Horizon
The EU Research & Innovation Magazine

European Commission

From sunlight to stored power: how hot air could solve solar energy's biggest challenge

EU-funded researchers are looking to hot air to overcome the supply and demand issues faced by solar energy and ease the clean energy transition.

11 March 2025 - By MICHAEL ALLEN

As the world shifts toward renewable energy, one major challenge remains: efficient energy storage. An EU-funded research team is exploring the use of compressed air to store excess energy collected from solar panels.

A pilot plant at Plataforma Solar de Almería, a solar technology research centre in southern Spain, will demonstrate a concept they call solar thermal energy that will offer a sustainable and cost-effective alternative to traditional battery storage.

By capturing and storing thermal energy (heat), this innovative approach ensures that solar power can be accessed even when the sun isn't shining, helping to stabilise the energy grid and accelerate Europe's transition to a clean energy future.

Balancing supply and demand

The root of the issue, according to Professor David Sánchez, an expert in energy systems at the University of Seville in Spain, is that increasing the installed capacity of photovoltaic panels is not going to help provide energy at night or guarantee that electricity is available whenever it is needed.

In theory, the sun provides ample energy. According to the Commission, solar power already contributes significantly to Europe's energy mix and, based on current market trends, has the potential to meet up to 20% of the EU's electricity demand by 2040.

But solar panels generate electricity when there is least demand – in the middle of the day. Then, in the evening, when the sun has set, electricity demand peaks, but solar energy is not available.

“Renewable energy is wasted because we don’t have enough storage,” said Fritz Zaversky, a research engineer at the National Renewable Energy Centre in Spain.

Mechanical storage

Both Zaversky and Sánchez are part of a four-year EU-funded research initiative called ASTERIx-CAESar that is developing an innovative, high-efficiency solar thermal power plant which integrates two separate concepts: concentrated solar power and compressed-air energy storage.

“Compressed-air storage is not a new concept and has been demonstrated already at commercial scale,” said Zaversky.

Currently, there are three compressed-air energy storage plants operating globally, in Germany, the US and China. Other sites are being explored and developed.

Compressed-air storage uses low-cost surplus electricity to compress air to a high pressure. This compressed air is stored and then used to drive turbines to generate electricity when power is needed.

Unlike batteries, these technologies do not rely on critical raw materials, for which there is competition from other battery-based technologies, like electric cars.

If, on top of that, an underground storage reservoir such as a cavern or old mine can be used as storage, this further lowers costs, Sánchez explained. But there is a flaw.

Fossil flaw

Compressed air cools during storage and needs to be heated before it can be used. Usually this is done using fossil fuels, which diminishes the eco-friendly credentials of the process.

“The concept is not carbon neutral because you burn natural gas,” said Zaversky.

To address this, the ASTERIx-CAESar team, comprised of energy experts and academics from eight EU countries, Switzerland and the UK, is looking to combine compressed air energy storage with another form of renewable energy known as concentrated solar power.

“Concentrated solar power uses many mirrors to focus sunlight on one single spot, and this is usually at the top of a tower,” said Zaversky.

In conventional concentrated solar power plants, the generated thermal energy is used to heat a liquid, usually molten salts, which then acts as thermal energy storage. When power is needed, the superheat from the liquid is used to create steam and drive a turbine to generate electricity.

However, according to Zaversky, conventional concentrated solar power plants are too expensive to be competitive against other renewables. The researchers are therefore proposing to combine the concentrated solar power technology with compressed-air energy storage, heating the compressed air with solar heat before expanding in the turbine.

“Our approach is to use solar heat instead of natural gas, to make compressed-air energy storage carbon neutral,” said Zaversky.

In the system they are developing, low-cost renewable electricity is used to compress air for storage during the day, while concentrated solar power feeds a thermal energy storage system.

When energy demand is high, the thermal energy is used to heat the compressed air as it is released from storage to drive turbines.

High temperatures

Sánchez said the main challenge will be to develop technology able to convert concentrated solar energy into thermal energy at around 800°C and store it at such high temperatures.

This is important, he explained, because it matches the temperatures used when burning natural gas. Also, higher temperatures increase the power output and efficiency of the process.

The pilot plant in Spain will put these ideas into action. They will be upgrading a concentrated solar power tower already in place by adding compressed air energy storage, using high-pressure storage tanks, to create the hybrid system.

The team aims to demonstrate that their hybrid concept works on a small scale. After that, Zaversky believes it will be necessary to develop an intermediate-scale demonstration plant. If that proves successful, the technology could start being used.

Solar efficiency

Their goal is to build a highly efficient solar thermal power plant that can ensure 24/7 availability of renewable energy. Because it will have enough storage capacity, it will be able to offer much-needed grid stability and help support the uptake of renewable energy.

The solar-to-electric energy efficiency conversion of this system is predicted to be around 40%, or double that of today's commercially available solar panels, which achieve 15 to 24% efficiency.

According to Zaversky, there are several sites in Europe where this concept could operate, especially in southern European countries such as France, Greece, Italy and Spain.

"The Greek islands are particularly favourable, because they have high solar energy available and there are locations where compressed air could be stored underground."

Research in this article was funded by the EU's Horizon Programme. The views of the interviewees don't necessarily reflect those of the European Commission. If you liked this article, please consider sharing it on social media.

More info

- ASTERIx-CAESar
- ASTERIx-CAESar project website
- REPowerEU – Affordable, secure and sustainable energy for Europe
- Photovoltaic Geographical Information System
- Solar energy