



FACTSHEET

ENERGY STORAGE

**BEHIND-THE-METER AND
ELECTRIC VEHICLES**

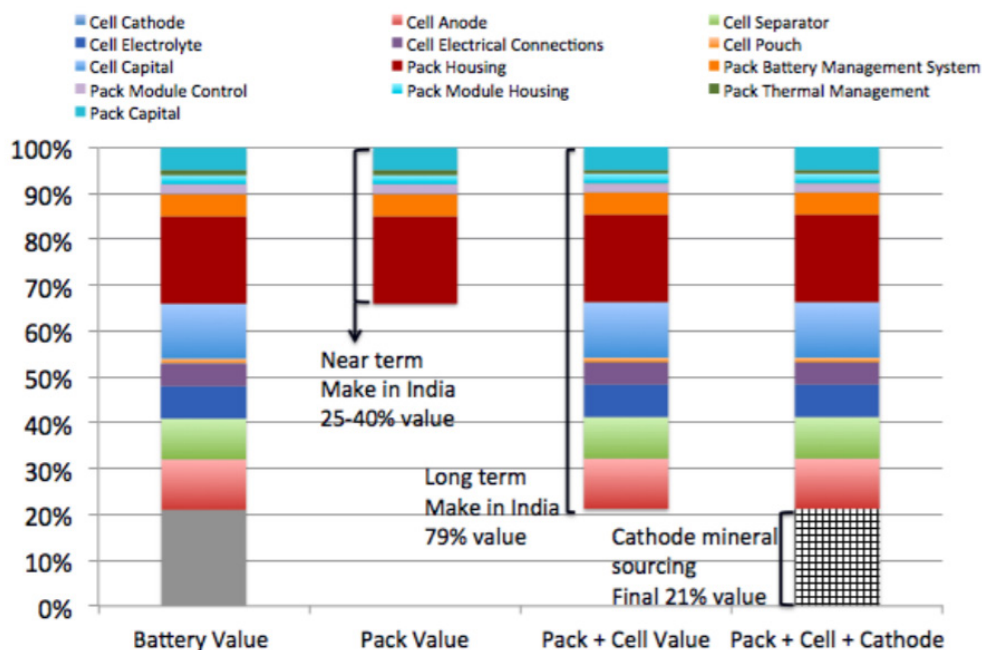
Introduction

According to IEA's *World Energy Outlook* analysis, supported by the agency's System Integration Model of India, adequate system flexibility will be essential for the security and reliability of electricity supply in the country in the coming decades (2020–40). The need for flexibility is expected to increase dramatically as the profile of demand becomes more variable, with steeper peaks. Moreover, given the seasonality of India's wind generation and the steep drop in generation from solar at sundown in all the modelled regions, storage is deemed to play an important role in the electricity markets, as the share of solar PV and wind increases from 4 per cent in 2017 to 28 per cent in 2040. By that year, India will account for 60 GW of the almost 220 GW of global battery storage capacity. Hydropower will also contribute to the flexibility of India's power systems; reaching nearly 110 GW of installed capacity by 2040 in the IEA's modelling analysis.

Demand for behind-the-meter batteries

- The deployment of small-scale battery storage systems is increasing in power systems across the world. This increase has been driven by the falling costs of battery storage technology, due mainly to the growing consumer market and the development of electric vehicles (EVs), along with the deployment of distributed renewable energy generation and the development of smart grids. In India, two factors can accelerate the demand-side response: The need for backup power and a rapid decline in battery energy storage system prices.
- Advances in digital technologies, such as artificial intelligence, blockchain, and predictive analytics, are giving rise to aggregated solutions and innovative business models. Start-ups around the world are rapidly commercializing intelligent networks of “behind-the-meter” (BTM) batteries to benefit electricity customers, utilities and grid operators.¹
- India stands to gain between 25–40 per cent (if only battery packs are manufactured nationally) to nearly 80 per cent (if both battery packs and cells are manufactured nationally) of the total economic opportunity represented by battery manufacturing for India's EV ambitions.

Battery cost breakdown and opportunities for value capture



Source: India's Energy Storage Mission, NITI Aayog and RMI

1. Available at <https://www2.deloitte.com/content/dam/Deloitte/bg/Documents/energy-resources/gx-er-challenges-opportunities-global-battery-storage-markets.pdf>, as accessed on 7 January 2021

- Globally, the increase in battery manufacturing capacity is led by China (with over 60 per cent of the total) followed by the US, Korea, EU and Japan (with less than 10 per cent each). EVs have been instrumental in bringing down battery costs. Battery costs have fallen by over 80 per cent since 2010 due to technological improvements across a range of applications. Global battery production is expected to increase 20-fold by 2040 under a business-as-usual scenario, driven by rising sales of electric vehicles.²
- Stricter emission norms coupled with growing attention towards fuel efficiency are expected to drive battery demand. Non-rechargeable batteries are expected to lose ground to rechargeable batteries on account of efficiency and enhanced lifespan.³
- Li-ion batteries are expected to capture a substantial portion of the market over the projected period on account of their low-energy density and are expected to infiltrate lead-acid battery applications, such as storage and automobiles, including plug-in electric vehicles, thus holding a majority market share by 2027.
- The adoption of Li-ion batteries in electric vehicles, energy storage systems, and portable devices is expected to rise at a fast pace owing to their low maintenance and higher energy densities. Nickel-cadmium and nickel-metal hydride batteries are the next major segments of the global market.

BTM applications

Demand side response and flexibility

Battery storage plays an important role on the consumer side by allowing uninterrupted power supply and diesel replacement, and in the form of mini-grids. With the opening-up of electricity markets, demand aggregation (grouping of consumers in the power system acting as a single entity) will catalyze participation in power system markets or the sale of services to operators. Demand aggregation (by aggregating demand-response resources or energy storage units) helps better integration of renewable energy resources by enhancing the demand-side flexibility of the grid. The benefits of aggregation include:

- **Load shifting:** Aggregators can enable real-time shifting of commercial and industrial loads to provide demand-side management services to grid operators. This makes a business case for deferred investments in distribution and transmission grid infrastructure.
- **Local flexibility:** Aggregators can provide flexibility at the distribution system operator-level, if there is a regional market for flexibility in place.⁵ The role of aggregators can be vital to enable demand-side flexibility, especially from the residential sector, since residential customers are typically small actors whose priority is to have a reliable and cheap service with the least possible effort. Aggregators would allow the participation of these customers in different services without requiring the consumer to monitor markets continuously. Evolution of regulatory frameworks is expected to enable aggregators to participate in the wholesale electricity market as well as the ancillary services market.

Increasing value of renewable energy

A key driver of growth in energy storage has been the co-location of renewable energy production facilities with energy storage resulting in more stable electricity production and ensuring firmer capacity during peak demand periods. Japan leads in behind-the-meter storage with over 200 MW of capacity. The key reason for this growth is expiration of the solar feed-in scheme in 2019, prompting owners of solar PV systems to purchase battery systems to increase self-consumption and mitigate losses. California, driven by the need for grid resilience in the wake of widespread wildfires, has installed over 10,000 behind-the-meter storage systems. The European Clean Energy Package (CEP) has defined storage as an entity separate from generation, transmission, or load, preventing it from being double-taxed when charging and discharging. Australia is also a key market for behind-the-meter storage as virtual power plants are quickly gaining popularity as a way to aggregate distributed assets.⁶ The use cases for behind-the-meter storage presently include:

2. Available at <https://www.iea.org/commentaries/india-is-going-to-need-more-battery-storage-than-any-other-country-for-its-ambitious-renewables-push>, as accessed on 7 January 2021

3. Available at <https://www.prnewswire.com/in/news-releases/strict-emission-standards-and-rising-ev-sales-to-fuel-application-of-li-ion-battery-materials-globally-858907095.html>, as accessed on 7 January 2021

4. Available at http://rmi.org/wp-content/uploads/2017/11/Report_India_Energy_Storage.pdf, as accessed on 7 January 2021

5. Available at https://aeee.in/our_publications/demand-response-in-power-markets/, as accessed on 7 January 2021

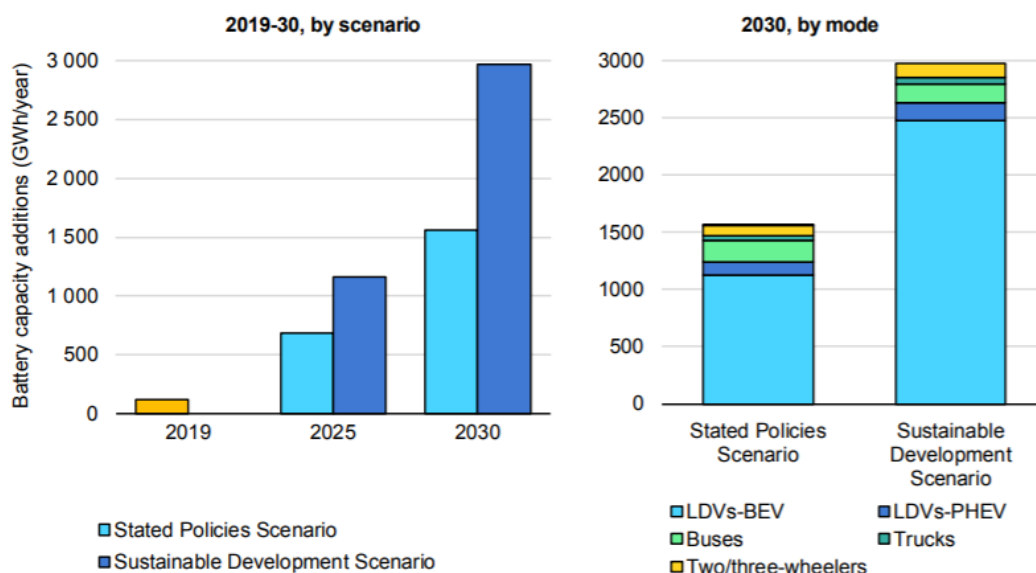
6. Available at <https://www.iea.org/reports/energy-storage>, as accessed on 7 January 2021

- **Commercial and industrial (C&I) (standalone):** Energy storage systems designed for behind-the-meter peak shaving and demand charge reduction for C&I energy users. Such units are often configured to support multiple commercial energy management strategies and provide optionality to provide grid services to a utility or the wholesale market, as appropriate in each region.
- **C&I (PV + storage):** Energy storage systems designed for behind-the-meter peak shaving and demand charge reduction services for C&I energy users. Such systems are designed to maximize the value of the solar PV system by increasing self-consumption, and optimizing available revenues streams and subsidies.
- **Residential (PV + storage):** Energy storage systems designed for behind-the-meter residential home use provide backup power, power quality improvements and extend usefulness of self-generation of solar with storage. Such systems also regulate power supply and smoothen the quantity of electricity sold back to the grid from distributed PV applications.

Electric vehicles

- IEA's *Global EV Outlook 2020* projects that, within the existing policy frameworks, global EV battery capacity (for all transport modes combined) will increase from around 170 GWh per year today to 1.5 TWh per year in 2030. To be in line with the goals of the Paris Agreement, a demand of 3 TWh is projected.
- Battery electric vehicles (BEV) are fully electric vehicles with rechargeable batteries and no gasoline engines. Plug-in hybrid electric vehicles (PHEV) are powered by both gasoline and electricity and can recharge batteries through both regenerative braking and “plugging in” to an external source of electrical power. In 2019, the average battery size used in BEVs increased by 14 per cent relative to 2018, in line with previous years. Average battery sizes for new BEVs ranges from 48 kWh to 67 kWh for cars. The trend of increasing battery capacity is expected to continue, with BEVs reaching an average driving range of 350-400 km by 2030, which corresponds to battery sizes of 70-80 kWh. For PHEVs, the average battery size has been roughly constant over the past five years at around 11 kWh, equivalent to an electric range of around 50-60 km.

Annual global battery capacity additions from EV sales, 2019-30



Source: IEA, 2020

- Li-ion batteries are likely to dominate the EV market over the next decade. There are three main reasons for this. First, the technology is well established with considerable experience in large-scale manufacturing and understanding of long-term durability characteristics. Second, large investment lock-ins for Li-ion manufacturing and supply chains constitute a barrier to entry for alternative technologies. Third, alternative technologies are at a lower range of readiness.

Energy storage in other contexts

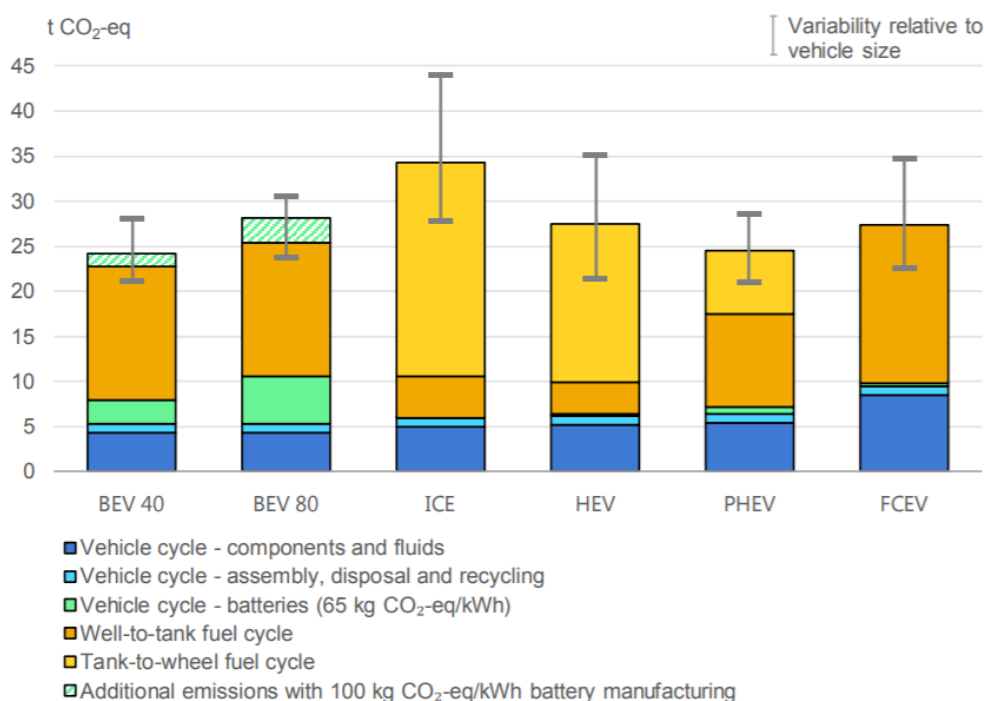
Supply security

- In the first half of the 2010s, batteries with higher energy density used cathodes with high cobalt content but the trend has been to increase energy density and to reduce the reliance on cobalt due to its price volatility and risky supply chains.
- The material demand for the batteries of the EVs sold in 2019 was about 19 kilotonnes (kt) of cobalt, 17 kt of lithium, 22 kt of manganese and 65 kt of nickel. In line with existing policies, cobalt demand is expected to expand to about 180 kt/year, lithium to around 185 kt/year, manganese to 177 kt/year, and class I nickel (> 99 per cent nickel content) to 925 kt/year in 2030. For carbon emissions to be in line with the Paris Agreement, a higher EV uptake leads to material demand values in 2030 to more than double these numbers.

Circular economy

- IEA's *Energy Outlook 2019* discusses the life cycle GHG emissions of EVs relative to other powertrains, including the influence of factors such as vehicle mileage, size and power. With a GHG intensity of electricity generation equal to the global average (518 grammes of carbon dioxide per kilowatt-hour [gCO₂/kWh] in 2018), BEVs, hybrid electric vehicles (HEVs) and fuel cell electric vehicles (FCEVs) have similar lifetime GHG emissions, and their emissions are lower than those of an average internal combustion engine (ICE) vehicle. Increasing the range of a BEV reduces its relative benefits compared to ICE vehicles.
- As the electricity used to charge EVs decarbonizes in major EV markets, the benefits of lower lifecycle GHG emissions of electric cars amplify relative to other powertrains.

Comparative life-cycle GHG emissions of an average mid-size car by powertrain, 2018



- Developing an effective waste management strategy for EV batteries is crucial as they rely on a short list of finite critical materials with few substitutes. Batteries are often discussed in the framework of the waste hierarchy: reducing first, followed by reusing, recycling, recovering energy, and treatment and disposal (European Commission, 2008). Also known as a cascading approach, this is a guiding philosophy used by policy makers for the sustainable management of many types of solid waste. When they are retired from an electric vehicle, batteries may either be reused in stationary storage applications, or sent to recycling facilities to recover constituent materials.

The Indian context

- The NITI Aayog, in association with the India Smart Grid Forum (ISGF), has come up with an Energy Storage Roadmap for India 2019–32, which includes the requirement of storage deployment for various applications in India.

Consolidated energy storage roadmap

	Consolidated Energy Storage Roadmap					
	Applications		Energy Storage (GWh)			
			2019-2022	2022-2027	2027-2032	Total by 2032
Stationary storage	Grid Support	MV/LV	10	24	33	67
		EHV	7	38	97	142
	Telecom Towers		25	51	78	154
	Data Centres, UPS and inverters		80	160	234	474
	Miscellaneous Applications (Railways, rural electrification, HVAC application)		16	45	90	151
	DG Usage Minimization		—	4	11	14
	Total Stationary (GWh)		138	322	543	1002
Electric Vehicle	E2W		4	51	441	496
	E3W		26	43	67	136
	E4W		8	102	615	725
	Electric Bus		2	11	44	57
	Total Electric Vehicles (GWh)		40	207	1167	1414
Total Energy Storage Demand (GWh)			178	529	1710	2416

Source: ISGF Energy Storage Roadmap for India, 2019-32

- In order to push ahead domestic manufacturing of storage batteries, the government has approved a Rs 18,100 crore production-linked incentive (PLI) scheme that includes advanced chemistry cell (ACC) manufacturing. A National Mission on Transformative Mobility and Battery Storage has been launched to promote electric vehicle penetration in India and to support 50 GWh of domestic ACC manufacturing. The features of the PLI scheme include:
 - Cash subsidy offered on output or the volume of cells manufactured and sold
 - Cells with higher performance specifications are eligible to avail incentives
 - Subsidy benchmarks to consider quality or performance characteristics of cells⁷
- Electricity (Amendment) Bill, 2020** will address issues such as contract enforcement, national renewable energy policy, renewable and hydropower purchase obligation, open access, adoption tariff, and payment security mechanism. In response to this, the India Energy Storage Alliance (IESA) put forward the following suggestions from energy storage companies:⁸

7. Available at <https://theprintmedia.in/2020/11/11/govt-to-offer-cash-subsidy-as-means-to-encourage-domestic-manufacturing-of-storage-batteries/>, as accessed on 7 January 2021

8. Available at <https://pib.gov.in/PressReleasePage.aspx?PRID=1634253>, as accessed on 7 January 2021

- Defining energy storage factoring in its flexible nature and applications, and its categorization as generation, transmission and distribution assets.
- Need for the National Energy Storage Mission and Policy in the Act to take cognizance of the evolution of policies for energy storage sector over the last few years and the expected performance improvement and cost reduction over the next decade.
- Inclusion of Storage Purchase Obligation (SPO) that consists of various existing and emerging cost-effective solutions that provide appropriate flexibility.
- Suggestions on building upon the National Smart Grid Roadmap by requiring state roadmaps to enable consumer production participation, renewable energy integration, future grid connectivity with micro-grids, EV (V2G and charging infra integration with utilities), differentiated supply (time of use, guaranteed supply, power quality, demand response and dynamic load management).



Centre for Science and Environment

41, Tughlakabad Institutional Area,

New Delhi 110 062 Phones: 91-11-40616000

Fax: 91-11-29955879 E-mail: cse@cseindia.org

Website: www.cseindia.org