International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 2
February 2018

Proposal of an Integrated Photovoltaic Solar Powered Vehicle

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Abstract- The renewable energy is vital for today's world as in near future the non-renewable sources are going to be exhausted. We are dependent on one form of energy or the other for full-filing 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 is that they are not environmental friendly. To deal with the problem, we need to look at the non-conventional sources of energy or green energy.

With regard to this idea we proposed the solar powered vehicle; one of the oldest alternative energy vehicles has many applications to the emerging electric vehicle market. This paper surveys the history and future of solar powered electric vehicle and provides an overview of a typical solar car with respect to Car Integrated Photovoltaic (CIPV) and Car Associated Photovoltaic (CAPV) design by considering variety of solar cells.

Keywords- Green Energy; Solar Cells; Solar Vehicle; BLDC Motor; Solar Window.

I. INTRODUCTION

The quest for a constant, safe, clean, eco-friendly fuel is never ending. Carbon based fuels are unsustainable and hazardous to our environment. Some of the alternatives are renewable energy sources which include solar, wind, tides, hydropower, biomass etc. One of the front runners in the area of renewable energy resources today is solar power. Photovoltaic (PV) cells are used to convert solar energy into electrical energy. Unlike solar thermal energy which converts solar energy into heat for either household purposes or industrial purposes [1].

A solar vehicle is an electric vehicle powered completely or significantly by direct solar energy. The term solar vehicle usually implies that solar energy is used to power all or part of vehicle propulsion. Solar vehicles are not sold in huge as practical day-to-day transportation devices at present but are primarily demonstration vehicles and engineering exercises often sponsored by government [2, 9]. This paper discusses about the usage of solar energy to power up the vehicle and a comparative analysis of different PV technology.

II. GREEN VEHICLE

A. Green Energy

The Fig. 1 shows the types of conventional and non-conventional sources pictorially. The energy extracted from the conventional source is known as non-renewable energy where as the energy related to other source is known as renewable energy. The green energy is a subset of renewable energy resources or otherwise naturally replenished, in contract to fossil fuels which take millions years to develop. Renewable energy sources also have a much smaller impact on the environment than fossil fuels, which produce pollutants such as greenhouse gases as a by-product, contributing to climate change [3].

Green energy, however, utilizes energy sources that are readily available all over the world, including in rural and remote areas that don't otherwise have access to electricity. Green energy can replace fossil fuels in all major areas of use including electricity, water and space heating and fuel for motor vehicles [4].

In the context of green energy, green power is a subset of it and represents those renewable energy

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resources and technologies that provide the highest environmental benefit. Customers often buy green power for its zero emission profile and carbon foot-print reduction benefits [5].

Fig. 1. Types of Source [3]

B. Preference Of Solar Power

Generation of solar energy has tremendous scope in India because of its geographical location. This reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts 3000 hrs of sunshine. Almost all parts of India receive 4-7 KWh solar radiation per m^2 [6].

Solar energy works by converting light energy from the sun into useable electricity. Developments in solar technologies continue to lower the cost of owning a solar powered system. A study conducted by the National Renewable Energy Laboratory (NREL) stated that homes with solar panels were valued 17% higher and sold 20% faster than homes without solar panels [7]. Here are a few reasons why solar is preferred over traditional fossil fuel and other green technologies:

1. Reduced Dependence on Fossil Fuels

Solar energy production does not require fossil fuels and is therefore less dependent on this limited and expensive natural resource.

2. Environmental Advantages

Solar power production generates electricity with a limited impact on the environment as compared to other forms of electricity production.

3. Modularity and Scalability

As the size and generating capacity of a solar system are a function of the number of solar modules installed, applications of solar technology are readily scalable and versatile.

4. Flexible Locations

Solar power production facilities can be installed at the customer site which reduces required investments in production and transportation infrastructure.

5. Government Incentives

A growing number of countries have established incentive programs for the development of solar and other renewable energy sources, such as

a) Direct subsidies to end users to offset costs of photovoltaic equipment and installation charges.

b) Low interest loans for financing solar power systems and tax incentives.

c) Government standards that mandate minimum usage levels of renewable energy sources.

Despite the cost, an advantage of photovoltaic systems is that anywhere a diesel generator is the technology of choice; many times a photovoltaic system is a much better life-cycle cost option.

C. Solar Powered Vehicle

If there is no such thing as a free lunch, how about a free ride? Think of how wonderful it would be if our vehicle could continue running without spending a rupees on fuel. If we drove a solar-powered vehicle, then that auto-dream would come true. Much like solar powered homes, solar powered vehicles harness energy from the sun converting it into electricity. That electricity then fuels the battery, which runs the vehicles motor [8]. Instead of using a battery some solar powered vehicles direct the power straight to an electric motor. By using a combination of a solar panel and an electric motor, we use the power of the sun and reduce the carbon dioxide emissions. But as of now it is not completely developed commercially because of its some definite limitation [9].

In this paper we discussed about the currently working solar car along with its pros and cons and also tried to discuss the future scope considering the Car Integrated Photovoltaic system by referring solar window system.

1. Working Principle Of A Solar Car

Solar cars are powered by the sun's energy. Silicon-based photovoltaic cells are most common solar collector and storage space where, due to electron movements and interactions, accumulated sunlight moves electrons around. These movements and interactions of electrons trigger electrical current or energy that eventually runs the car [10].

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In general the solar array collects the energy from the sun and converts it into usable electrical energy. Solar energy also needs to be stored into the batteries of the solar car since sun is not always available. After the energy is stored in the batteries, it is available for use by the motor & motor controller to drive the car [11].

2. Solar Panel

Solar panel is an indispensable component of photovoltaic system. It is an array of several solar cells. The array can be formed by connecting them in parallel or series connection depending on the energy requirement and reliability with different size of panels as given below. Photovoltaic cells are made up of semiconductors, usually silicon, which absorbs the light. The sun's energy frees electrons in the semiconductors, creating a flow of electrons and that flow generates electricity [12].

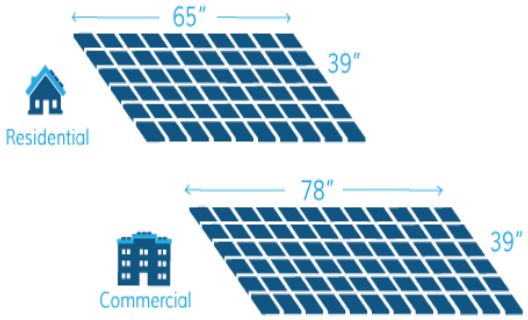

Fig. 2. Comparison of solar panel size [13]

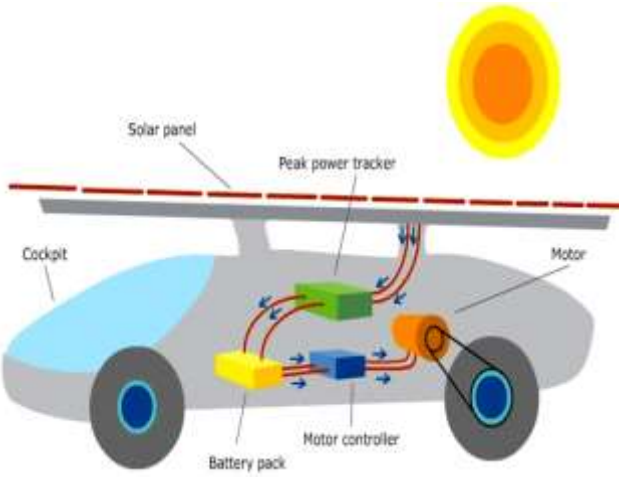

Fig. 3. Sketch of a Solar Car [11]

a) Monocrystalline Silicon Cell

The crystalline silicon solar cells have high efficiency than that of other solar cells and easy availability which forced the manufacturers to use them as a potential material for solar cells. In most of the cases, the monocrystalline type solar cells are used as they have the efficiency nearly about (16-20) % but due to higher cost and weight of the material, it is still a cause of concern for both the manufacturers and the end users. Therefore, the industries are looking for alternatives of the mono-silicon [6, 14].

b) Polycrystalline Silicon Cell

It is composed of many smaller silicon grains of varied
crystallographic orientation, typically >1 mm in size . A high temperature chemical vapor deposition method is used for forming smaller grained polycrystalline silicon cell. So polycrystalline type of solar cell may be the other option which has lower cost, as compared to the monocrystalline cell, having the efficiency of (12-18) % [8, 15].

c) Thin-film (a-Si based) Solar Cell

The thin-film technology based solar cells are cheaper as compared to silicon based solar cells due to the fact that the requirement of material is lesser in the manufacturing process of the former. Normally the thickness of the solar cell is just 1 micron, or about 1/300th the size of mono-crystalline silicon solar cell. The amorphous silicon (a-Si) being non-crystalline and disordered structure form of silicon is having 40 times higher absorptive rate of light as compared to the monocrystalline silicon. The efficiency of this cell is nearly about (8-15) %. Thus the amorphous silicon based solar cells are very famous as compared to other materials with respect to its light in weight [16, 17].

From the above classification of solar cells it could also be concluded that each of the classified solar cell had its own advantages and disadvantages. In this paper the proposed solar powered vehicles, where solar cell plays the vital role, should here chosen carefully. So, the vehicle will not only efficient but also reliable.

3. Peak Power Tracker

It is a microprocessor based dc-dc converter used as a tracker which tracks the maximum power from the solar panel and match the solar array voltage with the system voltage. In this case, the power tracker in the car receives the energy from the solar array and changes this energy into a compatible form of energy that the car can use. After it converts energy, it sends the energy to the battery for its charging [18, 19].

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4. Battery Pack

After the power tracker converts the energy into usable electrical energy, which in turn will be stored in the lead acid or lithium polymer batteries. This energy is supplied to the motor when necessary through the motor controller and makes them available for the motor's use. The preference of battery is considered for the vehicle on the basis of its efficiency, depth of discharge and its life span. On the above based factors, normally the lithium polymer battery is preferred in the solar car [20-22].

5. Motor (Drive) Controller

The drive controller takes power from the batteries and adjusts the amount of energy that delivers to the motor to correspond to the throttle. It can include an automatic or manual means for starting or stopping the motor, choosing forward or reverse rotation, selecting and controlling the speed, modifying or limiting the torque and shielding against faults and overloads. Therefore the electric vehicle motor controller is a machine that is employed to regulate the torque generated by the motors of electric vehicles by means of modifying the energy flow from the power sources to the motor [23,24].

6. Motor

The motor uses the energy, which controlled by the drive controller to drive the wheels. Normally Brushless DC motor (BLDC), Brushed DC motor and AC Induction motors are used in green car. Out of these the BLDC is preferred due to its simpler maintain, more durable, (85-95) % efficient, simpler to control in regard to speed control and reversing mechanism, lighter in weight and able to self start. The composition of the BLDC motor also keeps the machinery inside a vehicle cooler and thermally resistant. There is no dangerous brush sparking, since the motor is brushless [25, 26].

7. Chassis and wheel

The primary challenge in developing and effective solar car chassis is to maximize the strength and safety, but minimize the weight. However safety is a primary concern, so the chassis must met stringent strength and safety requirements. The materials used for solar chassis are fiber-reinforced plastic composite (thematrix), fiber glass and aluminum sheet. There is no standard in choosing wheel for solar cars. Thin wheels are always preferred for the car speed with respect to its weight consideration [27, 28].

III. SOLAR POWERED CAR WITH CAPV

A. Specification for Car

Considering,

Total mass of car (including 4 persons and others) = 800 Kg,

Torque required to pulling the car approximately 80 Nm,

Radius of wheel (r) = 6 inch =15.24 cm,

Maximum velocity = 120 Km/hr,

Dimensions: Length = 4.26 m,

Width = 1.52 m,

Height =1.41 m.

Area of the car = 4.26*1.52 = 6.47 m^2

Length of wheel = 2*π*r = 95.76 cm

Total distance covered in 1 hour =120 Km=1, 20, 00,000 cm

$$RPM\ of\ wheel\ needed = \frac{Total\ Distance\ covered\ in\ 1\ minute}{Length\ of\ wheel}$$

$$= \frac{12000000/60}{95.76}$$

$$= 2088.55\ RPM$$

So, the revolution of the wheel is approximately 2089 RPM.

$$Wattage\ of\ the\ motor = \frac{RPM\ of\ wheel * Tourqe\ Required}{9.55}$$

$$= \frac{2089*80}{9.55}$$

$$= 17.49\ KW$$

So, approximately 18 KW rating of the motor is required.

B. Battery Specification

Considered parameters,

Chemical composition = Lithium-ion type,

Specific Energy = 0.265 KWh/Kg,

Charging capacity = 850 Ah,

Battery pack voltage = 24 V,

Life span = 10, 000 cycles,

Efficiency (η) =80%.

Storage capacity of the battery = 24 V*850 Ah

= 20400 Wh

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= 20.4 KWh

The capacity of the battery 20.4 KWh means if the battery is fully charged it can provide 20.4 KW power to the motor to run the vehicle for 1 hour.

C. Solar Array Specification

For this paper we consider only three types of silicon made solar PV system for standard test conditions (STC): 25^0 C cell temperature, 1000 W/m^2 irradiance and 1.5 AM.

The unit of the nominal power of the photovoltaic panel in these conditions is called watt-peak (Wp).

Considering,

Sunshine time per day = 6 hrs,

Lost factor = 0.85 (Natural system losses),

Area of a panel = (78*39) $inch^2$ = 3042 $inch^2$ = 1.96 m^2

Taking design aspect of the car, area available for solar panel installation (90 % of the total car area) = 5.88 m^2

No. of panel that can be installed = 5.88 / 1.96 = 3.00

Here the solar array consisting of 3 nos. of solar panel.

1. Monocrystalline PV system

Rating of the Panel: 24 V, 345 Wp, ɳ = 18%.

Energy produced in a day = 345*6*0.85 Wh

= 1759.5 Wh

= 1.76 KWh

Energy generated by solar array = 1.76*3 = 5.28 KWh/day

2. Polycrystalline PV system

Rating of the Panel: 24 V, 290 Wp, ɳ = 16%.

Energy produced in a day = 290*6*0.85 Wh

= 1479 Wh

= 1.48 KWh

Energy generated by solar array = 1.48*3 = 4.44 KWh/day

3. Thin-film (a-Si) PV system

Rating of the Panel: 24 V, 200 Wp, ɳ = 10%.

Energy produced in a day = 200*6*0.85 Wh

= 1020 Wh

= 1.02 KWh

Energy generated by solar array = 1.02*3 = 3.06 KWh/day

From the above calculation, we conclude that monocrystalline solar PV system had got the upper edge over the type with respect to the energy generated for a particular panel installation area; but this is not cost effective as rupees per watt-peak is quite higher than others, as mentioned in table I. So to design a cost effective solar car as of now, it is visible to be the Thin-film, but it is not energy efficient.

Table I. COMPARISONS OF SOLAR CELLS BASED ON SOLAR CAR

Types of Solar Cell	Monocrystalline Cell	Polycrystalline Cell	Thin-film (a-Si) Cell
Efficiency (%)	18	16	10
Watt-peak (Wp)	345	290	200
Watt/m^2	176.02	147.95	102.04
Total Energy Generated (KWh/day)	5.28	4.44	3.06
Cost (Rs. /Wp)	60	45	32

In this context (to get more energy efficient) we propose CIPV system where Thin-film solar cells are used as before along with solar window concept.

IV. PROPOSED SOLAR POWERED CAR WITH CIPV TECHNIQUE

In car integrated photovoltaic system we can use solar window or solar glass in place of traditional glass. The dimension of front, back and four sides' glasses of the proposed solar car are considered and corresponding generated energy is calculated with respect to thin-film solar cell efficiency (10 %).

Dimensions: Front Glass = 0.5 m^2;

Back Glass = 0.465 m^2;

Front Side Glass = 0.267 m^2 (each);

Back Side Glass = 0.3 m2 (each);

Total area of the glasses = 0.5 + 0.465 + (2*0.267) + (2*0.3)

= 2.09 m^2

Total Energy Generated =102.04*2.09*6

=1279.58 Wh/day = 1.28 KWh/day

From the above calculation it can be concluded that by using transparent solar window along with thin-

film solar panel, we can additionally generate a minimum of (1-1.5) KWh/day with considering the shadings effect. We can also replace the solar panel with the integrated photovoltaic concept on the space of the solar car, which fruitfully satisfies our prospect of CIPV.

Fig. 4. Pictorial representation of the proposed car [29]

➢ *Advantages of CIPV over CAPV*

- More energy can be produced over the same sun-shine period of a day.
- Space of the vehicle can be effectively used.
- Cost to produce the same KWh is reduced with compared to the associated solar panel of the same type in the car.
- Design of the vehicle will be appreciated.
- Effective frictional resistance offered by the air can be reduced by integrated photovoltaic design.
- Temperature control can be effectively done by solar window technology.
- The indoor air quality can be improved and also make it noise free.

V. FUTURE SCOPE

Most of the concept cars launched today are focusing on solar energy and hybrid technology. These vehicles are hypothetical in design but also carry one of the most expensive components to assemble a vehicle such as titanium carbon fiber and glass etc. So to design both efficient and economically green vehicle researches are under process by considering some parameters, such as:

- Apart from hybrid technology only solar powered car can be designed with highly efficient solar cell, which are under research, such as concentrated solar PV, amorphous silicon hydrogen (a-Si:H) cells, multi junction solar cells etc. which have expected efficiency greater than 30 % [30-33].
- By introducing plug-in system, means, using high Amp-hr. batteries with high efficiency and depth of discharge, charging of the batteries can be done by AC voltage source along with suitable inverter design. So the range of the vehicle can be increased over the charging period [34-36].
- Along with the electrical improvement, mechanical design can also be improved according to the torque and space requirements [28, 37].

VI. CONCLUSION

Solar energy panels are playing a major role in the economy today in terms of eco-friendly atmosphere and cost saving. But when it comes to the automobile industry and the quest of powering the huge engine it is still in the research phase as how to compete with the fuel efficient vehicle. The important of utilization of solar power in electric vehicle application is discussed in this paper. The proposed solar powered car will be cost effective and provide noise less operation as compared to the currently working vehicle under the same range of operation. In this paper, the advantages of integrated photovoltaic design is compared with associated photovoltaic design under variation of solar cells of panel with a fixed capacity of battery rating that required to drive the motor in our proposed car models.

References

[1] Erdinc O, Uzunoglu M. “Optimum design of hybrid renewable energy systems: overview of different approaches”, Renewable Sustainable Energy Revolution 2012; 16:1412–25.

[2] T.Balamurugan, Dr.S.Manoharan, "Design of Solar/Electric Powered Hybrid Vehicle (SEPHV) System with Charge Pattern Optimization for Energy Cost", International Journal of Engineering and Technology (IJET) Vol 5 No 6 Dec 2013-Jan 2014.

[3] https://www.mnn.com/earth-matters/energy/stories/what-is-green- energy as on date 14.11.17.

[4] Jintai Cui, Bo Du, "Energy Source Prospects for the New Century", Trends of Overseas Technology, 2000, (368), pp. 19-21.

[5] Weitang Fan, "Present Status and Development Trend of Energy Source", Shanxi Energy Source and Energy Conservation, 2004, (34), pp. 1-3.

[6] Tyagi V, Rahim NA, Rahim N, Jeyraj A, Selvaraj L. "Progress in solar PV technology: research and achievement", Renewable Sustainableable Energy Revolution 2013; 20:443–61.

[7] Philipps S, Bett A, Horowitz K, Kurtz S. "Current status of concentrator photovoltaic technology", National Renewable Energy Laboratory (NREL); 2015; 8:93–111.

[8] Alisaa Kumari, Ankita Ranjan, Shivangi Srivastava, "Solar Powered Vehicle", International Journal of Electronics, Electrical and Computational System IJEECS ISSN 2348-117X Volume 3, Issue 3 May 2014.

[9] C. C. Chan, "An Overview of Electric Vehicle Technology", September 1993, Proceedings of the IEEE, VOL. 81, NO.9, pp. 1202-1213.

[10] Mangu, R., Prayaga, K., Nadimpally, B. and Nicaise, S. "Design, Development and Optimization of Highly Efficient Solar Cars: Gato Del Sol I-IV". Proceedings of 2010 IEEE Green Technologies Conference, Grapevine, 15-16 April 2010, 1-6.

[11] www.sciencelearn.org.nz as on date 10.12.17.

[12] A.K.Pandey, V.V.Tyagi, et. al, "Recent advances in solar photovoltaic systems for emerging trends and advanced applications", ELSEVIER-renewableable and sustainableable energy review: 53 (2016) pp. 859-884.

[13] https://news.energysage.com/average-solar-panel-size-weight/ as on date 10.10.17.

[14] Congedo P, Malvoni M, Mele M, De Giorgi M. Performance measurements of monocrystalline silicon PV modules in South-eastern Italy. Energy Convers Magazine 2013; 68:1–10.

[15] Pandey A, Tyagi V, Tyagi S. "Exergetic analysis and parametric study of multicrystalline solar photovoltaic system at a typical climatic zone", Clean Technol Environmentmental Policy 2013; 15:333–43.

[16] Yang J, Banerjee A, Guha S. "Amorphous silicon based photovoltaics—from earth to the final frontier". Solar Energy Materials & Solar Cells 2003; 78:597–612.

[17] Green MA, Basore PA, Chang N, Clugston D, et.al. "Crystalline silicon on glass (CSG) thin-film solar cell modules". Solar Energy 2004; 77:857–63.

[18] D.Shmilovitz, "On the control of photovoltaic maximum power point tracking via output Parameters", IEEE Proc. Elect. Power Appl.2005, PP 239-248.

[19] S.J.Chiang and H.Dong, "A new scheme for maximum photovoltaic power tracking control", IEEE Trans. Ind. Electron, Vol.45. no.3, PP 385-394, Jun 1998.

[20] Ke Bao, Shuhui Li and Huiying Zheng, "Battery Charge and Discharge Control for Energy Management in EV and Utility Integration", 2012 IEEE.

[21] Lam L, Bauer P. "Practical capacity fading model for Li-ion battery cells in electric vehicles", IEEE Trans Power Electron 2013; 28:5910–8.

[22] Castello CC, LaClair TJ, Maxey LC. Control strategies for electric vehicle (EV) charging using renewables and local storage. In: 2014 IEEE transp electrif conf expo, IEEE; 2014. p. 1–7.

[23] J. Chu, I. Moon, G.Choi, J. Ryu, and M. Mun, "Design of BLDC Motor Controller for Electric Power Wheelchair" (2004 IEEE), pp 92-97.

[24] Shivani Jain, Neha Tiwari "Grid Solar Hybrid Speed Controller for Electric Vehicle – A Working Model", International Journal of Scientific Engineering and Research (IJSER) ISSN (Online): 2347-3878 Volume 3 Issue 1, January 2015.

[25] I. Alphonse, Dr. S. H. Thilagar, F. B. Singh, "Design of Solar Powered BLDC Motor Driven Electric Vehicle", International Journal of Renewable Energy Research, Vol. 2, No. 3, 2012.

[26] Zhu, Z. Q.; Howe, D. Electrical Machines and Drives for Electric, Hybrid, and Fuel Cell Vehicles, Proceedings of the IEEE, 2007, vol. 95 (4), pp. 746-765.

[27] C. C. Chan, "An Overview of Electric Vehicle Technology", September 1993, Proceedings of the IEEE, VOL. 81, NO. 9, pp. 1202-1213.

[28] Z. Taha, R. Passarella, J. Md Sah, N. Abd Rahim , "A review on energy management system of a solar car", Proceeding 9th Asia Pacific Industrial Engineering and Management Systems Conference, Bali, 2008, 2527-2530.

[29] https://www.treehugger.com/slideshows/cars/bluecar-electric-car-by-pininfarina-and-bollora/ as on date 11.12.17.

[30] A.K.Pandey, V.V.Tyagi, Jeyraj A/L Selvaraj, N.A.Rahim, S.K.Tyagi, "Recent advances in solar photovoltaic systems for emerging trends and advanced applications", ELSEVIER-renewable and Sustainable energy review: 53 (2016) pp. 859-884.

[31] Al-Alili A, Hwang Y, Radermacher R, Kubo I. "A high efficiency solar air conditioner using concentrating photovoltaic/thermal collectors", ELSEVIER– Applied Energy 2012; 93:138–47.

[32] Rony Sorkar, Zubaear Alam & Galib Hashmi "Design and Development of a Low Cost Solar Automated Vehicle", Global Journal of Researches in Engineering: F Electrical and Electronics Engineering Volume 15 Issue 6 version 1.0 Year 2015.

[33] Ng PK, Mithraratne N. "Lifetime performance of semi-transparent building integrated photovoltaic glazing systems in the tropics", ELSEVIER– Renewable Sustainable Energy Rev 2014; 31:736–45.

[34] Victor del Razo, Hans-Arno Jacobsen, "Vehicle-Originating Signals for Real-Time Charging Control of Electric Vehicle Fleets", IEEE Transactions On Transportation Electrification, Vol. 1, No. 2, August 2015.

[35] Spina, M.A., de la Vega, R.J., Rossi, S.R., et al. (2012) "Source Issues on the Design of a Solar Vehicle Based on Hybrid Energy System". International Journal of Energy Engineering, 2, 15-21.

[36] Tesfaye M, Castello CC. "Minimization of impact from electric vehicle supply equipment to the electric grid using a dynamically controlled battery bank for peak load shaving". In: 2013 IEEE PES innovate smart grid techno conf, IEEE; 2013. p. 1–6.

[37] Z. Taha, J. Md Sah, R. Passarella, et.al, "A solar vehicle based on sustainable design concept", Proceedings of the IASTED International Conference Solar Energy (SOE 2009), Phuket, Thailand, March 16 - 18, 2009.