A study on Campus-Friendly Solar Powered Electric Vehicle

Gangesh Shukla[1], Karmit Raval[2], Dhruvi Solanki[3], Urvashi Patel[4], Dhaval Dave[5]

[1,2,3,4]*B.Tech Student, Dept. of EE, Parul University, Vadodara, Gujarat, India*
[5]*Asst. Professor, Dept. of EE, Parul University, Vadodara, Gujarat, India*

Abstract - This paper presents a study on campus-friendly solar powered electric vehicle. Solar energy is one of the important sources of renewable energy which can be a feasible alternative to fossil fuels. On a bright sunny day the sun rays give off approximately 800-1,000 watts of energy per square meter of the earth surface. If energy from the sun is clean and free, why aren't we using it to power our vehicles? Is a solar powered vehicle a good solution? Solar power is the term for using the sun's energy to power a device or an electrical system. Solar panels are made up of a grid of solar cells. These cells collect the sun's energy and convert it into electrical energy. Now the Solar vehicles harness energy from the sun by converting it into electricity. This electricity fuels the battery that runs the vehicles motor. Instead of using a battery, some solar vehicles direct the power straight to an electric motor. Nowadays the solar vehicles can be categorized as a 'green vehicle' which is powered by renewable energy with zero carbon emission.

Key words: Solar energy, solar powered electric vehicle (SPEVs), grid, solar cells, Green vehicle

1. INTRODUCTION

In the present world, the demand for energy is increasing day by day. Sooner or later it will be much higher than the present condition. So the world is now heading towards renewable energy leaving behind fossil fuels energy for their harmful effects on environment. As solar energy is renewable and less harmful to the environment, it is gradually taking the place of fuels. To make the optimum use of solar power we took the initiative to work on our project. Our solar power hybrid car uses solar panel and batteries instead of using fossil fuels. So it can be considered as a fully eco-friendly vehicle which is the crying need of present situation of the world. By considering these things we have made our solar vehicle which is more effective and efficient for regular transportation uses. Hopefully solar powered Electric car will be able to replace the fuel vehicles and will play a major role in creating a safe and clean environment.

The motive force to a shaft by an electric motor which is run by solar energy after some important conversion in electric vehicles instead of an internal combustion engine which is environmental pollution free is the basic working principle of solar powered electric vehicles. The electricity produced by photovoltaic (PV) cells using sunlight powers the electric motor directly for driving of solar-powered vehicles (SPEVs). During sun shining the electricity is produced by PV cells otherwise, the vehicles use consuming energy in its batteries. The main component of a solar car is its solar array, which collect the energy from the sun and converts it into usable electrical energy. The solar cells collect a portion of the sun's energy and store it into the batteries of the solar car. Before that happens, power trackers converts the energy collected from the solar array to the proper system voltage, so that the batteries and the motor can use it. After the energy is stored in the batteries, it is available for use by the motor & motor controller to drive the car. The motor controller adjusts the amount of energy that flows to the motor to correspond to the throttle. The motor uses that energy to drive the wheels.

2. SOLAR VEHICLES

A. History of Solar Vehicles

In the late 1970's photovoltaic devices and electric vehicles were combined for the first time. Facing the pressure of the oil crisis, engineers and environmentalists started looking for an alternative source of energy and finally found solar as the best alternative. In order to create more coverage and examine interest in solar powered transportation, Hans Tholstrup organized a 1,865 mi (3,000 km) race across the Australian outback in 1987 ,better known as the World Solar Challenge (WSC), in which competitors were invited from industry research groups and top universities around the globe. General Motors (GM) with their Sunraycer vehicle won the event by a large margin, achieving speeds over 40mh [2]. In response to their success, GM came up with the US Department of Energy (DOE) to hold the GM Sunraycer in 1990 [3]. Approximately the same length as the WSC, Sunraycer is considered to be a more difficult race due to more varied terrain and climates as well as more challenging road surfaces and traffic blocking. USA conducted American Solar Challenge in 2001, then the North American Solar Challenge in 2005, which are now held every two years across different routes. A new record for the longest solar vehicle race, covering 2460 mi (3960 km) from Austin, Texas, USA to Calgary, Alberta, Canada was setup in the year 2005. Initially motivated by research, the building of solar vehicles is now referred to as ―brain sport, developing dozens of new vehicles each year for the sole purpose of competition, not production. Solar vehicle competition enables engineers to research and develop new technologies. With the unique nature of the solar community and events, these technologies remain an available resource. Considerable improvements and attentive technologies of electric vehicles has been developed that can be applied to a broader range of automobiles to provide more efficient, effective and reasonable alternatives over combustion engine vehicle.

B. Why Need Solar Powered Vehicles?

The air pollution that warming the earth as a result of pollutants from the automobiles, which is about 23% of the total air pollution as shown in Fig.1. One of the great problems faced in urban areas throughout the world is the increase in vehicles due to an imbalance between the public transport and the increase in population which, finally results in a huge amount of air pollution.

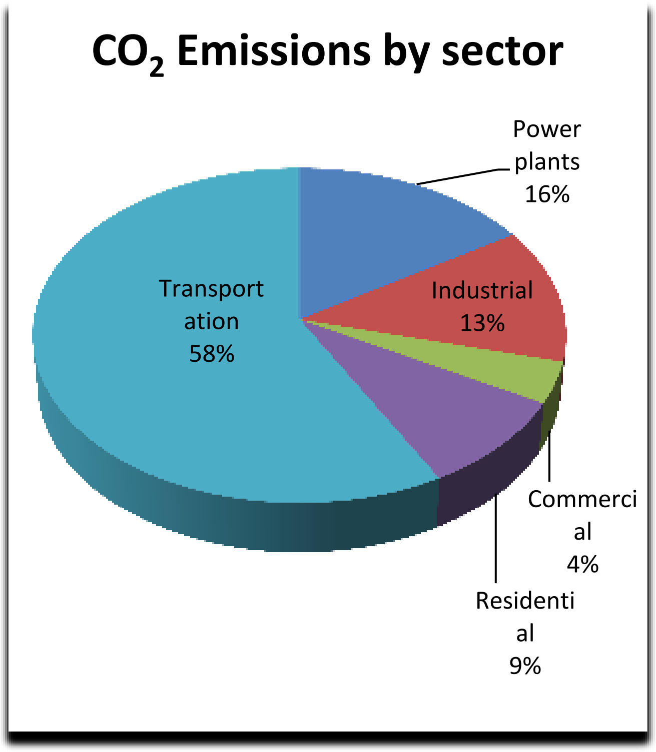

Fig.1. Different Sectors of CO_2 Emissions [1]

With the increasing rate of population, the number of vehicles is also increasing due to the imbalance between these two factors and finally the pollution rate is also increased. Over the last two decades, many experiments have been done to control emission from IC engine. So in this respect, this solar powered vehicle may be one of the solutions because of pollutant free property.

3. WORKING

A solar car gets the energy it needs to move from sunlight. If you look at the solar car below you can see that much of its surface looks black. This helps it to absorb the sunlight-black objects absorb most of the light that falls upon them. Usually, black objects just get hot in the sun. But in a solar car, some of the light is converted to electricity by a device called a "solar cell." Each of the dark panels that you can see in the photograph contains many such solar cells. The electricity is used to drive the car's electric motor. Excess electricity is stored in a battery for cloudy periods.

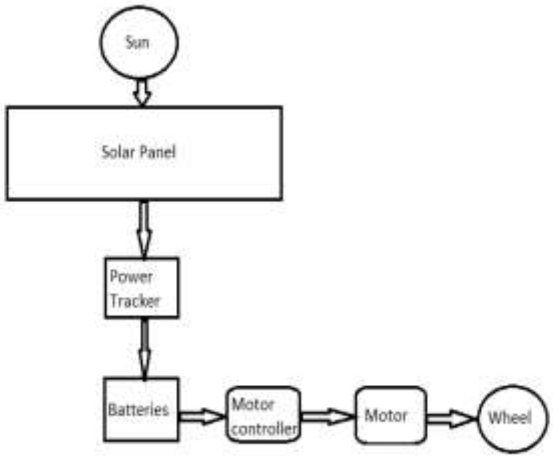

Fig.2. Working Principle of solar powered Vehicle

If we could make perfect solar cells that converted all the light falling on the car, its engine would have about 10 horsepower. But even the best of today's solar cells can convert only 20% to 24% of the sun's power into electricity. Therefore, under full sunlight, the motor puts out about 2 hp. With the help of the battery, the output-for short times can be increased to 8 hp.

4. COMPONENTS USED

A. Solar Panel

Fig.3. Adjustable angle Solar Panel

A standard solar panel consists of a layer of silicon cells, a metal frame, a glass casing and various wiring to allow current to flow from the silicon cells. Silicon (atomic -14 on the periodic table) is a non-metal with conductive properties that allow it to absorb and convert sunlight into electricity. When light interacts with a silicon cell, it causes electrons to be set into motion, which initiates a flow of electric current. This is known as the "photovoltaic effect," and it describes the general functionality of solar panel technology. [2]

The general photovoltaic process, as described above, works through the following steps:

1. The silicon photovoltaic solar cell absorbs solar radiation

2. When the sun's rays interact with the silicon cell, electrons begin to move

3. Moving electrons creates a flow of electric current, captured by nodes and wiring in the panel

4. Wires feed this direct current (DC) electricity to a solar inverter to be converted to alternating current (AC) electricity

B. Power Tracker

Fig.4. Role of Power tracker [3]

Power trackers convert the solar panel voltage to the system voltage.

In this step the power tracker in the car receive the energy from the solar array, and change the energy that it receive to energy that the car can be use.

After it converts energy, it sends the remaining energy to the battery.

C. Batteries

Lead–acid battery having a very low energy-to weight ratio and a low energy-to-volume ratio, its ability to supply high surge currents means that the cells have a relatively large power-to-weight ratio. These features, along with their low cost, make it attractive for use in motor vehicles to provide the high current required by automobile starter motors.

Fig.5. Batteries [4]

D. Motor Controller

The motor controller adjusts the amount of energy that flows to the motor to correspond to the throttle. The motor uses that energy to drive the wheels.

E. DC Motor

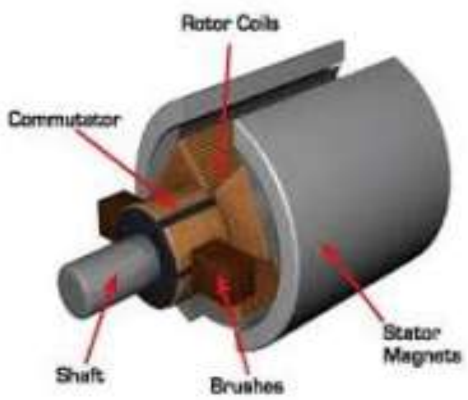

Fig.6. Diagram of DC motor

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic; to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line. DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

5. CALCULATION

A. Amount of Energy that can Battery Store

Battery capacity is measured in Amp Hours (e.g., 20 AH). You need to convert this to Watt Hours by multiplying the AH figure by the battery voltage (e.g., 12 V).

For a 20 AH, 12 V battery the Watt Hours figure is

20 x 12 = 240 WH

This means the battery could supply 240 W for 1 hour or 120 W for 2 hours, i.e., the more energy you take, and the faster the battery discharges.

B. Solar Panel Generate Over a Period of Time

The power generation rating of a Solar panel is also given in Watts (e.g., STP010, 10 W). To calculate the energy it can supply to the battery, multiply Watts by the hours exposed to sunshine, then multiply the result by 0.85 (this factor allows for natural system losses).

For the Solar 10 W panel in 4 hours* of sunshine,

10x4x0.85 = 34 WH. This is the amount of energy the Solar panel can supply to the battery.

C. Calculating the Annual Solar Energy Output of a Photovoltaic System

The global formula to estimate the electricity generated in output of a photovoltaic system is:

E = A * r * H * PR

E = Energy (kWh), A = Total solar panel Area (m^2), r = solar panel yield (%), H = Annual average solar radiation on tilted panels (shadings not included), PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

r is the yield of the solar panel given by the ratio: electrical power (in kWp) of one solar panel divided by the area of one panel. Example: The solar panel yield of a PV module of 250 Wp with an area of 1.6 m^2 is 15.6%.

D. Calculating the solar panels needed

Identify what are the power of the equipment that you want to run on solar energy and the hours to run it them every day. Take an example a 14" DC fan 20 W to run 12 hours at night and a 16 W light to run 5 hours at night.

The formula of the power of the solar panels needed is power of equipment X running hours X 1.5 (lost factor)/4 hours of sunshine. Lost factor include the humidity and high temperature in the equator zone, battery charging and discharging lost and inverter conversion lost.

From the example, the solar panel needed for the fan is 90 W and the solar panel needed for the light is 30W. So the total solar panel needed will be 120 W. In this case, you can buy 2 pieces of 60 W solar panels or 1 piece of 140 W solar panel.

This calculation will work fine if the solar panel is not place under shade.

E. Calculating the Batteries Needed

To package the battery needed, you have to decide how many days you want to have backup power. Taking the example 14" stand fan 20 W to run 12 hours at night and a 16 W light to run 5 hours at night. Total power a day is 320 W = 12 V 26.7 A.

Daily usage of the battery = Total power usage/12 V = 320 W/12 V = 26.7 A.

Take note this value is only valid for sunny days. 2. To have 3 days backup battery = 26.7 A x 3 days = 80 aH.

F. Solar Energy Calculation

One single solar panel from type standard 150 Watt/24 volts can deliver a power of 150 Watt per hour, considering full sunshine. Knowing that the sun shine vary during the day, the effective sun power of one day is equal from 4 to 6 hours of a maximum measured at midday. Since this maximum at midday is not the same every day, it should be taken in consideration, that more or less heavy cloud reduces the possible power. The electrical power is stored into batteries, similar to the one used in cars.

Example: One solar panel of 150 W/24V produce between 150 W x 4 h = 600 Wh and 150 W x 6 h = 900 Wh.

One battery of 12 V/110 Ah has a capacity of 12 V x 110 Ah = 1320 Wh

G. The torque required for different speed

Torque is also an important factor for designing the tricycle because torque is required to move the vehicle from a stop. The required formula for calculating the developed torque in the tricycle is T= F × r

It is mainly important for acceleration, not for maintaining speed. In order to get up speed and overcome the wind resistance and friction torque is initially required. So torque is required to move the vehicle from a stop and helps it get up steep hills. From the Table 1, it is observed that with the decreasing of torque-velocity increases

Sr. No.	Velocity in km/hr	Torque in N-m
1	1	325
2	5	65.4
3	10	36
4	12	23.5
5	15	14.5
6	20	10.2

Table.1. Data of torque at different speeds.

it is seen that initial torque is high. With increasing speed, torque is reduced. At maximum speed, torque is minimized. At the beginning when the velocity is only 1 km/hr, the torque developed was 325 N-m, but with the increasing velocity, torque is also reduced. As in 5 km/hr velocity developed torque is 65.4 N-m and finally, at 20 km/hr velocity, torque is reduced to a minimum value of 10.2 N-m.

6. TOTAL COST OF PROJECT

The main parts of the constructed solar tricycle are Solar Panel, Battery, Power Tracker, Motor controller and wheels with equipment. The cost of this equipment's with the material cost and setting the cost of the solar powered vehicle is shown in Table 2.

Description	Price in INR
Solar panel	3500
Battery, Motor,	7000
Power Tracker, Controller	2500
Materials and equipments	3500
Wheel, Braking, Fabrication cost	3000
Total Cost	**19500**

Table.2. Costs with different equipments used in the project

7. ADVANTAGES

1) Unlike regular vehicles, solar powered Vehicles are able to utilize their full power at any speed.

2) Solar powered Vehicles do not require any expense for running.

3) Solar Vehicles are quite.

4) Solar Vehicles require very low maintenance.

5) A solar Vehicle produces no harmful emissions.

8. DISADVANTAGES

1) Solar Vehicles don't have speed or power that regular vehicles have.

2) Solar powered Vehicles can operate only for limited distance.

3) If there is no sunlight.

4) If it is dark out for many days, the car battery will not charge and this can be a problem. This is the main reason why people don't rely on solar vehicles.

5) Good & efficient solar powered Vehicles are expensive.

6) Parts used in solar Vehicle are not produced in large quantity so they are expensive.

9. CONCLUSION

The objective of this study is to design and construct of a cheaper solar powered vehicle. After performance study, it is obtained that storage system can run the solar vehicle about 12 km. The maximum speed of the solar vehicle has been found at 20 km/h. So, the solar powered vehicle is designed and constructed in this study can be used as a green vehicle in developing countries due to its less expensive and zero pollution effect nature.

REFERENCES

1) The world solar challenges, Cited on 2010 June 11 available from: http://www.anzses.org/files/The%20WORLD %20Solar%20Challenge.pdf

2) Zahari Taha, Rossi Passarella, Jamali Md Sah and Nasrudin Bin Abd Rahim (2008). A Review on Energy Management System of a Solar Car, The 9th Asia Pacific Industrial Engineering & Management Systems Conference,3-5 December 2008, Nusa Dua, Bali, paper 93, pp. 2527-2530.

3) Zahari Taha, Rossi Passarella, Nasrudin Abd Rahim, Jamali Md Sah (2010a). Driving force characteristic and power consumption of 4.7 kW permanent magnet motor for a solar vehicle, ARPN Journal of engineering

and applied sciences, vol 5, No 1 January 2010, ISSN 1819-6608

4) Hazel O'Leary(2002) greets contestants of the Solar Car Challenge Competition in 1995.

5) Hamakawa Y (2002) Solar PV energy conversión and the 21st century´s civilization, Solar Energy Materials & Solar Energy 74, 13-23.

6) Callahan, Parker, Sherwin, and Anello's study.

7) Solar cells: past, present, future. Adolf Goetz Berger*, Joachim Luther, Gerhard Willeke,

8) A high-efficiency triple cycle for solar power generation (2002). Kribus A.

9) Singh, R., Gaur, M. K., Malvi, C. S. "Study of Solar Energy Operated Hybrid Mild Cars; A Review." International Journal of Scientific Engineering and Technology. 1(4), pp. 139-148. 2012.

10) Arulbel Benela, R., Jamuna, K. "Design of Charging Unit for Electric Vehicles Using Solar Power." In: 2013 International Conference on Information Communication and Embedded Systems (ICICES), Chennai, 2013, pp. 919-924.

11) Sankar, R., Pushpaveni, T., Prakash, R. "Design and Development of Solar Assisted Bicycle." International Journal of Scientific and Research Publications. 3(3), pp. 452-457. 2013