A SOLAR CHARGING SYSTEM FOR A PORTABLE ELECTRIC SKATEBOARD

NUR FATIN SYAHIRA BINTI ROZAK
TC 14012

BACHELOR OF ENGINEERING TECHNOLOGY
(ENERGY & ENVIRONMENTAL)
UNIVERSITI MALAYSIA PAHANG

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A SOLAR CHARGING SYSTEM FOR A PORTABLE ELECTRIC SKATEBOARD

NUR FATIN SYAHIRA BINTI ROZAK

Thesis submitted in fulfilment of the requirements for the award of the degree of Bachelor of Engineering Technology in Energy & Environmental

Faculty of Engineering Technology
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STATEMENT OF AWARD FOR DEGREE

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of degree of Bachelor of Engineering Technology in Energy & Environmental.

Signature:

Name of Supervisor: DR. MOHAMMED HAYYAN ALSIBAI

Position: LECTURER, FACULTY OF ENGINEERING TECHNOLOGY, UNIVERSITI MALAYSIA PAHANG

Date: JANUARY 2018

Signature:

Name of Co-Supervisor: NURUL NADIA BINTI HAMRAN

Position: LECTURER, FACULTY OF ENGINEERING TECHNOLOGY, UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

In recent decades skateboarding has expanded from recreation into a form of transportation, by customizing a conventional skateboard into an electric skateboard. This project present the design and methodology used in building an electric skateboard that has an alternative solar power charging. The objective of this project are to develop an alternative mode of transport that is highly portable and low cost, high durability and reliable for daily commute with minimum maintenance needed. In this thesis, performance testing of solar charging with the electric skateboard is done to achieve third objective of the project which is to reduce the impact on environment by developing a solar system charger. The results show that electric skateboard can be charged using solar charging system and also normal charge. Moreover it can reduce the environment air pollution. Furthermore, by using solar charging sytem, we can save cost of paying electricity bill when charging the electric skateboard on normal charge since we the system produce their own electricity on off grid solar system. This project also achieve a fast charging with solar system dependent on sun availability and power of battery left to charge the electric skateboard.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO^2	Carbon Dioxide
km	Kilometer
%	Percent
Kmph	Kilometer per hour
°	Degree Celsius
V	Voltage
A	Amphere
mm	Millimeter
DC	Direct current
AC	Alternative current
P_{max}	Maximum power output
A_c	Area of collector
W/m^2	Watt per square metre
W	Watt
Ah	Amphere-hour
PV	Photovoltaic
kWh	Kilowatt hour
η_{max}	Maximum efficiency

CHAPTER 1

PROJECT BACKGROUND

1.1 INTRODUCTION

The goal of this project is to expand the use of skateboard from driveways and skate parks to city and streets, where it had expanded from a recreation activity to a form of personal mobility transportation. With higher demand of personal transportation nowadays, we introduce an electric skateboards as an alternative green transportation, with a which provide lots of benefits in aiming to maintain a pollution free with zero emissions, free parking, freedom from gridlock and less impact on human health and on the natural environment compare with normal vehicles where it affected and increase the green house emissions at present time and its impacs will be worse in the near future. In most situations of traffic jam in the city, riding an electric skateboard will be faster and cheaper other normal vehicles either own or using public transportation.

Throughout the years, many students in Universiti Malaysia Pahang (UMP) choose to walk for a short distance and take public transport or car along far distance buildings inside campus. Usually, students have to take at least 15-20 minutes to travel to classes around university because most campus have long distances between each building. The idea of having a portable and fast transportation, where people don’t have to use physical force, become as benefit for people to use it in this new era green technology.

To improve on pass team's success, we must make significant changes to the vehicle to reach our goal. There are three objectives that need to achieve for this project which are to develop an alternative mode of transport, electric skateboard that is highly portable and low cost, high durability and reliable for daily commute with minimum maintenance needed, to improve the efficiency to achieve longer travel distance within a single charge besides to reduce the impact on environment by developing a solar system charger.

1.2 PROBLEM STATEMENT

Transportation is one aspect we cannot live without in these day and age. However, the transportation systems nowadays come along with lots of problems including global warming, environment degradation, health issues (physical, emotional, mental, and spiritual) and emission of greenhouse effect. In fact, the transport sector attributes to 23% of the globe's greenhouse gas emission resulting from burning of fossil fuels. All of this puts lot of burden on the national governments to devise policies to reduce greenhouse gas emissions as well as oil demands. Green transportation revolves around efficient and effective use of resources, modification of the transport structure and making healthier travel choices (Converse Energy Future, 2017). Besides, according to World Bank's 2015 Malaysia's Economic Monitor report, the congestion cost in Malaysia had amounted to 1.1%-2.2% of Malaysia's GDP in 2014, where this sum of cost is divided into 3 types of cost, including delays, fuel, and CO^2 and other emissions (Gil Sander, Blancas Mendivil, & Westra, 2015).

It is common to know that that these recent years, fuel price is increasing. Moreover, buying a car is a large and often necessary purchases and the price of car will keep depreciates over time. Besides, maintenance service and road tax are also high cost expenses that vehicle owners couldn't avoid. By contrast, electric skateboard only requires minimum operation and maintenance fees, no insurance fees, attract no road tax and typically do not require a license to ride in most countries. Furthermore, they are efficient, environmentally friendly, and far denser, when parked and driven, than the equivalent rows of cars. Riding an electric skateboard could also help eliminate the requirement of parking spaces, especially in urban areas where parking spaces are highly limited.

Therefore, a green technology transportation is needed to develop to replace the current transportation. In our research, using a solar charging skateboard to commute is another great mode of green transportation. Skateboarding has expanded from its predominant form of recreation into a recognizable form of transportation. Solar electric skateboard is an ideal form of transportation for trips that are too far to walk. A standard electric skateboard is normally control by a radio frequency remote control and have a maximum speed up to 30 km per hour. Hence, we develop a solar electric skateboard by many strong and best material to overcome those problems. Moreover, an electric skateboard design is portable and lightweight to be carried everywhere so it is not a burden for different age of people. It is a low cost product so that people can afford to purchase it and it need less maintenance compared to other transportation.

1.3 OBJECTIVES

The main objective of this project is to develop an alternative mode of transport, electric skateboard that is highly portable and low cost, high durability and reliable for daily commute with minimum maintenance needed. Since charging the battery is one important procedure this thesis is dedicated to two objectives:

1. To reduce the impact on environment by developing a solar system charger.
2. To achieve fast efficient charging of the electric skateboard battery using the solar charging system.

CHAPTER 2

LITERATURE REVIEW

In this chapter, some research and survey related to the performance of green transportation is presented. The main topics that have been researched about existing problems of green transportation system and their reasons. A fact that green transportation already implemented in some country since it ease traffic congestion and solve urban pollution and environmental problems in cities but there are some lack that appear from the shifting technology.

Light weight vehicles with incorporated with alternative renewable energy are slowly entering the transportation industry, especially in congested cities. This type of alternative mode of transport meets the demand of minimizing carbon footprint and also responds to the future energy transitions. (Sivert, A., Betin, F., & Lequeu, T. , 2014)Here, we reviewed on the implementation of solar panels in tricycle and boat. The tricycle (Beedu, R., 2015) for example features a few specifications that is able to help cyclist in better riding experience, including increased speed with minimum paddling, and help cyclist to climb up slopes. Tricycle are one of the major mode of transportation in rural areas, and most of the cyclist face problem while going up slope, hence with the modification on the tricycle, it can help cyclist to reduce fatigue at the same time providing shade. As part of the modification, a hub motor is incorporated into the front wheel of the tricycle, and two Li-ion batteries with a regulator is mounted below the carrier. Additionally, in order to reduce the battery charging time, the tricycle also have two solar panels fixed to a stand that is mounted on the back of the tricycle that is able to increase charging time up to 5% of the total charging time. Figure 1 shows the build of solar powered tricycle.

Figure 1. Solar Powered Tricycle

With all the modification on the tricycle above, the maximum speed on flat road with zero slope without pedaling is 9kmph, while the maximum speed on road with 7.5° slope without pedaling is 7kmph, and 5kmph at a 15° slope. On a single charge, the tricycle is able to travel a distance of 19km in an hour without pedaling (Beedu, 2015).

The Solar boat (Spagnolo, G. S., Papalillo, D., Martocchia, A., & Makary, G., 2012), is designed for tourist transport along the coast, rivers and lakes. The boat is powered by lithium-ion batteries that can be charged any time by photovoltaic generator placed on a flat top structure, as shown in Figure 2. In this design, the area available for the photovoltaic array is about 55m2. The project installs a solar module of 42 Sanyo's HIT Power 225, where every single panel has a dimension of 1,580mm x 798mm x 46mm, maximum power voltage od 43.4V, maximum power current of 5.21A, which leads to a maximum output power of 225W in standard test conditions. The panels on the solar boat is connected into 6 strings of 7 panels in series, providing an output maximum power voltage of 304V, and maximum power current of 31.26A.

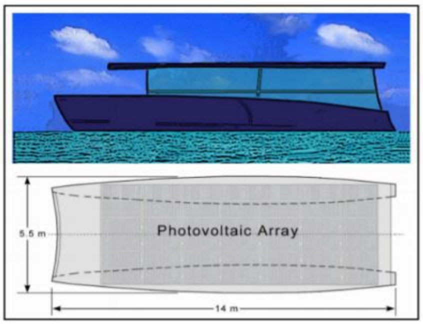


Figure 2. Solar-Electric Boat

2.1.1 Types of solar cells

Traditionally, solar cells have different types with their different efficiency, matterials used and performance depends on the wether and temperature. Among the many types of solar cell, we choose 2 types which are widely used around the world and followed with the technology manufactured nowadays. Below is the table of different characteristics of type of solar cells that a listed at the best solar cells today.

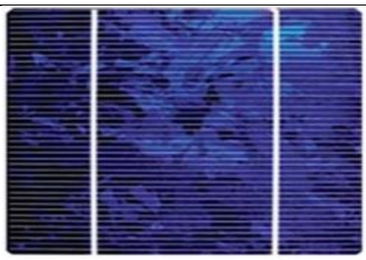
Type of solar cells	**Monocrystalline silicon solar cells**	**Polycrystalline silicon solar cells**
Efficiency	High efficient	Less efficient
Area	requires less area for a given power	requires less area for a given power
Performance	Best at standard temperature. Performance degrades in low-sunlight conditions.	Best at moderately high temperature. Performance degrades in low-sunlight conditions.
Made up of	Single silicon crystal	Fusing different crystal of silicon
Water resist	Yes	Yes
Cost	High	Economic
Example		

Table 1. Different type of solar cells

Among these 2 types, we choose monocrystalline silicon solar cells because it has high efficiency to collect energy from the sun and with our condition temperature in Malaysia, is at best we using this type because it performed well at standard temperature.

2.1.2 Types of solar charger controller

Solar charger controller is one of the important part in using solar system. There are two different type of solar charge controller with two different charging method. Before we choose the most suitable solar charge controller, we need to understand the difference between Pulse Width Modulation and Maximum Power Point charge controller.

1. PWM charge controllers

PWM called Pulse-Width Modulation comes when the battery bank is full. During charge, the controller will allows as much as the current from the PV panel to the target voltage of battery, and it will stop quickly and switch off the connection between the battery bank and the panel array. This PWM will ensure your battery bank is efficiently charge and will protect the battery from overcharge. To use this PWM, the voltage of the solar panel must be same with the battery.

2. MPPT charge controllers

MPPT called Maximum Power Point Tracking comes from an indirect connection between PV panel and the battery bank. It is an algorithm that used for extracting maximum available power from PV module under certain conditions. The indirect connection includes a DC/DC voltage converter which can take PV voltage then convert it into extra current at a lower voltage without using its power. The MPPT will adjust its input voltage to harvest the maximum power from the solar panels to transfer the power to supply at varying voltage requirement of the battery and boosting it.

Table 1. Shows the comparison between the general differences of PWM and MPPT charge controllers.

MPPT (Maximum Power Point Tracking)	**PWM (Pulse Width Modulation)**
PV panel can be higher or lower than the battery voltage	PV panel and battery voltage must be match
Reduce harvesting efficiencies when used in low power applications	Low power applications have better energy harvest with PWM controller
Voltage at maximum power (VMP) is reduce when in warm temperature, while it will boost the charging in cold temperature	Performs well in warm temperature and when the battery is almost full
It extracts maximum power from solar panels and charges battery efficiently	It only utilizes the power generating from solar panels and charges the battery
Efficiency up to 96%	Efficiency up to 70%
It uses 96W of output power of 100W solar panel	It uses 70W of output power of 100W solar panel

Table 2. Different of solar charger controller

Therefore, we decided to choose Pulse Width Modulation (PWM) because we only use a simple system which is not required high voltage of solar panel also we want to ensure our battery bank is efficiently charge and protect it from overcharging. Furthermore, the price of Pulse Width Modulation (PWM) is quite cheaper for simple system compare with Maximum Power Point Tracking (MPPT).

2.1.3 Types of batteries

In the charging system of electric skateboard, we make a comparison of which battery is better to be use in the system to store energy from solar panel. The battery is an electric power supplies that is widely used. (Tsui and Michael Pecht, 2011) Battery also is a device that stores energy for the electric power supply. Batteries are used in the electric energy storage for stand-alone photovoltaic systems during no sunlight. (N.S. Wade, P.C. Taylor, P.D. Lang, P.R. Jones, 2010)

PV stand-alone system designed for the people in remote areas where there is no electricity distribution networks. The working principle is divided into two times during the day, solar cell absorbs sunlight in order to produce electricity and supply to load as well as charge the exess electricity to battery simultaneously. During the night when there is no sunlight, solar cell can't generate the electricity. Hence, energy from the battery that charges during the day will be supplied to the load. (Soteris A. Kalogirou, 2009) This is the situation when battery is needed on stand-alone photovoltaic system to supply electricity to the load both during the day and night.

There are few types of battery are suitable to be used in photovoltaic system, but we focus on 2 types which are lead-acid battery and lithium ion battery. These 2 types have their advantage and disadvantage to the system, economic and environment. Table below is the comparison between 2 types of battery use in photovoltaic system.

Types of Battery	Lead Acid Battery	Lithium Ion Battery
Capacity used	Limited usable capacity-typical 30-50%	Useable capacity is 80% or more of total capacity
Life cycle	Limited life cycle-typically 400-500 cycles	Extremely high cyle life-typically 2000-5000 cycles
Efficiency	Lower efficiency due to high maintenance	Greater efficiency for big loads
Weight	Heavy weight	Light weight
Cost	Cheap	Very costly (between 3-4 times of lead acid battery)

Table 3. Types of battery

In this project, we decided to choose Lead Acid battery since the cost is cheap compare to Lithium Ion battery which cost 3 to 4 times more than Lead Acid Battery. Eventhough Lead Acid battery have a side impact to the environment, it still can be control by ensuring it is disposed with a proper recycling method.

CHAPTER 3

METHODOLOGY

3.1 THEORY

This part of the thesis will discuss about the theories, calculations and procedure that we will use in our project. We divide our findings into a few parts, which are the solar panel, battery bank, solar charger controller, and inverter.

3.1.1 SOLAR PANEL

In solar system, sunlight can be directly harvested into solar energy with the use of small and tiny photovoltaic (PV) solar cells, by hitting photons to the solar cells and absorb by semi-conducting materials. Semiconductor solar cells are fundamentally quite simply devices. Semiconductors have the capacity to absorb light and to deliver a portion of the energy of the absorbed photons to carries of electric current – electrons and holes. A semiconductor diode separates and collects the carriers and conducts the generated electrical current preferentially in a specific direction. Thus, a solar cell is simply a semiconductor diode that has been carefully designed and constructed to efficiently absorb and convert light energy from the sun into electrical energy.

Solar cells shown as the Figure 2.2.5 below convert the energy of light directly into electricity (DC) using photovoltaic effect. The process of conversion first requires a material which absorbs the solar energy (photon), and then raises an electron to a higher energy state, and then the flow of this high-energy electron to an external circuit. Silicon is one such material that uses such process (S. 13 May, 2013)

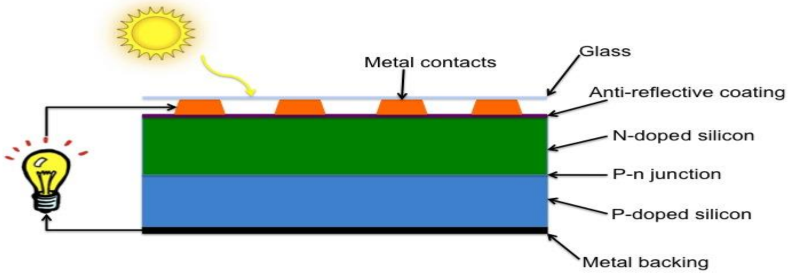


Figure 3. Solar cell structure

A solar cell consists of a layer of p-type silicon placed next to a layer of n-type silicon, figure 4. In the n-type layer, there is an excess of electrons, and in the p-type layer, there is an excess of positively charged holes (which are vacancies due to the lack of valence electrons). Near the junction of the two layers, the electrons on one side of the junction (n-type layer) move into the holes on the other side of the junction (p-type layer). This creates an area around the junction, called the depletion zone, in which the electrons fill the holes.

When all the holes are filled with electrons in the depletion zone, the p-type side of the depletion zone (where holes were initially present) now contains negatively charged ions, and the n-type side of the depletion zone (where electrons were present) now contains positively charged ions. The presence of these oppositely charged ions creates an internal electric field that prevents electrons in the n-type layer to fill holes in the p-type layer.

When sunlight strikes a solar cell, electrons in the silicon are ejected, which results in the formation of "holes"—the vacancies left behind by the escaping electrons. If this happens in the electric field, the field will move electrons to the n-type layer and holes to the p-type layer. If you connect the n-type and p-type layers with a metallic wire, the electrons will travel from the n-type layer to the p-type layer by crossing the depletion zone and then go through the external wire back of the n-type layer, creating a flow of electricity.

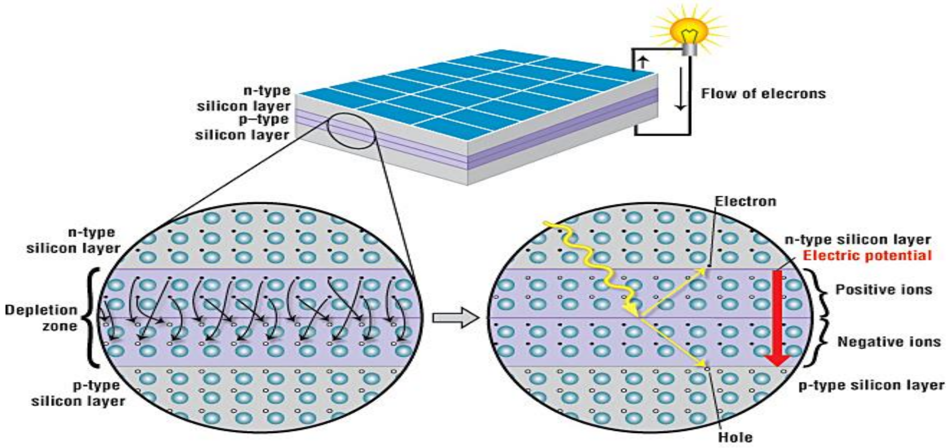


Figure 4. p-type & n-type silicon layer

The efficiency is the most commonly used parameter to compare the performance of one solar cell to another. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. In addition to reflecting the performance of the solar cell itself, the efficiency depends on the spectrum and intensity of the incident sunlight and the temperature of the solar cell. Therefore, conditions under which efficiency is measured must be carefully controlled in order to compare the performance of one device to another (Gohz, 2015)

The efficiency of a solar panel is determined as the fraction of incident power which is converted to electricity and is defined as:

$$\eta_{max}(\,maximum\ efficiency) = \frac{p_{\max(maximum\ power\ output)}}{(E_{Sy}^{SW}\ (incident\ radiation\ flux)\ \times\ A_c\ \ (area\ of\ collector))} \times 100\%$$

Where incident radiation flux be described as the amount of sunlight that hits the earth's surface in W/m^2. The assumed incident radiation flux under standard test conditions (STC) that manufacturers use is 1000 W/m^2.

3.1.2 BATTERY BANK

Before the solar system is connected to electric skateboard, how many watts that need to provide from the solar system is was studied first since its function to charge the battery. (GoGreenSolar, 2017).

Battery calculations:

$$charge\ time\ (hours) = \frac{(amp - hours\ \ \times 1.15)}{charge\ rate}$$

$$charge\ rate\ (Amps) = \frac{Watts\ (W)}{Volts\ (V)}$$

Hence, the charge time will show how long the battery will achieve the full charge. We use the 12V lead acid battery (figure 5) since the solar panel only 90W and 100W with 12V as to achieve our target which is fast charging because it’s rechargeable battery and can work as a charger. In this project, we decided to choose lead acid battery because it is affordable and (Suratsawadee Anuphappharadorn, Sukruedee Sukchai, Chatchai Sirisamphanwong and Nipon Ketjoy, 2014) stated that photovoltaic stand-alone using lead-acid battery is more suitable than using lithitum-ion battery eventhough lithium-ion battery have many advantage compare to lead acid battery but in initial investment cost of battery, lead acid battery is the best choice.

Figure 5. Lead acid battery

3.1.3 SOLAR CHARGER CONTROLLER

A solar charge controller actually is a type of regulator as known normally in every part of solar charging system. Since we planned to install off grid solar system, solar charger controller is the important thing need to have in the system. The main role of solar charge controller is to maintain and protect the battery from overcharging. The reasons why we need it because:

1. Reducing the voltage of solar panel

• If we don't put the controller between a solar panel and a battery, the panel will overcharge the battery by generate too much voltage to the battery, hence it will damage the battery the result the battery will explode.

2. Monitoring the voltage of your battery

• The controller will detect if the battery's voltage is too low or not. If it low then the controller will disconnects the load from the battery to avoid the battery from being too drained.

3. Stopping reverse current at night

• As to prevent any damage to solar system at night, controller is use to stop current reverse from flowing back into the solar panel.

Therefore, the solar charge controller we use is pulse width modulation (PWM), figure 5.

Figure 6. PWM Solar Charger Controller

3.1.4 SOLAR INVERTER

When using a solar panel, we not only need to consider solar charge controller and battery, but also a solar inverter. Solar inverter actually plays an important role in a solar energy system. Solar inverter contains large capacitors which it can be used to store power also to improve the output waveform. The use of solar inverter is to convert the electricity from solar panels and create it into a form of electrical energy that we can use for any electrical appliances, lighting or other electronics even used to charge the mobiles and batteries too.

The principle of solar inverter is start from the sun shine hit on solar photovoltaic (PV) system, then the electrons within the solar cells will start to move around and produce direct current (DC) energy. The energy produce from solar system will stored in battery tank. The solar inverter then is connected to the battery tank to change the direct current (DC) energy from the battery tank to alternative current (AC) energy that can be use with any electrical appliances.

Before choosing the right inverter, there are few types of solar inverter that we need to understand with. Solar inverter have 3 types which are:

- Stand alone (off – grid) inverter – it is used in isolated systems. The DC energy is drawn from battery. The battery is chargerd from the photovoltaic arrays. This type of inverter do not interfaced with the utility grid.
- Grid – tie inverter – its phase matches with the utility supply. It consist of saspecial circuit for matching the voltage and frequency of the grid. It is connected to the utility grid and gets disconnected when it does not detect the presence of grid. That is it will automatically shut down during the utility outage.
- Battery backup inverters – It gets energy from battery. It uses an onboard charger to manage the battery charge. The excess energy will be given back to the utility grid. If utility outage occurs, then it will give AC supply for selective loads

In this project, we decided to choose 500W for alternative current (AC) to convert the variables direct current (DC) output of photovoltaic (PV) solar panel into a alternating current (AC) that can be use for AC load. The power of load that we use is 80W which is Imax AC/DC Dual Power Professional Balance Charger/Discharger, figure 6.

Figure 7. Imax AC/DC Dual Power Professional Balance Charger/Discharger

The consideration was taken for our equipment which is Imax with power consumption is 80W. Eventhough, these equipment may have a greater consumption several times compare with normal working power (typically caused by electric motors), this should be taken into account when chooing the correct size of inverter. According to general guidance (lelevkin, n.d.), the range of continouous power rating of inverter that we should choose for the power consumption from the equipment are from 300W until 6000W. Since we choose 500W of power inverter, we don’t have problem to convert the connection to make it running, figure 7.

In theoretically, the power of inverter that we need is followed with the formula:

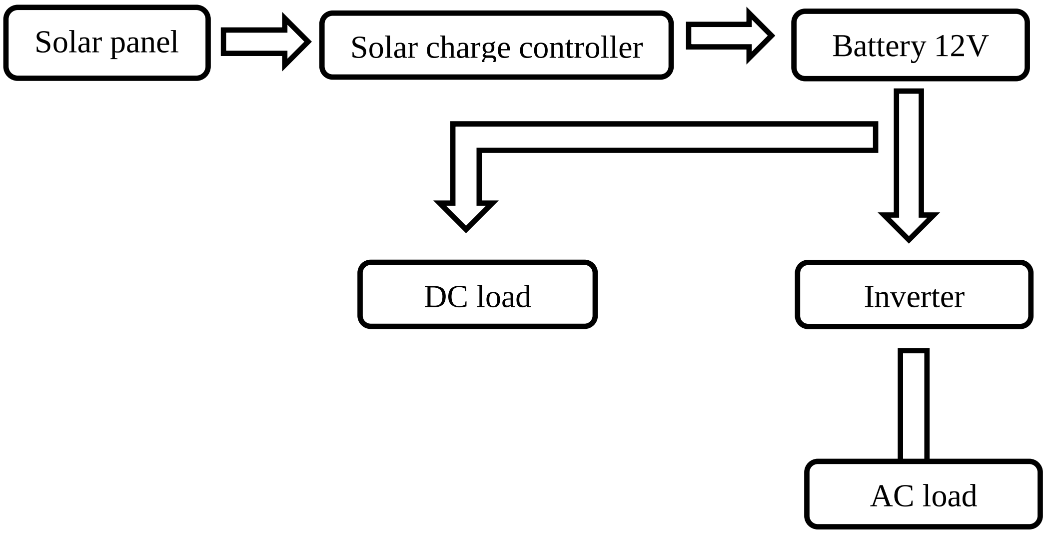
$$power\ of\ inverter = \frac{power\ requirement}{power\ factor}$$

Most of the inverters have efficiency about 60% to 70%. So we assume power factor is 0.7.

Figure 8. 500W of solar inverter

3.1.5 CONNECTION SYSTEM

Below is the block diagram that show hows the connection work from solar panel to direct current (DC) or alternative current (AC).



3.1.6 ELECTRICITY CONSUMPTION

The feed in-in-tariff payment for the electricity we generate from normal plug give a high cost in electricity bill. The power consumption of electrical appliance at home and the usage hour affected the cost of bill in a month. Currently, the electricity tariff for Peninsular Malaysia is RM 1.52 sen/kWh until Dec 30 of this year. So, to know the power consumption (Michael Bluejay, 2015) that we use daily for charging the electrical skateboard, the formula is followed below:

$$kWh = \frac{Watts \times Time\ (hrs)}{1000}$$

$$electricity\ bill\ consumption = kWh\ \times electricity\ tariff$$

Therefore, comparison made between solar energy and conventional energy. The off grid solar system was choose in this project. The comparison will be shown in result.

3.2 MATERIAL SELECTIONS

In this project, a 90W and 100W with different area of solar panel was chosen. The different of panel power is because the size and number of cells in the solar panel is not same. Below are the solar panel that we use in this project. Furthermore, to make electric skateboard easy to charge at sunny day and if it's away from any plug, we designed a solar charging station to make it ease to charge at suitable place, figure 9.

Figure 9. 90W of solar charging station

We also used portable solar panel where it is handcarry anywhere if we go to some place that away from the solar charging station, figure 10.

Figure 10. 100W of foldable solar panel

3.3.1 PERFORMANCE OF SOLAR PANELS

A) TESTING SOLAR PANEL FOR VOLTS (V)

Procedure:

1. Put solar panel in direct sunlight and set the multi-meter to the “volts” setting.
2. Touch the multi-meter’s (red) positive lead to solar panel’s positive wire.
3. Then touch the multi-meter’s (black) negative lead to solar panel’s negative wire.
4. The volts reading tested are displayed on the multimeter.

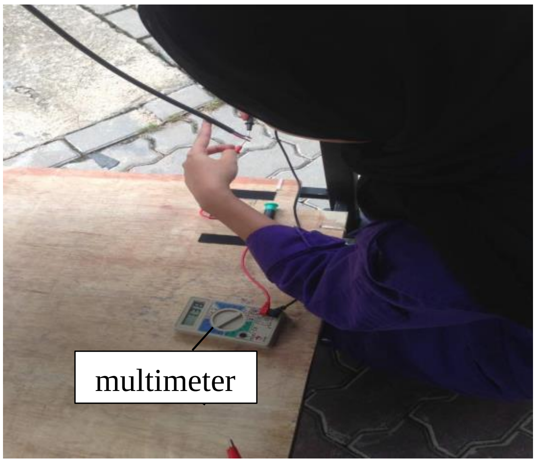


Figure 11. Testing panel with multimeter

This testing were done because we want to check our solar system is it perform properly or not. Hence, by measuring the system we can know the output of solar panel given when it is directly to the sun.

B) TESTING OPERATING CURRENT

Procedure:

1. Connect the panel to the charge controller and battery.
2. Ensure that the multimeter is set at 10A, at least to start with.
3. Disconnect the positive cable between the battery and the charge controller.
4. Measure the operating current by connecting the positive from the multimeter to the positive cable from the charge controller, and the negative from the meter to the positive battery terminal.

The efficiency are calculated and shown at the result.

$$\eta_{max}(\,maximum\ efficiency) = \frac{p_{\max(maximum\ power\ output)}}{(E_{Sy}^{SW}\ (incident\ radiation\ flux)\ \times\ A_c\ \ (area\ of\ collector))} \times 100\%$$

3.3.2 CHARGING OF BATTERY BANK

Procedure:

1. Put solar panel to sunlight and connect the red wire (positive) and black wire (negative) of solar panel to solar charger controller.
2. Connect new red wire (positive) and black wire (negative) to solar charger controller at battery sign.
3. Clip the red wire (positive) and black wire (negative) from the connection of battery sign to 12V lead acid battery.
4. Setting the solar charger controller to make sure the battery is charging.
5. Measure the time of charging the battery tank until its full.

Figure 12. Solar charger controller

3.3.3 CONNECTION OF INVERTER TO AC LOAD

Procedure:

1. Clip the red wire (positive) and black wire (negative) of inverter to battery tank.
2. Plug on AC load to inverter.
3. Switch on the inverter.
4. Make sure the small green led behind the inverter is lights up.
5. Connect battery from electric skateboard to AC load (Imax) AC/DC Dual Power Professional Balance Charger/Discharger.
6. Record the timing of charging electric skateboard with solar charging system.

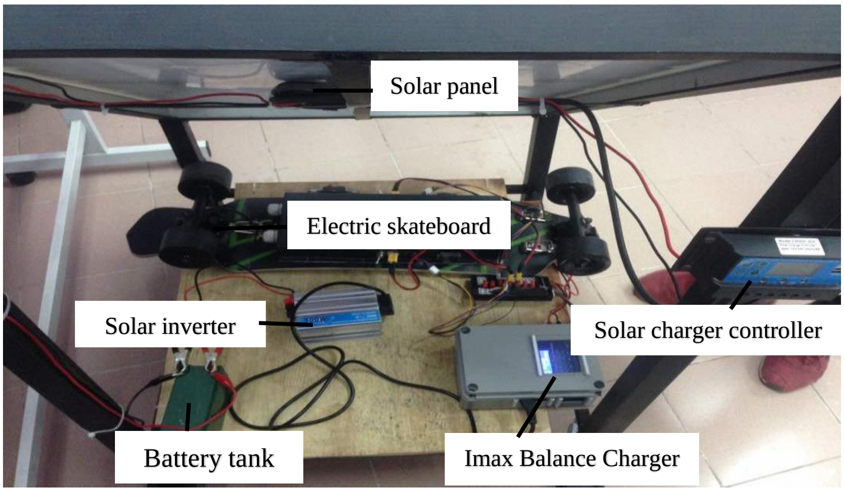


Figure 13. Connection of solar charging system to electric skateboard

CHAPTER 4

RESULT AND DISCUSSION

4.1 EFFICIENCY OF SOLAR PANEL

As the efficiency of solar panel is depends on the solar irradiance which is 1000 W/m2 from manufacturer, we only calculated theroritically from the specification of solar panel which is depends on the size of solar cell including the size of solar panel.(_What about)

We use the equation

$$\eta_{max}(\,maximum\ efficiency) = \frac{p_{\max(maximum\ power\ output)}}{(E_{Sy}^{SW}\ (incident\ radiation\ flux)\ \times\ A_c\ \ (area\ of\ collector))} \times 100\%$$

a) 90W solar panel

$$\eta_{max}(\,maximum\ efficiency) = \frac{90\ W}{(E_{Sy}^{SW}\ (1000\ W/m^2)\ \times\ A_c\ \ (0.68m\ \times 1m))} \times 100\%$$

$$= 13.24\%$$

b) 100W solar panel

$$\eta_{max}(\,maximum\ efficiency) = \frac{100\ W}{(E_{Sy}^{SW}\ (1000\ W/m^2)\ \times\ A_c\ \ (0.68m\ \times 0.51m))} \times 100\%$$

$$= 28.83\%$$

4.2 PERFORMANCE OF BATTERY TANK

We use the equations:

$$charge\ time\ (hours) = \frac{(amp - hours\ \ \times 1.15)}{charge\ rate}$$

$$charge\ rate\ (Amps) = \frac{Watts\ (W)}{Volts\ (V)}$$

We use 7Ah 12V lead acid battery as power tank therefore the calculations are as following:

a) 90W solar panel

$$charge\ time\ (hours) = \frac{(7.0\ Ah\ (Ah\ of\ lead\ acid\ battery\ used) \times 1.15)}{charge\ rate}$$

$$charge\ rate\ (Amps) = \frac{90\ W}{12\ V}$$

$$charge\ rate\ (Amps) = 7.5\ A$$

$$charge\ time\ (hours) = 1.07\ hours$$

b) 100W of solar panel

$$charge\ time\ (hours) = \frac{(7.0\ Ah\ \ \times 1.15)}{charge\ rate}$$

$$charge\ rate\ (Amps) = \frac{100\ W}{12\ V}$$

$$charge\ rate\ (Amps) = 8.3\ A$$

$$charge\ time\ (hours) = 0.96\ hours$$

We also made a comparison between theoritical calculation and real experiment for this system. Since sky condition also affected the charging system, the best time of charging is at peak hour which are between 11.00am to 1.pm.

Performance of battery tank to be charger fully is depends on how many Watt provided from solar panel. As mentioned above, in this project we use 7Ah 12V of lead acid battery, The more Watt, the fastest it can be charge the battery. According the calculation above, the charging time of battery tank from solar panel is approximately to 1 hour only.

4.3 PERFORMANCE OF INVERTER USE

$$power\ of\ inverter\ use = \frac{80\ W}{0.7}$$

$$power\ of\ inverter\ use = \ 114\ W$$

From the formula above, 80W is the power of load usage or power of requirement which is from Imax AC/DC Dual Power Professional Balance Charger/Discharger. Since most inverter have the efficiency about 60% to 70%, we assume it to be 70% or 0.7. Therefore, from the calculation above, we can see that only 114W of 500W are used from the inverter.

Hence we decided to choose higher specification of power inverter which is 500W more than power of inverter use also because this type of power inverter is cheap as it is popular for car use. Besides, this system also can be use for any electrical appliances that have less power (Watt) than power of inverter (500W).

4.4 Comparison of electricity usage

$$kWh = \frac{80\ W \times 2.5\ (hrs)}{1000}$$
$$= \ 0.2\ kWh$$

$$electricity\ bill\ consumption = 0.2\ kWh\ \times RM\ 1.52/kWh$$
$$= RM\ 0.30$$

	Solar charging system	Conventional charging system
Duration of charging (time)	2.5 hours	2.5hours
Electricity usage (kWh)	0.2 kWh	0.2 kWh
Energy cost (RM)	None	RM 0.30

Table 4. Different of charging system

We also make a comparison between solar charging system and conventional system which by plug it to normal plug as to make a differentiation which one system is better , table 3. From the result, we can see that by using solar charging system we don't have to spend any cost to pay the electricity bills since our solar charging system using an off-grid system that we don't have to payback to TNB since we produce electricity by our own from this system.

Meanwhile for conventional charging system, we need to payback to TNB since we use their system. But this is not included for a month of charging the electric skateboard. Since the sun is sometimes not available always because of the weather and cloud, we decided to use both system but it will focus more on using a renewable energy system which is solar charging system.

As a conclusion, by develop this system we can reduce the use of fuel and also electricity usage. Furthermore, by building an electric skateboard it also can reduce environmental air pollution that come from the burning of fuel.

4.5 GANTT CHART

Month Research	Feb'17	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan '18
Title selection and review	•										·	
Research on Design		•										
Finalize Design			•									
Selection of suitable materials				•								
Proposal writing				•								
Proposal presentation				•								
Submission of final proposal				•								
Materials order				•	•							
First Prototype -Drawing								•				
Review Prototype -Solar Panel Rack -Enclosure cover -Cover box										•		
Finalize Prototype -Assembling -Testing											•	

Report preparation											•	
Submission of report											•	
Poster preparation											•	
Report presentation											•	
Report finalize												•

Table 5. Gantt Chart

4.6 COST ANALYSIS

	Basic Solar system parts	
	Name of Part	Price List
1.	Monocrystalline Solar Panel 90W 12V	Rm 625.00
2.	Monocrystalline Suitcase Solar Panel 100W 12V	Rm 799.00
3.	PWM 20A 12V Solar charger Controller	RM 41.10
4.	Lead Acid Battery 7.0Ah 12V	RM 70.00
5.	Solar Inverter 500W	RM 66.10
	TOTAL	RM 1601.20

Table 6. Cost Analysis

CHAPTER 5

ETHICAL CONSIDERATION

There are a few safety measures to be taken into accounts. First of all, one should wear safety boots and jackets while working at the Senior Design Project Workshop. Then, during testing the solar system, firstly observe polarities when connecting solar panels and batteries. Find the voltage (V) and current (A) ratings of your panel, you can usually find these written on the back of the panel. Check that sunlight conditions are suitable for producing readings on the system. Make sure there is bight sunlight falling directly onto the panel to obtain the rated output of your. Next, make sure you understand how to use the multimeter and that you are using appropriate settings for the power you expect to measure. Furthermore, make sure that the battery is not fully charged otherwise it will not be able to accept current if we want to test a charge controller. When disconnecting the panel, regulator and battery, take care to disconnect the panel from the regulator first, and then disconnect the regulator from the battery. When reconnecting, connect the regulator to the battery first and then connect to the solar panel. This will avoid causing damage to the regulator. Remember that photovoltaic panels produce electricity when exposed to light, so it is recommended to cover the front of the solar panel if outdoors to help avoid shocks. This is particularly important for higher voltage panels. Lastly, verify the system wiring is correct and intact but do not short circuit either the panel or the battery.

CONCLUSION

From this project, we can conclude that portable electric skateboard can be implement as an alternative green transportation by using solar energy as power source give a lot of benefit towards environment. Besides electric skateboard can reduce environmental air pollution and effect of greenhouse gases to living thing. Furthermore, portable electric skateboard also reduce the use of fuel’s products not like normal car. Moreover, riding an electric skateboard could also help eliminate the requirement of parking spaces, especially in urban areas where parking spaces are highly limited. From this project we have achieve fast charging battery from monocrystalline solar panel and also to the load as long there is availability of the sun when charging electric skateboard. We also take a consideration for some improvement in this project which is make the solar charging system more portable when riding electric skateboard for example put some of solar cells that can charge directly onto the electric skateboard. From this recommendation, we can save the cost for building a solar charging system for electric skateboard.

REFERENCES

ARTICLES

GoGreenSolar. (2017). Retrieved from GoGreenSolar.com: https://gogreensolar.uservoice.com/knowledgebase/articles/138100-how-long-will-it-take-a-solar-panel-to-charge-a-battery

Li, H.-r. (2016, February 10). *Science direct*. Retrieved from http://www.sciencedirect.com/science/article/pii/S1877705816003416

Michael Bluejay. (2015, February). *Saving Electricity*. Retrieved from http://michaelbluejay.com/electricity/cost.html

JOURNALS

Beedu, R. (2015). Design, Development and Performance Evaluation of Solar Power Assisted Tricycle. *International Journal of Research in Engineering and Technology*, 513-517.

N.S. Wade, P.C. Taylor, P.D. Lang, P.R. Jones. (2010). Evaluating the benefits of an electrical energy storage system in a future smart grid. *Energy Policy*, 7180-288.

Sivert, A., Betin, F., & Lequeu, T. . (2014). Pedagogical study of an electric bike with low energy consumption, management and dimensioning of onboard energy. *Wseas Transactions on Advances in Engineering Education*, 54-65.

Soteris A. Kalogirou. (2009). *Solar Energy Engineering Processes and Systems* , 488-493.

Spagnolo, G. S., Papalillo, D., Martocchia, A., & Makary, G. (2012). Solar-Electric Boat. *Journal of Transportation Technologies,*, 144-149.

Suratsawadee Anuphappharadorn, Sukruedee Sukchai, Chatchai Sirisamphanwong and Nipon Ketjoy. (2014). Energy Procedia. *Comparison the Economic Analysis of* *the Battery between Lithium-ion and Lead-acid in PV Stand-alone Application*, 352-358.

Tsui and Michael Pecht. (2011). *Battery Management Systems in Electric and Hybrid Vehicles. Energies*,, 1840-1857.

WEBSITES

Gohz. (2015, January 25). *How to calculate solar panel efficiency*. Retrieved from GoHz.com: http://www.gohz.com/how-to-calculate-solar-panel-efficiency

lelevkin, A. (n.d.). Retrieved from Programming by Weltkind: https://www.photonicuniverse.com/en/how-to-choose/ac-inverter/