A vision becomes reality with the 21st century energy revolution

From rooftop panels to grid-scale battery storage, the solar revolution is reshaping the global energy system at record speed. As costs fall and deployment surges, photovoltaics and BESS are emerging as the twin engines driving electrification, decarbonisation and a new era of affordable, resilient clean energy worldwide.

Since the beginning of the solar energy era around the year 2000, photovoltaics have grown in a way that is unprecedented in energy history. No other energy source has ever been adopted so quickly on a global scale. Following the oil crisis of the 1970s, governments and researchers sought to harness solar radiation as a limitless alternative energy source for industrial use.

Today, photovoltaics and solar thermal energy have firmly established themselves as clean, efficient energy generation technologies. According to a study by the International Energy Agency (IEA), photovoltaics now dominate the annual increase in electricity generation capacity worldwide and are gaining an ever-increasing share of the local electricity mix. Solar energy is displacing fossil fuels due to lower costs and higher efficiency.

Technology development: economies of scale and restructuring of the energy system

The unique selling point of solar energy is its decentralised applicability. Rather than a centrally organised energy system characterised by large fossil fuel and thermal power plants, the energy revolution driven by solar energy is taking place 'bottom-up': solar cells are mass-produced and continuously scaled up and standardised.

According to Tim Meyer's book Strom (Electricity), the price of PV modules has fallen by over 90% in two years, a decline which is also being driven by ongoing technological improvements. Because PV is inexpensive and easy to use, private consumers also have access to it and can become energy producers on a very small scale.

Today, photovoltaics is mainly used in applications such as large-scale PV power plants and rooftop installations, in the commercial and industrial sectors, as well as in private homes and residential buildings.

Sector coupling: electrification is the key to decarbonisation

Using renewable electricity to electrify the heating and transport sectors is both economically sensible and the preferred technical solution due to the cleanliness and efficiency of solar power. It is the only way to decarbonise the economy and society as a whole, and thus counteract climate change.

Therefore, solar energy should not be viewed solely as a source of energy generation. Instead, the industry is moving towards offering systemic solutions that contribute to the storage and conversion of solar power for various sectors, the expansion of electric mobility, and the adaptation of energy infrastructure for electrification.

World market and global market development

Wind and solar power have long since taken the lead in the expansion of new power sources, and there is no end in sight to the exponential growth of solar energy. According to the Global Solar Council, it took 68 years to install the first terawatt (TW) of solar power, from 1954 to 2022, but only two years to double that figure to two terawatts, from 2022 to 2024. According to market research institute GlobalData, cumulative PV capacity could rise to between 4.8 and 7 TW by 2030, i.e., a factor of two to three compared to 2024.

A study by the Fraunhofer Institute for Solar Energy Systems ISE found that the average annual growth rate of cumulative PV installations between 2014 and 2024 was around 27%. The rapid expansion of solar energy in China is driving global growth.

According to a market study by the industry association SolarPower Europe, China accounted for 55% of the 597 gigawatts (GW) added globally in 2024. A significant factor in the affordability of solar energy is the overproduction of solar modules, driven by China through the establishment of enormous, state-subsidised production capacities. According to an IEA estimate, global PV module capacity reached 728 GW in 2024.

Solar thermal energy is growing more slowly but steadily and will reach 560 GW thermal (GWth) in 2023, according to the industry association Solar Heat Europe.

Opportunities for the countries of the 'Global Sunbelt'

Thanks to sharply lower costs, higher efficiency and a rapidly growing global manufacturing sector, solar energy is now the cheapest form of electricity generation in many parts of the world. It is gaining ground not through subsidies, but through its competitive advantages in terms of cost.

Its application is also of particular interest to countries in the so-called Global Sunbelt, which offer ideal conditions for solar energy use due to high levels of solar radiation. In many of these countries, developing an energy system based on low-cost solar energy as the dominant energy source would be highly advantageous due to increasing population growth and energy demand.

Battery energy storage systems. The Swiss Army knife of the energy transition

Since the early 2010s, when lithium-ion technology first began to scale beyond consumer electronics into electric vehicles and grid applications, battery storage has evolved from a niche innovation into a versatile 'enabling technology' with truly disruptive potential for the global renewable energy transition.

As solar and wind power expand at a record pace, storage has emerged as the essential counterpart allowing the full exploitation of their generation potential and seamless integration into the electricity grid.

Without Battery Energy Storage Systems (BESS), the continued growth of photovoltaics would face its natural limits: when sunlight is abundant, excess generation must be stored to maintain grid stability and supply electricity when demand peaks.

By capturing surplus solar power and releasing it at the right time, batteries turn variable renewable energy into a reliable supply. They enhance system flexibility, reduce transmission losses, defer costly transmission upgrades and relieve network congestion.

Technology development: versatility and innovation

A wide range of battery chemistries has emerged to meet different performance, cost and sustainability needs. Lithium-iron-phosphate (LFP) and nickel-manganese-cobalt (NMC) batteries currently dominate, while sodium-ion and solid-state technologies are advancing quickly.

According to the market study 'Renewable Power Generation Costs in 2024' of the International Renewable Energy Agency (IRENA), the cost of utility-scale BESS dropped to 192 US dollars per kWh in 2024, which is a 93% decline since 2010, driven by

industrial scale-up, improved materials and production efficiencies.

Complementary storage technologies such as flow batteries, thermal storage, pumped hydro and green hydrogen continue to expand the portfolio of flexible energy solutions.

IRENA highlights that since 2018, energy shifting, which consists in large-scale BESS storing and injecting electricity according to price signals, grid load and current supply and demand, has become the primary application for BESS, accounting for 68% in 2024. It is followed by residential use with 13%, ancillary services with 6% and commercial and industrial use with 5%.

The ability to combine multiple value streams (arbitrage, ancillary services, capacity reserve) is making storage projects more bankable and attractive to investors.

Hybridization and system integration

Hybridization is a key trend that combines renewable generation sources with BESS. In the United States, for example, 55% of new solar installations are now hybrid systems combining photovoltaics and BESS. These configurations reduce project development costs, minimize land use and grid connection expenses, and enable higher utilization of solar assets.

Across emerging markets, hybrid PV systems are gaining traction as cost-effective solutions to balance variable generation and improve energy access.

World market and global development

The global BESS market continues its exponential rise. According to market intelligence firm Rho Motion, global BESS installations increased by 54% in 2025 compared with the first half of 2024. Annual capacity additions for BESS grew from just 0.1 gigawatt hours (GWh) in 2010 to 169 GWh in 2024, with China (84 GWh) and the United States (41 GWh) leading the charge. Rho Motion forecasts the market to expand at a compound annual growth rate (CAGR) exceeding 20% through 2030, with annual installations expected to reach 100 GW by the end of the decade. BloombergNEF predicts that worldwide installed capacity will surpass 1 terawatt-hour (TWh) by 2030.

With costs falling, performance improving, and policy frameworks aligning, BESS is truly the Swiss Army knife of the energy transition, delivering flexibility and reliability for the further expansion of renewables worldwide.

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