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The hydropower renaissance in Europe

The EU drive towards green energy is seeking to harness a traditionally clean power source – with some tweaks.

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Dr Jeremy Bricker, a hydraulics and coastal engineer, is dreaming big.

Somewhere on the North Sea coast, he imagines construction of a dam to manage the supply of clean energy to Europe's "lowlands".

Dam good

Bricker is also working towards that goal. He and other engineers are part of a project that received EU funding to advance a ground-breaking energy-storage option based on water.

Under their plan, a circular dam built just off the coast would keep seawater out of an inner, artificial lagoon where the water level would be lower.

Pumping water out of the lower lagoon into the surrounding ocean would be done when there's an oversupply from other renewable sources – such as sun and wind. When energy is needed, water would then be allowed to flow back into the lagoon through energy-generating turbines, pushed along by the force of the surrounding ocean.

'In the inner lagoon, we could store the energy equivalent of thousands of batteries,' said Bricker, an associate professor at Delft University of Technology in the Netherlands.

He is scientific coordinator of the project. Called ALPHEUS, it is due to wrap up in September 2024 after four and a half years.

Using gravity to allow water to flow back into the lower lagoon through turbines would make it possible to generate hydropower on demand when supply is low, filling a supply gap and providing a clean-energy storage solution.

Universities, including Chalmers in Sweden, Braunschweig in Germany and Ghent in Belgium, and companies joined forces across eight European countries to develop the key new technologies needed for a hypothetical offshore dam, such as water turbines fit for use at sea.

Back to the future

While thousands of hydropower installations already exist around the world, they are almost exclusively in mountainous regions where the natural terrain lets gravity show its force, or where river flow is powerful enough to be harnessed for energy production.

Interest in the technology is growing again – this time for potential use in flatter areas including seas – because it could help green the European economy.

Europe aims to become the first climate-neutral continent by 2050. This goal will require a shift away from fossil fuels, including coal, natural gas and oil, and towards renewables, such as hydropower.

The EU aims to increase the share of renewables to 42.5% in 2030 from 23% in 2022. That share will have to rise even more for climate neutrality to be achieved by 2050.

Nimble needs

One challenge is that renewables like wind and solar can be intermittent. Clouds can block the sun and the wind can stop blowing.

When this happens, the energy system needs to be able to react quickly to balance supply and demand. This means being able to store surplus energy and reintroduce it into the grid when needed.

While batteries currently serve this purpose, they have limitations. They store small amounts of energy, depend on critical raw materials and have a relatively short lifespan, particularly when compared to that of a dam.

'If we don't build up more energy storage, we might be facing blackouts and grid instability in the future,' said Bricker, whose career has taken him from the United States to working at universities in Japan and the Netherlands.

Demonstrating flexibility

Meanwhile, other researchers in Europe have been upgrading existing hydropower installations using artificial intelligence so water can take on a bigger role in the renewables line-up.

As part of another EU-funded project, these experts designed technologies to improve the energy storage potential, performance and flexibility of hydropower stations.

Called XFLEX HYDRO, the project ended in February 2024 after four and a half years.

Integrating larger and larger amounts of intermittent solar and wind energy – also referred to as variable renewable energies (VREs) – will require more flexibility than is currently possible to avoid disruptions in supply.

'We're seeing a renaissance of hydropower,' said Dr Elena Vagnoni, a lecturer at the Swiss Federal Institute of Technology Lausanne, or EPFL, and the scientific coordinator of XFLEX HYDRO. 'A new, renewable power grid needs flexibility. That changes the way we look at hydropower.'

The project combined the expertise of European power utilities, global equipment manufacturers, research institutions and energy consultancies in Austria, France, Germany, Portugal, Spain and the UK.

It carried out full-scale demonstrations of its new technologies in facilities in France, Switzerland and Portugal.

Efficiency gains

Intermittent supply drops increase wear and tear on installations that were designed with a more regular energy supply in mind.

‘In the past, you would turn on the pumps once a day at most,’ said François Avellan, honorary professor at EPFL who acted as a scientific advisor to XFLEX HYDRO. ‘Now we need to start them several times a day, depending on the weather. That puts a severe strain on these installations.’

The project tested out a new system – a “hydraulic short circuit” – at the Grand'Maison dam in the French Alps, the largest pumped storage hydropower installation of Europe.

At peak capacity, it can feed 1 800 megawatts of energy into the grid, equivalent to a mid-sized natural gas or coal plant.

The new technology allows Grand'Maison to pump water and generate electricity at the same time. The XFLEX HYDRO software manages the energy flow to keep it constantly in balance with the needs of the grid.

The expected increase in efficiency would reduce reliance on gas and coal plants and potentially save around 90 000 tonnes of carbon-dioxide emissions a year, according to Avellan.

Meanwhile, Bricker of ALPHEUS said its participants are looking for an industrial partner that can scale up the project’s technology. EU funding helped to make his dream of an offshore water power installation an achievable reality – actually building it will take years more of research and private investment.

‘The technology is here,’ he said. ‘Now it just needs industrial leadership and funding.’

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- XFLEX HYDRO
- EU energy research and innovation
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