LSI GROUP

# Transforming India's Energy Landscape:

## The Solar-BESS Synergy and the Path to Net-Zero


*Creating Value,Partners in Growth.*

# LIST OF TOPICS

# EXECUTIVE SUMMARY

- India's urbanization, industrialization, and population growth are driving the rise in electricity demand, facilitating the way for more power generation from fossil fuels, leading to subsequent carbon emissions. India aims for net-zero emissions by 2070 and 45% reduction in carbon intensity by 2030, prompting the adoption of sustainable energy solutions. With a projected power capacity of 468.53 GW in 2025 and a 6% CAGR in consumption between 2025-2030, India is expected to become the second-largest global energy consumer. India aims to achieve 500 GW renewable capacity by 2030, 30% EV adoption by 2030, and 45% carbon emissions reduction by 2070.

- India's peak power demand is predicted to rise by 32% from 2,77,201 MW in 2026 to 3,66,393 MW by 2031-2032, necessitating strategic planning and investments in the power sector. With a solar capacity of 108.33 GW, India is expanding its renewable energy footprint. This is underscored by the projected increase in the percentage of solar power generated electricity from 11.95% in 2023 to 39.43% in 2040. This increase reduces the subsequent carbon emission from the traditional fossil fuel sources, from 6.79% in 2023 to a projected value of only 2.57% in 2030.

- The Battery Energy Storage System (BESS) is projected to increase average power savings by 33% during normal demand and 37% during peak demand over a forecasted 5-year period (2025-2030), demonstrating its potential to optimize solar energy utilization and reduce power deficit.

- Electricity demand is predicted to rise 32% by 2031-42, with 40% renewable energy mix affecting grid stability, necessitating smart grid upgrades to address the average 19% T&D losses.

- BESS are crucial for India's renewable future, storing India's electricity generated from solar, promoting grid resilience, cost savings, and decarbonization. The BESS market has grown from 2 MWh in 2017 to 120 MWh in 2024. With projected capacity requirements of almost 250 GWh by 2032 and 1840 GWh by 2047, it requires strategic investments and policy support for energy security and sustainability. It is expected to have a market CAGR of 11.41%.

- Solar power integration with BESS significantly reduces carbon emissions, supporting India's net-zero emissions target by 2070 and achieving a 45% reduction in carbon intensity by 2030. This integration is projected to reduce emissions by 3.6% CAGR, compared to a 2% CAGR increase without solar.

- The abundant solar resources offer significant potential for carbon emission reduction, but their intermittency necessitates efficient storage.

- Battery costs are predicted to decrease to USD 103/kWh by 2030, with BESS efficiency ranging from 80-95%, and investments expected at USD 55+ billion by 2032.

- The manufacturing and supply chain is transitioning from import dependence to domestic production, projected to decrease to 20% by FY27 and a four times increase critical minerals demand by 2030.

- The BESS industry faces challenges such as high initial costs, supply chain vulnerabilities, and regulatory hurdles, including risks from import dependency on lithium and cobalt, infrastructure gaps, and skilled workforce shortages.

- The Energy Storage Obligations are a key policy and regulatory framework for energy storage, guiding future reforms. They include a BESS Scheme aiming for 4000 MWh by 2030-31, 40% of capital costs covered by viability gap funding, an increase in energy storage obligations from 1% to 4%, and a National Framework for Promoting Energy Storage Systems. The policy also mandates 2-hour storage for new solar projects, hybrid systems, and reducing battery import reliance to 20% by FY27.

- BESS improves grid stability and efficiency by reducing transmission and distribution losses, optimizing solar power utilization, and minimizing energy and peak demand deficits. It includes frequency and voltage regulation, peak load shaving, supply-demand balance, intermittent renewable energy integration, and reducing solar electricity deficit by 0.9% during peak demand, with each 1% added BESS capacity.

# SALIENT FEATURES OF THE REPORT

- *India is embracing solar power due to rising electricity demand in order to combat the two-fold motive of tackling the growing energy demand while cutting carbon emissions and improving energy efficiency at the same time. The* ***Forecast of India's Energy Mix in power Generation in India*** *illustrates how the* ***proportion of electricity produced by solar is rising relative to other electricity generation sources.***

- *The* ***Forecast of Growth Rate of Carbon Emission after incorporating the impact of solar power in India*** *suggest that* ***incorporating solar power into India's carbon emission from energy forecasts will significantly reduce carbon emissions growth rates*** *by enhancing solar power capacity utilization, which is crucial for mitigating emissions, primary energy consumption.*

- *The* ***Battery Energy Storage Capacity in India, Annual Battery demand projections and Projected battery Storage addition in India*** *highlight the* ***progress of the crucial Battery Energy Storage Systems (BESS) in regards to India's energy transformation****, emphasizing how they may help stabilize the grid, integrate solar power, and speed up the process as a result of the country's renewable energy goals.*

- *The* ***Forecasts of Power Deficit Scenario during normal demand scenario and Forecast of Power-Deficit Scenario during Peak Demand*** *underscore the* ***significant reductions in energy deficit after implementing BESS.*** *The* ***Average Percentage for Power Savings Increment with Efficient BESS*** *is a testament of* ***how BESS can potentially optimize solar energy utilization from this savings, and promote sustainability in the power sector.***

# INTRODUCTION

India is implementing renewable energy policies to reduce carbon emissions and improve environmental quality. The country's energy policies aim to achieve sustainable development growth, with the government setting continuous targets for renewable energy adoption and reducing global warming on a year-on-year basis.

The Indian government plans to reduce traditional vehicle production by 2030 to a significant proportion and transition to electronic vehicles is expected to comprise 30% of the total vehicles produced, to combat global warming and reduce energy imports.

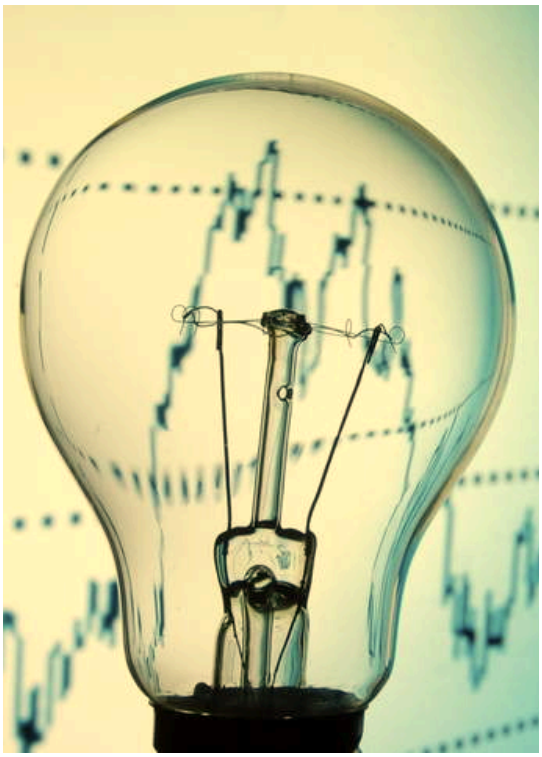
The International Energy Agency predicts India to become the second-largest global energy consumer by 2035, with a demand of 90000 MW to meet basic electrical needs, according to load forecasting by IEA.

The shift towards electric vehicles could increase electricity demand, potentially bringing India back to square one, and thus, adopting renewable energy in electricity generation is crucial to avoid this undesirable outcome.

Urbanization, industrialization, and population growth are driving increased reliance on electricity, necessitating continuous investment in infrastructure, energy efficiency measures, and resilient energy systems.

India's renewable energy sector has grown significantly, with over 170 GW of solar and wind power installed in 2024. India's electrical infrastructure is crucial for economic growth, but it needs to transition to renewable energy sources like solar, wind, and hydropower.

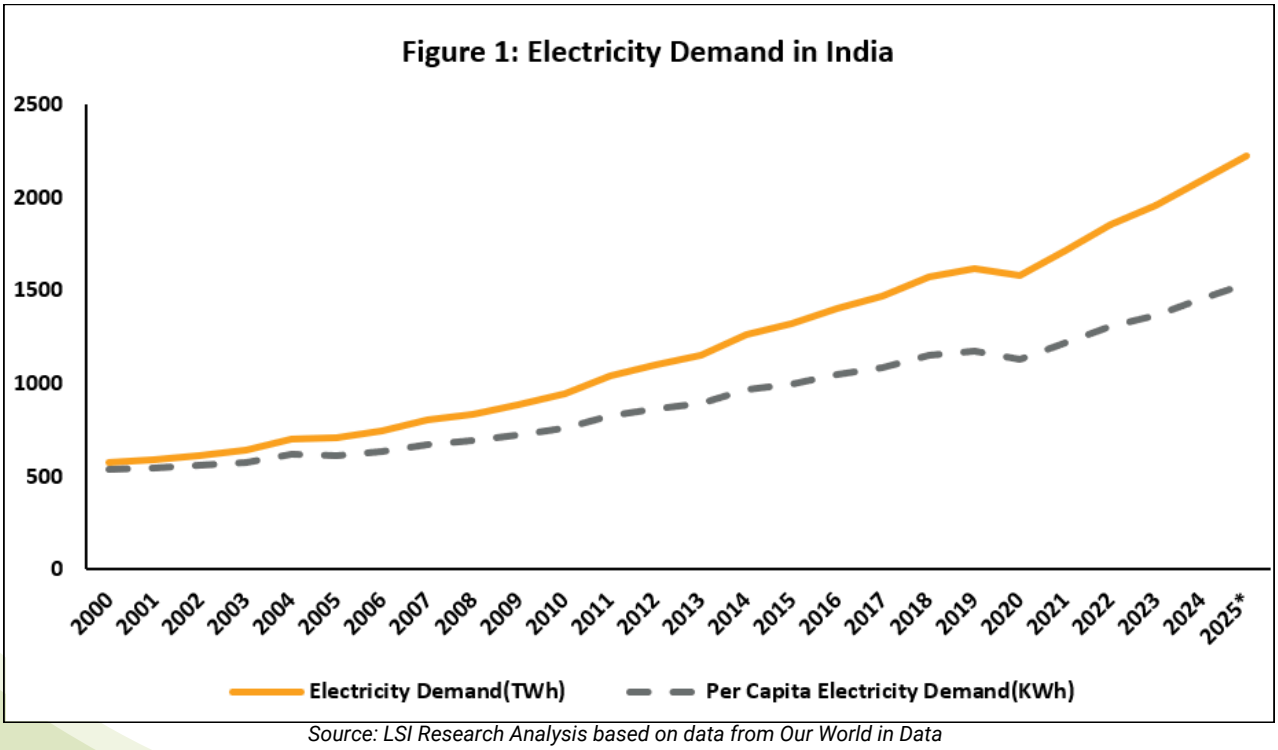
# India’s Electricity Demand and Supply Landscape



- Currently India ranks third globally in electricity production and consumption. India’s power capacity with annual increment of 5.8% is going to attain 468.53 GW in 2025. India needs to generate 4,000-4,500 billion units of energy annually and achieve 500 GW of renewable energy capacity.

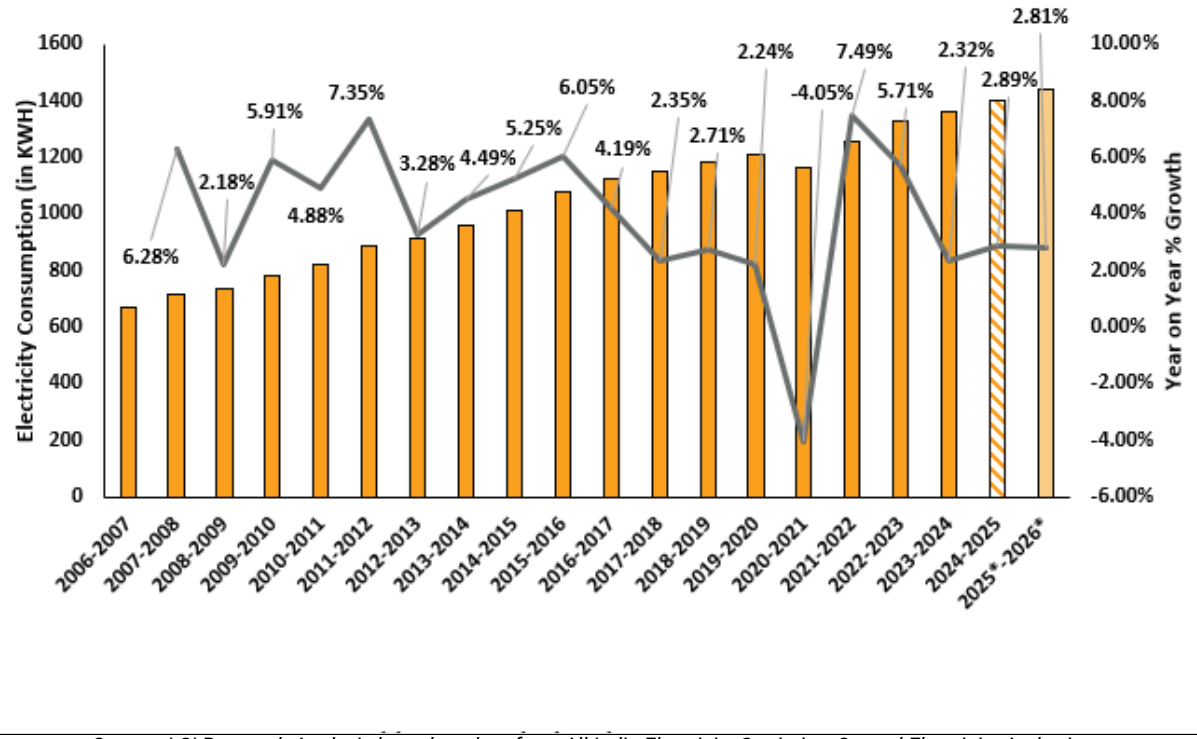
- India's renewable energy sector has been growing significantly, which may be strategically be used to cater to India’s energy demand. The country's energy demand and per-capita energy consumption experienced rapid recovery from the pandemic time, and is expected to reach 6% in 2025.

**Figure 1: Electricity Demand in India**



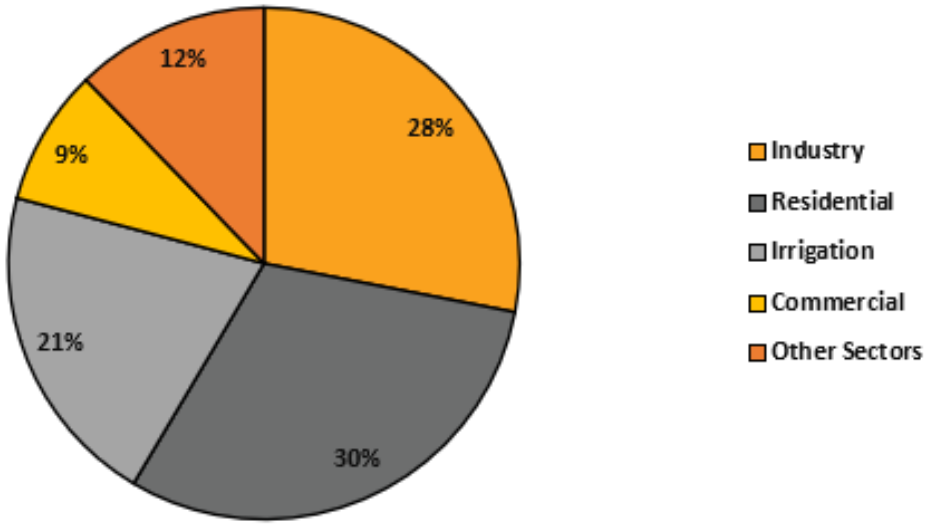

*Source: LSI Research Analysis based on data from Our World in Data*

**Figure 2: Scenario of Per Capita Electricity Consumption in India**



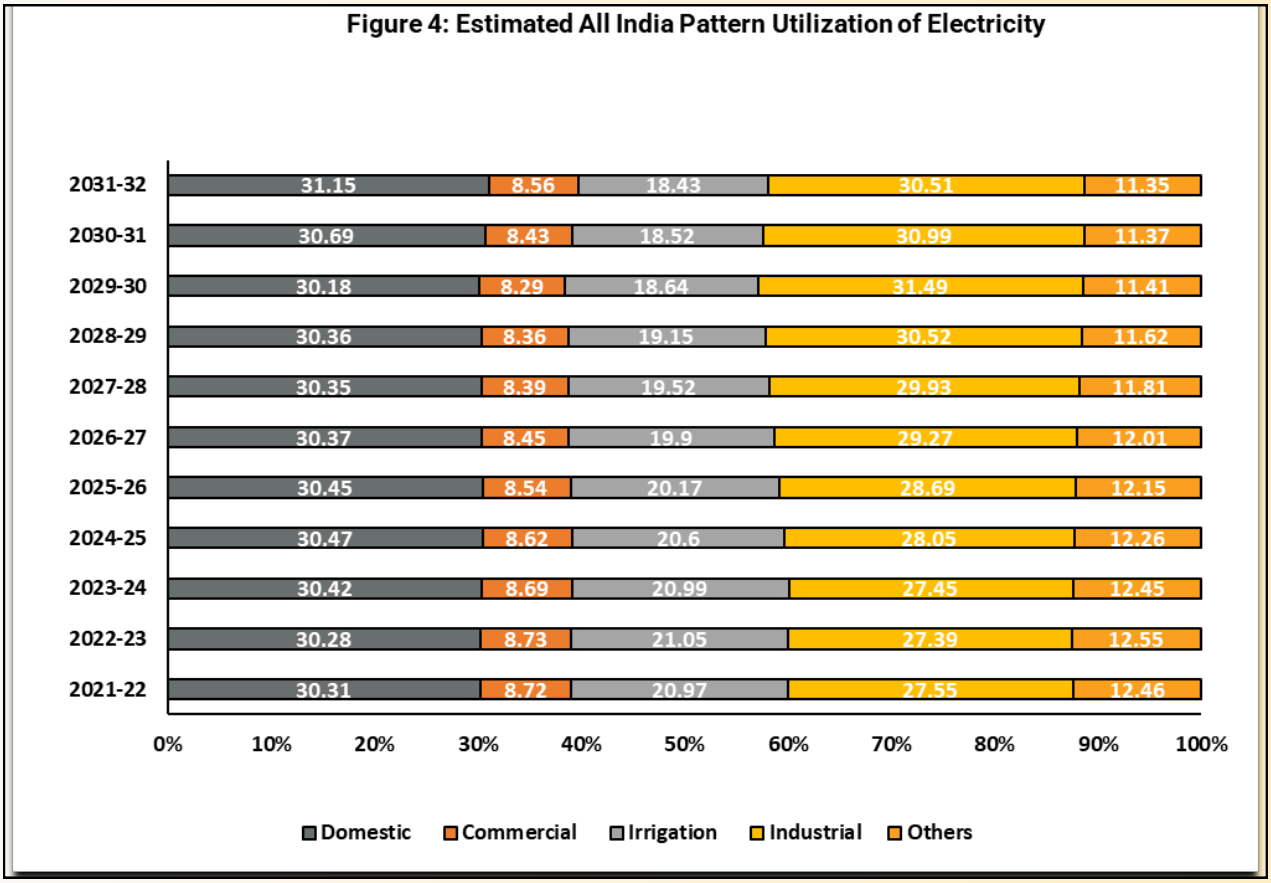

*Source: LSI Research Analysis based on data from All India Electricity Statistics, Central Electricity Authority*

**Figure 3: Electricity Usage in Different Sectors in India in 2024**




*Source: LSI Research Analysis based CEA Data*

The energy mix, with a 40:60 renewable-non-renewable ratio, highlights progress but challenges. It emphasizes the need for infrastructural development and balancing environmental sustainability with economic prosperity.



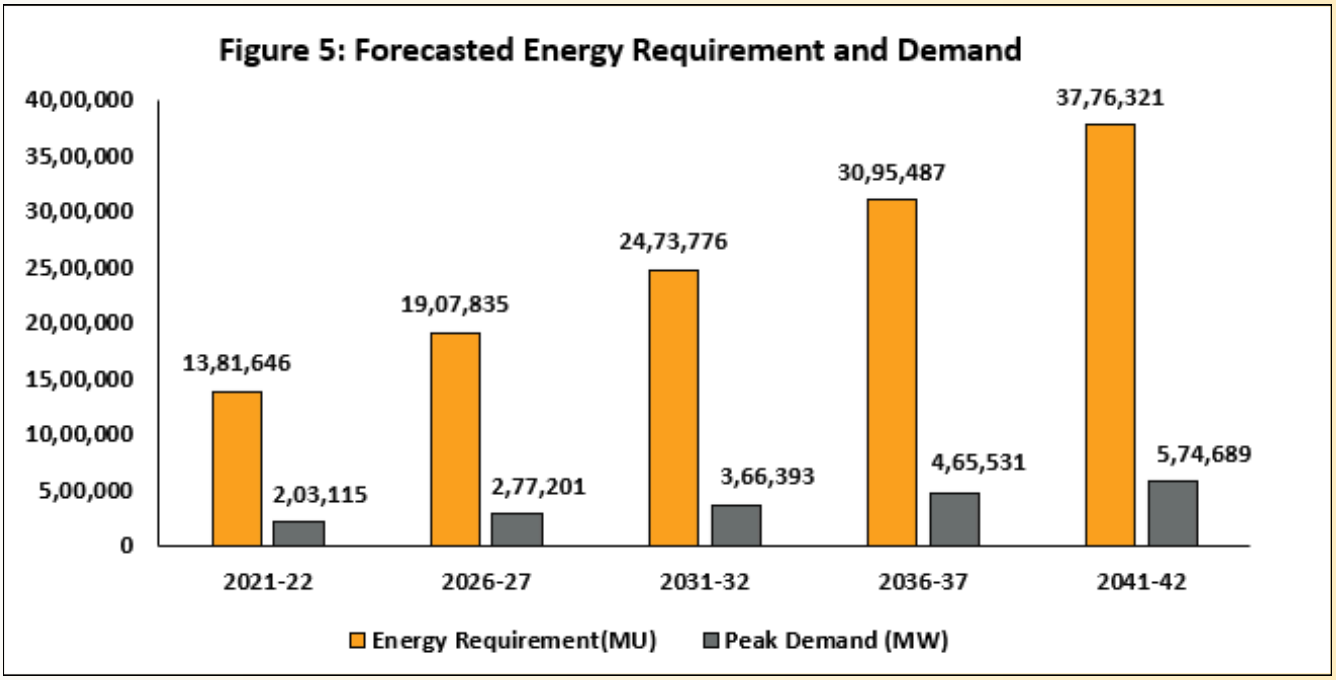

*Source: LSI Research Analysis based on data from Central Electricity Authority*

## Demand Forecast of Electricity in India

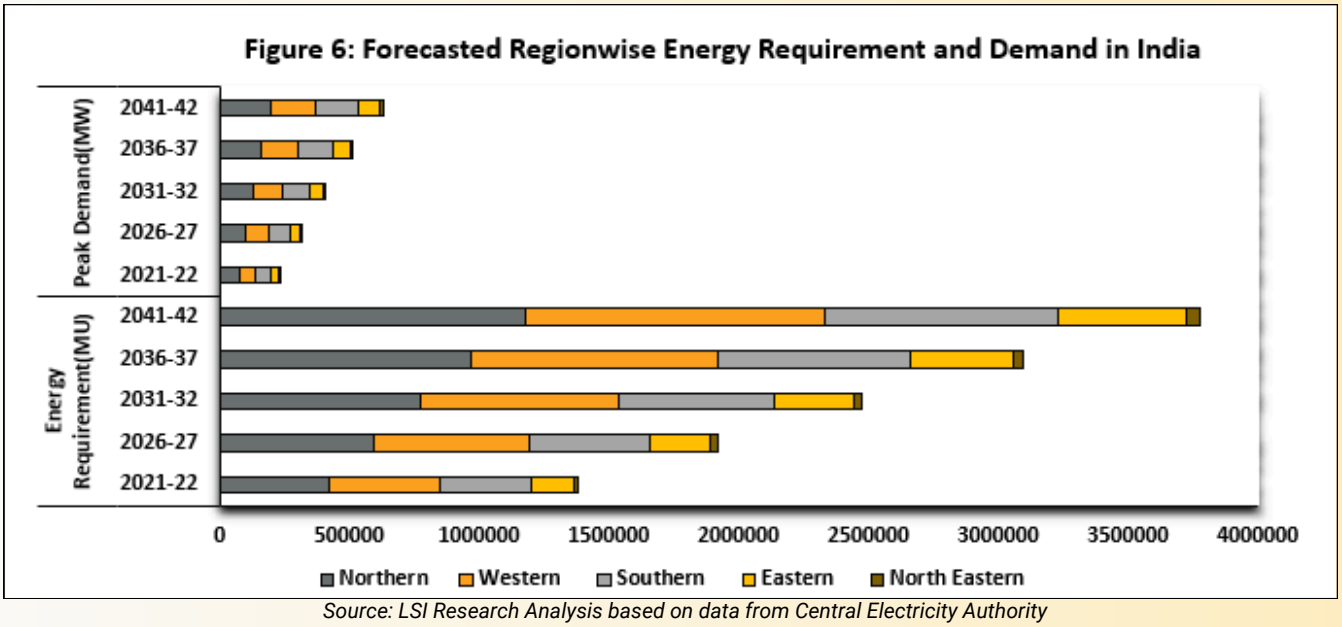
India's power requirements and peak demand are expected to rise significantly from 2025-2042 due to economic growth, urbanization, and rising consumption. This trend has implications for investment, energy security, sustainability, and policy emphasis. The global average annual growth rate of 3.4% through 2026 aligns with this trend, highlighting the electrification of various industries. The largest increases are expected between 2026-2027 and 2031-2032, with peak demand increasing by nearly 89,192 MW and energy needs reaching over 600 MU. This underscores the need for long-term energy strategies to ensure sustainable growth, manage energy security, and address environmental concerns.

The increasing demand for energy-intensive technology like electric vehicles is driven by industry development, population growth, rural electrification, and the popularity of electric vehicles. This demand necessitates innovative technologies and infrastructural upgrades in regional regions, primarily due to electric car adoption and industrial expansion.

India's peak power demand is expected to rise by 32% from 2,77,201 MW in 2026 to 3,66,393 MW by 2031-2032, highlighting the need for strategic planning and investments in the power sector. The forecast also predicts a 7.5% increase from 2024 to 2031-32, indicating economic expansion and the need for renewable energy.

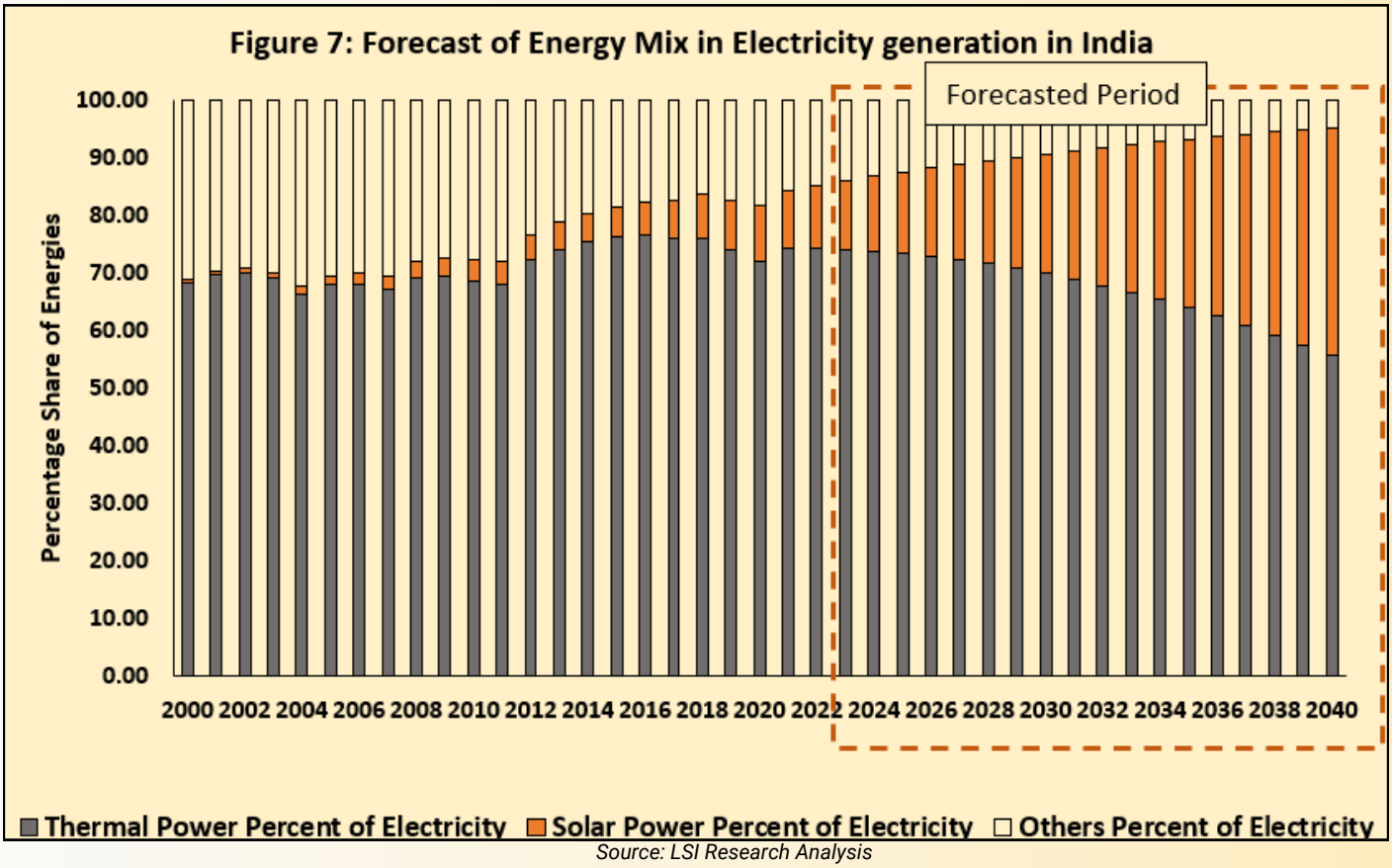



*Source: LSI Research Analysis based on data from Central Electricity Authority*



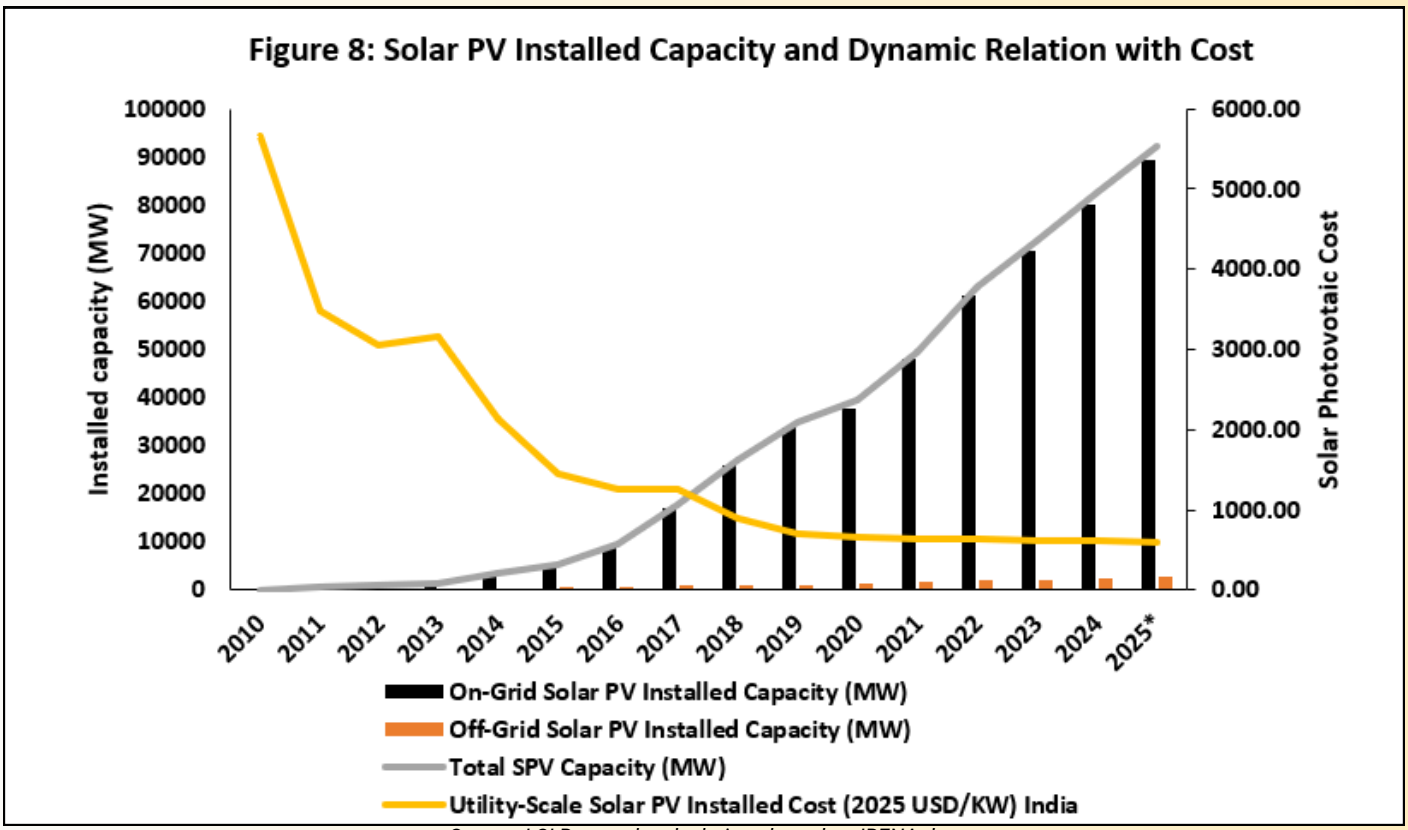

*Source: LSI Research Analysis based on data from Central Electricity Authority*

- Across the urban-rural India there is an increasing demand for energy-intensive technology influenced by population growth and rural electrification and the popularity of electric vehicles During 2025-30, process of industrialization, urbanization, and overall projected economic growth of 6.5% to 7.5% will lead to an electricity consumption having a 6% CAGR, increasing the peak demand for renewable energy. This demand necessitates innovative technologies and infrastructural upgrades, and shift towards renewable energy to achieve a sustainable growth path.




*Source: LSI Research Analysis*

India's electricity demand is expected to reach 458 GW by 2032. Solar power, a renewable resource, can help meet this demand while reducing reliance on fossil fuels. With an installed solar capacity of 108.33 GW as of 2025, India's solar capacity is expected to cater to 25-27% of the electricity demand by 2032. This is a step towards India's aim to generate 33-35% non-fossil fuel energy post 2032. India is expanding its renewable energy footprint through initiatives like the International Solar Alliance and large-scale solar parks. Expanding solar energy generation can reduce reliance on fossil fuels and enhance energy security.

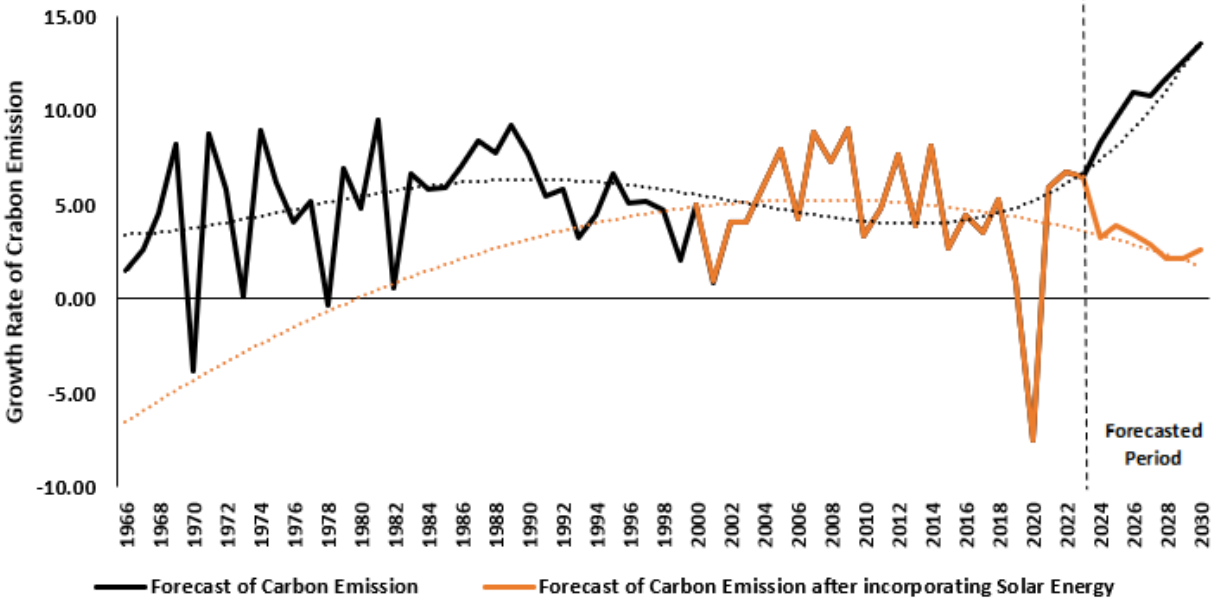



*Source: LSI Research calculations based on IRENA data*

# Dynamic Relation of Carbon Emission and Solar Power in India – A Scenario Analysis

This section analyses the carbon forecast situation in India, incorporating renewable energy like solar power, in relation to primary energy consumption and GDP growth, following previous explorations.

**Figure 9: Forecast of growth rate of carbon emission after incorporating the impact of solar power in India**




*Source: LSI Research Analysis*

A scenario analysis of forecast of growth rate of carbon emission (excluding solar power impact), vis-à-vis forecast of growth rate of carbon emission incorporating rate of capacity utilization factor (CUF) of solar power is represented.

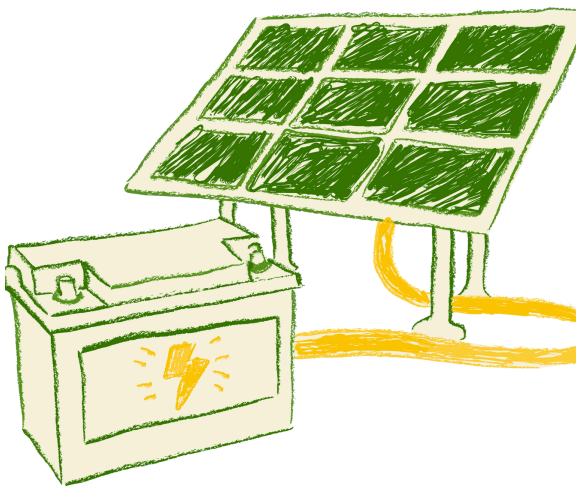
CAGR of forecast of growth rate of carbon emission (excluding impact of solar power) is found to be of **increasing nature** of 2%, and CAGR of forecast of growth rate of carbon emission incorporating the impact of solar power is found to be of **decelerating nature** of 3.6%. It is quite evident from the figure that there is a trajectory change in downward direction growth rate of carbon emission in the forecasted period after the inclusion solar power.

Solar power generation is intermittent, necessitating the use of Battery Energy Storage Systems (BESS) to store excess energy during peak production hours and release it when demand surges. BESS stabilizes the grid, ensuring a continuous and reliable power supply, and supports India's goals for carbon neutrality and sustainable development. As battery technology costs continue to decline, integrated solar-plus-storage solutions offer a practical pathway towards energy security and sustainability, particularly in remote regions with underdeveloped traditional grid infrastructure.

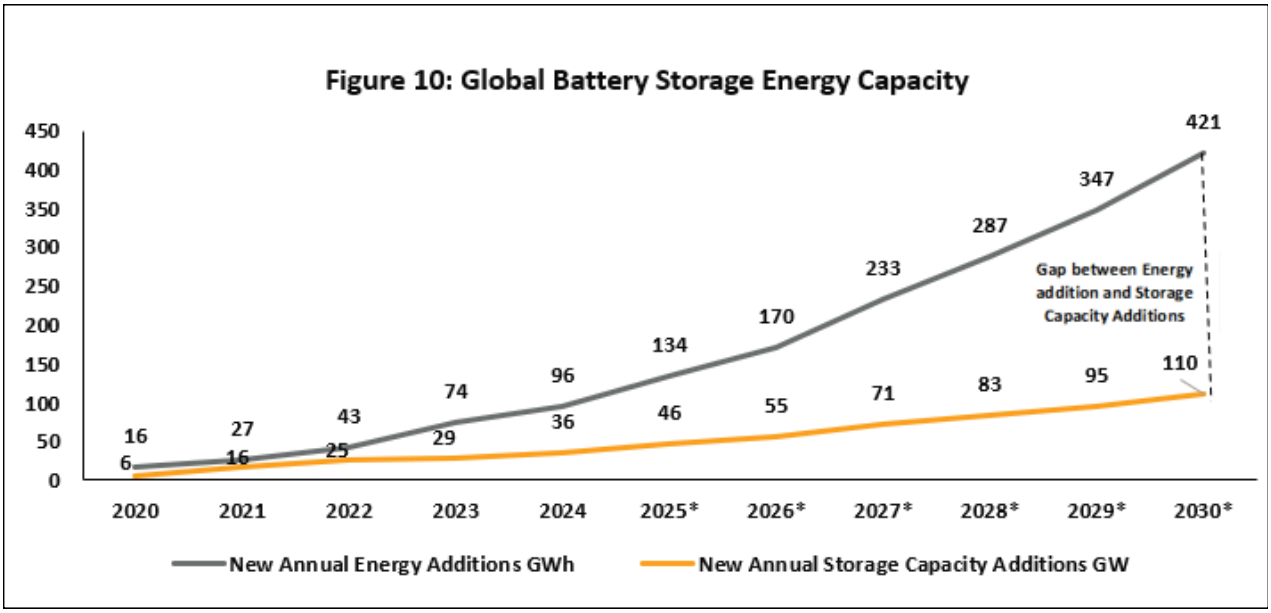
# Introduction to Battery Energy Storage Systems (BESS) in India

The energy storage system (ESS) market in India offers numerous opportunities due to renewable energy adoption, regulatory changes, and technological advancements. A strategic approach is needed to capitalize on these opportunities, focusing on underserved needs, resilient supply chains, and customer-centric products. India's battery storage sector is crucial for the country's renewable energy transition, especially in solar power integration. Battery Energy Storage Systems (BESS) ensure efficient energy storage, improve grid stability and integration, and reduce dependence on fossil fuels. BESS is a key component of India's renewable energy strategy, enhancing grid penetration, ensuring stable electricity for consumers, and positively impacting DISCOMs' profit by facilitating peak demand power supply, tapping into profitable tariffs, and increasing revenue. BESS ensures grid stability, and long-term sustainability. The successful integration of solar power and BESS will shape India's energy landscape, ensuring a reliable, sustainable, and resilient electricity network. BESS consist of common chemical choices like Lithium-ion, Lead-Acid, Sodium and Nickel. Lithium-ion batteries are a popular choice for energy storage in India, due to their extended lifespan, low-maintenance needs and small space requirements.

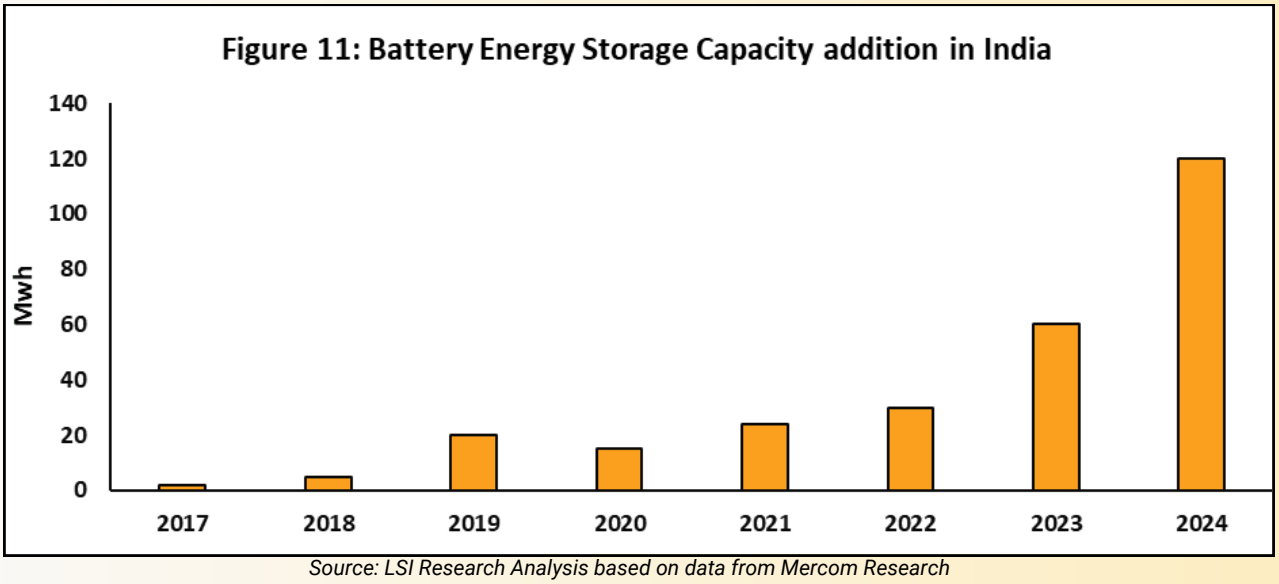
# Importance of BESS in India's Energy Transition:



- Battery Storage is critical for India's solar power sector, ensuring grid stability, reducing fossil fuel reliance, and managing renewable energy intermittency.
- India aims to achieve 35% renewable energy by 2035 followed by net-zero carbon emissions by 2070. The electricity generated from ample non-fossil fuel energy needs a significant amount of BESS capacity addition for storage.
- BESS is projected to reach 250 GWh by 2032.




*Source: LSI Research Analysis*




*Source: LSI Research Analysis based on data from Mercom Research*

The National Solar Mission in India, launched in 2010, significantly accelerated the country's solar energy adoption by creating a strong policy and regulatory framework. As solar power generation increased, the need for efficient energy storage solutions became evident, leading to the integration of BESS in 2017. The mission's success created the demand and infrastructure context for BESS integration, crucial for storing excess solar energy and ensuring grid resilience. As India continues to expand its renewable energy capacity, the synergy between solar power and BESS is essential for energy security and reliability. The National Action Plan on Climate Change launched a mission to support India's renewable energy transition, integrating BESS since 2017. This seven-year initiative improved grid reliability, optimized renewable energy utilization, and accelerated India's transition towards a sustainable energy future.

India's BESS market, which grew from 0.0002 GWh in 2017 to 0.12 GWh in 2024, is expected to reach 250 GWh by 2032, driven by economies of scale, aligned with falling battery costs over the years, and supported by policies

BESS is expected to significantly contribute to India's energy transition, promoting solar penetration and a renewable energy-dominated electricity market. Its rapid scaling presents transformative potential for battery manufacturers, solar developers, and grid operators, reducing solar curtailment, lowering costs, and improving grid resilience, based on global market lessons.

The **growth trajectory for BESS in solar electricity** is characterized by **three phases: initial slow adoption, modest experimental growth, and an inflection point in 2025**. Projections show continued exponential growth, reaching 250 GWh by 2032 and 1,840 GWh by 2047, with a CAGR exceeding 30%. This pattern follows **classic technology S-curve economics**, where **initial slow adoption gives way to rapid scaling once cost thresholds are crossed and market mechanisms mature.**

India's renewable targets are driving business opportunities in battery manufacturing, solar-storage hybrids, and ancillary services. In 2025, BESS is gearing up to support grid mandates and align with coal phase-out plans, providing grid flexibility and 24/7 renewable power supply, by storing a substantial portion of daily solar generation.

# Overview of India's BESS Market

## Market Growth and Drivers:

- The sudden rapid growth of BESS capacity addition is driven by renewable energy targets, grid stability needs, and government incentives.
- India aims for 500 GW of renewable energy capacity by 2030, with BESS playing a key role in integrating solar and wind power.
- Energy Storage Obligation (ESO) mandates increasing storage capacity from 1% in FY 2023-24 to 4% by FY 2029-30.
- Government initiatives include the BESS Scheme (4000 MWh by 2030-31) and the Viability Gap Funding (VGF) scheme, covering 40% of capital costs.

## Investment Opportunities:

- The global BESS market is estimated at USD 7.8 billion in 2024, projected to reach USD 37.2 billion by FY 2032, driven by rapid investments necessitating the need for increased storage capacity.
- Investments in BESS are expected to reduce fossil fuel dependence, stabilize electricity prices, and lower transmission losses, with government policies such as the PLI scheme, VGF, and ESO playing a crucial role.
- India's BESS market offers trillions in investment opportunities, driven by technological advancements, particularly in lithium-ion batteries.

# BESS Efficiency and Technological Advancements

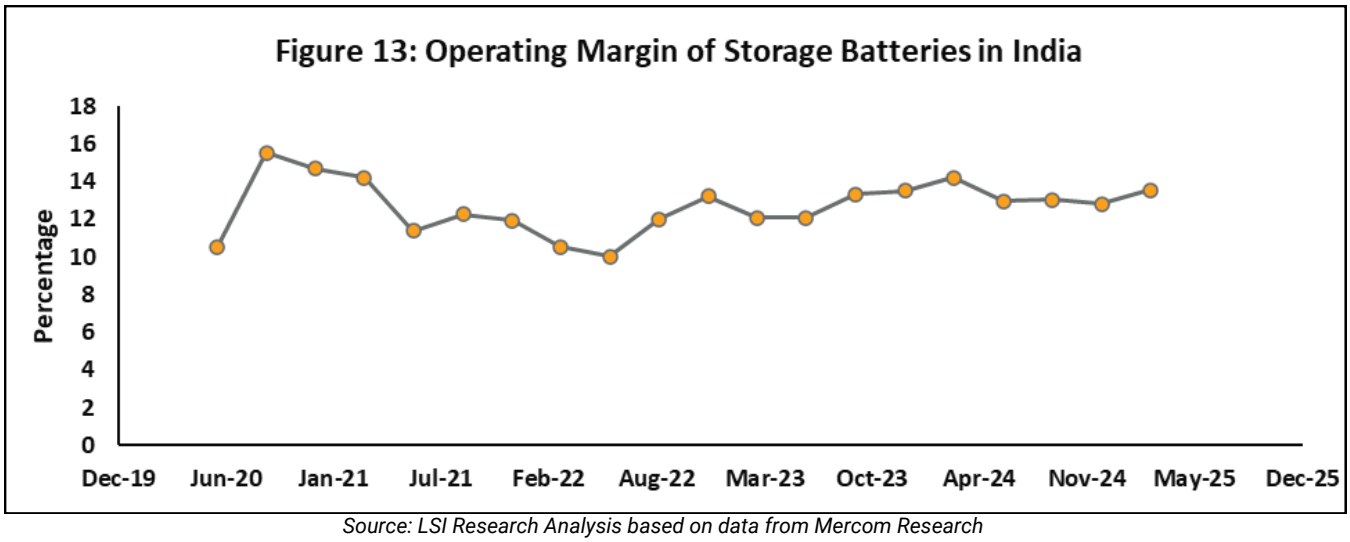
## Efficiency Improvements:

- Modern BESS systems achieve 80-95% efficiency, with newer lithium-ion installations performing even better.

- Technological advancements in energy density and battery longevity are driving improvements.

- India's battery storage industry is facing significant operating margins fluctuations due to volatile lithium prices, unstable procurement, and inconsistent supply chains. The industry's heavy reliance on imported lithium minerals and fluctuating global demand make it vulnerable to supply chain disruptions and price swings. The dynamic demand for lithium, driven by renewable energy storage and electric vehicle adoption, contributes to the fluctuating operating margin.

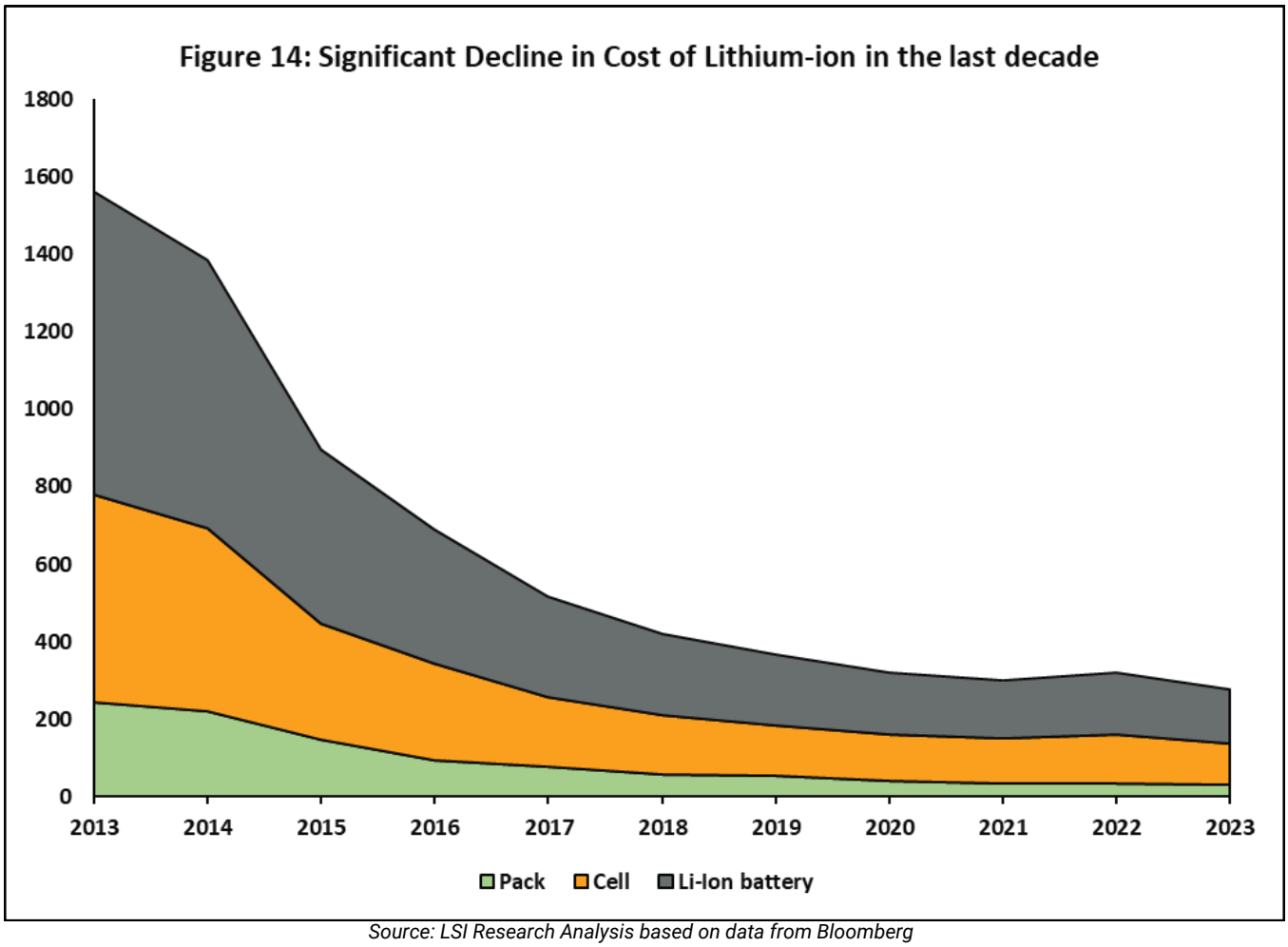
- But to ensure long-term stability, India must focus on securing alternative supply chains, investing in domestic battery manufacturing, and exploring alternative energy storage technologies. Long-term stability depends on domestic mining and global supply chain diversification.




*Source: LSI Research Analysis based on data from Mercom Research*

## Cost Reductions:

- Battery storage costs are expected to decline due to economies of scale, local manufacturing, and policy incentives.
- Lithium-ion battery demand expected to surge to 127 GWh by FY30. By 2030, lithium-ion battery costs could drop to USD 103/kWh for standalone systems and USD 92/kWh for co-located solar PV systems.



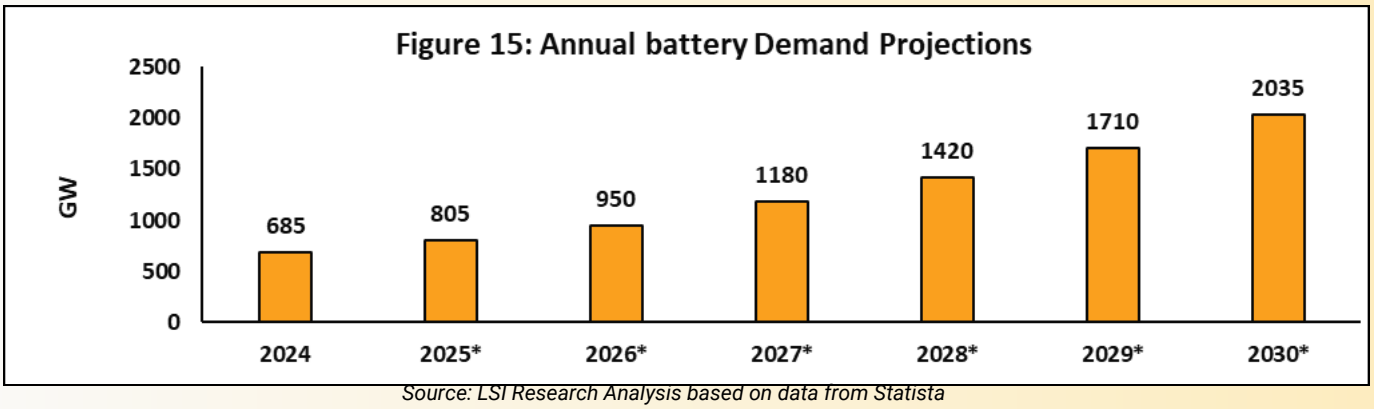

*Source: LSI Research Analysis based on data from Bloomberg*

# Battery Demand and Capacity Addition

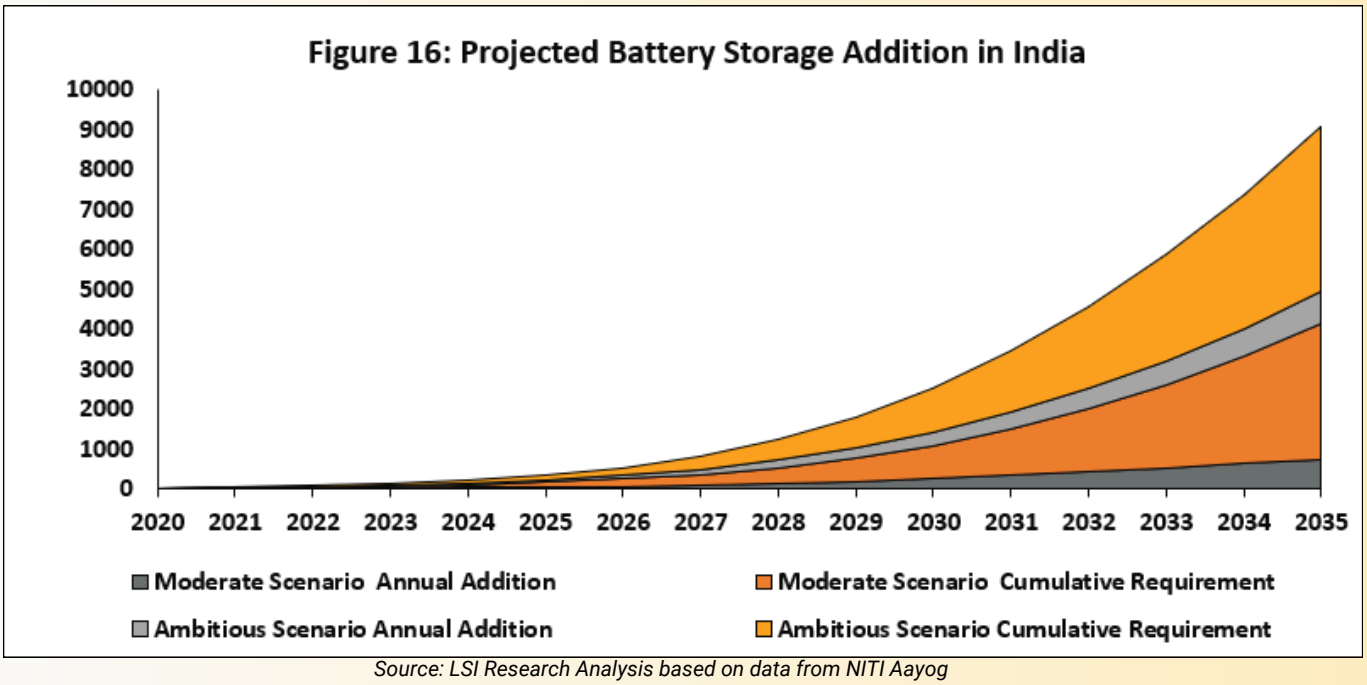
## Battery Demand Growth:

- India's lithium-ion battery demand is expected to reach 54 GWh by FY27 and 127 GWh by FY30. This growth is attributed to the increasing adoption of electric vehicles, India's commitment to decarbonizing its electricity grids, and its ambitious renewable energy targets.

- The BESS capacity is projected to reach 250 GWh by 2032, requiring an estimated USD 55 billion in investments.




*Source: LSI Research Analysis based on data from Statista*




*Source: LSI Research Analysis based on data from NITI Aayog*

## Domestic Manufacturing vs. Imports:

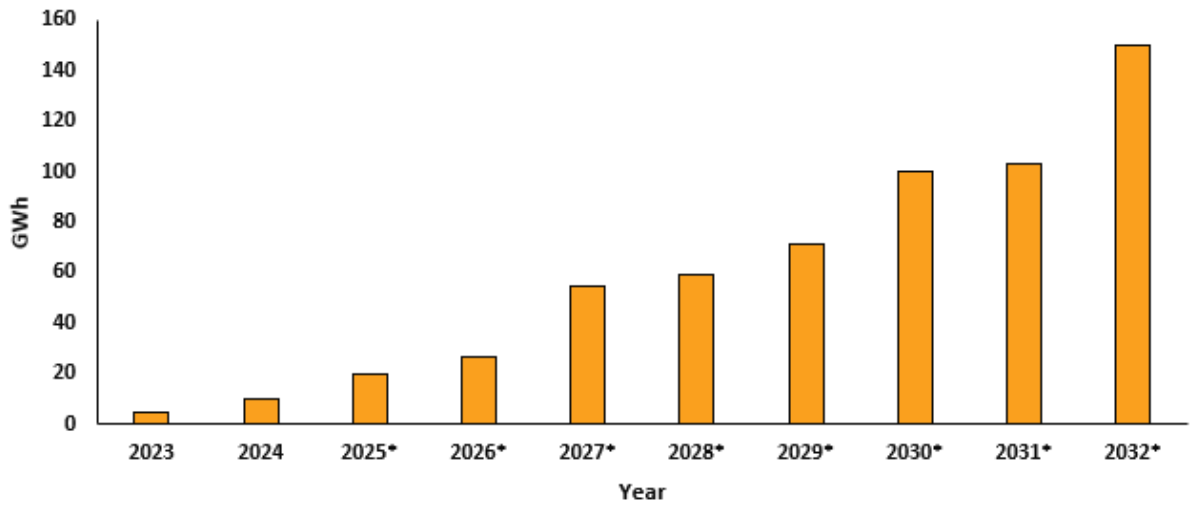
India is shifting from heavy imports to domestic manufacturing to reduce reliance on foreign suppliers and strengthen the supply chain.

Currently, 15 GWh of domestic lithium-ion battery storage is met through imports.

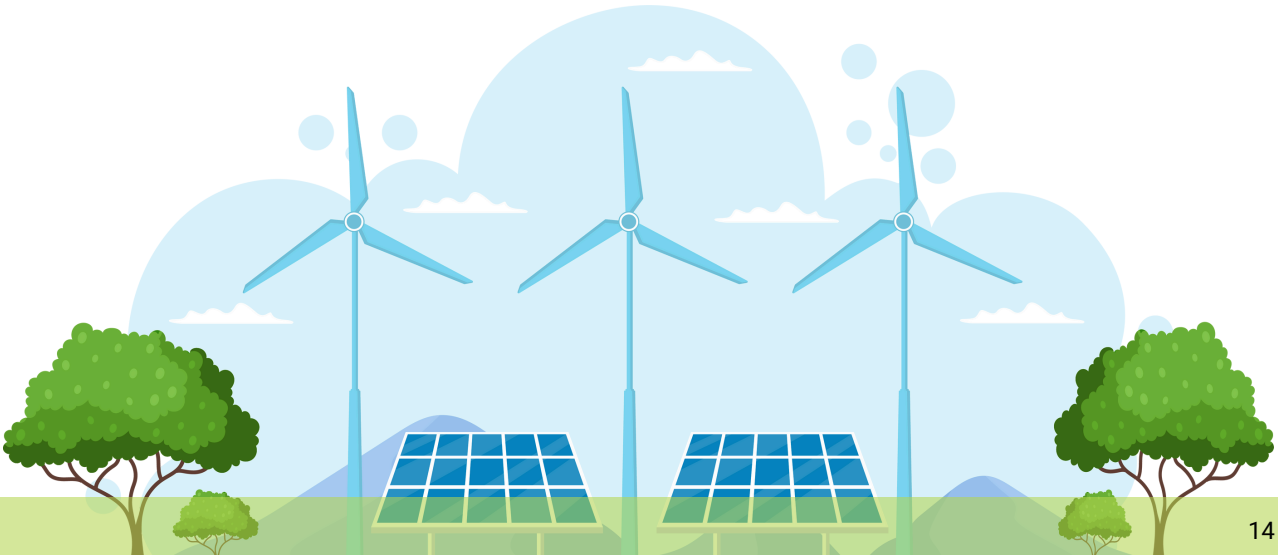
The PLI scheme and other government initiatives are promoting local battery manufacturing and reducing import dependency.

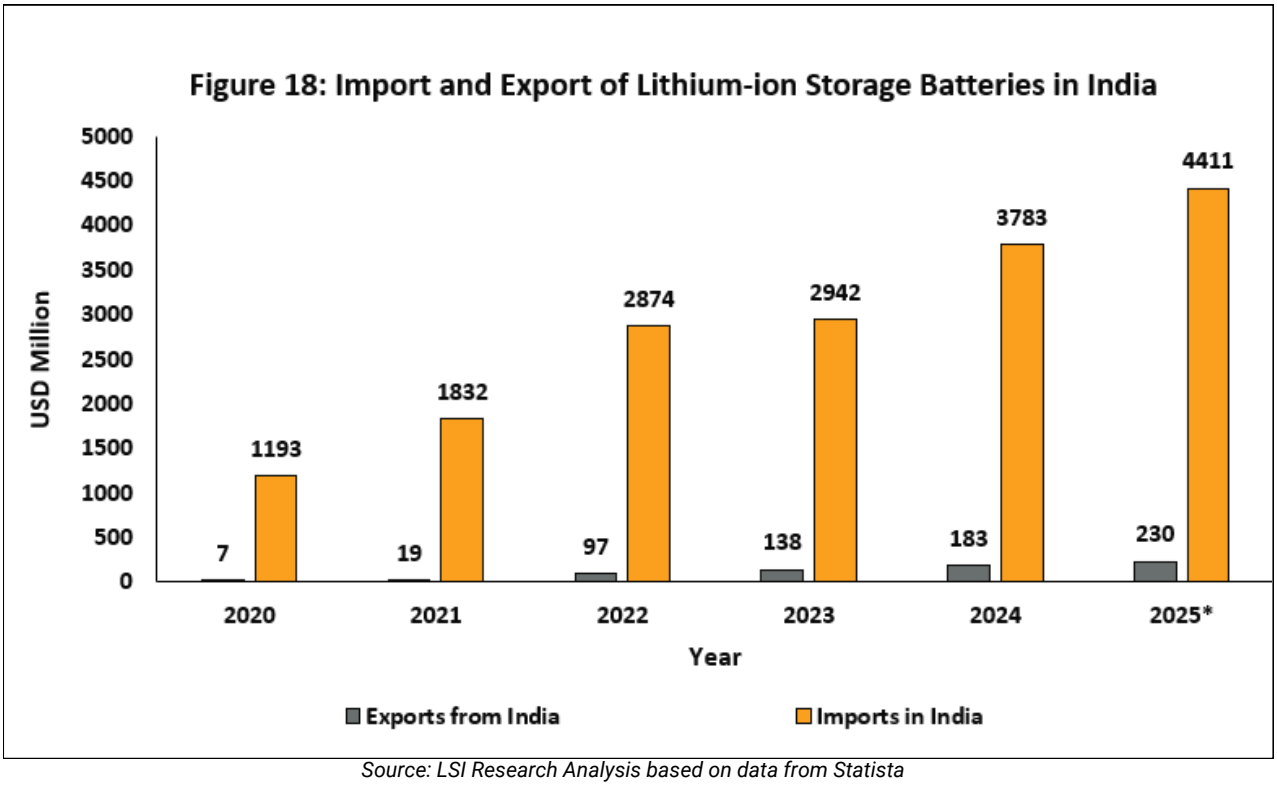
India currently heavily relies on imports for lithium-ion battery requirements, but the situation is evolving with the PLI scheme and domestic manufacturing plants expected to reduce import dependence.

**Figure 17: Projected Annual Production of Battery Energy Storage Capacity**




*Source: LSI Research Analysis based in data from Multiple Sources*






*Source: LSI Research Analysis based on data from Statista*

## Critical Minerals:

- Critical minerals are essential components in creating energy storage batteries. India is focusing on securing access to critical minerals like lithium, cobalt, graphite and nickel through international collaborations and domestic exploration.
- Demand for Critical Minerals in India are expected to rise, almost four times by the end of 2030.
- Challenges include supply chain risks, cost volatility, and geopolitical dependencies, particularly on China and African countries.

# Future Projections and Economic Implications

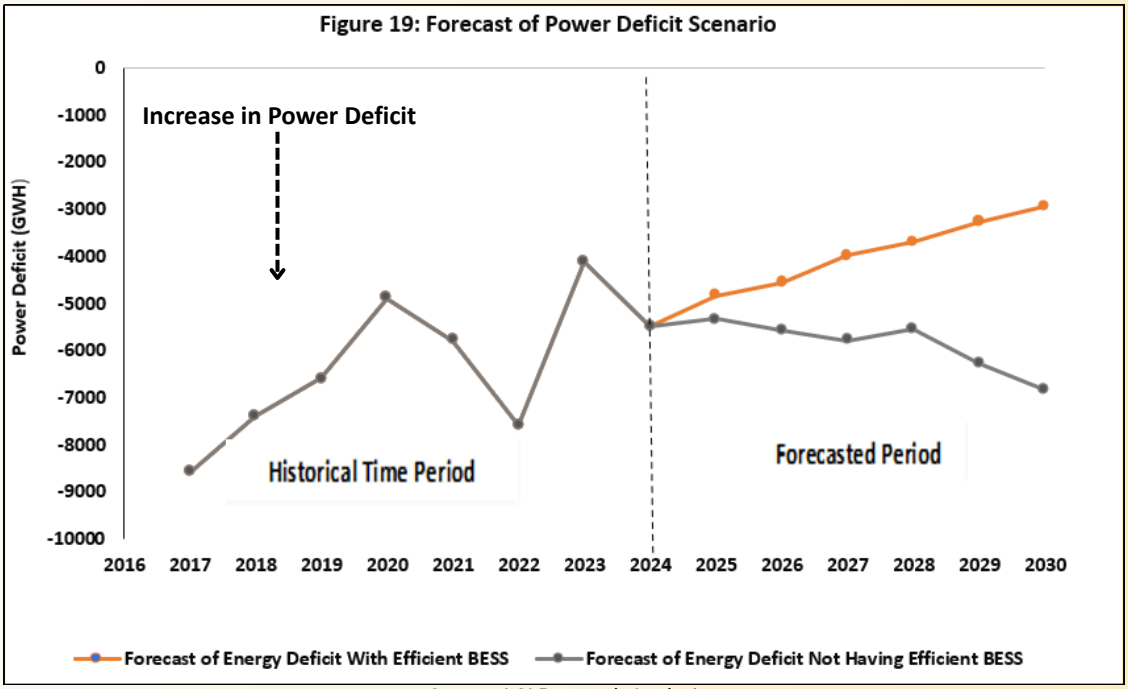
India's energy storage capacity requirement is projected to reach 34.72 GWh by 2026-27. This is expected to increase to 250 GWh by 2031-32, with the market size increasing to USD 9 billion.

The market is expected to grow at a CAGR of 11.41% till 2032, with significant opportunities in grid-scale storage and renewable integration.

The sector is expected to attract significant investments, with funding opportunities projected to reach Rs. 3.5 lakh crore by FY32.

BESS deployment will create jobs, reduce energy costs, improve grid reliability, and accelerate renewable energy adoption.

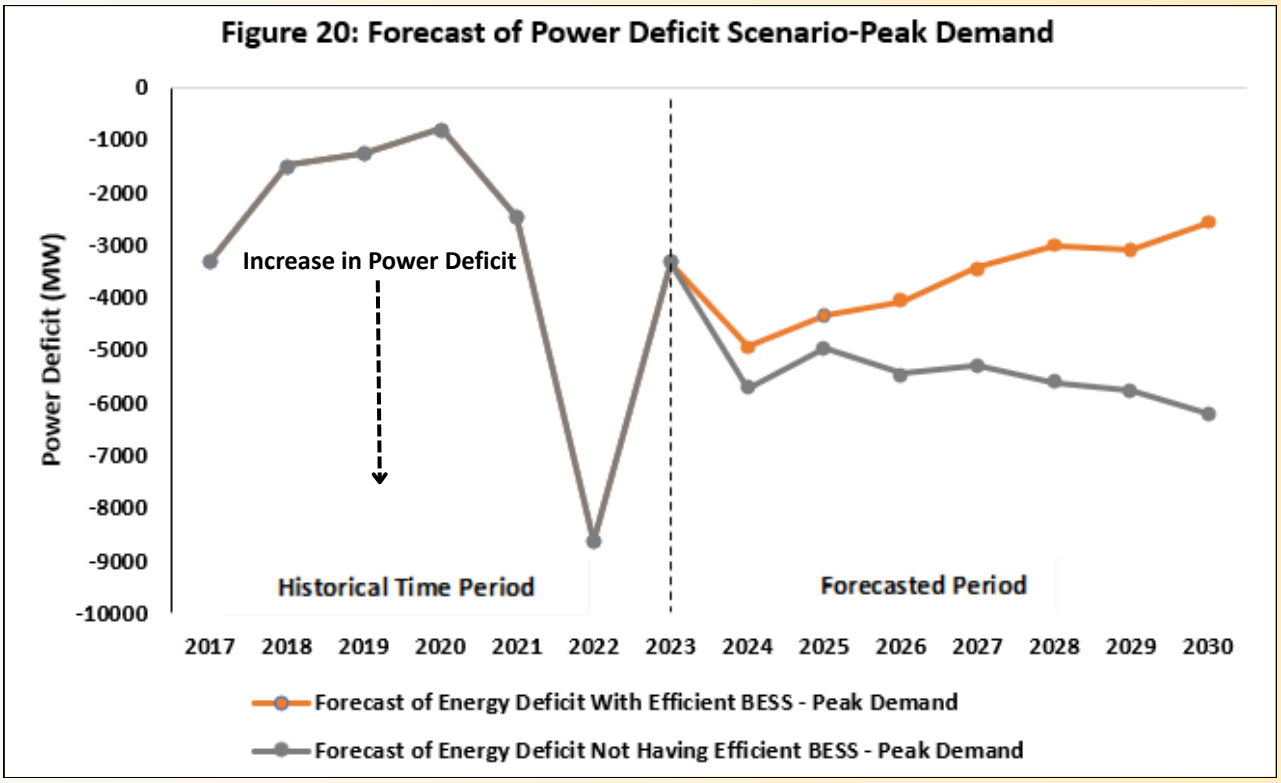
Driven by renewable energy goals and declining costs, India’s BESS market will have a cumulative size of USD 57 billion by 2047, underscored by an energy storage requirement of 1840 GWh.




*Source: LSI Research Analysis*

The **integration of BESS with solar power** is expected to significantly **reduce the energy deficit**, with **a projected reduction of 2,944 GWh by 2030 compared to 6,844 GWh without BESS.** This is a significant improvement of 3,900 GWh. The energy deficits remain identical between 2016 and 2024, but diverge significantly from 2025 to 2030, indicating the growing effectiveness of BESS in reducing deficits. However, a significant energy deficit of 2,944 units remains in 2030, highlighting the need for more solutions due to market trends, technological advancements, supportive policy frameworks, and BESS integration as a standard component.

The integration of BESS with solar energy reduces operational costs, making renewables more viable for commercial and industrial sectors. This leads to increased grid stability, investor confidence, and an expanding BESS market, fostering innovation in energy storage solutions. This reduces energy deficits, enhances energy security, reduces dependency on fossil fuels, and lowers carbon emissions, contributing to sustainability goals. Solar power producers will benefit from increased revenue opportunities, as they can store energy during off-peak hours and sell it at higher prices during peak demand. The industry impact includes increased investments in energy storage solutions, enhanced solar power integration, and new market opportunities. The widespread adoption of BESS enhances energy security, decreases carbon emissions, and aligns with global sustainability objectives.




*Source: LSI Research Analysis*

The **integration of BESS with solar power capacity** is expected to **improve grid resilience, promote sustainable energy, and address energy deficits. By 2030, the projected energy deficit is expected to decrease by 3,646 MW, with efficient BESS reducing it to 2,573 MW.** This highlights the critical role of BESS in optimizing solar power utilization and grid stability. This highlights BESS's ability to store excess solar energy and release it during peak demand periods.

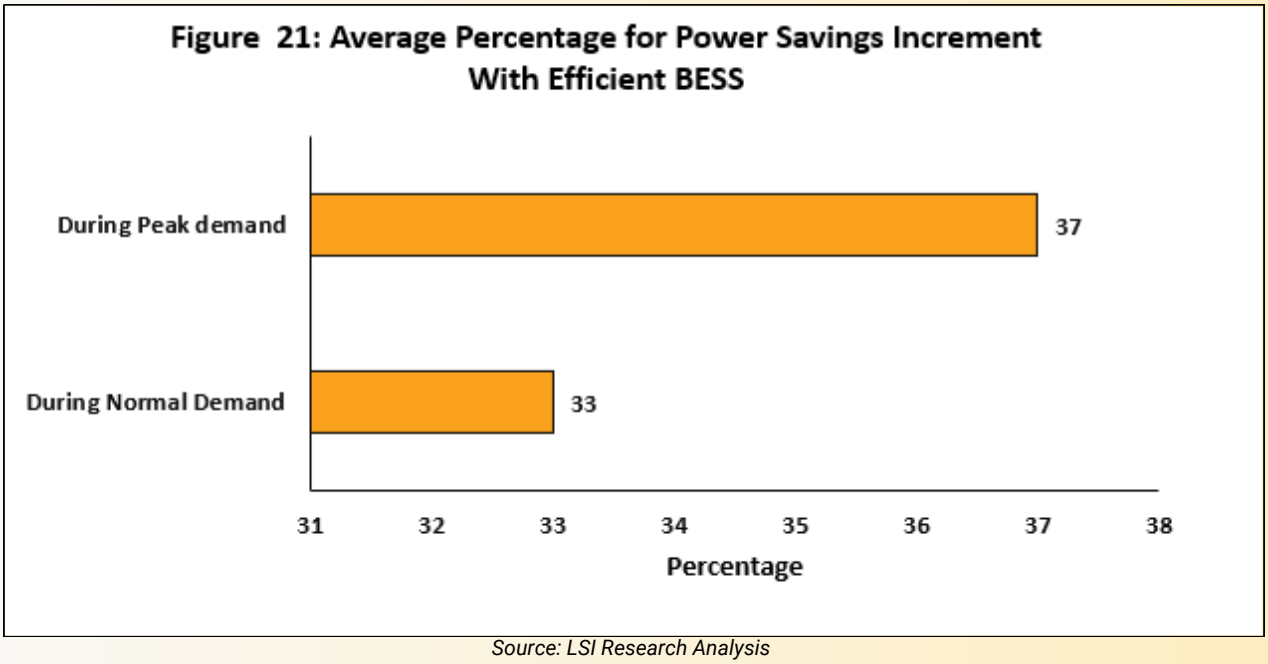
The future of BESS-integrated solar power is promising due to technological advancements, declining battery costs, and policy support for energy storage solutions. This trend will ensure a reliable and sustainable power supply, mitigating energy shortages and fostering long-term energy independence. Increased investment in BESS technologies will drive industry growth, enhance grid stability, reduce fossil fuel reliance, and foster economic benefits through lower energy costs and innovation. This trend suggests fundamental shifts in business models, infrastructure planning, and supply chain evolution, with economic implications including improved grid stability, greater energy independence, price stabilization, job creation, and reduced curtailment costs. The future also sees continued improvements in BESS efficiency, market growth, policy support, and potential convergence with other renewable sources and smart grid technologies. Advanced control algorithms, smart grid integration, distributed deployment, AI for demand prediction, and vehicle-to-grid technology can further enhance this process.

**The addition of 1% capacity to BESS reduced the solar electricity deficit by 0.6% during demand and 0.9% during peak demand, improving its reliability.** This reduces energy deficits, allowing businesses to save on grid electricity and participate in demand response programs, and enhances energy resilience for uninterrupted power during outrages, crucial for industries like manufacturing and data centres.

BESS can significantly reduce energy shortages and enhance solar power reliability by integrating it with solar power. This integration improves energy efficiency, reduces deficits, and enhances grid stability, leading to lower operational costs, increased investment attractiveness, and improved energy security.

**The projected capacity addition of BESS increases average power savings by 33% during normal demand and 37% during peak demand, over a forecasted time period of 5 years (2025-2030), demonstrating its potential to optimize solar energy utilization. By 2030, the BESS is expected to convert solar surpluses into reliable peak-hour supply, resulting in a 57-59% reduction in power deficit given the projected power generation and requirement.**

**Figure 21: Average Percentage for Power Savings Increment With Efficient BESS**




*Source: LSI Research Analysis*

# Role of BESS in Grid Stability, Renewable Integration and Solar Power Optimization

## Grid Stability:

BESS mitigates intermittent power generation from solar and wind, ensuring a stable electricity supply during peak demand.

It enhances frequency and voltage regulation, reduces transmission losses, and balances supply-demand gaps.

Peak load shaving is a crucial solution for reducing peak demand and improving energy management in smart grids. By incorporating peak shaving technologies like demand response, energy storage, renewable energy integration, and load shifting, the power grid can be more efficient, reliable, and sustainable. Peak load shaving is essential for efficient energy management, and smart grids offer opportunities to achieve this. However, integrating these technologies into smart grids faces challenges such as renewable energy integration, communication/control systems, and cybersecurity.

Addressing challenges and adopting recommended techniques can make power systems more efficient, reliable, and sustainable, enabling a greener future.

## Transmission and Distribution (T&D) Loss Reduction:

T&D losses in India's power sector are a persistent issue, influenced by factors such as infrastructure limitations, dispersed solar power generation, and variability of output.

BESS helps reduce India's high T&D losses (over 20%) through smart grid technologies, Advanced Metering Infrastructure (AMI), and infrastructure modernization.

Deploying BESS systems at strategic points within the grid can help mitigate T&D losses by providing localized power supply and reducing load on long transmission lines.

## Peak Demand Management:

- BESS stores excess solar energy during peak production and releases it during high demand, reducing the need for new grid investments.

## Solar Power Optimization and Integration:

BESS is essential for managing solar power intermittency, storing surplus energy, and ensuring dispatchable renewable energy.

India needs 14 GW/28 GWh of battery storage capacity by 2030 for solar and wind integration, with 250-500 MWh required per 1 GW of solar capacity.

## Utility-Scale Mandates:

- The government mandates a minimum two-hour energy storage capacity for new solar projects, with plans to integrate 73.93 GW/411.4 GWh of storage capacity by 2031-32.


# Challenges and Opportunities in the Solar-BESS Sector

## CHALLENGES:

- High initial costs, supply chain dependencies, and regulatory hurdles remain significant barriers.
- Infrastructure gaps and the need for skilled workforce development are also critical challenges.

## SUPPLY CHAIN VULNERABILITIES:

- India's BESS sector faces challenges due to dependence on imported critical minerals, exposing it to geopolitical risks and price volatility.
- Mitigation strategies include diversifying supply sources, boosting domestic manufacturing, and investing in R&D for alternative battery technologies.

## HIGH INITIAL COSTS:

- The high upfront costs of BESS deployment remain a barrier, despite declining battery prices.
- Government incentives like VGF and PLI are crucial for improving economic viability.

## OPPORTUNITIES:

- Declining battery prices, government initiatives, and technological innovation present growth opportunities.
- The sector offers potential for grid stability, renewable integration, rural electrification, and economic growth.

# Policy and Regulatory Landscape

## Current Policies:

India has implemented policies like the National Energy Storage Mission, Energy Storage Obligations, and mandates for co-located energy storage with solar projects.

The government has allocated 40 GWh of integrated battery production capacity, with plans to allocate an additional 10 GWh. Existing and new battery manufacturers are establishing production facilities, and India's import dependency is expected to decline to 20% by FY27 due to large-scale integrated battery production facilities.

Policies like the VGF scheme, National Framework for Promoting Energy Storage Systems, ESO aim to accelerate BESS adoption

The Production-Linked Incentive (PLI) scheme promotes domestic manufacturing of advanced chemistry cells, including lithium-ion batteries.

## Future Regulatory Reforms:

Regulatory reforms focus on creating market structures for energy storage participation, demand-driven tenders, and fiscal incentives to support widespread BESS adoption.

# Long-Term Benefits and Future Outlook

## Sustainable Energy Future:

BESS supports India's transition to a sustainable energy future by reducing reliance on fossil fuels, increasing energy security, and mitigating climate change.

Solar-BESS integration will play a key role in achieving India's net-zero emissions target by 2070.

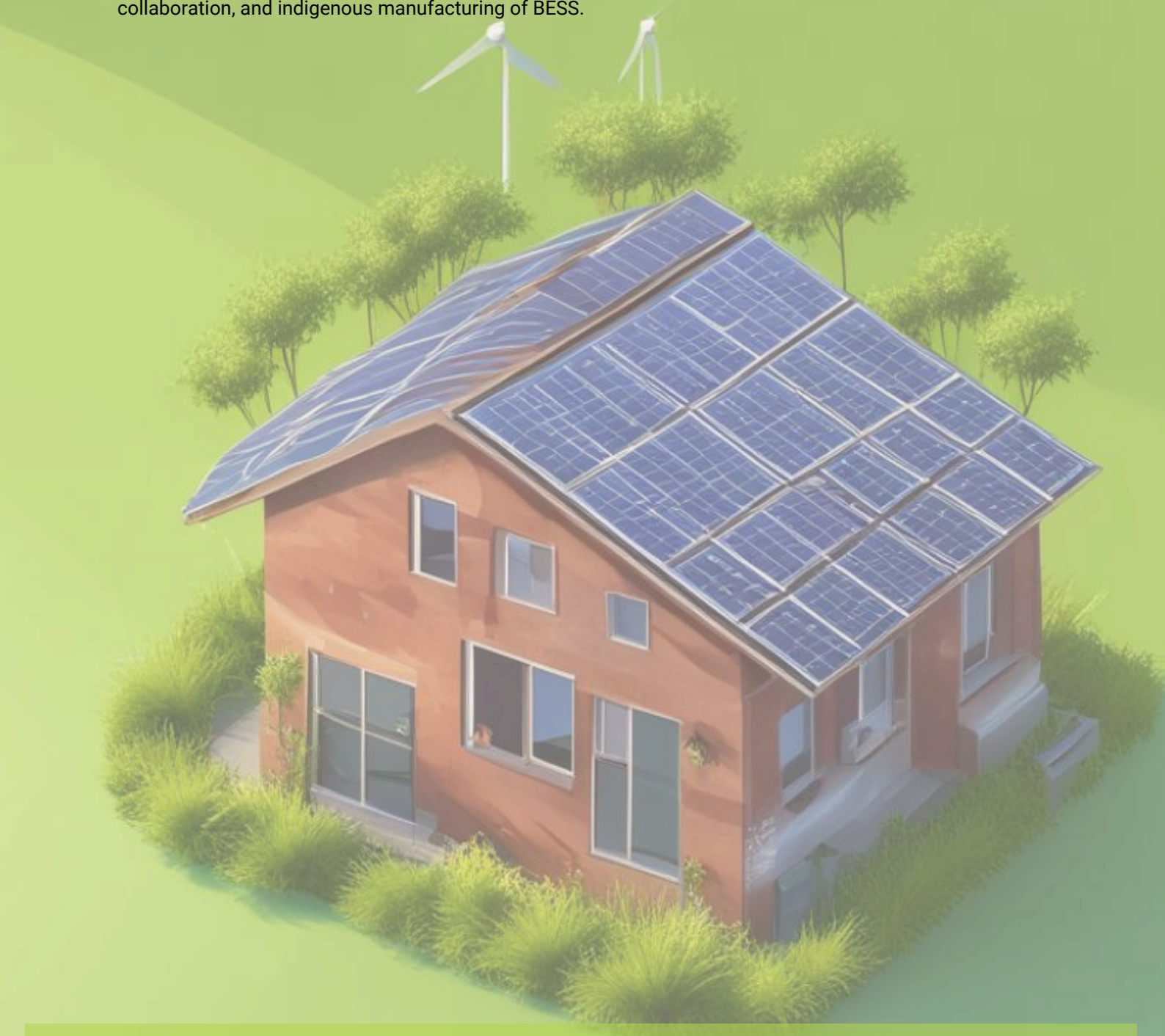
## Grid Stability and Economic Value:

BESS enhances grid stability, reduces carbon emissions, and provides economic benefits like peak load shaving, frequency regulation, and cost savings.

The sector is expected to attract significant investments, with the investment opportunities projected to exceed Rs. 5 lakh crore post 2035.

# Way Forward

India's growing electricity demand necessitates a strong clean energy transition, with solar power expected to contribute 25% of total power generation by 2030. However, solar intermittency poses challenges in grid stability and transmission efficiency. BESS an address these issues by storing excess solar energy, reducing grid instability, transmission losses, and energy intermittency. India's renewable energy strategy aims for net-zero emissions by 2070 and a 45% reduction in carbon intensity by 2030, supported by climate finance and strategic interventions such as policy support, infrastructure development, and technology innovation. Integrating BESS with solar power is crucial for successfully incorporating renewable energy into India's conventional energy mix. Despite challenges such as grid integration, land acquisition, financing issues, and regional disparities, India can advance its renewable energy goals through policy support, infrastructure development, technology innovation, financial incentives, BESS capacity building, stakeholder collaboration, and indigenous manufacturing of BESS.



# NOTES

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