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Investment Feasibility Analysis of Hybrid Battery Lithium-Ion and Super Capacitor for Electric Motorcycle in Surabaya City

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Abstract

Increasing carbon emissions is the main problem behind the issue of global warming, which is one of the most profound issues for scientists and researchers today. This study illustrates the negative impact of motor vehicle emissions on the environment, with statistical data showing the significant contribution of the transportation sector to carbon dioxide emissions globally. In addition, it illustrates the calculation of the investment to be spent by investors in building a lithium-ion hybrid plant and supercapacitors. The cash flow shows that the project is feasible to proceed with positive financial results, including an IRR of 14.23%, NPV of USD 1.358.652 and NBC indicating a higher ratio of benefits than costs. Although it takes almost 10 years to break even, the sensitivity analysis shows that the project remains viable if production is < 263 units and raw material prices do not exceed USD 516.970. In addition, this plant has significant potential to reduce CO2 emissions, with an average reduction of about 68.29% per year, supporting the government's target of reducing carbon gas emissions by 43.20% by 2024. Therefore, this project not only promises financial benefits but also supports efforts to reduce carbon emissions in Indonesia.

Keywords
Sustainable Development Goals (SDGs), Electric Vehicles (EV), Lithium-Ion Battery and Supercapacitor, Investment Feasibility.

1. Introduction
The transport sector is currently far from zero emissions, as the current composition of the road vehicle fleet is predominantly petrol vehicles (Leard & Mcconnell, 2020). By 2021, it is estimated that around 3 billion metric tonnes of carbon dioxide will be emitted by passenger vehicles worldwide(Lipu et al., 2022). Statistics show that 41% of total carbon dioxide emissions come from the transport sector globally. In the United States, in 2020, about 29% of carbon emissions were generated by passenger vehicles according to the USA Environment Protection Authorities (Asekomeh et al., 2021). The use of electric vehicles is one of the steps to reduce carbon emissions in the transport sector. However, there are still various issues that need to be further studied such as proper battery selection, fast charging, and hybridization algorithms. Therefore, further investigation is needed to improve electric vehicle technology to achieve the Sustainable Development Goals (SDGs) (Asekomeh et al., 2021). The use of electric vehicles is a step that supports the achievement of Sustainable Development Goals (SDGs), especially in the 'Climate Action' target which aims to reduce greenhouse gas emissions. This innovation is an environmentally friendly alternative by cutting energy consumption and CO2 emissions resulting from burning fossil fuels (Subekti, 2020).

With the carbon emissions produced by conventional vehicles, it is also supported by the growth in the number of motorized vehicles that continues to increase in Indonesia every year (Yulanto & Iskandar, 2021). Based on data from the Central Bureau of Statistics, it was noted that in 2017, there were around 118,922,708 units of motorized vehicles in Indonesia (Yulanto & Iskandar, 2021). Then, in 2018, the number of motorized vehicles increased by around 5.8% to 126,508,776 units. In 2019, the number of motorized vehicles in Indonesia reached approximately 133,617,012 units, showing an increase of approximately 5% (Yulanto & Iskandar, 2021). The growth in the number of vehicles may result in a significant increase in fossil fuel consumption, however, it is worth bearing in mind that such a surge in consumption risks causing a fuel deficit in Indonesia oil deficit in Indonesia. This is reflected in the data on oil production as of January 2021 in Indonesia, which reached around 686,000 barrels per day, while oil consumption reached around 1,392,000 barrels per day (Yulanto & Iskandar, 2021)

The growth in the number of motorized vehicles that increases every year shows an imbalance between production and consumption, causing the demand for fuel to increase which can have an impact on excessive consumption of fossil fuels and environmental pollution, so the use of Electric Based Vehicles (KBL) is a solution to reduce dependence on fossil fuels (Yulanto & Iskandar, 2021).To create a healthy environment through clean energy Indonesia, in accordance with Government Regulation No. 79 of 2014, is committed to increasing the share of new renewable energy (NRE) to overcome fossil energy limitations, especially in the context of the commercialization of electric vehicles which is part of the national energy policy direction (Setyono & Kiono, 2021). Indonesia needs good support from the government in developing and marketing electric vehicle products. This is seen from the positioning of Indonesian people who still do not have the ability and desire to have an electric vehicle. Therefore, regulatory support from the government helps people easily choose to have an electric vehicle. The government has provided support for EVs through Presidential Regulation No. 55/2019. These electric-based vehicles include electric cars (EVs), hybrid electric vehicles (HEVs), as well as electric motors and hybrid motors (Yulanto & Iskandar, 2021). So, one of the cities that supports the program is Surabaya City. Surabaya City is the second metropolitan city after Jakarta and the capital of East Java Province, which is experiencing an increase in population. The rapid population growth in Surabaya City has driven an increase in the use of motorized vehicles, raising concerns related to carbon emissions (Anggraeni, 2022). Surabaya City is included of three cities in Indonesia that can be called a smart city that can improve the efficiency and effectiveness of mobility in this city (Novita Sari et al., 2020). This was done in response to the negative impacts that vehicle use in Surabaya City has on the environment and air quality. With the rapid growth in the number of motorized vehicles, Surabaya is faced with challenges such as exhaust emissions, and worsening air pollution. The growth was reported by the Central Bureau of Statistics in Surabaya City which stated that the use of transportation in 2021 was mostly using passenger cars and motorbikes with a total of 16,413,348 and 120,042,298 (Badan Pusat Statistika Kota Surabaya, 2021a).

Based on the Central Bureau of Statistics in Surabaya City, it is stated that every year the population growth increases with a total of 1,343,084 by gender and age group 20 to 49 in badan (Badan Pusat Statistika Kota Surabaya, 2021a). Population growth has an impact on increasing demand for private vehicles, especially motorbikes. There has been a significant increase in people's purchasing power and ability to buy these vehicles. However, the impacts of increased motorbike use include air pollution problems, traffic congestion, and high energy consumption, as well as increased pollutants in the form of exhaust emissions due to the increasing number of motorized vehicles. Therefore, it is necessary to use Electric vehicles (EVs) in Surabaya City as an environmentally friendly alternative solution. However, in the development of Electric vehicle (EV) technology, one of the most important aspects of this innovation is the Acceleration of Battery Electric Vehicle (BEV) Programme. The Indonesian government seeks to reduce carbon gas emissions as a national measure, with a CO2 reduction target of up to 0.056 gigatons, specifically through vehicle electrification based on Presidential Regulation Number 55 of 2019 (Habibie & Sutopo, 2020). Previous research has researched the impact of electric vehicles on the environment and natural resources, research shows that electric vehicles have great potential to reduce greenhouse gas emissions, reduce dependence on limited natural resources, and address air pollution and the impacts of climate change (Susilawati, 2023)

The rapid development of electric vehicle use encourages Indonesia to become the center of the world's electric vehicle industry, however, it needs investor support to accelerate commercialization. Therefore, to attract investors, it is necessary to consider infrastructure readiness, ease of doing business, government policies, and research and development (Tulus Pangapoi Sidabutar, 2020).To realize electric vehicles, measurements of electric vehicle components are needed. Several studies have conducted a thorough review of electric vehicle innovations, including recent developments in battery technology, charging, systems, and research and development (Tulus Pangapoi Sidabutar, 2020) In battery technology, charging, and control systems, as well as related issues such as charging infrastructure and government policies (Susilawati, 2023). Previous research has conducted research that plans the location and allocation of charging station development as well as, the feasibility of charging station investment to be built using the NPV (Net Present Value), IRR (Internal Rate of Return), and PP (Payback Period) methods to produce an investment feasibility analysis of charging station development planning. Therefore, in the transition to electric vehicles, the analysis of battery components is crucial in the supply chain to increase consumer interest in performance and durability, as batteries are the main power source in electric vehicles that are heavily relied upon for the operation of portable electronic equipment (Nasution, 2021). One type of battery that is commonly used in Indonesia is the lithium-ion battery, which is used in the first domestically-made electric motorbike, Gesits. However, lithium-ion batteries have drawbacks such as limited energy capacity and a limited lifespan that require battery replacement within a certain period (Thowil Afif & Ayu Putri Pratiwi, 2015)

To overcome the limitations of lithium-ion batteries, a hybrid system with capacitors is needed to increase battery life and provide extra power. The analysis of investment feasibility in hybrid lithium-ion batteries and supercapacitors for electric motorbikes in Surabaya City is very important to overcome the limitations of lithium-ion batteries, to determine business feasibility using NPV, IRR, and PP methods as well as, provide insight to stakeholders in decision making and procurement plans for electric vehicle manufacturing in Surabaya, as well as encouraging the transition from conventional motorbikes to electric motorbikes in the hope of providing sustainable economic benefits, supporting efforts to reduce greenhouse gas emissions, and supporting the acceleration of the realization of electric vehicles in government programs.

2. Literature Review

The electrification of the transport industry and V2G technology are undoubtedly for the long term(Tan et al., 2021). An EV being discharged and charged without considering battery degradation, online, is not economically viable due to the additional impact of V2G cycles on battery life**.** From a policy standpoint, the anticipated growth of electric vehicles offers great potential for V2G to play an important role as a power grid service. (Uddin et al., 2018).The implementation of mandatory Indonesian National Standard for primary batteries partially does not have a significant effect on the import value of primary batteries imports (Susanto & Kristiningrum, 2019)**.** The potential of supercapacitors as a single energy store in electric buses, particularly in Indonesia. Technically, this is very possible and has several advantages over batteries, regarding continuity of operation, age, and efficiency**.** Batteries and battery chargers in Indonesia are ready enough to support the development of electric bicycles when viewed from the aspect of technical specification diversity (Wijaya et al., 2021). Lead-acid batteries are a viable option to use today (M. Brunner & M. Brunner, 2021). Commercialization of technology in the global market has proven successful. Supercapacitors based on pineapple crown and leaf biomass are industrially viable. Then the EV motorbike battery plant construction project can proceed to the next stage (Oetomo, 2023). Hybridized lithium-ion batteries and supercapacitors that show good performance in anticipating 3 (three) mobility conditions of electric vehicles, namely acceleration, stabilisation and deceleration conditions. HESS performance is also proven to fulfil the required mobility conditions of electric vehicles (Hasan & Hudaya, 2023).The feasibility of investing in batteries and supercapacitors that match the operating power required by electric motorbikes through a review of technical aspects, market aspects, economic aspects, and environmental aspects (Betsyeda, 2023). With the reduction of carbon gas emissions, it is hoped that the air quality in the atmosphere will be better and the people will be healthier (Istiqomah et al., 2022).The development of electric vehicles is growing fast due to a positive impact on the environment in reducing carbon emissions (Istiqomah et al., 2020).

3. Methods

This research aims to evaluate whether investment in hybrid lithium-ion batteries and supercapacitor technology for electric motorbikes in Surabaya City is feasible in terms of economic aspects. This analysis is carried out to determine the feasibility of hybrid battery and supercapacitor investment. Furthermore, data processing uses the investment feasibility method to calculate the net present value (NPV). If the NPV value is positive, it indicates that the project cash flows are sufficient to repay the invested capital and provide the required rate of return on that capital. the following is the NPV formula:

$$NPV = \sum_{t=0}^{n} \frac{\text{Cft}}{(1+\text{k})}$$

Cft = Cash flow per year in period t
K = Interest rate (discount factor)
t = Year to - t
n = Project life

Meanwhile, the use of Internal Rate of Return (IRR) also serves as a pointer to investment efficiency, where IRR can be considered as a method to calculate the interest rate of an investment and equate it to the current value of the investment, based on future net cash calculations. Here is the IRR formula:

$$\text{IRR} = \sum_{t=1}^{n} \frac{\text{Bt} - \text{Ct}}{(1+\text{IRR})}$$

Bt = Benefit year t
Ct = Cost of year t
T = Year
n = Project Lifespan

The Payback Period (PP) method is an evaluation tool to determine the period required to return the amount of investment that has been spent, based on the anticipated cash flow from the funded investment. Here is the PP formula:

$$PP = \frac{\text{Investment Total(100\%)}}{ROI}$$

- Net profit and gross profit income

Gross Profit Revenue = Sales Value - Operating Expenses
Net Profit Revenue = Gross Profit Revenue Value - Taxes

- Break Even Point (BEP)

BEP is the level or value of revenue output or the value of sales output whose total value is equal to the total costs incurred, so that at the BEP point, it causes the condition of the company in a state of not making a profit, but also not getting a loss, formulated as follows (Oetomo, 2023)

By analyzing the NPV, IRR, and PBP results, a decision can be made on whether an investment is feasible. This process provides a foundation for in-depth analysis of the feasibility of hybrid lithium-ion battery and supercapacitor investments. Also, to provide an accurate picture of the potential success of investment in hybrid lithium-ion batteries and supercapacitor technology.

4. Data Collection

The data collection describes assumptions on company fixed costs, and two data variables direct raw material from lithium and supercapacitor to compare the total HPP of each variable. From this comparison, the calculation of the use of each raw material can be seen so that it can be known that the use of cheaper raw materials will make the production process more efficient in terms of price. Table 1 contains assumption data, Table 2 and Table 3 include a comparison in terms of price in the use of lithium and supercapacitors as raw materials.

Table 1. Assumption Data

DATA	QUANTITY	REFERENCE
INFLATION	3,586%	Ten years inflation in Indonesia (Arif Widianto, 2017)
TAX	30%	Example of calculation of corporate income tax below and above 4.8 billion (Mas Rafi, 2020)
UMP INCREASE	6,13%	East Java UMP rises 6.13 percent, set at Rp 2,165,244 (Mela Arrmani, 2023)
MARKETING EXPENSES	10,1%	Marketing budget should be like this! (Marketeers, 2023)
TOTAL REMUNERATION	14	12x Salary 1 x Holiday Allowance 1 x Bonus
BPJS EXPENSES	11,27%	BPJS Health Contribution Nominal Adjusting Salary? Here's the explanation (Suara, 2024)
INSURANCE EXPENSE	0,152%	Allianz Fire Insurance (Allianz, 2024)

The data assumptions listed in the table can help map fixed costs in the electric bicycle production process. The mapping aims to allow the company to estimate the cost of sales in accordance with fixed costs and production costs. Apart from estimating fixed and production costs, the table helps estimate the increase in fixed costs to estimate sales prices when experiencing an increase in fixed costs.

4.1 Capex

CAPEX (Capital Expenditures) is the total expenditure allocated by a company or organization for investment in fixed assets or long-term working capital. So, from the results of detailed data collection and processing, the CAPEX table in this chapter will provide an in-depth overview of the allocation of funds required for various aspects of the project development.

Table 2. Capital Expenditure (Capex)

Name	Economic Life	Purchase Price	Depreciation
BUILDING ASSET			
Factory Warehouse 65x28m2	20	$ 878.641,00	$ 27.677,00
Building Renovation		$ 111.821,00	
TOTAL		**$ 990.462,00**	
MACHINE ASSET			
Mixing Machine	8	$ 21.656,00	$ 162,00
Coating Machine	2	$ 40.125,00	$ 1.003,00
Calendering Machine	2	$ 20.063,00	$ 401,00
Slitting Machine	2	$ 3.912,00	$ 117,00
Assembly Machine	2	$ 451.410,00	$ 9.028,00
Testing Machine	2	$ 2.408,00	$ 90,00
Pressing Machine	2	$ 7.822,00	$ 156,00
TOTAL		**$ 547.396,00**	
EQUIPMENT ASSET			
Phone	7	$ 86,03	$ 1,54
Computer	4	$ 851,60	$ 26,61
Laptop	3	$ 512,43	$ 21,35
Office Table	7	$ 124,74	$ 2,23
Production Table	2	$ 245,78	$ 15,36
Seat	16	$ 293,92	$ 2,30
Cabinet	2	$ 159,64	$ 9,98
Print	1	$ 86,94	$ 10,87
AC	28	$ 6.622,00	$ 29,56
Conveor	6	$ 2.998,26	$ 74,96
Hand Pallet	6	$ 147,12	$ 6,13
TOTAL		**$ 12.128,46**	
VEHICLE ASSET			
Pick Up Box	1	$ 10.322,00	$ 903,18
Motorcycle	1	$ 540,71	$ 94,62
TOTAL		**$ 10.862,71**	
JOB TRAINING			
HSE Expert Plus	18	$ 1.659,06	
Soft Skill and Technical Field	18	$ 5.529,96	
TOTAL		**$ 7.189,02**	
COPYRIGHT MANAGEMENT AND LICENSING			

Name	Economic Life	Purchase Price	Depreciation
Industrial Design and Registration Service	1	$ 184,33	
Copyright Certificate Acquisition	1	$ 12,29	
recording of License Agreement Industrial Design	1	$ 122,89	
Business Established License	1	$ 245,78	
TOTAL		**$ 565,29**	
STANDARDIZATION			
Battery ISO Standardization	1	$ 2.457,76	
TOTAL		**$ 2.457,76**	
		$ 1.571.062,00	

4.2 Opex

OPEX (Operating Expenses) is the total cost incurred by a company or organization in carrying out its operational activities. OPEX pays attention to the cost structure which is divided into two, namely, fixed costs and variable costs. Raw materials are variable costs that fluctuate with production levels, while factory operating costs (BOP) and other fixed costs are fixed cost components that are not affected by production volumes. Below is the breakdown for Opex:

4.2.1 Lithium-Ion

Lithium-ion batteries are one variant of secondary batteries that can be recharged or rechargeable batteries and have environmentally friendly properties because they do not contain hazardous materials (Figure 1). The advantages of these batteries are apparent compared to other secondary batteries, especially in their outstanding energy storage stability (capable of lasting up to 10 years or more), high energy density, lack of memory effect, and relatively lighter weight when compared to other types of batteries. Therefore, with the same weight, lithium-ion batteries are capable of producing twice the energy compared to batteries of other types (Maiorino et al., 2024).

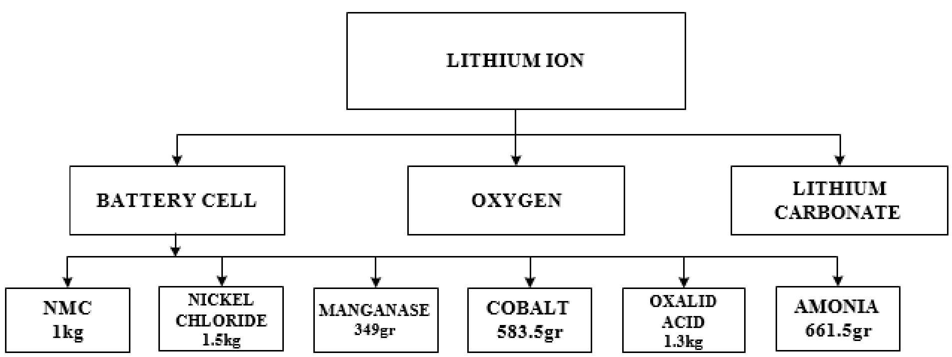

Figure 1. Lithium-Ion Schema

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Table 3. Direct Raw Material Lithium

VARIABEL DIRECT RAW MATERIAL LITHIUM				
Name	**Quantity**	**Unit Price**	**1 Pack Battery**	**Total**
POLIMINE Nikel klorida | Nickel Chloride(NiCl2.6H2O)	1kg	$ 10,98	1.5kg	$ 16,47
POLIMINE Mangan Sulfat | Manganese Sulphate (MnSO4.H2O)	1kg	$ 1,88	349gr	$ 0,66
POLIMINE Kobalt Sulfat | Cobalt Sulphate (CoSO4.7H2O)	1kg	$ 37,66	583.5gr	$ 22,17
POLIMINE Asam Oksalat | Oxalic Acid	1kg	$ 2,26	1.3kg	$ 2,94
Oxygen 1 m3	1 tube	$ 1,13	1 tube	$ 1,13
8mmonia (NH3)	2.5L	$ 30,75	361.5gr	$ 4,45
Catode	1.2x100x100mm	$ 2,82	0.6x100x100mm	$ 1,69
Current Collector	200mm	$ 25,62	0.6x100x100mm	$ 0,77
Separator	138x148mm	$ 1,15	0.6x100x100mm	$ 0,34
Elektrolit	500ml	$ 8,35	361.5gr	$ 6,03
Pack battery	1 pack	$ 21,97		$ 21,97
POLIMINE Litium Karbonat | Lithium Carbonate (Li2CO3)	1kg	$ 97,28	400gr	$ 38,91
TOTAL COGS				$ 117,53

The information provided in this table provides a more in-depth understanding of the composition to make comparisons between lithium-ion batteries and supercapacitors used in the production process. The battery component selection process is the result of intense Focus Group Discussions (FGDs) with researchers who are experts in the battery field.

4.2.2 Supercapacitor

Supercapacitors are energy storage devices that are similar to batteries. Supercapacitors are derived from carbon technology, specifically carbon nanotubes. The carbon technology applied in these capacitors creates a very large surface area with a very small separation distance. Each supercapacitor consists of two electrodes immersed in a conductive solution or conductive polymer called an electrolyte (Table 4). These electrodes are separated by a separator made of dielectric material. This separator not only serves to avoid charge overlap between the two electrodes, but also has electrical properties that affect the overall performance of the supercapacitor. To find out about the working principle of lithium batteries, it is necessary to table what are the constituent components of supercapacitors (Figure 2).

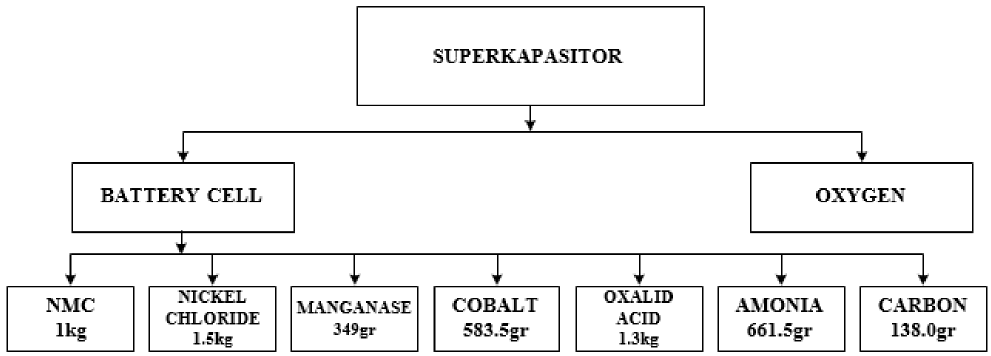

Figure 2. Supercapasitor Schema

Tabel 4. Direct Raw Material Superkapasitor

VARIABEL DIRECT RAW MATERIAL SUPERKASITOR				
Name	**Quantity**	**Unit Price**	**1 Pack Battery**	**Total**
POLIMINE Nikel klorida | Nickel Chloride(NiCl2.6H2O)	1kg	$ 10,98	1.5kg	$ 16,47
POLIMINE Mangan Sulfat | Manganese Sulphate (MnSO4.H2O)	1kg	$ 1,88	349gr	$ 0,66
POLIMINE Kobalt Sulfat | Cobalt Sulphate (CoSO4.7H2O)	1kg	$ 37,66	583.5gr	$ 21,97
POLIMINE Asam Oksalat | Oxalic Acid	1kg	$ 2,26	1.3kg	$ 2,94
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Catode	1.2x100x100mm	$ 2,82	0.6x100x100mm	$ 1,69
Current Collector	200mm	$ 25,62	0.6x100x100mm	$ 0,77
Separator	138x148mm	$ 1,15	0.6x100x100mm	$ 0,34
Elektrolit	500ml	$ 8,35	361.5gr	$ 6,03
Pack Battery	1 pack	$ 21,97		$ 21,97
carbon |Calgon Carbsorb	1kg	$ 5,52	138.0gr	$ 0,76
TOTAL COGS				$ 79,18

In both tables, the components have differences, one of which is Calgon Carbsorb, which is not included in the summation because it is not the main raw material for lithium-ion battery production. Conversely, components such as POLIMINE Lithium Carbonate or Lithium Carbonates (Li2CO3) are also not included in the table because supercapacitors, which are part of this analysis, do not use such raw materials. Lithium carbonate is used as a raw material in the production of lithium-ion batteries but is not involved in supercapacitors. Thus, in the calculation of battery component prices for supercapacitors, lithium carbonate is not included as it is not used in the production of the analyzed supercapacitor products.

5. Results and Discussion

After defining the supporting data and the variable data from comparing the use of two different raw materials. Furthermore, the total cost of factory overhead, direct labor, total cost per year of lithium, and total cost per year of supercapacitors can be identified to compare the more cost-effective use of the two different raw materials.

Table 5. Direct Cost

Direct Cost	Total Cost Yearly
Factory Overhead Cost	$ 49.479
Direct Labour Cost	$ 70.055
Variabel Direct Raw Material Lithium	$ 168.952
Variabel Direct Raw Material Superkapasitor	$ 171.028

From the Table 5, the use of supercapacitors in motorbike raw materials tends to be more widely used. This shows that the use of supercapacitors tends to be more cost-efficient because supercapacitors have a lower price of $ 38 compared to the use of lithium. Apart from cost, the use of supercapacitors has several advantages over lithium batteries. The advantages of supercapacitors are illustrated in Table 6.

Table 6. Battery Characteristic

Characteristic	Lithium Ion	Supercapacitor
Working Temperature	0 °C ~ 45 °C	-40 °C ~ 65 °C
Temperatur Discharge	-20 °C ~ 60 °C	-40 °C ~ 65 °C
Charging Time	20 minute ~ 2 hour	10 second ~ 5 minute
Usage Age	3 ~ 10 year	18 - < 25 year
Specific Energy (Wh/kg)	150 ~ 300	2.5 ~ 15
Specific Power (W/kg)	1000 ~ 3000	500 ~ 5.000
Cost Per Unit of Energy ($/kwh)	$ 97 ~ $ 291,8	$ 94,1
Cost Per Unit of Power ($/kw)	$ 486 ~ $ 1.459	$ 126 ~ $ 500,9

The battery specification table shows the significant differences between lithium-ion batteries and supercapacitors in various aspects of performance and cost. In terms of operating temperature, lithium-ion batteries have a narrower range, from 0°C to 45°C, while supercapacitors can operate at more extreme temperatures, from -40°C to 65°C. This suggests that supercapacitors are more suitable for applications in environments with large temperature fluctuations, such as in space or in areas with harsh climates. In terms of charging time, supercapacitors stand out thanks to their ability to fast recharge in a short time, from 10 seconds to 5 minutes, compared to lithium-ion batteries that require 20 minutes to 2 hours of charging time.

The fast charging capability of supercapacitors makes them suitable for applications that require instantaneous energy recovery, such as regenerative braking in electric vehicles. In addition, the battery life or duration shows that lithium-ion batteies have a shorter life of 3 to 10 years, while supercapacitors can last 18 to less than 25 years. This suggests that supercapacitors have the potential to be used in long-term applications that require less maintenance. In terms of specific energy and specific capacity, lithium-ion batteries have higher values than supercapacitors. The specific energy of lithium-ion batteries ranges from 150 to 300 Wh/kg, while supercapacitors only have about 2.5 to 15 Wh/kg. Similarly, for specific capacity, lithium-ion batteries have values of 1000 to 3000 W/kg, while supercapacitors have values of 500 to 5000 W/kg. Although supercapacitors lose out in terms of energy and specific capacity, their main advantage lies in fast charging and longer lifetime. In terms of cost, lithium Ion batteries have a higher cost per unit of charging energy and capacity compared to supercapacitors. The cost per unit of energy of lithium-ion batteries ranges from $ 97 to $ 291,8. Meanwhile, supercapacitor batteries range from $ 94,1. Supercapacitors have a lower initial cost, are more economical in the long run due to their longer lifespan, and lower maintenance costs.

5.1 Market Study

Analysis of market aspects aims to determine the size of the existing market potential, the estimated market share that can be controlled, and the marketing strategy used by the company or business (Oetomo, 2023). Table 7 illustrates the demand for electric motorbikes in Indonesia.

Table **7.** Demand for Electric Motorbike in Indonesia

Electric motorbike demand Indonesia			
Year	**Resident**	**Electric motorbike**	**Demand**
2019	267,000,000	-	-
2020	269,870,000	-	-
2021	272,760,000	-	-
2022	275,690,000	-	-
2023	278,650,000	66,978	0.02%
2024	281,640,000	67,696	0.02%

Table 6 Demand for electric motorbikes in Indonesia is a major concern to reduce dependence on fossil fuels and greenhouse gas emissions. The data shows that the demand for electric motorbikes is still in the early stages of development. The data in Table 6 shows that from 2019 to 2022, no electric motorbikes were registered, indicating the low adoption of this technology in that period. This can be seen in the data for 2023 and 2024. In 2023, the demand for electric motorcycles reached 66,978,000 units, while in 2024, demand increased to 67,696,694 units. While these numbers may seem small in the context of Indonesia's large population, the increase in demand signals a growing interest in electric motorcycles in society. According to sources, in Indonesia alone since 2021 the production capacity has reached 877,000 units per year (Soraya Novika, 2021).

In Indonesia, if 2023 there is a rapid increase to reach 66,978,000 units/year is considered very high for electric motorbike enthusiasts with only a 2-year interval. Because this research was conducted in Surabaya as a sampling site, the conditions in Surabaya are described in Table 8.

Table 8. Demand for Electric Motorbike in Surabaya

Electric motorbike demand Surabaya			
Year	**Resident**	**Electric motorbike**	**Demand**
2019	3,090,000	-	-
2020	3,157,126	-	-
2021	2,880,284	-	-
2022	2,887,223	-	-
2023	2,893,698	695,547	0.02%
2024	3,088,748	742,430	0.02%

From Table 7, the demand for electric motorbikes in Surabaya has fluctuated over the past few years. Although the population remains high, the demand for electric motorbikes was not seen in previous years. However, there was a significant change in 2023 and 2024 when demand began to emerge. In 2023, a demand of 695,547 units was recorded, which increased to 742,430 units in 2024. Factors such as environmental awareness and government incentives may be the main cause of this change. With this increasing demand trend, the electric motorbike market in Surabaya shows significant growth potential in the future. If with conditions in 2023 - 2024 the demand for electric motorbikes is 742,430 units / year with the capacity in Indonesia, it is still considered very high for electric motorbike enthusiasts for the scope of Surabaya City alone.

From the explanation above, it can be analyzed that the data presented in Table 6 regarding the demand for electric motorbikes in Indonesia provides important information about market conditions related to this demand. With a percentage of demand for electric motorbikes in Indonesia of 0.02%, this indicates that demand for electric vehicles is growing, although still at a relatively low level compared to conventional vehicles. Meanwhile, processing the data in Table 7 which records the demand for electric motorbikes in Surabaya provides a basis for forecasting future demand. Assuming that the percentage of demand in Surabaya reflects the same percentage as demand across Indonesia, a prediction of demand in 2024 can be made. From table 7, it can be seen that demand in Surabaya in a given year reached 742,430 units.

If it is assumed that Surabaya is a reflection of overall market conditions, then it can be assumed that national demand in Indonesia will also continue to increase. However, to ensure that Indonesia can fulfill this demand, it is necessary to consider the available production capacity. The information obtained shows that the production capacity of electric motorbikes in Indonesia in 2024 will be 2 million units per year. Thus, with a predicted demand for electric motorbikes in Surabaya in 2024 of 742,430 units, Indonesia and Surabaya have sufficient production capacity to fulfill this demand. This suggests that the market potential for electric motorbikes in Surabaya could be a promising opportunity for the automotive industry and renewable energy storage in the future.

With the opportunity at hand, Indonesia has taken proactive steps by establishing several factories to produce electric motorbikes and batteries on its own. Nonetheless, the use of lithium batteries as a power source is still dominant in Indonesia, although lithium-ion batteries have the constraints of limited lifespan and high price. Therefore, the presence of supercapacitors is considered a potential solution to overcome these challenges, because supercapacitors are more affordable. This opens up opportunities for the development of new energy storage sources, such as a hybrid of lithium-ion batteries and supercapacitors, which combine the advantages of both technologies.

5.2 Cash Flow

The chapter also focuses on collecting and processing cash flow data. Through careful analysis of cash flow, patterns can be uncovered that help understand the overall financial health of a plant. After all the data has been collected and processed, the next step is to process the cash flow data (Figure 3). This stage is a key part of financial analysis that aims to understand how cash flows in and out of a business in a given period. The following is the processing of the flow Table 9 with the index used, direct labor Cost is presented in Table 10.

Tabel 9. Factory Overhead Cost

FACTORY OVERHEAD COST				
Type	**Total**	**Unit**	***Monthly***	***Yearly***
Marketing activities (flyers, etc.)	12	month	$ 1.580	$ 18.970
Vehicle Operations (fuel, tolls, service,taxes, scales)	12	month	$ 2.703	$ 32.439
500 km3 Water	12	month	$ 291	$ 3.496
Electricity 35,000 kVA	12	month	$ 2.169	$ 26.038
Internet	12	month	$ 0,31	$ 371
TOTAL				$ 81.317

Table 10**.** Direct labor Cost

DIRECT LABOR COST					
Type	**Total**	**Unit**	**Price**	***Monthly***	***Yearly***
Manager Salary	1	Person	$ 495	$ 495	$ 5.951
Employee Salary	16	Person	$ 292	$ 4.685	$ 56.243
Manager BPJS	1	Person	$ 55	$ 55	$ 670
Employee BPJS	16	Person	$ 33	$ 528	$ 6.338
TOTAL					$ 689.166

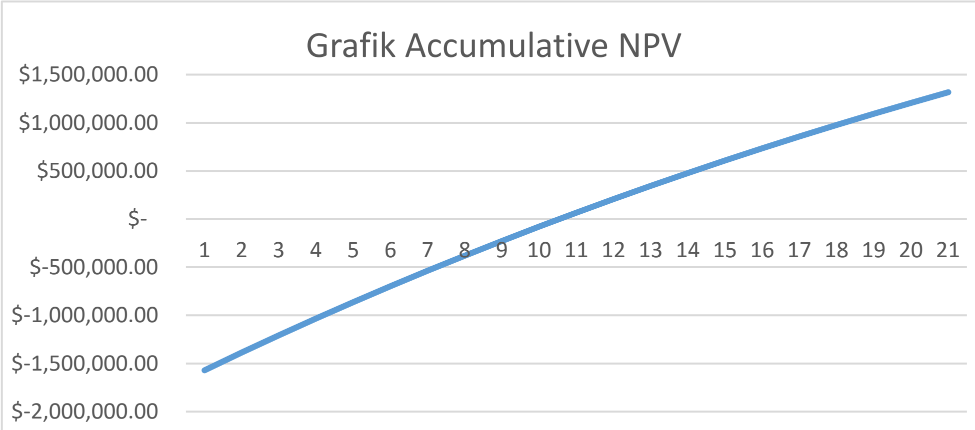

Figure 3. Grafik Accumulative NPV

The accumulative Npv graph shows that the payback period is at 10 years with an IRR of 14.16%. The IRR figure of 14.16% shows a value of more than 13% so this research shows the feasibility of this investment (Figure 4).

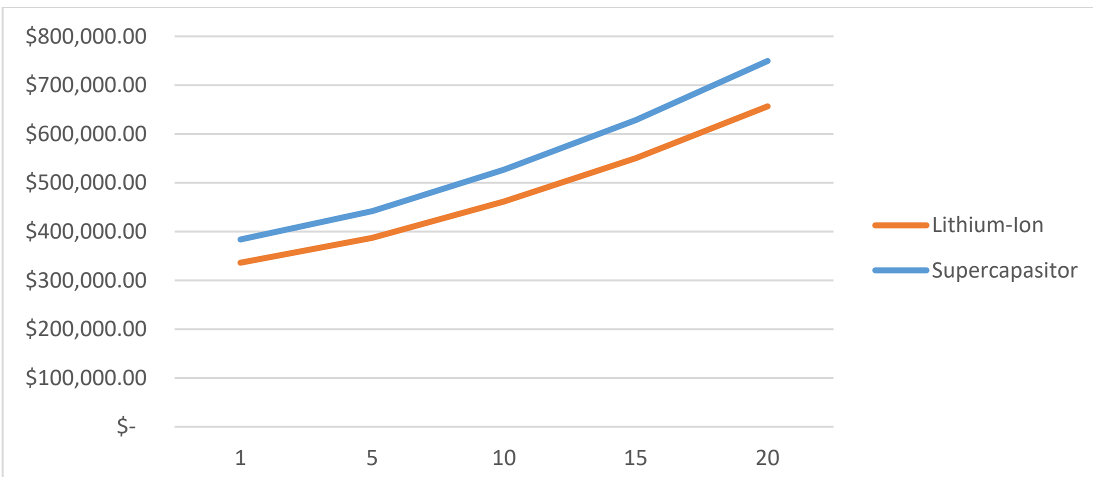

Figure 4. Comparison Lithium-Ion and Supercapasitor

The graph above is a cashflow graph of the use of Lithium-Ion and Supercapacitors as raw materials in this research. The cashflow graph shows that supercapacitors are higher than lithium-ion. This is due to the use of supercapacitors more than lithium-ion. In this research, the use of supercapacitors amounted to 180 units and Lithium-Ion amounted to 120 units. The use of supercapacitors is more expensive because the price per pack of supercapacitors is cheaper than lithium-ion. Therefore, the graph shows that the cost of using supercapacitors is greater than Lithium-ion.

5.3 Sensitivity Analysis

Sensitivity analysis is an important tool in investment project evaluation used to understand how changes in key variables such as interest rates, production costs, selling prices, or sales volumes affect financial results, such as Net Present Value (NPV), Internal Rate of Return (IRR), or Payback Period. This sensitivity analysis is conducted by considering two main variables: changes in production quantities and changes in raw material prices. The following is an example of calculations on sensitivity analysis, for the overall calculation can be seen in Appendix I. 1 and 2:

Sales = (1 + change in sales) x fixed production quantity

= (1 + -5.0%) x 300
= 28

Cost = (1 + change in cost) x fixed cost
= (1+2.5%) x \$ 486.369
= \$ 504.661

5.4 CO2 Reduction

The following is a comparison table of carbon dioxide (CO2) emissions between conventional and electric motorbikes (Table 11) :

Table 11. CO2 Comparison of Electric and Conventional Motorbike

Demand for electric motorbikes				Environment						
Surabaya -				Demand	Waste			Kg.CO2		
Year	Population	Electric motorbike	Demand		Year	LI	SK	Conventional	Electricity	CO2 reduction
2019	3,090,000	-	-	-	2019	-	-	-	-	
2020	3,157,126	-	-	-	2020	-	-	-	-	
2021	2,880,284	-		-	2021	-	-	-	-	-
2022	2,887,223	-	-	-	2022	-	-	-	-	-
2023	2,893,698	695.547	0.000240366	0.02%	2023	0.00433	0.000721098	11,864,161,800	3,761,807,400	68,29%
2024	3,088,748	742.430	0.000240366	0.02%	2024	0.00433	0.000721098	12,663,866,800	4,015,372,400	68,29%

Calculation Example:

Lithium Ion Battery = Has a lifetime of up to 3 years

Supercapacitor = Has a service life of up to 18 years

GCD = 2 x 3 x 3
= 18

KPK = 1 x 3
= 3

Lihtium Ion waste in 2024 = demand x 18
= 0.02% x 18
= 0.00433

Supercapacitor waste in 2024 = demand x 3
= 0.02% x 3
= 0.00072 %

Amount of CO2	= Total population x CO2 produced
generated Conventional	= 3,088,698 x 4100 kg CO2
	= 12,663,866,800 kg CO2
Total CO2 generated	= Total population x CO2 produced
CO2 Electricity	= 3,088,698 x 1300 kg CO2
	= 4,015,372,400 kg CO2
CO2 percentage difference	= conventionally generated amount - conventionally generated amount) / conventionally generated amount
	= (12,663,866,800 - 4,015,372,400)/ 12,663,866,800
	= 0.682926829
	= 68,29%

The rapid use of electric motorbikes by 2024 can reduce CO2 emissions. This can be seen from the table above which explains the environmental feasibility of adopting an electric motorbike rather than a conventional motorbike illustrates the comparison of carbon dioxide (CO2) emissions between conventional and electric motorbikes, as well as the CO2 reduction that can be achieved if using an electric motorbike.

6. Conclusion

Based on the results of the analysis that has been carried out in the research on the feasibility analysis of hybrid lithium-ion batteries and supercapacitors for electric motorbikes in Surabaya, several important conclusions can be drawn:

1. The combination of technology between the use of supercapacitors and lithium-ion needs to be done to overcome the shortcomings in lithium-ion batteries, namely in terms of price and durability of lithium-ion batteries to create cheap electric vehicles and also durable in terms of batteries by combining these two technologies.
2. The combination of supercapacitors and lithium-ion can support to increase public demand so that with the increase in public demand for electric vehicles, it can also help to reduce $CO^{2.}$

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Biographies

Betsyeda Frea Anuarita is a graduate of the Industrial Engineering program, having successfully completed her studies with a focus on practical applications in the field. Throughout her academic journey, she developed expertise in research and writing final projects. Her research specifically delved into the field of batteries, a topic with growing relevance in today's technology-driven world. Her final project themes are valuable references for those interested in the intersection of industrial engineering and energy storage solutions. With a strong foundation in system analysis, optimization, and process improvement, Betsyeda has honed the skills to tackle real-world challenges. Having completed her research in the battery sector, she is well-versed in the complexities of battery technology, efficiency, and sustainability. Betsyeda's work contributes to the ongoing development of solutions that are critical for various industries, including energy, transportation, and electronics, positioning her as a knowledgeable professional in the field.

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