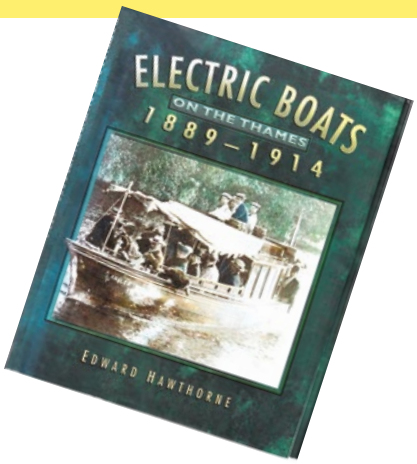
Solar Gypsy Boat

Positive buoyancy sandwiched Catamaran hull
12 X 5.5 ft
Seats 6.
24 v 350 + W Solar propulsion (100 /130 lbs thrust motor),
12v 10 W Solar music / headlights / cabin light.
Hybrid version with twin motors (2hp solar + 2 hp electric)
Spare battery set with charger for rainy days / night
Choice of colour

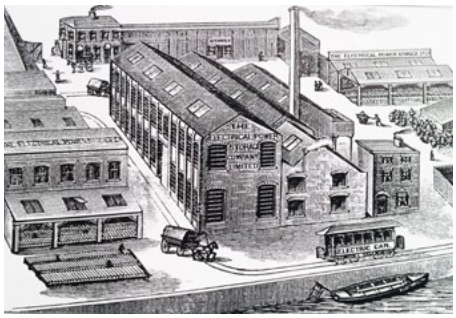


Edward Hawthorne was a mechanical engineer by training and a past chairman of the Electric Boat Association User's Group. His superb and fascinating book is no longer in print and his family have kindly permitted EBi to serialise extracts

Dawn of an Era



One September morning in 1882 a boat was slipped into the Thames amid London's Dock lands. To the dockers and seamen, she was just another small ferry boat joining the dozens which plied between the great ships loading and unloading in the busiest port in the world.. To the group of engineers and boat builders watching the launching she was an experiment, heralding a new method of propulsion which would do away with the dirt smoke and inconvenience of the steam engine. On board she carried a ton of batteries which were to provide the electricity to motors connected to the boat's propeller. Appropriately, this 26 ft long iron-hulled boat capable of carrying twelve passengers was named *Electricity* and *The Times* reported that she was 'the very first in which the electric propulsion of a boat has been undertaken on commercial scale.' Among the watchers was Anthony Reckenzaun, a brilliant engineer who had arrived in this country aged twenty-two from Austria ten years earlier and became engineer to the Electrical Power Storage Company (EPS Co) which had decided to build an electric boat. The layout he evolved used batteries- accumulators as they were called in those days - developed by the EPS Co, and two motors manufactured by the Siemens Company. The motors were connected by belt drives to the propeller shaft. On her first trial on the 29 September she ran from Millwall to London Bridge and turning came down on the ebb tide to berth at Millwall 24 minutes later. The trials of the Electricity proved that sufficient accumulators could be carried in a realistic layout to provide the energy necessary to obtain acceptable speed and duration. However it was clear that the weight and size of the motors and their gearing had to be reduced. The first step was only to use one motor connected direct to the propeller. The new design was put into practice in 1883 when the second electric boat was launched into the Thames. Again she was fitted out by the EPS Co at their works in Millwall, but the hull and superstructure were designed and built by Messsrs Yarrow at heir yard at Poplar, just a short distance upstream. This launch of galvanised steel was 40 ft length and 6 ft beam and by placing all the accumulators and machinery under the floor and seats, she could carry forty passengers. On her first trip the launch made the 6 mile journey down river on a moderate tide from Temple Pier to Greenwich in thirty-seven minuted. Over a



The Electrical Power Storage Company's works at Millwall in London's Dockland

measured mile an average speed of more than 8 mph was obtained. In 1884 Reckenzaun designed the electrics for the third launch to appear on the Thames. *Australia* was built by Messrs Forrest & Sons to the orders of Messrs Stephens, Smith & Co, engineers for an Australian firm. The hull was of mahogany, 25 ft length and 5 ft 7 in beam. Stephens, Smith & Co must gave been satisfied with the Australia for they contracted for a second boat, the 36 ft galvanises steel- hulled *Volta*. Launched in August 1884 she incorporated a number of new features, chief of which was the use of two Reckenzaun motors couple in line to the propeller shaft. In September 1886 *Volta* crossed the Channel solely under electric power for Dover to Calais and back in a total time of 8 hours and five minutes. The potential for electric boats was slowly being realised. In May 1887 a new boat *Countess* belonging to the Electric Locomotive and Power Co was launched. Built by Messrs Lester & Perkins at the Royal Albert Docks she was 90 ft in length 11 ft 6 in beam and draught of 3 ft. Little was subsequently heard of the Countess and the title of the largest electric boat in the world was taken over by the 65 ft *Vicountess Bury* launched in 1888. During these six years from 1882 to 1888 Anthony Reckenzaun, backed up by Sellon and Volkmar of the Electrical Power Storage Co and supported by a few entrepreneurs and boat builders, laid the basis for the growth of electric pleasure boating during the 1890s. They showed that electric propulsion was a practicable proposition and might have real commercial potential particularly for ferry and leisure craft. They adopted land based electrical technology used in pumping stations, tramways and electric lighting installations to suit the environment of waterborne craft. They demonstrated electric boats ranging in size from 20 to 90 ft, single and twin motor systems, geared and direct drive, currents up to 90 amps and EMF's up to 120 volts, battery capacities up to 370 ampere-hours, from cells containing forty plates and having a specific output of 42 wh/kg, motor powers up to 7 hp, and boat speeds up to 11mph. The technology was ready for a man of vision to seize the opportunity it presented. That man was Moritz Immisch

click on the red dots

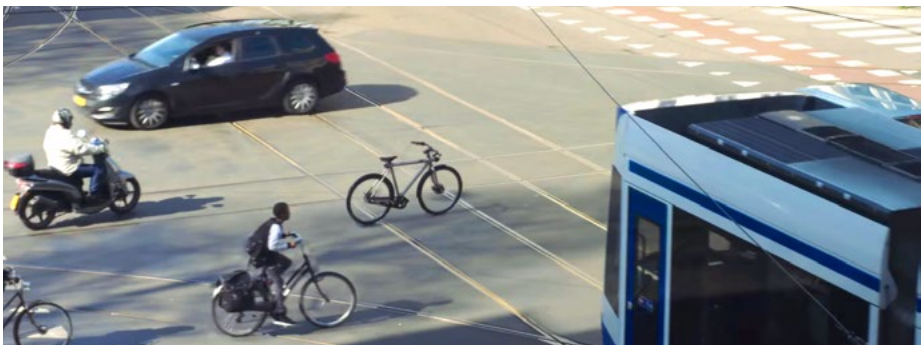
OEVs

Red London bus goes green

Hydrogen fuel is a great way to power public and private transport. The only emission is water vapour which means that no carbon dioxide or other air pollutants are released into the air. London is looking to be a world leader in hydrogen and fuel cells and wants hydrogen fuel to play a major role in the city's clean, sustainable energy future. If the hydrogen itself is produced from a carbon-neutral source such as London's waste, solar or wind power, it has the potential for carbon-neutral and emission-free energy. London's transport authority knows it works as their RV1 bus ran on it until recently and hydrogen fuel cell buses continue to operate along the 444 bus route. The world's first hydrogen double deck buses will be introduced on three London bus routes next year, in helping tackle the capital's air quality crisis. Hydrogen-powered vehicles have a range similar to conventional diesel vehicles achieving 350-400 miles on a single tank of fuel, and they can be refuelled within 3-5 minutes.

Bike can go off on its own

In 2016 Google Netherlands posted a video of a self-driving bicycle which was taken to be an April Fools' Day joke. However, a team of students from Tsinghua University in Beijing, China, have created a self-riding bicycle which can not only auto-balance but is capable of riding by itself, avoiding obstacles, taking turns, understanding human voice commands and making independent decisions. The bike's artificial intelligence is powered by a new kind of hybrid computer chip, called Tianjic. A team made up of members from a host of institutions in China, one in Singapore and one in the US, has built this advanced chip which uses both computer-science-based machine-learning algorithms and brain-inspired circuits in several coding schemes. The chip is designed and built in such a way that it can process algorithms and modelling simultaneously in the autonomous bike.



Luggage to follow

Piaggio Fast Forward, backed by Vespa, has launched its first consumer product: the Gita, a little spherical robot that will follow people carrying up to 40 pounds of their belongings. The Gita has a rechargeable battery that powers an estimated four hours of continuous operation. When totally depleted, the battery recharges to optimum power in under two hours by plugging the charger into a standard wall outlet.

Harley Davidson Livewire

Harley-Davidson launched their first electric bike the Livewire at the end of last year. The Livewire features a high-voltage battery (or RESS; Rechargeable Energy Storage System) composed of lithium-ion cells surrounded by a finned, cast-aluminum housing. The battery provides a minimum of 98 Miles (158

Km) of city range or 95 miles (152 km) of combined stop-and-go and highway range. An onboard Level 1 charger and power cord connects to any standard household outlet to get a full charge overnight. A faster charge can be made at a level 3 DC charging station. Motorcycle magazine tests suggest that the bike's ratings are on the conservative side.

Phablets and Tablets

Tablet *Kindle* *Phone*

The Electric Boat magazine went digital in Spring 2016 and at that time reviewed what was needed to transition from print to pixels. In the fast moving world of digital communication Don Wright looks again at the latest developments in software and hardware

Ihe ubiquitous smartphone is taking over all aspects of modern day communication. Forget showing Kodak holiday snaps when meeting up with friends, forget buying fan magazines to see what teenage idols are doing, forget gawping at celebrity gossip periodicals, forget sitting down in front of the television to watch the news, the mobile phone is rapidly replacing all these former methods of consuming content.

A recent report from App Annie which analyses phone use revealed that last year that mobile phone users in the UK were on their phones for an average 2.4 hours a day, a rise of 15% on previous years, spent £2.5 billion on apps, an 85% increase on the last three years, and made 21.5 million downloads. The phone is used most of the time for social and related communication but as the new decade is bringing the next generation of smart phones the report said that the major trend in the UK and worldwide was the move to viewing more entertainment on the phones.

The Samsung Galaxy Fold launched at the end of last year folds down to a pocket mobile size 4.6 inch outer

Samsung Galaxy Fold

screen, and folds out to become a 7.3 inch mini-tablet display.

Combined with 5G the Galaxy Fold is the best current example of the future of smartphones. 5G is the fifth generation wireless technology for digital cellular networks which started to be deployed last year and brings an exponential increase in speed, connections and capacity, and can support up to a million devices per square kilometer, a tenfold increase on 4G. It is not only smartphones that are using the latest tech. Lenovo has announced that it has prototypes for both a foldable and a 5G laptop. Folding screens maybe the future but at around £2,000 the Galaxy Fold is presently twice the price of the most expensive smart phones.

Which brings me to the Amazon Kindle which I reviewed as an entry level e-reader in 2016. I recently took advantage of a Black Friday offer and bought a 32GB Kindle Fire for £40. The 16GB version was on offer at £30 but as I have TV and Radio i players, Spotify, YouTube and Office Suite apps I always go for the model with higher storage. As I said in 2016 the Kindle Fire is by far the cheapest tablet on the market and while it does not match the specification of more expensive competitors it is more than adequate for reading Electric Boats *interactive* and other magazines and books. The basic Kindle Fire (there is a higher priced HD model) has a 7 inch1,024 x 600 display but I have never found this relatively low resolution to be a problem on a screen of this size.

Finally, a recent study in the United States revealed that between 1998 and 2017 there were 76,000 recorded cases of mobile phone related injuries, the majority occurring when using the phone while walking or driving. So if you are reading Electric Boats *interactive*, when you are out and about. please do take care.

Lenovo Foldable Laptop

4 more info - click on the red dots