Comparative Analysis of Entry Level Internal Combustion Engine Vehicles (ICEV) and Electric Vehicles (EV)

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Abstract

The automotive industry is one of the leading sectors that has a quite a large contribution to the economy in Indonesia. Internal Combustion Engine Vehicles (ICEV) become the main engine type of cars in Indonesia. Electric Vehicle (EV) showing positive trend as Indonesians automotive customer alternative of engine cars besides ICEV even though the number of car sales is still low compared to ICEV. In this research, comparison of 2 entry level cars from Honda Brio RS Urbanite as a ICEV and Wuling Air as a EV are conducted through extensive analysis of data and present worth analysis. In annual mileage costs, the Wuling Air EV is estimated at IDR 4,405,000.00 compared to the Brio RS Urbanite, which has a cost of IDR. 7,352,000.00. For the annual cost of ownership, which includes purchase costs Rp 311.000.000,00 for Wuling Air EV and Rp 237.400.000,00 for Brio RS Urbanite, annual maintenance, and annual tax Wuling Air EV is superior to Brio RS Urbanite, which is IDR 5,581,366.00 compared to 12,277,000.00 this annual ownership costs have also included maintenance cost. Apart from that, from the Present Worth calculation, it can be seen that the Wuling Air EV has outperformed the Brio RS Urbanite.

Keywords
Electric Vehicle, Combustion Engine Vehicle, Automotive, and Present Worth Analysis.

1. Introduction
The automotive industry is one of the leading sectors that has a quite a large contribution to the economy in Indonesia by contributing an investment value of Rp. 99.16 trillion with a total production capacity of 2.35 million units per year (Ministry of Industry 2021). It can be seen from the number of sales that fluctuate from year to year and sales increased in 2021 by 70.33%. Cars as one of automotive industry main transportation mode of people in Indonesia also showing positive trends year to year shown in Figure 1.

Electric vehicles are one of the upcoming means of transportation and are going to be the main choice in the future (Dericioglu et al. 2018). The rise of electric vehicles started in the early 1970s during the first fuel crisis in California. In the 1980s the battery that was soon going to be utilized for EVs started to be the main focus for the concern of shortage of fossil fuel supply and air pollution that comes along with it (Ajanovic 2015). Electrical power is the main driver of electric vehicles (Ahmad, et. al. 2018) and of the most effective way to reduce the consumption of fossil fuel (Boulanger et. al. 2011). The measures taken to slow down climate change and developing renewable and sustainable energy, needs a massive transition of energy from fossil fuels to renewable and sustainable energy. With the slowly decreasing amount of fossil fuel in the near future this situation hopefully will motivate researchers, car manufacturers, and other stakeholders to join the race for searching alternative resources like electrical power that is used for cars (Mehar et al. 2015). Compared to fossil fuels-based vehicles, EV has lower noise level, high energy utilization rate, environmentally friendly and could reduce glass house effect in transportation (Song et al. 2016). Not only from an environmental aspect, EV is also expected to reduce the dependency of fossil fuel and increase global energy resilience (Dawami et al. 2020).

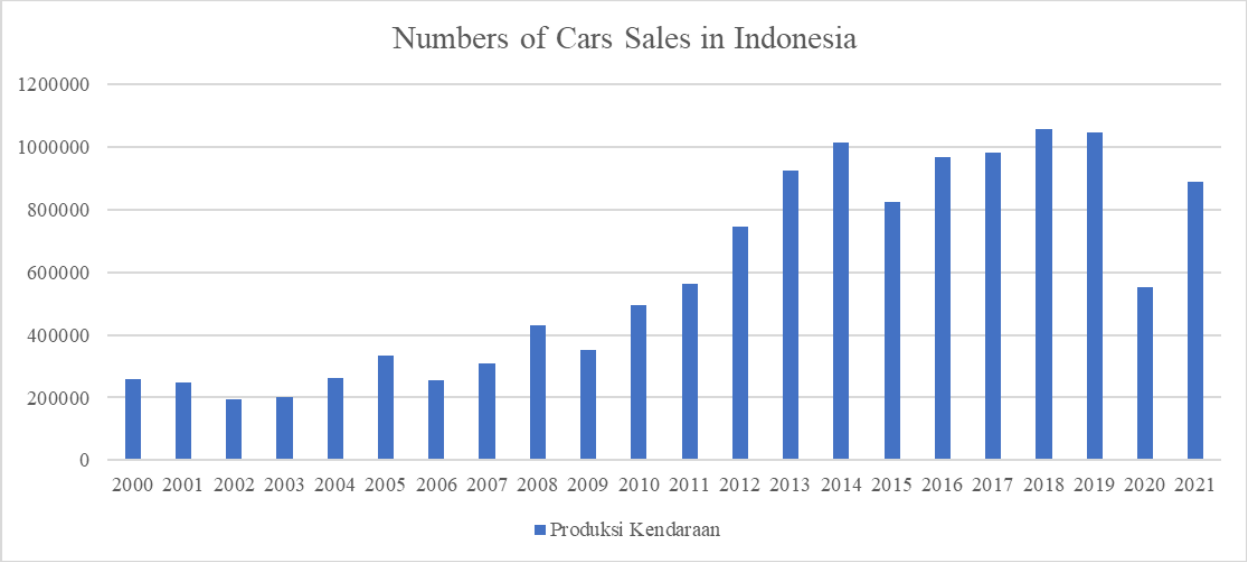

Figure 1. Number of Cars Sales in Indonesia (Statista)

EV has been one of the strategies of the automotive industry the government tries to implement in recent years, this is shown through multiple policies established by the government to make sure that battery powered vehicles will become Indonesians one of main transportation means in the next couple years. The support of Indonesia's government in speeding up the distribution of EV implementation in Indonesia is manifested in Regulation No. 14 Year 2015 regarding National's Industrial Development Master Plan, Regulation of President No. 22 Year 2017, regarding National's Energy Policy, and Regulation of President No. 55 Year 2019 regarding Acceleration of Battery Based Vehicle Program (Ministry of Transportation 2022). Even though EV in Indonesia is starting to get some recognition. But according to these concerns regarding EV such as, limited travel distance, the price of the car that are still quite expensive, the not yet readiness of infrastructure, public behavior of refueling vehicle (Subekti 2014) has influenced the sales of EV in Indonesia which shows low numbers compared to ICE vehicles (0,5% out of total cars sales in Indonesia) though the sales of the EV shows positif trend. Governments are boosting policies to promote EV deployment, build charging infrastructure and secure supply chains. Indonesia aims to become leaders in EV markets in the region and to supply growing demand in other Asian countries. In 2021, Thailand, a new entrant in EV markets, announced ambitions of 30% of domestic vehicle production to be ZEVs by 2030 and 100% of new vehicle registrations to be ZEVs by 2035. It also announced a package of incentives to promote EV deployment. Indonesia recently created a government-owned battery corporation that aims to build 140 gigawatt-hours (GWh) of battery capacity by 2030, of which 50 GWh will be for export. (Today's global battery manufacturing production capacity is about 871 GWh) (*Global Electric Vehicle Outlook 2022*).

Indonesia has a production target of 600 000 electric LDVs and 2.45 million electric two-wheelers by 2030. It aims to leverage its large raw nickel ore reserves upstream while offering incentives further downstream for EV component producers and manufacturers. This follows on from the Presidential Regulation to prioritize domestic EV production. It aims to ensure a certain percentage of Indonesian sourced EV components and nickel are used in EV production. (*Global Electric Vehicle Outlook 2022*).The sales of EV in Indonesia's automotive domestic market have shown a positive trend as shown in Figure 2. The EV Sales in Indonesia (January 2022 - October 2022 (Katadata 2022). The highest sales number was achieved in October 2022, with the number of 2157 units of EV sold.

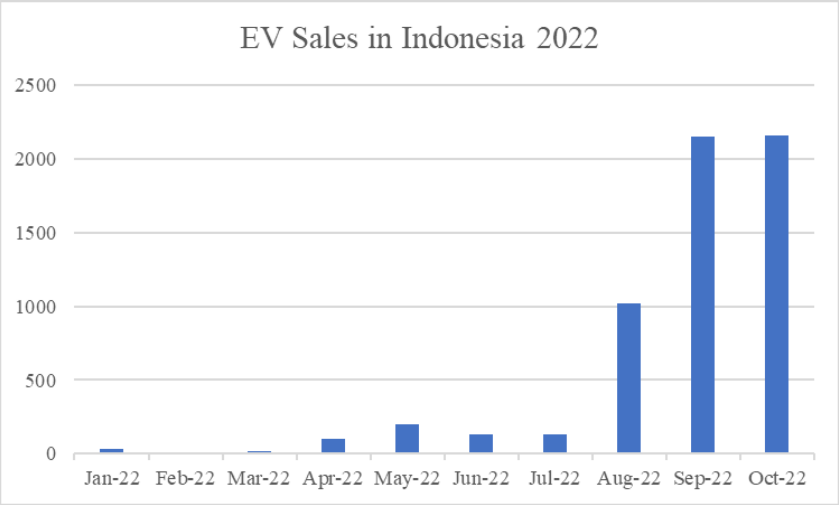

Figure 2. EV Sales in Indonesia (January 2022 – October 2022)

Looking at the data of EV sales in Indonesia according to brand, since January 2022 until September 2022, the biggest sales volume of EV sales according to Gaikindo is Wuling Air EV Long Range, followed by Wuling Air EV Standard Range and Hyundai Ioniq 5 Signature Extended (Katadata 2022). Figure 3 shows EV Sales based on Brand in Indonesia (January 2022-September 2022).

With the advance development of EV technology, policy standards of EV also developed along the way in terms of policing and facilitating Electric Vehicle (Ruiz et al. 2018). According to Wibowo et al. (2021), effective strategy and utilization of information systems as critical support for facing this challenge. This is in accordance with the Undang-Undang No. 20 Year 2014 which administered Standardization and Fitness of the National Standardization Body that is a Government Institution responsible for defining Indonesia's National Standards (SNI) and fitness assessment (BSN 2015).

Figure 3. EV Sales Based on Brand in Indonesia (January 2022 – October 2022)

On the other hand, the sales of Internal Combustion Engine based vehicles still become the main options for Indonesia's automotive customers. With the broad variation of machine capacities, number of seats, and types make Indonesia's automotive customers have discretion to choose the most suitable cars.

1.1 Objectives

Indonesia market value of electricity for EV projected to grow by 2030, which is equivalent to about one-tenth of today's fuel market value. Thus, the environment is always associated with the importance of using electric vehicles, even though economic factors are also part of the consideration in how Indonesians choose vehicles. This economic factor is discussed more related to vehicle operating costs which in this study will be discussed and compared between electric and fuel vehicles.

In this study, we will try to compare entry-level vehicles in the form of fuel-fueled cars with electric cars. This comparison is by looking at several factors, namely, purchase costs, ownership costs, energy, maintenance and taxes. The types of vehicles that will be used are the Honda Brio as a petrol car and the Wuling Air EV as an electric car. So that this research is expected to provide benefits for readers to find out which type of car is more economical and profitable for users.

2. Literature Review

2.1 Electric Vehicle

An electric car or electric vehicle in general is a vehicle or means of transportation driven by electricity, this vehicle does not use an engine with various types of combustion. The first battery-driven electric vehicle was invented in 1834, and 50 years later in 1885 the internal combustion engine driven car or called the Internal Combustion Engine Vehicle (ICEV) was invented. This shows that EV came before ICEV. Compared to other conventionally powered vehicles, EVs offer several advantages, including (Sanguesa et. al. 2021):

1. Zero Emission: this type of vehicle generates very little pollutant.
2. Simplicity: the elements in an EV machine are few when compared to a conventional vehicle.
3. Reliable: by having fewer and simpler components, EVs have less potential for damage.
4. Cost: the cost of maintenance and the cost of the required electricity is relatively cheap when compared to the cost of fuel and maintenance of conventional vehicles.
5. Comfort: driving with an EV feels more comfortable because there is no vibration or noise generated by the engine.
6. Efficient: EVs are more efficient when compared to conventional vehicles. But the overall efficiency wheel to wheel (WTW) also depends on the efficiency of the power plant. For example, the overall WTW for petrol vehicles is 11% to 27% whereas diesel vehicles are 25% to 37%. In contrast, EVs driven by electricity from natural gas-powered plants show WTW efficiencies of between 13% and 31% whereas EVs driven by renewable energy show efficiencies of up to 70%.
7. Accessibility: This type of vehicle is possible for urban areas that do not allow other internal combustion vehicles (e.g., zero emission zones). The existence of EV will actually improve air quality in urban areas.
8. Mileage: the range of an EV, which is usually only able to reach 200 km to 350 km with full charging, can now be increased up to 364 km (Nissan Leaf) or 500 km (Tesla Model S).
9. Charging time: to fully charge the battery bus takes 4 to 8 hours. But with the "fast charge" facility, charging 80% can be done in 30 minutes.

2.2 Internal Combustion Engine Vehicle

Piston machines are machines in which energy is transferred from a fluid (gas or liquid) to a moving displacer (e.g., piston) or from the piston to the fluid. Combustion engines are machines in which chemical energy is converted into mechanical energy as a result of the combustion of an ignitable mixture of air and fuel. The best-known combustion engines are internal combustion engines and gas turbines, and internal combustion engines are piston engines (Basshuysen 2016). ICE or sometimes be called Otto engine based on the name of its founder Nicholaus Otto. ICE engine works with the trigger of mixture between fuel and air with the help of spark plug to ignite the mixture resulting in controlled explosion to move the crank shafts inside engine that finally move the car. The engine capacity of the cars also affects the fuel consumption and car's performance. In Indonesia, cars with engine capacity lower than 1500 cc become the customer's favorite due to affordability and the low fuel consumption.

ICEV Cars have some advantages namely:

1. The research of ICE cars has been conducted for years, therefore the efficiency of the engine itself increases as the time goes by.
2. ICE cars offer wide range of types and prices.
3. Quicker in fueling process, means it is quicker to "charge" the car.
4. Longer travel distance.
5. Established supporting infrastructures.

2.3 Engineering Economy

Deemed as the heart of decision making for engineers, engineering economy involves formulating, estimating, and evaluating, the expected economic of alternatives designed to accomplish a defined purpose. Because the formulas and techniques used in engineering economics are applicable to all types of money matters, they are equally useful in business and government, as well as for individuals. Since most decisions affect what will be done, the time frame of engineering economy is primarily the future. Therefore, the numbers used in engineering economy are best estimates of what is expected to occur. The estimates and the decision usually involve four essential elements:

1. Cash flows
2. Times of occurrence of cash flows
3. Interest rates for time value of money
4. Measure of worth for selecting an alternative

2.4 Investment Criteria

The concept of equivalence of the value of money against time, basically shows a logic that can be used to state that, at a certain interest rate, the state of the flow of funds of an investment plan will have an equivalence value at a certain moment or a certain serial (uniform) value. Based on this concept, several benchmarking methods are derived that are used to evaluate several investment plans, which then compare the relative attractiveness value of each investment plan, so that the best investment plan can be selected among the available alternatives. The methods namely: Present Worth Analysis (PW), Annual Cash Flow Analysis, Rate of Return Analysis, Benefit-Cost Ratio Analysis, Payback Period Analysis. Present Worth Analysis (PW) is used to determine the current equivalent value of the future flow of funds (cashflow) from a projected investment plan or certain asset. So that if cashflow in the future can be estimated, then with the chosen interest rate can be calculated the current value of the investment plan. Or for a certain asset, if the cashflow is also known, the price of the asset can be calculated. The formula of calculating PW is the following:

$$PW = FW \frac{1}{(1+r)^n} \text{..... (i)}$$

Whereas
PW = Present Worth
FW = Future Worth
r = Rate of Return
n = Number of Periods of Lifetime

2.5 Depreciation

Depreciation is reduction in the value of a property or asset due to time and usage which caused by:

a. Physical damage resulting from the use of such tools or property.
b. Newer and bigger production or service needs.
c. Decrease in the need for production or services.
d. These properties or assets have become obsolete due to technological developments.
e. The discovery of facilities that can produce better products at lower costs and a more adequate level of safety.

In this research will be used Straight Line Depreciation Method to compare both options. Straight Line Depreciation Method (SLD) is based on the assumption that the reduced value of an asset proceeds linearly (proportionally) to the time or lifespan of the asset. This depreciation method is represented by this following formula.

$$Dt = \frac{P-S}{N} \text{..... (ii)}$$

Where
Dt = The amount of depreciation in year "t".
P = Purchase cost of asset.

S = Salvage value of the asset.
N = Lifetime of the asset.

2.6 Presidential Regulation No.55/2019 on Battery Electric Vehicles.

This 2019 regulation marks a new chapter in BEV development in Indonesia. The regulation offers clear guidance to the automotive industry on BEV development and provides opportunities for local governments and universities to become involved. This regulation has four objectives: (i) identify responsible and leading ministries/agencies for implementation, (ii) set a BEV definition and developing technical specifications, (iii) create BEV manufacturing capacity, and (iv) facilitate the market transition from ICEs to BEVs.

Presidential Regulation No. 55/2019 serves as overarching guidance for developing specific policies related to EVs and their charging infrastructure. Indonesia has not yet developed supporting policies or clear incentives schemes for vehicle electrification; however, several ministerial regulations to support adoption of EVs were enacted in Q3 and Q4 of 2020. And in early 2020 the Ministry of Finance proposed to Parliament a carbon tax on automotive products43 that was expected to boost EV use by consumers, but the draft was rejected by the Parliament (2021 – International Council on Clean Transportation).

3. Methods

Descriptive research studies were used in this study with the aim of analyzing the differences between internal combustion engine and electric vehicles in terms of purchase costs, ownership costs, energy, maintenance and taxes. This research uses a qualitative approach with extensive data collection gathered from any kinds of information sources such as company annual reports, cars specification data, and previous research. While the procedure of conducting this research started with defining an introduction to capture the phenomenon of a problem that is going to be observed so that the objective of the research can be determined. Next step we conduct literature review from previous researches and from supporting theories we could find from any credible sources. The third step, we determine the method and research conceptual model that will be used to gather information and data so that the conclusion can be drawn. Fourth step is data collection through information search from sources and previous research. On the fifth step all the data collected will be analyzed and discussion regarding the output of the analysis will be presented. On last step, will be explained conclusion of the research to answer the objective of the research, also this research will offer recommendations based on the result of the research. Engineering economy calculation used in this research to decide which option is better economically based on mileage cost and ownership cost.

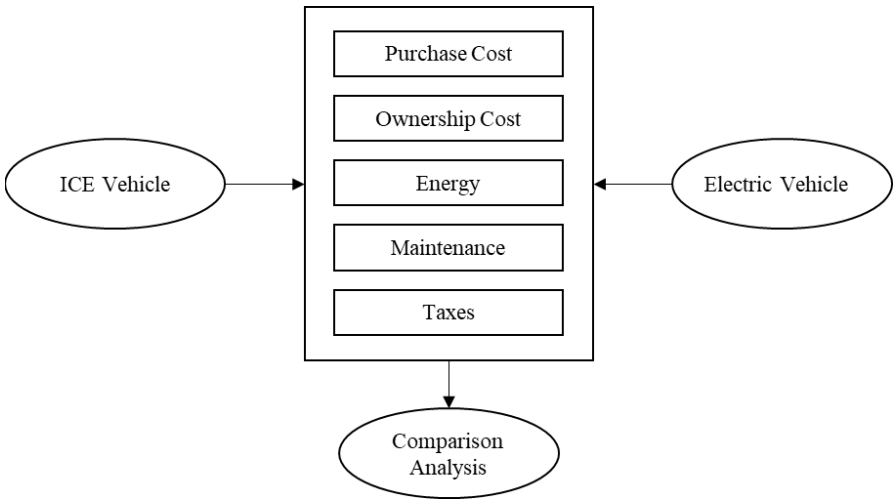

Figure 4. Conceptual Model

4. Data Collection

Driving battery electric vehicles (BEVs) tends to be less expensive than driving fuel-powered vehicles. However, the variation in the price of fuel completely parallels the variation in the price of electricity. Therefore, this study was designed to examine the comparison between cost of driving BEVs and fuel vehicles.

Table 1. Battery and Fuel Mileage Cost Comparison

Calculation Battery Charge		
Wuling Air EV	SPKLU / KWh	Rp 2.475
	Battery Capacity (KWh)	26,7
	Mileage Based on Battery Capcaity (Km)	300
	Mileage / Year (20.000 Km)	66,7
	Estimated Battery Cost / Year	Rp 4.405.500
Calculation Fuel		
Brio RS Urbanite	Fuel (Pertalite / L)	Rp 10.000
	Fuel Consumption	27,2
	Mileage / Year (20.000 Km/yr --> 60 Km/Day)	735
	Estimated Fuel Cost / Year	Rp 7.352.000

Table 2. Ownership Cost Comparison

Vehicle Type	Description	Detail
Wuling Air EV	Purchase Cost	Rp 311.000.000
	Annual Maintenance	Rp 647.400
	Annual Tax	Rp 528.500
	Annual Ownership Cost	Rp 5.581.366
Brio RS Urbanite	Purchase Cost	Rp 237.400.000
	Annual Maintenance	Rp 1.754.000
	Annual Tax	Rp 3.171.000
	Annual Ownership Cost	Rp 12.277.000

Based on table shown above, it can be concluded that both for mileage cost and ownership cost put EV in this research represented by Wuling Air EV ahead of ICEV represented by Brio RS Urbanite. The distance traveled used in this data (60 Km/ day or 20000Km/ year) is the average travel distance of workers in Jakarta who are traveling from satellites cities such as Bogor, Depok, Tangerang, Bekasi (Badan Pusat Statistik, 2015). For the annual mileage cost Wuling Air EV has estimated cost of Rp 4.405.000,00 compared to Brio RS Urbanite which has Rp. 7.352.000,00 for mileage cost. For annual ownership cost which covers purcchase cost, annual maintenance, annual tax, again Wuling Air EV is ahead of Brio RS Urbanite with Rp 5.581.366,00 compared to 12.277.000,00.

5. Results and Discussion

In making usage and investment decisions, calculations are needed to see the future price between ICEV and EV. For these two types of vehicles, it is important to carry out calculations of Present Worth (PW), Depreciation rate, and Net Book Value (NBV). Based on the information collected, a comparison of ICEV and EV can be calculated based on Tables 3 and 4.

Table 3. Present Worth Value Analysis

	Wuling Air EV	Brio RS Urbanite
Investment	Rp 311.000.000	Rp 237.400.000
Annual Cost	Rp 5.581.366	Rp 12.277.000
Salvage	Rp -	Rp 40.000.000
Lifetime	10 Years	
Int. Rate	5%	
PW	-Rp 34.099.308	-Rp 307.642.994

As shown in Table 3, with the interest rate of 5% (Bank Indonesia) it shows that if we compare both options through PW Analysis it looks like Brio RS as the representation of ICEV is behind of Wuling Air EV as the representation of entry level EV.

Table 4. Straight Line Depreciation Method Comparison

t	Wuling Air EV		Brio RS Urbanite	
	Dep.	NBV	Dep.	NBV
Y0		Rp 311.000.000		Rp 237.400.000
Y1	Rp 31.100.000	Rp 279.900.000	Rp 19.740.000	Rp 217.660.000
Y2	Rp 31.100.000	Rp 248.800.000	Rp 17.766.000	Rp 199.894.000
Y3	Rp 31.100.000	Rp 217.700.000	Rp 15.989.400	Rp 183.904.600
Y4	Rp 31.100.000	Rp 186.600.000	Rp 14.390.460	Rp 169.514.140
Y5	Rp 31.100.000	Rp 155.500.000	Rp 12.951.414	Rp 156.562.726
Y6	Rp 31.100.000	Rp 124.400.000	Rp 11.656.273	Rp 144.906.453
Y7	Rp 31.100.000	Rp 93.300.000	Rp 10.490.645	Rp 134.415.808
Y8	Rp 31.100.000	Rp 62.200.000	Rp 9.441.581	Rp 124.974.227
Y9	Rp 31.100.000	Rp 31.100.000	Rp 8.497.423	Rp 116.476.804
Y10	Rp 31.100.000	Rp -	Rp 7.647.680	Rp 108.829.124

Tabel 4 shows depreciation rate of both options through Straight Line Method with 10 years of asset's lifetime. At the end of tenure (Year 10) Brio RS as the representation of ICEV has bigger NBV compared to Wuling Air EV as the representation of EV. It is also compatible with (Schloter, 2022) that show vehicles have a degressive depreciation relationship over the age of the vehicle, but that electric vehicles have a substantially higher depreciation of 1.16% per month (13.9% per annum) compared to gasoline vehicles with 0.87% per month (10.4% per annum). This conclude that at the end of tenure (Year 10), Brio RS Urbanite has bigger valuation than Wuling Air EV.

EV and ICEV have different target groups regarding demographics, mobility patterns, and attitudes (Haustein and Jensen, 2018). For now, the entry-level EV class that is marketed is still limited, so from a sales point of view, ICEV is still superior in terms of sales. With government support, it is hoped that in the next few years, there will be various types of EVs so that people will find it easier and more interested in these vehicles. With more and more EV users, it is hoped that it can also reduce greenhouse gases and fossil fuels. But there are increased levels of human toxicity due to the greater use of metals, chemicals, and energy to produce powertrains and high-voltage batteries (Verma et al. 2021). An important and expensive element in EVs is the battery, so future technologies and innovations are needed to allow higher amounts of power to be stored and charged in a shorter period of time (Sanguesa et al. 2021).

6. Conclusion

The development of industry 4.0 and the issue of sustainability, EVs are the automotive industry's future in reducing greenhouse gas emissions, pollution, and limited use of fossil fuels. Currently, in Indonesia, there are still very few types of EV cars at the entry level. For this reason, based on the research objectives set previously to analyze the comparison of entry-level Internal Combustion Engine Vehicles (ICEV) and Electric Vehicles (EV) based on several factors such as purchase costs, ownership costs, energy, maintenance, and taxes.

In annual mileage costs, the Wuling Air EV is estimated at IDR 4,405,000.00 compared to the Brio RS Urbanite, which has a cost of IDR. 7,352,000.00. For the annual cost of ownership, which includes purchase costs Rp 311.000.000,00 for Wuling Air EV and Rp 237.400.000,00 for Brio RS Urbanite, annual maintenance, and annual tax Wuling Air EV is superior to Brio RS Urbanite, which is IDR 5,581,366.00 compared to 12,277,000.00 this annual ownership costs have also included maintenance cost. Apart from that, from the Present Worth (PW) calculation, it can be seen that the Wuling Air EV has outperformed the Brio RS Urbanite. If we look at the depreciation of the two types of vehicles in the next 10 years, Brio RS as an ICEV representative, has a larger NBV compared to Wuling Air EV as an EV representative.

However, the thing that needs to be considered in using an EV is the battery element. The battery is an important factor and must be replaced after several years of use, so it requires a fairly high cost to replace it. It is hoped that in the future, there will be innovations and research related to EV batteries that can be replaced in certain parts that are damaged, and replacements are not carried out as a whole.

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