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A PROJECT REPORT
ON
ELECTRIC VEHICLE

Submitted in partial fulfilment of the requirements for the degree of

BACHELOR OF TECHNOLOGY

In

ELECTRICAL ENGINEERING

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JUNE-2024

CHAPTER NO: -1

INTRODUCTION OF ELECTRIC VEHICLE

1.1 What is Electric vehicle?

An EV is defined as a vehicle that can be powered by an electric motor that draws electricity from a battery and is capable of being charged from an external source. The grail behind the electric vehicle is to replace an internal combustion engine with an electric motor which is powered by the energy stored in the batteries through power electronic traction inverter. The Electric motor uses 90–95% of input energy to power the vehicle, which makes it a very efficient one. The key components of an Electric car are battery, charging port, charger, DC/DC converter, power electronics controller, regenerative braking, and drive system.

The purpose of the electric motor is that it utilizes the electrical energy stored in batteries for powering the Electric vehicle. The EVs become environment-friendly as they are recharged with lower emission power sources. The cells are charged from the electric grid. The primary function of the battery is to provide power to the Electric car for making it in running condition. Generally, EVs use lithium-ion batteries because they are more efficient than other cells due to their lightweight and negligible maintenance. The manufacturing of these Li-ion batteries is bit expensive as compared to the nickel-metal hydride and lead-acid batteries. Depending upon the climatic location and maintenance schedule, the Li-ion batteries last up to 8 to 12 years.

The charging port is the point that permits the vehicle to connect with an external power supply system through a charger to charge the battery. The function of the charger is to take AC supply from the power source using a charge port and converts it into DC power for charging the battery. It also monitors the voltage, current, temperature and state-of-charge of the battery while charging it.

The DC/DC converter converts high voltage DC from the battery to low voltage DC power to run the vehicle accessories. The power electronics controller controls the speed of the traction motor and torque by managing the flow of electrical energy from the traction battery.
The regenerative braking plays an essential role in maintaining vehicle strength and achieving improved energy. This braking method uses the mechanical energy from the motor and converts kinetic energy into electrical energy to give back to the battery. Regenerative braking also enhances the range of the EV, so it is widely adopted in all hybrid and BEV models. Here the electric motor generates forward momentum when the car moves forward, and when the brake is applied, it can be used to charge the batteries, which is known as regenerative braking. It can recover 15% of used energy for acceleration. Being an effective component, it is unable to recharge the electric vehicle fully.

The role of the drive system is to generate motion by transferring the mechanical energy into the traction wheel. Based on the use of the components, the electric vehicle has several internal configurations and does not require conventional transmission. For example, some design uses multiple smaller motors intended for powering each wheel individually. On the other hand, a large electric motor possibly is coupled to the rear wheels using differential housing. The electric-powered vehicle utilizes much simpler components when compared with the elements of a gasoline-powered car engine. However, electric vehicles would not go much faster as a gasoline powered car can.

1.2 EV patent analysis: battery or fuel cell?

With the increasing concerns for environmental protection and energy crises, the automotive industry is undergoing a deeply technological transformation from the internal combustion engine vehicle (ICEV) towards low emission vehicles (LEVs). LEVs are composed of battery electric vehicles (BEVs), Hybrid electric vehicles (HEVs), and Fuel cell electric vehicles (FCEVs), in which a partial or full-electric drivetrain is contained [1]. Technological change may revolutionize the foundation of the automotive industry [2]. In particular, the powertrain of BEV may replace the powertrain components of ICEV with battery packs, electric motor, and charger [3]. As an emerging clean energy technology, the BEV technology has gained increasing attention in the world and enjoyed good development in some countries. Many studies focus on technology innovation (TI) from a national level, which has an advantage in explaining how to improve LEV technology development over time due to a tensional relationship between the territoriality embedded and spatially dispersed externality.

However, innovation mode and product characteristics in the BEV industry are changing. Taking the increasing spatial complexity of the innovation process into account, Binz and Truffer [4] proposed an analytical framework of the global innovation system (GIS) for TI dynamics. The BEV industry in its infancy falls into the production-anchored type of GIS due to the territorially embedded innovation system and standardized new products. The

the diffusion of LEV technologies across organizations or technology areas. For instance, Sun, Geng, Hu, Shi, and Xu [9] took the top 38 organizations development of BEV technology increasingly depends on a science and technology-driven innovation mode at the rapid developing stage, while new products are more and more customized. The shift of innovation mode in the BEV industry leads to a significant reconfiguration of its spatial GIS. Technology diffusion is beyond national borders and enhances the process of science and technology-driven innovation . Under the context of innovation globalization, the boundaries of territorial innovation systems may get blurred increasingly .

Moreover, the “wave of LEV development” , which refers to the period of increased technological development, is not successive but intermittent because the process of LEV development is not smooth. For instance, the first wave of BEV development was broken in the 1990s . The current wave, the fourth wave of LEVs development, is the BEV development that was initiated in 2006 [6]. Therefore, mapping the BEV technology diffusion across countries can help policy-makers or managers to better understand the trend of the BEV technology for the future.

Technology innovation systems (TIS) is a socio-technical system that focused on the development, diffusion, and use of new technologies . It can be understood from various dimensions, such as a technological, sectoral, national, or global perspective. Most studies engage in exploring in China as samples to measure the progress of BEV technologies. Phirouzabadi, Juniper, Savage, and Blackmore applied the co-assignees of patents to discuss how the automotive powertrain systems influence each other. However, there is a limited discussion about BEV technology diffusion from the perspective of GIS.

To close this gap, this paper aims to address the following questions: What is the evolutionary pattern of BEV technology diffusion across countries; Which countries are more likely to be the source or recipient of the BEV technology in the process of technology diffusion. We combine the data on priority patent applications and international patent families proposed by Haščič and Migotto [11] to measure technology diffusion from a global perspective.

The paper is organized as follows. Following the introduction, we have a short review of the literature on the TIS and technology diffusion in the BEV industry. In section 3, the methodology and data are introduced, and then the results of mapping global BEV technology diffusion are presented in section 4. Finally, a conclusion is drawn after discussions conducted in section 5.

1.3 Timeline for lithium-ion battery performance

The pursuit of achieving a sustainable carbon neutral future has triggered immense R&D for the development of effective energy storage materials and delivering technologies [1,2]. However, the expanding energy demands necessitates a giant leap in green mobility through feasible technologies that can be employed from chip to grid level [3]. Supercapacitors, batteries and fuel cells are widely being investigated as effective energy storing sources with varying energy dissipation capabilities and end applications . In parallel, Li-ion batteries (LIBs) since its first induction in market in 1990 by Sony has been anticipated and still stands to be the most vital among all battery technologies . In 30 years of usage LiBs have established their dominance as most encouraging power storage device for various portable electronics owing to its superior energy density, wide operating voltage and long cycle life [11]. In the current state of art, LiBs are being dissected as encouraging means of decarbonizing transportation by powering electric vehicles (EVs) as future technologies [12]. To address the repercussions LiBs have undergone significant improvement in terms of aesthetics and functionalities to mitigate the future energy needs. All the aspects that could potentially lead in leapfrogging the cell performance are being widely looked upon to enable applicability of high performance technologies simultaneously addressing safety concerns at larger scale . One such exemplar shift is the use of solid state electrolytes (SSEs) motivated by intrinsic elevated modulus of solid ionic conductors, destined to provide straightforward pathways towards high-energy-power driven rechargeable batteries .

All solid-state lithium batteries (ASSLBs) employing SSEs promise scalable and simple battery design with enhanced performances and electrochemical stability over larger windows of operation. SSEs can empower reduced packing volumes facilitating cell stacking to achieve heightened energy outputs . SSEs enable lithium diffusion and also define themselves as Li-ion conductors serving both as electrolyte and separator in ASSLBs . The replacement of traditionally excelling liquid electrolyte to highly foreseen SSEs is a non-trivial process and requires appropriate investigation and implementation from theoretical fundamentals to practical fabrication with numerous challenges to be addressed . The implementation of ASSLBs on the market highly necessitates feasibility and transition of successful laboratory scale research to industrial bulk production . The pre-requisite of SSEs fore mostly mandates high conductivity but also should satisfy the criterion of superior electrochemical stability, wide electrochemical window, good mechanical rigidity and a tunable elastic moduli . The ionic conductivity also a measure of Li diffusion migration ability of SSE is crystal structure dependent relying on its ability to migrate Li-ions via specific pathways through the solid lattice. The introduction of defects, and ion channels designing by doping and lithium vacancies have been strategic in enhancing the ionic conductivity of SSEs. Different chemistries of SSEs in certain class of solid electrolytes have achieved room temperature ionic conductivities as high as 1 mS/cm analogous to liquid electrolytes. A satisfactory SSE also demands favorable electrode/electrolyte interface to avoid transport limitations which has led to evolution of innovative interface designs for dendrite free long-term performance of energy murky metals. Additionally, the electrochemical and air stability of SSEs have also witnessed vast improvements through doping and buffer layer coating to significantly augment their performance .

1.4 EV powertrains and technologies

The automotive industry's two-pronged push toward higher fuel efficiency and lower carbon dioxide emissions pose a number of technical challenges for the sensing systems required to support these platforms, as well as for the battery management systems and all aspects of the powertrain.

To maximize the driving range per charge for a given battery capacity, the entire power conversion chain must achieve the maximum efficiency possible. In a panel discussion at the Roadmap to Next-Gen EV & AV virtual conference, three industry experts examined the powertrain challenges confronting EV manufacturers, OEMs and Tier 1 suppliers. Joining EE Times/Power Electronics for the discussion were Mike Kultgen, general manager for battery management systems at Analog Devices; Joseph Notaro, vice president for worldwide automotive strategy and business development at ON Semiconductor; and Mike Doogue, senior vice president for technology and products at Allegro MicroSystems. Here are some highlights from their conversation

CHAPTER NO: -2

TYPES OF ELECTRIC VEHICLES

2.1 Hybrid Electrical vehicle

A hybrid electric vehicle consist of IC engine and electric motor. Here the batteries get charged by the engine and by the energy generated when decelerating and braking. In the current scenario, they are referred to as hybrid vehicles because they combine a combustion engine and an electric motor as a power converter.

Hybrid electric vehicle technology is deployed worldwide as they have many advantages of offering contemporary performance with no worry about the charging infrastructure dependency. They can also reduce fuel consumption to a great extent through electrification of powertrain. The HEV can be connected in many topologies depending upon the type of hybrid system. These are series hybrid, parallel hybrid, and power-split hybrid.
In a series hybrid, the electric motor is the only means to provide power to the wheel. The motor gets the power either from the battery or from the generator. Here the batteries are being charged through an IC engine to provide power for driving electric motor. The computer decides amount of power originates from battery or the engine/generator. Both the engine/generator and the utilisation of regenerative braking energize the battery pack .The series HEV usually have a bigger size battery pack and large motors with a small internal combustion engine. They are assisted by ultra-caps, which help in improving the efficiency of the battery, thereby decreasing the loss. During braking, they take regenerative energy and deliver peak energy during acceleration. Their advantages of using series hybrid drive train are i) Ideal torque-speed characteristics of electric motor make multi-gear transmission un necessary ii)

Mechanical decoupling between the internal combustion engine and drive wheels allows the IC engine operate at its narrow optimal region. However, a series hybrid drive train has some disadvantages. They are i) the overall efficiency be reduced because the energy is converted twice, i.e., from mechanical energy to electrical energy and then to mechanical energy ii) Here big traction motor and two electric machines are required because it is the only torque source of a driven wheel. These vehicles are typically used in a military vehicles, commercial vehicles, and buses since they have adequate space for their large engine/ generator system .

In a parallel hybrid, the engine is connected directly to the wheels, which leads to smaller energy loss and less flexibility in the mutual positioning of the powertrain components compared with the series HEV drivetrain as well. Here the power is supplied from engine, motor, or from the combustion of both motor and engine to the wheel. Parallel hybrid can drive the vehicle individually or together (the combination of single electric motor and ICE). Generally, it has small battery packs that rely upon regenerative braking to keep it recharged.

In Power-split hybrid system, motor, generator, and the engine, all are attached to a transmission with a planetary gearbox. They can be arranged in both series and parallel configurations in a single frame. Here the battery and the engine alone or together can power the vehicle, and the battery can be charged simultaneously through the engine. Different speed and torque of every component are employed to decide the power delivered to the wheel. The speed and load can be varied to get maximum engine efficiency. The power flow of parallel HEV.

2.2 Plug-in hybrid electric vehicle

Plug-in hybrid electric vehicle (PHEV) comprises of an internal combustion engine and an electric motor. These vehicles are powered by gasoline and have a large rechargeable battery, which is charged up with electricity. The benefits of Plug in Hybrid Electric Vehicles are:

Less petroleum use
PHEV use about 30–60% less oil than conventional vehicle. Since electricity is mostly produced from domestic sources, plug in hybrid reduces the dependency of the oil.

Greenhouse gas emission
Usually PHEV emit less greenhouse gas than conventional vehicle. However, the amount of gas emission depends on how electricity is produced. Nuclear and hydropower plants for example are cleaner than coal fired power plant.
Recharging take time
Recharging with a 120 V household outlet may take several hours whereas with a 240 V, home or public charger it take 1 to 4 h. The fast charge of upto 80% of the capacity take as little as 30 min. However these vehicle do not need to be plugged in. They can only be fueled with gasoline, but without charging, they will not achieve maximum range or fuel economy.

Estimating fuel economy
Environmental Protection Agency provides a fuel economy estimate for gasoline only and for electric only or gas and electric operation both for combined city highway driving as a plug in can run on electricity, gasoline or combination of two.

The largest solar-powered charging station was launched in China in 2015, which is equipped for charging 80 EVs in each day. It also launched a pilot project in Shanghai for testing the ability of the electric vehicle to incorporate sustainable power source with the electric grid. Japan has likewise included more electric charge points powered by solar photovoltaic system than petrol stations in 2015. The top five countries selling electric vehicles as in 2018 are

China, European countries, the US, California, and Norway . Several new models are being announced by the manufacturing companies that is likely to be available at low price in the following years. Plug-in electric vehicle has become one of the promising gateways for the reduction of CO_2 emission and reduce dependency on the use of fossil fuels.

Many studies were conducted globally on hybrid electric vehicles. Related works presented by Galus and Andersson, 2008 uses an agent-based approach, while Waraich et al., 2013 used micro-simulation for plug-in hybrid electric vehicle based on technical constraints and individual objectives. The model-based non-linear observers (MBNOs) are developed for HEV by Yang et al., 2007 for estimating the torque of permanent magnet synchronous motor. Wu et al., 2016 conducted a study on the stochastic framework for energy management in the smart home by using energy storage of plug-in electric vehicle and photovoltaic power supply. For optimal control, Tesla model S of 85 kWh battery pack and Nissan Leaf of 24 kWh battery pack brings about 493.6% and 175.89% less than those without optimal control. In China, Zou et al., 2013 conducted an investigation on the heavy-duty parallel hybrid electric truck by building up a feed-forward model for examining optimal energy management strategy and concluded that the dynamic programming algorithm improves the mileage of the hybrid-electric truck. In another study made by Hu et al., 2017 in China revealed that convex programming based on an optimal control scheme has an extremely close accuracy to the dynamic programming, which approximately runs 200 times faster. The daily cost of 0.85$ is fundamentally not as much as that in the heuristics PHEV scenario. A similar study conducted by Wu et al.,2016 in Chengdu, China, based on stochastic dynamic programming problem for optimising the electric power allocation amongst utility grid, home power demand, and plug-in electric vehicle battery. Hu et al., 2016 conducted a study in China and found that the capacity choice can be flexible, and the life cycle cost can be improved when there is an advance in fuel cell service life. By using a 10 Ah of Li-battery, their system showed better performance by 1.4% than the existing one. The small and large capacity Li batteries resulted a higher life cycle cost. Bashash et al., 2011 found that the multi-objective genetic algorithm optimizes the charge pattern of a PHEV. It not only minimizes the cost for petroleum and electricity but also the total battery health deterioration over a 24-hour naturalistic drive cycle. The Pareto font of optimal charge pattern is obtained from the results of this optimization. This Pareto font specifies that, for a PHEV to be rapid charged, one should minimize the battery degradation and energy cost. The result is obtained by utilizing an electrochemistry based model of anode-side SEI development in lithium-ion batteries. SEI growth is a prime aspect that governs the degradation of the battery. Hadley and Tsvetkova, 2009 made a study on the impact of penetration of PHEV into the power grid and found that the kind of generation used to recharge PHEV and emission greatly depends upon the time and area of recharge. Kelly et al., 2012 studied on the load profile charging and gasoline consumption of PHEV in USDOT's, National household Travel survey based on driving pattern data. They took the information about 17,000 electric vehicles for tracking their battery SOC for determining timing, quality of gasoline consumption, and amount of electricity for a fleet of PHEV. They also examined the PHEV characteristics based on their charging location, charging rate, size of the battery, and charging time. A similar study conducted by [46] about the challenges and policy option of PHEV into the power grid. Various other studies conducted across the globe on plug-in hybrid electric vehicles

2.3 Battery Electrical vehicle

The battery electric vehicle also termed as BEV is fully electric vehicle. It has no gasoline engine, but consists of high capacity rechargeable battery packs that can be charged from an external source. The battery-electric vehicle utilizes the chemical energy stored in rechargeable batteries to run the electric motor and all electronics involved internally. The BEV could not only reduce the carbon dioxide emission from the light-duty vehicle fleet but also reduce the dependency on fossil-fueled vehicles (Andwari et al., 2017) .The BEVs are said to hold the largest share in the Indian market, contributing more than 70% trade-in 2017, which is expected to grow in the coming years. Though the BEVs dominated the sale over PHEV in many countries until 2014, there is a rapid growth of PHEV in the last two years, and the sale has gone almost equal with the BEV. In view of sorts of batteries utilized in the Indian market, it can be classified as Lead-acid batteries, Nickel-metal hydride batteries, and Lithium-ion batteries. In India, the state of Maharashtra has the highest selling volume of Electric cars in 2017. There are similar kinds of literature that study the comparative strategy for estimating the SOC and SOH of hybrid and battery electric vehicles .The H_{inf} observer-based fault estimation of battery in HEV application have been presented by and the algorithm for determining the temperature and thermal life of traction motor in commercial HEV has been discussed by .

Andy et al., 2010 proposed two steps model that first segments the road traffic and their respective demands into a hierarchy of clusters, in a natural and automatic manner, followed by optimization by using linear programming for assigning the stations to the demand cluster. This work is believed to be useful for city planning, and for designing a refuelling infrastructure in an urbanized area for BEVs. Cuma & Koroglu, 2015 [72] did a comparative review in the estimation strategy and different methodologies used in hybrid and battery electric vehicles. Battery Electric Vehicles (BEVs) satisfy two conditions i.e. an electric motor is powered by a battery that replaces the ICEV and the tank, and when not in use, the vehicle is plugged into the charging port .

The strategy for estimating the SOC of the lead-acid battery has been presented in .The traditional methods such as the Open circuit voltage and the Ampere-hour (Ah) counting are examined by .The SOC of sealed lead-acid batteries was estimated by using the Fuzzy logic based algorithm . Robat & Salmasi, 2007 . determined the SOC online by the locally linear model tree (LOLIMOT) method, which is a kind of neuro-fuzzy network. The hybrid and electric vehicles consider lithium-ion batteries due to their high possessing power, long life cycle, and energy ..

Based on technology classification, an EV can be categorised by considering their qualities, for example, charging time of the batteries, driving range of an EV, and the maximum load the vehicle can take. The charging time and the driving range are essential attributes that are distress to the customer. Charging time mainly depends upon the capacity of the battery and kinds of batteries employed. The driving range could be as low as 20 km to as high as 400 km for every charge .Likewise, the top speed could go up to 160 km/hour in a few EVs, with a charging time of less than 8 h and tends to be higher in some vehicles. In developing countries like India, the hybrid electric vehicle has been a growing interest in recent days due to the significant improvement in EVs. In future, a lot of innovations are expected to change the EV scenario as EV manufacturer look forward to reducing the production cost.

2.4 Fuel cell Electric vehicle

Like all-electric vehicles, fuel cell electric vehicles (FCEVs) use electricity to power an electric motor. In contrast to other electric vehicles, FCEVs produce electricity using a fuel cell powered by hydrogen, rather than drawing electricity from only a battery. During the vehicle design process, the vehicle manufacturer defines the power of the vehicle by the size of the electric motor(s) that receives electric power from the appropriately sized fuel cell and battery combination.

Although automakers could design an FCEV with plug-in capabilities to charge the battery, most FCEVs today use the battery for recapturing braking energy, providing extra power during short acceleration events, and to smooth out the power delivered from the fuel cell with the option to idle or turn off the fuel cell during low power needs. The amount of energy stored onboard is determined by the size of the hydrogen fuel tank. This is different from an all-electric vehicle, where the amount of power and energy available are both closely related to the battery's size.

CHAPTER: - 3

COMPONENTS OF ELECTRIC VEHICLE

3.1 Traction Battery pack{a}

Traction batteries, also known as electric vehicle battery(EVB) are used to control the electric engines of a battery electric vehicle (BEV) or crossover electric vehicle (HEV). The significant accentuation on Traction battery configuration is the need of a high ability to weight and volume proportion, since the vehicle should likewise convey its capacity source. Traction batteries are every now and again deep cycled and require a quick charging rate for use for the most part inside 24 hours. Commonplace applications are rationale power for fork lifts and electric trucks. Traction batteries are as a rule of the rounded plate design, which performs all the more well during deep cycle activity.

Traction batteries is distinct from Starting, Lighting, and Ignition (SLI batteries since they are made to keep power up for a period of time. Deep cycle batteries are used rather than SLI batteries for these applications. Traction batteries should be designned with a high ampere-hour limit. Batteries for electric vehicles are portrayed by their moderately high capacity to-weight ratio,energy to weight proportion and energy density; more modest, lighter batteries lessen the heaviness of the vehicle and improve its presentation. Contrasted with fluid energizes, most flow battery advances have a lot of lower explicit energy; and this regularly impacts the greatest all-electric scope of the vehicles. Nonetheless, metal-air batteries have high explicit energy in light of the fact that the cathode is given by the encompassing oxygen in the air.Rechargeable batteries used in electric vehicles incorporate lead-acid, Ni-Cd, nickel metal hydride, lithium ion, Li-ion polymer, and relatively uncommon, zinc-air and molten salt batteries. The measure of electricity put away in batteries is estimated in ampere hours or in coulombs, with the all out energy regularly estimated in watt hours.

Since the last part of the 1990s, progresses in lithium-ion battery innovation have been driven by requests from consumer electronics, computers, telephones, and electronic product. The BEV and HEV commercial center has received the rewards of these advances both in execution and energy density. In contrast to prior battery sciences, remarkably nickel-cadmium, lithium-ion batteries can be discharged and recharged every day and at any condition of charge.

3.2 Power Inverter (B)

An inverter (or power inverter) is a power electronics device which used to convert DC voltage into AC voltage. Although DC power is used in small electrical gadgets, most household equipment runs on AC power. Hence we need an efficient way to convert DC power into AC power.

The inverter is a static device. It can convert one form of electrical power into other forms of electrical power. But it cannot generate electrical power. Hence the inverter is a converter, not a generator.

It can be used as a standalone device such as solar power or back power for home appliances. The inverter takes DC power from the batteries and converts into AC power at the time of the power failure.

A power inverter used in the power system network to convert bulk DC power to AC power. i.e. It used at the receiving end of HVDC transmission lines. This inverter is known as a **grid-tie inverter**.

3.3 Controller{c}

The controller in an electric car is the device that controls the flow of electricity from the battery to the electric motor. It is the "brain" of the electric car's drive system. The controller gets its power from the battery, and it uses this power to control the electric motor. The controller tells the electric motor how much power to use, and when to use it. The controller also monitors the battery, and makes sure that the electric car does not use more power than the battery can provide. The controller is a very important part of the electric car's drive system, and it is one of the most complex parts of the car. The controller has to be very reliable, because if it fails, the electric car will not be able to drive.

3.4 Electric Traction Motor(D)

A **traction motor** is an electric motor used for propulsion of a vehicle, such as loco motive electric or hydrogen vehicle, or electro multiple unit trains.

Traction motors are used in electrically powered railway vehicles (electric multiple units) and other electric motor including electric milk floats, trolleybuses, elevators, roller coasters, and conveyor system, as well as vehicles with electrical transmission systems {diesel electro motive }electric hybrid vehicle and battery electric vehicle

CHAPTER: - 4

TECHNOLOGIES

4.1 Batteries

Electric vehicle batteries differ from **starting, lighting, and ignition** (SLI) batteries, as they are typically lithium-ion batteries that are designed for high power-to-weight ratio and energy density. Smaller, lighter batteries are desirable because they reduce the weight of the vehicle and therefore improve its performance. Compared to liquid fuels, most current battery technologies have much lower specific energy, and this often impacts the maximum range of all-electric vehicles. Unlike earlier battery chemistries, notably nickel-cadmium, lithium-ion batteries can be discharged and recharged daily and at any state of charge. Other types of rechargeable batteries used in electric vehicles include lead–acid, nickel-cadmium, nickel–metal hydride, and others.[1]

The battery makes up a significant portion of the cost and environmental impact of an electric vehicle. Growth in the industry has generated interest in securing ethical battery supply chains, which presents many challenges and has become an important geopolitical issue. As of December 2019, the cost of electric vehicle batteries has fallen 87% since 2010 on a per kilowatt-hour basis.[2] As of 2018, vehicles with over 250 mi (400 km) of all-electric range, such as the Tesla Model S, are available.[3]

The price of electricity to run an electric vehicle is a small fraction of the cost of fuel for equivalent internal combustion engines, reflecting higher energy efficiency.

4.2 Supercapacitors

A **supercapacitor** (**SC**), also called an **ultracapacitor**, is a high-capacity capacitor, with a capacitance value much higher than solid-state capacitors but with lower voltage limits. It bridges the gap between electrolytic capacitors and rechargeable batteries. It typically stores 10 to 100 times more energy per unit volume or mass than electrolytic capacitors, can accept and deliver charge much faster than batteries, and tolerates many more charge and discharge cycles than rechargeable batteries.

Unlike ordinary capacitors, supercapacitors do not use the conventional solid dielectric, but rather, they use electrostatic double-layer capacitance and electrochemical pseudocapacitance, both of which contribute to the total capacitance of the capacitor.

Supercapacitors are used in applications requiring many rapid charge/discharge cycles, rather than long-term compact energy storage: in automobiles, buses, trains, cranes and elevators, where they are used for regenerative braking, short-term energy storage, or burst-mode power delivery.[] Smaller units are used as power backup for static random-access memory (SRAM.

4.3 Motors

Electric vehicles use one or more electric motors powered by a battery pack to accelerate and drive1. There are several types of electric motors used in electric vehicles, including2:

- DC Series Motor
- Brushless DC Motor
- Permanent Magnet Synchronous Motor (PMSM)
- Three Phase AC Induction Motors
- Switched Reluctance Motors (SRM)

All types of electric-vehicle motors share two major parts: the stator and the rotor3. EVs use both Alternating Current (AC) and Direct Current (DC) motors, and there are several variations of each4. Hybrid electric vehicles (HEVs) have an internal-combustion engine and an electric motor that assists only at low speeds, while fuel cell electric vehicles (FCEVs) use electric motors[5].

4.5 Power electronics

Power electronics are devices that process and control the flow of electrical energy in electric vehicles. They connect the energy sources, such as the battery pack, to the power actuators, such as the traction motor2. They also control the speed and torque of the motor, and manage the battery system. The main power electronics devices in electric vehicles are the onboard charger, the inverter, and the DC-DC converter.

CHAPTER: -5

ELECTRIC VEHICLE IN FUTURE

5.1 Fleet turnover

The composition of the stock of vehicles driving on our roads today reflects the accumulation of new vehicle sales less vehicle retirements over time. People tend to have a poor intuitive understanding of such processes that involve stocks, flows, and accumulation .and therefore the impact that introducing relatively less-efficient vehicles into the fleet, which will remain in use for many years, will have on fleet fuel consumption and GHG emissions into the future. Surveys we have undertaken on both the general public and highly-educated MIT graduate students indicate that people systematically underestimate how long it takes for new vehicles to move through the fleet, and underestimate how long new vehicles last on average (figure 1), which has increased over time with improving new vehicle quality . These misperceptions are likely to lead people to underweight the effect that the vehicles we purchase today will have into the future, and be overly optimistic about how quickly new technologies can diffuse into the on-road vehicle fleet.

5.2 Auto manufacturer conversions

The conversion process involves removing the internal combustion engine (ICE) and its related components from the vehicle and replacing them with the electric drivetrain components provided in the kit. The electric motor becomes the new power source, while the battery pack stores and supplies energy to the motor. To ensure optimal performance and efficiency, the controller manages the flow of electricity between the battery and the motor.

Electric car conversion kits are available in various configurations to suit different vehicle models and individual preferences. Some of the electric car conversion kits are specifically designed for particular car models, while others offer greater flexibility and compatibility across a wider range of vehicles.

Bosch eAxle is an efficient, compact cost-attractive electric car conversion kit. It provides solutions for battery e-vehicles and hybrid applications. It comes in a compact unit that comprises of electric motor, transmission, and power electronics that fuels directly the vehicle's axle. Its compact design helps in saving installation space and reduces complexity.

Bosch eAxle is an excellent solution for all who are looking for the main drive or need a second eAxle to boost the car's performance.

Highlights

- By using silicon carbide semiconductor technology, Bosch eAxle kit has increased its efficiency by 96% for more range and at the same time has reduced its battery.
- Due to the assembling of all components into a compact system, you get to save on components and expensive connecting cables. This makes it an excellent cost-effective car conversion kit.
- It is one of the best solutions present in the market with high scalability (50-300KW), different voltage levels (400/800V), and high flexibility. Due to its flexibility, it can be used for all vehicle types and can cater to individual customer demands.
- Increase performance by using eAxle at 800V with the help of silicon carbide semiconductors. This also helps in reducing the size of the electric motor.

5.3 Electric vehicle costs

The average transaction price for an electric vehicle (EV) is $56,437, according to Kelley Blue Book — roughly $10,000 higher than the overall industry average of $46,329 that includes gas and EVs. In terms of pricing, an EV is equivalent to an entry-level luxury car.

To save time charging EVs and extend battery life, many drivers also install what's known as "Level 2" chargers in their home, for a total cost of around $2,000, including installation. With a Level 2 charger, it will take less than eight hours to charge your vehicle, according to JD Power.

Most EVs come with a Level 1 charging cable that can be plugged into a common 120-volt household electric outlet, but it can take up to 40 hours to fully charge your vehicle. It's cheaper, but less convenient.

While surveys show that the price gap between EVs and gas-fueled vehicles is expected to shrink in the next decade, that will depend on continued improvements in battery technology, which could result in cheaper production costs.

In the meantime, customers can offset some of the premium paid for EVs through tax credits. The federal government offers a non-refundable tax credit worth $2,500 to $7,500 for newly purchased electric vehicles made after 2010.

However, the credit only applies to the first 200,000 vehicles a manufacturer sells. Tesla and General Motors already surpassed this number, so no credit is available from these manufacturers. A list of electric vehicles that still qualify for the federal tax credit can be found here.

It's also possible that your state offers its own tax credit or rebate. The EV advocacy group Plug In America has an interactive map that shows electric car incentives in each state. New York, for example, offers a rebate worth up to $2,000.

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RESULT AND DISCUSSION

The rise of electric vehicles has become significant. This is because the focus is now more on alternative energy sources and reducing carbon emissions than ever before as a result of global warming and climate change. After the launch of Electric Vehicles (EVs), the automotive industry is one significant sector that is speeding up its move towards green energy. The major companies in the automotive industry are spending billions on EVs as the future of the business, and governments are pushing EVs through framing numerous policies, such as providing incentives to consumers. The increased adoption of EVs appears to be the next big automotive revolution after the internal combustion engine.

CONCLUSION

Electric Vehicles are the future of the country. As per various recent surveys, it is clear that the market of EVs will increase to many folds by 2030 with more production. People will eventually start shifting to electric vehicles looking at the advantages and government-launched schemes. Therefore, the rise of electric vehicles can be the next big thing and therefore, it can be the future of the world. EVs will not only help in cost-cutting, but they will also reduce the amount of air pollution in the country. Therefore, looking at the present benefits of electric vehicles, it can be concluded that the EV market will certainly grow in the coming years.

REFERENCES

Electric vehicles will play a dominant role in the transition to a low-carbon transportation system. As we track and forecast this evolution, learning rates help to quantify the historical rate and pace of change for emerging transportation options, the interaction of technology-specific and system-wide changes, and the economics of different policy options. In this chapter, we review the leading issues related to determining learning rates for electric vehicles and the potential scale-up for battery electric vehicles worldwide. Globally, electric vehicle deployment has increased rapidly over the past decade. Continued growth over the coming decade remains critical to achieve the level of ambition necessary to decarbonize the transportation sector. Therefore further data on learning rates and studies on innovation in battery electric vehicles are needed to enable and benefit from their decarbonization potential. In addition, research on incentives to develop appropriate technologies and policies to integrate electric vehicles into the existing electric grid infrastructure and transportation systems will inform further policy options and cost-reduction targets.

ABSTRACT

Electric vehicles will play a dominant role in the transition to a low-carbon transportation system. As we track and forecast this evolution, learning rates help to quantify the historical rate and pace of change for emerging transportation options, the interaction of technology-specific and system-wide changes, and the economics of different policy options. In this chapter, we review the leading issues related to determining learning rates for electric vehicles and the potential scale-up for battery electric vehicles worldwide. Globally, electric vehicle deployment has increased rapidly over the past decade. Continued growth over the coming decade remains critical to achieve the level of ambition necessary to decarbonize the transportation sector. Therefore further data on learning rates and studies on innovation in battery electric vehicles are needed to enable and benefit from their decarbonization potential. In addition, research on incentives to develop appropriate technologies and policies to integrate electric vehicles into the existing electric grid infrastructure and transportation systems will inform further policy options and cost-reduction targets.

ACKNOWLEDGEMENT

I have taken efforts in this project. However, it would not have been possible without the kind support and help of many individuals and organisation. We would like to extend my sincere thanks to all of them.

I am highly indebted to ESTC Ramnagar: for their guidance and constant supervision as well as for providing necessary information regarding the project and also for their support in Completing the project.

I would like to express our gratitude towards our parents and Member of ESTC for their kind co-operation and encouragement which help us in completion of this project.

I would like to express my special gratitude and thanks to

- Mr. Akhilesh Singh
- Mr. Sanjeev Kumar Chetti

My thanks and appreciations also go to our university in developing the
and people who helped me with their abilities.