ICRIER

SHAKTI SUSTAINABLE ENERGY FOUNDATION

Exploring cost-reduction strategies for Electric Vehicle (EV) Batteries

Key Highlights

Inspiration

Electric Vehicles (EVs) are viewed as a solution to several challenges – reducing emission of greenhouse gases, sustainable economic growth, improving air quality, and reducing fossil fuel imports – in India. However, the transition from a fossil fuel-based transport system to an electric mobility system faces variety of road blocks. One of the major barriers to this transition is unaffordability of EVs vis-a-vis traditional internal combustion engine vehicles. The battery in an EV is its most expensive component – accounting for 50 per cent of its total cost; thus, the affordability of EVs is directly proportional to the affordability of a battery. This study explores the strategies that could reduce the battery costs and make EVs affordable and improve its uptake in transport and mobility system in India.

Objective

The objective of the study is to design a comprehensive strategy and recommend a mix of policy instruments that are implementable by the Central /State governments and other stakeholder like EESL, OEMs, etc.

This objective is achieved by disintegrating the main research question in the following sub-questions:

Table 1: Sub-questions, methodology used and their significance

Question	Methodology	Significance
What are the major cost components of an electric vehicle battery?	Disaggregation of battery cost using BatPac (an excel-based model to estimate the performance and cost of an electric vehicle battery).	The goal is to identify areas of intervention by analysing the cost component of a battery. Moreover, since technologies are an important consideration for intended application use and thus cost; this question also resulted in comparison of multiple battery technologies.
What is the current status of EV battery value chain in India?	Interviews with multiple stakeholders that are part of value chain and literature review.	While previous step helped in identifying the area of intervention theoretically, this step results in analysing the applicability of the model in Indian context in terms of maturity of different aspects of battery manufacturing and interests of stakeholders. The information on ways to reduce the cost of a battery is also collected in this step.
What could be the strategies to reduce the cost of batteries? Relative importance and ranking of these strategies?	Strategies are identified based on first two steps and literature review of policies in countries that have done well in promoting EVs. The model developed in first step provided key cost components of a battery – possible area of intervention and interviews with stakeholders helped in formulating the strategies in the identified areas along with other measures that were deemed important by them. The literature review helped in understanding the current policy instrument mixes vis-à-vis identified strategies. These strategies are then ranked using an Analytic Hierarchy Process (AHP). The data for AHP was collected during a workshop conducted at Indian Institute of Management, Bangalore.	It is the culmination of the first two steps and outlines options for policy makers to reduce the cost of batteries. The ranking exercise subsumes the prime concerns of all stakeholders as it involved subject matter experts from industry, research and government. The strategies are ranked by these experts on the criteria of their impact on reducing cost and on time and investment required by them.

Given the technical nature of the model developed, the report dedicates a chapter on apprising readers about a battery, its components and functioning and discusses certain battery technologies (chemistries).

Battery technologies:

Lithium-ion batteries that are most widely used batteries for electric vehicle applications consist of four major components- anode, cathode, electrolyte, and separator. The negative electrode of the battery, anode, is made up of graphite whereas the positive electrode cathode is made up of lithium's compound. The current electrolyte used is liquid lithium salt, while research is going on developing solid-state electrolytes, sulphur-based electrolytes, polymer-based electrolytes, etc. The chemistry of cathode in a cell remains highly contentious. The compounds of lithium such as LFP (Lithium Ferro Phosphate), NCA (Nickel Cobalt Aluminium), NMC (Nickel Manganese Cobalt) that are used as cathodes in lithium-ion cells are widely compared for their efficiency and performances. This report considers these technologies and few other emerging technologies in the cost modelling section to determine their suitability for a certain application (2-wheeler, 3-wheeler, buses, cars, etc.).

Changing the chemical composition of the components alters the theoretical values of output parameters – discharge rate, gravimetric density, volume density, cycle life, safety, etc. – of a battery. These parameters determine the utility of a battery for an application. The stakeholder consultation undertaken for the report helped in understanding the relationship between different output parameters and applications. While chemistries determine theoretical values of output parameters, design and production processes determine practical/applied values of these parameters.

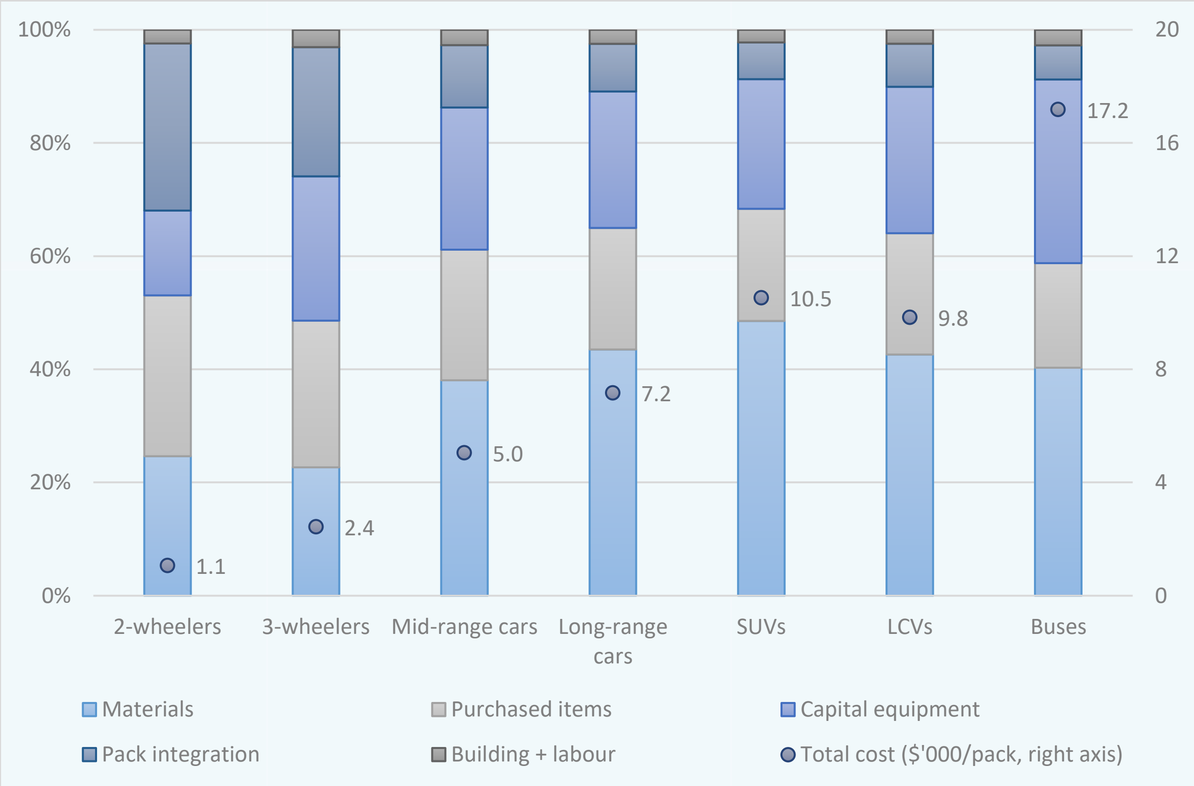
Estimating the cost of batteries:

The cost of battery is disaggregated by building a bottom-up model of battery cost by using the BatPaC (Battery Packaging and Cost estimation) tool, a publicly available, peer-reviewed, and customizable Microsoft Excel-based computer program developed by the Argonne National Laboratory (U.S.).

The costs of battery raw materials (positive and negative electrode active material, current collector foils, electrolyte, separators, carbon and binders), cell/module purchased hardware (thermal conductors, interconnects, state-of-charge regulator, terminals, bus-bars, sensors, disconnects) and battery packaging and integration used in the model reflect 2018 international prices, while those of labour and capital are aligned with the domestic market prices (Indian market) for the same year.

The final price of the battery pack to vehicle manufacturers calculated by the model represents the estimates of both 2018-19 costs and those projected to 2028-29 (without accounting for inflation in the future).

Figure 1: Breakdown of costs with overhead items distributed to the primary cost-factors



Source: ICRIER research based on BatPaC

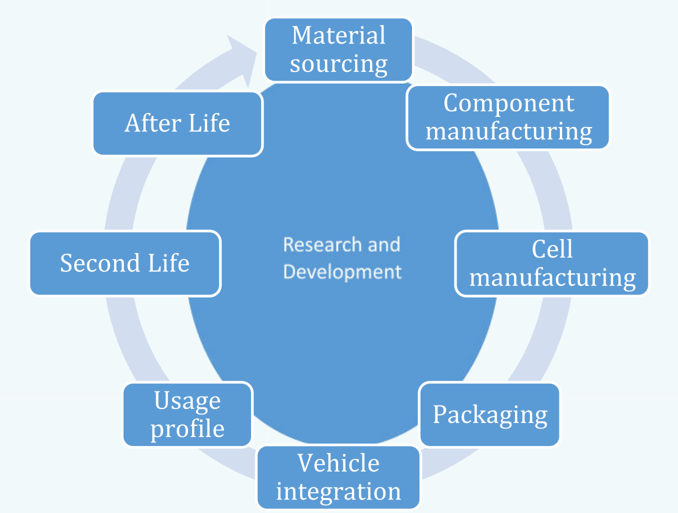
The cost breakdown analysis for each type of EV suggests that, apart from the positive active material, which has a significant contribution in all the seven cases, negative active material and electrolyte (five out of seven cases, each) strongly dominate the share in the cost of batteries. The formation cycling, testing, and sealing or the cell finishing process also heavily influence the final price of the pack (all cases). Along with these, module hardware and separator material (five and four cases, respectively) are also indispensable with regards to cost optimization, across applications. The shares of building and labour costs combined per pack are found to be insignificant for all the cases.

The disaggregation indicates the importance of availability of critical cell components in managing the cost of a battery along with development of ancillary industries (module hardware, separator, etc.) that would play an important role in reducing the final cost of the battery. To understand these findings and their implication and relevance in the Indian context, the value chain of battery manufacturing is outlined in the study.

EV battery value chain in India:

This outline helped in identifying the relevant stakeholders and in collecting information that was used in developing the model and identifying the cost reduction strategies.

Figure 2: Outline of EV battery value chain in India



- EV Battery Value chain is studied and presented as a circular chain in which every stage needs support in terms of Research and Development.
- Most of these stages are in a nascent stage in the country and the existence of some is insignificant.
- Each stage has its opportunities and challenges in reducing the cost of a battery and finally the cost of EVs and their utilization in transport and mobility system.
- The second life and after-life stages of a battery are also considered for their role in reducing cost.

Based on the analysis of the value chain and consultations with stakeholders, we identified that the cost reduction of batteries is also possible beyond the sale of vehicle among other options as indicated by the modelling exercise. All these options are detailed in the table below:

Table 2: Cost reduction drivers in value chain

Value chain	Cost reduction drivers	Impact on cost (Short / Medium/ Long term)
Material sourcing & Component manufacturing	Access to supply chains Manufacturing, Lower transactions cost	Long Term Long Term Medium / Long Term
Cell manufacturing	Manufacturing Lower financing, transaction & import costs	Medium Term Medium Term
Packaging	Local components and software at scale	Short / Medium-term
Vehicle integration	Standardization of battery designs & protocols to achieve domestic scale	Short / Medium-term
Usage profile	Various business cases to reduce Total Cost of Ownership (TCO)	Short / Medium-term
Second-life / Reuse	Extended life & alternative uses	Medium Term
After-life / recycling	Cost recovery from material recycling	Medium Term
Research & Development	Technology development	Medium / Long Term

Source: ICRIER Research, calculations based on data from secondary and primary data collection

Based on the modelling results and interviews, the study identifies few strategies. Moreover, since the transition to an electric mobility system is a complex policy problem, EV policies of different countries are also discussed along with India to present a comprehensive background.

Policy Perspectives and Propositions

The uptake of EVs faces a variety of challenges and entails the development of an electric mobility system. The governments will have to play an essential role in developing such a system by designing non-traditional policies. In this report, we reviewed policies in different countries – Norway, China, Sweden, Germany, The United States, The United Kingdom – including India (both at the center and state levels). The objective of this review is to learn from the experiences of countries that have done well in promoting EVs and use these lessons to identify strategies from the information available from the first two steps in the report. Based on the modelling exercise and stakeholder Interviews, following strategies are identified:

A. Incentivizing Cell Manufacturing.

B. Development of ancillary industries for pack components– Battery Management System (domestic production of PCBs, ICs, etc.), Binder and other products used in batteries apart from cells.

C. Incentivizing reverse logistics, reuse for stationary usage (grid, invertor, RE storage), recycling of batteries, and recovery of critical metals / materials.

D. Improving the availability of critical cell components like Lithium, Cobalt, Graphite

E. Standardization – Battery standards, Testing standards, etc. to prevent the entry of non-standardized batteries in market and promote investments.

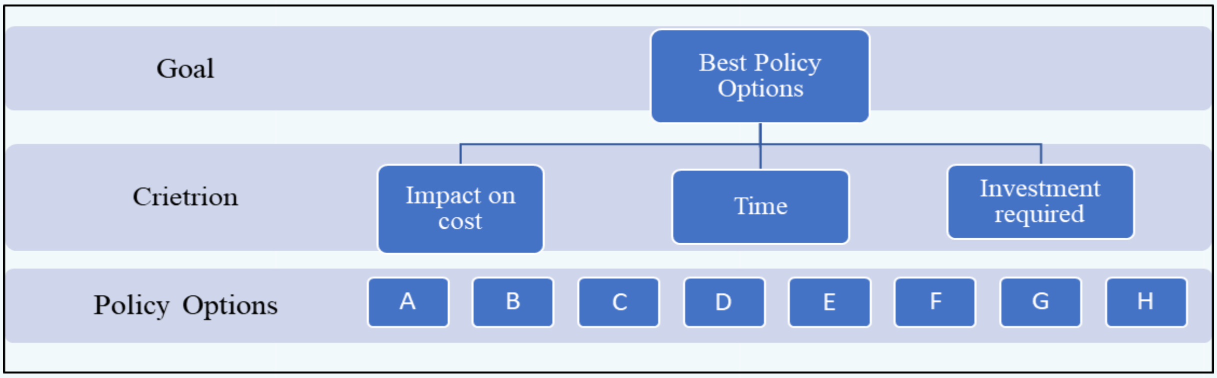
F. Battery as a Service – Innovative business models to reduce the cost of the battery for final consumer.

G. Demand aggregation – Aggregation of demand in case of public transport to augment the overall demand for batteries and promote domestic cell manufacturing.

H. Dedicated Battery research institute – which works on all aspects of batteries including cell chemistry and pack components in collaboration with the government and the industry.

These strategies are then prioritized using the Analytic Hierarchy Process (AHP) in a workshop with experts from industry, research, academics, etc. The problem is characterised as shown in the figure below:

Figure 3: Representation of the problem as a hierarchy



The first step in the activity determined the relative importance of these criteria, i.e. what is most important for a strategy – is it the impact on reducing the cost, time taken, or the investment required? The analysis shows that the impact of these strategies in reducing the cost is the most important criterion, followed by time. The table below shows the relative weight of these criteria based on the ranking done by the experts.

Table 3: Relative importance of criteria

Criterions	Weight
Impact on cost	0.64
Time taken	0.22
Investment required	0.14

Source: ICRIER research based on the stakeholder feedback exercise

Based on these weights, all other eight strategies were ranked, and results are presented in the table below:

Table 4: Ranking of strategies

Alternatives	Rank
Incentivising Cell Manufacturing.	1
Improving the availability of critical cell components like Lithium, Cobalt, Graphite	2
Standardisation – Battery standards, Testing standards etc. to prevent the entry of non-standardized batteries in market and promote investments.	3
Development of ancillary industries for pack components– Battery Management System (domestic production of PCBs, ICs, etc.), Binder and other products used in batteries apart from cells.	4
Incentivising reverse logistics, reuse for stationary usage (grid, invertor, RE storage), recycling of batteries and recovery of critical metals/materials.	5
Demand aggregation – Aggregation of demand in case of public transport to augment overall demand for batteries and promote domestic cell manufacturing.	6
Dedicated Battery research institute – which works on all aspects of batteries including cell chemistry and pack components in collaboration with the government and the industry	7
Battery as a Service – Innovative business models to reduce the cost of the battery.	8

Source: ICRIER research based on the stakeholder feedback exercise

Cell manufacturing and improving the availability of critical cell components are the most prioritized strategies followed by standardisation and development of ancillary industries. These results agree with general intuition that domestic manufacturing of cells will reduce the cost of batteries and thus, three out of top four are about promoting cell manufacturing and battery packaging in the country. Standardisation is a relatively inexpensive policy instrument that can play an important role in preventing the entry of sub-standard batteries in the market. It will act as a barrier to entry in the market and will encourage investments by providing a fair and competitive market for everyone. Standards will also help end-users in decision making and will address anxieties over the safety of batteries and electric vehicles. Most of the other options were found to have similar rank and priority. However, assurance of demand and creation of market will play an essential role in encouraging investments. Hence, financial assistance to end-users, mass procurement, charging infrastructure and awareness about EVs are important and must be pursued simultaneously as these will play a crucial role in creating demand.

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