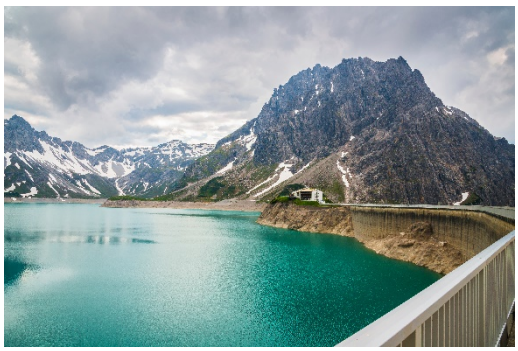
What if increased energy storage could help fix climate change?

The European Union is committed to achieving climate neutrality by 2050, which requires a drastic increase in the share of energy from renewable sources in the electricity mix. However, the availability of some renewable energy sources is variable and intermittent, creating concerns about system reliability. Devising new energy storage capacities could solve this issue and contribute to the EU's climate neutrality goal.

Historically, energy systems have been dominated by large power plants able to produce great quantities of energy in a short time. This centralised mode of production has the advantage of easily balancing supply and demand at any time. However, such primarily fossil fuel-powered plants, are not known for being nature-positive. As part of the European Green Deal, the Fit for 55 package aims at adjusting the EU climate laws to achieve climate neutrality, by reducing EU greenhouse gas emissions to at least 55 % by 2030 compared to 1990. With fossil fuels still constituting a large part of the energy mix, the EU will need to considerably increase its share of renewable energy to pursue this objective.



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Renewable energy is a sustainable resource that naturally renews or replenishes itself. Common sources include wind, solar, geothermal energy, hydropower, biomass, and biogas. It is estimated that between 2018 and 2050, the worldwide renewable energy share in power generation will increase from 25 % to 86 %, with most of the increase coming from wind and solar. In the EU, over 60 % of the EU-28 electricity mix still had to become renewable, and further electrification is expected. However, a major obstacle hinders renewable energy penetration in the power grid: wind turbines and solar panels have variable, or intermittent, nature (e.g. they are dependent on weather and climate conditions), and thus cannot be programmed 'on demand' at the request of power grid operators to fulfil market needs, unlike most of the fossil fuel power plants they will replace. Power grids necessitate a permanent balance between production and demand. Therefore, it is an ongoing challenge to increase the share of renewable energy in the electricity grid.

One of the ways to achieve this is through energy storage. The main types of energy-storing systems are: electrochemical (batteries), mechanical (pumped hydro storage), and chemical (hydrogen). These technologies can help provide flexibility, encompassing different timescales: from a discharge time of hours for batteries, to several months for pumped hydro storage. Hydrogen has an average power range (1 kW-1 GW) as well as an average life duration (<30 years), but very poor efficiency (20-40 %; hydrogen will also likely be used to decarbonise hard-to-abate industrial processes, so capacity may be built up despite the poor efficiency). Both the power range (1 kW-50 MW) and life duration (<20 years) of batteries are lower, but they are more efficient (90-98 %). A third possibility is pumped hydro storage, which has the highest power range (10 MW-3 GW) and life duration (>80 years). However, it has intermediate efficiency (70-85 %) and is less environmentally sustainable, as it contributes to biodiversity loss in aquatic life.

Energy storage system limitations include their limited storage capacity, high cost, and extensive requirements in terms of physical space and transportation infrastructure. Thus, the process of storing energy still needs to be optimised to reach the EU's commitment to decarbonise the energy sector by 2050.

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Potential impacts and developments

Optimising energy storage would allow an increase in wind and solar energy use. Since 2016, the increase in annual battery installations in the EU has been accompanied by a rising share of renewables in the energy mix and a decrease in the share of fossil energy, laying the groundwork for the virtuous cycle that will be required in the future to drive adoption of renewables. Innovation is key to improving the elasticity of substitution between renewable and fossil-fuel energy production, as it enables the full potential of these natural resources to be exploited by dispatching their energy to the grid whenever it is needed.

Another beneficial impact would be on the stability of the power grid, where deferring large quantities of excess energy over different periods could help stabilise fluctuation in supply and demand. At a time of geopolitical and economic uncertainty, energy storage could enhance the EU's energy security, reducing dependence on third-country fossil fuels, strengthening strategic autonomy and potentially increasing its geopolitical leverage. Developing climate-neutral energy storage systems and technologies would ensure larger distribution and prevent extreme price fluctuations, contributing to affordable energy, a priority in tackling energy poverty in the EU.

However, several barriers persist in developing and deploying storage systems. First, how to increase the capacity and efficiency of existing technologies, whilst ensuring an ideal economic and regulatory context, for their development. Moreover, in the short term, the impact of energy storage on greenhouse gas emissions is more uncertain and would depend on the competitiveness of renewable energy sources compared to fossil fuels. There is also a wide application gap at national level: most Member States require storage facility operators to pay double network or energy taxes (as both producers and consumers), a burden that discourages its development. Unlike for gas, a common regulatory approach for electricity storage is still missing. In addition, energy storage can have a harmful impact on the environment and human health: the mining, use, disposal and recyclability of raw materials – especially for batteries – are yet unresolved issues that further touch upon issues of human rights and labour standards.

Anticipatory policy-making

Energy storage is part of the principles stipulated in EU law, that Member States, regulatory authorities, and system operators must follow to deliver appropriate investment incentives for generation and efficient electricity dispatch. In its 2020 resolution, the European Parliament called on the European Commission to develop a comprehensive strategy on energy storage to enable the EU's transformation to a climate-neutral economy. The Commission's REPowerEU plan further highlights energy storage as a significant asset to ensure the flexibility and security of the EU's energy supply. Currently, only 5 % of the EU's installed capacity is used for storage. The European Commission estimates that the EU will need to store six times more energy to achieve net-zero greenhouse gas emissions by 2050.

The EU supports energy storage in three main areas: a strategic framework for the development of energy storage technologies, EU research and innovation funding instruments, and a legislative framework for its development. Legislative and non-legislative policy action on market regulation and economic incentives could help boost demand by lowering market prices and resolving double taxation issues.

Several Horizon Europe research and development projects are currently in place to find ways to increase the capacity and efficiency of existing technologies and make power grids more flexible. New technologies will need to be developed to increase the share of renewable energy in the EU and the consumer contribution to decentralised energy storage.

Pumped hydro storage can be harmful for biodiversity, and batteries' raw materials need to be more recyclable. To ensure energy storage is more nature positive, as well as technological and economically viable, standards to assess the environmental impacts of energy-storage systems should be developed and extended to other forms of energy storage.