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A Study on Present Status and Future Trends in Electric Vehicle Technologies

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ABSTRACT—

The problem of emissions has become a specifically conclusive one for the transportation sector making the hour about a sustainable transportation system crucial. As the world turn towards environment friendly products and services, the transition from internal combustion engines (ICEs) to electric vehicles (EVs) because of the latter's zero-emission nature. Still, I want to note that the use of EVs is not completely innocent, for example, during charging and decommissioning of automobiles. However, when comparing the carbon emission made by EVs and ICEs, EVs make significantly lower emissions. Additional measures to draw down the ecological effects include further study on EV technology. This research work is also a comprehensive look at the various problems related to EV technologies specifying the economical, technical, and environmental issues.

The paper also analyses the contribution of governmental policies in increasing the opportunities and availability of and affordability of EVs and discusses disaster risks, both natural and man-made. It talks about current infrastructural constraints like power infrastructure, charging stations necessary for high usage of EVs. Further, it assesses the total carbon impact and other possibilities in the future for the evolution of EV technology, making it a unique reference material on the present issues and solutions and the future expectations.

Keywords: ***Battery, Battery charging, electric motors, plug-in hybrid electric vehicles (PHEV) plug-in fuel cell vehicles, power electronics devices.***

INTRODUCTION

Electric cars were first introduced in the late Nineteenth Century, and perhaps had its highest sales in the early Twentieth Century. This was due to GA alloys of developing advanced gasoline engines that led to reduced focus on EV's but regardless companies like GM and Toyota persisted, producing EVs throughout the late 20th century. Affordable electric cars did not hit the market until Tesla was created in 2003 and began making the Roadster, which was the first car to use lithium-ion batteries. Recently a new segment of plug-in hybrid electric vehicles has emerged which possess both the characteristics of EV and hybrid vehicles The main PHEVs available in the market are GMs Chevy Volt and Toyota Prius[1]. Electric Vehicle (EV) is a growing segment as the way forward for transportation and India specifically requires immediate focus in that direction due to poor air quality. The Indian government is actually working out ways to make EVs more favourable, while its conducive for electric two-wheelers in the next year, 2020 and electric four-wheelers by 2030. EVs includes fully battery electric vehicles (BEV), hybrid electric vehicles (HEV), and plug-in hybrid electric vehicles (PHEV). Hence, this paper will discuss awhile focusing on initiatives launched towards enhancing the uptake of EVs and the hurdles facing green technology revolution in India[2].

Automotive companies see EV as a solution to air pollution in the cities and excess emissions of carbon compounds. Advantages of using electric vehicles range from environmental impact, tendency to cost less to maintain than internal combustion engine vehicles, and efficiency. However, such vehicles are still faced with some challenges such as; short driving range, times taken to charge the battery, and high costs of batteries. This paper will also review some of the important characteristics of EV technologies and charging modes and batteries and the current market scenario along with the requirement of better batteries and charging technologies for integration of EV in smart cities[3]. People are increasingly demanding EVs mainly for lower greenhouse gas emission, which stands at 25% of the emission rates on energy-intensive industries. Some of the benefits associated with EVs include; torque, reduced emissions, and integration with renewable energy systems and intelligent grid systems. Previous to being used by EVs, they were in decline with the switch to internal combustion engines, though with the appearance of new models such as Chevrolet Volt, Nissan Leaf, Tesla Model S and others, they are used again. This paper discusses currently used and promising subsystems of electricity vehicles, energy storage systems, various charging arrangements, and control schemes[4]. Having been invented in the late 1800s, electric vehicles (EVs) are surging forward due to these factors: advanced technology and low battery prices. Their elimination of the tailpipe emissions benefits driven by their improved miles per gallon, as well as the possible option for decarbonization by utilizing renewable electricity further boosts the attractiveness factor than ICE vehicles. While auto makers pump more money into electrification, annual EV sales have remained on the higher side. In this paper the global status of EV markets and technologies along with charging infrastructure and the integration with power systems and additional discussion on projections of the future and potential advancements are outlined[5]. Energy resources fall into three categories they are oil and natural gas and other hydrocarbons, nuclear power and alternative energy sources. The most utilized energy source is hydrocarbons But they are dangerous to the environment so much that they are destructive. The increase in newfound sources of energy particularly the renewable energy types is intended to remove emissions from combustible hydrocarbons. The third type of electric cars – fuel-cell electric vehicles (FC-EVs) – run on hydrogen or biofuels, which emit only water vapor[6]. With increased population and energy demands around the world, particularly within the transport sector, there is increasing concern over carbon emissions from climate change, warming and pollution. Battery electric cars and plug-in hybrid electric cars produce roughly 60 percent less CO2 than traditional cars. Despite the fact that the production of EV might lead to emissions, the consumption phase leads to socially significant reductions; both regarding GHGs and NV. Nevertheless some barriers like high costs, limited availability, and insufficient recharging infrastructure remain a concern from which one draws the conclusion that these issues require further research[7].The increase in global energy demands, mainly from fossil energy sources, has caused a major effect on climate change, and outcomes in elevated temperature of 1.4- 5.8 °C by the end of the century. Instead, the focus is the development of electric cars (EVs, or BEV: Battery Electric Vehicles) and lithium-ion batteries (LIBs) as green solutions. However, still, problems such as thermal runway in LIBs require BTMS to regulate temperature and ensure safety and efficiency. A change from the use of fossil fuels energy sources is important in the fight against greenhouse gases, and a way of dealing with the effects of climate change[8]. Electric vehicles (EVs) continue to gain popularity because of the environmental management advantage as well as the opportunity to enhance driveline topologies. The development of EV vehicles can be categorised into three phases, however, early versions remain eclipsed by ICEs. The evolution of power electronics and the oil crisis revived interest in EVs despite barrier such as battery cost and energy density. Government backing of environmentally-friendly automobiles and structural factors are the main forces that are encouraging the adoption of such vehicles, and the PM motor is considered a promising approach to improving their efficiency[9]. Global demand of fossil fuel combined with depletion of these reserves makes ICEs with efficiency of only 20% far from optimal; 80% is wasted as heat and greenhouse gases. On the other hand, the fundamental benefits of owning an electric vehicle (EV) include; high efficiency, reduced number of parts, and compatibility with higher grids. PECs and motor drives play a significant role in improving the performance, life cycle, and prospects of EVs. Classification, function, and challenges of PECs in differing electric vehicle systems are prepared in this paper[10].

Literature Review

Electric vehicle propulsion technologies are analyzed with a focus on such burning issues as key problems and opportunities for the development of new attractive forms of EVs [1]. Electric vehicles promise to intensify its growth as a trend promoted by the government and industries as a worthy replacement to distinct vehicles. In India, the implementation of EV has a primary task of reducing the rate of pollution in urban areas [2]. The articles review different aspects of EVs, including the kinds of EVs currently available, the technologies used in their construction, and their benefits over ICEs; recent sales patterns; charging methods; and innovations underway [3]. Electric cars or EV in short, stand as an environmental-friendly option to commercial vehicle that runs on fossil fuel. Discussed areas include configuration options for EVs, power supplies, charging techniques, and management mechanisms [4]. Making use of vehicles that use electricity instead of fossil fuels, Electric Vehicles (EVs) advocate for sustainable and environmentally friendly transportation. Prominent areas of focus are EV configurations and Powers, Charging techniques, and Control techniques [5]. The existing hydrogen fuel cell technologies and models are discussed and important parameters for the integration of FC-EVs are identified which comprise overall efficiency of well-to-wheel, optimization of hydrogen distribution system, reduction of cost of hydrogen production and development of favorable public perception towards FC-EVs [6]. EVs are important in cutting energy consumption and the environmental problems such as global warming. Everything in relation to ICE vehicles can be changed to make a shift towards electric cars more efficient and help reduce fossil fuel consumption [7]. Current issues and recent developments in battery thermal management systems (BTMSs) for electric vehicles (EVs) are presented. One of the biggest advantages of the use of EVs is that they do not produce any emissions and make little noise [8]. Future development of traction machines with high power density is discussed, where analysis of Permanent Magnet Machines (PMM) has been made due to their efficiency and torque capacity. Subsequent improvements in PMMs envisage usage of higher reluctance torque [9]. The power electronics converters in electric, HEV, and fuel cell vehicles are discussed in relation with cost, efficiency and performance at the present time and their future potential [10].

METHODOLOGY

The need to design the smart electric vehicles entails multiple domain innovation including efficiency, performance, sustainability and reliability of EVs. Outsourced, this methodology disseminates key factors that can define success in EV technologies, which encompasses BMS solutions, Charging solutions, Environmental solutions, Power electronic solutions, Motor control, and Thermal management. Through such segments, it is possible for EVs to be able to develop ever higher expectations by consumers, tackle technical issues as well as further develop competitiveness against ICE vehicles.

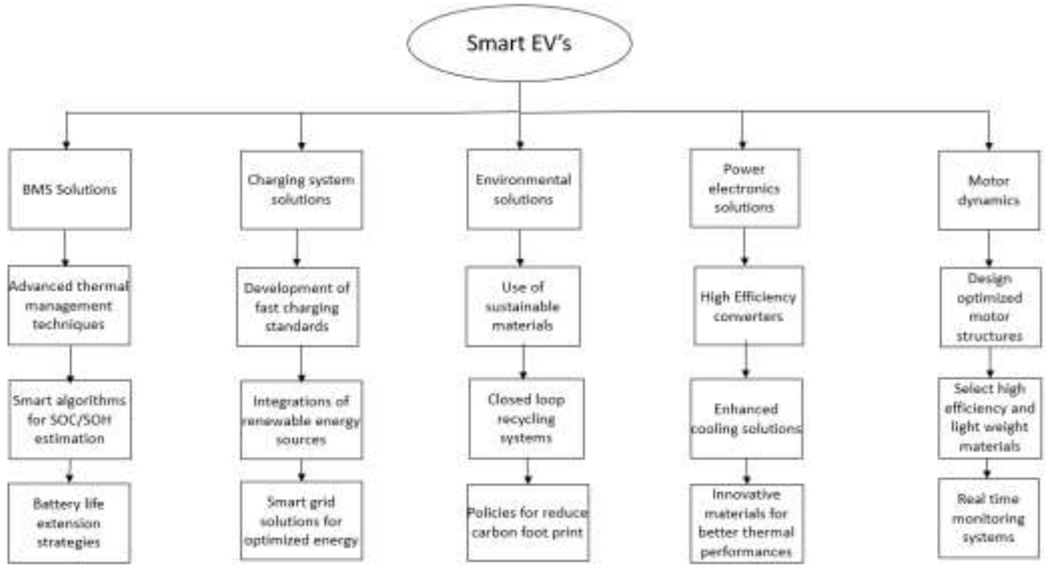

Fig 1. Solutions For Smart EV's

Batter Management System (BMS) Solutions

The BMS is crucial in controlling and managing the battery in terms of safety and performance and throughout the car life. Since battery packs are one of the largest chunks of EV costs, battery maintenance is paramount. Use of sophisticated thermal control mechanisms such as fluid cooling, circulation of air and operation of pcms can reduce overheating, which leads to degradation of performance as well as is hazardous. These strategies allow batteries to operate at the best efficiency possible, even if the conditions are like winter or summer.

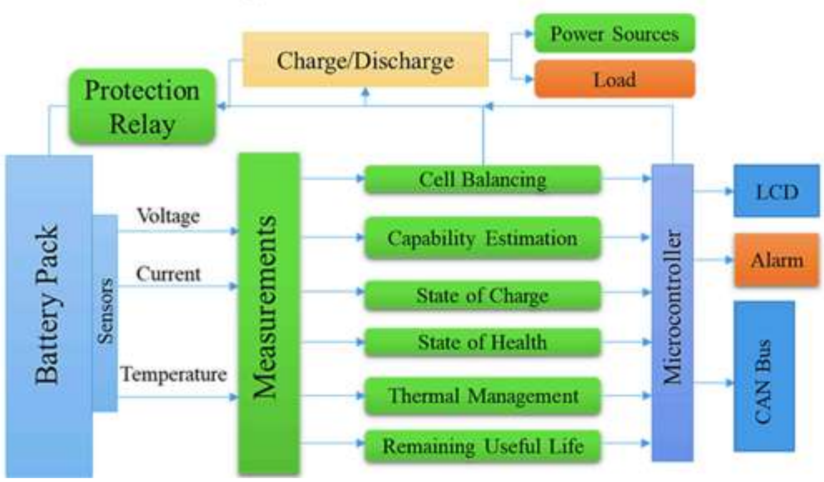

Fig 2. Battery management system

Also, SOC/SOH detection algorithms which are implemented in battery management systems leverage machine learning algorithms and predictive analytics for real-time evaluation of the battery. SOC informs the driver about remaining capacity of the battery, while SOH is an estimation of the battery's ability to store and supply energy in future. Both of these estimations are important in avoiding potential failure occurrences as well as in enhancing the energy handling. Other factors that help in increasing battery capacity, while reducing regular service costs for batteries, would include, managing on charge cycles, equalizing cell voltages, and setting limits on charge/discharge rates, all of which assist in enhancing battery durability, giving more value to consumers.

Charging System Solutions

The availability of the charging infrastructure is, therefore, central to the consumer uptake of electric cars. They include rapid charging stations ranging from 150 kW to 350 kW DC charges only that cuts the charging time from hours to minutes thus makes the EVs useful for long trips. Again, fast charging also poses design challenges on batteries since, due to this feature, batteries often experience thermal stress and therefore must incorporate elaborate cooling systems. In addition to fast-charging stations, research is being done to continue delivering wireless charging technologies for even increased user convenience without cables and connectors.

Charging grid should also incorporate renewable energy sources in order to achieve the idea of decarbonization which EVs support. These are fossil fuel free solar charging kiosks and wind integrated charging centers so as to connect renewable energy based electricity and eco-friendly vehicles. Renewable energy continues to enhance power distribution through smart grids that implement proper management of load and are airtight during high energy demands. In vehicle to grid technology, the car itself becomes an energy asset by storing energy which can be injected back to the grid in periods of scarcity.

Environmental Solutions

Environmental friendliness is one of the most prominent aspects in development of EVs. The collection of materials for building battery electric cars to the end of the battery driven electric vehicle life cycle implies compliance with sustainability. There is an upsurge in the use of recycled materials like recycled aluminium, recyclable plastics commonly referred to as bio plastics and eco leather in the production of auto parts. The list includes the minimization of emissions in the manufacturing sector thus making for a better environmental product and a reduction in vehicle weight which boosts energy utilization.

Closed loop recycling mostly targets the recovery of critical materials like lithium, cobalt, nickel, and many others from the spent batteries. Recycling not only reduces the effect on the environment of mining these scarce resources but also contains cost Mito; Government policies to decrease carbon emissions are emerging in many countries, consistent with incentives for near-zero-emission manufacturing, carbon credits, and electric vehicles. These policies play a significant role of proactively supporting longevity of electric mobility.

Power Electronics Solutions

Power electronics play an essential role in controlling energy distribution in a vehicle specific between the battery, motor, and all other electricity-consuming elements. These converters have large efficiency in comparing to old-fashioned converters which reduce power losses in conversion of DC power from the battery to AC for the motor. Innovative converters like the SiC-based converters, show higher efficiency, thus leading to longer electric vehicle ranges and quicker acceleration. These high performance parts also assist in putting the major components of the drivetrain in a compact form and this also adds to power efficiency.

Heat produced by power electronics is another difficult factor that has to be addressed. Some of the efficient cooling solutions for example, liquid-cooled converters help keep electronic components within certain safe temperatures thus avoiding degrading of performance. Further, better materials for thermal management used in a system — such as heat sinks based on graphene — are also emerging to provide enhanced thermal dissipation to reduce system failures. That is why the thermal regulation of power electronics helps to maintain their steady working at various driving modes and prolong their life span.

Motor Dynamics

The architecture and structural layout of the motor system determine the efficiency and driving character of an EV. The motor structures are aimed at boosting torque density and reducing losses that crop up frequently through novel arrangements such as the PMSMs and induction motors. Another aspect of engineering is also compact motors as to create additional space inside the vehicle and improve its aerodynamics.

State-of-art materials which include carbon fiber, aluminium alloys and composite metals are used to design high- efficiency vehicle thus cutting down the vehicle's weight and leading to improved energy efficiency and enhanced driving range. This makes the motors to be loaded lightly hence elongating their lifespan. Real time monitoring unit constituting integrated part of drivetrain measures necessary motor performance characteristics including torque, speed and temperature. They also help plan maintenance time avoiding the random fail time which is costly and time-consuming to the vehicle operations.

Thermal Management Strategies

One major challenge, especially in electric vehicles, is thermal management as batteries, power electronic and motors release heat during use. Proper refrigeration system plays a great role in ensuring safety and functionality of these parts. Battery cooling systems are also quite common where fluids are employed not only for temperature regulation for batteries, but where fast charging is used or during high performance. PCM will emit insulation and prolong the runtime of active air cooled systems for further heat dissipation.

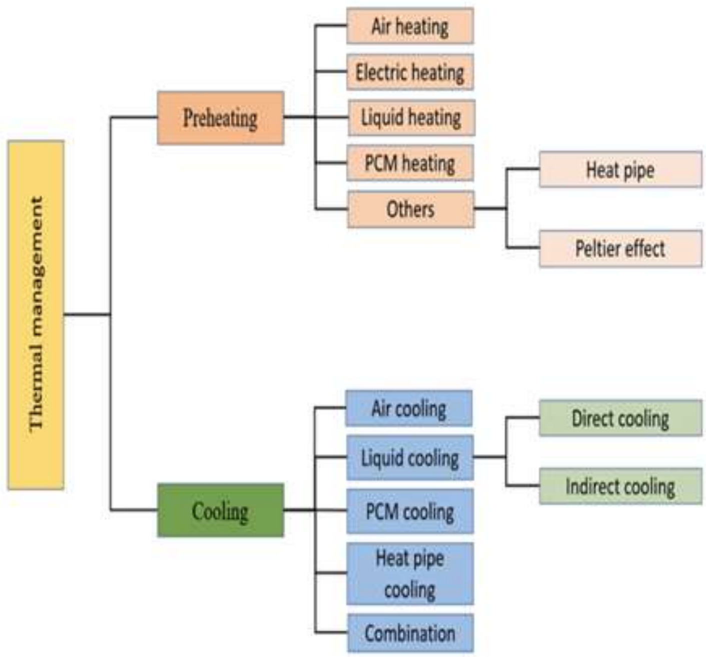

Fig 3. Thermal Management Strategies

Effective thermal management enables any critical component, the battery pack, inverters, motors among them to run at optimum temperature. By using smart sensors and control systems the heat generation patterns are easily identified at an early stage and control systems such as air conditioning is automatically adjusted to prevent overheating. Superior cooling not only protects the car but also helps to preserve the durability of the most important parts by reducing thermal exposure. This integrated approach to thermal management improves the general dependability and safety of the EV.

The approach adopted for smart electric vehicle design provides a comprehensive approach for battery, charging, environment, power electronics, motor and thermal strategies. By strengthening all these pillars, the car manufacturers will be in a position to produce, efficient and sustainable cars, which is also reliable, and can easily adapt to the future technological changes. The coordinated interaction of these factors guarantees that smart EVs will fully respond to the increasing consumer demand for environmentally friendly vehicles, while maintaining their efficiency and convenience. In that regard, the continuous improvement of the abovementioned areas will remain crucial for addressing these challenges, fostering market appeal while supporting global development toward sustainable transportation and decarbonization of transportation networks.

Results and discussion

This state of affairs in the EV technology demonstrates considerable progress in battery systems, charging networks, and power train. Lithium-ion batteries still dominate the energy storage market due to their high energy density and long cycle life, as well as the low cost which increased the range of electric cars. New technologies like solid-state batteries are to be seen that offer further efficiency and safety improvements compared to conventional batteries as well as an increased life expectancy due to minimized hazards that are traceable back to flammability. In addition, progressive technology improvements such as regenerative braking, lightweight structures and the general aerodynamics of the vehicle have compounded to improving the general energy efficiency and performance of the EVs. The increase in such infrastructure, which has recently been propelled by respective government activities and private investments, plays a critical role in addressing consumer range anxiety, thereby promoting wider implementation of electric automobiles. Furthermore, its link with smart technologies like vehicle to grid (V2G) makes the electric vehicle a moving storage unit where, during an outage or demand excess, electric Vehicle provides backup power. The conversion of transportation from traditional sources of energy such as fuel to electricity has remained one of the emergent trends in the recent past due to mainly concerns over environmental impacts and innovation technology. This has become one of the most important features of transitioning to EVs, partly driven by the requirement for advance battery technology. New developments have meant that modern lithium-ion batteries are still being improved through better energy density, time taken to charge the batteries and even life expectancy. However, research is already under way and many firms now prefer to invest in solid state batteries that can potentially deliver more energy per unit of mass, require no dangerous chemicals, and last far longer than their lithium-ion counterparts. These batteries use encased electrolyte instead of a flowing liquid electrolyte which is known to cause fire and improve the thermal management. In addition, the tendency to saturate the product with a renowned material, such as Sodium, is gradually growing. Nevertheless, applications of sodium-ion batteries are yet in the experimental stage, but they have potential for fulfilling the requirement for cheaper solutions which can help to increase the availability of electric vehicles, particularly in the developing economies.

Besides, battery development, expansion of the charging infrastructure also helps to drive the mobility transformation to electric vehicles. AUTO Suppliers and automotive manufacturers are working on the connectivity of comprising of residential use, public stations, highway stations and others. Apart from range anxiety, this large network also inspires potential buyers, because charging is always easily accessible. Also the incorporation of the renewable energy sources including sun and wind energy system to charge stations is a major achievement towards sustainability. Therefore, through allowance of charging of electric vehicles with clean electricity, the environmental impact of electric vehicles can be greatly minimized. In addition, smart charging is becoming an increasingly popular service feature that enables flexible pricing and demand management for more effective grid operation to customers' and utility companies' advantage. That reveals one of the hallmarks of electric vehicle companies' intent to assume the green responsibility, is to make the change as smooth as possible, for the public to make the shift towards adopting sustainable modes of transport. Even within electric vehicles that have become a marketplace niche now, there is a clear transition from mere automobiles to technology-automaker blends. This makes perfect sense especially when we bear in mind that cooperation between automotive firms, IT companies, and power producers is moving toward the creation of mobility services that are more complex than can be built around the car alone. New Generation car-sharing and ride-hailing service providers are having more electric vehicles in their fleets as a sign of the flexibility of the automobiles. It is not surprising that this transition is but redesigning customers and establishing a cooperative environment to solve traffic issues and pollution. Moreover, the ubiquitous use of autonomous driving technologies can be a significant bonus in steps to increase efficiency and safety levels in electric vehicles. As car-driving capabilities begin to improve, it is natural to assume that electric vehicles will adapt to smart cities and improve their traffic circulation while minimizing the need for everyone to own their cars.

Furthermore, there is new information about influence of governmental policies and stimuli for further development of electric vehicle application. Governments in many countries are tightening restrictions as to emissions, offer tax credits for purchasing EVs, and steer investments into providing support to green technologies. Such policies are putting pressure on auto makers to come up with electric cars in order to meet the market demand hence more varieties. The threat of rivalry is high given that at present traditional automotive companies are expanding their portfolios in EV market and on the other side there are new comers with disruptive business models and state of the art technology solutions. New sales figures for electric vehicles are anticipated to grow greatly over the next few years, the market is projected to expand at an exponential rate worldwide thanks to innovative technology, need for environment protection, and government support. Thus, electrification of transportation is a revolutionary breakthrough in the idea of mobility challenging numerous subsequent processes in terms of environment, city planning, and power consumption. With advancement in battery technologies and charging networks, electric cars are gradually progressively becoming realizable by consumers. It is through the merger of more than one industry together with boosting government support that society will witness a future whereby electric vehicles will drive the automotive market. This transition also solves pressing climatic issues and sets the stage for improved efficiency of future urban transport that benefits everyone.

Conclusion

EV is fast transforming the Automobile Industry as a basic response to various key environmental issues including global warming, ozone depletion and health effects due to the use of fossil energy resources. The transport industry is one of the largest contributors to the growing trend of population's carbon dioxide emissions and, therefore, it is crucial to upgrade from IC engines to EVs for the purpose of attaining a higher energy density as well as avert the exhaustion of limited resources in the form of fossil fuels. The shift involved can permanently reduce carbon outputs and ward off several looming ecological disasters. The move toward nontraditional vehicles – EVs – faces challenges that make the transition far from smooth. There are some vital sectors, where future research and development are needed for the large-scale production of EVs; these are the process of construction of EVs, the components used for the construction and the integration of overall complex systems of EVs. More so, the battery technology needs an upgrade in order to boost the performance and efficiency of the vehicles. There is also existing power grid which also require a little upgrade to make it suitable for use with the EV charging infrastructure. Another issue relates to economics, possibilities of the disruption of the conventional financial industries where automotive vehicles have dominated and employment possibilities affected. Other challenges to EV use are technological, such as range limitations and worries about recharging availability. However, it is important to look at some environmental problems with batteries such as, where the raw materials for batteries are sourced, and where the batteries themselves are dumped. There is also existing power grid which also require a little upgrade to make it suitable for use with the EV charging infrastructure. Another issue relates to economics, possibilities of the disruption of the conventional financial industries where automotive vehicles have dominated and employment possibilities affected. Other challenges to EV use are technological, such as range limitations and worries about recharging availability. However, it is important to look at some environmental problems with batteries such as, where the raw materials for batteries are sourced, and where the batteries themselves are dumped.

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