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Unlocking the Potential of Grid-Scale Battery Storage Business

Current Status and Challenges

August 2025

This document presents a partial English translation and reconfiguration of selected sections from the original Japanese-language report issued in July 2025.

Acknowledgement

We received valuable input from experts, including grid-scale battery storage project developers, in related fields while preparing this report. We would like to express our gratitude to their contributions.

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About Renewable Energy Institute

Renewable Energy Institute is a non-profit think tank which was established in August 2011, in the aftermath of the Fukushima Daiichi Nuclear Power Plant accident. It aims to build a safe and secure society based on renewable energy and a sustainable energy system and economy that mitigates climate change.

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Introduction

In recent years, the installation of grid-scale battery storage systems connected to power grids has been growing exponentially. Traditionally, electricity has required a balance of supply and demand in real time, as storing electricity was considered difficult. This limitation has hindered the expansion of variable renewable energy (VRE). However, with the advancement of energy storage technologies that allow for charging and discharging, it has become possible to shift electricity supply and demand over time, significantly reducing barriers to VRE integration.

Furthermore, the proliferation of stationary batteries is expected to be complemented by a growing number of electric vehicles with onboard batteries, enabling the development of virtual power plant (VPP) systems. These advancements could transform market transactions and related services, potentially driving innovation across the entire power system.

Despite the growing attention to grid-scale battery storage, large-scale deployment began globally in the late 2010s and in Japan around 2023. As such, the sector is still in its early stages of development, and institutional frameworks and market mechanisms have yet to fully mature. This report aims to provide an overview of the early-stage grid-scale battery storage business in Japan, identify key challenges, and outline the direction of future development.

Grid-scale battery storage is one type of stationary battery storage. As discussed later, there are also other types, such as systems co-located with renewable energy and behind-the-meter systems. Stationary battery storage refers to batteries that are installed in a fixed location and used for repeated charging and discharging.

This report primarily focuses on grid-scale battery storage projects that contribute directly to the stable supply of electricity.

In preparing this report, we conducted interviews with many grid-scale battery project developers. We would like to express our sincere gratitude to all those who kindly participated.

Chapter 1: Positioning and Business Models of Grid-Scale Battery Storage

Section 1: Stationary Batteries as a Means of Flexibility

In advancing the decarbonization of the power system, the large-scale integration of VRE such as wind and solar is essential[1]. However, the greater the share of VRE, the more difficult it becomes to balance supply and demand. With increasing periods of oversupply, curtailment of output becomes more frequent. While conventional power systems relied on load-following operations of thermal power plants to adjust output, the shift away from thermal generation for decarbonization necessitates diversified approaches to supply-demand balancing and the provision of inertia. This is the essence of 'flexibility' in power systems.

Flexibility can be achieved through various means: load-following operations of thermal and hydroelectric plants, wide-area grid interconnections, pumped hydro storage, and demand-side measures such as demand response. Additional methods include market enhancements such as the introduction of negative prices in spot markets, and curtailment of renewable energy electricity when done rationally. Among these options, stationary batteries have recently attracted significant attention.

Batteries are capable of dynamically adjusting supply and demand. In an era dominated by VRE, batteries can store excess electricity during oversupply periods and discharge it during shortages when prices spike. This not only supports stable supply but also maximizes the use of VRE, alleviates grid congestion, and reduces the need for costly transmission infrastructure investments. Lithium-ion batteries can respond in less than a second without the need for rotational startup. They can provide frequency control (FCR), voltage support, emergency backup power, and black start[2] capabilities. Recently, they have also begun offering synthetic inertia[3]. Compared to existing flexibility measures, stationary batteries offer multifunctionality and ease of use.

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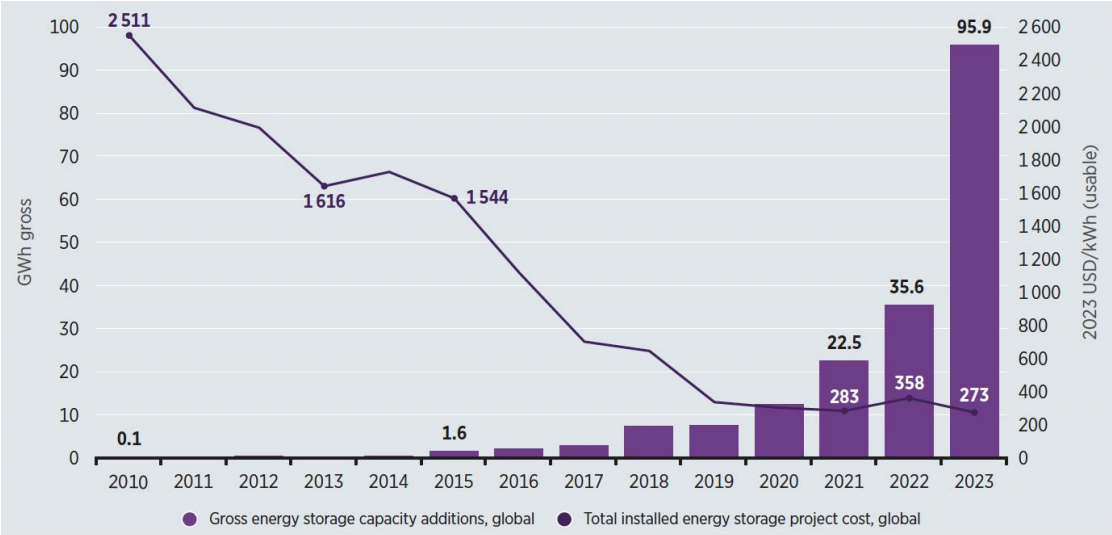
[1] For example, the IEA (2023) projects that in order to achieve global decarbonization by 2050, 89% of the world's power generation mix will need to come from renewable energy sources, with 71 percentage points of that accounted for by VRE.

[2] A black start refers to the capability to start up a power plant without external power supply during a blackout, in order to restore the power grid.

[3] Inertia refers to the function of stabilizing the grid frequency, a role that has traditionally been fulfilled by rotating machines such as thermal power generators. While inverter-based resources like VRE and battery storage were once considered incapable of providing inertia, advancements in inverter control technology have now made it possible for them to do so.

Although the excellent characteristics of batteries for supporting stable supply have long been recognized, their historically high costs limited their use in grid operations. However, with the widespread adoption of electric vehicles driving down the cost of lithium-ion batteries, the cost of grid-scale and co-located batteries (utility-scale battery storage[4]) has dropped to about one-tenth of its previous level over the past decade. This cost decline is the primary factor driving the recent rapid increase in battery installations globally.

Figure 1 Global gross battery storage capacity additions by year and total installed electricity storage project cost



Source: IRENA (2024:145).

The second factor is the large-scale integration of VRE. In countries and regions such as Ireland, Germany, and South Australia in Australia, the share of VRE in the power generation mix has reached around 40% or even higher. As a result, greater system flexibility is required to maintain a stable electricity supply while minimizing curtailment. Moreover, the daily fluctuations in spot electricity prices have become more pronounced, thereby improving the economics of arbitrage (taking advantage of price differentials) in battery storage operations.

Section 2: Three Types of Stationary Battery Storage – Grid-Scale, Co-located with Renewable Energy, and Behind-the-Meter

Stationary battery storage generally refers to batteries installed at fixed locations and used for repeated charging and discharging. Unlike batteries embedded in mobile devices such as laptops or electric vehicles, they are not constrained by weight or volume, so high energy density is not essential. However, longevity, responsiveness, and cost-efficiency are required. In the past, large lead-acid batteries have been used for emergency power supplies and voltage control at substations, though they were limited in the number of charge-discharge cycles. The cost reduction of high-density lithium-ion batteries since the

[4] In this report, references to "utility-scale batteries" in overseas sources are interpreted as including both grid-scale systems and those co-located with renewable energy.

late 2010s has enabled the emergence of large-scale stationary batteries that can be charged and discharged on a daily basis to contribute to grid operations.

Stationary batteries can be categorized into three types based on installation location and usage: (1) grid-scale batteries, which are the main focus of this report; (2) batteries co-located with renewable energy facilities; and (3) behind-the-meter batteries used by consumers.

Table 1 Three Categories of Stationary Battery Storage Projects

		Market in Japan	Stand alone	Co-located	Behind-the-Meter	
					Industrial / Commercial	Residencial
Frequency Stabilization	Fast Frequency Reserve(FFR)・Synthetic inertia	----	◎	◎	◎	△
	Frequency Containment Reserve (FCR)	Balancing market	○	○	○	△
	Automatic Frequency Restoration Reserve (a-FRR)		○	○	△	×
	Manual Frequency Restoration Reserve (m-FRR)		○	○	△	×
	Replacement Reserve(RR)		○	○	△	×
Revenue Enhancement	Planned generation and imbalance avoidance	JEPX	×	○	△	×
	Curtailment avoidance and time-Shifting	JEPX (Day-ahead)	×	○	△	△
	Arbitrage	JEPX (Day-ahead)	○	○	△	×
	Provision of supply capacity	Capacity market	○	○	△	×
	Grid congestion relief (re-dispatch)		○	○	△	×
Others	Maximum power intake limitation (peak cutting)		×	×	○	○
	Expansion of renewable energy self-consumption Rate		×	×	○	○
	Emergency power supply (Isolated operation)		○	○	○	○
	Voltage control (power factor / reactive power)	----	◎	◎	◎	◎

Source: Created by Renewable Energy Institute

◎: Technically feasible and expected to warrant the creation of new markets
○: Technically feasible
△: Technically feasible but requiring further consideration for market entry, etc.
×: Not applicable

Grid-scale battery storage is connected to the power grid independently of power generation facilities and provides services such as supply-demand balancing and frequency control. It also earns revenue through arbitrage in the spot market. Energy capacity ranges from several MWh to several hundred MWh.

Batteries co-located with renewable energy sources, such as wind or solar, are installed on the same site or nearby, receiving the electricity generated there while being connected to the grid. As Japan shifts from a Feed-in Tariff (FiT) to a Feed-in Premium (FiP) scheme, these batteries are increasingly used for time-shifting power output and avoiding imbalances. In other words, these systems can charge using VRE electricity during periods of curtailment and discharge to the grid during high-price periods, thereby earning revenue through arbitrage and premium payments. While they can also generate income through grid system services such as frequency control—similar to grid-scale battery storage—their operation is primarily aimed at maximizing the revenue of a specific power generation project. The storage capacity of these batteries depends on the capacity of the associated VRE generation facility, and typically ranges from several hundred kWh to several tens of MWh.

Behind-the-meter batteries are installed by consumers, such as factories or commercial buildings, to reduce peak demand or serve as backup power. They are typically not standalone businesses and, in many cases, cannot recover their investment on their own. They are often combined with solar power for self-consumption, in which case the primary objective is to expand self-consumption by shifting the timing of electricity supply. Capacity varies widely depending on demand, with even residential batteries of around 10 kWh falling into this category.

In Japan, the majority of installed capacity is behind-the-meter, mostly for residential use, amounting to over 8 GWh. In contrast, grid-scale and co-located batteries combined account for just over 2 GWh. However, since behind-the-meter systems serve individual consumers, they do not directly contribute to grid stability. In the era where VRE becomes the dominant power source, the main means of providing system flexibility will be the other two types of battery storage—particularly grid-scale batteries. In fact, the IEA (2024:68) projects that the global energy storage capacity[5] will increase sixfold from 2023 to 2030, reaching 1,500 GW under the Net Zero Emissions by 2025 Scenario. Of this increase, 90% is expected to come from stationary battery storage, with approximately 80% accounted for by grid-scale and renewable co-located battery storage projects (utility-scale batteries). Accordingly, this report focuses primarily on grid-scale battery storage, while also partially addressing co-located systems, given the overlap in their roles.

[5] Battery storage capacity is expressed in two units: power capacity (kW) and energy capacity (kWh). Power capacity, or rated output, refers to the maximum amount of electricity that can be charged or discharged instantaneously. Energy capacity, or storage capacity, indicates the total amount of electrical energy that can be stored overall.

Section 3: Business Models for Grid-Scale Battery Storage

In Japan, grid-scale battery storage is legally treated as a power generation business. However, the business model differs significantly from that of renewable energy generation, as batteries do not produce electricity themselves. The primary revenue streams come from time-shifting through charge/discharge operations, ancillary services, and capacity provision.

The business lifecycle begins with the installation phase. Site selection must consider weight, noise, and safety, but compared to renewable energy plants, batteries are generally easier to site and quicker to build. This ease of installation is a key advantage given the long lead times often associated with solar and transmission projects due to local opposition.

Financing is critical during this phase. Although battery prices have fallen, installation costs still range from 20,000 to 50,000 yen per kWh. A 10s-of-MWh scale facility can cost several billion yen[6]. Operating costs, by contrast, are relatively low—mainly maintenance, power purchase for charging, transmission fees, and losses during discharge. Therefore, securing initial investment is vital to business viability.

The second phase involves grid connection. Like generation projects, battery operators must apply to the transmission and distribution system operators (TDSOs), and may be required to cover grid upgrade costs. Recently, delays in application processing have become a significant bottleneck, impacting both capital costs and project timelines.

In the third phase, once operations begin, revenue is generated through participation in markets: arbitrage in the spot market, services in the balancing market, and capacity auctions. However, market prices fluctuate daily and it is difficult to predict them accurately in advance. Not all operators possess the skills to forecast prices or execute trades effectively, resulting in significant disparities in profitability. The market-driven nature and uncertainty of revenue generation represent a major difference from renewable energy generation projects operating under a fixed-price feed-in tariff scheme. As a result, many operators invest in batteries but outsource market participation to aggregators.

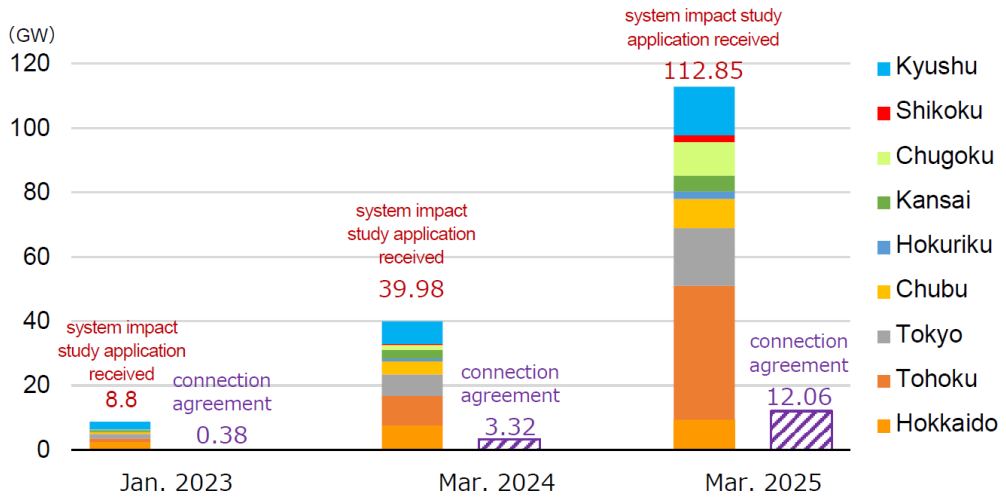
[6] Kinokawa Battery Storage Plant, jointly developed by Kansai Electric Power and ORIX Corporation and commissioned in December 2024, has a capacity of 48 MW / 113 MWh, with total construction costs, including the batteries, reportedly amounting to 8 billion yen (Nikkei, November 23, 2024).

Chapter 2: Current Status of Grid-Scale Battery Storage in Japan

Section 1: Installation Status in Japan

In Japan, the deployment of grid-scale battery storage is accelerating rapidly. As of March 2025, applications for interconnection to transmission and distribution systems have surged to approximately 113 GW, about 12 times the number recorded in January 2023. However, only about one-tenth of these applications have resulted in actual connection agreements. Furthermore, as of March 2025, only 0.23 GW had completed interconnection. It will be necessary to closely monitor how far this will increase in the future.

Figure 2 Power Capacity of Grid-Scale Battery Storage: system impact study application (received) and connection agreements



Source: Created by Renewable Energy Institute based on Agency for Natural Resources and Energy (2023) (2024) (2025)

The figures for connection agreements represent the nationwide total.

While these figures represent power capacity, in terms of energy capacity, the Mitsubishi Research Institute (2025:9) estimates that grid-scale and co-located batteries combined accounted for just over 2 GWh as of 2023. For 2030, the projected energy capacity of grid-scale battery deployment ranges between 14.1 and 23.8 GWh (Mitsubishi Research Institute 2023:9). This corresponds to the projected power capacity of 4.68–7.94 GW; therefore, if all 12 GW of capacity already under connection agreements (Figure 2) were to commence operation, it would greatly exceed that projection.

Section 2: Policy Support Measures in Japan

The Ministry of Economy, Trade and Industry (METI) has actively promoted and supported the deployment of grid-scale batteries. First, the provision of subsidies has contributed to the deployment. In fiscal year 2021, the government implemented the "Support Project for the Introduction of Grid-Scale Batteries to Accelerate Renewable Energy Deployment" (supplementary budget: 13 billion yen). In fiscal year 2022, it launched the "Support Project for the Introduction of Distributed Energy Resources to Expand Renewable Energy" (budget: 25 billion yen) and the "Subsidy for the Introduction of Customer-Led Solar Power and Renewable Energy Co-Located Battery Storage" (budget: 25.5 billion yen). Since fiscal year 2023, the "Support Project for the Introduction of Grid-Scale Batteries" has been continued. Grid-scale batteries have also been designated as eligible for support under the Green Transformation (GX) policy, and from fiscal year 2024, financing through GX Economy Transition Bonds has begun.

Second, the legal positioning of grid-scale battery storage projects has been clarified. The 2022 amendment to the Electricity Business Act defined stationary battery storage systems with a capacity of 10 MW or more as power generation businesses. As a result, legal procedures such as notifications and grid connection processes were formalized, facilitating smoother project implementation.

Third, market frameworks that serve as revenue sources for grid-scale battery storage have been developed. Since fiscal year 2023, grid-scale batteries have been made eligible to participate in the Long-Term Decarbonization Power Source Auction. In the fiscal year 2024 auction, 6.956 GW of battery capacity was bid, and 1.37 GW was awarded contracts (Organization for Cross-regional Coordination of Transmission Operators, 2025:14)[7]. Furthermore, with the full menu of the balancing market launched in fiscal year 2024, additional revenue opportunities have become available. Details of these developments will be discussed further in Chapter 3.

Fourth, the 2024 amendment to the Act on Special Measures Concerning Renewable Energy explicitly stipulated that, for co-located battery storage, the amount of electricity charged from renewable energy generation and that from the grid shall be apportioned, with the former being eligible for FiP premium payments. This serves as an incentive measure for battery storage systems co-located with renewable energy.

[7] The awarded capacity for pumped hydro storage, a traditional form of energy storage, was 361 MW.

Section 3: Deployment Examples in Japan

Table 2 lists major grid-scale battery projects in Japan with power capacities of 1 MW or more, organized by region and chronological order.

The number of projects starting operation has surged since 2023. Project owners range from formerly integrated electric utilities to renewable energy developers and new power suppliers including energy companies and trading firms engaged in these businesses. There are few cases in which a single company undertakes all functions of a project; more commonly, market operations are outsourced to aggregators, while EPC (engineering, procurement, and construction) is contracted to specialized EPC companies. There are also cases where ownership is shared among multiple entities, which is presumed to be for the purpose of risk diversification and complementing expertise. Battery manufacturers are often GS Yuasa and PowerX. Regionally, many projects have been concentrated in areas under Kyushu Electric Power Transmission and Distribution, where curtailment rates are high, and in areas under Hokkaido Electric Power Network, where the co-location of battery storage has traditionally been required for the grid connection of VRE generation. However, since 2024, the number of projects in the service areas of Tohoku Electric Power Network and TEPCO Power Grid has also been increasing.

For example, Tagawa Battery Plant in Fukuoka Prefecture is jointly owned by NTT Anode Energy Corporation, Kyushu Electric Power, and Mitsubishi Corporation. The project received a subsidy of approximately 117 million yen and operates in coordination with a remote solar power plant, functionally resembling a co-located system. EPC was managed by EXEO Group, and the lithium-ion battery was supplied by GS Yuasa.

Another major example is Kinokawa Battery Plant in Wakayama Prefecture, operated jointly by Kansai Electric Power and ORIX Corporation. With a capacity of 48 MW / 113 MWh, it is one of the largest in Japan. Market operations are handled by Kansai Electric's subsidiary E-Flow, while ORIX oversees operation and maintenance. This project also received 2.5 billion yen in subsidies.

The most prominent project is the 240 MW installation at the Kita Toyotomi Substation in Hokkaido. This is a battery storage facility associated with the transmission line of North Hokkaido Wind Energy Transmission Corporation, which was constructed to serve wind power generation in northern Hokkaido, and it functions as a demonstration project by METI. Although such a large-scale battery was initially installed solely for the wind power generation under an output fluctuation mitigation requirement by Hokkaido Electric Power Network, that requirement has since been abolished. Therefore, the battery system is now expected to operate as a commercial asset for arbitrage and ancillary services.

Table2: Examples of Major Grid-Scale Battery Storage Projects

	Start of Operation YY/MM	BESS Name and Location Owner/Operator	Power Capacity MW	Energy Capacity MWh	Remarks: Battery Type, etc.
Hokkaido	22/4	(Abira Town, Hokkaido) Hokkaido Electric Power Network	17	51	RF
	23/4	Kitatoyotomi Substation (Toyotomi Town, Hokkaido) North Hokkaido Wind Energy Transmission	240	720	Li
	23/6	Shiroishi ESS Project (Sapporo City, Hokkaido) Pacifico Energy	2	8	
	24/3	Within the ENEOS Muroran Plant (Muroran City, Hokkaido) ENEOS Power	50	88	Li
Tohoku	23/12	Mitsuuroko Miyagi Prefecture Sendai Battery Energy Storage Plant (Sendai City, Miyagi Prefecture) Mitsuuroko Green Energy	1.534	6.14	
	24/5	Sendai Grid-Scale Battery Storage Facility (Sendai City, Miyagi Prefecture) Kanden Energy Solutions	10.8	43	Li, within the Sendai Power Station premises
Tokyo	24/5	(Nasushiobara City, Tochigi Prefecture) TEPCO Power Grid	1.999	6.31	Li
	24/7	Sagamihara Battery Energy Storage Plant (Sagamihara City, Kanagawa Prefecture) Tokyu Construction	1.999	4.064	Li
	24/12	Chiba Kimitsu BESS (Kimitsu City, Chiba Prefecture) Kurihalant	1.999	7.596	Li
	24/12	Ota Kozumida BESS (Ota City, Gunma Prefecture) Joyo	2		
	24/12	Kiryu Sakaino BESS (Kiryu City, Gunma Prefecture) Joyo Shoji	2		
	25/1	Kumagaya Kakinuma BESS (Kumagaya City, Saitama Prefecture) Koyusya	2		
	25/2	OLYPowerstorage Mimuro-cho (Isesaki City, Gunma Prefecture) Olympia	1.998	7.404	Li (LFP)
	25/2	Kiryu Kotohira BESS (Kiryu City, Gunma Prefecture) Tokyo Chikudenchi Hatsuden (Shirokuma Power)	2	8.064	
	25/3	Yatogo Storage Station (Kumagaya City, Saitama Prefecture) Bando Storage Station Unit 1 (Tohoku Electric Power, Mizuho Leasing)	1.96	7.46	Li
	25/4	OLYPowerstorage Midori-cho (Ota City, Gunma Prefecture) Olympia	1.998	7.404	Li (LFP)
	25/5	Tsumagoi Battery Storage Station (Tsumagoi Village, Gunma Prefecture) Tsumagoi Battery Storage Station LLC (Tokyo Electric Power Company Holdings, NTT Anode Energy)	2	9.3	Li
	25/6	Nirazuka Storage Station (Isesaki City, Gunma Prefecture) Bando Storage Station Unit 1 (Tohoku Electric Power, Mizuho Leasing)	1.96	7.46	Li
	25/6	Kozumida Storage Station (Ota City, Gunma Prefecture) Bando Storage Station Unit 1 (Tohoku Electric Power, Mizuho Leasing)	1.99	7.4	Li (LFP)

	Start of Operation YY/MM	BESS Name and Location Owner/Operator	Power Capacity MW	Energy Capacity MWh	Remarks: Battery Type, etc.
Chubu	23/9	Mitsuuroko Aichi Tahara Battery Energy Storage Plant (Tahara City, Aichi Prefecture) Mitsuuroko Green Energy	1.5	6	
	24/10	Mibugawa Ina Grid Battery Storage (Ina City, Nagano Prefecture) Marubeni Power Retail	2	8.1	Li
	25/5	Tsu Power Station (Tsu City, Mie Prefecture) Toho Gas	11.4	69.6	NAS, Former Tsu LNG Station Site
Kansai	23/3	(Toyooka City, Hyogo Prefecture) Toyooka Regional Energy Service (Kaneka, Itochu)	2	6	Li, reuse of EV batteries, Community microgrid business
	24/12	Kinokawa Energy Storage Plant (Kinokawa City, Wakayama Prefecture) Kinokawa Energy Storage (Kansai Electric Power Co., Inc., ORIX Corporation)	48	113	Li, within the Kinokawa Substation premises
Kyushu	16/3	Buzen Battery Electrical Substation (Buzen City, Fukuoka Prefecture) Kyushu Electric Power Transmission and Distribution	50	300	NAS, vacant space within the Buzen Power Plant premises
	22/8	Omuta Battery Energy Storage Plant (Omuta City, Fukuoka Prefecture) NExT-e Solutions, Kyushu Electric Power Company	1	3	Li, reuse of electric forklift's batteries
	23/6	Pacifico Energy Itoshima ESS Project (Itoshima City, Fukuoka Prefecture) Pacifico Energy	2	8	
	23/7	Tagawa Power Station (Kawara Town, Fukuoka Prefecture) NTT Anode Energy, Mitsubishi Corporation, Kyushu Electric Power	1.4	4.2	Li
	23/10	Eurus Nagasaki Koyagi Battery Park (Nagasaki City, Nagasaki Prefecture) Eurus Energy	2	5.1	Li
	24/1	Eurus Shiratori Battery Park (Tagawa City, Fukuoka Prefecture) Eurus Energy	1.5	4.58	
	24/6	NNR Shizen Energy Battery Hub Umi (Umi Town, Fukuoka Prefecture) NNR Shizen Energy (Nishi-Nippon Railroad, Shizen Energy)	1.92	4.659	Li, reuse of EV batteries
	24/9	Kirishima Battery Energy Storage Plant (Kirishima City, Kagoshima Prefecture) Kirishima Battery Energy Storage Plant (JPN Energy Integrated System, Green Energy & Company, DMM.com)	1.99	8.128	Li (LFP)
	24/9	Denki no Eki Kawajiri (Kumamoto City, Kumamoto Prefecture) Denki no Eki Kawajiri (JR Kyushu, Sumitomo Corporation, etc.)	1.5	6	Li, reuse of EV batteries
	24/12	NNR Shizen Energy Battery Hub Iizuka (Iizuka City, Fukuoka Prefecture) NNR Shizen Energy (Nishi-Nippon Railroad, Shizen Energy)	1.92	4.659	Li, reuse of EV batteries
	25/4	Fukuoka Wakamatsu Battery Storage Station (Kitakyushu City, Fukuoka Prefecture) NTT Anode Energy	1.999	8.226	Li (LFP)
Okinawa	22/3	Nakagusuku Bay Substation (Uruma City, Okinawa Prefecture) Okinawa Electric Power	10	15	

Source: Prepared by the Renewable Energy Institute based on company press releases and media reports.

Note: Battery types are as follows — Li = lithium-ion battery; Li(LFP) = lithium iron phosphate lithium-ion battery; NAS = NAS battery; RF = redox flow battery.

Chapter 3: Challenges for Grid-Scale Battery Storage

As discussed earlier, interest in grid-scale battery storage has grown rapidly in recent years, leading to what some describe as a 'boom' in investment. While this highlights the sector's future potential, such rapid development has also brought several issues and concerns to the surface.

Section 1: Concentration and Delay in Grid Connection Application Procedures

A key issue is the concentration and prolongation of application procedures for connecting to transmission and distribution systems. As noted in Chapter 2, only about one-tenth of applications lead to actual contracts, and some companies appear to be applying with the intent of reselling project rights. The surge in application numbers has placed a heavy burden on TDSOs and has extended project lead times and increased costs for battery operators.

Additionally, system impact study time per application has also increased. Unlike conventional generation facilities, batteries deal with both reverse power flow (discharge) and forward power flow (charging), making assessments more complex. While cautious examination of charging impacts is understandable due to limited precedent, grid-scale batteries typically charge during oversupply conditions, thus contributing to supply stability. Therefore, efforts to reduce study times are essential.

The Agency for Natural Resources and Energy is working on reforms in this direction. As of May 2025, it is considering a 'Quick Connection Scheme' that allows earlier grid connection if the operator agrees to certain conditions, such as charging restrictions. Furthermore, similar to solar power, there is a growing call for the early introduction of non-firm connection rules.

Other issues include inconsistencies in application requirements across utilities, creating significant administrative burdens for operators active in multiple regions. Additionally, battery systems with 10 MW or more, those connecting to extra-high-voltage systems, or those bidding in specific balancing market product (Synchronized Frequency Restoration Reserve, S-FRR) must install dedicated communication lines to interface directly with the central power control system. This installation can take several years. Moreover, since the Load Frequency Control (LFC) signals sent from the central dispatch center via dedicated communication lines differ among TDSOs, current battery storage projects must undergo specifications and testing tailored to the specific area in which they operate. Standardizing the central dispatch control system will be essential to accelerate future battery storage deployment.

Section 2: Uncertainty of Revenue from Markets and Market Design

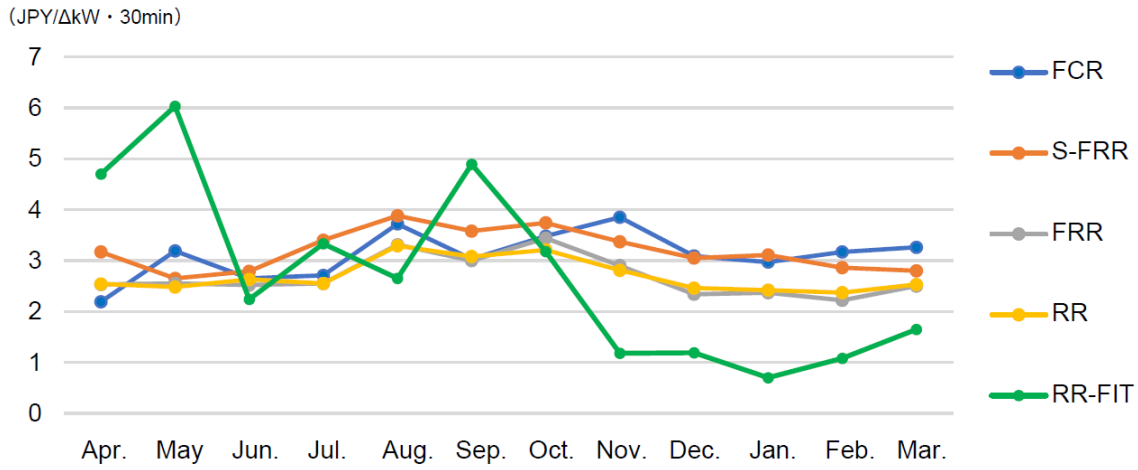
As described in Chapter 1, grid-scale battery operators derive revenue from participation in three main electricity markets: spot markets (arbitrage), balancing markets, and capacity markets. The ability to earn income depends heavily on operational skills and market strategy.

Arbitrage in the spot market can yield high profits during periods of large price fluctuations, such as in 2022. However, in more stable price environments, profit margins shrink. Japan's lack of negative pricing further limits arbitrage potential compared to overseas markets.

According to industry interviews, spot market income alone is often insufficient. The balancing market is seen as a more reliable source of revenue. The recent battery boom in Japan is closely linked to the development of this market. The balancing market began with Replacement Reserve for FIT (RR-FIT) in April 2021, and by April 2024, all product categories were fully established.

Initially, RR-FIT attracted the most attention due to the absence of a price cap. In April 2024, the average successful bid price for batteries in this category was 234.89 yen/ΔkW per 30 minutes. As bid prices subsequently declined, focus shifted to other categories such as Frequency Containment Reserve (FCR).

Figure 3 Monthly Trend of Average Clearing Prices in the Balancing Market for FY2024



Source: Created by Renewable Energy Institute based on EPRX (2025)[8]

[8] Frequency Containment Reserve (FCR) is intended to stabilize frequency immediately and require a response time within a few seconds. Synchronized Frequency Restoration Reserve (S-FRR) aims to restore frequency and require a response time from several tens of seconds to a few minutes. Frequency Restoration Reserve (FRR) is designed to maintain supply-demand balance and require a response time on the order of several minutes. Replacement Reserve (RR) aims to correct supply-demand imbalances and require a response time from several minutes to within 15 minutes. Replacement Reserve for FiT (RR-FiT) is used for wide-area grid adjustments and unplanned contingencies, requiring a response time of more than 15 minutes.

The establishment of multiple markets has significantly contributed to the growth of grid-scale battery storage projects. However, apart from the spot market, these market mechanisms have only been developed in recent years, meaning their history is short and operational data remain limited. Furthermore, starting in fiscal year 2026, all products in the balancing market will transition to day-ahead trading, followed by planned integration into a newly designed market currently under discussion, known as the "Simultaneous Market." This is expected to result in frequent regulatory changes. Each such change compels project operators to adapt, thereby increasing revenue uncertainty.

Section 3: Cost of Stationary Battery Storage

As shown in Chapter 1, the cost of stationary battery storage has declined dramatically in recent years, driving the expansion of grid-scale battery deployment. While this trend is expected to continue, uncertainties remain—particularly regarding international supply chains and raw material procurement.

Government subsidies have played a crucial role in supporting battery deployment. While the eventual phase-out of subsidies is necessary for a healthy market, their discontinuation could result in a short-term cost rebound and slow adoption.

Another issue is economic security. While most batteries installed in Japan are domestically produced, globally, Chinese manufacturers like CATL have a significant market share and competitive advantage. Battery storage, including that for electric vehicles, is positioned as a strategic product in the decarbonization era, and amid U.S.–China tensions, there are growing concerns about the use of China-made stationary batteries. The question of domestic versus foreign batteries could have major implications for cost and policy going forward.

Conclusion

As this report has shown, grid-scale battery storage projects have rapidly expanded in recent years across the globe. This expansion is driven by the sharp decline in battery costs and the large-scale integration of VRE, which has significantly enhanced the competitiveness of grid-scale batteries as a means of providing system flexibility. With the increasing deployment of VRE, the structure of grid operation, transmission and distribution businesses, and thermal power generation businesses may experience structural transformations. Grid-scale battery storage could thus play a critical role in driving innovation throughout the entire power system.

However, this transition is still in its early stages and, in the short term, may appear overheated. Consequently, issues such as delays in grid connection procedures and uncertainties in market operations have begun to emerge. Realizing innovation in the power system will require rational reforms in regulations and institutional frameworks.

The purpose of this report was to present an organized overview of the current situation. The Renewable Energy Institute plans to continue its investigation, including more detailed comparisons with international cases, and will offer specific policy recommendations based on those findings.

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