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Technology Watch: net zero edition

Alternative fuel options such as hydrogen, ammonia, and methanol are charting a new course for maritime sector decarbonisation.

Pages 05, 07 & 17

BAE SYSTEMS

Foreword

Contents

Outsmart **Insight**

Independent Delivery Partner

Technology Watch is delivered in partnership with Outsmart Insight Ltd, a UK-based technology intelligence company – powered by crowdsourcing and supported by a global network of scientists, engineers and innovators who are developing next-generation technology in labs around the world.

Collaborating will be key to achieving our ambitious net zero goals and it is great to see such a range of innovative approaches in this special edition of Technology Watch: net zero. As you may know, BAE Systems has committed to achieving net zero across our sites and facilities by 2030 and net zero across our supply chain and products by 2050. To meet these aspirations, it is important that we recognise and utilise the many ideas already starting to prove themselves, such as those highlighted here.

Since net zero covers a broad range of topics; for this edition we have focused on 5 areas: Alternative low-carbon & synthetic fuels; efficiency & optimisation; simulation and modelling; carbon removal & emissions capture and finally fixed infrastructures.

The use of digital, data and model-based approaches to address energy efficiencies is a particular highlight for me. Benefits of digital twins to manage carbon emissions are illustrated at different points of the product lifecycle (page 16-21). In addition there are a variety of novel digital solutions utilising behavioural science, machine learning and artificial intelligence (page 10-15) which highlight the growth opportunities for new products to manage energy consumption and emissions.

Many alternative fuel options such as hydrogen, ammonia, and methanol, are presented. In the Maritime arena, there remains a variety of choice and it is clear that a single "winner" has not yet emerged. Indeed, some companies appear to be backing multiple options and this may be the approach defence will also adopt.

Read more about BAE Systems' own development of sustainable technology across electrification, more efficient facilities and synthetic training.

I am encouraged by the variety of ideas and solutions in this magazine that stem from SMEs, many of whom are working with larger companies to bring their capability to market. In fact, there were so many interesting signals to highlight, we have included a list of links at the end of this magazine to some of those signals that, simply for space reasons, we couldn't include. Please follow the links and enjoy reading these too.

Finally, I hope you feel inspired by what you read in here, to find potential projects and collaborations that will help us to reduce our emissions and achieve our net zero aspiration.

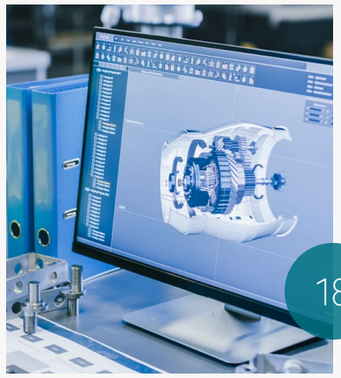
Cathy Davis

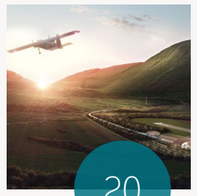
C.Eng, FIET

Head of Strategy, Sustainability, Simulation & Synthetics

BAE Systems Chief Technology and Information Office

As a leading technology company in the defence and security sectors, BAE Systems actively positions itself at the cutting edge of science and technology in order to maintain and advance its world-leading capabilities.





Set against the global environment, where the pace of innovation continues to accelerate and is profoundly diversifying, it is necessary for BAE Systems to keep abreast of science-driven innovation and breakthrough technologies as they emerge across the global horizon.

Sponsored by our Chief Technology and Information Officer, the CTIO Team brings you Technology Watch: net zero edition, a digest of insights from sources outside the organisation in order to enhance our broad, external view of global developments and how this technology is evolving.

We seek to promote awareness of breakthrough technologies, deepen our understanding of their short- and long-term impact to BAE Systems, stimulate discussion and inspire imaginative thinking in ways that could improve the performance and enhance the capabilities of our products and services.

This issue of Technology Watch focuses on Sustainability through five themes. We value your questions, comments or feedback at:
ctocomms@baesystems.com

Technology Watch is prepared by Outsmart Insight for BAE Systems, taking inputs from a variety of verified sources in the public domain.

Views expressed in this publication are from independent specialists and do not necessarily reflect those of BAE Systems.

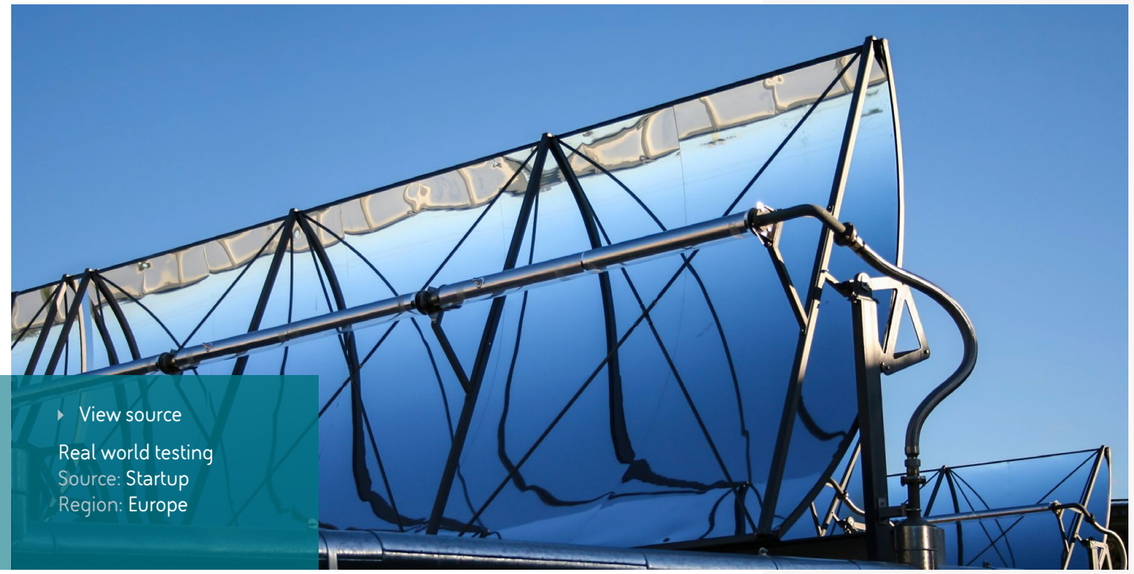
Alternative low-carbon and synthetic fuels

Emerging innovation in the sustainable manufacture of drop-in fuels, as well as synthetic and low-carbon alternatives for aviation and maritime platforms

Further reading...

Watch this video to learn more about Synhelion's technology.

Watch now



View source

Real world testing
Source: Startup
Region: Europe

Solar energy could turn air into carbon-neutral aviation fuel

What's the innovation:

Fuels produced from sunlight and air – which are compatible with existing aircraft infrastructure – could soon become a reality. Synhelion, a Swiss startup, has developed a technology to concentrate the sun's heat to power a process that converts CO_2 and water into syngas, which can be turned into jet fuels.

How it works:

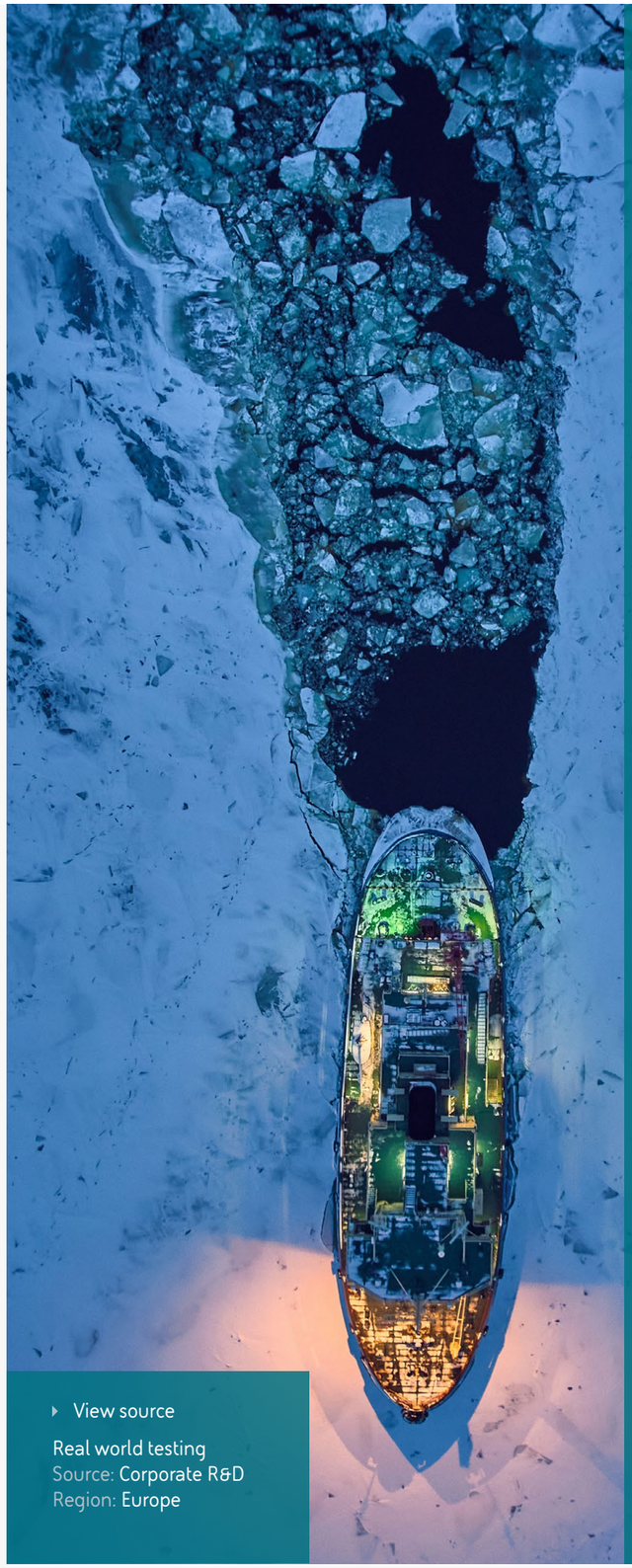
- Synhelion's technology takes in ambient air, which contains carbon dioxide and water.
- An array of mirrors focus sunlight to a single point, creating temperatures of 1,500°C. This heats a thermochemical reactor which removes the oxygen from the carbon dioxide and water, producing syngas, a mix of hydrogen and carbon monoxide.
- The syngas is then processed by standard gas-to-liquids technology into fuels, such as gasoline, diesel, or kerosene.

Context:

- Solar fuels are carbon neutral since they absorb the same amount of CO_2 in production as they release in combustion.
- Synhelion says its system also captures excess heat through thermal energy storage to enable 24/7 operation, giving high plant uptime that delivers competitive pricing.
- Production plants are ideally placed in arid areas, meaning they do not compete for agricultural land, unlike biofuels.

What next:

Synhelion is working on opening its first industrial-scale production plant in Brainergy Park Jülich (Germany), where production is set to commence in 2023, with a goal to produce 2 million litres of Syngas per year by 2025. Swiss International Air Lines and Lufthansa Group recently announced a strategic collaboration with Synhelion to bring its fuel to market, which will make SWISS the first airline in the world to use solar kerosene.



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Real world testing
Source: Corporate R&D
Region: Europe

Dedicated fuel supply for methanol engines to provide a low carbon power for ships

What's the innovation:

Methanol has the potential to be a low carbon fuel for shipping, but requires new power systems to work. Wärtsilä (Finland) has developed a dedicated fuel supply system, MethanolPac, that can be used with its new methanol engines to provide a turnkey solution for equipping new vessels, and retrofitting existing ones.

How it works:

- Methanol fuel can be synthesised from CO_2 and hydrogen in a reaction powered by renewable energy. Burning green methanol releases equivalent CO_2 as is captured in production, making it carbon neutral.
- However, methanol has different physical properties to conventional marine fuels and requires tailored pressurised delivery, control, and safety subsystems.
- MethanolPac comprises pump modules, valves, and instrumentation that make it the first dedicated technology for delivering methanol fuel for combustion in methanol engines.

Context:

- A wind turbine installation ship, under construction for Van Oord (Netherlands) will feature the first combined installation of MethanolPac along with a Wärtsilä 32 Methanol engine.
- There are more than 5,000 Wärtsilä 32 conventional fuel engines in operation worldwide suitable for upgrade to use methanol, and for retrofit of MethanolPac.
- Wärtsilä claims that this upgrade pathway simplifies and lowers the cost of retrofitting more sustainable power systems to existing vessels.

What next:

In addition to its methanol offering, Wärtsilä is developing power systems for other new fuels, such as an ammonia engine by 2023 and a hydrogen engine by 2025. Wärtsilä's stated goal is for ship operators to have access to alternative power systems as the respective fuels become commercially available.

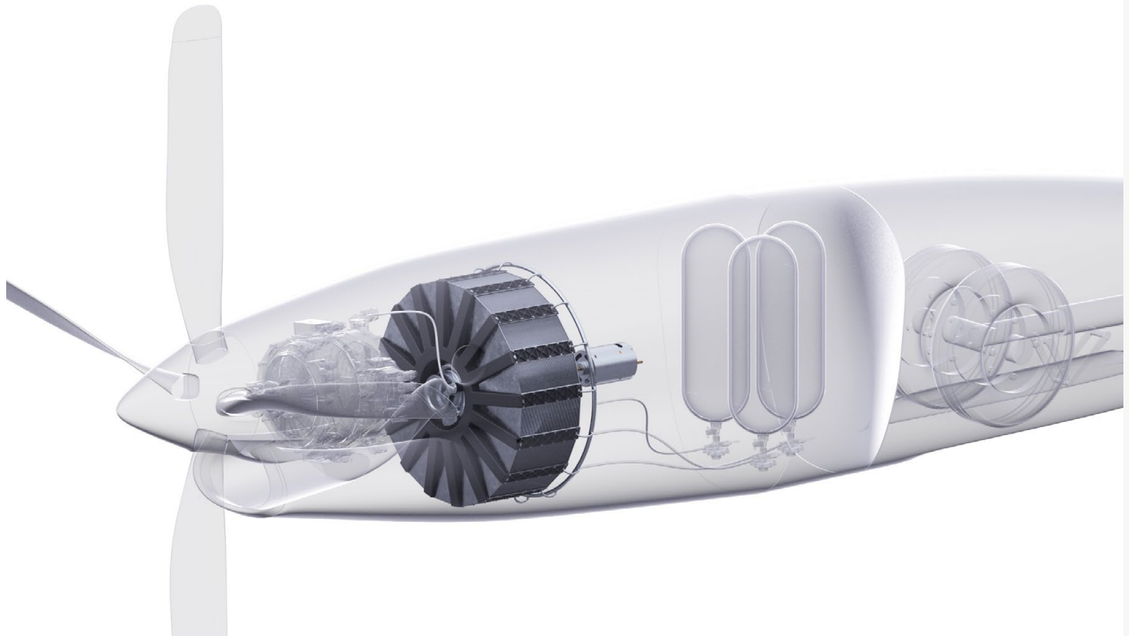


Image © HyPoint, Inc.

▸ View source

Real world testing
Source: Startup
Region: North America

Lightweight hydrogen fuel cell could extend zero carbon flight

What's the innovation:

Hydrogen fuel cells could offer zero carbon power, but their viability for aircraft is limited by how much energy they can deliver for their weight (specific power). Current fuel cells could power short flights, but adding sufficient power for longer flights would incur a higher weight penalty. Now, Hypoint (US) says it has developed a lightweight hydrogen fuel cell that could enable hydrogen powered flights for longer than allowed by existing technologies.

How it works:

- Hydrogen fuel cells convert energy created by a reaction between oxygen and hydrogen into electricity.
- The Hypoint fuel cell utilises a turbo-air subsystem both to supply oxygen for the reaction and for cooling. By using air for both, it removes the weight of the liquid cooling system used in most fuel cells, making the system 3x lighter.
- The system also features innovations in other components within the cell – membranes and bipolar plates – further improving lightweighting and cooling efficiency.

Context:

- The modular fuel cell has a specific power of 2,000W/kg and energy density of 1,500Wh/kg. This overcomes the notional 500Wh/kg threshold required for commercial flight by a factor of three.
- That creates an extended flight range, and a viable solution to decarbonise a wide range of flight applications, from drones to multi-engine aircraft.
- With additional longevity upgrades, such as corrosion-resistant coatings, HyPoint claims its system can deliver up to a 50% reduction in aircraft cost of ownership and operational cost whilst achieving 4x the engine lifespan.

What next:

HyPoint has announced that its prototype has passed proof of concept and viability testing. The company says it is now working on further tests to validate the fuel cells with the U.S. Department of Energy's National Renewable Energy Laboratory and hope to begin shipping full-scale versions this year.

From fertiliser to fuel: decarbonising shipping with ammonia

What's the innovation:

The infrastructure required for producing, transporting, and storing hydrogen gas is a major bottleneck for commercial hydrogen fuel cells. To overcome this, startup Amogy (US), has created a system which uses ammonia as the fuel, which it converts into hydrogen, which then powers fuel cells, all in one integrated process.

How it works:

- Amogy's integrated power system uses liquid-fuel ammonia and can be placed on ships for power generation.
- Its reactor consists of a high activity catalyst that enables cracking of ammonia into hydrogen and nitrogen, at lower operating temperatures and higher efficiencies than existing off the shelf technologies.
- This hydrogen then feeds a standard Proton Exchange Membrane (PEM) fuel cell, which uses it to generate electricity.

Context:

- Ammonia is energy dense and can be easily stored on ships.
- Ammonia is the second most produced chemical in the world, so infrastructure to manufacture, store, and move it is common around the world, unlike that for hydrogen.
- Amogy claims its technology offers 3x greater energy density (>700Wh/kg) than lithium-ion batteries and, due to the abundance of ammonia, its system is relatively cheap with a cost of <£0.20/kWh – similar to current automotive diesel.

What next:

Amogy secured $22.3m in funding during its first year, and more recently secured backing from Amazon to further develop its technology. The company aims to launch a small demonstration vessel powered by its technology by early 2023.

Further reading…

Read the White Paper commissioned by Amogy on the future of Ammonia as a zero-carbon fuel for transport.

▸ View source

Real world testing
Source: Startup
Region: North America

Prometheus uses renewable energy to turn air into fuel

What's the innovation:

Low carbon fuels are required for decarbonising transport but are in short supply. Prometheus Fuels (US) claims its Titan Fuel Forge is a scalable system powered entirely by renewable energy, and capable of creating carbon-neutral electrofuels from atmospheric CO_2 and water. Electrofuels are a store of surplus renewable electricity in chemical form.

How it works:

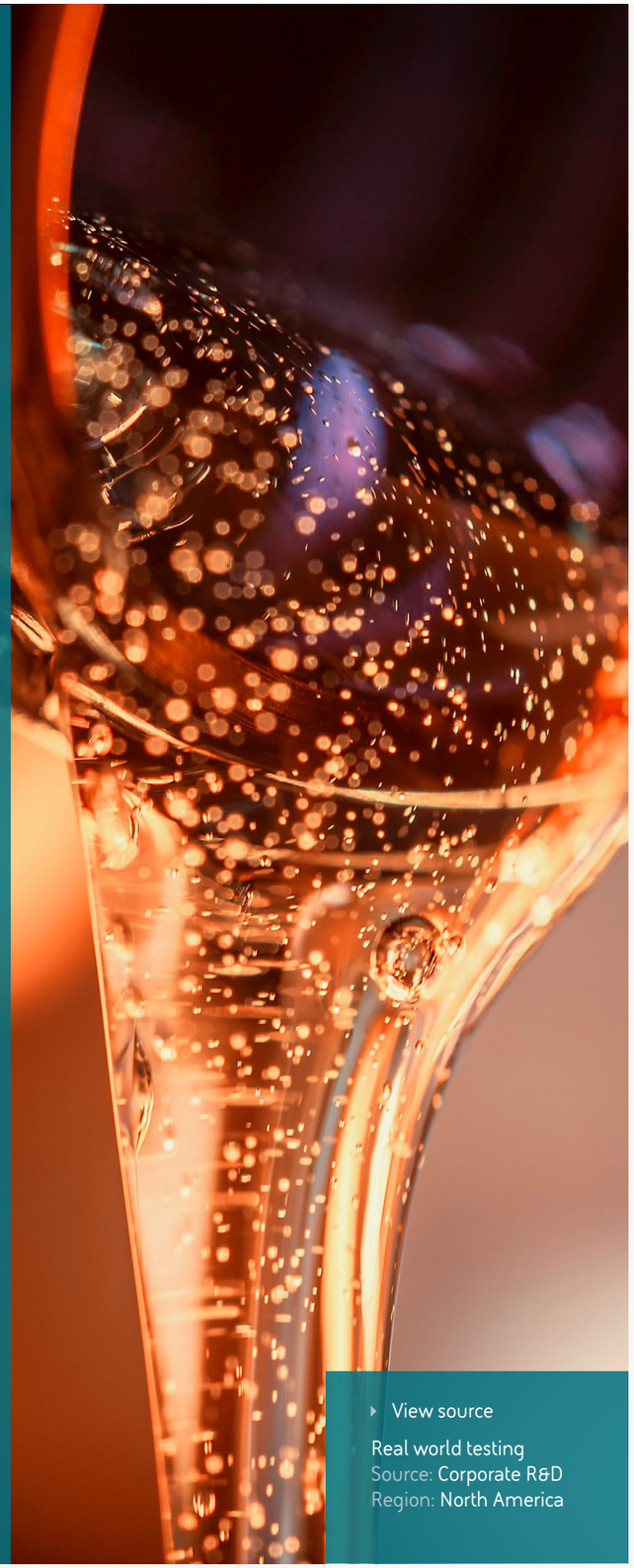
- Intake fans draw down air and CO_2 from the atmosphere, mixing it with water in a spray-formed waterfall.
- The mixture is then passed through a membrane-electrode assembly, where the electric charge drives a reaction between the CO_2 and water to form long chain alcohols. The process is powered by renewable energy.
- Carbon nanotubes are used to harvest the alcohols, rejecting water, before the purified alcohols are combined to produce hydrocarbon fuel, such as petroleum, diesel, or jet fuel.

Context:

- Maersk (Denmark) has recently invested in Prometheus and accepted a position on its board to help scale the technology.
- Prometheus claims a single Fuel Forge can produce over 450,000 litres of fuel from 900 tonnes of atmospheric CO_2 per year.
- Powered by cheap renewables, the technology is scalable and has few geographic restrictions, meaning it could be deployed in underutilised areas, such as deserts.

What next:

Maersk aims to use electrofuels to power some of its shipping fleet. Prometheus is working on scaling its technology and securing further partners.



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Real world testing
Source: Corporate R&D
Region: North America

Switching to Synthetic Natural Gas could reduce maritime emissions by up to 80%

What's the innovation:

MAN Energy Solutions (Germany) claims to have found a viable way to decarbonise shipping fuel, in the form of synthetic natural gas (SNG). To prove the technology, it operated a containership on a liquid natural gas (LNG) and SNG blend, and found a drop in emissions of 34% when compared to traditional heavy fuel oil.

How it works:

- MAN manufactures SNG via a reaction between carbon oxides and hydrogen.
- The SNG used in the trial was created at a power-to-gas plant in Wertle, Germany, which generates its own green hydrogen, and uses 100% renewable energy to power the reaction.
- The SNG was combined with LNG in 50:50 proportions and used to power a container ship, owned by Elbdeich (Germany) and equipped with a MAN multi-fuel engine, travelling between Germany and the Netherlands at standard operating conditions.

Context:

- The trial reduced greenhouse gas emissions by 27% compared to LNG alone and 34% compared to heavy fuel oil.
- MAN claims that running a vessel solely on SNG could deliver emissions reduction of up to 80%.
- Although burning SNG releases carbon dioxide, the amount is equivalent to that used to produce the fuel, resulting in a carbon neutral loop.

What next:

MAN hopes to work with the shipping industry and regulators to enable the rollout of more sustainable synthetic fuels. It is also further improving its multi-fuel engines by reducing the escape of methane from the combustion chamber.

Further reading...

Learn more about MAN Energy Solutions' Synthetic Natural Gas.

Photo © MAN Energy Solutions SE

View source

Real world testing
Source: Corporate R&D
Region: Europe

Efficiency and optimisation

Emerging innovation in AI, machine learning and big data analytics for tracking emissions and optimising for efficiency aboard vessels and airframes

Further reading…

Read more about how SailPlan is helping Harvey Gulf to cut vessel emissions

View source

Real world testing
Source: Startup
Region: North America

US Coast Guard to trial AI and real-time monitoring platform to track maritime emissions

What's the innovation:

SailPlan (US) has developed an emissions monitoring platform with a toolset for shipping to help track and reduce greenhouse gas emissions. The service can be used by fleet operators, and by regulatory bodies. For example, the US Coast Guard (USCG) will trial the platform using 'smart buoys' in the Chesapeake Bay to track emissions regulation compliance and local air quality.

How it works:

- SailPlan's platform combines data directly from vessels and other connected devices, weather information, and shipping traffic to monitor greenhouse gas.
- Up to six exhaust gases and particulates can be measured by direct sensing and SailPlan's proprietary algorithms.
- The technology can visually track emission hotspots and provide AI-assisted suggestions around how to optimise the emissions of single vessels or entire fleets.
- Additionally, it allows for the monitoring and sharing of information that affects shipping and navigation – like weather, current and tide data – which is also of use to mariners.

Context:

- SailPlan is one of several recent maritime analytics startups focused on decarbonising the maritime sector.
- For example, Green Sea Guard (UK) has developed a cargo ship emissions monitoring system that can detect nine exhaust gases.
- Alternatively, Everimpact's (Denmark) carbon monitoring system uses sensors on exhaust stacks, and will be trialled by Mitsubishi (Japan) on a number of its ships.

What next:

SailPlan is increasing the uptake of its platform. In early 2022, Harvey Gulf (US), a marine transportation company focused on deepwater operations in the US Gulf of Mexico, announced a deal to equip its Liquified Natural Gas (LNG) fleet with the system.

Photo © The test of Signol's app onboard BSMD-managed vessels not only improved crew decisions with regard to fuel consumption but also aimed to boost seafarers' morale and wellbeing due to ongoing communication and personal interaction ©BSM

View source

Real world testing
Source: Startup
Region: Europe

Behavioural science app 'nudges' ship crew to make greener decisions

What's the innovation:

Can maritime crew be persuaded to make more fuel-efficient decisions, using only reminders from their phone? The results of a trial between cleantech company Signol (UK) and Bernhard Schulte Shipmanagement (Germany) suggests so – the companies claim promising improvements in fuel efficiency during a six-month trial in 2021. In the trial, senior shipping crew used Signol's behavioural science app to encourage them to make individual decisions, such as speed adjustments, that would improve overall efficiency.

How it works:

- Signol's behavioural science app analyses operational shipping data to identify ways to increase fuel efficiency and reduce emissions.
- Each week, the app sends 'nudges' to crew, setting them personalised targets to reduce fuel usage and improve efficiency, based on their achievements so far.
- Through a combination of fair targets and positive feedback, Signol gently nudged seafarers to implement fuel-saving practices.

Context:

- Bernhard Schulte states that the test showed that individual decisions can play a valuable role in decarbonising the shipping industry, and that the project showed promising results which need to be verified by further tests.
- Signol has mostly worked in aviation in the past, using behavioural science to influence pilots' behaviour. In 2021, it released a white paper outlining the results of an eight-month 2014 study with Virgin Atlantic (UK), which the company claims demonstrated the most cost-effective carbon-abatement solution in history, and £4.85m in fuel savings.

What next:

Over the coming years, Signol will expand its offering to involve more airlines and shipping companies.

View source

For sale
Source: Corporate R&D
Region: Europe

Rolls-Royce showcases maritime platform management to optimise vessel operation and efficiency

What's the innovation:

Rolls-Royce (UK) recently unveiled, 'mtu NautIQ', an integrated platform management system (IPMS) that claims to offer intelligent crew support, autonomous control, and remote operation. According to Rolls-Royce, NautIQ can offer full autonomy, or operate in the background, providing improved ship operating capability to crews.

How it works:

- NautIQ comprises multiple subordinate systems that can each monitor and control various different ship subsystems, utilising sensors, computer vision, electronic navigation, and AI.
- The sensors provide information to the IPMS on marine conditions, location, and the status of all ship systems, such as its power and propulsion systems. NautIQ's AI then uses this data to optimise operations.
- Rolls-Royce claims that NautIQ will enable improvements such as increasing uptime, reducing drag, and charting shorter or more efficient routes that use less fuel.

Context:

- Rolls-Royce partnered with Sea Machines (US), a leading provider of maritime AI, to develop the latest generation of NautIQ.
- NautIQ was used this year to pilot a ship on a 1,800km round trip from Hamburg (Germany) remotely from Boston (US).
- The mtu NautIQ automation system family has been designed for both newbuild vessel systems and for easy retrofit of older vessels.

What next:

Rolls-Royce claims that this is part of its Power Systems business unit's transformation into a provider of integrated sustainable power and propulsion solutions.

Further reading…

Watch Rolls-Royce and Sea Machines promoting their technology in action.

Watch now

New machine learning system could decrease ship fuel consumption by 10-15%

What's the innovation:

A major cause of fuel inefficiency for ships is due to the loads exerted on their propulsion system by waves. Marine Edge (Israel) has developed a machine learning (ML) technology that it claims can monitor the performance of ships' propulsion systems and optimise fuel burn, reducing the cost of a ship's operation and its carbon footprint.

How it works:

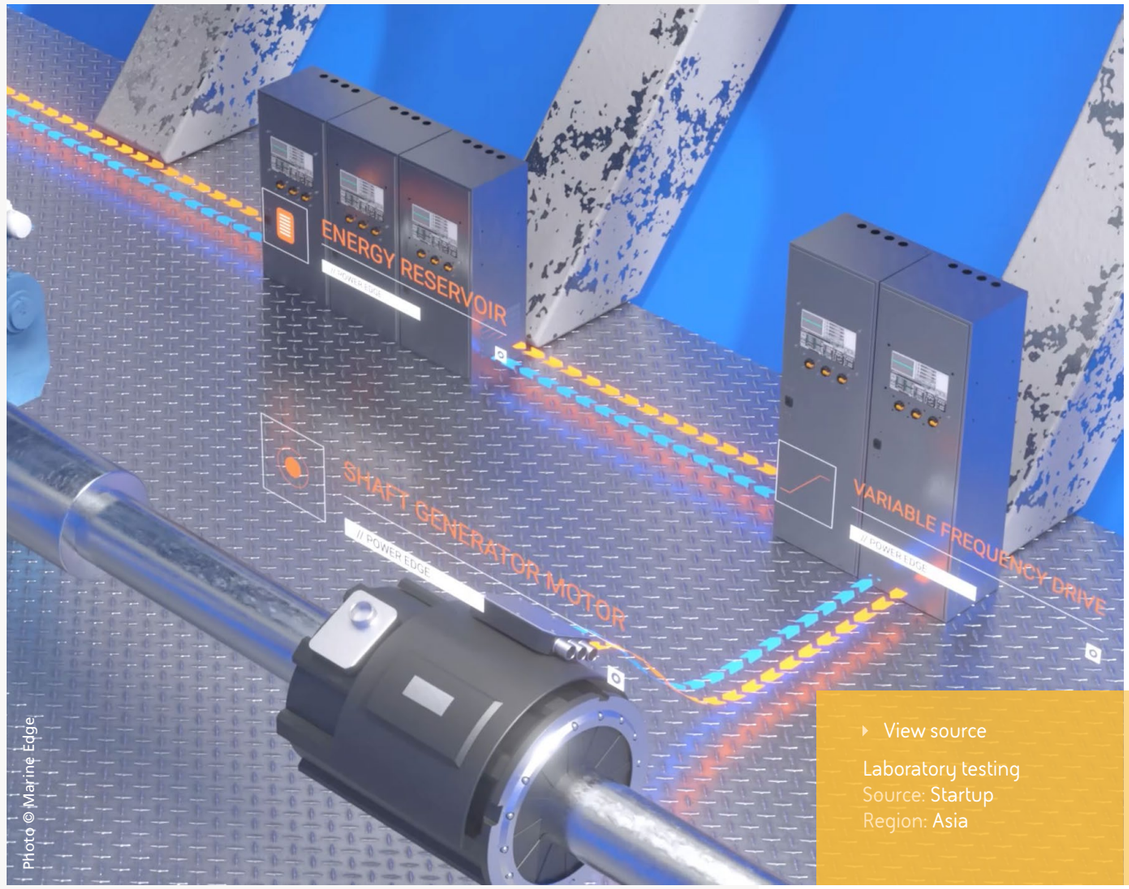
- Waves change the load placed on the drivetrain of shipping vessels. For example, choppy waters decrease propulsive efficiency and increase fuel consumption, due to periodic changes in propeller submergence.
- Marine Edge's ML technology monitors a ship's drivetrain and power systems and learns how changes in heave and pitch affect propulsion.
- It can then make adjustments to the drivetrain and power management systems to optimise fuel consumption for different water conditions.

Context:

- The largest expense for any cargo ship is fuel. Therefore, there is a significant incentive to reduce fuel usage and shipping emissions.
- Marine Edge claims its technology can reduce shipping fuel consumption by 10-15% at any sea state.
- The technology is currently focused on optimising merchant ships on long haul journeys.

What next:

Shipping company Eastern Pacific Shipping (Singapore) have announced a major investment in Marine Edge as part of a technology accelerator programme.



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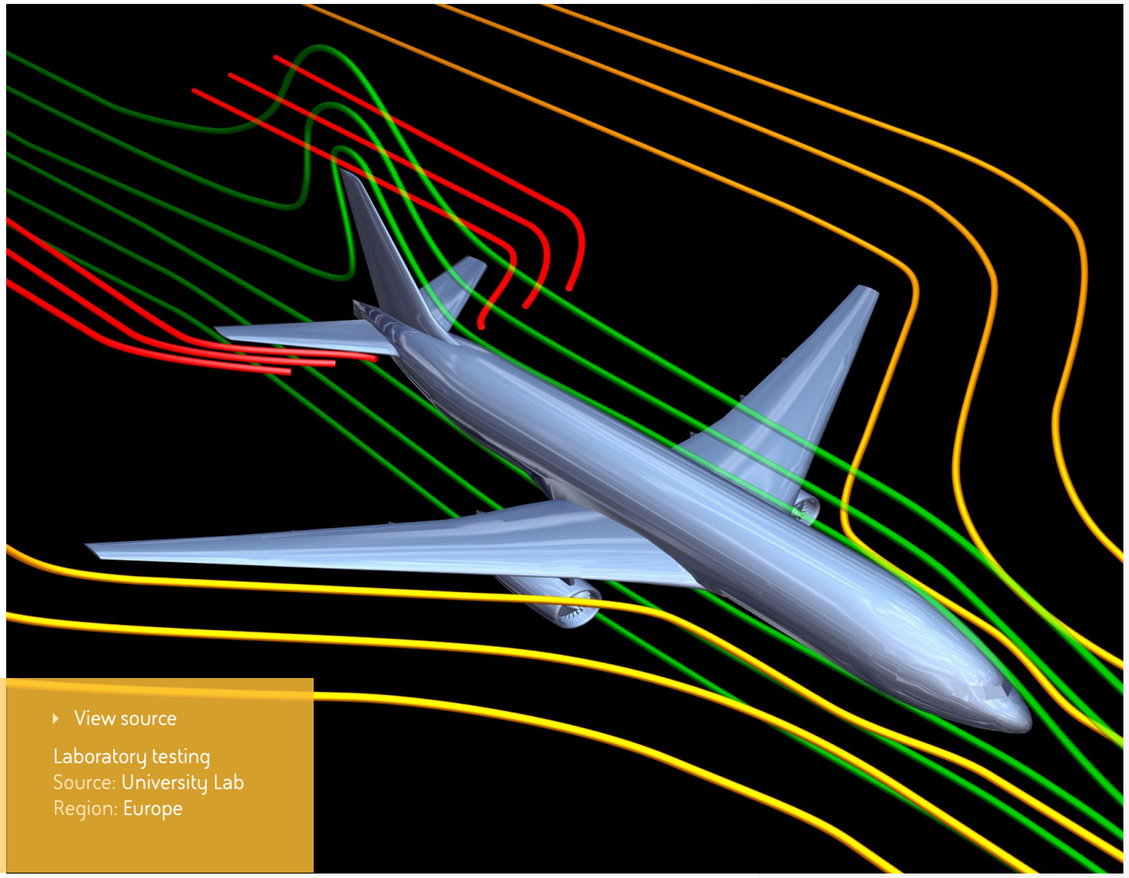
Laboratory testing
Source: Startup
Region: Asia



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Laboratory testing
Source: University Lab
Region: Europe

Wing sensors advance airflow understanding to optimise aerodynamic efficiency

What's the innovation:

Understanding airflow patterns around an airframe is critical to improving its design. SKOPA, an EU-funded project led by the Technical University of Berlin (Germany), has developed new sensors capable of providing richer information on the aerodynamic effects that increase drag.

How it works:

- The project developed fibre optic sensors for surface pressure, and hot-film sensors for skin friction, which were embedded in a wing.
- Fibre optic strain gauges work by adding a Bragg grating to a fibre optic cable, such that when the cable is deformed under strain the Bragg grating also changes and hence also the measured interference pattern.
- Hot-film sensors respond to change in resistivity across their surface, caused by air cooling the heated film. This provides measurements of amplitude and direction of skin friction, which can identify adverse pressure gradients that cause airflow separation.

Context:

- The trend in modern aircraft engines is to have large nacelles, closely integrated to the wing to achieve more fuel efficiency. However, this also increases the risk of flow separation.
- Regions of airflow separation impact the lift-drag ratio and aerodynamic efficiency of an aircraft, increasing fuel consumption.
- Data from the new sensors can be used to optimise the wing-pylon interface design to ensure gains made in engine efficiency are not offset by losses in the airframe.

What next:

After being validated on an industrial wing model, the sensors are now being used as part of another EU project, Clean Sky 2, where it will validate local active flow-control at the wing-pylon interface to minimise airflow separation. The programme managers also hope the sensors will be used to improve efficiency at other points on airframes.

Further reading…

Read more about the objectives and methodology of this study

METIS' new platform brings more data to the maritime industry than ever before

What's the innovation:

The maritime sector is amongst many industries being transformed by the Internet of Things (IoT). Smart connected vessels could realise benefits including optimised maintenance, more efficient fuel usage, and monitoring temperature-sensitive products, like vaccines. To support this, METIS (Greece) has announced its latest data-acquisition platform for shipping, Ship Connect, which it claims is compatible with all data sources and requires minimal resources to collect millions of data points from ships and transfer them into downstream data applications in real time.

How it works:

- All shipping data sources, including bridge, navigation systems, power plant, and propulsion, can be collected by METIS' framework.
- The data is transferred securely in less than a second from the vessel, via satellite, to METIS' cloud-based data distribution system.
- This incoming data can be fed into simulation and modelling tools in real time, to optimise engine operation, fault detection and predictive maintenance, or improved environmental performance.
- Built using open-source architecture, Ship Connect can also integrate with third-party systems.

Context:

- The maritime sector generates a significant volume of data such as route information and geolocation, weather, fuel, maintenance information, cargo status and the operation of onboard machinery.
- METIS' previous cloud platform already measures 6.3 billion performance data points per month on almost 270 ships, all of which are eligible for upgrade to Ship Connect.

What next:

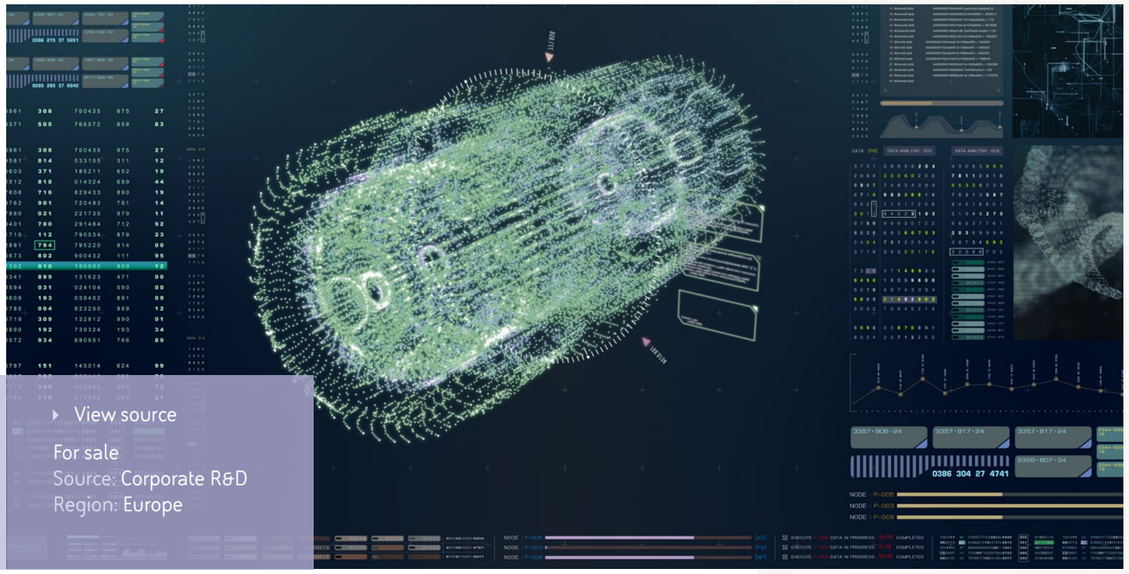
METIS is partnering with diesel engine specialist Carl Baguhn (Germany) to implement Ship Connect on existing ships and land-based power plants under the brand GreenFuture. The platform will also be used in the EU ENGIMMONIA project to test the adoption of ammonia-based maritime fuels.

View source

For sale
Source: Startup
Region: Europe

Simulation and modelling

Emerging innovation in digital twins, computational modelling and simulation to help decarbonise and mitigate emissions from maritime and air platforms



View source

For sale
Source: Corporate R&D
Region: Europe

Digital twins of jet engines has helped avoid 200,000 tonnes of CO_2

What's the innovation:

Imagine if a personalised user manual and exact life expectancy could be given for an individual engine? Rolls-Royce (UK) claims its IntelligentEngine digital twin models are capable of that and more. Powered by machine learning, the digital twin can update in real-time to provide insight and optimise engine fuel efficiency and maintenance.

How it works:

- Rolls-Royce has built a cloud-based digital twin of the engine, detailing its parts, performance, maintenance history, and so on, and modelling how these all work together.
- Sensors embedded within each engine collect hundreds of data points every second during operation, monitoring how each engine flies and the conditions it is flying in. These are fed into the twin.
- The twin can be used to understand how an individual engine is being run and how this changes under different flight conditions, which allow tailored operating plans, reducing fuel usage.

Context:

- Since introducing the first iteration of its digital twin platform in 2014, Rolls-Royce says it has helped clients avoid 200,000 tonnes of CO_2 through better operating procedures and policies.
- The twin is also used for predictive maintenance, which Rolls-Royce claim has reduced unplanned grounding of planes by 5%, an issue that can increase carbon emissions due to the need to reroute flights.

What next:

Rolls-Royce's vision for the IntelligentEngine is increasing connectivity and contextual awareness. The models can also be extended to study and predict behaviour under extreme conditions or the impacts of critical component failure, helping to further inform engine design.

Further reading...

Watch this explainer from Rolls-Royce about their IntelligentEngine technology

Watch now

Photo © Portsmouth International Port

View source

Real world testing
Source: Startup
Region: Europe

Portsmouth Port is simulating a more sustainable future with green hydrogen generation

What's the innovation:

To make shipping more sustainable, the supporting infrastructure for the vessels must be improved. Digital software company IOTICS (UK) is working with Portsmouth International Port to create a digital twin of the port in order to simulate port operations after the introduction of green hydrogen.

How it works:

- Historical and real-time data is gathered from the port's infrastructure to create a digital twin which provides a virtual representation of dockside and offshore activities.
- Data from a hydrogen electrolyser also feeds into the model.
- The twin simulates the port environment, particularly with regards to the logistics and refuelling, allowing operators to test new systems including green hydrogen production, and understand its effect on other port infrastructure.

Context:

- The UK Government has set ambitious emissions reduction targets for maritime and the project aims to help to achieve that goal by demonstrating the potential of green hydrogen (produced via electrolysis of water, powered using renewable energy).
- According to port representatives, the light goods vehicles in the port have already been replaced with zero-emission electric vehicles.
- It believes that green fuels are more viable than battery power for heavy machinery and vehicles, and a hydrogen-powered vessel has been procured as part of this project.

What next:

Portsmouth International Port is aiming to become carbon neutral by 2030 and the UK's first zero-emission port by 2050, whilst also acting as a 'living lab' to inform research and education. According to IOTICS, the digital twin modelling approach is scalable and can be transferred to other sites and use cases, further enabling the deployment of hydrogen.

Further reading...

Read about how BAE Systems has worked with the Royal Navy to significantly reduce emissions at Portsmouth Naval Base

View source

For sale
Source: Corporate R&D
Region: North America

Software platform assesses decarbonisation impact of new technologies before ship is built

What's the innovation:

Quantifying the full lifecycle impact of maritime decarbonisation can present a myriad of different emissions reduction strategies. American Bureau of Shipping (ABS, US) has recently released 'Energy Efficiency Evaluation' (EEE), a software platform that combines simulation and modelling to analyse the quantitative impact of vessel decarbonisation technologies at the ship design stage.

How it works:

- Prior to construction, a vessel's design is created in a simulation and modelling suite.
- EEE allows users to virtually compare different design and operational options, then evaluate the performance impact of adding new technologies. This provides predictions of the vessel's fuel consumption.
- For existing vessels, this process uses data from the ship itself, combining it with various potential retrofit concepts to evaluate their potential impact. It can also provide new vessel operation strategies for the reduction of fuel consumption and emissions.

Context:

- Maritime regulations are evolving to reflect a greater need for sustainability. ABS claims that EEE can help clients maintain or obtain environmental compliance for existing and new vessels.
- Given the 30-year average lifespan of commercial maritime vessels, comprehensive life cycle cost and emissions analysis is critical for making designs sustainable at the design/ concept stage. EEE claims to be the first to provide such a service to the maritime industry.

What next:

ABS is using its platform as part of a new joint development project with Hudong–Zhonghua Shipbuilding (China) and Wärtsilä (Finland) for a future, modular Liquified Natural Gas Carrier vessel concept.

Further reading...

Read more about the ABS joint development with Hudong-Zhonghua Shipbuilding and Wärtsilä.

Cloud-based digital twin offers real-time carbon emissions profiling

What's the innovation:

Requirements to reduce fossil fuel consumption means ships need real time fuel monitoring, as well as ways to explore more fuel efficient ways of operating. Such measurements usually need investment in new sensors and data technologies. Startup We4Sea BV (Netherlands) has an alternative; a hardware-free digital twin.

How it works:

- The platform imports over 80 technical and operational characteristics of the ship such as speed, draft, and heading and merges them with real-time position and environmental data, including wave heights, currents, and wind.
- This is used to create a digital 'sister' vessel that allows operators to digitally assess metrics such as fuel efficiency in real time. This is done without physical modifications, like the installation of sensors.
- This real-time information allows owners to benchmark vessel performance by correcting for weather impact, supporting decisions to improve vessel performance and optimise voyages.

Context:

- According to We4Sea, less than 10% of vessels have active fuel monitoring on board, partly due to the need to install new hardware components.
- The platform has been certified by Verifavia (a carbon emissions verification body) and found to be compliant with the 2015 European MRV Regulation, which requires ships over 5,000 tonnes to monitor, register and verify their CO_2 emissions.
- We4Sea estimates its platform could offer a typical bulk carrier (with 30MT daily consumption and 220 sailing days per year) an average 3-5% fuel saving, which would translate to an annual net saving of up to £230k per vessel.

What next:

Thanks to a recent agreement with P&O Ferries group (UK), We4Sea BV has expanded the range of vessels its technology can serve. The company has also partnered with a number of major maritime organisations, including Unifeeder (Denmark), Roll (Netherlands), and Inmarsat (UK).

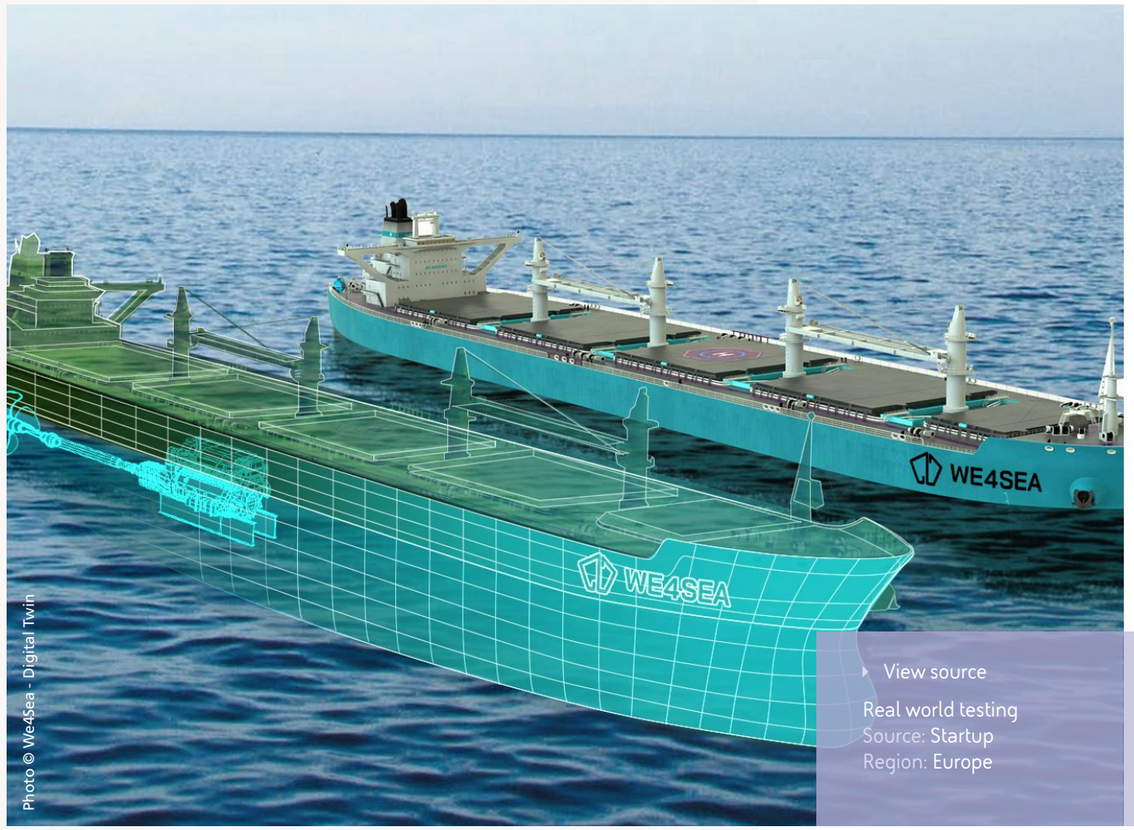


Photo © We4Sea - Digital Twin

View source

Real world testing
Source: Startup
Region: Europe

Image © Weston Williamson + Partners

View source

Real world testing
Source: Corporate R&D
Region: Europe

Digital twins could help make hydrogen-powered flight a reality

What's the innovation:

Green hydrogen is a potential zero carbon fuel for aviation. It can be produced using renewable energy, and when converted to power its only byproduct is water vapour. However, current refuelling technology is not able to deliver the rapid refuelling needed to make hydrogen commercially viable for the aviation sector. Siemens (Germany) and Protium (UK) are using a Digital Twin of a refuelling system, which they hope will allow them to design a rapid hydrogen refuelling process.

How it works:

- Siemens will develop a digital replica of aircraft refuelling systems.
- The twin can then be used to simulate the real-world performance of potential hydrogen refuelling systems, reducing the number of expensive, physical prototypes required.
- Siemens and Protium claim that the digital twin approach will save money and time in bringing a viable rapid hydrogen refuelling system to market.

Context:

- A key aim of the project is to increase industry confidence in the potential of hydrogen-powered flight to be commercially viable for aviation.
- The refuelling system is only one aspect of hydrogen infrastructure for aviation being developed, alongside storage and transport for hydrogen fuel.
- For example, Universal Hydrogen (UK) is working on modular hydrogen capsules that can be transported and loaded onto aircraft using existing infrastructure.

What next:

To fuel hydrogen-powered transport, Protium has announced the development of a 40MW green hydrogen plant in England, which is due for completion in 2026.

Maritime Digital Twins could improve fuel efficiency and reduce carbon emissions

What's the innovation:

Marine Digital GmbH (Germany) is a deep-tech startup founded in 2020, focused on decarbonising the Maritime Industry through AI and Digital Twin technologies. Its digital twin model utilises machine learning to monitor, predict and optimise fuel consumption by monitoring various internal and external parameters, and make route-optimisation recommendations.

How it works:

- Hardware installed on the vessel gathers information about the vessel, such as location, speed, RPM, and transmits it to the Marine Digital cloud.
- A cloud-based machine learning module analyses this data alongside information on the planned route, arrival times, and weather conditions. It uses these to model optimal speeds and considers alternative routes to save fuel.
- A web interface presents the resulting insight in real-time to support decision-making, as well as data for environmental reporting.

Context:

- Many industries, including maritime, are becoming increasingly interested in software-driven automation and control systems. Digital twins are one approach to combining real-world data and a simulated environment to meet the emerging needs of this industry.
- The Marine Digital digital twin also has applications in predictive maintenance and catering management.
- Demand for digital technologies that support maritime decarbonisation has exploded in recent years. According to US software company OrbitMI – which has developed a toolkit (SET Maritime) for evaluating these technologies – there are more than 550 software vendors in this space, across categories such as vessel performance monitoring, voyage management, and navigation.

What next:

Marine Digital is developing a Fuel Optimisation System using its digital twin which it claims will reduce fleet fuel consumption by 5-12% thereby reducing CO_2 emissions by 600 tonnes per year.

Further reading…

Explore the benefits of digital twins in shipping as outlined by Marine Digital.

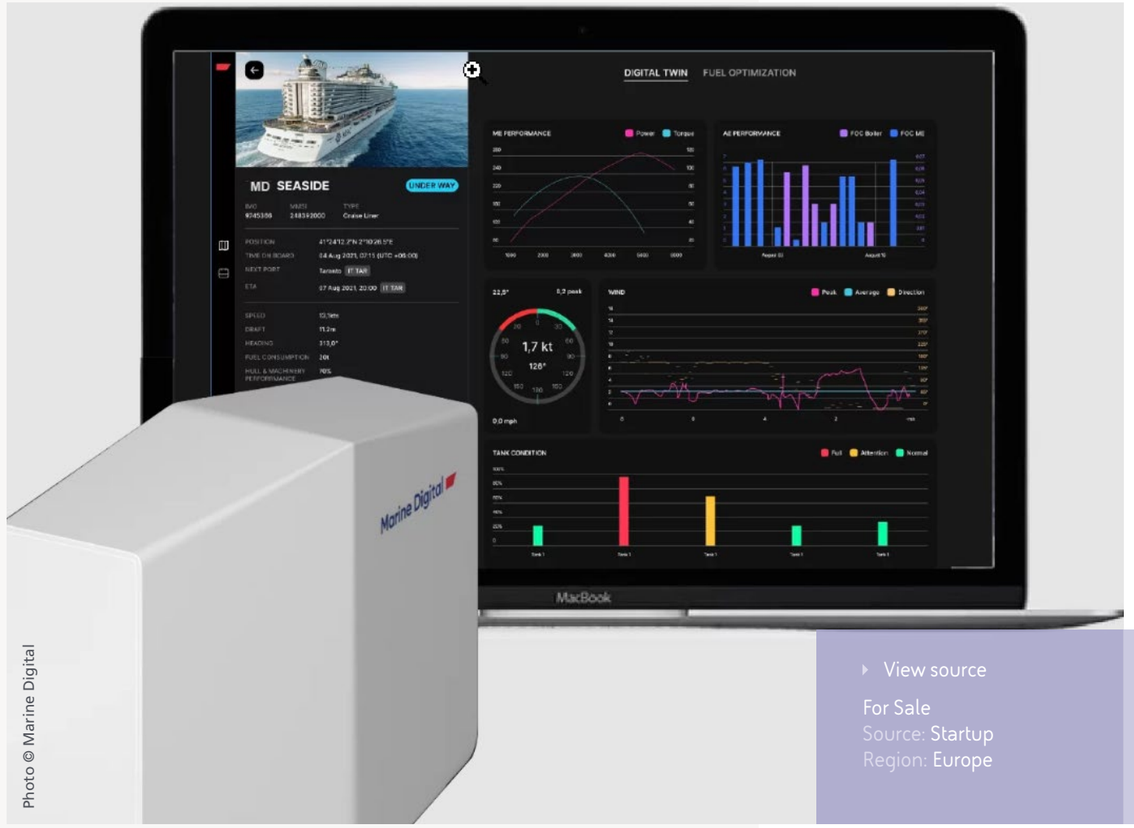


Photo © Marine Digital

View source

For Sale
Source: Startup
Region: Europe

Carbon removal & emissions capture

Emerging innovation for carbon removal, exhaust scrubbing and direct emissions capture from fast jets and maritime vessels

View source

Real world testing
Source: Startup
Region: North America

Onboard system for maritime vessels could capture and store CO_2 emissions whilst at sea

What's the innovation:

Unlike onshore carbon capture and storage (CCS), capturing CO_2 on ships is constrained by space and difficulty retrofitting to the exhaust stack. Carbon Ridge, a California startup (US), is developing a new system designed to be installed onboard ships. It uses existing gas separation technology, which has been engineered into a modular and externally mounted system. The company claims it takes 80% less space than alternative CCS technologies.

How it works:

- The Carbon Ridge CCS consists of a modular stripper, condenser and storage tank, the latter two of which require almost no structural modification to the ship.
- Exhaust gas flows into the stripper, which removes CO_2 and passes it to the condenser. This liquifies the gas and passes it into the storage tank.
- The tank is emptied upon return to port, and the CO_2 is sequestered.

Context:

- Carbon Ridge claims its onboard CCS avoids extensive retrofit, is easy to install, and offers sufficient space and cost saving benefits to be viable.
- Given limited short-term options for low-carbon shipping propulsion, Carbon Ridge believes that onboard CCS could offer the most viable route to meeting incoming IMO emissions targets.
- Carbon Ridge has formed a partnership with Scorpio Tankers Inc. (Monaco) to develop the technology further and trial a small-scale prototype on a Scorpio ship.

What next:

Assuming successful demonstration of its onboard CCS, Carbon Ridge aims to roll out the technology across the Scorpio fleet.

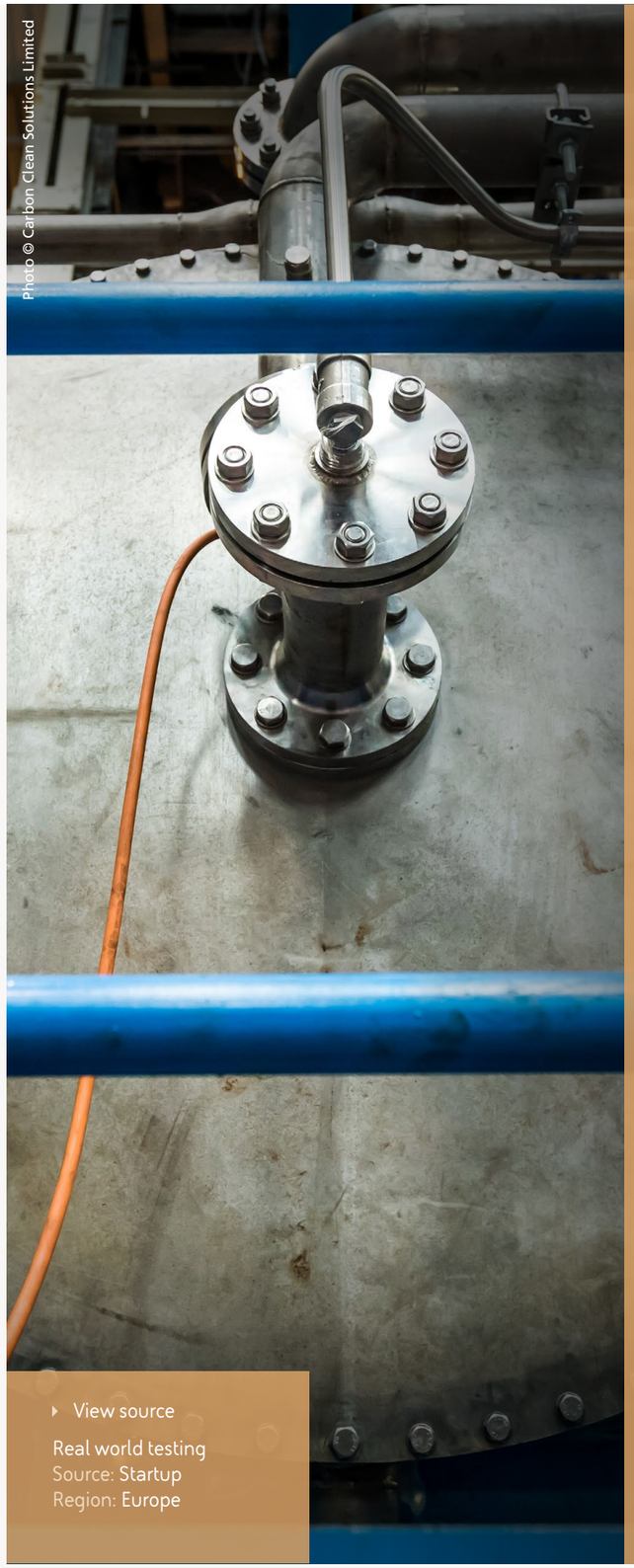


Photo © Carbon Clean Solutions Limited

View source

Real world testing
Source: Startup
Region: Europe

Carbon capture technology is 10x smaller than conventional options

What's the innovation:

To stand a chance of reaching net-zero by 2050, we need 50% more carbon capture and storage than current trajectories, according to the International Energy Agency. However, the size and expense of installing carbon capture technology directly at CO_2-producing sites is a significant barrier to uptake. Carbon Clean (UK) believes it has a solution in CycloneCC™. It claims this is the world's smallest industrial carbon capture technology and will make CO_2 capture economically viable for even small industry sites.

How it works:

- CycloneCCTM combines two innovations: its proprietary buffer salt solvent absorbs CO_2 from feed gas. Its rotating packed beads improve absorption through centrifugal force.
- The solvent is heated to release the CO_2, which is stored, with the 'clean' solvent returning through the system.
- This design makes CycloneCC's footprint 10x smaller than conventional carbon capture options, according to the company.

Context:

- CycloneCC is a modular system built on a skid mount, meaning each unit can be delivered and fully operational in less than eight weeks. It has been successfully tested at a 1 tonne-per-day site in the UK.
- The company claims it will reduce the CO_2 capture cost to £24/tonne. This is below the current EU carbon price, which should make it economically viable.
- Carbon Clean's semi-modular CDRMaxTM system, which containerises 80% of the carbon capture system, is already globally operational on 40 industry sites.

What next:

Partnering with Veolia (France) and CEMEX (Mexico), scaled-up versions of CycloneCC (up to 100 tonne-per-day) are being developed. Carbon Clean hopes for market roll out in 2023. The company also plans to deploy the system onboard ships.

Onboard CO_2 capture could recycle a vessel's carbon emissions

What's the innovation:

Can onboard CO_2 capture and storage form part of a circular carbon solution? Value Maritime (Netherlands) thinks it can, and has claimed a world-first of equipping an operational ship with a CO_2 capture module. Its 'Filtree' system captures CO_2 from emissions and uses it to charge a 'CO_2 battery'.

How it works:

- The system uses a patented filtration technology that first cleans particles from the vessel's exhaust gas, then removes CO_2.
- The CO_2 is stored in a 'CO_2 Battery'; an onboard storage facility which can charge and discharge CO_2 infinitely. Technical detail on the storage mechanism has not been made public.
- Once a ship reaches port, the CO_2 is discharged from the battery and used for industrial or agricultural applications (in the trial, for greenhouse agriculture in the Netherlands). The battery can then be used again.

Context:

- The CO_2 capture module is the size of a shipping container and claims to be 3x smaller than a traditional emissions scrubber.
- In October 2021, a successful demonstration on a 152m Visser Shipping (Netherlands) cargo vessel used two batteries to capture enough carbon dioxide to reduce the ship's carbon emissions by 70%.
- Because the system also removes sulfur from the exhaust gas, ship operators can use cheaper high-sulfur fuel, while still meeting emissions regulations.

What next:

Following the trial, Value Maritime says five more CO_2 capture modules have been ordered by the shipping industry. It claims the system should eventually capture 90-100% of carbon emissions, but higher rates will come with trade-offs in terms of sacrificing cargo space for CO_2 batteries.

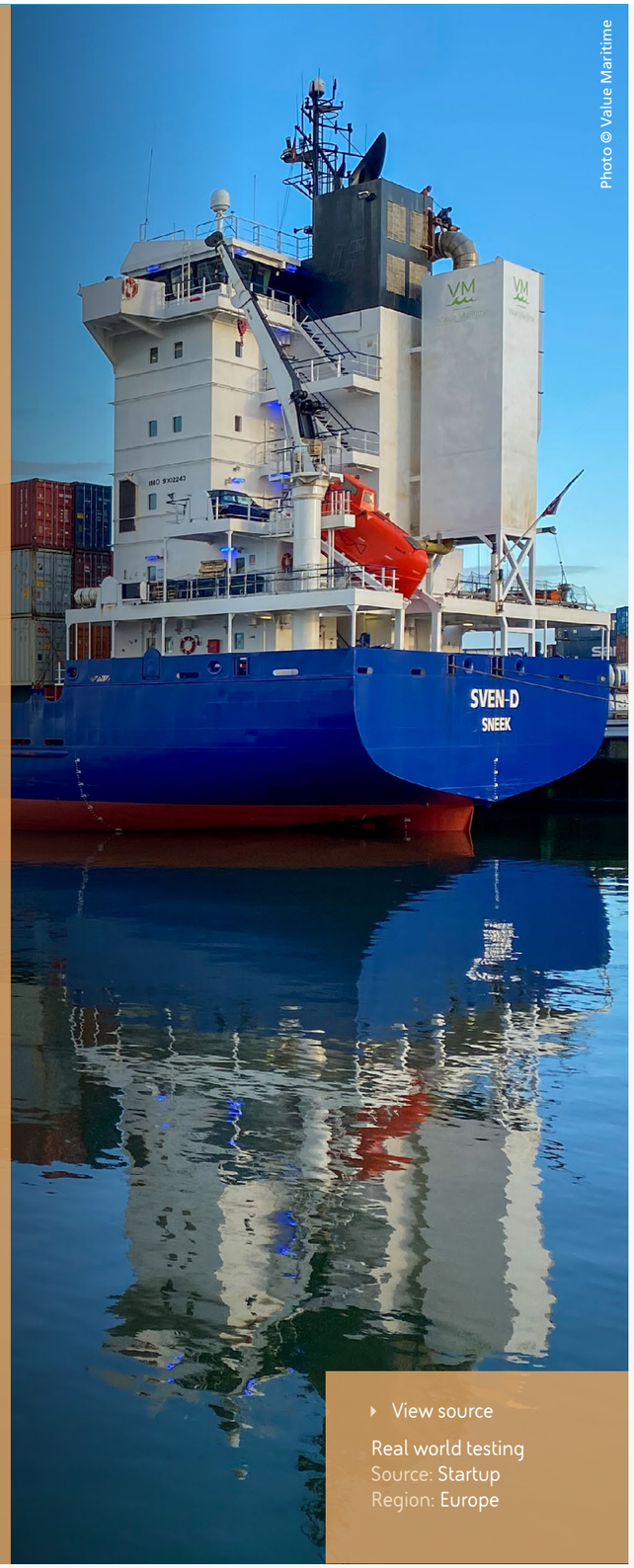


Photo © Value Maritime

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Real world testing
Source: Startup
Region: Europe

Airlines could use Direct Air Capture to offset aviation emissions

What's the innovation:

Aviation is hard to decarbonise because it requires high energy-density, readily available fuel. An alternative to reducing emissions is to offset the carbon released. Airbus (Europe) hopes to lead the way in demonstrating a feasible carbon offset scheme, through the purchase of 400,000 tonnes of CO_2 removal over four years from 1PointFive's (US) Direct Air Capture (DAC) facility, which uses Carbon Engineering's (Canada) technology.

How it works:

- Carbon Engineering's technology sucks air into a large cooling tower-like facility. It uses a potassium hydroxide solution to bind CO_2 from the air into an aqueous solution.
- A series of chemical processes are used to progressively increase the CO_2 concentration and purify the carbonate solution.
- The end product is pure, compressed gaseous CO_2 that can either be stored underground or recycled for other uses. Carbon Engineering's first DAC plant will store the CO_2 in the Permian Basin, Texas.

Context:

- Airbus' deal pre-purchases carbon sequestration for its future emissions.
- DAC is not currently a cost-effective decarbonisation tool for most industries, as capturing emissions at the source is usually cheaper, but this is unlikely to be technologically viable for aviation.
- Carbon Engineering is also developing its AIR TO FUELS™ process, using DAC-derived CO_2 to make sustainable transport fuel. Its first pilot plant opened in 2017 and currently produces around one barrel of fuel per day.

What next:

The construction of the DAC facility in Texas is due to start later this year. The facility should be operational in 2024, and will have a capture capacity of one million tonnes of CO_2 per year.

Further reading...

Watch the DAC technology explainer by 1PointFive.

▶ Watch now

▸ View source

Real world testing
Source: Startup
Region: North America

View source

Real world testing
Source: Startup
Region: North America

US Air Force is decarbonising long-distance flights with a CO_2-based fuel

What's the innovation:

Whilst batteries could power short flights, they are not a near-term option for long-haul aviation, as the energy required would add too much weight. As an alternative, startup Twelve (US), in partnership with the US Air Force, instead plans the 'electrification' of fuel itself. It is using an electrochemical reactor to turn CO_2 removed from the air and industrial sources into jet fuel. Twelve claims its 'e-Jet®' fuel has 90% lower lifecycle emissions than conventional jet fuel.

How it works:

- CO_2 is reduced in an electrochemical reactor with water (H_2O), using a proprietary metal catalyst.
- This produces CO and H_2 as insoluble gases in an aqueous solution, which are then separated out. The ratio of CO to H_2 depends on the exact catalyst used, and the applied voltage.
- Twelve then refines these into certified jet fuel.

Context:

- e-Jet® can be used by most turbofan jet engines with no modifications, and Twelve claims it matches the performance of petroleum-based jet fuel, while burning cleaner because of fewer contaminants.
- The US Air Force hopes the technology will reduce dependence on imported petroleum and risk associated with fuel transport.
- The technology developed by Twelve can also be used to convert CO_2 into other chemicals that traditionally use a petroleum-based feedstock.

What next:

The first phase of the project with the US Air Force ended in December 2021, with a report of findings expected. The next phase aims to increase the volume of fuel produced.

Scrubbing CO_2 from maritime emissions before they pass through the exhaust stack

What's the innovation:

Could onboard scrubbing of maritime emissions help to decarbonise the shipping industry? Wärtsilä (Finland) is hoping to prove so, conducting research into the feasibility of scaling up onboard emissions scrubbing carbon capture and storage (CCS). The company has announced initial research suggesting maritime CCS is a technically viable solution.

How it works:

- Modular emissions scrubbers manufactured by Wärtsilä have traditionally removed sulfur. New technologies aim to build on this to remove CO_2 from exhaust gases before they pass through the ship's exhaust stack.
- Ideally, the CO_2 will then be separated as a liquid to be stored on board.
- Wärtsilä is using its 1 MW test plant in Moss, Norway, to design and pilot new CCS technologies.

Context:

- Maritime CCS is a growing industry. Several trials by Wärstilä and others are currently in progress.
- Wärtsilä is partnering with Solvang (Norway) to bring a maritime CCS solution to market. At its test facility, it says the pilot scrubber is capturing 60% of carbon emissions.
- Another company, Langh Tech (Finland) has been trialling adding alkalis to existing scrubbers to react with exhaust CO_2 and strip it into water in the scrubber.

What next:

The first full-scale trial of the partnership with Solvang will take place later in 2022, with the goal of having a full-scale system in place by 2023 on a 7 MW ship. Wärtsilä is aiming for its Norwegian pilot plant to be a test-bed to accelerate the market development of viable onboard CCS solutions.

Further reading…

Read more about Wärtsilä's partnership with Solvang.

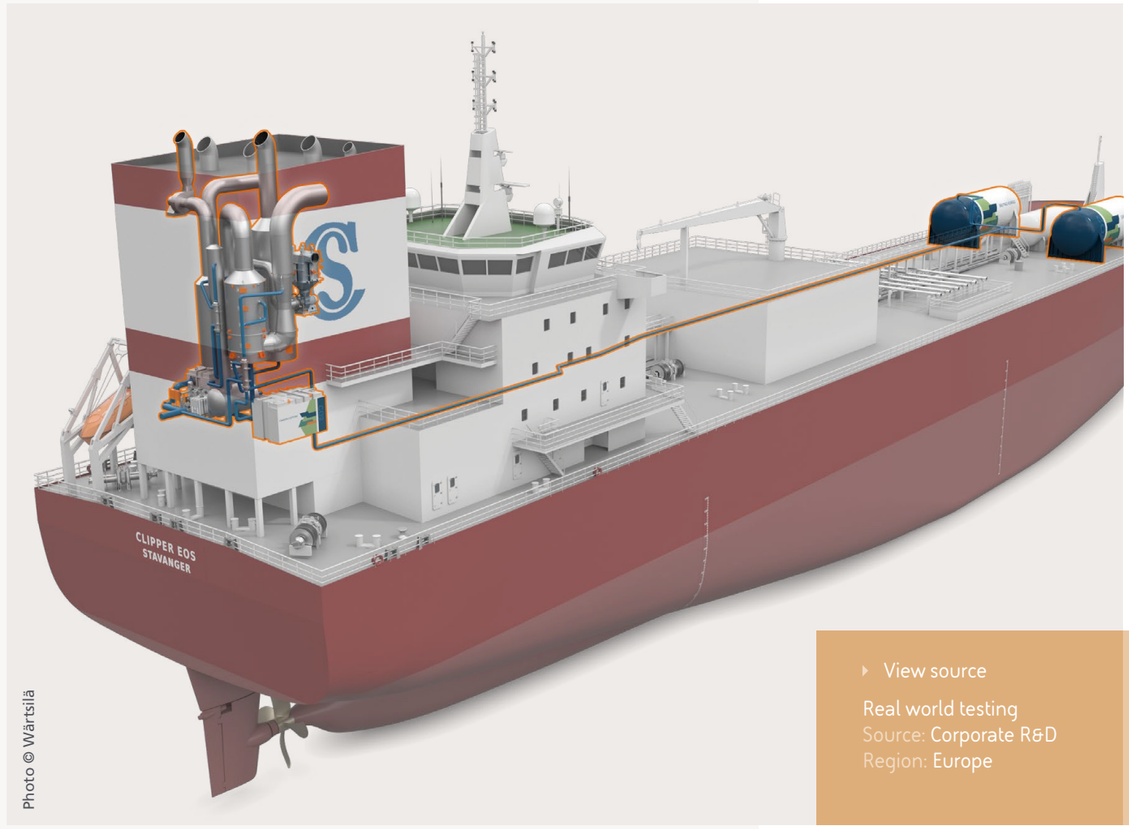


Photo © Wärtsilä

View source

Real world testing
Source: Corporate R&D
Region: Europe

Fixed infrastructures

Emerging innovation in grid-storage, thermal pumps, energy management and energy recovery in industrial sites, manufacturing facilities and office buildings

Further reading…

Listen to the CEO of PolyJoule discussing the science and design behind its batteries.

View source

Real world testing
Source: Startup
Region: North America

Plastic batteries made from sustainable materials could store energy more cheaply on land than lithium-ion

What's the innovation:

Lithium-ion (Li-ion) is currently the main player when it comes to battery storage. However, lithium is facing a supply squeeze and is hard to dispose of safely. PolyJoule (US) claims to have an alternative; a battery design that uses a sustainable plastic-based electrode to provide cheaper, safer, and longer-lasting energy storage than the best Li-ion battery. Although bulkier than Li-ion, its technology could be well-suited for stationary applications such as storing energy from renewable power.

How it works:

- PolyJoule's electrodes are made from conductive polymers and graphitic carbon that replace lithium and lead in Li-based electrodes.
- A conductive polymer is an organic-based compound that is not a metal, but can act like one. Its chemical structure forms a conductive backbone that allows electrons to flow.
- The battery design uses a standard two electrode electrochemical cell and is constructed using the same methods as other common battery types.

Context:

- PolyJoule's electrodes are fabricated from abundant raw materials, reducing cost by an order of magnitude compared to Li-ion batteries.
- Their devices offer 12,000 cycles at 100% discharge, compared to 500 cycles for a typical Li-ion battery.
- The company says its technology is well suited to mission critical power applications such as power conditioning, peak shaving, hybrid power energy storage, and high-power data centre backup.

What next:

The company has already built 18,000 cells and implemented them into a pilot project. It now plans to ramp up commercialisation, including performance testing and safety certification. Polyjoule is targeting a device that offers $65/kWh of storage and is simple to fabricate using commercially available machines.

View source

Real world testing
Source: Startup
Region: Europe

A solid-state approach to low-carbon refrigeration

What's the innovation:

Barocal Ltd (UK), a spin-out from the University of Cambridge, has developed a pioneering technology to help decarbonise heating systems, air conditioning and refrigeration. Its barocaloric technology involves a solid-state temperature changing material that can be used in place of refrigerant gases to create greener heat pumps.

How it works:

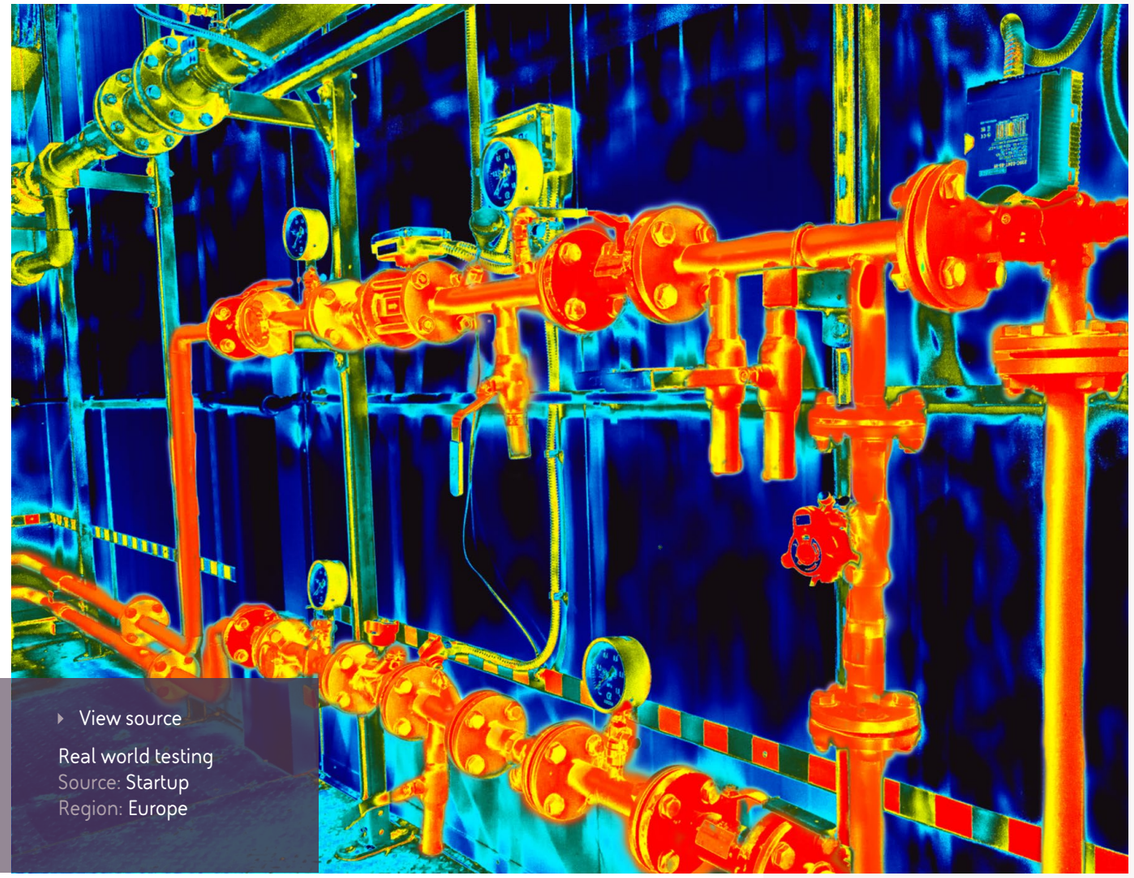
- Many cooling systems use refrigerant gases such as hydrochlorofluorocarbons (HCFCs). These refrigerants circulate through tubes and absorb heat from a closed system (e.g. a fridge) by undergoing a gas-to-liquid phase transition. These gases damage the ozone layer when released.
- Barocal has developed a refrigerant that is a solid organic plastic crystal.
- When pressure is applied or removed to these organic crystals, they experience a change in their molecular configuration that creates large thermal changes. This can be harnessed to provide a cooling effect in a similar way to common refrigerants.

Context:

- According to Barocal, its material is non-toxic, non-flammable and recyclable, potentially providing a replacement to many refrigerants that are harmful and under pressure to be phased out.
- The company also claims its material is more efficient than traditional refrigerant gases, reducing the energy needed to create cooling, thereby helping decarbonise heating and cooling which it says accounts for 38% of the UK's CO_2 emissions.
- Barocal say its technology offers similar cooling capacities to commonly used gas compression refrigerants (600 kJ/K.kg).

What next:

Barocal has secured £1.3m in investments to accelerate commercialisation, and recently partnered with Grant Instruments, a global manufacturing company, to help scale up its technology.



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Real world testing
Source: Startup
Region: Europe

Low-cost material generates electricity from waste heat

What's the innovation:

Industrial processes often produce thermal energy, which is lost via exhaust or to their immediate surroundings. Most of this is low grade heat that is difficult to utilise. To try to capture some of this waste heat, startup Poligy (Germany) has invented a new material that transforms heat into kinetic energy for electricity generation, even at temperatures as low as 50 °C.

How it works:

- Two different polymers, each with different rates of thermal expansion, are pressed together to form a bipolymer strip.
- When the bipolymer is exposed to higher temperatures, one half of the strip lengthens more than the other, causing the material to bend.
- The bending effect is sufficiently strong to move an external system, such as a dynamo, that generates electricity.

Context:

- 2,800 million tonnes of CO_2 emissions per year are attributed to waste thermal energy losses from industrial processes. Low grade heat, typically that under 250 °C, has few viable means of recovery.
- Poligy claims its bipolymer can convert 4-15% of waste heat within a temperature range of 50-150 °C.
- The bipolymer works mechanically, as opposed to alternative heat capture systems such as Organic Rankine Cycle (ORC) engines, which are expensive and often use toxic, carcinogenic, or ozone depleting working fluids.

What next:

Poligy's bipolymer is being trialled as part of an EU programme featuring two prototypes with an estimated energy recovery capacity of 37.5MWh/year each. As part of the same programme, six additional installations are planned to deliver up to 787.5MWh/year electricity generation from currently unused waste heat.

Bespoke heat pipe heat exchangers could improve waste heat recovery

What's the innovation:

Recovering waste heat from industrial processes reduces energy consumption and emissions. However, the wide variety of exhaust temperatures and gas constituents means off-the-shelf heat exchangers are usually imperfect. To address this, the EU-funded ETEKINA project has developed tailor-made heat pipe heat exchangers (HPHEs) for different industrial applications.

How it works:

- HPHEs contain pipes that are part-filled with a 'working fluid' and installed vertically through a partition.
- Hot dirty exhaust gas flows into the bottom half, vaporising the working fluid so it rises above the partition. A clean fluid (e.g. air) flows through the top, absorbs the heat, and takes it somewhere that needs heating.
- HPHE heat transfer efficiency is determined by many complex parameters including surface area, material, configuration, and fluid choice.
- The team used modelling techniques to assess the best combination of parameters for different industrial applications.

Context:

- The project successfully developed three bespoke HPHEs, including one for the ceramics industry. HPHE units, manufactured by project partner Econotherm (UK), have been installed at three sites in Spain, Slovenia, and Italy, with installed capacity over 1MW. The project exceeded its target of 40% waste heat recovery at all sites.
- The HPHE concept is scalable and can be adapted to any type of industrial exhaust. A replicability tool also allows customers to use their own data to assess the waste heat recovery potential of the project's HPHEs.

What next:

Econotherm is now able to manufacture the HPHEs for use around the world. A second EU-funded project, iWAYS, has been launched to recover large volumes of water condensation observed in the ceramics factory HPHE.

Further reading...

Watch this video to learn more about the ETEKINA heat pipe technology.

Watch now

View source

Real world testing
Source: Startup
Region: Europe

Photo © Seramic Limited

View source

Real world testing
Source: Startup
Region: Asia

Ceramic made from recycled waste provides thermal energy storage with 80% lower carbon footprint

What's the innovation:

Heavy industry generates over one billion tonnes of waste every year with most going to landfill. Seramic Materials (UAE) has developed a new ceramic material, Flora, which is made from heavy industry waste, and which it claims can store thermal energy at temperatures up to 1250°C.

How it works:

- Ceramics are inorganic, nonmetallic materials that have been hardened at high temperature. Some have structures that make them suitable for heat storage.
- Seramic Materials used waste industrial materials – including incinerator ash and steel slags – which are crushed, refined, and mixed to create a fine powder feedstock that it uses to make the new Flora ceramic.
- Flora's structure gives it high specific heat capacity and thermal stability (i.e. an ability to store heat well) at temperatures over 700°C, making it suitable for storing industrial grade thermal energy.

Context:

- Thermal storage is highly valuable for capturing heat when surplus is generated, and releasing it when there is not enough.
- For example concentrated solar power (CSP) generates lots of process heat during the day, but none at night. Storing excess heat in storage materials, then releasing it at night, can allow CSP plants to run 24/7. Industrial processes and some renewables also often generate unneeded heat that can be stored and used elsewhere.
- Due to its manufacture from recycled waste, Seramic Materials claims the carbon footprint of Flora is up to 80% lower than conventional ceramics, and cost of production is 5% to 50% lower than competitors, removing a major barrier of thermal energy storage ceramics.

What next:

Seramic Materials report it has secured its first commercial client for Flora and are actively developing new waste heat recovery processes using the material.

AI-powered ventilation systems supercharge efficiency of building environment control

What's the innovation:

By some estimates, commercial buildings account for roughly 40% of global greenhouse gas emissions. Brainbox (Canada) has developed a networked AI system for controlling building ventilation and environmental control across multiple sites. The company claims that this can smooth power demand, reduce electricity grid congestion, and make consumption patterns more predictable.

How it works:

- The system is connected to a building's heating, ventilation, and air conditioning (HVAC) system. Combining internal information with outside factors, like weather, the AI is able to predict the thermal state of a building subzone with up to 99.6% accuracy, according to Brainbox.
- The system is then able to optimise the control of both heating and cooling by building zone in a predictive (rather than reactive) manner, supposedly maximising efficiency and comfort.
- Furthermore, Brainbox claims that by networking multiple buildings together, electricity production and consumption can be more efficiently managed, and buildings can work together to reduce grid congestion.

Context:

- 9.3 million square metres of real estate has already been optimised using Brainbox's system.
- Brainbox claims that its AI can decrease the carbon footprint of building operations by up to 40% and lower the energy costs of HVAC systems by up to 25%, whilst simultaneously extending HVAC system lifespan by 50% and improving occupant comfort.
- A successful pilot of the networked system was trialled across multiple commercial and retail buildings in Toronto, in partnership with Toronto Hydro (Canada).

What next:

Brainbox recently raised £20 million in its Series A fundraising round to further expand its offering. The next objective is to add indoor air quality control to its AI by adjusting ventilation according to air pollution or pollen count.

View source

Real world testing
Source: Startup
Region: North America

Supplementary signals

Reference	Section	Summary
Source	Alternative Low-Carbon & Synthetic Fuels	sHYp's membrane free electrolyzer can use sea water without desalination nor purification. This can be the source of H_2 and O_2 for future ships and aircraft. This is particularly relevant to ships which would be able to run indefinitely without refuelling with this technology.
Source	Alternative Low-Carbon & Synthetic Fuels	Through synthetic biology, Cemvita Factory (US) is developing techniques to use genetically-modified microbes to convert CO_2 to more useful hydrocarbons, which could include jet fuel or its precursors. United Airlines (US) has invested in the startup.
Source	Alternative Low-Carbon & Synthetic Fuels	Johnson Matthey (UK) has launched HyCOgen technology, which is a catalysed process that converts green hydrogen and carbon dioxide into carbon monoxide. These products can then be transformed into synthesis gas that is used for fuel and chemical production.
Source	Efficiency & Optimisation	Nautilus Lab technologists (US) have developed a software solution, which aims to reduce carbon emissions of large ships by providing AI-based route recommendations. Based on parameters, the software can provide real-time route optimisation.
Source	Efficiency & Optimisation	Moonware (US) has developed an electrically powered tow tug with fleet management logistics software based on AI, applicable to both commercial aviation and urban air mobility. The software aims to automate operations to reduce ramp agent workload and improve ground coordination.
Source	Efficiency & Optimisation	Oerlikon Balzers (US) has realised a coating based on PVD (Physical Vapour Deposition) technology, a non-hazardous coating option capable of limiting friction between mated parts to improve performance. This in turn results in a direct reduction of environmental footprint.
Source	Simulation and Modelling	SATVIA (UK) develops the AI platforms DecisionX: Fleet and DecisionX: NetZero. The former is used to optimise fuel and emissions consumption, and aircraft maintenance planning. The latter focuses on optimising the flight routes and mitigating the formation of contrails.
Source	Simulation and Modelling	ShipReality (Greece) developed an industrial metaverse platform, where mixed reality design automation software assists in shipping decarbonization, through automated assisted operations, and optimised ship design. The Start-up is backed by Katapult Ocean (Norway).
Source	Simulation and Modelling	Startup Bearing (US) has launched its AI-powered maritime optimisation platform which uses ship performance models to predict fuel consumption and provide actionable emission-reducing insights to operators. Bearing has recently partnered with Mitsui O.S.K. Lines (Japan).
Source	Carbon Removal & Emissions Capture	Daphne Technology (Switzerland) has tested the prototype of its maritime emissions reduction system, SulPure, which removes sulphur oxide and particles from exhaust gases via new nanotechnology, and produces components for agricultural fertiliser as a by-product.
Source	Carbon Removal & Emissions Capture	Mitsubishi Shipbuilding, 'K' line and Class NK (Japan) has successfully tested separation and storage of CO_2 from the exhaust gases of an active ship. The system was adapted from an onshore carbon capture plant, and shows the feasibility of onboard carbon capture.
Source	Carbon Removal & Emissions Capture	Langh Tech (Finland) has reported a successful onboard test of a new modification of their existing maritime SOx scrubbers to also capture and store CO_2. The process uses alkalis to react with exhaust CO_2, and produced a 7% CO_2 emissions reduction in this trial, confirming proof of concept.
Source	Fixed Infrastructures	Startup Antora Energy (US) has solved the problem of intermittent renewable energy sources storage and release. It has developed a thermal energy storage system based on carbon blocks and thermal photovoltaic panels, paving the way for zero emission heating and electricity for heavy industries.
Source	Fixed Infrastructures	Ubiquitous Energy (USA) has developed windows that can harvest sunlight and convert it to electricity. Its current applications are architectural glass, and the company is exploring how its proprietary coating technology could be applied to the surfaces of vehicles in the future.
Source	Fixed Infrastructures	Universal Hydrogen (US) is developing a modular system to transport green hydrogen from production sites to airports on existing freight networks. This needs no new cargo equipment to load hydrogen fuel to aircraft, enabling hydrogen to be integrated into the aviation fuel network.

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