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**Residential Rooftop Solar System:
Expectation vs. Reality in Greater Taipei**

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Residential Rooftop Solar System: Expectation
vs. Reality in Greater Taipei

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I. Introduction

For the past few years, solar energy has been the fastest growing power generation method around the globe. It has been confirmed that solar power is cheaper and cleaner than traditional coal power, which is a major source of air pollution. As a result, the capacity of the installed solar panels has doubled or even tripled in most countries for the last few years. Consumer-grade or residential rooftop solar system in recent years is a major focus for many countries, and especially for Taiwan, a country with very limited land mass, could use any spare space. However, due to the general public's lack of proper knowledge, the lackluster promotion by government, and the traditional belief of feng shui, the residential rooftop solar system adoption in Greater Taipei is relatively low compared to its calculated potential capacity.

In 2016, Taiwanese government implemented a two-year solar power promotion plan in the hope of achieving 1.52GW (1520MW) of solar power capacity by 2018, and rooftop solar system is a crucial part of this. Although this goal has been crushed now, the bigger goal of generating 20% of all electricity from renewable energy by 2025 is still very far off (currently at only 5% to 7%). As this research is focused on Greater Taipei (Keelung, Taipei City, New Taipei City), I have roughly calculated the potential capacity of rooftop solar panels in the area with the help of government documents, which is about 3860MW (INER). Unfortunately, the current number is relatively low at 30.4MW as of now.

The intention of this study is that it explores the potential prospect of the policy regarding solar power and find out the problems and obstacles that might hinder the adoption of rooftop solar system in the case of Greater Taipei. In order to understand this study, we first need to understand what is rooftop solar system and get some of the frequently asked questions right. In short, it is solar panels on the roof of residential buildings with the benefit of supplying your own electricity or selling it to electricity company. Additionally, because of the light absorption ability, rooftop solar system can also reduce indoor temperature, and thus reduce A/C electricity consumption. The system also comes with real-time performance monitoring apps on smartphones, tablets, or computers. The rate of return is usually 6%~13% depending upon the size of your roof and other factors (anything over 5% is considered good investment), and the time it takes from applying to fully running the system would take 3 to 6 months in Taiwan (Initial Solar).

There are many successful cases that can serve as guidelines for us, especially those that have similar climate condition as Taiwan. Freiburg, a city in Germany, though has less overall sunlight than Taiwan (Freiburg 1800hr/y vs Taiwan 2200hr/y), produces 4 times more energy than it consumes (Social Enterprise Insights). It is thanks to well-thought out government policies, educations, and infrastructure that they are able to achieve that impressive performance in an already amazing country that has 30% of their electricity generated from renewable energy (The Logical Indian).

Among all the factors, government's policy and assist have the most influence. People apply for rooftop solar system through government certified companies or contractors (Chen). Residents can use the electricity generated from the system as they wish, and the surplus will feed into the grid and Taipower will pay for it, which is called "feed-in tariff". The price of feed-in tariff is decided by the price when the system is completed and is fixed for 20 years, which means the price will not fluctuate (Initial Solar). The government used to have subsidies for the system, however, at the time of conducting the research (April 2019), it had been canceled.

II. Literature Review

For the last decade, solar power has been a big part of the conversation regarding renewable energy. The interesting part is that after learning more about renewable energy, I found that most people lack proper and correct knowledge on solar power and some thought Taiwan has no potential of utilizing renewable energy. Among older generations, "feng shui (風水)" or geomancy is one big reason to not accept rooftop solar systems. It's a system of laws considered to govern spatial arrangement and orientation in relation to the flow of energy (chi), and whose favorable or unfavorable effects are taken into account when siting and designing buildings. Together with the above two factors, general public's lack of awareness and the lack of government promotion is undermining the potential of utilizing more solar power through rooftop solar system in Taiwan.

Before jumping into the research, we have to take a look at the current situation of solar power in Taiwan as well as the potential of Greater Taipei, the target area of this study. As of the end of 2018, Taiwan's solar power capacity is about 2342MW (Taipower data).

Tainan and Yunlin are the two top counties with the highest capacity that blow everyone out of the water, and both of them have just over 390MW of installed capacity. Greater Taipei (Keelung, Taipei City, New Taipei City), however, only has 30.7MW combined in contrast to its calculated potential capacity of 3860MW (INER).

It was pointed out in a previous research done in Taoyuan area that some common problems such as the lack of government promotion and education, or the lack of urgency for the public are the main reasons that are holding back the adoption of rooftop solar system (Chuang). Deficient education would contribute to general public's false information on solar power, and poor promotion doesn't help increase people's urgency on adopting solar panels in order to resolve energy or environmental issues.

With mature and leading technology of solar power and long hours of sun sunlight, Taiwan has very solid and competent foundation for utilizing solar power. Through research, solar power was said to be able to replace most of nuclear energy and part of thermal electricity (Hu). This research is a further proof that Taiwan has amazing potential of developing renewable energy.

It is particular in Taiwan to consider feng shui when buying real estate. Although it is often considered as superstition, a lot of people are still somehow abided by this hidden rule when making decisions, and even housing price is affected by it. In a study conducted in 2004, about 90% of the people do believe in feng shui in Taiwan (Hung), and it also would affect real estate prices by as much as 10% (Lin). As a result, it is not surprising that part of the people would reject rooftop solar system because of feng shui.

III. Methodology

A. Questionnaire Design

This Questionnaire is designed to find out general public's awareness, basic knowledge about solar power, the potential difficulties they face, and willingness to install the system, and it consist of four major sections. The participants are divided into house owners and non-house owners for better accuracy and comparison.

The first question divides participants into house owners and non-house owners, and essentially, they will answer two separate questionnaires. However, the two questionnaires

are the same up until the last section. The first section collects some basic personal information like gender, age, job, and awareness of the solar power related information. The second section is to test the basic knowledge of general public. It consists of most frequently asked questions and the answers are composed of one correct answer and a couple of most common mistakes. The third section is to get to know what are some of the biggest obstacles and inconveniences that people have because these problems will have to be addressed first before installing rooftop solar system. The final section serves to collect people's willingness of installing rooftop solar system and the reasons for those who choose not to.

B. Participant and Data Collection

The survey was conducted using Google Form and was shared via social media with the help of friends and families. The questionnaire received 179 responses, including 87 house owners and 92 non-house owners, and the survey collection ran from April 8th to 12th.

C. Data Analysis Procedure

The data collected will be presented in descriptive form, which are pie charts, bar charts, and tables for easier read. For more realistic data and results, house owners and non-house owners answer two different set of questionnaires. Since all of the questions are multiple choices, the analysis is measured in percentage.

IV. Results

Among 179 respondents, 87 own a house, as shown in Table 1 and Table 2.

Table 1. Gender and age for house owners

Gender	87 house owners	Age	87 house owners
Male	37	20 down	0
Female	48	21~30	1
Conceal	2	31~40	1
		41~50	31
		50 up	54

Table 2. Jobs for house owners

Job	87 house owners
Employee	87
Student	0

Table 3 and Table 4 are the profile of 91 non-house owners.

Table 3. Gender and age for non-house owners

Gender	91 non-house owners	Age	91 non-house owners
Male	33	20 down	4
Female	59	21~30	28
Conceal	0	31~40	23
		41~50	16
		50 up	21

Table 4. Jobs for non-house owners

Job	91 non-house owners
Employee	72
Student	20

A. Questionnaire Section 1. General awareness of solar power

Sec.1.1. What is the main source of your information/knowledge of solar power?

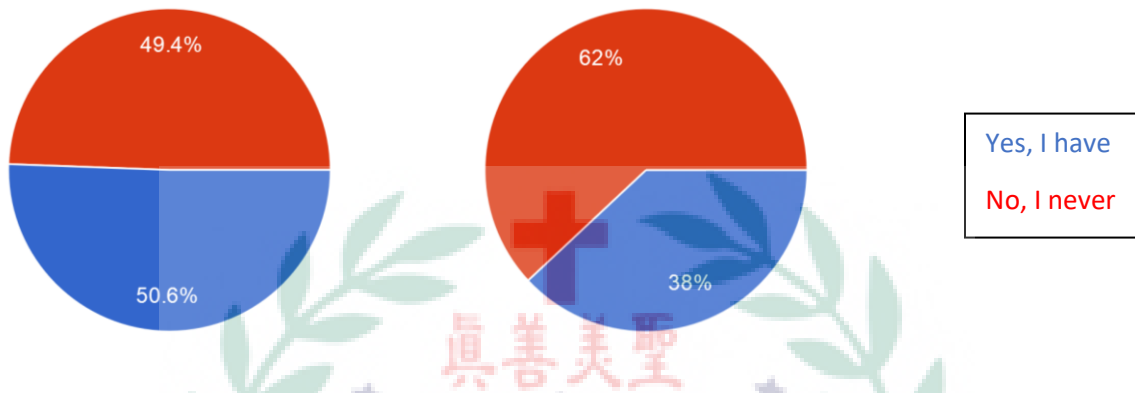
There are 86 people combined who mainly get their information from TV news report, and 30 get their information from social media articles or ads. There are, however, only 12 people who get their information from government promotion or education.

Sec.1.2. Do you pro-actively look for information of solar power (consult professionals or search on the web)?

100 people have never looked for information spontaneously, while 79 have. Something worth noting is that house owners are more pro-active than non-house owners.

As shown in Figure 1., there are half of the house owners who have pro-actively seek information of solar power while only 1/3 of the non-house owners have.

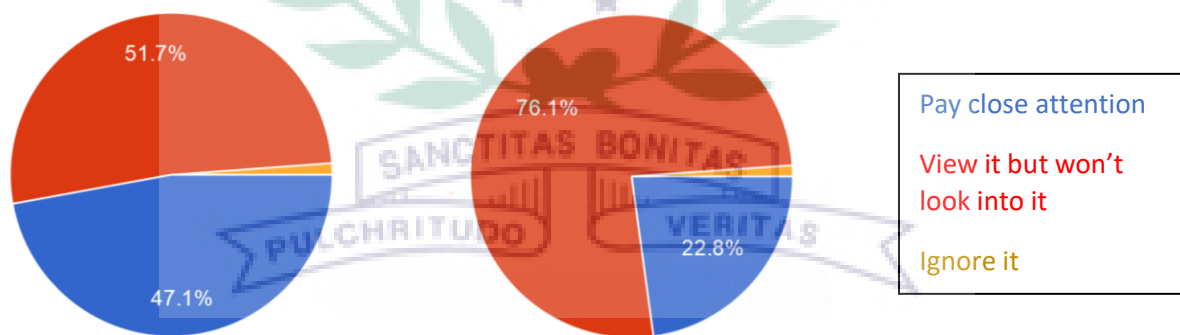
Figure 1. Do you pro-actively look for information of solar power? (left is house owners; right is non-house owners)



Sec.1.3. If you come across solar power related report or news, do you usually...?

115 people would view it but not look into it, while 62 would pay close attention to it. 2 said they would completely ignore it. In a similar sense as last question, house owners are more engaged in information of solar power. Almost half of the house owners would pay close attention to it while only 1/4 of the non-house owners would do so.

Figure 2. When coming across solar power related content, do you? (house, non-house)



B. Questionnaire Section 2. Basic knowledge and frequently mistaken questions

Sec.2.1. Cost comparison between renewable energy and traditional coal power generation.

The correct answer is that renewable energy has lower cost to generate electricity than coal. Only 31 of the people got the right answer, and the other 148 people either chose the wrong answer or simply state that they don't know the answer.

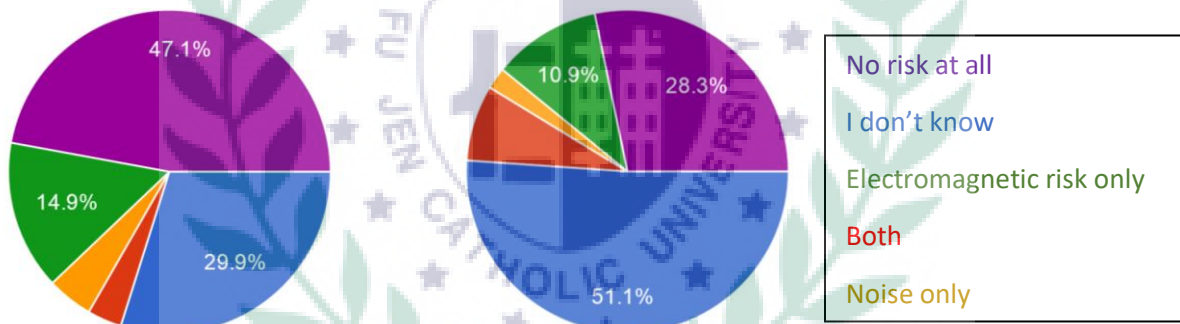
Sec.2.2. What happens to solar panels when it is overcast or installed in rainy area?

On this one of the most asked questions, 113 people got the right answer, which is that solar panels can obviously still produce electricity but at a lower rate.

Sec.2.3. Does rooftop solar system pose noise or electromagnetic risks?

Only 67 people got the correct answer. Rooftop solar system does not pose any risk and it actually produces less electromagnetic wave than cellphones. Discrepancy is again present on this question between house owners and non-house owners. Half of the house owners chose the right answer, while 1/4 of the non-house owners score the right one.

Figure 3. Does rooftop solar system pose noise or electromagnetic risks? (house, non-house)



Sec.2.4. The pollution solar panels create.

The truth is that it pollutes less than semiconductor when manufactured, and it only produce some pollutant during manufacture process. There are 50 people combined who got this right, and that is about 1/4 for both house owners and non-house owners.

Sec.2.5. Does solar panels efficiency decline over time?

The solar panels efficiency does decline at about 0.8% rate annually and so we are looking at around 80% remaining after 20 years. 11 people combined was knowledgeable that they picked the right answer and half of the people picked “I don’t know.” Although this question is more technical, it is still one of the frequently asked questions.

C. Questionnaire Section 3. Potential obstacles or inconveniences

Sec.3.1. Do you live in apartment building/condo or single house (you own the roof)?

Majority of the people, 130, live in apartment/condo, which is common in Northern Taiwan, and 49 live in single house unit or they basically own the roof that they can do as they wish to the roof. The process of applying for and installing rooftop solar system on apartment/condo buildings are quite complex as of right now in Taiwan. Resident assembly or committee needs to be held and certain criteria needs to be met in order to legally implement the system.

Sec.3.2. Are there illegal structures on your roof?

45 people acknowledged that they have illegal structures on their roof while 14 do not know if they have it. According to law, solar system cannot be built on illegal structure.

Sec.3.3. Are there any tall buildings obstructing sun light in the vicinity of your home?

Only 46 people live around tall buildings that obstruct their sunlight. Living around tall buildings obstructing sunlight would reduce the efficiency of solar panels, and that just might be a deal breaker.

Sec.3.4. Is your usable roof space smaller than 15 ping/49.5 m² (1 ping = 3.3 square meters)?

89 people have roof bigger than 15 ping and 52 have smaller roof. The rest simply don not know about their roof size. It is calculated that roof smaller than 15 ping/49.5 m² got a rate of return too low that it is not recommended to install rooftop solar system.

Sec.3.5. Do you or any of your family members believe firmly in feng shui (geomancy)?

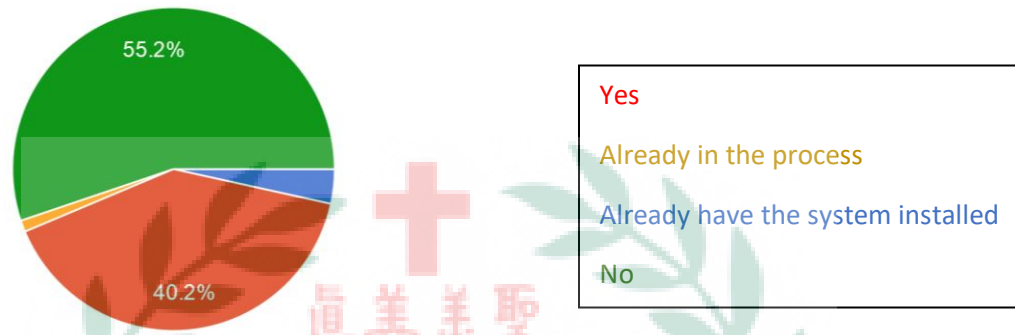
90 people combined chose yes, making it 50% of the people that believe in feng shui. The result indicates that the number of people who believes in feng shui has declined since the study done in 2004.

D. Questionnaire Section 4. Willingness to install rooftop solar system

Sec.4.1. For house owners: Are you willing to apply for and install rooftop solar system?

From Figure 4., we can tell that among 87 house owners, 48 are not willing to. 35 are willing to while 1 is in the middle of the process and 3 have already installed it.

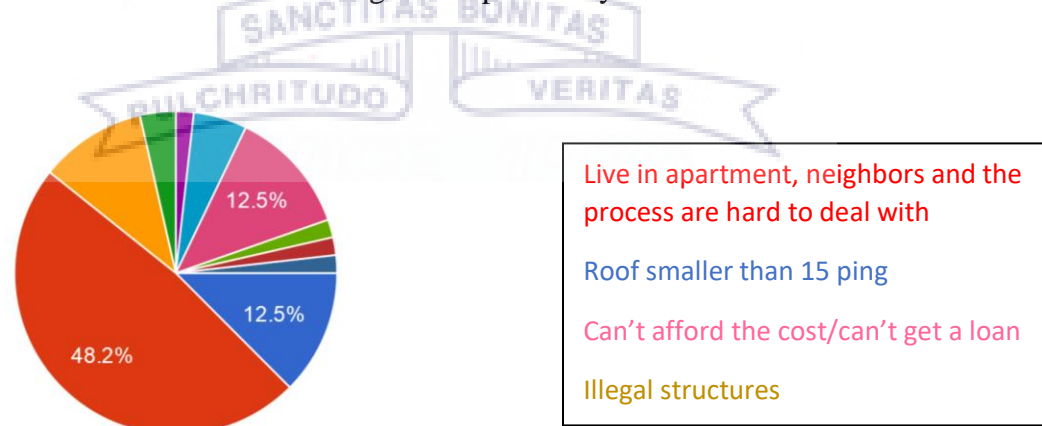
Figure 4. Willingness of Installing Rooftop Solar System for House Owners



Sec.4.2 For those who chose no in the last question, choose one biggest reason.

In Figure 5., we can see that among those 48 people, half of them live in apartment and think that dealing with neighbors are too difficult. 7 of them have roof smaller than 15 ping/49.5 m² while another 7 of them simply can't afford the cost or could not get a loan from bank for some reason. Furthermore, 6 of them was held back by illegal structures that they simply don't want to deal with it. Surprisingly, there are only 2 people who is affected by feng sui, which is not expected.

Figure 5. Main Reason for Not Installing Rooftop Solar System



Sec.4.3. For non-house owners: Are you willing to encourage your family to install rooftop solar system? For people who are currently renting houses, supposedly you own a house, are you willing to install?

As for non-house owners, we can see from Figure 6. that out of 92 respondents, 60 of them are willing to encourage their family to install it while 31 are not. 1 has even tried to do it already.

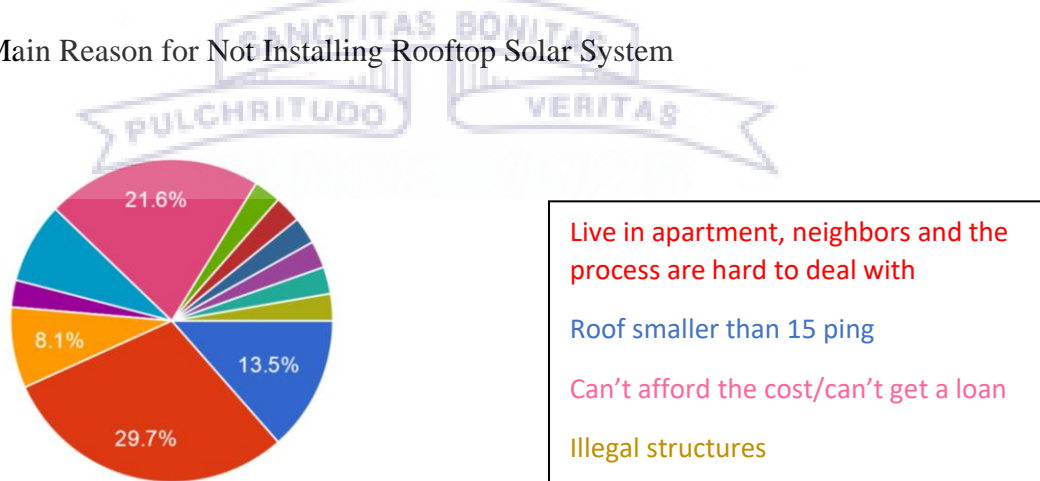
Figure 6. Willingness of Installing Rooftop Solar System for Non-House Owners



Sec.4.4. For those who chose no in the last question, choose one biggest reason.

According to Figure 7., among the 31 who are not willing to do it, about 1/4 (11) of them also have neighbor problems. 8 of them is due to the cost they can't afford, and 5 of them have roof smaller than 15 ping/49.5 m².

Figure 7. Main Reason for Not Installing Rooftop Solar System



V. Analysis & Discussion

According to the survey questionnaire, the general public still lacks awareness on renewable energy and is rather passive on the topic. Majority of the people are also uneducated on the solar power in general, and for the most questions, less than half of the people got the right answers. This might have something to do with the government's lack of proper promotion. Additionally, due to the housing in Northern Taiwan is mostly apartment/condo buildings, about half of the people who are not willing to install solar system chose dealing with neighbor is too difficult as their main reason.

Majority of the people lacks correct and proper information on the very basic aspect of solar power. Although this does not seem to be the main reason why half of the people are not willing to participate in rooftop solar system, it clearly indicates that government's promotion is very ineffective, and the school education neglects the topic of renewable energy, which is very important in the future of every country's infrastructure. Since most people get their information of solar power from TV news, government could cooperate with them to make the promotion more effective.

In Northern Taiwan, apartment or condo buildings are very common due to land restriction and high population density. In the survey, more than 70% of the people have to share roof space with neighbors, and the laws make it very difficult to utilize roof space for individual residents. According to the law Condominium, two thirds of the residents have to attend the assembly or committee, and out of those who attends, three fourths of them need to agree in order to install rooftop solar system. That is why half of the respondents picked neighbor problems as their main reason why they are not willing to install rooftop solar system, because it is tremendously difficult to get a green light. Some experts and companies have shown concern and urged government to amend the laws and the process of the application for rooftop solar system. Not to mention this law was legislated decades ago, and some of the contents are out-of-dates or cannot accommodate for the circumstances of today. Some changes need to happen.

The second biggest problem for people is the cost of installing the system. As of the writing of this search, there is no government subsidies on the cost of installing the system. It used to be available but the subsidies were canceled recently. Without subsidies, the cost is very high (70k to 100k per KW; 30 ping/90 m² of space could install 10KW), and the

payback period will extend. As a result, this circumstance would decrease the appeal of investing in rooftop solar system.

Surprisingly, as opposed to the hypothesis, the influence of feng sui is almost not present anymore. Since most respondents are of older generation, the hypothesis is that feng shui would influence their decision making tremendously. Perhaps modern people don't regard feng sui as heavily as people in the past anymore, or neighbor problems and the cost of the system simply overwhelm the importance of feng shui.

VI. Conclusion & Suggestion

In Northern Taiwan, rooftop solar system adoption is still relatively low compared to its potential capacity. The lack of correct knowledge exposed the lackluster government promotion and education. However, the elephant in the room is the complexity and difficulties the laws bring to the apartment/condo buildings. Most people in Northern Taiwan share roof with neighbors, and the apartment resident committee requires too much effort to pass the application. The ever-changing government policy on subsidies is also killing the industry of rooftop solar system. Without subsidies, the appeal of installing the system is too little considering it is a tremendous investment and the payback period can be very long for certain group of people. Finally, the influence of feng shui has seemingly decreased over the years, and is apparently out-weighted by many other stresses in life according to the survey. One suggestion for future research is the inclusion of different profiles, such as different job types or education levels. That would make more interesting comparison than just house owners and non-house owners. It overall opens up more variety of data and ways of analysis.

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