SAARC Energy Centre, Islamabad

Pakistan

THE REPORT

Video Conference to Disseminate the Study on "Assessment of Industry Readiness for Manufacturing of Battery Electric Vehicles in SAARC Countries"

29th September, 2020

Organized by
SAARC Energy Centre Islamabad

29th September, 2020

SAARC Energy Centre
697, Street 43, Sector E-11/4 (NPF),
Islamabad, Pakistan
www.saarcenergy.org

Introduction

1. SAARC Energy Centre (SEC), successfully conducted a Video Conference to disseminate the Study on "Assessment of Industry Readiness for Manufacturing of Battery Electric Vehicles in SAARC Countries" on 29th September 2020. Video Conference Agenda is available at Annexure-I.

2. Battery Electric Vehicles (BEVs) can assist in improving efficiency in electricity systems through storage and demand-response services. The use of BEVs can reduce local air pollution and country's share in global carbon emissions. It also helps in lower spending on fossil fuels which are, in case of most SAARC Member States, imported from abroad at the expense of precious foreign reserves. In this context SEC conducted a study on "Assessment of Industry Readiness for Manufacturing of Battery Electric Vehicles" in 2019.

3. The purpose of this video conference was to disseminate the study report to the audiences. This video conference was aimed towards getting feedback from member states for value addition in the study report, and to build awareness among Member States. The study authors and other experts shared their research and knowledge through presentations.

Participation

4. The Video Conference was attended by 37 professionals representing public sector organizations, representatives of Regional/International organizations, academia, private sector, and other stakeholders within and outside SAARC region. The study authors from the Lahore University of Management Sciences (LUMS) Pakistan, Indian Institute of Management Bangalore (IIMB) India, and other experts shared their research and knowledge through presentations. The participants list is available at Annexure-II.

Description

5. The Video Conference was started with welcome remarks by Program Coordinator, Dr. Tanvir Ahmad, Programme Leader (Technology Transfer) of SAARC Energy Centre. Afterwards, he invited Dr. Shoaib Ahmed, Deputy Director SEC to deliver the Opening Remarks on behalf of Director SEC. After the Opening Remarks, the Program Coordinator read out the Agenda of the Video Conference which comprised of presentations by the Resource Persons. Each presentation was followed by a brief Q&A session. The Program Coordinator read out

findings/Conclusions, which were gathered during the Video Conference. Before closing the Video Conference, Dr. Shoaib Ahmed on behalf of Director SEC offered remarks of appreciation to all the participants and Resource Persons.

Technical Proceedings

6. The video conference hosted talks and presentations from four experts (two study authors and two reviewers). The experts list is available at Annexure III. The presentations delivered during this video conference are available at Annexure IV. These presentations are also available at SEC's website http//:www.saarcenergy.org. A brief information on the content of the delivered presentations is as follows:

Presentation 1 – Industry Readiness for Manufacturing of Battery Electric Vehicles in Pakistan

Dr. Muhammad Shakeel Sadiq Jajja, Associate Professor, Lahore University of Management Sciences (LUMS) Pakistan

7. Dr. Muhammad Shakeel Sadiq Jajja is an Associate Professor of Operations and Supply Chain Management and Director of Executive MBA program at the Suleman Dawood School of Business at Lahore University of Management Sciences, Lahore. His research work has been published in top tier international journals. Dr. Jajja has participated in Global Colloquium on Participant-Cantered Learning at Harvard Business School. He has also received Doctoral Fellowship of Association of Management Development Institutions in South Asia. Prior to joining LUMS, Dr. Jajja has also worked with IBA Karachi, PNRA, PIA, Atlas Honda, and Dawood Hercules Chemicals Limited Pakistan.

8. In his presentation, he presented an assessment of industry readiness for manufacturing of BEVs in Pakistan. He informed the participants about different Original Equipment Manufacturers (OEM) and research organizations for BEVs in Pakistan. Dr Jajja concluded that initial target markets in Pakistan shall be Two/three wheelers, commercial vehicles and institutional customers.

9. He further concluded that first demand shall be generated in the country for BEVs, only then will the manufacturing industry flourish. He finished his presentation with the argument that lessons learnt as well as best practices for indigenizing the tractors manufacturing industry can be used for promotion of BEVs in Pakistan.

Presentation 2 – Industry Readiness for Manufacturing of Battery Electric Vehicles in India

Dr. Haritha Saranga, Professor, Indian Institute of Management Bangalore (IIMB), India

10. Dr Haritha Saranga is a Professor at the Indian Institute of Management Bangalore (IIMB), India. She has been awarded IIMB Chair of Excellence for her contribution to research and teaching excellence at IIM Bangalore. She also chairs the 'Doctoral Programme' at IIM Bangalore. She is a Fellow of MIRCE Academy, Exeter, UK, and a recipient of the T.E. Filbee Research Fellowship. She has published several articles in top-tier international journals, has also co-authored a book, titled Reliability and Six Sigma, and has written many cases and book chapters.

11. Dr. Haritha apprised the participants about Indian market readiness for manufacturing BEVs. She explained different case studies, ongoing projects in both the public and private

sectors. She also explained a case study from the IIMB, where manual bicycles are converted to electric bicycles increasing the efficiency by manifolds.

12. She informed the participants about phase-II of the FAME policy of the Indian Government. The Indian government is focusing on converting public transportation into electric vehicles with the help of private sector. Dr Haritha also concluded that the governments in SAARC Member States must make policy to generate demand for BEVs, which in turn will flourish the local industry for BEVs manufacturing.

Presentation 3 – Present Eco-system of BEV manufacturing: Challenges & Opportunities

Mr. Pinal Satish Mehta, Associate Director, CRISIL Research India

Mr. Pramit Pal, Senior Research Analyst – Customised Research, CRISIL Research India

13. The final presentation was delivered by experts from CRISIL Research India, who were also the reviewers of the study being disseminated in the video conference. Both experts have vast experience in renewable energy and BEVs, specifically in the context of SAARC region.

14. The presentation started with explanation of major pillar for enabling BEV manufacturing in a country. This was followed by detailed description of the stakeholders involved in manufacturing of BEVs. China is leading in almost every aspect of manufacturing BEVs. This includes readiness status of the industry, access to global supply chains, regulatory and policy incentives for BEV manufacturing. However, USA and EU are also investing heavily in BEV technologies.

15. The CRISIL team concluded that globally, EV growth is expected to remain strong; new innovation in battery technologies and scaling up of manufacturing capacities will help companies and countries achieve economies of scale, thereby reducing EV costs. The SAARC Member States shall come up with the right policies and improved investments for promoting the local industries for manufacturing of BEVs.

Discussion and Conclusion

Dr. Tanvir Ahmad, Programme Leader (Technology Transfer)

16. Dr. Tanvir Ahmad thanked everyone for attending the Video Conference. He informed the participants that there is great potential for manufacturing of BEVs in all SAARC Member States. He stated that there are numerous advantages of BEVs which includes reduced fuel consumption, environment friendly technology and preservation of natural resources of Member States.

Closing of Video Conference

Dr. Shoaib Ahmed, Deputy Director (Coord), SAARC Energy Centre

17. Dr. Shoaib Ahmed on behalf of the Director SEC thanked all the Resource Persons for delivering excellent presentations and their excellent response to the queries raised by the participants. He informed all the participants that the presentations and recording of the Video Conference proceedings will be available on SAARC Energy Centre's website (www.saarcenergy.org). He requested the participants to submit suggestions/comments for any further improvement of these Video Conferences and suggest new topics to SEC. He closed the Video Conference with a thank you note to everyone attending the Video Conference.

Annexures

Video Conference Agenda

Video Conference to Disseminate the Study on "Assessment of Industry Readiness for Manufacturing of Battery Electric Vehicles in SAARC Countries"

Tuesday, 29th September 2020

Time Slot	Contents
1300 – 1305	Introduction
1305 – 1310	Opening Remarks Mr. Mohammad Naeem Malik Director, (SAARC Energy Centre)
1310 – 1345	Industry Readiness for Manufacturing of Battery Electric Vehicles in Pakistan Dr Muhammad Shakeel Sadiq Jajja Associate Professor, Lahore University of Management Sciences (LUMS) Pakistan
1345 – 1355	Q & A
1355 – 1430	Industry Readiness for Manufacturing of Battery Electric Vehicles in India Dr Haritha Saranga Professor, Indian Institute of Management Bangalore (IIMB), India
1430 – 1440	Q & A
1440 – 1515	Present Eco-system of BEV manufacturing: Challenges & Opportunities Pinal Satish Mehta and Pramit Pal CRISIL Research India
1515 – 1525	Q & A
1525 – 1540	Report Feedback Session
1540 – 1550	Conclusion and Recommendation
1550 – 1600	Closing Remarks by Director SEC

Information for the participants:

1. All times mentioned in agenda are according to Pakistan Standard Time (PST). The participants from other Member States may attend video conference by following their own national time. The time conversion for all Member States is given below for reference:

Country	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Sri Lanka
Local time	(PKT-00:30)	(PKT+01:00)	(PKT+01:00)	(PKT+00:30)	(PKT+00)	(PKT+00:45)	(PKT+00:30)

2. The participants can ask questions to presenters by typing questions or clicking to the Raised Hand option into the Attendees Pane of the main window of GotoWebinar software. You may send in your questions at any time during the presentations; we will collect these and address them during the Q&A session at the end of each presentation.

3. All participants can also submit comments/views and/or observations on this video conference to SAARC Energy Centre through email to Dr. Tanvir Ahmad, Programme Leader (Technology Transfer) (pltt@saarcenergy.org).

List of Participants

Sr.No.	First Name	Last Name	Email Address
1	Jahanzeb	Hassan	adminofficer@saarcenergy.org
2	Abdul	Wahab	deo@saarcenergy.org
3	Dr. Saddar	Mohazzam	md@neeca.gov.pk
4	Dr. Shoaib	Ahmed	ddcoord@saarcenergy.org
5	Mehnaz	Khurshid	cs@saarcenergy.org
6	Syed	Hassan	zahoor@lums.edu.pk
7	Baber	Siddiqui	baber.siddiqui@psopk.com
8	Pinal	Mehta	pinal.mehta@crisil.com
9	Azfar	Yazdani	asfar.yazdani@psopk.com
10	Huma	Kamran	soniahuma2005@gmail.com
11	Muhammad Adnan	Akram	adnan_akram@millatgears.com
12	Pramit	Pal	pramit.pal@crisil.com
13	Abdul	Wahab	wahab.saarc@gmail.com
14	Mohsen	Entezary	imentezary@gmail.com
15	Majid	Ali	engr.majidali.baig@gmail.com
16	Engr. Farman	Azhar	farman.azhar05@gmail.com
17	Bushra	Sardar	sardarbushra@yahoo.com
18	Shakeel	Abbas	engrabbas100@gmail.com
19	Muhammad	Aamir	muhammad.aamir@fecid.paf-iast.edu.pk
20	Qamar	Malik	qamar.malik@abbottenergy.ca
21	Faiz	Bhutta	faiz.bhutta@gmail.com
22	Nimal	Perera	nimal_pr@sltnet.lk
23	Nazeer	Muhammad	nazeer_saadi@yahoo.com
24	Waliur	Rahman	wali.heritage@gmail.com
25	Dr Bhupendra Kumar	Singh	bhupendra.singh@cii.in
26	Abdul Hasib	Chowdhury	hasib@eee.buet.ac.bd
27	Haritha	Saranga	haritha.saranga@iimb.ac.in
28	Tanvir	Ahmad	pltt@saarcenergy.org
29	Bhaskar	Pradhan	plet@saarcenergy.org
30	Tula	Poudel	poudeltula123@gmail.com

Sr.No.	First Name	Last Name	Email Address
31	Shifaat	Rehman	shifaatqurtuba@gmail.com
32	Hizbullah	Khan Jadoon	hizbullahkj1998@gmail.com
33	Danyal	Ahmad	danyal.ahmd786@gmail.com
34	Dr. Shakeel Sadiq	Jajja	ssj@lums.edu.pk
35	Dr. Naseem	Iqbal	naseem@uspcase.nust.edu.pk
36	Ahmad	Talha	rftt@saarcenergy.org
37	Milabh	Shrestha	milabhivanovic@gmail.com

List of Resource Persons in Video Conference

Sr. No.	Name	Designation	Organization	Country	Email address
1.	Dr. Muhammad Shakeel Sadiq Jajja	Associate Professor	Lahore University of Management Sciences (LUMS)	Pakistan	ssj@lums.edu.pk
2.	Dr. Haritha Sanga	Professor	Indian Institute of Management Bangalore (IIMB)	India	haritha.saranga@iimb.ac.in
3.	Mr. Pinal Sathish Mehta	Associate Director	CRISIL Research	India	pinal.mehta@crisil.com
4.	Mr. Pramit Pal	Senior Research Analyst	CRISIL Research	India	pramit.Pal@crisil.com

Presentation 1 – Industry Readiness for Manufacturing of Battery Electric Vehicles in Pakistan

Dr. Muhammad Shakeel Sadiq Jajja, Associate Professor, Lahore University of Management Sciences (LUMS) Pakistan

Industry Readiness for Manufacturing of Battery Electric Vehicles in Pakistan

Dr. Syed Zahoor Hassan (Lahore University of Management Sciences)
Dr. Shakeel Sadiq Jajja (Lahore University of Management Sciences)*
Dr. Haritha Saranga (Indian Institute of Management Bangalore)

This research was mainly funded and supported by SAARC Energy Center Islamabad.

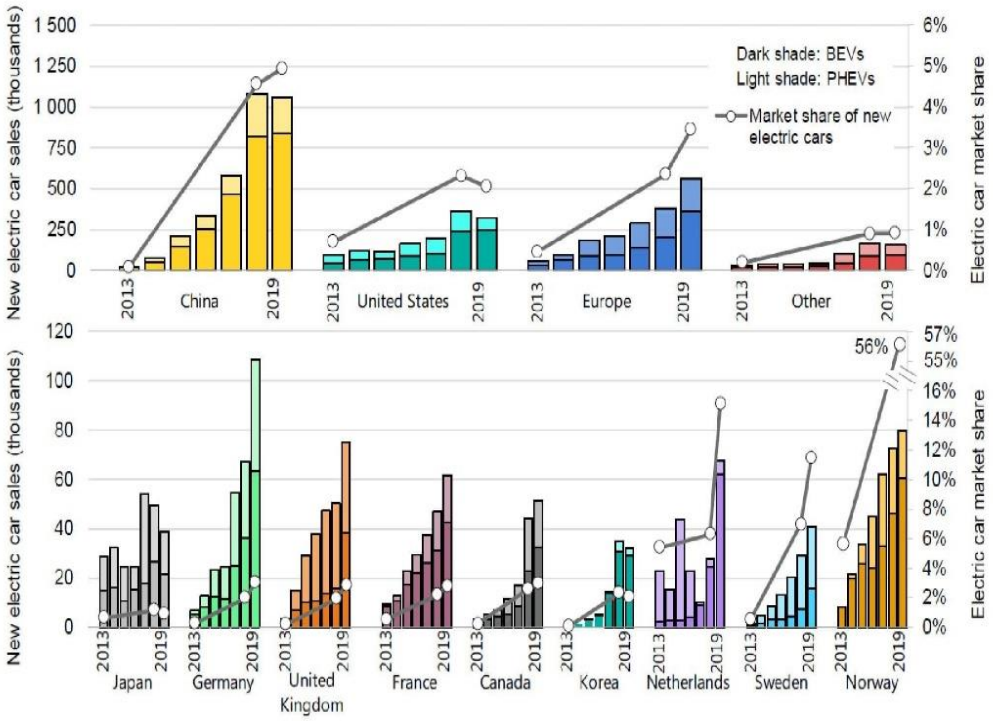
Research Objectives

- Collect the auto industry insights for potential transition towards BEV manufacturing through field survey/interviews.
- Analyze the field findings and develop a baseline information for the Member State about:
  - where they stand right now
  - elements having potential to become strength in BEV value chain.
- Recommend improvements to strengthen the competitiveness of local auto industry in respect to manufacturing of BEVs

Global Trends

- Electric mobility is expanding at a rapid pace globally.
- In 2018, the global electric car fleet exceeded 5.1 million, up 2 million from the previous year and almost doubling the number of new electric car sales.
- Battery electric vehicles (BEVs) account for 64% of the world's electric car fleet
- The People's Republic of China remains the world's largest electric car market, followed by Europe and the United States
- Norway (2018) and Germany (2019) - the global leader in terms of electric car market share in sales
- Vision 30 @ 30 – Aims to reach 30% EV market share by 2030. Signatories: China, Japan, Finland, France, Netherlands, Sweden, India…

Global Trends – Sales and Market Share, 2013-19



Global Trends – Key Benefits

- Energy efficiency: Three-to-five times
- Oil bill: Reduce economic reliance on oil-based fuels
- Air pollution: BEVs have zero tailpipe emissions and can address pollution issues, especially in urban areas and along road networks
- Green House Gas emissions: Significant reductions especially from road transport relative to ICE vehicles
- Noise reduction: Quieter than ICE vehicles, especially in the two/three-wheeler category

Global Trends – Regulatory Drivers of Diffusion

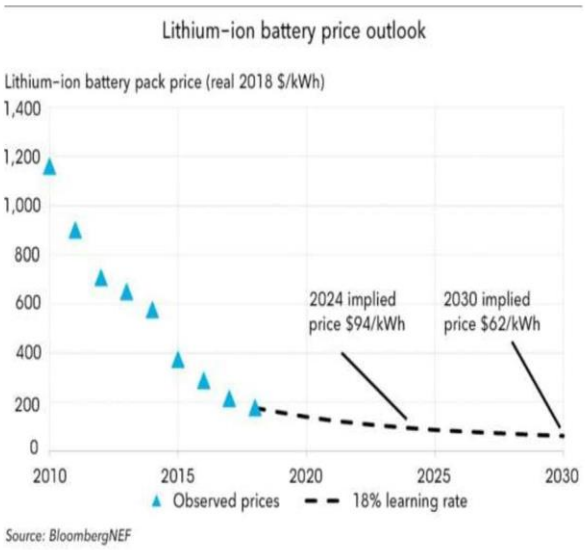
- Policy measures used by leading countries:
  - **Fuel economy standards** e.g., Corporate Average Fuel Economy and ZEV mandate in U.S.A
  - **Fiscal Incentives** e.g. tax credits and subsidies to manufacturers and consumers for zero- and low-emissions vehicles
  - **Economic Instruments** e.g., free registration or license plates, lower toll or parking fees, and access to bus lanes to boost the value proposition of EVs
- Globally policy support is being used to address the strategic importance of the **battery technology value chain**.

Global Trends – Regulatory Drivers of Diffusion

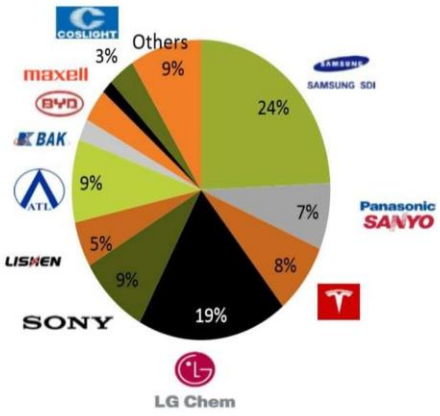
- **Procurement Programs:** To stimulate demand and to introduce publicly accessible charging infrastructure
  - **Shenzhen** government mandated operators to go electric, **16000 electric buses** operate, the largest-scale electric bus transition observed in a city.
  - Europe: **100 electric buses** on routes in the **Schiphol Airport** area in the Netherlands
- **Infrastructure Support Policies**: Buildings, parking lots, publicly accessible places, and highway
- **Adoption of standards** to facilitate inter-operability of various types of charging infrastructure.

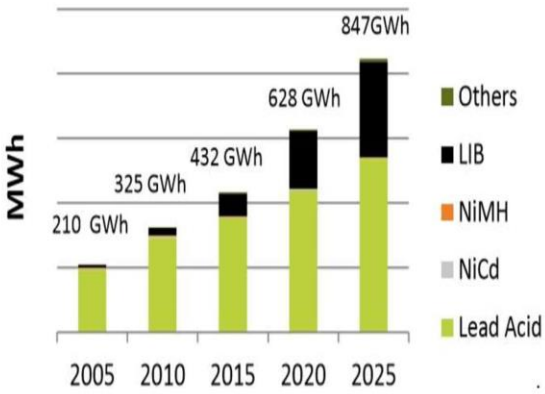
Global Trends – Battery's Declining Prices

- Improvements in battery productions and chemistry
- Increased scale of production in manufacturing plants
- Redesign of vehicle manufacturing platforms using simpler and innovative design architecture
- Digital technologies adapting battery capacity size to user needs
- Improvements in Lead-Acid batteries
- Graphene Technology
- Supercapacitor (SC)



Global Trends – Battery Market Share





Lithium Ion Battery Market Share

Global Trends – China

- The biggest manufacturer of EVs
- The biggest market for EVs (approx. 3 x US)
- Buys more than half of the world's new electric cars
- Target of 5 million EVs by 2020
- New Energy Vehicles (NEV) mandate: OEMs must earn enough credit to match 12% of their output
- Roadmap for NEV sales share: 7-10% by 2020, 15-20% by 2025 and 40-50% by 2030
- Proposal for tightened fuel economy standard for cars (100km/4L by 2025)

Global Trends – China's EVs/Battery Manufacturing Facts

- Leads two-wheeler EVs market: produced 26 million units and an estimated stock of 250 million units (1/4th of the global stock) in 2018
- Domestic OEMs have 94% market
- Incentives being phased out in recent years as industry matures and cost of production falls.
- Investment in battery manufacturing is most notable in China
- 80% share in global Lithium supply in 2020 up from 25% in 2016
- Least cell manufacturing cost in the world at $217/kWh.
- 90% of the EVs produced by Chinese manufacturers use locally made lithium-ion cells
- Foreign OEMs and vendors must form JVs with local firms to enter the Chinese market

Global Trends – China's EVs OEMs (BYD) – Others

- Shenzhen-based manufacturer BYD - world's largest electric vehicle manufacturer for the past three years running, in both consumer and industrial EVs.
- Revenue : 130.05 Bn Yuan and 20% market share in 2018
- BYD – vertical integration strategy- has the world's biggest battery plant in China
- BYD main supplier of electric buses in North America, Europe, Latin America
- Announced production of 0.6 million electric car sales in 2020.

Entrepreneurial ventures

- Power Electronics Pakistan (PEP), Lahore
  - Three wheeler (E-Rickshaw)
  - Converted normal open rickshaw into electric
  - Controller and wiring by PEP
  - Closed premises usage
- Jolta, Lahore
  - Two wheeler (70, 100, 125) and closed three wheeler
  - Controller and battery management system developed locally
  - EV Kit (battery, battery management system, DC motor, and controller)
  - Technology partner
  - Testing on logistics fleet
  - Working on Graphene based technology

Entrepreneurial ventures

- S. Zia ul Haq & Sons (SZS), Karachi
  - Importing and making of four (cars, vans, pickups) and two (scooters) wheelers
  - Targeting same prices as ICE based vehicles
  - Seeks to localize battery and chargers manufacturing
  - Complete built unity => Semi knock down => Complete knock down
  - Working on motors in Gujrat/Gujranwala
- InerZ, Islamabad
  - Research, design, and engineering company
  - Efficient battery pack (space, cost and energy)
  - Targeting 70cc bike and price
  - Prototyping and test stage
  - Large scale commercial vehicles fleet e.g., TCS

Existing Automobile Manufacturers (Perspectives)

- Sazgar Engineering
  - Current focus on ICE and BEVs (three and four wheelers)
  - Developed a prototype of electric three wheeler (lightened body)
  - Price is highly dependent on battery
- Omega Industries (Road Prince)
  - Current focus on ICE based vehicles
  - Developed hybrid two wheeler about four years ago
  - Focus on demand – allow import – ensure buyers (remove license, registration free, school/college/university students)
  - Development will naturally begin: Import => reverse engineering => design
  - Begin from: 3 wheeler, commercial, and possibly lead acid to reduce cost

Existing Automobile Manufacturers (Perspectives)

- Nishat Hyundai
  - Current focus on internal combustion engine (ICE) based vehicles
  - Putting plant together before June 2021 to benefit from Auto Development Policy 2016-21
  - Initial demand points: commercial three and four wheelers
- Atlas Group
  - Continuing focus on ICE based vehicles
  - Principal led
  - Battery business is OEM driven: Lead acid => Maintenance free => Li ion
  - Pathway: CBU => SKD => CKD => Assembly => Parts
  - Initial demand point: four wheeler cars (trend setters)

Component manufacturers (Current Situation)

- Battery
  - Treet Daewoo (Lead acid: deep cycle and maintenance free batteries)
  - Atlas (Lead acid)
  - Some effort towards importing and assembling Li ion cells is happening
  - Challenge is optimization of energy density, charging time, price, temperature, efficiency (temperature sensitive), weight, life cycle, …
  - Graphene based technology and ultra capacitors: globally battery constraints seem coming down sharply
- Motor manufacturing
  - Gujranwala (Golden pumps, Diamond Motors, Akhlas Motors,..)
    - Various types of motors though mostly AC motors
    - Sophistication and export orientation is lacking
    - Mostly from recycled material (electric sheets: majority recovered from international scrap; copper wire: original requires scale so second hand used; bearing: several levels of quality ABCD..)
    - Key facilities for research and development such as for testing for international standards lacking
    - Efficiency and temperature relationship
    - Can possibly reverse engineer over time (5-7 years) and designing might take longer
  - Possible role of fan manufacturing industry

Component Manufacturers (Current situation)

- Cables
  - Fast Cables
  - Two items: conductor (almost constant) and insulator (varies)
  - Current automobile market size is too small for large companies
  - BEVs can bring opportunities in 4 wheelers
  - In BEVs, unlike ICE based vehicles, temperatures not very high
  - Though lab equipment is missing it can quickly catch up
- Controller
  - Companies like Jolta and InerZ are working to develop their own

Universities and R&D Institutions

- LUMS Business School
  - Faculty
  - Graduate Students
- LUMS Energy Institute
- NED Karachi
  - Student projects
  - Working with Mehran fans to develop motors
- UET Lahore
  - Test beds of electric motors
- UET Peshawar

International players

- Interested in:
  - Pakistan's market
  - Manufacturing for global markets
  - Integrated electric kits providing combination of:
    - Battery packs
    - Battery management system
    - Motor
    - Controller
    - Battery swapping system

Economic sense of BEVs

- Upfront cost
  - Battery is the major cost in BEVs (approximately 30-50% in Li ion based BEVs)
  - Cost goes very high with Li ion battery
  - Affordable price with lead acid but issues of lead acid
  - Li ion is the way to go – for now
- Companies in Pakistan are targeting some design innovations to bring the upfront cost down e.g., SZS (4 wheeler) and InerZ (2 wheeler)

Regulatory framework

- In past few SROs to encourage import of BEVs and related parts by reducing duties
- Auto Development Policy 2016-21 is based on ICE based vehicles
- EVs Policy for two and three wheelers 2020
- Policy making in conflicting objectives: new players, existing players, climate change, localization
- Pakistan hoping to become 17th signatory of International Energy Agency's 30%@2030 initiative
- Green banking regulations of State Bank of Pakistan (mainly focus on solar energy)
- Energy infrastructure

Key Points

- Key components
  - EV kits: Seem a transition for aspirant 2/3 wheelers
  - Battery (Li ion and or lead acid) – Reducing cost: step wise localization beginning from assembly of cells
  - Battery management system: critical for Pakistani environment
  - Motor: leverage the existing knowledge to localize in 5-7 years
  - Controller: some companies are working on it
  - Body: requires innovation to bring the cost down
  - Cables: seem quite ready
- Financing (high upfront cost)
  - Loans for BEVs
  - Battery leasing models: Cars and batteries
- Starting target markets: Two/three wheelers, commercial vehicles, institutional customers
- Policy (Enhancing demand versus enhancing demand as well as localization)
- Learnings from past developments in auto industry
  - Tractors industry

Thank you!
Questions.

LUMS

SAARC ENERGY CENTRE ISLAMABAD

IIMB
तेजस्वि नावधीतमस्तु

Presentation 2 – Industry Readiness for Manufacturing of Battery Electric Vehicles in India

Dr. Haritha Saranga, Professor, Indian Institute of Management Bangalore (IIMB), India

Assessment of Industry Readiness for Manufacturing of BEVs in India

Haritha Saranga
IIM Bangalore
INDIA

Overview

- Evolution of Battery Electric Vehicles (BEVs) in India
- Various schemes introduced by Indian government for adoption of BEVs
- Current developments in various segments of auto industry
- Battery charging infrastructure
- Investments into BEV supply chain
- Q&A

Evolution of BEVs in India

First Market introduction

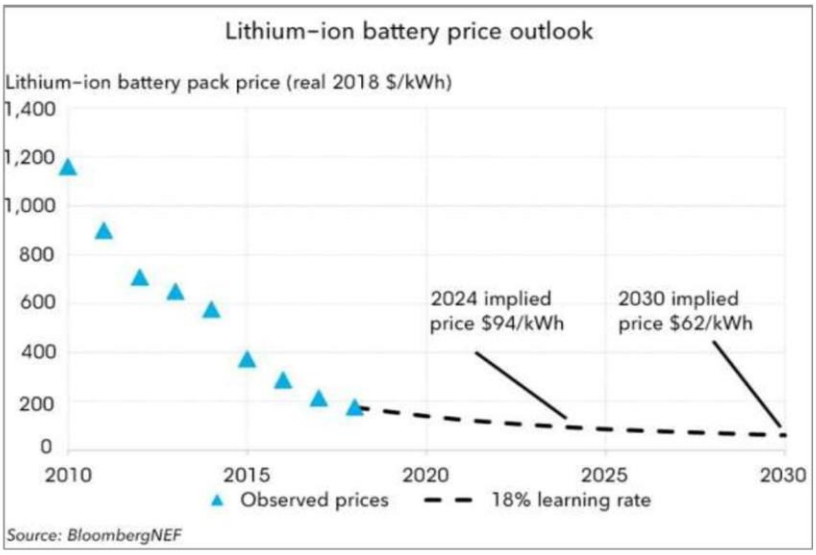
- First BEV in PV segment was introduced in India in 2001
- However, the number of BEVs sold in PV segment were a mere 3,400 in 2019-20
- Similarly, the first Electric two-wheeler was introduced in India in 2006
- And the EV sales in two-wheeler segment stood at 152,000 in 2019-20
- A total of 600 electric buses were sold in 2020.

Why such slow progress?

- Customers' reluctance to shift to EVs
- Manufacturers' reluctance to introduce new products
- Lack of Infrastructure, such as charging stations or battery swapping facilities
- Lack of incentives and push by government for adoption
- High cost of Battery

Falling Prices of Lithium-ion Battery

- Battery price was close to $1200/kWh in 2010; but dropped to $200/kWh in 2018.
- By 2025 batteries are likely to cost less than $100/kWh, as cathode chemistries that are less dependent on cobalt or advanced NCA batteries become more popular



Government push for BEVs in India

- India's huge dependence on imported crude oil
  - India imported nearly **85% of its crude oil needs** in the year 2019-20 and spent **$102 billion dollars** on oil imports
- Greenhouse gas (GHG) emissions from ICE based vehicles
  - **22 out** of the **30 most** polluted cities in the world belong to India
- The Indian government began pushing for BEVs in earnest from 2015 with FAME (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India) policy
- **Phase I of FAME** - started in 2015 with an outlay of *Rs.* 895 crore, with a vision that **30%** of the automobiles sold in India should be electric by **2030**.
- **Mild Hybrids** were also subsidized under Phase I, along with strong hybrids, plug-in hybrids and pure electric vehicles; **BEVs with Lead Acid Batteries** also received subsidies
- Two-wheelers with a **speed of 40km/hr** and range of 60-70 Km per full charge got a subsidy of ***Rs.* 22,000**

The Phase II of FAME Policy

- The Indian government announced an outlay of **₹10,000 crore for FAME II policy** to boost the number of electric vehicles in India from April 2019 onwards (nearly $1.4 billion in subsidies to buyers)
- **₹1,000 crore** has been earmarked for setting up **charging stations** for electric vehicles in India
  - 2,700 charging stations shall be set up in metros, cities with million-plus population, smart cities and cities of hilly states across India
- To receive subsidy under FAME II, BEV makers must **source minimum 50% of the components locally**
- The **target** for allocation of financial resources under FAME II:
  - 7,090 electric buses
  - 20,000 strong hybrids
  - 35,000 electric cars
  - 500,000 three-wheelers
  - 1,000,000 two-wheelers

Additional Incentives for adoption of BEVs in India

- The GST rates on EVs have been reduced from 12% to 5%.
- The GST on EV chargers has been reduced from 18% to 5%.
- Income tax rebates of up to ₹1.5 lakh to customers on interest paid on loans to buy electric vehicles
- Makers of components such as solar electric charging infrastructure and lithium storage batteries can avail investment-linked income tax exemptions and other indirect tax benefits.
- Annual subsidy of Rs 700 crore will be allotted for manufacturing of batteries for electric vehicles and mobile phones.
- Energy Efficiency Services Limited (EESL) is procuring 10,000 EVs from reputed manufacturers for distribution to Government Departments.
- The Delhi Government approved 1000 Electric buses to be used in Delhi's public transport system, and other states have similar schemes.

Two-wheeler Industry

- **25% of the pollution** in India is being created by two-wheelers, and shift to BEVs will reduce one fourth of our pollution
- Subsidies from FAME II amount to Rs. 10,000 for each kilowatt-hour (KWH) of battery capacity, which is almost 50% of the total battery cost.
- Charging infrastructure is not too difficult to create, only a plug point is needed for AC charging at homes.
- Fast charging can charge up to 80% of the battery in 1 hour (e.g., Ather Energy)
- The industry leaders predict that capacity of two-wheelers should reach 3-4 million by 2024.

Cost Differential between ICE & BEV

	ICE based	Electric vehicle
2-wheelers	36,600	3,400
4-wheeler (hatchback)	3,06,640	44,000

- The purchase cost of a BEV is nearly twice as that of an equivalent ICE based vehicle
- However, several studies have shown that BEVs cost much less to operate and maintain than ICE vehicles.
- Cost of Operating two-wheeler for 2 years & four-wheeler for 4 years (Maintenance + Operating Cost) in India, based on Indian gasoline costs and the vehicles available in Indian market

Three-wheeler Industry

- India's last-mile connectivity market is worth $42 billion, largely led by e-rickshaws and auto-rickshaws.
- India has more than 1.5 million battery operated e-rickshaws.
- The aggregators are playing a key role in adoption of e-rickshaws in metro cities like Delhi.
- **SmartE** currently has about 1,000 e-rickshaws, and it has plans to increase its fleet size to 10,000 and expand into 9 new cities in the next 18 months.
- SmartE currently sources vehicles from Mahindra and Kinetic Green and energy solution providers like Panasonic, Exicom and Sun Mobility
- **Ola Electric** plans to deploy one million EVs by 2021 in India. They started this with deployment of four-wheelers and e-rickshaws in the city of Nagpur and Delhi, and are introducing electric 2-wheelers with App Scooter (acquired from Netherlands), in Europe and Asia.
- Companies are trying to figure out what is the **best business model** in BEV context

Solar rickshaws make debut on IIT-Delhi campus

Current Sourcing practices of 2 & 3-wheelers

EV Type	Manufacturer	Battery	Battery Management System (BMS)	Motors	Motor Controller
Electric Two Wheelers	Ampere Vehicles	Imported	Own design	makes own motors, chargers and controllers	
	Hero Electric	Cells imported; battery packs assembled in-house	Own design	Imported from Taiwan & China	
	Ather Energy	Cells imported; battery packs assembled in-house	Own design; locally manufactured	Designed & developed drive train incl. motor controllers	
	TVS Motors	Cells imported; battery packs made in-house	Own design		
	Emflux Motors	Imported from Samsung, Korea	Developed BMS, motor controller and motor		
	Electrotherm	Imported		Designed & developed motors and controllers	
Electric Three Wheelers	Gayam Motor Works	(Local Lead-Acid Battery)	Own design BMS	Imported	Imported
	Lohia Auto	(Local Lead-Acid Battery)		Imported	Imported
	Saera India	Local Lead-Acid Battery		Imported	
	Goenka Elecric Motor Vehicles	Local Lead-Acid Battery		Localised	Localised

Four-wheeler Industry

- India's largest electric vehicle maker **Mahindra and Mahindra** has committed more than ₹1,000 crore to build manufacturing lines for electric vehicles (eVerito & e20) and powertrains—to be supplied to other OEMs—in Maharashtra and Karnataka.
- **Tata Motors** is working closely with its Jaguar Land Rover unit to design electric vehicles, offers the EV version of its Tigor compact sedan (only for commercial users) & recently launched Tata Nexon SUV for consumers
- South Korea's **Hyundai Motor Co.** introduced the Kona SUV in July 2019, becoming the first automaker in India to offer a long-range battery in an EV.
- New entrant **MG Motor India Ltd** introduced an electric sport-utility vehicle MG ZS EV in India.
- **Mercedes Benz** is launching its Electric SUV, EQC in Indian market in October 2020.
- **Nissan Motor Co** has plans to launch its BEV Leaf in India this year. They have recently introduced it in 4 South American countries (Brazil, Argentina, Colombia and Chile).

Electric Buses

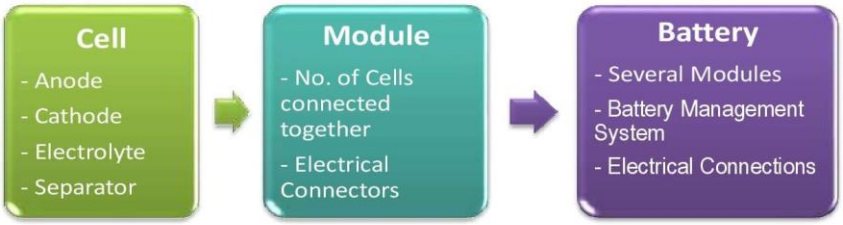
- Indian government is focusing on converting **public transportation** into electric vehicles
- **Olectra**, a JV between an Indian firm and China's **BYD** is the leading e-bus manufacturer in India
  - Has over 100 buses plying in various cities
  - Has bagged a contract for 765 buses from various state govts in 2020
- **Tata Motors** is one of the first indigenous firms to develop electric buses and won orders from Guwahati, Indore, Jammu, Jaipur, Kolkata and Lucknow
- **JBM-Solaris** and **Ashok Leyland** are the other two major players in this segment
- **133 Electric buses** have been deployed across **Pune city** in the first phase of its e-bus programme
- Both **charging** and **battery swapping** solutions are being explored for operating e-buses in India

Current Sourcing Practices of Electric Car & Bus Makers

EV Type	Manufacturer	Battery	Battery Management System (BMS)	Motors	Motor Controller
Electric Cars	Mahindra	Cells Imported; battery packs assembled in-house	Own Design	Imported	Own design
	Tata Motors	Imported	Outsourced	sourced from Electra EV, a group Co.	
	Hyundai Motors	Imported	Outsourced	Imported; sourced from parent Company	
	MG Motors	Imported from SAIC CATL Power Battery System, a JV between SAIC & Amperex Technology in China		Imported; sourced from parent Company	
Electric Buses	Ashok Leyland	Imported	Imported/Outsourced		
	Olectra - BYD	Imported from BYD China			
	JBM Solaris	Cells imported; battery packs (own design) outsourced	own design; production outsourced	Outsourced	Outsourced

Source: based on http://www.eai.in/blog/2018/12/electric-vehicles-supply-chain-india.html - Energy Alternatives India (EAI) and additional inputs from our interactions with OEMs (*)

BEV Supply chain



- 17 parts in an EV replace an internal combustion engine (ICE) with over 400 parts
- EVs also need less servicing and require no value-added consumables like the ICE based engine
- India only has cell-to-pack manufacturing (assembly) plants totalling 1 GWh of annual production capacity, but needs 10 GWh capacity by 2023 and 30 GWh capacity by 2025
- The existing OEMs are importing batteries from China, Taiwan, and Korea.

Planned Investments into Battery Plants

Manufacturer	Technology Partner	Plant Location	Capacity MW/Year	Items to be made
Delta	Taoyuan Taiwan	Krishnagiri, TN	50 MW	Battery Module & Assembly
BHEL	LIBCOIN, Australia		1 GWh	LI-Ion Cells & Batteries
Mahindra Electric	LG Chem, South Korea	Chakan Maharashtra	Rs. 1000 Crs	Battery Module & Assembly
Exide	Leclanche, Switzerland	Gujarat		Battery Module & Assembly
Acme		HP	300 MW	Battery Assembly
Adani		Gujarat		Integrated Li-battery mfg
EON Electiric		Haridwar, Utt		Battery Module & Assembly
Exicom		Gurugram	500 MW	Battery Module & Assembly
HBL Power Systems		Hyd Telengana		Li-Ion Cells & Batteries
Suzuki Toshiba Denso		Hansalpur Gujarat	Rs. 1150 Cr ($180m)	Battery Module & Assembly
Amara Raja Batteries Limited	ISRO	AP	100 MWhr $300bn	Battery Module & Assembly
Tata Chemicals Limited	ISRO	Dholera Gujarat	Rs 40 bn ($600m) 10 GWh	Li-Ion Cells & Batteries

Charging Infrastructure

- Indian government has earmarked **₹1,000 crore** for setting up **2,700** charging stations
- Availability of at least one charging station in a **grid of 3km x 3km**
- Major highways connecting major cities on both sides of the road should have a charging station at an interval of about **25 km** each
- The Indian government has also roped in **public sector oil** companies like BPCL, HPCL and Indian Oil to create charging infrastructure in the country.
- **SAIC** recently tied up with Finland-based clean energy major Fortum to install 50-kilowatt **fast-charging stations in five cities** in India.
- Sun Mobility is working with various state and central government agencies, as well as fleet aggregators like SmartE to create battery **swapping infrastructure** in India

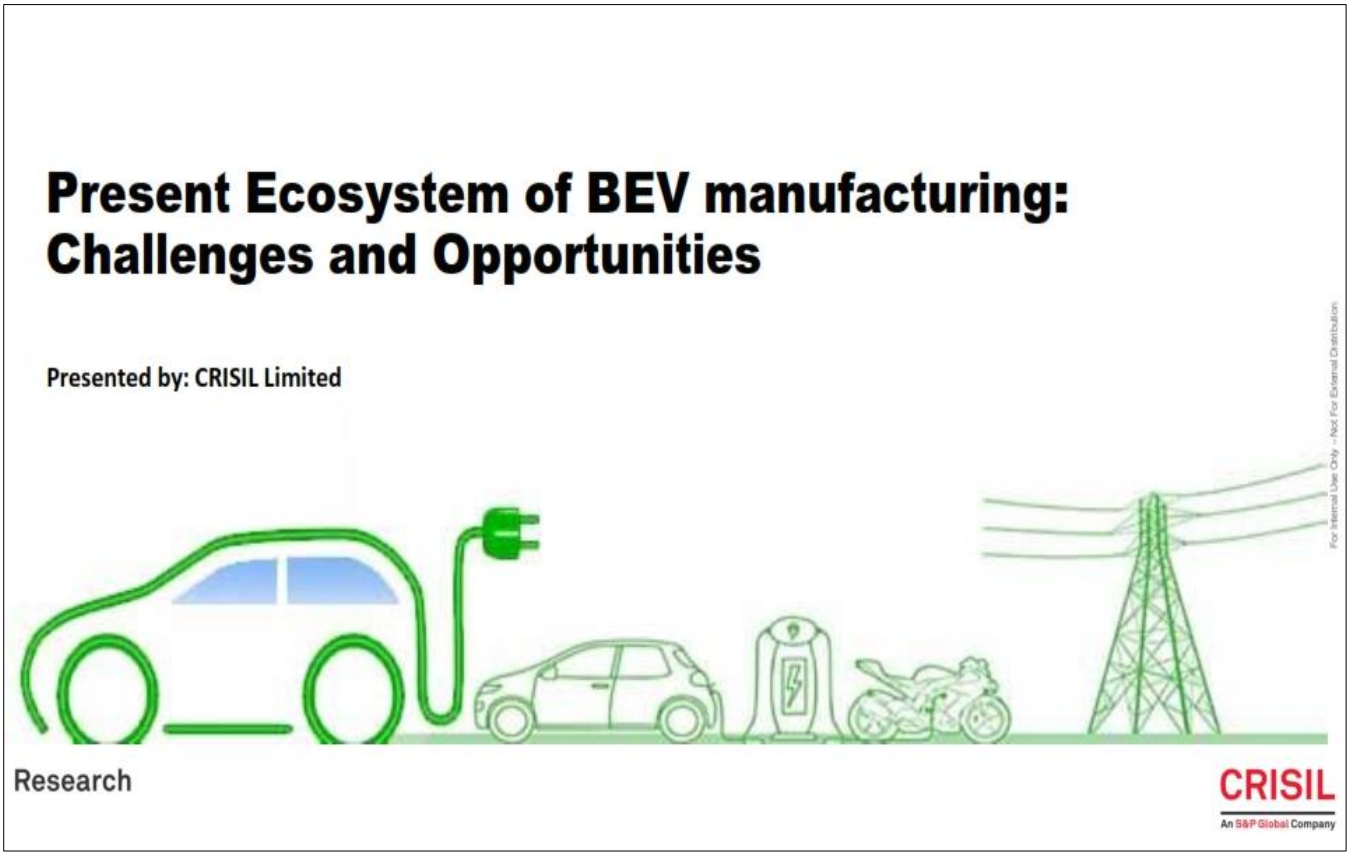
Academic & Research Institutions

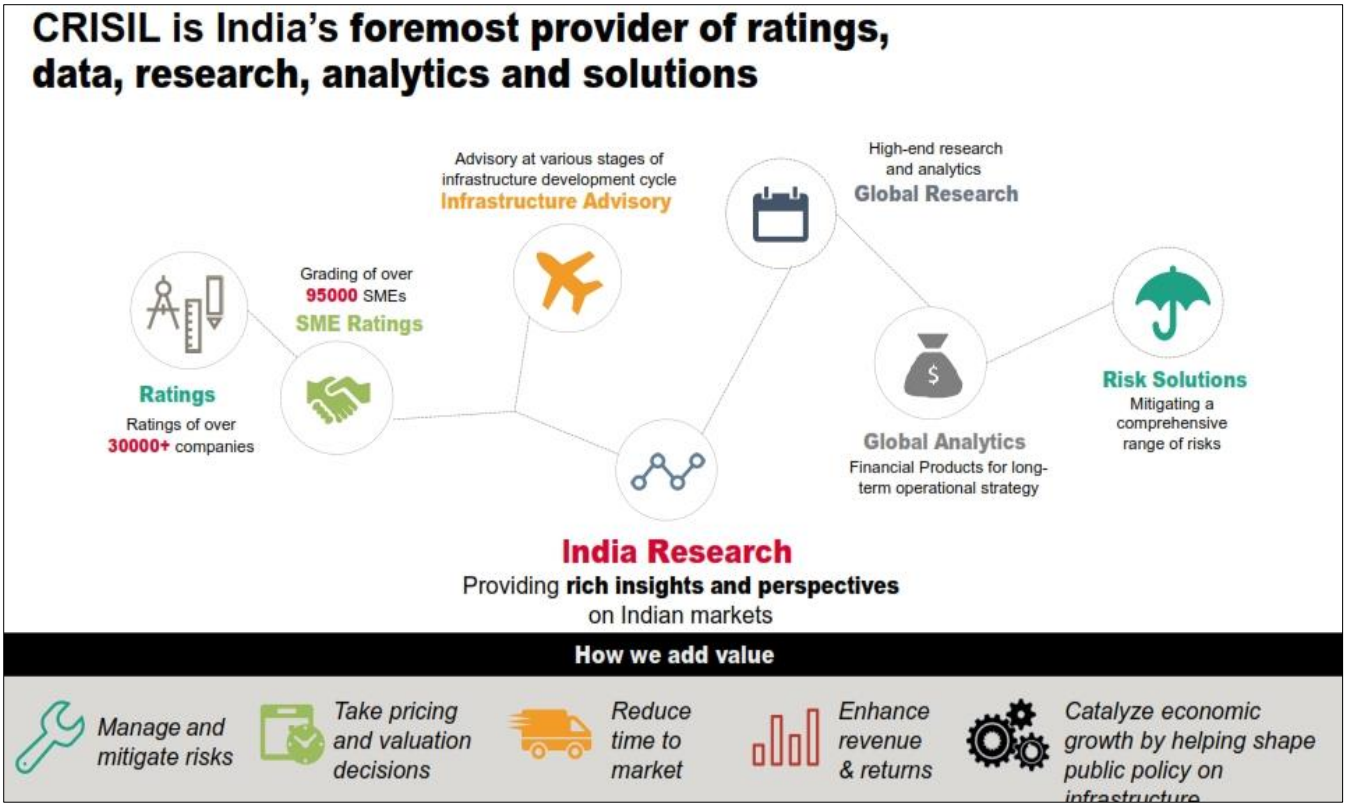
- Central Electrochemical Research Institute (CECRI), based out of Tamil Nadu, has decided to set up a factory to produce batteries for electric vehicles, with Rs. 100 crore investment.
- CECRI claims to beat Chinese players on prices (while current prices are ruling at $220/kW, CECRI can sell for $190)
- CECRI is also in the process of getting technical help from Fraunhofer Institute of Germany to improve battery performance and with the manufacturing unit.
- Professor Ashok Jhunjhunwala of IIT Madras nurtured several start-ups and groups to develop new batteries and EV models in India.
- Center for Battery Engineering and Electric Vehicles (C-BEEV) of IIT Madras is a start-up that is collaborating with several manufacturers and trying to find a cost effective BEV for India

Presentation 3 – Present Eco-system of BEV manufacturing: Challenges & Opportunities

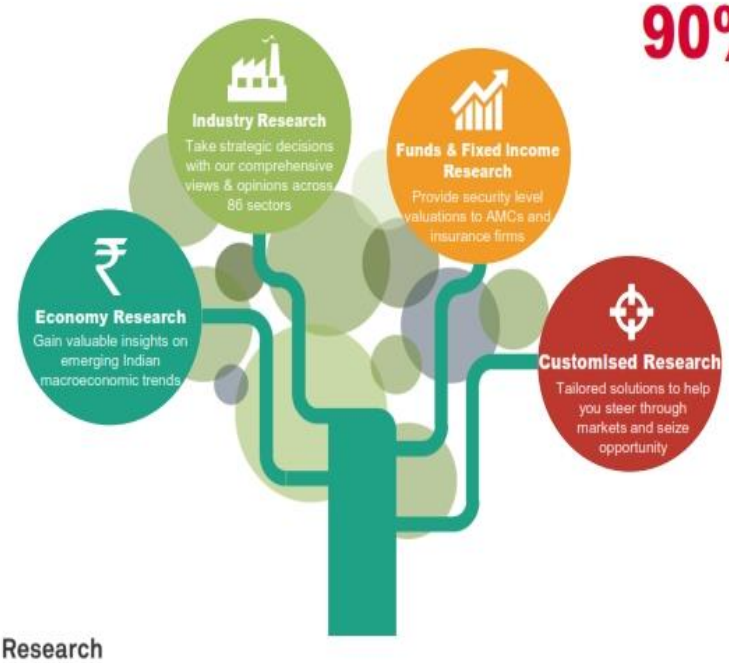
Mr. Pinal Satish Mehta, Associate Director, CRISIL Research India

Mr. Pramit Pal, Senior Research Analyst – Customised Research, CRISIL Research India





India's largest independent research house providing comprehensive, integrated and cross-sectoral coverage



90% of India's banking industry by asset base served

Global and Indian clients exceeding **1,200+**

86 industries and sub-sectors tracked on regular basis since **two decades**

KEY INDUSTRIES COVERED

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Customised research offerings

Business Planning

- **Identification of attractive sectors/ sub-segments**
  - Demand-supply dynamics, profitability and opportunity
  - Sector / Company financial health
  - Policy and regulatory view
- **Opportunity mapping for planning**
  - Market dynamics, capacity utilization, economics
  - Policies and regulations
- **Demand dashboards across locations and sectors**
- **Commodity price tracking**
  - Short term/long term, regional markets, brand-wise assessments

Strategic initiatives

- **Pre-investment commercial due-diligence**
  - Market assessment
  - Channel feedback
  - Financial assessment
  - Management assessment
- **Post investment monitoring**
  - Market feedback, end-user and growth outlook
  - Exit strategy
- **Assessment of partners and tie-ups**
- **Market entry strategy**

Fund raising & valuations

- Feasibility/Viability studies /Credit Assessment
- Valuations including structured instrument valuation
- Exit diligence

Competitor Benchmarking

- Competitor strategy – expansion, value addition, supply chain assessment, channel feedback, market intelligence
- Cost Benchmarking

Research

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Major Pillars for enabling BEV manufacturing in a country

Readiness status of industry

Manufacture and stakeholder willingness to enter EV business

End-use EV market and potential demand growth

Access to global supply chains

Availability of raw materials

Competitiveness in the EV manufacturing space

Key policy and regulatory stance towards EV manufacturing in the country

Steps taken to encourage PPP

Ease of funding opportunities in the segment

Indigenous skill development to promote domestic manufacturing of components

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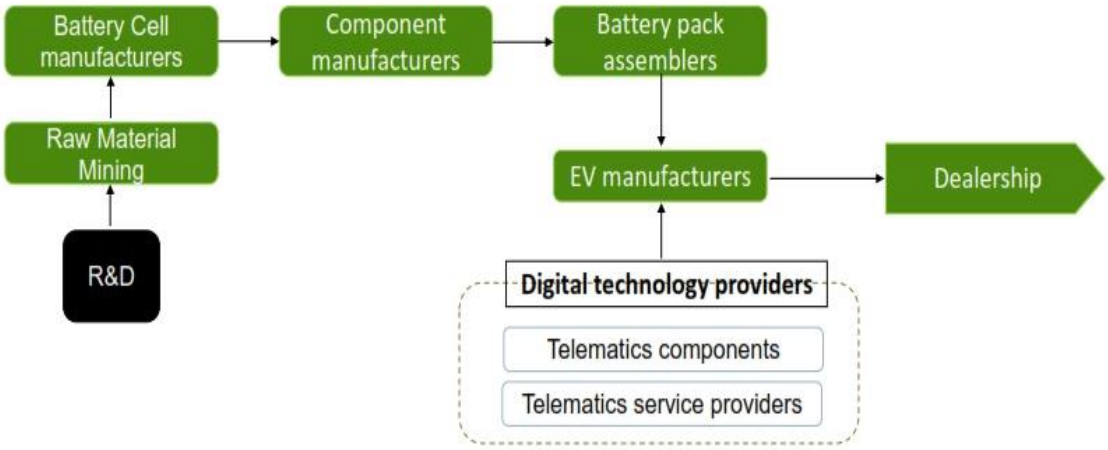
Stakeholders of a BEV manufacturing ecosystem

I. EV manufacturing



II. After Sales services

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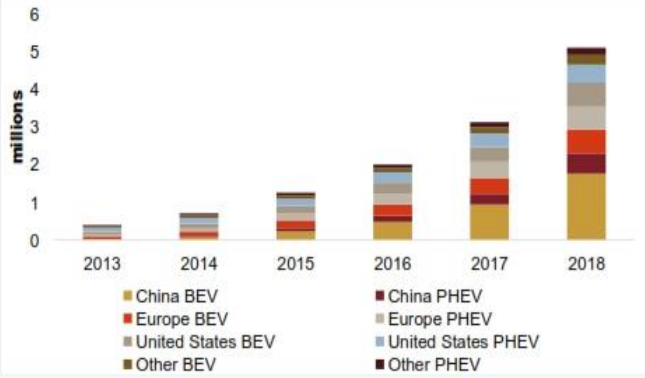
Pillar 1: Readiness Status of industry

Global EV Market



- As of end-2018, the global stock of EVs surpassed 5 million, an increase of 63% (3.14 million in 2017) from the previous year (IEA estimates). China led the deployment, accounting for ~45% of the electric car fleet, followed by Europe (24%) and the US (22%)
- The biggest EV penetration (in terms of volume and sales) occurred in China. The nation outperformed all other countries on both the market side as well as the industry side (component manufacturing).

Investments in EV manufacturing

China	$135.7 billion
Germany	$71.7 billion
USA	$34 billion
South Korea	$20 billion
Japan	$18.9 billion
France	$10.4 billion
Others	$9.4 billion

- Global automakers are planning an unprecedented level of spending to develop and procure batteries and electric vehicles over the next five to 10 years, with a significant portion of their budgets targeted at China
- Global auto makers like Volkswagen, Daimler, Ford, Fiat, Toyota, Nissan and Renault have begun investing in EVs (vehicles as well as batteries)

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Note: Includes investments which have been publicized and does not reflect planned investments; Data as on April 2019
Source: IEA EV Outlook

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Pillar 2: Access to global supply chains

China's grip on battery metals supply chain

Stage 1: Mining

Nickel	8%	0%	31%
Cobalt	0%	0%	1%
Graphite	1%	0%	65%
Lithium	0%	1%	0%
Manganese	0%	0%	6%

Source: Benchmark Mineral Intelligence

- China's dominance in battery raw materials can most clearly be seen in the market for graphite, which produces 65 per cent of the world's graphite
- Producing countries supply Lithium majorly from brines of Argentina, Chile and Bolivia and hard rock from Australia
- Cobalt mine supplies is monopolistic: more than 70% of cobalt mined originates from DRC, followed by Russia, Cuba, Australia and Canada

Stage 2: Chemical Processing

Nickel	13%	1%	65%
Cobalt	17%	0%	82%
Graphite	0%	0%	100%
Lithium	0%	4%	59%
Manganese	7%	0%	93%

Source: Benchmark Mineral Intelligence

- China's dominance in battery raw materials encompasses across all major chemicals
- The USA has build up some supply chain in Nickel and cobalt
- The EU continues to lag behind, with no major share in chemical processing space

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Pillar 2: Access to global supply chains (contd.)

China's grip on battery metals supply chain

Stage 3: Cathode and Anode Production

Cathode	0%	0%	61%
Anode	0%	0%	83%

Source: Benchmark Mineral Intelligence

- 61% for cathodes are produced in China
- 83 per cent of the world's anodes for lithium-ion batteries are produced in China, owing to dominance in graphite usage

Stage 4: Li-ion Battery Manufacturing

Cells	6%	10%	73%

Source: Benchmark Mineral Intelligence

- The rise of battery mega factories has predominantly been taking place in mainland China, which has contributed to ~73% of output in 2019
- Of the 136 lithium-ion battery plants in the pipeline to 2029, 101 are based in China

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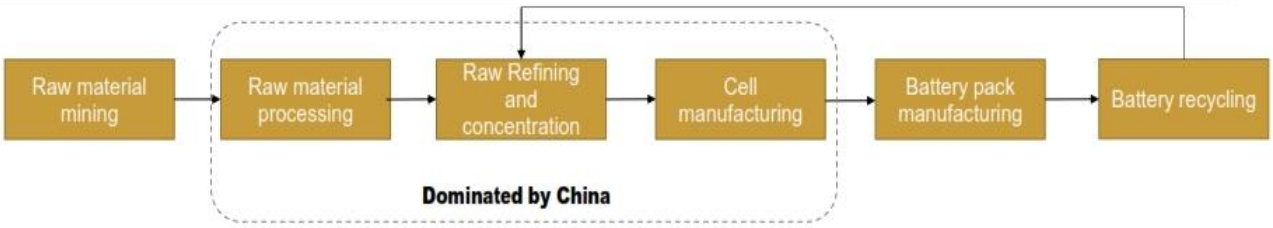
Pillar 2: Access to global supply chains (contd.)

Stakeholders of a BEV manufacturing ecosystem



- China's dominance in chemical production of battery-grade raw materials stand at ~80% of total global production
- Monopolistic advantage in capacity ownership can lead to global supply chain issues and pricing power by China
- Both USA and EU are still missing the chemical links in the supply chain
- In fact, the European Union have already sounded alarm with the European Commission warning that over-reliance on imports of critical raw materials can undermine EV industry. The commission has added Lithium into the critical supplies list

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Pillar 3: Regulatory and Policy Incentives for BEV manufacturing

Examples from USA

Advanced Technology Vehicle Manufacturing (ATVM) loan program	Loan support for PEVs and PEV components, as well as associated engineering integration costs. Three loans of more than $3 billion have been distributed to major firms including Nissan and Tesla, for PEV manufacturing
Advanced Stimulus-funded grants for advanced battery manufacturers program	Direct loans to manufacturers of up to 30% of the cost to re-equip, expand, or establish manufacturing facilities; more than ~$5 billion grant program have been provided by the end by 2018
PEV-related research and development (R&D)	Direct grants for high-risk/reward research on next-generation battery systems. DOE expended ~$2 billion till date towards innovation in batteries and electric drive technology, vehicle and systems simulation and testing
Federal PEV tax credits	$2500 per vehicle with a 4 kWh battery, up to $7,500 per vehicle for 16 kWh batteries. A phase-out period for a manufacturer's vehicles kicks in after the given manufacturer has sold 200,000 qualified PEVs.

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Pillar 3: Regulatory and Policy Incentives for BEV manufacturing (contd.)

Examples from European Union

Strong policy overview to push EV sales	By 2025, the EU has sharpened the EV target to 20% of total sales while Norway has banned sales of gasoline and diesel cars. By 2040, France, Italy and UK (earlier part of EU) plan to target 100% zero-emission vehicle sales
Subsidies on EVs	Countries have set out tax benefits (registration tax, ownership tax), EV parking benefits, subsidies and sops for EV sales
Public funds-backed investments and research	• Governments, universities, EU institutions and scores of businesses, including the leading carmakers, have been pooling funds and working on a new industrial policy to improve EU's technological independence in EV manufacturing • The EU is focusing on building open, competitive markets for EV manufacturing with strict controls on public subsidies

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Pillar 3: Regulatory and Policy Incentives for BEV manufacturing (contd.)

Examples from China

Only 5,000 EVs were sold in China in 2011; 1.2 million EVs were sold in 2019

Dual Credit system

Allows auto manufacturers, regardless of country of origin, to sell surplus EV credits to other firms to earn additional revenue and has prompted foreign manufacturers like Volkswagen and General Motors to seriously consider manufacturing more EVs in China

Subsidies on EVs

Central subsidies covering electric buses, public vehicles (including taxi fleets), local governments roll out additional subsidies in the form of grants and loans

Federal support for manufacturing EVs

- Federal support for industry and academia to push manufacturers beyond niche vehicles and bolster largescale PEV commercialization.
- This includes grants and loans to industry, basic research and development support to academia and national labs, vehicle demonstration funds, support for charging infrastructure, market and other applied research,
- Grants are provided for training and education, including emergency response, technician training, and other supporting roles

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India in Focus

Long term outlook for EVs: Electric Vehicle penetration to be driven by 3Ws and 2Ws

Vehicle Segment	EV Penetration (Sales)		
	FY19	FY24 P	FY30P
	0.1% (~3,600)	3-5% (~1,76,000)	25% (1,299,000)
	0.6% (~126,000)	12-17% (~3,497,000)	50% (13,168,000)
	0.5% (~500)	2-4% (~4,500)	20% (~42,000)
	0% (~100)	3-5% (~24,000)	10% (~86,000)
	0.01% (~700)	43-48% (2,97,000)	70% (~931,000)

Vehicle Type	Drivers for EV adoption for the period FY20-FY24	Drivers for EV adoption for the period FY25-FY230
Two Wheelers	E-Scooters to have better TCO than ICE scooters but weaker than ICE Motor cycles by FY24	Scooters to majorly shift to EV, motorcycles below 125 cc will begin conversion, majorly in the urban and semi urban regions
Three Wheelers	E- Auto to have favorable TCO and cost of acquisition (COA) as compared to a CNG powered three wheeler by FY24	Better cost economics, low running costs and rise in CNG prices to allure auto owners towards EV
PV and CV	Low annual running will hinder EV adoption in personal cars by FY24 while higher daily running to aid EV adoption in cab aggregators	CV segment expected to majorly convert to EV; PV segment will begin showing traction due to lowering cost and conducive economics
Bus	Subsidies will drive EV adoption for State Transport Undertakings (STUs)	Government push, lowering of battery prices to drive adoption

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India in Focus

Regulatory and federal policies driving E-mobility

1 | *National Electric Mobility Mission Plan*: The scheme intended to catalyse market development (demand generation, technology development, pilot projects and charging infrastructure) for creation of an EV ecosystem

2 | *FAME II*: The FAME-II intends to support 10 lakh two-wheelers, 5 lakh three-wheelers, 55,000 four-wheelers, and 7,000 buses that operate on lithium-ion batteries or other electric power-trains. Under the scheme the government will offer incentives for electric buses, three-wheelers and four-wheelers to be used for commercial purposes

3 | *Subsidy support for setting up EV charging stations:* The Indian government plans to offer subsidy support to states for deployment of 5,000 EV charging stations in cities and highways

4 | *Focus on domestic manufacturing of EVs:* In order to encourage vehicle manufacturers to produce EVs in the country, the government plans to raise custom duties on EV parts and batteries in a phased manner. As part of the phased manufacturing program (PMP) of the Department of Heavy Industries, basic customs duties on completely built units of electric buses and trucks will be doubled from 25% to 50% from April 2020.

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India in Focus

Stance taken by major states to promote EV manufacturing

With a target of 50 GWh, the NITI Aayog plan would support the establishment of anywhere between three to ten giga-factories of 20 GWh to 5 GWh capacity each in the country

1 | Gujarat, which has already seen large-scale investments for Li-ion battery manufacturing, is offering additional support in the form of subsidized utilities under the state's electronics policies.

2 | Telangana has announced the availability of 200 acres of land plus power and water for the manufacturing unit at a concessional rate

3 | Andhra Pradesh, as early as 2017, announced the allocation of 200-400 acres for development of the electric mobility-focused industrial park. The state also plans to provide capital subsidies of 50 per cent of fixed capital investments in building and common infrastructure (up to a maximum of INR 20 cr [INR 200 mn = $ 2.8 mn].

4 | Maharashtra has set its intent in setting up India's first five giga-factories. In addition to the capital subsidies on fixed capital investments, the state government shall be an equity partner up to nine per cent in large, mega, and ultra-mega projects, with FCI greater than INR 500 crores.

5 | Tamil Nadu, would be offering SIPCOT land at a subsidized rate in addition to other incentives

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India in Focus

Opportunities in EV manufacturing

- With a global growth rate of 60% in EVs, India has the opportunity to become a global player in the space
- The market share of electric cars is around 2% in China while it is around 39% in Norway, whereas the Indian market share of electric cars is a meagre 0.06%
- Global focus on making supply chains self-reliant provides an opportunity for domestic manufacturing of EVs
- The government has raised tariffs on Li-ion batteries, providing domestic manufacturers a powerful incentive
- Roughly 50% of Build of Materials (BOM) in an EV is different from that of an ICE vehicle, it will create a new opportunity for auto component manufacturers

Challenges in EV manufacturing

- Lack of rare earth materials in the country
- Sourcing challenges for elements like lithium, cobalt, nickel, most mines and capacities have already been leased out by global EV majors
- Lack of a supporting supply chain, manufacturing and infrastructure ecosystem that deters the pace of adoption.
- Lack of dedicated focus on incubating new technologies pertaining to EVs, R&D spends are low
- Lack of large-scale investments towards EVs by home-grown auto majors. This makes global investments sceptical

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Conclusion

- Presently, the global BEV manufacturing is tilted heavily towards China, however, USA and EU are investing in EV technologies
- China has gained dominance by securing access to supply chains, other countries are playing catch up
- Globally, EV growth is expected to remain strong; new innovation in battery technologies and scaling up of manufacturing capacities will help companies and countries achieve economies of scale, thereby reducing EV costs
- India's EV market is fledgling, however, it is poised to grow to ~80 million EVs by 2030
- Domestic manufacturing ecosystem in India is small to non-existent, however, with the right policies and improved investments by auto makers to manufacture EVs, it can tip the balance from challenge to opportunity for India

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