NITI Aayog

RMI INDIA
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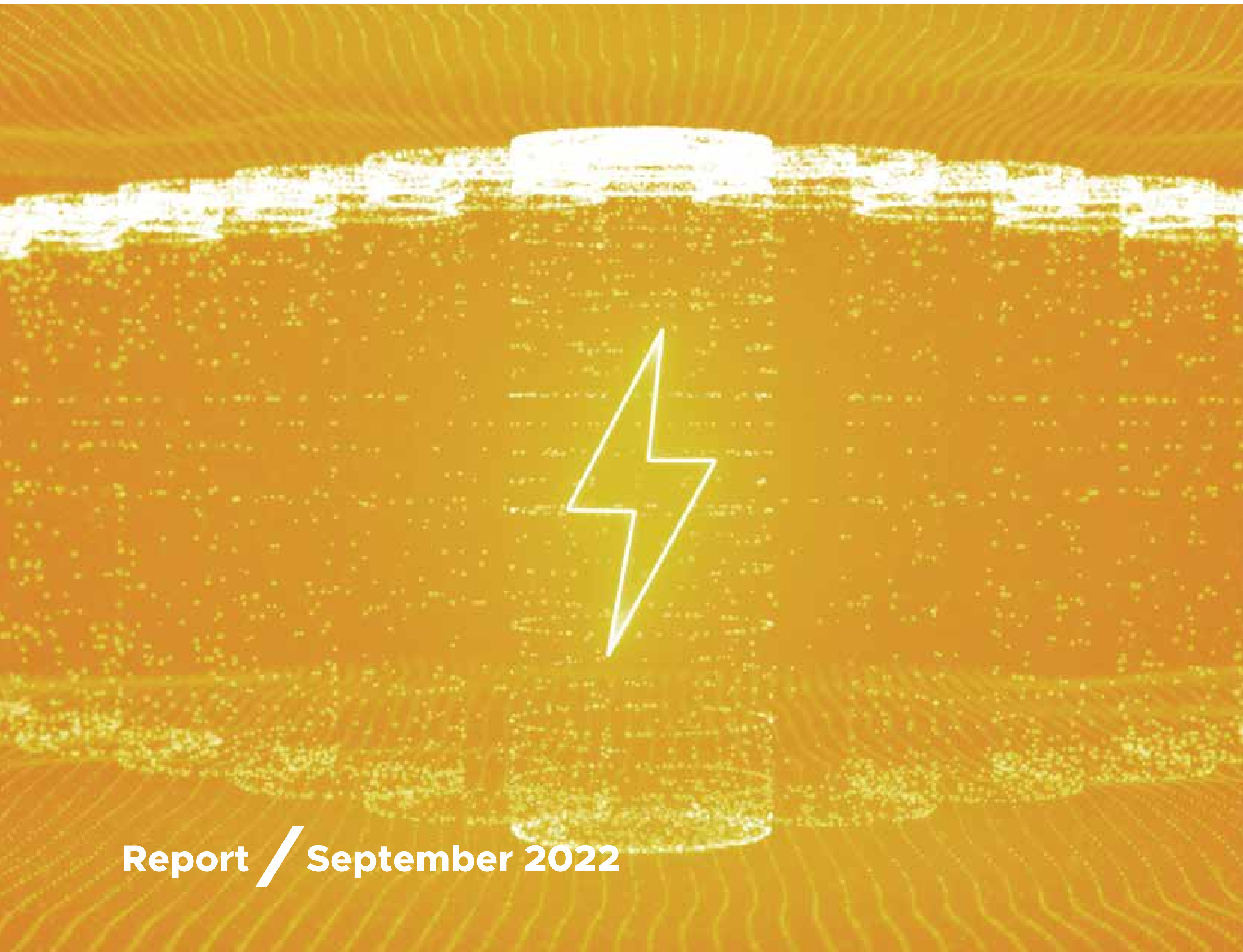
# Need for Advanced Chemistry Cell Energy Storage in India

Part III of III



Report / September 2022

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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 foster Cooperative Federalism.

## About RMI

RMI is an independent non-profit 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. RMI has been supporting India's mobility and energy transformation since 2016.

## About RMI India

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

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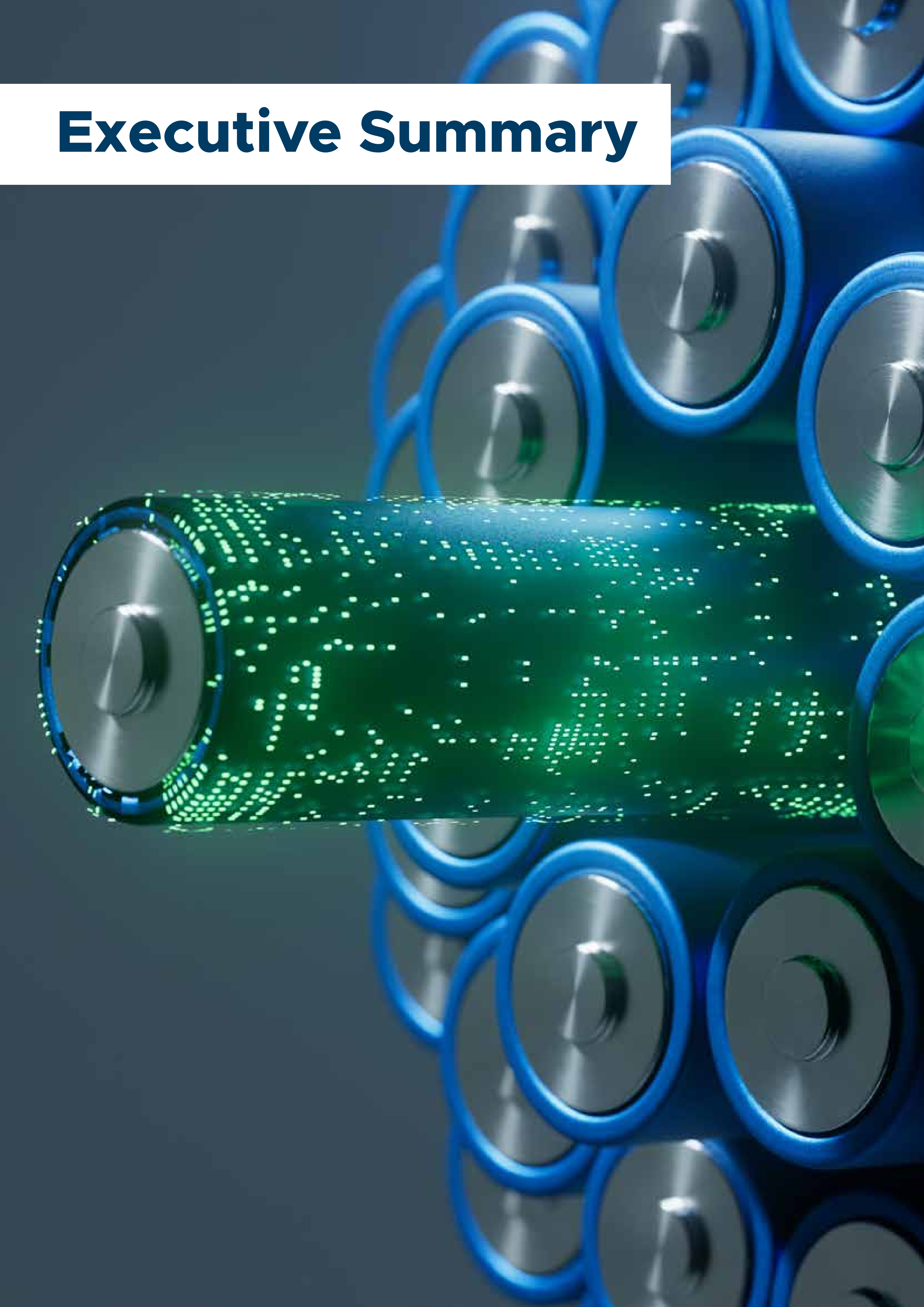
# Abbreviations

| | |
|---|---|
| **ACC** | Advanced chemistry cell |
| **ANSI** | American National Standards Institute |
| **EV** | Electric vehicle |
| **GWh** | Gigawatt-hour |
| **IEC** | International Electrotechnical Commission |
| **kWh** | Kilowatt-hour |
| **LCO** | Lithium cobalt oxide |
| **LFP** | Lithium ferro (iron) phosphate |
| **LiPF6** | Lithium hexafluorophosphate |
| **LiB** | Lithium-ion battery |
| **LMO** | Lithium manganese oxide |
| **LNMO** | Lithium nickel manganese oxide |
| **LTO** | Lithium titanate |
| **NCA** | Nickel cobalt aluminium |
| **NMC** | Nickel manganese cobalt |
| **PLI** | Production Linked Incentive |

# Executive Summary



# Executive Summary

The Government of India (GoI) announced the successful bids for the ambitious Production Linked Incentive (PLI) Scheme, worth $2.5 billion earlier this year,[i] which aims to kick-start domestic manufacturing of advanced chemistry cell (ACC) batteries. Developing a localised advanced cell supply-chain ecosystem will help India create a competitive advantage in the mobility, grid energy storage, and consumer electronics spaces. This domestic supply chain will insulate itself from any supply shocks that could put the entire battery ecosystem at risk. The development of a domestic battery manufacturing ecosystem is crucial to achieving India's ambitious goal of electric mobilisation and 500 gigawatts (GW) of installed non-fossil fuel energy by 2030.

Countries across the globe are seeking to catalyse the growth of energy storage industries, and the time frame for India to establish itself as a leader in global energy storage manufacturing is short and highly competitive. In the first report of this series, India's annual demand for ACC batteries was projected to rise to between 104 gigawatt-hours (GWh) and 260 GWh by 2030 across multiple sectors. This growth represents a fifty to a hundredfold increase from existing domestic demand for batteries, which is close to 2.7 GWh.[1] What underpins this massive growth potential is the accelerated adoption of electric vehicles (EVs) and rapid decarbonisation of the electricity grid (grid-level storage for renewables), guided by ambitious government targets (including COP26 commitments) and supporting policies.

The opportunity has culminated in the recently finalised $2.5 billion (PLI) scheme on ACC energy storage and its potential role in creating domestic economic value.

Beyond the PLI scheme, an enabling environment for long-term sustainable growth will be needed to facilitate the growth of this sunrise industry. Direct fiscal incentives, tax credits, and partnerships with industry leaders are among the strategies that have been used across the globe to catalyse the growth of energy storage manufacturing. Integrated policies that address different aspects of the energy storage industry, combined with support for demand and supply, and access to competitive financing opportunities will be key to successfully capturing the full value of a sustainable domestic battery cell manufacturing industry in India.

As with any new technology, there are numerous risks associated with setting up battery manufacturing plants in India. Establishing the entire value chain presents a challenge, given rapidly evolving battery chemistries and the steep learning curve and investment risks in adapting to new technology and manufacturing processes. Availability of raw materials, raw material processing and technologies, risk of technology transfer, development of alternative chemistries, and lack of expertise in the sector may be major impediments. In addition, the nascent state of the industry may lead financial institutions to impose a risk premium on investments, and availability to low-cost financing may be a barrier in a competitive field. Understanding these risks will allow for optimal strategising to mitigate potential roadblocks, as well as developing and enabling a favourable ecosystem for battery manufacturing.

Beyond the central and state incentives, complementing steps can be taken to build investor confidence within the sector. The principles of public–private partnership (PPP) can ensure an optimal sharing of risk between the beneficiary firm and the government, bolstering investors' confidence. Demand creation initiatives can also be a vital component where state governments will play a key role. A strong circular economic policy framework can reduce demand for scarce, imported materials. Co-locating battery plants with renewable energy resources can ensure low-cost power supply for an energy-intensive industry.

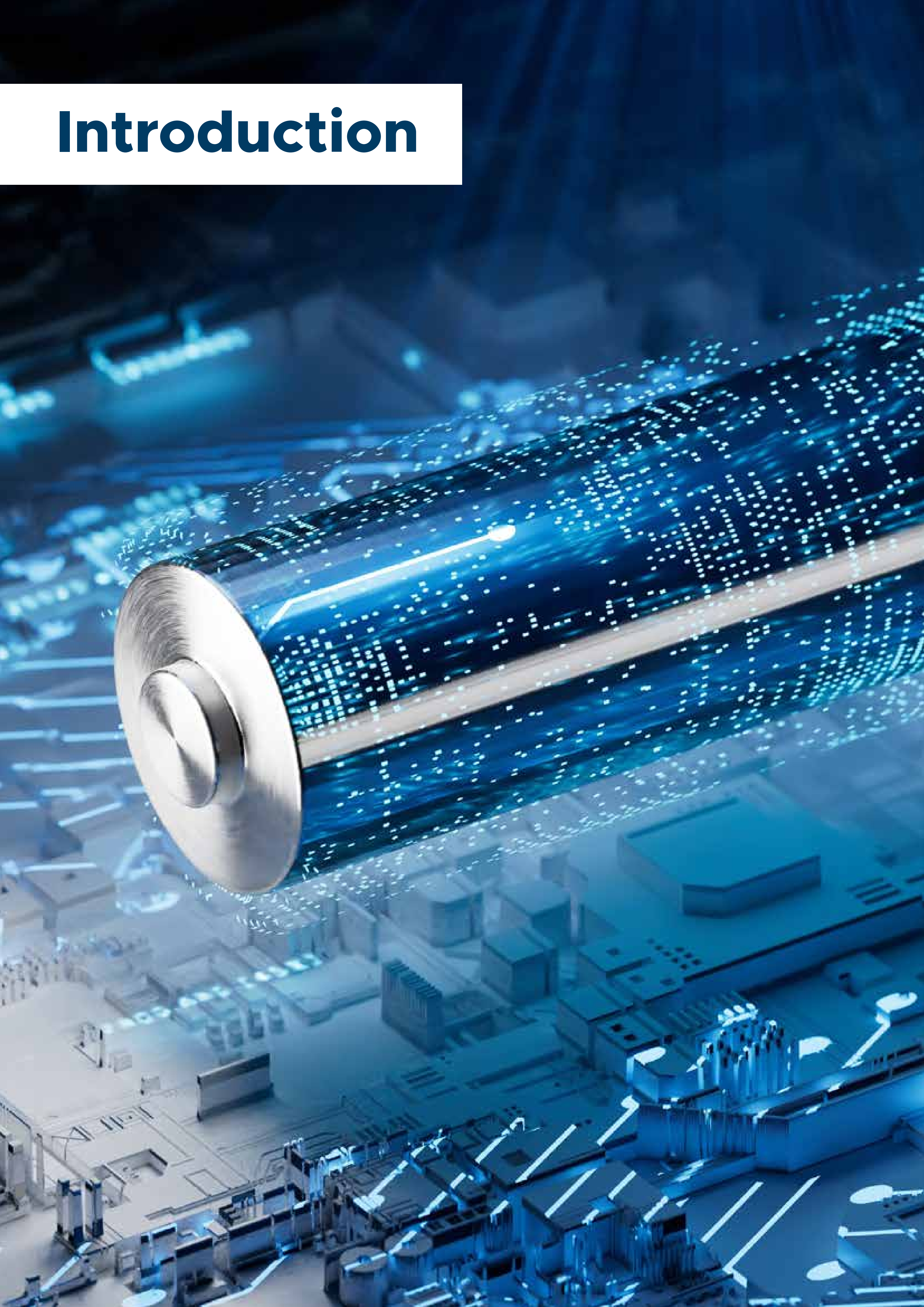
Significant growth as a battery manufacturing hub could help establish India as a centre for cutting-edge research and innovation, boost its manufacturing capabilities, create new jobs, and foster economic growth. The policies and incentives recommended in this report could pave the way for top-level battery manufacturers to invest in India and could guide manufacturers towards breakthrough chemistries and technologies.

[i] All dollar amounts referred to in this report are in US currency unless otherwise stated.

# About the Report

This is the last in a three-report series designed to create a shared understanding among stakeholders of the current status and future trends that are emerging in the ACC battery sector and to build awareness of India's supportive programme on ACC battery storage, most importantly the PLI scheme for battery cell manufacturing. NITI Aayog, RMI, and RMI India present a thorough assessment of the PLI scheme for ACC batteries, an analysis of the roles of stakeholders, the value of PPPs and other financing for industry growth, and how to hedge risks associated with the growth of a new industry. This final report of the series introduces the contour of the PLI scheme, looks at key leverage points for maximising the success of the scheme, and explores long-term sustainable growth of a domestic battery manufacturing sector.

# Introduction



# Introduction

The first report of this three-part series projected that India's annual demand for ACC batteries would rise to between 104 GWh and 260 GWh by 2030 across multiple sectors.[2] This growth represents between a fiftyfold and hundredfold increase from existing domestic demand for batteries, which is close to 2.7 GWh. What underpins this massive growth potential is the accelerated adoption of EVs and rapid decarbonisation of the electricity grid, guided by ambitious government targets and supporting policies.

The second report of this series presented a common understanding of battery characteristics, performance criteria, and the different chemistries available. Given that batteries can cater to a wide range of applications across the transport, power, and consumer electronics sectors, there is a need to develop a technology-agnostic ecosystem that promotes multiple battery chemistries that will cater to the variety of anticipated demand sources. In the long term, newer battery chemistries have the potential to significantly shift cost and performance thresholds, leading to a larger market for energy storage by enabling new applications that previously were cost- or technology-prohibitive.

The expected scale and growth of the country's battery market are sufficiently large to justify giga-scale manufacturing capacity in the years ahead. Large-scale domestic battery manufacturing will reinforce and support complementary transitions towards increasing shares of renewable energy generation and electrification of the transportation sector. But the benefits of battery manufacturing will not be limited to increased deployment of clean energy solutions and will extend across the larger economy.

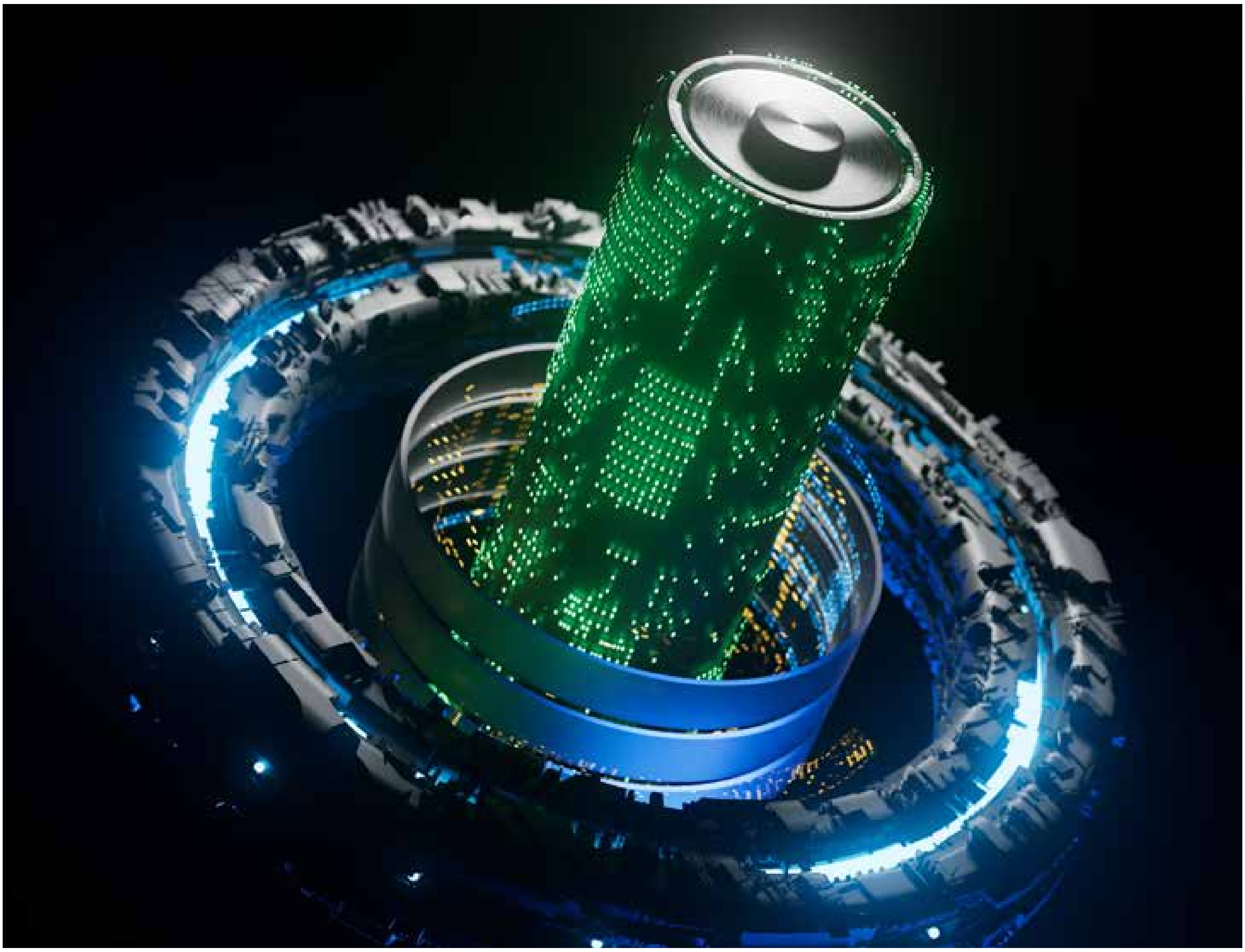
Between 2014 and 2020, the cost of imported lithium-ion cells has increased sevenfold, from \$180 million to over \$1.2 billion.[3] The increasing demand for advanced batteries presents a large macroeconomic opportunity if demand is met with domestic manufacturing and not imports. This benefit stems from a few factors: potential savings in energy imports and enhancement of energy security, environmental benefits as a result of decreasing $CO_2$ emissions, and the macroeconomic impacts of associated job creation.

India's heavy dependence on energy imports (particularly for oil) makes it vulnerable to volatility in global commodity prices. Oil price increases can percolate down the economy, affecting second- and third-degree economic indicators such as inflation spikes and economic slowdown. Fuel price subsidisation has been a resulting practice to reduce consumer impact. Although subsidies may partially shield consumers, the government must absorb a high bill to pay for the discounted price. Transition to EVs, enabled by battery manufacturing, will invariably have an impact on India's energy and commodity imports and, through that, the larger economy. Reduction of imports of oil and batteries will also enhance energy security benefits. The EV transition and greater renewable energy integration that battery manufacturing can enable will also help reduce $CO_2$ emissions. Considering the social cost of carbon, this will have impacts throughout the economy.

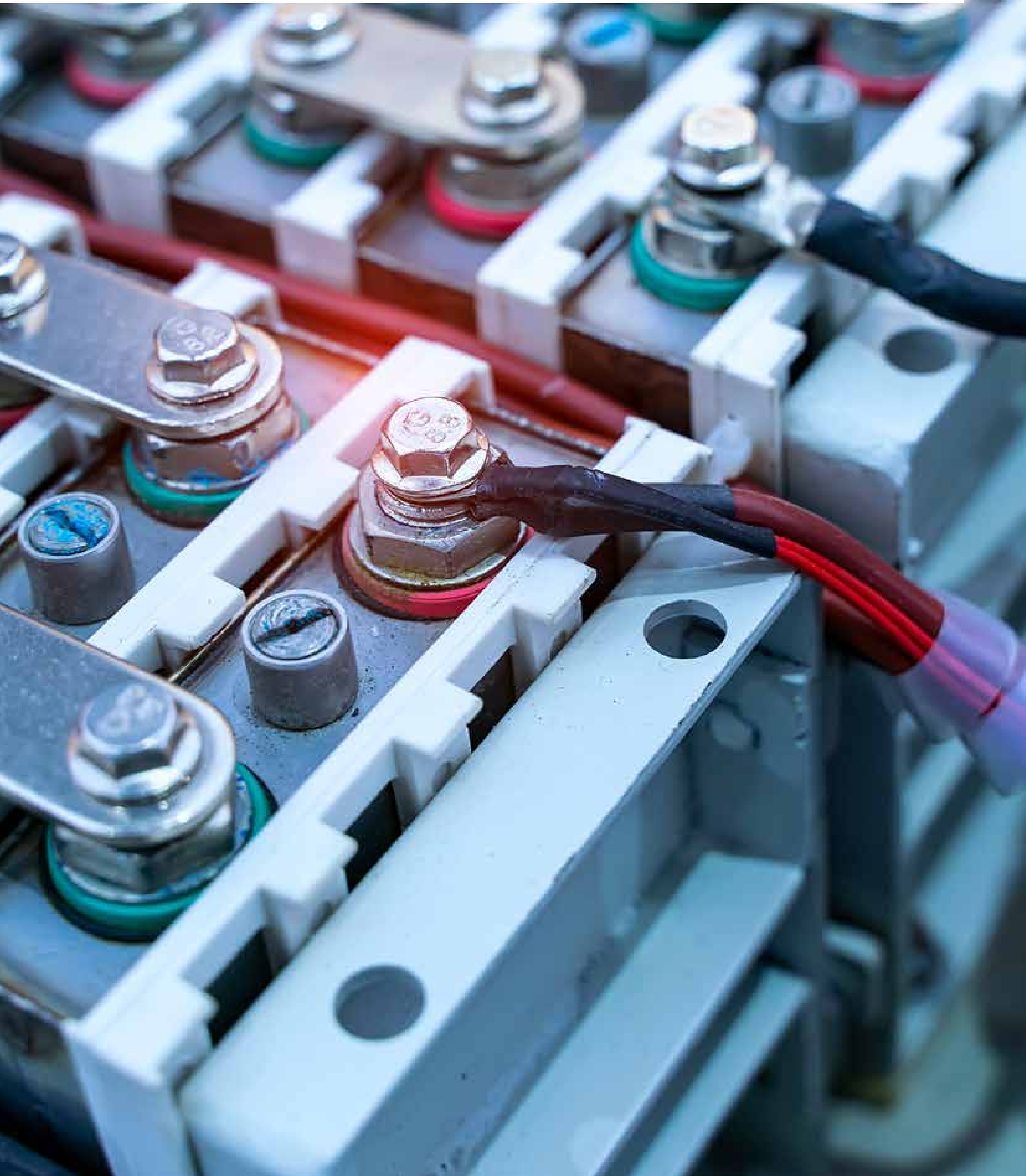
Finally, the impact on employment and high-skilled job growth is expected to be significant. The European Union estimates the direct job creation potential of lithium-ion battery (LiB) plants to be around 90 to 180 jobs per GWh/y production.[4] Given the relatively lower labour and logistics costs in India, potential direct and indirect job creation resulting from gigafactories in the country could be much higher. Furthermore, the impact on downstream industries such as EVs and renewables will also result in employment growth in the country.

With the $2.5 billion PLI scheme for ACC energy storage, India stands to reap these benefits while seizing the opportunity to establish itself as a global leader within this sunrise sector. The GoI announced the winnings bids of the PLI Scheme earlier this year. The scheme aims to attract global investments to establish battery gigafactories in India. Under the scheme, the selected bidders will set up manufacturing facilities within two years, with the goal of 50 GWh of domestic capacity by 2030. Beyond the PLI scheme, policy and incentive tools are available to ensure that India remains competitive in the ACC manufacturing space, including direct fiscal incentives, tax credits, and partnerships with industry leaders.

It is vital to understand how these frameworks can be used to best ensure long-term success for India's nascent battery manufacturing sector. The objective of this report is to present the PLI scheme and the role that sound industrial policy — consisting of integrated policies and coordinated efforts by multiple stakeholders — can play towards establishing a sustainable domestic manufacturing ecosystem in India for advanced energy storage.



# Catalysing Action and Investment



# Catalysing Action and Investment

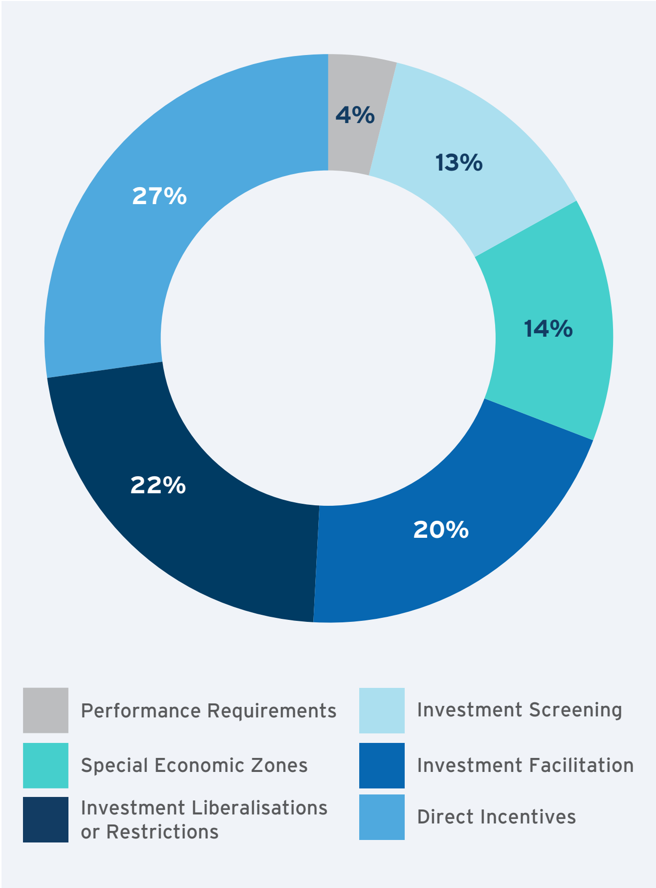
## National Incentives and Investments in Energy Storage Manufacturing and Sales

Countries across the globe are seeking to catalyse the growth of energy storage industries through direct fiscal incentives, tax credits, and partnerships with industry leaders. These efforts range from national investment in energy storage manufacturing plants to end-use incentives for purchasing home or commercial storage systems to increase local demand. India is poised to capture long-term benefits from early investments in a burgeoning market.

Sound industrial policy generally consists of a set of integrated policies that address different aspects of the specific industry in question and include demand and supply support mechanisms. The right mix of policies to support industry growth depends on the stage of the specific industrial development. Much can be learned from looking at global industrial policymaking over the past decade. Historically, policies that aimed to initiate growth in a new industry tended to be government-led, industry-specific (i.e., targeting a specific industry) and relied on domestic demand. The battery industry in India can be seen as a startup industry that will need early government support.

Exhibit 1 shows the relative popularity of industrial policies enacted in 2010–17, as reported by the United Nations Conference on Trade and Development's annual Investment Policy Monitor.[5] Although these trends are not industry-specific, they provide insights into options for India to support development and quick expansion of the Indian battery manufacturing industry.

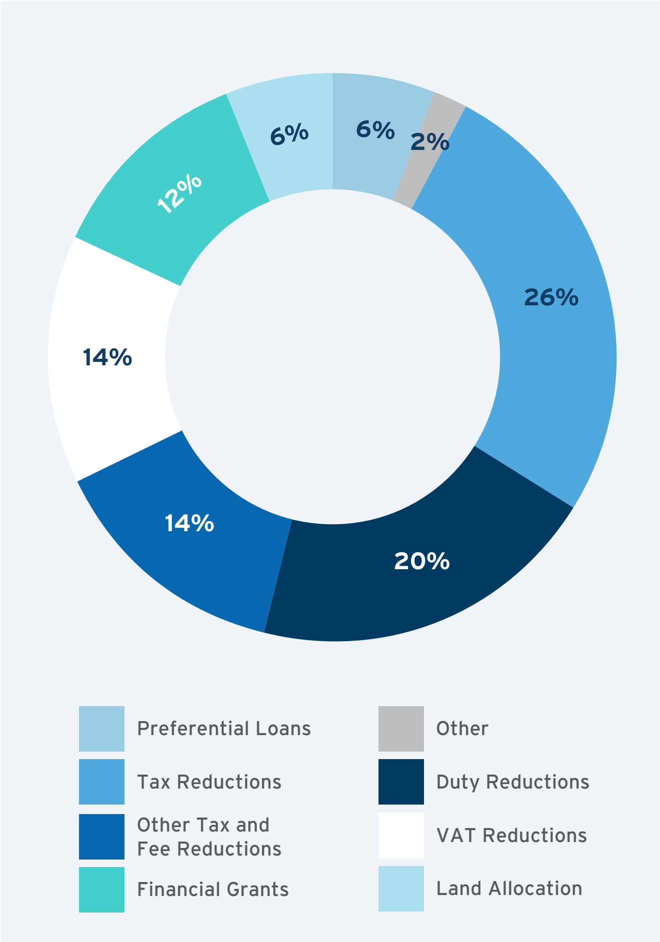
**Exhibit 1** Relative Popularity of Industrial Policies Worldwide (2010–17)




Source: United Nations Conferences on Trade and Development[6]

**Incentives** are key instruments in industrial policy globally. They tend to be used in most policy packages reviewed in the *2018 World Investment Report* and have increasingly been tied to some form of performance requirement. Manufacturing sectors tend to attract greater incentive packages because of their ability to generate local employment and contribute to export revenue. Exhibit 2 provides a summary of fiscal and financial incentives based on 80 global schemes in the past decade.

## Exhibit 2 Relative Use of Fiscal and Financial Incentives Worldwide




Source: United Nations Conferences on Trade and Development

**Performance standards** are frequently linked to investment incentives, with the most common performance indicators being minimum investment amount, contribution to R&D and technology transfer, and job creation. Among other performance indicators are minimum requirements of local content, minimum export requirements, and joint venture or partnership requirements. Although minimum investment requirements and job creation are becoming more common, technology transfer and R&D requirements are losing popularity because of the high logistical burden associated with monitoring and verification.

**Special economic zones** are also popular policy supports that governments can create to attract foreign investment and integrate local firms into the global value chain. Special economic zones offer a set of infrastructure and services to companies operating in the zones. These include information and communication technology, customs streamlining, tax services, and streamlining business licenses. Although special economic zones have been successful, they have also faced challenges such as poor site locations, poor labour conditions, inadequate governance, and heavy capital expenditures. However, good planning, strong implementation and governance, and high institutional coordination can increase the likelihood of success. Specifically, for battery manufacturers, special economic zones can stimulate investment by providing land, infrastructure, and a streamlined regulatory environment, which lower the risk for firms making such investments and transfer some of the risk to the host government.

Finally, **investment facilitation** in the form of policies and regulatory frameworks that make it easier for foreign investors to establish, expand, and operate their businesses in the host country are beginning to play a bigger part in industrial policies globally. Investment facilitation is often achieved through the formation of investment promotion agencies, coordinating bodies, or other organisations equivalent to a chamber of commerce. Multi-stakeholder coordinating organisations can identify challenges to investment and advancing streamlined solutions. National-level policy support has been central to accelerating the international market for advanced battery cells and has played a dominant role in boosting global manufacturing leaders such as China, Korea, and the United States. As shown in Exhibit 3, each of these countries has implemented a broad set of supportive policies aimed at catalysing domestic battery manufacturing.

## Exhibit 3 Examples of Industrial Policies Used Worldwide

| Policy | Example |
|---|---|
| **Performance-Linked Tax Incentives** | In the United States, the states of Nevada and Georgia provided significant tax breaks to battery manufacturers (Tesla and SK Innovation, respectively), based on commitments of jobs and eventual tax base. |
| **Special Economic Zone** | China established the region of Gansu as a zone for battery manufacturing, ultimately attracting Denmark-based company Lithium Werks (recently acquired by Reliance Industries) to establish a facility. |
| **Investment Facilitation** | The European Commission formed the European Battery Alliance (EBA), which will serve as a coordinating body for industry stakeholders and government agencies. In addition to allocating funding, the alliance will streamline the regulations and permitting processes for battery manufacturing. |

Source: Interviews with industry experts

### Box 1: India's Missed Opportunity — Solar Photovoltaics

The time frame for India to become a leader in global energy storage manufacturing is a short one. China already controls most of the market, and other countries are moving aggressively into the space. As was learned in the global solar market over the past 5 to 10 years, advanced energy manufacturing dominance is achieved by countries willing to move fast and provide governmental support.

China provided strong government support to move quickly into solar cell manufacturing and currently controls more than 80% of world solar manufacturing.[7] Eighty-five percent of India's solar cells are imported from China, and at this point, Indian companies struggle to enter the market when competing with low-cost, highly experienced, and large-scale foreign manufacturing players.[8] By the time India started providing incentives on solar manufacturing, cost margins of Chinese-made solar cells made any competition from domestic producers irrelevant. Strict World Trade Organization open-trade regulation also prohibited explicit protectionism.[9]

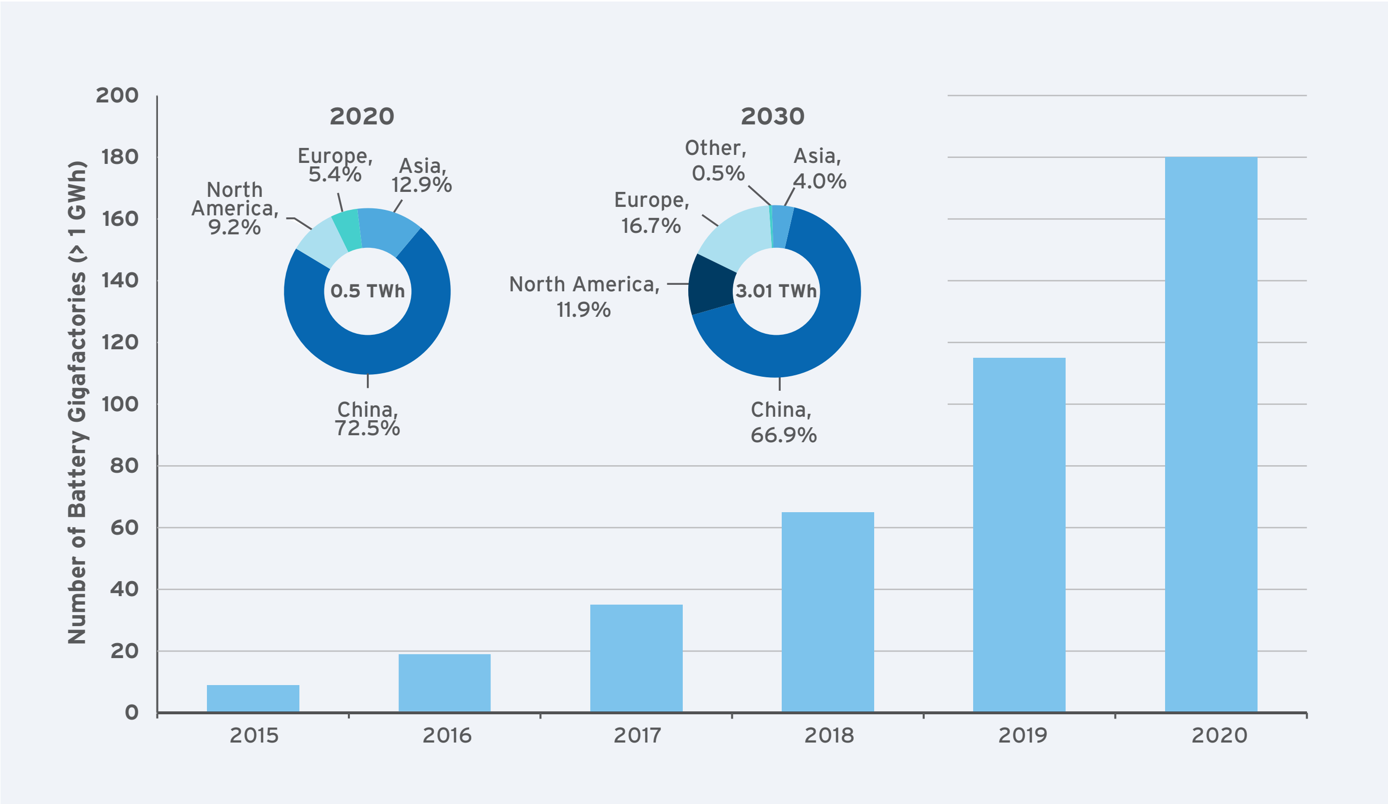
Lastly, given the need to encourage large solar deployment, developers employing Chinese cells always had a cost-competitive advantage in bidding. India eventually had to choose between cleaning up its grid and waiting for the domestic solar industry to take off. Despite attempts to expand the industry, only 3 GW were manufactured in India in 2018, compared with a world market of over 320 GW.[10] To address this manufacturing gap, the Ministry of New and Renewable Energy launched a PLI scheme for solar module manufacturing in May 2021, with an initial value of INR4,500 crore (approximately $616.8 million). The initial request for bids in October 2021 attracted 18 eligible applications, totalling more than 54 GW of manufacturing capacity per year. An additional INR19,500 crore (approximately $2.6 billion) was made available in February 2022 to accommodate all applicants.[11] To avoid a similar situation in the energy storage market, India will need to undertake immediate aggressive actions to be a key player in one of the largest growth industries of the 21st century.

## Global Case Studies and Best Practices

Battery gigafactories have witnessed rapid growth over the past few years with countries recognising the role of batteries in decarbonising the transport and power sectors. The number of individual gigafactories in the pipeline increased from close to 40 in 2017 to more than 180 in 2020 across the globe.[12]

Based on the current pipeline for gigafactories, global battery cell capacity is projected to grow from 500 GWh in 2020 to over 3 TWh by 2030.[13] Close to 70% of the global cell capacity already online or under construction is anticipated in China, while Europe and North America would account for about 30% of battery cell capacity (see Exhibit 4).

## Exhibit 4 Build-Out of Battery Gigafactories (>1 GWh), 2015-20, and LiB Cell Capacity, Existing (2020) and Planned (2030)




Source: Simon Moores, "The Global Battery Arms Race: Lithium-Ion Battery Gigafactories and Their Supply Chain"

The following section will identify best practices, policies, and initiatives that helped create a conducive environment for battery manufacturing to flourish in respective countries.

### China

China is a leader in the global energy storage market. Driven by a growing EV industry, Chinese companies are investing billions of dollars in manufacturing facilities. This has also attracted a tremendous amount of investment from international firms, such as the Dutch company Lithium Werks, which invested $1.85 billion in a Chinese cell manufacturer.[14]

China has invested heavily in R&D, including $214 million as part of the 12th Five Year Plan to explore and develop innovative technology and advanced battery solutions, with subsidies to battery manufacturers BYD (Build Your Dreams) and CATL (Contemporary Amperex Technology Co. Limited).[15] China has also cultivated the world's largest electric vehicle market, with the nation's cumulative electric vehicle sales in the past decade representing 47% of the world's total. The credit goes to China's early EV market strategy to push electric vehicles in government and public fleets. As a result, electric buses and micro electric cars mostly used in ride-sharing fleets have been among the most successful EV niche markets. The demand creation for EVs played a vital role in spurring the battery manufacturing ecosystem in China.

China is unique as it has been able to directly invest in and enable battery manufacturing through top-down investments in battery companies, clean metal processing, and manufacturing facilities. Chinese regulators have been ambitious in their goal to dominate the global battery market. The country's approach has consisted of a combination of the key investment strategies listed above: performance-based incentives, special economic zones, and investment facilitation.

### Europe

Several countries in Europe are trying to compete for a leadership position in the energy storage market. The European Commission leads these efforts through the EBA.

The EBA serves as a "cooperation platform" that aims to create a competitive battery manufacturing value chain in Europe.[16] To that end, the Alliance created oversees the European Commission's Strategic Action Plan on Batteries, which outlines a variety of commitments, including efforts to secure raw materials for the industry, improve regulatory frameworks, and directly support cell manufacturing.[17]

The European Commission launched the EU research and innovation programme Horizon 2020 in 2018. Horizon 2020 set aside approximately €500 million for battery projects.[18] It has since been succeeded by Horizon Europe, a seven-year research and innovation initiative.[19] This includes €95.5 million for activities across the value chain, including sustainable processing, refining, and recycling; environmentally sustainable processing for electrode and cell component manufacturing; and advanced technologies, such as solid-state batteries.[20]

The European Investment Bank (EIB) has played a critical role in supporting energy storage, particularly through commercial-scale demonstration projects. The EIB provides loans, guarantees, and equity funding to reduce risks for private investors. The European Fund for Strategic Investments is the main pillar of the Investment Plan for Europe. It provides first loss guarantees enabling the EIB to invest in more, often riskier projects.

The EIB recently announced its support for Europe's first gigafactory, developed by Northvolt for LiB cells in Sweden, with backing from the Investment Plan for Europe. EIB will provide financing worth $350 million, following the successful financing of Northvolt in 2018, which the EIB supported with a €52 million loan.[21]

Europe's strategy has benefitted from its focus on cross-sectoral collaboration and coordination. EBA and other similar efforts have played the role of investment facilitation while laying the foundation for recent performance-based investments.

### United States

The United States' investment in battery manufacturing began in 2009, with the American Recovery and Reinvestment Act. This programme led to significant funding of battery manufacturing facilities across the country, with awards totalling $1.4 billion in grants going to a variety of facilities with the intention of accelerating the development of a domestic battery supply chain.[22] This included investments in lithium supplies (raw materials), lithium-ion cell components, diverse battery chemistries, and new pack-assembly facilities.

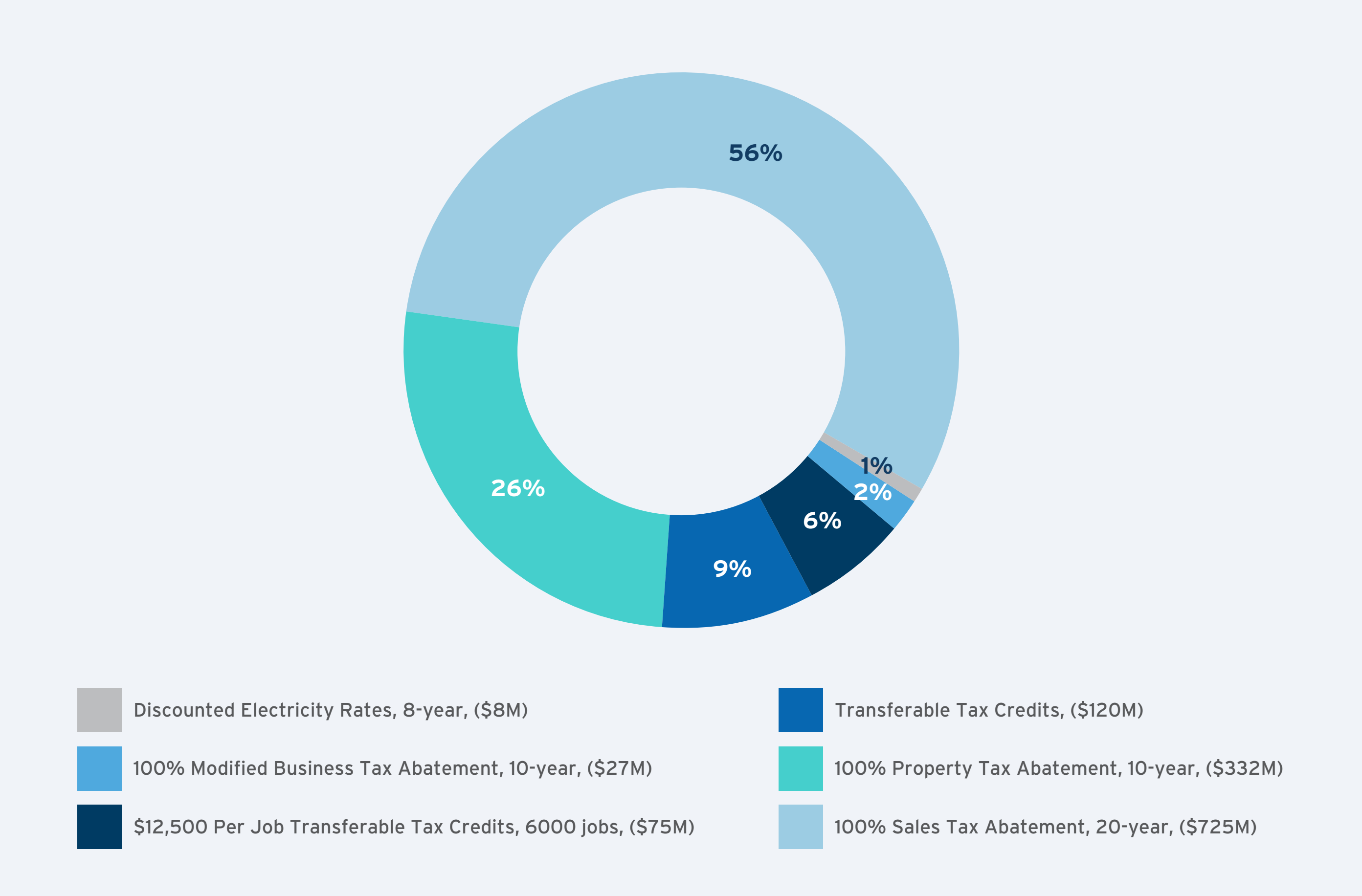
The United States has also announced its intention to use the Defense Protection Act to encourage domestic production of battery materials. This is aimed at reducing barriers for companies receiving government funding for extraction of lithium, nickel, cobalt, graphite, and manganese.[23]

Aside from its early federal investments, the United States has focused significantly on a strategy of performance-based incentives. This has primarily occurred at the state level with incentive packages offered in exchange for the promise of jobs and eventual (but delayed) tax revenue.

## Tesla Gigafactory — Nevada

The most notable among the investments in battery manufacturing in the United States is the Tesla gigafactory near Reno, Nevada. Before Tesla's selection of Nevada as its manufacturing state, four other states – Arizona, California, New Mexico, and Texas – competed for the gigafactory. Tesla chose Nevada because of its enticing $1.25 billion incentive package, which included a 20-year sales tax holiday and 10-year property tax holiday.[24] In return, Tesla promised to create 6,500 direct jobs at the site, as well as 22,700 indirect jobs statewide.

## Exhibit 5 Summary of Gigafactory Subsidy Package

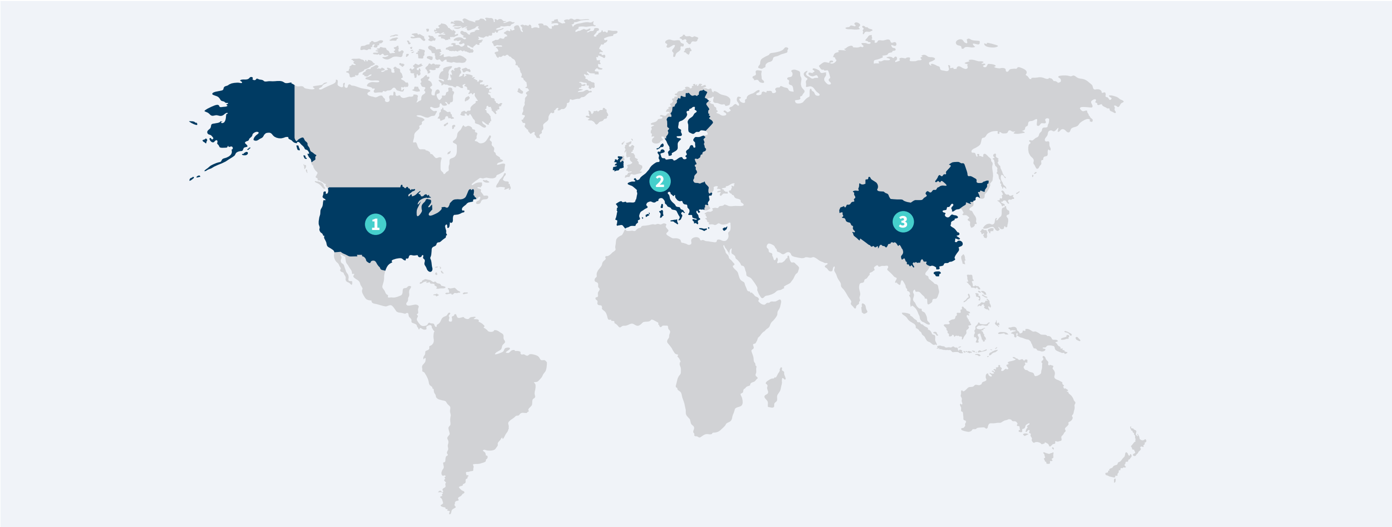



Source: Reno Gazette Journal

Similarly, the state of Georgia successfully attracted Korean battery manufacturer SK Innovation by offering a suite of incentives totalling $300 million.[25] The bulk of the incentives are tax credits or exemptions that require SK Innovation to hire and retain workers for specific periods. SK Innovation has promised to invest $1.6 billion in a factory and hire 2,032 employees at an average wage of $40,000 a year. In return, Georgia produced the following package of incentives and criteria:

- A state project development grant of $18.75 million
- 283 acres of free land valued at $18.76 million
- $122.7 million in incentives, including 20 years of property tax breaks, from Jackson County, where the plant is being built
- Mega project tax credits for new jobs created valued at more than $53 million if the company meets its goals
- Georgia Quick Start training, valued at nearly $7.4 million, to prepare new workers
- A "claw back mechanism" that allows Georgia to seek repayment if SK Innovation fails to meet 80% of its combined jobs and investment goal.

# Exhibit 6 Global Case Studies




1
**United States**
**R&D, Capital Support:** Federal grants of ~$2.4 billion to battery manufacturers
**Tax Breaks:** State-level tax credit programs (Georgia, Michigan, Nevada, South Carolina)
**Securing Supply Chain:** Defense Production Act invoked to allow government funding for domestic extraction of lithium, nickel, cobalt and manganese
**Recyclability:** $5.5 million phased competition prize to incentivize investment in recycling processes aimed to capture ~90% of discarded LiBs

2
**Europe**
**R&D, Capital Support:** EBA investing €6 billion in battery manufacturing, including €1.2 billion in production sites in France and Germany; EU's Horizon 2020 and Horizon Europe will fund €600 million for R&D projects
**Concession Finance:** €4.5 billion in lending to battery tech projects
**Tax Breaks:** Hungary has offered tax credits to Samsung SDI and tax breaks to Tesla for R&D
**Securing Supply Chain:** European Raw Materials Alliance links financial institutes and national authorities with extraction and production assets
**Recyclability:** Proposed regulations mandate minimum EV battery collection (70% by 2030) and minimum recycled content standards by material

3
**China**
**R&D, Capital Support:** R&D grants for advanced LiBs; subsidy forgiga-scale manufacturing ≥ 8 GWh
**Concession Finance:** Non-recourse soft credit of $521 million for Tesla; RMB loans @ 90% of 1-year rate, USD loans @ LIBOR +1%
**Tax Breaks:** Exemption of 4% consumption tax for advancedbattery manufacturers; transferable tax credits; 100%exemption on sales tax, property tax, and modified business tax
**Securing Supply Chain:** 50% of refining capacity for key metalsunder state-owned/state-incentivized companies
**Recyclability:** Reduced VAT (3% instead of 13%) and VAT refundincrease from 30% to 50% for eligible recyclers

## Rest of the World

### Japan

Japan recently formed the Consortium for Lithium-Ion Battery Technology and Evaluation Centre (Libtec), which consists of major manufacturers, such as Toyota, Honda, Panasonic, and Yuasa. Libtec's mission is to foster the development of solid-state batteries for EVs with a range of 550 kilometres by 2025 and 800 kilometres by 2030. In 2018, the Japanese government invested up to $14 million, which will be distributed by the Ministry of Economy, Trade, and Industry to Libtec, whose members include Asahi Kasei and Toray Industries.[26] Similar to Europe, Japan has established a consortium that is meant to streamline investment in batteries — with a focus on launching innovative approaches to solid-state batteries.

### Australia

With an estimated 2.8 million metric tons of lithium ore, Australia has the second highest reserves (after Chile) in the world.[27] To improve the development of its resources, the federal government, the state government of Perth, and the industry are together investing $135 million.[28]

In addition to possessing significant lithium resources, Australia is poised to be a critical player in the manufacturing of battery storage systems. The South Australian government launched a AU$50 million Grid Scale Storage Fund to support construction of new energy storage projects in the region.[29] It has also signed a memorandum of understanding (MoU) with the federal government's Australian Renewable Energy Agency (ARENA), to assess projects for joint funding under ARENA's Advancing Renewables Program.[30] ARENA announced $72.3 million in funding for large-scale energy storage products in 2021.[31]

### Indonesia

Indonesia holds sizeable reserves of several key materials for conventional lithium-ion battery chemistries, including nickel, cobalt, and manganese. In 2019, Indonesia represented 29.6% of global nickel ore production.[32] The Ministry of Investment signed an MoU with the Hyundai Consortium to invest $1.1 billion in a cell factory targeting annual production of 10 GWh by 2026.[33] Indonesia has also introduced policies to accelerate domestic EV industry growth. These include minimum local content requirements for EVs and fiscal incentives, such as tax exemptions, import duty exemptions, and reduced electricity tariffs.[34]

### Thailand

Thailand has a strong automotive manufacturing sector and aims to use industry expertise to increase production of EVs to 30% of total Thai automotive production by 2030. Thailand has offered a relocation policy package since 2019, including no local content requirements and no excise tax for EVs in the Eastern Economic Corridor (a special economic zone on Thailand's east coast). In November 2020, import duties were reduced 90% for raw or essential materials for EV batteries, through winter 2022.[35] There are plans for 64 GWh of cell manufacturing capacity by 2026, as part of a partnership with Energy Absolute.[36]

### Consumer Demand Creation: Incentives for EVs and Battery Storage Systems

Several countries have sought to increase demand for batteries through consumer-driven EV incentives, as well as incentives for residential and commercial-scale battery storage systems. Combined, such subsidies can produce significant consumer demand and, in turn, spur greater production. Global demand creation incentives are summarised in Exhibit 7.

## Exhibit 7 Demand Creation Subsidies around the World

# The ACC Battery Manufacturing Scheme

# The ACC Battery Manufacturing Scheme

India's battery manufacturing ecosystem is in a nascent stage compared with global counterparts like China, Europe, and the United States. India needs to develop a domestic hub for battery manufacturing to unlock significant economic value and accelerate the country's drive towards energy independence. Recognising the crucial role that battery storage will play in India's energy sector, the GoI rolled out the PLI scheme in 2021, with the objective of promoting domestic manufacturing of various ACC batteries.[37]

The initiative aims to establish 50 GWh of battery manufacturing in India. Beyond building India's battery manufacturing, the PLI scheme can also help unlock the following benefits for the country.

## Exhibit 8 Anticipated Domestic Benefits of the PLI Scheme

| | |
|---|---|
| **Direct Investment** | Attract around INR45,000 crore in domestic battery manufacturing. |
| **Facilitate Make-in-India Battery Cells** | Greater emphasis upon domestic-value capture and reduction on import dependence, allowing an import substitution of INR20,000 crore annually.[ii] |
| **Net Savings** | Import bill reduction during the period of the scheme from accelerated EV adoption results in savings of INR2.5 lakh crore.[iii] |
| **Greenhouse Gas Emissions (GHG)** | The scheme will be a key contributing factor in reducing India's GHG emissions, as battery storage enables increased penetration of renewable energy on the grid and facilitates the demand for electric vehicles. |
| **R&D** | Emphasis on R&D on battery technology to achieve higher specific energy density and cycle life, which can help promote newer and niche battery technologies. |

Source: Press Information Bureau Delhi

[ii] Battery demand under conservative and accelerated scenarios was used as an input to develop a phased production ramp-up plan under the PLI scheme. Value capture share from this phased capacity build-out was then used to calculate the monetary value of battery import substitution each year that can be expected because of the programme.

[iii] Net savings include import bill savings resulting from a reduction in oil imports (due to adoption of EVs, based on RMI analysis) and the avoided social cost of carbon associated with damage to property, health, and climate impacts.

## The Programme

As battery technology and chemistry dictate their utility, the PLI scheme follows a technology-agnostic approach and offers greater incentives for high-performance battery cells. This incentive structure will help establish a diverse and well-rounded battery ecosystem in the country that can cater to multiple sectors. This can also encourage manufacturers to invest in R&D and to manufacture such cells in India.

The scheme invited battery manufacturers to submit bids for setting up production capacities for at least 5 GWh and totalling up to 50 GWh of advanced chemistry battery cell manufacturing. The following section highlights the key features of the PLI scheme:

- The programme aims to provide close to $2.5 billion in financial incentives to help set up 50 GWh of domestic battery manufacturing over the next five years.
- The selected manufacturers are expected to set up manufacturing facilities within two years, and the financial subsidy offered by the GoI will be distributed over five years based on the volume of cells manufactured and sold.
- The programme takes a technology-agnostic initiative and offers higher financial incentives to battery technologies that can offer better performance in terms of energy density and cycle life.
- Manufacturers are expected to commit at least 25% of domestic value addition within two years and a minimum of 60% value addition within five years.
- The PLI scheme follows a quality- and cost-based selection process that objectively ranks manufacturers based on their bids and awards manufacturing capacity based on their respective ranks.

## Tripartite Agreement and Programme Agreement

To ensure the bankability of the manufacturing facility and with emphasis on key performance indicators, the incentive framework under the PLI scheme has been fused with the principles of PPP. This structure ensures an optimal sharing of risk between the battery manufacturer and the government, and is expected to bolster investors' confidence and become instrumental in putting India as a leader on the world map.

The PLI scheme proposed a tripartite agreement among the central government, the state government, and the respective battery manufacturer. The obligation of the GoI under the tripartite agreement is to disburse the subsidy to the qualified manufacturer as per the programme agreement. The state government inviting the manufacturer to set up production in its respective state is expected to de-risk some of the key aspects of the project, including cost of land, electricity, and infrastructure facilities covered further in the next section.

## State Grand Challenge

State governments will play a critical role in the success of the programme. A state-level grand challenge is envisioned within the PLI scheme for states to attract potential manufacturers via infrastructure support and incentives.

The grand challenge is intended to benefit state governments and battery manufacturers. Inviting battery manufacturers to states can kick-start the creation of a local battery ecosystem, as suppliers supporting battery manufacturers might also consider establishing production in the same state, which could help the state economy and drive positive job growth. Incentives will also help de-risk private investments in the battery manufacturing space and improve the cost competitiveness of batteries.

## Central and State Incentives

Manufacturers participating in the PLI scheme are assessed based on specific technical and financial parameters, including domestic value addition and volume of cells manufactured. The scheme is designed to favour manufacturers that demonstrate higher domestic value addition and can ramp up their committed capacities at an early stage. The PLI scheme also lays out the potential incentives that can be offered by a state government to attract a battery manufacturer to set up a facility in its state.

The incentives are designed to spur the new industry and lower specific barriers to entry for manufacturers by offering financial subsidies, tax exemptions, and market offtake certainty. Financial incentives in the PLI scheme are intended to reduce the levelised cost of manufacturing ACCs in India and achieve cost parity with the international market; these incentives are in addition to existing demand-side incentives (like FAME II) for electric vehicles.

Exhibit 9 outlines central and state incentives that have been proposed for manufacturers under the PLI scheme.

## Exhibit 9 Central and State Initiatives

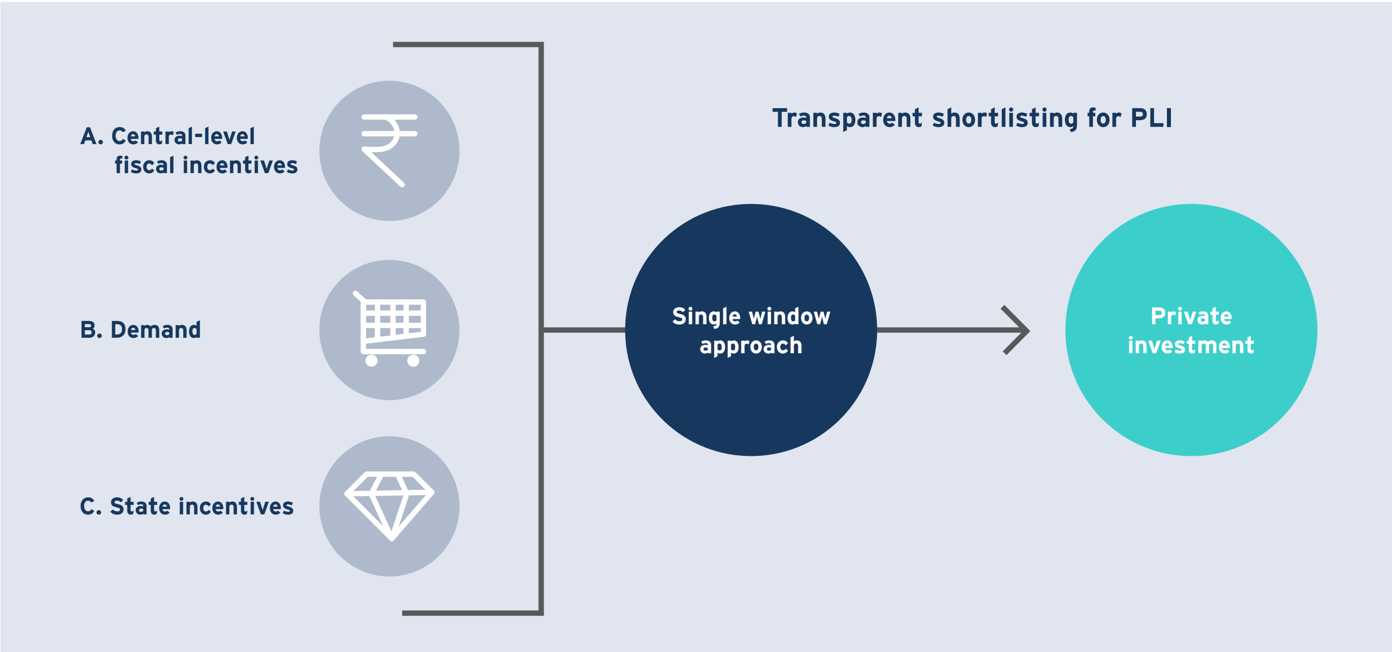
| | |
|---|---|
| **Fiscal Incentives** | • Maximum base subsidy of INR2,000/kWh for manufacturers, which is designed to gradually phase down over time. |
| | • The states are expected to offer electricity to manufacturers at below the average cost. In case of open access, states are expected to facilitate the process for manufacturers and extend benefits in relation to transmission and wheeling charges at concessional rates. |
| | • The states can offer additional subsidies to manufacturers over and above the incentives proposed in the ACC PLI scheme by the central government. |
| **Land and Infrastructure** | • State governments can acquire, lease, or transfer land parcels that are free from encumbrances and hand over the possession of such land to battery manufacturers at or below market price to establish manufacturing hubs. |
| | • States should offer sites in close proximity to highways and ports to minimise connectivity challenges for manufacturers. |
| | • The programme also allows state governments to offer trunk infrastructure facilities such as access roads, sewage, water, electricity infrastructure, and effluent treatment plants to manufacturers. |
| **Permissions** | • To ensure efficient approval of permits and licenses, states are also expected to support manufacturers by setting up single window clearance mechanisms in a time-bound manner. |
| | • Beyond these major incentives, the scheme also allows manufacturers to negotiate and seek any additional incentives with the states directly. |

### Risk Hedging

The GoI has proposed multiple initiatives with the intention of de-risking investments in the domestic manufacturing of ACC batteries in India. A three-pronged approach is envisioned by the GoI with specific interventions under each prong to drive investments (see Exhibit 10). To ensure ease of business for battery manufacturers, a single window clearance approach and transparent shortlisting processes are some of the initiatives proposed under the PLI scheme.

Beyond the central and state incentives mentioned in earlier sections of this report, an array of demand creation initiatives has been formulated by the GoI to build investor confidence within the sector. The demand creation incentives are covered in further detail in the next chapter.

**Exhibit 10** Three-Pronged Approach to Interventions




The GoI has identified the need for imposing customs duties on the import of battery packs and cells to improve the cost competitiveness of domestically manufactured batteries against cheaper imports. A phased manufacturing programme has been proposed in which a graded duty structure can be imposed on lithium-ion cells, battery packs, and ancillary components used in the manufacturing of EVs (see Exhibit 11).[38]

The phased manufacturing programme will help minimise investment risks because a clear roadmap of duties on specific items enables manufacturers to plan their investment accordingly. The proposed phased manufacturing programme roadmap (through 2030) indicates that battery components (the anode, cathode, electrolyte, etc.), battery materials (cobalt, lithium, nickel, etc.), and machinery to set up plants for ACC manufacturing will also attract larger duties in the future. Deploying these duties could make India's cell manufacturing cost competitive as well and could result in a significant increase in domestic value addition.

## Exhibit 11 Proposed Basic Customs Duty Matrix (2021-30)

| | Goods | 2020–2022 | 2022–2023 | 2023–2025 | 2025–2027 | 2027–2031 | 2031 & beyond |
|---|---|---|---|---|---|---|---|
| 1a | ACC batteries or battery including EV batteries, except for 1b and 1c | 5% | 15% | | | | |
| 1b | Lithium-ion batteries of cellular mobile phones | 15% | | | | | |
| 1c | ACCs and batteries used to manufacture goods under chapter 8471 of the custom tariff heading | 0% | | | | | |
| 2 | ACCs (such as lithium-ion cells) for manufacture of battery packs | 5% | 10% | 10% | 10% | 10% | 10% |
| 3 | Parts such as anode, cathode, electrolytes, and separators required to manufacture ACCs | 2.5% | 2.5% | 5% | 10% | 10% | 10% |
| 4 | Goods (processed and unprocessed) required to manufacture parts of ACCs, such as graphite, cobalt, lithium, nickel, except for copper and any other product that is announced | 2.5% | | | | | |
| 5 | Plant and machinery required to set up a plant for manufacturing ACCs | 0% | 0% | 0% | 5% | | 7.5% |

### PLI Scheme Incentive Recipients

The PLI scheme launched in 2021 secured bids from 10 companies totalling 128 GWh of capacity, which was 2.6 times more than the goal. Among the bids received, 3 selected bidders signed the program agreement under the PLI scheme in July 2022 as shown in Exhibit 12.

## Exhibit 12 Annouced PLI scheme awardees who have signed the program agreement

| Company | Awarded Capacity | Plans |
|---|---|---|
| Reliance New Energy Solar | 5 GWh | Subsidiary of Reliance Industries Ltd, planning to invest INR75,000 crore to build 100 GW of renewable capacity.[39] |
| Ola Electric | 20 GWh | Softbank Group–backed electric two-wheel vehicle manufacturer, planning cell factory with up to 50 GWh of capacity.[40] |
| Rajesh Exports | 5 GWh | Planned capacity target is 16 GWh, with an investment of INR8,000 crore in the immediate future.[41] |

Source: Saur Energy International

## Risks Across the Value Chain

Beyond the concerns regarding availability of raw materials, which is a major impediment, other risks include technology transfer, know-how of advanced cell chemistries, development of alternatives, and on-going R&D in material science. Lack of technical expertise and knowledge pertaining to the sector, especially when it comes to hiring skilled labour for plant operations and maintenance, will be a key operational risk.

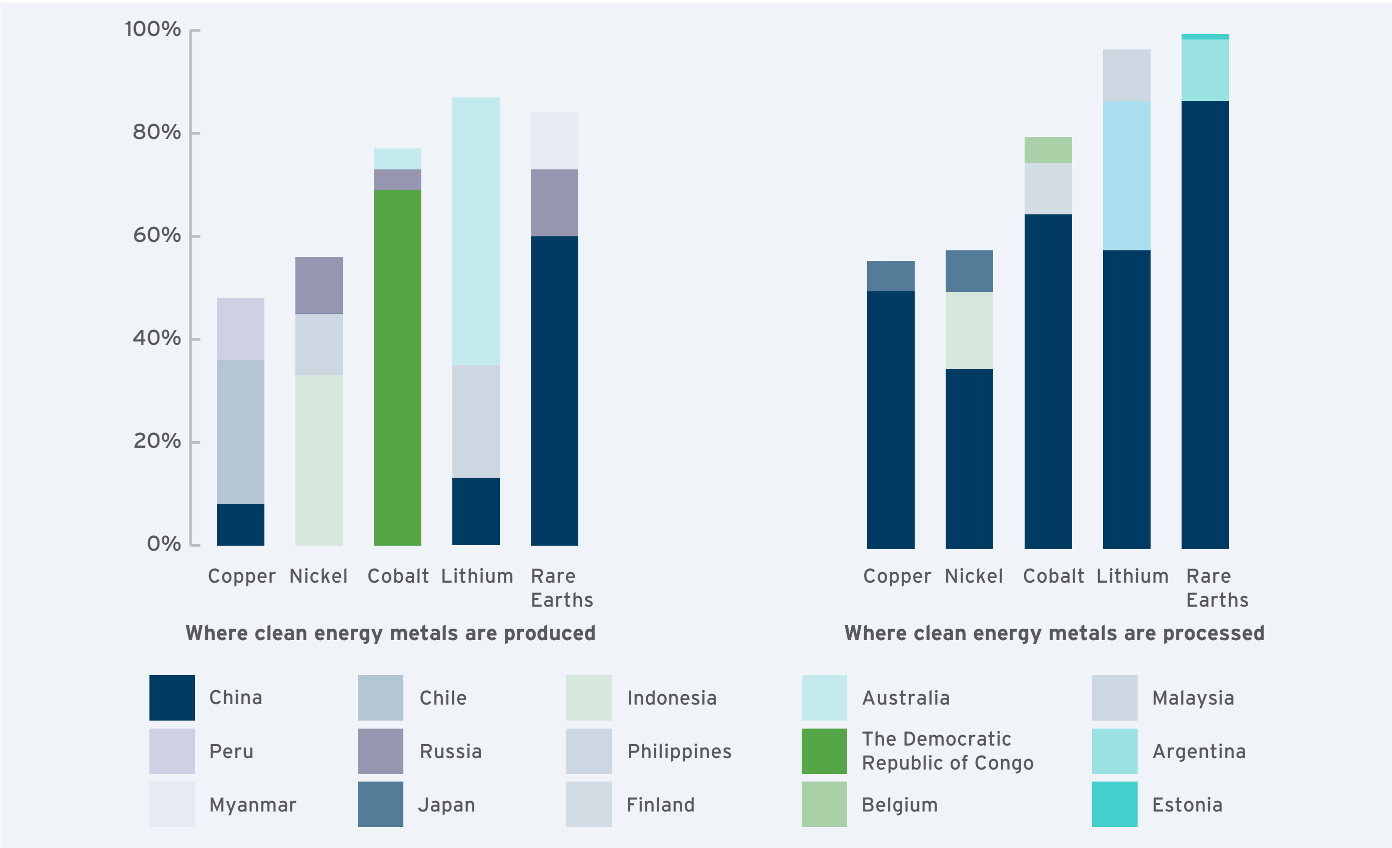
From an investment standpoint, given that the industry is extremely new, financial institutions are likely to impose a risk premium on these investments. Moreover, battery manufacturing in India represents a paradigm shift in technology, and availability of low-cost financing may become a barrier for smaller domestic players. Also pivotal are other grassroots-level issues, such as availability of land, proximity to ports for easy logistics movement, gas availability in the vicinity, overall connectivity, and regional-level approvals and clearances.

It is imperative to understand these risks and devise an optimal strategy to mitigate them beforehand to develop an enabling ecosystem for battery manufacturing. This section provides an overview of potential hurdles that may require further deliberation and requisite action.

### Raw Material Supply Risks

Raw material sourcing presents a significant barrier to capturing a large portion of the battery manufacturing value chain. India has extremely low reserves of in-house ingredients such as lithium and cobalt, which form key components in current advanced battery chemistries for manufacturing cathodes and electrolytes. Additionally, the country has limited reserves of battery-grade graphite (anode material) and relies on the Chinese market for imports.[43] India will require new infrastructure in the form of advanced metal processing and refining machinery that is essential for processing raw materials to the correct concentration.

**Exhibit 13** **Distribution of Global Metals Production and Processing**




Source: VC Elements

China's head start in the overall supply chain (see Exhibit 13) and its local tie-up/collaborations with lithium-producing countries have further increased its control over raw material sourcing and may present additional challenges for India.

### Policy, Regulatory, and Taxation Risks

From a long-term investment perspective, clarity on policy is very important. The discontinuation of policies on tax holidays and reduction of accelerated depreciation benefits from 80% to 40% may have an impact on the growth of the clean energy sector. At the regional level, even with the state EV policies in place, many do not have dedicated instruments to support indigenous battery manufacturing. Additionally, regional-level policies can provide incentives such as capital subsidies, electricity duty exemption, State Goods and Services Tax (SGST) reimbursement, R&D subsidies, power subsidies, etc.

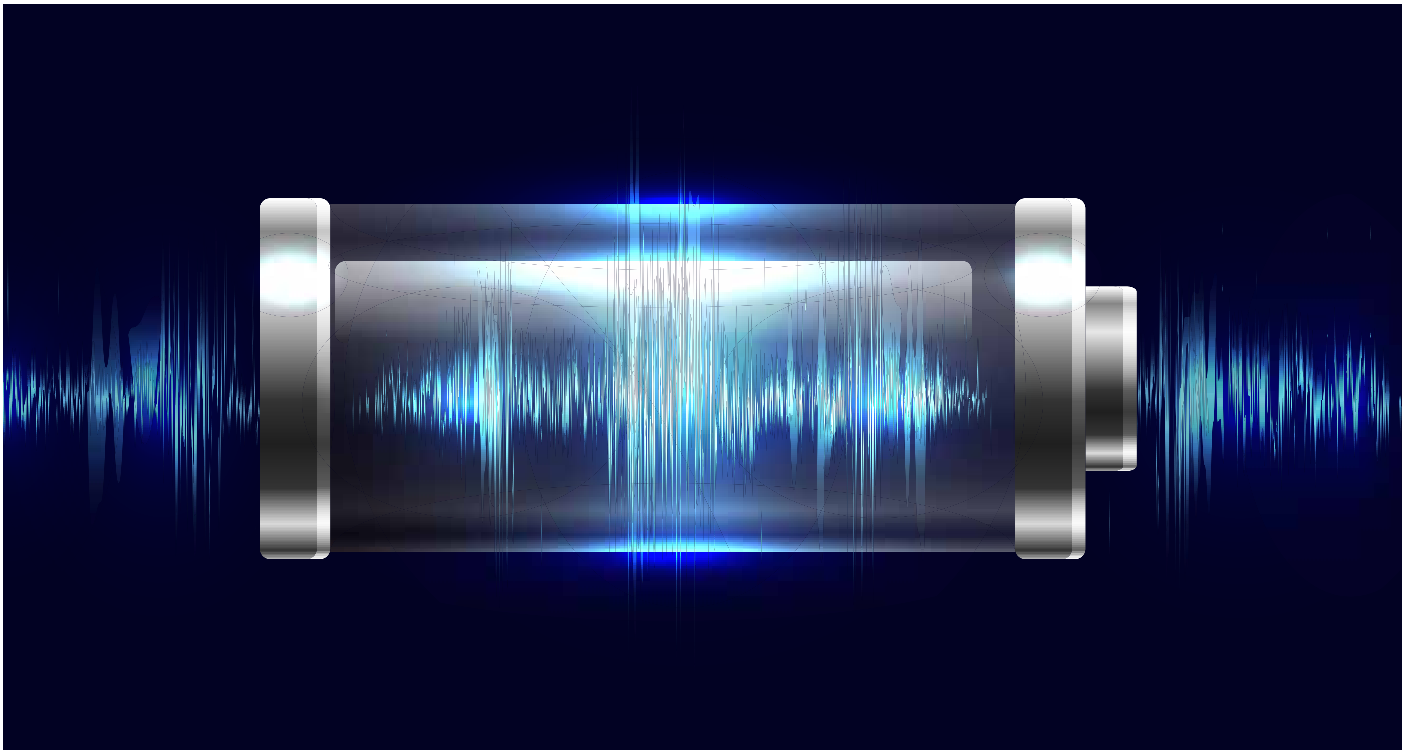
As in other countries, assured offtake is a potential concern for India that can have large financial implications for manufacturers. Manufacturing is being encouraged in anticipation of a large demand for storage, EVs, and consumer electronics. Hence, policy clarity plays a crucial role in augmenting investor confidence.

### Technology and Material Science Risks

The battery market is evolving as battery chemistries see continued advancements in material science. Globally, variants of lithium-ion NMC batteries, such as NMC-622 and NMC-811, are being developed to reduce the proportion of cobalt required. R&D exists to explore potential savings from using silicon for anodes instead of graphite. Identifying the kind of battery technology that is ideally suited for the Indian market and establishing the entire supply chain in the country are key investment decisions. Further, the lack of appropriate technology transfer and exchange of information due to technology patents is also a key concern, limiting technical expertise gained at local levels.

### Financing and Market Risks

For large investors, financing may not seem to be a big hurdle, but for smaller players, availability of low-cost financing can be an issue. Banks and financial institutions may be reluctant to provide loans for a new technology because of lack of technical expertise, standard evaluation templates, and standardised financial models. Moreover, from a financial perspective, there will be uncertainty or security-related concerns when it comes to resale value (should the asset or technology become obsolete). The lack of assured offtake (market-driven) or a guaranteed market once the battery production is in place further aggravates the issue of financing. To compensate for this, banks may charge a higher interest rate for a comparatively newer technology to minimise their risk. Lastly, financial institutions will not be aware of the actual pricing dynamics of batteries (up-front cost in the Indian market) and how to measure the output of production.



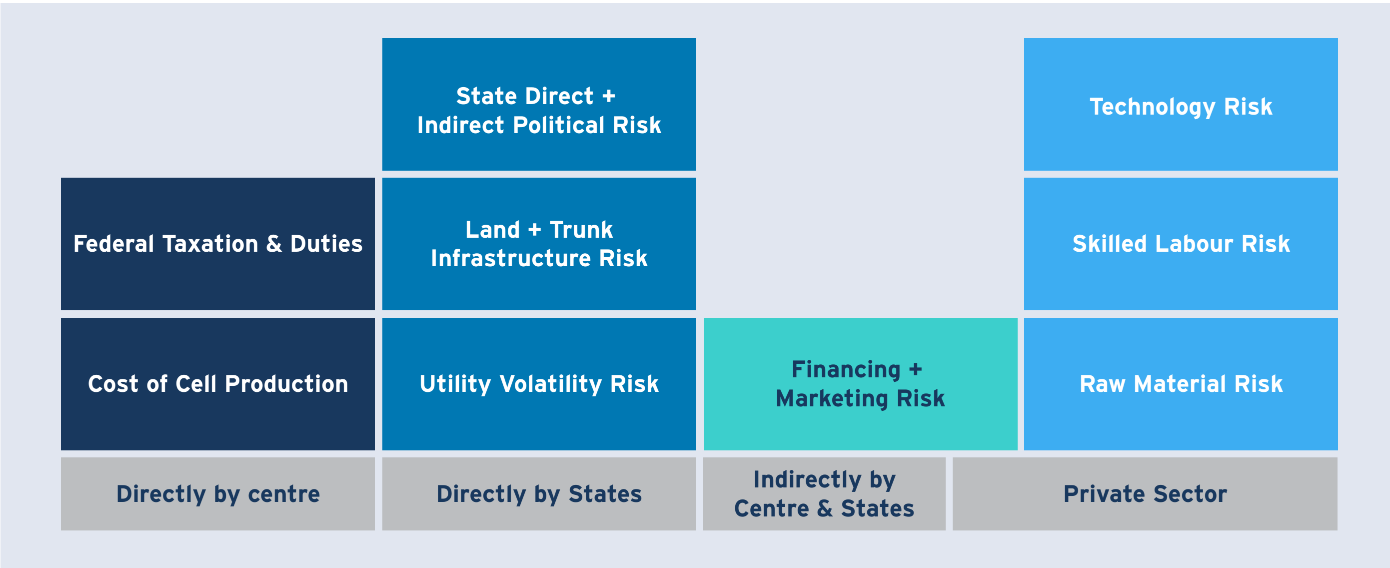
# Keys to Success

# Keys for Success

## Stakeholder Roles

Developing India's battery manufacturing industry requires a phased approach that integrates a larger fraction of the value chain over time, as local demand grows and local technical expertise and capacity evolve to meet demand. This will require a coordinated and strategic approach to attract supply and stimulate demand. Doing so will increase investor and manufacturer confidence in the marketplace and overcome the risks outlined in the preceding chapter. The programme has been designed to ensure that exposure to major risk areas across the value chain can be distributed across key stakeholder groups. The basic premise of expected allocation of risk to centre, state, and private-sector players is shown in Exhibit 14.

**Exhibit 14** Risk Allocation Across Stakeholders




## Policy, Regulation, and Taxation

Policy instruments must be specifically designed to stimulate battery manufacturing at the central and regional levels. State EV and storage policies should consider including direct benefits in the form of capital subsidies, interest subsidies, electricity duty exemptions, and other benefits for domestic advanced battery production employed in EV applications.

Demand creation will require not just horizontal collaboration among the various ministries of the central government, but also policy alignment between the centre and state government. It is essential to develop a number of demand creation avenues through favourable policy and regulatory mechanisms. At both central and state levels, the policy instruments (upcoming EV and storage policies) must be designed to support both the buyer's side and the lithium-ion manufacturing landscape. Government committees and other organisations must coordinate strategy across ministries, state governments, and municipal corporations through national policies and regulations. These groups must establish common rules for generation, transmission, distribution, and storage to create a fair and competitive electricity market without favouring any stakeholder group or specific technology.

## Technology and Material Science

Because of the relative newness of battery manufacturing technology, India lacks some of the technical tools and knowledge related to advanced battery chemistries, including practical exposure to operation within plants. Hence, it is essential for the government to support technical capacity-building activities at the local level. Local Indian players must look to form joint ventures with international players to get access to patented technology to gain technical expertise. Local joint ventures should be promoted for research on advanced chemistries catering to the Indian environment, including undertaking pilot projects. The formation of a central technical committee that consists of battery technology experts who conduct research and analytics on advanced battery chemistries is recommended. The same committee can also take up the task of capacity building at central- and state-level departments, such as the System of National Accounts, electricity distribution companies, etc.

As with any new technology, there are numerous risks associated with setting up battery manufacturing plants in India. Establishing the entire value chain in India presents a challenge, given rapidly evolving battery chemistries and the learning curve and investment risks linked with new technology and manufacturing processes. Learning how to handle these risks will be critical to scaling up and achieving India's battery manufacturing ambitions.

## Unlocking Public–Private Partnership

Successful PPPs will be fundamental for maximising the promises of the PLI scheme and securing the long-term growth and competitiveness of the domestic battery manufacturing industry in India. As stated previously, PPPs offer a way to optimally manage risk between government and private actors, such as the battery manufacturers. States should be encouraged to provide incentives to investors for the establishment of local manufacturing facilities.

State governments can provide support under various categories, including infrastructure support and a subsidised utility such as electricity. Additionally, state governments can provide financial incentives in addition to those proposed by the central government under a phased manufacturing programme.

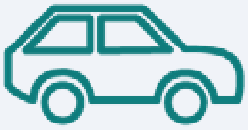
Beyond national-level policies, states will be critical in instituting and operationalizing many of the demand creation measures. Some states are targeting demand creation through EV sales by establishing deployment goals and incentives. Twenty-two states have published, are in the process of finalising, or have begun designing EV policies (draft stage).[44] Operationalizing these policies will require coordination and cooperation among various stakeholders (such as forming a dedicated EV cell), including Metro and mass transit operators, state transport units, electricity distribution companies, regional transport offices, city municipalities and urban planning bodies, and traffic police.

States in India are focusing on EV deployment goals and incentives, including e-buses (4 million–plus population cities) and charging infrastructure. However, states can pursue a more robust plan of incentives for EV manufacturing. Potential incentives include a capital subsidy of land, plants and equipment, discounted electricity and water tariffs, reimbursement of the SGST, and interest subsidy and stamp duty exemption. Five states have demonstrated interest in catering to increased EV manufacturing, including Tamil Nadu, which has proposed $2.5 billion in investments. Other states can also realign their tax structures.

## Encouraging Demand Creation

Creating market demand is a vital component of attracting investments needed to kick-start ACC battery manufacturing. To stimulate growth in domestic ACC manufacturing and encourage the development of domestic manufacturing capacities, the GoI has deployed several central-level initiatives that encourage demand creation in sectors like electric vehicles and grid-level storage. A few key initiatives and recommendations are highlighted in Exhibit 15.

## Exhibit 15 Key Demand Creation Initiatives and Recommendations

| | |
|---|---|
| **Electric Vehicles**<br> | a. Replacement of internal combustion engine (ICE) vehicles with EVs in all central government ministries, agencies, and public-sector enterprises, including Indian Railways<br>b. Replacement of all ICE vehicles of cab-aggregators in India in a phased manner<br>c. Framework for complete revamp of current installations of battery storage in locomotives and other static applications across Indian Railways with ACCs and batteries<br>d. Implementation of e-highways for heavy commercial vehicles on a few select highway corridors on pilot basis<br>e. Electric buses and vehicles to be included in the portfolio of all state road transport undertakings<br>f. Proportion of electric commercial trucks on Indian roads to be increased<br>g. All town planning laws/schemes and model documents to provide for provision of charging infrastructure in all commercial buildings, shopping malls, and multi-storeyed residential apartments, etc., as well as fuel stations |
| **Grid-Level Storage**<br> | a. Demand aggregation and integration for solar pumps, along with battery storage under the KUSUM scheme; suitable incentives for integrated solar rooftop and ACC battery storage<br>b. Replacement of diesel generators to minimise diesel consumption used for power backup, especially on islands and in remote/hilly regions, military outposts (border areas), etc.<br>c. Formulation of policy and regulations for ancillary services to the grid (e.g., fast response frequency regulation or system services to improve balancing, etc.) and for applications in distribution systems like peak shaving, load following, etc.<br>d. Firm bid trajectory and phasing of tenders until 2030 for renewable energy capacity addition, along with adequate provision for battery storage<br>e. Soft loans and/or other forms of concessional finance to state electricity distribution and transmission companies to deploy battery storage solutions<br>f. Inclusion of storage batteries for unlocking potential of spinning reserves |

As outlined earlier, it is critical that direct incentives for manufacturing be provided simultaneously with demand-stimulating measures.

## Securing Finance

The global battery storage sector has witnessed phenomenal growth over the past few years. The sector has seen corporate funding (including venture capital funds, public markets, and debt financing) increase from close to $2.8 billion in 2019 to over $17 billion in 2021. The funding raised in 2021 was the highest since 2014, and the deal count nearly tripled compared with 2020 (see Exhibit 16). As the number of projects grows, particularly for increased capacity in the battery manufacturing supply chain, industry will need access to high levels of capital to meet demand.

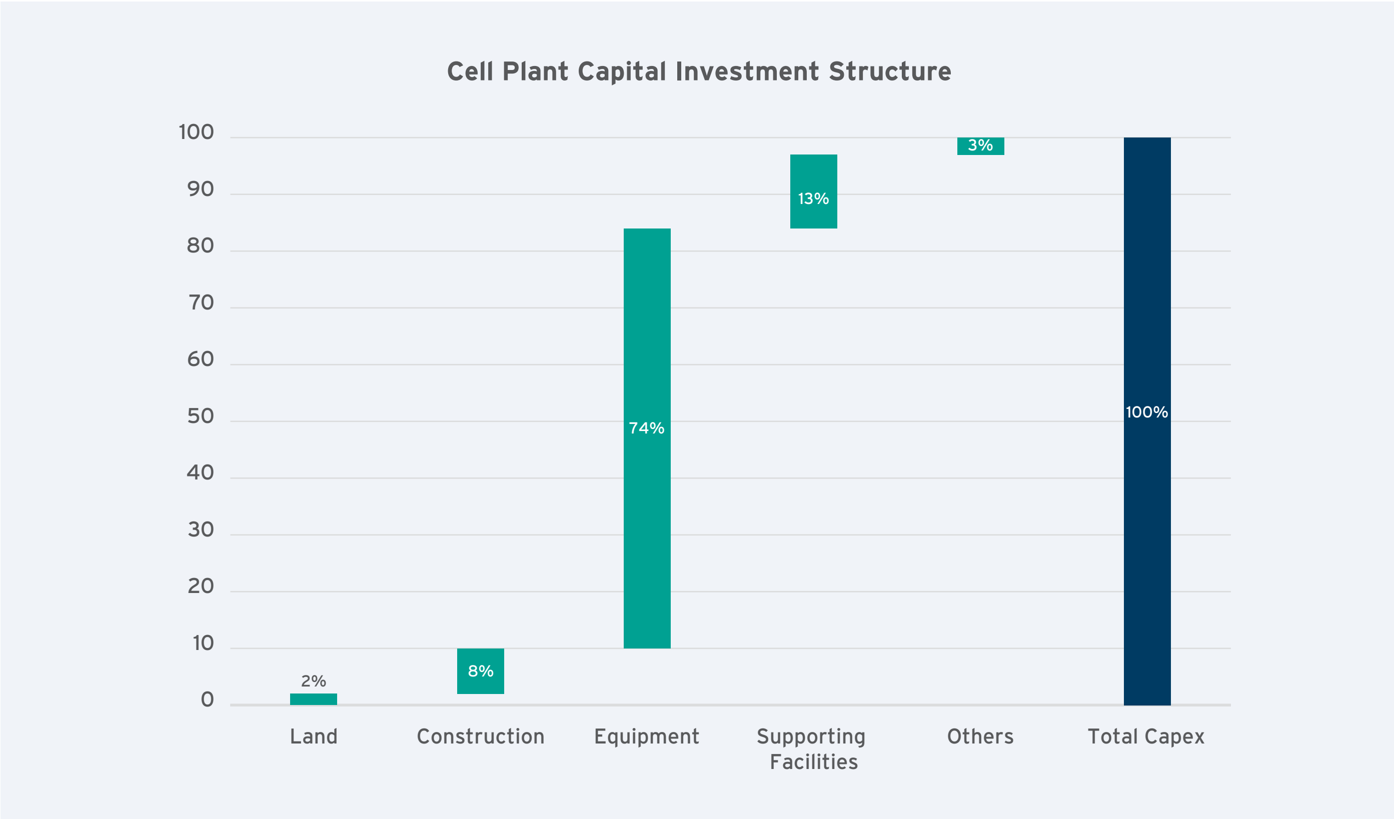
**Exhibit 16** **Battery Storage Corporate Funding, 2019-21**


Source: Mercom Capital Group, Mercom Clean Energy Insights

Countries with major battery manufacturing hubs have leveraged various financing instruments to kick-start their domestic production capabilities. As the geography for cell manufacturing diversifies, the financing mechanisms will as well. In Europe, the EIB has supported manufacturers with loans, along with a mixture of private equity financing.[45] The United States has been a hotbed for disruptive startups, with a strong ecosystem of venture-based financing and capital players. China has also tapped into private equity investment coupled with government support via subsidies to build out its domestic battery ecosystem. These financing strategies are necessary to address the high up-front costs associated with building a battery cell manufacturing plant.

Capital expenses, the up-front funding needed to open a plant, constitute a barrier for market entrants. Larger facilities, with more than 8 GWh/y in capacity, have been shown to be twice as productive per euro invested as smaller projects.[46] However, building a cell manufacturing plant of that scale demands high up-front funding. Recent projects with more than 8 GWh/y have invested, on average, about $120 million per GWh/y in capacity.[47] About 74% of this funding is for necessary equipment (see Exhibit 17).

## Exhibit 17 Cell Plant Capital Investment Structure




***Note:*** *This represents the projected capital expenses for an NMC-532 cell plant.*

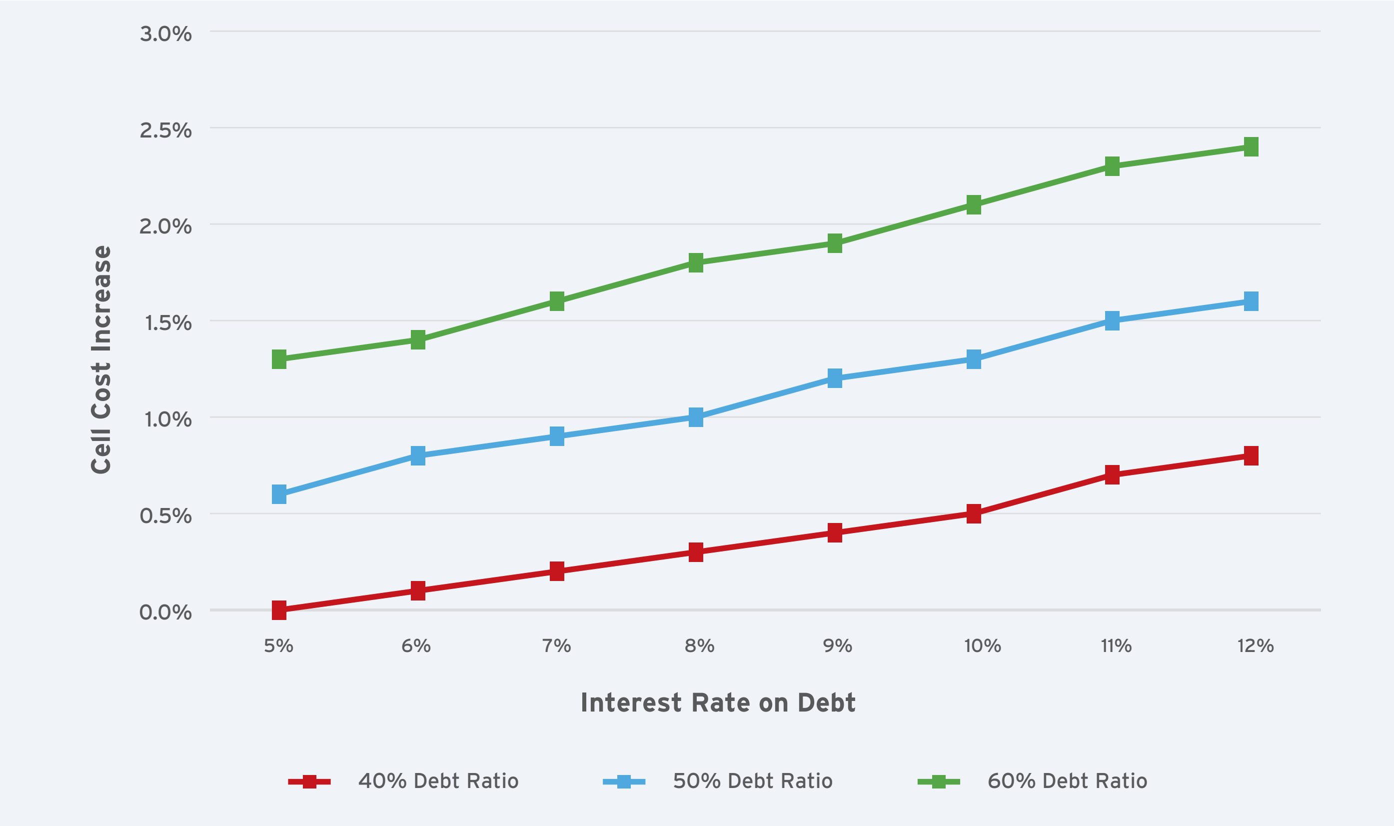
Source: BloombergNEF's Bottom-Up Battery Cost Model

To meet the PLI scheme's target of 50 GWh of annual cell production capacity, about $6 billion of capital will be required. Further investment in R&D and the value chain, such as in electrolytes, electrodes, or on-site recycling, would add more capital expenses.[48]

As the global pipeline for battery cell manufacturing plants matures, perception of risk for debt financers should decrease, which can unlock potential for new project funding opportunities. Though financing activity in India has improved in the past few years, it remains limited compared with deep capital markets such as the United States and Western Europe because of higher risk perception.[49] Debt financing can allow equity partners in a project to hedge some risk, while potentially improving relative gains over the lifetime of the project. However, the size of debt relative to the capital expense can have a major influence on how competitive the product's pricing can be.

Renewable energy or energy storage projects will often sign a power purchase agreement with a designated offtaker to ensure consistent revenues — a contract to provide a threshold amount of the service at a fixed cost. Similarly, battery cell manufacturers will contract with EV manufacturers to act as designated offtakers. Access to lower interest rates for debt financing can improve the competitiveness of India's cell manufacturing to make the domestic industry more attractive to offtakers. In addition, the ratio of debt financing to the capital expense of the manufacturing plant may also have an impact on cell pricing (see Exhibit 18).

## Exhibit 18 Access to Low-Interest Debt Can Affect Competitive Cell Prices




***Note:*** *Model is based on an example project with a 10-year loan, a straight-line agreement, and fixed per kWh manufacturing, materials, and labour costs, as well as a set debt service coverage ratio. See Appendix for methodology.*

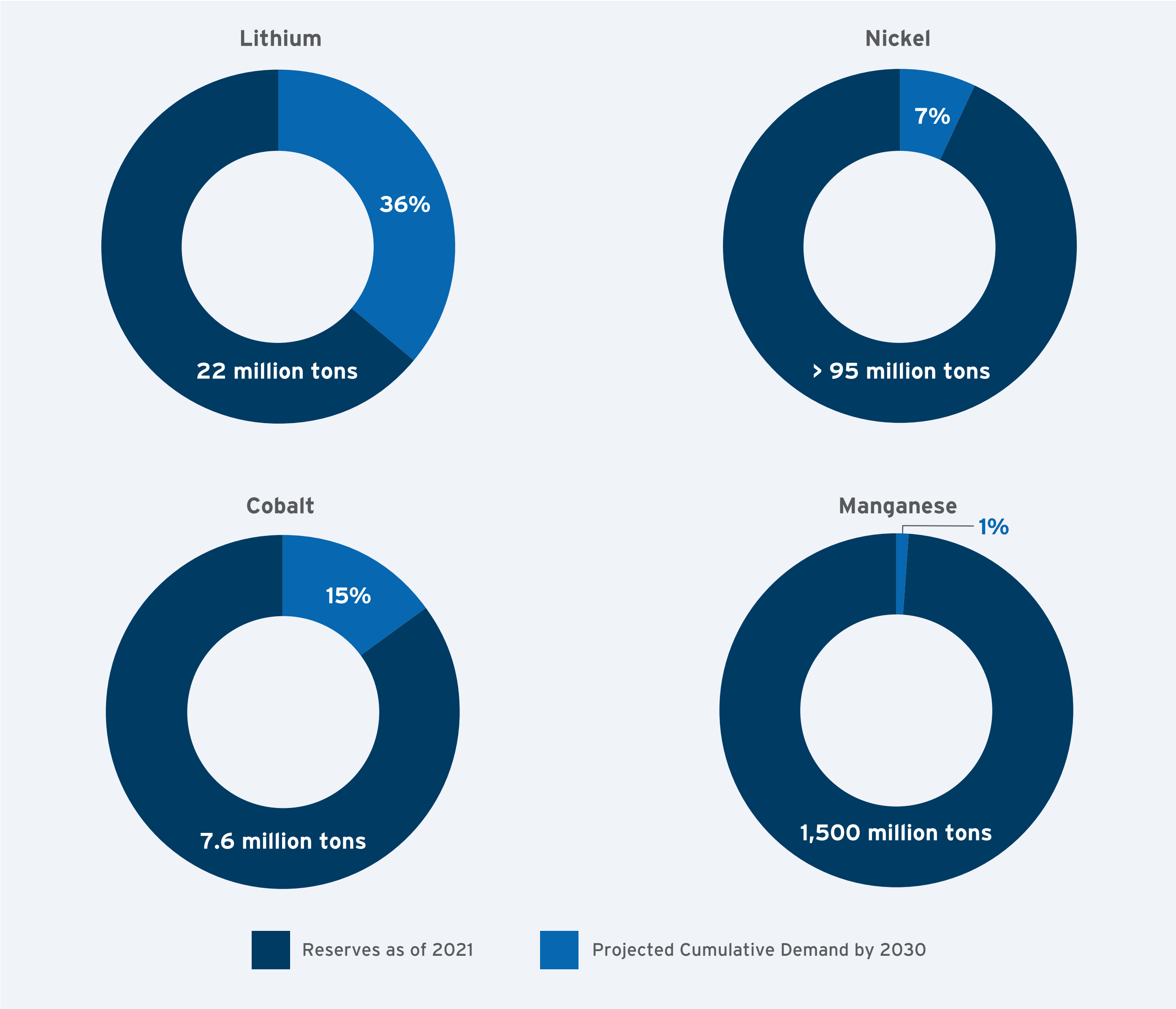
Project debt can be structured in multiple ways, which will affect financing for a project. These include structures where payment to principal or payment to principal and interest are constant through the life of the loan. The nature of debt structure, loan term, and debt ratio will be highly variable depending on the details of the project and the evaluated risk by the lender. Lower interest rates can also ensure that debt financing is well sculpted to the scope of the project and that the lifetime cost of debt does not exceed a project's capital expenses. The cost competitiveness of domestic battery manufacturing in India will hinge significantly on the availability of low-cost capital.

The inclusion of energy storage systems in the harmonised list of infrastructure in the National Budget 2022 is a welcome step, which could accelerate the adoption of storage technologies by improving commercial viability. The move could catalyse deployment of battery systems for grid-scale services by allowing cell manufacturers to access infrastructure credit from banks and low-cost capital from potential domestic and global investors.

### Securing Raw Material Supply

Although India has limited reserves of some of the most important lithium-ion components, global supplies of minerals for current battery chemistries are not considered to be resource-constrained. A 2017 study led by researchers at MIT, the University of California – Berkeley, and Lawrence Berkeley National Laboratory concluded that supplies of most of the key constituent elements of the current generation of lithium-ion batteries, including manganese, nickel, and natural graphite, are sufficient to meet the anticipated increase in demand worldwide (see Exhibit 19). With respect to lithium, most studies indicate that supply can outpace demand based on significant reserves and a diversity of extraction technologies. Meeting all expected global battery needs through 2030 would require just 2% of the currently recoverable lithium reserves.[50] Cobalt may pose the most significant materials risk in the short term for lithium-ion battery production, given its geographic concentration in a few areas and the associated geopolitical risks. India could develop external supply chains in both the near and long terms, as well as invest in battery recycling, to ensure that its access to these critical raw materials remains strong.

## Exhibit 19 Comparison of Key Battery Metals Demand and Reserves




***Note:*** *Demand shown as share of current reserves as per US Geological Survey.*

Source: US Geological Survey

To mitigate the raw material risk, manufacturers should consider developing alternative battery chemistries using less resource-constrained materials. Many manufacturers are exploring low and no-cobalt battery architectures that will help reduce costs and address supply chain constraints associated with limited cobalt reserves. For acquiring the necessary raw material (particularly lithium) needed to kick-start battery manufacturing from the initial stage of procurement, India should consider signing MoUs with countries such as Australia, Chile, and the Democratic Republic of the Congo for a stable, uninterrupted supply of processed raw material, particularly for nickel and cobalt. India has already signed one such MoU with Bolivia,[51] which is aimed at facilitating supplies of lithium carbonate to India and exploring joint ventures in lithium battery/cell manufacturing plants.

Battery recycling almost becomes indispensable when there is lack of in-house availability of dedicated raw material. R&D related to recovery of precious metals such as lithium and cobalt can assist in bringing down the cost of batteries. Additionally, ensuring lesser waste of raw material will help in reducing dependence on imports. Drafting regulations and standards pertaining to battery recycling will be necessary to cement growth of this sector.

## Box 2: Self-Reliance for Battery Metals — KABIL

Khanij Bidesh India Ltd (KABIL), a joint venture of three major public-sector mining enterprises, is an initiative by the GoI to identify, evaluate, and acquire assets of critical minerals abroad. The initiative was created in 2019 to drive momentum in the e-mobility and renewable energy sectors by mitigating raw material–supply concerns to a certain degree. KABIL has shortlisted source countries such as Argentina, Australia, Bolivia, and Chile for asset acquisition and has signed several MoUs to direct joint investments in exploration and development of mineral resources. Recently, it signed an MoU with Australia to jointly identify lithium and cobalt deposits with an initial investment of $6 million.[52] Similarly, an initial agreement was signed with Argentina to explore and secure a long-term supply of battery-grade lithium.[53] Gujarat also signed an MoU to set up India's first lithium refinery in the state, which will use lithium ore secured from overseas assets to produce cathode material.[54]

## Reuse and Recycling of Batteries to Mitigate Raw Material Risk

To ensure the success of the PLI scheme, the efficient use of earmarked funds, and the establishment of India as a global leader in the LiB market, concerted efforts must be made to embrace circular economy principles within the LiB space. Under a circular economy model, disposal should be avoided to the extent possible, with hazardous materials kept on a reuse/recycle mode. Globally, moving from a linear to circular economic model for LiBs "could result in a reduction of 34 Mt in GHG emissions while creating an additional economic value of approximately $35 billion."[55]

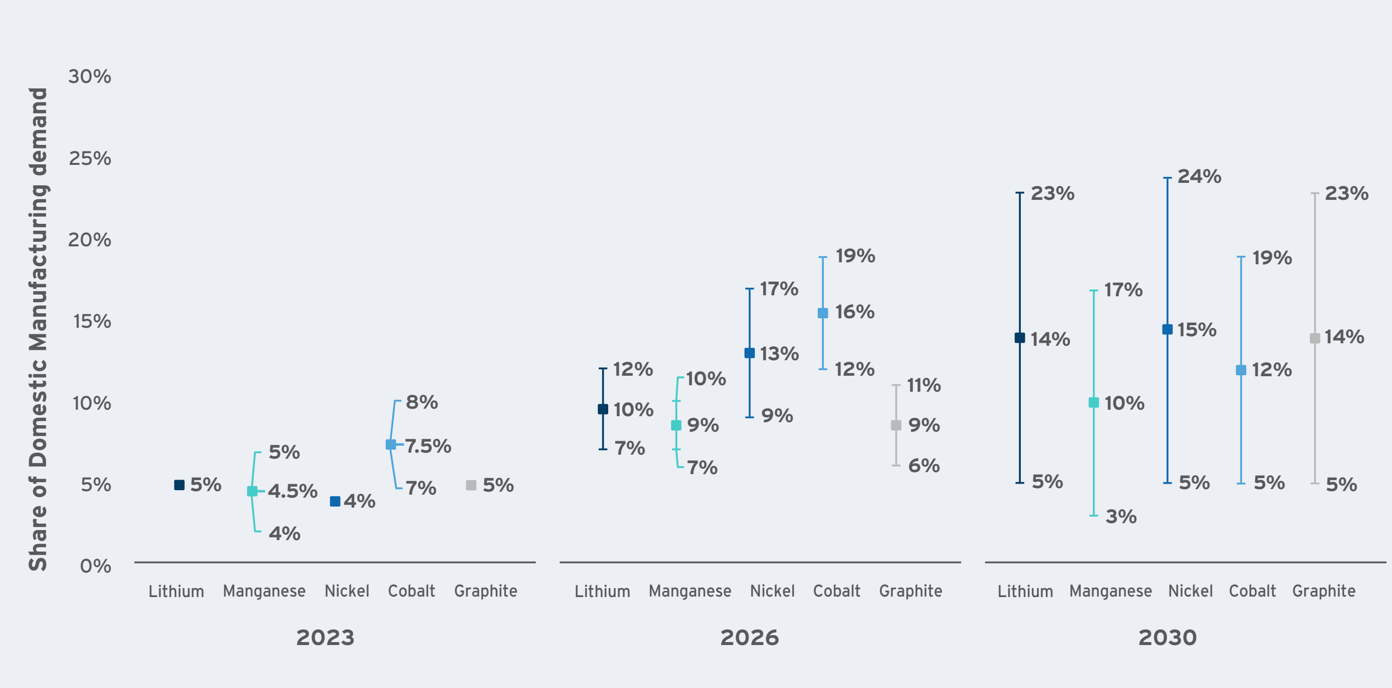
For LiBs, which heavily depend on scarce resources, the circular economic model not only reduces the life cycle–assessment impacts of mineral extraction, refinement, and manufacturing, but may also alleviate price and supply risks. India lacks domestic resources for many minerals key for LiB manufacturing, including lithium, nickel, and cobalt. Embracing a circular economic model complements the PLI scheme by increasing control of the LiB supply chain and reducing reliance on importations to meet domestic demand growth. Adoption of a circular economic framework relies on clear policy that incentivises reuse and recycling, as well as innovations and redesigns that reduce upstream material demand.

### Recycling

In India, inadequate policy measures present a major hurdle for LiB recycling. In February 2020, the Ministry of Environment, Forest, and Climate Change introduced the draft "Battery Waste Management Rules, 2020" for proper management of battery waste. As introduced, the draft rules establish an Extended Producer Responsibility programme covering battery stakeholders, mandating collection of 30% of end-of-life batteries (by the kilogram), effective two years after implementation. The policy target graduates to 70% of end-of-life batteries by the seventh year.[56] Current domestic LiB capacity lags behind many global markets. Stakeholders expressed that operating capacity is capable of processing 1% of annual end-of-life LiBs, and despite planned growth, capacity will be sufficient for only about 9% of the waste stream by the end of 2022.[57]

The recovery process for LiB materials can be highly efficient. Innovative processes in China and North America have demonstrated material recovery rates that exceed 90% of key materials such as lithium, cobalt, and nickel.[58] Recyclers in India have stated that innovative recycling technologies can recover about 98% of materials from LiBs. This technology is chemistry agnostic, able to process and recover materials from all prominent LiB types.

## Exhibit 20 Potential Minerals Recovered as a Range of Percentage of Domestic Manufacturing Mineral Demand[59]




***Note:*** *Range represents Conservative and Accelerated Scenarios for EV market penetration and BESS demand*

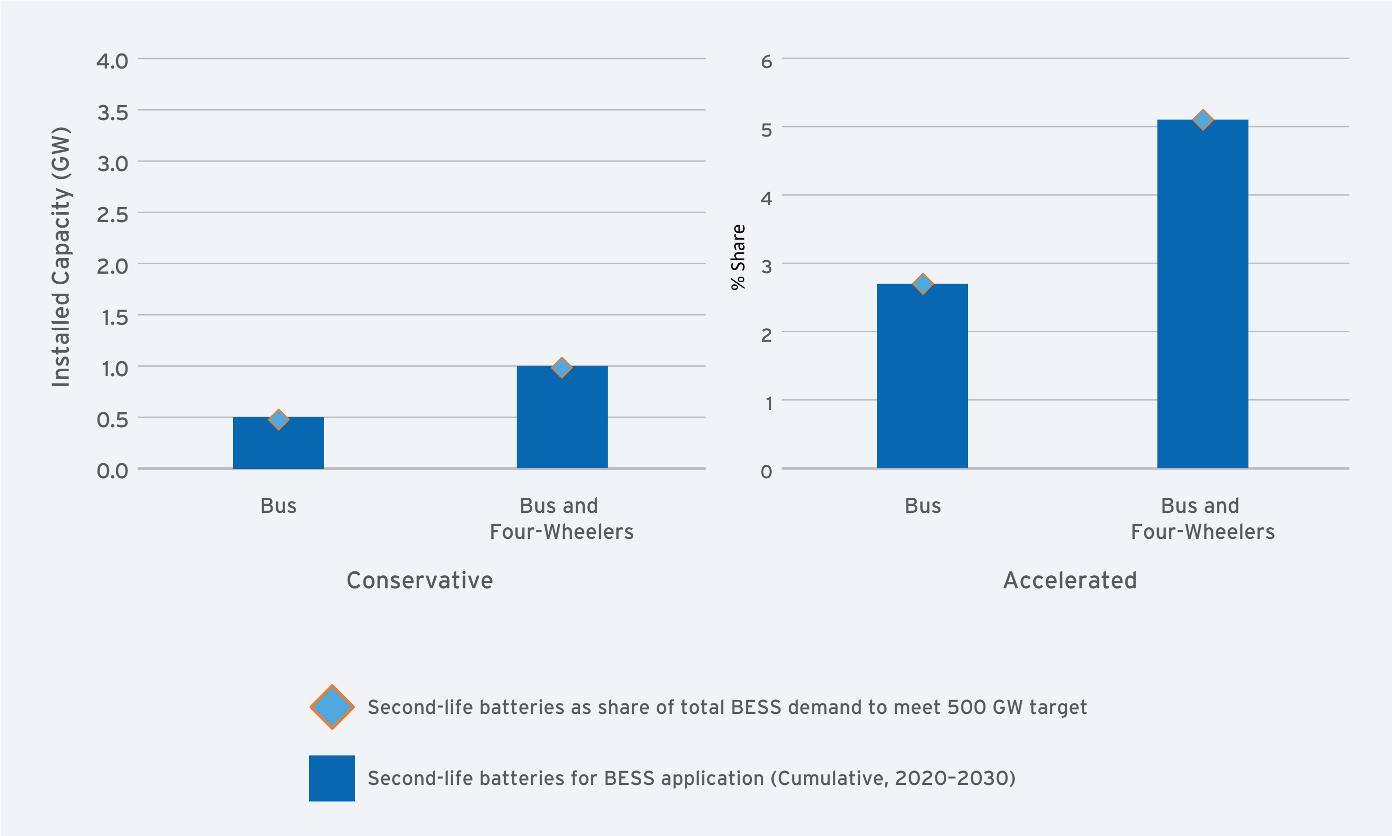
Currently, recyclers in India take on the burden of battery procurement. End-of-life batteries can be sourced from three classifications of users: formal sector (manufacturing facilities), service centres, and the informal sector (consumers, and small and medium-sized enterprises). In the absence of a formal collection and transportation plan, the burden, particularly for procurement from the informal sector, falls to recyclers. This is reflected in the costs of recycling, where procurement is the greatest expense. Adoption of an Extended Producer Responsibility programme could address this issue by formalising collection and transportation agreements and establishing a methodology for the formal sector to incentivise the informal sector to collect or dispose of end-of-life LiBs in an appropriate manner. Stakeholders anticipate that, without a proper incentive, EV end-of-life LiBs will largely be supplied by the informal sector, creating a hurdle for effective collection and limiting potential reductions in a recycler's procurement costs.

### Reuse

EV LiBs typically reach end-of-useable life at 70%–80% of their original capacity. Although collection and recycling will recover the value of the minerals in the LiBs, the value of the residual capacity can be captured through second-life applications. The benefits are multiple: avoided use of new batteries results in cascading savings across the supply chain, including emissions associated with mineral extraction, refining, transportation, and manufacturing. Potential stationary storage applications for second-life use of EV batteries include front-of-meter uses, such as providing ancillary services, energy shifting, and reducing transmission congestion.

In India, reuse of LiBs sourced from four-wheel passenger and commercial vehicles and e-buses would provide between 1.2 and 5.9 GWh of storage capacity by 2030. These second-life applications could alleviate 8%–12% of battery energy storage systems needs in 2023, and nearly 4% by 2030 in an accelerated deployment case. In terms of total installed capacity by 2030, this could mean 0.5–3.4 GW (2.1–13.2 GWh), accounting for 1%–5% of total needs by 2030.[60]

## Exhibit 21 Second-Life LiB Potential as Share of Total Battery Demand Required to Meet India's 500 GW Non-fossil Fuel Installed Capacity Target




***Note:*** *Conservative and Accelerated Scenarios reflect EV market penetration and BESS demand*

LiB consumers have expressed concerns about using recovered battery packs for secondary-life purposes. Key hurdles for adoption of recovered LiBs for secondary uses include the lack of a transparent system for assessing battery health and a lack of a warranty ensuring performance standards. Devising a methodology for certifying LiB refurbishers, as well as metrics for assessing and guaranteeing performance standards, would improve the market for second-life LiBs.

### Sourcing Green Electricity for Battery Manufacturing

Battery manufacturing is an energy-intensive industry that requires electricity and steam inputs at various process stages to convert electrode active material into useable, energy-dense cells. Electricity costs constitute nearly 2.5% of the total cell-level cost,[61] which can add up to significant operation expenses at the giga-scale manufacturing level. This is a potential opportunity to further optimise the power procurement for a facility's energy demand, thus contributing even more to lowering the overall cost of a cell. Major cell makers such as CATL and Tesla already have targets for sourcing 100% of electricity required through renewable energy sources, highlighting a global push towards a sustainable battery manufacturing sector.

As India looks to catalyse domestic manufacturing of ACCs, a key consideration for cell makers and developers will be sourcing electricity for various processes such as electrode production (mixing, coating, drying, etc.), cell assembly, and finishing, and for general facility use. Co-locating battery plants with renewable energy sources such as solar, wind, regional hydro plants, etc., can ensure a low-cost power supply and drive down manufacturing-related $CO_2$ emissions. This strategy also aligns itself with India's broader goals on emissions reductions as announced at COP26.

Strategies to reduce energy and emissions intensity of cell manufacturing include:

1. **Optimising manufacturing processes**
   Cell manufacturing consists of a series of processes that may be broadly classified as electrode production, cell assembly, and cell finishing. Electrode production uses active materials, additives, binders, etc., to prepare and mix slurry that is coated on current collectors and dried; this is followed by calendaring and slitting/stamping to produce electrodes with required conductivity and shape to fit cells. Electrodes are then sent for final drying to produce cells.

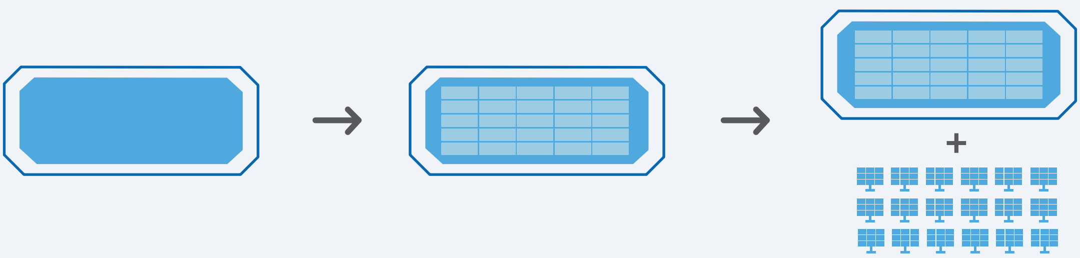
   The entire manufacturing process consumes between 45 and 65 kWh of electricity per kWh of output cell storage.[62] However, two subprocesses – drying and solvent recovery – plus final drying use almost 75% of the total electricity demand.[63] There is considerable value in making these processes more energy efficient which could lower the electricity demand at the facility level, possibly reducing the manufacturing floor area requirement and reducing emissions.

   For example, Tesla has announced plans and R&D to replace the conventional wet slurry mixing with dry electrode manufacturing that could speed up the production rate by four times and reduce battery pack costs by up to 12%.[64] Digitalisation and automation of these processes will be crucial to improving material use and energy efficiency of cell production.

2. **Low-cost, clean energy input**
   Electricity procurement for the above-mentioned processes from low-cost renewable energy sources, particularly by co-locating facilities with utility-scale solar projects or regional hydroelectric plants, and installing rooftop solar, can unlock major savings for a manufacturing facility. A manufacturing base of 50 GWh annual cell production could require anywhere from 2.25–3.25 TWh electricity demand, which if sourced through clean energy sources could mitigate impacts to local grids, ensure supply reliability, and lower overall manufacturing costs for cells. Exhibit 22 illustrates savings on energy and emissions that can be realised by procuring power from rooftop solar and open access renewable energy plants.

## Exhibit 22 Sourcing Green Electricity for Gigafactories

| | 50 GWh battery manufacturing facility | Maximising rooftop solar potential - 24 MW | Rooftop solar potential & offsite open access - 1,500 MW |
|---|---|---|---|



| | | | |
|---|---|---|---|
| | **2.25-3.25 TWh** annual electricity demand | **Rooftop solar can meet up to 1.5% of annual electricity demand** | **Rooftop solar and open access can meet 100% of annual electricity demand** |
| $ | **$150-$350 million** annual cost of power purchase | **Achieve electricity savings of $3.4 million** | **Achieve electricity savings of $100-$140 million** |
| | Annual emissions of 1.63-2.33 Mt $CO_2e$ | **Achieve emission savings of 0.03 Mt $CO_2e$** | Annual emissions of remaining 1.6-2.3 Mt $CO_2e$ |

## BOX 3: Global Case Studies on Clean Battery Manufacturing

Global cell manufacturing experts such as Tesla, CATL, and Northvolt have announced significant additions to production capacities, expected to come online in the next five years. A clear trend in state-of-the-art facilities is a move to sustainable manufacturing, driven by a concerted focus on clean energy procurement, efficiency improvements due to process automation and R&D, electrified transport, and waste material recycling.

**The Tesla Gigafactory** in the state of Nevada in the United States, which produces powertrains for electric vehicles, as well as LiB cells for its EV models, has a clear target to source 100% of its electricity from renewable sources. The facility kicked off this ambitious target by announcing that it intends to install and use up to 24 MW capacity of rooftop solar on its full building area; the current installed capacity is much lower at about 3.2 MW.[65] There are similar plans for the company's other gigafactories, with a vision to eventually make all facilities carbon neutral.

**CATL's** cell manufacturing plant in Sichuan province, China, has already been announced as the world's first zero-carbon facility of its kind. This has been achieved with an integrated and automated plant-management system that allows gains in manufacturing process efficiency and least carbon-intensive operation at the equipment level. The facility sources nearly 80% of its annual energy requirement through hydropower, which is available nearby, thus reducing emissions by about 0.4 million tons.[66]

The above-mentioned facilities are examples from a growing list of battery manufacturing plants that are markedly transitioning to more sustainable operations, including clean energy use for processes. Northvolt's Ett Gigafactory in Sweden, for example, has also announced targets of 100% renewable-sourced power for facility operations by 2030.[67] These can serve as lighthouse facilities to guide similar trends in India as firms set up cell manufacturing plants because low-cost energy could also help improve the economics of such investments.

# Conclusion

# Conclusion

Battery manufacturing represents one of the largest economic opportunities in the 21st century. Countries and companies have positioned themselves for a chance to own a slice of one of the most lucrative markets of the new millennium; countries or companies that create and manufacture the dominant battery technologies will control some of the world's largest growth sectors — consumer electronics, EVs, advanced electricity grids, and more. Billions of dollars are pouring into battery research at this critical juncture, and India has the capability to step into an advantageous position. Given the country's strong track records in research, manufacturing, and entrepreneurship, India could rise to a dominant position in the global battery market.

But this will not happen in a vacuum. Ambitious goals, concerted strategies, government support, and a collaborative approach will be necessary. The time for major movement is now. In a year or two, the world market could already be cementing. Any delay in entering the marketplace is likely to mean ceding it to foreign manufacturers. Other countries are providing incentives to de-risk the sector and encourage the rapid growth of companies in the ACC space. National-level supports are necessary to entice companies to enter the space in India.

Significant growth as a battery manufacturing hub could help establish India as a centre for cutting-edge research and innovation, boost its manufacturing capabilities, create new jobs, and foster economic growth. The policies and incentives recommended in this report could pave the way for top-level battery manufacturers to invest in India and could guide manufacturers towards breakthrough chemistries and technologies. But this phased manufacturing programme is just the first step. India should invest in being at the forefront of advanced development. The growth in the battery market brings many opportunities and risks. As that market expands, it will change the state of the world energy system, creating a wealth of opportunities in old and new sectors. Having supportive, transparent, and consistent government frameworks at national, state, and local levels should increase corporate willingness to bear these risks; this should provide a forum for cooperation that may be critical in overcoming challenges.

Though speed is essential, measures must be carefully considered, and companies that are supported must be verified to be acting in good faith. Minimum standards for value capture and technical specifications are necessary to ensure that companies are committed to India's domestic growth and are creating valuable products for the world ACC market.

The commonly discussed vision of the future — renewable energy, electrification, the Internet of Things, increased communication, transformative mobility, and more — is enabled and accelerated by increased access to low-cost, effective battery chemistries. India's decisive action can help realise such a future by strategically supporting growth in supply and demand for energy storage technologies, creating lasting benefits for itself and the world.

# Appendix

# Appendix

## Securing Financing Debt Impact Methodology

The projections on impact interest rates for debt and debt ratio on cell prices are based on a project finance model using cost data sourced from Bloomberg's Bottom-Up Battery Cost Model (BattMan 2.0). The BattMan 2.0 model provides projections for capital and production costs, which are regionally specific to India. For the project finance model, costs associated with the NMC-532 chemistry were used. Capital costs for the battery cell manufacturing plant include: land, construction, equipment, supporting facilities, and other costs such as working capital. Production costs for battery cells include cell materials (cathode, anode, electrolyte, separator, and housing), labour, manufacturing costs, and equipment and plant depreciation. Production costs are applied on a per kWh basis. Production costs have been assumed to be static, thus not accounting for impacts of inflation or material cost changes.

The project finance model is based on a plant with 5 GWh of annual battery cell output. BattMan 2.0 assumes a scrappage rate, so the plant's capacity is increased to 5.25 GWh per year to achieve the targeted 5 GWh output. With an assumed ampere hours of 60, it would take approximately 4.6 cells per kWh, and the plant would produce approximately 2.9 million cells annually (before applying the scrappage rate). Annual expenses for production are then applied to the estimated production. The PLI scheme subsidy was also calculated, applying to the first five years of the project's production. This begins at INR2,000 per kWh and declines to INR860 per kWh by the fifth year, while accounting for increasing anticipated domestic value capture.

The project model assumes a 10-year loan for capital costs, with scenarios for eight different interest rates and three debt ratios. The loan is paid off in the straight-line fashion, meaning equal amortised payments to principal each year and declining interest payments. Combined, payments to principal and interest constitute "debt service."

For most battery plants, manufacturers will sign an offtaker agreement with an EV manufacturer, and cell prices will be determined through this agreement (akin to a power purchase agreement for energy generators). Typically, annual production expenses will be subtracted from annual revenue to determine cash available for debt service (CADS). The debt service coverage ratio (DSCR) is the ratio between CADS and debt service in the payment period. For this model, there is no known cell price, and thus revenue is unknown. To determine revenue, an assumed DSCR was applied to each year. This DSCR was 1.35, the average for Adani Green Energy Limited Restricted Group 1.[68] This DSCR was multiplied by the debt service to determine annual CADS. Annual expenses were then added to the CADS to find the required revenue to meet the DSCR. This revenue can then be used to find cell prices on either a per-cell or per-kWh basis.

The cell prices are not static in this model because of the impact of the PLI scheme subsidy and declining debt service. For the purposes of calculating the impact of interest rates and debt ratio on cell prices, the average cell price over the 10 years of the loan servicing period was used.

This project financing model does not account for other costs that may be incurred, such as transportation or marketing costs for the product, or tax rates. These inputs will be highly variable by company and region.

## Sourcing Green Electricity for Battery Manufacturing

The following assumptions were used to project savings on energy and emissions that can be realised by battery cell manufacturers procuring power from rooftop solar and open access renewable energy:

1. Energy requirement per unit of cell storage manufactured = 45–65 $kWh_e/kWh$[69] (this is typical for large gigafactories; for instance, Northvolt Ett facility's 8 GWh pilot line will consume nearly 50 $kWh_e/kWh$ cell storage produced)
2. Average tariff rates of electricity supply for industry = INR7/kWh
3. Average emissions intensity of India's power sector = 725 g $CO_2$ e/kWh[70]
4. Typical facility area for a 40 GWh battery gigafactory = 200,000 square meters[71]
5. Feasible rooftop solar plant capacity installable per square meter area = 0.1 kW[72]
6. Rooftop solar plant average capacity utilisation factor (CUF) = 17.5%[73]
7. Utility-scale PV plant average CUF = 20%[74]
8. Typical open access tariff = INR3.8/kWh[75]

***Note:*** *Typical values mentioned above are assumed for Karnataka as a case.*

# Endnotes

# Endnotes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