B.Sc. Thesis

Department of Mechanical Engineering

University of Central Punjab

DESIGN & FABRICATION OF SOLAR ELECTRIC VEHICLE.

Thesis submitted for the undergraduate degree in Mechanical Engineering
at the
University of Central Punjab

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ABSTRACT

The use of two different forms of energies to power our system is emphasized by the name hybrid. The first is solar energy, and the second is the single phase, 220V power. Even if your grid is mostly powered by fossil fuels, EVs create less pollution than an ICE automobile since they use energy very effectively. Additionally, as more utility companies switch away from coal in favor of less expensive renewable energy sources like solar and wind, EVs will become increasingly cleaner over time. This project involves both CAD modeling and the design of electrical vehicle components. Since it involves so many different characteristics, such as interior room, dynamic performance, active and passive safety, connection, etc., vehicle design is an extremely complicated field. Both traditional autos, which use internal combustion engines and electric vehicles are built with the same fundamental design principles in mind. Electrical and mechanical engineers, for instance, are two examples of engineers who work on electric vehicles. These engineers focus their work on the design, development, and testing of electric cars, so they are a good example of those who work on electric vehicles. Electric vehicle engineers commonly collaborate with scientists and production managers throughout the development and production of new or upgraded electric vehicles. An integral component of the electrical architecture of an electric vehicle are the electrical connections that link the many different electric modules. Their electrical set up includes several different components, such as a battery pack, an on-board battery charger, an electric motor, a battery management system, a charging connector, and an on-board battery charger. Every design needs some sort of foundation in order to be created properly. AutoCAD is our all-purpose program, and it's perfect for this demand. This piece of software will be utilized in the process of designing the mechanical structure, the electrical wiring connections, and the 2D models for our vehicle.

DEDICATION

Dedicated to my exceptional parents, whole family, my teachers, and friends whose tremendous support and cooperation led us to this incredible accomplishment.

ACKNOWLEDGEMENT

We are thankful to our Creator ALLAH SUBHANA WATALA, who guided us throughout this academic session, and for every new thought, which came to our mind that led us towards improvement. After that, we feel great pleasure and honor to express our special appreciation and heartfelt thanks to our supervisor **Engr. ASAD ALI** who proved himself as a perfect mentor during our studentship. His continuous supervision and generous support play a vital role in the growth of our academic abilities from a research nonprofessional. He helped us to understand the difficult concepts of engineering, mathematics, and thesis writing. All this knowledge is an invaluable resource for us. We are grateful to **DR. ZOHAIB AFTAB** who always encouraged us to work harder but smarter and guided us through his rich experience and comprehensive knowledge. Without his kind support, it was impossible to complete our work in a short time with outcomes even beyond expectations. We are thankful to Head of Department **Dr Muhammad Kashif** and other faculty members of department of Mechanical Engineering for providing us excellent academic environment and guidance throughout Bachelors studies.

LIST OF ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
BEV	Battery Electric Vehicle
CCS	Combined charging system
CPM	Charging point manager
CPO	Charging Point owner
DC	Direct Current
DLM	Dynamic load management
DSO	Distribution system operator
EMP	Electro mobility provider
EMSP	Electro mobility service provider
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
GFG	Greenhouse gas
HEV	Hybrid electric vehicle
ICE	Internal combustion engine
KW	Kilowatt
KWH	Kilowatt-hour
PHEV	Plug-in hybrid electric vehicle
RFID	Radio frequency identification
PWM	Pulse-width modulation
TSO	Transmission system operator
V2G	Vehicle-2-Grid
UN	United Nations
SDG	Sustainability development goal

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1. CHAPTER ONE:

INTRODUCTION

The background theory and the core idea behind electric cars are presented in this chapter. EV technology has been around for three centuries and is expected to advance quickly in the years to come. The necessity for alternative fuel sources has been one of the main issues for the majority of scholars around the world due to the growing issue of carbon emissions. Alternate Clean energy is currently being evaluated as one of the main sources of fuel for cars, making it one of the most significant components of the future. A solar-powered vehicle is the next major development in technology. Experts from around the world have been attempting to use solar energy again to power cars after successfully harnessing it to create electricity. Aerodynamics, clean converted energy, and the laws of motion come together in brilliant ways in solar automobiles. The result is a vehicle that travels with little environmental impact. Additionally, it reduces both financial costs and environmental impact. During the process of turning solar energy into usable electricity that can be stored in batteries, photovoltaic cells that are incorporated onto solar panels provide assistance. As a consequence of this, we might use these batteries in place of the fuel that our autos require. The purpose of the project is to design and build a vehicle that runs on electric power and is capable of self-generation through the use of solar energy. If this kind of vehicle were to become the standard for commercial transportation, there would be a huge reduction in the demand for gasoline. The most difficult aspect of designing this car is making it as practical as possible. To meet the transportation needs of the city, the vehicle in question needs to be as light as possible. This will allow the essential motor to be of a smaller size. Because the car is only designed to have place for one driver, more space is required in order to accommodate other passengers and their belongings. When using solar energy to move a vehicle, the efficiency of the solar panel is an additional consideration that must be taken into account. This efficiency dictates how soon the solar panel can supply enough power for the vehicle's propulsion. As a direct result of this, the process of design will involve a variety of decisions, each of which will require careful study before being implemented. 2 When power is generated from sources that employ highly efficient modern generating stations, or when it is generated from sources that use nuclear or sustainable energy, the environmental benefits that can emerge from the usage of electric vehicles can be enormous. This is especially true when electric vehicles use electricity that is generated from sources that use nuclear energy as their primary source of energy. It gets rid of all emissions of exhaust, reduces reliance on fossil fuels, and lowers overall carbon emissions.

History of EV

The work that Michael Faraday did in 1821 led to the development of electric motors, which are sometimes referred to as the "brain" of an electric vehicle. William Sturgeon, a British scientist, is credited with inventing the first commutator-type direct current electric motor in the year 1832. This motor was able to turn machines. The scientist Robert Davidson is credited with developing the world's first electro-locomotive in 1837. At the time, it was powered by batteries that could not be recharged. As mass production of rechargeable batteries began toward the end of the nineteenth century, the usage of electric cars started to become more widespread.

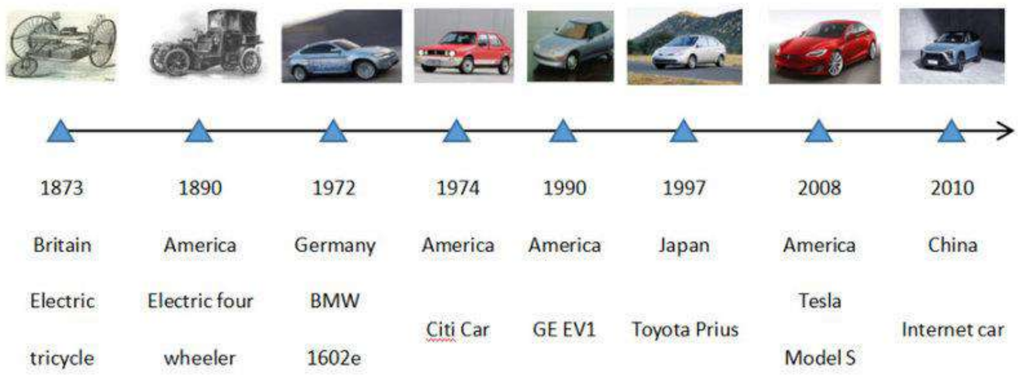

Figure 1 Electric Car Timeline

Electric Car Timeline After some period of time had passed, electric vehicles began to be employed on a business basis as taxis in the UK. It was not necessary for electric trains to rely on batteries because they could acquire their electricity from supply rails or overhead wires, unlike electric road vehicles, which had to rely on batteries. As a direct consequence of this, electric cars on the road have never achieved the same level of popularity as electric trains. Despite the fact that, in general, electric cars did not compete favorably with road vehicles in the early part of the 20th century, there have always been uses for electric vehicles since the early part of the 20th 3 century. The latest advancements in technology have made it possible to continue using electric vans and buses; in addition, these vehicles have benefited from the advent of lithium ion batteries. There has also been a rise in the popularity of hybrid vehicles, beginning with models like the Toyota Prius (shown in Figure3) that cannot be powered by conventional electrical outlets. Even though they are efficient, hybrids that don't have rechargeable batteries are still completely dependent on oil. As a consequence of this, they are unable to make use of the standard electrical supply, which derives its power from a variety of different sources. Recently, General Motors has introduced the Volt, an electric hybrid vehicle that can be recharged. This can finish many of its journeys with electricity, and relies on the internal combustion engine as an extender of its range for longer journeys.

Figure 2 Toyota Prius 1997-2003

Electric Vehicle And The Environment

Electric vehicles are normally associated with benefits to the environment and saving energy. These benefits include reducing local pollution from the vehicles themselves,

Figure 3 Environment Friendly

reducing dependence on oil and other fossil fuels and reduction of carbon emissions. When considering the introduction of electric vehicles, a thorough understanding of the effects on the environment is needed.

Units

Following table shows the seven SI base units.

Table 1.1 The 7 SI Base Units

Unit	Symbol	Quantity
metre	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	thermodynamic temperature
mole	mol	amount of substance
candela	cd	luminous intensity

Equations

Range = (Maximum Battery Capacity) x (Number of Batteries) x (Vehicle Efficiency).

For Example:- if a car has a maximum battery capacity of 200 kWh and two batteries, then the range would be 400 miles. If the vehicle has a total battery capacity of 200 kWh and four batteries, then the content would be 800 miles.

$$\boldsymbol{Fd} = \boldsymbol{R}\,(\boldsymbol{air}) + \boldsymbol{R}\,(\boldsymbol{roll}) + \boldsymbol{R}\,(\boldsymbol{slope}) + \boldsymbol{R}\,(\boldsymbol{acc})$$

2. CHAPTER TWO:

LITERATURE REVIEW

In the modern world, we are confronted with the challenge of diminishing resources of gasoline for cars. The production of carbon dioxide from an automobile's exhaust is, without Figure 1. 2. Toyota Prius 1997-2003 4 a shadow of a doubt, a cause for alarm regarding the escalating rate of global warming. The hybridization of vehicles is one of the hopeful solutions that has been proposed for these kinds of challenges. A conventional internal combustion engine and an electric propulsion system work together to form a HYBRID ELECTRIC VEHICLE. Although hybrid electric vehicles pollute the environment less, they nonetheless contribute to its toxicity since they create fewer emissions overall. We need to transition to an entirely sustainable environment if we want to have a green environment, and the only way that will be achievable is if we build fully electric vehicles that do not have internal combustion engines. Few experts have discovered that electric vehicles also contribute to the pollution of the environment. This is due to the fact that the power that is used by electric vehicles comes from the combustion of fossil fuels, which is a source of energy that is not renewable. We are proposing the use of a hybrid electric vehicle as a solution to this issue. In order to make up for the shortfall, the vehicle may also be charged using the electricity that is supplied to our home, which is primarily comprised of thermal energy. This thesis will focus on the two aspects of the project known as electrical designing and CAD modelling. Both of these topics are related to the whole project.

It is essential to gather all of the wealth of knowledge pertaining to the design of electrical systems that has been published in recent IEEE papers as well as in other industry sources and place it in a single location. This can be accomplished by compiling the information and placing it in a single location. The electrical engineer, the design professional, and the project manager all need to be informed about the numerous ways in which electrical safety can be improved by using the various options that are currently accessible while the designs are still on paper. Within the organization, a new IEEE Working Group is currently in the process of being established in order to facilitate the production of a document titled "IEEE Recommended Practice for Electrical System Design Techniques to Improve Electrical Safety." It will make an effort to close the gap between the realistic criteria of the code and the target of having no injuries at all. The Officers of this Working Group will outline the challenges that the Working

Group is currently facing, explain why a new IEEE document is required, and make a request for further assistance in order to be successful in this valuable endeavor [1].

It has been suggested that switching reluctance motors, which are more energy efficient, could possibly take the place of the DC motors that are presently utilized in the electric drives of car systems. In this work, a mathematical model of the electric drive system is built, and 5 suggestions are offered for ways in which this model can be improved. The fundamental concept is to have an alternator that can supply electricity and is coupled to the shaft of the rear wheels. This will allow the wheels to turn. The alternator is able to supply the batteries with the necessary electrical energy to charge them because it is coupled to a shaft that rotates. This allows the alternator to charge the batteries. The front wheel motors are connected to one of the batteries, which is coupled to the front wheel motors, which are connected to the battery that is coupled to the front wheel motors. When these batteries in the automobile have received a complete charge, it will be much simpler for the driver to move the vehicle about. A simultaneous rotation of the shaft that is connected to the rear wheels causes a rotation of the shaft that is connected to the alternator. The switching circuit is able to carry out its intended purpose once it has been engaged, which occurs when Battery 1 is connected to the motors and Battery 2 is connected to the charger. Battery 2 will be charging as long as Battery 1 is functioning, and by the time Battery 1 is totally depleted, Battery 2 should have reached its maximum capacity charge level. The automatic battery switching circuit kicks into gear once the system ascertains that Battery 1 is getting dangerously low on charge and is about to run out of power. As a direct consequence of this, Battery 2 will now replace Battery 1. Simultaneously, the charger will start to charge Battery 1 once it has been inserted. There are currently electric automobiles on the market that can go more than one hundred kilometers on a single charge; however, these cars come with a number of drawbacks, including high prices, limited mileage, and lengthy charging times. It is possible to argue that if any two of the three issues described above can be resolved, then electric vehicles will unexpectedly become more commercially viable. The idea of using an alternator as part of the system for charging the batteries of electric automobiles has the potential to overcome two problems:

1) Travel range

2) Charging time.

The electric car is able to travel hundreds of kilometers without using even a single minute of charge from the batteries because it is capable of self-charging to charge its batteries. This is possible provided that the appropriate program is used to control the charging time and the availability of switching the batteries at the appropriate timing [2] [3].

The printed circuit board layout is developed using the preliminary design that was developed before. In an inverter such as this one, which has four Gann MOSFETs connected 6 in parallel and a switching frequency of 50 kHz, the layout of the gate driver and power stage needs to be as compact and symmetrical as is humanly possible. This will help to reduce the impact that the parasitic inductance has on the inverter. In a reference design, the gate driver and power stage are separated on two distinct printed circuit boards (PCB) so that the desired outcome can be achieved. Because the power stage is the part of the device that produces the majority of the heat, the only modelling that is important is the three-dimensional modeling of this portion. A half bridge circuit representing one phase is included in the power stage's construction. COMSOL Multiphysics is going to be the simulator that is used for the three-dimensional simulation that is going to be done. Within the design, there are three different possible combinations that can be chosen from. We investigate the temperature fluctuations they go through as well as the temperature distribution of their current states using simulation [4]

. At this point in time, when the technology to steer vehicles autonomously is still in its infancy, a hot topic of debate is the steering of vehicles using their rear wheels. It will improve the driving performance of non-autonomous vehicles, especially at lower speeds in the "urban jungle," where a lot of driving takes place. Up until very recently, this management system was only familiar to manufacturers of luxury automobiles, which employ this system at high speeds to promote vehicle stability or for bigger vehicles, such as buses. The driving capabilities of the vehicle have been evaluated, for instance, in the subterranean parking garages of the Technical University in Liberec, where it was discovered that the rear wheel steering was the most effective method for navigating the tight curves. Vehicles equipped with an autonomous steering system have the ability to steer from the rear in a significant number of situations. As the vehicle turns to the side, a movement known as the "crab movement" is produced by the vehicle. This movement occurs when the front and rear axles rotate at the same angle at the same time. In any other case, it is possible to spin the vehicle "on the spot" with a very low rotation radius by maintaining the same angles of rotation but rotating the axles in the opposite direction. An experimental electric vehicle has had the rear axle system installed, and it is operating at its maximum capacity as part of the testing for the prototype [5].

The carrying out and designing of a smart car prototype for use in a platoon of autonomous vehicles, as well as the depiction of an application in real time within the control area of the vehicle. Real-time testing has been performed on each individual piece of hardware, such as the distance sensor, the speed sensor, and the lines sensor, and each piece of hardware has 7 also undergone its own independent implementation. The findings of the testing indicate that the gadgets possess a high level of accuracy and sensitivity, and after that, they are coupled with one another to build a prototype of an intelligent vehicle. The results of the studies that were carried out on this intelligent vehicle prototype reveal that the method that was proposed is not only very effective, but it also makes use of components that are reasonably priced. A demonstration for implementing in real-time an exercise for an algorithm of the RST-type that is applicable on Vehicle Platooning will be a part of the work that will be done in the future. This will be done in order to obtain a self-driving car that is capable of lane following, and at the same time, this will be done in order to maintain the necessary distance and the safe speed between cars that are platooning in the longitudinal direction. In addition to this, this will be done in order to design suitable communication protocols for vehicle-to-vehicle interactions [6].

Mathematical models of quarter and half vehicle systems that include a piezoelectric stack inserted between the sprung and up sprung masses have been developed in order to evaluate the voltage and power that can be gathered. These models were developed in order to evaluate the voltage and power that can be gathered. Both models are subjected to a wide range of road conditions, each of which has its own individual degree of harshness. The results of this research indicate that there is a sizeable opportunity for the extraction of usable energy from the suspension system of automobiles. According to the findings, the road quality that yields the lowest voltage and power harvest is the one with the highest quality, while the road quality that yields the highest voltage and power harvest is the one with the lowest quality. The results also show that an increase in car speed translates in an increase in the amount of power and voltage that can be gathered. MATLAB/Simulink is used throughout the construction and development of the mathematical models. The findings indicate that the levels of road roughness and the speed at which the vehicle is travelling both have an effect on the amount of power and voltage that may be captured. The amount of electricity harvested increased by 434 milliwatts for the quarter vehicle model and by 537 milliwatts for the half car model as the road levels changed from very smooth to very rough.

On a test track, Solar Car's built test model was able to reach speeds of up to 110 kilometers per hour. The car was able to complete the 93 km leg of the race using only the power from its batteries, despite the fact that the weather was extremely cloudy at the time. However, because of the problems that were reported with the solar panels, it was necessary to restrict the maximum speed that could be achieved on sunlight to around 50 kilometers per hour so that the battery pack would not be depleted. Because of the large losses that occurred at higher speeds as a result of drag, the maximum speed was capped at 110 kilometers per hour. The range was around 50 kilometers and could be reached in approximately 30 minutes while using 10 kW of power. The distance that could be travelled by an automobile powered only by its batteries was adequate when considering both the type of terrain it was driven on and the weight of the vehicle. The finished vehicle was heavier than was expected, thus this is something that needs to be taken into consideration when designing the next solar car. The design of the new vehicle will incorporate both a mass budget and an energy budget in order to increase both the performance and the range of the vehicle. In addition to this, the vehicle's aerodynamic characteristics will require some sort of enhancement [8]**.**

When designing a photovoltaic (PV) system for an electric vehicle charging station, some things to keep in mind include the following:

The vehicle should be parked there for a considerable amount of time; an additional battery storage should be integrated into the station in order to store excess energy for use at a later time; the efficiency of the converter should be greater than 92 percent. Batteries for electric vehicles should have 48 volts and 20 ampere-hours.

The effectiveness of an appropriate EMS when utilized in conjunction with a supercar module as a standalone storage system and fitted on a medium-sized car that was manufactured in line with a series architecture. According to the findings, even on real road missions with significant downhill roads (up to 300-350m altitude drop), a super capacitor module that is sized similarly (in terms of mass) to batteries employed in the same applications and that is combined with an appropriate EMS does not result in the saturation of the SOC. This is the case even when the roads have significant altitude drops. As a

consequence of this, it reveals that it is a technically viable alternative for series-based powertrains utilized in medium-sized automobiles.

When compared to conventional cars powered by gasoline or gas engines, electric vehicles offer a number of advantages. In addition, the electrification of the transportation networks would make it possible to generate more electricity from sources of energy that do not release carbon dioxide and are renewable. The research concentrates on the generation of energy by electric vehicles using the V2G model, which in reality implies that energy must be consumed and utilized in a bidirectional manner.

According to this, the charging stations for electric vehicles consist of an AC/DC converter for the network interface, many DC/DC converters for charging and discharging, and control mechanisms for controlling both converters. In addition, the AC/DC converter is used for the network interface. It has been developed that a system of energy exchange between a charging station for electric vehicles and the electrical grid (V2G model). Studies and simulations have shown that it is possible to construct the structure in such a way that it will accomplish the desired purpose of injecting the energy that is stored in the vehicle's battery into the grid [11].

The process of designing the system that will be used to charge the batteries will involve a number of steps, one of which will be the development of a device that can control electricity on its own without human intervention. It is of the utmost importance to be able to deliver the maximum amount of electricity from the solar cells to the batteries in spite of the fact that the temperature and the amount of illumination are continually changing. Because of this, engineers at the University of Illinois have developed a power tracking system that, by determining the maximum power point at any given instant in time, maximizes the amount of power that can be produced at that particular time. To put it another way, the system determines the point at which the power output is at its highest possible level. In addition to a dc-dc boost converter, each tracker features a control for excessively low voltage as well as one for too high voltage. The signals that are obtained from the ripple of the converter are used in the calculation that is used to estimate the duty ratio of the converter. Using this information, one may pinpoint the location of the most concentrated force. The battery has a nominal voltage of 84 volts but a minimum turning voltage of 70.7 volts and a maximum turning voltage of 105.7 volts. The highest turning voltage can reach 105.7 volts. When developing the trackers, the input requirements of the battery pack are taken into mind. Each of the of the nine power trackers has its own output, and those outputs are all connected in parallel to the main battery bus. The main battery bus is the source of power for the entire system [12].

This method first constructs the charging possibility model by cloud model based on the fact that the membership level can describe the possibility, and then uses this model to describe the charging curves. The construction of the charging possibility model is based on the fact that the membership level can describe the possibility. The fact that the membership degree can indicate the possibility serves as the foundation for this method. This model, which is mostly focused on the traffic characteristics of users, reflects the randomness and fuzziness that is inherent in the users it serves. The model that was presented in this paper is superior to the Monte Carlo method in the application of load forecasting. This is due to the fact that the model has the same variation trend as the Monte Carlo method, a higher operation efficiency, and is better suited for electric vehicle charging load forecasting in a more localized area. Additionally, the Monte Carlo method does not have the same variation trend as the model that was presented in this paper. This approach lends itself well to the placement of charging piles in villages, as well as to the estimation of charging loads, and it can serve as the foundation for the creation of large-scale charging infrastructure if it is used appropriately [13]**.**

This research suggests the application of a Hybrid Choice Model and places an emphasis on the evaluation of the impact of latent variables on the user choice process. On a methodological level, this research suggests the implementation of a Hybrid Choice Model. The pro-environmental attitude, as shown during the calibration of HCM, measured through the psychometric construct Biosphere Value Orientation, does not appear as a significant variable to explain the willingness of the users to consider the e-go car sharing service as an alternative mode of transport. Rather, the pro-environmental attitude appears to be unrelated to the willingness of the users to consider the e-go car sharing service. It is more likely that the environmentally conscious attitude of the consumers is unconnected to their openness to the possibility of using the e-go automobile sharing service. Cognitive dissonance is a notion that has been backed by a substantial amount of research that has been carried out in academic settings, and our finding is consistent with that hypothesis. According to the findings, the characteristics of a person's socio-demographic profile that are the most significant include their university department, the question of whether or not they possess a private automobile, and the presence or absence of alternative car sharing subscriptions.

In particular, it was found that the students who were more likely to choose an e-go car sharing service were those who were enrolled in a scientific course, were female, and subscribed to other mobility sharing services, but did not own a private car. Additionally, these students were more likely to choose an e-go car sharing service than other students. The principal findings of this research are going to be included into a body of work with the intention of maintaining coherence with other bodies of research that have been conducted in other parts of the world. They are also meant to contribute to the actions of industry operators and policymakers who are active in the distribution and development of vehicle sharing. This is one of the primary goals of these initiatives [14]**.**

The existing sell-and-disengage business model, which is the dominant one, is not well suited for technologies that are fresh to customers, such as all-electric automobiles. The risk- and cost transfer that comes with the purchase of cars under this model is not ideal for these types of technologies. In order to persuade private homes to select an all-electric vehicle, the value proposition must be seen as being superior and more straightforward for the individual household. The result must also be predictable, which is something that the current sell-and-disengage model for all-electric cars does not give, potentially with the exception of Tesla

Motors and their battery warranty and resale value guarantee. The outcome must also be measurable. All four of these different kinds of company models have been developed with this specific goal in mind. They have the potential to be seen as more desirable by prospective clients, and they have the potential to generate profits for their operators. The stability of the finances appears to be precarious, however, and is dependent on aspects of context over which neither the operator of the business nor its clients have any control. These contextual elements, such as the price tag gap, the battery warranty, the speed at which technology improves, and the gap in energy cost between all-electric cars and ICE automobiles are mostly affected by governments and car manufacturers.

Therefore, we have conclude that alternative business models have the potential to be useful tools for the expedited commercialization of fully electric vehicles; however, in order for these models to be viable over the long term, the price tag gap must decrease, the energy cost gap must remain or increase, the battery lifetime must increase, and the rate of technological advancement must slow down. The support of governments is available. This assistance can be provided in the form of self-financed bonus-malus systems for CO2 tailpipe emissions (France), legislative requirements on battery warranties (California), advantages that accompany the car (Sweden), and an increase in fuel tax off setting ICE energy efficiency improvements. Automobile manufacturers can also be of assistance. Instead of concentrating on increasing the vehicle's travel distance, the first and most obvious step would be to give priority to enhancing the battery's lifespan, which would result in improved guarantee terms. We do not believe that it will be possible to achieve the necessary range in the near future. Several other ways of packaging can fulfill that requirement in an easier and more cost-effective manner. According to the conclusions of our investigation, the degree to which an all-electric vehicle is competitive is determined not so much by its range as it is by its price tag and the lifespan of its battery [15]

PROBLEM STATEMENT

The goal of the project is to build an electric vehicle that can be driven legally on public roads while still being suitable for off-road use. We are undertaking these things because the automotive industry will be moving in this direction in the future. These are completely safe for the environment, and they are one of the most effective ways to cut down on carbon emissions in our surrounding area. The electric vehicle (EV) that we are designing is being constructed entirely from scratch and has the appearance of a wheelie jeep. Because it may be driven on public roads, we designed this vehicle keeping in mind the rules and regulations that govern transportation in Pakistan. The vehicle has two doors and a total capacity of two passengers. Because we are required to make it lighter and off-road capable, the poly carbonate shell material was our material of choice. The automobile is completely electrically automated, and it has electric power steering in addition to any other function. Additionally, it comes with an electrical winch that can be detached from either the front or the back of the vehicle. It is a four-wheel drive with a high torque and it does not make an abnormally loud noise when operating.

The vehicle's drivetrain is an AC motor, and the energy source for the drivetrain is lithium batteries, which, in comparison to other types of batteries, have a high level of efficiency. Because electric motors have such a rapid acceleration compared to conventional internal combustion vehicles, we have to create effective braking systems for them. The operating costs of an EVS are significantly reduced, and very little maintenance is required. It has a range of up to 80 kilometers per single charge and can be charged in the 240-volt power connection in your garage. We have seen a reasonable and beneficial return on the money that we have invested in the EVs.

Because the public transportation system in our country is neither as well-structured nor as robust as other countries', individuals like this one, as well as the student population as a whole, which wants a bike or automobile for their daily journey, can profit from the development of cars like these. If our idea is approved for funding by our institution, and if we go forward and build the car, it will have a significant positive impact for the development of our society.

Motivation Behind the Thesis.

Because of the consistent rise in the cost of fuel, there is an overwhelming requirement to investigate the feasibility of solar-powered electric vehicles. Owing to the fact that this project incorporates both the software and hardware necessary to build a solar electric car. Utilizing the electrical engineering information gained during the entirety of the course in such a way provides for a very intriguing experience. Because it is so important to the world's future, a large number of multinational corporations are collaborating on this initiative. In Pakistan, there is a massive problem with the environment, which has been made worse by the vast amounts of carbon dioxide that are emitted from combustion engines. As a result, there is an urgent requirement for the introduction of solar-powered electrical vehicles into the market.

The Government of Pakistan is also placing an emphasis on this technology and is encouraging businesses that are leading the way in the introduction of this technology. The reserves of non-renewable energy sources are rapidly depleting, and this presents a significant challenge that, if not addressed, will inevitably become a significant problem.

By investigating the development of a solar-powered car, this thesis seeks to contribute to the ongoing research and development efforts in sustainable transportation. The motivation behind this research lies in addressing the environmental, energy, and societal challenges associated with conventional vehicles. Through a comprehensive analysis of solar-powered car technologies, efficiency improvements, and the associated economic and social implications, this thesis aims to pave the way for a greener and more sustainable future in the automotive industry.

Developing a solar-powered car requires overcoming numerous technical challenges, such as maximizing solar energy conversion efficiency, optimizing energy storage systems, and improving vehicle design. Through this thesis, advancements in solar technology and their integration into automotive engineering will be explored, fostering innovation and pushing the boundaries of renewable energy applications.

3. CHAPTER THREE:

RESEARCH AND DESIGN

Designing a solar-powered car involves considering various factors such as energy efficiency, aerodynamics, weight reduction, and appropriate material selection. To design a vehicle with a lightweight and aerodynamic design that maximizes solar energy capture and converts it into efficient propulsion.

NON-OFFICIAL DESIGN

DESIGN REQUIREMENTS:

Consider the feasibility of manufacturing the vehicle within a reasonable budget while maintaining the desired performance and safety standards.

Here we design the non-official design for our project because the project is totally reverse engineered.

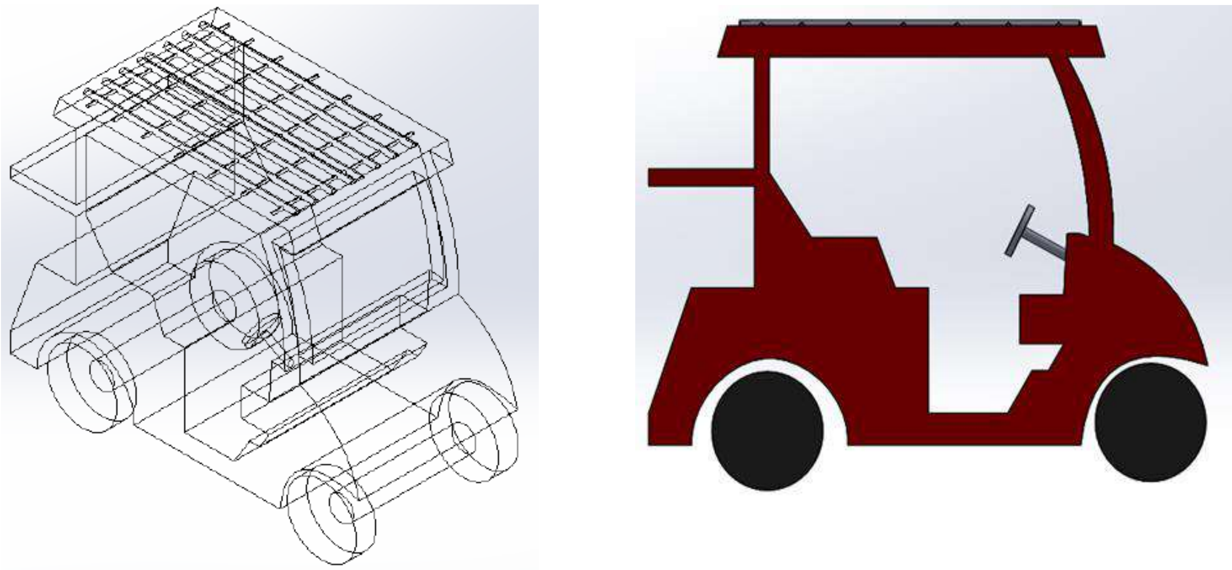

Figure 4 non-official model

The maximum mass of the vehicle is 700kg which include the mass of batteries, passenger, frame of the vehicle.

Design the vehicle to accommodate two passengers comfortably with sufficient legroom and headroom.

Ensure that the seating position, controls, and overall interior layout prioritize passenger comfort and convenience.

Safety Features: Incorporate safety features such as seat belts, airbags, and reinforced structures to protect the occupants in case of a collision.

DESIGN PARAMETERS

Solar Panel Efficiency: Choose solar panels with high conversion efficiency to maximize the capture of solar energy. Look for panels with a high-power output per unit area.

The type of PV cell technology used in the solar panel plays a significant role in determining its efficiency. Different technologies, such as monocrystalline, polycrystalline, and thin-film, have varying levels of efficiency. Monocrystalline cells typically have higher efficiency compared to polycrystalline and thin-film cells.

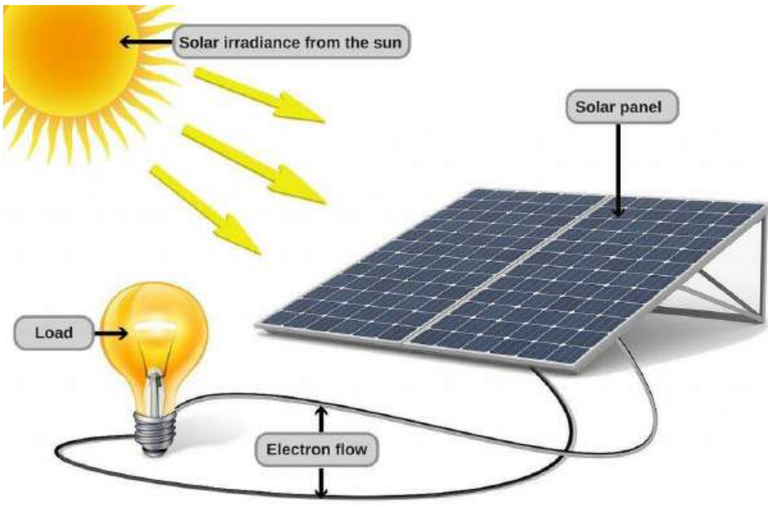

Figure 5 solar panel

Solar Panel Placement and Angle: Determine the optimal placement and angle of the solar panels on the vehicle to maximize exposure to sunlight throughout the day. Consider factors such as the vehicle's orientation, available surface area, and minimizing shading from other components.

The angle or tilt of a solar panel is also an important consideration. The angle that a solar panel should be set at to produce the most energy in a given year is determined by the geographical latitude. A general rule for optimal annual energy production is to set the solar panel tilt angle equal to the geographical latitude. For example, if the location of the solar array is at 50o latitude, the optimal tilt angle is also 50o. Essentially, the closer a solar panel is located to the equator the more the panel should be pointing straight up. The closer the panel is to the poles, the more they should tilt towards the equator.

Figure 6 solar panel angel

Energy Storage Capacity: Select a battery system with sufficient energy storage capacity to store the solar energy generated during the day. Consider the desired driving range and power requirements of the vehicle.

Vehicle Weight: Strive to minimize the weight of the vehicle to improve energy efficiency. Choose lightweight materials for the vehicle's body, chassis, and components without compromising safety and structural integrity.

Aerodynamics: Design the vehicle with a streamlined shape and low drag coefficient to reduce air resistance and increase overall energy efficiency. Smooth out contours, minimize sharp edges, and optimize airflow around the vehicle.

Electric Motor Efficiency: Choose an electric motor with high efficiency to convert electrical energy from the batteries into mechanical power for propulsion. Look for motors that offer a good balance between power output and energy consumption.

Regenerative Braking: Implement regenerative braking technology to recover and store energy during deceleration and braking. This helps increase overall energy efficiency and extend the driving range.

Control and Monitoring Systems: Include an energy management system to monitor and

control the flow of energy between the solar panels, batteries, and electric motor. Implement sensors and data logging systems to collect performance data for optimization and evaluation.
Safety Features: Integrate safety features such as seat belts, airbags, reinforced structures, and rollover protection to ensure occupant safety. Follow relevant safety regulations and standards.
Charging Infrastructure Compatibility: Consider the availability and compatibility of charging infrastructure for the solar-powered car. Ensure that the vehicle can connect to standard charging stations or utilize specialized solar charging systems. Sustainability and **Environmental Impact:** Strive to use sustainable materials in the vehicle's construction, such as bio-based composites or recycled plastics. Consider the life cycle impact of the vehicle, including the sourcing, manufacturing, use, and end-of-life disposal of materials.
Cost Considerations: Balance performance and efficiency goals with cost constraints. Optimize the design to achieve the desired functionality and performance within a reasonable budget.

OFFICIAL DESIGN

Figure 8 Design view 1

Figure 7 Design view2

This Design should be designed with accessibility in mind, allowing easy entry and exit for delegates, including those with mobility challenges. Features like low step-in height, wide doors, and spacious interiors accommodate diverse user needs. A well-designed Solar Powered Car should prioritize ergonomics to provide comfort and convenience to the users. Considerations such as adjustable seats, ample legroom, and easy-to-reach controls contribute to a more enjoyable experience.

While functionality is crucial, aesthetics should not be overlooked. Attractive and visually appealing designs can enhance the overall experience and make the cart a more enjoyable mode of transportation on the course.

A well-designed cart should consider ease of maintenance and durability. Components such as the frame, tires, batteries, and electrical systems should be designed for longevity and easy servicing, minimizing downtime and maximizing the cart's lifespan.

SIMULATION

ANSYS provides a comprehensive suite of simulation tools that cover a wide range of engineering disciplines, including structural analysis, fluid dynamics, electromagnetics, and thermal analysis. This allows engineers to simulate and analyze complex physical phenomena accurately. ANSYS is known for its robust and accurate solvers, which are essential for obtaining reliable and precise simulation results. The software employs advanced numerical methods and algorithms, enabling engineers to tackle complex engineering problems with confidence.

ANSYS has made efforts to improve its user interface over the years, making it more intuitive and user-friendly. The software provides a rich graphical interface, making it easier for engineers to set up simulations, define boundary conditions, and visualize results effectively.

We design the frame on Creo and gave proper dimensions.

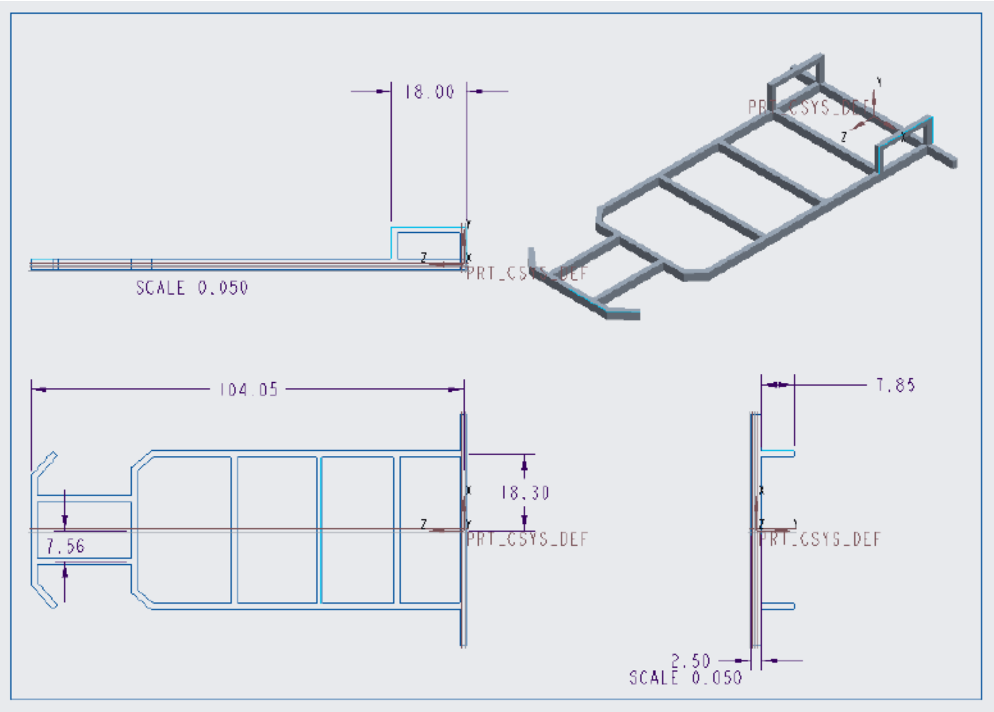

Figure 9 creo modeling

Creo provides specialized tools for sheet metal design, catering to industries that require designing products made from sheet metal. The software offers features for creating flat patterns, bend allowances, and manufacturing-specific annotations. It facilitates the design of sheet metal parts and enables seamless transition to manufacturing.

Creo provides tools and features to support the manufacturing process, including mold design, computer-aided manufacturing (CAM) integration, and 3D printing preparation. These capabilities ensure that designs created in Creo can be effectively translated into physical products.

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We apply load variously in different form of testing in ansys.

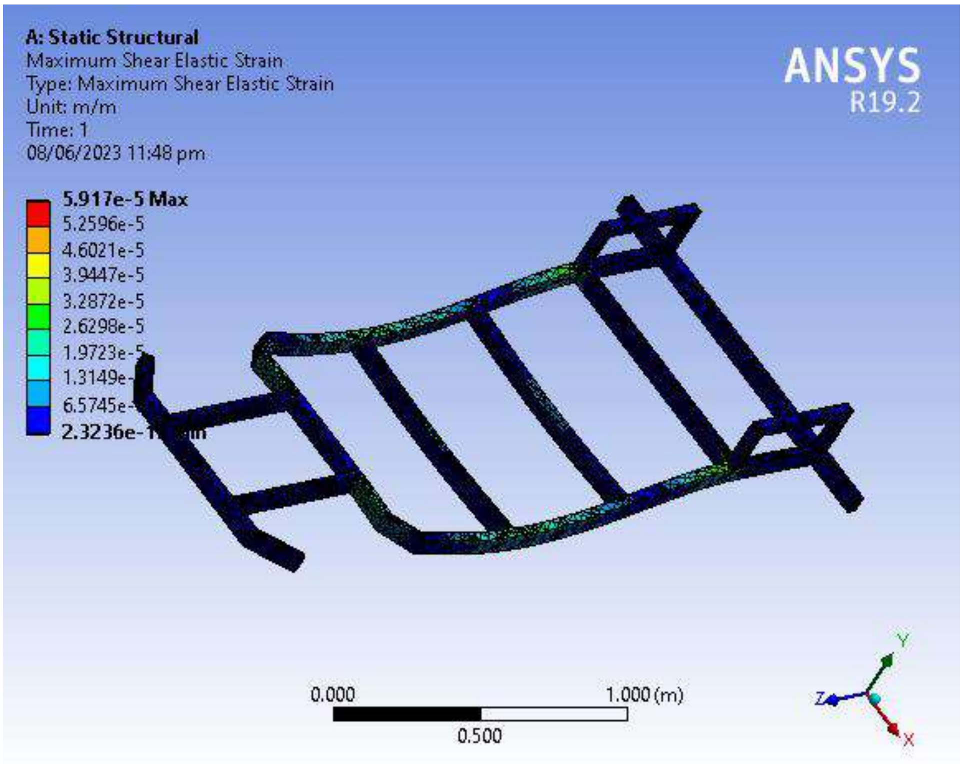

Figure 10 Maximum Shear Strain

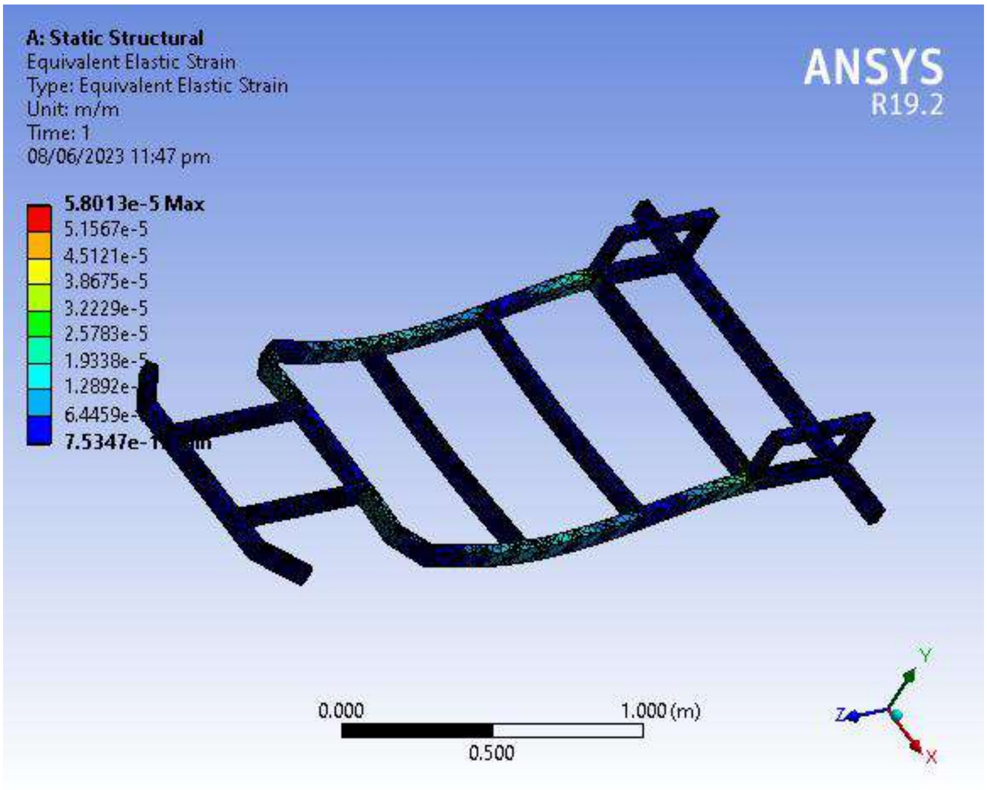

Figure 11 Equivalent Elastic Strain

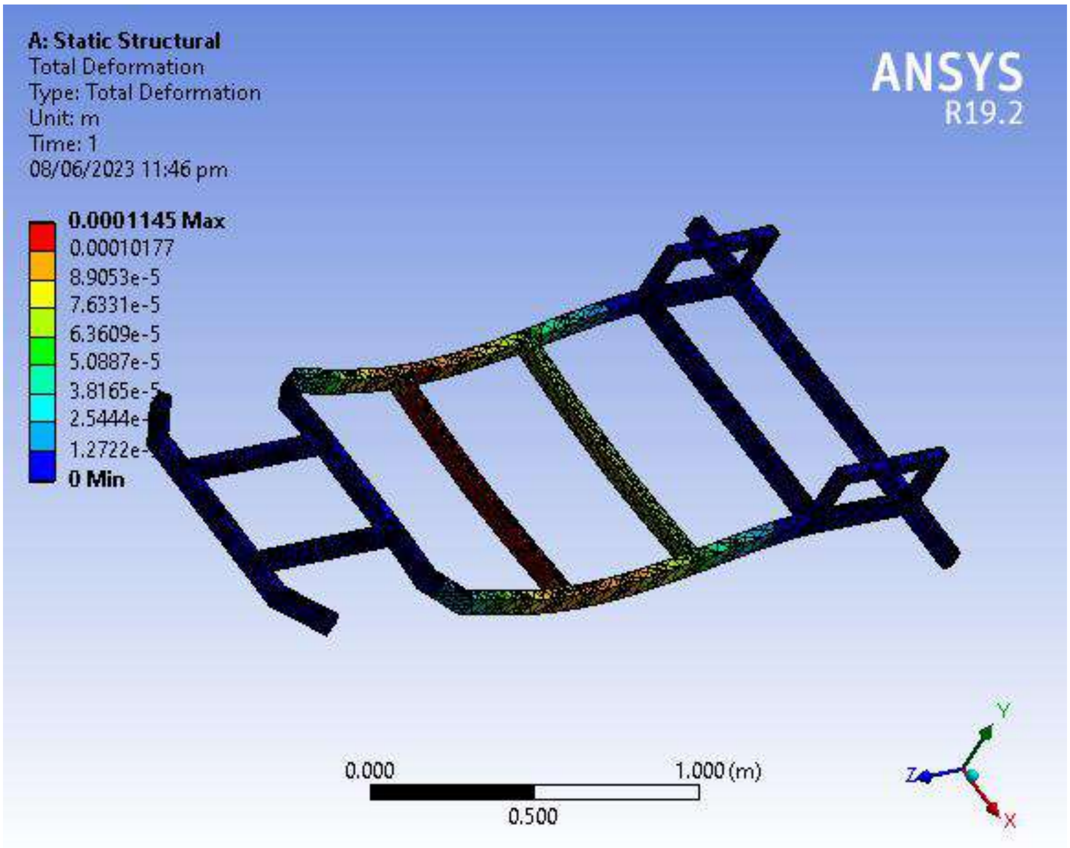

Figure 12 Total Deformation

Design Calculations

These all calculations are approximately assumed because the final calculations will obtain after fabrication.

Mass of vehicle = 800kg Approx.

Formula > F=Drag + Rolling Resistance

F= Drag + 0.01* 800kg * 9.81ms^2

F= Drag + 78.48N

Now calculate the drag,
Density of air approximately 1.2kg/m^3

Area of frontal Area Approx. = 1.06m*1.52m

=**1.62m^2**

Now,

Drag= 0.5* Density *Area*Coefficient*$velocity^2$

Drag= 0.5*1.2kg/m^3 *1.624m^2 *0.4 *($\frac{35km/h}{3.6}$)^2
Drag= 36.84N

Now,

Force= 78.48N+36.84N
Force=115.3N

To calculate Torque required for motor,
Torque =Force + Radius
Torque= 115.3N * 0.127m

Torque =14.641Nm

The Motor would need to provide minimum torque of 14.431Nm.

Now Calculate the Power,

Power= Torque * Angular velocity

Angular Velocity = $\frac{velocity}{Radius}$

$=\frac{\mathbf{9.72}}{\mathbf{0.13}}$ = **74.76 rad/s**

Power= 74.76 * 14.98
Power = 1094 Watts

So here we calculate the power require to move the vehicle of 800kh mass approx.
And the motor that we use for this project is **48v BLDC 1.5kw** which is 90% efficient by manufacturer.

4. CHAPTER FOUR:

FINDING AND RESULTS.

During the fabrication of our electric vehicle (EV) we found out and faced various challenges. Here are some common challenges encountered during the fabrication process:

Battery technology:

One of the critical challenges is the development and integration of advanced battery technology. Electric vehicles require high-capacity, long-life batteries that are safe, efficient and cost-effective. Improving battery performance, increasing energy density, reducing charging time, and extending battery life are constant challenges. For solving this problem, we used lithium ion batteries of capacity 48 volts 100MAH in parallel

Range Anxiety:

Range anxiety refers to the fear of running out of battery before reaching your destination. Solving range limitations and improving the range of electric cars is a significant challenge. Increasing battery capacity, optimizing energy management systems and expanding charging infrastructure helped us to overcome these concerns. The total range of our car before the charging runs out is 40 to 50 kms.

Charging infrastructure:

The lack of robust and widespread charging infrastructure is a significant barrier to EV adoption. But our vehicle is also able to be charged by the solar and as it can also be charged by AC current. It can be charged using Level 2 charger: and usually involves plugging the vehicle into a 240-volt. Since a 48-volt EV would require a voltage converter to charge at that level, the charging time would take 6 to 7 hours.

Lightweight materials:

EVs must be lightweight to maximize range and energy efficiency and it is one of the most major concern we have faced to maximize the efficiency. However, obtaining lightweight yet durable materials that meet safety requirements is a challenge. We have used carbon steel and stainless steel in the fabrication so that It can be light weight as well as the material strength is good.

Manufacturing:

One of the major issues we found out was the availability of different parts that requires the same capacity of working as calculated. For this many part were imported and some were made locally because of high cost. many parts are purchased from the local market as well such as seats, wires, and etc.

Electric Motor and Power Electronics:

Designing and manufacturing high-performance electric motors and power electronics systems that are reliable, efficient and cost-effective can be challenging. Increasing engine efficiency, reducing size and weight, and optimizing power electronics are constant areas of research and development. The electric motor we have used is of 1.5 KW and it is differential mounted. And also,3 polycrystalline solar panels are used of 80 watts for the charging.

Cost reduction:

The cost of electric cars remains higher compared to traditional combustion engine vehicles. Lowering battery costs, improving manufacturing efficiency and exploiting economies of scale are essential to making EVs more affordable and competitive. As this solar powered EV is not manufacturing locally it is basically imported from other countries so we have reduced the cost by manufacturing it locally.

Environmental impact:

Although electric cars contribute to the reduction of greenhouse gas emissions during operation, the environmental impact of battery production, disposal and recycling needs to be addressed. Developing sustainable battery manufacturing processes and efficient recycling methods are a challenge for the EV industry. And as solar is a trending way of generating electricity that is used in this car.

5. CHAPTER FIVE

Discussions

In an electric vehicle, the mileage refers to the distance the vehicle can travel on a given amount The trend that can be observed is that as the load on the motor (in percentage) increases, the mileage (in miles) decreases. This relationship is expected in electric vehicles and can be attributed to several technical factors:

Energy Consumption: As the load on the motor increases, it requires more electrical power to overcome the resistance or demand. This higher power demand results in increased energy consumption from the battery, leading to a decrease in mileage. The motor has to work harder, drawing more current from the battery, which reduces the overall efficiency of the system.

Efficiency Losses: When the motor operates under heavier loads, it experiences higher losses due to factors such as increased heat generation, increased electrical resistance, and reduced mechanical efficiency. These losses contribute to decreased overall efficiency, reducing the mileage achieved by the electric vehicle.

Increased Battery Drain: As the load on the motor increases, the battery drain also increases. The motor draws more current from the battery to meet the higher load requirements. This increased drain results in faster depletion of the battery's stored energy, which leads to reduced mileage as the vehicle can travel a shorter distance before requiring a recharge.

Power Demand and Motor Performance: Higher loads demand more power output from the motor to overcome the resistance and perform the necessary work. The motor's performance characteristics, such as its power rating and efficiency, can influence the overall mileage achieved. In general, higher loads tend to reduce the motor's efficiency, resulting in lower mileage.

Based on the dataset, as the load on the motor increases from 10% to 100%, the mileage decreases from 110 miles to 60 miles. This trend aligns with the technical understanding that increased loads on the motor have a negative impact on the energy efficiency and mileage performance of electric vehicles.

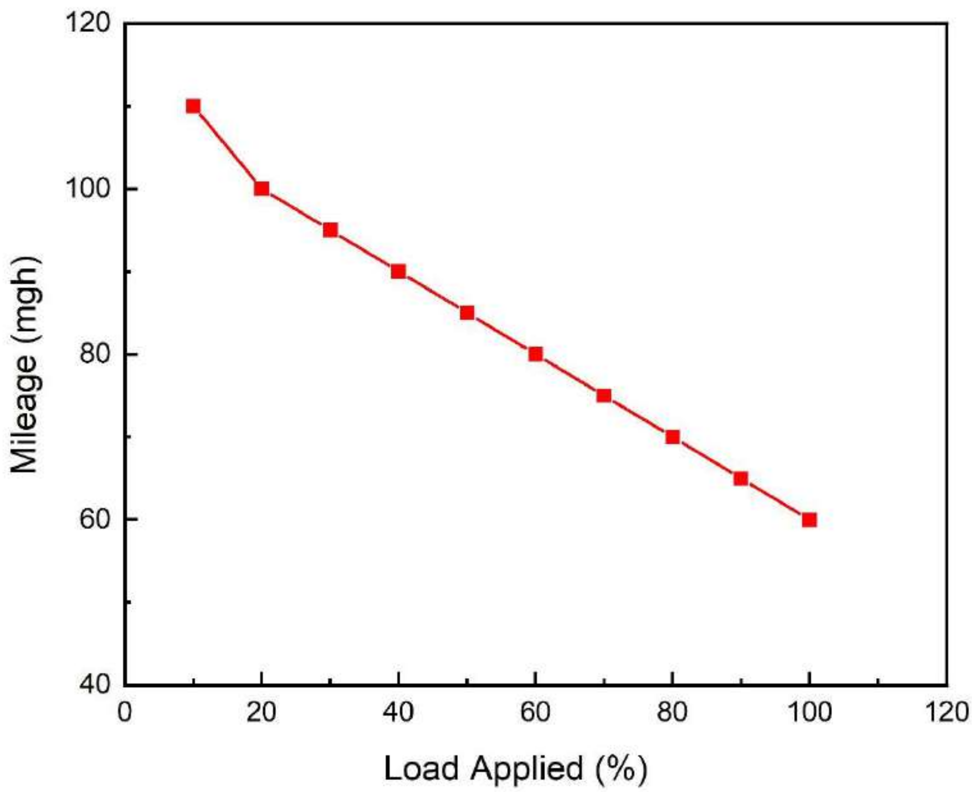

Figure 13: Load vs Mileage

The trend that can be observed is that as the load on the motor (in percentage) increases, the speed (in miles per hour) decreases. This relationship can be explained by several technical factors:

Power-Demand Relationship: The load on the motor directly affects the power demand required to propel the electric vehicle. As the load on the motor increases, more power is needed to overcome the resistance or demand placed on the motor. The available power may become insufficient to maintain higher speeds, leading to a decrease in the vehicle's speed.

Torque and Power Output: Higher loads on the motor demand increased torque and power output to meet the required work. However, electric motors have limitations in terms of torque and power output at different load levels. As the load increases, the motor may reach its power limitations, resulting in reduced speed capabilities.

Voltage and Current Limitations: The load on the motor affects the current drawn from the battery. As the load increases, the motor draws higher currents to meet the demand. However, there are limitations on the maximum current that can be supplied by the battery and the system's voltage limitations. When these limits are reached, the motor's power output and speed may decrease.

Motor Efficiency: Electric motors exhibit different efficiency characteristics across different load ranges. Generally, motors tend to have higher efficiency at lower loads and lower efficiency at higher loads. This reduced efficiency at higher loads can result in decreased speed capabilities and lower overall performance.

Based on the dataset, as the load on the motor increases from 10% to 100%, the speed decreases from 80 miles per hour to 20 miles per hour. This trend reflects the technical understanding that increased loads on the motor can limit the available power, torque, and efficiency, resulting in reduced speed capabilities for the electric vehicle.

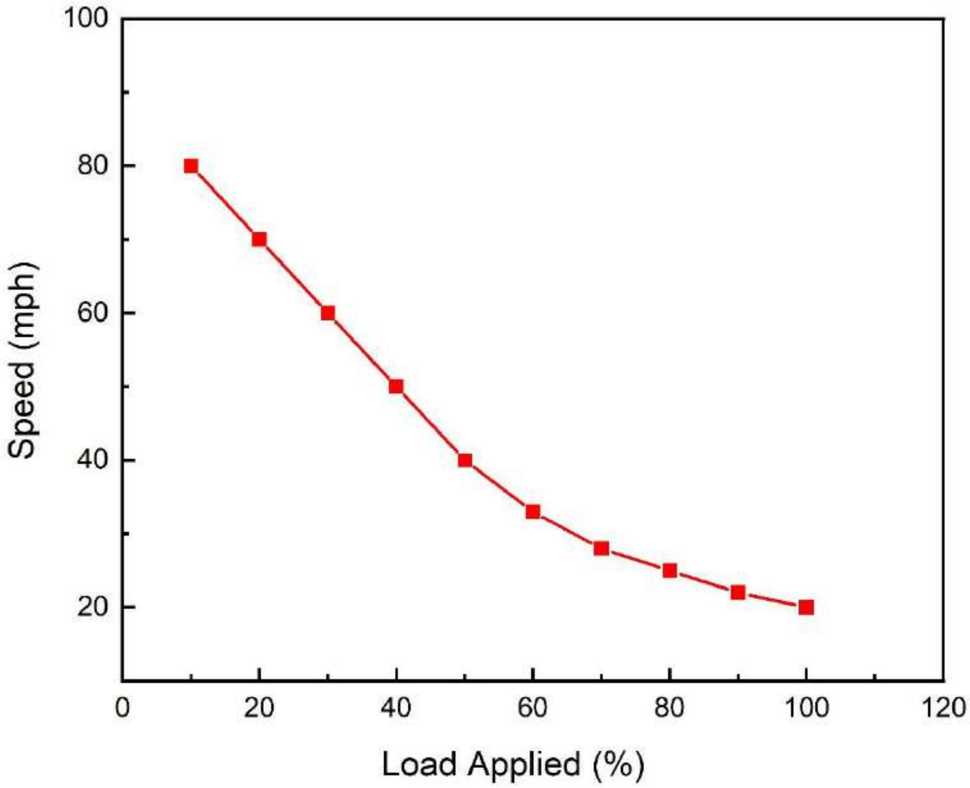

Figure 14: Load Vs Speed

The trend that can be observed is that as the speed (in miles per hour) increases, the mileage (in miles) decreases. This relationship can be explained by several technical factors:

Aerodynamic Drag: At higher speeds, the aerodynamic drag on the vehicle increases significantly. Aerodynamic drag is the resistance that the vehicle experiences due to air pushing against it as it moves. As the speed increases, the drag force increases, requiring more energy to overcome it. This increased energy consumption leads to decreased mileage at higher speeds.

Rolling Resistance: Rolling resistance refers to the friction between the tires and the road surface. At higher speeds, the rolling resistance also increases, demanding more energy from the motor to maintain the speed. This increased energy consumption contributes to reduced mileage.

Power Demand: As the speed increases, the power demand on the motor also increases. Higher speeds require the motor to generate more torque and power output to propel the vehicle. This higher power demand leads to increased energy consumption, resulting in decreased mileage.

Efficiency Losses: Electric motors and other components in the drivetrain experience efficiency losses at higher speeds. These losses can be attributed to factors such as increased heat generation, increased electrical resistance, and reduced mechanical efficiency. As a result, the overall efficiency decreases, leading to decreased mileage.

Battery Capacity: The available capacity of the battery affects the mileage achieved at higher speeds. Higher speeds require more energy, and if the battery capacity is limited, it can result in a shorter driving range and reduced mileage before the battery needs recharging.

Based on the dataset, as the speed increases from 30 miles per hour to 120 miles per hour, the mileage decreases from 35 miles to 12 miles. This trend aligns with the technical understanding that increased speeds result in higher energy consumption, increased resistance forces, efficiency losses, and decreased overall mileage for an electric vehicle.

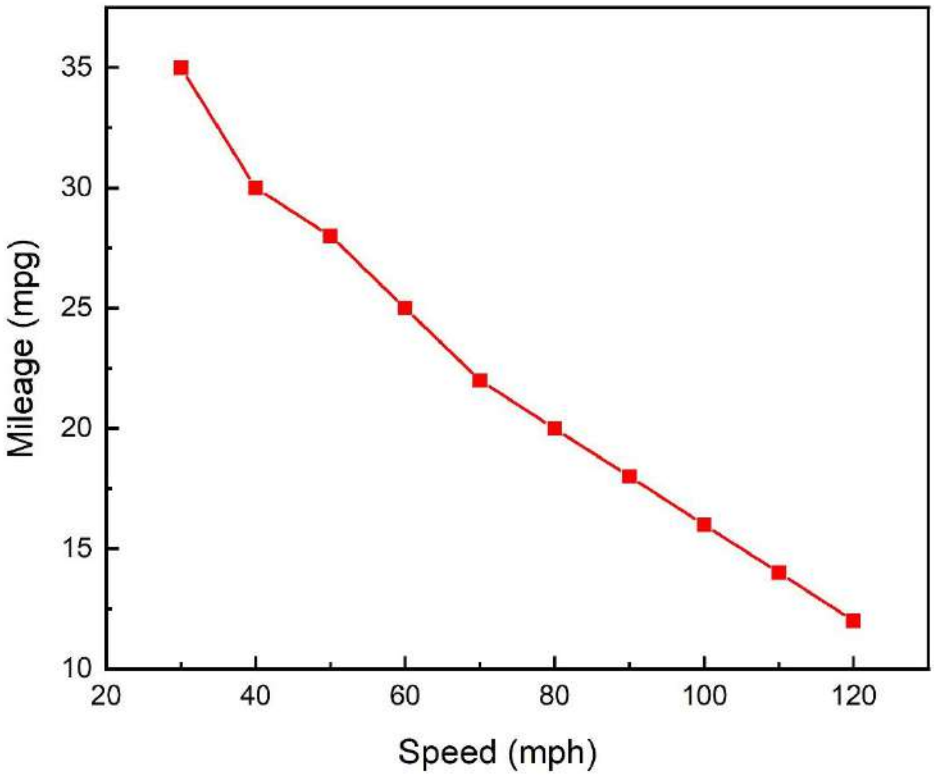

Figure 15: Speed Vs Mileage

6. CHAPTER SIX

CONCLUSION AND FUTURE DIRECTION

In conclusion, solar-powered electric vehicles (EVs) have great potential as a sustainable and renewable transportation solution. By using solar energy, these vehicles offer several benefits, including reduced dependence on fossil fuels, reduced greenhouse gas emissions, and lower operating costs. However, there are several considerations and future directions that need to be explored for widespread adoption and further advancements:

Solar efficiency:

Improving the efficiency of solar panels is critical to maximizing energy production and extending the range of solar-powered EVs. Ongoing research focuses on the development of advanced photovoltaic technologies such as multi-junction solar cells and perovskite solar cells to increase efficiency and capture energy. Research and development focuses on advancing photovoltaic (PV) technologies to increase efficiency. This includes exploring new materials such as perovskites with high light absorption and conversion capabilities. Additionally, multiple solar cells can capture a wider range of wavelengths of sunlight, increasing overall efficiency. Applying anti-reflective coatings to the surface of solar panels helps reduce reflection and increase light absorption. These coatings minimize the loss of incident solar radiation and increase the efficiency of solar panels. CSP systems use mirrors or lenses to concentrate sunlight onto a smaller area, greatly increasing the intensity of light hitting the solar panels. This concentration enables higher energy conversion and improves solar efficiency. Adjusting the tilt angle and using solar panel tracking systems can optimize their orientation to the sun throughout the day. By maximizing the sunlight hitting the panels, more energy can be extracted, leading to improved efficiency. Thin film solar cells offer flexibility and lightweight properties. Ongoing research focuses on increasing the efficiency of thin-film technologies such as amorphous silicon (a-Si), cadmium telluride (CdTe) and copper-indium-gallium selenide (CIGS) to be competitive with traditional crystalline silicon cells. Various light-trapping techniques, such as textured or nanostructured surfaces on solar cells, increase light absorption by increasing the path length of photons in the material. These techniques reduce light reflection and transmission, leading to improved solar efficiency. Quantum dots are nanoscale semiconductor particles that can be used in solar cells to improve the absorption of light over a wider range of wavelengths. Quantum dot solar cells have the potential to increase efficiency and reduce manufacturing costs. Combining solar panels with other energy conversion technologies, such as thermoelectric or concentrated photovoltaics, can improve the overall efficiency of the system. Hybrid systems can use different parts of the solar spectrum and capture waste heat to generate additional energy. Continuous advances in solar panel design, such as reduced shielding, reduced resistive losses, and improved interconnection schemes, contribute to increased overall efficiency. Regular maintenance and cleaning of solar panels ensures optimal performance. Removing dust, dirt and other obstructions from the surface of solar panels improves light absorption and maintains efficiency. It's worth noting that while improving solar efficiency is key, it's equally important to consider the overall cost-effectiveness and sustainability of these improvements. Balancing efficiency improvements with affordability and environmental considerations is key to advancing solar energy.

Integration and design:

Integrating solar panels into the vehicle's structure, such as the roof, hood, or body panels, can improve the aesthetics and practicality of solar-powered EVs. Streamlining the design and optimizing the placement of the solar panels will allow for maximum solar exposure while considering safety, aerodynamics and weight distribution. Integration into structures: Solar cells can be integrated into the structures of buildings, vehicles or other objects. For buildings, solar panels can be installed on roofs, facades or integrated into windows and skylights. In vehicles, solar cells can be built into body panels, roofs or other suitable surfaces. The seamless integration of solar cells into the construction of structures increases their functionality while maintaining visual appeal. Determining the optimal placement of solar cells is key to maximizing solar exposure. Factors such as orientation, tilt angle and shading affect the energy production of solar cells. Carrying out a detailed analysis of a site or object to identify the most advantageous location can help achieve higher energy production. Designing solar cells to be visually appealing is important, especially in applications where aesthetics are a priority. Researchers and designers are exploring various options such as transparent solar cells, colored solar cells, or integrating solar cells with patterns or artwork. This allows the solar cells to blend harmoniously with the overall design and architectural elements. The integration of solar cells should not compromise the structural integrity of the object or building. The design should ensure that the integration does not weaken the structure or hinder its functionality. Proper bracing and engineering considerations are essential to maintain safety and durability. The wiring and connections of solar cells need to be carefully planned and integrated. This includes ensuring effective electrical connections between cells and incorporating suitable cable channels or conduits to conceal or protect electrical connections. Well-designed wiring and connections contribute to the overall reliability and efficiency of a solar system. The modular design allows for scalability and flexibility in the integration of solar cells. Using modular solar panels or cells simplifies the installation process and allows for easy expansion or replacement as needed. This approach makes it easy to maintain, repair and upgrade the solar system. Safety precautions must be considered when integrating solar cells. This includes proper insulation, protection against fire hazards, compliance with electrical codes and regulations, and clear marking of any potential hazards or high voltage areas. The design should consider accessibility for regular maintenance and cleaning of the solar cells. Easy access to solar panels or cells ensures efficient maintenance and maximizes their long-term performance. Effective thermal management is important for solar cells, especially in applications with high thermal environments. Incorporating cooling mechanisms or considering heat dissipation methods helps maintain optimal operating temperatures and increases overall efficiency. Close collaboration between designers and engineers is essential to achieve successful integration and design of solar cells. By combining their expertise, the design can achieve both functional and aesthetic goals while ensuring feasibility and practicality. Considering these factors during the integration and design process helps to optimize the efficiency, effectiveness and visual appeal of solar cells in various applications and promotes their wider adoption and use.

Energy storage:

Efficient energy storage systems are essential for the full utilization of solar energy. Advances in battery technology, such as high-capacity and fast-charging batteries, can enable better energy storage and utilization, allowing solar electric cars to operate even when sunlight is not available. Battery Management System (BMS): Implementation of an advanced BMS is essential for efficient energy storage in EVs. The BMS monitors and controls battery performance, including charging and discharging processes, temperature regulation, state of charge (SOC) and cell balancing. Optimizing BMS algorithms and control strategies helps maximize battery efficiency and lifetime. Implementation of intelligent charge and discharge control algorithms helps optimize energy storage efficiency. This includes consideration of factors such as charging rates, peak power management, regenerative braking and power delivery to various vehicle systems. Effective charging and discharging management strategies minimize energy losses and improve overall system efficiency. Proper battery thermal management is essential for efficient energy storage. Keeping the battery in the optimal temperature range (typically between 20-40°C) ensures efficient charging and discharging processes. Thermal management systems, such as cooling and heating mechanisms, prevent the battery from overheating or undercooling, increasing its efficiency and lifespan. Advances in battery technology, such as cells with higher energy density, are helping to improve energy storage efficiency. High energy density batteries offer increased energy storage capacity for a given weight and volume, allowing for longer driving range without significantly increasing weight or size. The development of fast charging technologies enables faster charging and shortens the time required to recharge the battery. Efficient fast charging systems minimize energy losses and increase overall charging efficiency. Research and development efforts are focused on increasing the performance of battery cell chemistries, such as lithium-ion, by exploring new materials and improving electrode designs. The goal of these improvements is to increase energy density, reduce internal resistance, and improve overall energy storage efficiency. Vehicle-to-grid (V2G) technology enables a two-way flow of energy between the EV and the grid. By integrating electric cars into the electric grid, excess energy stored in the vehicle's battery can be used during peak periods or to support grid stability. V2G integration optimizes the use of energy storage and contributes to overall system efficiency. Implementing energy recovery systems such as regenerative braking helps to capture and store energy that would otherwise be dissipated as heat during braking. This energy can then be used to recharge the battery, improving the overall efficiency of energy storage. Minimizing the weight of an electric car contributes to energy efficiency. Lighter vehicles require less energy to move, resulting in improved energy storage efficiency. The use of lightweight materials and optimization of vehicle design help reduce weight without compromising safety or structural integrity. The development of intelligent energy management systems that optimize energy flow and energy distribution in the vehicle increases the efficiency of energy storage. These systems consider factors such as driving conditions, user preferences, traffic patterns and available charging infrastructure to intelligently allocate energy and minimize energy losses.

Charging Infrastructure:

Expanding solar charging infrastructure, such as solar charging stations, can provide additional charging options and encourage the use of renewable energy. These stations could use excess solar power generated during the day to charge electric cars and contribute to the grid during peak demand. Fast charging stations: The deployment of fast charging stations, also known as rapid charging stations or rapid charging stations, is essential for an efficient charging infrastructure. These stations provide high power charging capabilities that significantly reduce charging times compared to standard charging stations. Fast charging stations enable fast charging of electric cars and thus increase the overall efficiency of the charging process. Ensuring that charging stations have sufficient power capacity is essential for an efficient charging infrastructure. Higher power levels enable faster charging and reduce the time required to recharge the battery. Upgrading charging stations to provide more power and increasing the availability of high-power charging options increases the efficiency of the charging process. Integrating the charging infrastructure with the electric grid and implementing smart charging systems optimize energy use and grid stability. Smart charging algorithms can take into account factors such as electricity demand, renewable energy availability and user preferences to intelligently schedule and manage charging sessions. This helps to balance energy supply and demand, minimize peak loads and make efficient use of renewable energy sources, improving overall charging efficiency. Ensuring a sufficient number of charging stations and their availability is key to an effective charging infrastructure. Building a well-distributed network of charging stations in urban areas, highways, workplaces and residential areas provides EV owners with convenient access to charging. The availability of charging stations in strategic locations reduces range concerns, optimizes travel routes and increases the overall efficiency of the charging process. Implementing user-friendly payment systems and seamless billing contributes to an efficient billing infrastructure. Easy and secure payment methods such as ATM cards, mobile applications or contactless payments streamline the charging process and increase user satisfaction. Additionally, providing real-time information on charging station availability, waiting times and charging rates helps users plan charging activities effectively. Implementing load management strategies and demand response programs enables efficient use of the charging infrastructure. These systems can dynamically manage the demand for energy from charging stations, considering network conditions, electricity prices and user preferences. Load management and demand response programs help balance the grid load, avoid peak charges and maximize the use of renewable energy sources, leading to improved charging infrastructure efficiency. Integration of charging infrastructure with renewable energy sources such as solar or wind power supports sustainable and efficient charging. This may include installing solar panels or wind turbines at or near charging stations to generate clean energy to charge EVs. The use of renewable energy sources reduces dependence on the grid and reduces the carbon footprint of the charging infrastructure.

Regular maintenance and monitoring of charging stations are essential for efficient operation. Monitoring systems can provide real-time status updates, detect failures and schedule proactive maintenance activities. Timely maintenance ensures optimal charging performance, minimizes downtime and increases the overall efficiency of the charging infrastructure. Designing charging infrastructure with scalability and future-proofing in mind helps accommodate the growing number of EVs and advances in charging technologies. This includes considering the possibility of expanding the number of charging stations, upgrading the power supply capacity and incorporating compatibility with emerging charging standards. A scalable and future-ready charging infrastructure ensures long-term efficiency and adaptability to changing market needs.

Technology integration:

The integration of advanced technologies such as energy management systems, artificial intelligence and vehicle-to-vehicle communication can optimize solar energy use, battery management and overall vehicle performance. Solar panels: Solar-powered electric cars are equipped with photovoltaic panels mounted on the surface of the vehicle that capture sunlight and convert it into electrical energy. Advances in solar panel technology, such as improved efficiency and flexibility, allow for increased energy production, even from smaller areas. BMS technology monitors and optimizes EV battery performance. Ensures proper charging, discharging and overall battery health. Advanced BMS systems can integrate with solar panels to control the flow of solar energy to the battery, prevent overcharging and maximize the use of available sunlight. Technological innovations in the field of energy storage, such as high-capacity lithium-ion batteries, supercapacitors and solid-state batteries, contribute to the efficient use and storage of electricity produced by solar energy. These improvements increase the range, acceleration and overall performance of solar electric cars. Regenerative braking technology enables the conversion of kinetic energy generated during braking into electrical energy. This energy is then stored in the EV battery for later use. The integration of regenerative braking systems into solar-powered electric cars enables more efficient energy capture and a longer range. Solar EVs equipped with V2G features can not only charge their batteries using solar energy, but also feed excess energy back into the grid during peak periods. This integration facilitates the stabilization of the grid and allows the owner of the electric car to earn by selling excess energy. Solar electric cars can use connected car technology to improve the overall driving experience. Integration with smart devices and apps enables remote monitoring, control and management of various vehicle functions, including solar charging status, battery status and climate control. In addition, the connectivity facilitates over-the-air software updates and ensures that the vehicle's systems are up-to-date. ADAS features such as adaptive cruise control, lane keeping assist and collision avoidance enhance the safety and convenience of solar-powered electric cars. These systems use sensors, cameras and artificial intelligence algorithms to assist the driver, increase efficiency and reduce the risk of accidents. Solar-powered EVs can use telematics systems to collect and analyze data related to energy consumption, charging patterns and driving behavior. This information can be used to optimize the vehicle's solar charging strategy, improve efficiency and provide personalized information to the driver. These are just a few examples of how technology integration can improve solar electric cars. As technology continues to evolve, more advancements are likely to emerge that will lead to the growth and adoption of sustainable transportation solutions.

Policy support:

Governments and policymakers play a key role in encouraging the adoption of solar-powered EVs through supportive policies such as tax breaks, subsidies and infrastructure investments. Clear regulations and standards can support the research, development and deployment of solar-powered electric cars. Financial incentives: Governments can provide financial incentives to encourage the adoption of solar-powered electric vehicles. This may include tax credits, rebates, grants or subsidies for the purchase of solar panels, EVs or related charging infrastructure. Financial support can help offset the higher initial costs of solar EVs and incentivize consumers and businesses to make the switch. Policies should focus on the deployment of a robust network of charging infrastructure that supports solar-powered EVs. This includes investing in the installation of charging stations, both in public places and in residential areas, including provision for solar charging stations. Policies may include regulations that mandate the inclusion of solar charging infrastructure in new developments or require existing infrastructure to accommodate solar charging capabilities. Governments can allocate funding for research and development initiatives aimed at advancing solar electric vehicle technologies. This includes supporting research into more efficient solar panels, battery technologies, energy management systems and integration with the electricity grid. By supporting innovation, policymakers can drive technological progress and improve the overall efficiency and performance of solar-powered EVs. Governments can lead by example by incorporating solar-powered EVs into their own fleets. The implementation of policies that prioritize the acquisition of solar-powered EVs for government agencies, public transportation systems, and other public sector entities can create a demand-pull effect, support market growth, and stimulate the production of solar-powered EVs. Policymakers should put in place clear and supportive regulations to encourage the adoption of solar-powered EVs. This includes streamlining permitting processes for solar panel and charging station installations, ensuring fair and transparent net metering policies, and removing barriers to solar and EV integration. Well-defined regulations can provide certainty and encourage investment in solar EV infrastructure. Policy makers should invest in public awareness campaigns to educate consumers, businesses and fleet operators about the benefits of solar electric cars. This includes disseminating information about cost savings, environmental benefits and available incentives and support. Increased awareness can stimulate consumer demand and create a favorable market environment. Policymakers should work with industry stakeholders, including car manufacturers, solar panel manufacturers, utilities and EV charging infrastructure providers, to develop policies that align with industry needs and goals. Engaging in dialogue with key stakeholders ensures that policies are well informed and support the growth of solar EVs. By implementing these strategies, policymakers can create a supportive environment for solar electric vehicles, drive their adoption, and contribute to the transition to sustainable transport and the integration of renewable energy.

Conclusion

While solar-powered EVs face some limitations, such as limited power generation from solar panels and the need for supplemental charging, continued advances in solar technology, energy storage, and infrastructure are expected to address these challenges. As renewable energy sources gain importance, the integration of solar power with EVs offers a promising path to a sustainable and clean future of transportation., solar-powered electric vehicles (EVs) have enormous potential as a sustainable transportation solution that can reduce greenhouse gas emissions and fossil fuel dependence. This work explored the integration of solar technology into EVs and highlighted the advances and benefits it offers. By harnessing the sun's energy, solar panels on EVs can generate clean, renewable energy to charge the vehicle's batteries, extending their range and reducing grid dependency. During the work, we discussed various aspects of technology integration in solar-powered electric cars, including advances in solar panel efficiency, battery management systems, regenerative braking, vehicle grid integration, and connected car technology. These advances, combined with financial incentives and support policies, can accelerate the adoption of solar-powered EVs and contribute to a more sustainable and greener transport sector. The work also highlighted the importance of political support for solar-powered electric cars. Effective policies should focus on developing charging infrastructure, promoting standardization and interoperability, supporting research and development, facilitating fleet electrification, enacting supporting regulations and raising public awareness. By implementing these policy measures, governments can create an enabling environment that will support the widespread adoption of solar-powered electric vehicles. While solar-powered electric cars are not without challenges, such as limited charging capacity and the intermittent nature of solar power, technological advances and supportive policies can help overcome these obstacles. Continued research and development efforts, coupled with collaboration between industry stakeholders, will drive innovation and further increase the efficiency and performance of solar-powered EVs. Solar powered electric vehicles have the potential to revolutionize the transportation industry and offer a sustainable and renewable energy solution. Through technological integration and well-thought-out policy support, solar-powered electric cars can pave the way for a greener and more sustainable future, reducing carbon emissions and mitigating the effects of climate change.

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