The Selection of Lithium Battery raw Materials by Environmental, Economic, and Social Sustainable

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Abstract. The development of technology is done to advance knowledge and simplify life, and to develop the issues that are around. The development of electric vehicles must be encouraged by the development of batteries used to run these vehicles. The batteries used are usually made from lithium, because it has a strong electrical shelf life, not easily damaged, fast charging power, and so forth. This study evaluates and selects the best raw materials for lithium batteries from three selected raw materials, namely Lithium Cobalt Oxide (LCO), Lithium Iron Phosphate (LFP), and Lithium Nickel Manganese Cobalt Oxide (NMC), because these materials are often used to make good lithium batteries and have some things in common. The approach used to choose the right standard material by knowing the life cycle of each material. This life cycle consists of three elements namely environmental, social, and economic. An environmental approach to find out whether the material used will have an impact on the surrounding environment such as air, water pollution and so forth. An economic approach to find out which materials are more economical so as not to burden the company and consumers who use them. The social approach is carried out to find out information about the material has been known by the consumer related to applicable standards.

1. Introduction
Problems in this world are increasingly complex and complicated to be solved with just one point of view. The population of the earth is currently faced with environmental problems that are crisis, such as global warming, disruption of the ozone layer and tropical rain forests, water and air pollution, and social problems such as poverty in developing countries, inter-religious conflicts, and so on [1]. The problem of air pollution is often found throughout the world. Developing countries have higher levels of air pollution. The impact of air pollution can disrupt human health, plants, aesthetics and comfort, or damage property. One of the causes of air pollution is smoke from burning vehicles. Because most vehicles at the moment the fuel does not burn completely on the engine which causes harmful smoke. There are 3 hazards caused by vehicle fumes namely: vehicle exhaust gases are carcinogenic, damage to the circulatory system, and trigger damage to the respiratory system [2].

Seeing from this problem, an electric vehicle was made to replace today's commercial vehicles. The development of electric vehicle technology is very fast and has spread widely throughout the world. The more development of electric vehicle technology, the more developed batteries for electric vehicles. Batteries are energy sources that can convert the stored chemical energy into electrical energy that can be used like an electronic device, so there is no need to connect the power cord to the
terminal to be able to activate electronic devices. Each battery consists of a positive terminal (cathode) and negative terminal (anode). The output of the electric current from the battery is direct current or also known as DC current (Direct Current). At this time lithium batteries have been found as a good battery for electric vehicles [3].

Lithium-Ion batteries began to be developed in 1912. Li-ion batteries are batteries that can be removed like laptop batteries, smartphones and tablets. Li-ion batteries have different compounds, such as Lithium Cobalt Oxide (LCO), Lithium Manganese Oxide (LMO), Lithium Nickel Manganese Cobalt Oxide (NMC), Lithium Iron Phospate (LFP), Lithium Nickel Cobalt Aluminum Oxide (NCA), and Lithium Titanate (LTO) [4]. Lithium batteries continue to be developed to suit electric vehicles and not only in terms of their development that must be considered, but the life cycle of lithium batteries also needs to be considered [5].

Life cycle analysis is an analysis of environmental impacts during the product life cycle from the extraction of raw materials to the end of their useful life. The environmental life cycle assessment (LCA / ELCA) has developed into an established tool and is widely used to assess the environmental impacts caused by products. Because it consists of all relevant 'product life' phases, such as production, use and disposal, which provide broad assessments and comprehensive results. By using three approaches namely economics (ELCA), environment (LCA), social (SLCA), and Life Cycle Costing (LCC) can arrange equipment to assess the sustainability of a product's life cycle [6]. This idea is in accordance with the 'three pillars' model of sustainability which considers environmental, economic, and social problems as three dimensions for modern sustainable concepts. Sustainability is the endurance of a system and process [7]. The principle of a sustainable development is the first environmentally sustainable where the extraction of raw materials from natural environmental resources for human needs for these resources has limitations. So that sustainable environment is implemented to protect the environment from over-exploitation and utilization of resources. Lithium batteries are used to reduce air pollution, one of the causes is conventional vehicle smoke, and to find out which lithium material is better and healthier for the environment [8].

Second, sustainable social which guarantees social justice in the distribution of wealth and services. Knowing the problems that occur in social related to the selection of raw materials to be used in batteries. Awareness of the social problems that often occur in the economic sector in certain countries, helps in the selection of supplies with more efficient social standards. In addition, the estimation of social problems helps producers anticipate social problems that might occur during future supply chain distribution, and prepare actions to solve them [9].

Third is a sustainable economy which maintains stable economic growth by restructuring productive systems to save energy resources. Where this aspect is used to assess the economic performance of the product. There are three perspectives taken, namely from the point of view of customers, producers and larger entities such as public authority or society as a whole. This aspect also influences the previous aspects, which are environmental and social. To avoid this, external effects need to be considered in determining the most cost-effective option for the community [10].

Based on the types of lithium raw materials used to make selected 3 raw materials which are often used to make batteries, namely Lithium Cobalt Oxide (LCO), Lithium Nickel Manganese Cobalt Oxide (NMC), and Lithium Iron Phospate (LFP). This research was conducted to determine the differences in the life cycle of the battery raw material viewed in terms of environmental, social, and economic.

2. Methodology

This type of research is a qualitative descriptive study, the research used to analyze data by describing or describing collected data that is applicable to the public or generalization (Sugiyono, 2008). Data obtained from previous studies that discuss lithium batteries for electric vehicles. This research discusses the raw materials of Lithium Cobalt Oxide (LCO), Lithium Nickel Manganese Cobalt Oxide (NMC), and Lithium Iron Phospate (LFP) to use lithium batteries, as well as the raw materials used as raw materials for lithium batteries. Then do an analysis of three life cycle cycles (ELCA, LCC, SLCA) to improve the performance of the raw materials to be used. Where offers several advantages such as battery cycle perspective, cycle perspective, and manage useful software and databases.
Figure 1. The sustainable Process

Then compare the results of the analysis of the three materials that will be used in making lithium batteries. Is it in accordance with what is desired and how the level of security and economics of these raw materials.

3. Results and Discussion
This research describes lithium-ion batteries made from Lithium Cobalt Oxide (LCO), Lithium Nickel Manganese Cobalt Oxide (NMC), and Lithium Iron Phosphate (LFP). The following table explains the slight differences in raw material for batteries:

| Specification                  | Lithium Cobalt Oxide (LCO) | Lithium Iron Phosphate (LFP) | Lithium Nickel Manganese (NMC) |
|--------------------------------|-----------------------------|------------------------------|---------------------------------|
| Voltage, nominal               | 3.60 V                      | 3.20V                        | 3.60V, 3.70V                    |
| Specific energy (capacity)     | 150-250 Wh/kg               | 90-120 Wh/kg                 | 150-220 Wh/kg                   |
| Charge (C-rate)                | 0.8 C, 1C maximum, 4.20V peak, 3 hr charge | 1C typical, 3.65V peak, 3 hr charge time | 1C, 4.20V peak, 3 hr charge time |
| Discharge (D-rate)             | 1C, 2.5V cut off            | 25-30C continuous, 2V cut off | 2C continuous, 2.5V cut off     |
| Cycle life                     | 500-1000 related to depth of discharge, load, and temperature | 1000-2000 related to depth of discharge and temperature | 1000-2000 related to depth of discharge and temperature |
| Thermal runaway                | 150 °C (302°F) full charge promotes thermal runaway | 270°C (518°F) very safe battery even fully charged | 210°C (410°F), high charge promotes thermal runaway |
| Applications                   | Mobile phones, laptops, cameras | Portable and stationary needing high load currents and endurance | E-bikes, medical device, Evs, Industrial |
| Comments                       | Very high specific energy, limited specific power, cobalt is expensive | The very flat voltage discharge curve, but low capacity. One of safest Li-ions. Elevated self-discharge. | Provides high capacity and high power. Serves as Hybrid cell. This chemistry is often used to enhance Li-manganese. |

The high specific energy makes Li-cobalt the popular choice for mobile phones, laptops and digital cameras. The battery consists of a cobalt oxide cathode and a graphite carbon anode. The cathode has a layered structure and during discharge, the lithium ions move from the anode to the cathode. The flow reverses on charge. The drawback of Li-cobalt is a relatively short life span, low thermal stability and limited load capabilities (specific power). Li-cobalt should not be charged and discharged at a current higher than its C-rating. This means that an 18650 cell with 2,400mAh can only be charged and discharged at 2,400mA. Forcing a fast charge or applying a load higher than 2,400mA causes overheating and undue stress. For an optimal fast charge, the manufacturer recommends a C-rate of 0.8C or about 2,000mA. The performance of Li-cobalt in terms of specific energy or capacity that
relates to runtime, specific power or the ability to deliver high current, safety, performance at hot and cold temperatures, life span reflecting cycle life and cost.

*Lithium Nickel Manganese Cobalt Oxide (NMC)*

One of the most successful Li-ion systems are a cathode combination of nickel-manganese-cobalt (NMC). Similar to Li-manganese, these systems can be tailored to serve energy cells or power cells. NMC in an 18650 cell for moderate load condition has a capacity of about 2,800mAh and can deliver 4A to 5A; NMC in the same cell optimized for specific power has a capacity of only about 2,000mAh but delivers a continuous discharge current of 20A. The secret of NMC lies in combining nickel and manganese. An analogy of this is table salt in which the main ingredients, sodium and chloride, are toxic on their own, but mixing them serves as seasoning salt and food preserver. Nickel is known for its high specific energy, but poor stability; manganese has the benefit of forming a spinel structure to achieve low internal resistance but offers a low specific energy. Combining the metals enhances each other strengths. NMC is the battery of choice for power tools, e-bikes and other electric powertrains. The cathode combination is typically one-third nickel, one-third manganese and one-third cobalt, also known as 1-1-1.

*Lithium Iron Phosphate (LFP)*

Li-phosphate is more tolerant to full charge conditions and is less stressed than other lithium-ion systems if kept at high voltage for a prolonged time. As a trade-off, its lower nominal voltage of 3.2V/cell reduces the specific energy below that of cobalt-blended lithium-ion. With most batteries, cold temperature reduces performance and elevated storage temperature shortens the service life, and Li-phosphate is no exception. Li-phosphate is often used to replace the lead acid starter battery. Four cells in series produce 12.80V, a similar voltage to six 2V lead acid cells in series. Vehicles charge lead acid to 14.40V (2.40V/cell) and maintain a topping charge. Time will tell how durable Li-Phosphate will be as a lead acid replacement with a regular vehicle charging system. Cold temperature also reduces the performance of Li-ion and this could affect the cranking ability in extreme cases.

4. Conclusion

Based on this research, it is known that lithium NMC and LFP batteries are both the most stable lithium batteries, but some projects may require a higher energy density so they adapt lithium NMC and some projects require a longer life cycle so they adjust LFP batteries. For LCO has been just to small production like robot, games, and others. Price for NMC and LFP is mostly same because they have combination material and for each ingredient the price is mostly same. For the environmental approach phosphate, manganese and iodide has different characteristics. Such as phosphate is more likely to be cold, manganese tends to be hot because it is made of metal, and iodide tends to be room temperature. And for social people or consumer mostly know LFP and NMC, because NMC almost same with Nickel Cobalt Aluminium (NCA). Because NCM just needs 100 cell battery and for LFP needs 200 cell battery.

5. References

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