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DESIGN AND IMPLEMENTATION OF PV SYSTEM FOR ELECTRIC VEHICLE

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Abstract— A plug-in electric car fueled by solar energy is a low- maintenance vehicle. The primary disadvantage of electric cars is their short range. The battery of the vehicle may be charged while it is in motion by installing a solar PV panel. Mechanical components like the gearbox and differential are not used here. Direct drive to the wheels enables effective driving.

We looked at the E-vehicle's working theory. We observed that BLDC (brushless DC) motors are typically used to power electrical vehicles. Currently, a lead-acid battery-provided DC source of 48v 39Ah powers this BLDC. This battery will be charged by being connected to a standard wall socket (220-230 V AC supply) and a battery charger. Because there are so many of these kinds of cars on the market, the effects of this practice result in a need for loading.

Keywords- BLDC, Solar PV, MPPT Charge controller, Battery, Differential Axle

1. INTRODUCTION

Automobiles are used to move everything around the globe. For cars, a significant amount of fossil fuel is burned. In fact, it would be amazing if we could keep using our automobiles without having to spend billions of dollars a year on fossil fuels and cope with the environmental problems that their combustion leaves behind. We require a replacement given the accessibility and pollution of fossil fuels. Electric vehicles are the ideal replacement because they don't pollute the environment. The key barrier is the amount of electric power that can be stored; the ride is limited by the battery's capacity. By incorporating solar power into cars, this storage problem can be solved.

The vehicles can be equipped with PV panels so they can be charged while they are moving, extending their range. That automotive fantasy would come true if we could travel in a solar-powered vehicle. Solar panels on solar cars would be used to collect energy from the sun. Solar cells, also known as photovoltaic cells, are solid-state devices that can directly convert solar energy into electrical energy through quantum mechanical transitions. A solar panel is a bundled, connected

assembly of solar cells

They produce no noise or pollution, have no revolving parts, and require no maintenance. The battery that powers the car's motors would then be fueled by the electricity thus produced.

Unlike a single motor operation our vehicle is driven with two motors which are placed at the wheel hubs. By these mechanical parts like gearbox clutch drive axles can be eliminated, so the regular mechanical maintenances are not required.

2. LITERATURE SURVEY

Utilizing clean and renewable energy has become a critical issue as the world's environmental issues become more serious. Vehicles are a necessary part of contemporary society's transportation system, but they are also one of the biggest producers of pollution. It is almost impossible to reduce the number of automobiles because of their status. The electric car is one way to reduce pollution. Overall, compared to a fossil fuel- powered car, an electric vehicle is more energy-efficient, ecologically friendly, and clean. [1]

An electrically powered vehicle has essentially three majors' electrical components. These include energy source (usually are chargeable battery bank), an inverter or, motor controller and an electric motor. In the case of a solar car, the energy source is typically a bank of batteries, which may be recharged by photovoltaic solar panels. The motor controller is typically a power electronics device which when supplied with the driver's input commands, controls the torque and speed of the electric motor [2]

The solution is PVEV is supported with a charging cable that plugs in to the vehicle and into a 230v wall socket. The electric vehicle has a built- i n features like security system, Seatbelt Detection system, Collision detection. [3]

Hence, by incorporation of the solar photovoltaic panels, the range of the Battery powered cars can be increased. Electric vehicles are currently emerging in the present market and the automobile industry is investing a lot of their R & 0 resources for the development of electric solar vehicles. These are the future of zero carbon emissive car transportation. The present work aims to develop a model of plug-in electric solar vehicle and discusses the design parameters of these vehicles to come in the market. [4]

3. DESIGN CALCULATIONS

Total Mass of electric vehicle: 455kg

- Weight of Chassis: 100kg
- Solar Panel: 21kg
- Battery: 64kg
- Person weight: 200kg

- Other: 70kg
- Standstill or Initial velocity of EV: 0
- Max velocity: 30km/hrs
- Time requires reaching max velocity: 3 minutes

3.1 Selection of BLDC Motor Calculation:

- Load Calculation I = 22A

V = 48

P = 900w

N = 2700 RPM

Pole = 8

•Terminal Resistance:

V = I*R

R = V/I = 48/22 = 2.18Omega

3.2 Selection of Lead-Acid Battery:

- Voltage = 48v
- Amp/hrs. = 60
- Rated watt-hour Capacity
- Rated Ah Capacity * Rated Battery Voltage.

= 60*48

= 1908 watt-hour

Charging Current = 15% of rated ampere hour

= 60 × 15 /100

= 6 Amp

Charging time = Ampere hour rating/ charging current

- Torque:

P = (2pi*NT)/60

900 = (2pi * 2700T)/60

= 60 /6 = 6.66 hr.

- Total Load of vehicle in watt = 624-WATT

T = (900 * 60)/ (2pi * 2700) = 3.18NM

- Output power:

W = (2pi * 2700)/60 = 282.74 rad/sec

Pout =T* W= 3.18*282.74= 899.12 watt

- Efficiency:

Pin = V x 1 = 48 x 22 = 1056 watt

% eta = (Pout)/(Pin) = 899.12/1056 * 100

= 85.15%

Pout Pin x 1056 x 0.8514= 899.12 watt

- Watt Hour = Load in watt x time

= 624 x 6.67

= 4155.08 Watt-hour

Kwh = Watt hour rating/1000

= 4162.08/1000 = 4.15 kWh

- 1 kwh = 1 Unit
- 4.15 kwh 4.15 Unit
- The unit consumed to charge battery per day =4.15 Unit

- So, cost required per day charging is 4.15 x 12= 49.80 Rs
- The unit consumed to charge the battery per month = 4.15x 30=124.5 unit
- The unit consumed to charge the battery per year=124.5 x12=1494.6 unit
- Full Load Current = 22 Amp In one charging distance travelled by vehicle
- In one charging distance travelled by vehicle= Ampere hour rating of battery/Full load current

= 60/22

= 2.72 Hrs.

- Distance travelled in one charging = 2.72 x Max. Speed

= 2.72 * 30

= 81.6 Km

3.3 Selection of Motor Controller Specification:

- Rated Voltage: 48 volts
- Peak Protection Current: 50 amp
- Rated Power:1000 watts
- Under-voltage protection: 42 volts Throttle voltage: 1 volt to 4.5 volts
- Phase commutation angle: 120 degree C
- Break de-energize: High Heat dissipation: Natural cooling provided
- Ambient temperature: 20 to 60°C

3.4 Specification of Digital Meter

- It gives indication of battery, indicators, park light
- Indicate speed of Vehicle.
- Input Voltage= 12v

4. PROPOSED SYSTEM

The proposed vehicle is not a complex one. It is very

Simple

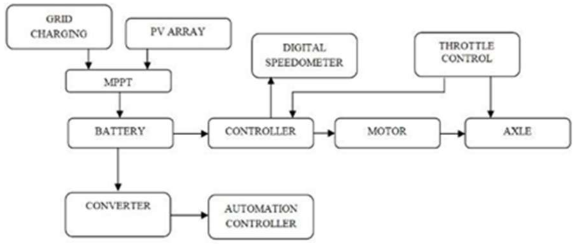

Fig 1. Basic Block diagram

A common accelerator is used for triggering both of the controllers. Brake switches will turn off motors while brake is applied. One of the motors will turn off while turning the vehicle to opposite to the motor position. The vehicle needs wires are interchanged for reversing. Reversing switch is mounted on steering column. In construction compared to Fueled vehicles. Electric Fig. 1 displays the design of the vehicle. System mainly consists of two motors controllers, reversing circuit, battery pack, and solar PV module with charge controller and an accelerator.

The battery, which can be charged using either a solar panel or a plug-in charger, serves as the main energy storage device for this solar-powered electrical vehicle. It has a motor controller to monitor a number of things, such as temperature, voltage, and speed. Other electrical equipment in a car can be powered by the battery packs by using a DC converter, which lowers the input voltage from the battery pack to a lower voltage, such 5V.

5. HARDWARE COMPONENTS

A. ACCELERATOR

Accelerator is used to trigger the motor controllers. Here we use a cable to attach accelerator pedal to accelerator circuit mechanically. Accelerator consists of a Hall Effect sensor and a magnet. An accelerator is shown in fig .2

C. DIFFRENTIAL AXLE

A vehicle with two drive wheels has the problem that when it turns a comer the drive wheels must rotate at different speeds to maintain traction. The automotive differential is designed to drive a pair of Wheels while allowing them to rotate at different speeds. The size of differential axle is 33" (33 inches).

Fig 2. Accelerator

D. BLDC Motor

Fig 4. Differential Axle

The two wires are for working voltage and other one is the switch wire through which Hall Effect sensor output is carried to motor controller

B. MOTOR CONTROLLER

The motor controller is the heart of the vehicle. All the electric parts of the vehicle are controlled by this. A BLDC motor controller is shown in Fig 3 It controls the speed of motor, breaking, battery voltage calculation, and speedometer.

Fig 3. Motor controller.

Regulator wire, speedometer wires, electrical accessory wire for lights, and wire to DC-DC converter. Motor controller consists of IGBT Switching transistors for controlling motor rotation.

Unlike a brushed DC motor, the commutation of a BLDC motor is controlled electronically. To rotate the BLDC motor, the stator windings should be energized in a sequence. It is important to know the rotor position in order to understand which winding will be energized following the energizing sequence.

Rotor position is sensed using Hall Effect sensors embedded into the stator. Most BLDC motors have three Hall sensors embedded into the stator on the non- driving end of the motor. Whenever the rotor magnetic poles pass near the Hall sensors, they give a high or low signal, indicating the N or S pole is passing near the sensors.

A brushless DC motor (BLDC motor) is an electronically commuted DC motor which does not have brushes. BLDC motor is shown in Fig .5.

Fig 5. BLDC motor.

E BATTERY PACK

The batteries are a vehicle's most important component. In order to get a working voltage of 48V in our Vehicle, four lead acid batteries are connected in series. Lead acid batteries are lighter and last three times as long as lead acid batteries. A single Lead acid battery is seen in Fig. 6.

Fig 6. Lead Acid Battery

F. SOLAR PV MODULE

The PV module is utilized in this instance to use solar power to charge the vehicle while it is operating. Polycrystalline solar cells are used here. In general, polycrystalline solar panels are less efficient than monocrystalline ones. Additionally, polycrystalline solar panels often have a blue tint rather than them on crystalline panels' black color.

Polycrystalline solar panels are also made from silicon. However, instead of using a single crystal of silicon, manufacturers melt many fragments of silicon together to form the wafers for the panel. Polycrystalline solar panels are also referred to as “multi-crystalline” or many-crystal silicon. Because there are many crystals in each cell, there is to less freedom for the electrons to move. As a result, polycrystalline solar panels have lower efficiency ratings than mono crystalline panels, but their advantage is a lower price point. Solar PV module is shown in figure 7. Polycrystalline solar panels tend to have slightly lower heat tolerance than mono crystalline solar panels.

Polycrystalline solar panels will tend to have a higher temperature co-efficient than solar modules made with mono cells. This means that as heat increases, output for this type of cell will fall. However, in practice, these differences are very minor.

Fig 7. Solar PV Module.

Panel Specification:

- Rated pick power Pmax: 300 watts
- Rated voltage Vmp: 36.14volt
- Rated current: 8.31Amp
- Open Circuit Voltage: 44.46 Volt
- Short circuit Current: 8.74Amp
- Panel Weight: 21 Kg

G CHARGE CONTROLLER

An electronic DC to DC converter called an MPPT, or maximum power point tracker, enhances the compatibility of the PV array (solar panels) with the battery bank or utility grid. The MPPT solar charge controller is shown in Fig. 8.

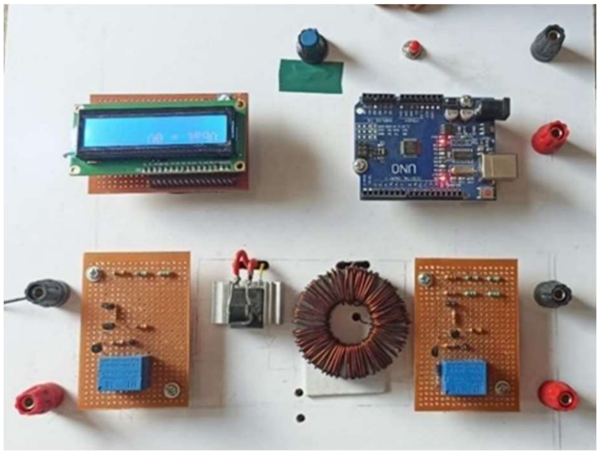

Fig 8. MPPT Charge Controller.

To put it simply, they convert a higher voltage DC output from solar panels down to the lower voltage needed to charge batteries. The charge controller looks at the output of the panels and compares it to the battery voltage. It then figures out what is the best power that the panel can put out to charge the battery. It takes this and converts it to best voltage to get maximum AMPS into the battery. Most modern MPPT's are around 93-97% efficient in the conversion. You typically get a 20 to 45% power gain in winter and 10-15% in summer. Actual gain can vary widely depending weather, temperature, battery state of charge, and other factors.

Fig 9. Prototype of Solar Powered Plug-EV

6. WORKING

The BLDC motor is driven by an electronic drive which switches the supply voltage between the stator windings as the rotor turns. The rotor position is monitored by the Hall Effect sensor which supplies information to the electronic controller and based on this position, the stator windings to be energized is determined. These electronic drives consist of IGBTs (2 on each phase) which operate motor drive.

A Hall Sensor is implanted on the stator to determine the position of the rotor. The hall sensor detects the location as the motor rotates and generates a high or low signal depending on the magnet's poles. Microelectronic devices use control voltage and have a variety of high-tech options. A microcontroller might be used to achieve this.

For a BLDC motor to operate at the correct rate, speed control is crucial. The input DC voltage may be changed to alter the speed of BLDC motors. The speed increases with increased voltage. PWM model changes the input voltage of the armature when the motor is operating normally or when it is operating below its rated speed. The flux is decreased by increasing the exciting current when the motor is run over its rated speed.

In this system, the third motor terminal is always electrically isolated from the power supply, and current is regulated through the motor terminals one pair at a time.

THREE Hall devices embedded in the motor are usually used to provide digital signals which measures rotor position with 60- degree sectors and provide this information to the motor controller. This approach can only create a current space vector with one of six possible directions since, at any one moment, the currents in two of the windings are of identical magnitude and the third is zero.

- Simulation MPPT

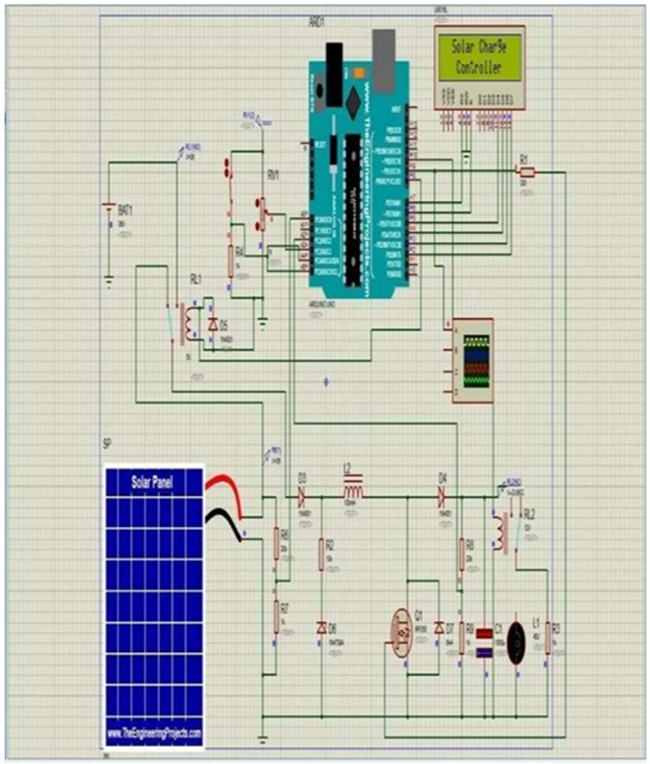

Fig 10. Proteus Simula

A boost converter is a type of DC-DC converter that can both step up and step down the voltage level of a DC input. The circuit is typically composed of an inductor, a switch (usually a MOSFET or a BJT), a diode, and a capacitor. There are many circuit simulation software packages available, such as LT Spice, Spice, and Simulink. Choose one that you are familiar with and that supports switching circuits. Use the schematic editor in your chosen software to draw the buck-boost converter circuit. Refer to the standard buck-boost converter circuit diagram to make sure you have connected the components correctly. Assign the values to the inductor, switch, diode, and capacitor. The standard values or calculate them based on your specific requirements. Set the input voltage of the boost converter to the desired level.

The frequency at which the switch will be turned on and off. This frequency can be calculated based on the values of the inductor and capacitor. To simulate the circuit and run the simulation and observe the output voltage and current waveforms. You can also observe the behavior of the inductor and capacitor during each switching cycle. Analyze the results Based on the simulation results, you can analyze the efficiency, stability, and overall performance of the boost converter. If necessary, you can modify the circuit by changing the component values or switching frequency to optimize its performance.

These types of motors are highly efficient in producing a large amount of torque over a vast speed range. In brushless motors, permanent magnets rotate around a fixed,armature and overcome the problem of connecting current to the armature. Commutation with electronics has a large scope of capabilities and flexibility.

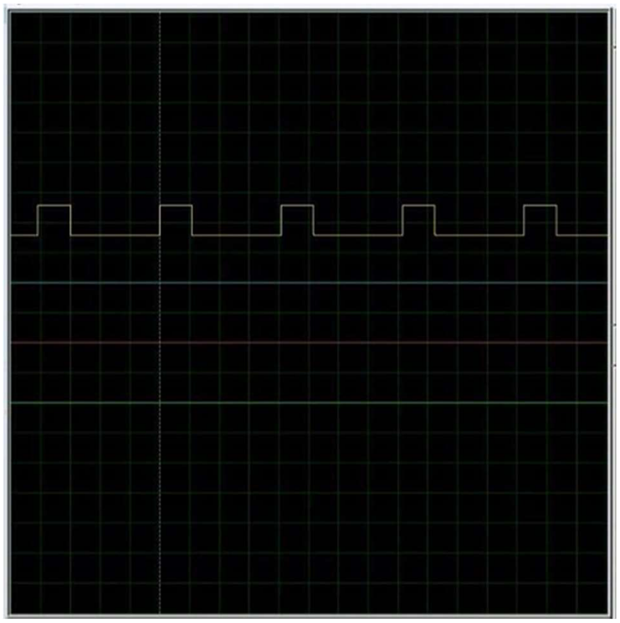

Fig 11. MPPT Voltage waveforms

The current waveform is shown in fig.11.Each winding therefore a staircase from zero, to positive current, to zero, and then to negative current. This produces a current space vector that approximates smooth rotation as it steps among six distinct directions as the rotor turns.

The controller provides pulses of current to the motor windings which control the speed and torque of the synchronous motor.

OPERATION:

Fig.12 shows the current and Voltage Waveform of the MPPT. The power point trackers usually operate like a Buck converter to charge the battery. They take DC input from the panel, change it to a high-frequency square-wave by a transformer (usually a toroid). Then again it is rectified to the desired DC level required by battery followed by an output regulator. The advantage of high-frequency circuit is that losses are less.

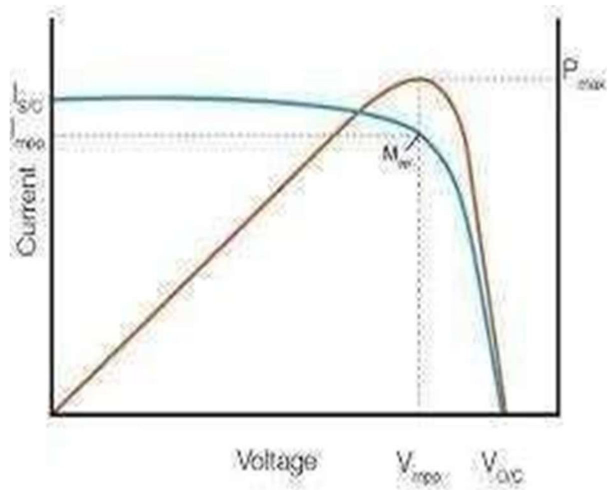

Fig 12. Current and Voltage Waveform of the MPPT

- **Testing Results of Vehicle**

Table.1 Vehicle weight and speed

Weight	Speed
No load	46kmph
With one Passenger (60)	36kmph
With Two Passenger	28kmph

- MATLAB Simulation MPPT Controller

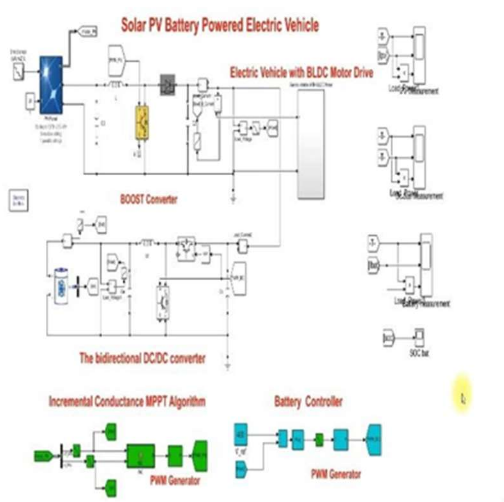

Fig 13 Matlab Simulation

- MATLAB Simulation Result

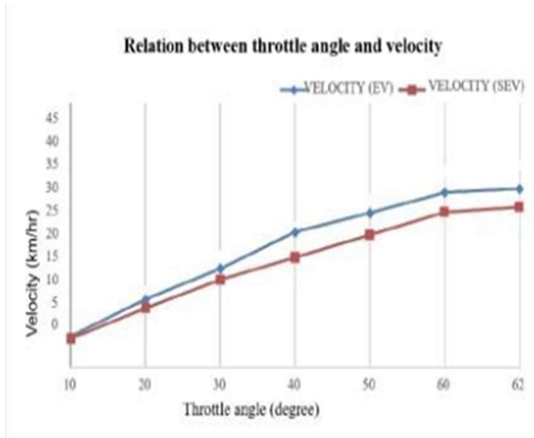

Fig.14 Relation between throttle angle and Velocity

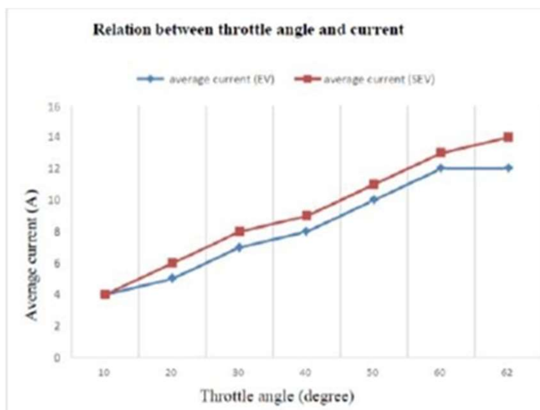

Fig 15. Relation between throttle angle and Current

Fig .14 shows the relation between throttle angle and Velocity line graph. The real performance testing take place in this segment. It contains an overview of the functionality of electric vehicle and solar assisted vehicle the graph and statistics obtained indicate that the electric trikes performance changes when solar assistance system is installed. Whether about 21kg of weight are added the vehicle the solar assistance systems velocity reduces, but the vehicles torque, power, and current all increase at the same throttle angle whether moving forward and backward.

Fig.15 Shows the relation between throttle angle and current the gathered data together with the graph, indicates that the power drawn, the RPM, and the current rise linearly with the throttle angle. All values get saturated at greater throttle angles. With no load at no load condition only 161w power is used from battery in forward and 44w in reverse condition at maximum throttle. The current consumption and the RPM of the motor is less in reverse condition then in forward direction.

- **Solar PV Battery Powered Electric Vehicle in MATLAB**

In today's world, the convergence of renewable energy and transportation has become increasingly important. As we strive for a sustainable future, solar PV battery- powered electric vehicles (EVs) have emerged as a promising solution. This article explores the integration of solar PV systems with EVs and how MATLAB, a powerful simulation and analysis tool, can be used to optimize their performance.

Solar PV battery-powered EVs represent a synergy between renewable energy and transportation. By harnessing the power of the sun through solar PV systems, we can generate clean energy to charge EVs, reducing our dependence on fossil fuels and mitigating greenhouse gas emissions. This combination holds great potential for a greener and more sustainable future.

- **Solar PV Systems**

Solar PV systems convert sunlight directly into electricity through the photovoltaic effect. These systems consist of several key components, including solar panels, inverters, charge controllers, and batteries. Solar panels are made up of solar cells that absorb photons from sunlight and convert them into electrical energy. Inverters convert the DC power produced by solar panels into AC power, which can be used to charge the EV or supply electricity to the grid. Charge controllers regulate the charging process and prevent overcharging or discharging of the batteries.

- **Electric Vehicles (EVs)**

EVs are vehicles powered by electric motors, drawing energy from rechargeable batteries instead of internal combustion engines. They offer numerous advantages, including reduced carbon emissions, lower operating costs, and quieter operation. EVs can be categorized into different types, such as battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). Their adoption is crucial in achieving sustainable transportation and combating climate change.

- **Integration of Solar PV and EVs**

The integration of solar PV and EV technologies brings forth several benefits. Firstly, it enables EV owners to charge their vehicles with clean, renewable energy, further reducing their carbon footprint. Additionally, excess solar energy generated during the day can be stored in batteries and utilized for EV charging during non-sunlight hours. This integration promotes self- sufficiency and energy independence.

However, there are challenges to consider when integrating solar PV and EVs. Variations in solar irradiance and weather conditions can impact the charging efficiency and availability of solar energy. Additionally, the power requirements of EV charging stations and the charging patterns of EVs need to be carefully analyzed and optimized. MATLAB provides powerful tools for addressing these challenges and optimizing the performance of solar PV battery-powered EVs.

- **MATLAB for Solar PV and EV Analysis**

MATLAB, a high-level programming language and environment, offers extensive capabilities for simulating, Analyzing, and optimizing solar PV and EV systems. With MATLAB, researchers and engineers can model the behavior of solar PV cells, simulate the charging and discharging processes of batteries, and analyze the overall performance of solar PV battery-powered EVs.

The comprehensive features of MATLAB enable users to calculate the solar irradiance at a specific location, evaluate the energy generation of a solar PV system, and predict the charging time and range of an EV based on its battery characteristics and usage patterns. Additionally, MATLAB provides optimization algorithms that can be used to maximize the energy efficiency of solar PV battery-powered.

- **Simulation and Optimization of Solar PV Battery-Powered EVs**

MATLAB facilitates the simulation and optimization of solar PV battery-powered EVs by providing a range of tools and functions. Researchers can create mathematical models that capture the behavior of solar PV cells, battery systems, and EV charging processes. By inputting relevant parameters and real-world data, they can simulate and analyze the performance of solar PV battery-powered EVs under various conditions.

Optimization techniques available in MATLAB allow researchers to fine-tune the performance of solar PV battery- powered EVs. They can optimize factors such as Charging rates, battery size, and charging schedules to maximize energy efficiency, minimize charging time, and extend the driving range of EVs. This optimization process helps in achieving an optimal balance between solar energy generation, battery storage, and EV charging.

7. CONCLUSION

It is imperative to switch to a new source of energy, namely solar power, which would be a cheap, efficient, limitless, and, of course, environmentally friendly alternative to meet the rising fuel demands and the catastrophic environmental pollution caused by driving carbon-based vehicles. Electric cars fueled bysolar energy are safe since they lack hot exhaust systems or flammable gasoline. They produce no emissions and are also odorless, smokeless, and silent. Because they have fewer or no moving components, they are more reliable and can be effectively charged almost anywhere. It goes without saying that it is incredibly cost-effective. The solar-powered EV would gain support from end users, including businesses, college campuses,and theme parks. PVEV's technology contributes to the environment.

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