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Solar Energy Gate To Improve Electric Vehicle Mobility- A Literature Review

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Abstract: the first electric vehicle (EV) was built between 1832 and 1839; the exact year is not known, in Scotland by Robert Anderson, who created the first crude electric carriage. It was not built until 1895, after A.L. Ryker built an electric tricycle and William Morrison built a six passenger wagon, that America paid attention to the electric vehicle **[1]**. The electric car is considered superior to the internal-combustion car because it has low sound of its engine. Then do what ensued in the evolution of the two cars on the superiority of the internal combustion car for two reasons. First: excellence in cutting long-distance, and secondly: the low weight of the amount of fuel such as gasoline or diesel fuel for the weight of a heavy battery to cut a reasonable distance. It was on the development of the electric car to wait until this day to catch a drive that run on gasoline. In the 1960s and 1970s electric vehicles reappeared because internal combustion vehicles were creating an unhealthy environment for the people in America at that time.

Index Terms: Batteries, Controller, Electric Vehicles, Photovoltaic cell, Semiconductors, Solar Energy, Solar cells

1 INTRODUCTION

The electric car has:
An electric motor.

- A controller.
- A rechargeable battery.

The electric motor gets its power from a controller and the controller gets its power from a rechargeable battery. The electric vehicle (EV) operates on an electric/current principle. It uses a battery to restore energy, and then provide power for the electric motor. The motor then uses this power to rotate a transmission and the transmission turns the wheels **[2]**. The electric vehicle contains mainly four main parts as: the potentiometer, batteries, direct current (DC) controller, and motor. As shown in Figure 1.

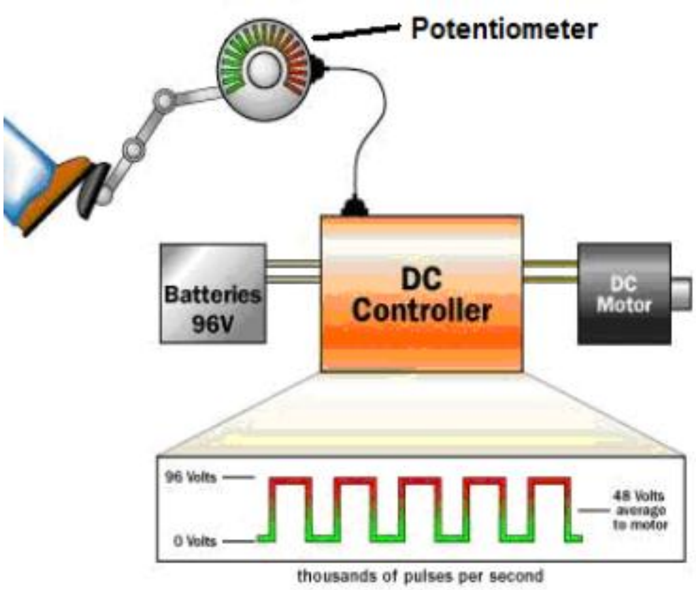

Fig. 1: *Parts of an electric vehicle [2].*

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2 Description of parts and their functions

2.1 Potentiometer

It is circular in shape and it is hooked to the accelerator pedal. The potentiometer, also called the variable resistor, provides the signal that tells the controller how much power is it supposed to deliver.

2.2 Batteries

The batteries provide power for the controller. Three types of batteries: lead-acid, lithium ion, and nickel-metal hydride batteries. Batteries range in voltage (power).

2.3 DC Controller

The controller takes power from the batteries and delivers it to the motor. The controller can deliver zero power (when the car is stopped), full power (when the driver floors the accelerator pedal), or any power level in between. If the battery pack contains twelve 12-volt batteries, wired in series to create 144 volts, the controller takes in 144 volts direct current, and delivers it to the motor in a controlled way [2]. The controller reads the setting of the accelerator pedal from the two potentiometers and regulates the power accordingly. If the accelerator pedal is 25 percent of the way down, the controller pulses the power so it is on 25 percent of the time and off 75 percent of the time. If the signals of both potentiometers are not equal, the controller will not operate [2].

2.4 Motor

The motor receives power from the controller and turns a transmission. The transmission then turns the wheels, causing the vehicle to run.

3 Theory of operation for EV

When the driver steps on the pedal the potentiometer activates and provides the signal that tells the controller how much power it is supposed to deliver. There are two potentiometers for safety. The controller reads the setting of the accelerator pedal from the potentiometers, regulates the power accordingly, takes the power from the batteries and delivers it to the motor. The motor receives the power (voltage) from the controller and uses this power to rotate the transmission. The transmission then turns the wheels and causes the car to move forward or backward. If the driver presses the accelerator pedal, the controller delivers the full battery voltage to the motor. If the driver takes his/her foot off the accelerator, the controller delivers zero volts to the motor. For any setting in between, the controller determines the battery voltage, thousands of times per second to create an average voltage somewhere between 0 and full battery pack voltage.

4 Advantages and disadvantages of the EV

The greatest challenge EVs face deal with the rechargeable battery. Most EVs can only go about 100–200 miles before recharging; fully recharging the battery pack can take four to eight hours. The electric vehicle has more advantages than disadvantages. The electric vehicle has many advantages such as fuel can be harnessed from any source of electricity, which is available at homes and businesses. In addition to that it reduces hydrocarbon and carbon monoxide by 98% and generally reduces pollution. It does not produce emissions which is very important in urban cities. However, the disadvantages of the electric vehicle are limited in the distance that can be driven before the complete failure of the battery. Accessories such as air conditioning and radios drain the battery. Besides, it is very heavy because of the weight of its components such as batteries, electric motor, controllers and chargers. The components of electric vehicle are also very expensive which constrained its movement **[3]**.

5 Solar Energy

It is fully known that the sun of the biggest sources of light and heat in life. Solar energy originates with the thermonuclear fusion reactions occurring in the sun. So, solar energy is the main source of the entire electromagnetic radiation such as visible light, infrared, ultraviolet, x-rays, and radio waves as shown in **Figure 2**. The sun radiates energy in space, the speed of light reaches 300,000 kilometers per second, and the solar radiation is absolutely necessary for the survival of any natural system vital. This energy consists of radiant light and heat energy from the sun. Out of all energy emitted by sun only a small fraction of energy is absorbed by the earth. Just this tiny fraction of the sun's energy is enough to meet all our power needs.

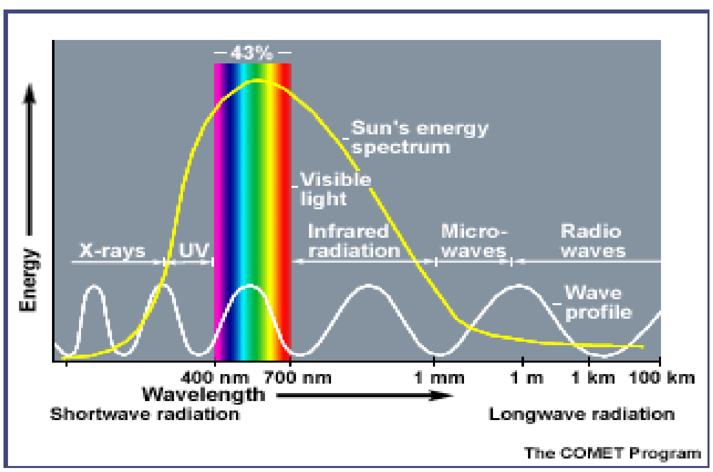

Fig. 2: *Solar wave energy [4].*

6 Insolation

Insolation is the amount of solar radiation reaching the earth. It also called Incident Solar Radiation. Maximum value is 1000 kW/m2.

6.1 Amount of solar energy

The surface receives about 47% of the total solar energy that reaches the Earth as shown in **Figure 3**. Only this amount is usable. Using present solar techniques some of the solar energy reaching the earth is utilized for generating heat, electricity etc.…. Even then the energy demand met by using solar energy is very less.

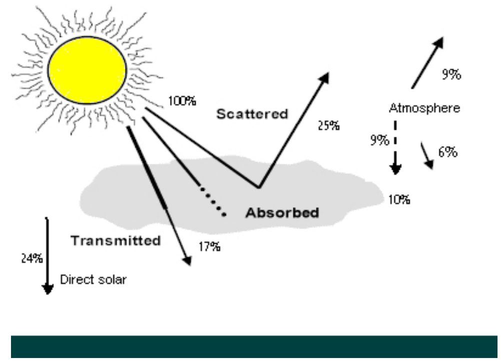

Fig. 3: *percentage of solar energy that reach the surface.*

6.2 Reasons behind using Solar Energy

The fossil fuels are not clean and nonrenewable sources so we can't depend on them forever. In Kuwait, Sun rises for many hours every day. The amount of solar energy is massive and it is much more than the average of electrical power consumed by humans. So the only option we have is solar energy because it is a nonpolluting and silent source of electricity and also low maintenance and long lasting energy.

6.3 Uses of solar energy

Now-a-days, solar technology is being used in so many aspects of lives such as**: [5]**

- Architecture and urban planning.
- Agriculture.
- Solar lighting.
- Solar thermal.
- Water treatment.
- Electricity Generation Using Solar Concentrators etc.
- Solar vehicles equipped with photovoltaic cells.

6.4 Photovoltaic Cell (PV)

Photovoltaic (PV) comprises the technology to convert sunlight directly into electricity. The term "photo" means light and "voltaic," means electricity. A photovoltaic (PV) cell, also known as "solar cell," is a semiconductor device that generates electricity when light falls on it **[5]**. Photovoltaic systems can generate electric power without emitting pollutants. Solar energy may be used to produce electricity using photovoltaic solar cells and heat in photo collectors by a photo thermal conversion process which is called the photovoltaic effect **see figure 4.** A Solar module contains many solar cells connected together **[6]**.

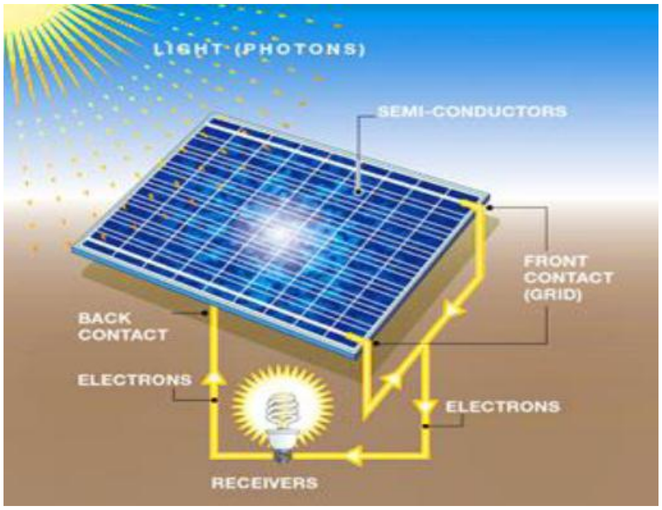

Figure 4: *PV layout*

When light falls on it; Photovoltaic cells are used to convert solar radiation directly into electricity. Solar cell is made of two layers of semiconductor as shown in **Figures (5)**, the light is absorbed by the silicon atoms as energy. This energy increases the number of electrons the electrons in the material which is associated with, and allows them to move freely inside the material. When the free electrons exposed to an electric field, it moves only in one direction generating an electric current. , and when connecting the ends of photovoltaic cell-shaped connector on the top surface and the bottom surface of the cell, we get the electrical current as long as the fall of light on photovoltaic cell continued **[6]**.

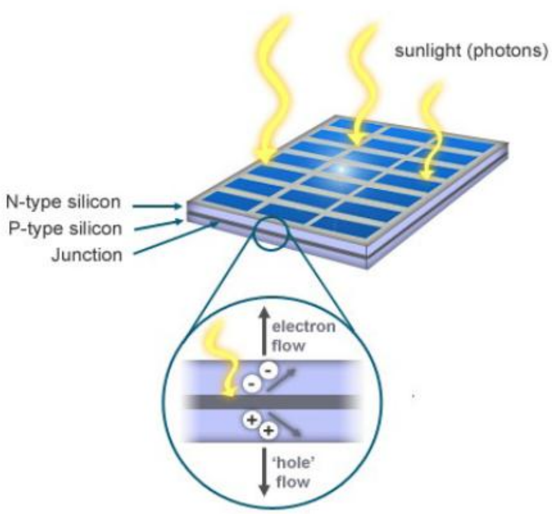

Fig 5: *Photovoltaic effect.*

6.5 Today's PV technology

Current PV technology is the result of decades of performance and price improvements. PV system components, the types of PV module technologies, and current status of PV prices and performance will be explained as following **[7]**.

7 Components of a PV system Fig.6.

7.1 The basic components of a PV system are

- **PV panels**
- **Batteries:** Typically, about 12 deep-cycle lead acid batteries
- **Charge controller:** To regulate the charging of the batteries
- **Inverter:** Converts the low voltage DC (direct current) power from the batteries into 110 volt alternating current for use by appliances.

The following diagram shows they are connected together:

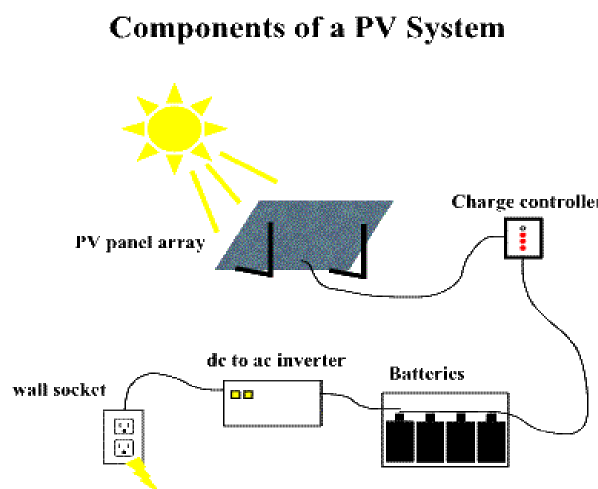

Figure 6: *Components of a PV system.*

First, the Sun shines on the panels to produce electrical power. That power is routed through a charge controller to the batteries. The charge controller regulates the charging of the batteries - the voltage on the batteries needs to be increased slowly, because charging them too fast or routinely overcharging the batteries quickly degrades them. Next, the inverter converts the dc (direct current) electrical power from the batteries into ac (alternating current) electrical power at 110 volts. This can then be fed to household appliances via a wall socket.

7.2 Types of PV cells

i. Crystalline Silicon

Crystalline silicon technologies constitute about 85% of the current PV market [7, 8]. This technology has a long history of reliable performance; c-Si modules have demonstrated operational lifetimes of more than 25 years [9]. There are two general types of crystalline, or wafer-based, silicon PV: mono-crystalline and multi-(poly) crystalline. Mono-crystalline semiconductor wafers are cut from single-crystal silicon alloys. Multi-crystalline semiconductor wafers are cut from directionally solidified blocks or grown in thin sheets. Mono-crystalline alloys are more difficult, energy intensive, and expensive to grow than simple blocks of multi-crystalline silicon. However, mono-crystalline silicon produces higher-efficiency cells. For both types, the silicon is processed to create an internal electric field, and positive and negative electrical connections are added to wafers to form a cell

[Figure 4.7]. Standard cell processes are used to complete the circuit for both mono- and multi-crystalline cells, and multiple cells are connected and packaged to form modules.

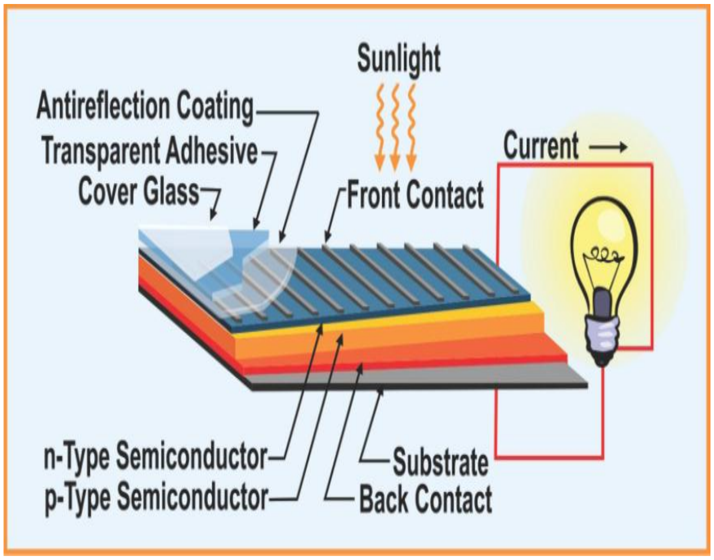

Figure 7: *Basic Components of a c-Si PV Cell [3].*

i. Thin Film [7]

Thin-film PV cells consist of a semiconductor layer a few microns (µm) thick, which is about 100 times thinner than current c-Si cells. Most thin films are direct band-gap semiconductors, which mean they are able to absorb the energy contained in sunlight with a much thinner layer than indirect band-gap semiconductors such as traditional c-Si PV. The most common thin-film semiconductor materials are cadmium telluride (CdTe), amorphous silicon (a-Si), and alloys of copper indium gallium dieseline (CIGS). The semiconductor layer is typically deposited on a substrate inside a vacuum chamber. A number of companies are pursuing lower-cost, non-vacuum approaches for manufacturing thin-film technologies. Glass is a common substrate, but thin films can also be deposited on flexible substrates such as metal, which allows for the potential for flexible lightweight solar modules. Thin films are very sensitive to water vapor and thus have traditionally been encapsulated behind glass to maintain performance. Eliminating the need for glass through the use of "ultra-barrier" flexible glass replacement materials is an important next step in thin film development.

7.3 PV Performance and Price

The performance of PV technologies has improved substantially, while PV manufacturing costs have declined during the past several decades due to a combination of technological innovation, improved manufacturing processes, and growing PV markets. All of these factors have contributed to a downward trend in PV prices.

7.4 PV efficiency

Energy efficiency factors must be carefully considered while designing any solar PV systems to get the best out of efforts and investment. The efficiency of a solar cell or module is the percentage of the sun's energy striking the cell or module that is converted into electricity **[7]**. **Figure 8** shows the typical differences of different PV cells efficiency are 25.1 % for mono-crystalline and 20.5 % for multi- (poly) crystalline silicon wafer-based technology. The highest lab efficiency in thin film technology is 20.5 % for CdTe and 20 % for CIGS solar cells. High concentration multi-junction solar cells achieve an efficiency of up to 45.0 % today. Generally, mono-crystalline modules are the most expensive but most efficient. Thin film is the cheapest but least efficient, CdTe has experienced significantly higher market growth during the last decade than the other thin-film PV technologies. And multicrystalline is in between these two types **[6]**.

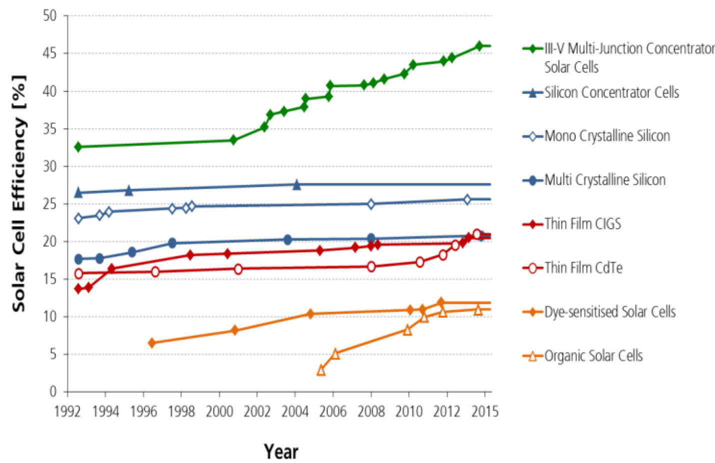

Figure 8: *PV typical efficiencies [6].*

7.5 PV costs and installation curve

This figure shows that the installation of Photovoltaic panels is a remarkable increasing till 2015, and their cost is in a continuous decreasing.

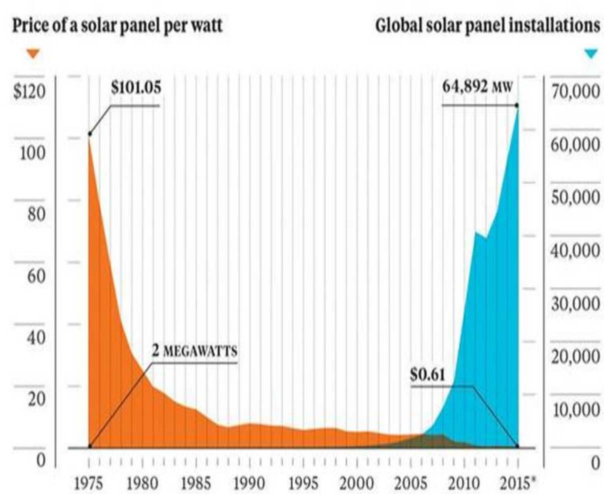

Figure 9: *PV Cost and Installation [11].*

7.6 PV Cell Model

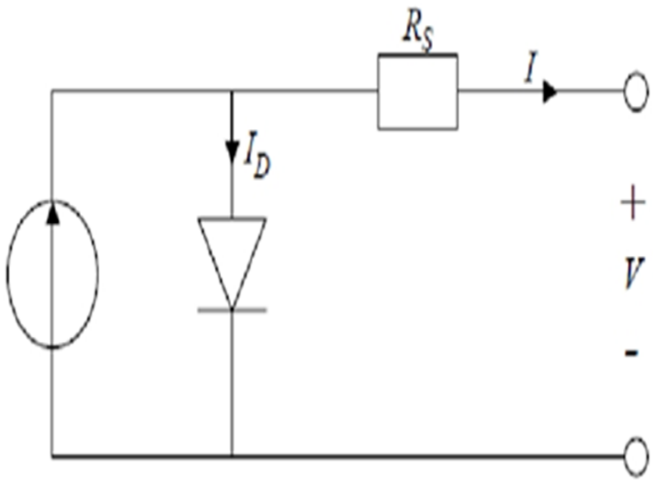

Figure 10: *PV simple model [12].*

When there is no sunlight, the solar cell is not an active device; it works as a diode. If it is connected to an external supply it generates a current I_D, called diode current or dark current. That is why the electric circuit model of solar cell is like, which contains a current source I_{ph}, a diode and a series resistance representing the internal resistance of a cell R_S. The net current (I) is therefore the difference between I_{ph} and I_D.

m = *Idealizing factor*
k = *Boltzmann's gas constant*

Tc = *absolute temperature of the cell*
q = *electronic charge*
V = *voltage imposed across the cell*

$I0$ = *Dark saturation current*

. I-V CHARACTERISTICS

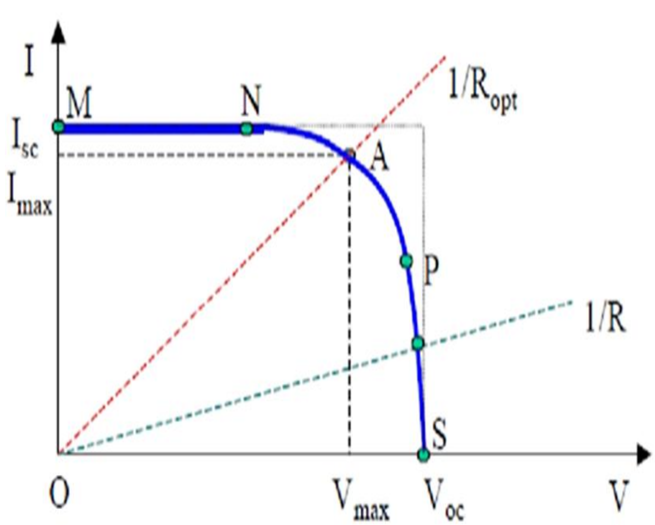

Figure 11: *characteristics curve for PV cells [12].*

If the terminals of the cell are connected to a resistance *R*, the operating point is determined by the intersection of the *IV* characteristic of the solar cell with the straight line of slope 1/R

7.7 Solar cell parameters

A PV cell has the following fundamental parameters: [12]
a) Short circuit current: Iph = Isc. It is the greatest value of the current generated by a cell under short circuit conditions i.e. V = 0.
b) Open circuit voltage: It corresponds to voltage of cell at night, when generated

Current I = 0. Mathematically,

c) Maximum Power Point: It is the point of IV curve (figure-4) where maximum power is dissipated.
d) Maximum efficiency: It is the ratio between maximum power and incident light power.
e) Fill Factor: It is the ratio between maximum power and the product of Isc and Voc.

7.8 Module Model

Cells are grouped into module. A PV module consists of N_{PM} parallel branches each having N_{SM} solar cells in series

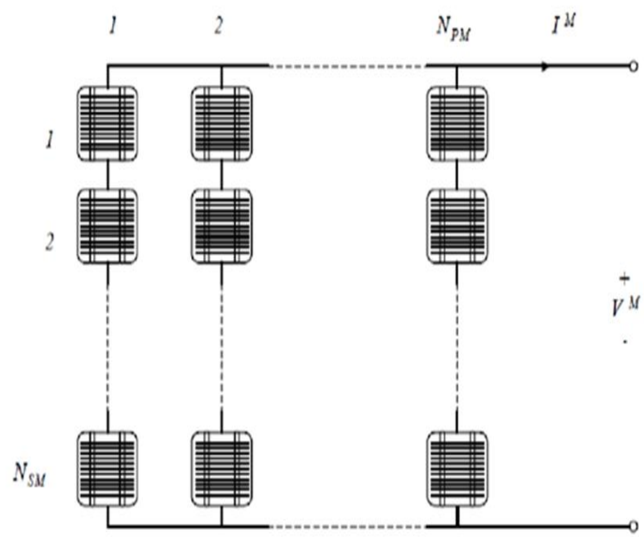

Figure 12: PV module model [13].

A model of this PV module can be obtained by replacing each cell by equivalent circuit of. Then the modules current IM can be expressed as-

$$I_M = I_{SC}^M \left[1 - \exp\left(\frac{V^M - V_{OC}^M + R_S^M . I^M}{N_{SM} V_t^C}\right)\right]$$

Where:

$'M'$ *superscript represents the module*

$'C'$ *superscript represents a cell*

$I_{SC}^{M} = Module's\ short\ circuit\ current = N_{PM} I_{SC}^{C}$

$V_{OC}^{M} = Module's\ open\ circuit\ voltage = N_{SM} I_{OC}^{C}$

$R_{S}^{M} = Equivalent\ series\ resistance\ of\ module = \frac{N_{SM}}{N_{PM}} R_{S}^{C}$

$V_{M} = Load\ voltage$

References

[1]. Bellis, M. History of Electric Vehicles. Retrieved January 31, 2010 from http://inventors.about.com/library/weekly/aacarselectrica.htm.

[2]. Brain, M. (2002). How Electric Cars Work. Retrieved January 29, 2010 from http://auto.howstuffworks.com/electric-car2.htm.

[3]. Ann Holms, Rony Argueta, " A Technical Research Report: The Electric Vehicle", Argueta – 6-7, March 11, 2010.

[4]. https://www.ucar.edu/learn/1_5_2_23t.htm.

[5]. Golam Shahriar Majumder, Touhidul Alam, Ashraf Uddin Ahmed Zubair, "Environment friendly solar car", BRAC University, Dhaka, Bangladesh, p.12, April 2010.

[6]. Olivia Mah "Fundamentals Photovoltaic Materials", National Solar Power research Institute, Inc., pp.2, 12/21/98.

[7]. Sabri L., Benzirar M., "Effect of Ambient Conditions on Thermal Properties of Photovoltaic Cells: Crystalline and Amorphous Silicon", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 12, pp.17818, 2014.

[8]. "Sun Shot Vision Study", pp.70, February 2012.

[9]. Mints, "Photovoltaic Manufacturer Shipments, Capacity & Competitive Analysis", 2010/2011. Palo Alto, CA: Navigant Consulting Photovoltaic Service Program. Report NPS-Supply6 (April 2011).

[10]. Jordan, D.C.; Kurtz, S.R. (2011). “Photovoltaic Degradation Rates – An Analytical Review.” Prog. Photovoltaics, in press.

[11]. Fraunhofer institute for solar energy system with support of PSE AG, "photovoltaics report", p.25, Freiburg, 17 November 2015, www.ise.fraunhofer.de.

[12]. http://www.treehugger.com/renewable-energy/striking-chart-showing-solar-power-will-take-over-world.html.

[13]. Hansen, A. D., Sørensen, P. E., Hansen, L. H., & Bindner, H. W., " Models for a stand-alone PV system", Denmark. Forskningscenter Risoe. Risoe-R; No. 1219(EN), p.9-14, (2001).