Journal of Engineering and Science Research 2 (4): 34-38, 2018
e-ISSN: 2289-7127

DOI: 10.26666/rmp.jesr.2018.4.6

Solar Tree

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Abstract: In this day and age, with the ever-growing population and energy demand, we should take the renewable option route in our energy source. We should also keep in mind that said energy should not cause any lasting environmental damage, one of the perfect example being solar energy. A country that is hot and sunny all year long is the perfect contributor to solar energy, case in point, Malaysia. With that in mind Solar Tree is designed and developed to facilitate consumers who need electric power at any place, anytime, anywhere. The objective of this study is to assess a mini project in the likes of Solar Tree that can generate electricity without harming the environment, despite the weather. Intended specifically to be a mini project, it is understandable that electricity generated is limited, with only up to 500W in total. As a trial, two electronic devices were tested, specifically a mobile phone and a laptop, as both devices are used almost every day. The data collected is then tabulated and analysed. It was concluded the solar tree developed proved efficient in charging both devices and will continue to do so given enough sunlight.

Key words: *renewable energy; solar PV; sustainable energy; solar energy; Malaysia*

INTRODUCTION

Renewable energy is not altogether a new concept in Malaysia. It was first introduced in 2000 where renewable energy was included in the country′s energy mix for grid connected power generation through the Five Fuel Diversification Policy 2000, under the Eighth Malaysia Plan (8 MP, 2001–2005) and the Third Outline Perspective Plan (OPP3, 2001–2010). Since then a lot of effort has been made to introduce the concept and spearhead Malaysia into more a sustainable development approach in its backbone [1].

Malaysia being a tropical country and sunny all year long, it is natural for the more prolific solar energy to caught the eye of the public. That and the effortless ‘plug and play’ features, unlike other resources which needs mechanical support such as motors or generators (hydro, wind, wave) or chemical support (bio fuels) which are mostly circumstances oriented [2]. With its inexhaustible source and lucrative feed-in-tariff (FiT) mechanism, solar energy is fast becoming the first choice of the public to wet their hands in renewable energy. It is a good choice for an environmentalist at heart as its payback period claimed by SEDA Malaysia for such technology is 7.2 years [3].

The Solar Tree is a project by the Mechanical Engineering Department in Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor to generate electricity through solar PV and conserve the environment, all at the same time. It is a bid to be more energy efficient in our daily lives, by having off grid solar PV generator. However, the power generated are quite limited, in this case up to 500W. It narrows the scope of this study down but it is still that is a good start towards a sustainable development country.

SOLAR PV

Concept

The photovoltaic cell, or PV cell, is a technology that converts energy in sunlight to electricity using an adaptation of the electrical semiconductor used in computers and other types of information technology. The PV panel takes advantage of the photovoltaic effect, discovered by Henri Becquerel in 1839, in

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which sunlight striking certain materials is able to generate a measurable electrical current [4]. Figure 1 shows a simple solar PV configuration. The solar panel is attached with fuses which is connected with the charge controller. The energy transformed into electricity from the solar panel will then flows through the charge controller. For the purpose of this study, two types are used; Pulse Width Modulation (PWM) and Maximum Power Point Tracking (MPPT). Any unused electricity is then stored in the battery for future use.The remaining energy will go through the inverter before it can be transferred to load. DC current produced is converted from a PV array into an AC current. A simplified diagram showing how a solar energy is converted into electricity is shown in Figure 2.

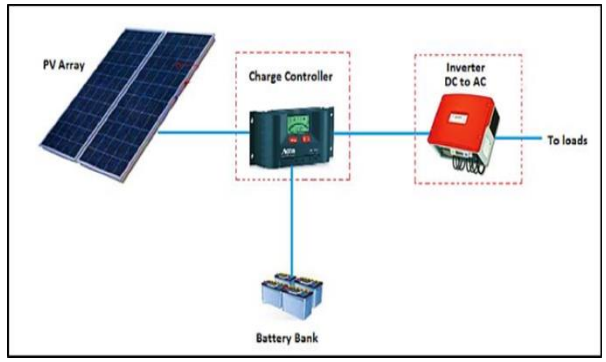

Fig 1 Solar PV configuration

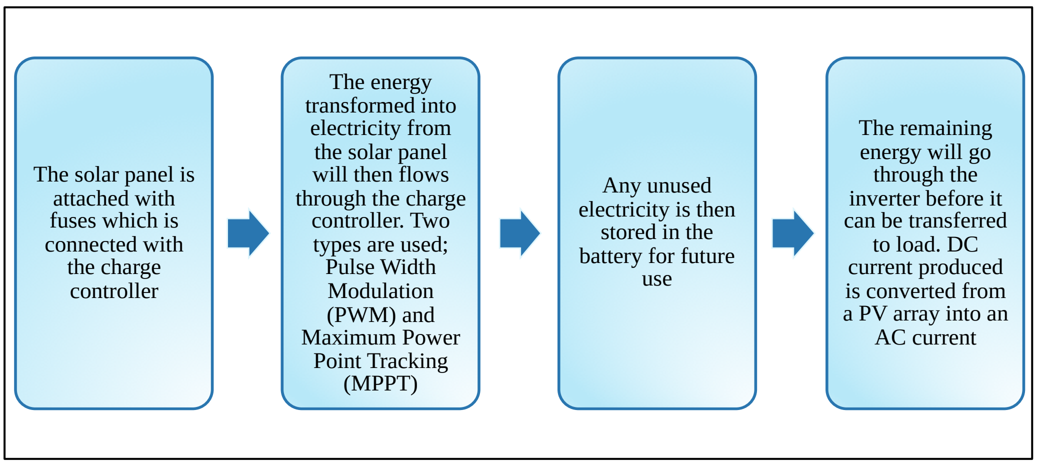

Fig 2 Converting solar energy

A PV panel consists of multiple photovoltaic cells (on the order of 50 to 120 cells) connected together in an electrical circuit that can be connected to an exterior circuit at a single point. Since the individual PV panel has a limited output compared to typical residential or commercial loads (maximum output on the order of 80 to 200 W per panel), a PV system usually combines a large number of panels together in an array, or integrated system of panels, so as to deliver the electricity produced at a single connection point and at the desired voltage [4].

The dominant material for creating PV panels is the silicon wafer, which can be manufactured in three forms: monocrystalline, multicrystalline, and amorphous. These names refer to the form of the PV cell, which may consist of a single crystal, multiple crystals, or may not have any crystalline structure. Single crystals are the most efficient in terms of converting sunlight to electrical output, but they are also the most difficult to manufacture and hence the most expensive. Conversely, amorphous PV cells are the cheapest to produce and have the lowest efficiency, with multicrystalline cells lying somewhere in the middle.

The Solar Tree is designed to integrate with the environment it is in. Thus careful consideration has been considered with an ergonomic design, compatible with Asian demographic, strong and reliable foundation and aesthetics. It has to draw people in to actually use it and appreciate the ease of solar energy in everyday lives. Figure 3 (a), 3 (b) and 3 (c) illustrates the initial concept while the finished product is shown in Figure 4. A close-up pf the PV panel used is shown in Figure 5.

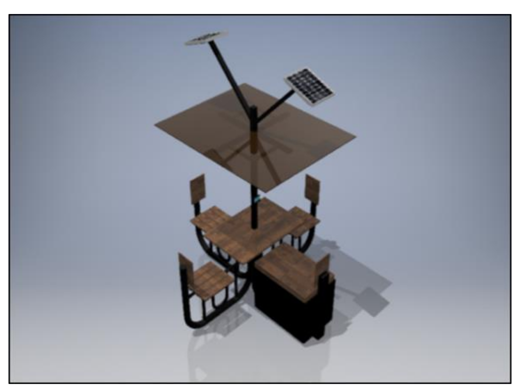

Fig. 3 (a) Solar tree design

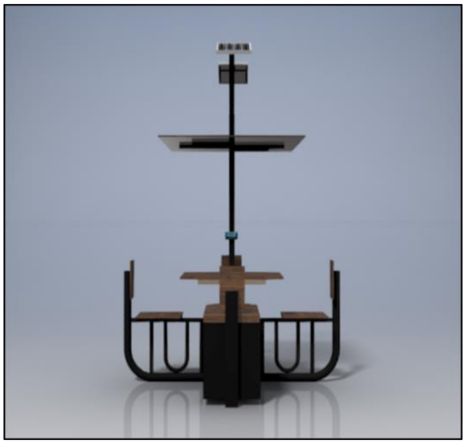

Fig 3 (b) Solar tree design (side view)

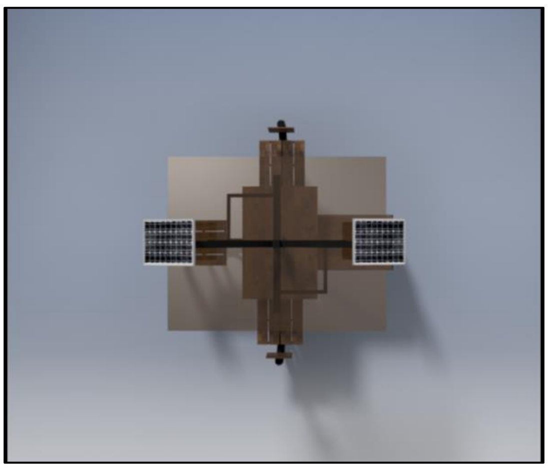

Fig 3 (c) Solar tree design (top view)

The requirement item for this project is the panel solar, battery, charge controller and also the inverter including a few fuses to connect between of the application. The solar panel is attached with the fuses which is connected with the charge controller. The energy transformed into electricity from the solar panel will then flows through the charge controller. Any unused electricity is then stored in the battery for future use. The remaining energy will go through the inverter before it can be transferred to load. A DC/AC inverter converted the DC current produced from a PV array into an AC current. Charge controller will control the amount of power stored in the battery. A circuit breaker is also installed in event of short circuit.

Fig 4 Finished product

Fig 5 Close up of the PV panel

Highlights and challenges

It seems that we can never sing enough praises for solar energy. Solar energy, often known as photovoltaic system, is an elegant means of producing electricity on site, directly from sun, without the concern for fuel supply or environmental impact [5]. It is most importantly free, has low emission of CO_2, environmentally friendly and as such has an infinite source – the sun. The electricity production through PV system is clean and safe for the environment compared to coal and fossil fuel [6]. It is renewable, clean and does not emit pollutants in the process of electricity generation.

Despite the abundance potential of solar energy, it is not without flaws. Efficiency has always been an issue with solar PV. A number of factors may contribute the inefficiency of PV modules. This include temperature, irradiation intensity, and dust [7]. It is widely accepted that efficiency of photovoltaic solar cells decreases with an increase of temperature, and cooling is necessary to counteract the effect. Dust is also affecting the PV efficiency because it may block the coming irradiance onto PV modules. This is vital as the solar irradiance is directly proportional to the PV module efficiency [6]. A PV system has to be decommissioned at the end of its useful life, this including the batteries (if any) and the panel itself. Both components have to be recycled and disposed of safely to keep the environmental harm to a minimum [6]. Other than that a solar PV is relatively safe to the environment.

Solar PV, as any other renewable energy technologies has long been associated with high capital cost. At present the cost of a 5 kWp BIPV turnkey roof-top system in Malaysia is about RM27,000/kWp [8]. In 2015, the average cost to develop a 4 kW solar PV system is RM 40,000, and it is expected to produce monthly income of RM 500– 600 for 21 years, or in total of RM 126,000–151,200 [9]. However, with the advancement of technology and the ever evolving RE, the cost will ultimately decrease or the efficiency will get higher, one way or another. If we are lucky we will get both benefits. As with the Solar Tree, it costs just under RM 1000 to build, the justification being the electricity produced is significantly lower.

Future of solar PV

Solar PV has huge potential in Malaysia with the public wholly agreeing to making solar power development a national priority [4]. It is achievable with the right strategy and approach. Recent research has resulted in conversion efficiency to 34.5%, much higher than 24% we have before [10]. This is indeed good news for especially for Malaysia and the sustainable development scenario in general. We could expect solar farms with higher productivity, lower capital cost and is marginally a good investment. The outlook for solar PV is for the most part good.

Nevertheless, to fully implement a large scale solar PV is not without its limitations. The government sadly must play their hands accordingly in this matter. One of the most important thing Government and NonGovernmental Organization (NGO) can do is creating awareness among the public such as benefits of solar energy, financial aspects, legal requirements and environmental advantages. Government can also provide details of information regarding implementation of the solar technology and build technical capacity. Implementing supportive policies such as imposing effective pricing laws and giving practical support to those who implement renewable energy technology. Independent power producers must get access to national power grid and Tenaga Nasional Berhad (TNB) should give preference on renewable energy projects [5].

The public also have a part to play in this matter. We should embrace the campaign purported by the government to solidify solar energy in Malaysia's energy grid. KETTHA as a whole has developed a battle plan to further edify RE technology to the masses. This culminates in The Green Technology Master Plan (GTMP), where it is fundamentally an outcome of the Eleventh Malaysia Plan (2016-2020) which has earmarked green growth as one of six game changers altering the trajectory of the nation's growth. Among the strategies outlined is to promote LSS (Large Scale Solar) farms. It is hoped by 2020, Malaysia will have an additional installed capacity of 1,200 MW of LSS farms, of which 200 MW will be in Sabah and 1,000 MW will be in Peninsular Malaysia [11].

RESULT AND DISCUSSION

The Solar Tree has been tested thoroughly to ensure efficiency and most importantly that it actually works. Two electronic devices were tested, specifically a mobile phone and a laptop. The data is collected according and tabulated in Table 1 below. From the table it can be seen that the Solar Tree succeeded in its purpose to generate enough electricity to charge both devices while still conserving the environment. With just under 5 hours sun per day, it successfully charges the devices devices with 92% efficiency. This is in line with the average efficiency of an inverter being 95.15% [12].

Through the optimum placement relative to the sun the Solar Tree will prove to be indispensable and could easily generate electricity during 12 hours of daylight. With an average of 12 h of sunshine daily, the average solar energy received is between 1400 and 1900 kWh/m2 annually [13]. The effectiveness is further increased with a suitable battery storage to provide electricity on not so sunny days. Thus, the public, in this case the students have dual benefits, having a place to rest after a hard day's studying and to charge their electronics.

Table 1 Off-grid systems approximate solar PV system wattage

Font Size	Mobile phone: Samsung J5	Laptop: Lenovo Flex 14"	Both devices
Electricity consumed (W)	12	85	97
Usage duration of device (hours)	24	24	24
Charge Controller efficiency (PWM: 80%,	92%	92%	92%

MPPT: 92%)			
Average sun (hours/day) *really sunny day	5	5	5
Minimum system size (W)	57.60	408.00	465.60
Recommended System Size (W)	62.61	443.48	506.09
Recommended Battery Size (12V):	48.00AMP-HOURS	340.00AMP-HOURS	388.00AMP-HOURS
Recommended Battery Size (24V):	24.00AMP-HOURS	170.00AMP-HOURS	94.00AMP-HOURS

CONCLUSION

The Solar Tree has by and large succeeded in its mission to produce electricity without adverse effects on the environment. The electricity generated has been utilized to power up electronic devices such as handphone and laptop, and many more further down the line. It also proves that it can still produce power, in spite of weather due to the battery storage installed in the system. The development of Solar Tree shows that renewable energy has taken roots in Malaysia and is a popular choice for individuals to generate electricity on their own. The straightforward feature of solar PV and the relatively low cost will pique the curiosity of the public for years to come, perhaps prompting new installations significantly. Suffice to say it will definitely add up in the long run, thus making sustainable development a possible reality.

REFERENCES

[1] Khor, C. and Lalchand, G. (2014). A review on sustainable power generation in Malaysia to 2030: Historical perspective, current assessment, and future strategies. *Renewable and Sustainable Energy Reviews*, 29, pp.952-960.

[2] Vanek, F.M., Albright, L.D. & Angenent, L.T. (2016). *Energy systems engineering: Evaluation and implementation*, New York: McGraw-Hill Education.

[3] SEDA. Feed-in tariff (FiT) in Malaysia; 2011.

[4] Gomesh, N., Daut, I., Irwanto, M., Irwan, Y. and Fitra, M. (2013). Study on Malaysian's Perspective Towards Renewable Energy Mainly on Solar Energy. *Energy Procedia*, 36, pp.303-312.

[5] Ab Kadir, M., Rafeeu, Y. and Adam, N. (2010). Prospective scenarios for the full solar energy development in Malaysia. *Renewable and Sustainable Energy Reviews*, 14(9), pp.3023-3031.

[6] Rahman, M., Hasanuzzaman, M. and Rahim, N. (2017). Effects of operational conditions on the energy efficiency of photovoltaic modules operating in Malaysia. *Journal of Cleaner Production*, 143, pp.912-924.

[7] Tyagi, V., Rahim, N., Rahim, N. and Selvaraj, J. (2013). Progress in solar PV technology: Research and achievement. *Renewable and Sustainable Energy Reviews*, 20, pp.443-461.

[8] Foo, K. (2015). A vision on the opportunities, policies and coping strategies for the energy security and green energy development in Malaysia. *Renewable and Sustainable Energy Reviews*, 51, pp.1477-1498.

[9] Wong, S., Ngadi, N., Abdullah, T. and Inuwa, I. (2015). Recent advances of feed-in tariff in Malaysia. *Renewable and Sustainable Energy Reviews*, 41, pp.42-52.

[10] www.engineering.unsw.edu.au. (2016). *Milestone in solar cell efficiency achieved by Australian scientists*. [online] Available at: https://www.engineering.unsw.edu.au/news/milestone-in-solar-cell-efficiency-achieved-by-australian-scientists [Accessed 25 Dec. 2017].

[11] KeTTHA (2010) *KeTHHA Green Practices*. Putra Jaya: Ministry of Energy, Green Technology and Water Malaysia - [Official Publication].

[12] Humada, A., Aaref, A., Hamada, H., Sulaiman, M., Amin, N. and Mekhilef, S. (2018). Modeling and characterization of a grid-connected photovoltaic system under tropical climate conditions. *Renewable and Sustainable Energy Reviews*, 82, pp.2094-2105.

[13] Ahmad, S., Kadir, M. and Shafie, S. (2011). Current perspective of the renewable energy development in Malaysia. *Renewable and Sustainable Energy Reviews*, 15(2), pp.897-904.