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RMI INDIA
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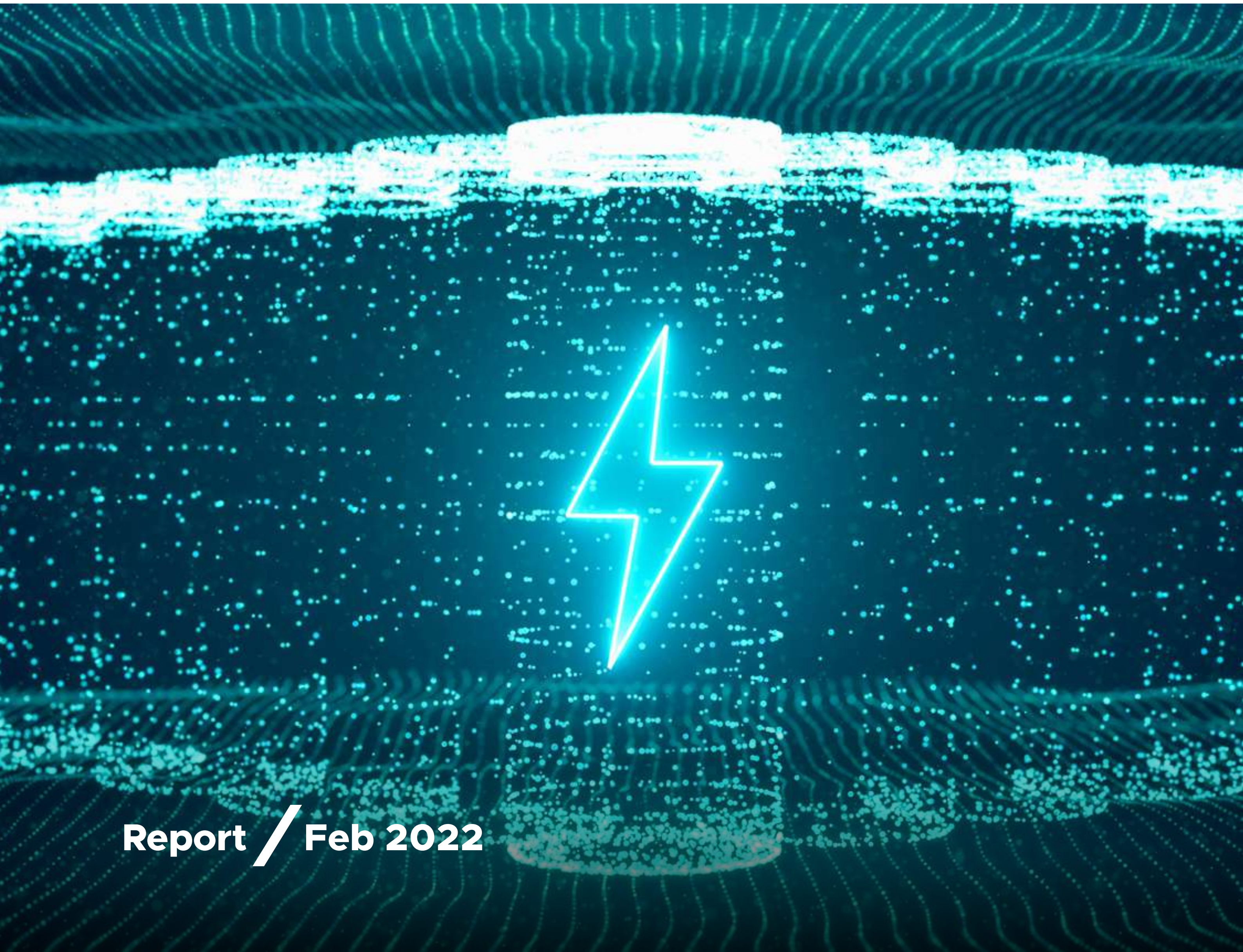
Need for Advanced Chemistry Cell Energy Storage in India

Part I of III



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About Us

About NITI Aayog

The National Institution for Transforming India (NITI Aayog) was formed via a resolution of the Union Cabinet on 1 January 2015. NITI Aayog is the premier policy 'Think Tank' of the Government of India, providing both directional and policy inputs. While designing strategic and long-term policies and programmes for the Government of India, NITI Aayog also provides relevant technical advice to the Centre and States. The Government of India, in keeping with its reform agenda, constituted the NITI Aayog to replace the Planning Commission instituted in 1950. This was done in order to better serve the needs and aspirations of the people of India. An important evolutionary change from the past, NITI Aayog acts as the quintessential platform of the Government of India to bring States to act together in national interest, and thereby fosters Cooperative Federalism.

About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

About RMI India

RMI India is an independent think-and-do tank. RMI India takes inspiration from and collaborates with RMI, a 40-year-old non-governmental organisation. RMI India's mission is to accelerate India's transition to a clean, prosperous, and inclusive energy future.

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Executive Summary

Executive Summary

The recently concluded COP26 has not only provided a much-needed impetus to move away from fossil fuel-based energy sources but has also demonstrated the need to adopt disruptive technologies to fastrack the transition to green energy. The Prime Minister of India has outlined an ambitious target of 500 GW of non-fossil fuel-based energy generation in India by 2030 and to reduce the total projected carbon emissions by 1 billion tonnes by 2030. To attain these targets, India needs a significant amount of grid storage and a large increase in the number of electric vehicles (EVs). However, this requires stepping up local manufacturing, exploring new avenues, and allowing global competition in sunrise sectors such as energy storage.

Energy storage has reach and leverage across numerous sectors of India's economy. A matured domestic battery manufacturing ecosystem is expected to create competitive advantages and contribute to India's energy security. This will require a combination of demand and supply-side measures.

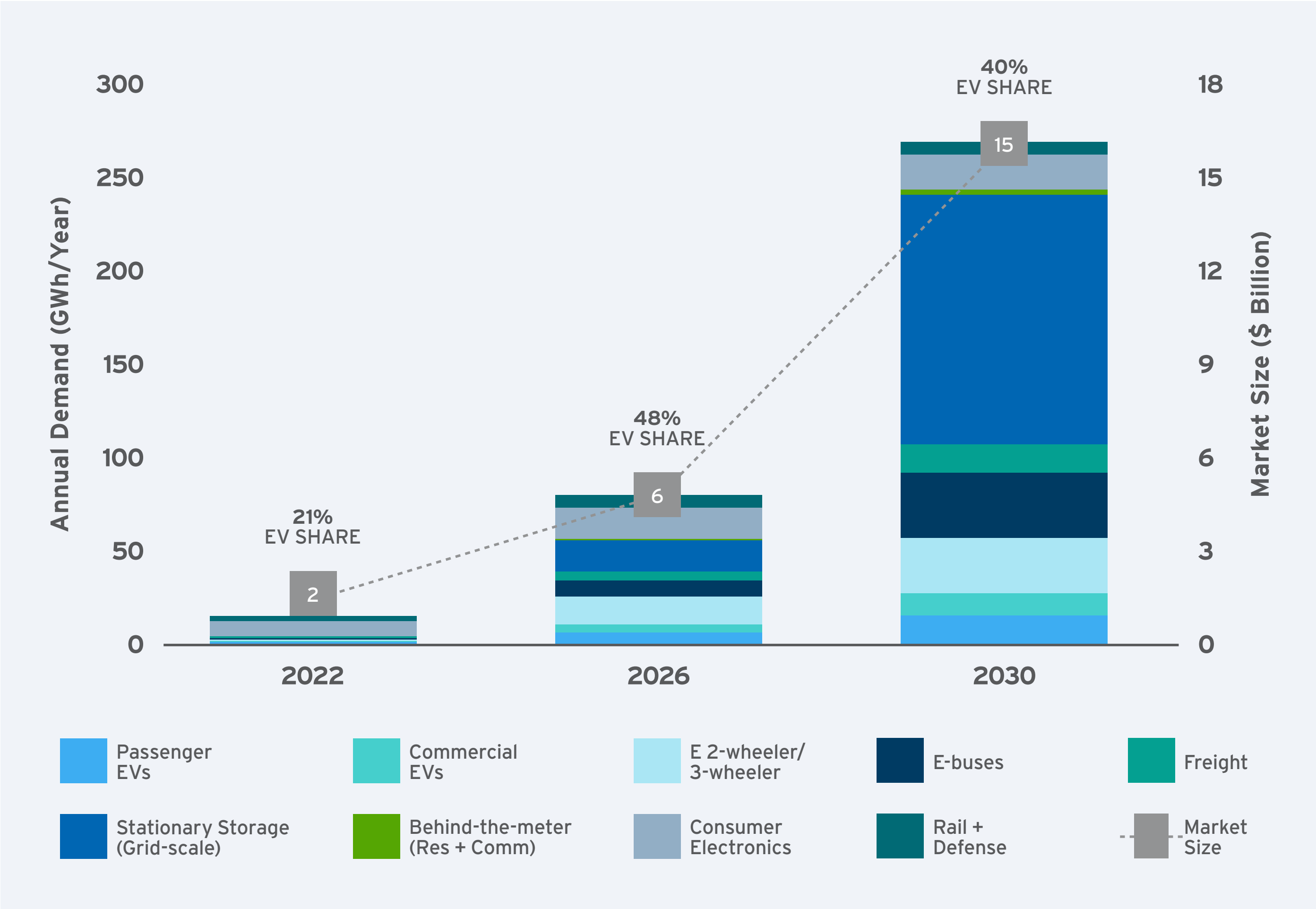
India is at a nascent stage of creating a domestic cell manufacturing ecosystem. There is, however, an enormous potential for large-scale battery manufacturing. The expected scale and growth of the country's battery market is substantial enough to warrant gigascale manufacturing capacity in the years ahead. Policies that induce India-based manufacturing to meet domestic demand can help the country create jobs and capture economic value from this sunrise sector.

Currently, India has a negligible presence in the global supply chain for manufacturing of advanced cell technologies.[i] Advanced batteries are a cornerstone technology, and their manufacturing within India could allow domestically sourced batteries to cater to the demand generated from EVs, grid storage applications, consumer electronics, and other uses. It is an opportune time for India to step forward and support the development of a domestic battery manufacturing ecosystem that meets its future energy storage market needs and helps reduce its dependence on imports to meet the future advanced energy economy demands.[ii]

This report estimates India's future demand for batteries under two scenarios: an "accelerated" scenario and a "conservative" scenario. The accelerated scenario assumes the current policy momentum for EVs, renewables, and other end-use applications. This will trigger the market and lead to high penetration of these technologies. In the accelerated scenario, battery demand rises in line with expected success of India's ambitions and incentives around vehicle electrification and grid decarbonization. The conservative scenario assumes battery demand rises in line with the most conservative expert forecasts.

Exhibit 1

Expected Growth in Indian Battery Demand (Accelerated Scenario)[1]



In the accelerated scenario, battery demand is expected to rise to 260 GWh by 2030 (see Exhibit 1). This would require nearly 26 gigafactories with an average advanced battery production capacity of 10 GWh per year. The conservative scenario battery demand would require 10 gigafactories by 2030. Since India has no manufacturing plants at this scale now, developing and rapidly scaling its advanced battery manufacturing industry is expected to require focused and coordinated public-private actions.

This market assessment informs the opportunity and criticality for India's emergence as a major global hub for advanced cells manufacturing. The recently announced **production-linked incentive (PLI) scheme** is the most important lever for enabling this opportunity to come to fruition.[2] In addition to this, sustained efforts must be made beyond the scheme to ensure adequate market development for these batteries as well as to address future preparedness challenges around sustainability of the material ecosystem and adaptation to future developments in advanced energy storage technology.

About This Report

This report is part of a three-report series designed to create a shared understanding among stakeholders of current status and future trends that are emerging in the advanced chemistry cells (ACC) battery sector and to build awareness of India's supportive programme on ACC battery storage, most importantly the Productive Linked Incentives (PLI) scheme for cell manufacturing. NITI Aayog, RMI, and RMI India present a thorough assessment of the global electric mobility and stationary storage sectors through a set of lenses, including international best practices in policy design, international technology trends in advanced cell batteries, global and domestic market sizing, and key risks across the value chain. This first report of the series looks at global trends and presents the opportunity that energy storage represents for India.

Introduction

Introduction

The global market for electric mobility and renewable energy is undergoing rapid growth supported by government policies, technological advancements, and declining costs. The implementation of the PLI Scheme signals India's commitment to the transformation of its mobility and energy systems. Such a transformation will do more than unlock the energy storage opportunity and the clean movement of people and goods. It will also create benefits that will reach almost every corner of the economy.

The focus on electrification of transportation as a primary technology pathway to achieve this transformation is driven by fundamental forces at the intersection of global technology trends and India's rapidly growing economy. Cementing this focus, India has pledged targets of 30% of new vehicle sales to be electric by 2030, which align with the broader goals of reducing carbon intensity of its economy by 45% by 2030 as announced at COP26.[3] This intersection presents India with a powerful opportunity to emerge as a global leader in new mobility solutions and battery manufacturing, positioning it for durable economic growth and global competitiveness. India is uniquely positioned to deploy EVs at scale, leapfrogging traditional mobility models that perpetuate congestion, air pollution, and oil import dependence while driving down the costs of batteries through economies of scale even faster than current projections anticipate.

To aggressively shift towards renewable energy, energy storage, and EVs, the Government of India announced a target of 500 GW of non-fossil fuel energy deployment by 2030,[4] and has signalled strong support of electric mobility through FAME II and other supportive policies,[5] including the recently announced Auto (US$3.5 billion) and Semiconductor (US$10 billion) PLI scheme. Growing India's battery manufacturing ecosystem to meet this local demand will create huge competitive advantages in mobility and consumer electronics. It will also support a stable and resilient electricity grid that can absorb increasing shares of renewable energy. In this way, batteries can have leverage over several of the most dynamic and growing sectors of India's economy.

Institutional leaders across the world are keen on playing an active role in the growing energy storage market. With the global market expected to exceed US$150 billion annually by 2030,[6] there is a clear motivation for India's market participation. India is well positioned to capture a large share of the growing global market and could represent up to 13% of global battery demand by 2030 with high penetration of EVs, increasing demand of stationary storage applications, and continued growth in the consumer electronics sector.[7] India must act now to promote the growth of a strong domestic advanced battery manufacturing market to compete with an uptick in global policy supporting domestic battery manufacturing in China, Europe, Southeast Asia, and the United States.

In order to stimulate growth in domestic ACC manufacturing and encourage development of dedicated gigascale (greater than 5 GWh/year in battery cell production) manufacturing capacities, the government of India called for the participants to bid for the scheme. This umbrella-level initiative addresses three key aspects that are imperative from the perspective of promoting advanced cell manufacturing in the country. These are:

- A central-level scheme extending suitable financial incentives for advanced chemistry cell battery manufacturing
- Key central-level initiatives pertaining to encouraging demand creation in electric vehicles
- Provision of a single-window framework to potential global investors to come and invest in India

State governments are expected to be major contributors in the success of the programme, and they will be encouraged to provide additional incentives for setting up manufacturing facilities through the state-level grand challenge, which is part of the program. In turn, this will help contribute to state economies and job growth. In the process of developing the policy framework, NITI Aayog organized consultations with all stakeholders, including major cell and battery manufacturing companies, within and outside India.

In addition to this incentive structure, measures to stimulate demand for stationary storage, EVs, and other applications are being developed and strengthened in consultation with the relevant ministries. Specific to EVs this includes measures like the Auto PLI scheme, FAME II Scheme, various state EV policies (see Appendix C for details), and several other fiscal and non-fiscal policy measures by central ministries and state governments. The government has sent a clear signal through several schemes and announcements that electric mobility is a primary technology path in achieving India's clean and connected mobility transformation (in line with the world).

Along with strong signals supporting electric mobility, the Government of India and the private sector have indicated promising market growth in the renewable energy industry. Achieving high levels of renewable energy penetration on the grid will naturally create a large market opportunity for stationary storage to complement solar and wind projects. Stationary energy storage systems (ESS) can provide a variety of services to stakeholders at all levels of the electricity system, including utilities, grid operators, and end-use customers. With the rate of cost decline in the industry, batteries are becoming highly competitive with incumbent technology, further creating new demand for stationary storage applications across a wide stakeholders group.

The strategic allocation of FAME II resources, an increasingly supportive policy and regulatory framework for electric mobility, and the collaborative and integrative role of the National Mission on Transformative Mobility and Battery Storage will potentially have a catalytic effect, helping India capture the economic opportunities at hand while delivering societal and environmental benefits.

Why Batteries, Why Now?

- **Global Climate Action and the Need to Integrate a Higher Share of Renewables:** With existing NDC targets reinforced by the recent announcement of a net-zero target by 2070, India is aiming to accelerate decarbonization efforts in line with global momentum on climate action. India has committed to meet 50% of its energy requirement from renewable energy by 2030, which includes a target of 500 GW of non-fossil fuel energy capacity by 2030. Advancement in battery technologies will be central to achieving these goals.

- **Energy Security:** India is dependent on imports for much of its energy value chain, chiefly commodities like crude oil and natural gas but also products like solar panels and lithium-ion batteries which are central to decarbonization. As energy transition accelerates, domestic battery manufacturing will be critical to ensuring a greater degree of energy security for the country.

- **Air Pollution:** Local air pollution continues to be a growing challenge for India. Of the top 30 most polluted cities in the world, 22 are in India,[8] and as urbanization accelerates, this problem is bound to compound. EVs will be essential to cleaning up distributed urban transport pollution.

- **Electric Vehicle Ambition:** To attain the leading position in this cutting-edge technology disruption, India has set an ambitious aim of achieving the EV 30@30 goals.[9,iii] This is poised to increase the annual share of batteries needed for mobility, making transport a critical demand sector for batteries.

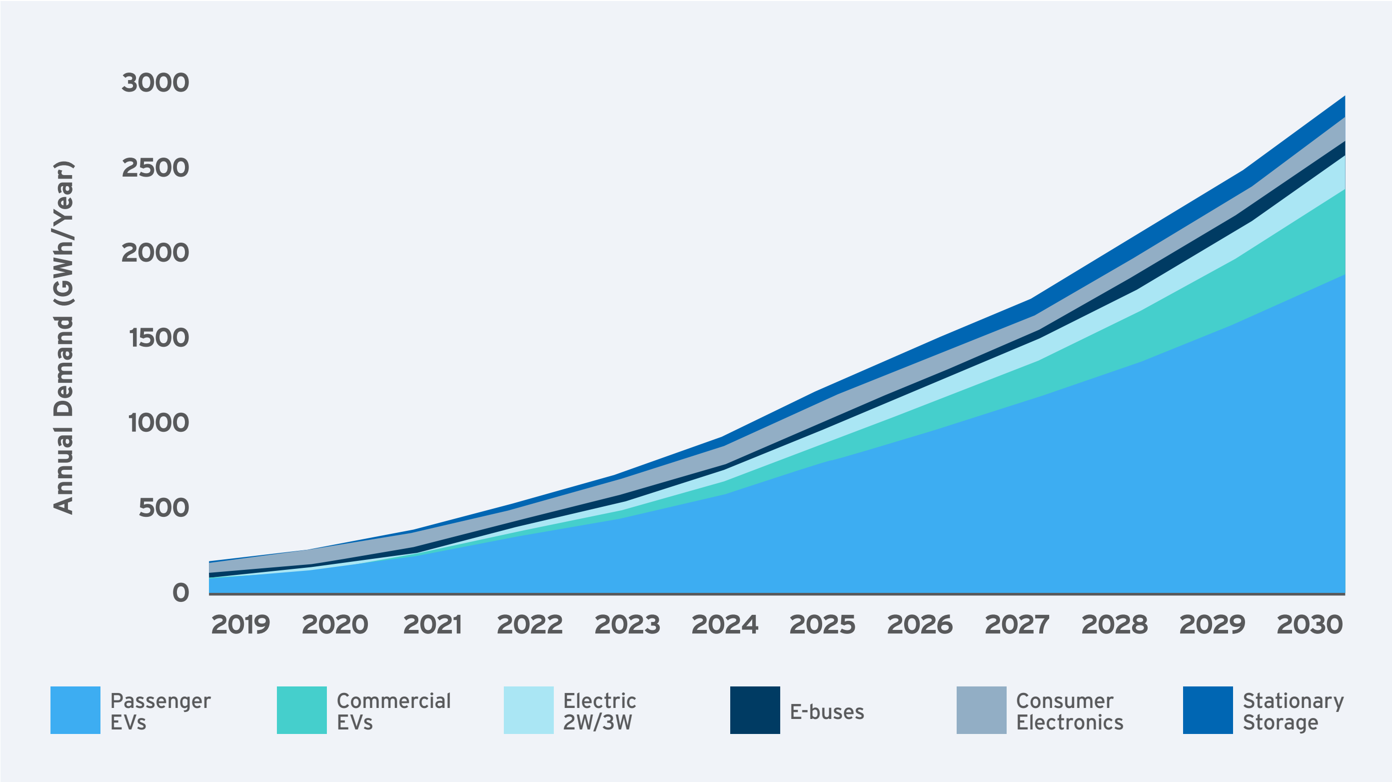
- **Industrial Development and Indigenization:** Battery manufacturing presents an opportunity to partake and become a leader in a global sunrise industry and accelerate indigenization of the energy and transport value chain.

- **Falling Battery Costs:** With the cost of batteries falling, many end-use applications are increasingly becoming economically viable. This trend will only accelerate as battery performance is continuously improving in tandem with the price decline.

Global Battery Storage Market Overview

An increasing level of policy and regulatory support combined with the rapid advances in energy storage technology and significant cost declines are creating enabling conditions for a rapid growth of the electric mobility market. According to RMI's research and Bloomberg New Energy Finance's (BNEF's) analysis, the global demand for lithium-ion batteries is expected to reach more than 2.8 TWh annually by 2030, with a vast majority of that demand serving electric transportation as indicated in Exhibit 2 below.

Exhibit 2 Global Annual Lithium-Ion Battery Demand By End Use[10]



Similar momentum is emerging in ESS applications. Investment in stationary energy storage globally reached US$6.3 billion in 2020. It is expected to continue at a rapid pace reaching US$22 billion by 2025 and more than US$30 billion by 2030 (as seen in Exhibit 3). There could be room for significant upside to this if grid decarbonization gets the critical momentum required to achieve net-zero goals. These projections also do not account for India's ambition to become a significant market for energy storage and a leader in battery manufacturing.

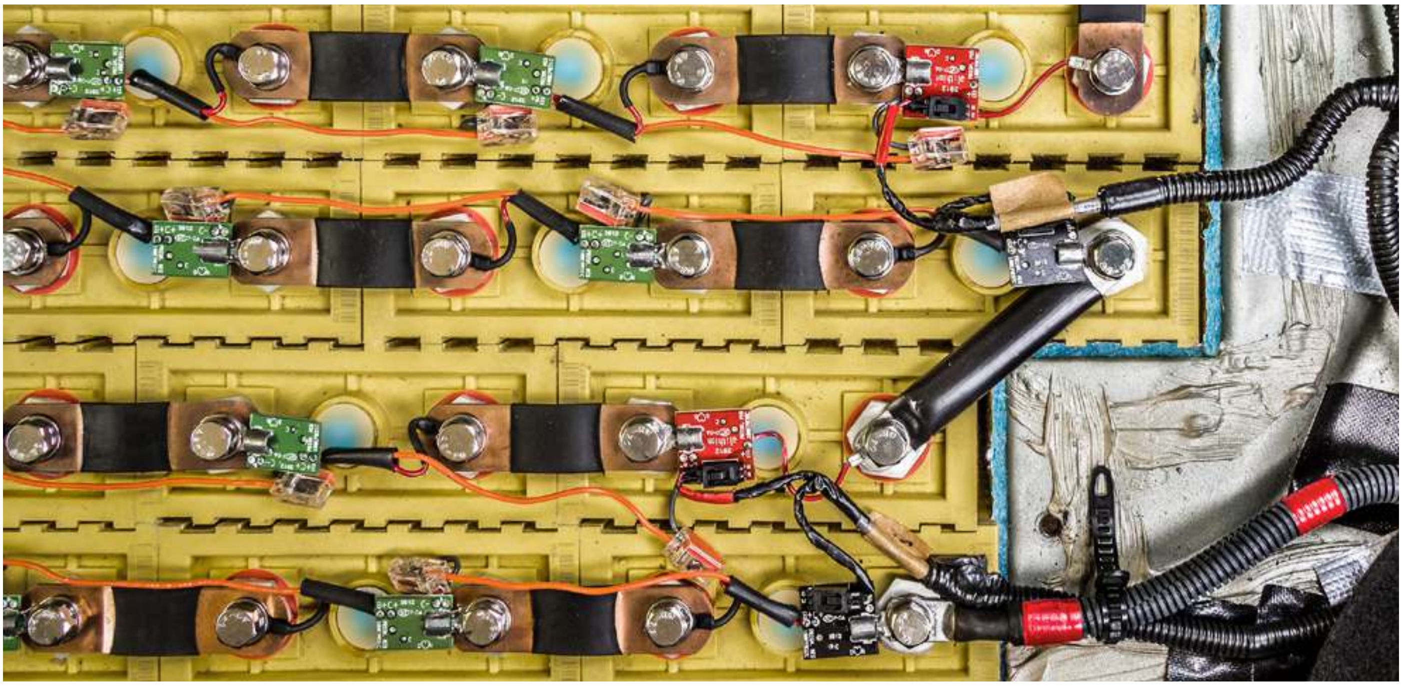
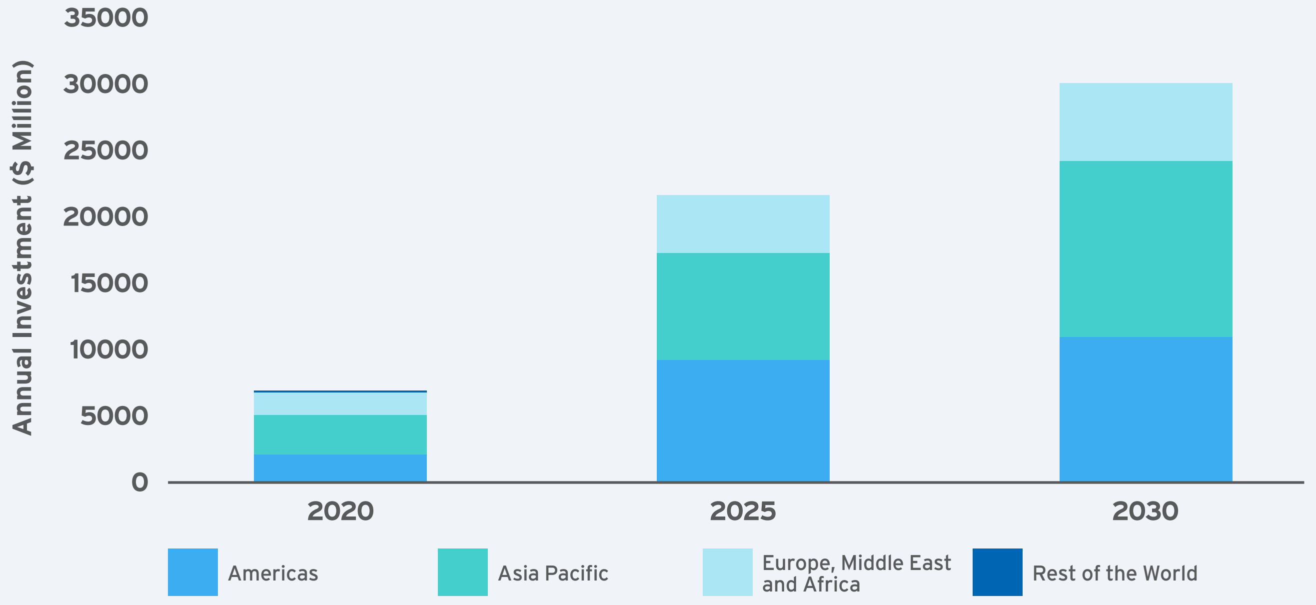
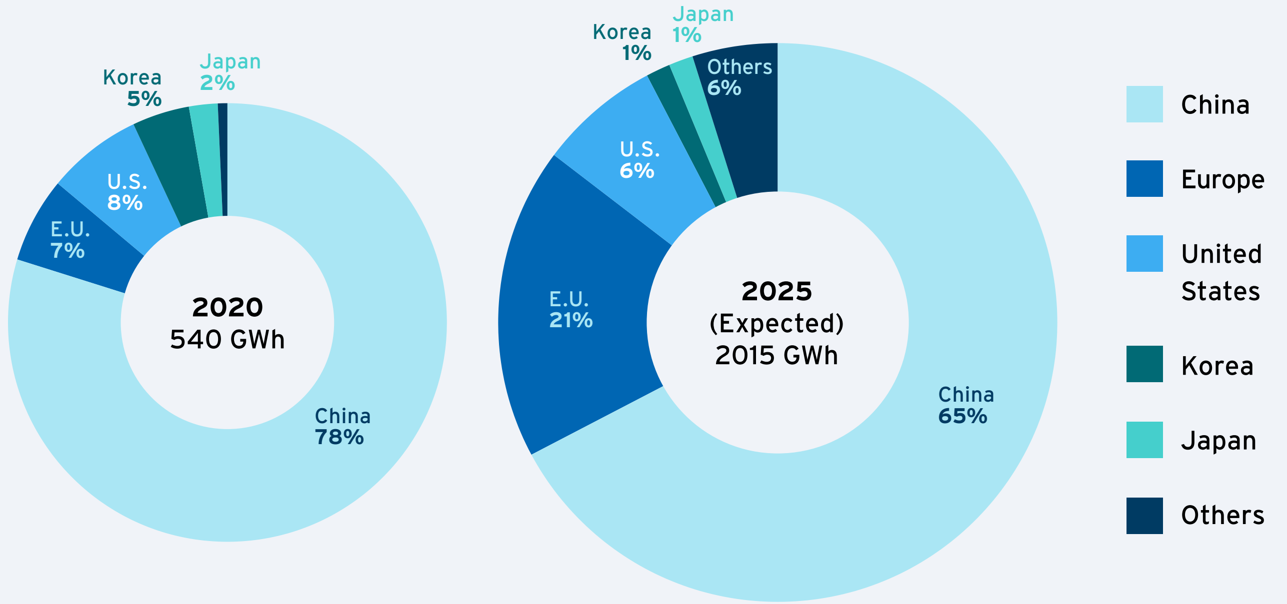


Exhibit 3 Annual Global Investment in Stationary Energy Storage—Outlook[11]



In response to this momentum and massive demand growth expectations, many countries are already moving quickly to establish manufacturing pre-eminence in the battery storage space. Gigafactories—factories with battery manufacturing capacities over 5 GWh/year—have begun developing worldwide (as seen in Exhibit A1 in Appendix A), and the global market is growing rapidly. China has been the fastest mover, and currently is responsible for 78% of global battery manufacturing capacity. The United States and Europe account for 8% and 7% of current manufacturing capacity, respectively (see Exhibit 4).

Exhibit 4 Lithium-Ion Battery Manufacturing Capacity by Country[12]



Projections indicate a rapid growth in both demand and manufacturing capacity, with many new entrants between now and 2025, as more countries compete for a share of the market. Beyond existing facilities, future ones are being built around the world (see Exhibit A2 in Appendix A). Exhibit 4 shows that projected capacity additions between now and 2025 will exceed 1,450 GWh of new annual production capacity globally, with China retaining a large share of the market and Europe emerging as a geography of high growth.

As the push towards the PLI scheme for battery manufacturing affirms, India has a window of opportunity to capture a large market share of electric mobility and the batteries required to support it. But as this overview suggests, the competition to dominate the space is clear and present. The success of India's PLI scheme will require a strong co-ordinated strategy to overcome its relatively nascent position in advanced cell manufacturing supply chain.

Value of Battery Storage Across the Ecosystem

Value of Battery Storage Across the Ecosystem

Before delving into sizing the opportunity for battery manufacturing in India, it is important to understand the different usages of batteries across the ecosystem. The applications for cost-effective deployment of batteries are constantly evolving and maturing as cost and performance improve, leading to a healthy diversification of applications across stationary storage, vehicles, and consumer electronics. Exhibit 5 below presents a timeline of when batteries will likely become competitive with incumbent technologies without subsidies and potentially replace them.[iv] The competitiveness and market attractiveness of advanced batteries and battery systems conveyed in the table below are a function of the expected cost competitiveness of batteries compared with the incumbent technology and informs the forecasted market size of each application during the indicated timeframe.

Exhibit 5 Battery Storage Market Attractiveness

Mobile Applications	2020	2025	2030
Personal four-wheeled EVs	Low	Medium	High
Commercial four-wheeled EVs	High		
Personal two-wheeled EVs	Medium	High	
Commercial two- & three-wheeled EVs	Medium	High	
Electric Buses	Medium	High	

Stationary Applications	2020	2025	2030
Microgrids Applications/Diesel Replacement	High	Medium	Low
Grid Support/Ancillary Services	High*		
Renewable Integration	Medium	High	
T&D Upgrade Deferral	Medium		High
C&I Behind-The-Meter	Medium	High	
Residential Behind-The-Meter	Low	Medium	

*Assuming participation in wholesale ancillary markets is possible

EV Owners and Fleet Operators

The usage and value of batteries in EVs are more direct. Batteries currently account for 25%–50% of the total cost of an EV depending on range and performance. While battery costs are declining rapidly, the battery will remain a critical component of the EV supply chain. As costs come down and specific energy densities continue to increase, the performance and cost competitiveness of EVs will continue to improve and will soon become the more attractive choice considering upfront costs, in addition to the already lower operational costs, compared to diesel, petrol, and compressed natural gas (CNG) vehicles.

EVs are attractive technologies due to their lower maintenance and fuel costs than petrol, diesel, or CNG vehicles; the number of moving parts in the drivetrain for a typical EV are just 20, compared to nearly 2,000 for internal combustion engine (ICE) vehicles, making them more reliable.[13] Vehicles with lower operational cost are attractive to fleet operators and commercial drivers due to the relatively large component of their business costs associated with vehicle fuel and maintenance. EVs represent a large cost-saving opportunity for commercial drivers, fleet operators, and owners of personal vehicles.

Stationary Storage Applications

Stationary ESS can provide up to 17 different services to stakeholders at all levels of the electricity system, including utilities, grid operators, and end-use customers. However, while batteries are technically capable of providing these services to the various stakeholder groups identified in this report, a few challenges must be tackled for system operators to be properly compensated for those services. The services described in the following sections are universal to electricity grids across the world. However, the nomenclature used here represents specific services defined in the US electricity market as a proxy for India because some of these grid services do not yet exist in the country. The following section of this report provides a summary of the storage applications that are possible when enabling regulatory and market frameworks are in place.

Distribution Companies and Transmission Utilities

Utility services from batteries generally fall into two categories: upgrade deferral and resource adequacy. Upgrade deferral refers to the use of energy storage and demand management to defer or completely avoid the need to invest in high-cost system upgrades for both transmission and distribution infrastructure (see Exhibit 6 below). Forward capacity or resource adequacy applications refer to the use of storage systems to meet short-duration system peaking constraints either from a generation or transmission perspective.

Exhibit 6 Energy Storage Value Streams for Utilities and Discoms

	Service Name	Description
Transmission Utilities (Power Grid) and Discoms	**Forward Capacity/ Resource Adequacy**	Instead of investing in new natural gas combustion turbines to meet generation requirements during peak electricity-consumption hours, grid operators and utilities can pay for other assets, including energy storage, to incrementally defer or reduce the need for new generation capacity and minimize the risk of overinvestment in that area.
	Distribution Upgrade Deferral	Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades is necessary to meet projected load growth in specific regions of the grid.
	Transmission Congestion Relief	Independent system operators charge utilities to use congested transmission corridors during certain times of the day. Assets including energy storage can be deployed downstream of the congested transmission corridors to discharge during congested periods and minimize congestion in the transmission system.
	Transmission Upgrade Deferral	Delaying, reducing the size of, or entirely avoiding utility investments in transmission system upgrades is necessary to meet projected load growth in specific regions of the grid.

Grid Operators

For grid operators, energy storage systems can provide a suite of ancillary services that supports the reliable and efficient operation of the electricity grid. The applications described below are largely differentiated by the time horizon for which the services are needed, ranging from fast-responding frequency regulation to longer duration daily storage or renewable firming (as seen in Exhibit 7 below).

Exhibit 7 Energy Storage Value Streams for Utilities and Discoms

	Service Name	Description
PGCIL/ POSOCO/Grid Operator/ Value Streams	**Energy Arbitrage (daily)**	Energy arbitrage is the purchase of wholesale electricity while the locational marginal price (LMP) of energy is low (typically during night time) and sale of electricity back to the wholesale market when LMPs are highest. Load following, which manages the difference among day-ahead scheduled generator output, actual generator output, and actual demand, is treated as a subset of energy arbitrage in this report.
	Frequency Regulation	Frequency regulation is the immediate and automatic response of power to a change in locally sensed system frequency, either from a system or from elements of the system. Regulation is required to ensure that system-wide generation is perfectly matched with system-level load on a moment-to-moment basis to avoid system-level frequency spikes or dips, which create grid instability.
	Reserves	Spinning reserve is the generation capacity that is online and is able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage. Non-spinning reserve is the generation capacity that can respond to contingency events within a short period, typically less than 10 minutes.
	Voltage Support	Voltage regulation ensures reliable and continuous electricity flow across the power grid. Voltage on the transmission and distribution system must be maintained within an acceptable range to ensure that both real and reactive power production are matched with demand.
	Black Start	In the event of a grid outage, black start generation assets are needed to restore operation to larger power stations in order to bring the regional grid back on line.
	Renewable Firming (daily)	Renewable firming is when fast-responding resources effectively smooth or firm up renewable generators output creating a more traditional dispatchable resource that can be easily integrated into the existing grid. As intermittent renewable generation increases, the need for fast-responding resources that match real-time generation and demand will increase. In addition, there is some uncertainty in weather forecasts and some undesirable electrical effects caused by some sources of renewable energy generation.
	Renewable Firming (seasonal)	Renewable resources such as wind and solar can fluctuate in output both at the daily scale and the seasonal temporal scale. Seasonal storage is required at very high levels of renewable penetration to store large amounts energy for weeks to months to bridge the gap between seasonally variable renewable energy output.

Electricity Customers

Customer-directed services provide benefit to the end-user and typically require installation of the system behind the customer meter. The monetary value of these services flows directly to the electricity customer in the form of bill savings or avoided costs. However, the provision of these services will inherently provide value to system operators and utilities because the customers program their system to respond to price signals from the utility, such as time-of-use (ToU) tariffs, demand charges, or other self-generator-related price signals designed to optimize grid operation (as seen in Exhibit 8 below).

Exhibit 8 Energy Storage Value Streams for Electricity Customers

	Service Name	Description
Electricity Customers: Residential, Commercial, Industrial, Agricultural	**Uninterruptible Power Supply**	Provides reliable uninterrupted power supply to critical loads in the event of a grid power outage or period of low-quality power supply from the grid.
	EV Charging	Provides means to flatten the load profile of EV chargers or charging depots to lessen the strain on the distribution system that arises from peaky and intermittent high-power draw. Primarily, it provides means to lower demand charges for the customer and lessen the need for system upgrades by the DISCOM.
	Solar + Storage Irrigation Pumping	Provides flexibility to solar pumping systems enabling night-time pumping or increased pumping during low sun days.
	Microgrid Applications for E-Mobility	Microgrids equipped with storage enable charging of EVs from 100% clean energy and low-cost local sources at any time of day. Microgrids support the adoption of electric mobility in rural areas without access to 24x7 power.
	Time-of-Use Bill Management and Demand Charge Reduction	Customers can use energy storage systems to reduce their bills by minimizing electricity purchases during peak electricity-consumption hours when time-of-use (TOU) rates are highest and shifting these purchase to periods of lower rates. For customers subject to demand charges (per kW charges), a storage system or energy management system can lessen peak demand by drawing from the battery during system peak load.
	Increased Photovoltaic (PV) Self-consumption	Minimizing export of electricity generated by behind-the-meter PV systems to maximize the financial benefit of solar PV in areas with utility rate structures that are unfavourable to distributed PV (e.g., non-export tariffs).

Consumer Electronics

The mobile and electronics industry in India is fast growing and diverse with a significant reliance on high-performance batteries across a wide range of applications. Mobile phones, power banks, IT hardware, telecom devices, smart agriculture, defence electronics, and other portable devices all require high density and safe integrated batteries. As India and the global population continue to move towards a highly connected and digitalized society, the demand for smart portable devices will naturally grow.

Box 1: Battery and Hydrogen–Similarities and Differences

Batteries and hydrogen are both energy carrier and storage technologies. As such they are only as green as the source of energy that gets stored in them. Both are competing solutions with significantly different efficiencies that promise to power modern mobility solutions and grid-tied storage for renewable electricity. Despite hydrogen's high energy density and lower life-cycle material impact, batteries are still the preferred solution due to significant advantages in terms of cost, technology maturity, and roundtrip efficiency. Additionally, battery prices have declined by nearly 89% since 2010.[14]

Similarly, for India, hydrogen potentially only makes sense at the margin in the long term when renewable penetration becomes extremely high.[15] This also hinges on the expected price decline for green hydrogen, which will depend on the decline of the prices for electrolysers and the renewable energy powering the production process.[16] There are also challenges associated with the safe storage and transportation of compressed hydrogen, which will need some strategic investments.

Despite the present shortcomings, it is globally recognized that hydrogen can play a role in the transition to a net-zero future. Hydrogen has a compelling value proposition for decarbonization of heavy industries like ammonia, iron and steel, and refining—sectors and industrial processes where electrification alone isn't sufficient for decarbonization.[17] Hydrogen also finds use as a potential feedstock for manufacturing synthetic fuel for long-distance shipping and aircrafts, as well as for long duration seasonal storage for power generation.

Opportunity for Advanced Chemistry Cell Energy Storage in India

Opportunity for Advanced Chemistry Cell Batteries in India

While energy storage has applications in many sectors, electric mobility is expected to be a primary driver of demand in India and globally. The majority share of global battery sales has shifted from consumer electronics to EVs over the past five years, with nearly 54% of global advanced battery sales going to the EV segment between 2015 and 2019.[18]

Electric Vehicles

Several national and state-level initiatives such as FAME II and state EV policies are creating an enabling ecosystem for an accelerated deployment of EVs, hoping to catalyse the market. The success of remodelled FAME II has led to a growing penetration of EVs, which could result in an annual demand for vehicle batteries in India alone exceeding 135 GWh/year by 2030.[19]

Several central ministries and departments have initiated policy and regulatory reforms and actions to reduce the barriers to adoption of electric mobility. Additionally, several state governments have formulated or are in the process of developing policies to promote EV market growth. Several state governments are setting ambitious targets for adoption of EVs in the next three to five years. These state-level targets are supported by policies beyond upfront purchase incentives and include waivers such as waiver of road tax, registration fees, and parking fees. (See Appendix C for additional details.)

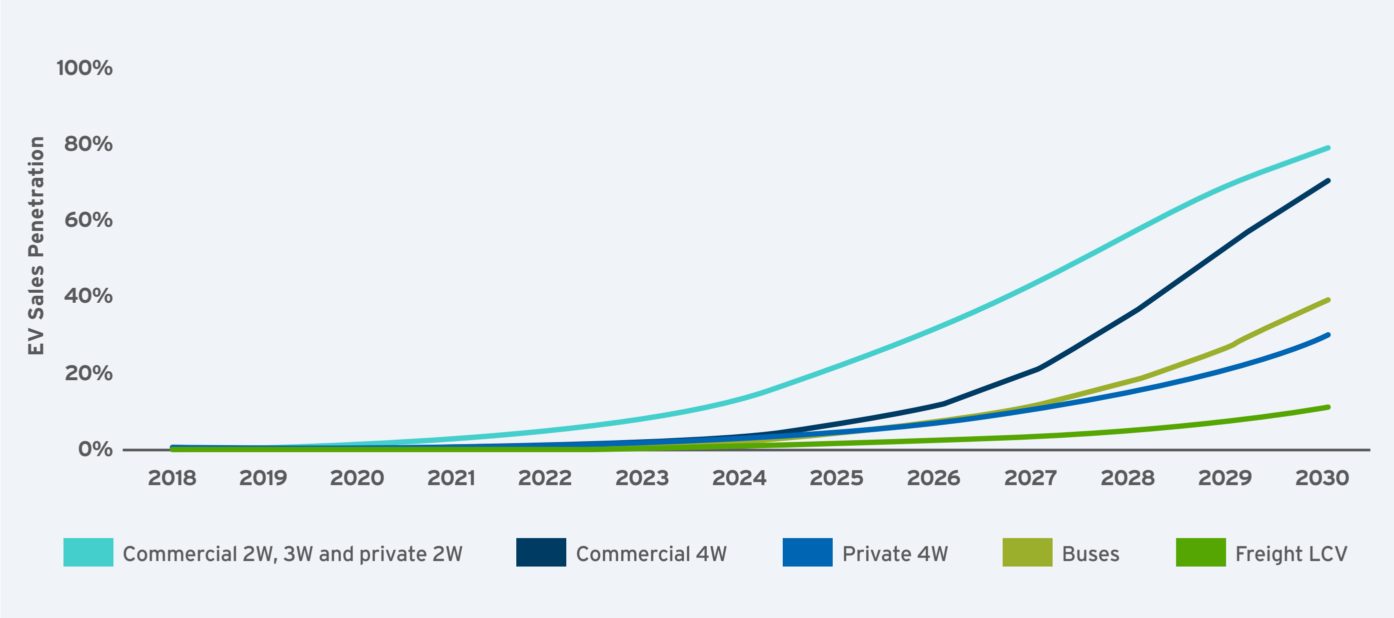
FAME II and most state EV policies are focusing on promoting electrification in public transport, commercial transport, and two-wheeler vehicle segments (a mass automotive transport medium in India). Over their lifetime, these vehicle segments (i.e., two-wheelers, auto rickshaws, high utilization four-wheelers [taxis], and buses), are already at cost parity in terms of the total cost of ownership (TCO).[20] For example, according to RMI analysis, the TCO of an e-bus without government incentives is estimated to be 6% less than that of a comparable diesel bus and marginally higher than that of a comparable CNG bus.[v] As battery prices fall, the upfront cost and TCO of EVs are expected to decline further.

The current focus of national and state governments on public transport, commercial transport, and two-wheeler vehicle segments; the favourable TCO for these segments; the increasing availability of vehicle models; and early market trends are indicative of the high potential of electrification in these segments.

Thus, the estimated future growth of EVs in India in this report assumes a faster and higher penetration in these segments in the accelerated case, and slower EV penetration growth in the conservative case. Scenarios are detailed below:

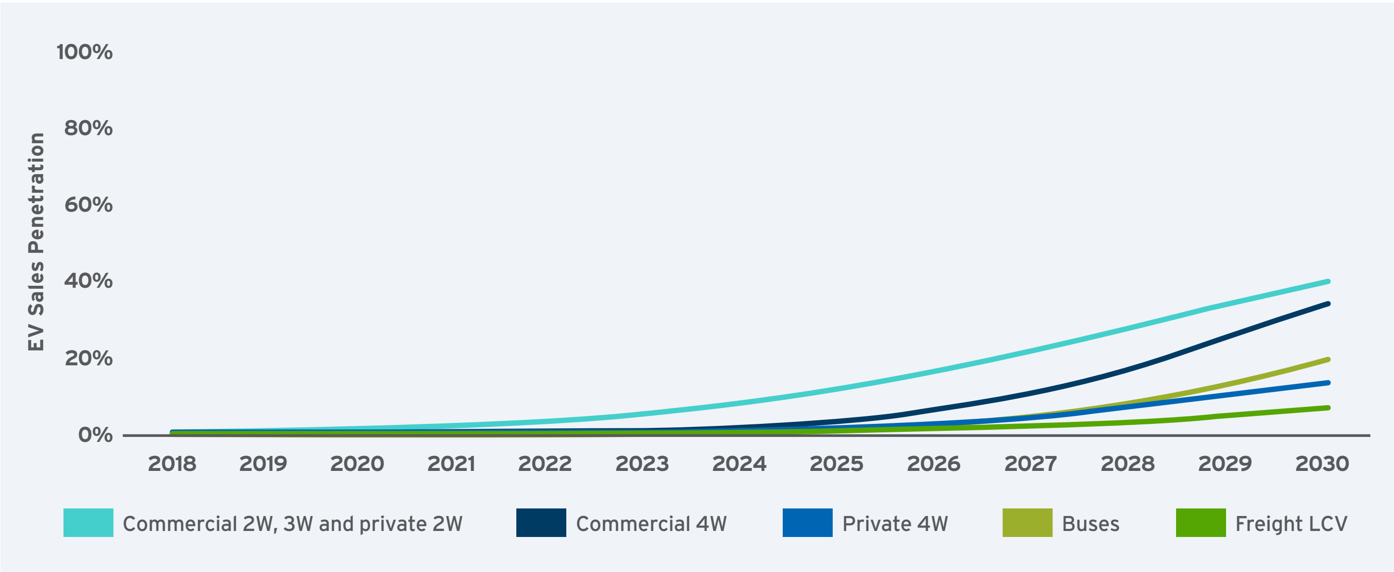
Scenario 1: The accelerated case scenario (in Exhibit 9), is modelled after the 2030 penetration levels as discussed in NITI Aayog and RMI's (2019) FAME II report adjusted for expected slowdown from the effects of COVID-19.[21] Segment-wise penetration of EVs in new vehicle sales in this scenario is 30% for private cars, 70% for commercial cars, 40% for buses, and 80% for two- and three-wheelers by 2030.[22] The scenario assumes that FAME II and other policy measures initiated by central and state governments will help trigger rapid adoption of EVs in the country.

Exhibit 9



Scenario 2: As seen in Exhibit 10, scenario 2 describes a conservative pathway where the adoption of EVs does not accelerate at the expected rate of Scenario 1 due to reasons such as a lag in the formation of the EV ecosystem, insufficient access to charging stations, challenges with distribution system upgrades to support fast charging, lower than expected introduction of EV models in the market, delay in price parity of vehicles, delay or changes in policy implementation, lack of consumer awareness, and more. This scenario assumes a weighted average EV penetration of 35% in new sales in 2030 across all vehicle segments.[23]

Exhibit 10 Conservative Scenario for EV Sales

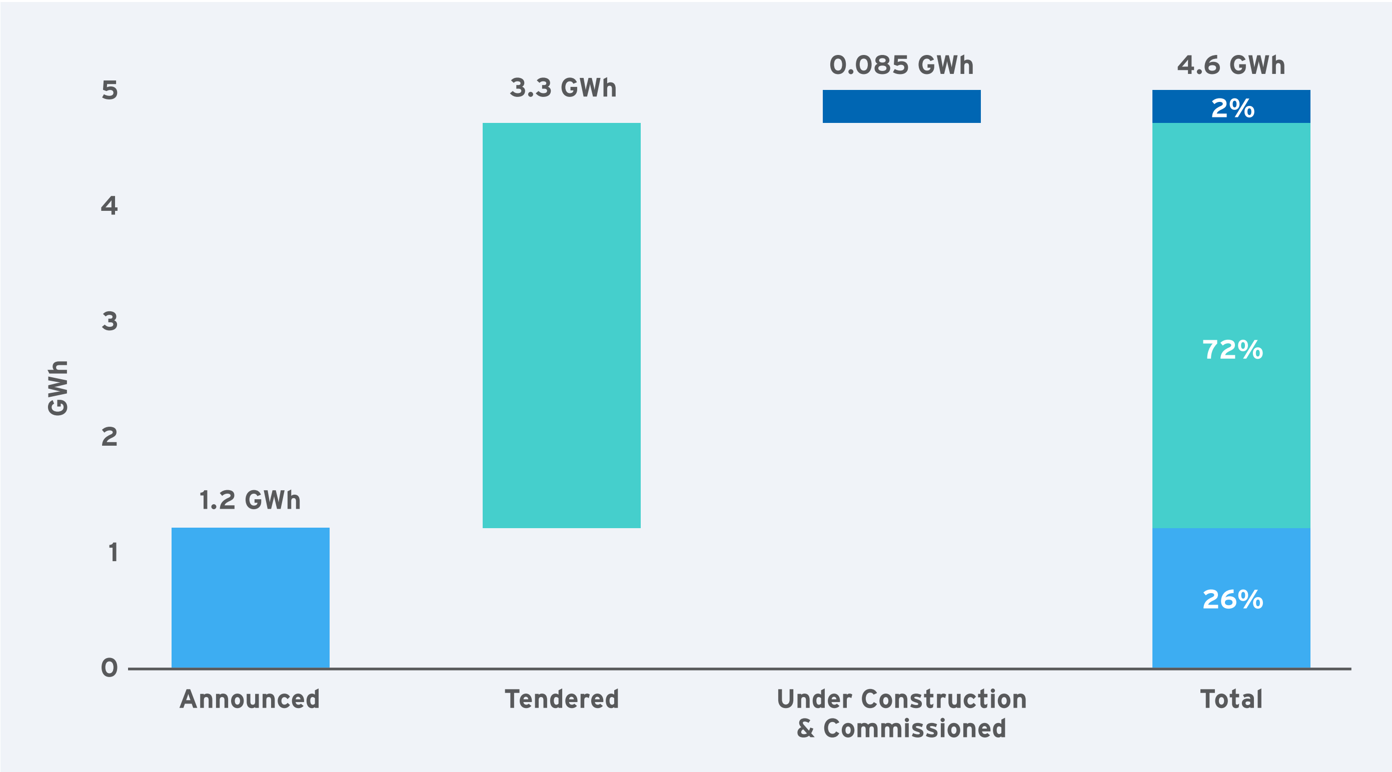


Stationary Storage

Beyond the expected growth in EVs, the stationary energy storage market is poised to experience significant growth as the need for grid flexibility will rise to integrate 500 GW of non-fossil fuel energy on the grid by 2030. Stationary energy storage will play a critical role at all levels on the power grid, including behind-the-meter applications, distribution and transmission systems, and large-scale centralized renewable generation facilities.

A major driver of early market growth for energy storage generation will be renewables integration, replacement of diesel generators for island grids, industrial back-up applications, and use in remote equipment such as cell phone towers. Transmission and distribution deferral, in particular, is an area where storage can play a key role and help offset high capital investment as India looks to augment and overhaul its transmission and distribution infrastructure. Storage will also be useful in ancillary services including frequency response. Early-stage pilots being deployed will eventually give way to a larger-scale deployment as the market and technology mature. While the total ESS commissioned or under construction is only around 85 MWh so far,[24] there is already a pipeline of projects amounting to 4.6 GWh (see Exhibit 11), suggesting emerging momentum in this sector.

Exhibit 11 ESS Capacity Under Various Stages of Development in India (see Appendix D for detailed project list)



Expectedly, stationary storage is a very important demand segment going forward. The growth of the grid-scale storage requirement is estimated using a least-cost capacity expansion plan out to 2030 that fulfils India's targets for 500 GW of non-fossil fuel capacity including hydro. The report considers two scenarios—a conservative case where investments are allowed in new coal capacity and an accelerated high renewables case where the growth in coal capacity is constrained to the current pipeline of under-construction projects. Data and projections from the Central Electricity Authority (CEA) were crucial benchmarks for this assessment.

This analysis projects that the cumulative capacity of stationary storage for grid support can reach 26 GW/104 GWh in the conservative scenario, and has the potential to expand up to nearly 65 GW/260 GWh by 2030 in the accelerated scenario. Details of scenario assumptions are listed in Appendix B.

Beyond flexibility and renewable integration, batteries will also be in demand for applications like distribution and transmission upgrade deferral, commercial and residential behind-the-meter, diesel generator set replacement, and ancillary services.

As a nascent sector, development of stationary storage for electricity applications will require adequate capacity building of relevant stakeholders, identification of specific use cases, and provision of incentives and concessional lending, either through the government or through multinational financial institutions (MFIs) to enable piloting and early market creation. To this end, the World Bank Group has proposed a line of credit amounting to US$1 billion for facilitating financing at competitive rates and tenors to the sector.[25] In tandem, NITI Aayog has also engaged the World Bank to extend technical assistance to various state governments and statutory bodies. This will be with a goal to encourage the techno-economic and regulatory condition to realize the full potential of batteries for stationary storage application in the country.

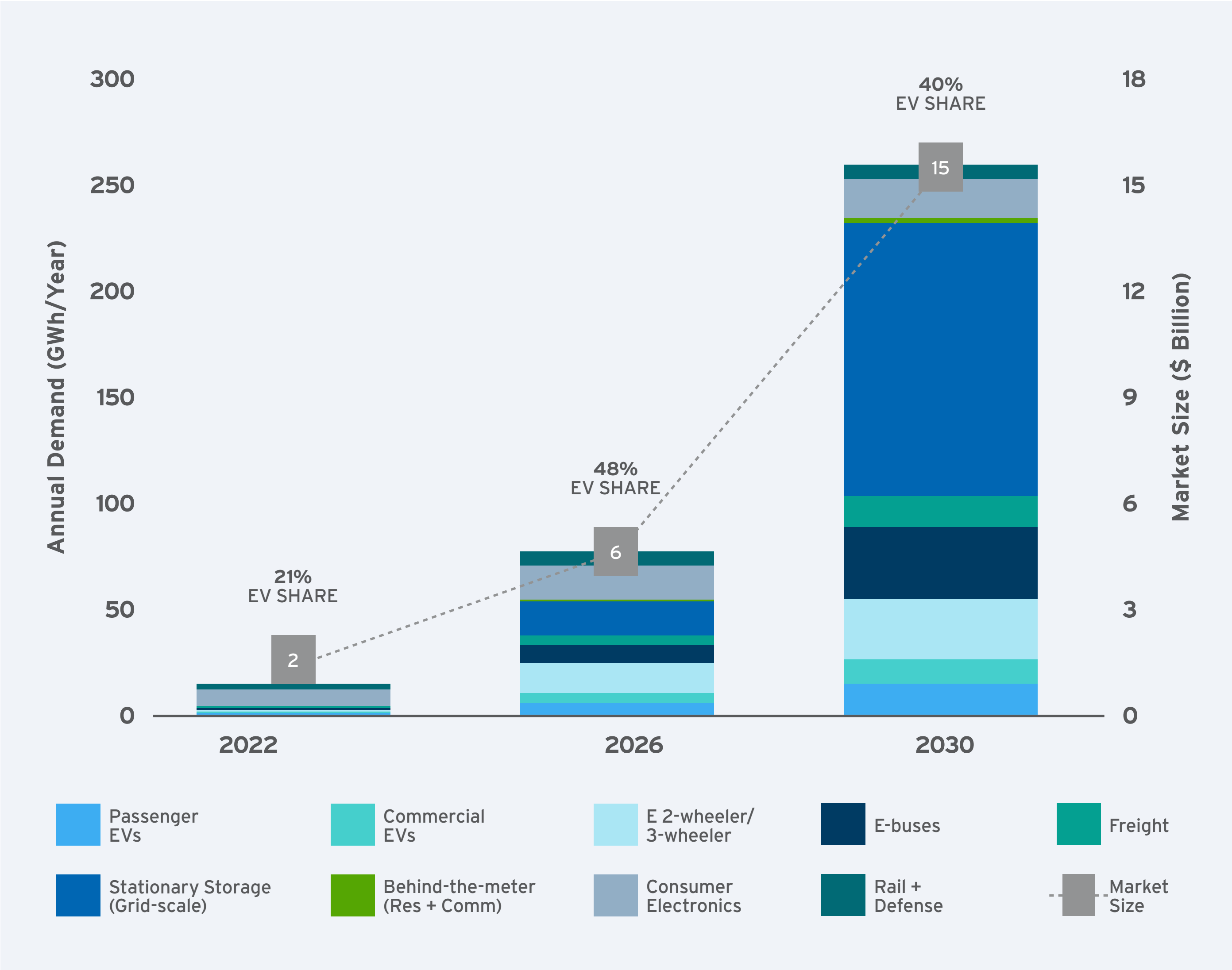
Consumer Electronics

Additional demand for batteries will continue to come from the consumer electronics sector with India Cellular and Electronics Association (ICEA) forecasting an annual demand of 18 GWh for mobile phones and power banks by 2025. Market growth in the consumer electronics sector is largely attributed to the growth in sales of mobile phones and power banks, increasing from annual sales of 300 million devices today to 1.2 billion devices annually by 2030. Additional demand from the consumer electronics sector includes Internet of Things (IoT) devices and telecom towers. Market forecasts in the consumer electronics sector and rail and defence industries were derived from ICEA market forecasts and RMI analysis based on expert interviews with ICEA.

Indian Battery Market Outlook

The annual market for stationary and mobile batteries in India could surpass US$15 billion by 2030, with almost US$12 billion from cells and US$3 billion from pack assembly and integration, under the accelerated case scenario. Even under a more conservative case it amounts to an annual market of US$ 6 billion. With a successful thriving local battery manufacturing industry and a supportive local supply chain, India can capture a significant value within the local economy on account of localization of the value chain from material processing up to pack assembly and integration.

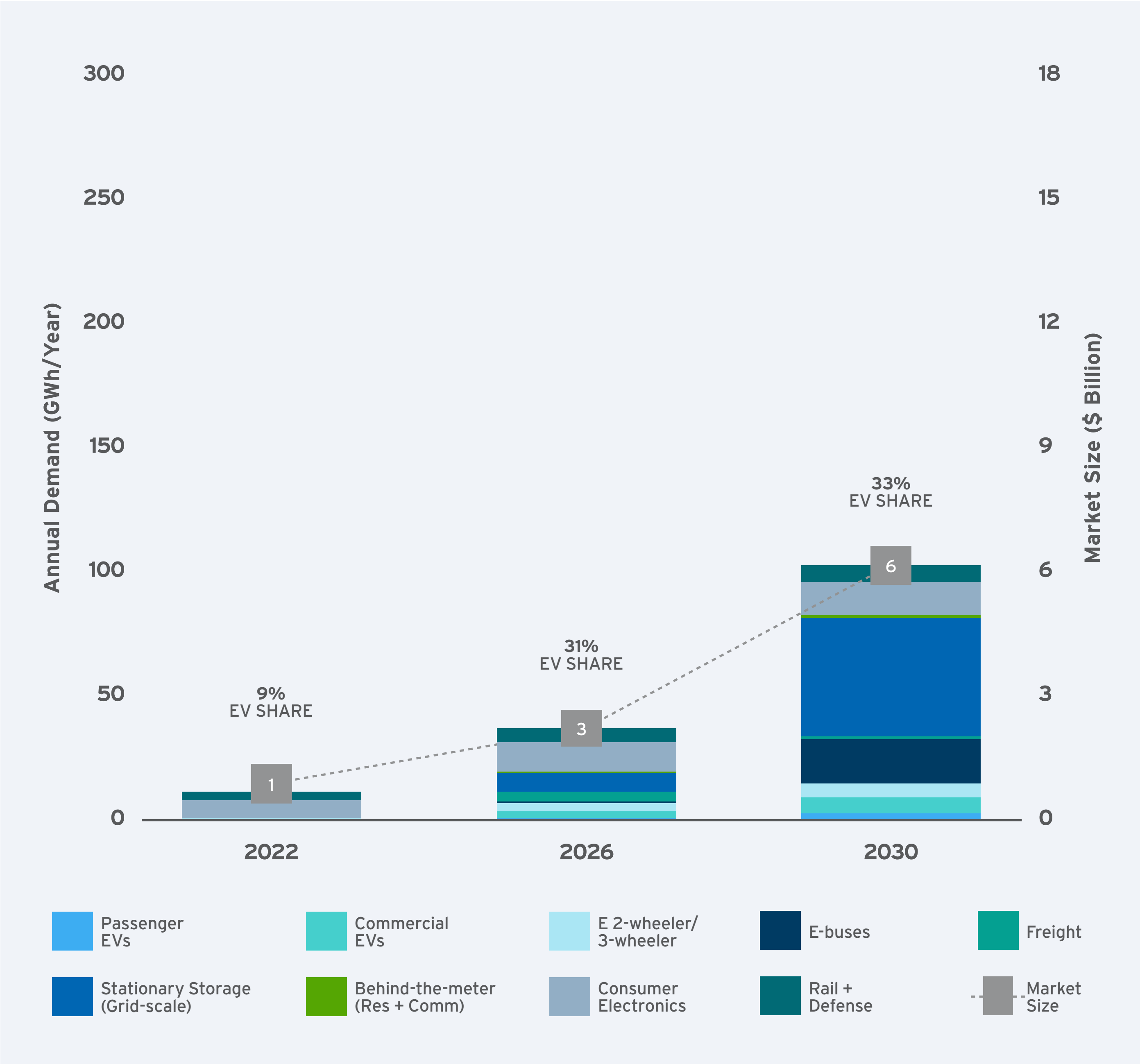
Exhibit 12 Indian Battery Demand Outlook—Accelerated Scenario[26]



Meeting demand for batteries with domestic supply will require rapid buildout of manufacturing capacity. Based on the accelerated scenario market forecast detailed above, India can meet domestic battery demand with two gigafactories of nameplate capacity of 10 GWh of annual production in 2022.

Starting in 2025, demand begins to increase exponentially to meet local battery demand from all segments, increasing from 5 gigafactories in 2025 to 26 gigafactories by 2030. The conservative scenario requires 3 gigafactories in 2025 and 10 gigafactories in 2030.

Exhibit 13 Indian Battery Demand Outlook—Conservative Scenario[27]



Even under the more conservative scenario, the expected demand is adequate for the PLI scheme. A key conclusion is the importance of policy push and demand-side incentives to accelerate market development for advanced cell batteries. It is also important to note that these outlooks do not address the potential for battery exports from India, which would provide even more demand from domestic battery manufacturing facilities.

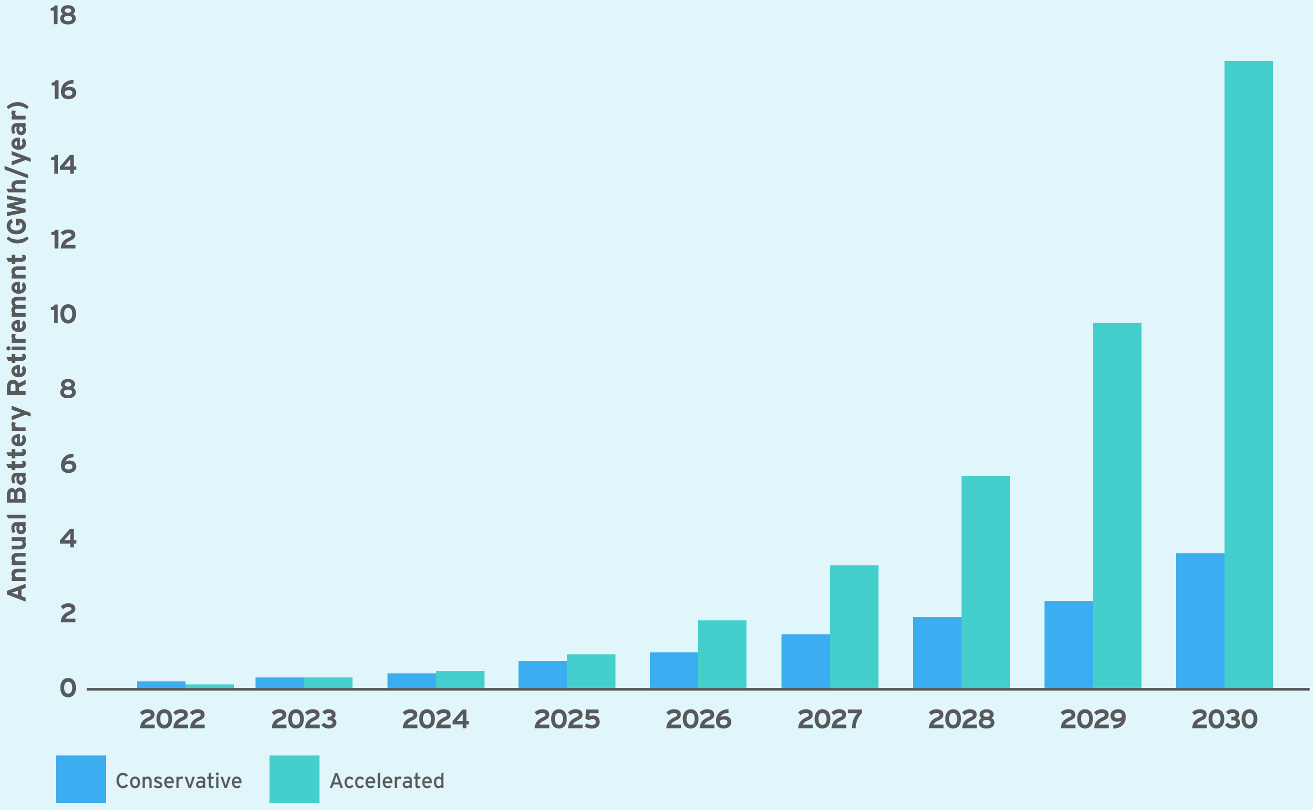
Box 2: Second Life and Secondary Use

Batteries slowly degrade over time and after a certain number of charge and discharge cycles, the cells are no longer capable of maintaining their nameplate energy rating. At some point in the life of an EV battery pack, the consumer may choose to replace the battery if its capacity is no longer sufficient to meet the end-use application needs. Typically, this replacement occurs when the battery performance falls below 70–80% of the initial nameplate storage capacity. While the battery may no longer be able to meet its original performance requirements, the battery still has life remaining and can be repurposed for a second-life application in line with its remaining performance characteristics.

Second-life batteries create a connection between the EV and stationary storage value chains and enable maximum value extraction of batteries before their eventual end-of-life recycling or disposal.[28] An example of this is a joint project between RWE and Audi in Germany which will use 60 end-of-life battery systems from EVs to provide 4.5 MWh of energy for secondary applications such as frequency regulation.[29]

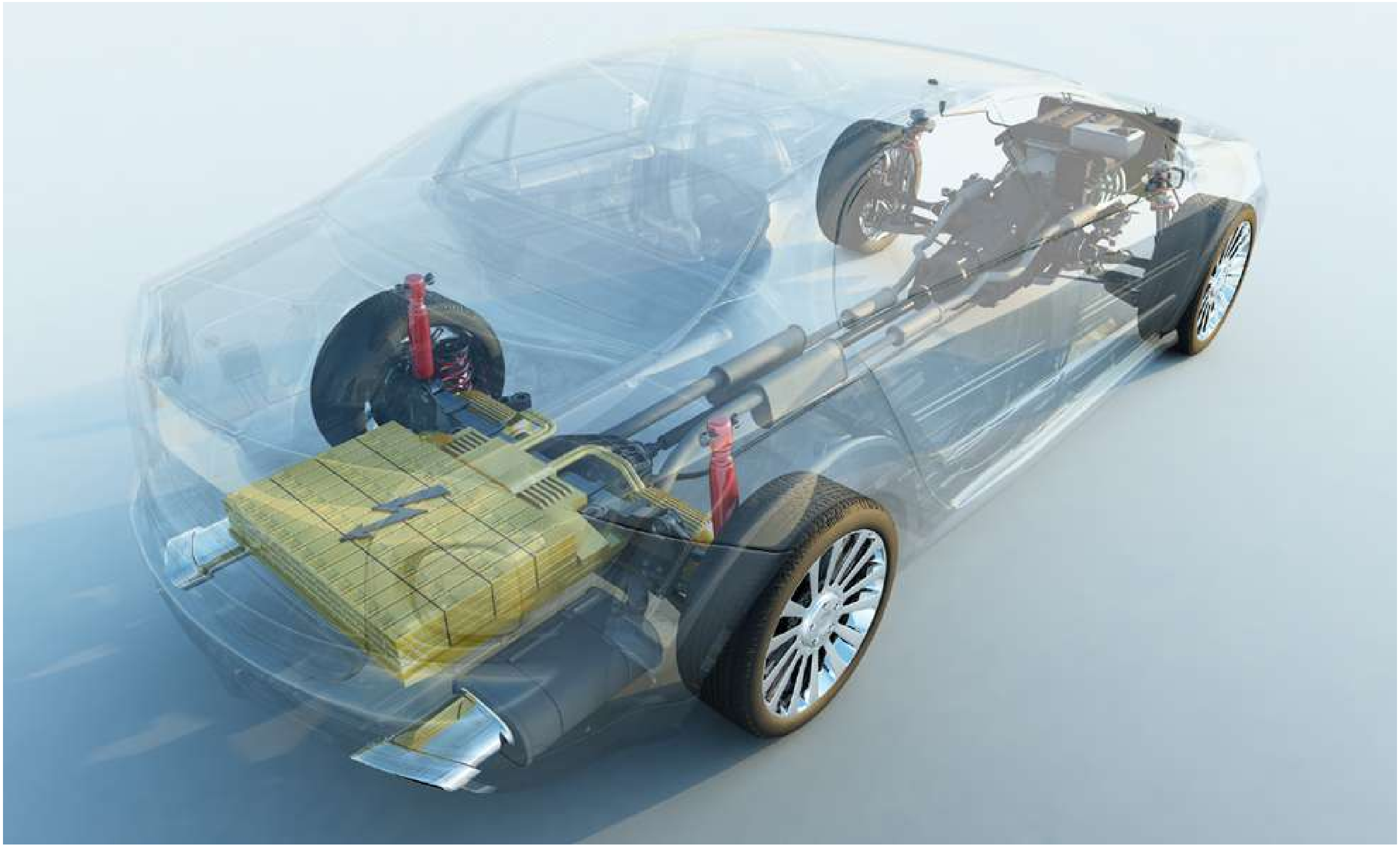
The rate of battery replacement in the EV segment in India will grow along with the EV market to between 3 and 16 GWh annually in 2030, for conservative and accelerated scenarios respectively, creating a large supply of second-use batteries with significant growth occurring after 2025 (as seen in Exhibit 14). The rate of battery replacement assumes vehicle batteries are replaced after they drop below the 70–80% threshold. Advancements in battery technology, including increased cycle life, will have an impact on battery retirements. Even accounting for extended battery life, battery retirement from all vehicle segments will exceed 19 GWh by 2040.

Exhibit 14 Annual Battery Retirement from All Vehicle Segments[30]



Second-use batteries will largely serve stationary applications with less demanding performance criteria. Encouraging second-use applications of batteries using both policy and market forces will help offset the need for new batteries and thus reduce the demand for imported raw materials. While second-use batteries have a large market potential, it is important to consider the costs associated with repackaging, testing, and commissioning of second-life systems. These systems may have to compete with new batteries that have costs that continue to fall.

To facilitate a healthy second-life market, appropriate rules and regulations need to be created that require original equipment manufacturers (OEMs) to manage the end-of-life disposal, recycling of, or reuse of batteries after first-life application. A framework of minimum specifications and standards must be established to ensure these second-use batteries can be installed safely and effectively.



Conclusion

Conclusion

India is expected to be one of the largest markets for energy storage by 2030 and is now at the crossroads for creating market mechanisms and planning investments that can ensure a comprehensive domestic battery manufacturing ecosystem. Sustained economic growth and demand for electricity will create the perfect growth opportunity for battery storage across EVs, grid-support uses, behind-the-meter applications, and consumer electronics.

Across a scale of conservative to accelerated cases, the report finds 106 GWh to 260 GWh of annual demand for batteries by 2030, respectively. Electric vehicles, including freight, are expected to drive approximately 40% of this demand. Beyond this, applications in grid support can allow the evolution of a resilient power sector and facilitate the addition of increasingly higher shares of renewables, supporting the transition to a decarbonized grid. Despite their significant value proposition, however, India is currently largely reliant on imports of cells from other countries and has very limited domestic assembly operations for modules and packs. Targeted strategies and planning must complement government ambitions to reduce continued reliance on imported cells.

This analysis must be situated within the context of the PLI scheme for manufacturing of advanced chemistry cell batteries. The PLI scheme encourages the development of local manufacturing that leverages India's factor costs and scale advantages while also providing export opportunity for a rapidly growing technology sector. But such a plan must be complemented by clear, stable, and long-term policies and incentives at all levels of government that further stimulate demand for batteries in the mobile and stationary applications.

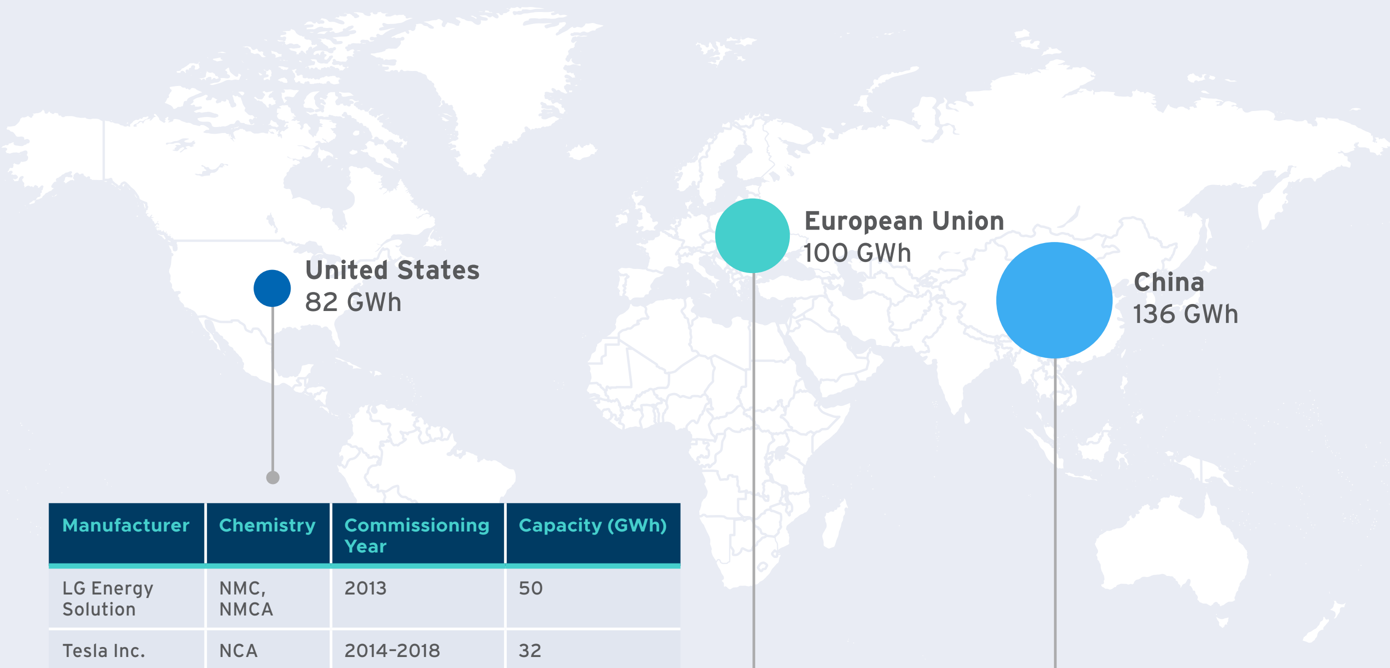
OEMs should engage with battery manufacturers in terms of design thinking so that the EV batteries can easily have a second life. India must also expand this capability to recycle end-of-life cells in order to secure a secondary supply of raw material over the long term for the gigafactories. Sustainability of the material supply chain will also be an important criterion not just from the value capture point of view but also from the larger energy security perspective of India's energy transition.

The PLI scheme promises to put India in a strong position in the global market and let the country realize the full value from this technology. But the ultimate utility of these gigafactories will hinge on the decarbonization pathway it accelerates, the larger industrial ecosystem it enables, and the value that India manages to capture within the country.

Appendices

Appendix A: Existing and Emerging Major Battery Manufacturing Facilities Around the World

Exhibit A1 Top 10 Existing Battery Manufacturing Facilities[31]



United States

Manufacturer	Chemistry	Commissioning Year	Capacity (GWh)
LG Energy Solution	NMC, NMCA	2013	50
Tesla Inc.	NCA	2014-2018	32

European Union

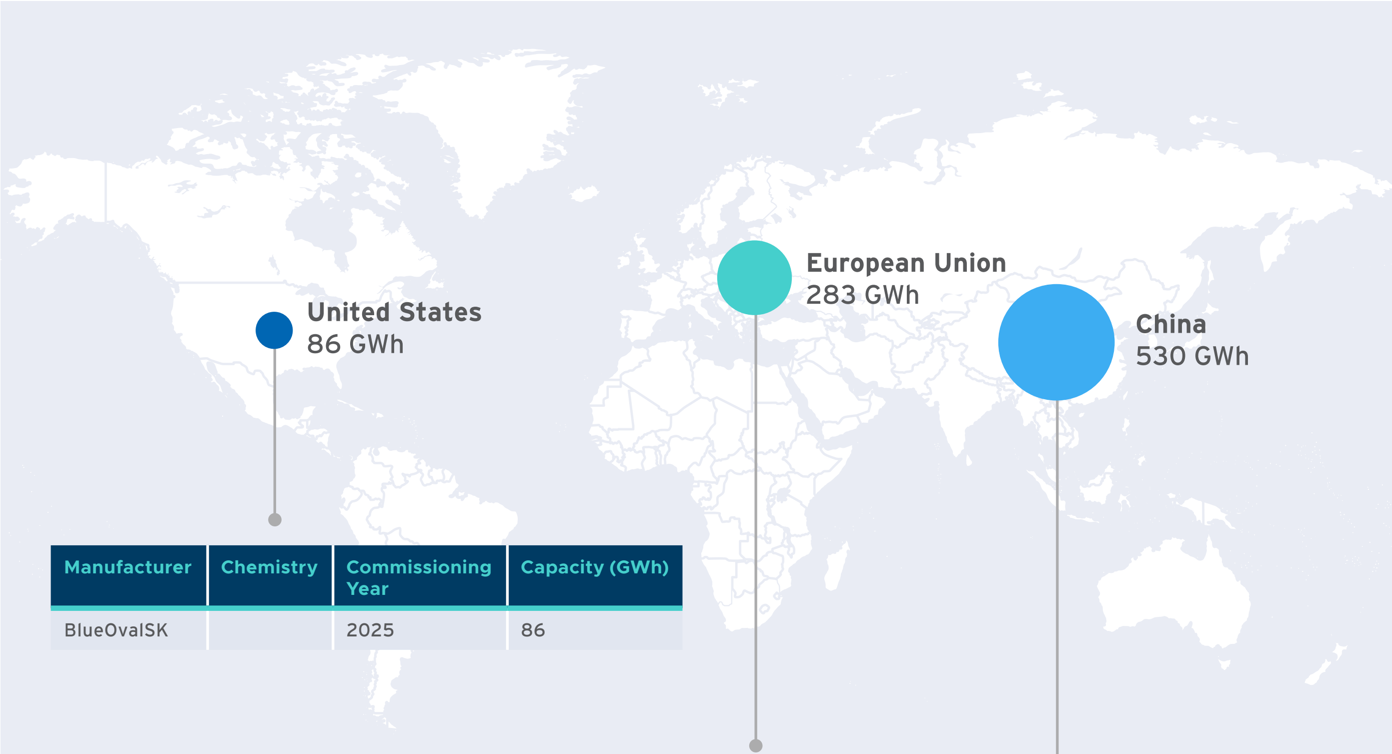
Manufacturer	Chemistry	Commissioning Year	Capacity (GWh)
LG Energy Solution	NMC, NMCA	2016-2021	70
Samsung SDI	NMC	2021	30

China

Manufacturer	Chemistry	Commissioning Year	Capacity (GWh)
LG Energy Solution	NMC	2019	32
SK On		2020	27
CATL	NMC	2019	24
BYD Co. Ltd.	LFP	2020	20
CATL-SAIC Motor	NMC	2019	18
CATL	NMC	2017	15

Cumulative Capacity
|||| 80 GWh
||||| 100 GWh
|||||| 120 GWh
||||||| 140 GWh
|||||||| 160 GWh

Exhibit A2 Top 10 Emerging Battery Manufacturing Facilities[32]



United States

Manufacturer	Chemistry	Commissioning Year	Capacity (GWh)
BlueOvalSK		2025	86

European Union

Manufacturer	Chemistry	Commissioning Year	Capacity (GWh)
CATL	NMC	2028	100
Tesla Inc.	NMC	2024	100
FREYR		2028	83

China

Manufacturer	Chemistry	Expected Commissioning	Capacity (GWh)
CATL		2024	120
Ruipu Energy		2027	100
CATL		2025	85
CATL		2024	80
Wanxiang A123	LFP	2023	77
China Aviation	NMC	2025	67.5

Cumulative Capacity

|||| 80 GWh
||||| 200 GWh
|||||| 300 GWh
||||||| 400 GWh
|||||||| 500 GWh
||||||||| 560 GWh

Appendix B: Modelling Assumptions and Methodology

Electric Vehicles

RMI's inhouse excel-based tool was used to estimate the EV battery demand outlook.

- Estimations for growth of EVs consider electrification in the following vehicle segments:
  - » Two-wheelers
  - » Three-wheelers
  - » Commercial four-wheelers (taxis)
  - » Private cars
  - » Buses
  - » Freight vehicles (light-duty, medium-duty and heavy-duty)
- EV market sizing analysis is performed for two different scenarios with different penetration levels (high and low penetration). Annual demand for batteries is determined based on the annual EV sales by segment and respective battery sizes. Battery sizes for the vehicles are:
  - » Four-wheelers (cars and taxis): 15 kWh
  - » Three-wheelers: 5 kWh
  - » Two-wheelers: 2 kWh
  - » Light Commercial Vehicles (LCV): 15 kWh
  - » Buses: 250 kWh
  - » Light-duty freight vehicles (2W/3W/4W): 2.4–14.4 kWh
  - » Medium-duty freight vehicles: 115–150 kWh
  - » Heavy-duty freight vehicles: 220–480 kWh
- Batteries are assumed to be replaced after 2,000 charging cycles and until the vehicle is scrapped. The average assumed lifetime kilometres for different vehicle segments are:
  - » Four-wheelers (private): 300,000 km
  - » Four-wheelers (commercial): 400,000 km
  - » Three-wheelers: 400,000 km
  - » Two-wheelers (private): 175,000 km
  - » Buses: 550,000 km

Grid-Scale Storage

- An open-source model, FlexTool,[33] is used to perform expansion planning using aggregate unit-level technical specifications and cost data guided by prior detailed studies from NREL and CEA. Hourly demand profile for 2030 is sourced from a published Nature forecasting study under scenarios of stable GDP growth, growth of public EV charging, and baseline cooling loads.
- The base year for the study is 2019–20; capacity expansion is allowed for target years 2026–27 and 2029–30. Annual demand and peak load projections from CEA's 19th Electric Power Survey (EPS) are used and scaled to hourly resolution using the Nature study's forecast.

	2026–27	2029–30
Energy Demand	2,145 TWh	2,325 TWh
Peak Demand	303 GW	355 GW

- Investments are allowed in conventional generating capacity (coal, gas, nuclear, and hydro), renewable energy projects, and 4-hour battery storage. Constraints on investments are guided by government targets (450 GW of renewables) and announced/under-construction capacity for coal, nuclear, and hydro as available with CEA and listed in the National Electricity Plan.
- Investment in additional gas capacity is not considered, considering the limited domestic gas availability.
- Retirement of approximately 22,700 MW of coal capacity by 2030 is considered, as per NEP 2018.
- Availability of hydro (storage) plants is estimated using actual generation SCADA data for all five sub-regions from 2019 to 2020 available on the respective Load Dispatch Center website.

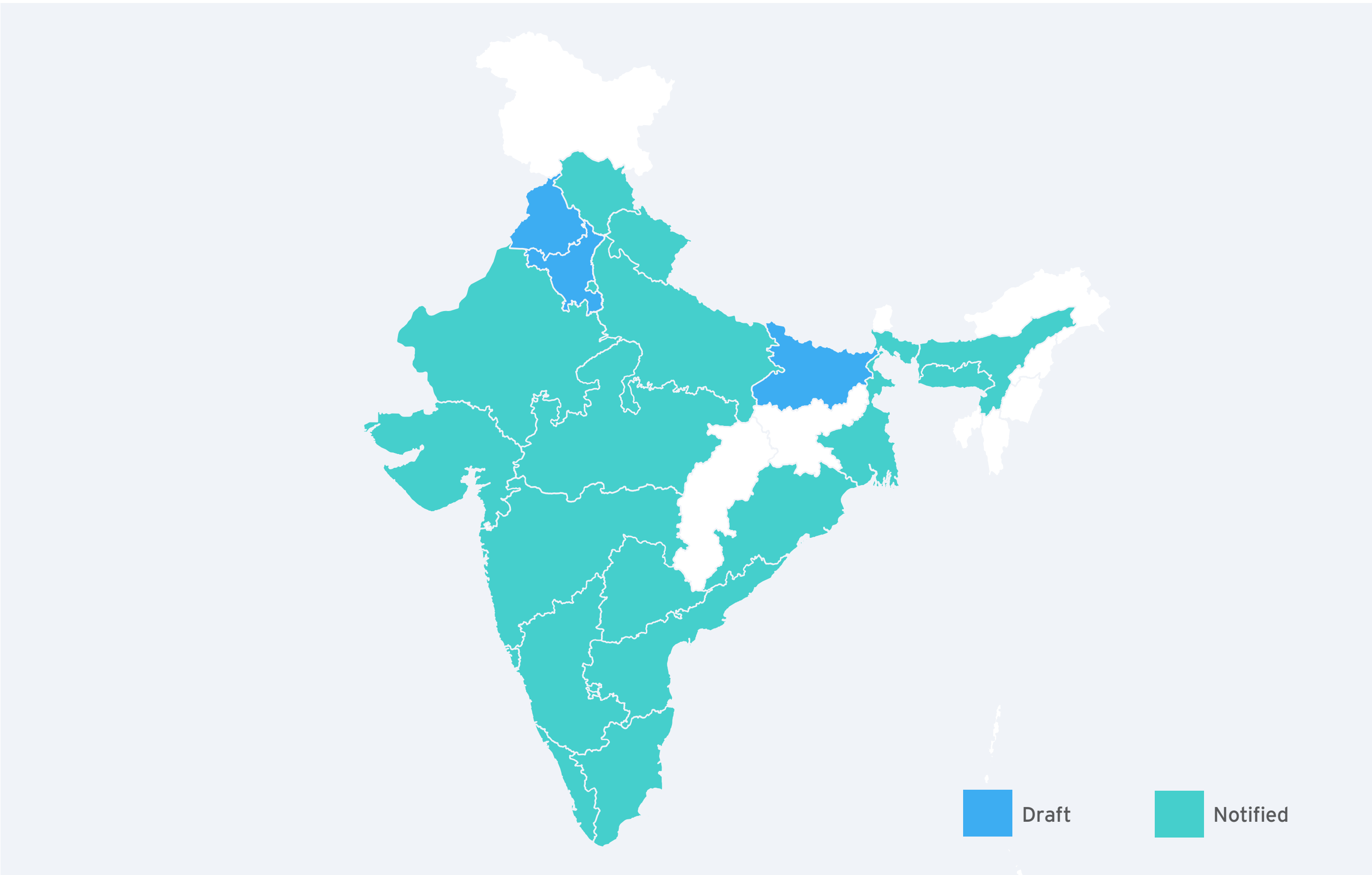
Appendix C: EV Demand Creation Efforts in India

Department of Heavy Industry and Public Enterprises (DHI)	• In 2015, the Department of Heavy Industry (DHI), Government of India, established its flagship scheme—the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India or FAME—that signaled the beginning of India's EV transition. Phase I of FAME incentivized 2.8 lakh electric and hybrid vehicles from March 2015 to March 2019 through subsidies worth about INR970 crore. • Near the end of the scheme, DHI announced FAME II—the Scheme for Faster Adoption and Manufacturing of Electric Vehicles in India Phase II—effective 1st April 2019. FAME II was provided a total outlay of INR10,000 crore dedicated to demand incentives and charging infrastructure. As a part of its eligibility criteria for vehicles, FAME II also established localisation criteria to promote domestic EV manufacturing. On 11th June 2021, after incentivization of over 77,000 EVs of its total target of 15,62,090, the DHI issued amendments to FAME II. On 25th June 2021, DHI also notified a two-year extension of the Scheme. It will now be valid to 31st March 2024. • 520 charging stations have been sanctioned under the Phase I of FAME scheme while under FAME II 2,877 chargers have been sanctioned in 68 cities with another 1,576 chargers being sanctioned across 9 expressways and 16 highways. • 6,265 electric buses have been sanctioned in 64 cities/state government entities/STUs for intra-city and intercity operation under FAME India scheme phase II. • Implementing manufacturing of EVs through the Phased Manufacturing Programme (PMP) • Approved a PLI scheme for the automobile and auto components industry with INR26,000 crores in budget on September 2021, aimed at building a robust value chain for automobiles, including EVs.
Ministry of Power (MoP)	• Issued a clarification stating that charging electric vehicles is considered a service and not a sale of electricity. This implies that no license is required to operate EV charging stations. • Released a notification on charging infrastructure standards to enable faster adoption of EVs. The notification permits private charging at residences and offices where the tariff for supply of electricity to EV charging station shall not be more than the average cost of supply plus 15%.

Ministry of Road Transport and Highways (MoRTH)	• Announced that battery-operated private and commercial vehicles will be given green license plates. • Announced that battery-operated, ethanol-powered, and methanol-powered transport vehicles won't need permits. • Issued a circular stating that driving licenses will be given for age group 16–18 years to drive gearless electric scooters/bikes up to 4 KWH battery size. • Issued a draft notification to exempt battery-operated vehicles from paying registration fees. • Issued a draft notification to hike registration fees for ICE vehicles. • Issued a circular asking states to reduce or waive road tax on EVs, which in turn will help reduce the initial cost of EVs.
Indian Space Research Organisation (ISRO)	• Issued a request for quotation (RFQ) document for commercialisation of indigenously developed lithium-ion battery technology. MoU with Tata Chemicals was signed in March 2019. Technology transfer to BHEL was completed in Nov 2019 (for the BHEL-Libcoin Gigafactory planned in Bangalore). AmaraRaja has also set up a lithium-ion battery tech hub in Tirupati in Feb 2021.
Ministry of Housing and Urban Affairs (MoHUA)	• Amended 2016 Model Building Bylaws to establish EV charging stations and infrastructure in private and commercial buildings.
NITI Aayog	• Released a concessionaire agreement for public private partnership in operation and maintenance of electric buses in cities through the Operating Expenditure (OPEX) model. • Implementing the National Mission on Transformative Mobility and Battery Storage to drive clean, connected, shared, sustainable, and holistic mobility initiatives. The Mission focuses on creating a Phased Manufacturing Programme (PMP) to support setting up of large-scale, export-competitive integrated batteries and cell-manufacturing giga plants in India, as well as localising production across the entire EV value chain.

Ministry of Finance (MoF)	• Rationalised customs duty for all categories of vehicles, battery packs, and cells to support Make in India and incentivise uptake of EVs. • Incentives announced under India's Union Budget for financial year 2019-20: » Income tax deduction of INR1.5 lakh on the interest paid on the loans taken to purchase EVs » Customs duty exemption on import of specific components » Basic custom duty will be increased on certain auto parts to promote Make in India initiative » Benefit of section 35AD for investments in the sunrise and advanced technology areas
Goods and Services Tax (GST) Council	• Reduced tax on EVs from 12% to 5% and on charger and charging stations from 18% to 5% (effective 1 August 2019). • Announced tax exemption on e-buses hired by public authorities (effective 1 August 2019).
State EV policies	• Many states have drafted and notified their electric vehicles policies with both fiscal and non-fiscal incentives. Depending on the states, support is being provided for both manufacturing as well as vehicle demand creation. Eighteen states have notified their EV policies (see Exhibit C1).

Exhibit C1 **Status of State Electric Vehicle Policy in India**



Appendix D: Battery Energy Storage Projects Being Developed in India

Exhibit D1 List of Energy Storage Projects Being Developed in India[34]

Project Developer/ Sponsor	Capacity	Location	Status
Bharat Heavy Electricals Ltd. (BHEL)-Okaya Power Group	410 kWh (Li-ion)	Delhi	Under construction
BSES Rajdhani Power Ltd. (BRPL)	6 x 674 kWh (Li-ion)	Delhi	Under construction
BSES Yamuna Power Ltd. (BYPL)	5 x 200 kWh (Li-ion NMC and LFP)	Delhi	Under construction
Solar Energy Corporation of India (SECI)	2150 kWh/1650 kW (Li-ion)	Lakshadweep	Under construction
Solar Energy Corporation of India (SECI)-Himachal Renewable Ltd.	2 MW Solar PV + 1000 kWh/1000 kW BESS (Li-ion)	Himachal Pradesh	Under construction
Sun Source Energy	1.95 MW Solar + 2.15 MWh BESS	Lakshadweep	Under construction
Tata Power	20 MW solar with 20 MW/50 MWh	Leh, Ladakh	Under construction
Tata Power (TPDDL) & Nexcharge	528 kWh/150 kW (Li-ion)	New Delhi	Under construction
TERI-USASSIST-BRPL	240 kWh/120 kW (Li-ion)	New Delhi	Under construction
TERI-USASSIST-BRPL	230 kWh/125 kW (Li-ion and Advanced lead acid)	Delhi	Under construction
Central Electronics Ltd. (CEL)	500 KWh/1,000 kW (Electrochemical)	Uttar Pradesh	Tendered
National Thermal Power Corporation (NTPC)	17 MW Solar PV + 6.8 MWh/6.8 MW BESS	Andaman & Nicobar Islands	Tendered

Railway Energy Management Company Ltd. (REMCL)	14 MWh/7 MW	Nagpur	Tendered
Solar Energy Corporation of India (SECI)	160 MW Wind-Solar Hybrid + 20 MWh/10 MW BESS	Andhra Pradesh	Tendered
Solar Energy Corporation of India (SECI)	20 MW Floating PV + 60 MWh BESS	Lakshadweep	Tendered
Solar Energy Corporation of India (SECI)	20 MW Solar PV + 50 MWh/20 MW BESS	Leh, Ladakh	Tendered
Solar Energy Corporation of India (SECI)	100 MW Solar + 150 MWh/50 MW BESS	Chattisgarh	Tendered
Solar Energy Corporation of India (SECI)	2,000 MWh		Tendered
Solar Energy Corporation of India (SECI)-ISTS	1,000 MWh/500 MW (Electrochemical)	Pan-India	Tendered
Solar Energy Corporation of India (SECI) Ltd.-HPSEBL	2.5 MW Solar Wind Hybrid Project + 1,000 kWh/100 kW BESS	Himachal Pradesh	Tendered
Tamil Nadu Generation and Distribution Corporation Ltd. (TANGEDCO)	1 MW Solar PV + 3 MWh/1 MW BESS	Tamilnadu	Tendered
ACME Cleantech Solutions Pvt. Ltd.	270 kWh/250 kW (Electrochemical)	Gurgaon, Haryana	Commissioned
Gram Power	3,000 kW (Electrochemical)	Rajasthan	Commissioned
Imergy Power Systems	120 kWh/30 kW (Vanadium Flow Battery)	Karnataka	Commissioned
SciEssence International	5 GJ (1,400 kWh/15,000 kW) GigaCapacitor based (Electrochemical)	Telangana	Commissioned
Bharat Heavy Electricals Ltd. (BHEL)	500 kW(Li-ion), 100kW(Advanced Lead Acid), 50 kW(Flow)	Telangana	Commissioned
Central Electronics Ltd. (CEL)-Exicom	160 kWh/40 kW (Advanced Lead Acid)	Uttar Pradesh	Commissioned

Central Electronics Ltd. (CEL)-Raychem RPG	350 kWh (Li-ion) and 150 kWh (Flow Battery)	Uttar Pradesh	Commissioned
Central Electronics Ltd. (CEL)-Raychem RPG	500 KWh/1,000 kW (Li-ion)	Uttar Pradesh	Commissioned
Electricity Department of Government of Puducherry	1,000 kWh/250 kW (Electrochemical)	Puducherry	Commissioned
Neyveli Lignite Corporation Ltd. (NLC) and Larsen & Toubro (L&T)	20 MW Solar PV + 8 MWh/16 MW BESS (Li-ion)	Andaman and Nicobar Islands	Commissioned
PGCIL-Zhejiang Narada	250 kWh/500 kW (Advanced Lead Acid)	Puducherry	Commissioned
PGCIL-Zhejiang Narada	250 kWh/500 kW (Li-ion)	Puducherry	Commissioned
Tata Power (TPDDL)–AES (Fluence)	10,000 kWh/10,000 kW (Li-ion)	Delhi	Commissioned
Andhra Pradesh Eastern Power Distribution Company Ltd. (APEPDCL)	5 MW Solar PV, 4 MWh BESS (Li-ion)	Andhra Pradesh	Announced
Solar Energy Corporation of India (SECI)	2 x 21 MWh/7 MW	Leh & Kargill	Announced
National Thermal Power Corporation (NTPC)	4 MW Solar PV + 1,000 kWh/1,000 kW BESS	Delhi	Announced
National Thermal Power Corporation (NTPC)	8 MW Solar PV+ 3.2 MWh/3.2 MW BESS	Andaman & Nicobar Islands	Announced
National Thermal Power Corporation (NTPC)	1,000 MWh	Pan-India	Announced
Panasonic India Pvt. and AES India Private Ltd.	10,000 kWh/10,000 kW (Electrochemical)	Haryana	Announced
SECI & Andhra Pradesh Southern Power Distribution Company Ltd. (APSPDCL)	2,500 kWh/5,000 kW	Andhra Pradesh	Announced
SECI and Karnataka Solar Power Development Corporation Ltd. (KSPDCL)	4 X 2,500 kWh/5,000 kW	Karnataka	Announced

Sun Source Energy	4 MW Solar + 2 MW/1 MWh BESS	Andaman & Nicobar Islands	Announced
Tamil Nadu Generation & Distribution Company (TANGEDCO)-Larsen & Toubro (L&T)	125 kW (Electrochemical)	Tamil Nadu	Announced
Tata Power	100 MW Solar + 120 MWh/40 MW BESS	Chattisgarh	Announced
SunCarrier Omega Pvt. Ltd. & Gildemeister	45 kW (Electrochemical)	Madhya Pradesh	
Tata Power and Delectrik	40 kW (Vanadium Redox Flow)	Delhi	
TMEIC Industrial Systems India Private Ltd.	750 kW (Li-ion)	Karnataka	

Definitions

i. Advanced cell technologies include lithium-ion cells and chemistries better than lithium ion available at commercial scale such as sodium ion, zinc air, flow batteries etc.

ii. India has launched the ACC PLI program with an outlay of INR18,100 crores (US$2.5 billion), the maximum incentive is fixed at 20% of the sale price of the cell or INR2,000 (or quoted price if lesser), whichever is lesser per KWh, bids submission date has been extended to 14th Jan 2022. The total capacity at disposal is 50 GWh.

iii. The EV30@30 Campaign sets a collective aspirational goal to speed up deployment and reach a 30% sales share for electric vehicles by 2030 among the participating countries.

iv. Incumbent technologies refer to those currently providing each of these services. For example, large thermal generators currently supply frequency regulation and ramping for renewable integration; transmission and distribution equipment is for system upgrades; diesel generator sets and lead acid are for behind-the-meter applications; and petrol, diesel, and CNG vehicles currently serve the majority of mobile applications.

v. This TCO analysis compares a CNG bus and a diesel bus with the e-bus model that is currently operating in Pune. All buses are 12 meters in length and air conditioned with an estimated life of 10 years, and the e-bus has a 320 kWh battery. The equipment and installation costs of the e-buses share of an 80 kW AC charging station and a 150 kW opportunity charging station are included, considering an average daily run of 225 km.

Endnotes

Endnotes

1. RMI Analysis

2. National Programme on Advanced Cell Chemistry (ACC) Battery Storage, Ministry of Heavy Industry and Public Enterprises, The Gazette of India, 2021, www.heavyindustries.gov.in/writereaddata/UploadFile/ACC%20Scheme%20Notification%209June21.pdf.

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