What a reliable clean power system looks like

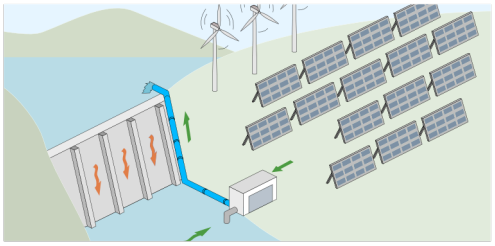
A combination of these nine clean flexibility tools could be used to fully harness renewable energy, every hour of the day

Renewables are the heart of a clean power system, but clean flexibility is the brain that keeps it running smoothly, constantly balancing supply and demand in real time to maintain grid stability. It makes the most of renewable electricity by **storing** some of that renewable electricity for later use, **shifting** non-critical demand to periods of abundant supply and **sharing** it across an expanded grid where it's needed more. At the same time electricity generation assets that **supply** the electricity are fully flexible, turning off at ease when there's excess solar and wind.

STORE

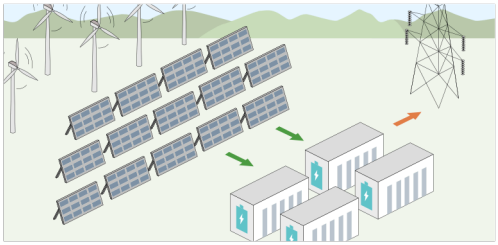
Four clean flexibility tools enable electricity to be stored across minutes, hours and days to save excess renewable power for times of higher demand

Pumped hydro storage



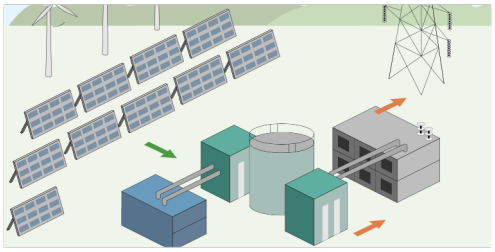
When generation exceeds demand, excess power pumps water to an elevated reservoir. When demand is higher than electricity generation, water is released to produce electricity. Electricity generation from existing hydropower plants can be improved with digital controls, automation, and efficient equipment; capacity can grow by raising dam heights.

Batteries



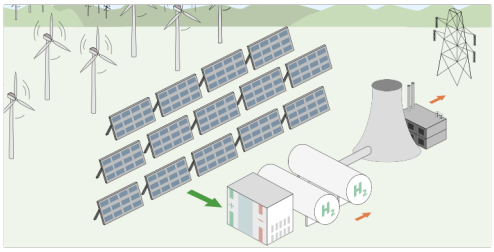
Excess power is stored when electricity generation exceeds demand; when demand is higher the electricity generation, stored energy fills the gap. In California, battery capacity is already moving solar power from daytime into evening, reducing the state's reliance on gas power plants.

Long duration energy storage (LDES)



New LDES technologies, such as compressed air storage, are capable of storing electricity for several days or weeks – useful when wind and solar output is expected to be low for extended periods. When there is excess power, air is compressed and stored in underground caverns. When demand is higher, stored air drives turbines to generate electricity.

Green hydrogen

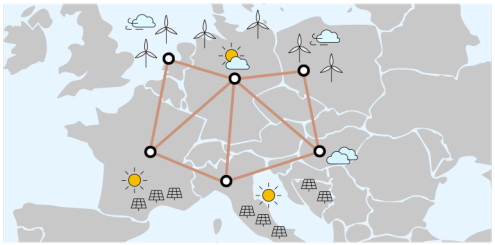


Renewable electricity can be used to separate hydrogen from water through electrolysis. The resulting green hydrogen can be stored, and when generation is lower than demand, it can be burned to generate electricity. This is an inefficient flexibility tool since more than two thirds of the initial electricity supply is lost in conversion.

SHARE

Sharing excess renewable electricity through grids and interconnectors

Grids and interconnectors

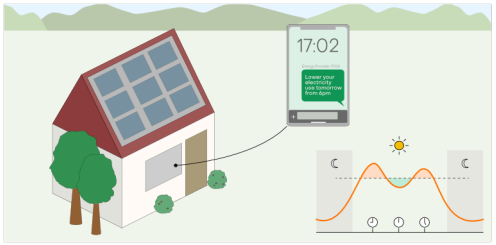


Grids and interconnectors allow a place with high wind and solar potential to fully develop it and share it with places that need the cheap electricity. They also help exploit temporary variations in weather conditions and electricity demand across different provinces of a larger country and across neighbouring countries..

SHIFT

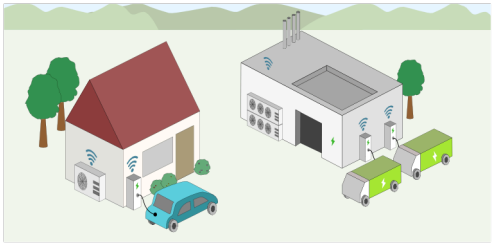
Two clean flexibility tools enable consumers to shift their demand and take advantage of windy and sunny hours with the cheapest electricity, reducing their bills

Peak shaving



When electricity generation is expected to be lower than a predicted spike in demand, consumers are offered incentives to reduce consumption during those times – reducing price shocks. Consumers are then encouraged to use more electricity when electricity generation is expected to be higher than demand.

Smart electrification

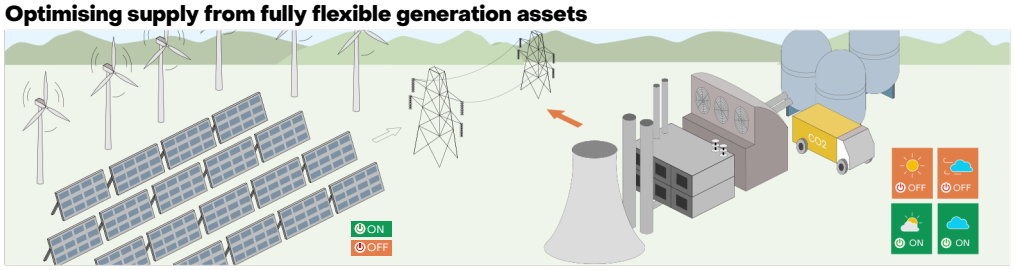


Technologies automatically respond to dynamic pricing: electric vehicles charge and heat pumps only switch on when renewable electricity supplies are abundant and prices are low, while smart meters and sensors automate technologies to turn down, or off, during expensive peak demand hours.

SUPPLY

As the share of wind and solar in electricity supply grows, all sources need to be able to switch off to make room for the cheapest electricity while keeping the grid stable

Optimising supply from fully flexible generation assets



Technical and contractual improvements can be made to fossil plants, enabling them to turn off more easily and cheaply. In electricity systems with very high shares of wind and solar energy, temporarily and quickly reducing wind and solar output can be used when electricity supply is much higher than demand.

At this year's COP29, the Azerbaijani delegation is proposing three key measures on clean flexibility – a global storage target, a grid expansion target, and action on green hydrogen. These three measures aim to significantly enhance the flexibility of the global power system, unlocking the full potential of the global goal to triple renewables agreed at COP28 last year. However, they only partially address the whole portfolio of nine clean flexibility tools - leaving out tools related to shifting demand and making supply more flexible; including these tools could truly unlock the potential of renewable energy.

Source: Ember

EMBER