A Study On Conversion Of ICE Vehicle To EV

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Abstract.

Due to the increase in oil prices and depletion oil resources, electric vehicles will undoubtedly be the next revolution in automobile industry. EVs generate zero emissions since they utilize power from batteries rather than fuels, making them eco-friendly. This shift towards electric vehicles will render the conventional mobility systems driven by internal combustion engine useless. Thus, there is an absolute necessity for converting IC engine vehicle to electric vehicle, as it will prevent the existing IC engine vehicles from being scrap.

Keywords. ***EV types, battery, motor, retrofitting, challenges.***

1. INTRODUCTION

Because there are more gasoline vehicles on the road, environmental pollution is increasing. Electric vehicles(EV) are extremely important in reducing pollution, and they are the best option when compared to regular automobiles. Due to environmental and economic considerations, electric vehicles have recently gained greater popularity than gasoline automobiles. With the improvement of battery and motor technology, EVs will become a viable alternative to petroleum automobiles[1]. EVs provide the following advantages over the conventional vehicles:

- No emissions: They do not emit any greenhouse gases from their exhaust. Furthermore, the process involved in manufacturing is more eco-friendly, regardless of the fact that manufacturing a battery has a negative influence on carbon emissions.

- Reduced complexity: Maintenance cost is less due to less number of components in an Electric Vehicle engine. There is no need for a cooling circuit, or a clutch, gearshift or any components to reduce noise in the engines. This makes them both simple and compact.

- Reliable: Since these vehicles have simpler and fewer components, they are less likely to break down. Furthermore, EVs are unaffected by engine explosions, vibrations, or gasoline corrosion, which cause wear and tear in conventional vehicles.

- Cheaper: In comparison to traditional combustion vehicles, the cost of the electricity required for the vehicle and it’s maintenance costs are much lower. EV’s seem to have a much lower energy cost per kilometer when compared to conventional vehicles.

- Comfort: Travel in an EV is more comfortable because there are no tremors or engine noise [2].

- Accessibility: EVs offers access to urban areas where other combustion vehicles are prohibited (e.g., low emissions zones). Electric vehicles are not subjected to same traffic restrictions as conventional vehicles in large cities, particularly when pollution levels are high.

2. CLASSIFICATION OF ELECTRIC VEHICLE

Electric vehicles can run purely on electricity or in combination with an IC engine. The most fundamental type of Electric vehicle is one that utilizes only batteries as its source of energy, but there are others that use various sources of energy. These are referred as hybrid electric vehicles (HEVs). Technical Committee 69 (Electric Road Cars) of the International Electrotechnical Commission proposed that the vehicles with two or more types of energy sources, converters or storage, can be classified as even if one of them provide electrical energy [2]. This specification allows for a wide range of HEV pairings, including battery and IC engine, battery and fuel cell, battery and capacitor, battery and flywheel, and so on. Therefore, both the general public and experts began to refer to vehicles with an electric motor and an IC engine as HEVs, battery and fuel cell vehicles as FCEVs and Capacitor and battery vehicles as ultra-capacitor-assisted EVs [2]. These terminologies have gained widespread acceptance, and EVs can now be classified as follows:

- Fuel Cell Electric Vehicle (FCEV)
- Hybrid Electric Vehicle (HEV)
- Plug-in Hybrid Electric Vehicle (PHEV)
- Battery Electric Vehicle (BEV)
- Extended range electric vehicle (ER-EV)

Fuel Cell Electric Vehicle (FCEV)

Fuel Cell Electric Vehicle are also known as Fuel Cell Vehicles (FCV). Fuel cells, which produce electricity through chemical reactions, are at the core of these vehicles [3]. Because hydrogen is the preferred fuel for this reaction, hydrogen fuel cell cars are sometimes termed as "hydrogen fuel cell vehicles." Fuel Cell Vehicles transport hydrogen in special high-pressure tanks, and oxygen, which is acquired from the surrounding air taken, is another ingredient in the process of power generation. The electricity generated from fuel cells, and this is utilized to power the electric motor, which drives the wheels. Excess energy is stored in battery or super capacitor storage systems [4].

Hybrid Electric Vehicle (HEV)

The electric motor and IC engine power the HEVs. The electric propulsion system is used by a HEV when the power demand is minimal. It has a considerable benefit in low speed conditions like cities. It also minimizes gasoline because the engine is turned off fully during standstill periods like traffic jams. This feature reduces greenhouse gas emissions as well. When more speed is necessary, the HEV shifts to the ICE. Both drive trains can boost performance by working together.

Plug-in Hybrid Electric Vehicle (PHEV)

The PHEV concept was developed in order to increase the range of HEVs that can run entirely on electricity [5]. Like a HEV, it has both an ICE and an electric powertrain, but the distinction is that the PHEV uses electric propulsion as the main driving force, necessitating a larger battery capacity than HEVs. PHEVs start in 'all electric' mode, run on electricity, and then call on the ICE for a boost or to charge up the battery pack when the batteries are low on charge. The ICE is employed to expand the range in this case. PHEVs have the ability to charge their batteries directly from the grid (but not possible in HEVs), as well as use regenerative braking. PHEVs have a lesser carbon footprint than HEVs because they may run on electricity for the most of the time. They also utilize less fuel, resulting in cheaper operating expenses.

Battery Electric Vehicle (BEV)

Battery Electric Vehicles are electric vehicles which rely exclusively on batteries to power the drivetrain. Battery Electric Vehicles must rely only on the stored energy in their battery packs; hence the range of these vehicles is directly proportional to the capacity of the battery. On a single charge, they can normally travel 100 to 250 kilometers [6], with top-tier models capable of travelling up to 500 kilometers [6]. Factors such as conditions and driving style, vehicle configurations, road conditions, weather, age, and battery type all influences the range. Charging of an exhausted battery pack takes longer than refueling a standard ICE car.

Extended-range electric vehicles (ER-EVs)

The ER-EVs vehicles are quite identical to BEVs. The difference is that the ER-EVs come with a backup combustion engine which is used to charge the vehicle's batteries if necessary. Unlike the engines found in HEVs and PHEVs, the engine here is utilized only for the charging of the battery and it is not connected to the wheels of the vehicle [7].

3. BATTERY

In an EV, the battery is the primary source of energy storage. In fact, it is considered as the driving force behind the electric vehicle's success [8]. There are various kinds of batteries. Batteries can be rechargeable and non-rechargeable. Below are the few main rechargeable batteries are mentioned.

Lead acid battery

The lead-acid battery which is the very first rechargeable battery ever made was developed in the year 1860 by Gaston Planté. Though used in electric vehicles they can also be seen in conventional automobiles. The electrolytes, as well as the positive and negative electrodes, are active materials in electrochemical charge/discharge. Diluted corrosive sulphuric acid acts an electrolyte. Sponge lead (Pb) serves as the negative electrode, while lead oxide serves as the positive electrode (PbO2)[9].

Nickel cadmium battery

In 1899, Waldemar Jungner invented the basic Nickel cadmium battery. These are basically constructed of Nickel hydroxide as the positive electrode and Cadmium hydroxide as the negative electrode which are immersed in potassium hydroxide where the utilization of alkaline electrolyte was made [10]. During its time, Nickel cadmium became the most popular battery for portable electronic devices.

Nickel metal hydride battery

Instead of cadmium (Cd), an alloy which stores hydrogen is employed for negative electrodes. When researchers first started working on Nickel metal hydride, they discovered that it was unsuitable owing to metal hydride instabilities, therefore Nickel metal hydride was developed, which is primarily utilized in satellites. Nickel metal hydride was developed after the identification of new hydride alloys that gave superior stability and had a significantly higher specific energy. Other advantage it has over Nickel cadmium is that it is environmentally friendly, as it contains no hazardous metals [10].

Lithium ion battery

M Stanley Whittingham proposed lithium batteries while working for Exxon in the 1970s [11]. For anodes, he considered titanium sulphide and lithium metal. The positive electrode of present Li-ion batteries is of metal oxide, and the negative electrode is of carbon, with lithium salt used as the electrolyte which provides the required ions for the reversible electrochemical process between cathode and anode. The lightweight of lithium-ion batteries' components, their internal resistance, high loading capacity, and high unloading and loading cycles are all advantages. The majority of electric vehicles and plug-in hybrids now use this sort of battery. Li-ion batteries should function within a reliable and safe operating range defined by voltage and temperature windows. Surpassing the limits of these windows would result in a rapid reduction in battery performance and may also pose a security risk.

Table 1: Comparison of different type of batteries [7]

	Lead acid	Nickel cadmium	Nickel metal hydride	Lithium ion
Energy density (Wh/L)	60-100	60-150	100-300	200-735
Temperature (° C)	-20 – 45	0 – 50	0 - 50	-20 – 60
Specific power (W/kg)	75-100	120-150	250-1000	350-3000
Specific energy(Wh/kg)	30-60	60-80	60-120	100-275

4. MOTORS

The propulsion system is at the heart of an electric vehicle [2], and the electric motor is at the center. Motor transforms battery's electrical energy into mechanical energy, allowing the vehicle to move. During regenerative action, motor serves as a generator, sending energy back to the source. Electric vehicle can possess varied numbers of motors depending on their needs. High efficiency, high torque, High power, wide speed range, dependability, robustness, affordable cost, small size and lower noise are among the requirements for an EV motor, according to references [12].

Brushed DC Motor

The stator of these motors is made of permanent magnets (PM), while the rotors feature brushes which power the stator. One of its advantages is its ability to deliver maximal torque at lower speeds. Its disadvantages include the huge structure, less efficiency, heat generated by the brushes, and the resulting loss in efficiency. Because the heat is generated in the rotor's center, it's also tough to remove. For such reasons Brushed DC motors are no longer incorporated in EVs [13]

Permanent Magnet Brushless DC Motor (BLDC)

This motor's rotor is built of PM, and an inverter provides an alternating current (AC) feed to the stator from a DC source. Due of the absence of rotor windings rotor copper losses in rotor does not take place, making it more efficient when compared to IM. It is also lighter, smaller, high efficiency in dissipating heat (from the stator), highly dependable, and has a better torque density and specific power [2].

Permanent Magnet Synchronous Motor (PMSM)

Permanent Magnet Synchronous Motor is one among the most advanced machines, which has the ability to function at various speeds without utilizing the gear system. This feature improves the compactness and efficiency of these motors. This setup is also ideal for in-wheel applications due to its ability of delivering great torque at lower speeds. PMSMs with an outside rotor are also viable to build without the use of rotor bearings. However, the one significant disadvantage of these machines occurs during in-wheel operations, when a large amount of iron is lost at high speeds, causing the system to become unstable [13].

Induction Motor(IM)

This is the most advanced of the several commutatorless motor driving schemes. To create Induction Motor drives which are able to address the needs of Electric Vehicle systems, vector control is useful. By torque control and decoupling field control, the field orientation control may make an Induction Motor behave as a separately excited Direct Current motor. The field orientation control can accomplish a range 3-5 times the base speed with the help of properly constructed Induction Motor [14], and the flux weakening extends the speed range while keeping the power constant over the base speed [15].

Switched Reluctance Motor (SRM)

Recently the Switched Reluctance Motor is popular due it's tolerance of fault which is mainly because its phases are not coupled with each other. It has a different power stage when compared with the motors mentioned so far. In the style of flyback circuit every phase winding are connected [7].

In-wheel and direct drive motor

Direct drive lowers the losses in drive train's mechanical parts. Motor is directly attached to the shaft, eliminating the need for a transmission, clutch, or gearbox. Recently, a researcher [15] has advocated for an in-wheel motor. In-wheel motor spins the rotor inside out and is linked to the rim and tyre of the wheel. It does not possess drive shaft or gearbox. Wheel-hub motor is another name for the motor. Its key advantage is that each wheel may be controlled independently. Each wheel spins at its own pace and in any direction. As a result, parallel barking is simple to produce. The technology can readily deploy the anti-lock braking system. It has been demonstrated that it can effectively avoid spinout. The structure of the entire vehicle is substantially simpler.

5. REVIEW ON CONVERSION PROCESS TO EV

[16] proposed the process of converting the conventional vehicle to electric vehicle. The process can be divided into 3 parts. First step is to dismantle the mechanical systems, second step is to install the electrical components and the third step is to install power system. The main constitutive elements like motors, energy storage and charging systems were also presented. Also it was suggested that the conversion will save the environment from pollution and also prevent the ice vehicles from going scrap.

[17] here the experimental setup for the process of retrofitting is presented. They retrofitted a four wheeler ic engine vehicle to electric vehicle. They also gave the motor parameters calculation and suggested that the motor specifications should be more than sufficient to replace the engine of the vehicle. They used BLDC motor and lithium polymer based battery pack was selected. Even the BLDC motor simulation results were provided. The operational cost comparison showed that EV is more cost effective than the IC engine vehicle.

[18] here a project of conversion of ICE to EV was presented. The process of conversion and also the conversion cost benefit ratio was presented. The main task of any conversion process is the selection of appropriate vehicle which should have lowest weight, simple construction and more space in the engine area. Therefore, the conversion was done on Opel Kadett C from 1978.

[19] here scooter with engine capacity of 80cc petrol internal combustion engine is converted to hybrid vehicle where the front wheel gets an electric hub motor. It is converted to a two-wheel drive scooter with the internal combustion engine which powers the rear wheel and the electric motor powers the front wheel. Simulation results and also the calculations for savings were presented. The results showed that hybrid scooter can run at a higher torque than the EVs and in case of emergency it can be operated in engine mode.

[20] proposed the conversion of the four-stroke gasoline powered bike into electric vehicle and selection of required components was done with the help of calculations. Here lithium ion battery and BLDC motor was used. Step by step process of assembling the components and the test results were provided. With the project's implementation it was seen that there was cost reduction and with the help of the components the range and speed for the vehicle can be obtained.

[21] presented the conversion of an IC Engine vehicle into an EV. Both the batteries charging power converters and the power train were developed for the process of conversion. The power train comprises of 3-phase inverter with space vector modulation and Field Oriented Control. The main components assembly of the EV was also presented.

[22] presented the conversion of the fuel based garbage vehicle to electric vehicle. The conversion process was done by replacing the existing parts like internal combustion engine, fuel tank, exhaust system, radiator, tailpipe etc., with induction motor and battery power train. The conversion process also helped in reducing the driver's efforts. It also describes the electric powered vehicle has a numerous benefits over conventional one.

[23] here the development of electric vehicle from internal combustion vehicle is shown. The cost of operation of an electric vehicle and an internal combustion vehicle is compared and it was seen that the electric vehicle has less operating costs. The components needed and design for the conversion is also provided.

[24] here an IC engine powered Mercedes Benz Class A 190 was converted into Electric vehicle. The materials required and the methods are also discussed. The results indicated that the conversion is feasible with the operating costs being low for the converted vehicle and this operating cost can be reduced by PVs to generate electricity.

[25] here a system for conversion of ICEV to BEV is shown. The total cost of ownership of the EV and the economic benefits of the BEV over the EV is presented. The working of the electric car and different components are explained.

6. SAFETY CHALLENGES

Electrical risks are a serious concern, given the massive quantity of electrical energy that may be stored in batteries and the use of high voltage (HV) cables [26]. As a result, if a defect occurs, a high-energy release could occur, potentially posing a safety danger, and because the battery cannot be turned off, there is always an electrical risk [26]. Other dangers include chemicals, which could be released as a result of battery technology, and collisions, which could puncture the battery or damage high-voltage wires, perhaps resulting in a fire [26]. The weight distribution of a vehicle will change if the IC Engine and exhaust system are replaced with the electric drive train, which will be studied and analyzed in the design and testing stages before manufacturing a new EV. However, in the case of an electric conversion, the vehicle was not designed to carry an electric drive train from the start, and thus, if not taken into account, it may affect the loads on the chassis, potentially causing structural damage in the future, as well as affecting dynamic handling and braking [27]. Another factor to consider is user safety during maintenance, with appropriate protection offered to users who might perform basic maintenance tasks, while vehicle technicians and repair staff must be sufficiently trained to assure complete safety while adjusting and changing parts [28]. Testing of the insulation resistance and the leakage current controller function, also the verification of battery status, should all be included in routine maintenance [28].As a result, these safety concerns emphasize some of the aspects why electric retrofitting must be conducted in a suitable standards, largely to avoid major failures.

7. CONCLUSION

Electric retrofits do have potential to assist in the transition to zero-emission vehicles, reducing the transportation sector's considerable contribution to GHG emissions. By embracing the re-use notion of a circular economy, transforming current vehicles could reduce the number of well-functioning vehicles going to scrap as a result of the purchase of new EVs. Furthermore, EV technology might be embraced at a moderate pace, eliminating the requirement to build and promote a large number of EVs in the near future. Thus there is an increasing need for converting existing combustion engine vehicles to electric vehicle. In this paper, we have discussed about the types of electric vehicles, different battery types used and also the different motors used. Here we have also discussed about conversion process and also the safety challenges that are faced in conversion process.

8. REFERENCES

[1] Ching-Ming Lai, Yu-Huei Chang, Ming-Hua Hsieh, Yuan-Chih Lin ”Development of a Bidirectional DC/DC Converter with Dual-Battery Energy Storage for Hybrid Electric Vehicle System,” IEEE Trans. Vehicular Technology., vol. 67, no.23, Feb 2018.

[2] Chan, C.C. The state of the art of electric, hybrid, and fuel cell vehicles. Proc. IEEE 2007, 95, 704–718.

[3] Fuad Un-Noor, Sanjeevikumar Padmanaban, Lucian Mihet-Popa, Mohammad Nurunnabi Mollah and Eklas Hossain, “A Comprehensive Study of Key Electric Vehicle (EV) Components, Technologies, Challenges, Impacts, and Future Direction of Development”, Energies 2017, 10, 1217;

[4] Miller, J.F.; Webster, C.E.; Tummillo, A.F.; DeLuca, W.H. “Testing and evaluation of batteries for a fuel cell powered hybrid bus”, the Energy Conversion Engineering Conference, Honolulu, HI, USA, 27 July–1 August 1997; Volume 2, pp. 894–898.

[5] Gao, Y.; Ehsani, M. Design and control methodology of plug-in hybrid electric vehicles. IEEE Trans. Ind. Electron. 2010, 57, 633–640.

[6] Grunditz, E.A.; Thiringer, T. Performance Analysis of Current BEVs Based on a Comprehensive Review of Specifications. IEEE Trans. Transp. Electr. 2016, 2, 270–289.

[7] Julio A. Sanguesa, Vicente Torres-Sanz, Piedad Garrido, Francisco J. Martinez, Johann M. Marquez-Barja, “A Review on Electric Vehicles: Technologies and Challenges”, Smart Cities 2021, 4, 372–404.

[8] Pruthvija B, K P Lakshmi, “Review on Battery Technology and its Challenges”, International Journal of Scientific & Engineering Research Volume 11, Issue 9, September-2020

[9] Cheng, K.W.E.. “Recent development on electric vehicles,” 3rd International Conference on Power Electronics Systems and Applications, PESA. 1 – 5, 2009

[10] Pruthvija B, K P Lakshmi, “Review on Battery Technology and its Challenges”, International Journal of Scientific & Engineering Research Volume 11, Issue 9, September-2020, 1706-1713.
[11] Lu, L.; Han, X.; Li, J.; Hua, J.; Ouyang, M, “A review on the key issues for lithium-ion battery management in electric vehicles”, J. Power Sources, 2013, 226, 272–288.
[12] Rajashekara, K, “Present status and future trends in electric vehicle propulsion technologies”, IEEE J. Emerg. Sel. Top. Power Electron. 2013, 1, 3–10.
[13] Jose, C.P. Meikandasivam, S, “A Review on the Trends and Developments in Hybrid Electric Vehicles”, Innovative Design and Development Practices in Aerospace and Automotive Engineering; Springer: Singapore, 2017; pp. 211–229.
[14] Yamada, K.; Watanabe, K.; Kodama, T.; Matsuda, I.; Kobayashi, T, “An efficiency maximizing induction motor drive system for transmissionless electric vehicle”, Proceedings of the 13th International Electric Vehicle Symposium, Osaka, Japan, 13–16 Octobor 1996; Volume II, pp. 529–536.
[15] K.W.E Cheng, “Recent Development on Electric Vehicles”, 3rd International Conference on Power Electronics Systems and Applications, 2003.
[16] K. S. Sathish Kumar, Franklin Xavier. A, Avinash. R, Muthupitchiya. P, Jerrin K Abraham.:“Conversion of an IC Engine Vehicle into Electric Vehicle”, International Journal of Engineering Research & Technology (IJERT), Vol. 7, Issue 06, pp. 4-7, Special Issue - 2019
[17] Ashish Rajeshwar Kulkarni, Sudhanshu Singh, Krishan Kant, Hemant Bharti.:“Experimental Electric Retrofitting of an ICE Vehicle with Simulation and Cost Analysis”, International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol. 9, Issue-9S, pp 45-50, July 2020.
[18] Mario Vraziu , Damir Vuljaj, Arsen Pavasoviu, Hrvoje Paukoviu.:“Study of a vehicle conversion from internal combustion engine to electric drive”, IEEE International Energy Conference (ENERGYCON), pp. 1544-1548, May 2014.
[19] Najmuddin Jamadar, Suhani Jamadar, Abhilasha Kumbhar, Shital Tanvandkar, Manali Patil, Sourabh Zagde, “Retrofitting of Existing Scooter into Hybrid Electric Scooter”, Journal of Automation and Automobile Engineering Vol. 4, Issue-2, pp 6-13,
[20] S.Vasanthaseelan, D.S. Dharun, S.Sreerag, R.Gokul.:“Conversion Of IC Engine Vehicle To Electric Vehicle”, International Research Journal of Engineering and Technology (IRJET), Vol. 6, Issue 03, pp. 3325-3330, Mar 2019.
[21] Delfim Pedrosa, Vítor Monteiro, Henrique Gonçalves, Júlio S. Martins, João L. Afonso. “A Case Study on the Conversion of an Internal Combustion Engine Vehicle into an Electric Vehicle”, IEEE Vehicle Power and Propulsion Conference, pp. 1-5, Oct 2014.
[22] Kapil Shrivastava, Ram Bansal, Himanshu Jain, Nimil Doshi, Niraj Soni And Nikita Soni, “Conversion Of Conventional Vehicle Into An Electric Vehicle”, Advances and Applications in Mathematical Sciences, Vol 20, Issue 1, pp. 15-24, Nov 2020.
[23] li Eydgahi, Edward Lee Long, “Converting an Internal Combustion Engine Vehicle to an Electric Vehicle”, Proceedings of ASEE Annual Conference, Vancouver, Canada, June 2011.
[24] Jardel Eugenio da Silva, Jair Urbanetz, “Converting a Conventional Vehicle into an Electric Vehicle (EV)”, Brazilian Archives of Biology and Technology, Vol 62, Jan 2019.
[25] Nachiket Chavan, Varun Rathor, “Transition Of Icev To Ev: Process And Efficiency”, International Journal of Engineering Applied Sciences and Technology (IJEAST), Vol. 5, Issue 3, pp. 402-408, Jul 2020.
[26] Freschi, F.; Mitolo, M.; Tommasini, R. Electrical Safety of Plug-In Electric Vehicles: Shielding the Public from Shock. IEEE Ind. Appl. Mag. 2018, 24, 58–63.
[27] Zakrzewicz, W.; Sys, E.; Mrowicki, A.; Siczek, K.; Kubiak, P. Safety Issues for Electric and Hybrid Vehicles; IEEE: Kielce, Poland, 2020.
[28] Robbie Watts, Aritra Ghosh, Justin Hinshelwood, “Exploring the Potential for Electric Retrofit Regulations and an Accreditation Scheme for the UK”,Electronics2021,10,31

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