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Designing a Solar-Powered Shower Room at Damai Beach, Kuching, Malaysia

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Abstract

This study presents the design of a Solar-Powered Shower Room at Damai Beach, Kuching. This paper covers various topics about the benefits of the use of solar energy, water heating technology, location surveying, and the cost of the infrastructure to be built on the beach. Although no prototype is meant to be built, the project was designed to realize the implementation facts in the real-world environment. This project could save a lot of fossil fuel energy using the direct conversion of solar energy to thermal energy, hence help us to build a sustainable future.

Keywords: Solar energy; renewable energy; shower room; hot water; system; fossil fuel; sustainable

Introduction

Solar energy is the energy that comes in a form of heat and light from the sun. Solar energy can be captured and converted into electrical energy using solar photovoltaic (PV) systems. Solar energy also can be converted into thermal energy through the solar thermal plant. The solar-powered shower room is designed to harness the energy of the sun to heat the water of

the shower room on the beach. It thereby replaces the use of an electrical heater hence save the cost in long term.

In 1839, Alexander Edmond Becquerel discovered the possibility of harnessing the sunlight by using the photovoltaic effect. Alexander claimed that "shining light on an electrode submerged in a conductive solution would create an electric current." Solar energy technology started to be efficient after 100 years when Russell Ohl invented the solar cell in 1941 [1]. Ultimately the goal of this project was to make a sustainable real-world project. As the global energy crisis emerged as one of the most concerning issues in today's world, solar power and other forms of renewable energy will continue to be an important source of energy in the future. This concludes that this research is important for the sustainability of the beach as one of the tourist attractions located in long term.

Solar Energy in Malaysia

In recent years, the rate of energy demand had risen tremendously as Malaysia is one of the third-world developing countries. Despite Malaysia is well-known for its rich resources of natural gas and oil, it had been depleting over years due to its wide range of use including transportation and electricity generation. According to Shafie, S. M., et al. [2]. In 2009, 94.5% of electricity is generated by using fossil fuel in the whole of Malaysia. But all of these scarce sources will go extinct like dinosaurs in the near future which lead Malaysia's government to take seriously renewable energy development as the next alternative for energy salvaging.

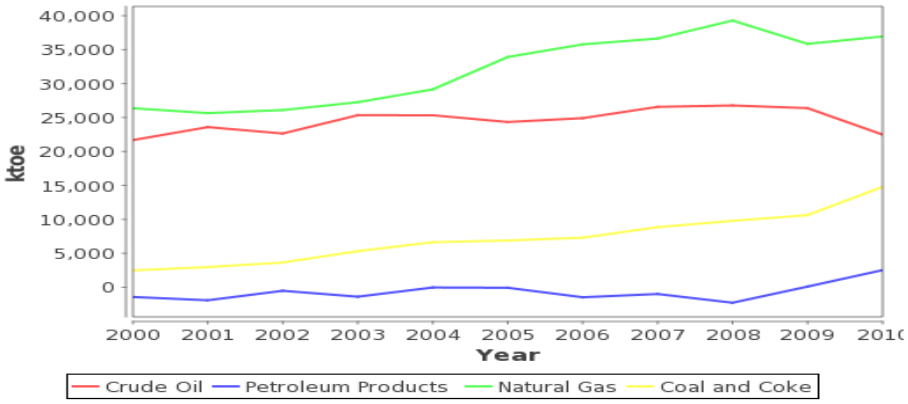

Figure 1: Statistic of the Malaysia Energy Supplies

Figure 1 shows the statistic of the Malaysia Energy Supplies from the Year 2000 to 2010 [3]. Malaysia is one of the other equatorial countries which receive annual average daily solar irradiations of 4.21kWh/m^2 to 5.56kWh/m^2 [4]. According to the Malaysian Meteorological Department [5], Malaysia only receives about 6 hours of sunshine per day. This is because the cloud covers cut off a partial amount of sunshine and thus decrease the solar efficiency. The tropical environment of Malaysia allows the variation in the amount of sunshine received especially during the monsoon season and drought season.

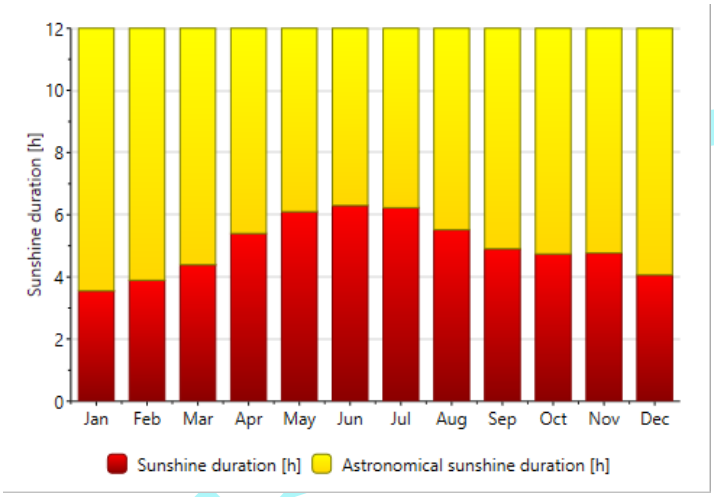

Figure2: Sunshine Duration at Kuching

Figure 2 has been derived from the solar calculator, shows the sunshine duration at Kuching, Sarawak throughout the year [6]. As is shown in Figure 2, Kuching is a blessed land with a lot of natural resources which include the all-year-long tropical climate that guarantee continuous solar power [6]. To harness this pollution-free energy, Photovoltaic (PV) or more commonly to be called solar panels are used. Despite the rich resource, solar energy harnessing is limited mostly to the standalone system which in most cases, in rural areas where there are no grid towers.

To encourage the use of renewable energy in Malaysia, the government of Malaysia had formed a statutory body namely Sustainable Energy Development Authority of Malaysia (SEDA Malaysia)[7] under the Sustainable Energy Development Authority Act 2011 (Act 726)[8, 9]. The main function of this statutory body is to direct and accomplish the execution

of the Feed-in Tariff (FiT) mechanism under the Renewable Energy Act 2011 (Act 725). FiT mechanism allows the electricity to be produced from a wide range of renewable energy resources to be sold to power utilities[8]. It is only natural that solar energy is the most efficient and cheapest energy on Earth especially in this case, Malaysia's strategic location near to the equator of Earth. Fit mechanism rewards the investors by paying them a premium price of generated electricity, making it a long-term passive income. Figure 3 shows the annual Average Solar Radiation of East Malaysia [5].

On June 16, Malaysia gets a lift in renewable energy expansion when the Amcorp Group based in Malaysia was awarded the contract of power plant's solar panels production to Chinese manufacturer Yingli Green Energy Holding Company[9]. The project is required to produce 40,000 photovoltaic (PV) panels which are expected to produce 13.6 million kWh of electricity every year for an area of 14 ha. With the collaboration of the FiT mechanism, the project started the first batch in January 2015 by the installation of 19 MW solar energy collectors at Kuala Lumpur International Airport (KLIA).

With the tariff of FiT at the rate ranging from RM0.85 to RM1.23 per kilowatt generated[9], these installations of solar panels can turn the classic airport into a semi-green energy production plant. The solar panels installed not only can help the developers to cut costs on utilities but also reduce the carbon footprint produced. The combination of the fall in the cost of solar equipment and "overpriced" tariffs has convinced the investors to invest in solar energy technology.

On the production side for solar technology, "Malaysia is one of the top producers of solar products in the world driven by foreign companies setting up manufacturing facilities in Malaysia. Generous tax breaks and availability of skilled workers at a relatively low labor cost were key factors in attracting these foreign investments"[10]. Despite the large production of solar products in Malaysia itself, these products are mainly for the export market only.

Solar Water Heating Technology

Solar water heating is the harnessing of solar energy for the use of heating water. In the early 1900s, scientists found out the technology of using solar energy to heat the water and hence keep improving the technology to make them more durable and efficient for daily uses [11]. The process is done using a solar thermal collector. There are several types of solar thermal collectors in the market including open-loop systems, closed-loop systems, drain back systems, and bubble pump systems. For this project, the closed-loop system will be used to heat the water which is commonly available in the market. Figure 3 has been derived from shows the increase of solar water heating system installations in the USA [11].

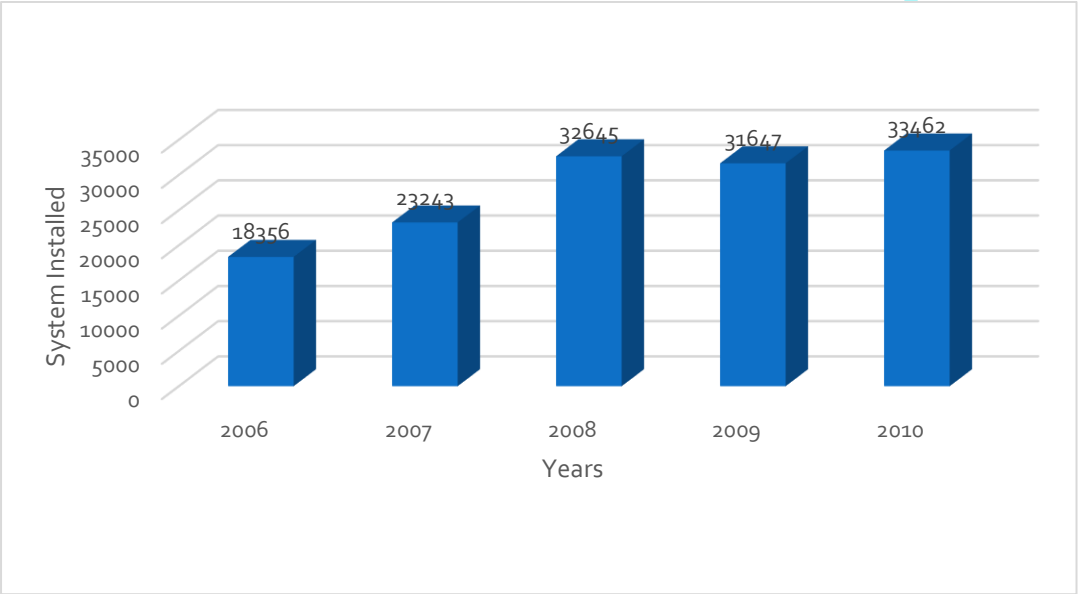

Figure 3: Solar Water Heating Installations

According to the Solar Energy Industries Association[12], the photovoltaic installations in the United States had been double over 2009 which include the solar heating system. This had proven that people started to aware of the importance of renewable energy in their daily life. The solar heating system does not only cut the cost of electricity for heating water but also can prevent the earth from being harm continually by using gas or electric booster. As technology gets more and more mature, the cost of installing a system is not as expensive as 10 years ago.

In general, the solar thermal collector is often installed on the roof or the wall facing the sun of the building. Solar heaters usually come with a set of collectors – consisting of copper tubes within an

insulated box to store the heated water and storage tank – storing the water that will be heated. The maintenance costs for the solar water heater are generally very low. Most of these systems come with a 5 or 10 years warranty and require little maintenance [13]. Once the installation is done, it usually will work with periodically check of leakage in the pipework.

The solar heating process starts with the array of solar collector panels on the roof of the building. This array is connected to the hot water storage tank and the working fluid flows through the pipework into the solar array and vice versa. As the working fluid flowing through the arrays, the solar energy heats the working fluid to a high temperature and flow back to the storage tank. The working fluid is not used for the user but it is used to heat the water stored in the tank.

Due to the advancement in technology and economic feasibility of water heating technology, the solar heating system contributed to one of the most popular systems for water heating. Solar heating can appear in numerous numbers of applications such as hot water production, heating and cooling of rooms, industrial use of the heating process, even the shower and hot water that are used in the household. By the year 2015, solar thermal technology has come to the stage of mature enough to be applied in everyone's home. As time goes by, technology becomes cheaper and more affordable for lower-income people.

Geographic Profile – Damai Beach, Kuching

Damai is one of the main beach resorts which are located in the North of Kuching, about 45 minutes of car travel from Kuching town. The area has sandy beaches with the jungle-covered mountain on the way towards the beach. Damai itself has several international-class resort hotels – Damai Beach Resort, DamaiPuri Resort and Spa, and Santubong Kuching Resort. Each of them has its private beach, free form swimming pool and offers water-skiing, windsurfing, mountain biking, tennis, squash, jet-skiing, and even a fitness center for sports lovers.

Not far from the beach, there is also the Arnold Palmer-designed international standard 18-hole golf course. Other than that, Damai also features Damai Central – centralized as the coastal land facing the view of South China Sea, Permai Rainforest Resort – offering

adventurous mountain climbing and hiking, Sarawak Cultural Village – the living museum portraying the heritage of the major racial groups in Sarawak, Santubong – the quiet fishing villages, and Buntal – a village full of seafood restaurants.

Damai beach is one of the best beaches for solar power harnessing for two reasons, the whole year round unlimited sunlight and fewer shades or obstacles that may obstruct the solar panel from receiving maximum sunlight. Since Damai beach is in Malaysia which is an equatorial country, the sun changes throughout the year are kept to a minimum. Unlike most western countries, the 4 seasonal natural phenomena may affect the whole efficiency and which is why they need a solar tracker.

Although this research paper will only discuss the solar panel implementation, the project could be expanded to tide energy or hydro energy in the future if it is proven efficient. Installation of solar panels will initiate the project to grow into a larger project in the future. The management of the beach will not only cut the current utility costs but also join in as a part of the green party.

While not all the beaches will need the installation of solar panels, Damai beach welcomed 1.1 million visitors from all over the world per year. It is indeed a big amount for such a beach resort as it is one of the most beautiful beaches in Sarawak. Since the energy consumption will be large, it is also important that the management start to think of alternate solutions to these lump sum of energy or as some emergency backup [14,15].

As far as the public is concerned, the main issue in the implementation of the solar panel at beaches is not reliable because of the higher degree of corrosion to reinforcement than normal building[16]. Salt can have a corrosive effect when reacting with the oxygen in the air. This effect will apply to buildings as far as two kilometers from the beach. To overcome the problem, expert advisors had to choose suitable materials to counter the corrosion problem.

Besides that, the rising sea levels during the monsoon seasons may also interrupt the whole project[16]. The building will need to be built far from the water to prevent it from flooding

the shower room during the monsoon seasons. Apart from that, foundations near the beach will need to be built firmly to prevent the effects of erosion and exposure of building to the coastal area[16,17]. This calls for more wall supports and increasing the elevation needed.

Electrical Heater Shower Room

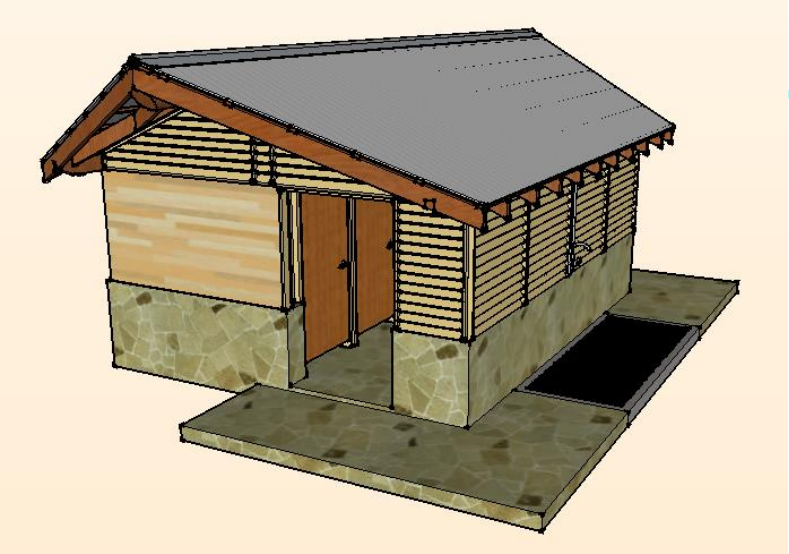

Figure 4: Sample Electrical Heater Shower Room

Figure 4 shows a standard electrical heater shower room that is placed on the beach. It has been sketched using the SketchUp software for this research paper. There are four shower rooms with two sinks as shown in Figure 5. A hot water shower is provided by an electric water heater. The cold water shower is mounted outside the shower building. The costs are high and not efficient in the long run.

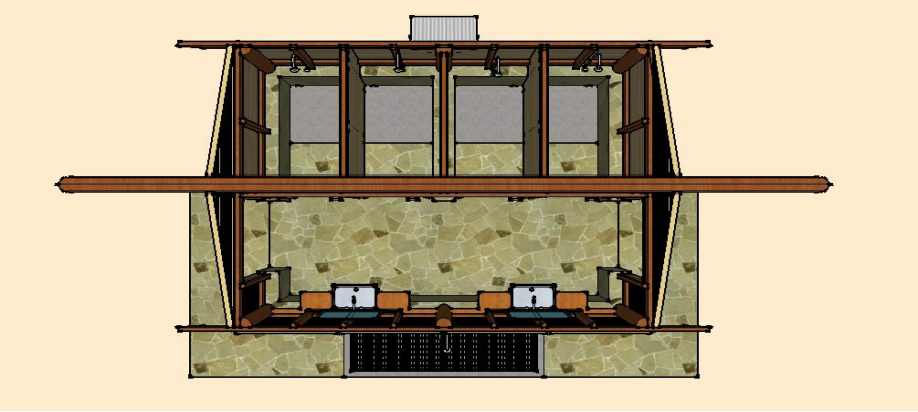

Figure 5: Top View of the Shower Room

Since the shower room is placed on the beach, all the main factors stated in the previous section will be taken into consideration. These include the materials used in the construction, the deep foundation needed as the base, and the minimum elevation to prevent flooding. These implementations will ensure the whole building to be firmly placed on the beach for a long lifetime. While the normal shower room that is installed at the beach are everywhere, not every shower room built fulfilled the above requirements.

Other than that, the inner design considerations are also important for a perfect shower room. A shower room will take into account both hot and cold water, for cleaning human. There will be also a need for piping to flow the wastewater into the drainage system. The shower room will be also in wet condition most of the time[18-23]. This will cause the air to be humid whole the time. As the beach shower room will be in hot condition, the hot humid air will cause condensation which made the room get dirt easily.

Solar-Powered Shower Room

Figure 6: Installation of Solar Panel on the Shower Room

Figure 6 shows the installation of the solar panel on the ready-made shower room. Since the normal electrical heater shower room is not cost-efficient, a solar-powered shower room will be discussed in this research project. For this project, the solar water heater will be mounted on the top of the roof. It will then be connected to the triangular tank inside the building as

shown in Figure 7. All the other features would be the same as the previous versions of the shower room.

To implement the solar-powered shower room, four Sharp Solar Hot Water System NA-F110 (A5) will be installed on the top of the roof. Some modifications will be made to the solar heater so that all the solar heaters installed will be connected to the same water tank. All the solar heaters will be connected so that the water will go through all of them before the heated water reach the tank.

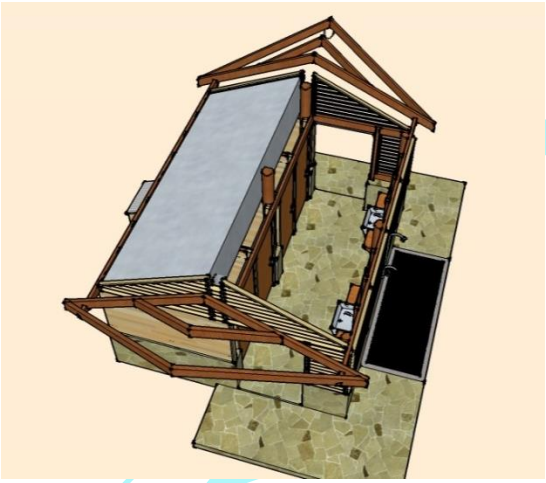

Figure 7: Water tank inside the shower room

Basically, the solar heater will only work during the daytime. Since the shower room will be placed on the beach, the average solar irradiance received will be sufficient to supply hot water 24 hours per day. The solar heater will start collecting around 9 am and reached its peak in the middle of the day. Visitors usually will come during this time, hence the water heated will straight forward for the domestic usage.

The sun will set around 6 pm for Malaysia. During that time, the tank will be reserved to supply hot water. While the efficiency is of this hot water is not as high as the electrical heater, it is enough to provide sufficient service for up to 60 tourists. Besides that, the main purpose of the shower room would be to clean up the body after the activities on the beach.

Discussions

In this research project, the comparison of the standard electrical heater shower room and a solar-powered shower room will be discussed. This research will cover the costing, temperature efficiency, carbon footprint effect, and lifetime of both types of shower rooms. Energy generation from solar [24-35], wind [36-38], and biomass [39-43] have advantages and disadvantages. Similarly, Hydropower has pros and cons [44-46]. The proper way of energy distribution and considering economic and environmental impact may mitigate the drawbacks [47-50]. Moreover, people can use less energy through green buildings [51-53]. However, saving energy through a solar shower room would be a good step.

Costing

According to the costing calculation by C.Paoli[19], the construction cost for a building that is to be constructed on the beach is approximately 900000€ which is RM3.5 million. The price is high because of the extra cost of reinforced materials, foundations, and elevations that are needed to build a stable building on the beach. In this research project, the specific amount for each section will not be discussed.

Besides that, the shower room will need several features to fulfill the customers. A shower room should provide the sinks, shower head, electrical water heater, and some other small appliances. For a standard electrical heater shower room shown above, all the appliances needed are listed in Table 1 below.

Table 1: Prices of appliances needed.

No.	Item	Quantity	Unit Price	Total Price
1	Panasonic Jet Pump Magic Health Series (DH-3KP2M)	4	RM619.00	RM2476.00
1	Sharp Solar Hot Water System NA-F110 (A5)	4	RM7500.00	RM30000.00

The main difference between the solar-powered shower room and the electrical heater shower room is the implementation of the solar panel. For the solar-powered shower room,

the electrical heater will be removed and replaced with the solar water heater. A standard solar water heater system will cost around RM4,000 to RM13,000 for each [20-22]. The shower room proposed had four showers. Therefore, there will be four solar water heater system to be implemented in this project.

Assuming each of the solar heaters will cost around RM7,500. Four of the solar heater will cost RM30,000. Since the shower room now is solar-powered, the electrical heater will be removed and Figure 8 is the new price for the shower room.

Figure 8: Costs for each type of Shower Room

Although the cost for the solar power shower room is much higher, it is reasonable since the authority will only need to pay for the startup of the project. In long run, it will be more cost-effective than the electrical heater as there is no running cost for energy.

Temperature Efficiency

While the electrical heater shower room uses electricity to generate heat, the process of heating will consume a lot of electricity and it is very costly. Despite the cost, the effect of heating will be more effective since it can continuously provide heat to the water. On the other side, the solar water heater will only heat the water during day time. Although the

heated water is stored in the storage tank, the temperature will be slightly lower than the electrical heater. Hence, the solar water heater will be less efficient in this aspect.

Carbon Footprint Effect

As the electrical heater need to use electricity to generate heat, the generation of electricity will produce a carbon footprint when the coal is burnt in the power station. A carbon footprint is meant to calculate the total quantity of greenhouse gas such as nitrous oxide, methane, and carbon dioxide emitted during a specific process or product lifetime. The normal method to generate electricity is by burning fossil fuels which will be exhausted in near future.

The gas-fired electricity generation can have a significant effect on the increase in carbon footprint. The supplies of natural gas which contain mainly methane will increase the carbon footprint effect during the production and burning process. Figure 9 shows the distribution of hourly electricity generation in Belgium in 2011. It is proven that the generation of electricity is high which contributes a lot to the carbon footprint effect the whole year long.

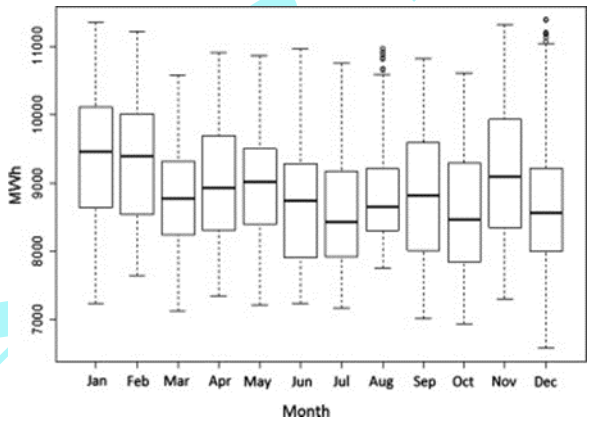

Figure 9: Electricity Generation in Belgium for 2011

On the other side, the production of the solar panel only produces a little carbon footprint. Solar panel indeed produces carbon footprint but not as many as the generation of electricity. Jordan et. al. [23] stated that the average level of greenhouse gas emissions of a solar PV panel is only around 72 grams over its lifetime. This is due to the production of crystalline silicon which is the main component of a solar panel. It can be concluded that the carbon footprint produce by a solar panel is less than the generation of electricity.

Life Time

Bestplumbers.com[19] suggested that the average life expectancy of a standard water heater is around 8 to 15 years. The lifetime will vary following the different weather and condition of where the electrical heater is used. The water heater usually will start to show the symptoms over 12 years old. Leakage can be seen around the base of the electrical heater indicating that the water heater will need to be replaced as soon as possible.

Although most solar panel manufacturers provide a 25 years warranty, the real lifespan of a standard solar panel can go far longer than 25 years as the solar panel will seldom spoilt and will only degenerate over time.

Conclusion

In conclusion, the solar-powered shower room project is implementable and can be very useful in the mere future. In this research project, the solar technology advancement in Malaysia is being discussed on how this green technology had been implemented by other people previously. Solar water heating technology is also introduced to be implemented in the solar-powered shower room. The geographical characteristics of the project location, Damai Beach are reviewed and proven to be a good site for this project implementation. Besides that, few comparisons are being made between the standard electrical heater shower room and the solar-powered solar room including the costs, efficiency, carbon emission, and the lifetime of both types of technologies. As all the fossil fuels and natural gas resources will be exhausted soon, more of these types of green building should be implemented and redesigned to cope with the changing environment of Earth. The Malaysian government should urge their people to look into this matter more seriously since Malaysia is blessed with free energy.

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