

Is Solar Energy an Extraordinary Method to Replace Using Fossil Fuels to Generate Electrical for Public Residents in Hong Kong?

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ABSTRACT : Compare with different renewable energy, solar energy is one most easily use at house. "The sun is the most important source of energy, for all living things in the world. The surface of the sun is 5800 Kelvin (K), this energy spreads by radiating everywhere. The sun transforms its own hydrogen, helium, into a great thermonuclear fusion reaction. Over time, this energy travels 150 million kilometers to the world." (Y. Sen 1, A. Takmaz 2, A. Kabakçı 2, G. Kabakçı 2, G. Deniz 2, a, 2018, Volume 7 (1), June 2018, pp 739-752 [1]). About the solar energy, it uses solar panels to capture sunlight's photons to transmit the electricity. And according to different material, they can divide to three generations. First generation solar panel is silicon wafers solar panel. It is most common and cheaper. Third generation solar panel is a subcategory of organic solar panel which is expensive than other. This project is researching "is Solar Energy an Extraordinary Method to Replace Using Fossil Fuels to Generate Electrical in Hong Kong?" through online survey and solar panel experiment. If it can, this project will be ideal hoped to be one of the reference index for the installation of solar energy in Hong Kong. And a formula have designed, "The minimum watt of a solar panel per year * the maximum units of a solar panel in a house * (1 - 3.43%)", this formula can be used to a new solar panel project for probability evaluating.

KEYWORDS: Renewable Energy, Solar Panel, Hong Kong.

Date of Submission: 20-10-2019

Date of acceptance: 03-11-2019

I. INTRODUCTION

1.1 General background

The one of the main reason for global warming is overusing fossil fuels, but change all of them to renewable energy like solar energy immediately in the world which is impossible. Also, if over depend on fossil fuel, the price of fossil fuel will be controlled on the fossil fuel manufacturer. So, the development of renewable energy and new energy are necessary. And one of feasibility renewable is solar energy, the photovoltaic (PV) effect was first observed in 1839. "They use a special process of converting photons to electrons to generate a current by making use of a special type of cell known as photovoltaic cell." (Dr. Mrs. A. P Rathkanthiwar, Megha Yadav, Kirti Chaudhari, Savita Ghanode, Ulka Ramteke, Feb 26, 2018[2]).

Global warming is not only necessary associated reason to reduce the dependency and use on fossil fuels such as oil, there is also an economic imperative. "The world's largest economic powers countries and companies now acknowledge that greenhouse gas emissions will need to be drastically reduced over the next 30-50 years to avert catastrophic environmental damages, as indicated by the IPCC's fourth Assessment (2007)." (Peter Stasinopoulos, Michael H. Smith, Karlson 'Charlie' Hargroves & Cheryl Desha, 2008 [3]).

Look for the world, the message "time is running out" updates an original warning sent from the Union of Concerned Scientists that was backed by 1,700 signatures 25 years ago. But the experts say the picture is far, far worse than it was in 1992, and that almost all of the problems identified then have simply been exacerbated. (Andrew Griffin, Monday 13 November 2017 [4]) "In 2006, the building sector accounted for 62% of energy consumption and 63% of CO2 emissions in Tokyo. Energy use and CO2 emissions from the building sector in the metropolitan Tokyo area have grown rapidly in the past two decades. From 1990 to 2006, energy consumption in residential and commercial buildings increased 21% and 46%, respectively, while energy use in the industrial sector declined over 40% and transportation energy use increased less than 1%." (Sha Yu, Meredydd Evans & Alison Delgado, 2017 [5]). Moreover, although solar energy has huge potential to develop, it

barely no apply in Hong Kong. So, this project will be hoped to be one of the reference index for the installation of solar energy in Hong Kong.

1.2 Research aim and objectives

Although Hong Kong's education is teaching Hong Kong's student, use the fossil fuel will produce air pollution to make the earth warmer and affect many extreme climate, the electricity supply company still use 90% up of fossil fuel to manufacture electricity and the government have not shown their determination to improve this situation, they have not launched any policy to compensate normal family to install equipment of renewable energy. Even China Light & Power Company Syndicate (CLP) is launching a scheme (call Renewable Energy Feed-in Tariff) to encourage Hong Kong's residents to increase the ratio of solar energy in Hong Kong recently. But it is not suitable for any Hong Kong family and has through a complicated audit. Otherwise, Since the disparity is too huge between rich and poor in Hong Kong, so even a few of Hong Kong peoples want to reduce fossil fuels in depending, their economic ability is not allowed all the electrical supply corporation to increase a ratio of renewable energy in shortly. The aim of the project is fingering out "if Hong Kong's residents install a solar panel in their own house, is it an extraordinary method to save the electrical bill?"

So, this project will find out the answers from different reason which is affecting the efficiency of solar panel like different angles of sunshine and a solar energy system will be designed to research the solar energy, all the experiment supposes to complete in two months.

Also, some objectives were selected, including: first, how many lifespan of different solar panel? Second, what are the reasons for the degradation of solar panel? Third, how can improve the efficiency of solar panel? Fourth, how effects the solar panel in the environmental factor of Hong Kong? Fifth, is Hong Kong peoples can effort the total replacement from tradition electrical supply to solar energy supply in their own flat?

II. METHODOLOGY

2.1 Introduction

This section offers a brief summary of the data and methods used in this study. Two main methods were selected to collect data, they are online survey and making some experiment.

The online survey is a subjective way to collect data. It can be known the willing of people since it collects respondent's feeling and opinions about the environmental-friendly and renewable energy. Therefore, the result can be used to compare with the other data to enhance the persuasive information.

The experiment is an objective way. It is surrounding the losses of solar panels to run the experiment. Then, the results will be used to calculate a representing ratio of losses and calculate the payback period, net profits or net losses on solar panel project.

2.2 Methodology used

2.2.1 Method 1 Online survey

Follow the rule, some questions be written:

Online survey question

1. Occupation
2. Age
3. How much people in your family?
4. How much average revenue of your family in a month?
5. How are you support environmental-friendly?
6. How much electricity tariff of your home in a month?
7. Do you think are electrical companies' sufficient environmental-friendly in Hong Kong?
8. What is renewable energy?
9. Will you mind to increase your electricity tariff for increasing ratio of renewable energy in Hong Kong?
10. Will you use the landscape of your home to exchange a solar energy system?

2.2.2 Method 2 Experiment

The experiment is the main method to collect data about losses of solar energy. And the experiment is objective method. Before the experiment, some calculations are needed and according to the result of calculations to buy the material. There have many different types of the solar panel, only Kernly solar panel and Tengxiz Optoelectronics solar panel be chosen as they can be fulfilled a suitable price and rated voltage. Also, a solar energy controller and a solar energy battery are bought by online shop in September 2018. The experiment period is between October and November. The design is solar panel, battery and a load (mobile phone battery) connect to the contractor, then make some material onto the solar to imitate exaggerating losses like putting aclamp near the solar panel to imitate the PID situation and drop a few of corrosive drain cleaning liquid to

imitate the nature corrosive situation. After that, keep measuring the output power of the solar panel through the electronic meter. Moreover, the result will be used to compare with the real electricity tariff in Hong Kong to find out “Is Solar Energy an Extraordinary Method to Replace Using Fossil Fuels to Generate Electrical for Poorer Residents in Hong Kong?”

2.2.2.1 Engineering Design

Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller. The load can become to connect a converter and connect it to the grid (elective).

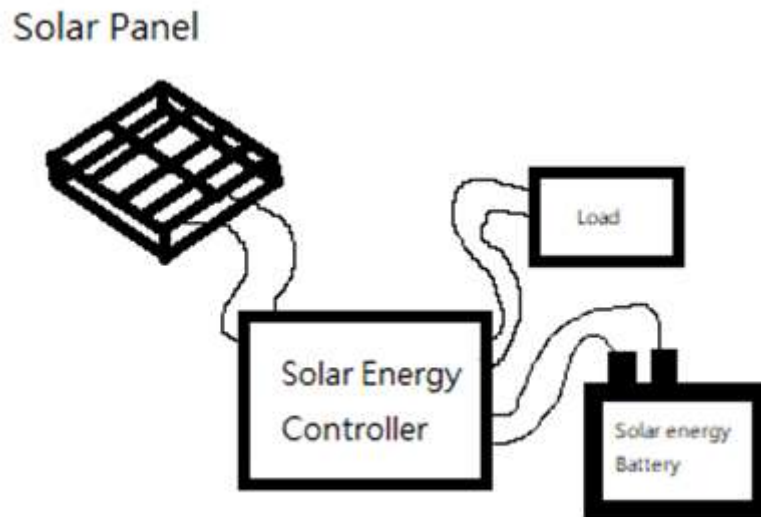


Figure (2.2.2.1) - Engineer Design

2.2.2.2 Experiment worksheet

Two different solar panel comparisons	
Figure (2.2.2.2.1.) - Two different solar panel comparisons	
Purpose	Compare two different solar panels (Tengxiz Optoelectronics Solar Panel & Kernly Solar Panel) which are similar price
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Tengxiz Optoelectronics Solar Panel
Date	29.10.18 – 2.11.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, connect the Tengxiz Optoelectronics Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value.
Average testing voltage 1	5.03
Average testing voltage 2	5.69
Disparity	12%



Table (1) - Two different solar panel comparisons

Acid rain (corrosive) testing	
Figure (2.2.2.2.2.) - Acid rain (corrosive) testing	
Purpose	Test the corrosive drain cleaning liquid how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Corrosive drain cleaning liquid
Date	5.11.18 – 9.11.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, drip the corrosive drain cleaning liquid onto the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	5.74
After testing average voltage	5.35
Disparity	6.79%



Table (2) - Acid rain (corrosive) testing

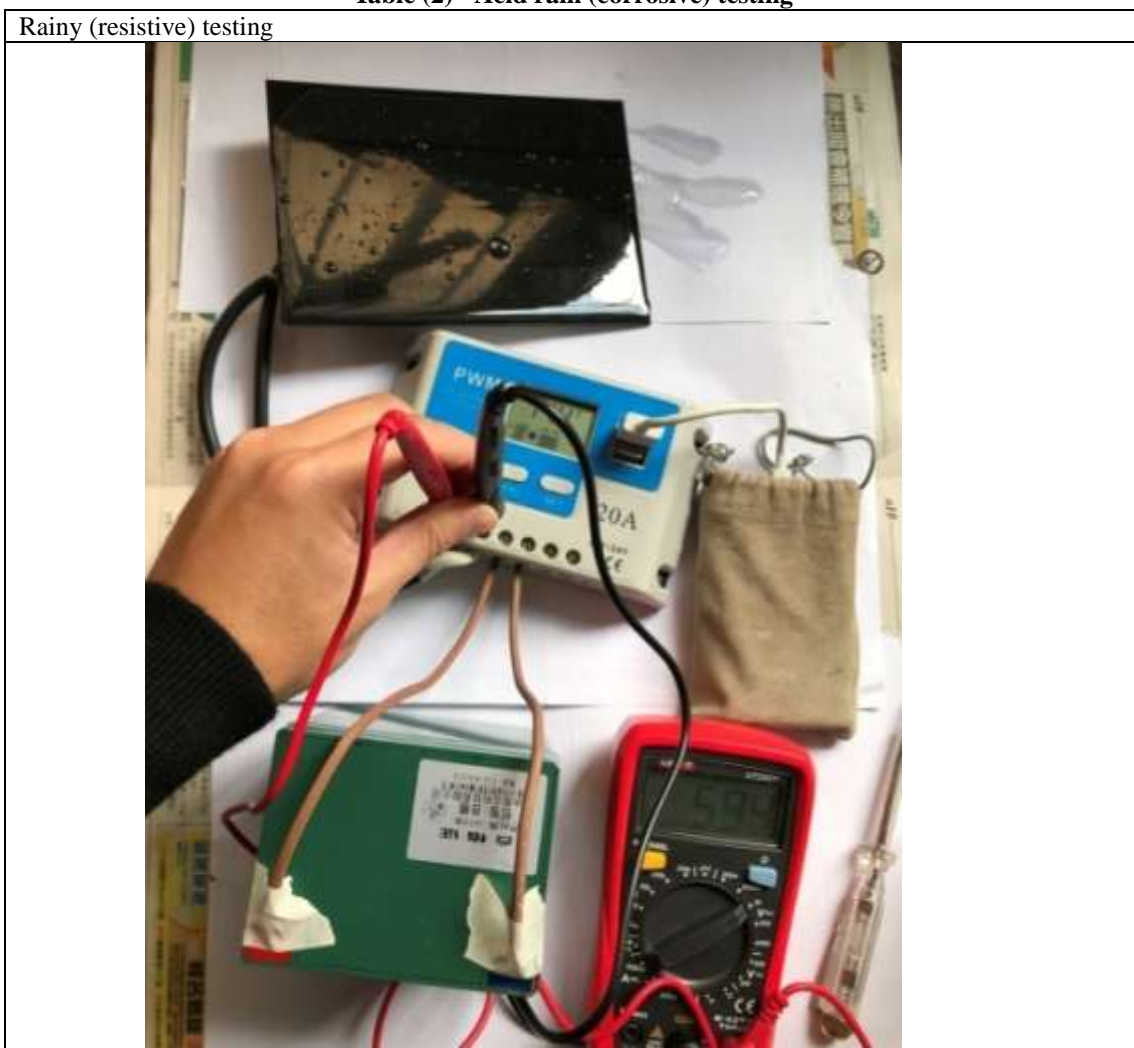


Figure (2.2.2.2.3.) - Acid rain (corrosive) testing

Purpose	Test the water how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Water
Date	12.11.18 – 16.11.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, drip the water onto the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	5.95
After testing average voltage	5.94
Disparity	0.17%

Table (3) - Rainy (resistive) testing

Potential induced degradation testing

Figure (2.2.2.2.4.) - Potential induced degradation testing	
Purpose	Test the iron (PID) how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Clamp(iron)
Date	19.11.18 – 23.11.18
Time	10:00 a.m. – 14:00 p.m.

Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, connect the Clamp which is representing an iron with the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	6.03
After testing average voltage	5.88
Disparity	2.49%



Table (4) - Potential induced degradation testing

Angle Testing	
Figure (2.2.2.5.) - Angle testing	
Purpose	Test the angle of the solar panel facing sun how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable
Date	26.11.18 – 30.11.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, move the Kernly solar panel to other angle and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	5.84
After testing average voltage	6.15
Disparity	5.31%



Table (5) - Angle testing

The effect of the plastic membrane Testing



Figure (2.2.2.2.6.) - The effect of the plastic membrane Testing

Purpose	Test the plastic membrane how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Plastic membrane
Date	3.12.18 – 7.12.18
Time	10:00 a.m. – 14:00 p.m.
Process	Find a original new Kernly solar panel and it had not been taken off the plastic membrane. Besides, connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, took off plastic membrane on the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	5.55
After testing average voltage	5.84
Disparity	5.23%

Table (6) - The effect of the plastic membrane Testing

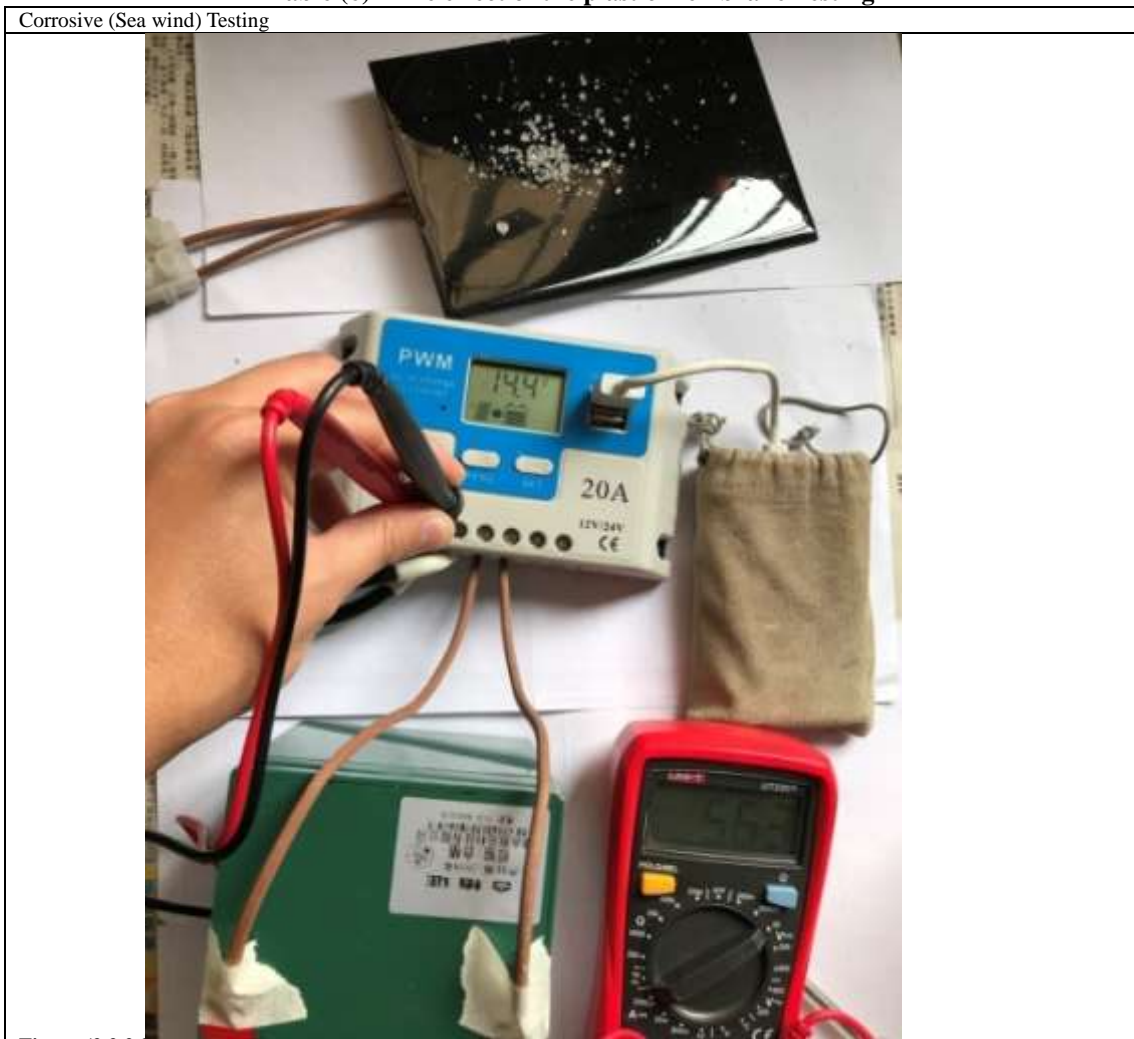


Figure (2.2.2.2.7.) - Corrosive (Sea wind) Testing

Purpose	Test the salt how to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Salt
Date	10.12.18 – 14.12.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the Kernly Solar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, drip the salt onto the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per hour.
Before testing average voltage	5.69
After testing average voltage	5.63
Disparity	1.05%

Table (7) - Corrosive (Sea wind) Testing

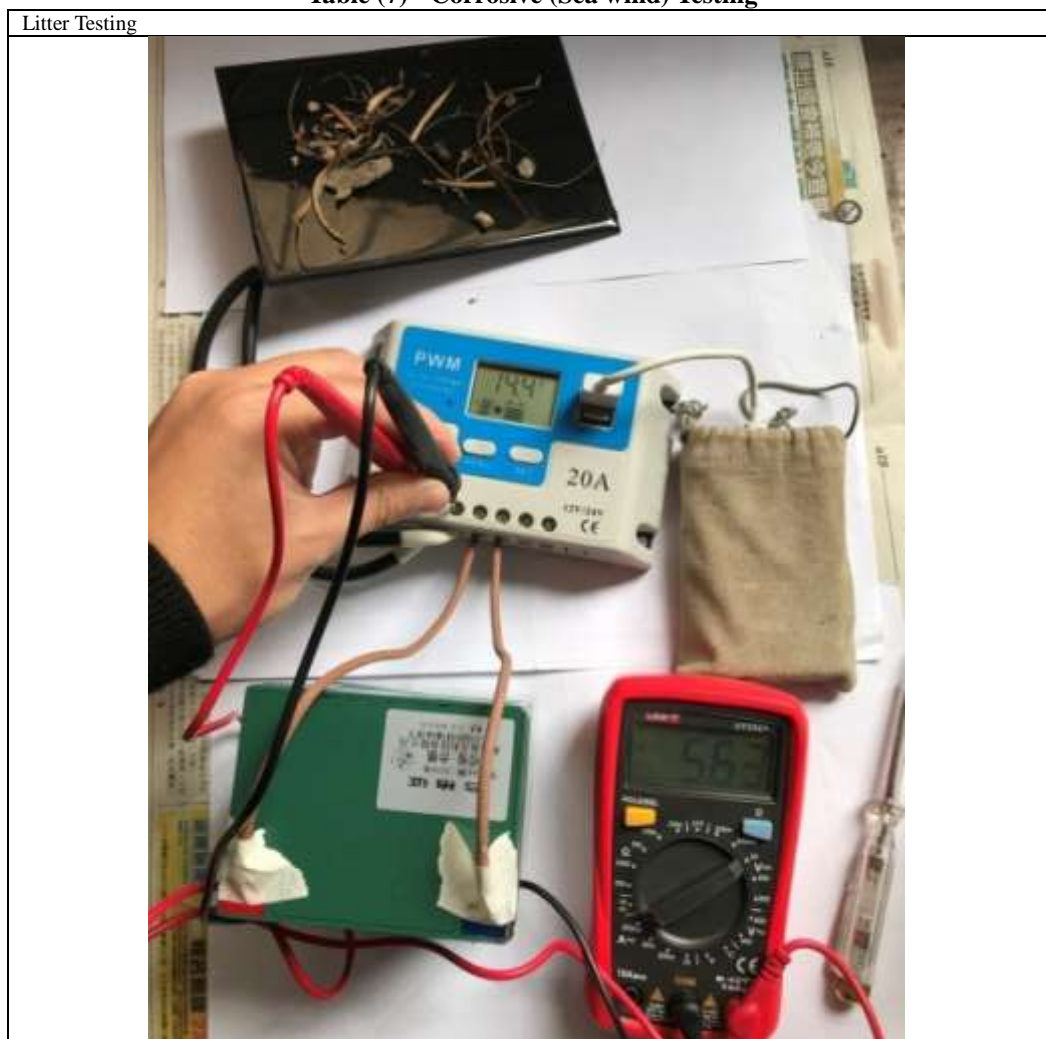


Figure (2.2.2.2.8.) - Litter Testing

Purpose	Test the litterhow to effect the solar panel
Equipment & material	Kernly Solar Panel, Solar energy battery, Solar energy controller, Electronic meter, Cable, Litter
Date	17.12.18 – 21.12.18
Time	10:00 a.m. – 14:00 p.m.
Process	Connect the KernlySolar Panel, solar energy battery and load to the solar energy controller, then use the electronic meter to measure the output of Kernly solar panel and drop the value. After that, drip some litter on the Kernly solar panel and use the electronic meter to continuous measure the output of Kernly solar panel per 15minute.
Before testing average voltage	5.67
After testing average voltage	5.84
Disparity	3%

Table (8) - Litter Testing

2.4 Summary

The purpose of the survey is finding respondent’s opinions on the renewable energy and the installation of solar panel on their windows, but it will affect their house’ landscape, will they still install? About the answers, most of respondents are supporting environmental-friendly, but if they have to pay something for it like their landscape or expense, the results become approximate half. It matches the situation since the poor people is not a small number in Hong Kong.

The purpose of the experiments is finding the losses of solar panels through different reason such as acid rain, potential induced degradation and different angle from sunshine etc. With regard to calculating a representing ratio of losses and calculates the payback period, net profits or net losses on solar panel project.

Regarding the results of experiments, the average losses are 3.43% in a week, it is an exaggerating number. It is observed solar panel is sensitive and easy to be affected by exterior reasons. Also, the payback period of Tengxiz Optoelectronics solar panel and Kernlysolar panel are approximate 13 years and 10 years. It is not an acceptable number for the poor peoples who are living in poverty line.

III. RESULTS AND DISCUSSIONS

3.1 Analysis and Discussion of Online survey

To sum up the results of the survey, first, about the family condition, most of the respondents are Housewife / Househusbands, they have 30%, 23.3% of the respondents are students. About the age, most of the respondents are 31-40 years old, they have 53.3%, 20% of the respondents are students. Regarding the "how much people in their family", 90% of the respondents have three or above families. Above the data displaying, most of the respondents of the survey, they can live in a three or above family. It means the respondents can understand their economic situation in their house.

Second, concerning the opinion of the environmental-friendly, total 60% of the respondents are supporting environmental-friendly (20% of the respondents are choosing 5, 40% of the respondents are choosing 4). 30% of the respondents are choosing 3 and they are the medium position, then, 10% of respondents are not supporting environmental-friendly (6.7% of the respondents are choosing 2, 3.3% of the respondents are choosing 1). That's meaning 60% of the respondents are supporting the environmental-friendly, thought according to question 8 (What is renewable energy?), only 66.7% respondents can choose the all three right answers (Wind power, Hydro power and solar energy), 33.3% respondents cannot choose the all right answer. It means the environmental-friendly education which should be further enhanced.

After that, even some respondents will support the environmental-friendly, they must face a real reason of economic. So, about the economic situation, 3.3% of the respondents are \$0-\$10000, 16.7% of the respondents are \$10001-\$20000, 53.3% of the respondents are \$20001-\$30000 and 26.7% of the respondents are \$30001 or above. Compare with the gross domestic product per capita, it is 46200 US dollars per year which means 30030 Hong Kong dollars per month in Hong Kong in 2017. Total 20% of respondents are below the GDPPC (3.3% of the respondents are \$0-\$10000, 16.7% of the respondents are \$10001-\$20000) and according to the poverty situation data of Census and Statistics Department, in four person or above family, they are under the poverty line. Then, only 6.7% of the respondents spent \$201-\$400 electricity tariff in a month, total 93.4% of respondents spent above \$400 electricity tariff in a month (46.7% of the respondents spent \$401-\$600, 46.7% of the respondents spent \$601 or above). It is not a cheap electricity tariff.

Besides, about the question 10 is "Will you use the landscape of your home to exchange a solar energy system?" 66.7% of respondents disagree and 33.3% of respondents agree and question 9 is "Will you mind to increase your electricity tariff for increasing ratio of renewable energy in Hong Kong?" 56.7% of respondents agree and 43.3% of respondents disagree. It is because the solar panel should be installed the place which can be struck by sunlight's photons like near window, so the sacrifice of landscape is necessary. But two over three people disagree sacrifice their landscape and more than half people don't sacrifice their more resource to exchange more environmental-friendly method of manufacturing electricity. In general moral, it may be wrong, but every family is facing different problems. They don't want to invest some money to exchange new electricity which needs some time to recover the cost. It has no model answer.

IV. CONCLUSION

Solar energy is clean renewable energy and unlike many other consumer goods, they don't 'give up the ghost' at the end of their warranty period and need to be replaced, but continue to still produce clean electricity, although at a slightly less efficiency each year. "With the global energy demand growing, fossil fuel reserves depleting and the increasing need to tackle climate change, there is an ever growing need to develop alternative clean energies." (E.M. Speller, 24 Aug 2016 [6]) "In fact, some decidedly old-school solar cells have been producing electricity daily for about 40 years or so, and are expected to continue to power homes and businesses for decades more but the inverter (which converts the DC from the panels into AC for feeding into the home's outlets and the grid) may need to be. The average inverter warranty ranges from 10 to 15 years, and unlike solar panels, will not just slowly get more inefficient, but will instead just quit working." (Derek Markham 2015 [7]). A formula have designed, "The minimum watt of a solar panel per year * The maximum units of a solar panel in a house * (1 - 3.43%)", the formula is further proving the results of this project: if the payback period of the solar panel project is more than 12.5 years or more, this will not suitable for the family who are under the poverty line. Some opinions will think if the economic condition is allowed, and the solar panel project is net worth, even it will take a long payback period, the solar panel is suggested to Hong Kong's residents who are above the poverty.

But they solar panel still has some disadvantages:

First, it is very sensitive, even put it on the table and don't do anything, their output still will interrupted change, since the photon is random to strike the solar panel and the solar panel is easy to be affected by other environmental reasons. This means the reliability should be suspected when the sun is not shining, there may no generation of energy.

Refer to the experiment results, total of eight experiments have done, all testing is for testing the property, the functions of the solar panel and how the reason of environment affected the solar panel.

Then, the two different solar panel comparisons, it is for comparing the function and property of two different solar panels (Tengxiz Optoelectronics Solar Panel & Kernly Solar Panel) which are similar property on online shop. Second, the acid rain (corrosive) testing, it is for imitating acid rain to erode the solar panel and measure the voltage after eroding. When any type of fuel is burnt, lots of different chemicals are produced. That pollution will mix with rain in the air, it becomes acid rain and erodes the solar panel. Third, the rainy (resistive) testing, it is for imitating the rain stop on the top of solar panel after raining and measuring how it resists the photon to strike the solar panel. Fourth, the potential induced degradation testing, it is for using the clamp to imitate an iron to interact the electronics onto the solar panel. Fifth, the angle testing, it is for how the solar panel to absorb the different intensity of photon from different angles. Sixth, the effect of the plastic membrane testing, it is for testing if build a plastic membrane cover the solar panel to protection, how many values will change. Seventh, the sea wind (corrosive) testing, it is for imitating sea wind to erode the solar panel. Eighth, the litter (resistive) testing, it is for mocking some dust, litter glue onto the solar panel after many years and nobody clear it up.

Second, first generation solar panel only have approximately 15% efficient, more efficient solar panels are relatively expensive, the world record for solar cell efficiency at 46.0% was achieved by using multi-junction concentrator solar cells, that is a third generation solar panel. Besides, all experiment is proving the real efficient achievement of the solar panel is lower the manufacturing property efficient. Every experiment ran approximately one week except the two different solar panel comparisons. The most disparity is acid rain (corrosive) testing, that is 6.79%. It affects the efficiency and the cost of solar energy directly.

Third, "the cost of a solar electric system depends on many factors, among them the size of the system, the complexity of the system, the distance the installer must travel, the type of installation, and the difficulty of the installation. Because solar resources and electrical consumption vary, most residential solar electric system falls within the 1 to 6 kW range, the most common being 3 to 6 kW systems. In an all-electric home equipped with a wide assortment of electric appliances – such as central air conditioners, electric space heaters, electric water heaters, and electric stoves – average monthly electrical consumption typically falls within the 2000 to 3000 kilowatt-hours/month range. Even in very sunny climates, very large PV systems on the order of 10kW." (DAN CHIRAS, Robert Aram & Kurt Nelson, 2010 [8]) The initial cost of the Tengxiz Optoelectronics solar panel in one person family is (\$4524 (DC to AC converter) + \$1010.5 (43 units of Tengxiz Optoelectronics solar panel) + \$176.47 (controller and battery)) = \$5710.97. They can provide 388.03 kWh / year. The initial cost of the Kernly solar panel in one person family is (\$4524 (DC to AC converter) + \$977.6 (52 units of Kernly solar panel) + \$176.47 (controller and battery)) = \$5678.07. They can provide 485.68 kWh / year. It might take up to 10 years to 15 years before you can break even with your initial investment. For some peoples, it is not easy to effort.

Fourth, when the solar panel fails to perform efficiently, it will operate some recycling processes, there are two main types of solar panels, requiring different recycling approaches. Both types—silicon based and thin-film based—can be recycled using distinct industrial processes. Currently, silicon based panels are more common, though that does not mean that there would not be great value in the materials of thin-film based cells. Although some research studies conducted on the topic of recycling solar panels have resulted in numerous technologies and some of them even reach an astonishing 96% recycling efficiency, it still makes some unavoidable waste for now. Then, the aim is to raise the bar higher in the future.

Fifth, for home users, a solar energy installation may require specific space as it only can be installed on rooftops, window or some places can be struck by sunshine. Refer to the online survey, 66.7% of respondents disagree to use the landscape of your home to exchange a solar energy system. It is because the median floor area of accommodation of domestic households is so small "it was about 430 square feet (sqft) and the median per capita floor area of accommodation was about 161 sqft, with more than 90 per cent of households in the territory living in accommodation of fewer than 753 sqft in 2016. In addition, among the approximately 2.508 million accommodations in Hong Kong, 8.1 per cent of them had a floor area less than 215 sqft, while 4.9 per cent of them were private permanent housing." (Michael Wong, Wednesday, 20 June, 2018 [9]) So, they want to save the remained landscape is understandable.

Eventually, is solar energy an extraordinary method to replace using fossil fuels to generate Electrical in Hong Kong? The answer is yes. Since for the poor people, the net worth is positive and it can reduce the dependence on fossil fuels to reduce pollution in the world.

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Tony Tsang" Is Solar Energy an Extraordinary Method to Replace Using Fossil Fuels to Generate Electrical for Public Residents in Hong Kong?" American Journal of Engineering Research (AJER), vol. 8, no. 10, 2019, pp 246-257