

Renewables 2023 Global Status Report Collection

Energy Systems & Infrastructure

Key Headlines in 2022

- Several countries achieved high penetration of variable renewable electricity (wind and solar power), driven by technological advancements, declining costs and growing concerns about the stability of fossil fuel supplies. These high shares are enabled by regional interconnections, digitalisation and energy storage developments.
 - Countries with high shares of renewables in gross electricity generation included **Denmark** at 61% (55% wind, 6% solar), **Uruguay** at 36% (33% wind, 3% solar), **Portugal** at 35% (28% wind, 7% solar) and **Greece** at 34% (21% wind and 13% solar).
- Investment in energy storage worldwide increased 46% in 2022 to reach a record high of USD 15.7 billion.
- Total pumped (hydropower) storage capacity increased by 10.5 gigawatts (GW) in 2022, for a global total of 175 GW; utility-scale battery storage reached a total installed capacity of 11 GW.
 - **China** accounted for most (82%) of the new capacity of pumped storage.
 - By the end of 2022, 11 national and sub-national jurisdictions had targets for energy storage capacity, whether pumped storage or battery storage.
- Only around 30% of grid investment was devoted to expansion, while a growing share was used to replace and upgrade equipment; the need for grid expansion remains.
- Across the **United States** and **Europe**, an estimated 1,000 GW of solar projects were reportedly stuck in the interconnection queue as of 2022, close to four times the amount of new solar capacity installed globally during the year. Meanwhile, more than 500 GW of wind power was waiting to be connected to the grid, five times as much as was installed that year.

Key Drivers

- Renewables not only help to reduce greenhouse gas emissions, but also can create new jobs and economic opportunities in local communities.
- A decentralised grid could provide electricity to those who do not have access to conventional centralised electricity system.

Key Challenges

- Integration of variable renewables in electric grids requires careful planning and co-ordination among different stakeholders.
- Generated electricity must be immediately consumed or stored, otherwise this leads to curtailment during periods of low demand.
- Returns on investment for pumped storage tend to be lower over longer periods of time, making investments to finance the large upfront capital less attractive than for other energy types.
- Battery storage's profit potential can vary greatly depending on local market rules and regulations in different states and regions.

Key solutions

- **Synthetic (virtual) inertia, synchronous condensers and grid-forming inverters** can help address the fluctuations in renewable power provision, enabling a more stable electricity supply.
 - In **South Australia**, the Hornsdale Power Reserve was one of the world's first big battery systems, providing synthetic inertia and other essential grid-support services.
 - In 2022, the **Australian** Renewable Energy Agency announced USD 116 million in conditional funding for eight grid-scale battery projects, which are equipped with grid-forming inverters.
- **Improved forecasting techniques, demand-side management and energy storage** enable operators to increase dispatch options for operators.
 - **Japan** has outlined a strategic plan that focuses heavily on demand-side measures, with new balancing and flexibility products being developed starting in 2022.
 - **India** updated its Renewable Purchase Obligation to include an energy storage obligation, and the country's national budget for 2023-2024 includes provisions for funding 4 GW of storage.
 - Scientists in **Spain** developed a new methodology for long-term prediction that focuses on the atmospheric circulation patterns on a planetary scale in 2022.
 - In Europe, two major pumped storage facilities came online in 2022 (**Portugal** – 40 gigawatt-hours (GWh) and **Switzerland** – 20 GWh).
 - In the **United States**, two projects with a combined pumped storage capacity of up to 17 GWh were submitted for the final licencing phase.
- **Dynamic line rating, flexible interconnectors and regional interconnections** can all help with grid improvement.
 - In 2022, **India** and the **Maldives** signed a memorandum of understanding to establish a transmission interconnection for renewable energy. **Egypt** and **Saudi Arabia** similarly signed a memorandum of understanding as well as subsequent contracts to establish an electricity interconnection line between the countries.
 - The **US** Department of Energy launched the Building a Better Grid Initiative to upgrade high-voltage transmission lines, with a budget of USD 20 million.
 - The **European Union** has an interconnection target of 15% by 2030, which mandates that countries have in place electricity cables that allow for at least 15% of the electricity produced to be transported to neighbouring countries.
 - The **United Arab Emirates** enacted a law allowing grid connection for distributed renewable generation, including individual systems, in an effort to diversify its energy mix and expand the grid.
- Digitalisation, such as **data analytics in weather forecasting, energy storage optimisation, blockchain-based energy trading and virtual power plants (VPP)** can be used to exploit and leverage the physical capabilities, or hardware components, of the system (such as the sensors of a weather station), together with the software capabilities (such as the algorithms used to forecast the weather conditions for a defined time horizon).

- Pacific Gas and Electric (PG&E) in the **US state of California** uses artificial intelligence, advanced price forecasting, portfolio optimisation and market bidding algorithms to ensure that the electric system is responding optimally to wholesale market reliability needs.
- The newly launched VPP in Shenzhen, **China** can pull together a capacity of 870 megawatts (MW), which is planned to increase to 10 GW by 2025.
- **Greece** officially inaugurated its first VPP in 2022.
- In the **United States**, the Puerto Rico Electric Power Authority (PREPA) selected Sunrun to deploy a 17 MW solar-plus-storage VPP network, marking the first large-scale distributed storage programme on the island.
- **Microgrids** can be used to optimise the performance of both renewable and conventional energy assets, particularly in rural areas and areas with no access to a unified power grid.
- **Sector coupling** is a means to integrate energy supply and demand across different electricity, heat and transport applications.
 - In **Finland**, Allianz provided EUR 25 million (USD 27.8 million) for a green hydrogen and power-to-gas project.
 - In **Denmark**, a 6 MW power-to-hydrogen prototype unit has been deployed to supply extra thermal energy to a district heating system.
- **Non-variable renewable energy plants** enable the power output to be controlled to meet signals imposed by the operator to ensure that the supply meets the load requirements.
- Incentives and investment in systems and infrastructure include:
 - In **China**, the release of the 14th Five-Year Plan for the Development of New Energy Storage Technologies in March 2022 called for government and private entities to build additional storage capacity, paving the way for more targeted investment.
 - **Japan** allocated JPY 13 billion (USD 100 million) in subsidies for stand-alone battery systems in 2022 and was reforming its regulations for battery energy storage systems in 2023.
 - The **US** Inflation Reduction Act provided an investment tax credit for stand-alone energy storage.
 - **Romania** allocated more than EUR 100 million (USD 109 million) in 2022 for commercial and industrial energy storage, and in 2023 the country published new technical regulations for energy storage.
 - **Israel** introduced a distinct favourable tariff for distributed solar systems for self-consumption that include a storage component.
 - **Australia's** state energy ministers agreed to offer tenders for renewable energy and storage at the federal level.
 - **France** enacted specifications for its energy storage tender mechanism.
 - **Germany** held innovative auctions that allocated 403 MW for solar-plus-storage projects on lands with dual use.