

DECEMBER 2024

EMPOWERING ASIA: REVOLUTIONISING THE ENERGY LANDSCAPE THROUGH BATTERY ENERGY STORAGE



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Executive Summary

The transition towards a sustainable future present both a critical challenge and a significant opportunity for the ASEAN region. Rapid economic growth, urbanisation, and industrialisation are driving rising energy demands. In this context, Behind-the-Meter (BTM) Battery Energy Storage Systems (BESS) stands as a key enabler of this transformation, offering innovative solutions to enhance energy security, integrate renewable energy sources, and ensure stable and efficient grid operations. This paper explores the role of BESS in the ASEAN energy landscape, examining current trends, benefits, challenges, and the pathway towards optimising its potential across the region.

Key Findings

Rising Energy Demand:

The Asia-Pacific region's energy consumption, led by the ASEAN countries, is on an upward trajectory. In 2022, this region accounted for over 43%^[1] of global energy consumption, with projections indicating a substantial increase in demand due to economic and population growth. The ASEAN region is witnessing a significant rise in electricity consumption, with an expected increase of 35% by 2030 and 210% by 2050^[2] under current policies.

Strategic Importance of BESS:

The ASEAN region, amid its journey of rapid economic and urban growth, confronts urgent energy challenges. The strategic integration of BTM BESS technology offers a critical solution, directly addressing the region's energy issues while capitalising on opportunities for renewable energy transition. The value of BTM BESS lies in its capacity to meet the region's specific energy needs:

- **Grid Stability:** Aging energy infrastructures and non-cohesive power networks jeopardise ASEAN's ability to maintain a reliable power supply, essential for ongoing development. BESS delivers a dependable mechanism for energy storage and on-demand redistribution, enhancing grid resilience which is vital for the region's progress.
- **Energy Access:** The disparity in electricity access across ASEAN hinders equitable growth. BESS enables the provision of consistent power to the most isolated areas, tackling energy scarcity and driving social and economic improvements through broader electricity availability.

[1] <https://sponsored.bloomberg.com/article/hsbcasean/sea-change-the-new-wave-of-optimism-in-southeast-asia>

[2] IRENA 'Southeast Asia Energy Outlook 2022', 2022.

- **Renewable Energy Integration:** The integration of abundant renewable resources into ASEAN's energy portfolio is limited by the variable nature of solar and wind energy production. BESS is crucial for capturing excess energy during periods of high production and releasing it as stable and secure energy during demand peaks or low production phases. This functionality is key to boosting the reliability and sustainability of renewable energy, aiding ASEAN in its shift towards a greener energy mix.
- **Revolutionise Energy Trading in ASEAN:** BESS revolutionises ASEAN's energy trading sector by enabling the efficient management and exchange of surplus renewable energy as carbon offset credits. This integration with the APG promotes sustainable practices and regional carbon emission reduction efforts. Additionally, BESS supports the ASEAN Strategy for Carbon Neutrality by facilitating multilateral power trades and enhancing grid connectivity and stability, showcasing its pivotal role in advancing energy trading and sustainability in the region.

Furthermore, the strategic deployment of Behind-the-Meter (BTM) BESS offers several key benefits for the ASEAN region:

- **For Electricity Consumers:** Increases self-consumption of renewable energy, provides backup power, reduces electricity bills by storing energy during off-peak times, and lowers peak demand charges.
- **For System Operation:** Stabilises the grid through frequency and voltage regulation, defers or eliminates the need for costly network and peak capacity investments, and enhances overall grid resilience.
- **For Mini-Grids:** Replaces diesel generators with cleaner alternatives, provides backup power, and smooths out the intermittency of renewable energy sources.

Country-Specific Analyses

Each ASEAN country presents unique challenges and opportunities in BESS adoption. Singapore's strides in BESS deployment exemplify its role as a key lead in the adoption and deployment of BESS technologies, while Vietnam, Thailand, Indonesia, the Philippines, Malaysia, and Cambodia showcase diverse levels of readiness and potential for BESS integration into their national energy strategies.

Recommendations

To harness the full potential of BESS in ASEAN, this paper proposes a series of targeted recommendations:

<p>Policy and Regulatory Frameworks</p>	<p>Develop and harmonise BESS-specific policies and regulations to streamline project approvals and encourage investment. This includes addressing infrastructure connection readiness, investment challenges, and fostering an enabling environment for BESS deployment.</p>
<p>Incentive Structures</p>	<p>Customise financial incentives such as subsidies and tax breaks to stimulate BESS investment, considering the economic and market conditions of each ASEAN country. These incentives should be designed to lower the initial capital costs and support grid auxiliary services to make BESS projects financially attractive.</p>
<p>Research and Development</p>	<p>Amplify efforts in R&D to overcome local challenges, including climate adaptability of BESS technologies and bridging technical skill gaps. Promote public-private partnerships and international collaboration for technology transfer and innovation.</p>
<p>Capacity Building</p>	<p>Prioritise enhancing technical capacity to accommodate BESS. This includes training programmes to build a skilled workforce for BESS operation and maintenance.</p>
<p>International Collaboration</p>	<p>Leverage on international collaborative initiatives, such as the ASEAN-EU Plan of Action, ADB and the Green Climate Fund to facilitate technology transfer, access green financing and share best practices in BESS deployment.</p>

Conclusion

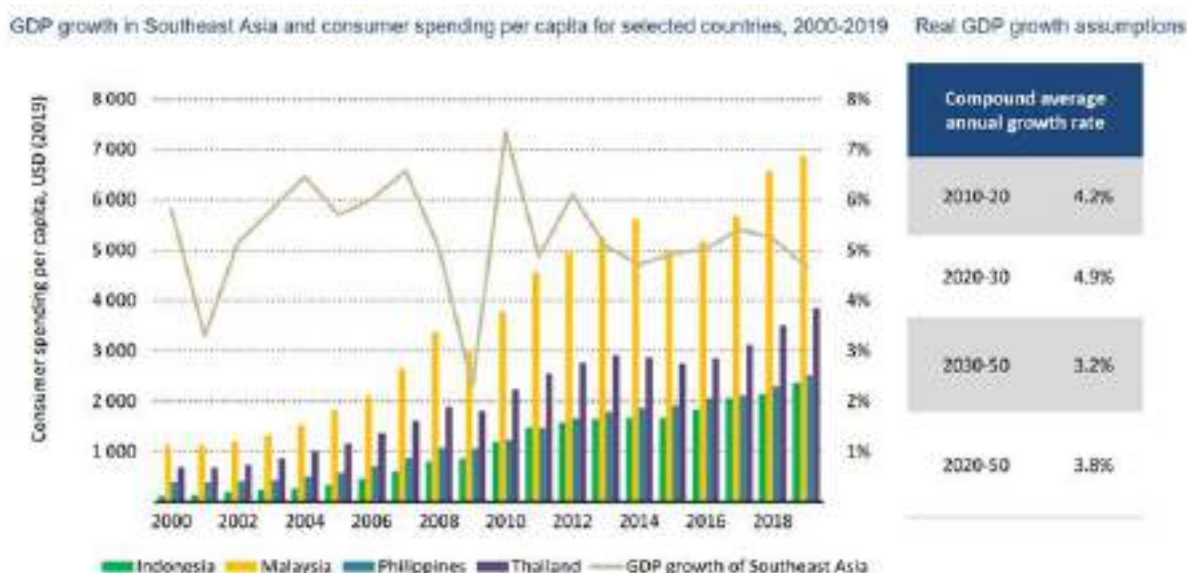
BESS should play a fundamental role in ASEAN's energy transition journey towards a sustainable and net-zero future. By addressing the challenges of each country, leveraging international cooperation, and fostering an environment conducive to innovation and investment, ASEAN can unlock the transformative potential of BESS. This will not only enhance regional energy security and sustainability but also position ASEAN as a leader in global energy innovation and transition.

Introduction

Overview of Energy Consumption trends and Economic Growth in ASEAN

The past decade has witnessed a substantial increase in Southeast Asia's population, which has grown by about 10%, reaching approximately 660 million people[3]. Concurrently, from 2010 to 2019, the region's economy has seen an average annual growth rate of 4.2%[4]. This economic prosperity, coupled with rapid urbanisation and industrialisation, has led to a surge in energy consumption across ASEAN countries.

Figure 1



Source: IRENA Renewable Energy Outlook in ASEAN 2022

Impact of ASEAN's Economic Growth on Energy Demands

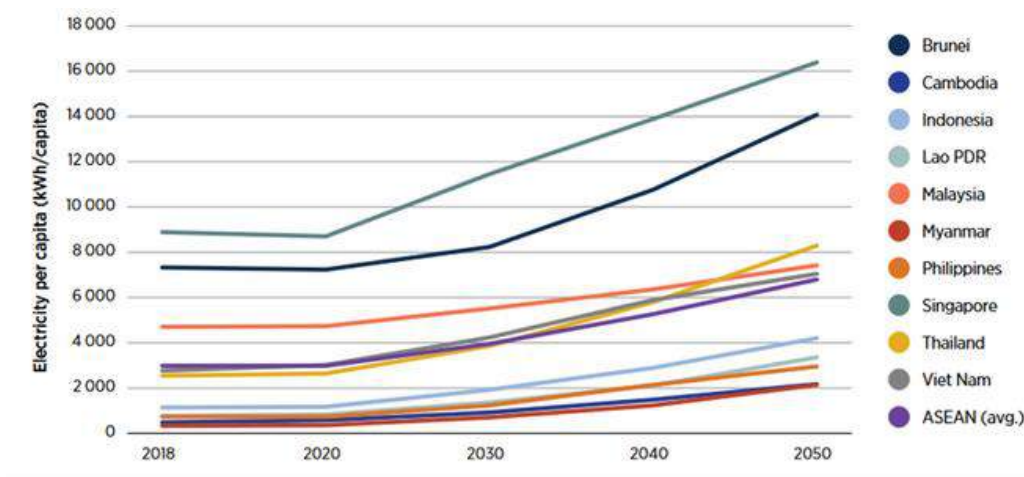
In the ASEAN region specifically, there has been a notable rise in electricity consumption per capita over the last two decades. The average consumption reached 1630 kWh in 2018 (figure 2), approximately one-fifth of the per capita electricity usage in OECD member countries. This trend is set to continue, with energy consumption predicted to increase by 35% by 2030 and 210% by 2050 under the current national energy policies (the PES), pushing the region's per capita annual electricity consumption to 6815 kWh[5].

[3] <https://sponsored.bloomberg.com/article/hsbcasean/sea-change-the-new-wave-of-optimism-in-southeast-asia>

[4] IRENA 'Southeast Asia Energy Outlook 2022', 2022.

[5] IRENA 'Southeast Asia Energy Outlook 2022', 2022.

Figure 2: Annual Electricity Consumption per capita, PES, by country, 2020-2050



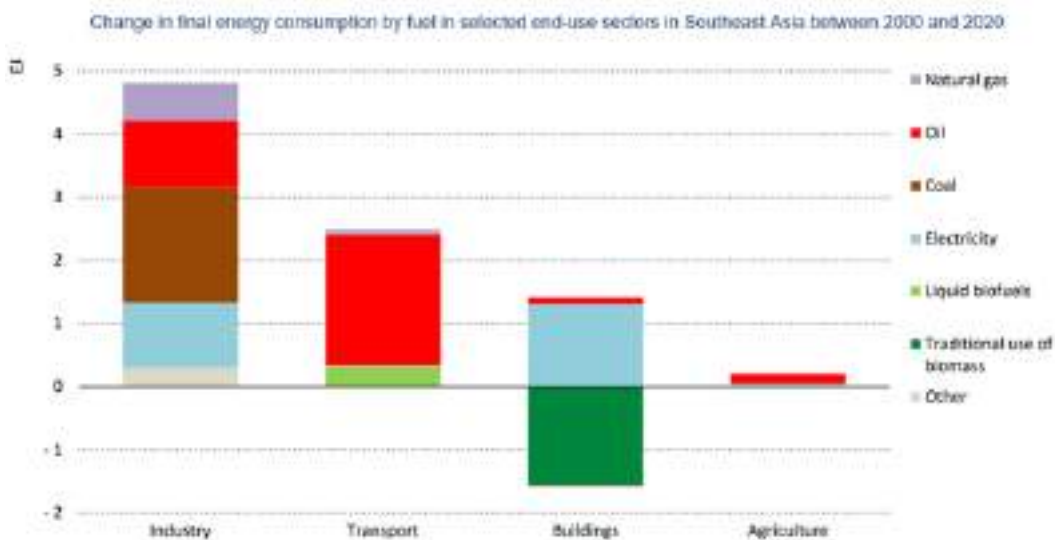
Source: IRENA, Southeast Asia Energy Outlook 2022

These trends underscore the need for sustainable energy solutions in the ASEAN region, given the dual challenges of meeting the growing demand for electricity while mitigating environmental impacts. The rise in consumption also highlights the importance of deploying advanced energy storage solutions like Battery Energy Storage systems (BESS) which are needed to support moves towards more renewable energy sources.

Sectoral Contribution to Energy Consumption

Over the past two decades, the energy consumption in the ASEAN region has experienced growth of approximately 70% [6]. These sectors stand at the forefront of the region's growing energy demand, highlighting their critical role in the overall energy landscape.

Figure 3:



Source: IRENA, Southeast Asia Energy Outlook 2022

[6] <https://www.adb.org/sites/default/files/publication/648701/adbi-wp1196.pdf>

Industry Sector:

This sector saw the largest jump in energy use, with energy-intensive industries such as steel production nearly quadrupling over the last two decades[7]. Coal use in industry expanded more than four times[8], while lighter industries like car assembly and garment factories pushed electricity demand up by 75%[9].

Transport Sector:

Oil demand in transport surged by 80% between 2000 and 2020[10]. Despite some growth in biofuels, oil remains the dominant fuel, comprising over 90% of the sector's energy consumption[11].

These trends reflect the weighty role of industrialisation and motorisation in escalating energy demands within ASEAN, highlighting the need for more energy management and sustainable development policies in the region.

Necessity for Reliable and Sustainable Energy Solutions in ASEAN

ASEAN's urban population is expected to reach 726 million by 2030[12]. This growth, coupled with increasing energy consumption[13], is set to heighten ASEAN's reliance on imported fossil fuels. This dependence poses substantial energy security challenges, especially given the volatility of fuel markets and their sensitivity to global crises, such as pandemics and geopolitical conflicts.

The surge in global commodity prices, influenced by events like Russia's invasion of Ukraine since mid-2021, has notably affected Southeast Asian countries[14]. Such developments underscore the vulnerability of ASEAN Member States to external energy market fluctuations and the imperative need for energy diversification. Furthermore, the rising cost of fossil fuel-powered energy, coupled with the decreasing expense of renewable sources, is making it increasingly financially sensible to transition towards renewable energy.

Transitioning towards renewable energy offers a pathway to attain energy security, mitigate the adverse effects of fuel market volatility, and address environmental concerns by reducing greenhouse gas (GHG) emissions. Each ASEAN Member State has recognised the importance of this shift and has taken steps to integrate Energy Efficiency/Energy Intensity (EE/EI) and renewable energy into their national strategies. These efforts are further supported by the submission of Nationally Determined Contributions (NDCs) as part of their commitment to the Paris Agreement, aiming to curtail emissions and contribute to global efforts in combating climate change.

[7] IEA (2022), Southeast Asia Energy Outlook 2022, IEA, Paris

[8] IEA (2022), Southeast Asia Energy Outlook 2022, IEA, Paris

[9] IEA (2022), Southeast Asia Energy Outlook 2022, IEA, Paris

[10] IEA (2022), Southeast Asia Energy Outlook 2022, IEA, Paris

[11] <https://asean.org/wp-content/uploads/2021/08/Sustainable-Transport-Indicators-ASEAN-Final.pdf>

[12] Yew, C. M. (2023). Capturing the rise of ASEAN amid economic resilience and growing wealth.

[13] <https://asianngo.org/magazine/post-magazine/article/article-detail/201/southeast-asia-s-energy-consumption-is-set-to-boom-over-the-coming-decades-alongside-a-growing-population-a-more-energy-intensive-economy-and-greater-access-to-the-grid>

[14] IEA (2022), Southeast Asia Energy Outlook 2022, IEA, Paris

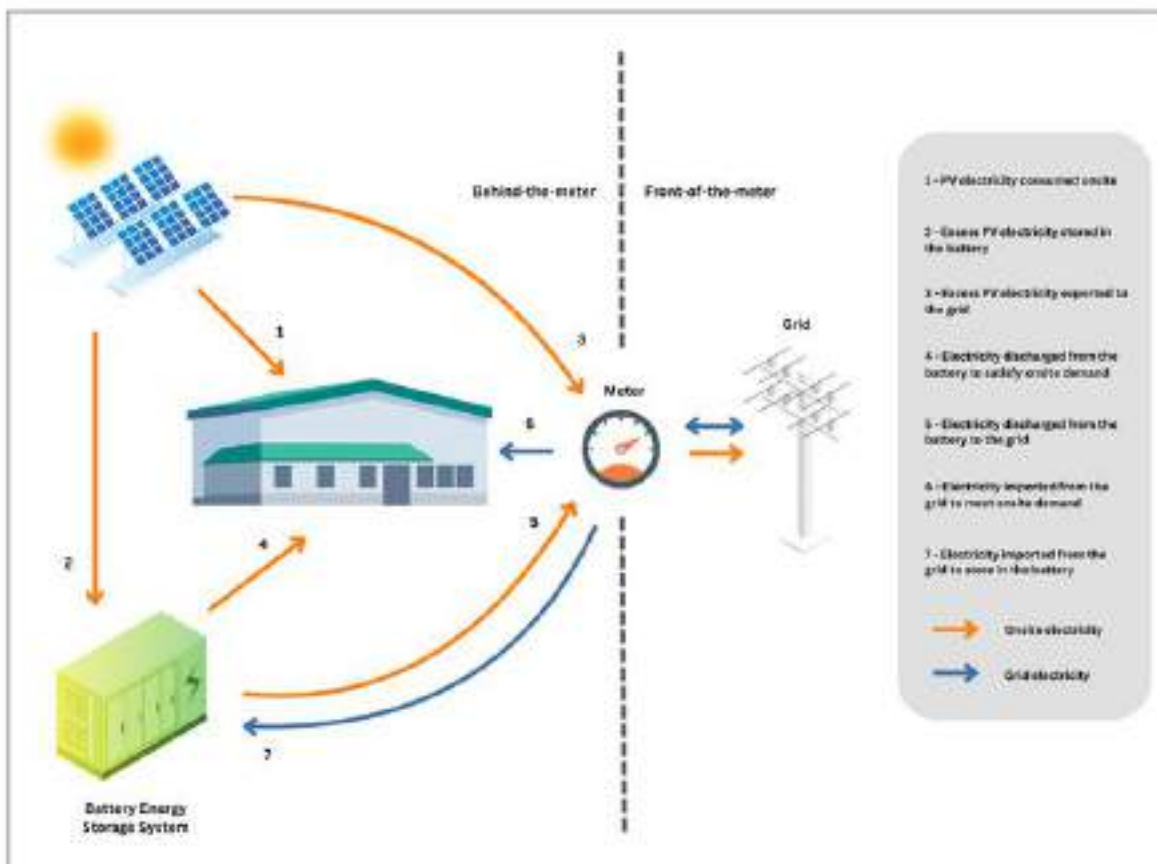
The push towards enhancing domestic energy capabilities, including the adoption of renewables, is not only a strategy to meet the increasing energy demands but also a proactive measure to mitigate the environmental impact associated with rapid economic development. This approach not only aligns with environmental objectives but also represents a pragmatic means to ensure the long-term energy security and economic stability of the ASEAN region.

Transforming ASEAN’s Renewable Energy Landscape with Behind-the-Meter (BTM) BESS

The global battery energy storage market, valued at approximately 5.4 billion U.S. dollars in 2022, is forecasted to reach over 17.5 billion U.S. dollars by 2028[15]. The Asia-Pacific region, including ASEAN, is poised to lead this market by 2026. In the face of escalating environmental concerns[16] and the urgent call for sustainable development[17], Behind-the-Meter (BTM) BESS stand as a critical technological solution for ASEAN's renewable energy challenges. BTM BESS uniquely addresses the region's acute needs: stabilising the electrical grid, enhancing energy access, and integrating renewable resources effectively.

Understanding BTM BESS vs. Conventional BESS

Figure 4: Behind-The-Meter BESS Diagram



[15] Avinashgogawale. (2023). Global expansion: Regions contributing to the \$17.5 billion Battery Energy Storage System Market.

[16] <https://asean.org/our-communities/asean-socio-cultural-community/environment/>

[17] <https://www.adb.org/news/features/seads-2023-call-accelerated-climate-action-towards-net-zero-asean>

Conventional BESS is typically installed at utility-scale facilities to provide grid support, store excess energy generated during low demand periods, and release it during high demand. These systems are often located at power plants or substations and are managed by utility companies to enhance grid stability and efficiency.

On the other hand, BTM BESS is installed at the consumer level, directly at homes, industrial facilities, complex commercial businesses, or smaller community facilities or at homes. This positioning allows consumers to store energy produced by their own renewable sources, like solar panels, wind turbines and heat pumps, or take advantage of lower-cost energy during off-peak times. The primary difference lies in the scale and location of the system: conventional BESS supports the broader grid, while BTM BESS empowers individual consumers users to manage their energy consumption more effectively.

Strengthening Grid Infrastructure in ASEAN with BTM BESS

As ASEAN nations undergo rapid economic growth and urbanisation, the demand for energy escalates[18], exerting pressure on aging infrastructure, resulting in grid instability and energy inefficiency. For instance, Brunei and Cambodia lack nationally interconnected power grid networks, exemplifying the critical need for infrastructural development and innovation[19]. Furthermore, countries like Indonesia and Malaysia contend with their own versions of fragmented power grids[20], making BTM BESS an ideal solution.

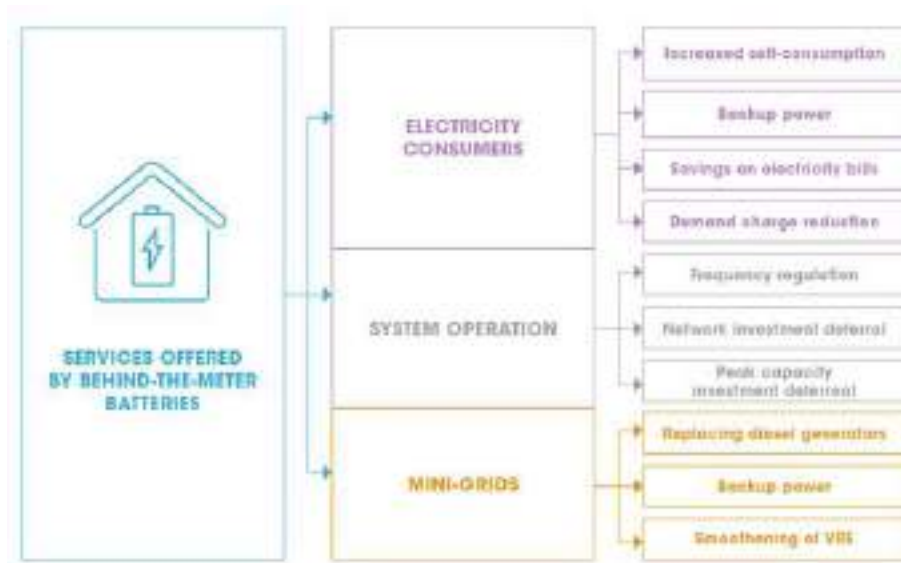
BTM BESS provides a versatile and dynamic solution for energy storage and management at the consumer level. When there's an excess of electricity—often during periods of low demand or high renewable production—BTM BESS stores this surplus by converting the electrical energy into chemical energy within the batteries. This process ensures that the energy is not wasted but kept for future use. Then, during peak demand or when renewable energy generation is insufficient, the stored chemical energy is converted back into electrical energy for use by the consumer. This bidirectional flow of energy allows BTM BESS to act as a buffer, optimising energy use, improving power quality and reducing reliance on the grid.

[18] <https://seads.adb.org/solutions/asean-energy-outlook-calls-accelerated-transition>

[19] https://esi.nus.edu.sg/docs/default-source/esi-policy-briefs/esi-pb-70_technical-potentials-and-challenges-to-regional-power-grid-interconnections.pdf?sfvrsn=1ebbf12e_3#:~:text=Achieving%20interconnections%20in%20regional%20power,the%20formulation%20of%20wheeling%20charges.

[20] https://esi.nus.edu.sg/docs/default-source/esi-policy-briefs/esi-pb-70_technical-potentials-and-challenges-to-regional-power-grid-interconnections.pdf?sfvrsn=1ebbf12e_3#:~:text=Achieving%20interconnections%20in%20regional%20power,the%20formulation%20of%20wheeling%20charges.

Figure 5: Table on service offerings of BTM BESS



Source: IRENA, *BTM Batteries: Innovation Landscape Brief*

BTM BESS offers several key services that make it particularly ideal for ASEAN:

Electricity Consumers

- **Increased self-consumption:** Allows consumers to use more of their self-generated renewable energy.
- **Backup power:** Provides reliability during power outages, crucial for remote and underserved areas.
- **Savings on electricity bills:** Reduces costs by storing energy during off-peak times and using it during peak periods.
- **Demand charge reduction:** Lowers costs associated with peak energy demand charges.

System Operations

- **Frequency and voltage regulation:** Stabilises the grid by optimising power quality.
- **Network investment deferral:** Reduces the need for costly grid infrastructure upgrades.
- **Peak capacity investment deferral:** Lessens the requirement for additional power plants by managing peak demand.

Mini-Grids

- **Replacing diesel generators:** Offers a cleaner, renewable alternative to diesel generators, especially in remote areas.
- **Backup power:** Ensures continuous energy supply in mini-grid systems.
- **Smoothing of Variable Renewable Energy (VRE):** Mitigates the intermittency of renewable sources like solar and wind.

BTM BESS's flexibility across both large-scale and localised energy systems makes it an essential tool for improving grid stability and access for ASEAN member states. By filling in grid gaps and enhancing local energy reliability, BTM BESS is key to advancing a more resilient and sustainable energy framework in the region.

01 Identifying Gaps in ASEAN's Energy Infrastructure

ASEAN's energy landscape is characterised by significant disparities in grid capacity and access to electricity, particularly in remote and underserved areas. While 95% of the region's population has access to electricity, persistent challenges remain. According to a report by ADB, approximately 940 million people in Asia Pacific experience frequent power interruptions, while about 350 million lack access to adequate electricity, further compounded by another 133 million who have no electricity whatsoever[21]. The recent energy crisis and COVID-19 pandemic have exacerbated these challenges[22], disproportionately affecting poorer and more vulnerable populations. These stark statistics underscore the urgent need for BTM BESS to address energy access disparities and enhance grid resilience across ASEAN.

02 Unlocking the Untapped Potential of Renewable Energy in the Region

The rapid expansion of renewable energy installations in ASEAN has presented a challenge of excess energy generation during peak production periods. According to the Global Energy Monitor (GEM)[23], solar and wind capacity in the ASEAN region surged by 20% in 2023, reaching over 28 gigawatts (GW).

However, the region's vast renewable energy potential remains largely untapped. Estimates from the United States' National Renewable Energy Laboratory reveal that the region's solar PV could generate over 45,000 TWh and onshore wind over 2,500 TWh, at competitive costs. Despite this, only 41 TWh of solar PV and 9 TWh of wind energy were generated in 2021[24].

BTM BESS arises as a key solution to this challenge due to its ability to maximise the benefits of renewable resources like solar PV and onshore wind by storing excess energy during peak production periods and releasing it when needed, thus enhancing grid stability and reliability for ASEAN member states and the region.

[21] <https://www.adb.org/news/features/qa-meeting-asia-and-pacifics-growing-electricity-needs>

[22] <https://www.iea.org/news/southeast-asian-nations-face-growing-energy-security-challenges-and-need-to-accelerate-their-clean-energy-transitions>

[23] <https://www.carbonbrief.org/wind-and-solar-capacity-in-south-east-asia-climbs-20-in-just-one-year-report-finds/>

[24] : National Renewable Energy Laboratory, Exploring Renewable Energy Opportunities in Select Southeast Asian Countries: A Geospatial Analysis of the Levelized Cost of Energy of Utility-Scale Wind and Solar Photovoltaics (June 2020)

03 **Revolutionising Energy Trading in ASEAN**

The emergence of carbon trading markets presents an important opportunity for the renewable energy sector in ASEAN. As the ASEAN Power Grid (APG)[25] facilitates enhanced electricity trade across borders, BESS integration enables participating nations to leverage surplus renewable energy production for carbon offset credits, thereby incentivising sustainable energy practices while fostering regional cooperation in mitigating carbon emissions. The APG, a crucial infrastructure project aimed at connecting the power grids of ASEAN member states, plays a central role in enabling this cross-border electricity trade.

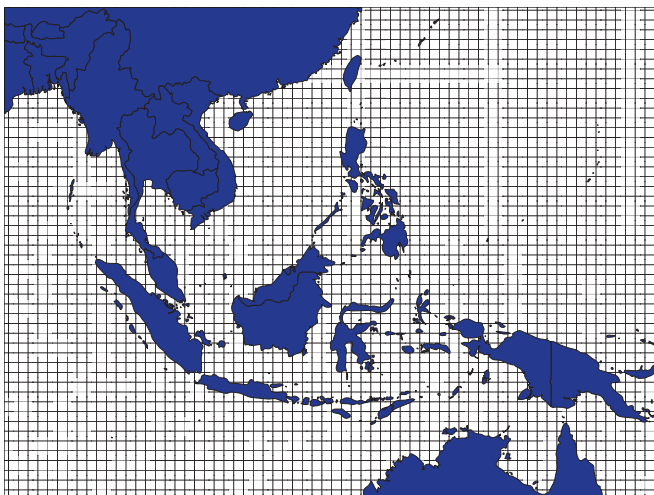
Moreover, regional power trading, physical interconnection, and policy cooperation are integral components of the ASEAN Strategy for Carbon Neutrality[26], which leverages the APG. This strategy includes enabling interoperability of regional transport and logistics infrastructure, establishing multilateral power trading mechanisms such as Corporate Power Purchase Agreement (CPPA) and Renewable Energy Certificates (REC), harmonising technical standards for grid interconnection, and encouraging ASEAN Member States (AMS) to support regional priorities such as third-party access.

Detailed information on the carbon trading market for each ASEAN member state is provided in Annex A, underscoring the tailored approaches and resources available to each country within this collaborative framework.

[25] ASEAN Power Grid - Enhancing Electricity Interconnectedness. asean.org. (2015).

[26] ASEAN Strategy for Carbon Neutrality. asean.org (2023, August).

Country-Specific Analysis of BESS in ASEAN



In the quest to enhance energy security, stabilise the grid, and integrate renewable energy sources, BESS solutions are emerging as vital components of the energy infrastructure in the ASEAN region.

This section evaluates the potential for BESS adoption across various ASEAN countries by examining four critical factors: the key drivers of BESS, the policy and regulatory landscape, country-specific status for BESS deployment, and the energy trading market and carbon credits environment. By analysing these factors, we aim to provide a comprehensive understanding of the opportunities and challenges each country faces in adopting BESS solutions.

Key Drivers



The ASEAN region, comprising diverse economies with varying levels of industrialisation and urbanisation, is at a crucial stage in its energy transition journey. The adoption of BESS is increasingly recognised as a key enabler for enhancing energy security, supporting grid stability, and facilitating the integration of renewable energy sources at the consumer level. Two primary driving factors are accelerating the deployment of BESS in ASEAN:

1. the significant growth in energy demand and;
2. the abundant potential for renewable energy development.

This section explores these driving factors in detail, highlighting their impact on the energy landscape and the opportunities they present for energy storage solutions.

Cambodia



Energy Demand Growth

Cambodia's energy consumption has been growing rapidly, with total energy consumption increasing by 7.2% per year and electricity consumption rising by 18.3% per year between 2010 and 2018[27]. This growing demand is primarily driven by the infrastructural sector, which accounts for 52% of final energy consumption[28]. This indicates a strong demand for energy solutions that can support this growth.

Renewable Energy Potential

The trajectory of solar energy in Cambodia has seen significant growth, with its share in the installed capacity rising from virtually zero in 2016 to approximately 12% by the end of 2021.

The Power Development Master Plan[29] of Cambodia projects solar PV capacity to exceed 3 GW by 2040. This creates a suitable environment for integrating BESS to enhance grid stability and support renewable energy sources.

Energy Demand Growth

Indonesia's energy consumption has been growing rapidly, with electricity demand witnessing a robust annual increase of about 6.5% from 2010 to 2022[30], reaching 316 TWh. This growing demand is primarily driven by households (40% of total consumption), the industrial sector (37%), and the services sector (22%).

Renewable Energy Potential

Indonesia is making large strides in reshaping its energy landscape with a plan spearheaded by Perusahaan Listrik Negara (PLN), the state electricity company. Between 2024 and 2033, PLN has outlined a vision to augment the country's renewable power capacity by an additional 31.6 GW[31], marking a shift towards sustainable energy sources.

Indonesia



[27] <https://energytracker.asia/energy-efficiency-in-cambodia-paving-the-way-in-southeast-asia/>

[28] <https://www.undp.org/cambodia/publications/energy-efficiency-buildings-accelerating-low-carbon-development-cambodia>

[29] Climate Change Laws of the World. (n.d.). Power Development Master Plan 2022-2040.

[30] Indonesia Energy Information. Enerdata. (n.d.).

[31] <https://www.reuters.com/sustainability/climate-energy/indonesia-state-utility-plans-316-gw-renewable-power-capacity-2024-2033-2023-11-15/>

Most of the current energy storage research in Indonesia is driven by the growing interest in electric vehicles and batteries[32]. A 2022 report[33] by the International Renewable Energy Agency (IRENA) found that Indonesia's electricity demand is expected to grow fivefold by 2050 when it reaches a population of 335 million people.

Malaysia



Energy Demand Growth

The Energy Commission of Malaysia has historically observed an annual electricity demand growth of around 2.5 percent.

Projections from the Malaysia Generation Development Plan 2019 suggest a more modest growth rate of 1.8 percent per annum for the decade 2020-2030[34].

Malaysia is anticipated to require about 10.0 GW of new capacity to accommodate growth and ensure system reliability, involving replacing retiring plants and adding new generation capabilities.

Renewable Energy Potential

Malaysia is on a path to substantially expand its renewable capacity from 6 to 14 GW[35].

Among its states, Sarawak stands out with ambitious climate initiatives, targeting over 70 percent RE usage by 2030.

The government has announced that it will not approve any new coal-fired power generation plants[36], signalling a decisive move towards a greener energy matrix.

[32] <https://www.huntkeyenergystorage.com/energy-storage-market-in-southeast-asia/>

[33] <https://www.irena.org/News/pressreleases/2022/Oct/Renewable-Pathway-More-Cost-Effective-than-Fossil-Fuels-in-Indonesia>

[34] Malaysia - renewable energy. International Trade Administration | Trade.gov.

[35] <https://www.trade.gov/country-commercial-guides/malaysia-renewable-energy>

[36] <https://www.eco-business.com/news/malaysia-plans-to-retire-all-coal-fired-power-plants-by-2044/>

Renewable Energy Potential

The Philippines, with over 7,000 islands, harnesses geothermal (14.6%, 1,932 MW), biomass (12.6%, 759 MW), hydropower (4.1%, 1,161 MW), and solar/wind energy (1.4%, 1,382 MW solar; 443 MW wind) [37].

Strategic location on the Pacific Ring of Fire and consistent trade winds enhances its renewable energy capacity.

Annual sunlight intensity is 1600-2300 kWh/m²/year with summer sunshine duration reaching up to 14 hours[38], providing superior natural sunshine conditions.

The Philippines



Singapore



Renewable Energy Potential

Singapore aims to deploy 1.5 GWp of solar energy by 2025 and at least 2 GWp by 2030, meeting 2% and 3% of projected electricity demands, respectively[39].

The country's annual sunlight intensity and summer sunshine duration provide superior conditions for solar energy development.

[37] Philippines - Energy. International Trade Administration | Trade.gov.

[38] <https://www.huntkeyenergystorage.com/energy-storage-market-in-southeast-asia/>

[39] Singapore green plan 2030. Singapore Green Plan 2030. (n.d.).

Renewable Energy Potential

Thailand's tropical monsoon climate provides rich photovoltaic resources with full-day radiation of 5.00–5.28 kWh/m²[40].

Substantial investments in solar and wind power infrastructure have leveraged Thailand's abundant sunlight and coastal wind potential.

Solar farms and rooftop installations have established solar energy as a primary renewable power source.

Wind energy expansion, particularly along coastal regions, has contributed to Thailand's renewable energy mix.

These advancements reduce Thailand's carbon footprint, enhance energy security, and promote economic growth through job creation.

Thailand



Vietnam



Economic Growth and Energy Demand

Vietnam's rapid industrialisation and economic growth have led to a significant increase in energy demand[41].

Power consumption is projected to rise to about 335 billion kWh by 2025, around 505.2 billion kWh by 2030, and between 1,224 billion kWh and 1,378 billion kWh by 2050.

Renewable Energy Potential

Abundant natural resources provide substantial potential for solar, wind, and hydropower.

The government emphasises the integration of renewable energy sources to enhance grid stability and sustainability.

[40] <https://www.huntkeyenergystorage.com/energy-storage-market-in-southeast-asia/>

[41] <https://www.trade.gov/country-commercial-guides/vietnam-power-generation-transmission-and-distribution#:~:text=The%20Government%20of%20Vietnam%20expects,consumption%20growth%20rates%20in%20Asia.>

The different ASEAN member states are navigating a crucial phase in their energy development, characterised by rapidly increasing energy demands and a decisive shift towards renewable energy. This environment makes the feasibility of BTM BESS solutions particularly promising. The region's robust infrastructural development and diverse consumption patterns underscore the critical need for scalable and flexible energy solutions.

Trends indicate that the rapid rise in solar and wind capacities across the region necessitates efficient energy storage solutions to manage intermittency and enhance grid stability. The growing emphasis on renewable energy integration, supported by substantial governmental and private sector investments, highlights the strategic importance of BESS in optimising energy storage and distribution, reducing carbon emissions, and enhancing energy security.

Moreover, the region's strategic planning for energy demand growth and renewable expansion showcases a balanced approach that prioritises both reliability and sustainability. This is evident in the ambitious renewable targets and significant policy commitments aimed at phasing out traditional energy sources in favour of greener alternatives. The adoption of BESS is further supported by advantageous natural conditions, such as abundant sunlight and wind resources, which amplify the potential for renewable energy generation.

In summary, the dynamic and multifaceted approach to energy management across ASEAN member states underscores the feasibility and critical importance of BTM BESS adoption. This not only addresses immediate energy consumption needs but also aligns with long-term sustainability goals, positioning ASEAN as a leader in the global transition towards resilient and sustainable energy systems.

Policy and Regulation

The policy and regulatory landscape are crucial for the adoption of BESS solutions in ASEAN countries.

Examining this factor is essential because supportive policies and clear regulations can significantly accelerate BESS deployment, while regulatory hurdles can impede progress.

National policies and initiatives often set ambitious targets for energy storage and renewable integration, providing clear goals for BESS deployment. Financial incentives such as grants, tax credits, and rebates reduce investment costs, making BESS projects more attractive. Regulatory frameworks ensure safety and reliability through standards and guidelines, while streamlined compliance processes facilitate quicker implementation.

Long-term energy plans provide strategic direction for integrating renewable energy and storage solutions. By fostering a supportive policy and regulatory environment, ASEAN countries can significantly enhance BESS adoption, ultimately improving energy security, grid stability, and renewable integration across the region.

Cambodia

Power Development Master Plan 2022-2040

Cambodia's Power Development Master Plan 2022-2040[42] outlines a blueprint for the country's domestic installed capacity supply mix leading up to 2030 and 2040, aiming to ensure energy security, promote sustainable development, and achieve carbon neutrality goals. By 2030, the plan envisions a diverse energy mix comprising of:

- 2,266 MW of coal (40.4%),
- 1,558 MW of hydro (27.7%),
- 490 MW of fuel oil (8.7%),
- 1,005 MW of solar PV (17.9%),
- and notably, 200 MW of battery energy storage systems (BESS) (3.6%).

This mix also includes 98 MW of biomass (1.7%), power imports from Laos (3,095 MW) and Thailand (700 MW), and substantial capacity savings through energy efficiency measures (equivalent to 1,215 MW).

[42] Climate Change Laws of the World. (n.d.). Power Development Master Plan 2022-2040.

By 2040, the composition shifts towards:

- a reduced reliance on coal (21.4%) and
- an increased focus on renewable energies, particularly solar PV (3,155 MW or 29.8%) and hydro (2,973 MW or 21.4%), alongside
- 420 MW of BESS (5.8%).

This future energy landscape also envisages a more substantial role for biomass (198 MW), natural gas (900 MW), and heightened energy imports from Laos and Thailand, complemented by enhanced energy efficiency measures saving an equivalent of 2,205 MW of capacity.

ADB and EDC Partnership

The Asian Development Bank (ADB) is collaborating with Cambodia's national utility company, Électricité du Cambodge (EDC)[43], to develop solar power capacity with BESS. This partnership includes transaction advisory services, a nationwide study, and a 100 MW pilot project, reflecting strong institutional support for BESS.

Indonesia

Energy Development Plan 2024-2033

Indonesia is making large strides in reshaping its energy landscape with a plan spearheaded by Perusahaan Listrik Negara (PLN), the state electricity company. Between 2024 and 2033, PLN has outlined a vision to augment the country's renewable power capacity by an additional 31.6 gigawatts (GW), marking a pivot towards sustainable energy sources. This initiative builds upon the 2021-2030 plan[44] where PLN aimed to construct 20.9 GW of renewable capacity alongside nearly 20 GW from gas and coal sources. As of September, 8.6 GW of this proposed capacity has already been realised, showcasing Indonesia's commitment to accelerating its renewable energy infrastructure.

Key objectives of Indonesia's energy development plan include:

- **Energy Access:** Achieving universal electricity access with the goal of 100% electrification by the end of 2024.
- **Efficiency:** Committing to a 1% annual reduction in energy intensity up to 2025.
- **Renewables:** Increasing the share of "new and renewable energy" in the primary energy supply to 23% by 2025 and further to 31% by 2050. Notably, renewables are expected to constitute 52% of electricity capacity additions from 2021 to 2030.

Government's Goal

The Indonesian government has set targets to position the country as a leading producer and exporter of batteries, essential for BESS[45]. Leveraging Indonesia's rich deposits of critical battery components such as nickel, lithium, and cobalt, this goal underscores the nation's strategy to tap into its natural resource wealth to fuel its renewable energy and technological advancements.

[43] Asian Development Bank. (2022, November 15). ADB, EDC Sign Mandate for 2 GW solar and battery storage power programme in Cambodia.

[44] RUPTL 2021-30: PLN steps up ambitions to accelerate. OECD. (n.d.).

[45] <https://jakartaglobe.id/business/indonesia-set-to-become-third-largest-lithium-battery-producer-luhut>

Malaysia

National Energy Policy, 2022-2040 (DTN)

Renewables:

- Increase in target for installed renewable energy capacity from 40% by 2035 to 70% by 2050.
- Diversification of renewable energy programmes under the principle of "willing buyer, willing seller."
- Scaling up the installation of solar systems in government buildings.
- Establishing an electricity exchange system for cross-border renewable energy trade.
- Enhancing the national power grid with smart grid features and increased access for third parties.

Transport:

- Targets for electric vehicle (EV) infrastructure: 9,000 AC charging points and 1,000 DC charging points by 2025.

Climate Change:

- Goals to reduce greenhouse gas (GHG) intensity of GDP by 35% by 2030 from the 2005 level, with a further reduction to 45% with international support.
- Vision for achieving carbon neutrality by 2050.

Renewable Energy Goals and Policies

- Initiatives such as the Large-Scale Solar (LSS) programme need-In Tariff (FIT) scheme, and net metering for distributed energy generation[46].
- Designed to facilitate the adoption of renewable energy sources by improving accessibility, affordability, and incentivising investment in renewable energy projects.

Philippines

National Renewable Energy Programme (NREP) 2020-2040 [47]

- **Renewable Energy Targets:** 35% of power generation by 2030 and 50% by 2040.
- **Capacity Expansion:** Increase from 22,317 MW in 2019 to 114,601 MW by 2040.
- **Universal Electrification:** 100% electrification by 2028.
- **Improving Energy Efficiency:** Reduce energy intensity by 40% by 2030 and total energy consumption by 24% by 2040.
- **Fossil Fuel Restriction:** No new coal-fired power plants beyond those in the pipeline.
- **Climate Change Mitigation:** Reduce GHG emissions by 70% by 2030, with international support.

[46] https://www.christopherleeong.com/media/5712/2024-01_malaysia-announces-renewable-energy-programmes.pdf

[47] National Renewable Energy Programme, 2020-2040. (2022.).

Energy Strategy and Coal Moratorium

Coal Moratorium[48]: Instituted in 2020, supports increasing the renewable energy share to 50% by 2040, reducing dependence on coal.

Singapore

Singapore Green Plan 2030 [49]



Figure 6: Infographic on SG Green Plan 2030

2025 Targets:

- Deploy 1.5 Gwp of solar energy.
- Deploy 200 MWh of Energy Storage Systems (achieved in February 2023).

2030 Targets:

- Increase solar energy deployment to at least 2 Gwp.
- Adopt best-in-class power generation technology.
- Improve energy intensity by 35% compared to 2005 levels.
- Phase out unabated coal generation by 2050.
- Reduce GHG emissions by 16% below BAU levels by 2020, stabilise emissions by 2030, halve emissions by 2050, and achieve net zero emissions in the second half of the century.

[49] Singapore green plan 2030. Singapore Green Plan 2030. (n.d.).

- Phase out unabated coal generation by 2050.
- Reduce GHG emissions by 16% below BAU levels by 2020, stabilise emissions by 2030, halve emissions by 2050, and achieve net zero emissions in the second half of the century.

Policy Support and Incentives

Market Integration (August 2015): Regulatory changes allowed ESS to contribute to the regulation market, enhancing competitiveness.

Funding Innovation (June 2016): Six projects received \$15 million under the Energy Storage Grant Call.

Utility-Scale Deployment (October 2017): Two local consortiums received S\$17.8 million for large-scale ESS projects.

Intermittency Pricing Mechanism (October 2018): EMA introduced a pricing mechanism for fair allocation of reserve costs.

Handbook on ESS

EMA published a comprehensive handbook[50] on BESS to support integration and understanding.

Thailand

Thailand's National Energy Plan (NEP) 2023 [51]

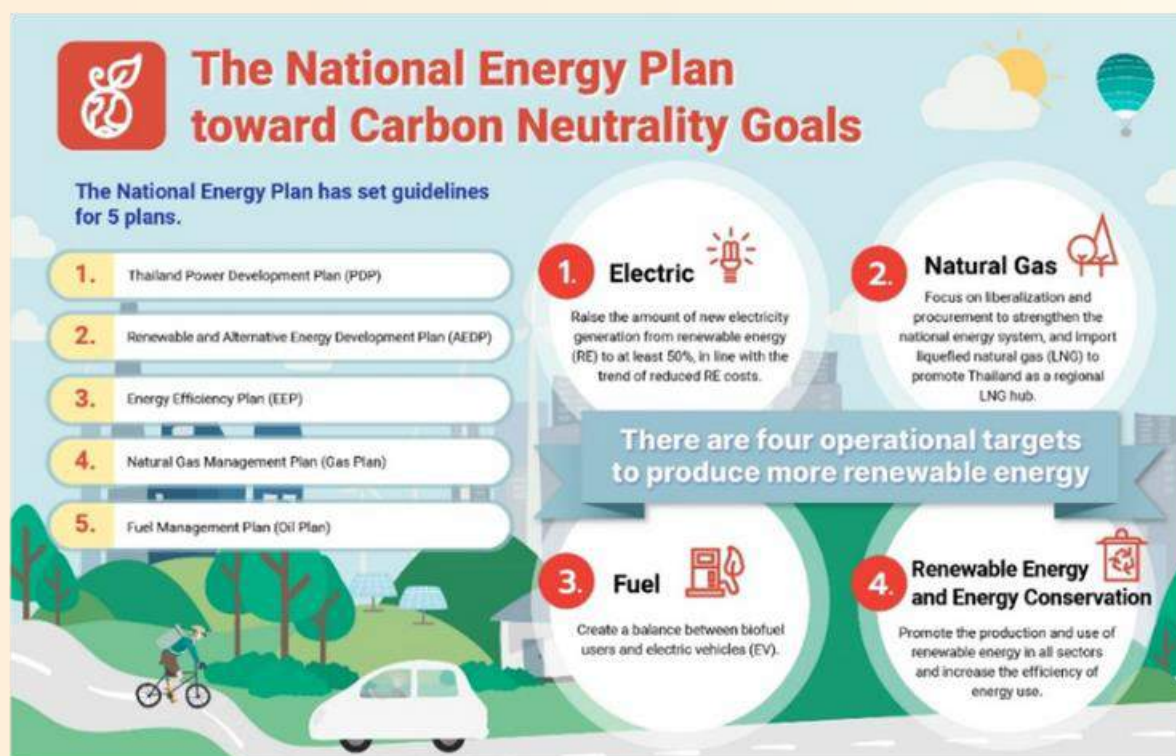


Figure 7: Infographic on Thailand's NEP

[51] Praiwan, Y. (2023, October 12). New plan expected to cut CO₂ output. <https://www.bangkokpost.com>.

Renewable Energy Goals:

- Achieve carbon neutrality by 2065-2070.
- Emphasise sustainability and widespread adoption of renewable energy sources, aligned with global climate change efforts.

Guidelines and Plans:

- Incorporate BESS to enhance energy security, support transportation electrification, and improve energy access in remote areas.

FIT Scheme for Renewable Energy:

- 25-year FIT for solar at 2.1679 baht per kWh.
- 25-year FIT for solar plus storage at 2.8331 baht per kWh.

Vietnam

Vietnam’s Power Development Plan (PDP8)[52]

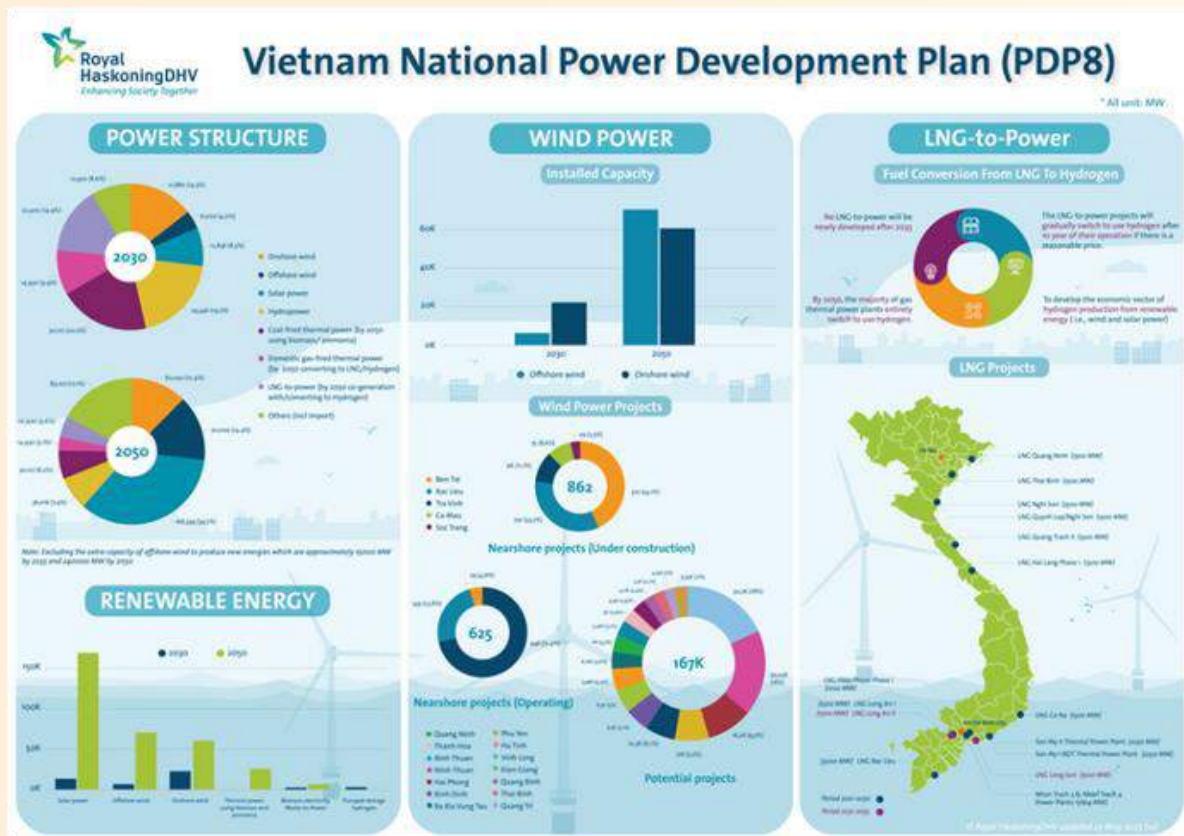


Figure 8: Infographic on Vietnam’s PDP8

[52] PricewaterhouseCoopers. (n.d.). Vietnam’s eighth National Power Development Plan (PDP VIII): Insights and key considerations for investors. PwC

Renewable Energy Goals:

- Onshore wind power capacity target of 21,880 MW by 2030.
- Offshore wind power capacity target of 6,000 MW by 2030, with potential expansion to 70,000-91,500 MW by 2050.
- Solar power capacity increase by 4,100 MW and rooftop solar power production increase by 2,600 MW by 2030.
- Hydropower capacity growth to 36,016 MW by 2050.
- Development of stored hydropower with a capacity of approximately 2,400 MW.

Coal Power Reduction:

- Stopping the development of new coal power projects by 2030.
- Stopping the use of coal-fired power generation by 2050.

Vietnam's energy policy and regulatory landscape, along with those of other ASEAN member states, is undergoing significant transformation to support a sustainable and resilient energy future. The emphasis on BESS is particularly notable, reflecting broader regional trends towards renewable energy integration and grid modernisation.

Across ASEAN, there is a marked increase in renewable energy capacity targets, driven by robust policy frameworks and strategic plans. Countries are setting ambitious goals for solar, wind, and hydropower, recognising the critical role of BESS in managing intermittency and enhancing grid stability. For instance, Power Development Plans, such as Vietnam's PDP8, set clear targets for expanding wind and solar capacities while phasing out coal power. These plans often include specific BESS capacity goals, highlighting the importance of energy storage in achieving renewable energy targets.

Governmental partnerships with international organisations, like the Asian Development Bank (ADB), and national utilities, exemplify strong institutional support for BESS adoption. These collaborations focus on developing solar power projects integrated with BESS, providing technical advisory services, conducting nationwide studies, and implementing pilot projects. Such initiatives underscore the importance of regulatory support and international cooperation in advancing energy storage technologies.

National Energy Policies across the region are aligning to enhance renewable energy adoption and improve energy efficiency. For instance, many countries are introducing Feed-In Tariff (FIT) schemes, net metering, and large-scale solar programmes to incentivise renewable energy investments. These policies create a favourable environment for BESS by ensuring that renewable energy projects are economically viable and technically feasible.

Strategic energy plans, such as Indonesia's Energy Development Plan 2024-2033, highlight the need for increasing the share of renewable energy in the primary energy mix and achieving universal electricity access. The Indonesian government's goal to become a leading producer and exporter of batteries, leveraging its rich deposits of critical components, underscores the strategic importance of BESS in the national energy strategy.

Policy measures also focus on enhancing energy security and reducing carbon emissions. For example, many ASEAN countries are setting targets for carbon neutrality, phasing out coal power plants, and implementing climate change mitigation strategies. These measures are supported by the development of smart grids and advanced energy storage solutions, which are crucial for managing the increasing share of variable renewable energy sources.

Overall, the policy and regulatory landscape in ASEAN is increasingly supportive of BTM BESS adoption. By setting ambitious renewable energy targets, fostering international partnerships, and implementing supportive policies, ASEAN member states are positioning themselves at the forefront of the global transition towards resilient and sustainable energy systems. The integration of BESS is central to these efforts, providing the necessary infrastructure to support renewable energy growth, enhance grid stability, and achieve long-term sustainability goals.

BESS Deployment in ASEAN



Understanding the status of BESS deployment in each ASEAN country is essential for identifying opportunities and challenges unique to each market. The level of BESS deployment provides insights into how well countries are integrating energy storage with their renewable energy initiatives, enhancing grid stability, and addressing energy security concerns.

By evaluating the existing projects, regulatory support, and market readiness, stakeholders can better understand the progress made and the potential for future growth in BESS adoption across the region. This section offers a comprehensive overview of the BESS landscape in ASEAN, highlighting key developments and trends that shape the energy storage market in each country.

Cambodia

ADB and EDC Partnership

Cambodia plans to support its energy sector through the adoption of renewable energy, with a focus on solar power in combination with BESS. The Asian Development Bank (ADB) has aided the country in this transition, marking a landmark collaboration with Cambodia's national utility company, Électricité du Cambodge (EDC)[53]. This partnership aims to develop 2 gigawatts (GW) of solar power, aligning with Cambodia's goal of achieving carbon neutrality by 2050.

ADB's engagement involves providing transaction advisory services to EDC, facilitating a nationwide study to explore opportunities for augmenting solar power capacity with BESS. This initiative, spanning from the current year through to 2030, is poised to shape Cambodia's renewable energy landscape. A key component of this collaboration is the development of a 100-megawatt pilot project, which stands as a testament to the potential of leveraging private sector efficiency, innovation, and capital in the renewable energy domain.

[53] Asian Development Bank. (2022, November 15). ADB, EDC Sign Mandate for 2 GW solar and battery storage power programme in Cambodia.

This pilot is expected to mobilise up to \$100 million in investments, setting a precedent for the rapid and efficient procurement of renewable power in the country. ADB's support for Cambodia's green energy transition encompasses not just the deployment of renewable energy sources but also encompasses comprehensive policy reform in energy planning and governance.

By improving grid stability and energy efficiency, ADB aims to foster clean, sustainable, and inclusive economic growth in Cambodia. This initiative builds upon ADB's prior engagements in the country's solar sector, including the establishment of Cambodia's first National Solar Park in Kampong Chhnang[54], which is expected to generate up to 100 MW of solar power.

Indonesia

PLN's BESS Pilot Project and De-dieselisation Efforts

Indonesia is taking significant strides in its energy sector transformation, with PLN at the forefront of integrating BESS into the national grid. This initiative is part of a broader strategy to transition from diesel-generated power to renewable energy sources, marking a shift in Indonesia's energy landscape.

In 2022, PLN signed a memorandum of understanding (MOU) with the Indonesia Battery Corporation (IBC) to construct a 5 MW BESS pilot project[55]. This collaboration underscores the country's commitment to reducing its reliance on fossil fuels and exploring renewable energy alternatives.

PLN's "de-dieselisation" programme aims to replace 250 MW of diesel-fired power with renewable energy within the same year. By 2024, the programme plans to convert 5,200 units of diesel plants into solar photovoltaic (PV) systems, culminating in a total capacity of 2 GW. This transition is driven by the increasing demand for battery storage in Indonesia, especially to support the growth of solar and wind power plants.

Collaborations and Technology Research

Beyond the MOU, PLN is engaging in strategic partnerships to explore and enhance BESS technology. Collaborations with two Korean companies are focused on researching BESS's potential to support the renewable energy transition and reduce costs through peak shaving—a method used to reduce electric power consumption during peak demand times. Additionally, PLN is working alongside a subsidiary of the Sinar Mas Group to support the country's electric vehicle (EV) charging infrastructure[56].

[54] Power plant profile: Cambodia national solar PV Park, Cambodia. Power Technology. (2024, February 5).

[55] Orissa International. (n.d.). 5 MW Battery Energy Storage System Pilot Project launched in Indonesia.

[56] Adimas Raditya, R. A. (2023, March 7). PLN focusing on EV charging infrastructure. Antara News.

Malaysia

Malaysia's BESS Pilot Project

Tenaga Nasional Bhd, Malaysia's leading utility company, has announced the launch of a pioneering 400 megawatt-hour (MWh) BESS pilot project at the beginning of the year[57]. This initiative represents Malaysia's first venture into utility-scale battery storage, a critical component in the nation's strategy to integrate renewable energy sources more effectively into its power grid.

The project is set to be executed by the national utility outfit and operated by the Grid System Operator (GSO), with the oversight provided by the Energy Commission. This collaboration underscores the importance of the project to Malaysia's energy transition goals and its commitment to strengthening the electricity supply grid network.

Philippines

BESS Integration in the Philippines: The Limay Project

In a stride towards enhancing grid reliability and supporting the integration of renewable energy sources, the Philippines has embarked on one of its largest integrated grid-scale BESS projects to date. Located in Limay, Bataan Province, this BESS initiative is spearheaded by Universal Power Solutions Inc. (UPSI), a unit of San Miguel Corporation Global Power Holdings Corp., in collaboration with ABB[58].

The project forms part of a broader contract with UPSI for a 240MW capacity BESS solution. Inaugurated in March 2023 by President Ferdinand R. Marcos Jr., the Limay site features a 50MW capacity packaged BESS solution provided by ABB. This system is designed to mitigate large frequency deviations that can lead to equipment damage and power system failures.

The Limay BESS project aims to address several critical challenges in the Philippine energy sector:

- **Grid Stability:** Enhancing the reliability and stability of the electricity grid on the main islands of Luzon and Visayas.
- **Renewable Energy Integration:** Supporting the country's ambitions to rely increasingly on renewable energy sources by facilitating their integration into the grid.
- **Economic Growth:** Enabling local industrialisation and economic growth by reducing grid imbalances that cause power interruptions.

[58] ABB powers up one of the world's biggest Battery Energy Storage Systems. News. (2023, June 7).

Singapore

Sembcorp Energy Storage System on Jurong Island

A hallmark of Singapore's BESS landscape is the Sembcorp Energy Storage System on Jurong Island[59]. Launched in 2023, this 285 megawatt-hour (MWh) facility stands as the largest of its kind in Southeast Asia. Commissioned by the Energy Market Authority (EMA), the project significantly bolsters Singapore's energy storage capabilities, with the capacity to power nearly 17,000 four-room flats for a day on a single 200MW per hour discharge.

The Sembcorp project exemplifies Singapore's proactive approach in leveraging BESS to mitigate the challenges of solar intermittency and enhance grid stability. It serves as a benchmark for integrating large-scale energy storage solutions within the urban and industrial landscapes, showcasing the city-state's leadership in energy innovation.

Thailand

EGAT's Renewable Energy Initiatives in Thailand

The Electricity Generating Authority of Thailand (EGAT) has been at the forefront of implementing renewable energy projects across the country. Among its notable endeavours are the inauguration of a solar power plant and BESS project in Mae Hong Son[60] province and the acceleration of the Unit 1 of the Hydro-floating Solar Hybrid Project[61] at Ubol Ratana Dam in Ubon Ratchathani Province.

- **Capacity:** A 3-megawatt solar power plant coupled with a 4MW battery energy storage system (BESS) has been established to address the province's energy security needs and mitigate frequent power outages.
- **Strategic Importance:** This initiative, positioned as part of the SMART ENERGY strategy, aims to fortify the power system's reliability in Mae Hong Son Province, aligning with Thailand's broader sustainable development goals.
- **Alignment with National Goals:** The project resonates with Thailand's Power Development Plan objectives to augment the clean energy mix and achieve Carbon Neutrality by 2050 and Net Zero Emissions by 2065.

[59] Tan, C. (2023, February 2). Sembcorp opens S-e Asia's largest energy storage system on Jurong Island to boost solar power supply. The Straits Times.

[60] Mae Hong Son begins commercial operation on Smart Grid Solar Farm and strives toward Green Tourism City. Electricity Generating Authority of Thailand. (2023, May 26).

[61] 54th anniversary of Egat to accelerate green power generation, expand hydro-floating solar hybrid, support investments, and drive Thai economy toward carbon-free society. Electricity Generating Authority of Thailand. (2023a, May 2).

Hydro-floating Solar Hybrid Project at Ubol Ratana Dam:

- **Acceleration:**

EGAT has accelerated the Unit 1 of this project, boasting a generating capacity of 24 MW, along with an installed battery energy storage system (BESS) to stabilise the power system during the transition from solar to hydropower.

- **Potential:**

EGAT envisions scaling up hybrid projects like this, with the potential to carry out projects up to 10,000 MW, showcasing its commitment to expanding renewable energy capacity.

- **Future Plans:**

EGAT plans to propose more hybrid projects to support the growing demand for green electricity in the business sector, further solidifying its position as a leader in sustainable energy development.

Vietnam

AMI AC Renewables Energy Storage System Project

At the forefront of Vietnam's BESS initiatives is the pioneering AMI AC Renewables Energy Storage System[62], located at the Khanh Hoa solar PV plant in Khanh Hoa province. This project, a collaboration between AC Energy and AMI Renewables, marks a major milestone with its 15MW output and 7.5MWh capacity, underlining Vietnam's commitment to proving the commercial viability of energy storage.

The project has garnered international support, including a substantial grant of nearly US\$3 million from the US Consulate General's US Mission Vietnam in 2023.

The deployment of BESS across ASEAN countries reveals a landscape marked by both common trends and diverse approaches, driven by unique national priorities and challenges. This evaluation highlights the key themes and variations in BESS adoption in the region, providing insights into the overall progress and prospects:

Common Trends

[62] Chandak, P. (2023, May 12). AMI AC Renewables and Honeywell collaborate on 7.5 mwh Battery Energy Storage Pilot Project in Vietnam. SolarQuarter.

Government Support and Policy Initiatives:

- Across ASEAN, there is a growing recognition of the importance of renewable energy and energy storage in achieving energy security and sustainability goals. Countries like Cambodia, Indonesia, Malaysia, and the Philippines have implemented national policies and incentives to encourage BESS adoption. These include grants, tax credits, and regulatory frameworks that facilitate the integration of energy storage systems with renewable energy sources.

Pilot Projects and Demonstrations:

- Many ASEAN countries are initiating pilot projects to test the feasibility and benefits of BESS. For example, Indonesia's PLN and Malaysia's Tenaga Nasional Bhd have launched significant pilot projects to explore BESS integration. These projects serve as testbeds for new technologies and provide valuable insights into the operational and economic aspects of energy storage.

Focus on Renewable Energy Integration:

- The push to integrate renewable energy sources like solar and wind is a common driver for BESS adoption. The Philippines' Limay BESS project and Thailand's solar and hydro-floating hybrid projects exemplify efforts to enhance grid stability and manage the intermittency of renewable energy. This trend underscores the region's commitment to reducing reliance on fossil fuels and mitigating climate change.

International Collaboration and Funding:

- International partnerships and financial support play a crucial role in advancing BESS projects in ASEAN. Cambodia's collaboration with the Asian Development Bank (ADB) and Vietnam's AMI AC Renewables project, supported by international grants, highlight the importance of global cooperation in fostering renewable energy initiatives. These partnerships bring in technical expertise and capital, accelerating the deployment of BESS.

Diverse Approaches

Economic and Technological Readiness:

- The level of economic development and technological readiness varies significantly across ASEAN countries, influencing their approach to BESS adoption. Singapore, with its advanced infrastructure and robust regulatory framework, is leading in large-scale BESS projects like the Sembcorp Energy Storage System. In contrast, countries like Malaysia are in the early stages, focusing on pilot projects and feasibility studies to assess BESS potential.

Regulatory and Market Dynamics:

- The regulatory and market environments vary widely, affecting the pace and scale of BESS adoption. Malaysia's structured regulatory oversight for its 400 MWh pilot project contrasts with the more flexible, exploratory approach seen in Cambodia's collaboration with ADB. These differences reflect varying levels of regulatory maturity and market readiness across the region.

In conclusion, while ASEAN countries share common goals and trends in adopting BESS, their diverse economic conditions, technological capabilities, and regulatory contexts lead to varied approaches and outcomes. Government support, pilot projects, renewable energy integration, and international collaboration are driving the region's progress.

However, tailored strategies that consider each country's unique circumstances will be essential to fully realise the potential of BESS, enhancing energy security, grid stability, and sustainability across ASEAN.

Energy Trading Markets and Carbon Credit Systems



Understanding the energy trading market and carbon credit environment is essential for evaluating the potential of BTM BESS solutions in ASEAN. The energy trading market enables the efficient distribution and utilisation of energy resources, providing opportunities for BESS to participate in ancillary services and peak shaving.

Additionally, the carbon credit environment incentivises the reduction of greenhouse gas emissions by allowing BESS projects to earn carbon credits, thus enhancing their financial viability. This section explores how these markets operate in various ASEAN countries, the opportunities they present for BESS adoption, and their role in promoting sustainable energy practices across the region.

Cambodia

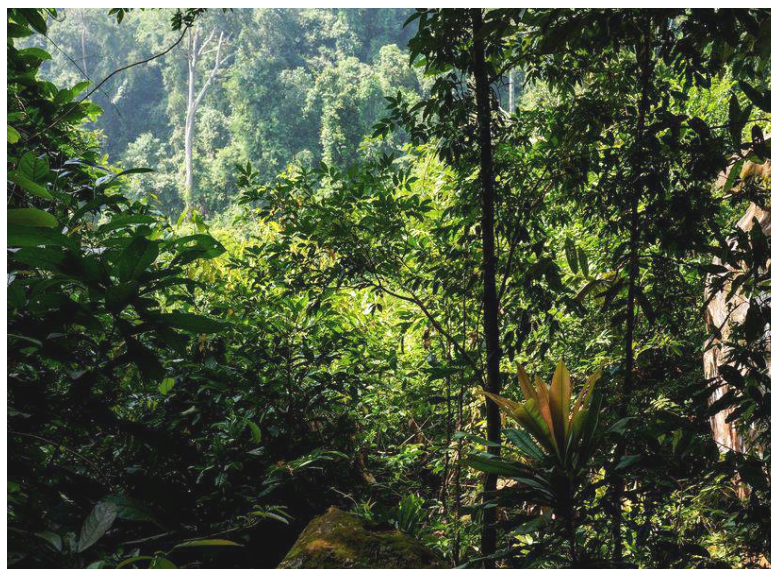
Energy Trading Environment

- **Regulatory Body:** The Electricity Authority of Cambodia (EAC) oversees the regulatory framework for the energy sector, ensuring compliance and fostering development within the industry[63].
- **Market Structure:** The electricity supply in Cambodia is managed by the state-owned Electricité du Cambodge (EDC), which plays a central role in the generation, distribution, and regulation of electricity within the country[64].

Carbon Credit Mechanism

Voluntary Carbon Market:

Through REDD+, Cambodia generates carbon credits by conserving forests and reducing emissions, contributing to global voluntary carbon markets. These efforts are further supported by a recent MOU[65] signed with Singapore, aiming to collaborate on carbon credits in alignment with Article 6 of the Paris Agreement. This MOU is a step towards formalising a framework for the international transfer of carbon credits, facilitating both countries in achieving their NDCs.



Indonesia

Energy Trading Environment

- **Regulatory Body:** The Ministry of Energy and Mineral Resources (MEMR), DG of Electricity, and DG of New and Renewable Energy regulate the power sector. The MEMR also oversees the regulatory framework for the energy sector, ensuring compliance and fostering development within the industry[66].
- **Market Structure:** The electricity supply in Indonesia is managed by the state-owned Perusahaan Listrik Negara (PLN), which plays a central role in the generation, distribution, and regulation of electricity within the country[67].

[63] <https://www.eac.gov.kh/site/responsibility>

[64] <https://opendevdevelopmentcambodia.net/topics/electricity-infrastructure/>

[65] Singapore and cambodia sign memorandum of understanding to collaborate on carbon credits. MTI. (2023, April 26).

[66] <https://www.adb.org/sites/default/files/institutional-document/666741/indonesia-energy-asr-update.pdf>

[67] <https://www.indonesia-investments.com/id/bisnis/profil-perusahaan/perusahaan-listrik-negara-pln-soe/item409>



Carbon Credit Mechanism

- **Indonesia Stock Exchange (IDX) [68]:** The IDX took a key step towards environmental sustainability by officially launching carbon trading operations on September 26, 2023. This development followed the issuance of a carbon exchange license by the Financial Services Authority (OJK) on September 18, 2023, aligning with Indonesia's goal to reduce its emissions by 31.89 percent by 2030.

The IDX oversees the carbon trading market, aiming to incentivise positive environmental practices within the Indonesian economy, particularly in the energy sector. The carbon trading framework is based on the Decree on Carbon Trading, which outlines two main types of carbon units available for trading:

1. **Undertakings Emission Ceiling Technical Approval (PTBAE-PU):** These units are approvals for technical emissions ceilings granted to businesses operating in specific sectors, allowing them to trade these allowances as part of managing their carbon footprint.
 2. **GHG Emission Reduction Certificate (SPE-GRK):** These certificates represent quantifiable reductions in greenhouse gas emissions and can be traded among entities within the exchange, promoting investments in emission reduction projects.
- **Foreign Carbon Units:** The IDX facilitates the trading of foreign carbon units, provided they are registered with the OJK, opening the door for international participation in Indonesia's carbon market.

Malaysia

Energy Trading Environment

- **Regulatory Body:** Energy Commission of Malaysia[69] (EC)
- **Market Structure:** The Malaysian Electricity Supply Industry (MESI) operates a single buyer model for electricity procurement[70]. The market includes bilateral contracts and power purchase agreements (PPAs).

[68] Indonesia Stock Exchange (IDX) launches Carbon Trading Operations. ASEAN Business News. (2023, November 3).

[69] <https://www.st.gov.my/eng/details/aboutus/1>

[70] <https://www.singlebuyer.com.my/MESI.php>

Key Features:

- Centralised procurement through the Single Buyer.
- Efforts towards market liberalisation and the introduction of the New Enhanced Dispatch Arrangement (NEDA).
- Renewable Energy Certificate (REC) trading.

Carbon Credit Mechanism

- **Malaysia Green Technology Corporation (MGTC):** Facilitates carbon reduction projects and carbon credit trading.
- **Voluntary Carbon Market (VCM):** Bursa Carbon Exchange (BCX)[71]: A shariah-compliant voluntary carbon market exchange enabling the trading of high-quality carbon credits through standardised contracts.

Function and Impact of BCX:

- BCX facilitates financing and development of domestic projects aimed at reducing or removing GHG emissions.
- Allows corporations to purchase carbon credits, aiding in balancing their carbon output and stimulating investment in green technologies and initiatives within Malaysia.



Philippines

Energy Trading Environment

- **Regulatory Body:** Energy Regulatory Commission (ERC)[72]
- **Market Structure:** The Philippines operates the Wholesale Electricity Spot Market[73] (WESM), a real-time market.

Key Features:

- WESM operates as a real-time market with transparent and competitive electricity pricing.
- Efforts to enhance market efficiency and reliability.

[71] Bursamalaysia.com. BURSA MALAYSIA. (n.d.).

[72] <https://www.erc.gov.ph/Objectives-and-Core-Values>

[73] <https://www.iemop.ph/the-market/>



Carbon Credit Mechanism

- No formal carbon trading market as of now.
- **Partnerships:** Collaborations with Japan for low-carbon energy projects.
- **Regulated Carbon Market:** Pending legislation for a Low Carbon Economy Act to establish a cap-and-trade system[74].

Singapore

Energy Trading Environment

Regulatory Body: Energy Market Authority (EMA) [75]

Market Structure: Singapore operates the Wholesale Electricity Market (SWEM), which includes the National Electricity Market of Singapore (NEMS). This market features a spot market, forward market, and derivatives market, providing transparent and competitive electricity pricing.

Key Features:

- Real-time pricing based on supply and demand.
- Transparent and competitive market structure.
- Integration of renewable energy sources.

NEMS Operations[76]:

- Began official operations on January 1, 2003, as the first liberalised electricity market in Asia.
- EMA oversees market supervision, and the Energy Market Company (EMC) operates the wholesale market, conducting live bidding every 30 minutes.
- The electricity retail market fully opened in 2018, allowing power generation companies to sell electricity in the wholesale market every half hour, with prices determined by real-time supply and demand. Electricity retailers buy in bulk from the wholesale market and sell to consumers through fixed-price contracts.

[74] <https://enviliance.com/regions/southeast-asia/ph/ph-carbon-credit>

[75] <https://www.ema.gov.sg/about-ema/who-we-are>

[76] Energy Market Company – Guide to Participation in the Singapore Wholesale Electricity Market

Carbon Credit Mechanism

- **Carbon Tax:** Implemented since 2019, set at SGD 5 per tonne of CO₂-equivalent emissions to incentivise emission reductions. Under the Carbon pricing (Amendment) Bill, price of carbon credits to increase to S\$25 per tonne from 2024 and S\$46 per tonne from 2026[77].
- **Sustainable Energy Association of Singapore (SEAS)[78]:** Promotes carbon trading and renewable energy projects.

- **Carbon Exchange:**

CIX Exchange[79]: Climate Impact X support low-carbon projects through a transparent, efficient, and scalable market, offering a credible venue for trading carbon credits. This initiative not only helps organisations in achieving their sustainability goals but also plays a crucial role in the global fight against climate change.



Thailand

Energy Trading Environment

Regulatory Body: Energy Regulatory Commission (ERC)[80]

Market Structure: Thailand's electricity market is operated by the Electricity Generating Authority of Thailand (EGAT) under a single buyer model, with bilateral contracts and power purchase agreements (PPAs)[81].

Key Features:

- Gradual steps towards market liberalisation.
- Focus on cross-border electricity trade with neighbouring countries.
- Development of renewable energy projects and Renewable Energy Certificates (RECs).



[77] <https://www.kwm.com/hk/en/insights/latest-thinking/development-of-carbon-trading-markets-in-southeast-asia.html>

[78] <https://www.seas.org.sg/about-us>

[79] <https://www.kwm.com/hk/en/insights/latest-thinking/development-of-carbon-trading-markets-in-southeast-asia.html>

[80] <https://www.erc.or.th/en/history-page>

[81] <https://www.adb.org/sites/default/files/linked-documents/49087-001-so.pdf>

Carbon Credit Mechanism

- Thailand Greenhouse Gas Management Organisation (TGO) [82]: Oversees the carbon credit market and promotes Clean Development Mechanism (CDM) projects.
- FTIX (First Voluntary Carbon Credit Exchange)[83]: Launched in September 2022, FTIX is a collaborative effort between the Federation of Thai Industries and TGO.

Role of FTIX:

- Comprehensive trading platform supporting the government's voluntary emission reduction programme.
- Enables trading of carbon credits, renewable energy, and RECs.
- Provides a mechanism for enterprises to certify and trade their carbon offsetting efforts.
- Plans to expand capabilities to international trading in the future, enhancing the platform's utility and impact

Vietnam

Energy Trading Environment

Regulatory Body: Electricity Regulatory Authority of Viet Nam (ERAV) and Ministry of Industry and Trade (MOIT)[84]

Market Structure: Vietnam operates the Vietnam Competitive Generation Market (VCGM)[85] and the Vietnam Wholesale Electricity Market (VWEM)[86], transitioning from a single buyer model to a competitive market.

Key Features:

- Transition from a single-buyer model to a competitive market.
- Development of wholesale electricity market (VWEM).
- Integration of renewable energy and feed-in tariffs.

Carbon Credit Mechanism

- Vietnam's Emission Reduction Purchase Agreement (ERPA)[87]: Facilitates carbon credit trading through emission reduction projects.



[82] https://tver.tgo.or.th/index.php?option=com_sppagebuilder&view=page&id=1249&lang=en&Itemid=1444

[83] Thailand launches Carbon Credit Exchange: Lombard Odier Asia. Thailand launches carbon credit exchange | Lombard Odier Asia. (2023, March 17).

[84] <https://moit.gov.vn/en/administrative-departments/directorate-agency/electricity-regulatory-authority-of-vietnam>

[85] <https://en.vmw.com.vn/more/vietnam-competitive-generation-market-vcgm.html>

[86] <https://www.allens.com.au/insights-news/insights/2023/04/New-regulations-for-determining-electricity-generation-prices-of-power-projects-participating-in-Vietnams-Wholesale-Electricity-Market/>

[87] <https://vietnamnews.vn/economy/business-beat/1639211/viet-nam-has-great-potential-in-development-of-carbon-credit-market.html>

National Carbon Market: Plans to establish a carbon market by 2025 as part of its climate strategy[88].

Clean Development Mechanism (CDM) [89]:

- Vietnam ranks 4th globally in the number of CDM Executive Board projects, reducing emissions by offering Certified Emission Reduction (CER) credits.
- These projects have resulted in substantial contributions to the global carbon market, with Vietnam accounting for 140 million tons of carbon dioxide reductions.

Joint Crediting Mechanism (JCM) with Japan[90]:

- Vietnam collaborates with Japan to produce ten million tons of carbon dioxide credits annually.
- This enhances Vietnam's carbon trading capacity and facilitates access to Japanese energy-saving and emissions-reducing technologies.

The adoption of BESS solutions in ASEAN faces varied challenges and opportunities, particularly in countries like Cambodia and the Philippines, where formal carbon trading markets are absent. The regional energy trading environments and carbon credit mechanisms play crucial roles in shaping the feasibility and attractiveness of BESS solutions.

In Cambodia, the energy sector is tightly regulated by the Electricity Authority of Cambodia (EAC) and managed by the state-owned Electricité du Cambodge (EDC). Although Cambodia has taken steps towards engaging in voluntary carbon markets through REDD+ initiatives and an MOU with Singapore, the lack of a formal carbon trading market limits direct financial incentives for BESS deployment. Nonetheless, these voluntary initiatives offer a potential pathway for leveraging international carbon markets to support BESS projects, which could be further enhanced by developing a structured carbon credit mechanism. Such developments could align Cambodia with global sustainability goals and attract necessary foreign investments to bolster its energy storage solutions.

Similarly, the Philippines operates its energy market through the Wholesale Electricity Spot Market (WESM), characterised by real-time and competitive electricity pricing. Despite this, the absence of a formal carbon trading market hinders the creation of robust financial frameworks needed to support large-scale BESS implementation. Nonetheless, the country's active partnerships with Japan and ongoing legislative efforts for a Low Carbon Economy Act signify a proactive approach toward emissions reduction and renewable energy adoption.

[88]<https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/energy-transition/052424-vietnam-expedites-domestic-carbon-market-development-to-tackle-cbam-article6#:~:text=Vietnam%20plans%20to%20establish%20a,carbon%20trading%20platform%20from%202025.>

[89] Progress report: Vietnam's Carbon Market, March 2023. Vietnam Briefing News. (2023, March 30).

[90]https://www.climatelinks.org/sites/default/files/asset/document/202204/LEAP%20II%20%20Carbon%20Markets%20Brief_final%20%28508%20Compliant%29.pdf

The impending cap-and-trade system could provide a robust framework for incentivising BESS, thereby enhancing grid efficiency and reliability. The success of these regulatory developments is critical for the Philippines to leverage BESS effectively as part of its broader sustainability and energy efficiency strategies.

In stark contrast, countries such as Indonesia, Malaysia, Singapore, Thailand, and Vietnam have established more advanced carbon trading markets and regulatory frameworks, significantly bolstering their capacity to adopt BESS solutions. Indonesia's carbon trading platform, launched by the Indonesia Stock Exchange (IDX), offers a structured environment for emissions trading, fostering positive environmental practices. This framework incentivises businesses to integrate BESS as part of their carbon management strategies, aligning financial benefits with sustainability goals.

Malaysia's Bursa Carbon Exchange (BCX) and Thailand's First Voluntary Carbon Credit Exchange (FTIX) also create beneficial conditions for BESS adoption by enabling the trading of high-quality carbon credits. These platforms not only provide financial incentives but also promote the financing of domestic projects aimed at reducing greenhouse gas emissions, stimulating investment in BESS technologies.

Singapore and Vietnam exemplify progressive approaches with their competitive electricity markets and comprehensive carbon management strategies. Singapore's real-time pricing market, carbon tax mechanism, and the Climate Impact X (CIX) exchange facilitate a transparent and efficient trading environment for carbon credits, encouraging BESS deployment to enhance grid stability and integrate renewable energy sources. Vietnam's transition to a competitive market, coupled with its extensive Clean Development Mechanism (CDM) projects and plans for a national carbon market by 2025, underscores its commitment to reducing emissions and fostering green technology investments, positioning BESS as a pivotal component of its energy strategy.

In conclusion, the varying degrees of regulatory support and carbon credit mechanisms across Southeast Asia significantly impact each country's ability to adopt BTM BESS solutions. While Cambodia and the Philippines face challenges due to the lack of formal carbon markets, their proactive steps towards voluntary initiatives and legislative changes provide a foundation for future growth. In contrast, countries with established carbon trading markets and supportive regulatory frameworks are better positioned to leverage BESS, aligning financial incentives with sustainability goals and enhancing energy efficiency. The development and enhancement of these mechanisms are crucial for accelerating BESS adoption across the region, contributing to global emissions reduction efforts and advancing energy security.






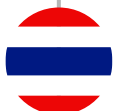

Challenges and Barriers



Despite its potential, the integration of BESS faces numerous challenges and barriers across different countries.

Each country presents a unique set of obstacles shaped by its economic, technical, regulatory, and infrastructural landscape. By understanding these challenges in detail, policymakers, investors, and industry stakeholders can develop tailored strategies to overcome barriers and promote the widespread adoption of BESS.

This analysis delves into the specific issues faced by Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam, highlighting the critical factors that impact BESS deployment in these nations.

Country	Challenges and Barriers to BESS Adoption
 Cambodia	<ul style="list-style-type: none"> • High investment costs of BESS technologies • Skills gap in Workforce
 Indonesia	<ul style="list-style-type: none"> • Presence of regulatory barriers such as the Local Content Regulations • Economic dependency on coal • Policy contradictions and inconsistencies
 Malaysia	<ul style="list-style-type: none"> • Immature Life for Second-life Batteries • Limited Integration of Smaller-Scale ESS • Policy and Regulatory Obstacles
 Philippines	<ul style="list-style-type: none"> • High investment costs of BESS technologies
 Singapore	<ul style="list-style-type: none"> • Regulatory Process • Climate concerns
 Thailand	<ul style="list-style-type: none"> • Current Market Design restricts competition • Inconsistent regulatory processes and policies
 Vietnam	<ul style="list-style-type: none"> • Many Barriers to Investments in RE projects • Policy Uncertainty and Administrative Inefficiencies



High Investment Costs

The high initial cost of BESS technologies and the need for substantial upfront investment pose many challenges. For example, based on ADB's report (ref. figure 5) on investment planning in Cambodia, the cost to implement a BESS project is roughly \$24.18 million[91].

Table 5: Financing Plan for BESS (\$ million)

Source	Amount (\$ million)	Share of total (%)
Green Climate Fund Loan	12.00	49.62%
Climate Investment Funds Loan	6.00	25.81%
Climate Investment Funds Grant	2.30	9.52%
Government of Cambodia	3.88	16.04%
Total	24.18	100%

Notes: Numbers may not sum precisely because of rounding.
Source: Asian Development Bank.

Securing financing for these projects can be particularly daunting in a market like Cambodia, where the energy sector's reliance on traditional power sources and the nascent stage of renewable energy adoption may deter small local businesses and consumers. Developing financial mechanisms and incentives to attract investment in BESS is a critical step toward overcoming these barriers.

Technical Expertise

The successful deployment and operation of BESS require a skilled workforce with expertise in advanced energy storage technologies. Cambodia faces the challenge of building this technical capacity[92], necessitating targeted training programmes and the development of local expertise in BESS technology, maintenance, and management. Enhancing technical skills is essential to support the long-term integration of BESS.

[91] <https://www.adb.org/sites/default/files/project-documents/52096/52096-001-tacr-en.pdf>

[92] Tech Talent Shortage Challenge for Cambodia, says ADB Study - Khmer Times. Khmer Times - Insight into Cambodia. (2022a, July 1).



Indonesia

Local Content Regulations on BESS

The stringent local content regulations[93], aimed at fostering domestic solar industry growth, inadvertently pose a challenge for BESS integration. With most solar project components requiring importation due to the local industry's limited production capacity, the development of solar projects—critical for charging BESS—becomes more expensive. This directly impacts the feasibility and cost-efficiency of deploying BESS as part of Indonesia's renewable energy strategy.

Coal Dependency

The Indonesian power generation mix's heavy reliance on coal[94] hampers the integration of renewable energy sources and, by extension, BESS. PLN's financial constraints, necessitating subsidies to offset deficits, along with existing long-term coal-based electricity contracts, limit local SMEs and households to invest in BTM projects that are essential for BESS viability. Without a decisive shift away from coal, the potential for BESS to stabilise and store renewable energy remains largely untapped.

Inconsistent Policies

Intriguingly, despite the Just Energy Transition Partnership (JETP) ambitious renewable energy targets, the Presidential Decree Number 112[95] introduced by the Indonesian government in 2022 facilitates a loophole for the construction of new coal power stations. These stations are earmarked for projects considered of "national strategic" importance, with a stipulation that they must cease operation by 2050 and achieve a 35% reduction in emissions within the next decade via technological improvements or carbon compensation. Initiatives are already in motion to erect new coal-powered installations for a purportedly sustainable industrial zone in Kalimantan[96].

This policy discrepancy undermines the nation's proclaimed commitment to renewable energy and the strategic integration of BESS, casting a shadow over the feasibility of Indonesia's net-zero emission objectives. This persistence in coal reliance is further exacerbated by factors such as the significant interests of political elites in the coal sector[97] and a surplus in coal production capacity.

Given the enduring dependence on fossil fuels for electricity generation and the slow progress in renewable energy uptake, the prospect of Indonesia meeting its ambitious climate and energy targets, including the effective deployment of BESS, seems increasingly challenging.

[93] Indonesia's local content requirements: An assessment on consistency with Free Trade Agreement commitments. navbar-brand. (n.d.).

[94] Linda Yulisman, W. S. and D. F. (2023, October 16). A dirty habit: Why Indonesia is addicted to coal and how it can go green. The Straits Times

[95] <https://peraturan.bpk.go.id/Details/225308/perpres-no-112-tahun-2022>

[96] <https://www.gpb.org/news/2023/02/06/despite-billions-get-off-coal-why-indonesia-still-building-new-coal-plants>

[97] <https://www.npr.org/2023/02/05/1152823939/despite-billions-to-get-off-coal-why-is-indonesia-still-building-new-coal-plants>



Limited Integration of Smaller-Scale ESS

Currently, the integration of smaller-scale energy storage systems is primarily restricted to individual solar PV systems that connect indirectly to the grid. Such installations must adhere to strict guidelines and technical specifications set by the Energy Commission[98]. This limitation reflects a cautious approach to integrating BTM BESS into the broader energy market, focusing mainly on supporting solar power generation on a smaller scale.

Inconsistent Policies

There is a lack of a comprehensive framework and guideline for BESS installation and operation in Malaysia. Unlike the solar PV sector, which benefits from a well-defined set of guidelines and standards encompassing aspects such as installation size limits, feed-in tariff rates, grid connection guidelines, safety requirements, and incentives, the BESS sector lacks similar official directives. The solar PV installation standards[99], for example, are clearly outlined in the Malaysian Standard MS1837 and further supported by the Sustainable Energy Development Authority and Energy Commission through tariffs, installation limits, and quotas. This robust framework has significantly contributed to Malaysia's ability to increase its PV installed capacity fivefold from 2015 to 2021 across residential, commercial, industrial, and large-scale solar (LSS) plant types[100].

In contrast, the absence of a formal regulatory environment for BESS introduces a high degree of uncertainty for stakeholders and investors, making it challenging to conduct a reliable lifecycle cost analysis for BESS adoption decisions[101]. This regulatory gap hinders the country's ability to leverage BESS as a critical component in its energy transition and grid modernisation efforts. These challenges highlight the complexity of integrating advanced energy storage solutions like BESS into Malaysia's energy infrastructure.

While the pilot BESS project marks a step forward, overcoming the hurdles related to market readiness, regulatory support, and the development of second-life battery applications will be crucial for Malaysia to fully leverage BESS technology in its transition towards a more sustainable and resilient energy system.

[98] Chiah, R., & Hin, R. K. B. (2022, June 2). In Review: Energy Regulation in Malaysia. Lexology.

[99] Moa, E.H.Y., Go, Y.I. Large-scale energy storage system: safety and risk assessment. Sustainable Energy res. 10, 13 (2023).

[100] Moa, E.H.Y., Go, Y.I. Large-scale energy storage system: safety and risk assessment. Sustainable Energy res. 10, 13 (2023).

[101] Moa, E.H.Y., Go, Y.I. Large-scale energy storage system: safety and risk assessment. Sustainable Energy res. 10, 13 (2023).



Philippines

Financing Hurdles

A primary obstacle in the development of renewable projects, including those involving BESS, is the reluctance of domestic banks to provide funding[102]. This hesitance stems from a combination of factors:

- **Lack of Sector Expertise:** Many local banks possess limited knowledge and understanding of the renewable energy sector, impacting their willingness to invest.
- **Perceived Risk due to High Costs:** Renewable projects, particularly those without secured power purchase agreements, are deemed risky by domestic banks due to the high investment costs[103]. This perception necessitates a re-evaluation of risk assessment tools to better align with the realities of renewable energy financing.



Singapore

Regulatory Process

The development and deployment of BESS in Singapore is not without its challenges[104]. Singapore's thorough regulatory framework ensures safety, reliability, and compliance with high standards. However, the meticulous approval process can extend project timelines and increase costs. Streamlining these procedures without compromising on safety and efficiency is a focus area for fostering a more conducive environment for BESS deployment.

Climate Concerns

The tropical climate, characterised by high temperatures and humidity, affects battery performance and lifespan. Singapore's BESS initiatives therefore include advanced cooling technologies and robust system designs to ensure reliable and safe operation in such conditions.

[102] Green bond market survey for the Philippines. (2022, July). ADB

[103] <https://asian-power.com/exclusive/philippines-track-energy-transition-re-targets-could-be-higher>

[104] NTU: Energy Storage Systems Technology roadmap for Singapore (2020).



Market Design Challenges

The electricity market structure in Thailand operates under an enhanced single buyer model, which primarily benefits large RE projects through government power purchasing policies[105]. This model places State-Owned Enterprises (SOEs) in the energy sector as dominant forces, initially leading the adoption and implementation of RE projects. Despite this, the model presents inherent conflicts, as these SOEs have an interest in maximising electricity sales, which contradicts the goals of energy conservation and renewable energy promotion that could potentially decrease their revenues[106]. This structure, while favouring large-scale RE projects, limits opportunities for other smaller players, which are increasingly significant in the renewable energy landscape.

Regulatory Inconsistencies

Thailand's energy transition, particularly in integrating BESS is hampered by regulatory, bureaucratic, and policy challenges. The unpredictability of permits and complex licensing pose substantial barriers, calling for a streamlined process. The introduction of financial incentives for solar power in 2007[107] led to an overwhelming number of applications, yet many projects did not commence due to policy inconsistencies and network capacity issues. This situation prompted a temporary pause in solar power development from 2010 to 2013[108].

The 2013 introduction of a fixed-rate feed-in tariff (FIT) for rooftop solar aimed to revive investor interest[109], yet it underscored the need for policy certainty to encourage investment in new technologies like BESS. While commercial and industrial segments showed strong uptake, residential adoption lagged, partly due to regulatory complexities and the need for clearer, more consistent support mechanisms.

These insights underscore the necessity for stable, clear policies and a unified regulatory approach to foster BESS growth, mirroring the requirements for a successful renewable energy transition. The BESS sector's integration into Thailand's energy landscape requires addressing these systemic challenges to reduce investment risks and capitalise on its potential for enhancing grid reliability and supporting renewable integration.

[105] Governing the Power Sector: An Assessment of Electricity Governance in Thailand. Bangkok, Thailand: WRI, (2006).

[106] Energy Transition in Thailand: Challenges and Opportunities (2017)

[107] Energy Transition in Thailand: Challenges and Opportunities (2017)

[108] Scaling Up Solar PV: A Roadmap for Thailand (2015)

[109] <https://policy.asiapacificenergy.org/node/6>



Investment Barriers

High costs and the need for private sector participation in grid expansion present significant barriers. Current investment rates for BESS installations range from \$360 to \$420 per kWh. An estimated \$14.9 billion in grid expansion investments is needed from 2021 to 2030, underscoring the critical role of private sector involvement.

Policy Uncertainty and Administrative Inefficiencies

Vietnam's electricity sector has faced significant challenges due to policy uncertainties, particularly over the last four years. PDP8 saw numerous revisions during its development, alongside the evolving Energy Masterplan, which left the sector in limbo regarding future energy strategies and decarbonisation efforts, deterring investment[110].

Additionally, the investment process is hindered by complex and inefficient administrative procedures, including site identification and land acquisition, which slows down grid development and act as investment barriers. The requirement[111] for projects to be included in the provincial annual land use plan, a process managed by the Provincial People's Council, introduces delays, and often does not align with project timelines. Despite the Law on Planning[112], introduced on 1st January 2019, aiming to streamline project inclusion, its complexity makes project implementation challenging. Such cumbersome regulations are particularly problematic for a developing country reliant on clear investment policies.

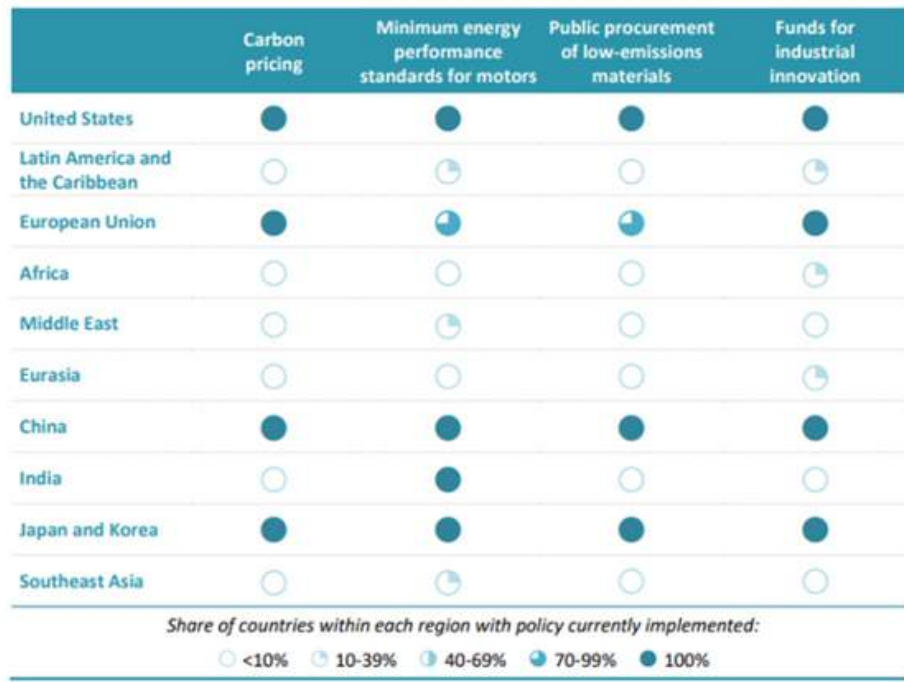
The deployment and adoption of BTM BESS across various countries are influenced by a complex interplay of financial, technical, regulatory, and infrastructural factors. High investment costs are a pervasive challenge, particularly in developing markets like Cambodia and the Philippines, where substantial upfront capital and the reluctance of financial institutions to fund renewable projects create significant barriers. Technical expertise is another critical factor, with countries like Cambodia needing to build local capacity through targeted training programmes to support BESS deployment.

[110] Energy Transition Partnership. (n.d.). Managing Vietnam's grid issues. energytransitionpartnership.org.

[111] <https://www.vietnam-briefing.com/news/land-rights-vietnam-what-they-are-and-how-you-can-acquire-land.html/>

[112] <https://www.mekongdeltaplan.com/storage/files/files/planning-law.pdf?>

Figure 9: Key energy demand policies for industry by region



Source: World Energy Outlook 2023

Regulatory landscapes play a crucial role in shaping BESS adoption. As highlighted in figure 9 above, Southeast Asia lags behind other regions in implementing key regulatory policies that promote BESS adoption. For instance, less than 10% of countries in Southeast Asia have implemented policies for carbon pricing, public procurement of low-emissions materials, and funds for industrial innovation. This lack of regulatory support contrasts sharply with regions like the European Union and Japan and Korea.

In Southeast Asia, stringent local content regulations in Indonesia, regulatory inconsistencies in Thailand, and the lack of a comprehensive framework in Malaysia underscore the challenges in creating a conducive regulatory environment for BESS. Policy uncertainty, as seen in Vietnam, and complex administrative procedures further exacerbate investment challenges, slowing down the pace of BESS adoption.

Despite these challenges, there are also opportunities for growth. Enhancing technical expertise, streamlining regulatory processes, and increasing financial incentives can significantly boost BTM BESS adoption. Countries that address these barriers effectively can achieve greater energy security, improved grid reliability, and progress toward their renewable energy targets.

Recommendations



Enhancing Policies and Creating an Enabling Environment

The advancement of BESS across ASEAN nations, each with its distinct energy landscape, necessitates a concerted effort to tailor policies and regulatory frameworks. These should not only align with the broader goals of energy security, sustainability, and carbon neutrality but also address country-specific challenges and opportunities. The following recommendations are aimed at fostering an environment conducive to the growth and effective integration of BESS technologies.

01 Targeted Policy Frameworks and Regulatory Support

Targeted Policy Frameworks and Regulatory Support are crucial for fostering the growth of BESS within the ASEAN region.

For instance, infrastructure readiness in Cambodia and investment challenges in Malaysia demand tailored regulatory approaches. Harmonising BESS regulations across ASEAN, while maintaining the flexibility to adapt to local contexts, can enhance the region's ability to implement and scale up BESS solutions effectively. Moreover, regulatory reforms aimed at streamlining BESS project approvals are essential to mitigate bureaucratic hurdles that can delay or deter project development, as observed in countries like Singapore and Thailand.

By fostering a supportive regulatory environment, ASEAN countries can attract more investment into the BESS sector, accelerate the deployment of these systems, and ultimately, contribute to the region's energy transition and climate goals.

- **Develop specific policies and regulatory frameworks:**

There is a pressing need for policies and regulations specifically designed to address the unique challenges and opportunities within each ASEAN country. For instance, Cambodia's focus on infrastructure readiness for BESS integration and Malaysia's emphasis on overcoming investment barriers require tailored approaches. This entails the development of harmonised BESS regulations across the region, offering a cohesive strategy that still allows for flexibility to cater to specific national contexts. For a full break down of country-specific policies, refer to Annex A.

- **Implement regulatory reforms to streamline BESS project approvals:**

The process of obtaining approvals for BESS projects can be cumbersome and time-consuming, often hindering the pace at which these projects can be developed and deployed. Learning from the experiences of countries like Singapore and Thailand, where regulatory challenges have been identified, ASEAN members should pursue reforms aimed at simplifying and expediting the approval process. This could involve establishing clear guidelines and timelines for project evaluations, reducing bureaucratic hurdles, and providing dedicated support services to assist project developers in navigating the regulatory landscape[113].

The implementation of these recommendations requires a collaborative approach, involving government agencies, regulatory bodies, industry stakeholders, and international partners.

02 Customised Incentive Structures

Customised incentive structures represent a tactical approach to fostering the development and deployment of BESS across diverse economic and regulatory landscapes. This concept revolves around the creation and implementation of financial mechanisms and policies designed specifically to address the unique challenges and opportunities within each country's energy sector. The rationale behind customising these incentives lies in the recognition that each country has its own set of economic conditions, energy market dynamics, and environmental targets, which in turn require a tailored approach to encourage the adoption of BESS technologies.

- **Establish incentive structures tailored to national contexts:**

Recognising the diverse economic and market conditions across ASEAN countries, it is crucial to design incentive structures that specifically encourage investment in BESS technologies. These incentives should be meticulously crafted to reflect the unique challenges and opportunities within each country, ensuring they effectively stimulate the growth of BESS projects. For instance, Cambodia, with its burgeoning renewable

[113] Kim E, Ha Y. Vitalization strategies for the Building Energy Management System (BEMS) industry ecosystem based on AHP analysis. *Energies*. 2021;14:2559.

energy sector and emphasis on solar power integration, may benefit from incentives that lower the initial capital costs of BESS, making renewable energy projects more viable and attractive to small local businesses and residential communities.

- **Subsidies, tax breaks, and financial incentives:**

A variety of financial mechanisms can be employed to encourage the adoption of BESS technologies[114]. Incentive structures should be meticulously designed to reflect the unique challenges and opportunities within each country. Implementing subsidies, tax breaks, and financial incentives can further lower the financial barriers to BTM BESS adoption. These could include reductions in import duties on BTM BESS components, income tax incentives for companies investing in energy storage, and direct financial incentives such as grants or low-interest loans.

The goal of these customised incentive structures is to make BESS projects financially attractive and feasible, thereby accelerating their adoption and integration into the energy mix of ASEAN countries.

03 **Focused Research and Development (R&D)**

Focused Research and Development (R&D) is an essential strategy for advancing the BESS landscape in the ASEAN region, particularly given the diverse set of environmental, technological, and socio-economic challenges present across different countries. Customised R&D efforts are essential to develop BESS technologies that can withstand unique local conditions—such as the hot and humid climates of Singapore, Malaysia, and Indonesia—while also addressing specific challenges like technical skill gaps in countries like Cambodia. The promotion of joint-research initiatives and public-private partnerships between governments, multilateral agencies and financial institutions is vital in this context. These collaborations can leverage the innovative prowess of the private sector alongside the regulatory and financial support of public institutions, creating a conducive environment for the development, testing, and deployment of effective and region-specific BESS projects.

- **Targeted R&D initiatives for localised challenges:**

It is essential to foster research and development efforts that are tailored to address the unique environmental, technical, and socio-economic challenges faced by ASEAN countries in deploying BESS. For instance, in regions with hot and humid climates, such as Singapore and parts of Indonesia and Malaysia, R&D could focus on developing BESS technologies that are resilient to such conditions, enhancing their efficiency and lifespan.

- **Promote joint-research and public-private partnerships:**

The complexity and scale of challenges in BESS deployment require collaborative efforts that leverage the strengths of both the public and private sectors. Encouraging joint-research initiatives can bring together the innovative capabilities of the private sector with the regulatory support and funding from public entities[115]. Such partnership

[114] [115] Cai, S., & Li, Y. (2021). Incentive policy for battery energy storage systems based on economic evaluation considering flexibility and reliability benefits. *Frontiers in Energy Research*, 9.

are crucial for developing and testing new BESS solutions that are cost-effective, efficient, and suitable for the specific needs of each ASEAN country. These collaborations can also serve as a platform for knowledge exchange, capacity building, and the creation of a skilled workforce dedicated to the BESS industry.

04 **Infrastructure and Capacity Building:**

Successful and sustainable electrification hinges on the foundational support of robust energy infrastructure. To accommodate the deployment of BTM BESS effectively, it is crucial for ASEAN countries to prioritise the enhancement of their energy infrastructure. This encompasses a broad range of activities, from upgrading existing grid systems to ensure they can handle the intermittent nature of renewable energy sources to specifically designing new infrastructure capable of integrating BESS technologies seamlessly. Proper integration is essential to harness the full potential of BESS, ensuring they can reliably store and dispatch energy as needed without causing disruptions or inefficiencies in the grid. For countries like Cambodia and the Philippines, where issues of grid stability and aging infrastructure are prevalent, this focus on modernisation is not just beneficial but essential for the reliable operation of their energy systems.

Moreover, the deployment of BESS itself contributes to the enhancement of grid and energy infrastructure. BESS can be strategically used to stabilise the grid and manage energy loads more efficiently, which in turn extends the lifespan of existing infrastructure and enhances overall functionality and resilience. By providing localised storage solutions, BESS can help balance supply and demand, reduce peak loads, and improve the reliability of the energy system.

- **Building Technical Capacity:**

The successful implementation and management of BESS technologies require a workforce that is both skilled and knowledgeable. This highlights the need for comprehensive workforce training programmes that cover the various aspects of BESS operation, from technical maintenance and troubleshooting to the regulatory and policy frameworks that govern their use. Special emphasis should be placed on countries like Cambodia, where there is a notable gap in technical expertise related to advanced energy systems. Developing a skilled workforce through targeted training initiatives and capacity-building measures^[116] will be key to overcoming these challenges and ensuring the smooth integration of BESS technologies.

- **Rural Electrification Efforts:**

Notable disparities in energy access between rural and urban areas, as observed in countries such as Indonesia and the Philippines, call for a concerted effort towards rural electrification. BESS can play a critical role in these efforts by enabling the storage and

[116] World Bank. (2023). Guidelines to implement Battery Energy Storage Systems ... Worldbank.org.

distribution of electricity generated from renewable sources in remote areas, thus bridging the energy access gap. Prioritising the electrification of rural areas through the deployment of smaller scale BESS solutions not only supports sustainable development but also promotes socio-economic growth by providing reliable energy access to underserved communities.

05 Engaging Industry Players

To accelerate the adoption of BESS within the ASEAN region, it is imperative to actively engage industry players across the energy sector. This includes energy companies, technology developers, and service providers, all of whom play a crucial role in advancing BESS solutions. Awareness and outreach efforts are essential in fostering an environment of collaboration and innovation. By highlighting the benefits and potential of BESS technologies, governments and industry bodies can encourage stakeholders to invest in research, development, and deployment, driving the collective effort towards sustainable energy solutions.

Moreover, the deployment of BESS itself contributes to the enhancement of grid and energy infrastructure. BESS can be strategically used to stabilise the grid and manage energy loads more efficiently, which in turn extends the lifespan of existing infrastructure and enhances overall functionality and resilience. By providing localised storage solutions, BESS can help balance supply and demand, reduce peak loads, and improve the reliability of the energy system.

- **Facilitating Industry Collaboration:**

The path to widespread BESS adoption is paved with challenges that no single entity or government can overcome alone. It is through collaboration and partnerships within the industry that these challenges can be addressed effectively. Governments should aim to create platforms and forums where private companies, public sector representatives, and research institutions can come together to share knowledge, exchange ideas, and explore collaborative projects. This collective approach not only accelerates technological advancements but also ensures that BESS solutions are tailored to meet the specific needs and conditions of the ASEAN region.

- **Public-Private Collaboration:**

A key component of engaging industry players is fostering public-private partnerships (PPPs) that leverage the strengths of both sectors. Multinational corporations (MNCs) like ABB, known for their professional and technical expertise in energy solutions, play an important role in this ecosystem. Governments can tap into the vast resources and innovation-driven technologies offered by such companies to enhance their BESS initiatives. ABB's extensive experience in power and automation technologies makes it a valuable partner in developing and implementing advanced BESS solutions. By collaborating with MNCs like ABB, governments can access cutting-edge technologies and best practices that can consequentially improve the efficiency, reliability, and sustainability of their energy storage systems.

- **Ministerial and Global Collaboration:**

Engagement should not be limited to national borders; ministerial and global collaborations play a critical role in the BESS landscape. By working together on an international scale, ASEAN countries can tap into a wider pool of knowledge, resources, and best practices. This includes forming partnerships with global organisations, other countries with advanced BESS deployments, and international technology providers like ABB. Such collaborations can enhance the region's capacity to implement cutting-edge BESS solutions, attract investment, and facilitate knowledge transfer.

- **Leveraging Global Networks:**

Engaging with global networks and platforms can provide ASEAN countries access to the latest BESS technologies and innovations. This involves participating in international forums, working groups, and alliances focused on energy storage solutions. By actively engaging in these global networks, ASEAN can ensure that it remains at the forefront of BESS development, benefiting from advancements in technology, policy, and market strategies.

- **Identification of Major Energy Consumers:**

Significant energy consumers, particularly in heavy industries such as steel mills and cold-chain facilities, should be strategically targeted with BTM BESS solutions. By focusing on these major energy consumers, stakeholders can optimise the deployment of BTM BESS where it will have the most substantial impact. This targeted approach is essential for managing peak demand, improving energy reliability, and enhancing the overall efficiency of energy use in these high-consumption sectors. The strategic deployment of BTM BESS in these industries is anticipated to result in significant energy savings and contribute to the overall stability and resilience of the grid.

Leveraging International Collaborative Initiatives

01

Strategic Utilisation of International Collaborative Initiatives

In navigating the complexities of BESS adoption, ASEAN countries stand to gain remarkably from leveraging international collaborative initiatives and policies. One such landmark framework is the ASEAN-EU Plan of Action, which sets targets for climate neutrality and sustainable economic growth. ASEAN countries can align with such international standards to address specific local challenges in BESS adoption, ensuring that the solutions implemented are not only effective but also environmentally sustainable.

02 **Green Initiative TEI in Partnership with ASEAN/South-East Asia**

The Team Europe Green Initiative[117] focuses on various pillars including green and smart cities, biodiversity and sustainable landscapes, clean, affordable, and secure energy, sustainable food systems, and circular economy. These pillars align closely with the goals of BESS adoption, offering synergistic opportunities for collaboration and progress.

Key Contributions of the Green Initiative TEI:

- **Financial Support:** The initiative brings substantial financial contributions, including a €783 million contribution to the ASEAN Catalytic Green Finance Facility from EU, EIB, KfW, AFD, and CDP. This funding can help to boost ASEAN's efforts in BESS adoption, providing vital resources for implementation and innovation.
- **Partnerships for Urban Solutions:** Through partnerships like the ASEAN Green Smart Cities project[118], the initiative provides avenues for collaboration in implementing BESS solutions in urban environments. This offers tangible opportunities for ASEAN cities to become more energy-efficient, resilient, and sustainable.
- **Support for Civil Society:** The initiative supports civil society in green advocacy and digital environmental education for young people. This support strengthens the movement towards sustainability and can help to address the issues of technical capacity in ASEAN.
- **Empowering Businesses:** Assistance to ASEAN businesses in profiting from green transition opportunities is another vital aspect of the initiative. By supporting businesses in adopting BESS technologies and sustainable practices, the initiative drives economic growth alongside environmental sustainability.

03 **Utilising Platforms for Targeted Technology Transfer and Green Finance**

Utilising platforms for targeted BESS technology transfer facilitates the exchange of knowledge and expertise, fostering collaboration between BESS technology providers and adopters. These platforms curate valuable resources, including green finance opportunities, to accelerate the adoption of BESS technology and drive sustainable energy solutions.

[117] europa.eu. (n.d.). Green initiative TEI in partnership with ASEAN/south-East Asia.

[118] asean.org. (2021, November). Smart Green ASEAN Cities: New initiative to promote sustainable and smart cities in ASEAN.

04 **Green Climate Fund: Energy Generation Access**

Under the energy transition initiative[119], the Green Climate Fund (GCF) scales up investment in renewable energy and energy efficiency within three main areas:

- **Energy Generation from Renewable Sources:**

GCF supports the deployment of BESS alongside renewable sources such as wind, solar, geothermal, hydro, and sustainable bioenergy. This includes financing transformational planning and programming to integrate BESS into long-term clean energy plans, catalysing innovation in BESS technologies and business models, mobilising funds at scale to de-risk investments in BESS projects and sharing knowledge to replicate successful BESS initiatives.

- **Efficient and Reliable Energy Transmission, Distribution, and Storage:**

GCF invests in BESS as part of efforts to enhance energy transmission, distribution, and storage systems. This involves supporting innovative BESS technologies and business models, mobilising funds to de-risk BESS investments, and sharing knowledge to promote the adoption of best practices in grid capacity, storage, and flexibility for higher penetration of renewable energy.

- **Promoting Access to Clean Energy:**

GCF promotes access to clean energy through investments in BESS projects that contribute to sustainable development and climate resilience while reducing emissions. This includes supporting the development of BESS solutions tailored to local needs, mobilising funds to unlock local capital for BESS projects, and sharing knowledge to strengthen the scientific verification of the link between BESS adoption, increased climate resilience, and access to electricity.

GCF's investments in BESS are anchored in the principle of country ownership and are aligned with existing national planning processes, such as NDCs, Technology Need Assessments (TNAs), and National Adaptation Plans (NAPs). Through its Readiness programme, GCF provides grants to help countries develop bankable investment plans based on their NDCs, including plans for integrating BESS into their energy transition strategies.

05 **ADB: Energy Transition Mechanism Partnership Trust Fund (ETMPTF)**

The Energy Transition Mechanism Partnership Trust Fund (ETMPTF)[120] is a collaborative initiative established in June 2022 under the Clean Energy Financing Partnership Facility[121]. It aims to accelerate the transition from coal-based power to clean energy in Asian Development Bank's (ADB) developing member countries (DMCs) by expediting the retirement of coal plants and facilitating the adoption of clean energy solutions to mitigate greenhouse gas emissions.

[119] Green Climate Fund. (2023, March 8). Energy Generation and Access.

[120]adb.org. (n.d.). Energy transition mechanism partnership trust fund. Asian Development Bank.

[121] adb.org (n.d.). Clean Energy Financing Partnership Facility. Asian Development Bank. y

ETMPTF supports projects focused on reducing greenhouse gas emissions by retiring or repurposing coal-fired power plants for clean energy, increasing the deployment of clean energy technologies, assisting DMCs in developing and implementing policies for transitioning from coal to clean energy, and ensuring a just transition to cleaner energy sources. All DMCs are eligible for support under ETMPTF, with priority given to DMCs in Southeast Asia, particularly Indonesia, Philippines, and Vietnam, during the initial phase.

06 **The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025**

The ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025^[122] stands as a platform for fostering technology transfer within the region, particularly in the realms of renewable energy and BESS. This strategic framework is designed to streamline the sharing of best practices and advanced technologies that are tailored to overcome the distinct challenges encountered by ASEAN countries. By leveraging APAEC, member states can access a repository of successful models and innovative solutions that have been effective elsewhere in the ASEAN region, allowing for their adaptation and implementation in local contexts. This targeted approach to technology transfer is crucial for enhancing the efficiency and sustainability of BESS deployments across diverse environmental and infrastructural landscapes.

- **Facilitating Regional Collaboration:**

In addition to technology transfer, APAEC also serves as a catalyst for fostering collaboration among ASEAN countries. This collective effort is essential for addressing shared challenges such as investment hurdles, regulatory barriers, and the development of technical skills pertinent to BESS. Through facilitated collaboration, member countries can pool resources, share insights, and jointly develop strategies that address the multifaceted aspects of BESS deployment. This collaborative approach not only accelerates the adoption of BESS technologies but also ensures that solutions are optimised for regional applicability.

By capitalising on platforms like APAEC for technology transfer and regional collaboration, ASEAN countries can enhance their capabilities in renewable energy and BESS deployment. This strategy promotes a unified approach to overcoming obstacles, leveraging shared knowledge and resources to tackle investment challenges, regulatory complexities, and skill gaps in the BESS sector. As a result, ASEAN can move closer to achieving its energy and sustainability goals, with BESS playing a central role in the region's transition to a greener, more resilient energy future.

[122] ASEAN Centre for Energy (ACE). (n.d.). ASEAN plan of Action for Energy Cooperation (APAEC) 2016-2025 - Phase I: 2016-2020. Asean.org

Global Case Studies and Emerging Technologies

Leading Countries in BTM BESS Adoption

The global BESS landscape highlights several countries that are at the forefront of BTM BESS adoption and deployment. These case studies provide valuable insights into best practices and innovative approaches that can be emulated to accelerate BESS integration worldwide.



Germany: Leading in Residential and Commercial BTM Storage

Overview:

Germany has been at the forefront of deploying BTM battery storage systems, particularly in conjunction with solar photovoltaic (PV) installations. By the summer of 2018, Germany had approximately 100,000 commercial and residential solar PV systems integrated with BTM storage[123]. This number double by 2020[124], illustrating the rapid adoption and scalability of these solutions.

Key Drivers

- **Financial Incentives and Subsidies:**

The German government provided substantial incentives and subsidies to encourage the adoption of solar PV and BTM storage systems. These financial benefits reduced the upfront costs for consumers, making the investment more attractive.

- **Energy Security and Independence:**

Consumers in Germany were motivated by the desire for energy security and independence from the traditional power grid. BTM storage systems allowed them to store excess solar energy generated during the day for use during peak demand times or at night.

- **Technological Advancements:**

Continuous advancements in battery technology, particularly in lithium-ion batteries, reduced costs and improved the efficiency and lifespan of BTM storage systems.

[123] Rathi, A. (2018), "100,000 homes in Germany now have battery-storage systems connected to the grid", Quartz, <https://qz.com/1372939/100000-homes-ingermany-now-have-battery-storage-systemsconnected-to-the-grid/>.

[124] Parkin, B. (2018), Germany Kicking Off Home Solar Battery Boom as Prices Drop

Case Study: sonnenCommunity

Overview:

The sonnenCommunity is an aggregator in Germany consisting of around 10,000 customers with battery storage, solar PV generation, or both. Launched in 2015, the sonnenCommunity was primarily used for peer-to-peer trading within the virtual power plant. In 2017, the virtual power plant began providing frequency regulation services to the power grid.

Key Features and Benefits:

- **Peer-to-Peer Trading:** The sonnenCommunity allowed members to trade energy peer-to-peer, optimising the use of locally generated solar power and storage.
- **Frequency Regulation:** By 2017, the virtual power plant provided primary frequency regulation services to the grid. This distributed “virtual” storage resource could react very quickly (sub-second), making it highly effective for grid stability.
- **Energy Independence:** Typically, members of the sonnenCommunity could cover 80% of their electricity needs using their solar and/or battery systems. The remaining electricity was purchased from the grid[125].

Challenges and Innovations:

- **Grid Congestion Management:** In 2016, measures to manage grid congestion cost Germany around EUR 800 million, with a significant portion for wind curtailment[126]. Re-dispatch measures were necessary as wind energy produced in the north could not be transported to industrial centers in the south.
- **Blockchain Integration:** In 2017, sonnen partnered with the German grid operator TenneT to launch the pilot project sonnen eServices. This project integrated batteries into the power system via a blockchain solution developed by IBM. The network of residential solar batteries helped reduce limitations imposed on wind energy during times of insufficient transport capacity.

Outcomes and Benefits:

- **Cost Savings:** Members of the sonnenCommunity benefited from significant energy cost savings by utilising their own generated power and participating in peer-to-peer trading.
- **Grid Support:** The virtual power plant provided crucial frequency regulation services, enhancing overall grid stability and reducing the need for traditional peaking power plants.

[125] St. John, J. (2016), “Sonnen raises \$85M to scale its behind-the-meter battery business”, Greentech Media, <https://www.greentechmedia.com/articles/read/sonnen-raises-85m-to-scaleits-behind-the-meter-battery-business>.

[126] Grey Cells Energy (2018), “Sonnen’s ‘Community’: Aggregating domestic battery storage”, <https://greycellsenergy.com/examples/sonnens-community-aggregating-domesticbattery-storage/>.

- **Innovative Solutions:** The integration of blockchain technology in the Sonnen eServices project showcased innovative approaches to managing grid congestion and optimising renewable energy use.

Challenges and Lessons Learned

- **Initial High Costs:**

Despite subsidies, the initial investment costs for BTM storage systems were still relatively high for many consumers. This barrier was gradually overcome as technology costs declined.

- **Regulatory and Policy Support:**

Strong regulatory and policy frameworks were crucial in driving the adoption of BTM storage systems. Continuous government support was necessary to maintain momentum.

Australia: Pioneering Large-Scale BTM Storage



Overview:

Australia has been a pioneer in large-scale deployment of BTM storage systems, driven by the high penetration of residential solar PV installations and favourable government policies. By 2020, Australia had installed over 110,000 residential battery systems[127], a significant increase from previous years.

[127] https://www.sunwiz.com.au/wp-content/uploads/2021/03/SunWiz-Australian-Battery-Market-2021-Purchasers_Redacted.pdf

Key Drivers

- **Government Incentives:**

National and state-level schemes[128], including tax breaks, subsidies, and interest-free loans, incentivised the installation of BTM batteries. These financial benefits made it more affordable for consumers to adopt these systems.

- **Network Tariff Reform:**

As part of its network tariff reform starting in 2017, the Australian Energy Regulator mandated [129] suppliers to transition from flat to variable, cost-reflective tariffs. This reform increased the attractiveness of BTM storage by allowing consumers to optimise their energy usage and reduce costs.

- **Policy Developments:**

In November 2023, energy and climate change ministers in Australia agreed to develop a National Consumer Energy Resources Roadmap[130]. By March 2024, they agreed to a range of priority reforms, including nationally consistent standards, new consumer protections, and network reforms to unlock consumer benefits from BTM generation and storage.

Case Study: The Virtual Power Plant in South Australia (VPP-SA)

Overview:

The VPP-SA project[131], announced in late 2016, was the first virtual power plant (VPP) project of its scale in Australia. The project aimed to explore three components of the VPP value chain:

1. **Customer and Field Operations:** The sale and installation of 1,000 BTM battery energy storage systems (BESS) across metropolitan Adelaide.
2. **Technical Capabilities:** The technical capabilities of BESS orchestration, incorporating both hardware and software performance.
3. **Value Pool Assessment:** The accessible value of BESS orchestration, including customer solar self-consumption value, network services, and wholesale market services (energy and Frequency Control Ancillary Services - FCAS).

Planned Project Outcomes and Achievements:

- **Objective:** Demonstrate at a commercial scale (5MW/7MWh and 950 battery systems minimum) the ability to control large numbers of distributed energy storage systems as a VPP to achieve various benefits.

[128] <https://jfklectrical.com.au/government-solar-panel-incentives/#:~:text=The%20Home%20Battery%20Scheme%20provides%20grid%2Dconnected%20South,system%2C%20and%20a%20solar%20panel%2C%20if%20required.>

[129] <https://www.aer.gov.au/about/strategic-initiatives/network-tariff-reform>

[130] <https://www.energy.gov.au/sites/default/files/2024-07/national-consumer-energy-resources-roadmap.pdf>

[131] <https://www.energymining.sa.gov.au/consumers/solar-and-batteries/south-australias-virtual-power-plant>

Outcomes Achieved:

- **Customer Benefits:** The project provided the ability for energy storage systems installed ‘behind the meter’ to deliver multiple services for the benefit of the customer, retailer, and network service provider (NSP). This included reducing customer bills and network peak demand, wholesale market arbitrage/cap trading, provision of FCAS services, and other grid support services (e.g., voltage support).
- **Commercial Scale Success:** AGL, the project leader, sold, installed, and orchestrated a full 5MW fleet of VPP BESS. The project successfully demonstrated the capability for the fleet to create value for consumers, networks, and wholesale market participants.

Key Features and Benefits:

- **Cost Savings:** Customers experienced significant energy cost savings by optimising the use of their solar generation and storage systems.
- **Grid Support:** The VPP provided essential grid support services, including frequency regulation and voltage support, enhancing overall grid stability and reliability.
- **Market Participation:** The VPP enabled participation in wholesale market services, providing additional revenue streams for consumers and enhancing the economic viability of BTM storage systems.

Challenges and Lessons Learned

- **Integration and Coordination:**

Ensuring seamless integration and coordination of a large number of distributed energy storage systems required sophisticated technology and close collaboration between stakeholders.

- **Regulatory Environment:**

Navigating the regulatory environment and securing necessary approvals was crucial for the project's success. Continuous engagement with regulators and policymakers was necessary to address challenges and adapt to changing regulations.

- **Consumer Engagement:**

Engaging and educating consumers about the benefits and operational aspects of the VPP was vital to achieving high participation rates and project success.

United States: Diverse BTM Storage Applications



Overview:

The United States has seen diverse applications of BTM storage systems across residential, commercial, and industrial sectors. With a strong emphasis on innovation and technological development, the US has become a leader in deploying advanced BTM storage solutions.

Key Drivers:

- **Inflation Reduction Act:**

The Inflation Reduction Act includes a residential clean energy credit that provides consumers with a 30% tax credit for the installation cost of clean energy equipment[132], including BTM battery storage systems with a capacity of at least 3 kWh.

- **State-Level Incentives:**

States like California, Arizona, Massachusetts, Hawaii, Colorado, and New York have implemented support packages for BTM storage, including time-of-use tariffs, additional incentives for self-generation, and specific storage tariffs. These measures make BTM storage systems more attractive and financially viable for consumers.

[132] IEA: World Energy Outlook Special Report: Batteries and Secure Energy Transitions

Case Study: Advanced Microgrid Solutions (AMS)

Overview:

Advanced Microgrid Solutions (AMS) uses different storage technologies and a data analytics software programme to provide commercial and industrial consumers with battery storage systems to optimise their energy usage. AMS also allows its fleet of battery storage systems to provide grid services to system operators. The data analytics software uses multiple data points, such as consumption, retail and wholesale energy prices, and energy efficiency metrics, to develop a customised energy profile for each customer. The software then optimises energy usage in real time, at both the building and fleet levels, to reduce costs.

Key Features and Benefits

- **Energy Optimisation:** The data analytics software optimises energy usage in real time, helping customers reduce their energy costs by leveraging the most cost-effective energy sources available.
- **Grid Services:** AMS's fleet of battery storage systems can provide essential grid services to system operators, enhancing grid stability and reliability.
- **Scalability:** AMS operates the world's largest virtual power plant (VPP), a 27 MW / 142 MWh fleet of batteries located at commercial and industrial sites across Southern California Edison's territory. This fleet delivered more than 2 gigawatt-hours of battery power for the utility in one year[133].

Project Outcomes:

- **Morgan Stanley:** AMS reduced the peak demand by 20% for Morgan Stanley using 500 kW / 1,000 kWh Tesla Powerpack batteries.
- **California State University:** AMS implemented a 2 MW / 12 MWh storage system spread across three sites at California State University, resulting in peak energy cost savings of USD 3.3 million.

Challenges and Lessons Learned:

- **Regulatory Compliance:**

AMS had to navigate a complex regulatory environment to secure the necessary approvals and ensure compliance with all relevant regulations. Continuous engagement with regulators and policymakers was essential to address these challenges and adapt to evolving regulations.

[133] St. John, J. (2019), "AMS breaks 2 gigawatthours in grid services", Greentech Media, <https://www.greentechmedia.com/articles/read/advanced-microgrid-solutions-breaks-2-gigawatthours-in-grid-services>.

- **Data Management:**

Managing and analysing vast amounts of data from multiple sources to optimise energy usage in real time was a significant challenge. AMS's success depended on the accuracy and effectiveness of its data analytics software.

- **Consumer Engagement and Education:**

Engaging and educating commercial and industrial consumers about the benefits and operational aspects of the VPP was vital for achieving high participation rates and project success. AMS had to invest in extensive outreach and support to ensure consumer buy-in.

Emerging Technologies: Advancements in Battery Technology for BESS

The future of BESS is being shaped by significant advancements in battery technology, addressing key issues such as cost, efficiency, and environmental impact. These innovations are crucial for overcoming challenges specific to Southeast Asia, including climate-related issues.

FEATURES	LITHIUM-ION (Li-ion)	IRON-BASED	ZINC-BASED
Energy Density	High	Medium	Medium
Thermal Management	Requires robust cooling	Less demanding	Less demanding
Safety	Fire risk, thermal runaway	High safety, stable	High safety, stable
Cycle Life	Long	Very long	Improving
Cost	High	Medium	Low to medium
Environmental Impact	Moderate	Low	Low
Maturity	High (widely deployed)	Medium (emerging)	Medium (emerging)
Efficiency	High (>90%)	Medium to High	Medium
Suitability for ASEAN	Requires significant cooling/fire suppression	Well-suited for hot climates	Well-suited for hot climates

Figure 10: Comparison Table of Batteries

1. Lithium-Ion Batteries (Li-ion)

Advantages:

- **High Energy Density:**

Li-ion batteries offer high energy storage capacity per unit weight, with an energy density of approximately 150-200 watt-hours per kilogram, making them efficient for space-constrained applications[134].

- **Efficiency:**

High round-trip efficiency (typically above 90%)[135].

[134] <https://www.bioenpower.com/blogs/news/the-pros-and-cons-of-lithium-ion-batteries-a-deep-dive>

[135] <https://www.aotbattery.com/new/Advantages-And-Disadvantages-Of-Lithium-ion-Batteries.html>

- **Maturity:**

Widely used and well-understood technology with extensive deployment in military, civilian and small electrical appliances.

- **Cycle Life:**

Relatively long cycle life, with the potential for thousands of charge/discharge cycles[136] (1,000 to 10,000).

Disadvantages:

- **Thermal Management:**

Requires robust cooling systems to manage heat, which can be a challenge in the hot and humid ASEAN climate[137].

- **Safety Concerns:**

Potential risk of thermal runaway and fire hazards[138].

- **Cost:**

Generally higher upfront cost compared to some alternative chemistries[139].

2. Iron-Based Batteries (e.g., Iron-Flow Batteries)

Advantages:

- **Thermal Stability:**

Better thermal stability compared to Li-ion batteries, reducing cooling requirements[140].

- **Safety:**

Lower risk of fire and explosion, enhancing safety in high-temperature environments[141].

- **Cycle Life:**

Excellent cycle life with little degradation over time[142].

- **Sustainability:**

Environmentally friendly due to earth's abundance of iron.

Disadvantages:

- **Lower Energy Density:**

Generally lower energy density compared to Li-ion batteries, requiring more space for the same energy storage capacity[143].

- **Efficiency:**

Slightly lower round-trip efficiency.

- **Commercial Availability:**

Less mature technology, with fewer commercially available products compared to Li-ion.

[136] <https://www.schumacherelectric.com/blog/the-benefits-of-lithium-ion-batteries/>

[137] <https://www.americansurplus.com/advantages-and-disadvantages-of-lithium-ion-forklift-batteries/>

[138] What Causes Thermal Runaway, Electrochemical Safety Research Institute, UL Research Institutes, <https://ul.org/research/electrochemical-safety/getting-started-electrochemical-safety/what-causes-thermal>

[139] <https://www.schumacherelectric.com/blog/the-benefits-of-lithium-ion-batteries/>

[140] <https://www.technologyreview.com/2022/02/23/1046365/grid-storage-iron-batteries-technology/>

[141] <https://goenergylink.com/blog/how-all-iron-flow-batteries-work/>

[142] [143] <https://www.sciencedirect.com/topics/engineering/flow-battery>

3. Zinc-Based Batteries (e.g., Zinc-Air, Zinc-Bromine Flow Batteries)

Advantages:

- **Thermal Management:**

Less demanding cooling requirements, better -suited for hot climate compared to Li-ion[144].

- **Cost:**

Potentially lower cost due to the abundance of zinc and relatively simple manufacturing processes[145].

- **Environmental Impact:**

Non-toxic and recyclable, with a lower environmental impact[146].

Disadvantages:

- **Energy Density:**

Lower energy density compared to Li-ion, similar to iron-based batteries[147].

- **Cycle Life:**

Can have issues with cycle life and efficiency degradation[148], although this is improving with technological advancements.

- **Development Stage:**

Still emerging with limited large-scale deployments compared to Li-ion.

Advancements in battery technology are crucial for the future of BESS, particularly in addressing the cost, efficiency, and environmental impact challenges faced by Southeast Asia. Lithium-Ion (Li-ion) batteries, with their high energy density and efficiency, remain dominant but pose thermal management and safety issues in hot climates. Iron-based batteries offer enhanced thermal stability and safety, making them suitable for the ASEAN region despite their lower energy density and commercial immaturity. Zinc-based batteries, being cost-effective and environmentally friendly, are well-suited for hot climates, though they still face challenges with energy density and cycle life. These innovations are pivotal for enabling behind-the-meter solutions in ASEAN, supporting a transition towards more sustainable and resilient energy systems. As technological advancements continue, a diversified approach using multiple battery chemistries will optimise BESS performance in Southeast Asia.

[144] <https://eepower.com/tech-insights/zinc-based-batteries-a-better-alternative-to-li-ion/#>

[145] [146] <https://www.spglobal.com/commodityinsights/en/ci/topic/alternative-battery-technology-review.html>

[147][148] <https://www.zimtu.com/understanding-zinc-ion-batteries-a-beginners-guide/>

Conclusion

In summary, this paper has methodically navigated the intricate landscape of BESS within the global and ASEAN context, identifying critical obstacles and articulating a suite of strategic recommendations to surmount these challenges. Central to this discourse is the imperative need for a targeted approach towards policy frameworks and regulatory support. Developing policies that address the specific challenges within each ASEAN country can enhance infrastructure readiness and streamline project approvals. Harmonising BTM BESS regulations across ASEAN, while maintaining flexibility for local contexts, can attract more investment and accelerate deployment.

Customised incentive structures are necessary to make BTM BESS projects financially attractive. Implementing subsidies, tax breaks, and financial incentives tailored to national contexts can lower the financial barriers to BTM BESS adoption and stimulate investment.

Focused research and development (R&D) initiatives tailored to local challenges, along with promoting joint research and public-private partnerships, are crucial. These efforts can drive innovation and develop cost-effective, efficient BTM BESS solutions suitable for the specific needs of each ASEAN country.

Enhancing energy infrastructure and capacity building is vital for the effective deployment of BTM BESS. This includes prioritising grid modernisation and workforce training in countries with significant grid stability and skilled manpower concerns and emphasising rural electrification to bridge energy access gaps.

Engaging industry players through awareness and outreach efforts, facilitating collaboration, and fostering public-private partnerships are essential for leveraging professional and technical expertise. This collaborative approach is crucial for driving innovation and advancing BTM BESS solutions within ASEAN.

Leveraging international partnerships and collaborative initiatives, such as the ASEAN-EU Plan of Action, and utilising platforms like the Green Climate Fund (GCF) and Asian Development Bank (ADB) for targeted technology transfer and regional collaboration, can enhance ASEAN's approach to BTM BESS adoption.

By addressing these areas, ASEAN countries can unlock the full potential of BTM BESS technologies, thereby enhancing their energy resilience, supporting renewable energy integration, and advancing towards their sustainability goals. The implementation of these recommendations demands a collaborative approach involving government agencies, regulatory bodies, industry stakeholders, and international partners, all moving in concert towards a sustainable and resilient energy future for the ASEAN region.

By addressing these areas, ASEAN countries can unlock the full potential of BESS technologies, thereby enhancing their energy resilience, supporting renewable energy integration, and advancing towards their sustainability goals. The implementation of these recommendations demands a collaborative approach, involving government agencies, regulatory bodies, industry stakeholders, and international partners, all moving in concert towards a sustainable and resilient energy future for the ASEAN region.

Annex A: Country-Specific Policy Recommendations

Cambodia

Challenges	Recommendations
Financial barriers	<ul style="list-style-type: none"> • Develop Financial Incentives: Implement policy measures such as tax breaks, subsidies, or feed-in tariffs specifically designed to lower the investment barrier for BESS projects. • Facilitate Access to Finance: Establish dedicated green finance mechanisms or funds to provide low-interest loans or guarantees for BESS projects, encouraging both local and international investors. • Risk Sharing Mechanisms: Introduce risk-sharing facilities or insurance products to mitigate perceived risks by investors and lenders in the renewable energy sector.
Skills gap in Workforce	<ul style="list-style-type: none"> • Capacity Building Programmes: Launch targeted training and education programmes in partnership with universities, technical institutes, and industry players like ABB to build a skilled workforce proficient in BESS and renewable energy technologies. • International Collaboration for Skills Transfer: Foster international collaborations and exchanges with countries that have advanced in BESS deployment, allowing for skills transfer and technical knowledge exchange. • Support for R&D and Innovation: Promote research and development in BESS technologies and applications, potentially through grants or incentives for innovation, to cultivate local expertise and technological advancements.

Indonesia

Challenges	Recommendations
Presence of regulatory barriers such as the Local Content Regulations	<ul style="list-style-type: none"> • Flexibility in Regulations: Advocate for amendments to local content regulations that offer more flexibility for BESS projects, potentially by introducing tiered compliance levels or exemptions for critical components that are not locally available. • Supporting Domestic Production: Invest in and support initiatives aimed at enhancing the domestic production capabilities for solar and BESS components, including R&D subsidies, technology transfer agreements, and partnerships between foreign and local firms.
Economic dependency on coal	<ul style="list-style-type: none"> • Diversification of Energy Portfolio: Encourage the government and PLN to adopt policies that promote energy diversification, reducing coal dependence by setting clear targets for renewable energy and BESS in the energy mix. • Financial Instruments for Transition: Work with international financial institutions and governments to create financial instruments and subsidies that make BESS projects financially viable for PLN, offsetting the economic attractiveness of coal. • Renegotiation of Contracts: Renegotiate long-term coal contracts to include more flexible terms that allow for the gradual integration of renewable energy sources and BESS, aligning with global sustainability targets.
Policy contradictions and inconsistencies	<ul style="list-style-type: none"> • Policy Harmonisation: Lobby for the harmonisation of energy policies to align with the Just Energy Transition Partnership (JETP) goals, ensuring that all new regulations reinforce the transition to renewable energy and the integration of BESS. • Stakeholder Engagement: Facilitate greater dialogue between government bodies, the private sector, and other key stakeholders to build consensus on the importance of consistent policies that support BESS and renewable energy adoption. • Strategic Environmental Assessments: Implement strategic environmental assessments for energy projects, ensuring that new coal projects are critically evaluated against their impact on Indonesia's renewable energy targets and environmental commitments.

Indonesia

Challenges	Recommendations
Presence of regulatory barriers such as the Local Content Regulations	<ul style="list-style-type: none"> • Flexibility in Regulations: Advocate for amendments to local content regulations that offer more flexibility for BESS projects, potentially by introducing tiered compliance levels or exemptions for critical components that are not locally available. • Supporting Domestic Production: Invest in and support initiatives aimed at enhancing the domestic production capabilities for solar and BESS components, including R&D subsidies, technology transfer agreements, and partnerships between foreign and local firms.
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Malaysia

Challenges	Recommendations
<p>Limited Integration of Smaller-Scale ESS</p>	<ul style="list-style-type: none"> • Guideline Revision: Revise existing guidelines and technical specifications to be more inclusive of various ESS applications beyond individual solar PV systems, facilitating broader integration into the grid. • Incentivise Distributed Storage: Implement policies to incentivise the deployment of smaller-scale ESS, including BESS, in residential, commercial, and industrial settings, such as rebates or tax deductions. • Promoting Distributed Energy Resources (DER) Integration: Develop and promote programmes that support the integration of distributed energy resources, including energy storage systems like BESS to enhance grid flexibility and resilience.
<p>Policy and Regulatory Obstacles</p>	<ul style="list-style-type: none"> • Regulatory Framework Development: Work towards establishing a comprehensive regulatory framework for BESS that includes guidelines on installation, operation, grid connection, safety requirements, and incentives, similar to the solar PV sector. • Stakeholder Engagement: Engage with stakeholders, including BESS providers, utilities, and end-users, in the development of these guidelines to ensure they address industry needs and concerns. • Clear Standards and Incentives: Adopt clear standards and provide incentives for BESS adoption, drawing on the successful implementation strategies of the solar PV sector. • Lifecycle Cost Analysis Support: Offer tools and resources to assist stakeholders in conducting reliable lifecycle cost analyses for BESS, reducing uncertainty, and encouraging investment. • Encourage participation from other industry players and stakeholders: Review current policies which limits foreign ownership of renewable projects.

Philippines

Challenges	Recommendations
<p>Lack of financial support and investment due to high risks and costs of BESS projects</p>	<ul style="list-style-type: none"> • Incentivise Renewable Investments: Implement government-backed incentives for banks and financial institutions that finance renewable energy projects, such as tax breaks or guarantees, to make these investments more attractive. • Create Competitive Return Frameworks: Encourage the development of financial products and services that offer competitive returns on renewable energy investments, challenging the prevailing preference for coal. • Risk Assessment Tools: Introduce or refine risk assessment models that accurately reflect the realities of renewable energy financing, potentially incorporating government guarantees or insurance products to reduce perceived risks. • Power Purchase Agreements (PPAs): Facilitate the establishment of secured PPAs for renewable projects to enhance their bankability, ensuring a stable revenue stream for investors and financiers.

Singapore

Challenges	Recommendations
<p>Long and tedious regulatory process for BESS projects</p>	<ul style="list-style-type: none"> • Simplify Procedures: Work towards simplifying the regulatory approval process for BESS projects, focusing on reducing red tape while maintaining safety and reliability standards. • Single Window Clearance: Implement a single-window clearance system to facilitate faster processing of BESS project approvals, serving as a one-stop shop for all regulatory matters.
<p>Climate concerns</p>	<ul style="list-style-type: none"> • Invest in R&D: Support research and development in advanced cooling technologies tailored for BESS, focusing on efficiency and minimal environmental impact. • Implementation of Best Practices: Adopt best practices and innovative solutions from other hot and humid climates, applying them to the Singaporean context to enhance battery performance and lifespan. • Climate-Resilient Designs: Develop and implement BESS systems with designs specifically engineered to withstand Singapore’s tropical climate, ensuring reliability and safety. • Regular Maintenance and Monitoring: Establish stringent maintenance and monitoring protocols for BESS to prevent overheating and prolong system life, incorporating smart monitoring systems for real-time performance tracking.

Thailand

Challenges	Recommendations
Current Market Design restricts competition	<ul style="list-style-type: none"> • Encourage Small-Scale Projects: Amend the electricity market model to provide more opportunities for small and medium-sized renewable energy projects, not just large-scale initiatives. This could involve creating a more level playing field with equitable access to the grid and power purchase agreements (PPAs). • Decentralisation of Energy Production: Support the decentralisation of energy production to encourage local and community-based renewable energy projects, including the integration of BESS, thereby reducing the dominance of SOEs. • Aligning SOE Goals with National Energy Objectives: Realign the objectives of State-Owned Enterprises in the energy sector to support the national goals of energy conservation and renewable energy promotion, potentially through regulatory mandates or incentives that encourage the adoption of renewable energy technologies.
Inconsistent regulatory processes and policies	<ul style="list-style-type: none"> • Consistent Policy Framework: Establish a stable and consistent policy framework that provides clear guidelines and support for renewable energy investments, including fixed-rate feed-in tariffs and incentives that are designed to last over the long term to build investor confidence. • Clear Support Mechanisms: Develop and communicate clear, consistent support mechanisms for all segments of the renewable energy market, including residential, commercial, and industrial sectors. This should include straightforward incentives, subsidies, or financing options that make the adoption of technologies like BESS more accessible to a wider audience. • Addressing Network Capacity: Prioritise investments and upgrades in grid infrastructure to accommodate the growing demand and integration of renewable energy sources, ensuring that policy initiatives are supported by the physical capacity to deliver energy reliably to all consumers.

Vietnam

Challenges	Recommendations
<p>Many Barriers to Investments in RE projects</p>	<ul style="list-style-type: none"> • Incentive Structures: Introduce incentive structures for private investors, including tax breaks, feed-in tariffs, and subsidies for BESS and renewable energy projects, to lower the investment threshold. • Risk Mitigation Instruments: Develop and offer risk mitigation instruments, such as guarantees or insurance products, to address concerns of private investors regarding the viability of investing in the energy sector. • Economies of Scale: Promote larger scale BESS projects and procurement processes to achieve economies of scale and reduce per kWh costs. • R&D Investment: Support research and development in BESS technologies to drive down costs and improve efficiency and performance.
<p>Policy Uncertainty and Administrative Inefficiencies</p>	<ul style="list-style-type: none"> • Long-Term Energy Planning: Ensure that long-term energy planning, including the Power Development Plan (PDP) and future energy policies and plans, are stable, transparent, and aligned with international climate commitments to provide a clear direction for the sector.