Science for Environment Policy

Twelve principles for introducing sustainable energy storage to the electrical grid

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Researchers have provided a set of guidelines to help policymakers, designers and operators develop sustainable solutions for energy-storage systems for electricity grids. The guidelines cover a range of energy-storage technologies and grid-integration options.

As societies move towards decarbonising the world's energy supply and reducing greenhouse gas emissions, energy storage is playing an increasingly important role in the way energy is produced and distributed. Energy-storage technologies are crucial for overcoming the problem of intermittent supply from renewable energy sources, such as wind and solar power. The aim is to introduce flexibility into the grid system, storing generated energy when demand is low and releasing it to the grid when demand is high. The environmental impact of energy-storage technologies differs depending on how these technologies are designed, operated and maintained.

This study produced a set of guidelines for system operators, companies that supply electricity to customers, and designers of energy-storage systems to help them assess the environmental outcomes of the available energy-storage systems and their integration into an electricity grid. The guidelines are valid for all energy-storage technologies, such as batteries, flywheels (energy is stored in spinning rotors) and compressed air systems. They are also applicable to different grid-integration applications, such as having a reserve capacity, deferring transmission and distribution upgrades and integrating renewables in the grid.

Over a two-year period, the researchers consulted with a wide range of scientists and stakeholders, including chemical engineers, industrial ecologists, chemists and electrical engineers. The stakeholders based their recommendations on existing academic literature and research and the researchers refined these recommendations through feedback from participants at several conferences.

From this process, the researchers developed 12 principles, grouped into three categories.

i. The integration of energy storage into grid networks:
Within this category are four principles. The first principle, for example, is 'Charge Clean and Displace Dirty'. This principle addresses how emissions can be reduced if cleaner sources of energy, such as renewables, are used to store energy at off-peak times when demand is low. This energy is then discharged when demand is higher, displacing dirtier energy that would have been used, such as that generated from coal.

The other three principles deal with using energy storage in place of building new infrastructure to increase grid capacity; choosing the most appropriate storage technologies for particular grid applications (such as supplying backup power) to reduce degradation of storage systems; and choosing the most suitable size of storage system to minimise overall emissions when integrated into the grid.

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European Commission

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Twelve principles for introducing sustainable energy storage to the electrical grid *(continued)*

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ii. The operation and maintenance of the storage systems:
The three principles in this category identify the need for appropriate maintenance to minimise degradation of the storage systems; the need to design and upgrade energy systems so that emissions are minimised over the lifespan of the storage system; and the need to design and operate energy-storage systems with maximum round-trip efficiency (the ratio of the energy used to store the energy to the energy retrieved from storage).

iii. The early stages of energy-storage system design:
Five principles include the need to: minimise the consumption of non-renewable materials; minimise the use of critical materials; make storage systems safe by using non-toxic and non-hazardous materials where possible; minimise emissions during production; and design for end-of-life.

Where there is conflict between applying individual principles, the researchers recommend that a comprehensive sustainability assessment is carried out to help policymakers, designers and operators assess any trade-offs that might be needed in the design, deployment and operation options that they are considering. The principles are intended as a high-level guide for the development of more specific policy and technology solutions.