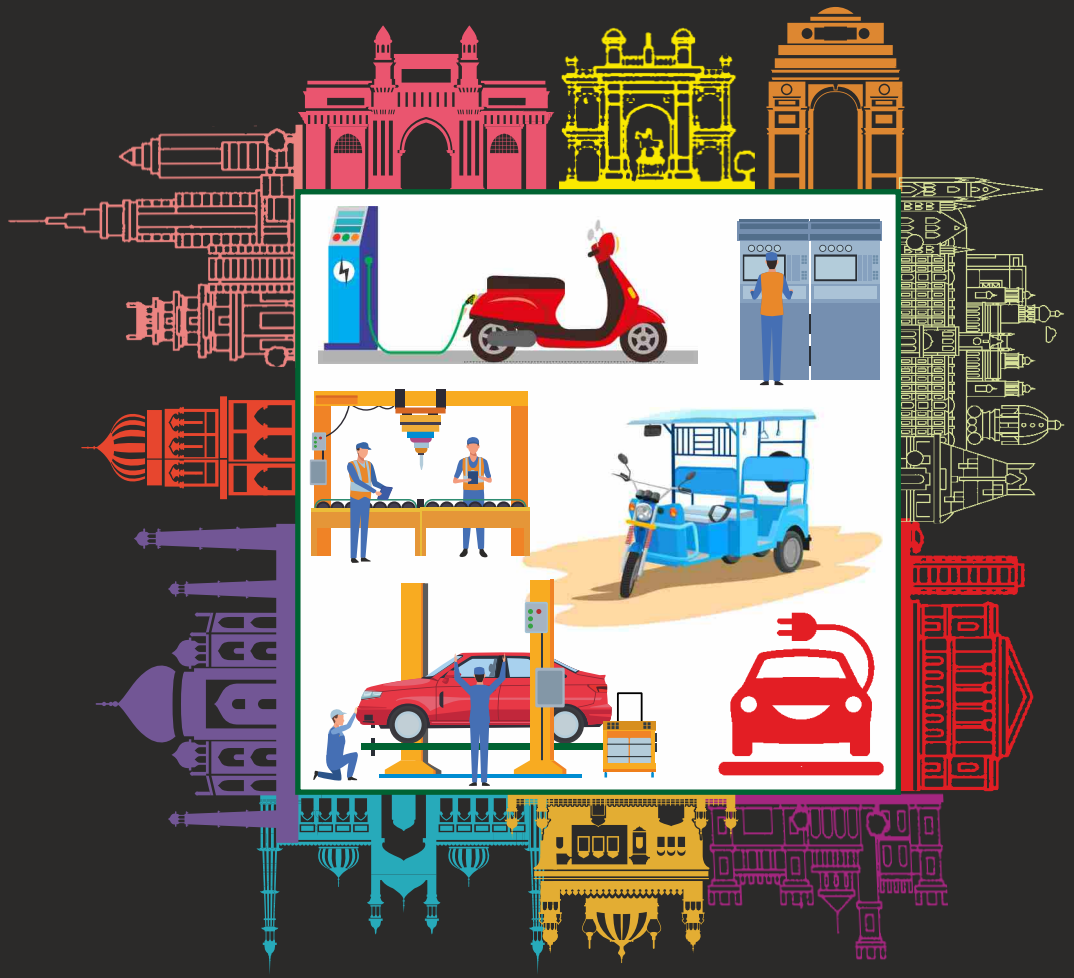
Prospects of Electric Vehicle Manufacturing in India

Linking Processes and Skills



CUTS International

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Prospects of Electric Vehicle Manufacturing in India: *Linking Processes and Skills*

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Finally, any error that may have remained is solely ours.

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Abbreviations

ACMA	Automotive Component Manufacturers Association
AI	Artificial Intelligence
ARAI	Automotive Research Association of India
ASDC	Automotive Skill Development Council
BMS	Battery Management System
CKD	Completely Knocked Down
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles
HMI	Human Machine Interface
ICE	Internal Combustion Engine
IoT	Internet of Things
IT	Information Technology
NCR	National Capital Region
OEM	Original Equipment Manufacturer
PCBA	Printed Circuit Board Assembly
PCS	Public Charging Station
R&D	Research & Development
SIAM	Society of Indian Automobile Manufacturers
SMEV	Society of Manufacturers of Electric Vehicles

1 About the Project

1.1 Introduction

Rising awareness regarding the environmental footprint of conventional Internal Combustion Engine (ICE) vehicles has paved the way for cleaner and more sustainable transport options across the world. In order to uphold its global climate commitments, under the Paris Agreement of 2015 and the recent Glasgow Climate Pact, the Government of India (GoI) has also been planning and implementing a significant shift towards electric vehicles (EV) by 2030. However, one of the major roadblocks for the E-mobility transition in India remains in the form of high upfront cost of the vehicles. This arises from high import dependency and limited local manufacturing of the critical components of EVs.

To tackle this, the Central Government launched the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles (FAME) scheme in 2015, which provided the EV manufacturing industry with an initial momentum. The second phase of the FAME scheme, launched in 2019, also focuses on generating demand for EVs by promoting indegenisation of the EV manufacturing value chain. The indegenisation agenda is currently being directed through a Phased Manufacturing Programme for developing domestic capacities of electric vehicle and component manufacturing as well as assembly.[1] To accelerate the process of indegenisation and self-reliance the Union Cabinet has also approved a Production Linked Incentive (PLI) scheme in May 2021, which aims to promote the manufacturing, export, and storage of lithium-ion cells, essential for developing EV batteries.[2] In order to align themselves with India's larger clean mobility agenda, an increasing number of states have recently been committing themselves to promote the use of locally EVs manufactured in their strategic mobility plans and are developing specific policies for enhancing EV production and adoption. The state policies are also focussing on readying the workforce for that transition through initiatives on skill development, employment generation, and research and development.

With rising policy support and evolving regulatory deadlines the OEMs have been rushing to design and develop EVs, batteries, and other EV components. However, given the nascent stage of

the industry and low volumes of production they are finding it difficult to avail such benefits. Further, institutionalisation of the process of vehicle and component testing and quality checks will take another 1-1.5 years.[3] On the livelihood front, India's significant dependence on imports (especially from China) for EV components has led to outsourcing of a large chunk of manufacturing jobs while assembly activities are being carried out in the country. Additionally, though EV start-ups seem to be on the rise in India, the current requirements are limited and tilted towards highly skilled or niche roles.

In this context, a just, inclusive and sustainable clean energy transition is the need of the hour for India. According to studies, the localisation of pre-manufacturing and component manufacturing processes showcase promising potential in terms of creating new job roles and providing localised employment opportunities across the entire EV ecosystem.[4,5] Thus, it is imperative that the transition creates direct and indirect opportunities through EV manufacturing along with creating jobs across the skill spectrum.

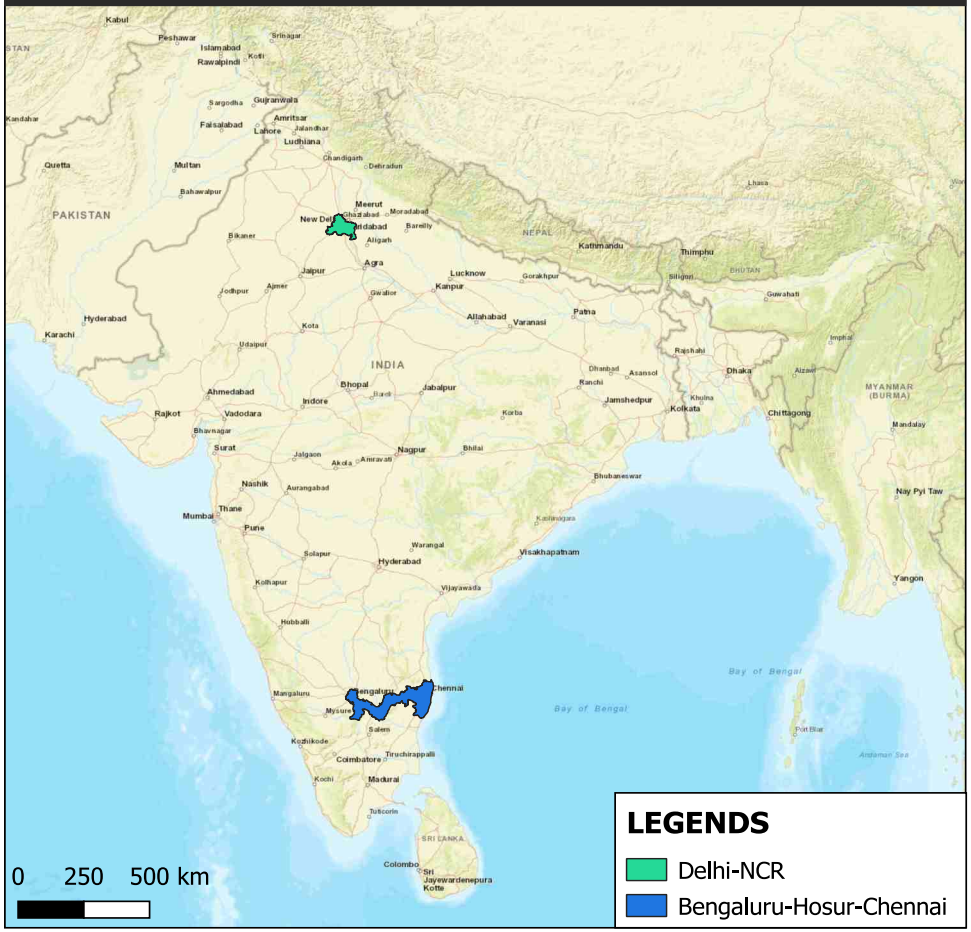
1.2 Objectives

The study aims to explore the qualitative attributes and employment potential of the business opportunities, which are being created through EV and its component manufacturing activities and which will be created due to the indigenisation of the EV manufacturing ecosystem. The overarching aim is to deconstruct the EV manufacturing ecosystem in terms of stakeholders, opportunities, job roles, and skill requirements.

1.3 Cluster Selection

In this project, ground level study of two different automobile clusters of India has been done to understand the EV manufacturing scenario in India. First cluster is Delhi- National Capital Region

Selected EV Manufacturing Clusters in India



(NCR), and second is Bengaluru-Hosur-Chennai (Karnataka, Tamil Nadu). While the first one is an old and significant automobile component manufacturing cluster, the Bengaluru-Hosur-Chennai cluster is emerging as a hub for EV manufacturing given its technological stronghold.

1.4 Approach and Methodology

Literature Review

An extensive review of existing literature on EV manufacturing ecosystem, policies, job and skill opportunities linked to EVs, and industry-academia linkages in the two selected clusters was conducted

Mapping of Stakeholders

Relevant stakeholders from the EV manufacturing and Skill development ecosystem in the two selected clusters were mapped through secondary research and scoping visits to the relevant clusters.

Primary Data Collection

Having mapped relevant stakeholders in the selected clusters, extensive consultations were conducted with identified stakeholders using semi-structured questionnaires. Key stakeholders for this purpose included stakeholders from EV and related component manufacturing industries, EV charging equipment manufacturers, software and technology development enterprises required for EVs, industry associations, skill development centres and academic institutions across the two selected clusters. In total, consultations were carried out with 56 stakeholders, out of which 26 were from Delhi-NCR and 30 from Bengaluru-Hosur-Chennai.

Data Analysis

A multi-dimensional systems approach was adopted for carrying out a qualitative analysis of business opportunities, job roles and skill requirements, across various processes in the EV manufacturing and developing a set of infographics on the basis of that. As a first step an extensive mapping activity was conducted for each cluster using secondary resources and insights from the field. Following that, linkages in the larger EV manufacturing ecosystem and smaller component manufacturing subsystems were drawn and analysed. Having established the stakeholder linkages, detailed mapping of job roles and corresponding skills and academic qualifications was carried out using heat-map analysis. Finally, a comparative analysis was carried out of the two selected clusters on the characteristics of the clusters, current opportunities and future potential.

Table 1 Category of respondents, and their cluster-wise distribution

Stakeholder/Organisation Category	Number of Respondents	Delhi-NCR	Bengaluru-Hosur-Chennai
EV Manufacturers/Assemblers	14	64%	36%
EV Body & Chassis	3	100%	0%
EV Electrical and Electronics Components	7	29%	71%
Charging Solution	7	29%	71%
EV Battery and its Components	4	25%	75%
EV Battery Recycling/Repurposing	4	25%	75%
Engineering Services	2	0%	100%
Skill Development and Educational Institutes	7	57%	43%
EV Spare Parts Traders	2	100%	0%
EV Incubators	4	25%	75%
Others	2	50%	50%

1.5 Limitations

While the research has aimed to provide a comprehensive picture, it has faced several operational challenges that have curtailed its scope. The following are the limitations of the study:

- Though an attempt has been made to cover all stakeholders in the EV manufacturing ecosystem, some stakeholders, especially in the E-4W segment have not been covered given the scope of the research.
- This research is primarily based on qualitative insights.
- The analysis is restricted to two levels of component manufacturers and does not delve into further differentiation of the ecosystem.
- The analysis is limited to Battery Electric Vehicles (BEV) and does not extend to other categories of Electric Vehicles.
- The quantitative aspects of business opportunities and employment generation have not been dealt with in-depth in this research. However, these can be taken up for further study to complement the current findings.
- The scope of the research is limited by the time and resources that were available for this purpose.

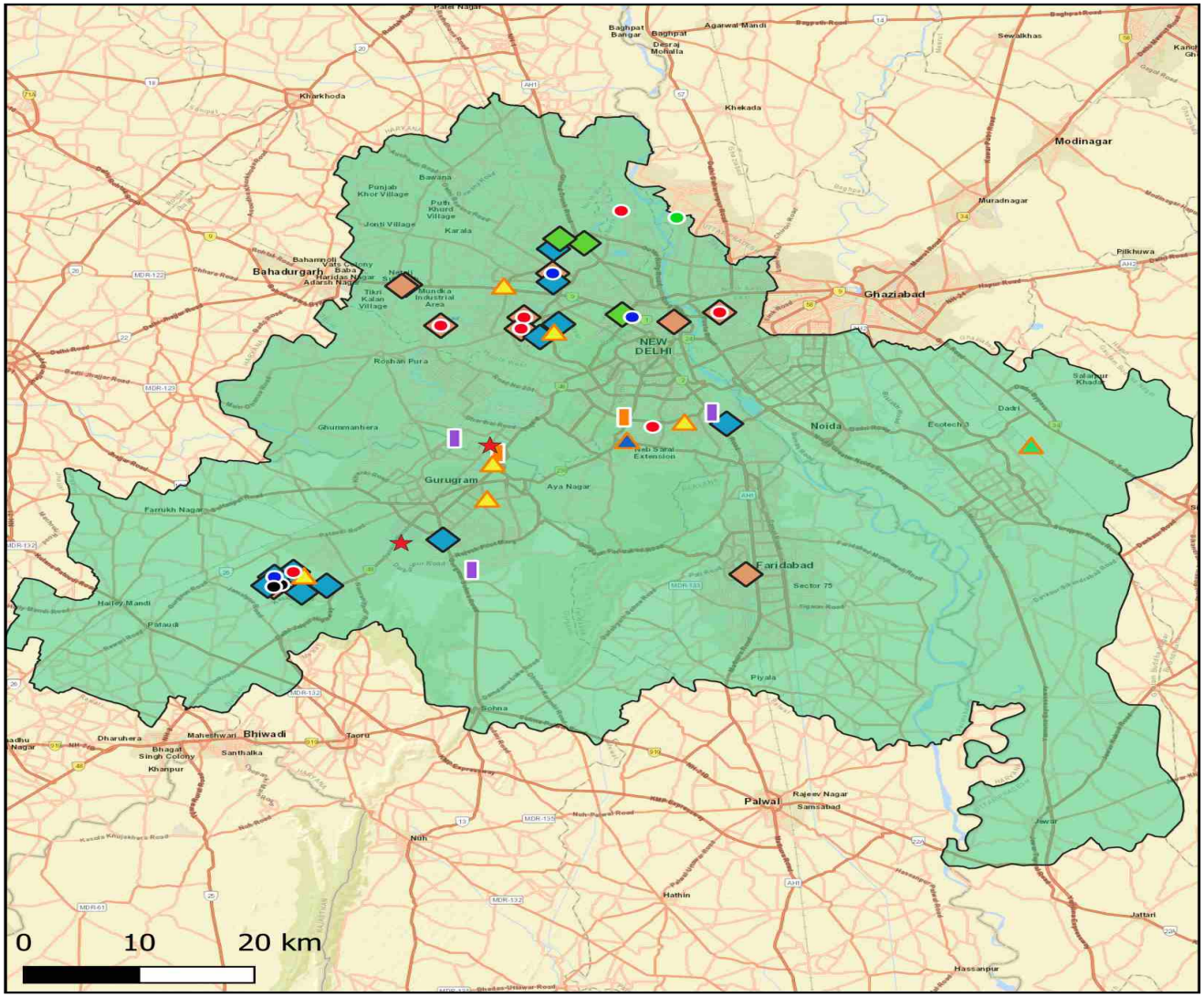
2

Overview of Selected EV Manufacturing Clusters

2.1 Delhi-National Capital Region (NCR)

The Delhi-NCR auto cluster consists mainly of Delhi, Gurugram, and other districts including Sonipat and Noida.

EV Manufacturing Ecosystem in Delhi-NCR



LEGENDS

(Category of Stakeholders)

EV Manufacturing & Assembly

- 2W
- 3W
- 3W & 2W
- 4W
- R&D

EV Components

- Electrical and Electronics Components
- EV Body Components
- EV Spare Parts Traders

EV Battery

- Battery Pack Developer
- Battery Recycler
- Battery Repurposer
- BMS Developer

EV Education/Incubation/Testing Centre

- EV Incubation & Testing Facilitators
- Skill Development and Education

EV Charging

- Charging Solution Providers

Automotive Engineering Services Providers

- Engineering Services Providers

Delhi

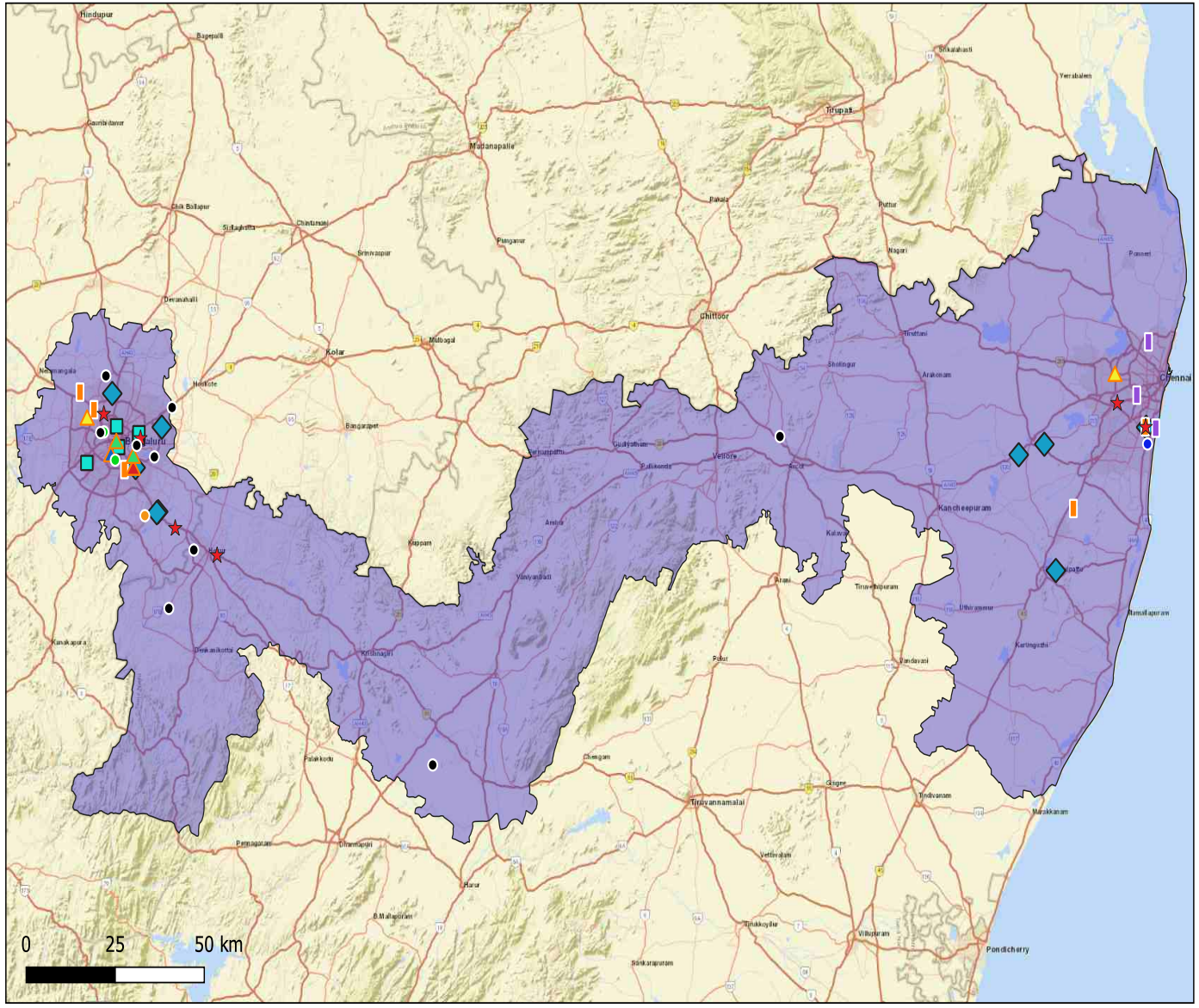
- The national capital New Delhi is known for its large EV consumer market and the availability of skilled workforce.
- Delhi has whole spare parts trading market, that imports the major powertrain components of the electric vehicles and supplies them to the CKD (Completely Knock Down) units in Delhi-NCR region as well as to most of the northern states
- The national guiding and decision-making organisations like the Society of Indian Automobile Manufacturers (SIAM), the Automobile Component Manufacturing Association (ACMA), Society of Manufacturers of Electric Vehicles (SMEV), Bureau of Energy Efficiency and Automotive Skills Development Council (ASDC) are all based in Delhi.
- The EV policy of Delhi focuses on incentivising the purchase and use of electric vehicles, especially two-wheelers and public transport vehicles and goods carriers to drive the large-scale adoption and reduce vehicular pollution.[6]
- Delhi Govt also envisions to make it a training hub for jobs in the EV ecosystem. Vocational courses are being designed to train EV drivers, mechanics, and charging station staff in partnership with auto OEMs and the Energy Operators. Recently, IIT Delhi has also announced to offer M. Tech. course in electric mobility from the year 2021.[7]

Gurugram

- Gurugram is located in the north Indian state of Haryana. It is one of the major satellite cities of Delhi.
- Top automobile companies like BMW, Eicher Motors, Hero, Honda, Hyundai, Yamaha, and Maruti Suzuki have their headquarters, manufacturing plants, and/or training centres in NCR. In the NCR cluster, New Gurgaon and Manesar serve as an adjoining manufacturing hub for Gurugram.
- International Centre for Automotive Technology (ICAT) which is one of the two main vehicle certification agencies is located at Manesar in Gurugram.
- Leveraging the existing supply chain of automobile manufacturing in the cluster, several electric vehicles and their component manufacturing plants have been set up in Manesar, Gurugram including Revolt Motors for electric two-wheeler manufacturing, and Delta Electronics Pvt. Ltd for charging equipment manufacturing.
- Manesar in Gurugram is a well-established hub of Completely Knock Down[8] (CKD) units of e-rickshaws. Body and chassis manufacturers are also prevalent in this cluster. Majority of the manufacturers make the vehicles with metal sheet, while few used Fibre Reinforced Plastic. For chassis ten step process of Electro Deposit Coating was used, that makes the chassis rust proof and increases its durability.
- Some existing OEMs like Hilux Automotive Pvt. Ltd, that has been providing lighting systems for conventional vehicles have now included EV components in their portfolio.
- The EV policy of Haryana (draft) aims to provide a thrust to manufacturing activities in the cluster.

2.2 Bengaluru-Hosur-Chennai (Karnataka, Tamil Nadu)

EV Manufacturing Ecosystem in Bengaluru-Hosur-Chennai



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- 2W
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EV Battery

- Battery Pack Developer
- Battery Recycler
- Battery Repurposer
- BMS Developer

EV Education/Incubation/Testing Centre

- EV Incubation & Testing Facilitators
- Skill Development and Education

EV Charging

- Charging Solution Providers

Automotive Engineering Services Providers

- Engineering Services Providers

Bengaluru

- Bengaluru, the capital city of the Indian state of Karnataka is widely regarded as the "Silicon Valley of India" or "IT capital of India".
- The major E2W players of India like Ola Electric, Ather Energy and Ampere electric vehicles have their manufacturing facilities in this cluster and corporate offices in Bengaluru.
- The city has existence of well-established facilities of Engineering Service Providers, R&D centres and testing labs.
- There are at least 47 start-ups in the city which are working in the EV sector including Ola Electric, Sun Mobility, and Ather Energy.[9]
- Karnataka has a well-established ecosystem for a vibrant automotive sector with a wide pool of technical manpower, robust R&D capabilities, and manufacturing expertise. The government of Karnataka intends to make Bengaluru- the EV capital of India.
- EV policy of Karnataka provides incentives to attract investments for EV manufacturing, support charging infrastructure, R&D, and skill development as well as demand-side incentives.[10]

Hosur

- Hosur is an industrial city located in the north-western part of the district of Krishnagiri in the Indian state of Tamil Nadu. It is also considered the satellite city of Bengaluru and houses several automobile manufacturing industries.
- It is home to major manufacturing industries including Ashok Leyland, Titan, TVS Motors, Caterpillar, Sundaram Fasteners, Schaffler, and many others. Proximity to Bangalore is seen as an advantage by the industry players setting up their units in Hosur
- It is emerging as a hub for EV and its component manufacturing with an advantage of proximity to the port. The players like TVS and Ola have the manufacturing unit for their electric scooter in or around Hosur.

Chennai

- Chennai, the capital city of Indian state of Tamil Nadu is home to some of the best educational institutions in the country like The Indian Institute of Technology Madras, the College of Engineering, Guindy, Anna University and SRM University. This makes it an important part of the EV ecosystem.
- These institutes also provide incubation facilities for several start-ups involved in design and development of EVs and their components. The incubatees can leverage the other facilities available at institutes like EV related courses, testing facility and collaboration with foreign universities.
- The institutes have matured several ideas that have reached from R&D to the product development phase, setting a perfect model for industry-academia linkage. One such example is of Ather Energy which is an IIT Madras born electric scooter start-up.

- By the provisions of Tamil Nadu EV policy, acquisition of land in Tamil Nadu is easier, as there is bipartisan support for industrialisation. Tamil Nadu also offers stamp-duty

- Due to R&D and engineering services support the cluster is emerging as a hub for EV start-ups. There are start-ups into E2W and micro mobility electric vehicles designing, charging solution developing, motor & controller designing, battery manufacturing and battery recycling

Table Degree of prevalence of the stakeholders in a cluster

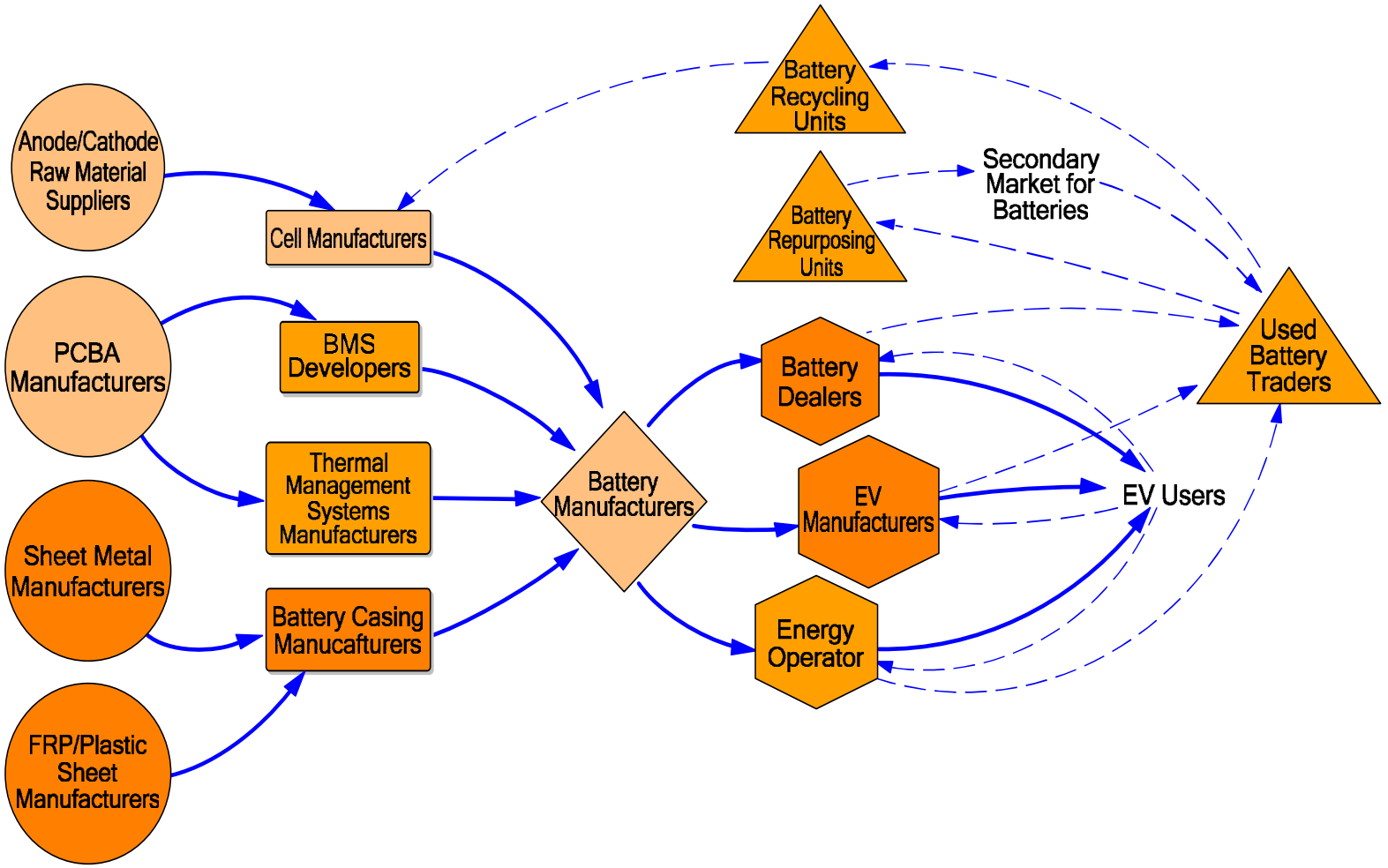
Cluster Composition	Delhi-NCR	Bangalore-Hosur-Chennai
E-3 wheeler manufacturers/assemblers		
E-2 wheeler manufacturers/assemblers		
Body and chassis manufacturers		
EV spare parts traders		
Industry associations		
Sector skill council		
Start-ups into EVs and their component development		
Business incubation centres		
R&D centres		
Testing facilities		
Engineering services providers		
Charging equipment manufacturers,		
Skill development and educational institutes		
Battery pack assemblers		
BMS developers		
Battery recyclers and repurposers		

Most Prevalent Least Prevalent

3

Linkages and Potential Opportunities in the EV Manufacturing Ecosystem

3.1 Battery Manufacturing Subsystem



HOW TO READ THIS INFOGRAPHIC

Shapes denote the type of stakeholder

- Key Component Manufacturer
- Primary component manufacturer of the key component
- Secondary component manufacturer of the key component
- Demand creator for the key component
- Facilitators

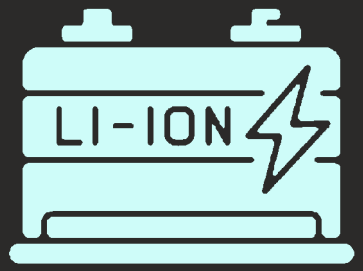
Arrows denotes the type of linkage

- Linkage between two stakeholders
- Linkage between two stakeholders after end of first life of components

Colour denotes the level indigenisation

- Sufficient Indigenisation
- Moderate Indigenisation
- Low Indigenisation

This infographic explores the interlinkages, gaps and potential opportunities in the battery manufacturing subsystem of the EV manufacturing ecosystem.



The two major components of battery manufacturing are Cells and Battery Management System (BMS). These components are assembled along with the thermal management system into the casing to form a battery pack.

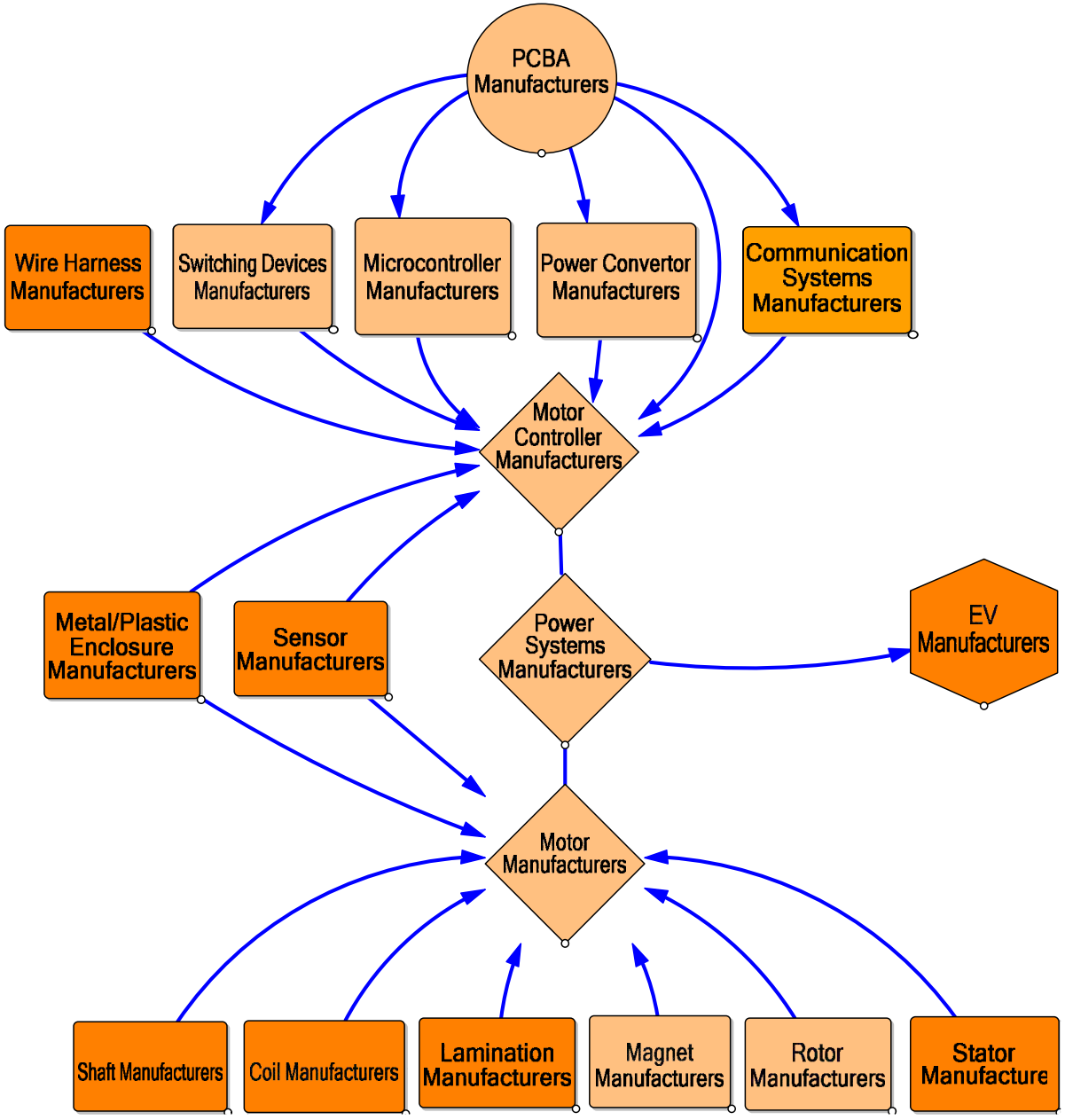
The battery packs are supplied to EV Manufacturers (OEMs), Energy Operators (who facilitate battery swapping) and Battery Dealers, from where it goes to customers with. As per latest Government regulations the batteries may be sold independently or with the vehicles.

After the primary use in a vehicle, the batteries are sold back or exchanged with new batteries from OEMs or battery dealers. The used batteries have around 70% of the capacity of a new battery capacity.[11] Thus, they are repurposed in other applications before the end of their full operational life.

After the end of their full operational life, the batteries go to the certified battery recycling agencies where the constituent materials are recovered and sent back to cell manufacturers. This establishes a circular economy for EV batteries

The recycling of lead acid batteries is prominent in India. In case of lithium ion and other advanced chemistry cell (ACC) batteries the technology of recycling is in its nascent stage since the batteries have not reached their end of life yet.

3.2 Power Systems Manufacturing Subsystem



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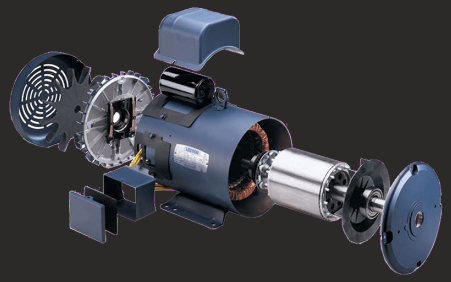


The power system of an electric vehicle consists of two components: the motor that provides the power to the wheels and the controller that controls the application of this power.[12]

The motor converts electrical energy into mechanical energy. Currently, electric vehicles in India use two types of motors, Brushless Direct Current (BLDC) Motors and Induction Motors. However, emerging motor technologies like Axial Flux motors are also being developed by Indian EV startups.

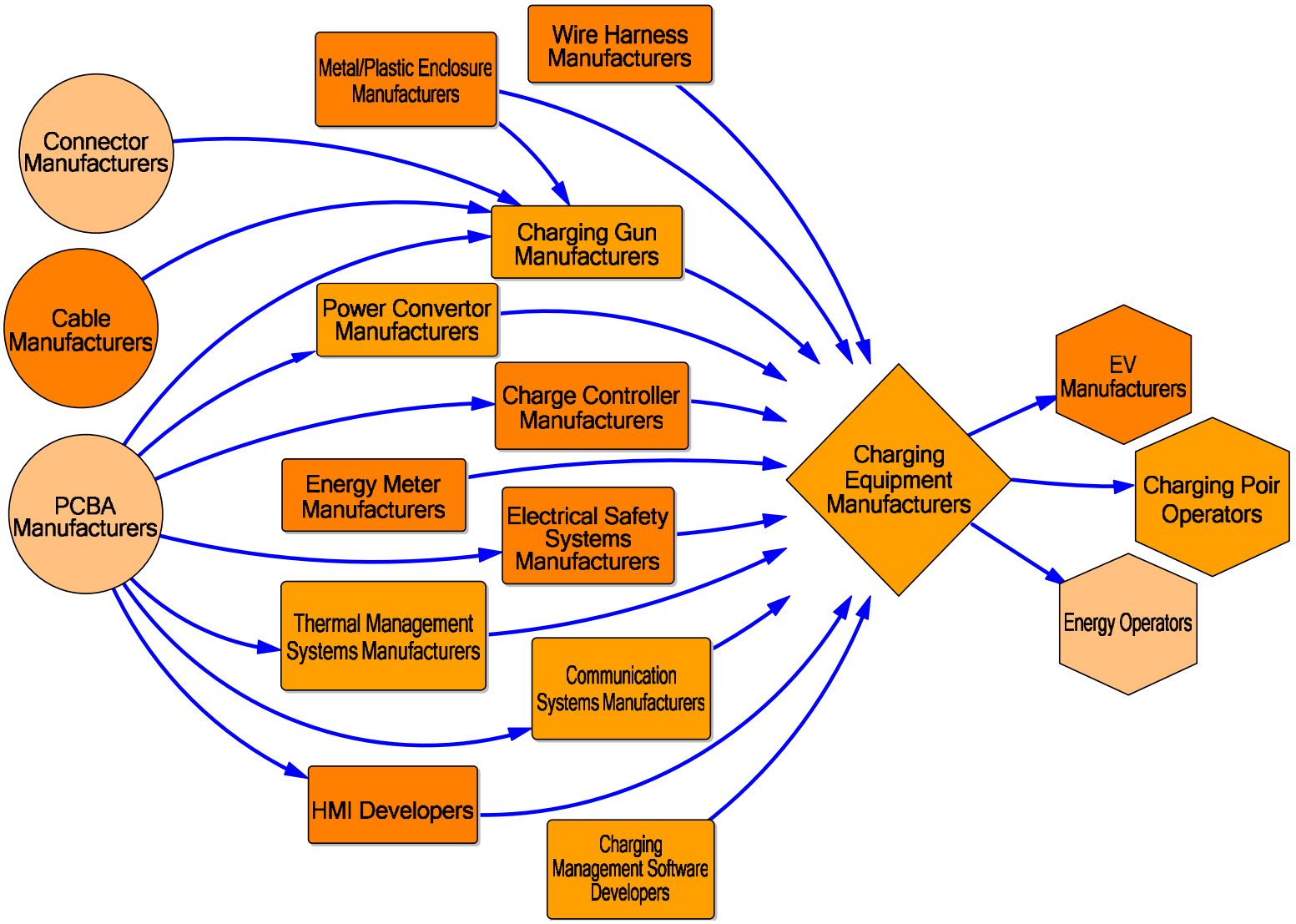
Manufacturers of components like coils, rotors, shafts, stators, lamination, and metal enclosures primarily feed primarily into the manufacturing of a motor.

BLDC motors use permanent magnets made up of rare earth metals. Due to unavailability of raw materials for magnet manufacturing in India the motor component supply chain is highly dependent on imports. Thus, EV motor manufacturing is still in its nascent stage in India.

The motor controller manages the energy flow from battery to motor based on inputs from various interfaces such as throttle or brakes. It primarily consists of power electronics components like microcontroller, power converter, switching devices, sensors, and communication systems.

Printed circuit board assembly (PCBA) is a key component of all power electronics components required in motor controllers. Due to the ongoing semiconductor chip shortage and India's high import dependency for PCBA's the power systems manufacturing supply chain has been impacted, in turn affecting EV manufacturing. However, the Indian Government is taking steps towards indigenisation of semiconductor chip manufacturing and has also introduced a PLI scheme for promoting it.[13]

3.3 Charging Equipment Manufacturing Subsystem



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- Moderate Indigenisation
- Low Indigenisation

This infographic explores the interlinkages, gaps and potential opportunities in the charging equipment manufacturing subsystem of the EV manufacturing ecosystem.

In India, the demand for charging equipment is created mainly by EV manufacturers for portable and on-board chargers, followed by charging point operators for public charging stations and then by energy operators for battery swapping stations.

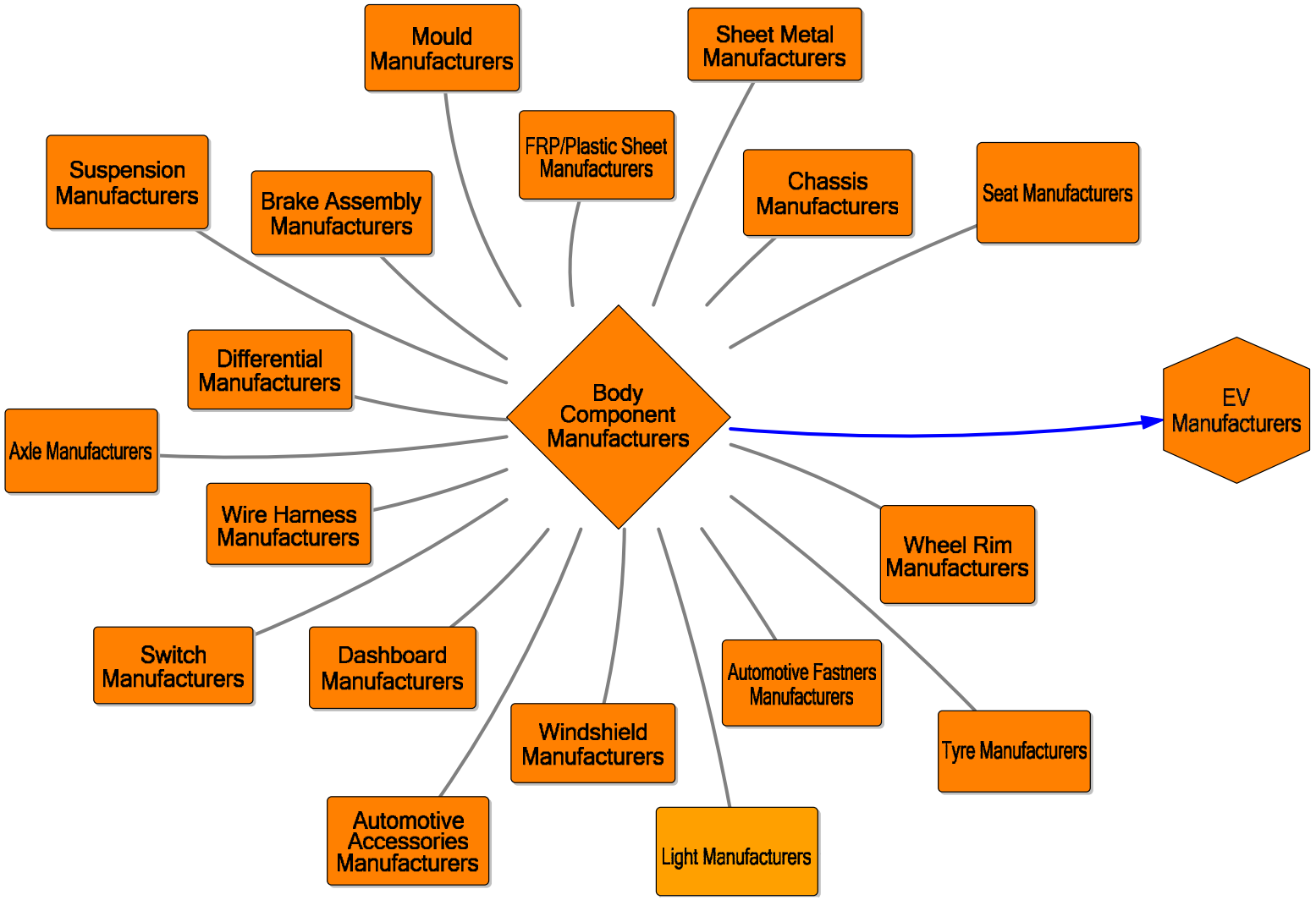
The major components of electric vehicle chargers are: charging guns, wiring harness, power converters, charge controllers, electrical safety systems (E.g. circuit breaker, relay) communication systems (E.g. CAN, Profinet) and a software for managing the whole charging set up.

Charging guns act as the interface between the charging device and the rechargeable battery of the electric vehicle. Connectors are a critical part of a charging gun as it differs across the segments and models of EVs. Due to multiple and complex designs and low volume of production of each type of connector, mould manufacturing for connectors has not been able to achieve economies of scale yet in India. This is a concern for the charging equipment manufacturing ecosystem.

The technological advancements brought about by EVs has led to a high dependence on a software system for managing charging activities including charge diagnostics, energy output, fleet management and billing. This is creating potential opportunities for software development firms to specialise in human machine interface (HMI) and charging management software.

Akin to power systems manufacturing, Printed circuit board assembly (PCBA) is a key component of all power electronics components required in charging equipment. Thus it has also been impacted by the high import dependency and global chip shortage.

3.4 Body Component Manufacturing Subsystems



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- Moderate Indigenisation
- Low Indigenisation

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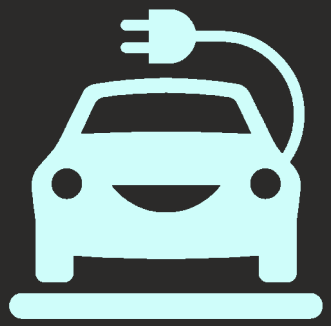

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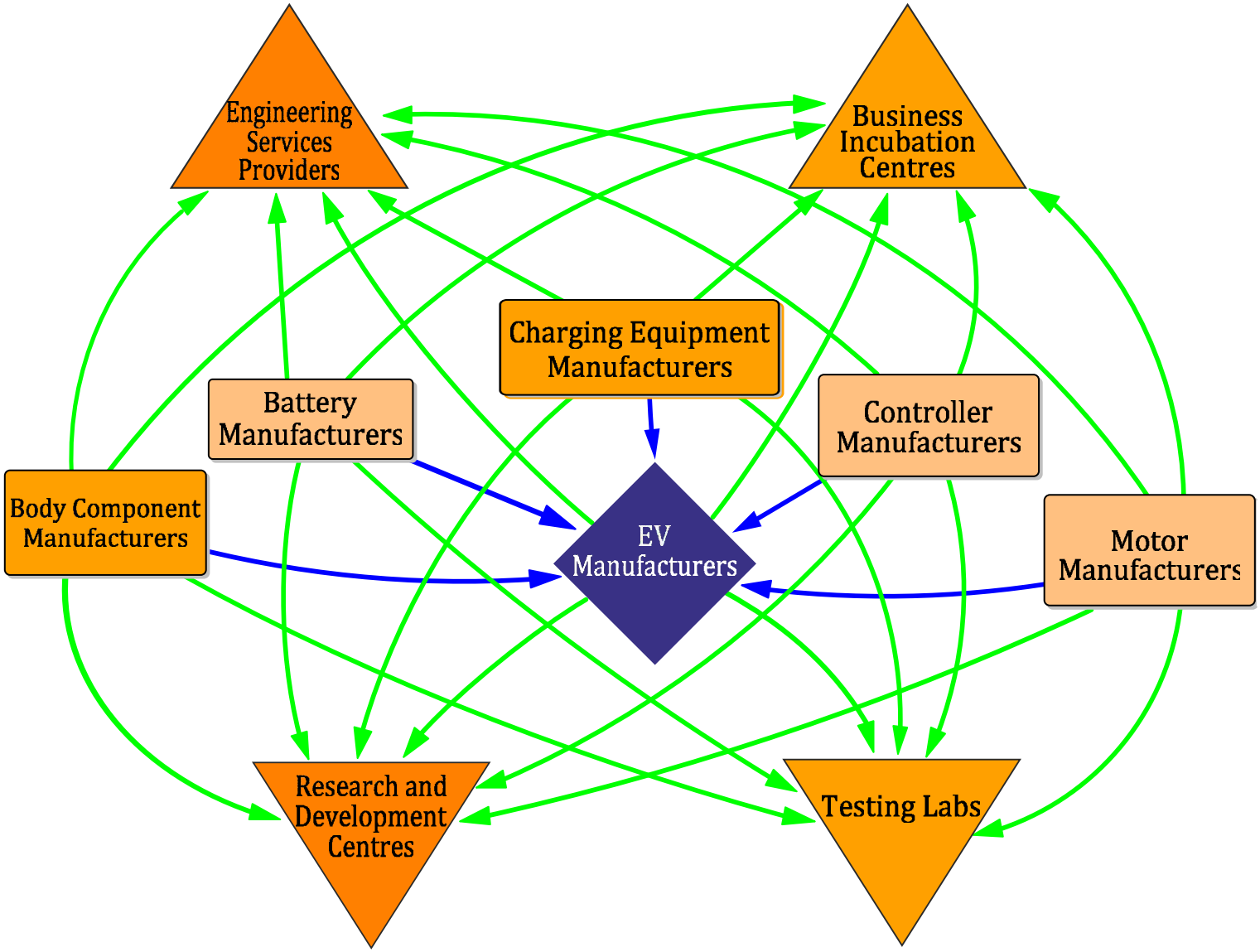
3.5 EV Manufacturing Facilitation Subsystem



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- Secondary component manufacturer of the key component
- Demand creator for the key component
- Facilitators

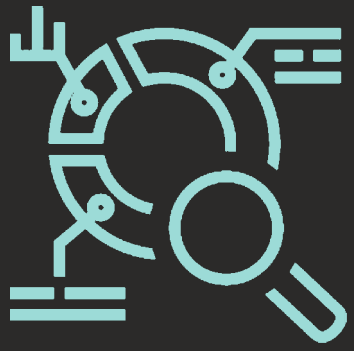
Arrows denotes the type of linkage

- Linkage between two stakeholders
- Linkage between manufacturer and facilitator

Colour denotes the level indigenisation

- Sufficient Indigenisation
- Moderate Indigenisation
- Low Indigenisation

This infographic explores the interlinkages between the key components of the EV manufacturing ecosystem and agencies which are supporting their growth, development and operations



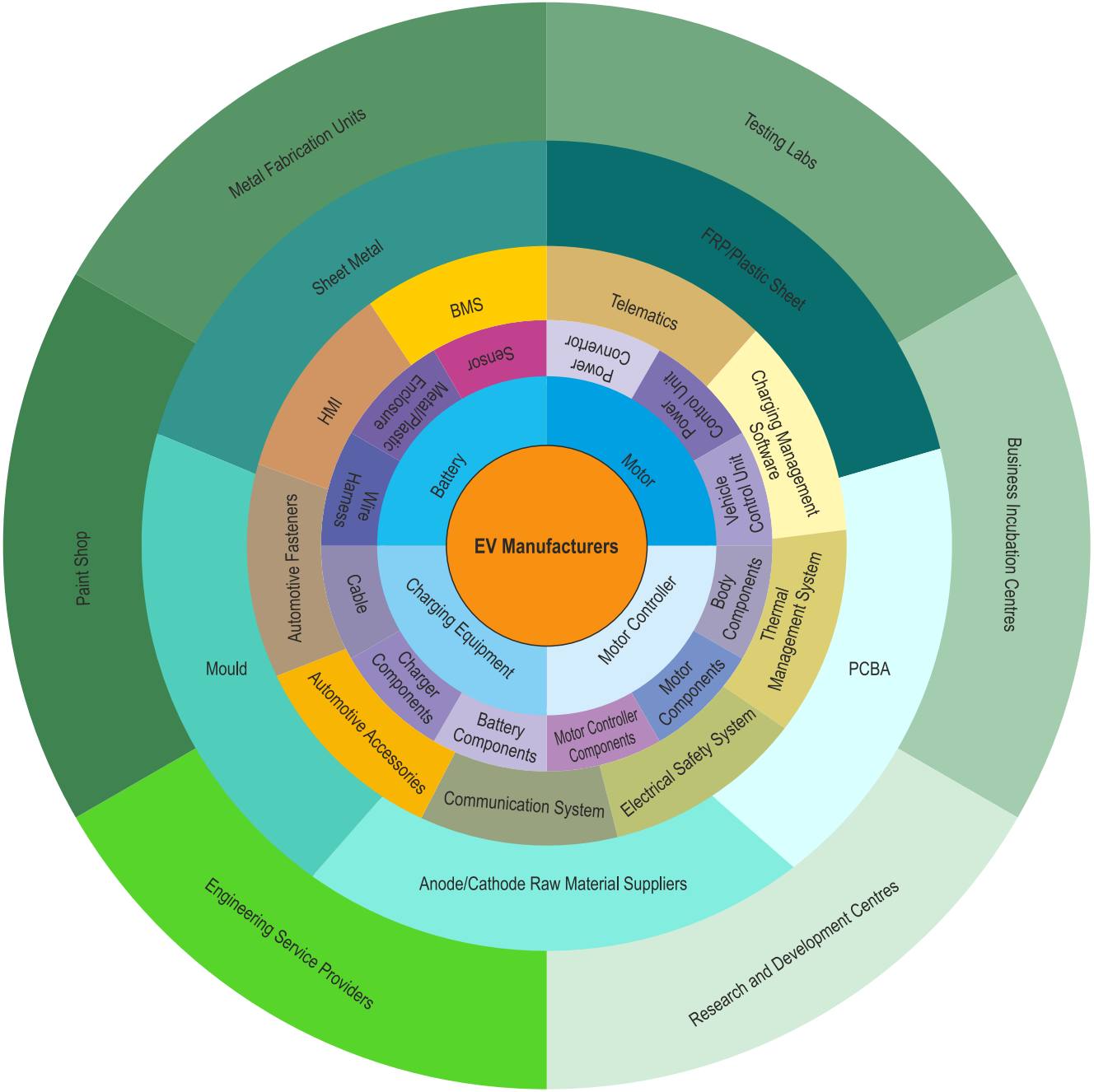
The EV manufacturing space has a fair mix of start-ups as well as large scale automobile manufacturers. However, the given higher dependence on electronic components and software in EVs, small manufacturers and start-ups have emerged as frontrunners of this transition. This has created a need for establishment of a support ecosystem within the EV ecosystem which provides diverse forms of assistance to the manufacturers of EVs or their components at different stages of product design and development.

The support or facilitation ecosystem primarily include

- Engineering Service Providers who provide outsourced technical services including product engineering, firmware development, manufacturing services, PCB design and assembly and mechanical design of a component.
- Research and Development (R&D) centres which foster innovation for continuous improvement in vehicle technology and efficiency. These are mostly associated with academic institutions and are critical for establishing academia-industry linkages.
- Business Incubation Centres which provide the necessary financial and infrastructural impetus to emerging manufacturers and young start-ups. These centres allow companies and ideas to take shape while operating at a lower cost during the early stages of a business.
- Testing Labs which facilitate the validation and certification of product quality. These centres may be present at a decentralised level for providing testing services during the product design and development phase, or at a centralised level to certify the final quality before commercial use of the product.

While Engineering Service Providers and R&D centres have been a part of the conventional automotive and electronics industries, they are currently realigning their scope to include the EV manufacturing ecosystem as well. On the other hand, Business Incubation Centres and Testing labs are currently present in a limited capacity in India and are mostly concentrated in the clusters where there is a focus on technology development (E.g. Bangalore-Hosur-Chennai).

3.6 Complete EV Manufacturing Ecosystem



HOW TO READ THIS INFOGRAPHIC

Each layer represents a group of stakeholders directly or indirectly linked with EV manufacturing with the innermost layer being the stakeholder with most direct involvement in the manufacturing of electric vehicles.

A culmination of the various component manufacturing subsystems, this infographic explores the interlinkages and potential opportunities in the complete EV manufacturing ecosystem.

EV manufacturing has the potential to provide multiple direct and indirect business opportunities and in turn create localised employment. While the core ecosystem consists of electric vehicles and their component manufacturers, the allied ecosystems consist of primary component manufacturers, secondary component manufacturers, auxiliary component manufacturers, raw material suppliers and manufacturing facilitators.

Primary component manufacturers include stakeholders involved in the manufacturing of components which are critical for electric vehicles i.e. batteries, motors, motor controllers and charging equipment. These stakeholders are currently in their nascent stage in India because of an import dependent supply chain. However, the indigenisation of these components will provide multiple opportunities in the core EV manufacturing ecosystem.

Secondary component manufacturers include manufacturers of those components which are required for making the primary components. This group of stakeholders include motor components such as stators and rotors, battery components such as cells and casings and body components such as differentials and suspension, amongst others. While most of these component manufacturers have been present in India for the ICE vehicle supply chain or electronics industry value chain some components specific to EVs such as connectors, cells, etc. are still in a nascent stage in India either due to unavailability of raw materials and infrastructure or due to low demand.

Auxiliary component manufacturers include stakeholders who are involved in the manufacturing of those components which support the structural and functional aspects of EVs. On one hand this includes developers/manufacturers of communication systems and battery management systems (BMS) and on the other hand they also include the manufacturers of automotive accessories and fasteners. These allied activities are as critical as the core components of the EV manufacturing ecosystem but are often part of other manufacturing ecosystems as well.

Raw material suppliers such as sheet metal manufacturers or PCBA manufacturers are those stakeholders who provide the raw materials for all the different components of EVs. They are a critical link in the EV manufacturing ecosystem making their indegenisation crucial if India wants to become self-sufficient in EV manufacturing.

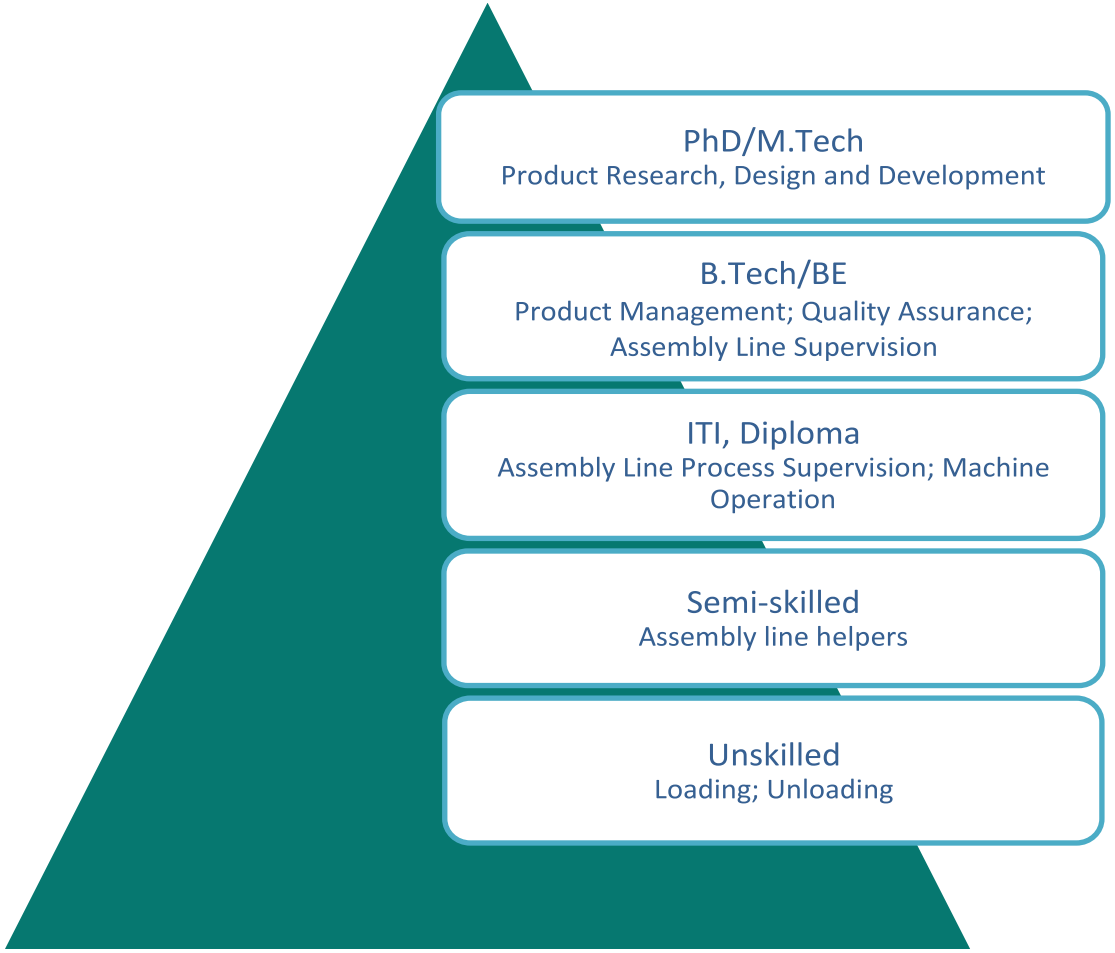
Facilitators of EV manufacturing like engineering service providers, metal fabrication units and R&D centres are those stakeholders which provide support to the other manufacturers in the ecosystem at various stages of design, development and production. They are critical pillars of the ecosystem and are significant for fostering domestic manufacturing capacities.

4

Academia-Industry Linkages in the EV Manufacturing Ecosystem:

Qualifications, Skills and Job Roles

4.1 Skill Pyramid: Linking Academic Qualifications and Job Roles in EV Manufacturing



This infographic explores the different levels of qualification of the workforce and the corresponding job roles available for them in the EV manufacturing ecosystem

- Like in any other manufacturing sector, the level of qualification has a direct linkage with the diversity and complexity of roles available in the EV manufacturing industry.
- The significance of the workforce for a particular manufacturing process is directly proportional to their skill levels.
- In case of roles that require lower qualification, there can be a shift of workforce currently engaged in ICE ecosystem into the respective EV ecosystem without significant upskilling and reskilling. However, for roles that require a higher qualification, specific skills related to various aspects of EV manufacturing become necessary.

4.2 Heat Map: Mapping Skills, Specialisations and Jobs in the EV Manufacturing Ecosystem

The broader roles pertaining to EV and its component manufacturing are as below:

Research:
To improve the performance and efficiency of the vehicles and respective components especially by improving technology and materials.

Manufacturing and Assembly:
To manage specialised manufacturing processes including machine tool operations and assembly.

Design & Development:
To design, manage supply chain quality, test, and integrate components.

Qualification, Roles and Skill Requirement in EV Manufacturing Ecosystem

EV Process/Skill Domain		Mechanical			Electrical			Electronics & Communication			Computer Science			Chemical		
		PhD/ Masters	Bachelors	ITI/ Diploma	PhD/ Masters	Bachelors	ITI/ Diploma	PhD/ Masters	Bachelors	ITI/ Diploma	PhD/ Masters	Bachelors	ITI/ Diploma	PhD/ Masters	Bachelors	ITI/ Diploma
Vehicle	Research															
	Design & Development															
	Manufacturing & Assembly															
Vehicle Control Unit	Research															
	Design & Development															
	Manufacturing & Assembly															
Body and Chassis	Research															
	Design & Development															
	Manufacturing & Assembly															
Battery	Research															
	Design & Development															
	Manufacturing & Assembly															
	Recycling															
	Repurposing															
Battery Management System	Research															
	Design & Development															
	Manufacturing & Assembly															
Motor	Research															
	Design & Development															
	Manufacturing & Assembly															
Controller	Research															
	Design & Development															
	Manufacturing & Assembly															
Charging Equipment	Research															
	Design & Development															
	Manufacturing & Assembly															
EV and its Component Testing																

Most Relevant — Least Relevant

The infographic matches the qualifications and skill domain of the workforce with the relevant manufacturing processes in the EV Ecosystem. It also highlights the degree of relevance of different qualifications for each manufacturing process.[14]

The design, development and manufacturing of a complete electric vehicle requires a mix of skills and specialisations. Mechanical engineers are essential for design and manufacturing of the vehicle parts, thermal management systems and vehicle assembly. Following this, Electronics and Communication engineers are essential for power electronic components and sensors. The skills of Electrical engineers are needed for developing wire harnesses and for quality control. Following this, Computer Science engineers are needed for making IoT modules for sharing real-time data generated by EVs.

Design and development of a VCU requires resources from Electronics and Communication Engineering and Computer Science Engineering for the firmware and algorithms respectively. Additionally, Electrical or Mechanical specialisations are essential for testing and assembly of the components.

EV battery pack manufacturing requires a majority of workforce from Electronics Engineering while a Chemical engineering specialisation is essential for research, development and recycling of cells. In battery recycling other engineering specialisations are also required at the operations stage. In repurposing the key skills required are mainly Electronics Engineering followed by Electrical.

For battery operated EVs, battery management systems play a critical role. Design and development of BMS mainly requires specialisation in electronics and communication for developing firmware. Computer science engineers are also needed for developing algorithms and improving the efficiency of BMS by using Artificial Intelligence.

Engineers for developing EV motors are majorly from electronics background followed by electrical and mechanical. For controllers, there is an equivalent requirement for electronics and electrical engineers followed by mechanical engineers.

EV charging equipment contains power electronics components, and therefore primarily requires electronics and communication engineers. The smart charging stations, which provide features like online booking, payment and LED display for advertisement also require computer science engineers for developing algorithms.

The external testing and certification agencies for EVs and their components require mechanical engineers followed by electronics and electrical engineers respectively.

Manufacturing and assembly for the different components as well as the complete electric vehicle require the engagement of workforce with ITI/Diploma qualifications and respective specialisation for operation of the machines or assembly line supervision.

Emerging qualification hybrids for EV manufacturing

- Bachelor in Computer Science with Masters in Mobility and Vehicle Design
- Bachelors in Mechanical with Masters is Aerospace Engineering
- Bachelors in Electrical with Masters in Electronics and vice versa
- Bachelors in Mechanical, Electrical and/or Electronics Engineering with Masters or training in-
  - MATLAB
  - Simulink
  - User Experience Design
  - Embedded Systems
  - Artificial Intelligence
  - IOT
  - LabVIEW Development
  - VLSI
  - Big Data Analytics
  - Ansys

Prominent multidisciplinary branches related to the primary engineering branches which may be considered by EV design and development enthusiasts

- Automobile/Automotive Engineering: Subdivision of Mechanical Engineering
- Engineering Design: Combination of Engineering fields like Mechanical, Electronics and Computer Science[15]
- Mechatronics: Combination of Mechanical and Electronics
- Instrumentation Engineering: Combination of Engineering fields like Electrical, Mechanical, Electronics and Computer Science[16]
- Production Engineering: Subdivision of Mechanical Engineering

Specialisation courses for EV and its component manufacturing

- Electric Vehicle Design and Analysis
- Computational Fluid Dynamics
- Advanced Driver Assistance Systems
- Control and Automation
- Industrial Engineering
- Power Electronics
- Heat Power
- Material Science Engineering

5

Cluster Comparison

Table 2 Comparison between the selected clusters based on field inquiry

Delhi-NCR	Parameters	Bangalore-Hosur-Chennai
3W of L3 & L5 category which includes cargo and passenger vehicles, plus customised vehicles for garbage collection and food stalls.	**Dominating Segment of EV Manufacturing**	**E-2W**, that includes passenger vehicles and vehicles for last mile connectivity fleets.
The focus is on the mechanical assembly while the software components are outsourced.	**Technology**	The focus is on integrated vehicle development including both the hardware and software components.
Most Prevalent: • E-rickshaw assemblers, • Body and chassis manufacturers, • EV spare parts traders, • Industry association and • Sector skill council • Business incubation centres **Somewhat Prevalent:** • Charging equipment manufacturers, • Skill development and educational institutes **Least Prevalent:** • Testing labs, • Start-ups into motor designing and into EV designing, • Battery pack assemblers, • Battery recyclers and repurposers	**Cluster composition**	**Most Prevalent:** • E-scooter manufacturers, • Start-ups into EV designing, charging solution developers, motor & controller designing, battery manufacturing and battery recycling, • Incubation centres • Testing labs • Engineering services providers which include product engineering, firmware development, IT services, Electronic Manufacturing Service, PCB design and mechanical design. **Somewhat Prevalent:** • Skill development and educational institutes • Charging equipment manufacturers **Least Prevalent:** • BMS Developers, battery pack assemblers • Battery recyclers and repurposers

Delhi-NCR	Parameters	Bangalore-Hosur-Chennai
The e-3W market is quite mature for L3 category. Currently, mass replication of products is taking place. Big players assemble 500-1000 per month. Also, there are several medium and small enterprises who assemble around 100 e-3W per month. Some big players are now entering into the assembly of the L5 category e-3W.	**Current focus**	Innovations are still happening in e-2W design, for making it smarter and more indigenised. Some start-ups like Ather Energy have reached the product development phase while many start-ups are still in R&D phase. Apart from this, many start-ups are into the design and development of EV components including motor, controller, battery, charger and BMS. Few start-ups are also working on technology for battery recycling.
Automotive Skill Development Council; Society of Manufacturers of Electric Vehicles; Statiq, Delta Electronics and Napino Auto (charging service providers); Goenka Electric Motor Vehicles, Letrix EV (e-rickshaw and e-2W assembler); Livguard Drivetrain under SAR Group; Revolt Motors (e-bike developers); CART- IIT Delhi (educational institute and incubation centre); Eco Motors and CY Gold (EV spare parts trader); Hilux (automotive lights manufacturers); start-ups like Quanteon Powertrain and Euler Motors.	**Key players**	Ola Electric, Ampere, Ather Energy and NDS Eco Motors (e-scooter manufacturers); Sema Connect, IPEC, EVRE and RRT Electro Power (charging solution providers); Grinntech and Micronix (battery manufacturers); Sloki Technologies and Zettaone Technologies (engineering services providers); IIT-Madras, IISC Bangalore, SRM University (educational institute and incubation centre); Attero and Li-circle (Battery recycling start-ups); Motorz and Elecnovo (motor and controller designing start-ups); Vaakulabs (BMS developer).
The transportation of EV components is done majorly by road or air. This may increase the logistics cost for importing/exporting components. However, the cluster serves as a hub of EV components for northern India, and hence achieves the economy of scale in importing.	**Import/Export**	The proximity to port has been an advantage for this cluster. Tamil Nadu comes under the top three states in the Export preparedness index 2020 (NITI Aayog)[17]
The EV policy of Delhi focuses on the adoption side and that of Haryana is still in draft stage. The 75 percent reservation of jobs for locals in Haryana has worked well for employment of local people in manufacturing of EVs and its components.	**Policies that are working**	EV policies of Karnataka and Tamil Nadu are finalised and are in implementation stage. The EV policy of Karnataka provides incentives to attract investments for EV manufacturing, support charging infrastructure, R&D and skill development as well as demand-side incentives.

Delhi-NCR	Parameters	Bangalore-Hosur-Chennai
		By the provisions of Tamil Nadu EV policy, acquisition of land in Tamil Nadu is easier, as there is bipartisan support for industrialisation. Tamil Nadu also offers stamp-duty exemption and subsidised land from the state's land bank in SIPCOT (State Industries Promotion Corporation of Tamil Nadu), SIDCO (Small Industries Development Corporation), and TIDCO (Tamil Nadu Industrial Development Corporation).
Since EV assembly is the major activity, it consists workforce from ITI, diploma, and labourers who are semi-skilled and unskilled	**Skills**	Since, the main focus is on R&D therefore it involves workforce from engineering background with B. Tech./BE and/or M. Tech and PhD.
Several start-ups are there in EV space working in co-working facilities in this cluster, providing opportunities for peer-to-peer knowledge transfer. However, R&D facilitation and incubation facilities are in a nascent stage in this cluster.	**Industry-Academia Linkage**	There are several start-ups in EV space that were incubated in educational institutes and have now reached the product development stage in this cluster. Given the presence of an existing start-up ecosystem, R&D facilitation and incubation facilities are quite mature in this cluster.

6

Way Forward: Harnessing the potential of the EV Manufacturing ecosystem

The EV Manufacturing ecosystem has tremendous potential for generating business and employment opportunities in the Indian automotive industry. However, the current focus on import and assembly of components will need to be realigned to domestic design, development and production. This will require a multipronged focus on policies, infrastructure and capacities. As India transitions from ICE vehicles to EVs it is imperative that it will be strengthening its domestic production capacities to be able to self-sufficiently meet the rising demand. Thus, as the transition materialises at multiple levels, a focus on the following aspects will be crucial for making it a booster for local economy and livelihoods.

- Cluster-based development of the EV manufacturing ecosystem: Establishing a localised end-to-end supply chain by creating clusters containing a balanced mix of different component manufacturers, vehicle manufacturers and raw material suppliers along with software developers.
- Standardisation of various EV components: Developing and implementing standards for various components including charger connectors and batteries, as a step towards enabling large scale production.
- Strengthening of domestic manufacturing infrastructure: Creating new manufacturing lines and upgrading infrastructure in existing auto clusters across the country to enable complete manufacturing of electric vehicles and their components, provide better quality assurance and create provisions for localised after-sales maintenance.
- Drafting and implementation of targeted policies: Implementing central and state level policies focussed on incentivising domestic production, such as, PLI schemes and subsidies while ensuring Indian manufacturers are able to become global leaders for manufacturing of those components in which they have a comparative advantage.
- Setting up of decentralised testing and certification labs: Creating a network of localised labs for improving access to testing during the design and development process. Along with that, setting up of regional level certification agencies to reduce the time and cost required for the process while simultaneously enhancing product quality.
- Development of a facilitation ecosystem: Encouraging the establishment of multidimensional facilitators such as incubation centres, R&D facilities, funding agencies for catalysing the growth and development of small and medium businesses and start-ups in the EV manufacturing ecosystem.
- Strengthening of industry-academia linkages: Bringing together industry and academia through industrial training programmes and R&D collaborations for simultaneously developing the forward and backward skill linkages.
- Promotion of diversity and inclusion in the ecosystem: Encouraging gender diversity across the design, development and manufacturing processes to ensure that the end product is inclusive.
- Creation of new partnerships aimed at indegenisation: Fostering Government and Industry level partnerships with other countries for importing raw material instead of manufactured components to ease supply-chain related challenges for domestic manufacturers.

Endnotes

1. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjBqe_Y9tP1AhXPUGwGHQ5KCNkQFnoECAQQAQ&url=https%3A%2F%2Fwww.acma.in%2Fuploads%2Fdoc%2FFAME%25202%2520Notifications_DHI_10th%2520May%25202019.pdf&usg=AOvVaw1nRHEtTKzKKI_NJNJFnUcY
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7. https://indianexpress.com/article/education/iit-delhi-to-offer-new-mtech-course-in-electric-mobility-from-this-year-7352419/
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13. https://jmkresearch.com/emiconductor-chip-shortage-will-it-put-brakes-on-indias-growing-ev-momentum/
14. The scope of this analysis is restricted to the core EV manufacturing processes and engineering qualifications and does not extend to ancillary processes or qualifications relevant for those.
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About the Project

In the times of a global discourse on sustainable development and lowering carbon footprints, the shift to cleaner alternatives in terms of transport is critical. A paradigm shift is imminent, given the role played by transport in an economy and the plethora of negative externalities on the environment and human health, associated with the use of traditional vehicles that operate on combustion of fossil fuels. Electric mobility has been the chosen way forward in most of the developed countries and has also been gaining traction in India, aided by enthusiasm from the businesses and the government.

This paradigm shift in mobility may open the gateways for new business opportunities and lead to the creation of a novel job ecosystem. Thus, a just transition would require a fair assessment of livelihood opportunities being affected and potential opportunities being generated.

This project aims to explore the nature and quantum of job losses due to Electric Vehicle integration at a city level & also the nature of new jobs & skills required due to it. This will help inform the pathways to a just transition which is socially, economically, environmentally and politically acceptable and viable.

For more information, please visit:
https://cuts-ccier.org/exploring-the-impact-of-electric-mobility-on-the-jobs-ecosystem/

CUTS International

Established in 1983, CUTS International (Consumer Unity & Trust Society) is a non-governmental organisation, with its Mission: Consumer Sovereignty in the Framework of Social Justice and Economic Equality and Environmental Balance, within and across Borders.

For details, please visit:
http://www.cuts-international.org.

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