Energy


# India's energy market: How global trends and learnings can help realize the potential of storage

*By Vikas Suhag, ICF*

## Executive Summary

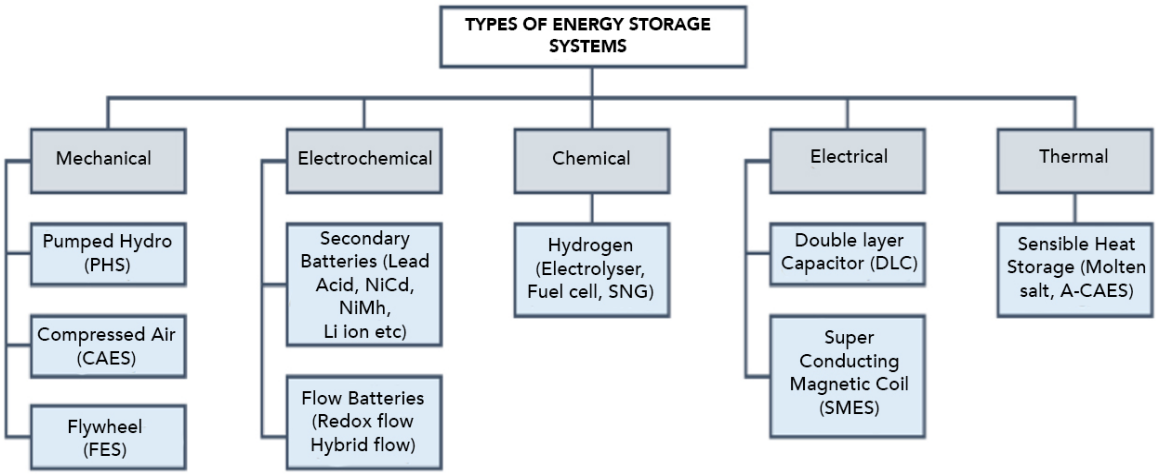
India's commitment to a greener, healthier future for all through energy transition is creating an urgent need to prioritize energy storage. By capturing electricity generated at one time and storing it for discharge on demand at another, energy storage will open up a whole new world of opportunities to realize the country's vision—including ever-greater reliance on renewables, better management of fluctuating grid demand and easier access to clean fuel for every citizen.

Revolutionizing India's power systems through storage will demand a deep understanding of the technologies, applications, policies, and business models best suited to its power market and energy ambitions. Although the sector is still in its infancy, lessons are emerging from storage pioneers such as the U.S. and South Korea that can guide India's decision-making. This white paper highlights the trends, solutions, and benefits being realized around the world that could help India leapfrog the development phase and go straight to deployment.

### Energy storage technologies

There are five types of energy storage. Ranging in size from small battery storage for domestic photovoltaic installations to large-scale pumped-storage hydropower, all have the same fundamental role: to absorb energy generated at one time and to discharge it to supply power at another. Applications range from the continuous supply of energy over a considerable length of time at one end of the spectrum, to power applications requiring rapid energy charging and discharging at the other.




## Introduction

Activity in the past few years indicates that energy storage is set to burst onto the scene of the world's power systems and markets. Global energy storage deployment reached a new record level in 2018, nearly double that of 2017.

While pumped hydro storage has dominated installed capacity for many decades, other technologies—especially fast response electrochemical systems—have gained significant traction in recent years.

Continuous technological innovation has stimulated the global expansion of energy storage. This trajectory is set to continue thanks to declining technology costs, increasing renewable energy capacity, and the growing need for power systems to integrate an increasing share of variable renewable energy.

Growth in storage is also being encouraged through supportive policies and mechanisms pioneered by early entrants into the energy storage market. The solutions they have developed and the lessons they have learned are accelerating activity in countries following close behind.

The top two countries leading energy storage deployment, China and the U.S., have both benefited from extensive market-regulatory support from their governments. Just a few examples bring home how successful energy storage deployment is dependent on government vision and action.

In China, the State Grid Corporation has launched several large-scale energy storage pilot projects, more than half of which are for ancillary services, to ensure reliability while integrating massive amounts of variable renewable energy (wind and solar) being installed in the remote western regions.

In the U.S., the Federal Energy Regulatory Commission (FERC) has issued several rulings to establish standards and mandates for fast-responding technologies including energy storage. It has also removed barriers for energy storage resources participating in all wholesale markets.

India's green power vision concentrates on transforming energy from a static, conventional network into a flexible, dynamic, and resilient system fit for the future. It is well placed to avoid the early stage of trial and error by adopting or adapting solutions proving successful elsewhere.

## Why is the time right for India to fast-track energy storage?

Energy storage technologies will provide India with the flexibility and scale it needs to cope with fluctuating energy generation and demand—and to realize a low carbon future network. Energy storage will support this transition by enabling reliance on renewables, managing the demands of the grid, and meeting consumer needs.

Storage also encourages investment by reducing the risk of curtailment and negative market pricing. Storage systems' efficient operation leads to lower system costs and consumer prices.

Four factors are now driving action in India's energy storage market:

### 1. Growing electricity access demand

India has already achieved 100% village electrification and is on track to achieve 100% household electrification. Consumption in these newly electrified homes will increase over time.

India's 19th Electric Power Survey estimates that electricity demand will increase to 15.4 tera units of electricity (TUs) by 2022 and 20.1 TUs by 2027. To meet this increase, significant investment in the generation, transmission, and distribution network is needed. Energy storage could play a crucial role in deferring this investment requirement.

### 2. Commitment to variable renewable energy

India has set itself ambitious renewable energy targets. The country aims to have 175 GW of installed renewable energy by 2022. By 2030, clean sources will account for 40% of all power generation capacity.

The exponential expansion of renewable energy (especially wind and solar, which are highly variable) introduces significant variability into the system. Using traditional thermal and hydro resources to balance that variance would be uneconomical and impractical.

### What would happen if India didn't deploy energy storage?

Without the means to store energy, India would experience increasing difficulty in balancing supply and demand, resulting in more frequent dropped loads and power outages. There are also likely to be significant renewable energy curtailments, wasting excess energy and hurting developers' bottom-line. In a storage-free scenario, fossil fuels would remain dominant in India's energy capacity mix.

There are ways to mitigate these negatives to some extent. Through the integration of demand response and forecasting, for example, and the introduction of regulation to help increase system flexibility. Such piecemeal solutions would be limited and not up to the scale of the challenge on their own.

### 3. Falling renewable energy costs

The country's growing use of renewable energies has been enabled by dramatically reducing prices and accelerating the energy transition—bringing forward the day when everyone will have access to affordable and sustainable energy.

While adding more variable renewables into the network will ensure greater energy security, it is also simultaneously hastening the need to address the issue of reliability. Energy storage is a critical component of grids powered by renewable generation.

### 4. Changing load curve

Rising affluence in India is leading to a rapid increase in the use of electrical appliances such as air conditioners, electric water heaters, and electric cooking devices.

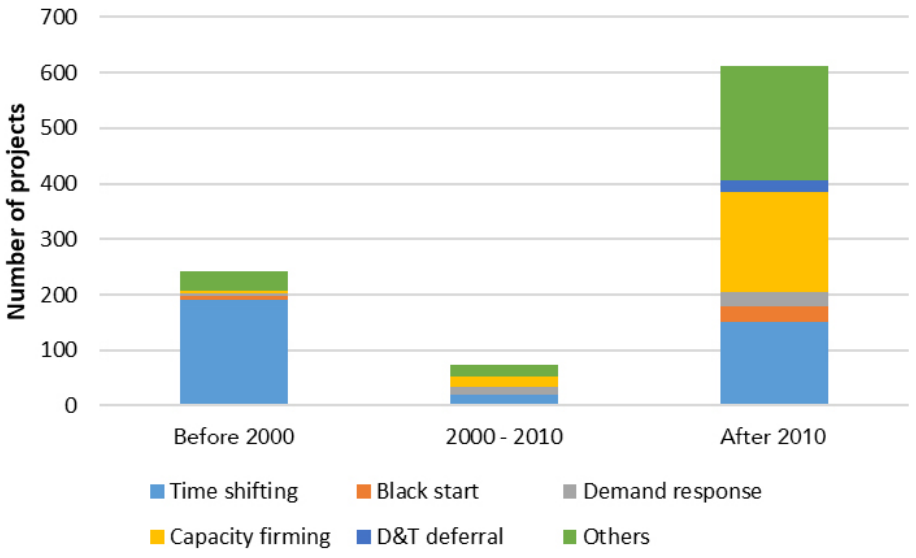
As the usage pattern of these devices is significantly different to traditional appliances—such as lighting, fans, and televisions—it is leading to changes in the load curve. Energy storage can be used as a tool to better manage these changes.

## What technology trends does India need to consider?

### Shifting to rapid response applications

There has been a paradigm shift in energy storage applications. The higher penetration of variable renewable energies is triggering a transition away from energy services like time shifting—where energy is stored for consumption at another time—to power services like capacity firming, which enables intermittent power output to be maintained at a consistent level for a period of time.

*Paradigm shift in energy storage applications*



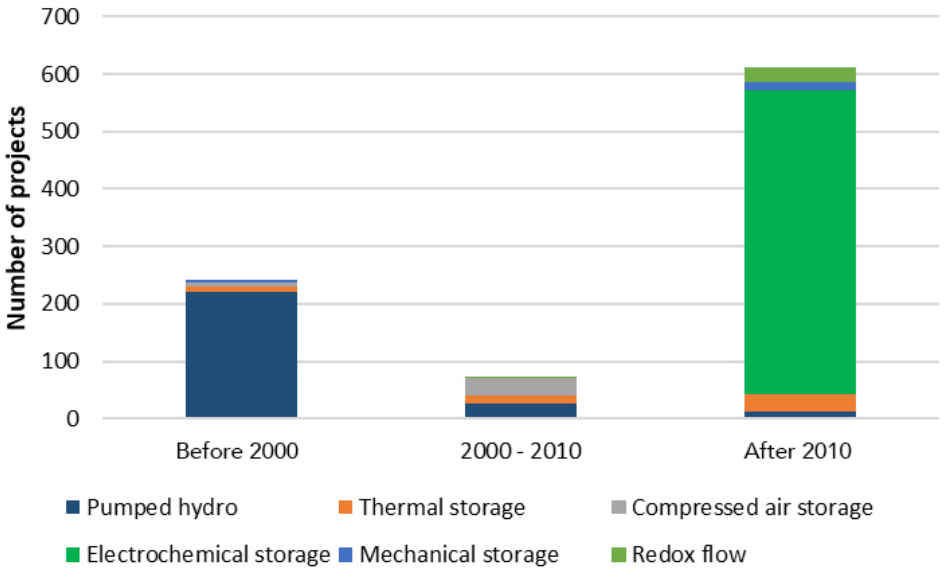
## Shifting to short duration power applications

Energy systems are becoming more volatile in the face of variable renewable generation and demand profiles. Traditional storage systems, however, are no longer meeting countries' needs.

Storage provided by hydropower stations—which account for 95% of storage applications in India—can only meet consistent, long-term power needs. Newer forms of storage such as electrochemical systems can take power response times from seasons to seconds.

Younger, more dynamic storage technologies are destined to dominate the market and drive the transition. These technologies enable the effective integration of variable renewable energies into the network. They can also enhance the efficiency of hydropower plants by bringing generation scheduling response times from 8–12 hours down to 15 minutes, storing any excess energy that would otherwise be wasted.

*Paradigm shift in energy storage technologies*




This new generation of storage solutions are not just shaking up the way the energy system works. They are also bringing innovative and disruptive companies into the energy market for the first time, drawn by the value they foresee in the storage sector. If this competitive environment continues to develop in India, the government-owned utility companies will need to consider how to ensure they don't lose out.

## Deploying storage as transmission and distribution solutions

Recent efforts have also focused on implementing energy storage as grid-connected resources. This is prompted by their benefits of lower capital cost, smaller footprint, and quicker deployment compared to transmission and distribution solutions.

Two Californian operators in the U.S. are assessing energy storage that provides transmission services, including transmission congestion relief, overload mitigation, and voltage control. These have contributed to the recent approval of a 70MW, four-hour storage-as-transmission-asset project.

In Europe, French utility RTE has proposed a 40MW "virtual transmission line" project relying on energy storage resources to ensure grid stability and lower network costs. Given the reducing capital cost of storage—and increasing investment in advanced IT infrastructure in the power sector for better planning and asset management—energy storage is anticipated to gain greater traction as grid resources around the world.

## What factors should influence India's storage technology mix?

India will need to consider the optimal mix of storage technologies to meet its needs. How should the country handle projected demand while increasing renewables and guaranteeing energy reliability, resilience, and affordability?

The pace of technological change makes this task something of a challenge. Looking at options through the lens of application suitability, price trends, and energy security can rule some technologies out and bring to the fore those that could become the backbone of India's energy transition.

### Prioritizing applications

The choice of a storage technology fundamentally depends on its purpose—the specific role it has to fulfill in the energy system. Is the primary aim peak load management or frequency regulation? Is the goal powering e-mobility? Or is network reliability the number one objective?

By prioritizing the requirements of storage applications at grid-scale, small-scale and off-grid, suitable technologies can then be identified and compared. As each storage technology can serve a range of applications, factors such as round-trip efficiency and cycle life will also need to be part of the equation.

### Predicting future costs

Learning from storage technology price trends to date—and using this knowledge to look into the future—is another valuable decision-support exercise. As few technologies other than pumped hydro storage have reached maturity, costs will continue to reduce with experience and volume.

Historically, storage system costs have fallen as production volumes increase due to economies of scale and manufacturing and engineering improvements. Overall price-reduction estimates for newer technologies range from 12–15% a year, with the cost of some expected to drop by as much as 50% within the next five years.

### Ensuring energy security

A third factor to consider is energy security. Not only is this issue at the heart of India's energy transition, it also has significance for domestic manufacturing.

While it's unlikely any country can be totally independent in terms of storage system supply, it's important not to compromise local development opportunities and raw material security through an over-dependence on imported technologies.

## How can India stimulate its energy storage market?

### Stimulating innovation in storage solutions

Stimulating innovation by incentivizing research and development has paid dividends in many countries. This is what enabled South Korea to become the largest battery energy storage market and overtake the U.S. in 2017. Thanks to an expansion of storage R&D efforts directed by the country's electricity master plan, it is now on target to slash energy storage system costs by half.

In one of the earliest, precedent-setting moves, the U.S. FERC gave a boost to newer storage solutions by increasing the pay for fast responding sources bidding into frequency regulation service markets. This gave batteries and flywheels a clear advantage over coal and gas plants, which have slower ramp-up rates. It is also credited with helping the U.S. storage market to flourish.

### Recognizing the financial value of storage

The environmental and societal value of energy storage—whose function is to increase reliance on renewables—is clear. So, too are the benefits storage brings to the grid in the form of increased efficiency and flexibility. For potential investors, the focus needs to be on whether these benefits can be monetized in order to justify investment.

There will be a growing number of ways energy storage assets can create new revenue streams as the market matures and new services are developed. There are also costs related to the energy transition that can be avoided through the use of storage.

Meeting increasing demand for energy by adding more capacity for generation, transmission, and distribution on the grid will demand some level of investment across the value chain. This investment can be postponed by using storage, which provides investors valuable choices about what to do with their funds in the meantime.

Growing use of renewable energies in India, however, has led to these resources now being subject to the same penalties as coal and gas for deviations from output commitments. As forecasting for renewables can never be 100% accurate (it's 85–90% at best), the use of storage to compensate for shortfalls or over-supply adds significant value.

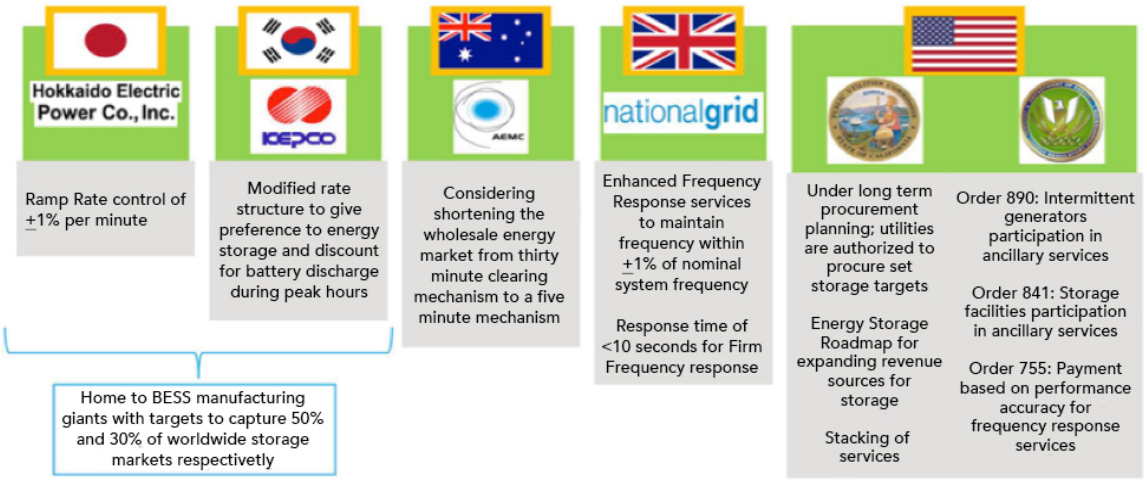
  

Quality of power generation also has a value in the energy market. In the past, coal and gas would always win out over unreliable renewables with their stable supply. Storage removes this difference from the equation. Factoring in their green credentials, renewable energies could be said to emerge as the most valuable energy of all.

## Creating opportunities through regulation

Governments around the world are showing how regulation and legislation can be used to create opportunities for storage aligned to their nation's energy needs. In the early market development phase, funding is the primary focus of new measures. In the deployment phase, direct support for storage is being given in the form of targets, tax benefits, preferential rates, and subsidies.

*Key global policies and regulations supporting energy storage*




*Storage leaders' policies and regulations are now focusing more on deployment than development*

| Policies focused on | | | China | USA | Germany | Japan | South Korea | Australia | United Kingdom |
|---|---|---|---|---|---|---|---|---|---|
| Early Development Phase | *Financial support* | *Funding for research & development* | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| | | *Funding for demonstrations* | ✓ | ✓ | | | | ✓ | |
| | *General support* | *Support manufacturing* | ✓ | | | ✓ | ✓ | | |
| | | *Stakeholder outreach* | ✓ | ✓ | | | | | |
| Deployment Phase | *Direct support* | *Storage targets* | | ✓ | | | ✓ | | |
| | | *Preferential rates for storage/renewables* | | ✓ | ✓ | ✓ | ✓ | | |
| | *Creating need/ opportunity* | *Ancillary services payment on accuracy & capacity* | | ✓ | | | | | ✓ |
| | | *Energy storage systems participation in ancillary services markets* | | ✓ | ✓ | | | | |
| | *Financial support* | *Subsidy* | | | ✓ | ✓ | | ✓ | |
| | | *Tax benefits* | | ✓ | ✓ | | | | |

## What energy storage business models might India adopt?

Energy storage is a disruptive force for power markets. It changes the nature of relationships within the existing electricity system and enables new entrants, services, and connections between power players and energy users.

New business models are emerging to capitalize on the introduction of this novel, independent asset class into the energy system. While they're still in their infancy, they can provide India with some useful insights.

What is already evident from the variety of early examples is that energy storage business models are multifaceted–depending on many technological, market, regulatory, and financial factors. It is also clear that the unique structure of a nation's power market will significantly determine how it might best shift to accommodate and benefit from energy storage.

### Comparing emerging business models

Business models to date tend to be grouped into two main types: ownership of energy storage facilities by distribution, generation, or transmission companies; and provision of energy storage "rental services" by independent storage service providers.

The ownership model comes with the typical concerns of capital investment and risk. In the case of energy storage, it also comes with a lack of control that is rare for asset owners. They cannot, for example, decide independently how much energy—or even revenue—to generate, as this is dictated by signals from the grid.

Other kinds of barriers exist that can limit owners' ability to capture the full value of storage. Chief among these are inadvertently restrictive regulatory frameworks. Electricity system operators in some countries are not allowed to own generation resources, which can be taken to include storage.

The independent storage service provider model sees new entities enter the market and make the initial major investment in energy storage facilities. They can develop dedicated, well-trained teams of specialists by focusing solely on providing storage services to distribution, generation, and transmission companies, rather than on the entire energy system.

These business models can all be seen in the world's most advanced energy storage markets such as the U.S., South Korea, Australia, and Europe. The major model in South Korea is asset procurement and use by utility companies, whereas a broader spectrum of models and storage as a service is gaining ground in the U.S.

### Exploring India's options and opportunities

Like all countries keen to accelerate the role of storage in its energy mix, India will need to reflect on the structure and state of its electricity sector in considering the most appropriate business models.

Government-owned distribution companies might be seen as strong contenders for ownership of energy storage facilities. However, their current financial health suggests they are not in a position to invest on the scale required.

The generation sector's mix of state- and independently- owned power producers puts it in a stronger position, and it is already investing in generators. Generation companies could feasibly deploy these resources and provide storage services to the distribution sector.

Encouraging independent storage service providers to enter the market looks to be a promising option in India. They add value via their specialist knowledge throughout the storage supply chain. They can also look after more than one facility, which is one way to bring down costs.

India's regulatory framework for the electricity sector is fundamental to the decision-making process. What it allows and disallows power players to do—as well as how it classifies their roles and responsibilities—will determine what type of agreements are possible between storage owners and their customers.

India will need to make crucial decisions so that its energy storage industry can move forward. It will also need to keep a watch on what's happening around the world, for three key reasons: business models have not yet been crystallized; costs and value will become better established; and new technologies may well open up as yet unseen commercial and collaborative opportunities come into view.

## How can India create an effective storage ecosystem?

We have looked at how India can benefit from energy storage, create opportunities for innovation and investment, develop an optimal mix of technologies, and establish supply options to meet demand. Now it's time to reflect on what it will take to realize these ambitions.

Powering progress will require an enabling framework of policies, processes, incentives, and capacity building. Equally important to success is creating a new community of storage experts, stakeholders, and technologists capable of stimulating, supporting, and maintaining the budding industry.

### Solving the storage identity crisis

India's regulations relating to the electricity grid were written at a time when energy storage was little more than the spark of an idea. So it remains unclear what exactly storage is in the legal sense. Is it a load, a generator, or both?

As a result, India is caught in limbo between the definitions and rules of the Electricity Act 2003 and the novel and multiple roles of energy storage. Progress can be unlocked—and workable agreements drawn up—by establishing a standard definition for storage.

## Embedding storage in the planning process

As India's population grows, industry expands and sales of electric appliances and innovations such as e-bikes emerge, the argument to plan ahead to meet future energy demand becomes more compelling. And so does the role of energy storage.

The established planning process currently focuses on investments in conventional electricity lines, generators, and plants. It needs to be brought up to date to automatically encompass energy storage facilities, on which the energy transformation depends.

## Establishing storage-friendly regulations

As many countries are demonstrating, regulation can be judiciously used to stimulate energy storage market development. It has a role to play in everything from directing investment in facilities to defining tariff structures and operating norms.

India has the opportunity to build on existing regulation to create a complete policy framework, providing the clarity and certainty that underpin market confidence and successful action. It is particularly important that storage owners know how they will be compensated for providing storage availability, services, and single and multiple—or stacked—applications.

### *India's existing minimal energy storage regulation and policy*

| Authority | Duration | Relevance to storage | Status |
|---|---|---|---|
| *State Electricity Regulatory Commissions* | *Forecasting, Scheduling & Deviation Settlement of Solar & Wind generators Regulation* | *Deviation penalty* | *Exists* |
| *Central Electricity Authority (CEA)* | *Technical Standards for Connectivity to the Grid (draft for amendment)* | *-Ramp rate <10% per minute*<br>*-10% storage for RE plants >50MW installed capacity* | *Needs notification* |
| *Central Electricity Regulatory Commission* | *Ancillary Services Operations Regulations* | *Frequency Controlled Ancillary Services* | *Needs deepening & broadening* |

## Supporting battery manufacturing

The cost of energy storage is one of the biggest challenges facing markets worldwide. It's a challenge felt very keenly in India, where import costs make storage significantly higher than in the U.S.

India has already started to address its lack of domestic battery manufacturing with a $1 billion program providing subsidies for companies purchasing land and incentives for building factories.

### *Battery manufacturing plans announced to date*

| Company | Location | Potential Capacity | Notes |
|---|---|---|---|
| *Tata Chemicals* | *Gujarat* | *50GWh* | – |
| *Suzuki Motor Corp & Toyota Motor Corp (Denso) & Toshiba* | *Gujarat* | *30m cells p.a. by 2025* | *production scheduled to start in 2020* |
| *Bharat Heavy Electricals Ltd (BHEL) and Libcoin consortium* | – | *30GWh* | *in discussions* |
| *Adani Group announced in 2019* | *Gujarat* | – | *plans to invest* |
| *Mahindra & Mahindra* | – | – | *announced open to manufacturing partnership with global player in 2019* |
| *Hyundai* | – | – | *announced investment intention if economy of scale advantage* |
| *Hero MotoCorp* | – | – | *evaluating investment in battery pack assembly in India* |

## What does the future hold for energy storage in India?

The early days of any new, highly technical sector are inevitably challenging. India has experienced its share of difficult and delayed energy storage projects as expertise, processes, financing, and standards have yet to be fully developed.

Building capacity among local technicians and establishing standards for batteries—in terms of their dimensions, geometries, and performance characteristics—will ultimately lead to trust and confidence among investors and across the energy sector.

The strength of India's distribution, generation, and transmission companies could be harnessed by organizations taking on the role of educator. That way, their employees will learn what they need to know about energy storage and its immense potential.

Do you think the suggestions outlined in this paper are enough to enable energy storage to really take off in India? The author welcomes your questions or insights via email.

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## About the Author

**Vikas Suhag** is an Energy Analyst with ICF. He has two years' experience in renewable energy assignments. He has provided research and analytical support for funding agencies (World Bank, GIZ and UNDP), government organizations and departments (Ministry of Railways, Government of Assam, Government of Rajasthan) and private sector clients and non-governmental organizations (BP, CLASP). He has provided secondary and primary research, analytical support, and market sounding activities for a solar techno-economic feasibility study for Indian Railways and a renewable hybrid project coupled with storage for the Solar Energy Corporation of India (SECI) and the World Bank. He is also involved in conducting market surveys for off-grid solar appliances such as solar home systems and solar water pumps. Vikas holds a bachelor's degree in Mechanical Engineering from the Manipal Institute of Technology.

  

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