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Design & Development of Solar Electric Bicycle

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Abstract: *The rider of an E-bike can choose to rely on the motor completely, pedal and use the motor at the same time or pedal only (use as a conventional bicycle) The P.V. panels must be mounted and installed at the electric bicycle without compromising riding comfort ability. The concept of the solar energy is that a high torque motor will be put on the bicycle which will be generated by the solar energy. The solar energy will be absorbed by the portable solar panel to generate the power. The power that had been absorbed by the panel can be used directly by the motor if the power matches the power requirement. If not, the motor will use the power from a battery. When the bicycle was not in use during the day, the solar panel will charge the battery. The system will make bicycle operate more efficiently. So, this is where electric bicycle mainly came into picture. People need a green, health preserving, fast mode of transportation and E-bicycle gave it all. More than just being these things electric bicycles is also able to generate back electric power by the use of pedal power through regenerative mode of the motor used. There are many uses of an Electric Bicycle. Our Aim is to making a Cheapest Rate Electric Bicycle from Market Price.*

Keywords: E-mobility, Solar E-bicycle, lithium-ion Battery, Battery Pack, etc.

I. INTRODUCTION

Energy is one of the most vital needs for human survival on earth. We are dependent on one form of energy or the other for fulfilling our needs. One such form of energy is the energy from fossil fuels. We use energy from these sources for generating electricity, running automobiles etc. But the main disadvantage of these Fossil fuel is that they are not environmentally friendly and they are exhaustible. To deal with these problems of fossil fuels, we need to look at the non-conventional sources of energy. The increasing mobility has directly led to deteriorating traffic conditions, extra fuel consumption, increasing automobile exhaust emissions, air pollution and lowering quality of life. Apart from being clean, cheap and equitable mode of transport for short-distance journeys, cycling can potentially offer solutions to the problem of urban mobility. Many cities have tried promoting cycling particularly through the implementation of bike-sharing. Electric bikes use batteries as a source of energy; thus, they require a battery charger system which powered from the solar cells energy.

Main reason to identify the need of finding and modifying E-Bike is to overcome the issue of the pollution because of vehicles in metro towns urban zones is swelling uninterruptedly. Considering the all class of society it is not reasonable for all to purchase (scooters, mopeds or motorcycles). So, combining both issues, environmental progress supporting and economical affordable alternative would be the best solution. Typical parts of E-bike are Brushless DC Motor (Hub Motor), Throttle (Accelerator), Battery Storage (11.1 V - 20A), Chain Drive, if necessary, Frame and other common bicycle parts. There are two parts of electric bicycle as per their functions and working: Power on Demand and Pedal Assist.

The motor is activated by a throttle with power-on-demand, customarily handlebar-mounted as well as on general scooters or motorcycles. By pedaling electric motor can be controlled with pedal-assist. The pedal-assist augments the efforts of the rider when they are pedaling. The e-bikes are known as peddles have a sensor to identify the pedaling force, the pedaling speed, or both. Disabling the motor is the brake sensing action. Systems with E-bikes could open up their use to a broader audience. The potential for modal shift from fossil fuel powered transport modes would thus increase. Furthermore, a roof may be placed on top of the E-bike station that could serve as combined weather protection and provider of electric energy by installing solar panels on the roof.

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If the available solar energy is sufficient, it could for example keep the system off-grid which means that stations can be placed temporarily where needed, e.g., close to festival areas or sports events. Placing solar panels on station roofs would introduce solar energy in places that otherwise would not have been considered. An E-bike charged with electricity from the sun may be one of the most efficient means of transport there is. The main reason is because its mass is lower than a cars or a scooter's and thus less energy is required for propulsion. The second reason is that bio- fuels or regular cycling requires conversion of solar energy to chemical energy which is characterized by low energy conversion efficiencies relative a solar panel.

There are several E-bike pools around the world. Some have been running for a few years and some are recently started. To name a few there are: Go Bike in Copenhagen, Eneloop SANYO in Tokyo, Cycle U share in Knoxville and E-call a Bike in Stuttgart. Of those systems, two are coupled with solar panels, Eneloop SANYO and Cycle-U-share. This research aims to design and implement electric bicycle battery charging system with solar energy sources. It is necessary to develop an electric bicycle battery charging system with solar energy sources. While many researches have been done in this field but most of them were not successful as the environmental conditions, the road conditions etc. were different for every different region. In this research, we are going to study the important factors that affect the working conditions of the bike and produce an improved version of the solar e-bike.

An E bike uses rechargeable batteries which can travel up to 25 to 45 kmph. As a result, it is faster than the normal cycle to reach your destination quicker and in better shape. E-bike is an electric and power-assisted bike which is one of the fastest-growing technologies of the bicycle industry. This bicycle uses an electric motor to help you along. So, you can ride it like a normal bicycle, but with less effort. A pedal-operated E-bike is the most popular option.

1.1 Problem Statement:

To Design and develop a solar electric bike having a battery charging system with photo voltaic solar panels using Lithium-ion Battery (11.1V-20A) for carrying a load of a person (up to 100 kg) under numerous conditions.

1.2 Objectives:

1. To Design a mechanism to capture solar energy.
2. To develop of electrical system having 120V A.C. outlet when the solar energy is not in use.
3. To develop of mechanism to transfer motor energy to bike and an additional mechanism for storing regenerative type energy.
4. To Perform Testing of Solar E-bike (Mileage, weather conditions, Torque, speed, overall Efficiency).
5. To study and analyze various researches work done earlier related to e-mobility for different applications and road conditions. After that to finalize the further scope of work in the same field through literature survey.
6. To make CAD model of proposed setup considering e-vehicle application for light weight vehicle i.e., e-bicycle.
7. To finalize best suitable type of battery for proposed e-bicycle.
8. Simulated analysis of circuit connection for proposed e-bicycle with initial working parameters to know the behavior of various performance parameters i.e., variation of state of charge, current and voltage with respect to time.
9. Manufacturing of battery pack as per the energy and power calculations for proposed setup to do the experimental analysis.

1.3 Methodology:

The Electric Bicycle System is a system's project that incorporates different ways of charging a lithium-ion battery of the 120V AC wall outlet, solar power, and regenerative method which is used to power a B.L.D.C. motor

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running a bicycle. The purpose of the project is to show that it is possible and relatively simple, to build an electric bicycle. This project can be broken down into five separate categories: the lithium-ion battery, AC-DC boost converter, the solar panel, the motor, and the Fuzzy logic controller. This design can become very efficient, cost-effective, and one day mass-produced, especially in developing countries where automotive transportation is an impossibility.

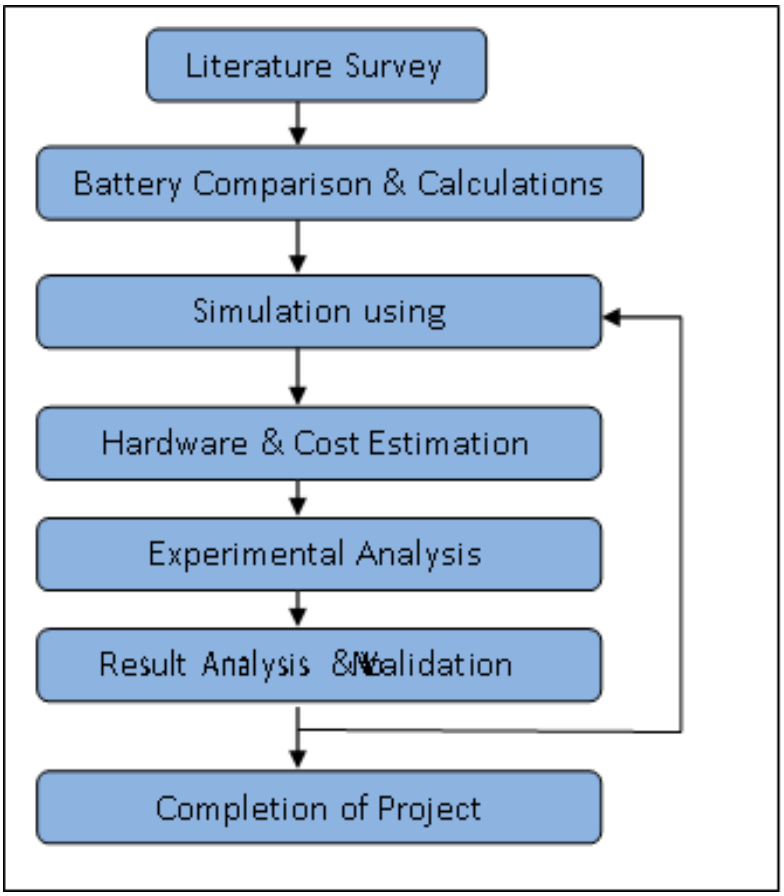

Figure 1: Methodology of the work

1.4 Scope & Proposed Idea of the Project:

Roughly, 30 per cent of the total passenger car fleet in India will be electric by 2040. The world is quickly adopting to electric vehicles and in the next couple of decades, EVs are going to be in more majority than I. C. engine vehicles. More locomotive industrialists are now allocating a rather large chunk of their resources towards the research and development of electric automobiles. The government of India had a plan of converting the entire fleet of vehicles to fully electric by 2030, which is barely 12 years away. But in January, 2018, it was sort of scrapped. If this actually happens, then India will be one of the largest markets for electric vehicles in the world, possibly only behind China.

In present project, our electric bicycle makes us of solar power and AC adapter as one of the energy sources. In future wind can also be used as a one of energy form by placing wind turbine at convenient place. Solar e-bike can be modified further and make it to use for physically disabled people. Even Solar e-bike can be digitized by advance sensors, etc. Gear variation system can also be implemented to increase torque and control speed.

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II. LITERATURE SURVEY

Table1: Summery of literature Survey

Sr. No	Author, Title and Publisher	Finding	Relevance with Project
1.	Georgia Apostolouet.al. in ICSTEM An Overview of Existing Experiences with Solar-Powered E- Bikes.	A typical e-bike can travel up to 25km/h, depending on the country's regulations, with motor power up to250 Watts, a battery of 24 V, 36V or 48 V, and capacity between 8.8 Ah to 15 Ah.	This paper presented research conducted so far on e-bikes and solar-powered e-bikes, as well as the main technical features of solar e-bikes. It also introduced the solar e-bike as a sustainable mode.
2	S. Adhisuwignj Et.al. in ICPEU Development of a Solar-Powered Electric Bicycle in Bike sharing Transportation System.	The fuzzy algorithm can be used as a controller in the process of charging in solar electric bike.	We can relate this with our project, as we can use fuzzy logic controller to keep the battery charging current in solar-powered electric bicycle.
3.	G. Srinivasa Rao Et.al. in JARDCS Design of Solar bicycle.	Previous models are rectified prototype and Required tests are carried out.	We further rectified this model and made various changes making more efficient model by use of li-ion battery.
4.	H. S. Upare Et.al. in (IOSR-JMCE). Design and Experimental Study of Solar Hybrid Bicycle.	The solar hybrid bicycle can be a very good application of renewable energy which will reduce pollution and can be useful device for villagers, where the provision of electricity is not adequate.	Multi charging vehicle can charge itself from both solar and AC power. Solar panels can be mounted on the backside of bicycle to capture the sun rays. When there is no presence of sun, AC current is use to charge battery. For controlling speed of the motor, an accelerator is given which controls the supply.
5.	C.Sivapragashet.al. I ICSTEM An innovative solar powered electric bicycle.	This paper shows the design of an electrical drive for a motorized bicycle is described, using commercial components available on the market. with proposed electric propulsion system using BLDC motor with sensory speed control along with smooth running operation is shown.	In this system an electric bicycle carries batteries that deliver electric power to a motor that is coupled to either wheel, the motor used here is brushless dc motor, it has high efficiency.
6.	Kartik S. Mishra et.al. in IJCET Design and development of Solar Hybrid bike.	They researched on the entire methodology of Solar E-bike.	This research paper gave us brief idea of components requirements, speed calculations, and Power requirements of Solar E-bike
7.	Fabian Fogelberg. et.al. in an overview of the energy system and the technical system design. Solar Powered Bike Sharing System with Electric Bikes.	Fabian Fogelberg's research was mainly focused on the efficiency of the solar power generation for solar energy in "Solar powered bike sharing system".	In this project, we are using photovoltaic panels. This Study by Fabian Fogelberg acknowledges us with various aspects of Solar panels and their efficient use in urban areas.
8.	Mr. Prashant Kadiet.al. in IJSRD Hybrid Powered Electric Bicycle.	These researchers mainly focus on hybrid electric vehicles and also made crucial comparison between all aspects of conventional and solar hybrid electric bike.	This research paper gave us an idea on the findings of solar e-bike till now and its future scope.

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III. PRPOSED SET UP AND TECHNICAL ANALYSIS

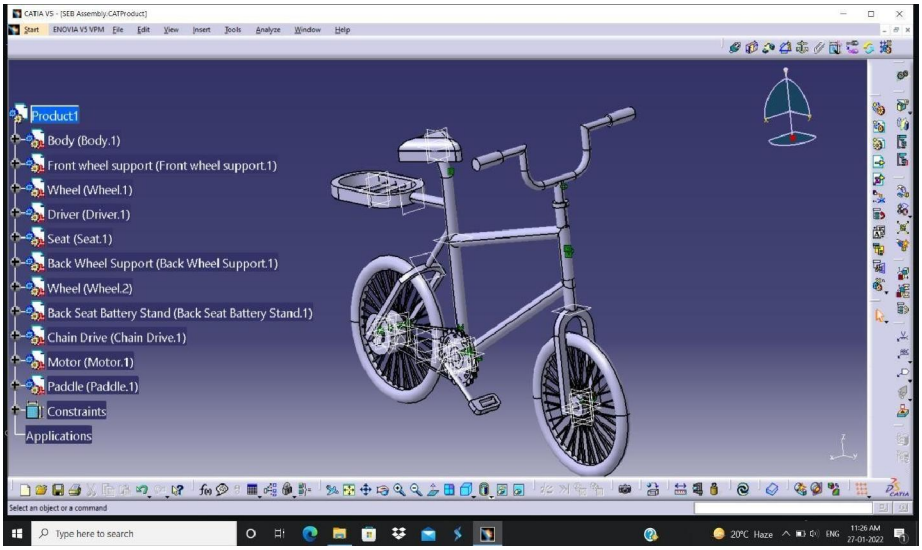

Figure 2: Proposed set up of hybrid cycle

Lithium-ion Battery:

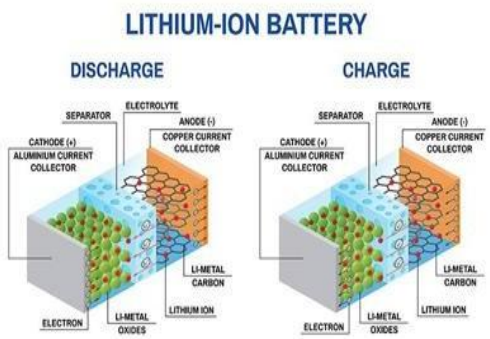

Figure 3: Working principal of li-ion battery

Figure 4: Structural configuration of Lithium-ion battery pack

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Lithium-ion Battery is rechargeable type of battery. Lithium-ion Battery is made up of anode, cathode, separator, electrolyte, and two current collectors (positive and negative). The negative and positive electrodes of a lithium-ion cell are made from carbon and metal oxide, respectively. The anode and cathode store the lithium. Separator is used to prevent physical contact between the anode and cathode. Lithium ions move from the negative electrode to the positive electrode during discharge and back when charged. Li-ion battery is lighter than other rechargeable batteries in view of battery capacity. It has longest life. It has highly efficient Charging. It has a high energy density along with a very small memory effect. It does not require maintenance. Its rate of self-discharge is much lower than that of Ni-Cd and Ni-Mh batteries. It is ideal for use in EBs due to its high energy efficiency. That's why we take Lithium-ion battery over the other batteries. Battery Pack:

Lithium battery pack technique refers to the processing, assembly and packaging of lithium battery pack. The process of assembling lithium cells together is called PACK, which can be a single battery or a lithium battery pack connected in series or parallel. The lithium battery pack usually consists of a plastic case, PCM, cell, output electrode, bonding sheet, and other insulating tape, double-coating tape, etc.

1. Lithium cell: The core of a finished battery
2. PCM (Protection Circuit Model) and BMS (Battery Management System): Protection functions of overcharge, over discharge, over current, short circuit, NTC intelligent temperature control.
3. Plastic case: the supporting skeleton of the entire battery; Position and fix the PCM; carry all other non-case parts and limit.
4. Terminal led: It can provide a variety of terminal wire charging and discharging interface for a variety of electronic products, energy storage products and backup power.
5. Nickel sheet/bracket: Connection and fixing component of the cell

Lithium Battery Assembly Process:

Cell Capacity Grading Voltage Internal Impedance Sorting and Matching Cell Spot Welding Welded PCM Battery Insulation Battery Pack Aging PVC Shrink Film Finished Product Performance Test Battery Code-spurting.

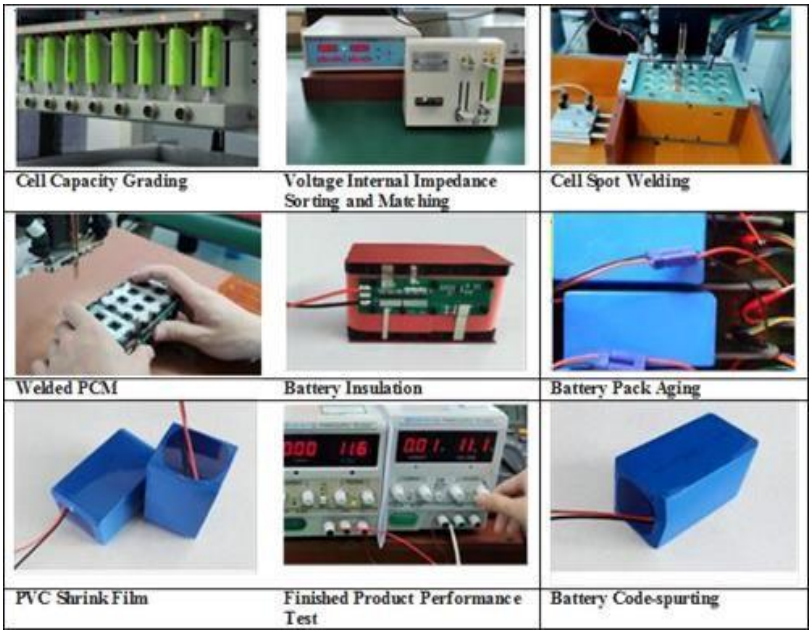

Figure 5: Battery pack manufacturing process

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Battery Management System (BMS) Cell Protection:

A BMS continuously monitors each cell's voltage. If the voltage of a cell exceeds the others, the BMS circuits will work to reduce that cell's charge level. This ensures that the charge level of all the cells remains equal, even with the high discharge (> 100Amps) and charge current (>10Amps). A cell can be permanently damaged if over-charged (over-voltage) or over-discharged (drained) just one time. The BMS has circuitry to block charging if the voltage exceeds 15.5 volts (or if any cell's voltage exceeds 3.9V). The BMS also disconnects the battery from the load if it is drained to less than 5% remaining charge (an over-discharge condition). An over-discharged battery typically has a voltage less than 11.5V (< 2.8V per cell).

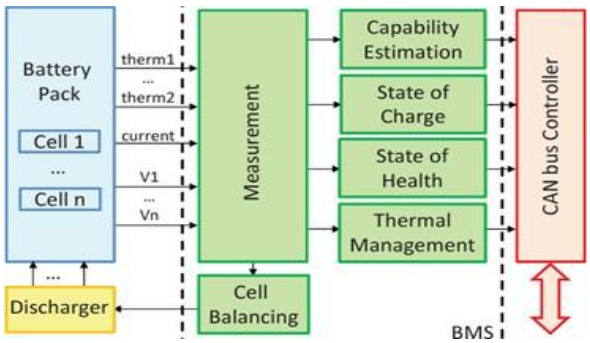

Figure 6: Battery Management System

Figure 7 BLDC Motor

Motor:

Basically, Two Types of electric motors used in electric vehicles:

- AC Motor
- DC Motor

Table 2: Comparative analysis of motors used in electric vehicle

Basic Parameters	AC Motor	DC Motor
Nature of Input Current	Alternating Current is the main input power.	Direct Current is the main input power.
Supply Sources	Three Phase or Single Phase	Energy is obtained from battery cells etc.
Number of Terminals	There are three input terminals RYB	There are two input terminals Positive and Negative.

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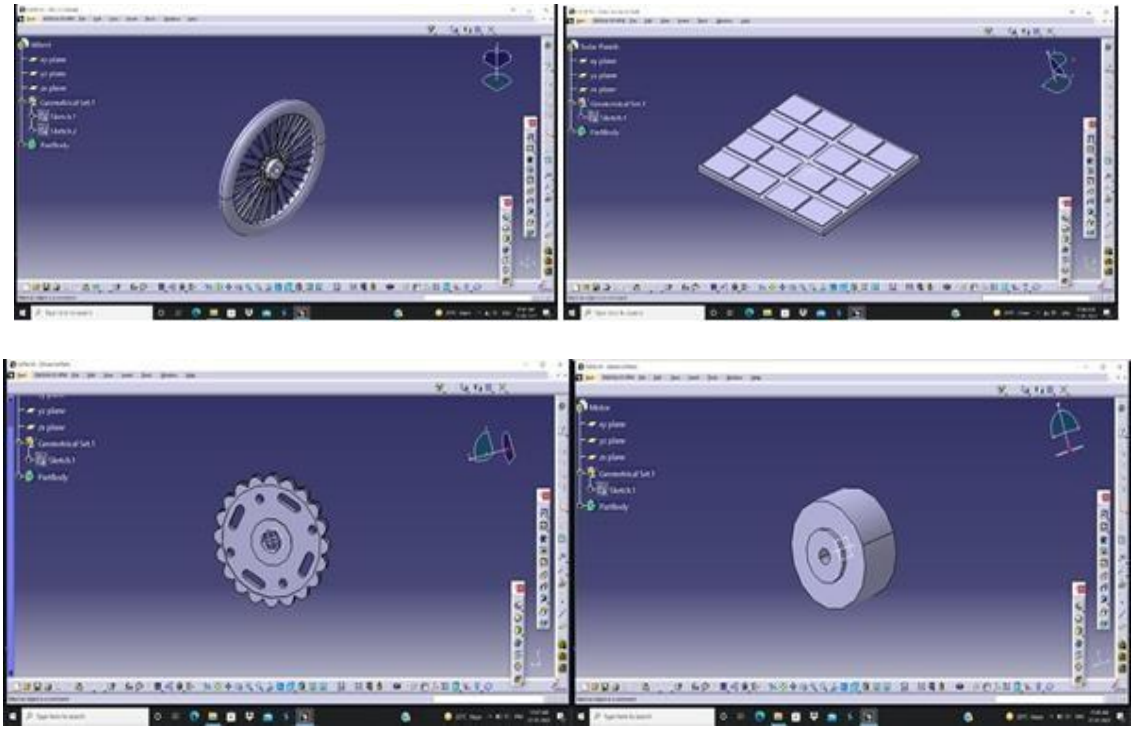
Carbon Brushes	There are no Carbon brushes.	There are Carbon brushes in DC Motor.
Applications	Suitable for large & industrial applications.	Suitable for small and domestic applications.
Starting	AC motor are not self-starting. It requires some external starting equipment's.	DC motor are self-starting equipment's.
Position of Armature	The Armature is Stationary and magnetic field rotates.	The Armature rotates while the magnetic field is stationary.
Maintenance	Less Expensive as compared to dc motor.	DC motor is more expensive.

The AC motor takes alternating current as an input, whereas the DC motor takes direct current. AC motors are known for their increased power output and efficiency, while DC motors are prized for their speed control and output range. DC Motor has the higher starting torque, quick starting and stopping, reversing ability. DC motors has variable speeds with voltage input. They are easier and cheaper to control than AC. That's why we take DC Motor over AC Motor. In DC Motor We take BLDC Motor because BLDC motor is best suitable for e-bicycle. BLDC Motor has longer life because no brushes are needed. It has high starting torque. BLDC motor has high efficiency over other motors. It has Noiseless operation. BLDC motor has high dynamic response. That's why we take BLDC Motor for our smart e- bicycle.

IV. SIMULATION AND EXPERIMENTAL ANALYSIS

CAD Modeling:

Table 3: Different models and steps of proposed modeling of e-bicycle



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Simulation

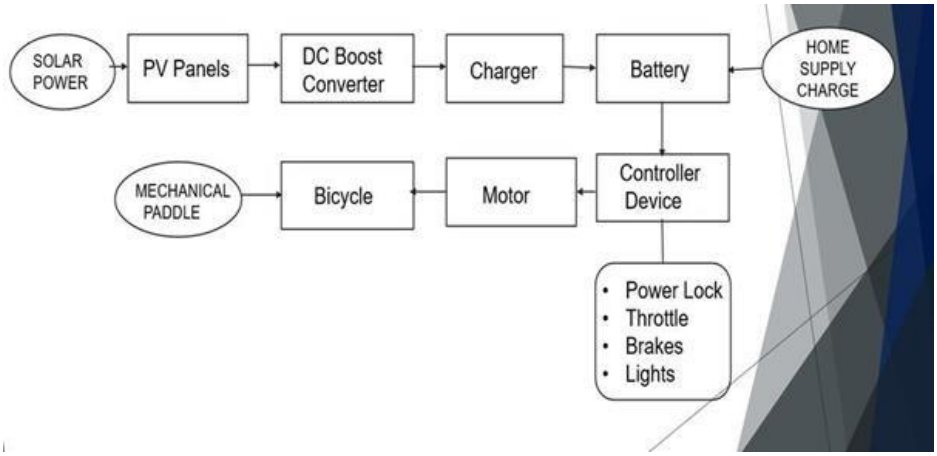

Figure 8: Block diagram of the Simulation

Table 4: Input Parameters for simulation

Vehicle Body Parameters	DC Motor Parameters	Battery Parameters
Mass - 100kg Number of wheels peraxle- 2 Horizontal distancefrom CG to front axle – 1.4m Horizontal distance from CG to rear axle-1.6m CG height above ground-0.5m Gravitational acceleration-9.81m/s2	Field type – Permanent Magnet Armature inductance-12e-6H No-load speed-10000 rpm Rated speed (at rated load) – 8000 rpm Rated load (mechanical power) – 250W Rated DC supply voltage – 25.1V	Nominal voltage(V) –25.1 Rated capacity (Ah) –10 Initial state-of-charge (%) – 100 Battery response time (s) – 15

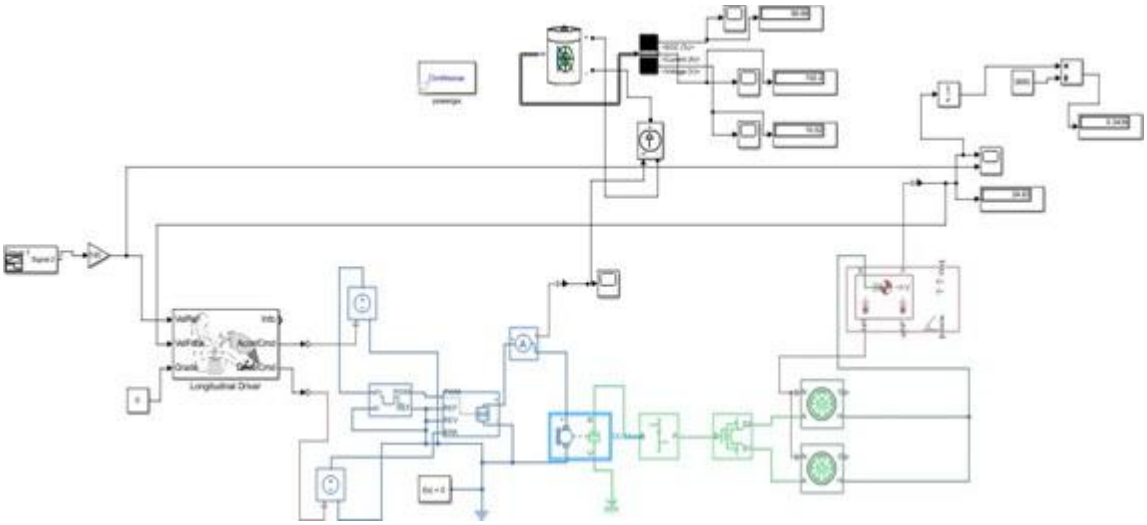

Figure 8: Battery based simulation circuit for electric vehicle

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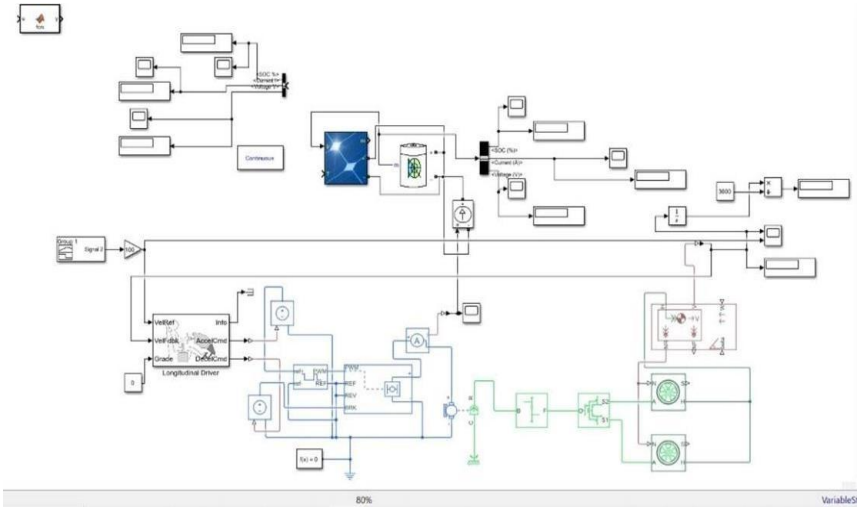
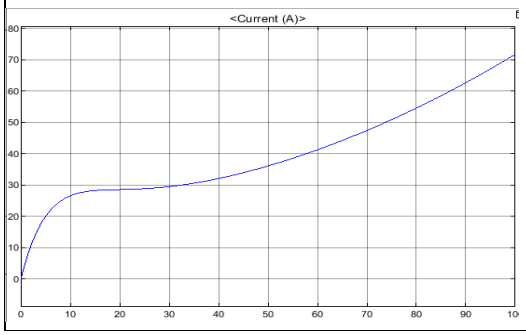
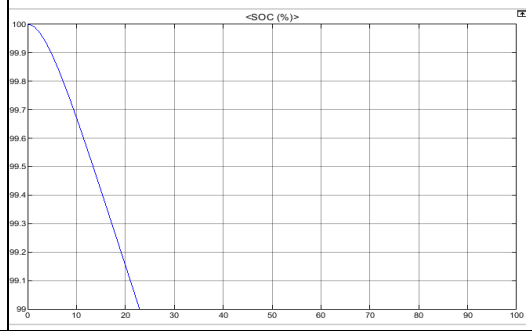
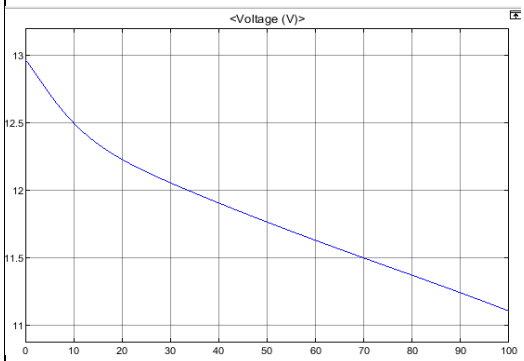
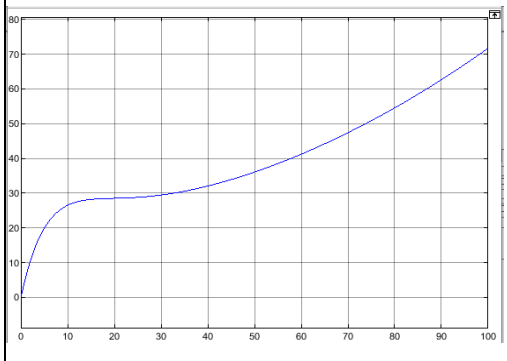


Figure 9: Simulation model of Electric Vehicle with HESS of Battery and solar panel

Results of Simulation:

Table 5: Results of Simulation model of Electric Vehicle with HESS of Battery and solar panel

SOC (%)	Current (A)
	
Voltage (V)	Speed (N)
	

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Experiential Analysis

Parts of Solar E-bicycle

***S*olar Panels:**

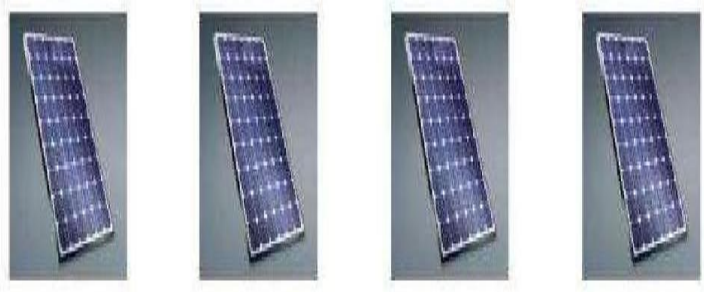

Figure 10: Solar panels used in HESS

Solar panels of 75 W capacities were selected due to space constraint. The solar panel is a photo-voltaic converter which works in bright sunlight and in diffused sunlight. The DC voltage booster keeps the voltage optimum for the battery to get charged even while the voltage falls below threshold in diffused sunlight. The blockage diode used in the charger prevents the reverse flow of current from the battery to solar panel.

Lithium-Ion Battery Specifications: Type- Rechargeable Battery Specifications-11.1V, 20Ah Individual cell type- 3.7V, 2.5A Connections- 3 series, 8 parallel.	**B.L.D.C. Motor specifications:** Specification-350Watt, 36Volt Rated Voltage: 36V No-load Current: 1A Rated Current: 7.5A Rated Power: 350W Rated Speed: 350W: 600rpm (20-30km/h about) Magnetic Pole Number: 15pairMotor Braking method: Drum/Disc Brake Motor efficiency: ≥ 83% Weight: 3.3Kg Shaft Diameter: 11.5mm (ROUND SIDE); 10mm (FLAT SIDE) haft length: 34mm Motor type: IP4 **BLDC Motor Controller:** Brushless Motor controller Specification- 36V-48V, 350W,16-18A Size: 10.3x7x3.5cm/4.06x2.76x1.38inch Suitable Motor Phrase Angle: 60 / 120-degree Item Weight: 280 g. Bicycle Wheel: Bicycle wheels are typically designed to fit into the frame and fork via dropouts, and hold bicycle tires. D = 66mm DC Adjustable converter Specifications- 6AInput: 10-32V Output: 12-35V
Arduino Board technical specifications: • Microcontroller: ATmega328 • Operating Voltage: 5V • Input Voltage (recommended): 7-9V • Input Voltage (limits): 6-20V • Digital I/O Pins: 14 (of which 6 provide PWM output) • Analog Input Pins: 6 • DC Current per I/O Pin: 40 mA • DC Current for 3.3V Pin: 50 mA • Flash Memory: 32 KB (ATmega328) (0.5 KB used by boot loader) • SRAM: 2 KB (ATmega328) • EEPROM: 1 KB (ATmega328) • Clock Speed: 16 MHz **Sensors** Blockage Diode Microcontroller-Atmega328 Voltage - 5V	
Input Voltage: 7-20V Digital I/O Pins -14 Memory -32 KB Clock Speed -16 MHz	**Other Accessories [Standard]** Throttle Break levers Sprocket Motor stand Ignition System Charger Multi-meter Cables, Nut, bolts, Miscellaneous.

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Working principle of solar e-bike

This Solar bicycle is a three in one system. They are:

1. By using Normal pedaling
2. By using solar power
3. By wall plugin charging

The working of solar E-bike mechanism is explained below:

The working principle of the system starts with the charging the battery either through Solar energy or wall plugin. In battery, there are two terminals. One is the positive Terminal and another one is the negative terminal. The wire connections were made for the flow of electrons from one part to another part. When the motor energizes through the current, the stator field coil gets magnetized and induces the rotor shaft to rotate in the counter clockwise direction. At the end of the motor shaft relevant Conditions were made for the seating of sprocket assembly. The sprocket – chain Arrangement is a power transmission device, which gives drive to the rear wheel. The solar electrical bicycle consists of main components that is solar panel, battery, DC motor, chain drive, wheel. This project consists of bicycle, solar panels, dc motor, battery, sprocket, chain. In this project, solar panel firstly absorb the sun rays and produce the energy, this energy will go to the battery. And this energy will use for start to motor.

Assembly

After collecting all the above-mentioned components, studying their specifications, testing the circuit in MATLAB Simulink & obtaining the desired results start connecting the parts. Connect the sprocket to the rear wheel to further connect the BLDC motor. After the motor is placed on the wheel, connect ignition system (power lock), throttle, battery, brake lights/indicator lights, to the motor controller with adequate wiring. Check is the wiring is proper and the assembly is working. Attach the new brakes by and throttle to our cycle. Drill 2 holes in a plastic box and place the motor controller, charging port & ignition starter make sure that the port & starter are placed in such a way that they fit the drilled holes properly seal the box and attach it to the cycle along with the battery.

Attach the LED & brake lights, connect & place the solar panels in such a way that its comfortable for the rider (preferably of the back carriage) further connect the solar panels with DC adjustable boost converter & attach the converter to the charging port of the box. Add blockage diode to avoid the reverse flow of the current, use a multi-meter to check all the values like voltage &current produced. Check all the connections, cables, readings & test the bike under suitable conditions.

Fabrication and Experimental Analysis Notations:

d = diameter of the cycle rim in meters.
r = radius of cycle rim in meters.
w = Angular velocity of cycle shaft.
N = Speed of cycle wheel in RPM
v = Linear velocity of the cycle in kmph
N=Normal reaction of the road on each tire in Newtons.
u=Coefficient of friction for asphalt roads for bicycle= 0.04 to 0.1. Therefore, u= 0.1
R-rolling resistance for bicycle is negligible as it lies between 0.002-0.004.
F=Frictional force between tire and road in Newtons.
T=Torque developed on the shaft due to frictional force in Newton-meters.
P=Power required to ride the cycle in Watts.
t=time required to charge the battery by A- C Supply in hours

Bicycle data available:

Cycle Rim Diameter d = 66.04 cm = 0.66 m

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Average Cycle Speed v = 20 kmph
Taking the maximum permissible Weight = 100 kg approximately.

Design:

- The design involves the calculation of power required to run a E-bike at a known speed (assume 20 km/h) and to develop a solar powered system to produce the required power.
- Since additional attachments are to be mounted on the cycle, a light weight cycle with geared system and suspension was selected. A Hercules Cycle was purchased
- Electric - Bicycle is eco-friendly and comfortable but costly. It is infeasible as there is no enough provision for charging in rural India. Hence a bicycle which can be peddled as well as run on solar powered battery seems to be suitable option to solve the issues discussed above.

Motor calculations:

- The maximum weight for normal functioning of the bike is equal to 100 kg.
- The maximum Normal reaction acting on each tire is equal to (50 x 9.81) = 490.5 Newton each.

Static Friction force acting on the tire while driving:

- F = u x N
- F = 0.3 x 490.5
- F = 147.15 N

Dynamic Friction force acting on the tire while driving:

- Coefficient of Dynamic load X N
- 0.004 X 490.15
- Dynamic friction force = 1.96 N

Torque acting on the tire:

- T= (Static friction force + dynamic friction force) *Radius of the bicycle wheel
- T= (58.86 + 2.3544) * 0.33
- T= 20.2 N.m

We also managed to get the specified torque for the bicycle, it was 21 N.m While is approximately equal to theoretically calculated torque.

Speed calculations:

- w = v r,
- w = (20 x 1000) (0.33 x 3600)
- w = 16.83 rad/sec
- w = (2 N) 60
- N = (60 x) (2)
- N = (60 x 16.83) (2)
- N = 161 rpm

Power calculations:

- P = (2 N T) 60
- P = (2 x 161 x 21) 60
- P = 353.878 W

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Therefore, the solar power is used as a supplementary energy to ride the bicycle. Amotor with power of 350 W with peak wattage 388W is selected.

Selection of lithium-ion battery.

Type of li-ion cell selected are 3.7 V & 2.5 A

Connecting 3 cells in series [voltage addition] we get a voltage of 11.1 V Connecting 8 cells in parallel [current addition] we get a current of 20A So, the selected battery is of the specification 11.1 V & 20 Ah.

Battery specification:

- Power = Voltage x Current
- P = V. I.
- 350 = 24 x I
- I = 14.58Ah

Hence according to the above calculations, to drive a motor of 350 W, 24 V capacity; we select 2 batteries of 12V, 12.5Ah. We connect these batteries in series to achieve a voltage of 24V as required by the motor. Power generated by the battery = 2(12+12.5) =300 watts.

Solar Charging:

Solar panel [watt] x Average hours of sunlight [hr] x efficiency = daily produced [watt]

=75 x 5 x 75% =281.25 watt

So, if panels produce 281.25 W in 5 hrs then 56.25 W is produced per hr.

Electrical charging:

- Time required to fully charging the battery is calculated.
- Power Supplied to Battery during AC Charging: AC Adapter Specification: 11.1V,20A
- P = V. I.
- P = 11.1 x 20 = 222W

Consider that the battery is at 0% charging rate, so we need to replace 480 W in the battery by solar charging. As the panels generate 56.25 watt/hr. the total time required to fully charge the battery will be

= Battery Capacity/watts generated in panels per hr.

= 222/56.25 =3.94hrs.

APPROXIMATELY- 4 hrs. of Charging

Run Time of the Solar E-Bike on a single charge:

Time = [Efficiency x Battery Voltage x Battery Current] / load capacity

= [0.85 x 11.1 x 20] / 100 =1.88 hrs.

So, the Solar E- bike will work up to approximately 2 hrs. in a single charge and can travel up to 20-24 km.

V. CONCLUSION

Conclusion:

- Literature survey showed very few works has been done on hybridization of battery and solar panel as energy storage systems.
- Simulation analysis shows considerable change in reduction on battery stresses and increase in battery state of charge and other working parameters.
- Experimental results showed significant solution in the field of electric vehicle using solar panel to charge energy storage device i.e., battery. Specifically, li-ion battery. it needs to evaluate structural and thermal parameters for more efficient solution.

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Future Scope

1. The present work deals with the design of solar E-bike. It makes use of the fuzzy logic controller that helps the battery to remain charged using the solar energy through solar panels. We are going to make use of this fuzzy logic controller in our solar e-bike.
2. Also, the researchers used brush-less D.C. motor for smooth and silent functioning of vehicle. We are going to use the Brush-less D.C. motor in our model for smooth running and for reducing the heat and friction losses.
3. Analysis of environmental conditions was done. This analysis and result were used for the further development of solar E-bike. For example-The use of plug charge system was made in case of absence of solar energy. Also, from previous research papers we have pointed out some defects that lead to decrease in efficiency of their model. In our model, we tried to eliminate those defects for better performance of our solar e-bike.
4. In ideal cases, all solar energy available would be collected by the solar panels but in a city environment this is not always the case since buildings will shadow the irradiation. A method of estimating these losses needs to be developed. When the sunlight hits the solar panels, a number of different losses will occur during the conversion to electric power. These will be dependent on a number of factors such as type of solar cell technology used, outdoor temperature etc.
5. By combining the simulation results of available energy from the solar panels with the energy requirements of the E-bikes it is possible to study different options of system design. Independent of the amount of data collected, there are some things that cannot be determined with great certainty as this report is of exploratory nature.
6. This means that some results might not apply to a real system. To deal with this problem, it was tried throughout the report to analyze the system carefully to ensure that the draw conclusions in the end will be relevant for a real case despite changes in for example use of the system.
7. A solar powered bicycle is practically designed and developed with an electrical efficiency greater than 80 percent and the maximum speed of this solar assisted bicycle is 30 km/h, can be travelled up to 35 to 40 km with full charge of battery. It can be used by any age group people up to the weight of 100 Kg.
8. The total cost of this solar bicycle is around Rupees 20,000. – Solar e-bike is modification of moped vehicles. It is powered by electrical energy. It is suitable for both city and country roads, that are made of cement, asphalt, or mud. Itis very much suitable for young, aged, handicap people and caters the need of economically poor class of society.
9. It can be operated throughout the year free of cost. The most important feature of this bike is that it does not consume valuable fossil fuels thereby saving a lot on fuel expenses. It is eco-friendly pollution free, as it does not have any emissions. Moreover, it is noiseless and can be recharged with the AC adapter in case of emergency and cloudy weather.
10. The theoretical analysis of various batteries and its connections we conclude that both series and parallel connection are needed for efficient battery pack. We got approximately 24v and 10Ah through battery calculation. Connection of batteries, 7 in parallel and 4 connections in series Connections by following all safety aspects and IS Standards.
11. The simulation work done using MATLAB Simulink shows variations of various battery and performance parameters of vehicle w.r.t. Time. Noticeable results are State of charge and Voltage were continuously decrease linearly, Velocity of e-vehicle And Current variation was non-linear w.r.t time as shown simulated results.

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