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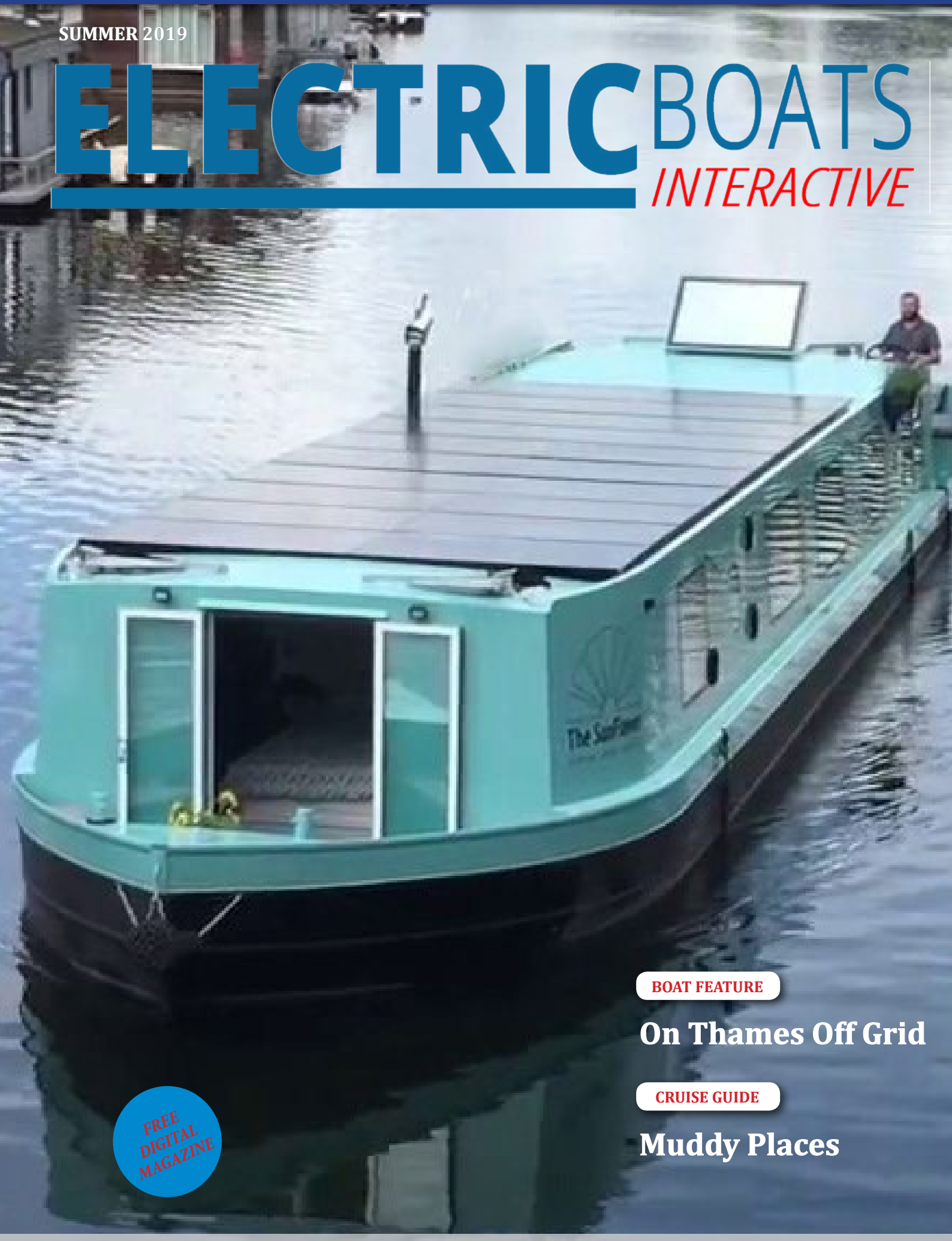

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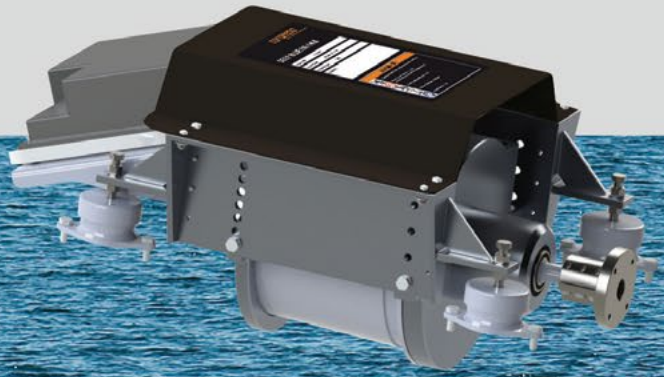

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ELECTRIC BOATS INTERACTIVE

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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	31 May
Winter	30 September

ELECTRIC BOATS INTERACTIVE

Volume 1
Number 1
Summer 2019

Tomorrow's world

Recent market research suggests that the global recreational boat market is expected to be worth US$50 billion by 2023, and that electric propulsion will play a key role in transforming the market.

It is over two years since a magazine dedicated to recreational electric boats and boating last appeared and there is some catching up to do, so this first edition of Electric Boats *interactive* is retrospective in parts. Although the London Boat Show was cancelled this year the UK inland waterways boat show at Crick Marina, organised by Waterways World in association with the Canal & River Trust, goes from strength to strength (page 8) and features ever increasing interest in all things electric.

In 2006 Elon Musk explained that the over-arching purpose of Tesla Motors was to help move from the mine and burn hydrocarbon economy to a solar electric economy. Cedric Lynch may have been ahead of Elon on this one and the eagle eyed may spot Cedric's solar powered canoe leading the charge (pun intended) to St Ives. As part of our retrospective we renew our interest in the world's largest solar powered boat on page 15 which is now half way around the world and half way through its latest venture.

In developing its electric car Tesla has made enormous advances in battery technology (page 12) which can only benefit all electric propelled craft. An example of this crossover can be seen on page 25 where the Torqeedo Deep Blue 80 inboard electric motors are powered with a lithium battery pack developed by BMW for its model i3 motor car.

A new feature on page 29 looks at OEVs (other electric vehicles) as a brief glimpse at tomorrow's world.

The advent of 5G, the next generation of mobile internet connectivity with faster speeds more reliable connections on smart phones and other devices, is very much the future and although a digital magazine will never emulate the look and feel of a traditional printed magazine (although phablets and tablets are getting lighter, thinner and even foldable) a digital magazine does have some advantages, not least the ability with a Wifi connection to interact with a story, picture or advert by clicking on the red dots which are portals to another world.

Go on - Try it

Don Wright

Cover: The Sunflower solar powered widebeam

Published by Futuremode Limited

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Summer 2019

In Brief

Waterways Heritage

The Inland Waterways Association has launched a new campaign aimed at discovering waterways heritage. With the help of the membership the IWA wants to record the historical gems of the UK's canal network – not just canal side buildings and locks but also the signage, canal furniture and remnants of its industrial past - looking to find out what has been saved, what has been lost and what is currently under threat. This activity is all part of a larger project to discover the true value of the waterways, both as a record of the past and as a resource for the future. For anybody wanting to take part in this initiative the IWA has devised a Heritage Tracker form which can be filled in and submitted online.

Silver Propeller

The Inland Waterways Association Silver Propeller Challenge lists some of the least visited stretches of water in the UK. One of these destinations is Welney or Welches Dam Lock on the Old Bedford River, which has to be among the most difficult to reach due to the fact that the Environment Agency blocked off the entrance to Welches Dam Lock with interlocked steel piles back in 2006. The only way into the Old Bedford River is via the Old Bedford sluice and the tricky and muddy tidal channel at Salters Lode, but intrepid IWA boaters haven't been put off and have reached Welney and Welches Dam five times in the past two years, proving that it is possible to get there. Each time, the boaters have received a warm welcome at the Lamb & Flag Inn at Welney. In March a group of IWA members and supporters gathered at the Lamb & Flag and gave the pub's licensee a framed collage of three photographs showing boats using the Old Bedford River to The Lamb and Flag.
Look out for the collage next time you are visiting the Lamb & Flag

Pure Boating at Wallingford

Henley Sales & Charter have signed a lease to continue operating a hire fleet of electric dayboats from 2019 and beyond at the Boat House pub in Wallingford. 'Wallingford really is an undiscovered gem, says HSC MD Gillian Nahum, 'It's only 15 mins drive from Henley. It benefits from cheap and easy parking, an open air swimming pool, a Waitrose some charming independent shops and a decent market. A half a day on one of our new electric boats, starting from our Wallingford base, can take you on a voyage of discovery down to Day's Lock for a walk up to Wittenham Clumps.'

Due to Wallingford's close association with Agatha Christie, who lived there for most of her life and who is now buried in Cholsey church yard, the latest addition to the six boat fleet is named *Miss Marple* and joins *Agatha* and *Poirot* and all the boats can booked online at the PureBoating website.

John Williams

Pat and Paul Wagstaffe pay tribute to one of the early pioneers in the development and growth of the UK's canal and river systems.

We were very sorry to hear of the death this year of John Williams. John trained as a high quality carpenter with his family building business before joining Shropshire Union Cruisers where became the carpenter responsible for fit-outs of narrow beam hire boats on the UK Canal System. John represented the Company on the then National Hire Trade Body – The Association of Pleasure Craft Operators. (APCO). (Now British Marine Inland Boating). He took a lead in bringing together a number of small and medium operators to work together to keep the existing canals open to navigation and to support schemes to restore derelict rivers and canals. John was appointed to the Inland Waterways Amenity Advisory Council, which played a significant role in changing political and local attitudes to derelict rivers and canals by proposing that should not be closed and filled-in and that they could become a catalyst in regeneration of cities, towns villages and the countryside. Later on John moved to the Norfolk Broads where he set up his own boatyard where he built, restored and serviced classic Broads Sailing Yachts. He enjoyed sailing on the Broads, cruising the Canals and Rivers of the UK and encouraging people to start boating in all its forms.

click on the red dots

Electric Eco-Kingsley

Fischer Panda has supplied a Bellmarine electric drive system for Elton Moss Boatbuilders new 70 x 12ft Eco-Kinglsey widebeam barge. The Bellmarine DriveMaster Ultimate 20kW electric propulsion system is supported by a Fischer Panda PMS AGT 130000 48V DC generator. Electric power provides all the propulsion and manoeuvrability needed for silent and emission free cruising.

The battery bank can be charged via an onboard charging system when connected to shore power. The electric propulsion system dramatically reduces the boat's annual maintenance costs compared with standard diesel engines and fuel consumption is also greatly reduced.

The liquid cooled range of DriveMaster Ultimate systems enable precise temperature management and improved efficiency. Designed to cope with a harsh maritime environment all the systems include motors with integrated thrust bearing, mounting frames and smart controller for compact installations, offering service free low cost cruising.

Electric Deep Diving

British automotive manufacturer Aston Martin has teamed up with US Triton Submarines to develop Project Neptune a fully electric deep diving submersible. Powered by 30kWh LiFeP04 battery system the sub will be able to operate for up to eight hours before needing a recharge. The limited edition vessel will accommodate two passengers and a pilot and be able to dive to depths of 500m. Since the start of the project in 2017, Aston Martin and Triton have refined the design of the sub's hydrodynamics, exterior body and interior layout. 'The interior was a great challenge,' said Aston Martin Marek Reichman, 'Unlike a sports car where the interiors are installed into an open sided cabin before the doors are fitted, everything you see inside will be lowered through the upper-hatch and assembled within the completed sphere of the pressure hull.'

In Brief

Plastic Challenge

Working with Coventry University, the Canal & River Trust, the waterways charity that cares for 2,000 miles of canals and river navigations in England and Wales, has published a detailed analysis of the plastics and other litter found in its waterways. The research, which reviewed data from 25 locations, found that plastics now account for 59% of waste found along its canals, and states that more than half a million items of plastic reach the oceans from the charity's canals and rivers every year. The CR&T spends over £1 million a year to help keep its waterways free of plastics and other discarded waste and says that if every visitor picked up and recycled just one piece of plastic each time they visit, the canals and rivers could be plastic free in a year.

C&RT reports

The Canal & River Trust has published its 2018/19 Annual Report & Accounts which detail continued investment in its 2,000 miles of waterways across England & Wales as well as further growth in the number of volunteers and supporters helping to look after their local canal or river. Spending on the Canal & River Trust's charitable activities topped £156m whilst those volunteering for the Trust gave a record 670,000 hours of their time. Green Flag status continued to grow with 250 miles of waterway now holding the quality assurance mark at year end (now 300 miles), there was a small rise in boats on the network, and record numbers of children were engaged through the Trust's education programme. Chair Allan Leighton said, 'The past year has seen continued progress as the Trust works towards its ambition of living waterways that transform places and enrich lives. We have maintained the investment in the network that is so vital to all our 4 million regular users - boaters, anglers and towpath visitors.'

The 20th Crick Boat Show took place at Crick Marina over the May Bank Holiday weekend and the event is the UK's largest inland waterways show. This year more than 27,000 people came to the show and the sunshine on the Saturday brought in the highest ever single day attendance with just over 10,000. With over 250 exhibitors there was plenty to see but the show also has free seminars the most popular being on boat ownership which was attended by more than 2,000 people over the three days.
At this year's show there was tremendous interest in all things electric and there were four electric or hybrid drive boats on display. One of these boats *Shine* was on the UK Electric Boat Association pontoon. The EBA has been an exhibitor at Crick since 2015 and has had a boat on show for the last four years (see below).

2019 *Shine*

Shine is the 57ft boat of EBA business member Mothership Marine. The roof has eight 250W solar panels charging a battery bank of 600Ah at 48V powering the 10kW 48V DC electric motor. There is a 6kVA diesel generator which can recharge the batteries if needed. A converter provides a 24V DC supply for domestic appliances.

2018 *Ampere*

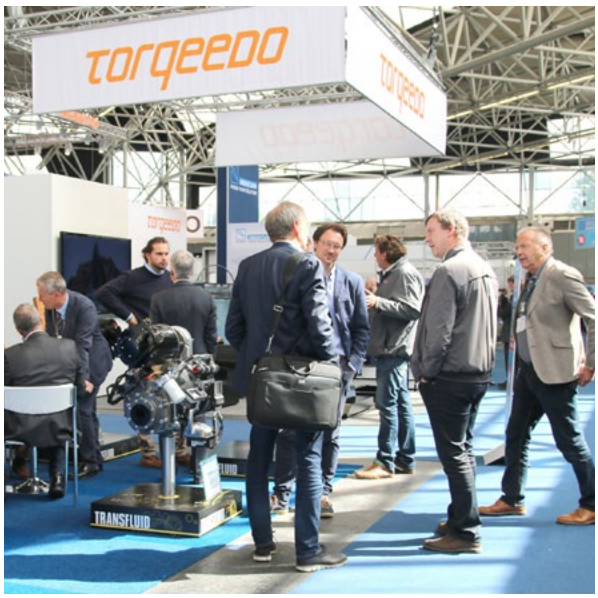
Ampere is the 58ft boat of EBA members Malcolm and Barbara Bridge. Built by Wharf House Narrowboats in 2015 *Ampere* is fitted with TEMA 15kW motor and a 1,250Ah battery bank. There an 8kVA Fischer Panda NE PMS generator with a 10kVA Victorn Quattro inverter, and four 100W 24V solar panels on the roof.

2017 *Sunflower*

Sunflower was the 45ft boat of EBA members Trevor and Pam Thorne. The boat was fitted with 10HP 8.5kW 48V Lynch LEM 200-127 10HP with 4QD controller. The original battery bank was four 12v 270Ah batteries charged by four 45W flexible solar panels on the roof supplemented by a 48V 70A/4kW Fischer Panda generator.

2016 *Olinda*

Olinda is the 60ft boat of EBA members Norman and Linda Hicks. *Olinda* has a hybrid propulsion system using the Thames Electric Ecodrive system which is configured to take over driving the boat's Beta diesel engine's propshaft when required. The brushless AC motor also has regenerative charging removing the need for a separate generator.



electric & hybrid marine WORLD EXPO 2019

With shipping industry increasingly adopting large scale electric propulsion the sixth Electric & Hybrid Marine World Expo held at Amsterdam in June was the largest show to date. Although primarily a conference for the commercial shipping industry it is the world's only dedicated exhibition of electric and hybrid marine charging and propulsion technologies and components and there were over 130 exhibitors at the 3 day event.

With a record-breaking number of exhibitors from more than 20 countries and over 40 conference sessions there was plenty to see and to learn for the thousands of attendees who saw more brand new, cutting-edge products launched than ever before, as well as numerous exciting projects and investments announced live on the show floor.
The conference saw leading experts from around the world present technical papers on the latest and next-generation technologies that will power the ships of the future. Laurens van Mourik, project manager sailing department, City of Amsterdam, provided an overview of the projects and pilots currently underway on the city's famous canals and outlined how it plans to reach its sustainability goals for 2025; and Jeremy Ward, managing director, East By West Ferries & Wellington Electric Boat Building Company, gave an insight into the development of the Southern Hemisphere's first fully electric passenger ferry, scheduled for launch in New Zealand by December 2019.
The exhibitors included Fischer Panda which was showing its new 100kW AZ podded motor for its 420V drive systems designed for commercial boat operators, in particular water taxis and smaller ferries with a displacement of more than 40 tonnes. The highly efficient permanent magnet motor is brushless and sensorless.
The full 800Nm torque is available throughout the entire speed range; even at lower speed the electric motor gives vessels a powerful and responsive motor. The pod is very quiet, requires no gear box and is fitted in a robust water cooled stainless steel housing.
Vita Yachts was showcasing the company's fully electric powerboats in production on Lake Maggiore, Italy. Twin water jet drives are powered by Vita's ground breaking propulsion system and deliver a cruising speed of 25kts and a sprint speed of 40kts. The company is the first manufacturer to achieve a Clearwater Gold Standard rating for its low environmental footprint.
The winners of the Electric & Hybrid Marine Awards have now been announced with a mixture of new and familiar names:
Corvus Energy claimed the Supplier of the Year title for the fifth consecutive year;
Kongsberg Maritime enjoyed double success, winning the Propulsion System Manufacturer of the Year and Innovation of the Year awards;
Viking Life-Saving Equipment took home the Engineering Team of the Year award;
and FourSeas' Tycho Brahe and Aurora diesel-electric passenger and vehicle ferries won the Electric & Hybrid Propulsion System of the Year award.

London Boat Show gives way

'lacking number and diversity of exhibits'

Although it didn't usually have a great deal for anybody interested in electric boats and boating, the London Boat Show which used to be the premier boating event at the start of every year did not go ahead this year. According to the show's organisers British Marine there was insufficient support from the marine industry. The show changed from a 10-day to a five-day format in 2018, and research by exhibition experts, who spoke with more than 67% of exhibitors from the 2018 show, revealed that whilst a number of marine companies supported the change to a five day show, a large number of key exhibitors were not prepared to commit to exhibiting to the shorter show. Visitor research also showed that consumer satisfaction at the 2018 show, in respect of the content, number and diversity of sailing and power boats exhibited, was 'below acceptable industry standards'.

The Wolverhampton Flight

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 first of a series on electric narrowboating Malcolm gives his personal assessment of the relevant technologies.

Electric narrowboating

Firstly 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. It is a work in progress so has already been changed a number of times since first written and will almost certainly be so again in the light of further information, experience and/or developments.

In this first article I look at motors and controllers.

A narrowboat 45-60' long and weighing 20+5 tonnes needs no more than 3kW (4 hp) to propel it at canal speed, though 4-5 times this is advisable to allow for stopping quickly or heading into a bit of 'fresh' on a river. 12-15kW (16-20 hp) should thus be adequate for such a boat. This is similar to the power of the Russell-Newburys which used to power working 'pairs', grossing nearly 100 tonnes, but less than half that of the most commonly fitted modern diesels. A 10kW motor should suffice for a smaller boat while 20kW might be better for a full length one. Be aware, however, that this last option often comes as two, 10kW motors on one shaft, sometimes with separate controllers, resulting in systems that can be tricky to set up. Because of the high torque of electric motors there should be no need for reduction gearing (and the losses that entails) so one delivering its maximum power at 900–1,500 rpm should be your target. While 10kW/24V motors are available, the voltage choice is essentially between 48 and 96V. The latter offers a wider choice of motors but, as far as I am aware, there are no suitable 96V inverter/chargers available so 48V is the preferred system voltage for an all-electric boat. It should also be noted that a 96V system must meet more stringent safety regulations as it is no longer classified as 'low voltage'.

Efficiency is important for all boats but is particularly so for an electrically-powered one as the battery bank is 'emptied' in a day or two rather than the weeks that a tank of diesel will last. The greatest drive efficiency (approaching 95%) will be obtained from an electronically-controlled, 3-phase, synchronous, permanent magnet motor and, because the continuous power that can be taken from an electric motor depends on its cooling, a water-cooled one is to be preferred. Asynchronous, field wound motors, though cheaper, are bulkier and 5-10% less efficient while DC ('Lynch') motors used to be another step down in efficiency, though recent adverts suggest that improvements may have been made. However, having brushes, they are always going to be noisier and need more maintenance than AC types.

Suitable motors can be found by searching the Internet for 'permanent magnet marine propulsion motor', or similar, which should throw up five or six manufacturers. Most motor manufacturers supply pre-programmed controllers.

Cheaper motors, intended for kit cars, have been around for some years but are mostly field wound and run at high speeds so are both less efficient and need gearing down, typically by 5 or 6:1. They also tend to be very noisy. However, Interior Permanent Magnet (IPM) motors, which have only appeared recently, are cheaper, while being reasonably compact, quiet and efficient so are worth considering - though they are also quite high revving and will need gearing down.

I will be looking at batteries in the next edition of **Electric Boats** *interactive*

Clubs and Associations

As Barbara Pennial points out in her history feature on page 27, boats propelled by electric motors were on canals and rivers long before the internal combustion engine took over propulsion and the resurgent interest in electric power 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 UK EBA has two Facebook pages:
Electric Boats and Electric Ships, which is open to all with currently in excess of 4,700 members, and Electric Boat Association, with 110 members which is restricted to the paid up UK EBA membership. The UK EBA can also be followed on Twitter and LinkedIn

EBA
Electric Boat Association of Greece

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, manufacturers, boat owners and business members.
The first Panhellenic Islands School Competition "Let's Go Port" is being co-organized by EBA Greece and the Ministry of Tourism. The subject will be Electric Boats & Ships and the competition will be between secondary education schools of all islands in the school year 2019-20.

ELECTRIC BOAT
ASSOCIATION OF CANADA

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.
The objective of the Association is to promote the use of electric-powered boats and to provide a place for those interested in electric boats and boating to find information about electric marine technology in Canada and connect with other electric boat enthusiasts and owners.

SEFF
Stifting Elektrysk Farre Fryslân

www.seff.nu

The Frisian Electric & Hybrid Boating Association (SEFF) was founded to promote electric and hybrid boating in the Netherlands Frisian province.
It is dedicated to the sustainable development of water sport activities and the reduction of environmental pollution, and as an independent association it looks to provide a link between the province, and the relevant business companies and recreational organisations. As part of its role SEFF has helped improve and expand the existing network of charging points.

ELECTRIC BOAT ASSOCIATION OF AMERICA
EBAA
www.electricboats.org

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.

AFBE
ASSOCIATION FRANCAISE POUR LE
BATEAU ELECTRIQUE

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 part of its promotional activities the AFBE takes part in a number of nautical events:
Salon Nautic of Paris
Nice and Amsterdam Boat Plug
Euromaritime Paris
Electric and Hybrid Amsterdam

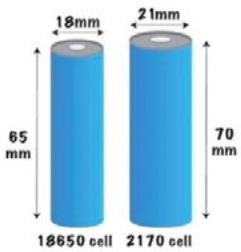
TESLA's Lithium

Tesla cars are powered solely by the electrical charge stored in batteries and it is arguable that the existence of Tesla is based on the fact that relative to their cost, size and weight Lithium ion batteries have the highest charge capacity of any practical battery formulation in history; high enough to make electric vehicles a practical reality.

The idea for using Lithium ion rechargeable battery cells was first proposed by a British chemist in the early 1970s. Battery cells are deceptively simple devices consisting of three basic components: two electrodes, the negative anode and the positive cathode separated by a chemical "soup", called the electrolyte. When Lithium ion batteries are charged, Lithium ions are forced to migrate to the negative electrode where they are deposited. During discharge the Lithium ions reverse direction to the Cathode.

Tesla has been using Panasonic Lithium ion 18650 cells manufactured since 2013. These are small battery cells, slightly larger than the standard AA cells. The Tesla cylindrical cells are 18 mm in diameter and 65 mm high. The 18650 battery is one of the most robust formulations available today, yielding very long-lived, reliable performance. The most popular battery pack supplied by Tesla contains 7,104 18650 cells in 16 modules of 444 cell capable of storing up to 85 kWh of energy. In 2015 Panasonic altered the anode design, increasing cell capacity by about 6%, enabling the battery packs to store up to 90 kWh of energy. More recently, Tesla engineers reconfigured the internals of the battery pack to hold 516 cells in each module for a total of 8,256 cells capable of storing just over 100 kWh of energy.


Tesla battery pack



In order to further improve cell efficiency and lower costs Tesla has built a large battery factory that is now producing a new cell design called the 2170 because it is 21 mm in diameter and 70 mm high to be used initially in Tesla Powerwall home storage products and Powerpack utility storage products as well as new car models. According to Tesla the 2170 design is 46% larger in volume than the 18650 and 10-15 % more energy efficient than the 18650 cells.

All rechargeable battery cells degrade over time as undesirable side reactions take place in the cells that produce by products that block lithium ions from reaching the anode during charging.. Early indications are that 18650 cell degradation is very slow, losing only a percent or two of capacity per year at worst.

The maximum charging voltage for a Panasonic cell is 4.2 volts. Panasonic specifies a maximum charging current of 2 amperes per cell. Tesla allows charging current to be up to 4 amperes. Therefore the maximum power that a Tesla battery pack can use for charging is 4.2 x N x I where N is the number of cells in the pack and I is the maximum current allowed per cell. For 85/90 kWh packs this is 7,104 x 16.8=119.3 kW. For the 100 kWh packs it is 8,256 x 16.8=138.7 kW. There is no way to charge faster without increasing the maximum charging current per cell which might hasten degradation of the cells or worse.

Tesla has created Supercharger DC charging stations that supply up to about 135 kW of power. The DC bypasses the car's charging circuitry and charges the battery pack directly taking around about 20 to 40 minutes, much faster than charging at home which typically uses a 240 volt circuit supplying 40 amps (about 10 kW of power) and can take several hours to fully charge.

Solar Boats and Boating

Sponsored by the International Powerboating Federation and the Prince Albert II of Monaco Foundation, the sixth Monaco Solar & Energy Boat Challenge was held In Monaco the beginning of July.

The competition attracted 34 teams (14 nationalities) offers a glimpse of the future putting a spotlight on developments taking place. With over 400 competitors, exhibitors and speakers, and an estimated thousand visitors over the four days, the event demonstrated the importance of sharing expertise and brainstorming of ideas which is at the heart of any successful innovation. The Monaco Yacht Club General Secretary Bernard d'Alessandri said, 'The Monaco Solar & Energy Boat Challenge is contributing to the thinking on yachting's future. Through this event and as part of the project to make Monaco a yachting capital, the Principality is providing a crossroads for experiments of the industry, engineers, boatyards, students and owners in their bid to meet the energy and environmental challenges facing the nautical sector.'

Competition in the Solar, Offshore and Energy class events was intense. The solar event which has featured in every year's Challenge was the best represented with 19 entrants, and the Dutch continue to sweep the board. For the first time since this event was launched in 2014, the solar fleet managed a three-hour non-stop race covering nearly 20 nautical miles at sea offshore.

In the Offshore Class, the battle for top spots was between students in the TU Delft Solar Boat Team and the yachting professionals in the Vita Yachts team. The Vita team won the 16nm endurance race, while the students from the Netherlands clinched victory in the 32nm Long Race with a focus on maintaining their boat's range and not speed. The Delft Solar Boat Team comprises 28 students from ten different faculties at the university and over 12 months, go through the entire process of designing, building, testing, and ultimately racing the solar-powered boat.

The Monaco competition is very much in line with the vision of the Monaco Yacht Club President HSH Prince Albert, who came to meet exhibitors and to encourage contestants. He said, 'Training and educating our young people, their development, creativity, awareness and involvement are the guarantors of a better future. Let us give them a chance, give them all the tools they need to succeed and above all put our trust in them.'


Delft University Champions

Solar Boats and Boating

We have been reporting on the pioneering solar boat *TURANOR Planet Solar* since 2102 when it first voyaged around the world using only solar power. After its record breaking circumnavigation the boat took on a new name and became a laboratory for the Swiss Foundation Race for Water. In 2017 *Race for Water* set off on a four year mission to investigate plastic pollution in the world's oceans.

Julien Girardo

Conserving the world's oceans

It is not necessary to travel far to meet plastic litter, a short walk is usually sufficient.
Unfortunately, as David Attenborough's BBC documentary Blue Planet revealed all too graphically plastic refuse has migrated into the worlds oceans where it is accumulating at an extraordinary level. After two months in the Philippines, the world's largest solar powered boat, is headed next for Malaysia. Everywhere it stops in the Pacific it posts reports of local populations being overwhelmed by an ever increasing water borne tide of plastic. Two years into their investigation *Race for Water* has concluded that collecting plastic waste at sea is impossible and that action must be taken on land, where part of the problem is that single use plastic has no or little recyclable value The Foundation is working with Biogreen, part of ETIA a French engineering Group that specialises in eco technologies. Biogreen has developed a small scale pyrolysis system that converts biomass, plastics, and waste into energy and other products, which gives it a value and encourages collection and processing. The system fits into shipping containers and is a size that can be sited locally to where plastic refuse is accumulating.
Microplastic particles created by the disintegration of plastic litter, are now being found in the deepest oceans, and in the air, soil, and rivers round the world.
The particles have not only entered the marine food chain but research has also shown that up to five grams a week are being ingested by humans.
The long term ecological and health consequence plastic pollution is as yet unknown. However, global warming is measurable and the long term implications of climate change increasingly apparent. *Race for Water* is very much aware that the world needs to deal with fossil fuel pollution as well as that of plastic and is committed to continuing to demonstrate that sailing with renewable energy is possible and that renewable energy transition is a reality.
After almost a decade the design and tech details of this futuristic boat are still very relevant today and we revisit them in our retrospective on page 15.

Julien Girardo

click on the red dots

Solar Boats and Boating

Sustainable Solar Power

Race for Water was built in Kiel Germany in 2010 and is 35 metres long with a beam of 15 metres and a displacement of 85 tonnes. The catamaran has 500m² of Sunpower solar panels, totalling 38,000 photovoltaic cells, located on the upper deck of the catamaran and on the two detachable wings, which can supply 93 kWh and power the engine at an average speed of around 5 knots. Maximum engine power is 120kW and average engine consumption is 20kW. The solar panels charge a 7.5 tonne 745kWh lithium-ion battery bank which when fully charged are capable of powering a variety of harbour side events such a concerts, light shows and exhibitions.

The boat went under a substantial refit when it was taken over by the Race for Water foundation and has added two further sources to its renewable energy mix. Working with Swiss Hydrogen SA the boat has an integrated on board system for producing hydrogen from seawater. 25 cylinders of hydrogen at 350 bar store of approximately 200kg of hydrogen, which can be converted into more than 2,600 kWh of electricity, more than four times the electrical storage contained in the batteries. Seawater is pumped, desalinated and stored on board This fresh water is then purified before being electrolysed using surplus solar power. The electrolyser produces hydrogen at 50 bar, which is then dried, compressed at 350 bar, and then stored in the dedicated cylinders. The hydrogen is converted to electricity by two 30 kW fuel cells, as required and makes it possible to be self-sufficient in energy for six days at a speed of 5 knots.

Race for Water in co-operation with Skysails, is also demonstrating a new-generation traction kite with a surface area of 40m², which extends to a height of 150m, the equivalent of 500m² of sail on the sea, or 200 kW of propulsion. It is managed automatically and will double the speed of the boat under certain conditions. Very much aware that plastics are not the only type of pollution facing the ocean, Marco Simeoni, the Swiss founder of the Race for Water Foundation, is committed to energy transition. 'For this four year Odyssey we are sailing a vessel powered only by clean energies: solar, wind and hydrogen,' he says, 'It is essential to demonstrate that sailing with clean energy is possible and that energy transition is a reality.'

Solar Tech

Rooftop solar

The global rate of is solar energy installations is growing and the average cost of installing solar has fallen from $7 per watt to $2.8 per watt, making rooftop solar attractive to many more homeowners. But the progress of rooftop installations is often slowed by having to use expensive and labour intensive structural assessments.

At present automating the process requires expensive three-dimensional aerial maps using LIDAR technology not available for many areas.

Now a team of researchers from UMass Amherst College of Information and Computer Sciences is proposing a new, data driven approach that uses machine learning techniques and widely available satellite images to identify roofs that have the most potential to produce cost-effective solar power.

Their "DeepRoof" system takes advantage of recent advances in computer vision techniques and uses satellite imagery to accurately determine roof geometry, nearby structures and trees that affect the solar potential of the roof. The team trained "DeepRoof"to recognise and extract planar roof segments using different roof shapes and sizes from six different cities. The results show that "DeepRoof" can identify the solar potential of roofs with 91 percent accuracy.

Solar tarrifs

At China's request the World Trade Organization is to set up a dispute panel tasked with judging whether US tariffs on solar panels violate international trade rules. The trade restrictions were imposed by President Trump's administration last year, part of a raft of measures initiated by Washington that have triggered a tit-for-tat tariff war between the world's top two economies. China filed its first complaint on the solar panel tariffs at the WTO in August 2018.

Solar Boats and Boating

The Sunflower is a proof of concept electric liveaboard broadbeam using solar generated power for both propulsion and domestic use.
Although designed to be a family home with space aboard for guests the boat is capable of cruising at around 3mph with very little sound or wash.
The technical specifications are looked at in detail below but the boat has proved so successful that it has gone into production and Thames Solar Electric has already completed a second fully solar powered widebeam.

Self-sufficient electric broadbeam

The Sunflower is a 65 by 13 feet 48 tonne broad beam canal and river boat and its most obvious external feature are the solar panels covering around two thirds of the roof. The 6kW array is controlled by two Voltocon MPPT units that can each handle up to 5kW of charge which would allow for more panels to be added to the system if required. The solar panels charge a fork lift truck battery bank of 48 2V lead acid cells with an automatic water top up system. Fully charged the battery bank has a total capacity of approximately 96kWh. The domestic use is approximately 5kWh which doesn't cover heating water so theoretically the battery bank could cover a couple of weeks without any input from the solar panels. But even on a cloudy day in autumn the panels produced around 400W at 8am and 1kW at 11am. Bright sunshine is not required although when the sun shines the panels output increases dramatically. When the battery bank is fully charged any excess power produced is used to heat a large water storage tank.
Propulsion is provided by two 13kW DC Lynch motors which belt drive two propshafts either side of a single rudder. The motors are mounted high up in the engine room allowing good ventilation and access. At a speed of around 3mph *The Sunflower* can cruise for between five and ten hours on the battery bank alone depending on variations in speed and power requirements. Cruising in good daylight, with the solar panels charging the batteries, improves the boat's optimum range. The motors are controlled separately which enables the boat to turn easily by running one motor in forward propulsion and the other in reverse. And of course the boat is very quiet.
The only other DC systems on the boat is a Vetus bow thruster and two water pumps, everything else, fridge freezer, dishwasher, washing machine and induction hob, are standard AC 230V appliances served by the two Voltocon controllers that are also 230V inverters. Having decided to go all electric the overall design of the boat is focused on saving energy; from the triple glazed windows to the concrete floor which is coated with resin and which provides underfloor heating while acting as a thermal store of energy in Winter There is a gap between the insulated floor and the boat's base plate which allows water cooled air to be drawn and circulated in Summer. It is such attention to design that takes *The Sunflower* to another level in energy self sufficiency.

Solar Boats and Boating

Helsinki to Finland by sauna

A self-made floating sauna has made a journey across the Gulf of Finland travelling from Helsinki to Tallinn in 16 hours.

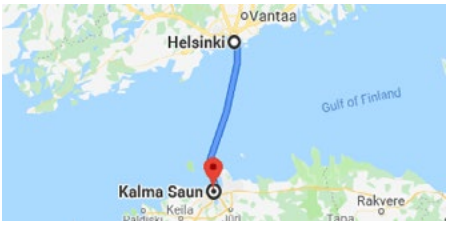
The sauna built on a raft by Finnish inventor Janne Kapylehto is equipped with four engines, solar power panels, a sauna for three, an observation post, sound system, a fridge and a grill.

The voyage of 82 kilometers took longer than expected as the raft faced 1.5 meter-high waves and winds of up to 15 meters per second.

Yet despite the rough weather, Kapylehto and his crew of two spent hours in the sauna during the voyage as well as using the grill for a barbeque.

The floating sauna was accompanied by an escort boat.

'The vessel performed really well and felt safe, even though there was water everywhere, rain and high waves. We wanted to do the trip because it was challenging and fun and also a way of celebrating the centenary of Estonia's founding,' Kapylehto said.



Floating home in Côtes-d'Armor

Moored at the port of Trebeurden in Côtes-d'Armor *Anthenea* is a completely autonomous floating house designed by a French naval architect Jean-Michel Ducancelle. Power is provided by five solar panels placed on the dome, a marine turbine, and a back-up genset The floating home has two floors, a living room with open kitchen, a dining room, two bedrooms, bathroom, a waste water treatment system, and a desalination system.

Solar Tech

Agrivoltaics

The most productive places on Earth for solar power are farmlands, according to an Oregon State University study published in the journal Scientific Reports.

The concept of co-developing the same area of land for both solar photovoltaic power and conventional agriculture is known as agrivoltaics.

For their study, OSU researchers analysed power production data collected by Tesla, which has installed five large grid-tied, ground-mounted solar electric arrays on agricultural lands owned by Oregon State.

Specifically, the team looked at data collected every 15 minutes at the 35th Street Solar Array installed in 2013.

The researchers synchronized the Tesla information with data collected by microclimate research stations they installed at the array that recorded mean air temperature, relative humidity, wind speed, wind direction, soil moisture and incoming solar energy.

Based on those results, Elnaz Hassanpour Adeh, a recent Ph.D. graduate from OSU's water resources engineering program and co-author on the study, developed a model for photovoltaic efficiency as a function of air temperature, wind speed and relative humidity.

'Our results indicate that there's a huge potential for solar and agriculture to work together to provide reliable energy,' said corresponding author Chad Higgins, an associate professor in OSU's College of Agricultural Sciences.

'We found that when it's cool outside the efficiency gets better. If it's hot the efficiency gets worse. When it is dead calm the efficiency is worse, but some wind makes it better. As the conditions became more humid, the panels did worse.

Solar panels are just like people and the weather, they are happier when it's cool and breezy and dry.'

Interactive Red Dots

Click on the Dot

Be taken to another world

ELECTRIC BOATS INTERACTIVE

Cruise Guide

Earith to St Ives

Cruise Guide

Earith to St Ives

According to the guides Earith is an old name meaning a muddy landing place and when St Ives was a small Saxon village on the riverbank it was first known as Slepe also meaning muddy or slippery. So our first cruise guide in this new interactive digital magazine takes us from one muddy place to another. Fortunately the riverbank access has been much improved over the centuries. We are travelling on a section of the River Great Ouse which flows through St Ives and Earith on its way to the Wash at King's Lynn. On the first part of our cruise the river is tidal up to Brownshill Staunch, but during the summer months the rise and fall is only about 30cms although heights can increase with heavy rainfall.

Westview Marina is where the Old Bedord and Old West Rivers meet to become the River Great Ouse. So as we leave the marina we turn right to head up the Ouse and pass Nb Sunflower, the all electric narrow boat that featured on the Electric Boat Association's stand at the 2017 Crick Boat Show.

Progressing up stream to Brownshill staunch, first lock of the cruise, we pass Bury Fen on the left bank where the brick piers at the rivers edge are the remains of the old St Ives to Ely railway. Brownshill Staunch dates from 1834 when staunches were simple barriers built to control the river water level. When open they created a ford for road traffic and when closed

created a depth of water for river navigation. Passage through the gate was simplest when the upstream and downstream water levels were aligned. The modern lock has electrically operated guillotine gates which are manually controlled by following the instructions on an electronic panel. There are large gravel workings on

Cruise Location

St Ives Town Quay

either side of the river which are connected by a covered conveyor beltway that crosses the river above the Brownshill sluice and lock. Brownshill Staunch is not only the tidal limit of the Ouse but also the end of the flood banks on the eastern edge of the fens and the river now starts to follow its own course.

Once through the lock we pass the Pike and Eeel Inn and Marina at Overcote. The inn dates from the 17th century and marks the site of the old Overcote ferry.

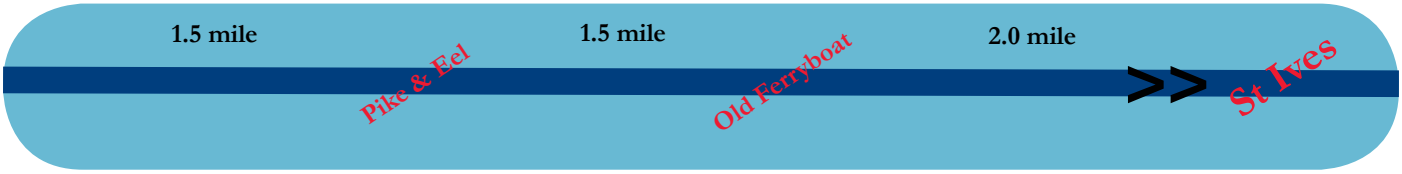
Moving upstream towards Holywell we come to an even older inn again situated at a past ferry crossing point. The Old Ferry Boat Inn was rebuilt in the 18th century and subsequently modernised but still retains some features that date back to the 14th and 15th centuries and possibly earlier.

The river here is a good area for reeds and rushes which are harvested in the summer months to be used in thatching and other traditional crafts.

After passing Holywell the river becomes shallower and narrower in parts before reaching the old railway bridges that are now used by the Cambridgeshire Guided Bus. Further on the river turns and is very shallow on the inside of the bend before turning again to head to St Ives Lock. Again this is an unmanned electric guillotine lock. Once through the lock the entrance to Jones Boatyard is immediately on the left. We then go under the St Ives bypass road bridge

and the river widens as it goes past the former old steam flour mill, now a modern flat conversion, on its way directly to the town centre. On this stretch of river there is a 4 knot speed limit. Public mooring is available at the Town Quay on the north bank immediately before the town bridge.

The cruise from Earith to St Ives is on very attractive stretch of the Great Ouse which is also enjoyed by grey seals and a wide variety of wildfowl including for the sharp sighted grey heron.



Info

Launching

Jones Boatyard, Boathaven, Low Road, St Ives PE27 5ET has cranage and slipway facilities.
Tel: 01480 495280

Licences

Short term licence fees depend on boat size. There is a 25% discount for electric propulsion which is detailed on the application form which can be downloaded from:
Environment Agency
Anglian Region
Kingfisher House
Goldhay Way, Orton Goldhay
Peterborough PE2 5ZR
Tel: 0370 850 6506
www.environment-agency.gov.uk

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PE27 5BX
Tel: 01480 700676
Real ales
Riverside garden
Wifi
www.floods-tavern.co.uk

Tourist Information

www.stives-town.info/tourism.asp

The Oliver Cromwell

A former Town Pub of the Year. The Oliver Cromwell has a good selection of local and national ales and ciders and was the CAMRA Cider Pub of the Year in 2017.
The pub was previously an 18th century house known as the Waterside before becoming legally recognised as a pub called the Feathers in 1841. When the Old Ship Inn closed in 1890 its ornate pub sign and bracket was transferred to the Cromwell, together with the spirit licence. The present owners took over in 2002 and have retained the pub's unique atmosphere.

St Ives

A Saxon village from around 500 AD which changed its name some 500 years later when a stone coffin with a skeleton inside was uncovered in nearby fields. Local monks decided that they were the remains of St Ivo a 7th century missionary and St Ivo's priory was built on the site. More recently the remains of a roman villa have been found on the site and the skeleton is more likely to have been Romano British. What is certain is that Oliver Cromwell was a farmer and churchwarden in the now prosperous town of St Ives which held of one of the four largest wool fairs in England. The first bridge across the river was built around 1100 and was replaced in 1420 with the present day stone bridge, two arches of which were demolished during the civil war and replaced with a drawbridge. These two southermost arches were rebuilt in 1716 and are a different shape to the others. The chapel on the bridge is one of only three bridge chapels in the country. It was consecrated in 1426 and has been used not only as a chapel but as a toll bridge, an inn and a private dwelling before being completely restored in 1930.
St Ives was once one of the busiest inland river ports in the country. For centuries the river and associated businesses of boat building, barging, rope making, grain storage, corn and lime shipping, and brewing, were its main industries. Many of the buildings associated with his industrial heritage can be found on the river front and around the historic Waits Quay situated on a small tributary branching off from the river at Holt Island just upstream from the town bridge.

Electric Boats International

Golden Gate Fuel Cell

United States

San Francisco Bay is soon to have the first fuel cell ship in the US and the first commercial fuel cell passenger ferry in the world. The ship is being built by Golden Gate Zero Emission Marine (GGZEM) in partnership with shipyards, equipment manufacturers and forward thinking operators looking to further Hydrogen Fuel Cell technology in the marine environment.. The catamaran ferry is scheduled to be launched in mid-2019 and will have a 264 kg hydrogen tank array of 250 bar compressed gas, which will provide up to 2 full days operation. With an aluminium hull and an overall

length of 70 feet the ferry will carry 84 passengers with a high visibility window arrangement.
There is a 300 kW (400 hp) shaft motor in each of the catamaran's hulls together with 100 kWh batteries to provide boost power to achieve up to 22 knots. Once launched the ferry will undertake three months of analysis and trials.

Zero emisssions

United States

A report from Sandia National Laboratories in New Mexico and California has found that when the synthesis of hydrogen, transportation and storage is taken into account hydrogen fuel cell technology, is not as clean as first thought. Hydrogen fuel cells do have zero emissions but when they use hydrogen sourced from natural gas the overall emissions are the same or worse than diesel engined vehicles. Two separate types of emissions were considered for the report. Greenhouse gases (GHGs) such as carbon dioxide (CO2), and other pollutant emissions such as unburned hydrocarbons, nitrous oxide (N2O) and particulate matter. As the only emission from fuel cells is water vapour the report focused on how hydrogen was made and delivered and compared the level of GHGs and other pollutants created by supplying hydrogen to a fuel cell ferry with those created by an equivalent diesel powered vessel. The report found that the pollutant emissions in respect of the hydrogen produced for a fuel cell ferry were far below those of an equivalent diesel ferry, no matter how the hydrogen is made. But the GHG emissions from making the hydrogen from natural gas were higher than the emissions of the diesel ferry. However when hydrogen is produced by electrolysis using renewable energy the overall GHG emissions fell by 76%.

Electric Rib

France

Zodiac Nautic has developed a fully electric tender, the Avon eJet 450. Powered by Torqeedo's 55kW Deep Blue electric motor and a modified version of the 30.5kW lithium ion battery pack used in BMW's i3 electric city car, the eJet gets about 90 minutes of range at 23kts, or seven hours at 5kts. It's maximum speed is around 31kts. According to Zodiac Nautic the new tender solves a number of problems faced by yacht owners with tenders including carrying fuel and issues of maintenance and reliability.

Electric Boats International

Electric Safari

Vietnam

Song Lo Shipbuilding in Nha Trang, Vietnam, has recently delivered a 15-vessel fleet of electric powered passenger excursion boats to Vinpearl's newest resort development in Hoi An. Vinpearl is the largest hospitality group in Vietnam with a chain of luxury hotels, villas and theme parks across the country and the new boats are being deployed at Vinpearl Land Nam Hoi An, a massive 62.4-hectare theme park where they are being used for sightseeing tours of the River Safari jungle habitat, as well as for entertainment in the replica Hoi An Old Town section of the park. The nine-metre FRP displacement craft are powered by Torqeedo Deep Blue 80 inboard electric motors with BMW i3 lithium batteries. They are reportedly the first fully electric powerboats ever built in Vietnam. The composite boats are fitted with wooden bench seating allowing up to 24 passengers per boat, who are supported by three crew members. The boats measures in at 8.7 metres long, 2.9 metres in beam and have a draught of just 35cm, for a full-load displacement of four tonnes. The in-built propulsion system is just 60kW, which is enough to propel these deliberately slow-moving cruisers through the grounds of the park at a cruising speed of 3.8 knots. 'We are very happy with the performance of the DeepBlue system for these boats,' said Nguyen Van Thanh, Director of Song Lo Shipbuilding Company. 'They are very quiet and provide a smooth ride. The installations and commissioning went very well, thanks to the excellent technical support we received from Torqeedo.'

Float charging

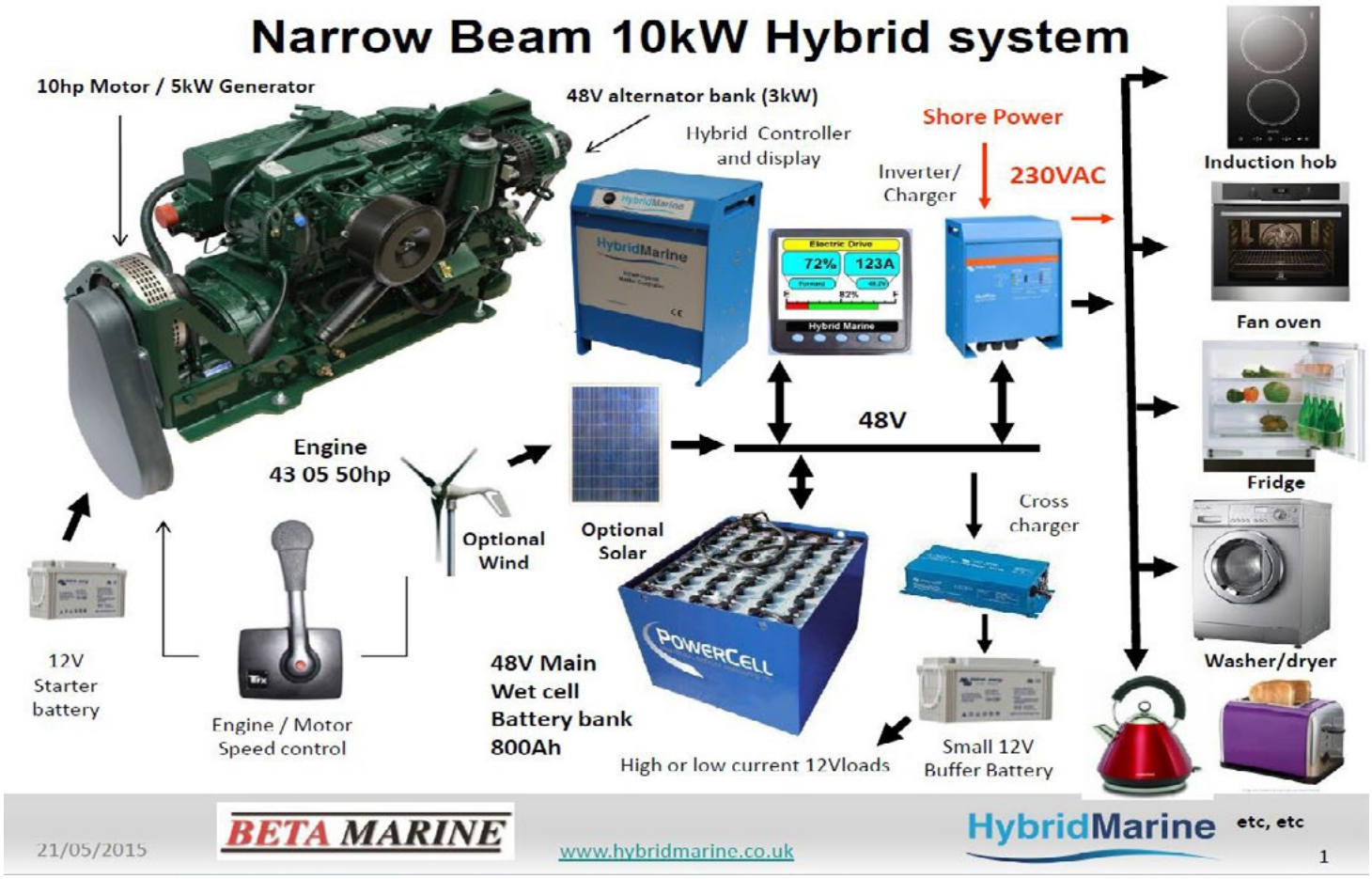
United States

The Blue Isles solar microgrid dock is a floating charging platform with a non skid solar panels, energy storage and power distribution system which can provide free and renewable electric power to boats in remote locations away from marinas. Developed by PowerDocks, an American company, the platform stores the energy received from the solar panels while floating. Boats can either moor or dock at the platform and then connect their own cables to a charging pedestal on the platform. The microgrid is fully customisable in size, materials energy generation and storage configurations. The platforms provide a 90 meter wifi connection range and boaters using Blue Isles can download a smartphone app that controls charging, monitors electricity usage and shows the temperature of the batteries on the platform.
The Blue Isles Solar Microgrid Dock was the 2018 winner of Electric & Hybrid Marine's Innovation of the Year Award.

All boats to be electric in Venice

Italy

Electric boats were one of the key features at the Salone Nautica di Venezia, held in June. The two Italian waterbus companies, Alilaguna and ACTV each displayed a hybrid-electric prototype able to handle the relentless 24 hour tourist demand. ACTV has decided to build an initial batch of 35 of these during the next two years to replace their noisy-smoky-diesel versions. Opening the show Venice Mayor Luigi Brugnaro spoke about a green sustainability for future generations and declared that in the future the only type of boat in Venice would be electric.



History and Heritage

Barbara Penniall continues to report on the history and heritage of electric boating.


Siver Sail


Switched Off electric narrowbat


Unity electric broadbeam

Electric motors turn full circle

In previous articles I have looked at the electric boat activity on the River Thames. At the end of the 19th century The Immisch Electric Launch Co. and the Thames Valley Launch Co. each had about sixty electric launches for hire, there were about the same number in private ownership and most of the large boat builders had experience in building, fitting out and hiring electric boats.

By this time working narrow boats were also a common feature of the inland waterways, particularly once the canal system expanded to link the industrial centres throughout the UK. Originally horse drawn, they provided a livelihood for many bargee families – living, working and travelling throughout the whole system. It was a network that provided a waterway highway to transport heavy goods. Towards the end of the 19th century steam power was beginning to be introduced to canal boats. In 1886 Fellow, Morton & Clayton Ltd (FMC) started to replace their horse drawn craft with steam power, working non-stop day and night on long distance runs, which of course, could not be done with horse power. However, the disadvantage of steam was the fuel required to power it which replaced valuable space that could have been filled with cargo. The development of the internal combustion engine at the turn of the century and the effects of the First World War proved the death knell for both steam and electric propulsion. Companies started to install diesel engines.

Following the Second World War, in 1948 the waterways were nationalised and most of the working boats still in operation were transferred to the British Transport Commission, which 20 years later became British Waterways. Unfortunately immediately following the war years the canals were showing signs of neglect and lack of maintenance. By the 1960s many working boats were surplus to requirements and following a particularly bad winter in 1963, when many boats and their cargoes were unable to move, the British Waterways Board decided to discontinue most of its boat carrying operations. By this time the canals were almost entirely used by pleasure and private craft with a few companies offering narrow boats for holiday hire and there was virtually no interest in electric propulsion.

The situation slowly changed with the import of electric outboards developed in the United States as trolling motors for fishermen on the lakes, and the practical activities of Rear Admiral Percy Gick and Lord St. Davids. The former, supported by the Midland Electricity Board, took an electric Trentcraft cruiser 600 miles up the Thames and around the canals and Lord St Davids moored *Silver Sail* a small narrow boat powered by a prototype Lynch outboard motor at the bottom of his garden on the Regents Canal, from where he cruised over 4,000 miles between 1981 and 1991. The two of them also founded the Electric Boat Association, the first of its kind in the world to promote the benefits of electric propulsion.

Although for most of the 20th century barges, or narrow boats as they are now more commonly known, were usually fitted with diesel engines, by the 1990s more leisure boat owners were exploring the advantages of fitting their craft with electric motors. Electric propulsion has now turned full circle. Companies which had previously concentrated on electric motors for smaller river craft now turned their attention to developing various alternatives to petrol and diesel powered motors in narrow boats. With the development of photovoltaics and solar panels being fitted to boats, long distances can now be travelled on the canals and inland waterways without suitable charging points being available.

Over the last few years, people are becoming more aware of the earth's diminishing resources and now that electric cars have become an acceptable form of transport, increasingly within the scope of most household budgets, the acceptance of electric boating is catching up fast. At all today's major boat shows there will be examples of electric or hybrid narrow boats and companies can be found exhibiting various alternatives to conventional propulsion. Once the authorities realise that the public prefer silent electric boating and improve the infrastructure on canals and rivers, then electric narrow boats will be accepted as being as normal as electric cars.

click on the red dots

OEVs

Now do you believe in flying saucers

Designed by Pierpaolo Lazzarini from Italian company Jet Capsule, the concept "flying saucer" seats two people and is powered by eight electric engines that have a battery life of up to 70 minutes. The vehicle is powered by eight electric rotary engines that push the saucer to an estimated top speed of 120mph (190kph)
The cockpit capsule is installed with an emergency parachute and has a carbon fibre casing to protect users. It is accessed either through an elevator that descends from the vehicle's main body or via detachable foot bridges. 'The vehicle does not change much with respect to the technology that is at the base of a standard drone,' said designer Lazzarini, 'But it is driven from the inside and can reach the average helicopter altitude.'

COTSbot Starfish killer

A starfish-killing, artificially intelligent robot is now patrolling the Australian Great Barrier Reef. The underwater autonomous vehicle is programmed to patrol the reef in search of destructive crown-of-thorns starfish (COTS), which it then kills by lethal injection. These starfish prey on coral polyps, and although they are native to the reef, their population has exploded in the past few years, possibly because of overfishing of their natural predators. The latest report from Australia's Great Barrier Reef Marine Park Authority places the venomous invertebrates alongside climate change and human activity as a significant threat to the reef which lost half its coral cover between 1985 and 2012.

Bee backpacks

University of Washington engineers have developed a sensor small enough to place on bees. Each sensor only need a tiny rechargeable battery and charges when the bees return to their hive at night. The sensors can gather data on humidity, temperature, light intensity and log the bees location. All the data can be uploaded when the bees return and the information can be compiled to study the crop health of an entire farm.

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