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Paper Authors

Budumuru Uday Kumar, Mudadla Venkatesh

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A LITERATURE REVIEW ON LIFE CYCLE COST OF ELECTRICAL VEHICLES OVER THAN COMBUSTION ENGINE VEHICLES

Budumuru Uday Kumar[1], Mudadla Venkatesh[2]
[1]UG Student, Department of Electrical and Electronics Engineering,
GMR Institute of Technology, Vizianagaram District, A.P, India
[2]Assistant Professor, Department of Electrical and Electronics Engineering,
GMR Institute of Technology, Vizianagaram District, A.P, India

ABSTRACT:
Manufacturing, use, and end-of-life are the three distinct phases that all vehicles go through; however, the emissions of carbon dioxide and other greenhouse gases are different for gas- and electric-powered vehicles. According to research based on 2015 data, the current statement of when our reserves emptied is this (oil: 51 years, coal: 114 years, natural gas: 53 years). As a result, within the next 25 years, people might get used to driving electrical vehicles, which also improve global life comfort levels and reduce greenhouse gas emissions and air pollution. However, an additional drawback of electrical vehicles over internal combustion engines is that a full charge for an electrical vehicle takes hours as opposed to a few fractions of a second for a combustion engine. The review's findings indicate that while the usage of EVs reduces greenhouse gas emissions (GHG), the degree of human toxicity increases as a result of the increased use of metals, chemicals, and energy for the manufacture of high voltage batteries and power trains.

Keywords: Climate change, Electric vehicle, Human toxicity Life cycle assessment, Life cycle cost analysis

1. INTRODUCTION:
Vehicle systems are expanding globally as a result of rising oil prices, including those for gasoline and diesel, energy security, and climate change. The daily functioning of a combustion engine produces air pollution. When compared to other combustion engines, their average emissions per kilometer are 150.4 grams of carbon dioxide equivalent. Up until 2030, the number of light-duty cars will rise by 1.3 billion, predicts GHG. Therefore, from a pollution reduction perspective, the introduction of electric vehicles—and especially electric passenger cars—has been seen as a huge opportunity to lower both urban air pollution and greenhouse gas emissions from the transportation sector. With the merging of several technologies, such as fuel cell electric vehicles, plug-in hybrid electric vehicles, and hybrid electrical vehicles, electric vehicles have emerged as one of the greatest solutions for transportation. People today want more done in less time, thus we utilize hybrid EVs in parallel so that we may use both fuel and battery to power the car. The main drawback of electric vehicles is that they take hours to charge whereas combustion engines only need seconds. The Electric car battery arrangement has to be arranged like as shown in Fig. 1. In fact, batteries are a key component of electric vehicles and one of the most significant differences between EVs and ICE vehicles (along with the powertrain). Additionally, the production of batteries results in energy consumption and environmental impacts, which have the potential to adversely affect the benefits of electric vehicles due to their use phase, with particular reference to climate change emissions. EVs are becoming more prevalent globally and encountering several difficulties as well.

According to plug-in electric car sales through December 2021, China has the largest sales due to its large population and high fuel prices, which may influence consumers to prefer electric vehicles.
Since there are no gears to shift through, electric vehicles move faster than internal combustion engines and may immediately apply their full power when you press the pedal. Electric vehicles are more pleasant and enjoyable to drive at moderate speeds since they make nearly no noise. The majority of electric cars can easily travel 200 km on one battery. Future advancements in battery technology could lead to new electric vehicle models with 400 km of range on a single charge, meaning that most people would need to top off their batteries every day or fully recharge them once a week. There is less energy to get since electric automobiles are significantly more energy-efficient (85–90% efficient) than internal combustion engine cars (17–21% efficient). The thermal efficiency of the majority of diesel engines is much below 50%. Only around half of the energy produced is converted to mechanical energy. The majority of electric cars can easily travel 200 km on one battery. Future advancements in battery technology could lead to new electric vehicle models with 400 km of range on a single charge, meaning that most people would need to top off their batteries every day or fully recharge them once a week.

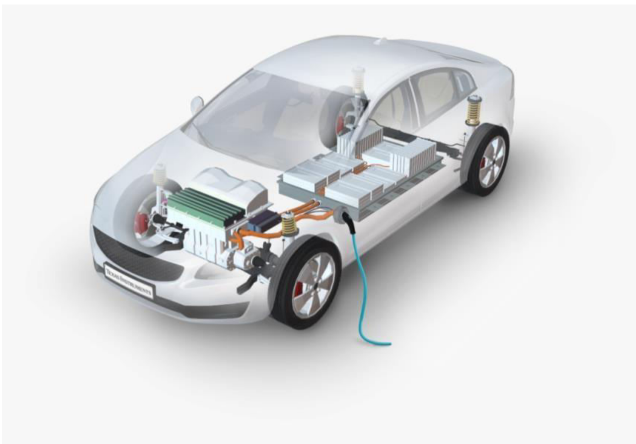

Fig. 1 Electric car battery arrangement

There is less energy to get since electric automobiles are significantly more energy-efficient (85–90% efficient) than internal combustion engine cars (17–21% efficient). The thermal efficiency of the majority of diesel engines is much below 50%. The cumulative sales through December 2021 by country/region as shown in the below graph (Fig. 2). Only around half of the energy produced is converted to mechanical energy. According to self, a financial technology firm, the average annual cost to operate a gas vehicle in the U.S. in 2022 is expected to be $4,336 compared to $3,679 for an electric vehicle. The average battery in an electric car nowadays has a lifespan of 15 to 20 years.

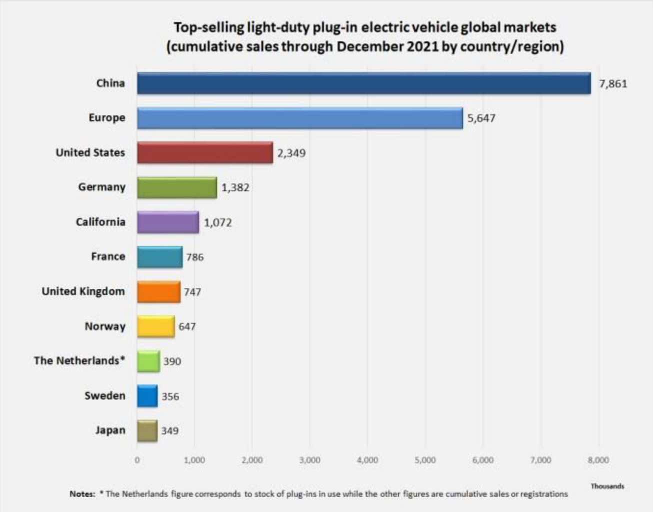

Fig. 2 plot between top selling duty plug in electric vehicle global markets

It's important to remember that electric vehicle battery technology is still in its infancy, so as the field advances, we can anticipate longer battery lives.

2. Methodologies:

The basic classification of the life cycle cost of a vehicle is based on a number of variables, including cost, infrastructure, battery analysis, life cycle, resources and energy, and recycling methods. The comfort with which our vehicle may be operated is the key concern of the customer. Customers are busy in many areas, so they do not choose which are time-consuming; instead, they choose combustion engines because these are comfortable. Therefore, we must improve in best way of technology to choose one and only option of Electric vehicles. Therefore, I want to think about what aspects we have to concentrate on to choose only Electric vehicles.

2.1 LIFE CYCLE COST:

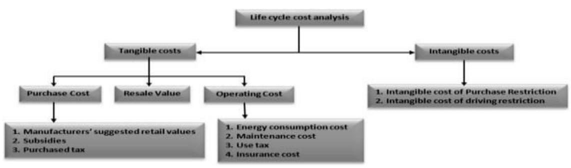

Fig. 3 types of life cycle cost analysis

The sum of all costs incurred over the course of the system's life is known as the life cycle cost.

The physical and intangible costs are the main components of the life cycle cost analysis of electrical cars, as depicted in the figure. As shown in Fig .3 Purchase cost, resale value, and operation cost are the three categories under which tangible costs fall. Manufacturers' suggested retail prices, referred to as "buy cost," refer to the amount that a product's maker advises consumers to pay when they are shopping. An MSRP can be found on any retail item, although cars are the most common object for which it is utilized. The "sticker price" is an informal term that occasionally refers to an MSRP. According to INDIA, the government grants a subsidy of INR 10,000 per kwh for the first 3500 purchasers on 2 wheelers with an ex-factory price of a maximum of INR 1.5 lakhs. For the first 200 EVs, you can receive an incentive of INR 4,000 per KWH if you buy an electric 3-wheeler. The vehicle's ex-factory cost cannot be higher than INR 5 lakh. In India, buying an electrical vehicle would result in tax reductions on GST thanks to the government's reduction of the rate from 12% to 5%. In the tax year 2022–2023, the government sets this at 2% for all fully electric vehicles. The BIK rate was zero percent up to 2020–2021, and then it increased to one percent in 202–2022. With a total battery capacity of 21.5 kwh and a cost of INR 434.75 for 100 kilometers, the Tata Tigor EV's total charging costs would be 21.5 kwh x INR 4.5% per kwh. 96.75 INR or such. Therefore, operating an EV is more cost-effective than an ICE vehicle. Currently, a third party insurance policy costs about 50,000 rupees for maintenance and repair of electrical cars compared to 120,000 rupees for fuel cars. More than 65 kw electric vehicles cost roughly 6,707 rupees. If 30-65kw then it costs nearly 2,738.

Table: 1 Life cycle cost analysis finding of various authors

YEAR OF ANALYSIS	LOCATION	KEY FINDINGS
2010	PORTUGAL	Due to greater initial purchase costs, BEV is not economically competitive with ICEV despite having lower operational expenses. Because the operating costs of an ICE vehicle were 0.054 €/km whereas those of a BEV were 0.024 €/km. Additionally, the increased acquisition cost for BEV was 0.18 euros per kilometer and for ICEV it was 0.10 euros per kilometer.
2017	U.S.A	When compared to gasoline and CNG-powered HDT, battery-powered HDT require the least amount of maintenance and repair since there are fewer fluids that need to be changed and fewer moving parts, which results in a lower maintenance requirement.
2020	CHINA	Due to the higher retail price of EV in 2020, LCC of EV is 9% greater than ICEV under Beijing driving cycle. Under low mileage conditions, the LCC gap between EVs and ICEVs could expand to 18–22%.

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Total LCC =capital cost + life time operations cost + life time maintenance cost + disposal cost – residual value

Retail costs, insurance costs, charger costs, service tax, and third party insurance are all factors in the purchasing phase. While electricity costs, maintenance, tyre replacement, insurance, and battery replacement are included in running costs. Additionally, the scrap value of the EV and the cost of battery recycling are included in the disposal cost [27]. In Table 1, multiple authors' important LCC findings are summarized.

2.2 INFRASTRUCTURE OF AN ELECTRICAL VEHICLES:

Electrical vehicles supply equipment is the primary part of a charging infrastructure for electric automobiles (EVSE) has to be their like as shown in Fig. 4. By taking power from the nearby power grid, the EVSE uses a linked connection and a control system to safely charge EVs. South Korea had the best EV per charge point ratio among the 20 nations in the research last year, with the world average for consumers and fleets considering electric cars (EVs), which include all Electrical vehicles, in 2021 being 9.5 EVs per charging station. Fuel range anxiety is a result of the current charging infrastructure's sometimes insufficient quantity and quality across Europe.

Currently, there are more than 1,640 public EV charging stations operating in INDIA, more than 940 of which are located in these cities. Based on a CEEW-CEF study. If study progress is continued in INDIA, the EV industry will be a $206 billion opportunity by 2030. This would necessitate an overall expenditure of $180 billion in infrastructure for EV production. The perceived high quality of the interiors is one of the hurdles facing today's EVs, if INDIA improves. Electric vehicle drivers have a very modern vehicle. Batteries actually account for the majority of the expense.

In India, 5 million barrels of oil are imported daily from other nations, and 80% of the population depends on internal combustion engines. Additionally, pollution from combustion engines increases. Petrol and diesel per liter cost about 110 rupees. If you charge an EV at home, it will cost you between 8 and 10 rupees per unit, depending on your state's power pricing. While domestic rates range from 3 to 8 rupees per unit, charging stations in DELHI charge 4-4.5 rupees per KWH.

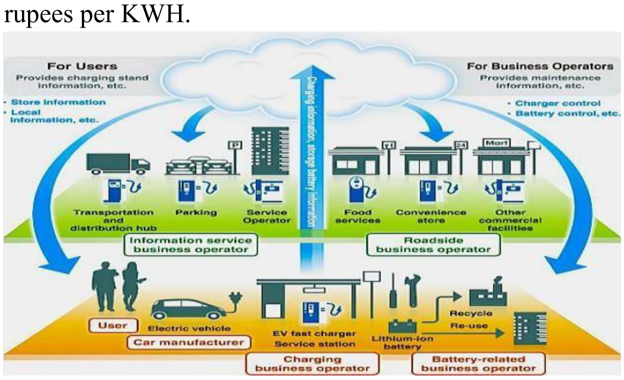

Fig. 4 charging stations

Electrical vehicles have a plethora of benefits. Combustion engines will be used less in INDIA if infrastructure improvements are made, including the installation of charge stations. Because the cost of importing crude oil is decreasing, the nation's net value will then rise. The money will then be used in a variety of additional ways.

Table: 2 Analysis of requirement for charging stations

ESTIMATED LOAD	RECOMMENDED DT SETUP	MINIMUM AREA REQQUIREMENT
100KW-300KW	Installation of one 11 kV pole or plinth mounted DT	4 m x 4 m (pole) 8 m x 5 m (plinth)
300KW-700KW	Installation of one 11 kV plinth mounted DT	9 m x 5 m
700KW-1500KW	Installation of two 11 kV plinth mounted DTs	10 m x 8 m

As shown in above table 2 for nearly 300 kW the minimum area requirement is (4m x 4m (pole) 8m x 5m (plinth)) for nearly 700 kW the minimum area requirement we have to set up the 11kv plinth mounted DT. For nearly 1500 Kw 10m x 8m we have to set up the two 11kv plinth mounted DTs.

The following planning recommendations should be borne in mind while integrating EV charging at a particular site:

• Reserve a location that is both accessible and obvious. Seen from the site's entrance.
• Decide where to charge so as to reduce civil work and wiring specifications, if applicable.
• Comply with all EV charging safety regulations. Planning according to the CEA's definition (Measures related to Electricity Supply and Safety) (Amendment)
• Clearly mark the designated parking places equipped with the proper signage and markings.
• Make sure there is enough room for vehicle movement, such as access the charging bays and leave them.
• Make sure the charging area is protected from theft and destruction.

Charging equipment:

Charging equipment for EVs is classified by the rate at which the batteries are charged.

Level-1: charging approximately 5 miles of range per 1 hour of charging

The majority of a driver's needs can be readily met by level 1 charging, which is commonly used when there is just a 120 V outlet available, such as when charging at home. For a mid-size EV, for instance, 8 hours of 120 V charging may restore around 40 miles of electric range. Less than 2% of American public EVSE ports were Level 1 as of 2021.

Level-2: charging approximately 25 miles of range per 1hour of charging

The J1772 connector is used by both Level 1 and Level 2 charging equipment. In the US, all commercially available EVs have access to Level 1 and Level 2 charging infrastructure.

Level-3: Approximately 100-200+ miles may be charged with DC rapid charging in 30 minutes.

The CCS connector, also known as the SAE J1772 combination, is unique because a driver can use the same

charge port when charging with AC Level 1, Level 2, or DC fast charging equipment.
The DC fast charging connector's two extra bottom pins are the only distinction. The CCS connector may be used to charge the majority of EVs that are currently on the market.

3. BATTERY ANALYSIS:

The battery is made up of a number of electrochemical cells that use an isothermal process with a constant supply of reactants to transform chemical energy directly into electrical energy.

Table: 3 Analysis of battery requirement

Battery type	Specific energy (Wh/Kg)	Peak specific power(W/Kg)	Efficiency (%)	Cycle life	Self discharge (% per 48 kwh)	Cost (cdn$/kwh)
Lead acid	35-50	150-400	>80	500-1000	0.6	144-180
Nickel-cadmium	50-60	80-150	75	800	1	300-420
Nickel-zinc	55-75	170-260	65	300	1.6	120-360
NiMH	70-95	200-300	70	750-1200+	6	240-420
Lithium-iron sulfide	100-130	150-250	80	1000+	n/a	130
Lithium-ion	80-130	200-300	>95	1000+	0.7	240

Lead-acid batteries:
The basic reaction of the lead acid batteries is:
Pb + Pb0 2 + H 2 S 0 4 = 2PbS04 + 2H2 0
The lead acid battery's primary limitation is the requirement for routine maintenance. When the battery is kept in storage for an extended period of time, this happens. This backlog has been reduced recently to the point that they can now be used for small-scale HEVs and EVs. Efficiency is greater than 80%, cycle life is between (50to1000), and selfdischarge is 0.6 kW as shown in table 3.
Nickel Metal Hydride batteries:
M(H) + 2NiO(OH) = M + 2Ni(OH)2
These batteries have serious limitations at cold temperatures, thus needing precise climate control system. Efficiency is 70%, cycle life is 1200+, self -discharge is 6 kWh as mentioned in table 3
Lithium-ion batteries:
LiMno2 ⇔Li(1-x)Mn204 + xLi+ + xe_
C + xLi+ + xe_ ⇔Li(x)C
LiMn204+C⇔Li x C + Li(1-x)Mn204
Efficiency is greater than 95%, self-discharge 0.7kwh as mentioned in table 3.
Therefore, maximizing the use of the electric drivetrain is the main consideration while building an electric drivetrain architecture, creating its supervisory control unit, and enhancing the performance of battery packs. Motor inside the car. The goal of these technologies' advancement is to replace electric propulsion replaced the mechanical propulsion that was fuelled by gasoline.
The sole source of traction is the motor. Additionally, the longer battery life, safety,
Market success will result from dependability and charging simplicity at cheap starting cost.
Factors affecting battery performance: These characteristics are affected by a wide range of variables, which changes battery performance. The main influencing factors for performance are described below.
• Current drain of discharge: Battery performance is correlated with the current drain rate
• Discharge mode: after conducting the necessary tests for a certain application, the discharge mode is used.
• Battery temperature: Low temperatures cause a reduction in battery capacity and an increase in internal resistance, which leads to greater losses and less efficiency. Higher temperature causes the resistance to diminish, increasing the discharge voltage. The level of chemical activity rises to the point where it happens quickly enough to result in a net reduction in capacity.
• Discharge type: Different discharge types alter the physical and chemical makeup of the battery, which has an impact on how well it performs.
• Duty cycles: A duty cycle's fluctuation in discharge current affects the battery's performance significantly.
• Charging mode: The various charging modes, such as constant current, constant current constant voltage, and constant voltages, have an impact on the battery's performance, much like the draining process does.
• Battery age and storage configuration: As a battery becomes older and is stored under different settings, its physical and chemical properties change. At lower temperatures, the battery's self-discharging, which varies with battery chemistry, is typically modest. During extended storage, some batteries have a tendency to form a passive layer on the electrodes, extending their service life and safeguarding the battery
• Battery design impact: An efficient cell design has a significant impact on the performance of a multi-cell battery. A significant variance in better performance, life safety, and dependability is brought about by the accuracy level of thermal and cell management.
The most crucial factor in choosing a battery is the comparison of energy to power densities. These patterns have been identified in the lab using constant power test data.

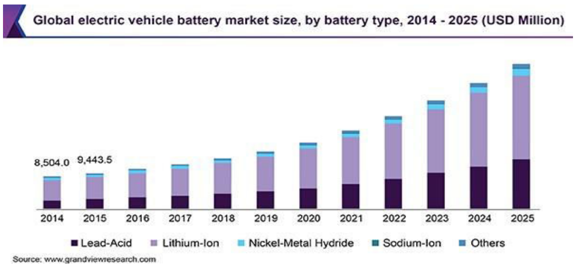

Fig. 5 plot of global electric vehicle battery market size, by battery type, 2014-2025

As shown in the above graph (Fig. 5) year of 2025 has the high global electric vehicles market size in that lithium ion battery has sold the most. Now a days lithium ion has high demand.

4 RESOURCES AND ENERGY:

Lithium, nickel, and cobalt are the three main metals used to make EV batteries. Analysts believe that the global mining capacity may not be sufficient to extract the minerals needed to create enough batteries to meet anticipated demand. Battery costs will decrease as more EVs are sold, and major battery manufacturers are competing to increase capacity. At the same time, the demand for key battery components like cobalt and lithium will increase significantly, which will put pressure on their prices. Since 2015, the price of cobalt and lithium has more than doubled, which has caused a net rise in EV product time.

The current number of public charges and EVs across Europe as shown in (Fig. 6). Electrical cars have a chance to replace fossil fuels in the transportation sector. Electrification of the transport sector can also bring benefits in terms of increased energy efficiency and reduced local pollution. The need for clean, renewable energy to charge EV batteries in the future. The removal of these items could result in moral and social problems.

More significantly, the supply risks of vital materials utilized in EV batteries highlight the problem of long-term sustainability of EVs. The extraction of some of these natural resources has a negative influence on the environment and raises moral and societal dilemmas. Direct current (DC) fast-charging stations would be necessary to refuel BEVs to reach their normal ranges today. Drivers of limited-range BEVs may find it annoying to frequently refuel using DC fast-charge, which takes around 20 minutes, to prolong a trip beyond the vehicle's all-electric range. How much of a tradeoff between price and range of a BEV will be necessary for general market consumers to select BEVs, particularly as their primary vehicle, is unknown.

A gasoline or fuel cell tank, however, may be refilled in a matter of minutes. Over 400,000 public charging stations are available to accommodate the more than three million EVs that are now in use worldwide. This number will need to sharply grow in order to achieve the anticipated gains in global EV usage by 2030. (Exhibit 1). To accommodate the anticipated number of EVs, it won't be adequate to simply build new charging stations the size of gas stations or replace old ones with charging points. It will need many 120 kW quick charging stations with eight outlets to offer the same amount of range per hour as a normal gas station today. In comparison to the US, Europe and China will be much more likely to experience a land squeeze. Compared to 75% of EV owners in the US, only 40% of European and 30% of Chinese EV owners have access to private parking and wall charging. Additionally, the difficulty is not limited to where to plug in or turn on; creation and distribution are also important considerations.

As long as EVs are charged off-peak, today's power plants can handle the large increase in EVs that will occur in the future. However, faster charging will have an effect at times of high demand. In actuality, the peak demand from a single EV using a top-of-the-line fast charger is eighty times greater than what is anticipated for a single EV.

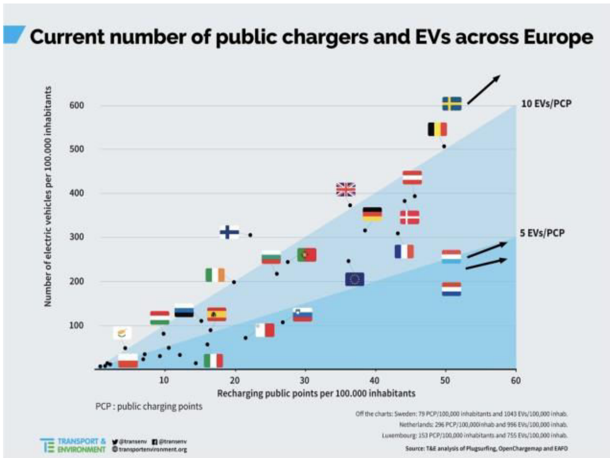

Fig.6 current number of public charges and EVS across Europe

5. Conclusion:

The development of alternative technologies for the automotive industry, such as electric vehicles (EVs), is linked to the use of fuel with low carbon content and aids in lowering greenhouse gas emissions. These technologies have been the subject of extensive research in recent years to address the world's most pressing carbon reduction challenges. In comparison to conventional automobiles, the LCA and LCC of EVs are briefly discussed in this paper. The study compares life cycle GHG emissions levels and human toxicity levels carried out in various countries and came to the conclusion that emissions levels for EV decrease in comparison to ICEV but there is an increase in human toxicity level for EV due to the greater use of metals, chemicals, and energy for the production of powertrain and high voltage batteries. EV also shown lower operating costs, but its overall LCC is greater due to higher battery acquisition costs, pricing uncertainties for future gasoline and electricity blends, and higher beginning costs.

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