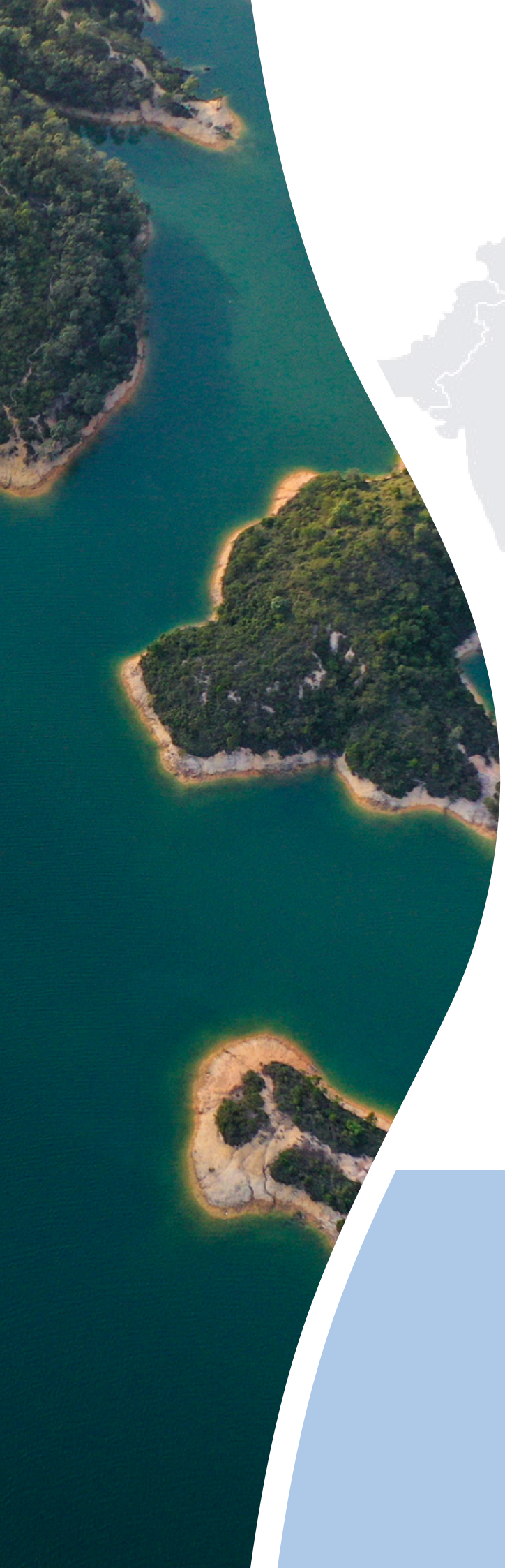


FLOW BATTERIES EUROPE

A united voice for flow batteries

REPORT ON REGIONS: ASIA PACIFIC

ANALYSIS OF ENERGY STORAGE POLICIES, FOCUSING ON FLOW BATTERIES

NOVEMBER 2024

www.flowbatterieseurope.eu

Contents

This report was developed by the Flow Batteries Europe (FBE) Secretariat, in collaboration with the China National Energy Storage Alliance (CNESA), VSUN Energy, and Sumitomo Electric. Their expertise and insights significantly contributed to the quality of the research presented herein. This is the first of the Flow Batteries Europe Reports on Regions series, looking into the flow battery industry and policies around the globe.

This report reflects the collective insights of the authors. The information and analyses presented are intended for informational purposes only and do not necessarily represent the views of FBE members, VSUN Energy, CNESA, or Sumitomo Electric. FBE does not take responsibility on the accuracy of the indicated data.

For inquiries regarding this report, please contact:

Daniela Pöhl
Email: d.pohl@flowbatterieseurope.eu
Phone: +32 2 743 29 86
Website: www.flowbatterieseurope.eu

Executive Summary

The Asia Pacific region is expected to become the largest flow battery market within the next few years. A large part of this development is to be credited to rising investments in energy storage projects. This is not only attributed to rising demand, but especially to enhanced policies and initiatives addressing energy storage systems (ESS), long-duration energy storage (LDES), and battery energy storage systems (BESS). Countries in the Asia Pacific region increasingly adopt ambitious ESS deployment targets and consider a diversified range of technologies to reach their aims. Subsidies and enhanced investment schemes, along with demonstration projects, have been substantial instruments to boost ESS and flow battery deployment and development in the region. Additionally, more favourable market conditions are being implemented in some countries, which should further accelerate a clean energy transition.

China's energy storage policy is advanced and ambitious, with local governments often surpassing national goals. Under the 13th Five-Year Plan (FYP) 2016-2020, a demonstration strategy was launched to promote new energy storage technologies, particularly encouraging large-scale deployment of emerging technologies like flow batteries. The 14th FYP for Energy Storage now sets medium and long-term targets to develop domestic capabilities in all core storage technologies, though lithium-ion technology will take the lead. Despite a slowdown in publicly subsidised large-scale demonstration projects in provinces like Liaodong and Hubei compared to the previous decade, the deployment of vanadium flow batteries (VFB) is increasing due to China's vast vanadium reserves, enabling self-sufficiency in production.

In recent years, Japan has accelerated its green transition by focusing more on the energy sector, including raising renewable energy sources (RES) targets and reviving nuclear power. New policies, such as the Green Transition Policy, the revised Electricity Business Act, and new auction schemes like the Long-term Decarbonisation Power Source Auction and the Feed-in-Premium scheme, incentivise the deployment of renewables and energy storage solutions. These schemes benefit storage systems by allowing them to generate revenue in capacity and spot markets. While Japan's battery strategy emphasises lithium-ion batteries for electric vehicles, significant growth is expected in stationary storage systems. Subsidies for innovative solutions like flow batteries, particularly through demonstration projects supported by the Ministry of Economy, Trade and Industry and the Ministry of Environment, have paved the way for this development.

Australia's energy storage and battery sector will continue to rely on public investment in the coming years, with new policy initiatives likely to have a positive impact. Programmes like Powering Australia and Rewiring the Nation create opportunities for energy and grid projects and establish new investment schemes under the Capacity Investment Scheme. The recently launched policies in May 2024 are expected to guide the development of Australia's LDES and battery sector. The Future Made in Australia agenda and the 2024-2025 budget will drive large-scale investments in clean energy manufacturing, with simplified measures to attract private investments. The new National Battery Strategy will support both lithium-ion and flow battery industries, addressing the variation in ambition and scope among sub-national policies. While some criticise parts of the 2024-2025 budget, such as the lack of demand-side measures, the Future Made in Australia initiative is a bold effort to advance the economy through the clean tech sector.

South Korea is a significant player in the global energy storage and BESS markets, with

advanced technological development. However, despite its 2050 net-zero target, the country lags behind other industrialised nations in climate goals and supporting policies. Limited resources also make Korea highly dependent on fossil energy imports. Plans to rebuild nuclear energy, similar to Japan's approach, could divert focus from renewable energy deployment. Current market conditions are unfavourable for clean energy adoption, affecting the energy storage sector despite Korea's leadership in ESS deployment during the 2010s. Korea has set ambitious energy storage deployment targets, divided into long and short-duration systems. A new, resource-intensive battery strategy aims to enhance battery technology and commercialisation. KEPCO, the government's power company, has tested flow batteries through demonstration projects, and one of the largest VFB producers is based in South Korea. The new ESS lifespan guarantee will further support flow battery deployment. To move forward, South Korea needs to align political targets with specific policies and reform market conditions to promote both renewable energy and ESS, creating favourable investment conditions.

Other countries in the Asia Pacific region, including India, Thailand, Singapore, Malaysia and Indonesia, are slowly picking up pace when it comes to battery and ESS development. Some measures include the consideration of ESS in strategic programmes and policy frameworks, as well as auctions and subsidies for BESS or renewable energy plus storage projects. While it is expected that the lithium-ion industry will dominate the development of ESS in these countries, it is noteworthy that flow batteries have been considered in some projects that received investment.

As Europe aims to accelerate its clean energy transition to meet climate goals and enhance energy security, the report underscores the critical role of energy storage in this endeavour. The Asia Pacific region has made significant steps in LDES, with robust policy frameworks and ambitious targets; therefore, Europe must enhance its approach to avoid falling behind. The report highlights the necessity of establishing similar or even more ambitious political priorities, subsidised programmes, and market mechanisms to attract investment and support LDES and flow battery deployment. A secure supply chain and diverse energy storage technologies are essential for a resilient clean energy industry. Europe needs to move quickly to strengthen its policies on energy storage. Taking decisive action is essential for meeting climate goals and ensuring competitiveness on the global stage.

CHINA

OVERVIEW

China is a global leader in energy storage technology development and deployment. The country has medium and long-term targets for ESS deployment, while Chinese provinces often exceed these ambitions. The current Five-Year Programme not only supports new storage technology development, including flow batteries, but also addresses its commercialisation and eases market conditions.

KEY ACTORS

Chinese governmental/public bodies:

- Ministry of Industry and Information Technology (MIIT)
- Ministry of Science and Technology (MoST)
- National Development and Reform Commission (NDRC)
  - National Energy Commission (NEC)
- Ministry of Finance (MoF)
- National Manufacturing Strategy Advisory Committee (NMSAC)

Industry associations:

- Chinese Renewable Energy Industries Association (CREIA)
- China Energy Storage Alliance (CNESA)
- Chinese Industry Association of Power Sources (CIAPS)

Companies in the flow battery industry:

- Rongke Power
- CEC Science & Technology Co. Ltd
- V-Liquid
- Yinfeng New Energy
- Shanghai Electric

POLICY GOALS

2025

- Non-hydro energy storage of 30GW
- Large-scale development of novel ESS technology
- Decrease of per unit cost of energy storage by 30%

2030

- Non-hydro energy storage of 100GW
- Full marketisation of novel ESS technology
- Peak CO_2 emissions

2060

Climate neturality

POLICY DOCUMENTS

- Guidance on Accelerating the Development of New-Type Energy Storage
- Implementation Plan for the Development of New Energy Storage Technologies during the 14th Five-Year Plan Period (14th FYP for Energy Storage)
- Implementation Plan for Promoting High-Quality Development of the Vanadium Battery Storage Industry

Leading energy storage policy and deployment

China, the world's largest CO2 emitter, is likely to peak emissions well before its 2030 target and aims for carbon neutrality by 2060, positioning energy storage as a cornerstone of its strategy. According to the China Energy Storage Alliance's (CNESA) database on global energy storage, more than 600 new national and local policies related to energy storage were issued in China in 2022 – a twofold increase compared to 2021. These policies mainly focus on renewable energy, electricity markets, tariffs, and subsidies. About 70 major energy storage policies were introduced at national level, while the most intensive policies were adopted in the Zhejiang, Shandong, Shanxi, Guangdong, and Jiangsu provinces.[1]

The policy framework behind these developments is the tandem between the 'Guidance on Accelerating the Development of New-Type Energy Storage'[2] and the 'Implementation Plan for the Development of New Energy Storage Technologies during the 14th Five-Year Plan Period' 2021-2025 (14th FYP for Energy Storage).[3] The programmes advocate for new technology breakthroughs and commercialisation of energy storage. They call for a wider ecosystem of government and private entities to build the energy storage sector and emphasising the role of market forces for investing in storage projects, which includes generation utilities and independent service providers. The aim is to support novel energy storage technologies entering from the early commercialisation stage to the large-scale development stage by 2025, and to achieve full marketisation stage by 2030. This is further supported by the goal to decrease the per unit cost of energy storage by 30% by 2025. Once these targets are met, the price can reach CNY 0.8 to 1.0 (EUR 0.10 to 0.13)[4] per watt-hour, making ESS commercially viable without subsidies.[5,6]

The 14th FYP for Energy Storage is therefore particularly advantageous for rather new technologies, comprising electrochemical energy storage, compressed air, flywheel, and thermal energy storage, while it excludes the highly commercialised pumped hydro storage. Through this mechanism, China targets a non-hydro 30GW of energy storage by 2025 and 100GW by 2030. Nevertheless, pumped hydro remains China's primary energy storage technology, with the goal to scale up 32GW capacity in 2022 to 120GW by 2030.[7]

According to CNESA global energy storage database, China has put 48.18GW new energy storage into operation as of June 2024, exceeding the national goal of 30GW (see Figure 1). Localities have reiterated the central government's aim of developing an integrated format of renewable energy combined with storage ('new energy + storage'), with required energy storage allocation rates between 5% and 20%.[8,9]

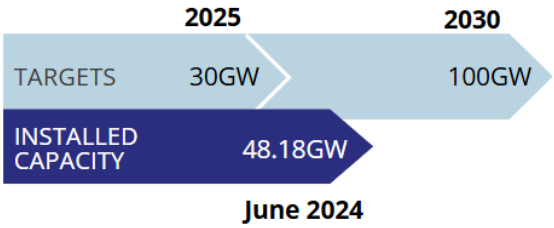


Figure 1 Energy storage capacity in China (non-hydro); targets and installed capacity.

[1] Energy Storage Industry White Paper | China Energy Storage Alliance
[2] National Development and Reform Commission, National Energy Administration's Guiding Opinions on Accelerating the Development of New Energy Storage State Council Department Documents | China Government Network
[3] Implementation Plan for the Development of New Energy Storage in the 14th Five-Year Plan | National Development and Reform Commission
[4] All currency conversions to euros throughout this report are based on exchange rates from 4 September 2024.
[5] China's Energy Storage Sector: Policies and Investment Opportunities | China Briefing
[6] EnTrans Factsheet Energy Storage | Sino-German Energy Partnership
[7] China targets 30GW of battery storage by 2025 as BESS output grows 150% | Energy Storage News
[8] EnTrans Factsheet Energy Storage | Sino-German Energy Partnership
[9] China's Booming Energy Storage: A Policy-Driven and Highly Concentrated Market | Apco

Box 1. China's energy storage and flow battery market: size and trends

China is leading the global energy storage market. At the end of 2023, China had put into operation a cumulative installed capacity of 86.5GW of ESS projects (including pumped hydro and new energy storage), according to the CNESA database. This represents around 30% of the total global market and a 45% increase from the previous year.[10] China's anticipated compound annual growth rate (CAGR) for the period 2023-2032 in the energy storage market is 18.9%.[11]

The Chinese government is placing more emphasis on 'new-type energy storage systems'. This includes various electricity storage technologies such as electrochemical systems (like batteries), compressed air, flywheel systems, and supercapacitors. However, it does not include pumped hydro energy storage. In 2023, the cumulative installed capacity of new energy storage surpassed 30GW for the first time, reaching 34.5GW/74.5GWh, with both power and energy scale increasing by more 150% year-on-year. While lithium-ion batteries accounted for about 97% of the installed new energy storage in 2023, other technologies, including flow batteries, saw new breakthrough applications.[12] Flow batteries represent merely 0.6% of this capacity in 2023 when in 2022 this value was at 2.3%.[13] As of June 2024, the total installed capacity of flow batteries in China is 275.4MW, exceeding significantly capacities in other countries.

Moreover, nearly half of all Chinese provinces reached a total installed capacity of more than 1GWh. Front-of-the-meter applications continued to lead, as well as standalone ESS projects, which had the largest newly installed capacity in 2023.[14] China not only breached the ESS sector records in 2023; its total installed clean energy power generation capacity surpassed that of fossil fuel energy, reaching nearly 51%. Hence, China's renewable push is directly linked to the ESS-boom.[15]

In addition, China has a different – and beneficial – market landscape in energy storage. *BloombergNEF* found that a fully installed flow battery system in China had an average cost of USD 423/kWh. However, when China is excluded from the analysis, the average cost of a flow battery system in other parts of the world rises to USD 701/kWh.[16] According to CNESA tracking, bid-winning price of VFB system in June 2024 was near USD 283/kWh. This can also be attributed to the lower vanadium prices in China, being a net-exporter of this raw material.[17] In addition, the cost of lithium-ion battery continues to decrease, which brings pressure to the cost reduction of VFB.

Obstacles to the 'new energy + storage' model

Several sources highlighted the issue of low utilisation rates of grid-scale battery energy storage systems throughout China. According to *Forbes*, in 2023, only 30% of the designed hours was used due to the lack of sustainable business models. More detailed data from the 'Research Report on the Operation of New Energy Distribution and Energy Storage' disclosed that the average equivalent utilisation coefficient of electrochemical energy storage projects is 12.2%, while the equivalent utilisation coefficient of new energy distribution and storage is only 6.1%. This same coefficient of thermal power plants is 15.3%, that of grid-side energy storage is 14.8%, and that of user energy storage is 28.3%.[18]

According to *Forbes*, the reason behind this is that project developers purchase energy storage systems only to meet the mandatory integration policy requirements.[19] However, at

[10] *White Paper 2024: Summary Version*, China Energy Storage Alliance, 2024 | CNESA, *Energy Storage Industry*
[11] China's Booming Energy Storage: A Policy-Driven and Highly Concentrated Market | Apco
[12] *White Paper 2024: Summary Version*, China Energy Storage Alliance, 2024 | CNESA, *Energy Storage Industry*
[13] *White Paper 2024: Summary Version*, China Energy Storage Alliance, 2024 | CNESA, *Energy Storage Industry*
[14] *White Paper 2024: Summary Version*, China Energy Storage Alliance, 2024 | CNESA, *Energy Storage Industry*
[15] China's Booming Energy Storage: A Policy-Driven and Highly Concentrated Market | Apco
[18] Problems and Solutions of Compulsory Distribution and Storage of New Energy Power Generation | 21jingji
[19] Crises Threaten China's Booming Energy Storage Market | Forbes

present, the construction of China's electricity market is in the early stage, and there is no operating environment that allows energy storage to participate in the electricity market arbitrage, auxiliary service market and capacity market, so the utilisation rate of most energy storage projects is not high. The existing electricity price policy is insufficient to compensate the energy storage, making these storage systems commercially unviable without subsidies.[20]

Diverse battery technologies lead ESS deployment targets, including flow batteries

What will remain, in any case, the driving force in new energy storage deployment in China and in achieving the 14th FYP goals are battery technologies. The policy set the tone to support all types of battery energy storage systems, including sodium-ion, novel lithium-ion, lead-carbon, and flow batteries.

Regarding policies focusing on batteries, current medium and long-term targets mainly focus around the EV sector and lithium-ion batteries. R&D efforts and public funding linked to KPI targets particularly focus on new battery technologies including lithium-sulphur, metal-air and solid-state batteries. The focus on these battery technologies also explains the fact that China has the smallest share of patents on flow batteries compared to its global counterparts. Programmes such as 'Made in China 2025', the 'Industrial Development Plan for EV 2021-2035', or the 'National Key R&D Programme' target the development and production of batteries and the EV sector in China (i.e., for the establishment of a strategic autonomy) and seek to further expand capacities along the value chain. By 2035, Chinese power battery technology is expected to be in an international leading position with a complete and independent industry chain. Moreover, the country has set specific and ambitious sustainability goals especially in relation to EV battery recycling targets, which often exceed those of the EU.[21] Additionally, while China's battery strategy was historically demand side driven (e.g., through tax incentives, subsidy programmes etc.), the government is increasingly adopting supply side measures (e.g., infrastructure building or research on battery safety) in the battery sector as it aims to strengthen its global market position.[22]

Although (stationary) energy storage is targeted under the current programmes and the 14th FYP for Energy Storage, China's 13th FYP (2016-2020) was more advantageous to the flow battery sector. A policy document released under the 13th FYP, the 'Guidance on the Promotion of Energy Storage Technology and Industry Development' published by the China National Development and Reform Commission, called for more investment in energy storage, including flow batteries. The programme aimed to build large-scale flow battery (and in general energy storage system) demonstrations around China, with its first project approved in 2016. The 100MW Dalian Flow Battery Power Station, now the largest flow battery worldwide, was connected to the grid in 2022 and its costs amounted to CNY 3.8 billion (around EUR 480 million). In a second construction phase, it will build up to 200MW/800MWh. Under the same programme, another large-scale VFB was approved of CNY 1.9 billion (EUR 240 million) and is constructed in combination with a solar PV and wind energy system in the Hubei Province. However, *Energy-Storage News* names factors such as unexpected volatility in the price of vanadium and demand for the metal in other industries like construction as

[18] Problems and Solutions of Compulsory Distribution and Storage of New Energy Power Generation | 21jingji
[19] Crises Threaten China's Booming Energy Storage Market | Forbes
[20] China's Booming Energy Storage: A Policy-Driven and Highly Concentrated Market | Apco
[21] Benchmarking International Battery Policies 2024 | Fraunhofer ISI
[22] Benchmarking International Battery Policies 2024 | Fraunhofer ISI

reasons for having slowed such public initiatives.[23,24,25]

Nonetheless, China continues with substantial investments in energy storage deployment. At the end of 2023, the government announced 56 new energy storage projects. 15 of these projects involve flow batteries, of which six projects amount to 3,900MWh and the remaining are projects coupled with other battery technologies, totalling 8,700MWh (see Figure 2). The announced demonstration projects are planned to be installed within the next three to five years.[26]

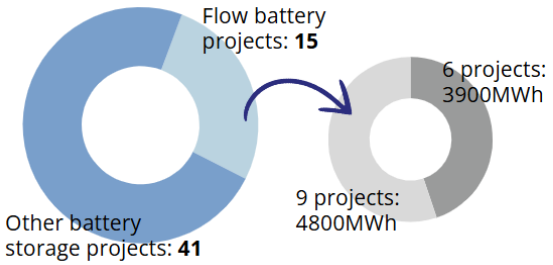


Figure 2 Chinese government's announced energy storage demonstration projects at the end of 2023.

Additionally, the Sichuan Provincial Department of Economy and Information Technology issued the 'Implementation Plan for Promoting High-Quality Development of the Vanadium Battery Storage Industry' on 8 May 2024 – China's first vanadium battery-specific policy. The policy 'aims to build a leading national vanadium battery storage industry base through initiatives such as conducting application pilot demonstrations, strengthening technological self-innovation, expanding the production and supply of vanadium products, promoting industry cost reduction and efficiency enhancement, accelerating the creation of industrial clusters, and cultivating improved standards and brands.'[27]

Overall, China has an advanced and ambitious energy storage policy with local administrations often exceeding national targets. The demonstration strategy for new energy storage technologies, which was launched under the 13th FYP, particularly incentivised the deployment of emerging technologies such as flow batteries on a large scale. The current 14th FYP for Energy Storage sets medium and long-term targets for new storage systems in order to build up domestic capabilities in all core storage technologies, albeit its implementation will be led by the lithium-ion industry. Although publicly subsidised large-scale demonstration projects such as the ones in the Liaodong or Hubei provinces have slowed down, VFB have experienced – and will continue to experience – an increase in deployment in China. This growth is partly due to China's ability to be self-sufficient in producing vanadium flow batteries, supported by its position as the world's largest holder of vanadium reserves.[28]

[23] First Phase of 800MWh World Biggest Flow Battery Commissioned in China | Energy Storage News
[24] After 6 Years, The 100MW/400MWh Redox Flow Battery Storage Project in Dalian Is Connected to The Grid | China Energy Storage Alliance
[25] Energy storage System Policies: Way Forward and Opportunities for Emerging Economies | ScienceDirect
[26] Insights into China's flow battery and energy storage market, International Flow Battery Forum 2024| Jena Flow Batteries
[27] China's First Vanadium Battery Industry-Specific Policy Issued | China Energy Storage Alliance
[28] Vanadium redox flow batteries: A New Direction for China's Energy Storage? | Fastmarkets

JAPAN

OVERVIEW

Japan has been increasing its efforts on renewable energy and energy storage deployment in recent years. Particularly the entry of ESS systems into the capacity market presents a great opportunity. While battery-specific policies focus on developing novel lithium-ion and solid-state batteries, flow battery deployment is often realised through subsidies.

KEY ACTORS

Japanese governmental/public bodies:

- Ministry of Economy, Trade and Industry (METI)
- The New Energy and Industrial Technology Development Organisation (NEDO)
- Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Industry associations:

- The Battery Association of Japan (BAJ)
- The Battery Association for Supply Chain (BASC)
- Japan Energy Association (JEA)

Companies in the flow battery industry:

- Sumitomo Electric Industries Ltd.
- LE SYSTEM Co., Ltd.

POLICY GOALS

2030

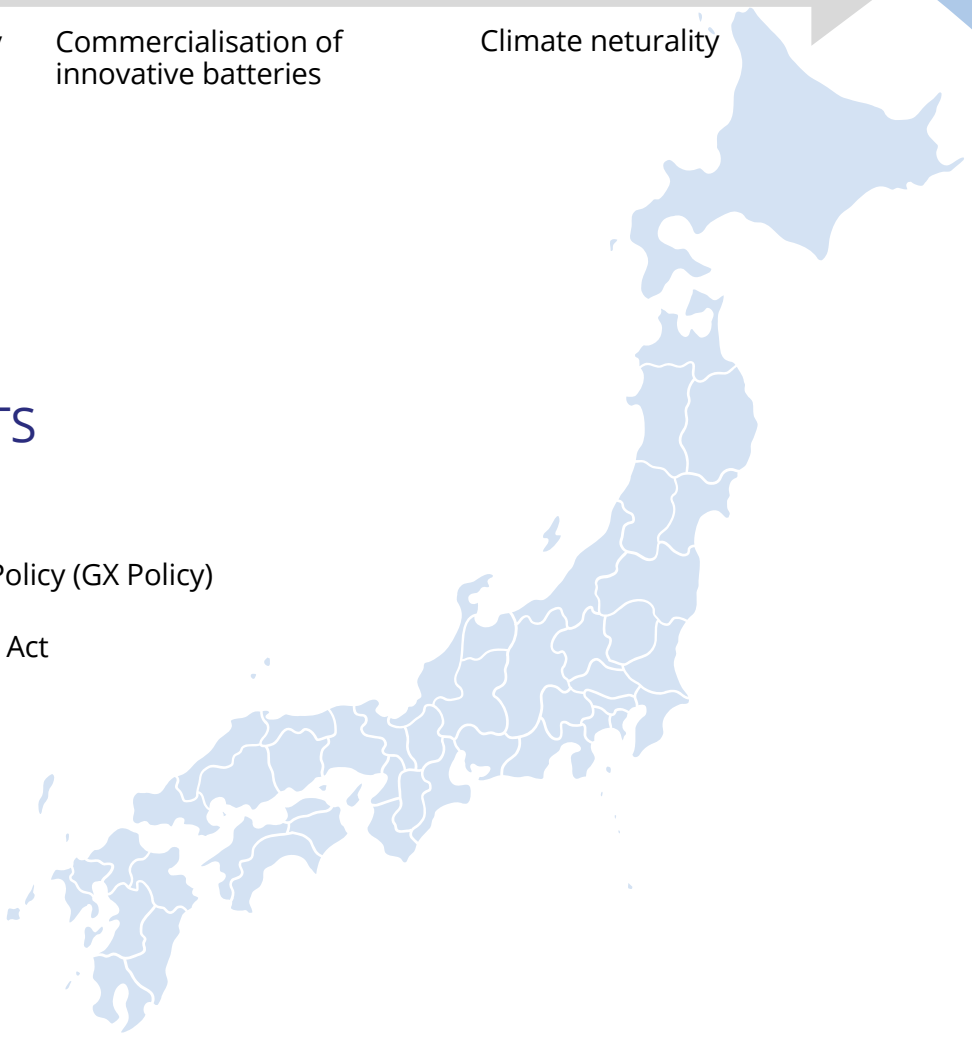
- Share of renewables electricity generation of 36-38%
- 46% of GHG emissions reduction
- Forecast of 24GWh of storage battery deployment and 14.1-23.8GWh of grid storage batteries

2035

Commercialisation of innovative batteries

2050

Climate neturality



POLICY DOCUMENTS

- 6th Strategic Energy Plan
- Green Growth Strategy
- Green Transformation Basic Policy (GX Policy)
- Electricity Business Act
- Economic Security Promotion Act
- Battery Industry Strategy

Tackling fossil fuel import dependency through an ambitious Green Growth Strategy

Under the 6th Strategic Energy Plan, published in October 2021, the Japanese government set the aim to achieve carbon neutrality by 2050; increase the share of renewables as part of Japan's total electricity generation to 36-38% by 2030 (with 19-21% solar and wind power) compared to an 18% share in 2019; and reduce greenhouse gas emission by 46% in 2030 compared to 2013 levels.[29] Currently, about 70% of Japan's electricity is supplied by fossil fuels (mainly by natural gas and coal) and the country is highly exposed to global commodity price fluctuations due to its limited domestic resources.[30]

The overarching policy framework that should lead Japan to carbon neutrality is the Green Growth Strategy launched in 2020. The strategy designates 14 areas as key development industries, including various green energy technologies and the automobile as well as battery sector. To enhance the identified sectors, the government at the time proposed five policy tools to implement the industrial policy: grant funding of JPY 2 trillion (EUR 12.5 billion) over 10 years through the Green Innovation Fund in order stimulate further private R&D investment; tax incentives; a guidance policy on finance; regulatory reforms; and international collaboration.[31,32,33]

Following the new Green Growth Strategy, a set of policies and reforms was adopted in the subsequent years. The enhanced climate goals have called for a change in the regulative framework, which includes the Green Transformation (GX) Basic Policy. The policy shall specifically serve as main instrument to reach the 2030 goals and as investment roadmap for this 10-year period, aiming to generate about JPY 150 trillion (EUR 930 billion) of public-private financing in various sectors. The Japanese government plans to raise JPY 20 trillion (EUR 120 billion) through sovereign bonds ('GX transition bonds') to spur private investments which should match up to the targeted JPY 150 trillion. The GX transition bonds will be backed by the introduction of a carbon fee and an emissions trading scheme.[34] GX commitments for the energy sector include the deployment of renewables (10GW of offshore wind and 104-118GW solar power by 2030); to restart nuclear power by aiming for 20-22% of Japan's energy mix by 2030 (as since the 2011 Fukushima accident the share of nuclear energy mix has been kept low); to establish success cases and support the development of a supply chain of ammonia/hydrogen co-firing; and to build a carbon capture, utilisation and storage value chain.[35]

BESS deployment stimulation through enhanced market mechanisms

In April 2023, the amendment to the Electricity Business Act (EBA) came into effect. The EBA classifies standalone BESS projects as independent power generation facilities, eligible for grid connection permits. This way, BESS systems can generate revenues by selling energy in the market operated by Japan Electric Power Exchange (JEPX) or by entering into capacity reserve agreements with the Organisation for Cross-regional Coordination of Transmission Operators (OCCTO)[36].

[29] The 6th Strategic Energy Plan | METI
[30] The Japanese Government's Reforms to Energy Policy | Baringa
[31] Japan's Carbon Neutrality and Green Growth Strategy | Korea Institute for International Economic Policy
[32] Overview of the Green Innovation Fund Projects | NEDO Green Innovation Fund Projects
[33] Overview of Japan's Green Growth Strategy, Through Achieving Carbon Neutrality in 2050 | METI
[34] Overview of Japan's Green Transformation | GR Japan
[35] Overview of Japan's Green Transformation | GR Japan
[36] The Organisation for Cross-regional Coordination of Transmission Operators, Japan (OCCTO) | Thomson Reuters

Box 2. Japan's energy storage and flow battery market: size and trends

The Japanese government has set a forecast for the introduction of stationary-use batteries to improve predictability for storage manufacturers. The forecast for the introduction of grid storage batteries is a cumulative total of approximately 14.1-23.8GWh in 2030, while for residential and commercial-industrial use the cumulative total is about 24GWh in 2030.[37] Yet, most installed large batteries are of short-duration, targeting frequency regulation. BESS in Japan is expected to experience a CAGR of 32.1% from 2024 to 2030,[38] while the flow battery market has an expected CAGR of 20.1% during 2023-2030. The total installed flow battery capacity in Japan currently amounts to about 170MWh.

Japan's JEPX is one of the world's most mature wholesale energy markets in the Asia Pacific region, operating since 2005 and over 40% of the country's total electricity demand is met through the spot market. As mentioned, BESS can earn revenue on this market through energy arbitrage. However, in the past few years, Japan has been challenged by high electricity prices due to limited supply and high global fuel prices. Due to the uncertainty with energy arbitrage revenue, Japan has been addressing its power market by opening the capacity market with the Long-term Decarbonisation Power Source Auction (see details below) and has opened ancillary service markets in 2024.[39] Formerly, ancillary services were procured regionally and served solely by thermal generation and pumped hydro plants.

The Electric Power Reserve Exchange established the Supply and Demand Adjustment Market in 2021, gradually introducing new ancillary services: tertiary adjustment reserve first, followed by primary and secondary reserves this year, with trading now available across all markets.[40]

The programme will provide subsidies to mitigate the development and operational cost risk for developers, which should encourage the development of stand-alone storage battery facilities.[41,42]

Opening Japan's wholesale energy trading market to energy storage applications presents a great opportunity for these technologies. The first BESS to enter the market was Pacifico Energy's lithium-ion battery a few months after the market opening. In August 2023, a municipal power company in Northern Japan ordered a VFB, completed in March 2024. The battery was delivered by Sumitomo Electric, a Japan-headquartered VFB manufacturer and one of the most important global players in the industry, operating in many parts of the world. Its biggest project in the country is connected to the Hokkaido power network with 60MWh+51MWh capacity. The deployment of such long-duration flow battery systems is crucial to showcase LDES capabilities in grid applications.[43] Nevertheless, it should be highlighted that Japan lacks policies and subsidy programmes addressing the promotion of LDES in particular.

Storage applications can also enter the capacity market in Japan, since 2020. OCCTO announced the Long-term Decarbonisation Power Source Auction in July 2023, with the first bid launched in January 2024, providing a 20-year fixed revenue on CAPEX costs for newly developed power sources. The auction 'is essentially a capacity market for low-carbon energy resources'[44] and covers hydro, hydrogen/ammonia nuclear, geothermal and biomass power; solar and wind; LNG-fired thermal power; BESS as well as pumped hydro

[37] Batteries Europe Plenary Session, 11 June 2024 | Kazuyuki Imazato (NEDO)
[38] Japan Battery Energy Storage Systems Market Size & Outlook, 2030 | Horizon Grand View Research
[39] Is the Japanese energy storage market moving forward? | MK Energy
[40] Tesla Megapack Battery Storage System Enters Japan's Ancillary Services Market | Energy Storage News
[41] Gearing up for growth – BESS in Japan | PFI
[42] Japan Update: Battery Storage Development Projects | DLA Piper
[43] Sumitomo Electric Makes Long-Duration Flow Battery Sale for Energy Trading in Japan | Energy Storage News
[44] Japan's Low-Carbon Capacity Auctions 'Will Have Significant Impact' on Business Case for Batteries | Energy Storage News

projects.[45] The expected capacity for the auction is around 4GW of which at least 1GW should be allocated to standalone BESS projects. Moreover, the minimum capacity requirement is 10MW and the system should operate at least 3 hours once a day.[46]

The results for the first bid (announced at the end of April 2024) included 1.1GW for 11 BESS projects, with many projects concentrated on the northern island of Hokkaido and the southern island of Kyushu, both of which have become renewable energy hotspots that have limited interconnection with grids elsewhere in Japan.[47] The Long-term Decarbonisation Power Source Auction projects cannot be subject to the Feed-in Tariff (FIT) or the Feed-in Premium (FIP) regimes, which were established before these Auctions to incentivise renewables.

Under the FIT scheme, utilities buy power from renewable generators at a fixed price regardless of market price fluctuations. FIT has contributed greatly to the deployment of solar and wind generation capacity in Japan. While FIT provides project developers with certainty as to the price the plant will receive for the electricity it generates, there is no incentive for generators to increase their output during peak demand hours or reduce output when the market is oversupplied.

Hence, in April 2022, the FIP regime was introduced, which 'aims to address this imbalance by paying generators a subsidy based on the wholesale market price, plus a marginal rate. This links the revenue the generator receives with the market price and will provide more incentive for them to increase supply during peak demand hours – such as through the use of battery storage.'[48] In other words, the new FIP scheme allows project developers to alter their business plans by adding BESS without triggering a change in the subsidy's base price.

A technology leader with a continued focus on lithium-ion batteries

LDES and battery projects in Japan are expected to grow significantly over the next years. However, when it comes to Japan's battery strategy, the focus lies on lithium-ion and solid-state batteries. Japan has historically been an early technology leader with focus on supply-side policies. Yet, as the country has been losing ground in global market competition, its focus shifted towards increasing production capacity and strengthening its domestic and global position in lithium-ion batteries. This shift is reflected in both the above-mentioned Green Growth Strategy and the Battery Industry Strategy. With regard to the latter, Japan had been intensively promoting R&D for solid-state batteries. However, in its revised Strategy of 2022, liquid electrolyte-based lithium-ion batteries were put into focus with detailed production targets. The goals include establishing a domestic production base of 150GWh per year of lithium-ion batteries and materials by 2030, 600GWh production capacity in the global market in 2030, and full commercialisation of all solid-state batteries around 2030.[49]

Regarding the Green Growth Strategy, a strong emphasis has been put on the automotive sector, setting specific domestic production targets for EV batteries. However, it is noteworthy that the Japanese government has set a forecast for the deployment of household and commercial/industrial storage batteries of 24GWh by 2030 and around 14.1-23.8GWh of grid storage batteries in 2030. Additionally, while the country aims for full commercialisation of solid-state lithium-ion

[45] Japan's Long-Term Decarbonization Power Source Auction | White & Case LLP
[46] Gearing Up for Growth – BESS in Japan | PFI
[47] Japan's First Long-Term Decarbonization | Auction Shulman Advisory
[48] Japan's FIP Scheme and Battery Storage Subsidy are Driving Forces to Boost Renewables | RatedPower
[49] Benchmarking International-Battery Policies | Fraunhofer ISI

batteries from 2030 onwards, it also seeks to commercialise innovative batteries (such as fluoride batteries, zinc batteries, and polyvalent ion batteries) by the mid-2030s. Efforts will mainly focus on lowering battery prices through the economics of scale; securing mineral resources; R&D/technology demonstration; promoting reuse and recycling; developing rules and standardisations.[50]

Noteworthy, in Japan, sodium-sulphur (NAS) batteries are a strong a competitor to flow batteries for long-duration applications. Indeed, large-scale applications of the technology are being deployed for commercial and industrial use as well as for residential applications.[51]

As mentioned before, Japan is facing stronger global competition in key technologies (especially from China), therefore the government has in recent years put a stronger focus on economic security, leading to the Economic Security Promotion Act launched in 2022. The Act aims to secure a stable supply of critical goods; ensure the stable provision of essential infrastructure services; support the development of cutting-edge critical technologies; and to establish non-disclosed patent applications.[52,53] For instance, storage battery supply chains are reviewed under the law and over JPY 150 billion (EUR 1 billion, depending on the FY) is allocated each year to strengthen the storage battery production base. Moreover, to strengthen its supply chains, Japan has enhanced its global collaborations. In the past two years, Japan has signed cooperation agreements with Canada (on the storage battery supply chain) and Australia (on the Partnership on Critical Minerals). In response to the US Inflation Reduction Act, the US-Japan Critical Minerals Agreement was signed in 2023.[54]

In the past few years, Japan has aimed to pick up pace in the green transition and to put the energy sector more into focus (e.g., by increasing renewables targets and revitalising nuclear power). A set of policies has been introduced which further incentivises the deployment of renewables and energy storage solutions, including the GX Policy, the revised EBA and new auction schemes (i.e., the Long-term Decarbonisation Power Source Auction and the FIP scheme). The latter will be advantageous to storage systems since they can generate revenue in the capacity and spot markets.

While Japan focuses on the development of lithium-ion batteries for the EV industry in its battery strategy, stationary storage systems are expected to grow significantly over the next years. This path has, in the case of innovative solutions such as flow batteries, been paved especially by subsidies for demonstration projects, especially by the Ministry of Economy, Trade and Industry and the Ministry of Environment.[55] As these projects are normally carried out by the best known in Japan industry player Sumitomo Electric, its largest projects are attributed to publicly subsidised initiatives.

[50] Benchmarking International-Battery Policies | Fraunhofer ISI
[51] Japanese utility Putting 70MWh NGK NAS Battery into Energy Trading Markets | Energy Storage News
[52] Economic Security Promotion Act | Cabinet Office
[53] Japan's Economic Security Legislation | European Parliament
[54] Batteries Europe Plenary Session, 2024 | Kazuyuki Imazato (NEDO)
[55] Redox Flow Battery Projects | Sumitomo Electric; Sumitomo Electric Receives Order for Redox Flow Battery System from Nippon P.S. for Its Head Office and Factory | Sumitomo Electric; International Demonstration Project on Japan's Technologies for Decarbonization and Energy Transition | NEDO

AUSTRALIA

OVERVIEW

New policy frameworks in Australia open opportunities for energy and grid projects, notably under the promising Capacity Investment Scheme. The Future Made in Australia agenda will be key for the LDES and battery sector, establishing the first Battery Strategy to highlight the advantages of flow batteries.

KEY ACTORS

Australian governmental/public bodies:

- Australian Renewable Energy Agency (ARENA)
- Department of Industry, Science and Resources
- Department of Climate Change, Energy, the Environment and Water
- Australian Energy Market Operator (AEMO)

Industry associations:

- Association of Mining and Exploration Companies (AMEC)
- Australian Energy Storage Alliance (AESA)
- Smart Energy Council
- Australian Energy Council (AEC)
- Clean Energy Council (CEC)

Companies in the flow battery industry:

- Australian Vanadium Limited (AVL) & VSUN Energy
- Vecco Group
- AVESS Energy
- Australian Flow Batteries (AFB)
- Thorion Energy
- Allegro Energy

POLICY GOALS

2030

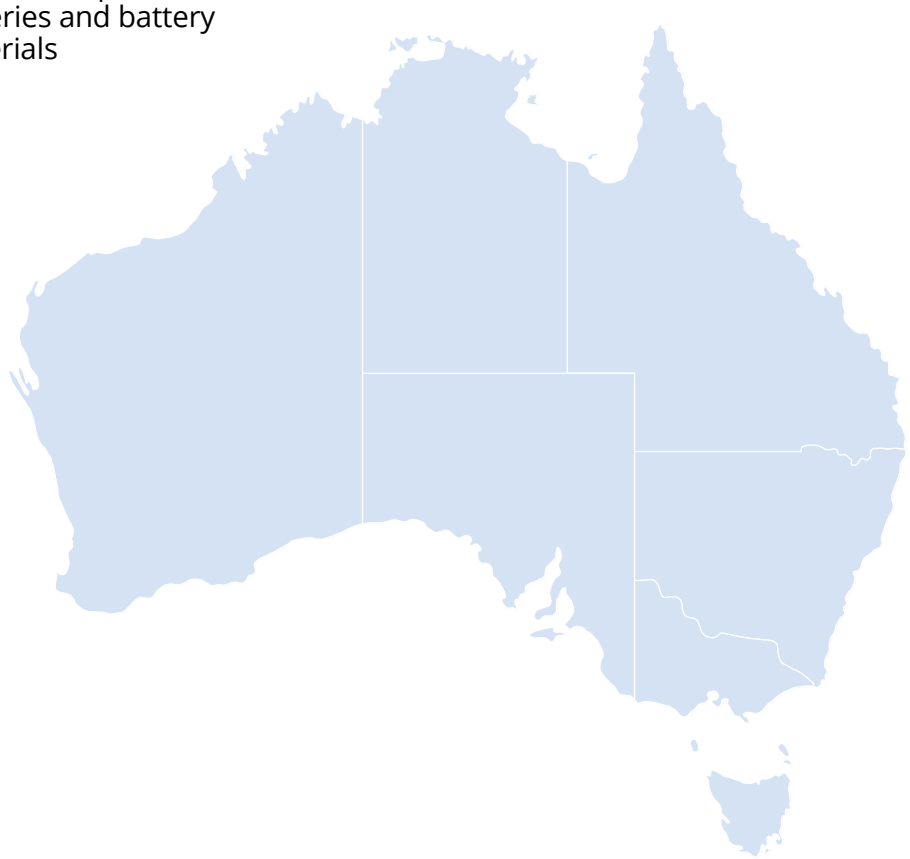
- 43% decrease of emissions
- 82% of renewables share in the National Electricity Market
- Additional 32GW of renewable capacity (incl. energy storage)

2035

Australia as a globally competitive producer of batteries and battery materials

2050

Climate neturality



POLICY DOCUMENTS

- Powering Australia
- Rewiring the Nation
- Capacity Investment Scheme
- Future Made in Australia
  - Future Made in Australia Act
  - National Interest Framework
  - National Battery Strategy
- Critical Minerals Strategy

Making renewable energy accessible: driving investment in green power and storage

Australia aims to decrease emissions by 43% by 2030 and to achieve net zero emissions by 2050. This is a central pillar of the government's Powering Australia plan, focusing on emission reductions related to energy. Through this strategy, the Australian Government is targeting 82% of renewable electricity generation.[56] Two key policies are linked to this framework, which focus on the energy system and LDES.

First, the Rewiring the Nation programme has been running since 2022 and foresees AUD 20 billion (EUR 12 billion) of investment over four years to modernise the country's electricity grid and update its transmission infrastructure. To minimise the costs of the necessary large-scale investments, the programme provides financing at discounted rates. The overall goal of this programme is to make clean energy more accessible and affordable to Australian consumers.

Second, the Capacity Investment Scheme (CIS) provides a national framework to encourage new investment in renewable energy sources, such as wind and solar, as well as clean dispatchable capacity, such as battery storage. The CIS involves the Australian government seeking competitive tender bids for projects to: i) deliver an additional 32GW of renewable energy generation by 2030; ii) fill expected reliability gaps as ageing coal power stations exit; iii) achieve the target of 82% electricity from renewable sources by 2030.

The CIS is being implemented through two key instruments. One instrument involves awarding long-term government support agreements (CISAs) to successful projects, setting minimum and maximum revenue levels to provide financial stability. Another instrument involves Renewable Energy Transformation Agreements (RETAs), which encourage states and territories to provide a favourable environment for renewable investments in return for federal CIS funding.[57]

CISAs broadly work in a similar way to the New South Wales government's long-term energy service agreements (LTESAs).[58] LTESAs are available for electricity generation, firming infrastructure, and LDES projects. The latter consist of a series of options to receive regular payments every two years. The contract can last up to 14 years for chemical batteries and up to 40 years for pumped hydro.[59] An Allens analysis suggests that, from a project perspective, LTESAs provide better revenue support while eligibility requirements may be easier to meet for CISAs.[60]

While the CIS has been a crucial step for acknowledging the importance of LDES, *Renew Economy* emphasises that the 2030 project deadline limits the impact of this recognition. To better support LDES, the CIS should allow contracts for facilities to be signed by 2030, acknowledging that their operational timelines may extend beyond this date. Additionally, since the CIS lacks comprehensive assessment of the value of projects lasting over eight hours compared to those lasting four hours, it should explicitly define the value of longer projects or hold separate tenders for LDES.[61]

It must be noted, however, that investment in large-scale projects has been in decline since the Renewable Energy Target (RET) was met in 2020, a policy that delivered substantial investment.[62] The RET was renewed for the period 2020-2023, aiming to add another

[56] Grids and Storage: The Key to a Reliable and Affordable Net Zero Future | Global Australia
[57] Capacity Investment Scheme Now Open for Business | Allens
[58] Capacity Investment Scheme Now Open for Business | Allens
[59] Long-Term Energy Service Agreements | AEMO Services
[60] Capacity Investment Scheme Kicks Off: What You Need to Know | Allens
[61] Capacity Investment Scheme: Why it Must Play the Long Duration Storage Game | Renew Economy
[62] Clean Energy Australia 2024 | Clean Energy Council

Box 3. Australia's flow battery and energy storage market: size and trends

Australia is emerging as one of the most attractive markets globally for BESS.[63] In 2023, Australia achieved a record-breaking deployment of 2,468MWh of energy storage across utility-scale, residential, and commercial sectors.[64] As for LDES deployments, the country reached more than 10,000MW of deployed capacity in 2023, which is expected to rise to more than 23,000MW by 2031.[65] However, it should be noted that only about 10MWh of flow battery systems are currently deployed in Australia.

While lithium-ion batteries dominate the market with short duration installations, Australia is a leader in the development and deployment of diverse battery chemistries, particularly for grid storage. The vanadium flow battery was invented in Australia at the University of New South Wales in the 1980s and various types of flow battery projects, including vanadium, zinc-bromine, and iron, are being developed in the country.[66]

According to a Mordor Intelligence report, the Australian ESS market is expected to register CAGR of 27.5% from 2023 to 2028. This growth is driven by battery price reductions, the rapid adoption of renewable energy, and government initiatives.[67] A Wood Mackenzie report projects a 28% increase in Australia's battery storage capacity from 2023 to 2032. Competitive wholesale and frequency control markets offer diverse revenue streams, and government funding provides revenue certainty for storage projects.[68] However, high initial capital requirements and component costs are expected to limit demand in the residential and small-scale commercial sectors. The Australian battery industry also faces competition from cheaper systems from China, where grid-scale storage costs are 30-40% lower and expected to drop by 50% by 2032.[69]

Declining costs of renewable energy, driven by advances in PV power generation, wind turbine materials and designs, and economies of scale, are boosting energy storage installations. Renewable energy is becoming more cost-effective than conventional power plants, positively affecting energy storage deployment.[70] However, Australia's National Electricity Market (NEM)[71] is also the 'world's most volatile electricity market', experiencing the highest fluctuation in daily electricity prices out of 39 electricity markets globally.[72]

Currently, the levelised cost of energy for standalone grid-scale storage in Australia remains high compared to other dispatchable generators but is expected to undercut gas-fired power generation by 2032. Wood Mackenzie anticipates that renewables plus storage will undercut coal and gas by 2028, leading to an accelerated buildout of battery storage capacity in the Australian market.[73]

33,000GWh of electricity from renewable sources. It incentivises the generation and use of renewable energy by creating certificates for both large-scale projects (like solar or wind power) and small-scale technologies (such as rooftop solar).[74]

A Future Made in Australia to strengthen the domestic clean energy and battery industry

In May 2024, the Australian government launched major initiatives to bring its renewable energy (and energy storage) sector forward. Future Made in Australia is a ten-years investment plan to help Australia build a 'more diversified and more resilient economy powered by clean energy, to create more secure, well-paid jobs and encourage and facilitate the private sector investment.'[75] The Australian 2024-25 budget will invest AUD 22.7 billion (EUR 13.7 billion) over a decade, mainly in green hydrogen, critical minerals processing, green metals, low carbon liquid fuels, and

[63] Australia's Energy Revolution: The rise of battery storage & hydrogen (forbes.com)
[64] Australia installed 2.5GWh of battery storage in record-breaking 'Year of the Big Battery'- Energy-Storage.News
[65] LDES-Council-Australia-Response-Capacity-Investment-Scheme.pdf (ldescouncil.com)
[66] The strengths and weaknesses of different battery chemistries in Australia (innovationnewsnetwork.com)
[67] Australia Energy Storage Systems (ESS) Market is (globenewswire.com)
[68] Australia leads global market for battery energy storage systems | Wood Mackenzie
[69] Australia leads global market for battery energy storage systems | Wood Mackenzie
[70] Australia Energy Storage Systems (ESS) Market is (globenewswire.com)
[74] Renewable Energy Target scheme | DCCEEW
[75] Investing in a future made in Australia | Prime Minister of Australia

clean energy manufacturing, including battery and solar panel supply chains.

The new industrial policy will be realised under the Future Made in Australia Act (to be adopted in 2024), which will also establish the new National Interest Framework, aiming to align economic incentives with national interests. The framework shall identify priority industries: those that can help Australia reach net-zero emissions and build long-term competitive advantages, as well as industries vulnerable to supply disruptions that need support to unlock private investment.[76]

Under the policy framework, about AUD 3.2 billion (EUR 1.9 billion) will be invested in the commercialisation of technologies crucial to net zero, including batteries; a Critical Minerals Production Tax Incentive shall enhance critical minerals production; and AUD 1.5 billion (EUR 900 million) aim to strengthen battery and solar panel supply chains.[77] Crucially, to spur private investment from Australia and abroad, the government will establish a 'front door' for investors in order to simplify the process (e.g., by providing a single contact point for investment proposals, identifying priority projects, delivering a joined-up approach to investment attraction and facilitation).[78]

On 22 May 2024, the Australian government launched the National Battery Strategy as part of the Future Made in Australia agenda. The strategy builds on five key priorities: build battery manufacturing capabilities to strengthen economic resilience, leverage Australia's comparative advantages and add value to the economy; build knowledge and skills to create secure Australian-made jobs; secure Australia's place in global battery supply chains; lead the world on sustainability, standards and the circular economy; and bring all levels of government together.[79]

Building energy storage to transition the grid to renewable energy is, among others, identified as key opportunity for Australia. The strategy outlines in what way batteries are critical for the green transition and, interestingly, confronts lithium-ion batteries with flow batteries, highlighting the latter's advantages in energy storage applications (see Figure 3).[80] This is not least because Australia is rich in critical minerals used for both types of batteries, including lithium, nickel, chromium, cobalt, graphite, and vanadium.[81] Indeed, the strategy is built around advantages unique to Australia, including its rich natural resources, high ESG standards, the reputation as trusted trading partner, and its pioneering role in battery and energy storage research.[82]

Figure 3 Australia's National Battery Strategy (2024), distinguishing advantages of lithium-ion batteries and vanadium flow batteries.

The centrepiece of the Battery Strategy is the AUD 523.2 million (EUR 300 million) Battery Breakthrough Initiative, offering production-linked incentives to boost critical battery manufacturing, including stationary energy storage. Additionally, the Building Future Battery Capabilities plan allocates AUD 20.3 million (EUR 12.3 million) for battery research, workforce development, and national collaboration. The AUD 1.7 billion (EUR 1 billion) Future Made in Australia Innovation Fund will support innovation,

[73] Australia leads global market for battery energy storage systems | Wood Mackenzie
[74] Renewable Energy Target scheme | DCCEEW
[75] Investing in a future made in Australia | Prime Minister of Australia
[76] Investing in a future made in Australia | Prime Minister of Australia
[77] Investing in a future made in Australia | Prime Minister of Australia
[78] A Future Made in Australia Fact Sheet | Australian Government Budget
[79] National Battery Strategy | Department of Industry Science and Resources
[80] National Battery Strategy | Australian Government
[81] Critical Minerals Strategy 2023–2030 |Australian Government
[82] National Battery Strategy | Australian Government

commercialisation, and pilot projects in priority sectors, including clean energy technologies like batteries (see Figure 4 for an overview of funding and programs).[83]

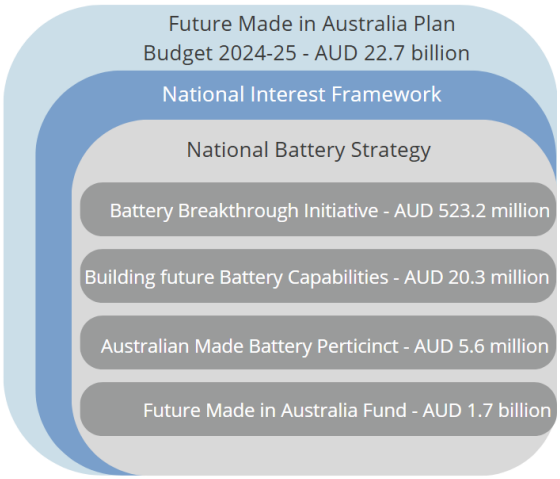


Figure 4 The Future Made in Australia Framework with policies and planned investments. Please note that this graph is intended as a non-exhaustive visual summary.

Under the Future Made in Australia Interest Framework, the government will allocate AUD 7 billion (EUR 4.2 billion) from 2027-2028 to 2040-2041 through the new Critical Minerals Production Tax Incentive, offering a 10% refundable tax offset on eligible processing costs for all 31 minerals on Australia's critical minerals list. This supports the Critical Minerals Strategy 2023-2030, which aims to leverage Australian minerals for the renewable energy transition and establish robust global supply chains. [84,85,86,87] The National Battery Strategy complements this by linking upstream and downstream efforts in the battery value chain.

State governments' initiatives and the support for local ESS development

In addition to the new initiatives and funds outlined above, the National Battery Strategy also launched the AUD 5.6 million (EUR 3.4 million) Battery Precinct in partnership with the Queensland government, with the aim to spur up to AUD 100 million (EUR 60 million) of investment. The initiative will invest in research to support pilot-scale manufacturing of battery technology, helping manufacturers grow their businesses.[88,89] A few months earlier, in February 2024, Queensland launched its Battery Industry Strategy 2024-2029, aiming to boost development, manufacturing and deployment of energy storage technology. The AUD 570 million (EUR 346 million) investment will be split across three themes: innovate and commercialise; invest, integrate and grow; position and promote.

Due to the presence of vanadium reserves in Queensland's north-west, flow battery materials development is planned to be supported through testing and pilot-scale manufacturing under the strategy.[90] Moreover, the state had already committed to supporting VFBs by backing the construction of an electrolyte factory by local manufacturer Vecco Group. Additionally, more projects are being developed in Queensland, including iron and zinc-bromine electrolyte plants alongside vanadium. In 2023, the Queensland government invested AUD 24 million (EUR 14.5 million) in its local flow battery capacity (zinc-bromine and iron flow battery industries).[91]

South Australia's Spencer energy project features one of the world's largest and

[83] National Battery Strategy | Australian Government
[84] Critical Minerals Strategy 2023–2030 |Australian Government
[85] Australia's Critical Minerals List and Strategic Materials List | Department of Industry Science and Resources
[86] Critical Minerals Production Tax Incentive (PTI)- AMEC | Association of Mining and Exploration Companies
[87] Investments to Capitalise on Australia's Critical Minerals and the Global Clean Energy Transition | Department of Industry Science and Resources
[88] National Battery Strategy: Australia Targets 'Globally Competitive Producer' Status by 2035 | Energy Storage News
[89] National Battery Strategy | Australian Government; National Battery Strategy | Department of Industry Science and Resources
[90] Queensland Battery Industry Strategy | Queensland Government
[91] $24 million Investment in Flow Batteries Supports Local Battery Companies | Ministerial Media Statements

Australia's first solar-powered vanadium flow batteries. The AUD 22 million (EUR 13.3 million) project, supported by the Australian Renewable Energy Agency, combines an 8MWh VFB with 6MWp of solar panels, delivering around 10GWh of dispatchable solar power annually. [92] Meanwhile, Victoria has advanced energy policies, legislating renewable and energy storage targets: 2.6GW by 2030 and 6.3GW by 2035. Through its Victorian Renewable Energy Target auctions, the state has implemented four solar-plus-storage projects, driving AUD 1 billion (EUR 600 million) in economic investment. [93]

In 2024, Western Australia launched its updated Battery and Critical Minerals Strategy 2024-2030 with an aim to develop value-addition for the battery and critical mineral industries. The vision for this strategy is to 'have an internationally competitive, ethical and value adding battery and critical minerals industry.' Western Australia is well-endowed with the minerals required for battery manufacturing, including vanadium for flow batteries.[94] AVL has constructed a vanadium electrolyte manufacturing facility and WA-based companies AVESS, AFB and Thorion Energy are manufacturing VFBs. VSUN Energy is developing VFB projects across Australia.

Energy storage and battery policies in Australia vary widely across states. At the federal level, storage targets were briefly discussed in 2022 under the Renewable Energy Storage Target, aimed at incentivizing low-emission capacity to firm up renewables.[95] Overall, Australia has relied heavily on state-level investments, contracts, and subsidies, supported by both federal and state governments. According to Csereklyei et al., regulatory market mechanisms for utility-scale battery storage will remain crucial in the short term, as current market conditions alone do not justify large-scale battery investments.[96]

New policy initiatives are set to boost the battery and energy storage industry. Policies like Powering Australia and Rewiring the Nation create new opportunities for energy and grid projects, supported by promising CIS investment schemes. The latest policies, launched in May 2024, are expected to guide Australia's LDES and battery sectors. The Future Made in Australia agenda and the 2024-2025 budget aim to drive large-scale clean energy manufacturing, with simplified measures to attract private investment. Notably, the new National Battery Strategy will support both lithium-ion and flow batteries, highlighting their unique advantages. This approach is vital given the uneven ambition of sub-national policies. While some criticise the budget for lacking demand-side measures, the Future Made in Australia agenda is as a bold step toward advancing the clean tech sector and strengthening Australia's position in the global battery market.[97]

[92] Case Study: Spencer Energy | Invinity Energy Systems
[93] Victorian Renewable Energy Target auction| VRET2
[94] Western Australia's Battery and Critical Mineral Strategy 2024 – 2030 | Government of Western Australia
[95] Australia's New Government 'Should Consider Renewable Electricity Storage Target policy' | Energy Storage News
[96] Utility-scale battery storage in Australia: A regulatory and market perspective | ScienceDirect
[97] Paying for A Future Made in Australia | The Strategist

SOUTH KOREA

OVERVIEW

South Korea has been a technology frontrunner and leader in ESS deployment, enabled through advanced policy initiatives in the past decade. Despite setbacks in the ESS sector caused by major fire incidents, the Korean government re-started the adoption of LDES support measures, listing flow batteries among the candidate technologies. Renewable energy adoption is, however, not as incentivised as in other countries, making Korea highly dependent on fossil fuel imports.

KEY ACTORS

South Korean governmental/public bodies:

- Ministry of Trade, Industry and Energy (MOTIE)
  - Korea Energy Technology Evaluation and Planning (KETEP)
  - Korea Evaluation Institute of Industrial Technology (KEIT)
- Ministry of Science and ICT (MSIT)
- Korea Energy Agency (KEA)

Industry associations:

- Korean Battery Industry Association (KBIA)
- Korean Society for New and Renewable Energy (KSNRE)
- Korea Association of Energy Services Companies (KAESCO)

Companies in the flow battery industry:

- H2 Inc.

POLICY GOALS

2030

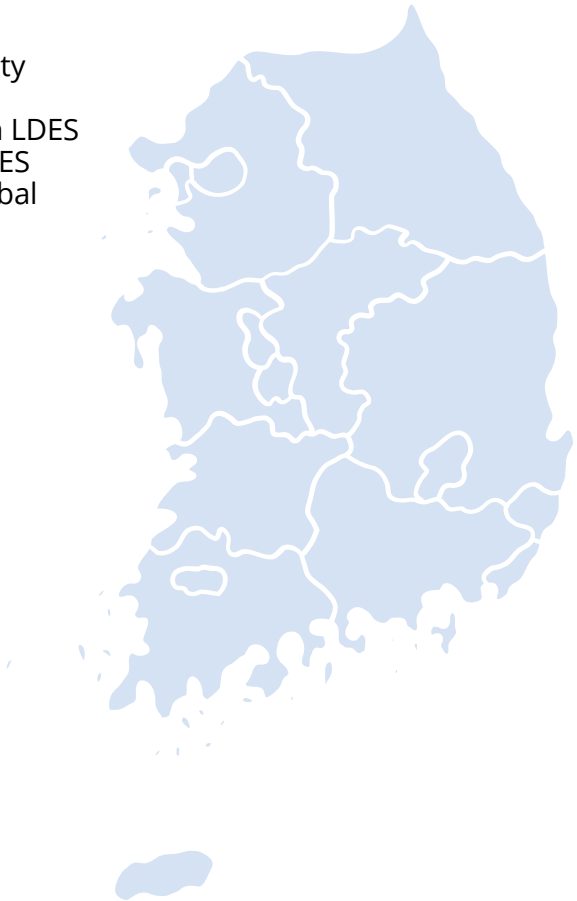
- 40% emission reduction
- 21.6% renewables share

2036

- 23.7% fossil fuel reduction
- 30.6% renewables share
- 24.5GW/127.3GWh of additional storage capacity (excl. pumped hydro)
  - 20.85GW/124.97GWh LDES
  - 3.66GW/2.29GWh SDES
- Capturing 35% of the global ESS makret

2050

Climate neturality



POLICY DOCUMENTS

- Green New Deal
- 10th ‘Basic Plan for Long-term Electricity Supply and Demand’ (Electricity Basic Plan)
- ESS Industry Development Strategy
- Secondary Battery Industry Innovation Strategy
- K-Battery Development Strategy

An environmental 'laggard' but ESS leader

South Korea aims for carbon neutrality by 2050 and its Nationally Determined Contribution (NDC) target is set at 40% of emissions reduction from 2018 levels by 2030. Moreover, in its NDC Korea aims to reduce fossil fuels in the energy sector to 23.7% and increase renewables to 30.6% by 2036. The Green New Deal, as part of the Korean New Deal, entails a low-carbon and decentralised energy supply pillar, which focuses on building smart grids, promote distributed energy production and eco-friendly vehicles. Under the pillar promoting innovation in green industries, technology development support will be provided to energy SMEs, and a green industrial cluster shall help with technology development, testing and production. Overall, the Green New Deal aims to achieve the 2030 emission reduction target by investing 73.4 trillion KRW (about EUR 50 billion).[98,99,100]

Nonetheless, current policy frameworks seem to lack appropriate measures to achieve set goals, as in 2023 fossil fuels still accounted for 58.5% of the power mix, while renewable energy contributed only 9.64%. In addition, targets aren't ambitious enough either to reach the country's overall decarbonisation goals.[101,102,103,104] South Korea is highly dependent on the import of fossil fuels, with 96% of its energy supply being imported as it lacks natural resources and it has one of the lowest energy independence scores (20.6%) in Asia.[105]

Despite being a 'laggard' among industrialised countries in terms of renewables deployment and energy transition efforts, South Korea has been a leader in the battery technology and early in the adoption of energy storage policy. Korea's efforts on ESS started in the early 2010s with the government introducing several programmes to increase the installation and usage of ESS, including:

- The establishment of the Energy Storage Technology Development and Industrialisation Strategies to propel technology development and demonstration projects;
- The support of hybrid systems combining ESS with wind power or PV, which receive four to five times the renewable energy certificates (RECs) issued to standalone ESS;
- The incentive for consumers to qualify for a discount on their electricity bills under the Electricity Charge Discount Programme;
- The requirement for buildings used by public institutions with a peak demand over 1MW to be equipped with an ESS capable of storing more than 5% of the peak demand;
- ESS' categorisation as high-efficiency energy equipment makes them eligible for an investor tax deduction.[106,107]

Although these policies have shown effect with substantial battery deployment increase rates, higher RECs for hybrid systems equipped with ESS ceased in 2021 and the installation of ESS in public buildings has been delayed. This was mainly due to fire incidents caused by improper installation and management as well as inadequate safety systems.[108,109]

[98] Korean New Deal | Government of the Republic of Korea
[99] Government Announces Overview of Korean New Deal | Ministry of Economy and Finance
[100] Korean New Deal- Digital New Deal, Green New Deal and Stronger Safety Net | IEA
[101] South Korea's Energy Mix and Its 10th Basic Energy Plan | Energy Tracker Asia
[102] South Korea's Transition Away from Fossil Fuels is Delayed- REGlobal
[103] South Korea | Climate Action Tracker
[104] South Korea's Energy Mix and Its 10th Basic Energy Plan | Energy Tracker Asia
[105] South Korea Energy Information | Enerdata
[106] Energy storage system policies: ScienceDirect
[107] Korean Power System Challenges and Opportunities |NEXT group
[108] South Korea: Low Renewable Energy Ambitions Result in High Nuclear and Fossil Power Dependencies (renewable-ei.org);
[109] Korean Power System Challenges and Opportunities |NEXT group

Box 4. South Korea's energy storage and flow battery market: size and trends

South Korea's ESS market has been one of the fastest-growing in the world due to strong government support. In the past decade, Korean companies held over half of the global ESS market. However, a range of lithium-ion ESS-related fires led to a significant slow-down in storage deployment.[110] After peaking at 975 installations with a capacity of 3.8GWh in 2018, the installation in 2022 decreased to 94 locations with a capacity of 252MWh. However, as also outlined in the policy analysis, Korea aims to revitalise its currently stagnant ESS industry by setting the ambitious goal of securing 35% of the global ESS market, including 20.85GW of LDES by 2036.[111]

Although Korea is a 'laggard' compared to other industrialised countries when it comes to renewables deployment, a significant increase in RES is expected over the next years. This is anticipated to enhance ESS deployment. Especially regions like Jeju and Honam, which have already a high share of RES and are frequently producing excess energy from renewables, have great potential for further ESS installations. In fact, for 2024 and 2025, auctions for LDES (6h) with capacities of 45MW and 50MW, respectively are being launched. In Honam, 600MW of LDES are under auction for each year.[112]

The South Korean government has estimated that around KRW 46 trillion (about EUR 30 billion) would be needed by 2036 to install the ESSs necessary to compensate for the inflexibility of renewable energy.[113]

While South Korea uses different types of energy storage technologies, the electrochemical is the most rapidly advancing system. Korea also stands among the global leaders in battery storage deployment. By the end of 2022, the cumulative installed capacity of battery storage in the country had reached 4.1 GW.[114] A BESS market report had even predicted a BESS industry growth in Korea at a CAGR of 29.6% from 2022 to 2027. Especially major lithium-ion battery manufacturer based in South Kores such as LG Chem and Samsung SDI Co., Ltd. have been investing heavily in developing battery technologies, which has contributed significantly in the BESS market growth.[115]

Overall, the South Korean ESS market is expected to rebound in the coming years due to enhanced government mechanisms. More favourable conditions for flow battery systems, especially related to LDES deployment targets and the ESS lifespan guarantee, will favour the Korean flow battery industry.[116]

Subsequently, the Electrical Safety Management Act has been amended to incorporate additional ESS safety requirements.[117] Despite the setback, the Korean government continues to target ESS in its policies and programmes. In January 2023, the Korean government released the 10th 'Basic Plan for Long-term Electricity Supply and Demand' (or Electricity Basic Plan), targeting renewable energy shares of 21.6% by 2030 and 30.6% by 2036. Crucially, 24.5GW/127.3GWh of storage capacity (including battery storage and excluding pumped hydro) should be installed in the period 2023-2036. Of this capacity, 20.85GW/124.97GWh should be long-duration and 3.66GW/2.29GWh short-duration systems (up to 30 minutes for frequency regulation) (see Figure 5).[118]

With a goal of 20.85GW of LDES installations by 2036, several solutions are listed among the

[110] Energy storage systems in South Korea- Statistics & Facts | Statista
[111] South Korea Aims to Secure 35% of the Global ESS Market by 2036 |Businesskorea
[112] Jeehyang Huh (H2, Inc), 'Recent developments in vanadium flow battery systems in South Korea', International Flow Battery Forum, 25 June 2024
[113] Energy storage Systems in South Korea- Statistics & Facts | Statista
[114] South Korea Energy Storage Systems Market Outlook to 2028 | Blackridge Research & Consulting
[115] South Korea Battery Energy Storage System Industry to Grow at a CAGR 29.6% from 2022 to 2027| (marketsandmarkets.com)
[116] Recent developments in vanadium flow battery systems in South Korea | International Flow Battery Forum 2024, Jeehyang Huh (H2, Inc)
[117] Korean Power System Challenges and Opportunities |NEXT group
[118] South Korea: Low Renewable Energy Ambitions Result in High Nuclear and Fossil Power Dependencies |Renewable Energy Institute

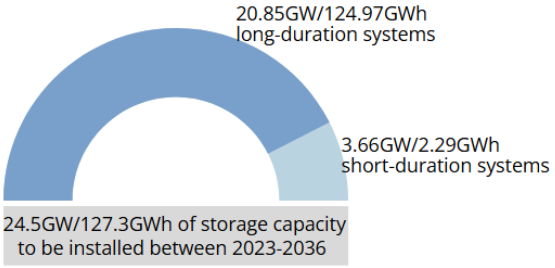


Figure 5 10th Electricity Basic Plan and its energy storage targets for 2036.

candidate technologies, including VFB. In addition, the Korean government implemented a regulation change for the ESS applications in 2023. The so-called ESS lifespan guarantee implies that a battery, regardless of its type, should operate under its rated discharge energy for the entire lifespan. This mechanism is particularly favourable for flow batteries due to their lower capacity degradation.[119]

In line with the Electricity Basic Plan, the government launched the ESS Industry Development Strategy in October 2023. Under the programme, Korea aims to capture 35% of the global ESS market by 2036 the construction of a flexible power system based on ESS. Key strategies include optimising long-term storage mixes, activating and expanding market-based promotion, developing essential energy storage technologies to secure market leadership, creating industrial foundations, and supporting global expansion. A special focus will be on the safety aspect regarding battery storage by enhancing standards for ESS fire safety, improve safety management systems through infrastructure development, and bolster ESS safety management.[120,121]

Unfavourable conditions for clean energy in Korea's electricity market

However, competitiveness has long been overlooked in Korea's energy policy, mainly due to the prioritisation of fossil fuel-oriented energy security over the establishment of an efficient and competitive energy market structure. The Institute for Energy Economics and Financial Analysis (IEEFA) found that South Korea's uncompetitive energy market, coupled with the global energy crisis, has caused significant financial strain on state-run energy companies, especially KEPCO, and increased power bills for ratepayers. The rising debt of KEPCO may require more government-backed debt, creating a 'double moral hazard' by reducing incentives for energy companies to cut costs and innovate, and for creditors to conduct diligent oversight. IEEFA warns this could increase government debt and future taxes. Politicising power tariffs and using bonds to cover losses may worsen financial issues. Keeping electricity tariffs low benefits consumers but burdens energy companies, the government deficit, and future taxpayers.[122]

Korea's fossil-fuel oriented energy policy not only harms competitiveness but also burdens the deployment of clean energy sources. This is mainly because under current market conditions variable prices are prioritised and it is more beneficial to deploy coal-fired power sources. Although carbon commissions are considered under an environmental dispatch mechanism, the measure has limited effect due to low carbon prices and a high share of freely allocated carbon allowances. Hence, according to an analysis of the Berkely National Laboratory, the Korean power market does not provide sufficient investment incentives for potential renewables investors. The clean energy business requires large initial investments that are recovered over many years, making it vulnerable to electricity market price fluctuations. Moreover, curtailment deters renewable energy investment in Korea due to oversupply issues, lack of economic compensation, and absence

[119] Recent developments in vanadium flow battery systems in South Korea | International Flow Battery Forum 2024, Jeehyang Huh (H2, Inc)
[120] Advancing Fire Safety and Rejuvenating the ESS Industry | KTC
[121] AVESS welcomes the Government of South Korea's Energy Storage System (ESS) Industry Development Strategy | Avess Energy
[122] South Korea's Power Trilemma | Institute for Energy Economics and Financial Analysis

of pricing mechanisms, and this problem is expected to worsen as renewable energy deployment increases. The ESS sector is further affected by insufficient compensation for resources that contribute to the supply-demand balance and system stability. In other words, ESS cannot make sufficient profit, as there is not enough price difference in the Korean power market for arbitrage. Moreover, the lack of negative pricing during renewable energy curtailment hinders ESS owners from profiting and recovering their investment costs, unlike in most electricity markets where negative prices allow ESS to earn money even while charging.[123]

Indeed, the difficulty in setting reasonable tariffs for ESS has led MOTIE to offer the government's first central contract market for BESS in August 2023, with projects receiving 15-year long-term contracts. Precisely, the tender bids were issued for battery projects of four hours or more, totalling 65MW/260MWh, and to be deployed on the island Jeju, where such measures were identified to be 'most urgent' according to the government. Nevertheless, since Korea has been a leader in ESS deployment in the 2010s and despite the backlash due to a range of fires, the country is still one of the most mature energy storage markets in Asia Pacific.[124]

A battery technology frontrunner in need to overcome obstacles

In line with this, Korea is a leader in rechargeable battery R&D and has a leading manufacturing base. While the level of battery manufacturing technology is currently similar in South Korea, China, and Japan, Korea has the disadvantage of having a weak domestic materials ecosystem, being highly dependent on imports for its supply chain.[125] To establish a resilient supply chain, the Secondary Battery Industry Innovation Strategy seeks to secure key battery materials. As a response to the US IRA, Korea launched the Post-IRA Public-Private Joint Strategy for Battery Industry Development in order to support domestic materials suppliers, as well as the National Strategy for Strengthening the Competitiveness of the Secondary Battery Industry, with KRW 20 trillion (EUR 13.5 billion) of public-private investment.[126]

In July 2021, the government launched the K-Battery Development Strategy which set the goal for Korea to become the world's No. 1 for batteries by 2030. Battery sales should amount to KRW 166 trillion (40% of the global market, EUR 112 billion), materials, parts and equipment sales to KRW 60 trillion (20% of the global market, EUR 40 billion), and battery exports to EUR 18 billion. These goals are supported by three pillars: securing advanced technology through public-private partnerships in R&D; building the world's leading production base by fostering a cooperative ecosystem; and growing the battery market by generating demand from both public and private sectors. The strategy contains a policy mix including R&D programmes, tax and investment incentives, infrastructures, and demand-side policies. Crucially, it not only describes government responsibilities and tasks, but also the expected cooperation of the private sector.[127]

Funding priorities are set on the commercialisation of three types of next-generation batteries: solid-state batteries, lithium-sulphur batteries, and lithium-metal batteries. Moreover, performance, safety and productivity for lithium-ion batteries are another R&D focus. Precisely for ESS applications, solid-state batteries should be

[123] Korean Power System Challenges and Opportunities |NEXT group
[124] South Korea Offers Central Market Contracts for 260MWh Energy Storage in Jeju Island Tender | Energy Storage News
[125] Overview of International RDI Battery Funding and Global-Benchmarks for Battery KPIs | Batteries Europe
[126] Benchmarking International Battery Policies | Fraunhofer ISI
[127] Benchmarking International Battery Policies | Fraunhofer ISI

enhanced due to their increased safety.[128] Additionally, recycling goals have been added to Korea's battery policy for critical materials such as cobalt sulphate, nickel sulphate, manganese sulphate, and lithium hydroxide.[129]

Nevertheless, flow batteries play a role in the Korean ESS market. Since January 2020, flow batteries are able to enter the ESS market tied to new renewable energy sources, which was a complementary measure to the in the previous year introduced RECs for flow batteries paired to renewables.[130] KEPCO has increasingly been deploying flow battery demonstration projects in the past few years, in order for the technology to be validated for the wider use within the Korean power network. H2 Inc., a leading VFB producer headquartered in South Korea, deployed a 200kWh ESS at a KEPCO site in 2019, followed by two 810kWh systems in 2020.[131] As H2 Inc. secured significant (private) funds over recent years, allowing the manufacturer to scale up production capacities to 330MWh per year with a new production site opened in 2023. Yet, KEPCO also tests foreign flow battery technologies, with the most recent demonstration project delivered by Invinity Energy Systems (a 1.5MWh VFB) in 2023.[132]

In sum, Korea is one of the most important energy storage and BESS markets worldwide and technologically advanced. However, despite its 2050 net-zero target, the country is a laggard compared to other industrialised nations, both in terms of climate targets (such as renewable targets) as well as complementary policy efforts. Additionally, also due to limited resources, Korea is highly depended on fossil energy imports. With plans to also (re)build nuclear energy, the country risks, similar as Japan, of doing a nuclear detour instead of increasing renewable deployments. What is more, current market conditions are rather unfavourable to clean energy adoption. This unavoidably affects the energy storage sector, even though South Korea has been a leader in ESS deployment during the 2010s. Yet, Korea is one of few countries with energy storage deployment targets (24.5 GW/127.3 GWh of BESS up to 2036), divided into long and short-duration systems. Moreover, the new, resource-intensive battery strategy will further enhance Korea's battery technology and commercialisation. The government's power company KEPCO has been testing flow batteries in the past few years with demonstration projects, having one of the largest VFB producers headquartered in South Korea. The new ESS lifespan guarantee will further be advantageous for flow battery deployment. What is pivotal for South Korea at the current stage is to further eliminate the outlined paradoxes by aligning political targets with tailored policies and market conditions. The latter must be reformed in a way to enhance both renewable deployment and ESS by enabling favourable investment conditions.[133]

[128] Benchmarking International Battery Policies | Fraunhofer ISI ; Overview of International RDI Battery Funding and Global-Benchmarks for Battery KPIs | Batteries Europe
[129] Overview of International RDI Battery Funding and Global-Benchmarks for Battery KPIs | Batteries Europe
[130] South Korean Government Allows Flow Battery to Be Used for ESS | ETNews
[131] Recent-Deployments of Vanadium Redox Flow Battery Storage
[132] Case Study: KEPCO | Invinity Energy Systems
[133] Reforming Korea's Electricity Market for Net Zero | Iea

OTHERS

India aims to achieve 500GW of clean energy by 2030, requiring a fourfold increase in renewable power compared to 2010-2020 levels. It also became the first country to establish a 'clean international incubation centre' to support clean-energy start-ups, including ESS and LDES. The FAME India II policy addresses the scale-up of ESS for e-mobility.

ESS adoption is a goal in **Malaysia**'s National Energy Policy 2022-2040 to facilitate the green transition and enhance energy security. The government has begun integrating BESS into the RES market and attracting foreign interest, with a collaboration on a pilot flow battery project.

Indonesia plans to double its 15% renewable energy share by 2030. Facing intermittency challenges, BESS plays a role in RES advancement. While the country lacks specific incentives for local ESS development, it has a few large-scale projects totalling 20GWh of storage.

While its ESS sector is still in its infancy, **Thailand** has increasingly adopted solar plus BESS applications in the past few years. Although the lithium-ion industry dominates the sector, it is noteworthy that the Thai power distribution company has invested in VFB systems. The Thai government will increasingly assess the feasibility of ESS business models.

Singapore reached its 200MW storage target for 2025 three years early. Despite challenges in the BESS supply ecosystem, the island-nation is exploring alternatives like VFBs with pilot projects. Additionally, the Energy Market Authority is promoting wider ESS deployment through grants and policy focus on PV integration, peak shaving, and grid services.

India

India has a net-zero pledge for 2070. Nevertheless, it has one of the world's most ambitious targets for scaling clean energy with a goal to achieve 500GW by 2030, meaning that India needs to install about four times the amount of renewable power than was delivered between 2010 and 2020. Moreover, India became the first country to establish a 'clean international incubation centre' to support and promote clean-energy start-ups, including storage and LDES.[134]

An important aspect of India's climate efforts is the development of EV and hybrid mobility. The Faster Adoption and Manufacturing of Electric Vehicles in India Phase II (FAME India II) Scheme intends to boost demand for EVs by offering upfront incentives and the creation of EV charging infrastructure. This measure is expected to contribute to the growth of ESS.[135] To expand battery production capacity, the Cabinet of India approved in 2021 a production-linked incentive scheme, the 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage'. ACC is defined as new generation of advanced storage technology, saving electricity as chemical or electrochemical energy. The programme aims to achieve manufacturing capacity of 50GWh of ACC and 5GWh of 'niche' ACC, providing around EUR 210 million.[136]

Thailand

Thailand's power remains heavily reliant on fossil fuels with only 10% of its current electricity supply coming from RES while 4% are wind and solar power. However, recent efforts in the country's decarbonisation include the new Power Development Plan, to be adopted within 2024, which set the proportion of renewable energy to increase to 51% of the total by 2037.[137] Energy storage was barely required until now due to the fact that, thus far, grid capacity stood at about 48.8GW, but peak demand has never exceeded 34.2GW.[138]

However, with rising electricity demand coupled with a higher share of RES, ESS is expected to increase. While the ESS sector is still in its infancy, already in the early 2020s, the Thai government awarded 24 solar plus co-located BESS projects, with a total capacity of 994MW. The BESS sector is expected to be dominated by the lithium-ion industry. [139] Nevertheless, it is noteworthy that Thailand headquartered electric power distribution company BCPG, one of the biggest in the region, has invested USD 24 million (EUR 21.6 million) in 2021 in VFB producer VRB Energy. This was to strengthen the sector by adding 'storage to existing and planned projects to optimise system performance and revenues, as well as exploring other business development opportunities in Thailand, including "localisation of manufacturing".'[140] Moreover, the Provincial Electricity Authority in July 2024 announced that it will assess the feasibility of energy storage business models.[141]

Malaysia

The adoption of energy storage is outlined as goal in Malaysia's National Energy Policy 2022-2040 in order to facilitate a green transition but also to enhance energy security.[142] While the strategy rather expresses the opportunity in developing existing hydro storage infrastructure, the Malaysian government has been taking first steps to integrate BESS in the RES market. In 2022, it permitted corporate virtual power purchase agreements on the

[134] LDES Council Australia Response Capacity Investment Scheme | IDES Council
[135] Asia Pacific Flow Battery Market Size & Forecast by 2030 | KBV Research
[136] Benchmarking International Battery Policies | Fraunhofer ISI
[137] A closer look at the new energy plan | Bangkok Post
[138] Thailand's Emerging Energy Storage Sector | International Bar Association
[139] Thailand's Emerging Energy Storage Sector | International Bar Association
[140] Investment to drive growth in vanadium redox flow battery deployment | Best Magazine
[141] Provincial Electricity Authority of Thailand Signs MoU to Assess Energy Storage System Feasibility | Energy Storage News
[142] National Energy Policy 2022-2040 | Menara Prisma

merchant electricity market, allowing trading of green electricity independently of traditional long-term agreements, with future potential for BESS policies. Although the local production of BESS has rather just started in Malysia,[143] foreign companies have become aware of the country's potential for these applications, including flow batteries. In 2021, Australian resources company TNG entered into collaboration with the local green energy firm AGV Energy to explore the potentials for VFB applications in Malaysia and to deploy a first pilot project as commercial application.[144]

Singapore

Singapore is more developed in terms of RES and ESS applications than its neighbour, although the island-nation is challenged by its limited availability of land. Nonetheless, with one of the most stable grids in the region, Singapore reached the 200MW storage deployment target for 2025 three years ahead of time.[145] What is more, Singapore not limits itself to lithium-ion batteries despite challenges in the supply ecosystem for BESS technologies. In 2022, the VFB of the local start-up VFlowTech has been selected among three projects for test deployment on Jurong island, where much of the industrial infrastructure is located. The technology is trialled for use in combination with EV charging. VFlowTech has also entered a joint venture with Thai company Banpu to develop a hybrid solution combing lithium-ion and VFB.[146]

In 2023, the national Energy Market Authority (EMA) of Singapore put out a grant call for proposals that facilitate the wider deployment of ESS. Moreover, the EMA considers in its policy paper the potential of ESS in the Singapore power system, specifically for PV integration, peak shaving and arbitrage, frequency regulation, enhance investment, and voltage regulation services.[147]

Indonesia

The share of RES in Indonesia is rather low with about 15% of the energy mix, yet the government has set the target to double the share by 2030. Solar and wind energy are among Indonesia's most advanced renewable resources, producing 207GW and 135GW of power, respectively. However, Indonesia's challenging geological landscape, characterised by many off-grid and remote areas, leads to intermittency issues that hinder the progress of solar and wind energy generation. Therefore, BESS technologies play a crucial role in the advancement of Indonesia's renewable energy sector.[148]

Lithium-ion batteries and the EV sector are in focus as Indonesia has one of the largest nickel reserves in the world.[149,150] As a result, the government does not appear to have any incentive policies specifically targeting battery energy storage deployment. Nonetheless, it is noteworthy that, although Indonesia has few BESS projects, they are at large scale with two projects totalling 20GWh of storage.[151]

[143] Malaysia Government Minister Welcomes Country's First 'Homegrown' BESS solution | Energy-Storage News
[144] Australia's TNG and Malaysia's AGV Energy to Produce Vanadium Redox Flow Batteries Using Green Hydrogen Technology-|Orissa International
[145] Singapore Seeks Solutions to Land Constraints and Other Challenges in Deploying Energy Storage | Energy Storage News
[146] Singapore Vanadium Flow Battery Maker Signs MoU with Advario | Energy Storage News
[147] 2024 Update Energy Storage Systems ("ESS") in Singapore | Bird & Bird
[148] Indonesia Clean Energy Battery Storage System | International Trade Administration
[149] How will Indonesia build up its closed-loop new energy industry chain? | Interact Analysis
[150] Overview of International RDI Battery Funding and Global-Benchmarks for Battery KPIs | Batteries Europe
[151] How will Indonesia build up its closed-loop new energy industry chain? | Interact Analysis

LESSONS LEARNED FROM ASIA PACIFIC

POLICY RECOMMENDATIONS FOR EUROPE'S WAY FORWARD

1. Set LDES deployment targets and adopt a sustained energy storage strategy
2. Enhance subsidies and investment schemes to support the viability of LDES
3. Facilitate market participation for LDES
4. Support flow battery manufacturing in Europe and build a resilient supply chain
5. Facilitate the application of a variety of energy storage technologies
6. Recognise the advantages of flow batteries for specific applications
7. Accelerate the implementation of the necessary policy mechanisms

As Europe seeks to accelerate the clean energy transition, driven by ambitious climate goals and the need for enhanced energy security, the installation of renewable energy sources is increasing rapidly. However, a green transition cannot succeed without sufficient energy storage. Europe must pick up pace to reach its net-zero ambitions and to remain a competitive player in the sector.

The Asia Pacific region is, and will continue to be, a frontrunner when it comes to (long-duration) energy storage development and deployment. Led by countries like China, Australia, Japan and South Korea, the BESS sector, including flow batteries, is experiencing the fastest growth in the region. Largely due to strengthened policy frameworks, mechanisms and energy storage targets part of the political strategies of these countries. While China has already reached its 2025 target of 30GW of energy storage by having 48.18GW in mid-2024, it aims for 100GW by 2030. In South Korea energy storage goals are divided in long- and short-duration systems: between 2023 and 2036, 20.85GW/124.97GWh of long-duration and 3.66GW/2.29GWh of short-duration energy storage shall be installed. Such goals feature the awareness of the importance of energy storage in the clean transition.

While political prioritisation of energy storage is essential to establish a guiding framework, the countries under scrutiny have also advanced subsidy programmes and investment schemes for energy storage. In Australia, LDES is supported under the Capacity Investment Scheme, providing long-term government support to projects and financial certainty. Additionally, several Australian states support local flow battery projects through subsidies. China has maintained government support for large-scale projects for the past decade, including the world's largest flow battery under its Five-Year Plan for Energy Storage. Europe needs similar mechanisms, such as grants, tax credits, and revenue strategies like long-term contracts for balancing, ancillary services or capacity markets, to enhance investor returns and accelerate LDES deployment, particularly in commercially challenging environments.

Subsidies empower installations of LDES and flow batteries and enhanced market mechanisms ensure long-term viability. Japan, for instance, allows storage applications to enter both capacity and spot markets, with BESS entering the capacity market through standalone projects. Following the opening of Japan's wholesale market to energy storage, a large-scale 8-hour flow battery entered the market, demonstrating interest in LDES. Europe should consider similar measures, such as adapting market rules to create a supportive environment for LDES deployment and facilitate the entry of emerging storage technologies.

A robust supply chain is key to a strong production base, especially in the battery sector. Australia, rich in resources like chromium and vanadium, is investing over EUR 4 billion in critical mineral processing to strengthen its global battery supply chain. China, with the largest vanadium reserves, supports new technologies like VFB. Both countries showcase targeted policies to boost flow battery manufacturing. Resource-scarce Japan invests over EUR 1 billion annually in its battery supply chain and secures critical minerals through partnerships with Canada, Australia, and the U.S. Europe should follow suit and leverage untapped vanadium reserves in Norway and Finland for the market-ready VFB technology. Additionally, organic flow batteries using sustainable materials, offer Europe a chance to domestically produce energy storage technologies. By developing raw materials, components, and systems locally, Europe can reduce reliance on international suppliers and minimise supply chain risks.

Whilst a secure supply chain is fundamental, a strong clean energy industry must rely on a range of storage technologies. Countries in the Asia Pacific region support the development and deployment of a variety of energy storage

applications, including electrochemical storage, compressed air, flywheel, thermal energy storage, and pumped hydro. In China, the FYP has set a specific focus on supporting different novel energy storage technologies to advance various sectors from development to commercialisation within the next years. This approach not only advances several energy storage sectors but ensures energy security through the diversification of technologies.

In addition, it is crucial to acknowledge that energy storage systems have distinct characteristics, offering specific advantages and limitations depending on the application. This applies especially to battery storage systems, where the most commercialised and widely used technologies are often prioritised. To drive a successful green transition, this approach must unquestionably be changed. Australia's National Battery Strategy compares lithium-ion and flow batteries, highlighting the former for their high energy density, which makes them ideal for various mobile applications, and emphasising flow batteries for their long cycle life, cost-effective scalability, and suitability for large-scale applications. Recognising these differences and outlining them in policy strategies signals the need to diversify storage systems based on the most suitable applications.

Beyond specific policy decisions that must be made in order to ensure a successful green transition, it is most important to take the appropriate steps quickly. This report has shown that in the Asia Pacific region, countries have acknowledged the central role of energy storge in this process ahead of Europe. Already in the 2010s, China and South Korea, for instance, had dedicated policies in place to incentivise ESS development and deployment, already enabling large-scale demonstration projects for flow batteries. Hence, to not fall behind global counterparts and to achieve its climate pledges, the EU must accelerate its policy actions in the renewable energy and energy storage sector.

Box 5. Lessons learned from Asia Pacific: EU policy recommendations

1. Set LDES deployment targets and adopt a sustained energy storage strategy
   Establish a 2030 target of 200GW of energy storage in Europe, with 50% being LDES, to meet future energy needs and drive investment; complemented by a strategy outlining implementation tools.
2. Enhance subsidies and investment schemes to support the viability of LDES
   Promoting LDES adoption, such as through grants, tax credits, and revenue mechanisms like long-term contracts boosts returns and reduces financial risks.
3. Facilitate market participation for LDES
   Adapting market rules and standards lowers barriers, ensures fair competition and supports the integration of LDES into the energy system.
4. Support flow battery manufacturing in Europe and establish a resilient supply chain
   With raw materials and organic chemistries available within Europe, domestically manufactured flow batteries can reduce reliance on international suppliers.
5. Facilitate the application of a variety of energy storage technologies
   Encouraging the use of diverse storage technologies ensures a balanced energy system, where different technologies can provide the resilience against supply or market shifts.
6. Recognise the advantages of flow batteries for specific applications
   Flow batteries are ideal for large-scale storage projects, making them crucial for balancing renewable energy sources and providing grid stability.
7. Accelerate the implementation of the necessary policy mechanisms
   Swift action is essential for Europe to remain competitive in the global energy market, meet climate goals, and seize the economic opportunities of the green transition.

ABOUT FLOW BATTERIES EUROPE

Flow Batteries Europe (FBE) represents flow battery stakeholders with a united voice to shape a long-term strategy for the flow battery sector. We aim to provide help to shape the legal framework for flow batteries at the EU level, contribute to the EU decision-making process as well as help to define R&D priorities. FBE is working to create and reinforce networks between key stakeholders in the flow battery industry.

Avenue Adolphe Lacomblé 59/8BE
1030 Brussels, Belgium

d.pohl@flowbatterieseurope.eu
+32 (0) 2 743 29 86
www.flowbatterieseurope.eu