

## FEASIBILITY STUDY FOR SETTING UP AN INDEPENDENT BATTERY ASSEMBLY LINE FOR AN ELECTRIC VEHICLE MANUFACTURING COMPANY

Aditya Vikram Bagaria<sup>\*1</sup>, Amulya Acharya K<sup>\*2</sup>, Prof. Rajeswara Rao<sup>\*3</sup>

<sup>\*1,2,3</sup>RV College of Engineering, Industrial Engineering and Management, Bangalore 560059, India.

---

### ABSTRACT

This paper presents the feasibility study of setting up a new battery production line for an electric manufacturing company. It is mainly based on the following alternatives: outsourcing the batteries from an external supplier or wholly manufacture the batteries in-house. Both the qualitative and quantitative approaches have been exploited to analyze and compare between the make or buy decision. As this production line has not yet been in place, monthly sales volumes are forecasted within the two years' time frame. Based on the forecasted demand, we find the required safety stock of materials, inventory cost, time between production runs and resources utilization for each option. Finally, in the quantitative analysis, the two years forecasted sales volume is used as a framework and several decision making-techniques such as break-even analysis and cash flow are employed to come up with the results in financial aspects.

**KEYWORDS:** Forecasting techniques, calendaring, cell assembly, qualitative and quantitative techniques, break-even analysis, cash flow analysis, feasibility study.

---

### I. INTRODUCTION

#### A. Problem Identification:

With the current situation of outsourcing the batteries, it poses a threat to the company rather than providing an opportunity. This could imply:

- High procurement costs
- Low scope for customization according to company requirements
- Standard control on the quality and other specifications.

The company has therefore decided to backsource the battery production line. To enable this, the company should identify the core processes and check the feasibility of performing the process in-house.

#### B. Purpose of study:

The aim of this study is to help the company achieve effective decision making with regard to setting up a battery line. It should provide both qualitative and quantitative aspects to consider. The company invests a large sum in purchasing the batteries. With changing technologies, the requirements change and the demands differ. This results in dynamic pricing which can affect the expenditures of the company.

Therefore, the company requires for us to perform the Feasibility study of establishing a new production line in-house to yield a better and stable profit.

#### C. Project Directives:

The company needs to decide between outsourcing the batteries and manufacturing them in-house. The conditions given by the company are as follows:

- Return on Investment within approximately two years
  - Total cost should not exceed the current price of buying from supplier
  - This study of feasibility is set in the timeframe of two years
-

Given, historical sales data, 2 years forecast of battery demand. Using this, a framework is generated to compare and evaluate between the two options.

#### **D. Project Limitations:**

Since the assembly line has not yet been set, unforeseen circumstances may arise such as unplanned stop time, machine breakdown, market fluctuations, government policies, level of competition, etc.

The manufacturing plant for this facility is located in Coimbatore and the R&D center is located in Bangalore. This distance between the authors and area causes difficulty in gathering data and a gap in passage of information.

The biggest hurdle however, is the current pandemic which has posed an uncertain future to the company. The global economy is largely affected and will have its effects lasting for many years to come. This study is made ignoring the present situation and proposes a potential project for when the economy returns to its stable state, once again.

## **II. CONCEPTUAL FRAMEWORK OF BATTERIES**

### **A. Product Description:**

A lithium-ion battery or Li-ion battery is a rechargeable battery. Lithium-ion batteries are employed in portable electronics and electric vehicles. Traditionally, lead acid batteries were used in place of these batteries. However, they have almost entirely been replaced by Li-ion batteries for several reasons as discussed below.

A battery mainly comprises of two phases, 'charging phase,' where electron flow is from the positive to negative electrode and the 'discharging phase' where the movement is from negative to positive electrode.

Lithium ion batteries have almost replaced the traditional lead acid batteries. The company however, uses both lead acid, as well as lithium ion batteries. In the recent Lithium ion version of vehicles being released, a single battery of 60V is directly placed in the vehicle system and all connections are made to it.

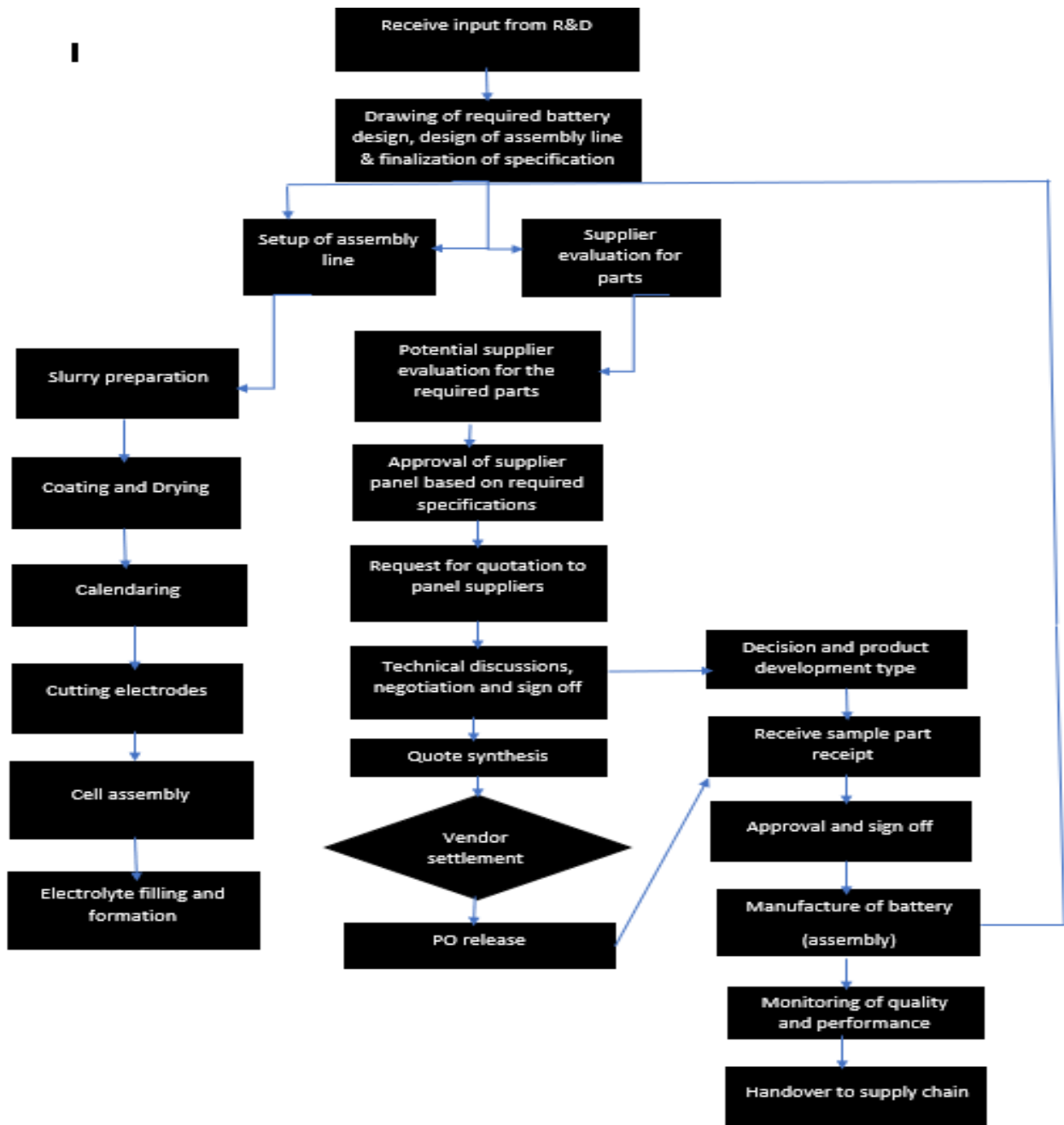
### **B. Components of a Lithium ion battery**

The components of a Lithium ion battery include:

- a) Cathode
  - Made up of lithium oxide
  - It determines the capacity and voltage of the battery
  - An aluminum foil holds the frame of the cathode
  - The cathode must be coated with an active metal
  - Greater the concentration of lithium, greater the potential difference between the cathode and anode which leads to a higher voltage of the battery.
- b) Anode
  - The anode must be coated with an active metal
  - During the discharging state, the anode emits lithium ions
  - Usually a graphite(carbon) material is used as anode as it is stable and less reactive.
- c) Electrolyte
  - It comprises of salts to facilitate movement of Li ions
  - The strength of the electrolyte depends on the speed of movement of the ions.
- d) Separator
  - It keeps the cathode and the anode apart
  - It prevents direct flow between the electrodes
  - It allows flow only through the internal microscopic hole

The cathode and anode together determine the basic performance of the battery. The electrolyte and the separator determine the safety of the battery.

**C. Process mapping:**



**Fig-1: Process Mapping Of The Battery Assembly**

**D. Advantages of Lithium ion batteries:**

- Light weight
- High energy
- Low self-discharge and high shelf life
- Quick charging
- Longer lifespan
- Low maintenance
- High voltage

**E. Stages in Production Process:**

- a) Slurry preparation: Preparation of binder and solvent, solid electrolyte, conductive additives and active materials.
- b) Coating and drying: Providing of a coating on the electrode.
- c) Calendaring: Electrodes are compressed
- d) Cutting electrodes: Electrodes are cut into strips
- e) Cell assembly: Electrodes are stacked one on top of the other
- f) Electrolyte filling and formation: Final assembly is completed by filling the electrolyte and filling other components according to the requirements.

### III. THEORETICAL BACKGROUND

**A. Forecasting techniques:**

These techniques provide inputs for planning and controlling the use of resources. The objective is to develop a useful forecast by applying the information at hand with the forecasting techniques that best fit the pattern of demand. It has two types:

a) Qualitative methods:

These are basically judgment methods that use intuition, for example, expert opinions or surveys to produce quantitative estimates about the future. This method is used when there is insufficient historical data (i.e., when there is less standardization and accuracy of data). This method is non-scientific but in cases like predicting success of new products or impact of new technology, it has proven to be successful. It is the best method for all time horizons of forecasting: short term, medium term as well as long term

b) Quantitative methods:

They are highly dependent on mathematical calculations and help to predict the future.

- Historical projection or Time-series method
- This method is used when the historical data is made available. The trend and seasonal patterns must be well defined. In such an event, data can be projected into the future so that short term forecasting can be made.
- Casual Method
- Causal methods are used when historical data are available. The fundamental ground on which causal methods are built is that when the relationship between the factor to be forecasted and other external or internal factors can be identified as the cause-and-effect relationship. Casual methods are used for long term forecasting and can help in predicting turning points.

**B. Outsourcing**

a) Definition

Outsourcing is the business practice of hiring a party outside a company to perform services and create goods that could be performed in-house by the company's own employees and staff.

b) Reason for outsourcing

The company has been outsourcing its batteries mainly because of its avid focus on the core business, which is, manufacture and assembly of the electric vehicle. Moreover, it did not have the financial stability or the resources in

the past to set up an independent assembly line. Setting up of an assembly line would incur heavy set-up costs, labor and resources for the company.

- c) Disadvantages of outsourcing
  - Diffusion of confidential information of the company to its existing suppliers
  - High dependence on its suppliers which causes a lot of delays to the company
  - Losing knowledge to integrate what has been outsourced
  - Hindrance to the expansion of the company in long term

**C. Feasibility study and Investment analysis**

a) Feasibility Study

There are 4 main types of feasibility based on which a study is done. They are

- Technical feasibility
- Financial feasibility
- Time horizon/schedule feasibility
- Operational feasibility

b) Investment Analysis

- Cash on Return

$$\text{cash on return} = \text{annual} \frac{\text{income}}{\text{total investment}}$$

- Payback period

$$\text{payback period} = \text{initial} \frac{\text{investment}}{\text{annual cash flows}}$$

- Internal rate of return
- Net present value

**IV. AGGREGATE ANALYSIS FOR THE PARTICULAR CASE STUDY**

**A. Qualitative analysis**

The quantitative analysis helps to identify the strengths and weaknesses of a venture, its opportunities and threats, the resources required to carry through, and ultimately the prospects for success.

For this case study, we have chosen to do perform the operational feasibility as well as technical feasibility tests.

a) Operational feasibility

Operational feasibility is the measure of how well a proposed system solves the problems. It teaches the management techniques to deal with change resistance and acceptance.

Given below is the technical feasibility analysis performed for this particular study. Each technical study has 6 elements based on which its study is conducted.

**Table-1:** Study of the Operational Feasibility

Element	Analysis
Process and urgency for its requirement	<ul style="list-style-type: none"> <li>• Requirement of setting up an independent battery assembly line for the construction of the battery.</li> <li>• Not having an independent assembly line can increase the dependency of the company on its suppliers.</li> <li>• Hindrance to the expansion of the company, long term.</li> <li>• Diffusion of confidential information of the company to its existing suppliers</li> </ul>

Evaluation	<ul style="list-style-type: none"> <li>• Suggestions for the process have heavy fixed costs and require high technical advancements.</li> <li>• It may increase the labour requirements and land requirements.</li> <li>• However, it reduces the dependency and can have multiple long-term benefits to the company</li> </ul>
Implementation	<ul style="list-style-type: none"> <li>• Implementation requires heavy capital, setting up costs and labour.</li> <li>• It can mildly affect the current process for a short period of time.</li> <li>• However, the company can sustain the temporary loss and benefit from the implementation in the long-term growth.</li> </ul>
Resistance	<ul style="list-style-type: none"> <li>• Lack of labour motivation to put in excess efforts to make up for the implementation lag</li> <li>• Labour objections, manager resistance and organisational conflicts</li> <li>• Government policies and regulations</li> <li>• Hindrance to the fixed routine that has been followed for over 8 years</li> <li>• Large fixed costs and set-up time could question the determination of the executives.</li> </ul>
Strategies	<ul style="list-style-type: none"> <li>• To ensure that the authorities and higher-level executives make the entire team aware of the long-term growth and benefits of the implementation.</li> <li>• Ensure enough labour is assigned to the line and no employee is overworked.</li> <li>• New processes and structures need to be implemented to ensure that the redesign is effective</li> <li>• The changed workspace environment demands a new schedule, incentives and new motives to ensure growth of the company</li> </ul>
Adapt & Review	<ul style="list-style-type: none"> <li>• The organisation would require at least 6 months to set-up and adapt to the new redesign.</li> <li>• Supervisory staff and a highly efficient management team is required for optimal functioning of the setup.</li> </ul>

b) Technical feasibility

Technical feasibility helps organizations determine whether the technical resources meet capacity and whether the technical team is capable of converting the ideas into working systems.

Given below is the technical feasibility analysis performed for this particular case study.

**Table-2:** Study of the Technical Feasibility

Technical Resources	Outsourcing batteries	Setting up battery assembly line
Material Requirements	<ul style="list-style-type: none"> <li>• Arrangements required for packaging materials.</li> </ul>	<ul style="list-style-type: none"> <li>• Cathode materials,</li> <li>• Anode materials,</li> <li>• Electrolyte,</li> <li>• Separators</li> </ul>

		<ul style="list-style-type: none"> <li>• Current collectors.</li> </ul>
Labour Requirements	<ul style="list-style-type: none"> <li>• Logistic support</li> <li>• Transportation facilities and labour requirement</li> <li>• Battery inspection department before shipment and after delivery</li> <li>• R&amp;D teams required to check growth of technology and evaluate vendors</li> <li>• Staff for selection of shipment from different suppliers and to ensure that transportation requirements are fulfilled</li> <li>• Accounting team to ensure payments</li> </ul>	Since the assembly line technology chosen is almost entirely automatic, the labour requirements would contain mainly supervising staff and maintenance staff.
Transportation Requirements	<ul style="list-style-type: none"> <li>• Preparation of bill of landing, purchase order.</li> <li>• Preparation of freight bills</li> <li>• Requirement for supply chain logic tracking system</li> </ul>	The manufacturing plant of Ampere vehicles is located at Coimbatore. The additional assembly line for the batteries would also be located at the same plant. Therefore, no additional transportation facilities would be required.
Locational Requirements	Diffusion of confidential information due to locational separation from the suppliers	(Accommodation of assembly line within the Coimbatore plant)
Technical Requirements	High dependence on its suppliers and the technologies they employ	Provision to understand, adapt and keep up with the growth in technology. Efficient R&D team is already existent. New technology is implemented at all times. Highly feasible.

**B. Quantitative analysis**

a) Break even analysis:

Break-even is a stage where the company neither makes profits nor loss on the assembly line setup. The break-even analysis is a financial tool used to determine at what stage the company will be able to make profits.

It acts as a forecasting tool that determines whether the company is viable to set a new production line. It is not only highly realistic, but also, acts as a guide to understand the pricing strategy. For this reason, the break-even analysis is a quantitative analysis technique.

Primarily, the break-even analysis comprises of two components, fixed costs and variable costs. Fixed costs are overhead costs that depend on the level of production and investment. For example, rent, labor costs, taxes, salaries, depreciation costs, energy costs, etc. Variable costs, on the other hand, are the costs that depend directly on the quantity of production. For example, raw material costs, packaging costs, etc.

The Total Cost (TC) expended by the company is the sum total of its Fixed Costs (FC) and Variable Cost (VC).

$$FC + VC = TC$$

As per the data granted by the company, we assess the following:

Fixed Costs:

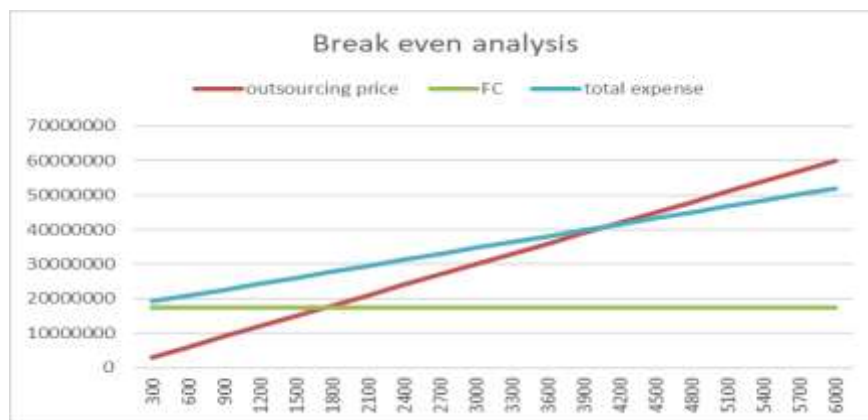
Factory rent	15,00,000
Salary	8,00,000
Machinery	1,50,00,000
Utilities	1,00,000
Maintenance wages	25,000
Total FC	1,74,25,000

Variable Costs:

Manufacturing supplies	4,000
Direct labour costs	400
Holding cost	1,000
Small tools	200
Power and light	150
Total VC	5,750

- The cost of outsourcing per unit is Rs. 10,000.
- The number of units required per month is 150.
- The break-even point is at 4100 units.

The graph shown below depicts the break-even analysis:



At the consumption rate of 150 pieces per month, the company will take over 27 months to reach the break even.

During this period the company would have spent a sum of Rs. 4,10,00,000 approximately.



b) Cash Flow Analysis

The cash flow analysis evaluates the project alternatives' cash flow, difference between the flow of funds into and out of the firm over a period of time including revenues, cost, and changes in assets and liabilities.

The base case for establishing an assembly line for battery is to buy the machinery and the raw materials. An initial investment of a fixed cost of Rs. 1,74,25,000 is required at the end of year 0 with the profit of Rs. 2,200/unit all through four years. Potential sale beyond 6000 will be lost due to the capacity of the machine used. An increase in demand of 20%, every year, has been predicted and considered. This assumption has been taken, based on the past sales records and increasing demand of the electric scooter in the market. A rate of 108% has been considered for cost of capital, to adjust inflation and calculating the net present value (NPV) of the project, considering the sales demand for the next four years.

Rate of return: 108%

Year	Projected Demand (units/year)	Projected Capacity (units/year)	Cash Inflow (Outflow) in Rs.
0	-	6000	(1,74,25,000)
1	1800	6000	3960000
2	2160	6000	4320000
3	2592	6000	5184000
4	3110	6000	6220800

Hence,

NPV= 22,59,801
----------------

## V. CONCLUSIONS AND RECOMMENDATIONS

Outsourcing is a strategic tool used by many organizations. The decision of whether to make or to buy the function or service, thus, can give a huge impact to the company if the decision has been made thoroughly and wisely. However, if the company does not consider it carefully and convince by only a short-term benefit, there is a high risk in losing the company's core competency. To effectively make the outsourcing decision, both qualitative and quantitative approaches have to be taken into consideration. Business core competencies as well as the financial aspect of business decision, such as production and inventory cost, cash flow analysis, etc. need to be identified and analyse, combining with management judgment to ensure that the right decision is made.

In this study, all the analysis techniques are based mainly on forecasting the demand for the electric vehicles and the growth in the importance of the batteries used in these vehicles. Based on the analysis performed in the previous chapters and the feasibility studies, we can conclude that setting up an independent assembly line is not only highly feasible but also, very profitable to the company.

Since the manufacturing unit of the vehicle is located at Coimbatore, there is already an establishment of facilities. The establishment would require assignment of a management and inspection committee.

Provided the initial lag can be managed and overcome, the in-house production would be rather profitable to the company and beneficial to the confidential policies of the company.

## VI. REFERENCES

- [1] Break-Even Method of Investment Analysis  
[https://mountainscholar.org/bitstream/handle/10217/193357/AEXT\\_ucsu2062237592004.pdf?sequence=1](https://mountainscholar.org/bitstream/handle/10217/193357/AEXT_ucsu2062237592004.pdf?sequence=1)
- [2] How to choose the right forecasting technique  
[https://www.academia.edu/download/50421898/How\\_to\\_Choose\\_the\\_Right\\_Forecasting\\_Technique.pdf](https://www.academia.edu/download/50421898/How_to_Choose_the_Right_Forecasting_Technique.pdf)
- [3] Environmental feasibility to re use electric vehicle batteries  
<https://www.sciencedirect.com/science/article/pii/S2213138814000071>
- [4] Cost assessment for advanced batteries in Electric Vehicles  
<https://pdfs.semanticscholar.org/4978/9bd096d71a854a930f20d80111a8a9b90c35.pdf>
- [5] Feasibility study of setting up a new production line  
<http://www.diva-portal.org/smash/get/diva2:121377/FULLTEXT01.pdf>