Battery Electricity Storage Systems, the energy sector's next big tech

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Abstract: Vietnam's rapid expansion in renewable energy, particularly solar and wind, necessitates the adoption of Battery Electricity Storage Systems (BESS) to address the intermittency of these sources and ensure grid reliability. This article provides an overview of BESS fundamentals, including their operational principles, economic implications, and potential benefits for Vietnam. Despite the current lack of large-scale BESS deployment in Vietnam, the global market is growing rapidly, driven by technological advancements and decreasing costs. The article examines the present state of BESS in Vietnam, highlighting local manufacturing capabilities and regulatory challenges. It also explores strategic approaches outlined in Vietnam's National Power Development Plan (PDP 8) and long-term projections for BESS integration. While BESS has the potential to significantly enhance Vietnam's energy landscape, its successful implementation will depend on addressing economic, regulatory, and technical challenges.

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1. Introduction

Vietnam's rapid growth in renewable energy, particularly solar and wind power, marks a significant step towards a greener future. However, to address the variable nature of these sources and ensure a reliable electricity supply, Vietnam may soon need to adopt Battery Electricity Storage Systems (BESS). BESS can store extra power when renewable sources produce too much, and release it when needed. This helps stabilize the grid, use more renewable energy, and reduce waste. With the global BESS market growing at over 20% annually and Vietnam's strong industrial manufacturing base, the question arises: Is BESS the next big development in Vietnam's power sector?

This article explores the fundamentals of BESS, including its functionality, economic implications, and potential benefits for Vietnam's energy landscape. We will examine the current state of BESS deployment in Vietnam, its future role, and the necessary regulatory framework to support its implementation. By addressing these key aspects, we aim to provide a comprehensive overview of BESS's potential to transform Vietnam's energy sector, making it more sustainable, reliable, and efficient.

2. Understanding Battery Electricity Storage Systems (BESS)

To fully grasp the potential impact of BESS on Vietnam's energy sector, it's crucial to first understand how these systems operate and their key characteristics. BESS store electrical energy for later use. These systems play a crucial role in managing the supply and demand of electricity, particularly in grids with a high penetration of renewable energy sources. BESS operates on a simple principle: they charge (or store energy) when there is surplus electricity and discharge (or release energy) when there is a deficit. The process involves three main steps:

1. **Charging**: Excess electricity, often generated from renewable sources like photovoltaic (PV) modules in the afternoon, is used to charge the batteries.
2. **Storing**: The energy is stored in the batteries until it is needed. Typical storage duration is four hours.
3. **Discharging**: When demand for electricity exceeds supply, in the evening for example, the stored energy is discharged to the grid.

BESS is a very modular technology. It can scale from household systems as small as a fridge to projects larger than a football field.

Household BESS installations are typically in the range of 3-20 kWh. As an example, in the USA a 13.5 kWh Tesla Powerwall costs $11 500 with installation. These systems enhance self-consumption by storing surplus solar energy generated during the day for use at night or during cloudy periods. They also provide grid support by reducing the load during peak demand times and can offer up to 11.5 kW of backup power during outages.

Integrating BESS with renewable energy projects, for example 30 MW solar or wind farms, enhances the overall efficiency and reliability of these projects. By storing excess energy generated during peak production times, BESS can reduce curtailment and ensure a steady supply of electricity. This integration also allows for better energy management and smoother grid integration. The Edwards & Sanborn solar plus storage project in California, online since January 2024, boasts the world's largest battery at 3,287 MWh of capacity to support 1.9 million PV modules.

Standalone utility-scale BESS are large installations that operate independently of specific generation sources. They are typically connected to the grid and can store over 100 MWh electricity. For example, the Hornsdale Power Reserve in South Australia has a capacity of 150 MW/193.5 MWh.

As with any emerging technology, BESS is evolving quickly, with various types of batteries and ongoing innovations shaping its future. There are several types of batteries used, but the most common and widely adopted are Lithium-Ion batteries. These batteries are favored today for their high energy density, efficiency, and long cycle life. Lithium-ion batteries used in BESS have an efficiency rate of 95% and a lifecycle of over 10,000 cycles. Other types of batteries include lead-acid, sodium-sulfur, and flow batteries, each with its own set of advantages and applications. Recent innovations include the development of solid-state batteries, which offer higher energy density and improved safety features over lithium-ion batteries.

Though BESS technology is promising, its widespread use depends heavily on cost-effectiveness. Let's examine the costs and benefits associated with implementing BESS in Vietnam's context.

The cost of installing and operating BESS is a significant barrier to widespread adoption. In 2023, EVN PECC3 estimated that the cost for a 2 MWh BESS system was 360–420 USD/kWh, and that the investment would requires electricity prices in Vietnam above 18 UScent/kWh to be profitable – this is twice the current levels. However, BESS costs are declining rapidly. According to BloombergNEF, the cost of lithium-ion battery packs has fallen by 89% in the past decade. This trend is driven by advancements in battery technology, economies of scale in manufacturing, and increased market competition. The 2022 Vietnam Technology Catalogue estimated that the nominal investment for BESS will decrease from 578 USD/kWh in 2020 down to 264 USD/kWh in 2030 – more than a fifty percent decrease.

Other concerns with BESS include the limited supply of Lithium, the environmental impact of battery production and disposal and, as it stands now in Vietnam, the reliance on international technology and expertise.

Despite these challenges, BESS offers significant economic advantages, particularly as renewable energy sources become more prevalent in Vietnam's power mix. These systems help reduce curtailment of renewable energy, meaning that less energy is wasted when production exceeds demand. BESS also enhances grid stability by providing ancillary services like frequency regulation and voltage support. In addition, they can defer investments in grid infrastructure by reducing peak demand and alleviating grid congestion.

- **Enhanced Efficiency**: BESS can store excess energy generated during periods of low demand and release it during peak demand, thereby enhancing the overall efficiency of the power grid. There is less need to build power plants for the peak demand period. Depending on LNG prices, BESS can already compete with open-cycle gas turbines, and possibly with gas engines, for that application.

Figure 1: Fluence's 20MW/20MW Kabankalan project, Negros Occidental, Philippines. Image: Philippines.

- **Improved Reliability**: By providing a steady and reliable power supply, BESS can reduce the frequency and severity of power outages. This is particularly important for a rapidly growing economy like Vietnam. BESS can provide blackstart capability, which is crucial for restarting power plants and restoring electricity after a complete or partial shutdown of the power system. This enhances grid resilience and recovery speed during major outages.
- **Energy Management**: BESS can help manage the intermittency of renewable energy sources, ensuring a balanced and stable supply of electricity. Vietnam has 20.1 GW of solar and wind power, and congestion in the electricity transmission grid sometimes lead to waste of electricity. In other rapidly developing renewable markets, curtailment rates can reach up to 10-20% of total renewable generation during peak times.
- **Grid Stability**: BESS can provide ancillary services such as frequency regulation and voltage support, which are essential for maintaining grid stability. In the Philippines, for example, the San Miguel Global Power is putting up approximately 1,000 MW of BESS, operating at 32 locations in the country. They started in 2018 from a 10 MW system on the Luzon grid in the Philippines in Masinloc, Zambales (see also Figure 1).

With decreasing costs and increasing demand, the trend in BESS economics is promising. In IEA's World Energy Outlook 2023, the world's installed BESS capacity grows from 45 GW in 2022 to 552 GW in 2030 for the baseline "Stated Policies" scenario, to 725 GW in 2030 for the "Announced Pledges" scenario and to 1,018 GW in 2030 for the "Net zero by 2050" scenario.

In any scenario, BESS is an very fast growing industrial sector. Having explored the fundamentals of BESS, let's now turn our attention to the current landscape of this technology in Vietnam.

3. The Current State of BESS in Vietnam

As of 2024, Vietnam has practically no BESS installed. So far, only private renewable power projects have trialed BESS development, there is nothing at the utility scale.

The largest electricity storage project in Vietnam is the Bac Ai Pumped Storage Hydropower Project. Located in Ninh Thuan province, the project has a capacity of 1,200 MW and is expected to play a crucial role in stabilizing the grid when it completes in a few years. This project does not use batteries. Instead, it will pump water up when electricity is available, and uses it to generate power like a hydroelectric power plant when needed. BESS are not as cost-effective as pumped hydropower storage, so it is rational to prioritize projects like this.

The startup Alternō proposes the “sand battery” as an energy storage technology in Vietnam. This is not BESS either. Instead of using electricity directly to dry agricultural product, the electricity is used to heat a mass of sand. Well insulated, the sand can stay hot for weeks so that renewable or off-peak grid electricity can be used. To discharge the energy, flowing air through the sand mass extracts the heat required for the process.

Vietnam is present in the industrial race to supply the technology globally. Vingroup and Gotion, a Chinese battery maker, has ventured into LFP battery manufacturing in 2022, building a factory in Ha Tinh. It expects to start production in the third quarter of 2024 with an initial capacity of 5 GWh per year. While primarily focused on electric vehicles, this initiative significantly boost the local supply chain for BESS. Siemens and AES manufacture the Fluence Cube, lithium-ion-based battery energy storage solutions (BESS) in Vietnam, nearly 2 GW have been exported worldwide. Other companies, such as LG Chem and Samsung SDI, are also building battery factories in Vietnam.

Vietnam can make BESS parts, but using BESS in the country is challenging. There's little local experience with BESS projects. Also, current laws don't allow BESS installations or make them profitable.

In light of these challenges, let us examine Vietnam's strategic approach to BESS implementation. The National Power Development Plan (PDP 8) states that “*Solar power development orientation must be combined with battery storage when the price is suitable*”, and they should be “*distributed in close proximity to wind and solar power sources or load centers*”. The plan expects battery storage to reach a capacity of about 300 MW by 2030. This would be only 0.2% of the national total power supply, the plan implicitly assesses that batteries are not yet reasonably priced for large-scale deployment in Vietnam, so the idea is to implement pilot projects to test the feasibility and benefits of BESS in different settings, including standalone utility-scale storage and integrated renewable energy projects.

The PDP8 aims for significant renewable energy growth by 2030: 21 GW of onshore wind, 7 GW offshore, and 18-20 GW solar. However, the plan's proposed 300 MW BESS capacity raises concerns about its adequacy in handling the intermittency of these renewable sources. Figure 2 shows that the existing levels of solar power capacity already strongly impact the demand addressed to thermal power generation: it was reduced from 20 GW in the morning to 9 GW at noon, before returning to 20 GW en the evening. The need for flexibility will only increase in the future. Rooftop solar systems for self-consumption, which are not bound by the plan's objective of 18-20 GW for solar PV, can be expected to depress the noontime demand by 5 to 10 GW as early as 2030.

Alternatives to BESS for managing this so-called "duck-curve" problem include demand side management, flexible thermal sources, other energy storage technologies like compressed air or gravity storage, and hydroelectric power plants. These are already used today to compensate for the variability of solar and wind: water can be turned on and off quickly. Additional hydroelectric storage facilities are planned. But as the EREA/DEA 2024 Viet Nam Energy Outlook Report states: "*Any significant increases in renewable generation will naturally challenge this current mode of operation, as there are limits and technical requirements to the balancing capacity of Viet Nam's hydropower plants.*"

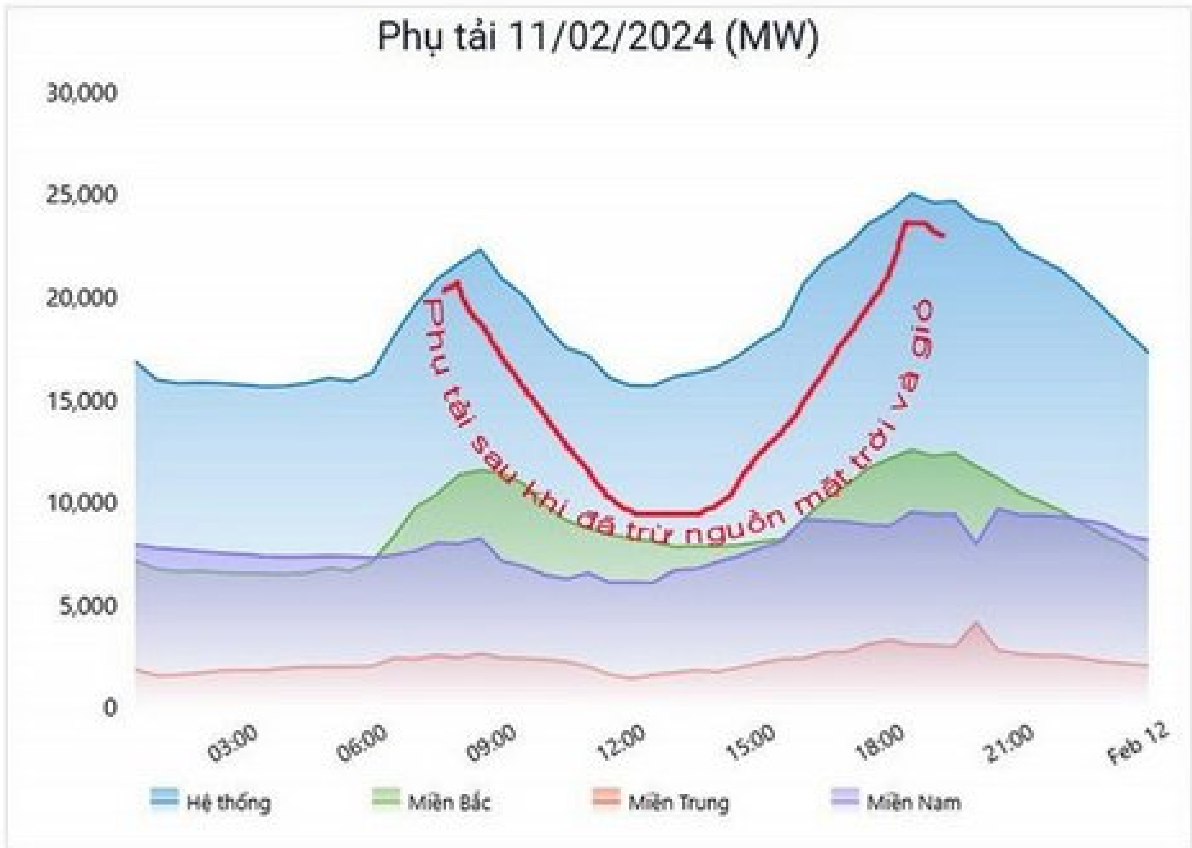

Figure 2: The duck curve has arrived in Vietnam. The red curve shows the load after substracting solar and wind sources on the first day of Têt. The blue area shows the total power load (GW), the green, red and purple areas the load in the North, Center and South regions. Source: A0

While near-term projections for BESS in Vietnam may seem modest, the long-term outlook paints a different picture. The PDP8's vision for 2050 is that the capacity of hydroelectricity and storage batteries will reach 30,650-45,550 MW to match the high proportion of renewable energy. The share of hydroelectric storage will be limited by the finite geological opportunities.

BESS also has a great role in the net-zero scenarios for Vietnam, but different stories can be told. The 2024 McKinsey study relies on about 20 GW of batteries in 2030 and about 60 GW in 2050. In the 2024 Vietnam Energy Outlook scenario, however, pumped storage serves the majority of storage need until 2045, when it reaches its full potential of 26 GW / 200 GWh. The first utility-scale battery storage are installed by 2035-2040 with small investments (0.6-1.5 GW). Battery storage investment increases rapidly after 2040, amounting to 98 GW in the NZ scenario in 2050. However, the study also finds that storage technologies such as Lithium-ion batteries are well suited as reserves to maintain a reliable and stable power system, and recommends to support large scale deployment of electric storage after 2030.

With the right policies and investments, BESS can transform Vietnam's energy landscape, making it more sustainable, reliable, and efficient. As the country continues to grow and develop, integrating BESS will be crucial in ensuring a stable and resilient power supply.

4. Who benefits from BESS?

BESS is relevant not only for EVN, but also for renewable energy producers and final electricity consumers. Who has interest to spend money to install batteries?

EVN, as the state-owned utility responsible for electricity generation, transmission, and distribution in Vietnam, stands to gain from the higher system efficiency permitted by deployment of BESS. The company prepares pilot projects to test the integration of BESS with the existing grid infrastructure. According to the PDP8 implementation plan, investment in Energy Storage by 2030 should include: a) A pilot BESS project of 50MW/50MWh capacity by EVN to explore ancillary services, inform pricing mechanism design, and establish technical standards. b) Additional pilot projects such as a 7MW/7MWh BESS integrated into a 50MW solar farm and a 105MW/105MWh BESS integrated within a 400MW solar farm. c) Other battery storage projects, 138 MW.

Financial resources are anticipated to come from international partners according to the Just Energy Transition Partnership, development partners such as the Asian Development Bank, and Vietnamese commercial banks. A preliminary study by the Institute of Energy, published in June 2024, demonstrates that "*a 50MW BESS can play a significant role in managing Vietnam's power system frequency stability. It is also observed that the location of BESS does not have much effect on the frequency stability. Therefore, for the purpose of frequency stability improvement, BESS can be installed at every bus in the power system if the land and connection plans are available.*"

Renewable energy project owners, including developers of solar and wind farms, can also benefit from integrating BESS with their projects. BESS enables project owners to store excess energy produced during peak generation times (the afternoon) and release it during periods of high demand (the evening). Batteries can help project owners reduce curtailment and sell ancillary services to the grid. In principle, the PDP8 does not limit PV+BESS and Wind+BESS combined projects, since they are not counted towards the 300 MW goal for 2030. However, whether a BESS improves the overall profitability of a renewable energy project depends on market conditions. As the next section will show, they are not yet favourable.

Consumers, both residential and commercial, can also play a role in the adoption of BESS. By installing BESS, consumers can enhance their energy independence, reduce electricity bills, and contribute to grid stability. BESS allows consumers to store energy generated from rooftop solar panels and use it during periods when solar generation is not possible, such as at night or during cloudy days. This reduces reliance on the grid and enhances energy security – factories can alleviate grid reliability concerns by installing a rooftop solar system with an attached battery. Wood Mackenzie reports that 11.1% of residential and 5.3% of non-residential solar systems installed in the US in Q1 2023 were paired with energy storage.

5. Regulatory Landscape

The Vietnamese government has recognized the importance of BESS in the country's energy transition. The revised National Energy Policy includes new incentives for BESS installations, such as tax credits and subsidies, which are aimed at accelerating the adoption of energy storage solutions. The government is also considering regulatory reforms to create a more favorable environment for BESS. This includes establishing clear guidelines for market participation and ensuring fair compensation for the services provided by BESS.

The legal framework for BESS in Vietnam is still developing, but it will likely build upon existing energy laws. The Law on Electricity provides the overarching framework for the power sector, while specific regulations will need to be developed for BESS. The MOIT actively monitors the implementation of energy policies, identifies issues, and proposes amendments as needed. This adaptive approach will be crucial as BESS technology evolves and is integrated into the energy mix. Vietnam has policies to support renewable energy, but not for the deployment of BESS. Permitting guidelines, market mechanisms, positive price signals, and continuous dialogue are needed to create a favorable environment for BESS:

- **Lack of Guidelines**: Circular No. 36/2018/TT-BCT outlines the licensing process for power generation projects but does not explicitly cover BESS. There are no comprehensive guidelines for the installation, operation, and maintenance of BESS, which creates uncertainty for investors and developers. There are always risks when storing lots of energy in a small place. Technical standards, safety protocols, and environmental considerations are necessary for legally responsible risk management.
- **Market Participation**: BESS faces barriers to participating in the electricity market. There are no established mechanisms for BESS to provide and get compensated for ancillary services like frequency regulation and voltage support. A BESS project can benefit from capacity payments. The idea is not yet implemented in Vietnamese electricity markets, although a discussion on the two-parts electricity tariff has started.
- **Financial Incentives**: Existing electricity tariff structures hardly justify investing in BESS. Energy storage is more profitable when there is a large difference between the peak and the low hours wholesale electricity price. On the contrary, current regulations in Vietnam are geared to reduce the volatility of this market.

Other countries have created rules that work well for BESS. For example, in Australia, BESS can make money in different ways, such as buying and selling energy at different prices and helping control the power grid's frequency. However the technology is not reserved to countries like the USA, China and Australia, where the BESS market is several GW per year. The Oasis de Atacama project in Chile, sized at 1 GW of PV production capacity with 4.1 GW of battery storage, recently reached financial close. Even larger projects have been announced by the Solar Energy Corporation of India and the Morroco-UK company Xlinks.

Under the latest power development plan, Vietnam aims to have renewable electricity sources accounting for 30.9%–39.2% of all sources by 2030, towards 47% conditionally on receiving support from international partner countries, otherwise . Making the high goal happen requires a massive collaboration in energy storage systems. BESS is a domain when technology transfer from developed countries could have a huge impact on the global energy transition. We would like to see an international organization in charge of buying container-sized batteries in bulk and renting them out on reasonable commercial terms to countries who can move fast forward on wind and solar energy.

6. Conclusion

In 2024, Battery Electricity Storage Systems (BESS) have become essential for managing the variability of renewable energy, alleviating grid congestion, and reducing energy curtailment. With a strong foundation in renewable energy, Vietnam's next step is to integrate BESS to fully leverage these resources.

BESS's modular nature means it is suitable at various scales, making it relevant for state utilities like EVN, renewable project developers, and consumers. Effective deployment in Vietnam requires a unified approach from all stakeholders. The government must lead by setting a regulatory framework that includes clear guidelines and market mechanisms that align private interests with public energy needs.

Promotion of BESS could follow the successful model of rooftop solar initiatives, involving awareness campaigns, capacity building, and demonstration projects. As technology costs decrease and the benefits of energy storage are increasingly recognized, more investors and developers will engage, and consumers will enjoy greater energy independence and potential cost savings.

Vietnam's current goal of developing only 300 MW of BESS by 2030 appears modest, but the figure does not include systems coupled to rooftop solar systems. To foster a resilient, efficient, and sustainable energy future, Vietnam should aim high. This includes establishing technical standards, developing market mechanisms for ancillary services, expediting pilot projects, and investing in local workforce development for BESS. This collective effort will accelerate Vietnam's transition to a greener energy system.

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