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Electricity storage: at the dawn of an energy revolution

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Confidential

Executive summary

Long considered technically and economically unrealistic, direct electricity storage is now a reality. In just a few years, grid-scale battery energy storage systems (BESS) have established themselves as an essential complement to solar and wind power generation, compensating for their intermittent nature. By supplying the excess energy produced during off-peak hours when consumption peaks, BESS reduce or eliminate the need for peaker plants - most of which are fuelled by gas or oil - and therefore reduce CO2 emissions, while controlling energy price fluctuations. They also provide a number of ancillary services: frequency or voltage stabilisation, real-time balancing of supply and demand, restarting the grid after an outage, etc.

The number and size of installations have exploded worldwide: 74 gigawatt hours (GWh) are expected to be installed in 2023, compared with 27 GWh in 2021 and 42 GWh in 2022. This exponential growth is set to continue in the years ahead, with some projections putting the figure at over 1,800 GWh cumulated capacity operating by 2030. This figure should be compared with the 9,000 GWh of total capacity of all the pumped storage hydropower (PSH) stations in service around the world, the result of almost a century of investment and representing virtually the only economically viable method of energy storage until now.

The development of high-capacity BESSs is currently mostly concentrated in the United States and China. But other major electricity markets, such as the European Union and India, could become major users. Grid-connected batteries may also be relevant in emerging countries. Small BESS have been in operation since 2021 in Malawi - one of the first countries in sub-Saharan Africa to be equipped - where they can be used to connect solar power plants to the grid without having to invest heavily in grid renovation. South Africa, meanwhile, is betting on large-scale BESS to solve its serious electricity crisis, while the Philippines and Barbados are using them to overcome the constraints associated with their island status.

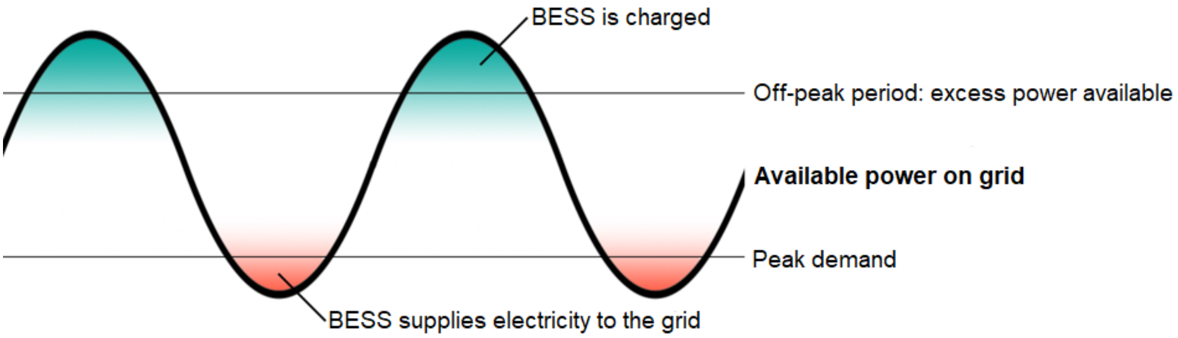
1. Operating principles of grid-scale battery storage[1]

Grid-scale battery energy storage systems (BESS) use batteries similar to those used in electric vehicles, more often of the lithium-ion type. These are integrated in large numbers into standardised modules, generally in standard-sized maritime containers (20 or 40 feet long). These 'packs', with a capacity of several megawatt-hours (MWh) - 3.9 MWh in the case of the Megapack from Tesla, one of the market leaders - can themselves be installed in series. Coupled with an inverter, a transformer and other equipment, they form a BESS, with storage capacities ranging from a few dozen to several hundred or even several thousand MWh. **The world's largest installation, at Moss Landing (California), was expanded in mid-2022 to reach a capacity of 3,000 MWh and an output of 750 megawatts (MW)** - which means it can deliver this maximum power for 4 hours.

1.1. The indispensable complement to intermittent renewable energies

Although the number of independent BESS is increasing - particularly for the largest installations - they are still most often **associated with solar or wind power plants**, or at least located in regions that produce renewable energy. **The main use of BESS is to 'smooth out' the production of renewable electricity**, which is intermittent by nature: they are **charged when the power supplied to the grid exceeds its needs** - at midday for solar power stations, often at night for wind farms - **and then release this energy when consumption peaks**.

Graph 1: BESS play a role in smoothing out available electrical power



Source: Global Sovereign Advisory

This principle offers a number of advantages. For energy suppliers, it allows them to **optimise their production by limiting the periods when their power stations are shut down, and to optimise their income** by selling their electricity when demand is strongest, and therefore prices are highest.

By smoothing out variations in production, including those that are more occasional and harder to predict (for example, when a cloud passes over a solar power plant or a gust of wind causes a peak in wind power), BESS can also **make it much easier to incorporate them into the transmission and distribution network**, thereby **limiting the heavy investment required by the electricity network operator to upgrade the network**. Historically, transmission and distribution networks have been designed to carry electricity produced on a regular, centralised basis. The deployment of renewable energy plants - which are intermittent and decentralised by nature - means that intelligent management systems, or smart grids, have to be installed[2], capable of balancing the load between the various nodes on the network; or that the network must be oversized

[1] For the sake of brevity, this study does not take into account other battery-based electricity storage models: batteries installed "after the meter" in homes or businesses; off-grid electricity grids; vehicle-to-grid electricity; virtual operators supplying electricity to the grid from batteries installed in private homes, etc. While the economic and technical models differ radically, these systems all aim to smooth out peaks in consumption, stabilise prices and balance the electricity grid.
[2] L'insertion des EnR sur les réseaux électriques en 3 minutes, Commission de régulation de l'énergie (France), December 2020

to absorb the surplus energy. **These difficulties in integrating renewable energies into existing electricity grids have long been a major brake on their development[3]**. The use of BESS can therefore prove particularly relevant in the case of fragile national grids that are insufficiently connected to those of neighbouring countries, and that therefore cannot call upon to smooth out peaks in consumption or production.

Lastly, large-capacity BESS can at least partially replace so-called peaker plants, which only come online during peaks in demand. Although they represent only a small fraction of the total electricity consumed, **they generate significant cost overruns**. Generally using gas turbines to provide the necessary power quickly, they are almost 50% less efficient than combined-cycle thermal power plants[4]. They also require a great deal of capital even though they are not used very often (250 to 1,500 hours a year[5]). Lastly, peak-load power plants play a key role in the price formation mechanism, sometimes causing price rises that are as drastic as they are unjustified (see the Europe box on page 5). In Lessines, Belgium, a 100MWh BESS installed by Corsica Sole, made up of 40 Megapacks manufactured by Tesla - billed as Europe's largest when it opened at the end of 2022 - has replaced a gas-fired power station that has been in service for 70 years[6]. In many other cases, notably in the United States, the construction of BESS has made it possible to avoid building gas-fired backup power stations.

1.2. Stabilising electricity networks

Because of their ability to inject electricity into the grid very quickly - in a matter of milliseconds - even relatively modest-capacity BESS facilities can also provide a number of ancillary services, such as **frequency or voltage stabilisation**, helping to **prevent blackouts** caused by imbalances in supply and demand. In extreme cases, they can even **restore power to the grid after a blackout**, also known as black start service: restarting conventional power plants requires an initial supply of electricity.

1.3. Adaptable, responsive systems

All these services already existed before the advent of BESS. Pumped storage hydropower (PSH) stations, which first appeared at the beginning of the 20th century, are still by far the main technique for storing surplus electricity, by pumping water at off-peak times to reservoirs located at altitude (dams, reservoirs, artificial lakes), which then feed hydroelectric turbines when electricity production is required. But unlike PSH stations**, BESS can be installed virtually anywhere, requiring neither relief nor large quantities of water**.

Similarly, **the responsiveness of BESS is far superior to that of PSH and even the most efficient natural gas-fired peaking power plants, which need several minutes to reach full load**[7] : a valuable advantage when it comes to stabilising unstable networks subject to sudden variations.

Finally, the modular design of BESS makes them extremely flexible to install: as well as being easy to transport and install, they can be **sized to meet operators' exact requirements**, from a single containerised module to several dozen or even hundreds for the most ambitious projects. It is also relatively **simple to increase the capacity of BESS by gradually adding new modules**.

2. An exponential increase in deployments

Although the first experimental BESS installations date back to the early 2010s[8]**, it was not until 2021 that the technology took off commercially**: according to the International Energy Agency (IEA), 6.4 GW of cumulative capacity was installed that year, and almost 11 GW by 2022, an increase of 72% over one year. However, the figures provided by the agency are fragmentary, since they only take into account the power that can be supplied by the installations (expressed in GW) rather than their storage capacity (in GWh), which is

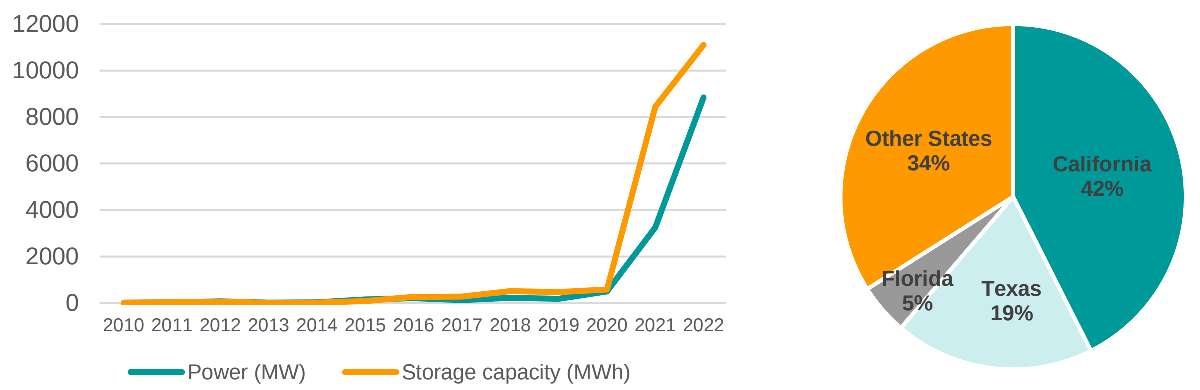
[3] Integrating Variable Renewable Energy: Challenges and Solutions - National Renewable Energies Laboratory, 2013
[4] Average Tested Heat Rates by Prime Mover and Energy Source - 2011 - 2021, International Energy Agency, 2022
[5] The Load Following Power Plant: The New Peaker, GE, 2017
[6] 40 Tesla Megapacks Replace 70-Year-Old Generating Station In Belgium - Cleantechnica, 12 December 2022
[7] The Load Following Power Plant: The New Peaker, GE, 2017
[8] A brief history of utility-scale energy storage, Renewable Energy World, 2017

more relevant for systems designed for this purpose. **According to energy consultancy Rystad, 27 GWh of storage capacity will be installed in 2021, and 43 GWh more in 2022** - an increase of almost 60%. The Norwegian firm is even more optimistic for the current year, when it **expects a further 74 GWh to be connected, an increase of 72% compared with 2022**[9].

2.1. California and Texas propel the United States into first place worldwide

In the United States, development has been very strong since 2020 (Graph 2), mainly in California and Texas (Figure 3). These new installations are designed to keep pace with - and facilitate - the development of solar and wind power generation, of which these two states have become major producers. **Almost all (97%) of the new solar power plants planned in California will include a battery component, according to the Department of Energy's Lawrence Berkeley National Laboratory**[10]. As a result of the large-scale deployment of solar power plants, California is facing a structural imbalance between its peak demand (after sunset) and its peak production (midday). This so-called "duck curve" consumption profile is forcing the CAISO (California Independent System Operator) grid operator and producers to find solutions for smoothing demand over time, including BESS. Outside California, this percentage is **48% on average in the United States**. And while according to the Institute, only 8% of planned wind farms in the United States plan to incorporate a BESS component, this figure rises to 45% in California. These disparities illustrate the great versatility of BESS installations, which can be adapted to the technical and climatic constraints of electricity producers and grid operators.

Graphs 2 and 3: BESS installations in the United States and breakdown of capacity by state



Source: U.S. Energy Information Agency

The acceleration of BESS installations in Texas also reflects a desire to remedy structural reliability issues of the electricity grid, managed by the Electric Reliability Council of Texas (ERCOT). The number of **projects exploded in the months following winter storm Uri in February 2021,** which caused a huge blackout by shutting down many gas-fired backup power plants at a time when demand was highest. Texas also has to contend with major peaks in summer consumption due to the widespread use of air conditioning. However, for political reasons, it is **totally disconnected from the rest of the American grid**, and cannot therefore import electricity from its neighbours. The large-scale installation of BESS batteries is therefore designed both to stabilise the network[11] and avoid a repeat of the catastrophic scenario experienced during winter storm Uri.

[9] New battery storage capacity to surpass 400 GWh per year by 2030 - 10 times current additions - Rystad Energy, 14 June 2023
[10] Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2022 - Lawrence Berkeley National Laboratory, April 2023
[11] Heat is battering Texas's power grid. Are giant batteries the answer? - Washington Post, 24 June 2023

2.2. Beijing adopts a five-year plan dedicated to BESS

In China, it is also the unprecedented development of solar and wind energy that is driving the growth in grid battery installations. This trend is being supported at the highest level of government: most BESS projects are being undertaken by state-owned companies, whether electricity producers or grid operators[12]. Above all, the central authorities have set themselves ambitious targets, **aiming to achieve 30GW of installed capacity by 2025. The State Grid Corporation of China (SGCC) alone would like to increase its own capacity to 100GW by 2030, compared with 3GW today[13].**

The development of BESS systems is now an integral part of the national energy strategy. In March 2022, the National Development and Reform Commission and the National Energy Administration published the Five-Year Plan for New Energy Storage Development, a part of the 14th Five-Year Plan (2021-2025). It aims to **reduce electricity storage costs by 30%,** so that BESS can be profitable without subsidies[14]. In fact, China can draw on its undisputed leadership in the production of batteries and the refining of the minerals needed to produce them[15]. In fact, the decision by the authorities to develop BESS systems is also an attempt to develop a virtuous economic circle, as was the case with electric vehicles[16]: it will offer new markets for its battery producers, but also for its solar panel and wind turbine producers, since BESS make it possible to eliminate the bottlenecks limiting the construction of new renewable power stations.

EU: towards greater support from public authorities, against a backdrop of war in Ukraine

Until now, the European Union has remained relatively untouched by the BESS boom. According to various sources[17], between 4.5 GW and 5 GW of capacity is currently operational, including installations in the UK. But the situation could change rapidly with **the reform of the European electricity market**, launched in response to the outbreak of war in Ukraine in February 2022. The outbreak of the conflict highlighted the EU's dependence on Russian gas and, above all, led to an explosion in electricity prices in many member countries. Under the current mechanisms of the European market, wholesale electricity prices are determined not by the average cost of production, but by the **marginal cost, i.e. the cost of the last MWh produced by peak power plants, which are brought online to meet peaks in demand**[18]. These plants are **generally fuelled by natural gas**, **the price of which has soared since the end of Russian gas imports** by the EU.

Although the final decisions have not yet been taken, the reform proposal presented by the European Commission in March highlighted the "*lack of flexibility solutions for non-fossil energy sources (storage or active participation in demand, for example)".* The text[19] envisages several avenues for the development of BESS, proposing in particular *to* "***require Member States to assess their needs in terms of flexibility solutions for the electricity system***"; to adapt intraday markets to storage technologies; and to authorise Member States to subsidise storage capacity. In July, the European Parliament's Committee on Industry, Research and Energy (ITRE) proposed amending the text to make it even more favourable to BESS systems, notably by adding Article 37a, which stresses the need to deploy grid batteries in order to achieve the full potential of renewable energies[20].

Alongside its proposal to reform the electricity market, the Commission has taken other measures to support BESS systems. In addition to issuing a series of recommendations on energy storage[21], the Net-Zero Industry Act, aimed at accelerating the production of clean technologies in the EU, included electricity storage at the

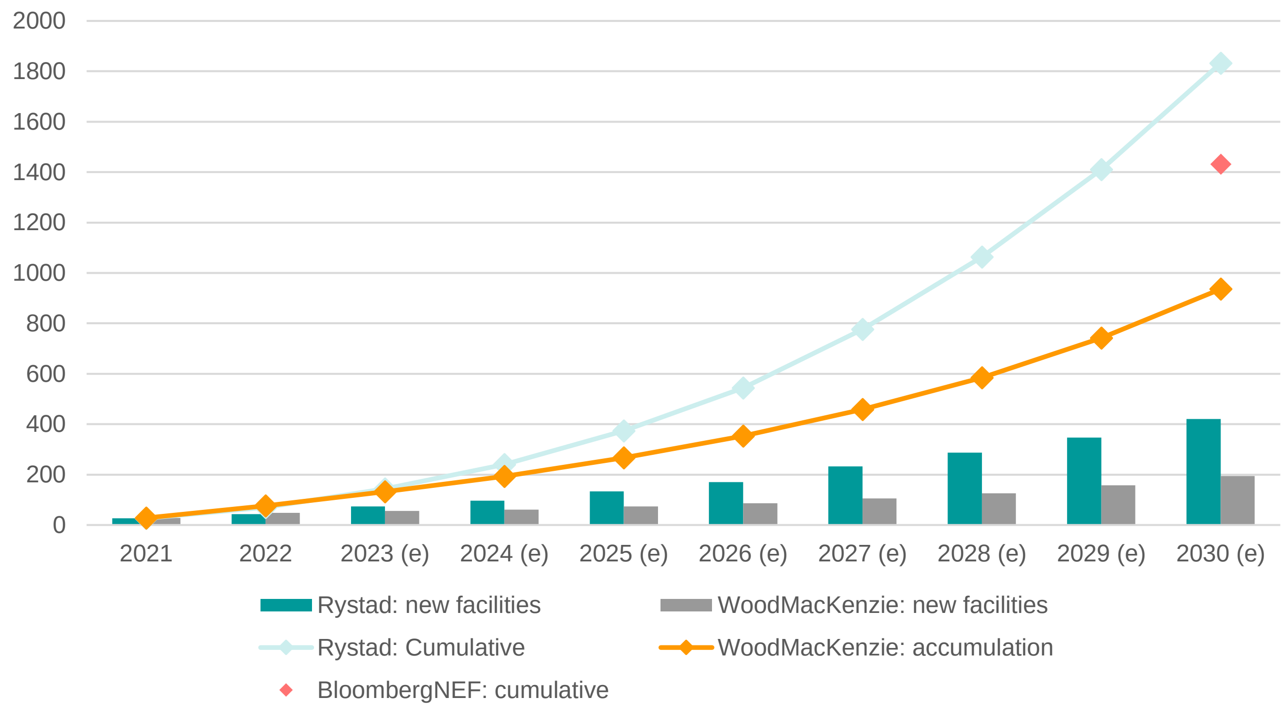
[12] Five things powering China's energy storage boom - Caixin, 20 July 2023
[13] China targets 30GW of battery storage by 2025 as BESS output grows 150% - Energy Storage News, 4 March 2022
[14] China's Energy Storage Sector: Policies and Investment Opportunities - China Briefing, Deezan Shira & Associates, 8 July 2022
[15] Strategic minerals: refining, the key to Chinese domination - Global Sovereign Advisory, July 2023
[16] Electric vehicles: what opportunities for emerging countries? Global Sovereign Advisory, May 2023
[17] Europe reached 4.5GW of battery storage installed in 2022; could hit 95GW by 2050 - Energy storage news, 20 April 2023
[18] https://www.lesechos.fr/industrie-services/energie-environnement/energie-comment-est-fixe-le-prix-de-lelectricite-en-4-questions-1784515
[19] Proposal for a Regulation (...) to improve the organisation of the EU electricity market, European Commission, 14 March 2023
[20] Report on the proposal (...) to improve the Union's electricity market design - European Parliament, 27 July 2023
[21] Recommendation on energy storage - European Commission, 14 March 2023

last minute among the technologies eligible for "net-zero strategic project" status[22], paving the way for subsidies and other public support.

2.3. Towards mass, worldwide adoption

Given the exponential and very recent nature of BESS deployments, it is difficult to predict their future growth. Estimates made by specialist energy consultancies range from simple to double: **Rystad is betting on more than 1,800 GWh of cumulative capacity worldwide in 2030, while WoodMacKenzie, which is more conservative, reckons on just over 900 GWh at the same date** (graph 4).

Figure 4: Rystad and WoodMacKenzie forecasts: new facilities and cumulative capacity (GWh)



Sources: Rystad Energy's Battery Solution (June 2023) / Wood Mckenzie: Global Energy Storage Outlook H2 2021 / BloombergNEF Energy Storage Market Outlook H1 2023

But this discrepancy can also be explained by the fact that **manufacturers and experts in the sector are constantly revising their forecasts upwards**: WoodMacKenzie's figures date from 2021, while Rystad's study was published in June 2023. BloombergNEF, the research division of the Bloomberg agency dedicated to renewable energies, for its part, has raised its forecasts for total installed capacity by 2030 several times in recent years. After estimating it at 1028 GWh in November 2021, it raised it to 1143 GWh less than a year later, in October 2022. **Its most recent projection, published in March 2023, is now for 1432 GWh of total installed capacity in 2030**, midway between the estimates of its peers.

There is also disagreement over the geographical distribution of this capacity. WoodMacKenzie forecasts that the United States will remain the world leader, ahead of China, despite a downward revision of its forecasts for the US market due to disruptions in the *pipeline of* renewable energy projects as a result of anti-dumping measures taken against Chinese solar panel producers in 2022[23]. BloombergNEF, on the other hand, believes that China will become the world's leading BESS operator, partly as a result of the adoption of the national five-year plan, which has already been implemented locally by several provincial governments. **However, they**

[22] European Commission's Net Zero Industry Act includes energy storage as eligible technology - Energy Storage News, 16 March 2023
[23] Global energy storage: staggering growth continues - despite bumps in the road - WoodMacKenzie, 28 July 2022

all agree that Europe will see strong growth - although it will continue to lag far behind the United States and China - **and certain countries such as India**.

A capacity one day comparable to that of pumped storage?

If the scenario envisaged by Rystad - 1800 GWh of total capacity in 2030 - comes true, it will become relevant to compare the cumulative storage capacity of BESS with that of pumped hydroelectric storage (PSH) stations. Representing around 9,000 GWh worldwide according to the International Hydropower Association[24], the latter will remain the main method of storing surplus electricity at that time, as well as being the most economically competitive in most cases. However, its combined capacity is likely to grow more slowly than that of BESS, due to the major constraints on the installation of new PSH stations, which require sufficient topography and a guaranteed water supply. In December 2021, the IEA estimated that new PSH plants with a combined capacity of 1,170 GWh would be built by 2026[25]. In other words, BESS could one day rival PSH in terms of capacity. This is all the more true given that the round-trip efficiency of BESS is slightly higher: around 86%, compared with an average of 80% for STEPs, according to figures drawn up by NREL.

2.3.1 Growth underpinned by the performance of the battery industry

This outlook is reinforced by the sustained growth in global lithium-ion battery production capacity, boosted by demand from the electric vehicle market and massive investment by the United States and the European Union to limit their dependence on China, the world leader in the sector. According to WoodMacKenzie[26]**, cumulative battery production capacity worldwide is set to rise from 1,110 GWh in 2021 to 5,500 GWh in 2030,** while the IEA even estimates that it could approach 7,000 GWh[27]. This additional production will enable BESS module manufacturers to raise their own production targets. Tesla, one of the leaders in this industry, which in 2022 produced the equivalent of 6.5 GWh of BESS (a figure which does not include the home storage systems it also manufactures), built more than 7.5 GWh in the first half of 2023 alone. And **the American group is planning to rapidly increase its capacity to 80 GWh a year**: its megapack factory in Lathrop (California) is due to reach an annual production rate of 40 GWh in the next few months, and last April Tesla launched the construction of a second production unit in Shanghai, with the same capacity[28].

2.3.2 Towards a drastic fall in costs

The cost of battery storage systems should also fall drastically in the coming years, thanks to the **falling price of batteries. Depending on the power installed, batteries account for 50 to 65% of the cost of installing a BESS**, according to calculations by the US National Renewable Energy Laboratory (NREL)[29]. Yet most experts in the sector are predicting a sustained fall in the cost of batteries. What's more, BESS manufacturers are already transitioning to LFP (lithium iron phosphate) batteries, which are cheaper because they use no nickel, manganese or cobalt (NMC). They also have a longer lifespan, a major advantage when installations are designed to operate for decades. **NREL therefore anticipates that the cost of installation**, which it estimated at USD 482/kWh on average in 2022, will **fall by 32% (its median scenario) to 47% (optimistic scenario)** by 2030[30]. The IEA estimates average capital costs at USD 372/kWh by 2030[31]. In the longer term, **the development of Na-Ion batteries, in which lithium is replaced by cheap sodium, could further accentuate this decline**. Initially developed by Chinese battery giant CATL, this technology is already finding outlets in BESS: a demonstrator was inaugurated in July in Qingdao, China[32]. Some manufacturers are also evaluating the potential of redox flow batteries, with liquid electrolytes stored in tanks. These systems could be highly competitive in terms of cost, even if their energy density is lower.

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[24] Pumped Storage Hydropower: the World's Oldest Battery - International Hydropower Association, June 2022
[25] How rapidly will the global electricity storage market grow by 2026? - International Energy Agency, December 2021
[26] Global lithium-ion capacity to rise five-fold by 2030 - WoodMacKenzie, 22 March 2022
[27] Lithium-ion battery manufacturing capacity, 2022-2030 - International Energy Agency, 22 March 2023
[28] Tesla to build Shanghai factory to make Megapack batteries - Reuters, 9 April 2023
[29] Annual Technology Baseline - Utility Scale Storage - National Renewable Energies Laboratory, 2022
[30] Cost Projections for Utility-Scale Battery Storage: 2023 Update - National Renewable Energies Laboratory, June 2023
[31] Battery storage is (almost) ready to play the flexibility game - International Energy Agency, February 2019
[32] World First' grid-scale sodium-ion battery project in China launched - Energy Storage News, 3 August 2023

Finally, BESS could also **benefit indirectly from the fall in prices and the rise in yields from solar panels and wind turbines**: the savings made on the construction of power plants enable operators to invest in storage systems that allow them to smooth out their production and/or optimise their income.

3. What is the outlook for emerging countries?

3.1. Africa between mini-centres and mega-projects

Until now, the adoption of BESS has tended to take place in developed economies, but is now also taking place in many emerging countries. **In Africa, the technology was first adopted by some of the poorest countries**, which are keen to develop the use of renewable energies but **whose electricity grids, which are not very robust and have little or no interconnection with those of neighbouring countries, are ill-suited to large-scale deployment**. In April 2022, Malawi inaugurated one of the very first BESSs in sub-Saharan Africa: this 10 MWh facility is part of the Golomoti solar power plant built by Infraco Africa and JCM Power. A year later, the country inaugurated a second BESS of the same capacity, integrated into the Dwangwa solar power plant built by Voltalia. The operator GreenYellow has also equipped its Ambokatra solar power plant (Madagascar) with a small storage unit (5MWh) in June 2022, and systems of comparable capacity are planned across the continent: in Senegal (20MWh), Chad (4MWh), Togo, Côte d'Ivoire, Mauritius, etc.; most often coupled with existing or planned solar power plants.

But some countries are pursuing far more ambitious projects. **South Africa, faced with the collapse of its electricity production capacity and under pressure from its donors and partners to abandon coal**, which still accounts for the majority of its electricity mix, has launched several BESS projects. In 2022, the Norwegian group Scatec has launched the construction of **three projects totalling 1,140 MWh** in the Kenhardt region, to be powered by its own solar power plants. These investments are being made as part of the RMIPPPP (Risk Mitigation Independent Power Producer Procurement Programme) launched as an emergency measure by the national operator Eskom to remedy the electricity shortage by calling on private independent producers.

Eskom is also responsible for carrying out a national project **announced in mid-2022 by President Cyril Ramaphosa himself**, which should result in the **installation of 1,449 MWh of capacity across the country by 2024**. South Korea's Hyosung, which has been selected alongside China's Pinggao to carry out the work, began work on the Elandskop site[33] in December 2022. Without waiting for these first units to be delivered, the authorities also called on private developers in early 2023 to build **six additional sites totalling just over 2 GWh over the next few years**[34].

The development of BESS in Africa is supported by many international donors, who see it as essential to the development of renewable energies, and in some cases less costly than upgrading the electricity grid. The Golomoti BESS in Malawi has benefited from a USD 25 million loan from the US **Development Finance Corporation** (DFC) and support from the **World Bank**. The World Bank has also mobilised USD 311 million for the development of renewable energies in West Africa, part of which is earmarked for storage. The **African Development Bank, the International Finance Corporation (IFC), USAID, the European Investment Bank (EIB) and** others are also involved to varying degrees in financing projects on the continent.

3.2. India, champion in the making?

India currently has an anecdotal share of the world's battery storage capacity (85 MWh in 2022 according to the India Energy Storage Alliance), but could become a major player in the coming years.

The report on the "optimal energy mix" published in April 2023 by the Ministry of Energy indicates that the **country's battery storage requirements will be between 208 GWh (baseline scenario) and 246 GWh**

[33] Construction of Eskom's first battery energy storage begins - Eskom, 8 December 2022
[34] South Africa's DMRE issues 513MW/2GWh battery storage RFP, Energy Storage News, 9 March 2023

(high demand scenario) by 2030[35]. This exponential growth in demand is linked to the sustained development of solar and wind power, which are becoming increasingly difficult to integrate into the national grid. **In some states (Gujarat, Karnakata, Rajasthan, Karnakata), the share of renewables already exceeds 10%, with far-reaching consequences for the management of the power grid**[36]. However, the authorities intend to accelerate the pace even further, aiming to add a further 250 GW of renewable capacity, to reach a total of 500 GW[37], in line with the government's "Net Zero Emissions by 2070" plan[38]. In the baseline scenario, the combined capacity of BESS would represent around 41 GW by 2030, **or the equivalent of 5.35% of the country's total electricity generation capacity at that date** (777 GW), but more than twice the total capacity of India's STEPs (18.9 GW).

To accelerate the deployment of BESS, which are mainly coupled with new solar and wind power plants, **the government plans to allocate USD 455 million in subsidies** to projects totalling 4GWh between now and 2030[39]. But several major projects have already been launched without waiting for this windfall. **Earlier this year,** the state-owned **Solar Energy Corporation of India (SECI) awarded a contract to JSW Energy**[40] **to build two sites totalling 1 GWh,** which are expected to be the country's first large-scale BESS.

Another state-owned company, NTPC Renewable Energy, has also issued several invitations to tender for the installation of several BESS, including a 500 MWh unit in Uttar Pradesh. However, while it had left it up to the candidates to propose the technologies of their choice in response to its major call for tenders in mid-2022 (3 GWh of storage across several sites), it chose Greenko Group to build pumped storage transfer stations. These proved to be the best solution for meeting the tender’s technical requirements, which mandated that the installations must be able to supply several hundred MW of electricity for 6 hours at a time. According to Greenko, pumped storage hydropower also offered much lower storage costs in this case than batteries: USD 58 per MWh, compared with USD 120 per MWh[41].

The deployment of BESS in India will also be supported by the country's major ambitions in terms of battery manufacturing. To limit its dependence on rival China, and at a time when its car and two-wheeler manufacturers are speeding up their transition to electric engines, the Indian government has selected five international and Indian manufacturers to build battery factories with a total capacity of 50 GWh by 2022[42]. 20 GWh are in the process of being reallocated, following the withdrawal of Hyundai Global Motors.

3.3. Barbados, Philippines...: island states at the forefront

In Barbados, the public operator Barbados Light and Power installed a 5 MW battery with a capacity of 21 MWh in 2018, within its largest solar power plant, inaugurated two years earlier on the Trents site in the north of the island. While diesel and gas-fired power stations still produced 90% of the country's electricity in 2019, representing more than USD 250 million in imports per year, **the authorities are aiming to achieve a 100% renewable energy mix by 2030. However, the island's electricity network is totally isolated**. **In 2022, the government therefore adopted a national electricity storage policy, including both large-scale BESS and systems installed on private homes**[43]. The construction of a 50 MW pilot site[44] will enable the wider deployment of this technology to be tested. By 2030, according to the national energy policy[45], BESS should represent a total capacity of 200 MW: 132 MW in centralised systems, and 68 MW in smaller systems. **This capacity will then represent 24% of the total capacity of the national electricity grid**[46], which could be a

[35] Report on optimal generation mix 2030 - Central Electricity Authority, Department of Energy, April 2023
[36] Renewables Integration in India - International Energy Agency, July 2021
[37] Government Unveils Plans To Add 250GW Renewable Energy Capacity In Next Five Years - Outlook India, 5 April 2023
[38] Renewable Energy in India, Press Information Bureau, 9 September 2022
[39] India to offer $455 million in incentives for battery storage projects - Reuters, 6 June 2023
[40] JSW Energy Arm Bags Two Battery Energy Storage System Projects From SECI - Outlook India, 19 January 2023
[41] Greenko Wins The World's First And Largest Technology Agnostic Long Duration Energy Storage Tender For 3000 Mwh - Press release from Greenko Group, 9 December 2022
[42] India takes 'step towards dream,' incentivising 50GWh of domestic battery manufacturing - Energy Storage News, 24 March 2022
[43] Barbados creates national energy storage policy, eyes billions of investment - Energy Storage News, 25 August 2022
[44] Barbados regulators order 50MW BESS pilot to support rapid decarbonisation by 2030 - Energy Storage News, 17 July 2023
[45] Barbados National Energy Policy, 2019-2030 - Ministry of Energy and Natural Resources, June 2019
[46] Barbados Energy Snapshot - Energy Transitions Initiative, US Department of Energy, 2020

world record. This high proportion can be explained by the isolated nature of the national grid and Barbados' ambitious renewable energy targets.

On the other side of the globe, the Philippines - where the grid is not only isolated from the rest of the region but divided into several autonomous networks - has also launched a highly ambitious BESS deployment programme. In particular, the Department of Energy has turned to the energy group SMC Global Power (a subsidiary of the Philippine conglomerate San Miguel) to install **32 BESS throughout the archipelago, representing 1,000 MWh of combined storage capacity, deployment of which is already well under way**. Initially, the main aim is to **address problems of grid reliability** and cope with peaks in demand. Solar and wind power account for an anecdotal share of the Philippine energy mix, and SMC Global Power makes no secret that its storage systems are powered by conventional sources: the group operates a large hydroelectric dam as well as coal- and gas-fired power stations. However, the installation of BESS is intended to facilitate the future development of solar and wind power, as President Ferdinand Marcos pointed out at the inauguration of one of SMC Global Power's BESS in March 2023[47]. The Philippines has set a target of achieving 50% of electricity from renewable sources (including hydropower) by 2040[48].

[47] Speech by President Ferdinand R. Marcos Jr. at the Inauguration of San Miguel Global Power's Battery Energy Storage System (BESS) - Presidential Communications Office, 31 March 2023
[48] Philippines Opens Renewable Energy to Full Foreign Ownership - ASEAN Briefing, Dezan Shira & Associates, 11 January 2023