Manufacturing Capabilities in

Emerging Energy Segments

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INDIA

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Content

1. EXECUTIVE SUMMARY

On its path to energy self-sufficiency, India is inexorably transforming its landscape in terms of energy sourcing and also of energy-oriented applications. For advancing this transitional momentum, clean and efficient technologies are highly imperative to be employed via effective business models, so as to counter indigenous challenges.

Some of the technologies described in this report are gaining precedence over their conventional counterparts. They are catalysing the nation's progress towards becoming a clean energy-based economy. Enormous new potential for smart, efficient and eco-friendly energy solutions can be seen in the power and transportation sectors.

Aside from the energy security factor, the new-age technologies belonging in the energy sector (or the new-energy technologies) are expected to flourish greatly in the near future on account of huge inherent market demand potential. The sunrise sectors including Electric Vehicle (EV) component, EV Supply Equipment (EVSE), Lithium-ion Battery (LIB), Battery Recycling, Hydrogen Energy and Smart Meter industries were taken under consideration in this report, signifying their present and potential manufacturing capabilities in the Indian context.

At approximately $536 million (2019) market valuation, India's EV component supplier market is estimated to grow at a CAGR[1] of 22.1% between 2020 and 2030[2]. The EVSE market, too, is at a very nascent stage in India. However, the associated infrastructure and capacity building for the equipments are being developed rapidly. In regard to the lithium-ion battery, the market valuation of Battery Energy Storage System (BESS) stood at USD 1.89 billion in 2019[3]. The consolidated lithium-based battery demand in the Indian market between 2020 and 2027 is estimated to be about 930 GWh with the potential demand for EV battery expected to be more than 3/4th of the overall (EV+Stationary) consolidated demand[4].

As per JMK research estimates, the battery recycling market is expected to start picking up in India from the year 2022 onwards. In the year 2030, the annual recycling market is expected to be around 22 to 23 GWh[5]. With respect to India's hydrogen market, the projected demand in 2050 is 28 Million tonnes (Mt) with the present

1 CAGR - Compound Annual Growth Rate

2 P&S Intelligence, EV Component Market in India to Grow With More Than 22.1% CAGR in Near Future, March 2021

3 ReportLinker, India Lithium-Ion Battery Market, March 202

4 Frost & Sullivan

5 JMK Research, Recycling of lithium-ion batteries in India - $1,000 million opportunity

demand being ~6 Mt per annum[6]. Furthermore, as of 9th April 2021, more than 2.37 million smart meters have been successfully deployed and roughly 7.6 million units are in the process of deployment[7].

Additionally, the report presents a graphical summary of state-wise presence of leading India-based manufacturing companies across EV Component, EVSE, LIB and Smart Meter industries. This is followed by two case studies highlighting the different aspects of partnerships between leading Indian and international companies.

6 TERI (The Energy and Resources Institute), The Potential Role of Hydrogen in India, 2020

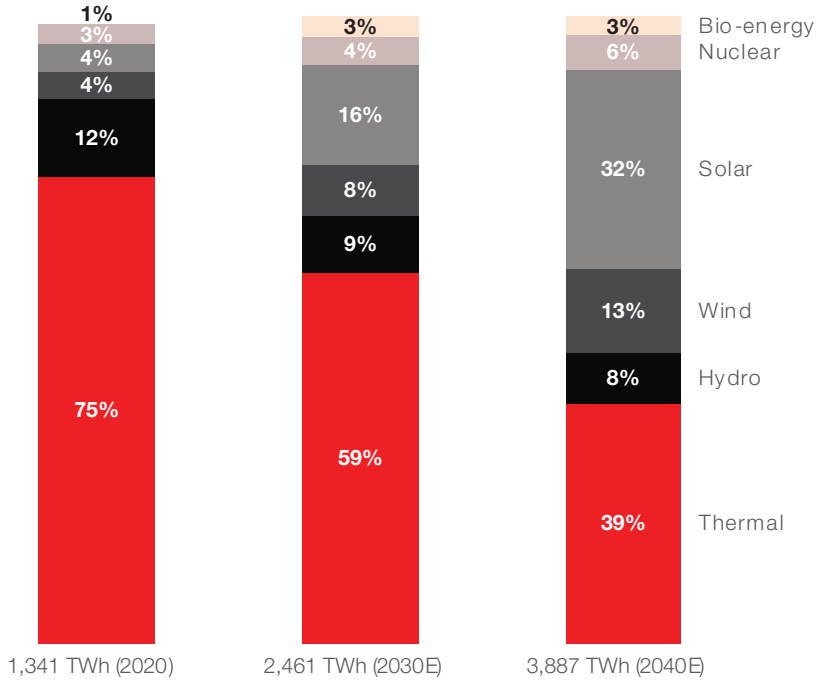
7 National Smart Grid Mission, Ministry of Power, Government of India

2. INDIAN ENERGY LANDSCAPE

New-age technologies enabling sustainable use of energy are indispensable to one of the highest energy consuming (in gross terms) countries in the world such as India. The energy consumption record of India for 2020 is 1,247 TWh. By 2025, the annual energy demand of the country is predicted to reach 1,622 TWh. The ever-rising demand can be attributed to India's expanding economy, population, urbanisation and industrialisation[8].

In 2020, three-quarters of India's electricity was generated from thermal power plants. Energy generated from renewable sources (including hydro and bio-energy) constituted about 22% of the total energy generation in 2020. It is expected that the share of renewables would increase to 36% by 2030 and 56% by 2040.

Fig. 1: Source-wise (%) distribution of energy generation



Source: CEA, IEA, JMK Research

8 IEA, India Energy Outlook 2021

India's energy landscape is unabatedly transforming to a less hydrocarbon-dependent environment as it is setting out to be one of the most significant hotspots in the world for sustainable cleantech market.

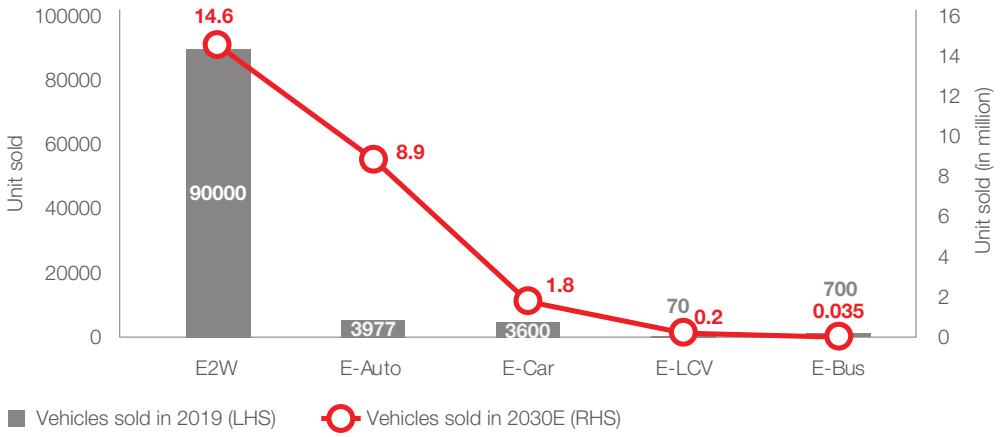
Enormous new potential for smart, efficient and eco-friendly energy solutions can be seen in the power and transportation sectors. The prominence of and inter-dependency between these two sectors would become very well defined and robust in the coming decade, with energy storage playing the most vital integral component in this environment.

3. MANUFACTURING CAPABILITIES OF 'SUNRISE INDUSTRIES' OF INDIA

The 'new energy'-oriented industries in the manufacturing sector are poised to develop and expand significantly in the future on account of huge market demand potential and strategic imperatives including energy security. Sunrise industries which are and will be offering smarter and efficient solutions for energy use are, henceforth, discussed in this report.

The domestic manufacturing strengths of the EV Component, EVSE and LIB industries necessarily determines the supply-side potential of the overall local EV industry. The Government of India has assigned the goal of achieving 30% EV penetration by the end of this decade, which translates to the presence of ~60 million EVs on road by 2030. It can also be noted that the demand for electricity from the e-mobility segment in India would increase to 45 TWh of energy by 2030[9]. Thus, it is highly important to build a robust e-mobility ecosystem consisting of collaborative yet self-reliant allied-industries.

Fig. 2: EV Market Volume across different segments in 2019 and 2030 (Expected)



Source: Frost & Sullivan

9 IEA (International Energy Agency)

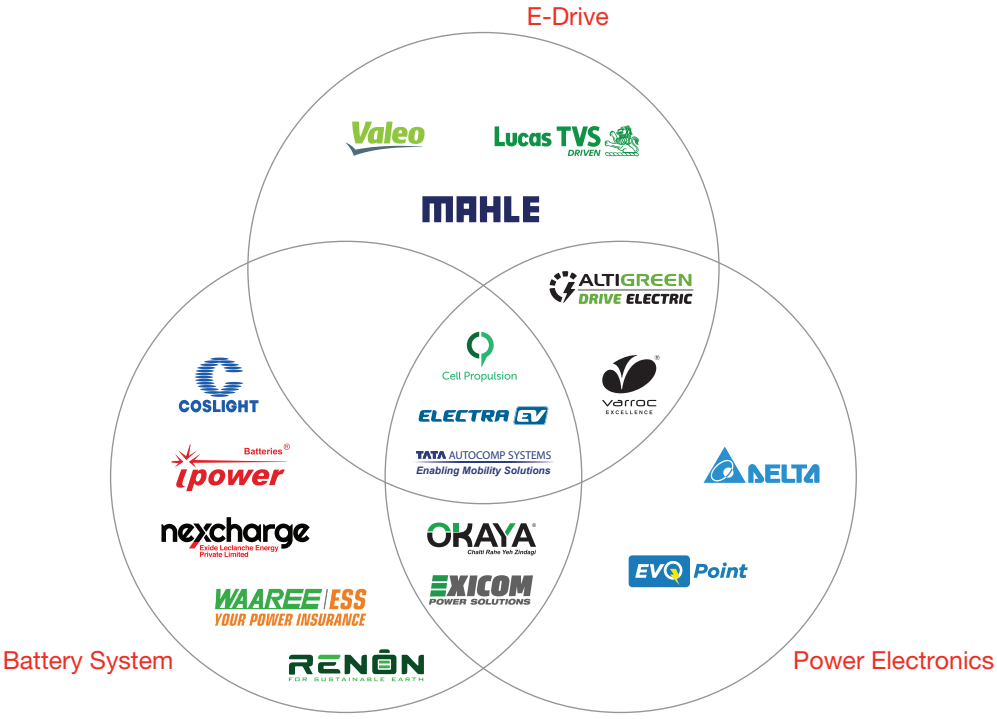
3.1. Electric Vehicle Component

The EV component market was valued approximately $536 million in 2019 and it is estimated to grow at a CAGR of 22.1% between 2020 and 2030[10]. It is also predicted that the Battery Management System for passenger car battery packs would register the highest CAGR of 61.7% between 2020 and 2030.

At present, India's EV component supplier market is disproportionately smaller in relation to the EV OEM (Original Equipment Manufacturer) market. The majority share of EV manufacturers rely on imported parts/ sub-parts for their final products; although a few EV OEMs such as Okinawa Autotech and Omega Seiki Mobility have achieved near-complete localization of their vehicle components.

Some of the major India-based EV component suppliers are categorized below on the basis of the three characteristic sub-systems of an Electric Vehicle – Electric Drive (E-Drive), Battery System and Power Electronics.

Fig. 3: A few major EV component suppliers present in India



Source: JMK Research

10 P&S Intelligence, *EV Component Market in India to Grow With More Than 22.1% CAGR in Near Future, March 2021*

Lack of scale of production in regard to India-made EV components is impeding the cost competitiveness of these products against their imported alternates. But, the rise in demand for EVs in recent months has encouraged the relevant ancillary industry to amplify its momentum. A significant catalyst for the accelerated pace of local component manufacturing is the Phased Manufacturing Programme (PMP) for xEV[11] parts for eligibility under FAME India scheme Phase-2. PMP was initiated in March 2019 to promote indigenous manufacturing of EV, its assemblies/ sub-assemblies and parts/ sub-parts, thereby increasing domestic value addition and capacity building within the country.

Some of the exclusive EV components are listed in the table below. As per the PMP plan, the manufacturing indigenisation of most of the xEV-exclusive parts are required to be effected no later than April 2021, in order to avail the incentives under FAME–2 scheme. Achieving substantial degree of localization in the future across various EV components would effectuate the realization of net positive benefit of EV adoption, as it would greatly reduce the country's import dependence for requisite raw equipments. In order to qualify for net gain, localization in motor controller and LIB needs to be at least 50% by 2025 and 60% by 2030 respectively.

Fig. 4: Components under PMP for eligibility under FAME–2 scheme and their current localization levels

EV (exclusive) component	Net localization	Conventional ICE/ Electric vehicle component	Net localization
AC charging inlet Type 2	35-40%	HVAC	
DC charging inlet CCS2/ CHAdeMO	15-20%	Power and control wiring harness along with connectors	45-50% (Low voltage) 15-20% (High voltage)
DC charging inlet BEVC DC 001		Electric compressor	0-5%
Traction battery pack	20-25% (LFP, Air cooled, 21 kWh)	MCB/ Circuit breakers/ Electric safety device	30-35%
Wheel rim integrated with hub motor		Electronic throttle	

11 xEV - Generic name for electromotive vehicles such as Battery Electric Vehicle, Hybrid Electric Vehicle, Plug-in Hybrid Electric Vehicle and Fuel-Cell Electric Vehicle

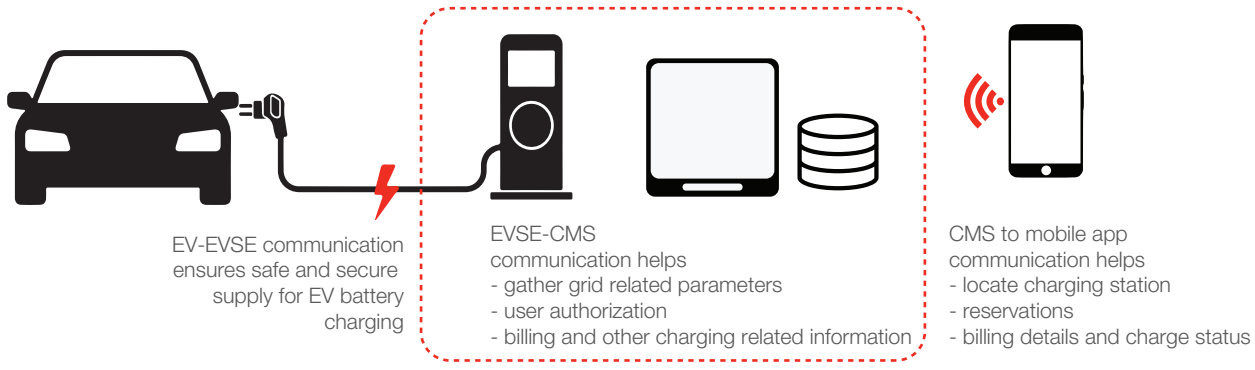
EV (exclusive) component	Net localization	Conventional ICE/ Electric vehicle component	Net localization
DC-DC converter	0-10%	Vehicle Control Unit	0-5%
On-board charger	0-5%	Instrument panel	
Traction motor	0-10%	Lighting	
Traction motor controller/ inverter		Body panel	

Source: Department of Heavy Industry, Nomura Research

3.2. Electric Vehicle Supply Equipment (EVSE)

Another essential ancillary segment for e-mobility which has significant potential in the Indian context is the EVSE industry. Considering the EVSE or the hardware component of the EVCI (Electric Vehicle Charging Infrastructure) architecture that includes charge points, connectors, chargers and associated equipments, the relevant market is at a nascent stage in India. Nevertheless, the infrastructure and capacity building for these equipments are being developed rapidly.

Fig. 5: Architecture of EV Charging Infrastructure



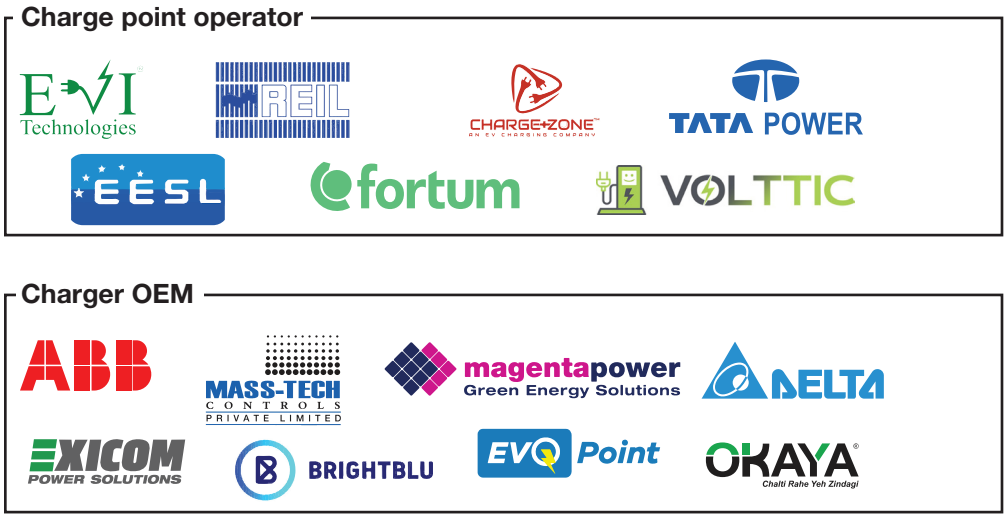
Source: DHI – Committee Report on Standardization of Public EV Chargers

The major players involved in the Indian EV charger manufacturing domain mostly include established companies who have expanded their electrical and electronics business portfolio (consisting of inverters, rectifiers, etc.) by venturing into the EVSE segment.

In India, the DC fast chargers have a range of 15 kW to 240 kW with guns conforming to GB/T[12] and Combined Charging System (CCS) 2.0 charging protocols. Whereas, AC type slow chargers operate between 3.3 KW and 22 KW with industrial connectors to type 2 connectors. However, India is yet to finalize adoption of a specific charging standard.

The key central-level financial incentive for EV charging infrastructure is the Indian government's INR 10 billion allocation for supporting establishment of the same under the FAME (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles) India scheme Phase-2. As of 15th March 2021, DHI has sanctioned 3,397 charging stations under FAME scheme. It is estimated that India would have a demand potential of over 2.9 million public charging points by FY2030[13]. EV charger OEMS such as ABB, Delta electronics, Mass-Tech, Okaya, etc. are some of the major manufacturers operating in India, producing components for both AC and DC charging.

Fig. 6: Popular players involved in the EV charging business



Source: JMK Research

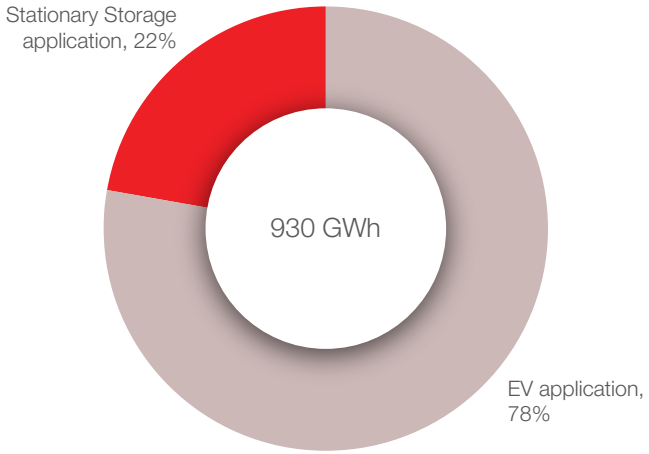
12 Guobiao tuijian or "recommended national standard" in Chinese)

13 CEEW Centre for Energy Finance, Financing India's Transition to Electric Vehicles, Dec 2020

3.3 Lithium-ion Battery (LIB)

With the growth in share of EVs, the market for LIBs is bound to grow significantly. Furthermore, the LIB demand from the stationary storage market also, is expected to surge at a high rate, once the battery prices fall below USD 100/kWh. Considering the companies operating along the LIB value chain, virtually all of them are invested in cell-to-pack assembly. These companies offer their in-house developed battery packs to e-mobility market and/or stationary storage markets such as Telecom, Renewables, etc. Some of the examples are: Okaya, Exicom, Coslight, ACME Cleantech, IPower, etc. In 2019, the Li-BESS India market valuation stood at USD 1.89 billion[14].

Fig. 7: Consolidated Market Demand for Lithium-ion Battery (2020-27) – Application-wise Split



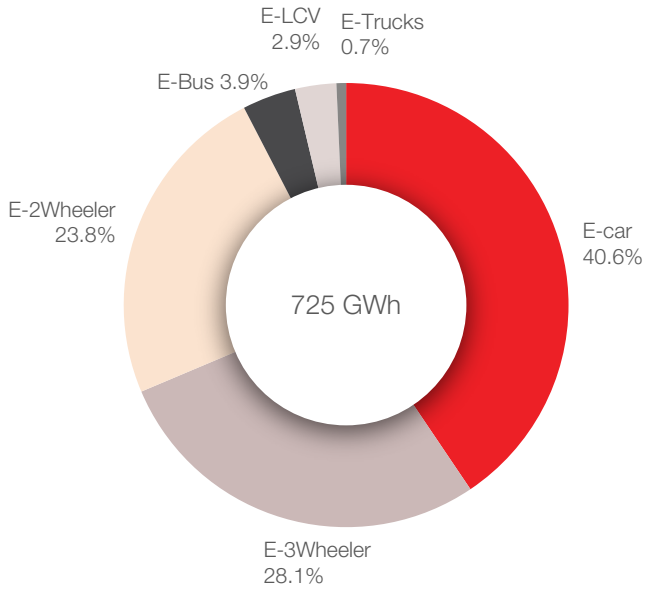
Source: Frost & Sullivan

14 ReportLinker, India Lithium-Ion Battery Market, March 2021

EV Application

The vast majority of the aggregate battery pack assembly plant capacity caters to the e-mobility segment, specifically the two and three wheeler EV segments. Post March 2019, with the Central government incentivizing the use of LIBs over the traditional LA (Lead Acid) batteries for e-mobility application, the share of the former battery-type in the market has been increasing ever since. The potential demand for Li-ion battery from EV market between 2020-2027 is about 725 GWh (refer figure below).

Fig. 8: Consolidated Market Demand (2020-2027) for Lithium-based EV Battery

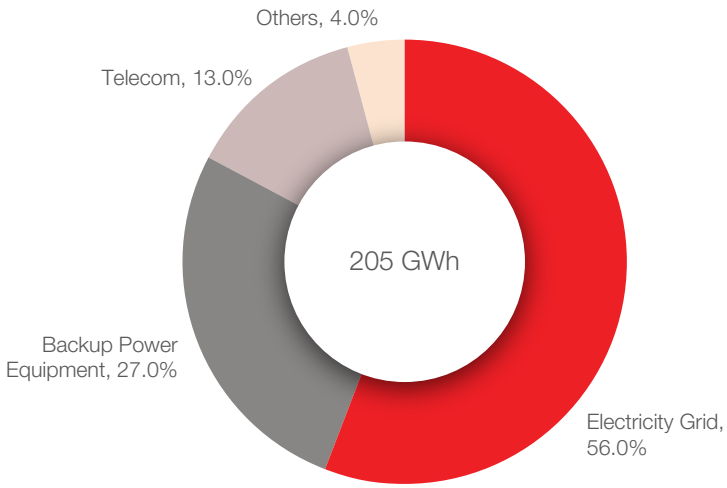


Source: Frost & Sullivan

Stationary Storage Application

As the share of renewables into the Indian energy mix increases, the value or demand for stationary storage would rise commensurately. The consolidated market demand for stationary (lithium-based) battery in India is estimated to be approximately 205 GWh between 2020-2027 as shown in the chart below. The grid application segment would contribute to more than half of this consolidated demand. As of March 2021, India has commissioned ~19 MWh of grid-based BESS projects and close to 354 MWh of such projects are scheduled to be commissioned in the next 1-2 years.

Fig. 9: Consolidated Market Demand (2020-27) for Lithium-based Stationary Battery



Source: Frost & Sullivan

India has a significant dearth of grid-scale battery manufacturing capacity. The development of the same in the current scenario is highly capital-intensive and is associated with low ROI (Return on Investment), given the insufficient existing demand for grid-scale storage. As per the Central Electricity Authority (CEA) of India, to support the addition of 460 GW of renewables in India by 2030, about 34 GW/ 136 GWh of battery storage would be needed.

Fig. 10: Major Players involved in the Indian Lithium-based Battery value chain

Player(s)	Product(s)	Plant location	Capacity	Investment
TATA CHEMICALS LIMITED	Battery pack (yet to be commercially produced)	Dholera Smart City, Gujarat	10 GWh (under development)	INR 40 billion
SUZUKI TDSG TOSHIBA DENSO	Battery pack (to be produced starting from 2021); Cells (first company to start cell production from year end 2020) Cell chemistry: LTO (Lithium Titanium Oxide)	Maruti Suzuki Supplier Park, Ahmedabad, Gujarat	-	INR 12.1 billion (Phase I); INR 37.1 billion (Phase II)

Player(s)	Product(s)	Plant location	Capacity	Investment
AMARA RAJA Gotta be a better way	Battery pack Cell (yet to be commercially-produced)	Tirupati, Andhra Pradesh	Pack assembly capacity - 500 MWh	INR 200 million, excluding technology transfer and bidding fees paid to the ISRO in January 2019; Targeting ~10 GW of cell production capacity, requiring investments of ~USD 1 billion over 5-7 years
EXIDE INDUSTRIES LIMITED	Prismatic Module, Cylindrical Module, Pouch Module, Low Voltage Pack, High Voltage Pack; Cell chemistry: NMC, LFP, LTO, etc.	Prantij, Sabarkantha, Gujarat	1,565 MWh (Cumulative)	INR 1.9 billion by FY20; Plans to spend about INR 0.8–1 billion annually in the JV.
ATL	Rechargeable Lithium-ion Polymer (LIP) batteries (yet to be commercially-produced)	Industrial Model Township (IMT), Sohna, Haryana	-	INR 5.5 billion for purchase of 180 acres of land; Plans to invest INR 70 billion in India over the next few years
XNRGI	High-temperature (HT) battery packs, Battery/Energy Management Systems, optional tracking and remote status monitoring hardware Cell chemistry: Silicon chip-based Lithium	Gurugram, Haryana	240 MWh of battery production capacity	-
epsilon advanced materials	Synthetic graphite anode	Ballari, Karnataka	5,000 tonnes per year, to expand capacity to 35,000 tonnes by 2025	INR 5 billion by 2025
INVERTED	Battery pack, Customized in-house BMS (in plans).	Okhla Industrial Area, Delhi	100 MWh per year	-
ACME	Battery pack	Rudrapur, Uttarakhand	350 MWh per year, plans to increase annual manufacturing capacity of 2-3 GWh by 2020	-

Player(s)	Product(s)	Plant location	Capacity	Investment
EXICOM POWER SOLUTIONS	Cylindrical and prismatic modules and packs, Energy Storage System (ESS); BMS; Cell chemistry: LFP, NMC	Gurugram, Haryana; Solan, Himachal Pradesh	75,000 packs per year	-
GREENFUEL	Battery pack Energy Storage System (ESS);Cell chemistry: LFP, NMC	Manesar, Haryana	100 kWh per month	-
GRINNTECH	Battery pack (Cell form factors - Cylindrical, Prismatic and Soft Pouch); Battery Management System (yet to be commercially-produced)	Chennai, Tamil Nadu	400 MWh per year	Executed an MoU with the Government of Tamil Nadu involving an investment of INR 1 billion in October 2020
Batteries® ipower	Battery pack, Cell (under development); Cell chemistry: LFP, NMC	Kundli, Sonipat, Haryana	500 battery packs per day	Post first wave of Covid-19 pandemic in 2020, company invested around INR 25 million; Plans to double the investment in next two years.
Livguard energy unlimited	Battery pack; Cell chemistry: NMC	Manesar, Haryana	-	US$ 20 million invested in 2019 for setting up battery assembly unit
LOHUM	Battery pack, ESS; Multiple cell chemistries & form factors	Greater Noida, Uttar Pradesh	Current: 150 MWh per year, Proposed: Expansion upto 1 GWh per year	Current: 150 MWh per year; Proposed:Setting up of India's largest integrated Li-ion unit with a manufacturing capacity of 3 GWh (1 GWh manufacturing and 2 GWh of recycling per annum) in Noida within 18 months.
RENON FOR SUSTAINABLE EARTH	Battery pack; Cell chemistry: LFP, NMC	Surat, Gujarat	200 MWh per year	Joint investment of USD 3.7 million in December 2019
WAAREE ESS YOUR POWER INSURANCE	Battery pack, Energy Storage System (ESS); Cell chemistry: LFP, NMC; Cell form factors: Cylindrical, Prismatic	Surat, Gujarat	400 MWh per year	Plans to use the newly infused operating capital of US$ 2 million to expand its manufacturing capabilities
OKAYA Chalti Rahe Yeh Zindagi	Battery pack, Energy Storage System (ESS); Cell form factors: Cylindrical, Prismatic	Himachal Pradesh	24,000 kWh per month	-

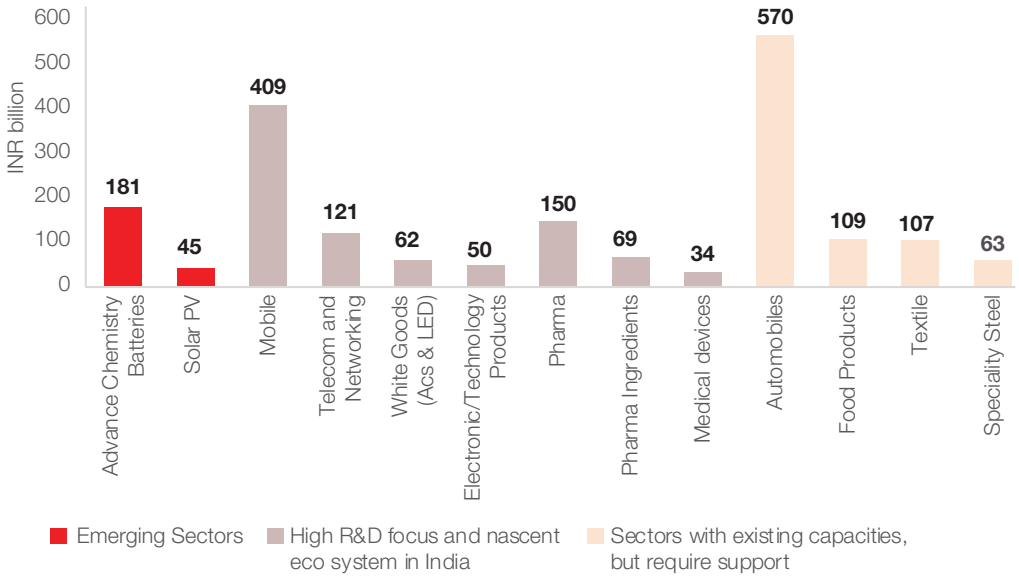
Player(s)	Product(s)	Plant location	Capacity	Investment
COSLIGHT	Battery, Energy Storage System (ESS)	Manesar, Haryana; Una, Himachal Pradesh	Planned: Cell manufacturing capacity - 2 GWh, LFP & NMC pack assembly capacity (Una plant) - 50 MWh	Invested INR 2.5 billion in Una, Himachal Pradesh (acquiring 32 acres of land) and developed infrastructure for cell manufacturing and battery pack assembly (operations starting from Oct-2021)
Vision Mechatronics	Energy Storage System (ESS); Cell chemistry: Lithium Iron Manganese Phosphate (LiFeMnPO4), Lithium Iron Yttrium Phosphate (LiFeYPO4)	Thane, Maharashtra	-	
AQUEOUSS HOLD THE VOLT	Battery pack; Cell chemistry: LFP	New Delhi, Delhi	10,000 batteries per month	
PURE	Battery pack, Energy Storage System (ESS); Cell chemistry: LFP, NMC	Sangareddy, Telangana	500 MWh; On the course of capacity expansion upto 5 GWh	

Source: Company Websites, Industry News Articles, JMK Research

Central Level Incentives – PLI (Production-Linked Incentive) Scheme

The Union Cabinet of India, on 11th November 2020, approved a INR 1.45 trillion production-linked incentive (PLI) scheme for ten sectors to attract investments and boost domestic manufacturing. As part of this scheme, INR 181 billion (USD 2.480 billion) have been allocated for Advance Cell Chemistry (ACC) battery industry.

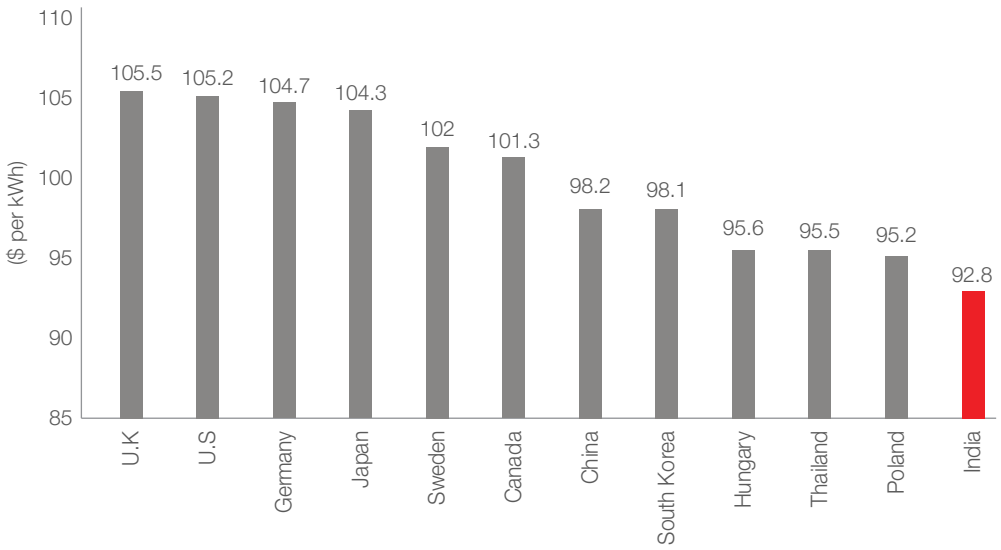
Fig. 11: Fund allocation under PLI scheme



Source: Press Information Bureau, Government of India

On 12th May 2021, the Indian government approved the proposal of Department of Heavy Industry (DHI) for implementation of the PLI Scheme 'National Programme on Advanced Chemistry Cell (ACC) Battery Storage' for achieving manufacturing capacity of 50 GWh of ACC and 5 GWh of "Niche" ACC. As per Bloomberg New Energy Finance (BNEF), India is the lowest cost country for li-ion based cell manufacturing. The ACC performance-based subsidy is expected to be as high as USD 27 per kWh at the cell level.

Fig. 12: Country-wise Manufacturing Cost of Li-based Pouch Cell



Source: BloombergNEF

Note: Cell type considered is NMC-622[15]

State Level Incentives

In order to attract investments for EV manufacturing, some Indian states[16,17,] with due regard to their EV policies, are offering supply-side incentives. These incentives may include interest-free loans, capital interest subsidy, tax exemptions, etc. Few examples of supply incentives are as follows:

- **Gujarat** is one of the top states in terms of investment in-flow for lithium-based battery manufacturing. The state also offers subsidized utilities under the ambit of the state's policies for electronics.
- **Telangana** had announced incentives of 200 acres of land plus power and water facilities for manufacturing units, at a concessional rate.
- **Uttar Pradesh** is incentivizing battery manufacturing by proffering 25% concession on cost of land for mega and ultra-mega industries.

15 NMC – Lithium Nickel Manganese Cobalt Oxide

16 Invest India, Opportunities in EV battery and cell manufacturing in India, July 2020

17 WRI India, A Review of State Government Policies for Electric Mobility

- **Andhra Pradesh** had notified allocation of 200-400 acres way back in 2017, for the development of an e-mobility focused industrial park. It also plans to provide capital subsidies of 50% of fixed capital investments in building and common infrastructure.
- **Maharashtra,** besides offering capital subsidies on Fixed Capital Investment (FCI), had announced that it will be an equity partner of 9% in large, mega, and ultra-mega projects, with FCI over INR 5 billion.
- **Karnataka** is providing incentives such as interest-free loans on the net SGST for EV manufacturing enterprises. It also plans to encourage EV manufacturers to provide in-plant training, by offering a stipend of up to 50% of the cost of training.
- **Tamil Nadu** will provide 20% land cost subsidy for EV battery manufacturing units. For MSMEs, there is additional capital subsidy for e-vehicle component or charging infrastructure.
- **Kerala** is proffering 20% capital subsidy for setting up new EV manufacturing facilities.

Each shaded cell in the table below indicates the provision of an EV or EV component manufacturing incentive for a particular state of India.

Fig. 13: State-level EV/ EV component manufacturing incentives

State	Capital subsidies	Tax exemptions and interest subsidies	Land development incentives	Infrastructure concessions & subsidies	Battery recycling initiatives	R&D initiatives
Andhra Pradesh	■	■	■	■	■	■
Assam	■	■		■	■	■
Bihar		■	■			■
Delhi					■	■
Gujarat	■	■	■	■		■
Karnataka	■	■	■	■		■
Kerala	■	■	■	■		■
Madhya Pradesh					■	■
Maharashtra		■		■		■
Meghalaya					■	
Odisha	■	■	■	■	■	
Punjab		■		■	■	■
Tamil Nadu	■	■	■	■	■	■
Telangana	■	■	■	■	■	■
Uttar Pradesh			■		■	■
Uttarakhand	■	■	■	■		

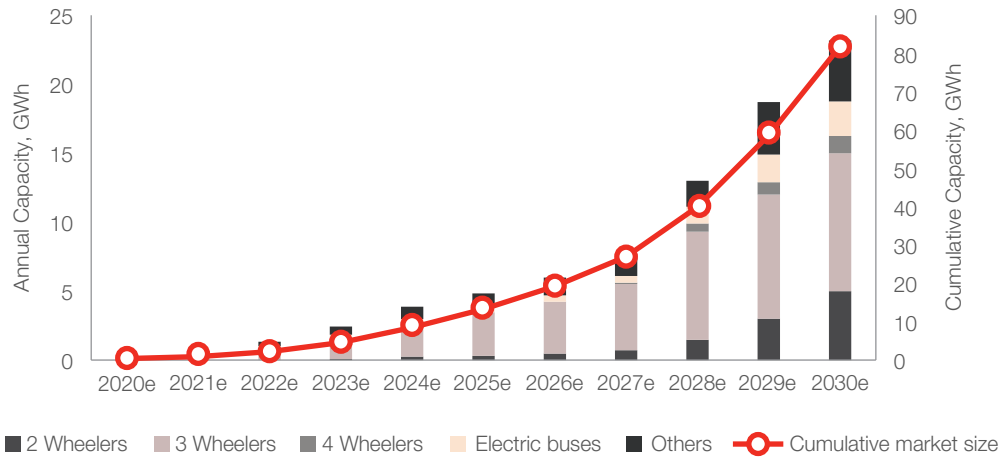
Source: WRI, JMK Research

3.4 Battery Recycling

With enormous amounts of lithium-ion batteries in application along with the lack of endowment of minerals like lithium, nickel and cobalt used in lithium-ion cells, India is clearly positioned to have tremendous potential in the battery recycling industry. The recycling of 'spent' batteries would lead to substantial reduction in India's import dependence for the rare precious metals.

As per JMK research estimates, the battery recycling market is expected to start picking up in India from the year 2022 onwards when LIBs, which are presently in use, would reach the end of their lifecycle. In the year 2030, the annual recycling market is expected to be around 22 to 23 GWh, which is more than a $1,000 million opportunity.

Fig.14: Lithium-ion Battery Recycling market in India



Source: JMK Research

Note: Others include batteries from stationary storage applications, mobiles, telecom sites, laptops etc.

Key Players

Many Indian companies have already started looking at this lucrative opportunity and have either already established or announced plans to set up recycling operations. Some of them include:

Fig.15: Companies involved or planning to involve in LIB recycling industry

Company	Location	Technology	Partnership
TES	Chennai/Singapore	Mechanical and Hydro-metallurgy	Recupyl (Singapore)
EXIGO	Haryana	Mechanical	In-house patents

Company	Location	Technology	Partnership
성일하이메탈(주) SungEel HiMetal	Andhra Pradesh	Hydro-metallurgy	In-house patents
	Bangalore, Karnataka	Mechanical	SungEEL India
Ecoreco	Mumbai, Maharashtra	Mechanical	Nippon Recycling
ECOTantra	Pune, Maharashtra	Mechanical	Nippon Recycling
EXIMO RECYCLING	Gujarat	Mechanical	N/A
	Gujarat	Electro & Hydro-metallurgy	In-house patents
ATTERO	Uttar Pradesh	Electro & Hydro-metallurgy	In-house patents
TATA CHEMICALS	Mumbai, Maharashtra	Hydro-metallurgy	
LOHUM	Delhi	Mechanical and Hydro-metallurgy	
ZIPTRAX	Delhi	Closed-Loop Recycling Process	

Source: IESA, JMK Research

3.5 Hydrogen Energy

India had initiated its journey for hydrogen energy development in 2006 by launching its first Hydrogen and Fuel Cell Roadmap, but had not progressed at the desired pace in terms of executing large-scale demo projects. However, in a recent development, the Finance Minister of India had announced the launch of National Hydrogen Energy Mission (NHEM) in the 2021-2022 National Budget. An investment of INR 25 crores (INR 250 million) has been designated in the current financial year (FY2022) by MNRE for Research & Development in hydrogen power.

Currently, India's hydrogen demand primarily comes from the chemical and petrochemical sectors. In the long-term, however, the demand would be influenced mostly by the automobile and power industries.

Fig.16: Hydrogen demand (MT) projection for India

Source: TERI, *The Potential Role of Hydrogen in India,* 2020

Most of the hydrogen consumed in India is derived from non-conventional sources. However, it is anticipated that about 80% of India's hydrogen will be produced via RE-based electricity and electrolysis by 2050. Green hydrogen has the potential to reduce more than $160 billion worth of imports to India across the markets involving crude oil, natural gas, coal, petroleum products and ammonia. The current price of green hydrogen in India is INR 300-400/kg ($4-$6/kg) but it can be potentially lowered to less than INR 150/kg ($2/kg) by 2030 by improving the efficiency of electrolysers and load factor of the solar plant. Also, in order to accomplish the price reduction, it is important for the nation to tap into the potential $20 billion global market of electrolyser manufacturing[18].

Many players have started exploring opportunities in this segment. Indian Oil developed a patented compact reforming process for production of Hydrogen-blended CNG (H-CNG) directly from natural gas. H-CNG can be used as an alternative to conventional fossil fuels in IC-Engine without major modifications in the engine architecture. Indian Oil, under the guidance of the Petroleum Ministry, had set up a semi-commercial plant of 4-tonnes per day capacity at Rajghat Bus Depot-I of Delhi Transport Corporation.

Furthermore, National Hydrogen Energy Board (NHEB), under the chairmanship of eminent entrepreneur, Ratan Tata, had created the National Hydrogen Energy Road Map for the country in November 2005. This aimed to achieve 1 million hydrogen-powered vehicles on the road, along with 1,000 MW of hydrogen-based power-generating capacity by 2020 at an investment of INR 250 billion.

Other players who have formed international collaborations to explore and/or utilize potential opportunities in this segment include:

Fig.17: International Collaborations in Indian Hydrogen Energy Market

FUSION FUEL / BGR ENERGY	Dublin-based Fusion Fuel Green and BGR Energy Systems are looking to set up a demonstration facility in Cuddalore, Tamil Nadu using Fusion Fuel's HEVO-SOLAR technology to generate cost-competitive green hydrogen. Later, the companies will co-develop projects throughout India, leveraging BGR Energy's extensive client network and existing commercial footprint.
SIEMENS / एनटीपीसी NTPC	Siemens Ltd. signed an MoU with NTPC Ltd. to identify, evaluate and set up reference use cases of hydrogen sector-coupling for various upstream and downstream applications.
ACME / Lhyfe	Acme Solar Holdings Ltd. and Lhyfe Labs SAS of France have signed an MoU to research, create, and collaborate for production of green hydrogen in target countries in Europe and India.

18 Mint, PLI scheme may extend to electrolyzers for producing green hydrogen, April 2021

snam adani	Italy's Snam S.p.A. and Adani Group are in collaboration to envisage exploration of the hydrogen value chain in India and global markets, as well as the development of biogas, biomethane, and low-carbon mobility.
snam Greenko	The two firms - Snam S.p.A. and Greenko - will collaborate on the study of hydrogen production methods from renewables, on the design of hydrogen-ready infrastructure and on final applications in both industry and transport.
GREENSTAT इंडियनऑयल IndianOil	Indian Oil Corporation (IOC) signed a pact with Greenstat Norway for developing a Centre of Excellence on Hydrogen (CoE-H) including CCUS (Carbon Capture, Utilisation And Storage) and Fuel Cells in cooperation with Indo-Norwegian Hydrogen Cluster companies/organizations.
GREENSTAT teri	The Energy and Resources Institute (TERI) and Greenstat Hydrogen India Pvt. Ltd. established a research partnership aimed at accelerating the deployment of hydrogen technologies in India. This will be focused on the establishment of a Norwegian Centre of Excellence on Hydrogen in India.

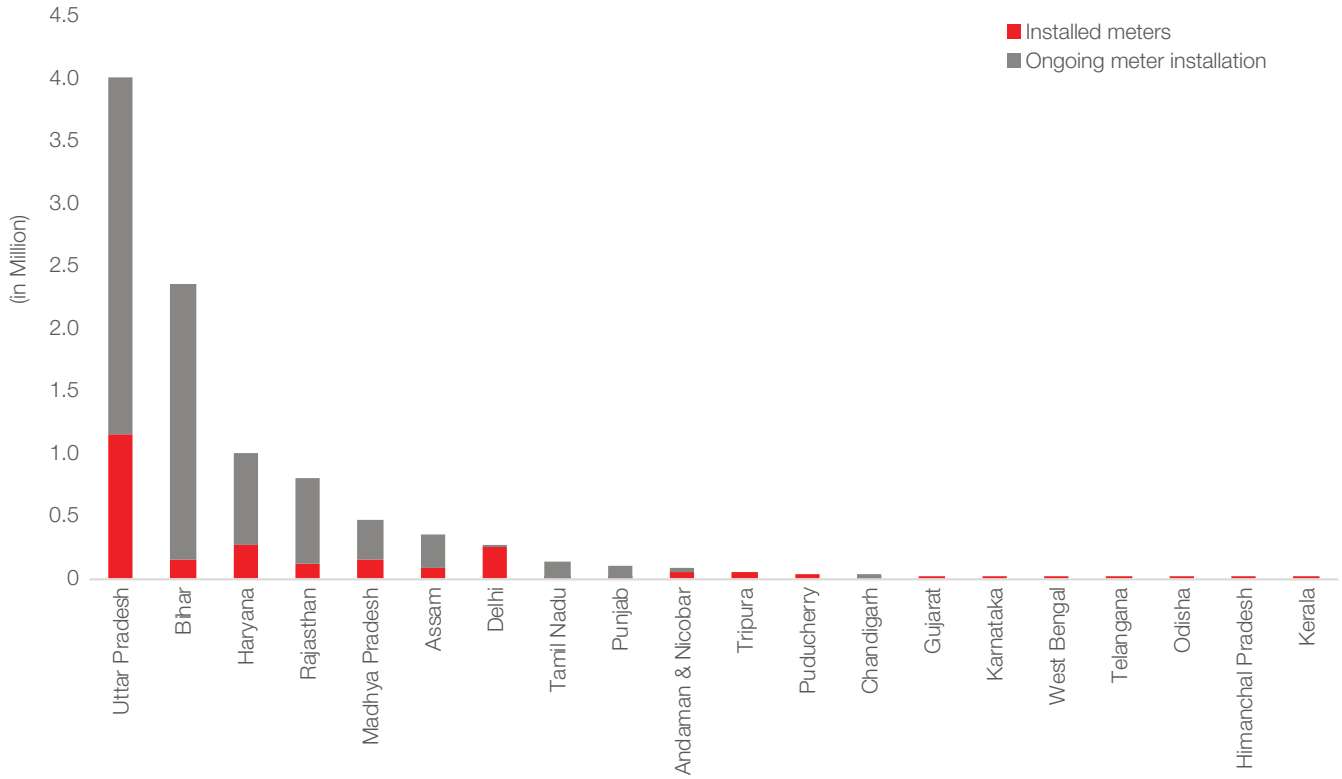
Source: Company websites, Industry News articles, JMK Research

3.6 Smart Meters

Launched in 2015, the urban renewal and retrofitting program by the Government of India known as the 'National Smart Cities Mission' envisions development of 100 cities across the country. The Smart Meter National Programme, an initiative under the umbrella mission of 'Smart Cities', aims to replace 250 million conventional meters with smart meters. The procurement task of these meters have been assigned to EESL (Energy Efficiency Services Limited).

More than 2.37 million smart meters have been successfully deployed till 9th April 2021 and roughly 7.6 million units are in the process of deployment. Further, projects involving about 1.07 million smart meters are in pipeline. Out of the total installed smart meters, Uttar Pradesh had installed the highest number (48.65% of the total) i.e. 1.15 million smart meters.

Fig.18: State-wise Installation Progress of Smart meters (As of 9th April 2021)



Source: National Smart Grid Mission

Some of the renowned smart meter manufacturers in India are Larsen & Toubro, HPL India, Genus Power infrastructure, etc. (refer Figure 18 for company-wise description). The collective capacity of all electronic meter manufacturers in the country would add upto around 100 million smart meters per year.

It is necessary to undertake certain measures to maximize effectiveness and reliability of smart meter technology in India. Low Power Wide Area Network (LPWAN) solutions for smart meters must be used as it is highly cost and power efficient as well as offers strong built-in security. Additionally, using the cost-effective eSIMs (Embedded SIMs) needs to be the norm as it provides 24x7 network coverage and contractual flexibility throughout the life of a meter. To counter potential security issues, it is critical to have a holistic cybersecurity system to secure the meters and the grid while also ensuring interoperability between different systems and networks of a utility.

Fig.19: Key Smart Meter OEMs in India

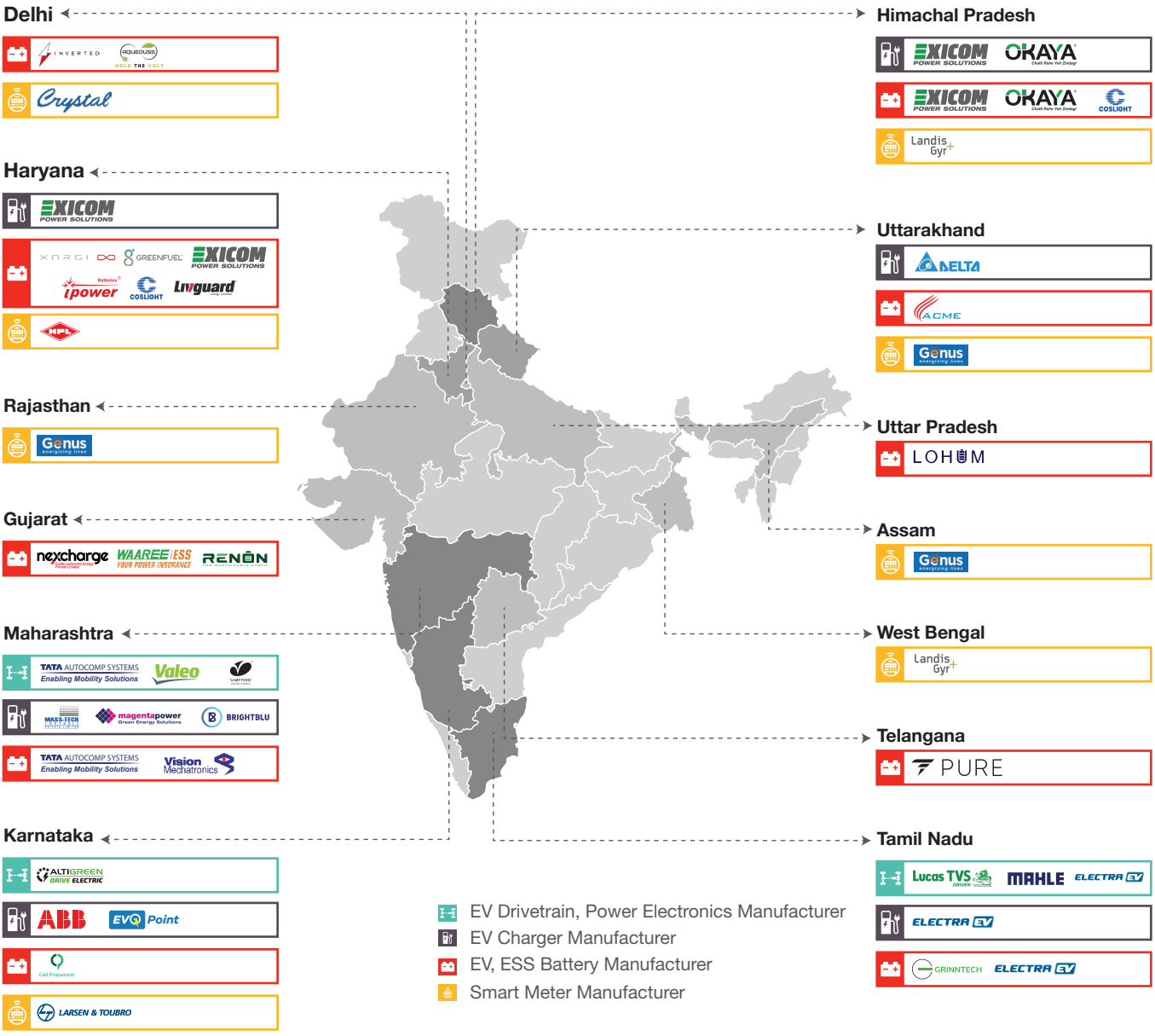
Company	Capacity	Product(s)	Other details
Genus energizing lives	10 million units per year	Jaipur, Rajasthan Haridwar, Uttarakhand Guwahati, Assam	First to supply 1.5 million smart meters to EESL under SMNP.
LARSEN & TOUBRO	Plans to expand capacity to 17 million meters per year	Mysore, Karnataka	Engaged by EESL to roll out the largest Advanced Metering Infrastructure solutions implementation comprising over 5 million smart meters across Haryana, Uttar Pradesh and NDMC
Crystal	-	New Delhi, Delhi	Supplied more than 100,000 Smart Meters by 2018; Awarded Smart Grid Project 2019 for installation of 100,000 Smart Meters for the Assam Government
HPL	11 million per year (capacity spread across both conventional and smart meters, this capacity is fungible and can be used for any meter type)	Gurugram, Haryana	Won an order to supply three-phase smart meters to be installed across the state of Punjab
Landis+Gyr	-	Joka, West Bengal Baddi, Himachal Pradesh	Partnering with Tata Power-DDL for deployment of 500,000 smart meters.

Source: JMK Research

4. LEADING MANUFACTURING COMPANIES ACROSS FOUR INDUSTRIES

The state-wise presence of leading India-based manufacturing companies across EV Component, EVSE, LIB and Smart Meter industries are shown in the figure below. The northern region of India has relatively higher density of manufacturers representing the EVSE, LIB and Smart Meter industries and the southern region, on the other hand, possesses greater EV component manufacturing capabilities.

Fig. 19: Manufacturing Locations of Major Players Across EV Component, EVSE, ESS and Smart Meter Industries



Source: JMK Research

Upcoming Li-ion cell/battery manufacturing facilities:

- Tata Chemicals is setting up an li-ion cell manufacturing facility at an investment of INR 40 billion ($600 million) with an initial capacity of 10 GWh in Dholera, Gujarat.
- TDSG, a JV between between TOSHIBA, DENSO and Suzuki Motor, has earmarked INR 50 billion ($700 million) corpus to build its lithium-ion battery manufacturing plant.
- Indian auto-components manufacturer, Lucas TVS has partnered with US-based 24M Technologies to manufacture semi-solid lithium-ion cells based on 24M's technology near Chennai, Tamil Nadu at an investment of Rs. 2,500 crores. The 10 GWh capacity plant will be built in two stages and the cell production is expected to begin in the second half of 2023.

5. CASE STUDIES

ABOUT:

On 26th February 2021, **Sterling and Wilson Pvt. Ltd. (SWPL)**, a Shapoorji Pallonji group company and India's leading engineering, procurement, and construction (EPC) company, partnered with **Enel X S.r.l.,** the energy services business of Enel SpA to enter the Electric Mobility segment in India.

PARTNERSHIPS:

SWPL signed a **50-50 joint venture (JV)** with Enel X, known for its innovative products and digital energy solutions, to launch and create world-class electric charging infrastructure in the Indian sub-continent. The JV intends to give a boost to the fast-evolving private e-mobility ecosystem by providing world-class products and software platforms to support the electric vehicle (EV) charging infrastructure build-up across the country.

With this partnership, SWPL will introduce Enel X's Juice family of high-tech, digital, and smart DC as well as fast AC electrical vehicle chargers that already have worldwide recognition, adjusted to the needs of the Indian consumer.

The JV between Sterling and Wilson and Enel X was scheduled to be incorporated on April 1, 2021 and it will start operating from the second quarter of 2021.

Sterling and Wilson Group (S&W Group)

S&W group is one of India's leading engineering, procurement, and construction

(EPC) company. The group operates across the globe in more than 30 countries with a strong presence in regions such as the Middle East, Africa, Europe, the Americas and Australia. S&W group has grown from a turnover of INR 22.45 billion in FY2012 to a turnover of INR 100.8 billion in FY2020. From being mainly focused on doing MEP projects in India, the group over the past 10 years has set up global operations in MEP, Diesel Generator Sets, Turnkey Data Centers, Transmission & Distribution, and Solar EPC. With its recent foray into Power Solutions, Sterling and Wilson is perfectly poised to play a pivotal role in the global trend of moving away from thermal plants to a future of renewable energy with storage.

Enel X

Enel X is Enel's global business line dedicated to the development of innovative products and digital solutions in sectors where energy is showing the greatest potential for transformation: cities, homes, industries and electric mobility. The company is a global leader in the advanced energy solution sector, managing services such as demand response for around 6 GW of total capacity at global level and 116 MW of

	storage capacity installed worldwide, as well as a leading player in the electric mobility sector, with around 175,000 public and private EV charging points made available around the globe. Enel X designs and develops solutions focusing on sustainability and circular economy principles in order to provide people, communities, institutions and companies with an alternative model that respects the environment and integrates technological innovation into daily life.
COMPANY:	**Exide Leclanche Energy Private Limited**
SERVICES:	Customized Energy Storage Solutions Provider
ABOUT:	Exide Leclanche Energy Private Limited is a Joint Venture Company (JVC) between Exide, India and Leclanche, Switzerland. It was incorporated in September 2018. **Exide Industries Ltd. (EIL)** is India's largest manufacturer of lead acid storage batteries and power storage solutions provider. It offers a comprehensive range of battery products – from cap lamp to submarine. **Leclanché SA** is one of the world's leading energy storage solution companies, headquartered in Switzerland. The company does in-house designing and manufacturing of high performance NMC & LTO lithium-ion cells.
PARTNERSHIP:	In regard to their roles in the JV, Leclanché provides access to its know-how and intellectual property for lithium-ion cells, modules and battery management systems, meanwhile Exide Industries leverages its extensive sales network and brand equity. The partnership was formed to facilitate production of lithium-ion batteries to provide energy storage systems for India's electric vehicle market and grid-based applications. Exide's investment in the JV went up from INR 410 million in FY19 to INR 1.9 billion in FY20, for an 80% stake. The company plans to spend about INR 0.8–1 billion annually in the JV. **Nexcharge,** a brand of Exide Leclanché Energy, has built India's largest factory equipped with fully automated assembly lines of li-ion battery packs, modules (Pouch/ Prismatic/ Cylindrical), and cell testing labs at Prantij, Sabarkantha, Gujarat. It is also supported by a state-of-the-art, in-house R&D facility in Bangalore. It aims to cater to the diverse segments of industry and utility markets through li-ion batteries of different chemistry viz. NMC, LFP, LTO, etc. Capacity of 1.5 GWh with six production lines has come on stream for battery pack assembly. Further, the company is expecting nearly 60% capacity utilization in three years.

6. SUMMARY OF SUNRISE INDUSTRIES – INDIAN CONTEXT

Timeline	Industry	Market Potential	Challenges	Opportunities
Short-term (next 2 years)	EV Component	• $536 Mn (2019) • Estimated growth: CAGR – 22.1% between 2020 and 2030	• Lack of robust supply network • Low scale of manufacturing	• Skilled manufacturing across various EV component systems • Huge opportunity for potential suppliers of high quality 2- & 3-wheeler components
	EVSE	• Current public charging points: > 3,020 units • Expected number by 2030: 2.9 Mn units	• Highly import dependent sector • Uncertainty regarding required production volume	• High demand for indigenization of manufacturing of cables, connectors, charger guns, etc. suitable for Indian environment
	Lithium-ion Battery	• $1.89 Bn (2019) • Consolidated demand between 2020-2027: 900-930 GWh	• High import dependency for Li-ion cells • Lack of R&D for improvement in design and chemistry of Li-ion cells suitable in the Indian context • Lack of Effective BMS (Battery Management System) & TMS (Thermal Management System)	• High selling potential for locally assembled good quality & economical Li-ion battery packs for the 2- & 3- wheeler segment

Timeline	Industry	Market Potential	Challenges	Opportunities
Medium-term (2-5 years)	Battery Recycling	• Potential demand by 2030: 22-23 GWh	• Absence of regulatory and scientific guidelines for battery recycling in India • Cost of recycling is very high (INR 90-100/ kg)	• Technology partnerships and (BTAs) bi-lateral or multi-lateral trade agreements with countries like Finland, Belgium, Germany, USA, and Canada
	Smart Meters	• Installed: 2.3 Mn units • Under deployment: 7.6 Mn units	• Cost of smart meters is the biggest challenge faced by utilities which can be taken care of by OPEX or hybrid business models. However, most discoms are employing capex model which is not efficient • Small number of smart meters create data islands that flunk the purpose of digitalisation.	• Liquidity injection by government of INR 900 billion for discoms will support demand for smart meters over the medium term. • Government's extensive rural electrification plan will also open up thriving opportunities for smart metering segment in India
Long-term (>5 years)	Hydrogen Energy	• 6 Mt per annum (2020) • 28 Mt per annum (2050)	• Lack of relevant technical proficiency and R&D • High storage risk	• By 2040, hydrogen is expected to be cost-effective as a storage resource for high RE-integrated electricity[19] • Production-Linked Incentive scheme for manufacturing electrolysers (in planning stage)

Source: JMK Research

19 *TERI, The Potential Role of Hydrogen in India, 2020*

7. CONCLUSION

India has set optimistic goals for itself through various policy initiatives, investing in infrastructure and heavy push for power generation through renewables. India's demand for alternative fuel sources, too, is expected to rise with various states drafting Electric Vehicle (EV) policies. With India's current GDP growth, rise in urbanisation and population growth, rethinking of the ecosystem is paramount for meeting the set goals. Grid technology tenders, achieving parity in pricing of storage technologies through economies of scale and state level policies to give a push to the solar sector will be key to the transition towards renewables.

With India being at the cusp of transformation when it comes to sourcing, distribution and consumption of energy, the foresight for the future of energy looks promising indeed. India will have to take some disruptive measures such as the use of alternative materials for energy storage, combination of renewable and coal-based power generation and adoption of smart grid technologies to enable faster uptake of clean energy. Lastly, the importance of policy measures and implementation cannot be discounted. An example of the same would be Import Substitution Policies (ISP's) which will enable the indigenisation of new technologies and an adoption of a revised tariff structure on thermal based power generation. India with its abundant availability of solar, wind and hydropower definitely has the potential to become a major renewable energy economy.

When it comes to Electric Mobility, the Indian government is actively pushing for demand side incentives for expediting adoption of EVs. The FAME II scheme of the Indian government has certainly given a big boost to the Indian electric mobility sector. There has been an exponential growth in this sector due to proactive government policies and measures. The government seeks to bring about a transformative change and a gradual adoption of electric vehicles by focusing on demand side incentives. The dynamic Indian mobility sector provides a range of opportunities for foreign ecosystem players, both in the short as well as the long term. The government is actively seeking to increase knowledge and technological capacity of the transport sector and it won't stop till it meets its goals of making a zero-emission nation by 2050.

Jobs in ICEV manufacturing will continue to grow as many manufacturers continue to improve the efficiency of engines (Bharat Stage 6[20]) for the next 20 to 30 years[21]. However, hiring skilled manpower is a major barrier today as most companies are only training their employees in-house, leading to an information and resource gap. Mobility

20 BS 6 or Bharat Stage 6 is the new emission standard that must be adhered by all new vehicles sold in the country since 1st April 2020.
21 CEEW, India's Electric Vehicle Transition: Impact on Auto Industry and Building the EV Ecosystem, 2019

services and 'EV as a service' is likely to emerge as a market. Car refurbishing business will find sustenance since the life of an EV is longer due to its reduced expected wear and tear. Furthermore, the drivetrain in an ICE vehicle contains 2,000+ moving parts typically, whereas in regard to EV, there is just around 20[22]. Digital technologies such as telematics for battery and vehicle diagnostics will develop further, which will help in improving their performance. Optimisation solutions such as these have the potential to spur the growth of business in the EV ecosystem as it continues to evolve.

Engine retrofitting technologies for conventional ICEVs have potential to scale up. Industry and researchers who have interests in the field of battery cells, packs and materials can aid in the mobility transformation of India and gain access to the third largest automotive market in the world[23]. The electric mobility ecosystem also offers opportunities to companies who specialise in the 'second life cycle' of batteries. There is potential revenue in supporting load balancing, time-of-day charging, energy banking and other uses after the usage of batteries in the automobiles. Since, disposing lithium-ion batteries has high environmental costs, second use of batteries has a market in the Indian EV market, considering the uptake of EV's and the eventual scale of batteries which will reach their end-of-life cycles in the near future.

Companies making smaller battery packs and offering battery swapping solutions have opportunities in India. By 2022, sales of Electric 2- & 3-wheelers are expected to reach 1.6 million in India[24]. In addition to these, treating batteries as a separate component of a vehicle is hindering the faster uptake of EVs due to the high upfront costs. Lastly, companies which are offering battery optimisation and management systems have the opportunity to tap into the large volume being offered by the Indian market and opportunities to collaborate with Indian OEMs. Companies which offer end-to-end solutions such as charging solutions, grid optimisation, battery management and digital payment solutions as per government norms and guidelines too have tremendous opportunities in India[25].

When it comes to the Hydrogen economy, India is certainly looking at the future by giving due consideration to the development of the Hydrogen Energy Industry. By incorporating the National Hydrogen Energy Mission (NHEM) in the National Budget of 2021-22, India is clearly on a mission towards giving cleaner technologies the policy impetus it needs. Fuel Cell technologies are the cleanest options from an emissions perspective and with the cost of hydrogen production from renewables going down steadily, it is expected to play a major role in the energy landscape of India through the automobile and heavy industries sector.

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22 https://insideevs.com/news/340502/heres-seven-reasons-why-electric-vehicles-will-kill-the-gas-car/
23 https://www.investindia.gov.in/sector/automobile
24 https://www.businesswire.com/news/home/20190412005148/en/Indias-2-3-Wheeler-Electric-Vehicle-Market-Future-Outlook-to-2022---Sales-are-Expected-to-Reach-1.6M-by-2022---ResearchAndMarkets.com
25 https://inc42.com/buzz/payments-electric-vehicles-government/

The future will be driven by technological advancement and the energy ecosystem will be playing a major role. India has the potential of being a major energy exporting economy with the potential it possesses for energy storage solutions, application of smart metering technologies and the abundance of solar power generation. The Indian government, as part of the 'One Sun, One World, One Grid' (OSOWOG) initiative by MNRE, wants the Indian Grid to be connected with the Middle East, South Asia, and South East Asian grids to share solar and other renewable energy resources.
With a number of renewable energy projects coming up in Gujarat and Rajasthan, India can be a major exporter of surplus energy to neighbouring countries if a robust connecting grid is established. India can become one of the top regional forces and a staunch competitor to China in the global solar as well as e-mobility market. However, with regard to the nascent EV market, the country needs to have a national-level EV policy which would eventually have a positive trickle-down effect on the states.

Currently, it is the states which are individually driving the adoption with their respective policies. Nevertheless, a national-level policy is essential to highlight the central vision and basic framework for guidance for the entire Indian EV ecosystem.

Yes is the answer, and policy makers will have to adopt proactive measures to ensure that the built momentum is not lost.

Lastly, while COVID-19 has clearly been a challenge for the energy sector and while we hope the economic consequences will be overcome in the short to medium term, we should also be cognisant of the bigger challenge that looms in the background – climate change. It is therefore imperative to ensure that we do not take our eyes off this problem and that we are looking over the horizon and seeking out long term goals and opportunities to drive future narratives.

8. ABOUT

SWISSNEX IN INDIA

Swissnex is the global network connecting Switzerland and the world in education, research, and innovation. Our mission is to support the outreach and active engagement of our partners in the international exchange of knowledge, ideas and talent. The five main Swissnex locations are established in the world's most innovative regions: Boston, San Francisco, Brazil, China and India. Together with around twenty Science Offices and Counsellors based in Swiss Embassies, they contribute to strengthen Switzerland's profile as a world-leading innovation hotspot.

Swissnex is an initiative of the State Secretariat for Education, Research and Innovation and is part of the Confederation's network abroad managed by the Federal Department of Foreign Affairs. The Swissnex network activities are based on a collaborative approach, relying on public and private partnerships, and funding.

JMK RESEARCH

JMK Research is a boutique consultancy firm providing market research and advisory services to Indian and International clients across solar sector. Based on its in-depth sector experience, comprehensive databases, strong industry network, key insights and detailed industry information is provided which helps clients develop successful business models and market strategies. Key services offered by JMK Research includes- Strategic consultancy, Market segmentation analysis, Customer analysis, Pricing strategy, Marketing case studies, Competition Benchmarking, Policy and Regulatory advocacy, Opportunity assessment studies, and Investment advisory.

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10. ANNEXURE

Table 1: Key EV component (E-Drive, Power Electronics, Battery) & EVSE component manufacturers in India

Company	Product(s)	Plant location(s)
Valeo	Fully Integrated Compact Electric Powertrain System	Pune, Maharashtra
ELECTRA EV	Powertrains, Battery Packs, Chargers	Coimbatore, Tamil Nadu
Lucas TVS DRIVEN	Motors and controllers	Chennai, Tamil Nadu
MAHLE	Motors and controllers	Coimbatore, Tamil Nadu
TATA AUTOCOMP SYSTEMS Enabling Mobility Solutions	E-drives, power electronics, battery packs	Pune, Maharashtra
ALTIGREEN DRIVE ELECTRIC	Automotive Power Electronics, EV Drivetrains	Bangalore, Karnataka
Varroc EXCELLENCE	Motors, Controllers, DC-DC Converters, etc.	Pune, Maharashtra
Cell Propulsion	Motors, Li-ion Batteries, High Voltage Power Electronics, etc.	Bengaluru, Karnataka
ABB	Chargers	Bengaluru, Karnataka
EXICOM POWER SOLUTIONS	Li-ion Batteries, Chargers	Gurugram, Haryana & Solan, Himachal Pradesh
OKAYA Chalti Rahe Yeh Zindagi	Li-ion Batteries, Chargers	Himachal Pradesh
DELTA	Chargers	Rudrapur, Uttarakhand
EVO Point	Chargers	Bengaluru, Karnataka
magentapower Green Energy Solutions	Chargers	Navi Mumbai, Maharashtra

Company	Product(s)	Plant location(s)
MASS-TECH CONTROLS PRIVATE LIMITED	Chargers	Jalgaon, Maharashtra
BRIGHTBLU	Chargers	Navi Mumbai, Maharashtra

Source: Company Websites, Industry News Articles, JMK Research