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Green Energy Storage – The Missing Link

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Green Energy Storage

Whilst there are currently no regulations specifically aimed at the data centre industry's net zero efforts, many developers, owners and operators are signed up to the Climate Neutral Data Centre (CNDC) pact of reaching carbon neutrality by 2030. Indeed, it is widely acknowledged that the industry will face increasing pressure to head in the right direction by its socially and environmentally aware corporate customers facing equally as demanding benchmarks by their customers.

There are many areas around the physical data centre that present energy considerations, either through process, technology, or design, but all are linked by two core factors – performance and investment. Every data centre requires a certain level of performance to balance environmental goals with service reliability. Implementing any solution can have a high upfront cost which will need to demonstrate a suitable and attainable return on investment.

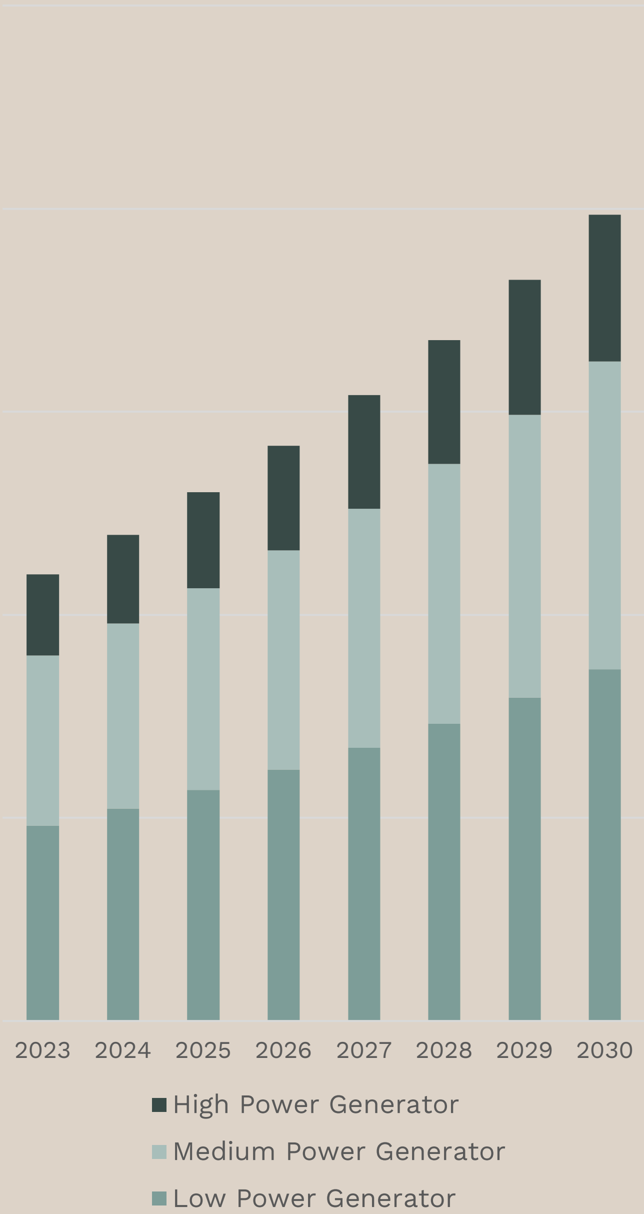
An area in which the industry is looking to improve is that of energy storage, specifically localised or on-site energy storage that contributes to the 100% availability desires of the data centre energy system. Historically, one of the most widely used, efficient and easy to handle energy storage solutions on the planet are the carbon-based fossil fuels. The qualities of wood, charcoal, coal, oil and gas have meant that these fossil fuels have driven almost every human endeavour and advancement for the past 300 years, initially using their energy directly, and then over the 20th century moving to one where (outside of the transportation industry) they are predominantly used to generate electricity.

Now the world is moving to find replacement sources of energy and the data centre industry needs to play its part to reduce its reliance on not only taking a direct feed of electricity generated by non-renewable energy sources, but also sourcing localised renewable energy generation methods and reducing its reliance on fossil-fuel storage solutions - such as diesel - to run emergency generators. But as the world acknowledges this is no easy task because the characteristics of fossil-fuels lend themselves so well to being transported, stored and then manipulated to giving off the dense energy they can hold, that any replacement needs to offer a similar performance.

Diesel – The Legacy Fuel

It is imperative for any data centre to have reliable source of back–up power in the event of a network outage, to ensure service performance. For many the use of diesel fuel has proven to be this reliable source as the go-to solution for on-site generator back-up or secondary power generation which supports the primary feed. Indeed, ReportLinker's Q4 2022 'Diesel Generator Global Market Report' suggests that the global diesel generator market (which of course the data centre industry accounts for only a fraction of) is expected to grow from $18.09 billion in 2022 to $25.35 billion in 2026 at a compound annual growth rate (CAGR) of 8.80%.

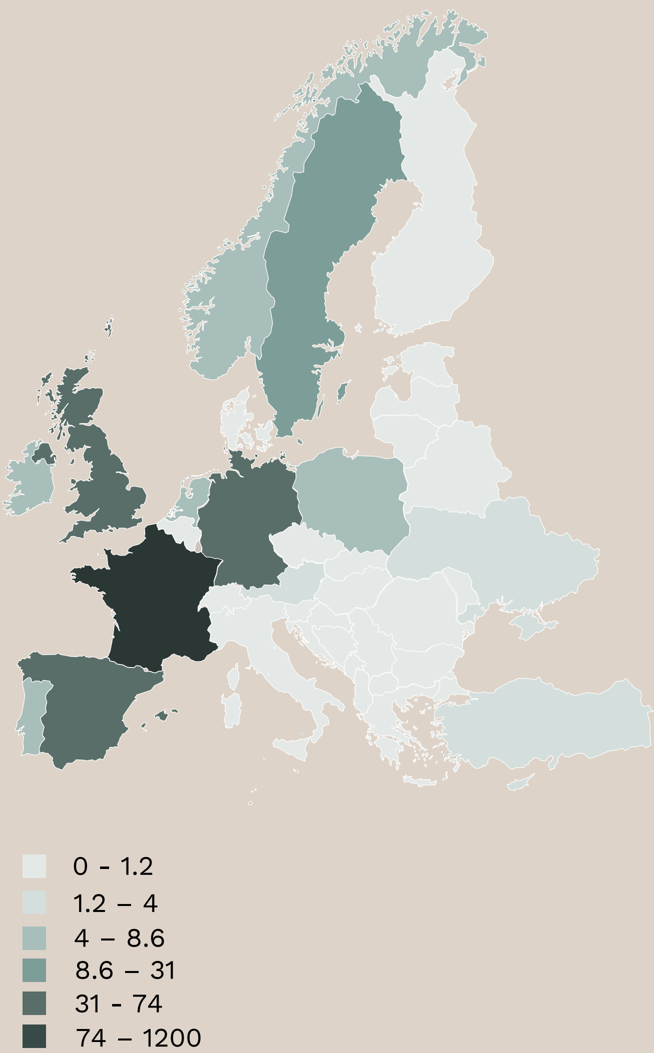
However, in this month's survey 'The Liability of Legacy', some 69% of respondents acknowledge that the latest fuel prices increases have led them to look for alternatives to diesel for their back-up power generators. Whilst the context of the question is set against fuel price rises, the direction of travel across the industry appears to be moving towards replacing diesel with more environmentally friendly alternatives. So how can we wean ourselves off this non-renewable energy source?



Technological advancement is very important in the diesel generator market with companies implementing next-generation advancements in generator technologies such as emissions control systems, combustion chamber modifications, advanced power output, offsite monitoring systems, and others to try to meet demand for maximum output with reduced environmental impacts. But it is surely the use of diesel as a fuel that jars the most against our environmental well-being.

Biofuels – An Alternative To Diesel

Biofuels are a possible alternative. Biofuel is derived from microbial, plant, or animal materials. Examples include Hydrotreated Vegetable Oil (sourced from vegetable oils such as rapeseed, sunflower, soybean, and palm oil as well as liquid animal fats), ethanol (often made from corn or sugarcane), and biogas (methane derived from animal manure and other digested organic material). Biofuels are therefore a renewable energy source, since the carbon released when the biofuel is burned is the same carbon taken up as the original source plant grew. In addition, with an energy content of around 40 MJ/Kg it fairs well in terms of energy density compared to the fossil-fuel it is trying to replace.



Map of total biofuel consumption in thousand barrels per day (Adapted from USEIA [42])

The problem with biofuels is the processing that turns plants into usable fuels requires energy and this results in CO2 emissions meaning that biofuels are not zero-carbon unless the entire process runs on renewable or zero-carbon energy. Biofuels also compete with food production for land, with concerns around deforestation, soil erosion and fertilizer run-off, which will become even more challenging as biofuel production increases. Fuels made from crop or general waste can be better, in terms of land use and carbon emissions, but availability of these wastes is limited, and processing technology needs improvement to be more cost-effective.
Water-based solutions in the form of algae production (green diesel) can be cultivated on land unsuitable for other purposes, with water that can't be used for food production. The natural oil made by microalgae is in the form of tricylglycerol, which is good for producing biodiesel. In addition, some algae species can produce hydrogen gas under specialized growth conditions, or the biomass burned like wood or anaerobically digested to produce methane biogas; all can generate heat and electricity.
Three major factors limiting commercial algae production exist: the difficulty of maintaining only the desirable species in the culture system, the low yield of algae oil, and the high cost of harvesting. Whilst there is now renewed interest in the use of algae to produce renewable energy, it was only in 2019 after more than a decade of research that the U.S. Department of Energy (DOE) concluded that the algae biofuel production was still too expensive to be commercialised soon

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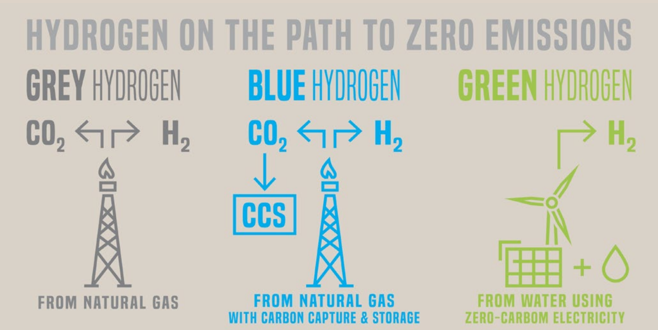
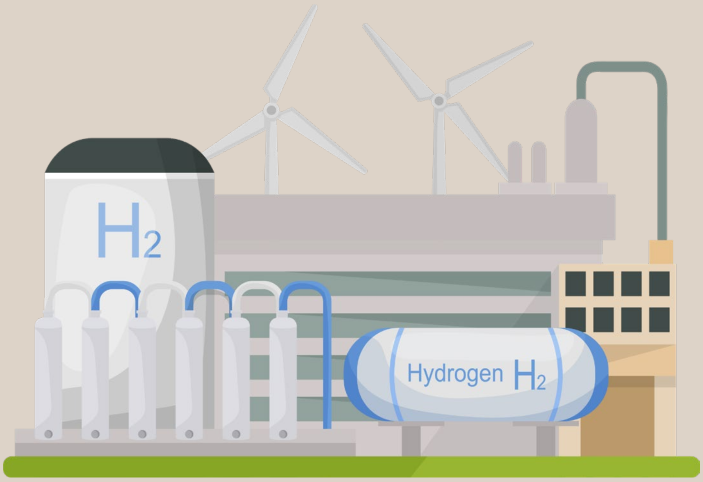
Hydrogen – a European Strategy

In April this year, the then UK Prime Minister Boris Johnson, announced (with typical hype) his intentions to "double hydrogen targets" in what was seen as a gamble on hydrogen usage as part of the Government's energy strategy to help bounce back following the economic trials of COVID and the fresh pressures of Russia's invasion of Ukraine on the availability and price of gas and oil. Indeed, this announcement followed his 2020 Ten Point Plan for a Green Industrial Revolution which centred around developing a thriving low carbon hydrogen sector in the UK as a key plank of the Government's plan to build back better with a cleaner, greener energy system.

Despite BREXIT, the UK and the EU have similar views, as the EU adopted its strongly pro-green hydrogen plan in 2020 and put forward its vision for the creation of a European hydrogen ecosystem to scale up production and infrastructure on an international scale. With 20 action points that were implemented by the first quarter of 2022 it was followed by the publication of the REPowerEU plan in May, which addresses its dependence on Russian fossil fuels by fast forwarding the clean transition and joining forces to create a resilient Energy Union where green hydrogen plays a significant role.





The REPowerEU plan's ambition is to produce 10 million tonnes and import 10 million tonnes of renewable hydrogen in the EU by 2030.

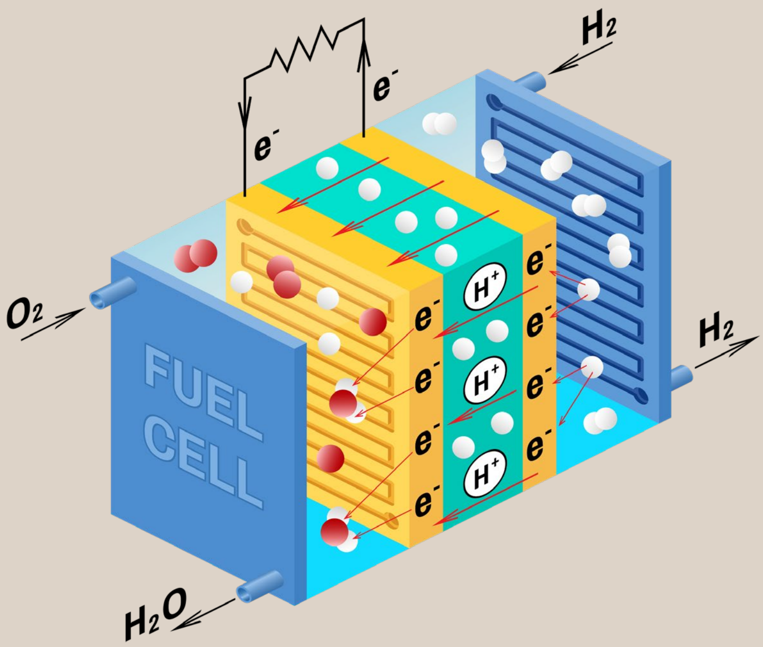
Hydrogen is the most abundant chemical element on the planet, present in almost everything – humans, animals, plants, and water. There is wide support for its potential as an energy store and fuel but as it is rare for hydrogen to exist in its own gaseous state, the questions of how to produce the huge volumes of hydrogen that are predicted to be needed is polarising many supporters.

The different types of hydrogen production are often referred to by a colour spectrum. There are around eight defined colours, but the main debated routes to production are Grey, Blue and Green. Grey hydrogen (made from natural gas using steam reformation) is currently the most abundant source of hydrogen production but produces CO2 as a bi-product and therefore a cause for concern. Blue hydrogen combines Grey Hydrogen production but captures the CO2 through carbon capture and storage (CCS) and is referred to as low-carbon hydrogen, whilst Green hydrogen is produced by water electrolysis powered by a renewable energy source – the most expensive production route due to the electricity needs, but arguably has the best environmental credentials.

There are challenges to overcome to enable the strategy of widespread deployment of hydrogen-enabled infrastructure across European geographies. These include:

- Cost - whilst expected to fall, the cost of production is still high versus existing carbon fuels
- Technology – still to be proven at scale
- Policy and Regulation – industry is waiting on Governments to provide regulatory levers and incentives, assurances on quality and safety
- Infrastructure – new networks needed and integration into existing infrastructure essential
- Supply and Demand Coordination – a balance between the two from early on is essential to develop a hydrogen economy
- Investment and Deployment – creating a sustainable environment to reduce first-mover cost disadvantages

The strategy behind the use of hydrogen within the energy system is based on its distinct set of characteristics which makes it manageable, transportable, and storable. Many of these characteristics are the same as those that drove the use of non-renewable fossil fuel gases over the years, but importantly hydrogen is "clean". So, it can be combusted in a boiler, turbine or engine to generate heat or electricity, which is driving its profile in both the residential and industrial energy markets. Importantly, the benefit of using hydrogen as a combustible fuel is that the bi-product is water and not environmentally harmful greenhouse gases such as carbon dioxide.

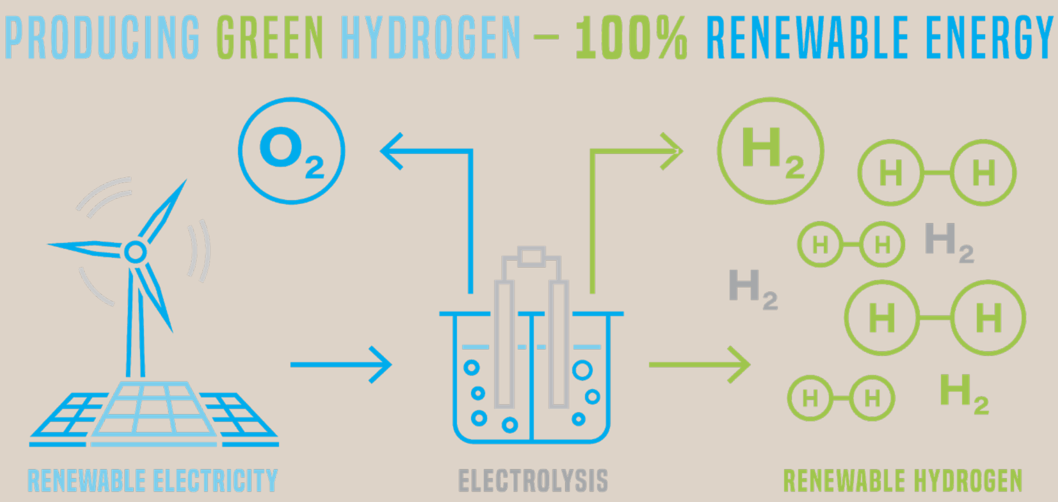


Hydrogen can also be used in a fuel cell. These are similar to a battery, converting the energy stored in chemical bonds to useful electrical energy. Unlike batteries, a fuel cell isn't recharged, but is supplied with a flow of hydrogen that reacts with an oxidant (air or pure oxygen) which is then converted to electrical energy. Fuel cells can be used almost anywhere that there is a need for electrical power. As they are more efficient than combustion engines and have higher reliability and lower emissions, they appear to be particularly suited to heavier transportation modes (road and sea freight, aviation) where the physics of lithium batteries means that the battery needed becomes too heavy and cumbersome.

Data centres are exploring hydrogen-powered fuel cells as a backup generator alternative, although it appears early in the technology cycle as to whether it provides the scale of power diesel generators offer, in a cost-effective manner. However, there are signs that the industry has embraced the challenge with several notable examples of operators looking to further the technology.

- The EcoEdge PrimePower (E2P2) project launched back in 2021 by a consortium of seven companies - including data centre giant Equinix - is a proof-of-concept initiative aiming to develop and demonstrate low environmental impact fuel cells that provide economic and resilient prime power solutions for the data centre environment
- Dutch data centre operator NorthC announced in February this year that it would be the first data centre in Europe whose backup power comes from 500kW of green hydrogen fuel cells at a new 1.5MW facility in Groningen.
- In August, Microsoft announced that it had successfully tested a three-megawatt hydrogen fuel cell system and would further test it for data centre use to check the feasibility of replacing diesel backup generators.

Long Duration Energy Storage (LDES)



Long Duration Energy Storage solutions enable the shifting of green energy from times of high supply to times of high demand, thereby helping preserve system balance and securing reliability. According to the Long Duration Energy Storage Council, the world's electricity grids will need to deploy 85-140 TWh of long duration energy storage by 2040. Hydrogen's ability to store energy for long periods of time and in large-scale quantities is an important part of its strategic value to a fully decarbonised energy system. The process of Green hydrogen production is seen as one solution to address over-generation from renewable sources such as solar or wind generators, avoiding curtailment by using hydrogen as a storage medium and fuel for use across the economy.

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Ownership & Management

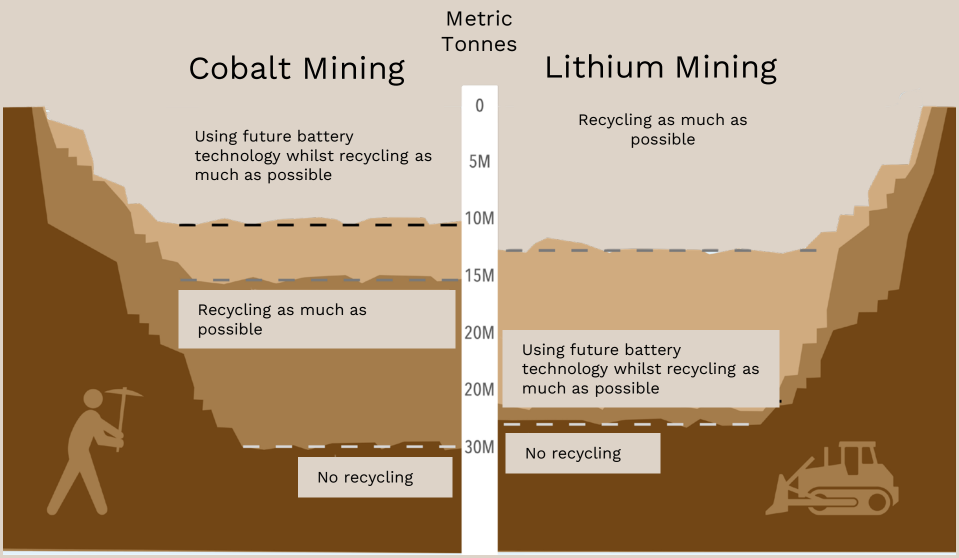
Valve-regulated lead-acid batteries (VRLA) have long been established as the building block of UPS solutions in data centres, although for a number of years the lithium-ion (li-ion) battery has been finding its way into the data centre, in a large part due to mass-users of li-ion batteries (smartphones, electronics and electric vehicles) pushing manufactures to innovate and improve li-ion technology.

Lithium is one of the lightest elements in the periodic table and it has one of the largest electrochemical potentials lending itself well to producing high voltages in the most compact and lightest volumes. Li-ion batteries tend to have a lifespan of over 10 years compared to 3 to 5 years for VRLA resulting in fewer battery refreshes and with their ability to operate at higher temperatures they could lower the total cost of ownership for data centre operators despite the initial cost of a li-ion battery being higher than a VRLA battery.

With 60-70% less weight than a VRLA battery and 40-60% less size overall, the footprint of a li-ion battery is much smaller, giving data centres more floor space for core IT, and with fewer refreshes required, the risk of incidents during battery replacement work is also lower, meaning higher reliability. All this suggests that the li-ion battery's use in the data centre energy system is set to grow.

However, the environmental credentials of li-ion batteries are perhaps not as clear-cut as we would like. With demand for li-ion batteries expected to grow substantially, particularly as industrial demand grows, the environmental impact of finding all the lithium required to enable that transformation could become a serious issue in its own right. It is estimated that more than half the world's supply of lithium sits beneath Argentina, Bolivia and Chile – the Lithium Triangle. The extraction process is very water-heavy, with around 500,000 gallons of salty water (brine) needed to extract 1 tonne of lithium.

Mined metal needed for batteries by 2050



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These areas however are some of the driest on the planet, so water-demand is a key concern, taking it away from other uses in areas that already suffer from water-shortage, and therfore placing serious pressures on the localised economies and ecosystems. Add to this the dangers of leaking toxic chemicals such as hydrochloric acid that are needed for the extraction, or waste products that are filtered out of the process, and the fact that less than 5% of li-ion batteries are being recycled, and there are some important environmental concerns. But, on balance, whilst li-ion batteries are not a perfectly green technology, they are seen as playing a very important part in the push to reducing the planet's reliance on fossil fuels through providing a reliable, effective energy storage solution that facilitates the push towards electrification.

Other LDES solutions include thermal battery technologies, typically a solid-state, high temperature thermal energy storage system using electric resistance coils to heat using green energy. The thermal batteries can be connected to on-site renewable energy installations to take off-peak electricity from renewables or allow companies to buy large quantities of renewable energy when costs are low and convert that electricity to heat. Energy is stored as ultra-high temperature heat with specialised turbines reconverting the heat to electricity when needed.

For example, research in 2021 by the Arizona State University for Swedish cleantech company TEXEL Energy Storage indicates that TEXEL's thermal battery technology paired with solar PV in California could deliver power at half the cost of pairing solar PV with a lithium-ion solution for large commercial and industrial scale applications.

Whichever LDES technologies succeed reliability will be key. The transition to a sustainable, zero-carbon energy system for the data centre industry will undoubtedly need ultra-low-cost storage produced from environmentally benign recyclable materials that offer long-term stability without degradation or energy loss.

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MEET THE EXPERTS

IF YOU WOULD LIKE TO HEAR MORE, PLEASE GET IN TOUCH

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