The Conservation of Solar Energy by Incorporating AI: A Study Conducted Using Solar Panels in Households of Sri Lanka.

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Abstract

Environmental pollution has come to become a growing issue for most parts of Sri Lanka as well as the world. One of the main causes for this pollution is the ways of generating electricity and energy in most parts of the country, which mainly consist of burning fossil fuels and thermal oil, which in turn not only increases pollution but creates health issues for neighboring areas and has proved to be a reason as to why the country loses a part of its income. Taking these current issues into consideration, an eco-friendlier method of generating energy is proven to be solar energy. This is a 100% clean renewable source that doesn't have any harmful emissions nor impacts the environment or citizens in a harmful manner. Sri Lanka being a country located near the equator, is blessed with sunlight at an intense level for at least 8 to 10 hours a day and is not taken advantage of when it comes to generating energy for the country. Therefore, this research is conducted with the aim of finding ways for households to be able to make use of this solar energy and incorporate Artificial Intelligence in order to conserve the excess energy for later use, such as during monsoons or at night when there is no sunlight available.

This study is thereby done by selecting households in an area and getting their view on this concept through a google form, which would provide quantitative information, as well as by observations and questioning the households, in order to get qualitative data as well, for a better understanding and accurate analysis to be conducted. The main limitation identified by the researcher was the inability to select a larger sample due to the pandemic situation. The researcher was also able to make a conclusion regarding the lack of knowledge the participants had, that resulted in them not having this concept implemented in their houses by now. On the other hand, as future improvements and recommendations, the researcher suggests that this concept should be introduced to households who already have the facility of solar panels, in order to get an idea on improvements and changes to be made, along with investment plans to be introduced to participants with hope of encouraging them to step into energy conservation using weather prediction and solar energy.

Contents

List of Abbreviations

CCC – Ceylon Chamber of Commerce

PM – Particulate Matter

SO2 – Sulphur Dioxide

EPL – Environmental Protection License

MW – Megawatt

GWH – Gigawatt Hours

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CHAPTER 1 – INTRODUCTION

1.1. Introduction

Sri Lanka receives significant amount of solar radiation across all geographical regions with a Global Horizontal Irradiance (GHI) that varies between 1,247 kWh/m2 to 2,106 kWh/m2 where the intensity of solar irradiation in lowland areas is high compared to that in mountainous regions. This change of irradiation is mainly due to the continuous presence of clouds in mountainous areas and the shadowing effect of mountains (Solar Energy, 2020). Replacing fossil fuels with solar power will provide an opportunity to eliminate much of the world's pollution, energy security challenges and greenhouse gas emissions as it is a source with low magnitudes compared to fossil fuels. Therefore, the purpose of this research is to identify the benefits of solar energy for households, that would ultimately help the country and environment. conserving solar energy for later use will also be discussed, and the research will help provide households with better knowledge and take into consideration their view and opinions on battery powered solar panels.

1.2. Research aim:

The aim of the research is to determine the relationship between AI and solar energy and make sure that using AI, individuals will be able to use predictive analysis and weather predictions in order to prepare for when there is less solar energy available. This will help in order to find the impact of solar energy in day-to-day work and how it can be further improved to best fit the environment and customers, while saving and conserving energy. The findings of this research will help in order to reduce consumer spending on electricity while also conserving the natural resources for better management in a more environmentally friendly manner.

1.3. Research objectives:

- To understand the impact of AI on solar energy
- To determine whether AI will bring a positive or negative impact on individuals
- To find ways people will benefit off of this concept
- To find ways to get the maximum out of the energy saved

1.4.Research questions:

- Do people already have any issues when it comes to energy generated by solar panels?
- Will storing excess energy and using weather predictions help people who already have solar panel facilities?
- How will people benefit from this concept?
- Is there a positive or negative impact on the conservation of energy concept?
- Is it beneficial for the households and will it make a difference in the country?
- Why the government of Sri Lanka doesn’t go for renewable energy sources?

CHAPTER 2 – LITERATURE REVIEW

1.5. Introduction

This chapter will discuss the literature related to solar energy and how it will affect the country. It also discusses current and past practices and its effects on the environment and economy.

1.6. Literature review

According to World Bank report release in August 2016, Sri Lanka loses 7.7% of its income due to environment pollution specially from burning fossil fuels. The country's contribution to global effort will increase by setting up renewable environment friendly energy sources, whilst also reducing climate challenges. Sri Lankan government's budget proposals for the year 2018 has thereby presented strategies for environmentally friendly developments to the country based on the United Nations sustainable development goals. (Wijesena and Amarasinghe, 2020)

As per the CEB's forecast during the period 2015 – 2034, Sri Lanka's electricity demand is expected to grow at 5.3 percent on average, whereas the peak demand is expected to grow at 4.7 percent on average. (Power, 2020). As of Jan – Apr 2020, coal has contributed 41% for the total electricity generation while Major hydro has contributed 21%, and thermal oil has contributed 38%. (Sri Lanka's Electricity Generation (Excluding Non-Conventional Energy) Decrease By 22.7 Percent To 964,043 GWH In April From January 2020 Due to Lower Demand | PUCSL, 2020).

"By granting the exemption, we are planning to minimize the barriers, and encourage the household, rooftop solar systems," Damitha Kumarasinghe, Director General of Public Utilities Commission of Sri Lanka stated. "This will offer better opportunity for Sri Lankan electricity consumers to access the environmentally friendly and renewable sources of electricity for a reasonable investment," he added

Devices and sensors of a grid are usually interconnected in order to collect huge amounts of data, and when AI is integrated into the system, this data can assist in providing new insights to the grid operator as it would offer flexibility to the energy suppliers to adjust the supply with demand effectively. (The Role of AI and ML in Solar Energy - Saur Energy International, 2020)

The heat from the sunlight is used to boil water to drive a steam turbine which generates electricity in almost the same way as done by coal and nuclear power plants which supply electricity for thousands of people. Over the past 15 years, the use of solar energy has risen at about 20% a year thanks to rapidly falling prices and gains in efficiency. The major markets for solar cells currently are in Japan, Germany, and the United States, who states that with the efficient coordination of energy companies and tax incentives, solar electricity will pay for itself in five to ten years. (2020)

The upside of solar energy is that it is a sustainable alternative to fossil fuels and has a low impact on the environment while being a potential for any country to produce. The cons are that it only produces energy when the sun is shining, needs a significant amount of land, and that certain solar technologies require rare materials. Pricey disadvantages of solar energy may be rendered negligible by technological advances that increase efficiency and storage capacity. Increasing the incentives for the development of solar energy may be worthwhile. (Solar Energy: Benefits and Drawbacks, 2020).

Data submitted by the Ceylon Electricity Board shows that excluding electricity generated by solar, wind and hydro power, Sri Lanka's total electricity generation stood at 964,043 MWh in the month of April 2020, down 22.7 per cent from 12,46,863 MWh in the month of January 2020. This reduction of electricity generation was caused due to the low demand of electricity as the industrial, hotel and manufacturing sectors paused operations temporarily during the pandemic situation of COVID 19 which led to an island-wide curfew. (Sri Lanka's Electricity Generation (Excluding Non-Conventional Energy) Decrease By 22.7% To 964,043 GWh in April from January 2020 Due to Lower Demand - Adaderana Biz English | Sri Lanka Business News, 2020)

Solar power is abundantly available in the country as it lies within the equatorial belt. Developed under the country's SPP program, by mid-2017 there were eight small-scale solar power plants with a total installed capacity of 51.36 MW. With the introduction of the net-metering system in 2010, rooftop solar PV systems became increasingly popular followed by the government's initiation on "Battle for Solar Energy" program in September 2016. By the end 2017, there were 93.7 MW of rooftop solar PV systems connected to the national grid, and the total solar PV capacity is targeted to reach 200 MW by 2020 (2020).

CHAPTER 3 – METHODOLOGY

1.7. Conceptual framework

The following conceptual framework was developed for the current study. It consists of 6 main independent variables: the solar energy collected, satisfaction of consumers towards the concept, the impact of artificial intelligence on energy conservation, the investment, weather predictions, and other alternatives as seen by the households. All this will then determine how the dependent variable: Solar energy conservation using AI will be affected.

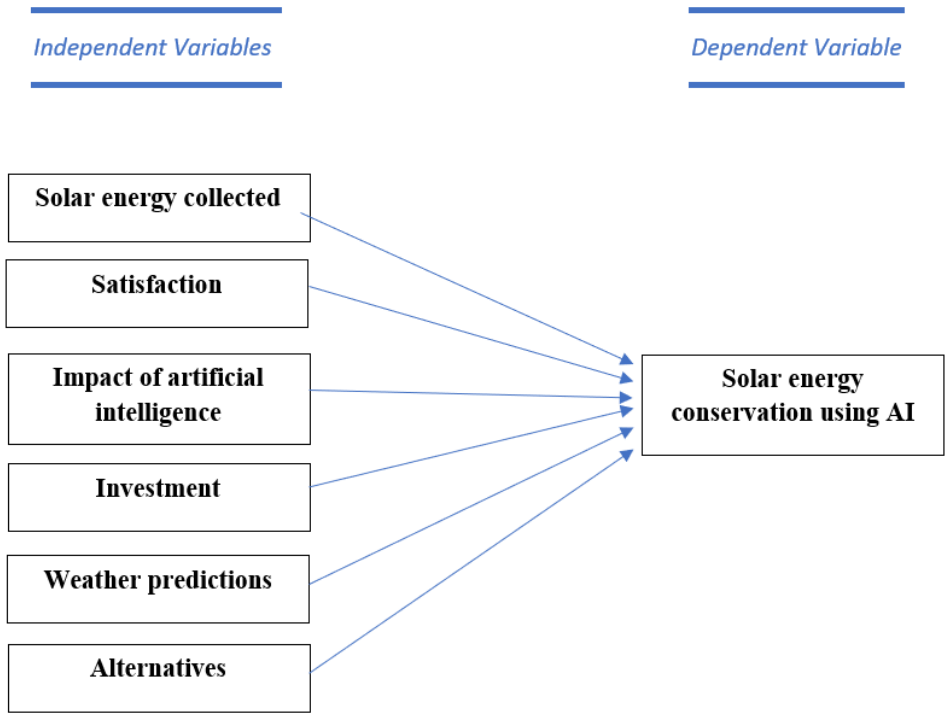

Figure 1 Conceptual framework

1.8. Research methodology

The research methodology will consist of the type of research conducted, how the data was collected and analyzed, and an analysis of how the method was utilized.

1.9. Research Philosophy

This research is done based on the **Pragmatism** philosophy, where there could be different ways of interpreting the research and accepting the fact that there can be different realities and views. Here research questions are considered to be more important in determining the research philosophy.

1.10. Research approach

A deductive approach was used to conduct the research. This method is a means of designing a research strategy to test a hypothesis based on an existing theory. It helps explain the causal relationships between concepts and variables, as well as makes it possible to measure concepts quantitatively, helping generalize research findings to a certain extent. This will be done by getting a random sample of participants and getting their feedback through a generated questionnaire based on current theories and observations. A conclusion will then be derived from the responses

1.11. Time horizon

A cross sectional timeframe has been selected, where the research is done over a single point in time without manipulating its variables, and looking into numerous characteristics

The research onion designed for the current study is as follows:

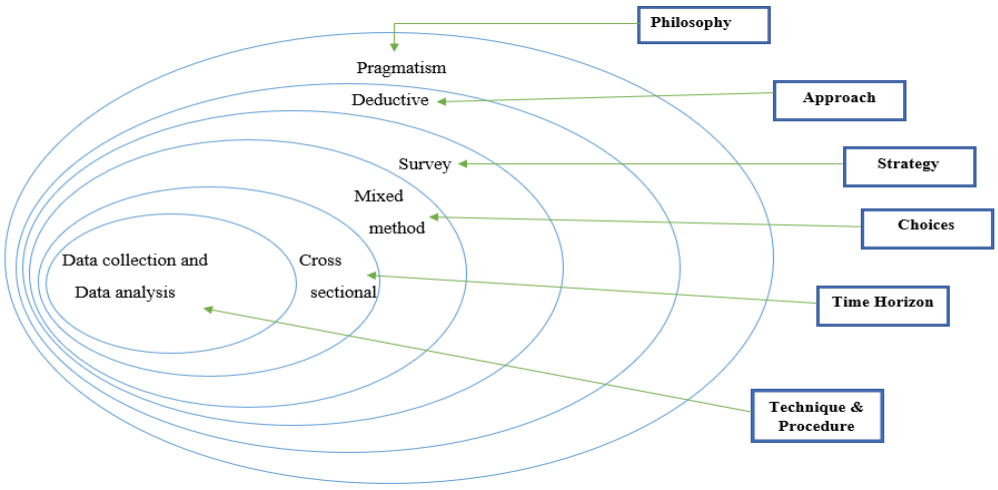

Figure 2 Research Onion

1.12. Research choice and strategy

1.12.1. Data collection method

Data was collected from 30 participants who were selected randomly and asked for consent to be involved in the study. This was proceeded in the form of a questionnaire prepared by the researcher through a Google Form that consisted of both open and close ended questions to improve accuracy. These participants were approached personally as it assisted in giving them a proper idea of the concept and better knowledge on the benefits of the concept. Participants were also allowed to clear any doubts, which helped them get a clear idea on benefits for future installations. This data was mainly quantitative data, which assisted in analyzing data to get a more understandable and readable conclusion. On the other hand, household's behavior towards changing into generating energy through this source of energy was also observed in order to come to a better and accurate conclusion. This method of data collection helped with the research as the researcher was able to get answers for all areas needed in a more effective manner. However, the main concern that arose was whether or not accurate information was provided by participants.

1.12.2. Data analyzing

Data collected through the Google Forms were analyzed through the summary charts generated by the form itself. This portrayed a clear picture on the overview of the responses given by the clients. In addition, a few charts were generated by the researcher from past data collected through secondary research, as well as by comparing responses given by the participants. This assisted with finding relationships between specific variables and how it'll affect the future decisions.

1.13. Costs

The table below represents the costs incurred during the completion of the research.

Table 1 Costs incurred during research

Description	**Amount (LKR)**
Telecommunications cost (Telephone, Data)	1,500
Printing Leaflets	800
Transportation	6,000
Total	**8,300**

1.14. Ethical issues

Sri Lanka and many other countries in the world use fossil fuels and burn biomass, non-renewable resources, to generate energy. This has been improved to be done at a cheaper costs where fossil fuel generators produce enormous quantities of this energy. Getting consumers to switch from this habit to a comparatively expensive means of generating energy is a rather difficult task. It is also challenging to go ahead with this sort of a project when political and economic institutions as most prefer stable routines over transformations and changes. However, the current method of generating energy causes a high amount of pollution which will later on be an issue globally, and if consumers are given a better idea and understanding on this, it would be easier to convince and go ahead with this project.

When coming into the collecting of data for the research, participants may also be ethically concerned about providing their personal information. This might lead them to not give proper information, assuming data will not be kept secure, or be misused. As a solution for these, participants will be given a signed agreement stating their information will be kept confidential until and after work with the research is completed.

1.15. Conclusion

This chapter discussed the research methodology that was selected, consisting of the approach, philosophy, research strategy and choice. It also covered the costs undertaken during the research, as well as the ethical concerns that were identified throughout the process. Data collection and analyzing methods were also discussed, whereas the research onion and conceptual framework was discussed in the form of diagrams.

CHAPTER 4 – PRESENTATION OF RESULTS

1.16. Introduction

This chapter will cover all the analysis of data collected through both primary and secondary research. Data for the secondary research was obtained through authorized websites and articles, whereas the primary analysis was conducted through data collected through the questionnaire and observations.

1.17. Secondary data analysis

1.17.1. Electricity generated as of July 2020

Daily peak demand – 2083.43 MW

Total daily energy – 33.9 GWH

Table 2 Electricity generated as of July 2020

Energy	GWH	Percentage
Thermal coal	12.94	38.33
Thermal oil	13.12	38.86
Hydro	6.64	19.67
Wind	1.06	3.14

(CEB, 2020)

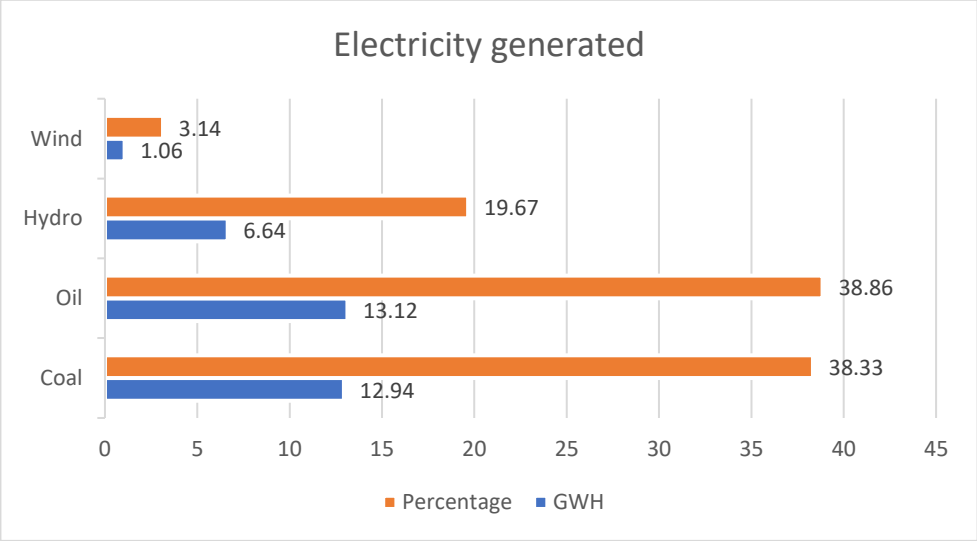

Figure 3 Electricity generated - July 2020

According to Figure 5 above generated by the researcher, electricity generated as of July 2020 in Sri Lanka has mainly been done by thermal coal and oil, contributing to almost 80% of the total energy. This is a rather expensive method of generating energy, which also contributes to a high percentage of the country's pollution. In a recent document by the CCC, it was also said that the heavy reliance on liquid fossil fuels for power generate causes significant air quality issues locally, when it comes to PM and SO2, which are the two main contributions to air quality issues in the country. Coal power plants have also said to have caused serious health and environmental issues for people in the neighborhood, and from 1st June 2017, has been violating various environmental laws for operating without an EPL. In 2018, SO2 emissions have been recorded to have passed double the legal limit according to the CCC as well (Pollution & Fossil Fuels, 2020).

Compared to the facts stated above, solar energy is a 100% clean and renewable source of energy, which would reduce the country's reliance on oil, coal and natural gases for electricity production. It will not create any means of pollution nor harm the landscape of the country or the ozone layer. Thereby, with residential solar systems, households will be able to gain energy independence with powered solar panels that work during the day and at night with energy stored (5 Advantages of Solar Power | Solar Benefits | Sunrun, 2020). A major issue that is not considered by people is the fact that thermal coal and oil are of limited supply, and will eventually run out, leading to issues when it comes to energy generation if the government individuals do not consider switching to more renewable sources of energy that are in high supply as of now, such as solar energy. Thereby this study will also focus on creating more awareness in households of the benefits they can personally enjoy, while also saving resources for future generations.

1.18. Primary data analysis

1.19. Presentation of results

A sample of 35 participants were randomly selected in order to gather data for this research. Due to the health and safety restrictions imposed with the prevailing situation in the country and the world, it was difficult to get a larger sample for the purpose of the research. There was however, a respondent rate of 86% considering 30 out of the 35 participants agreed to take part in this research. A questionnaire (**Annexure 1**) was used in order to get a proper quantitative idea on the subject matter.

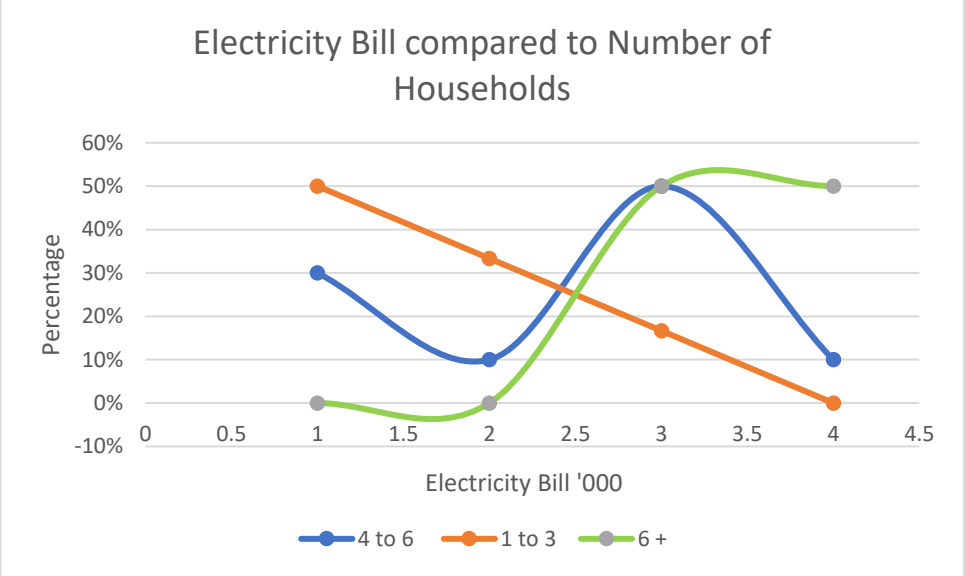

Figure 4 Electricity Bill compared to Number of Households

Figure 6 generated by the researcher shown above, depicts the comparison of the number of households to the electricity bills generated per month. In a household with 1 to 3 residents, a majority (50%) get a bill between Rs.3,000 and Rs.5,000, whereas in households with 4 to 6 residents, a majority pay bills between Rs.7,500 - Rs.10,000. On the other hand, when there are over 6 residents, there has been an increasing trend where electricity bills are at an increasing rate of over Rs.7,500.

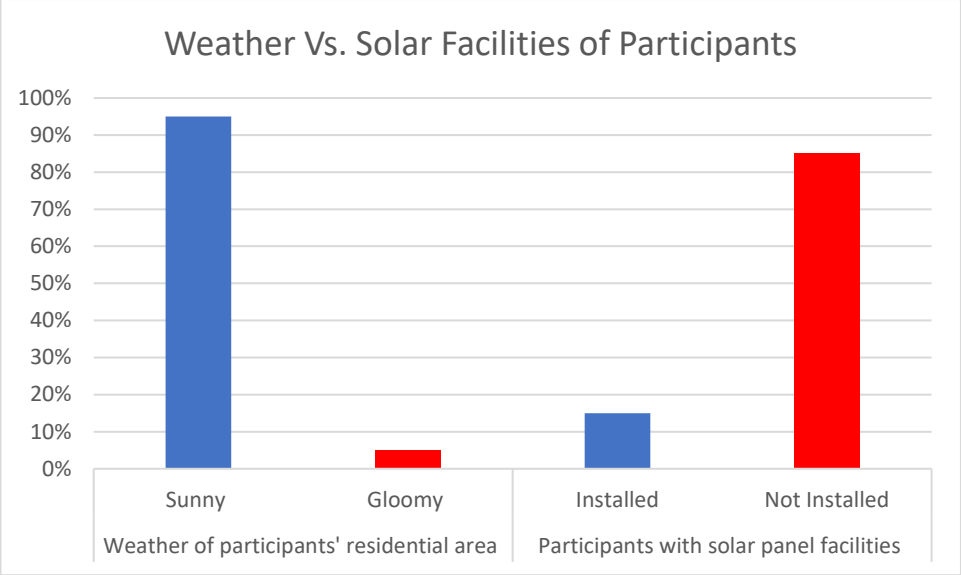

Figure 5 Weather Vs. Solar Facilities of Participants

The chart above (Figure 7), generated by the researcher depicts the relationship of the weather of the participant's residential area to the number of participants with the solar panel facilities. According to the chart, it can be seen that 95% of the participants claim that they live in more sunny areas with abundant sunlight, whereas only 5% of participants live in more gloomy areas. Although the 95% of the participants have the advantage of excess sunlight, only 15% of them have solar panel facilities and enjoy benefits of reduced electricity bills, whereas 85% of the target participants do not have these facilities. When asked why these participants haven't opted to solar panels yet, most of them responded in the following ways:

- Lack of awareness
- Didn't find a proper company
- Don't have a permanent residence
- Not sure about benefits
- Haven't really thought of it earlier
- Cost

One response that stood out the most was that the participant claimed that they would not be able to enjoy the benefits from solar panels as they aren't home during the day, which they suggested would not be a great investment. This response was a lot supportive for the case as it proved the need for weather predictions and energy conservatives to be incorporated to existing panels. This would thereby aid in collecting and saving up the solar energy throughout the day for when the households do get home when there is less sunlight.

When these participants were questioned, it came to show that 65% (as shown in Figure 8 below) of the residents didn't have proper knowledge on the benefits of solar energy, while 20% of the sample were sure of the benefits of this concept.

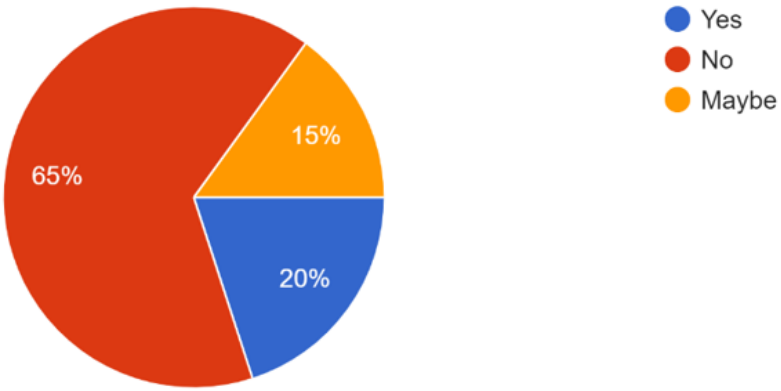

Figure 6 Idea on benefits of solar energy

15% of the sample were unsure of the benefits, which assisted in answering our next question on whether these participants were willing to know more information of the use and benefits gained by using solar energy (shown in Figure 9 below). According to the chart, 95% of the participants showed interest in knowing more information about solar energy, in hopes of making decisions on investing on this concept later into the future. All these participants therefore were given a leaflet, and explained all the benefits they would be able to enjoy with the installation of solar panels along with weather prediction systems, while also contributing to save the environment from pollution and also saving these resources as it will eventually run out, creating issues in the future if people are to rely on the current methods of energy generation.

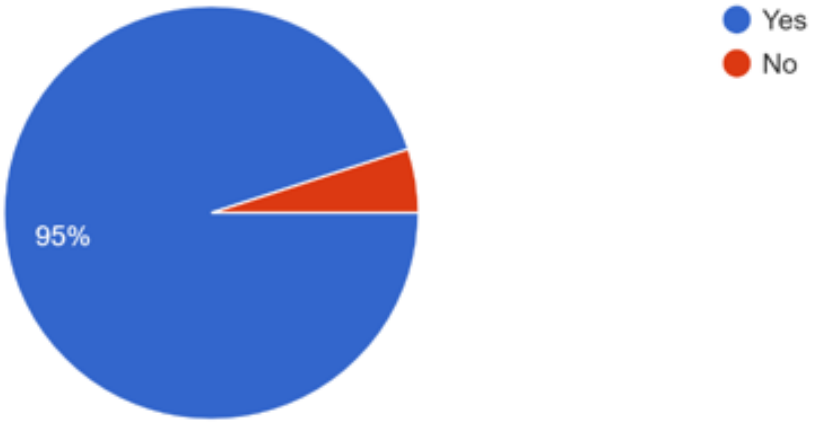

Figure 7 Participant's need for more information

Once these participants were provided with proper knowledge and explained to with benefits on the concept, 40% of the respondents were willing to step towards this concept, and 45% of the respondents needed time to think but were interested in this concept, proving the study that participants were unaware of the concept of AI incorporated into these systems. This is shown in Figure 10 below.

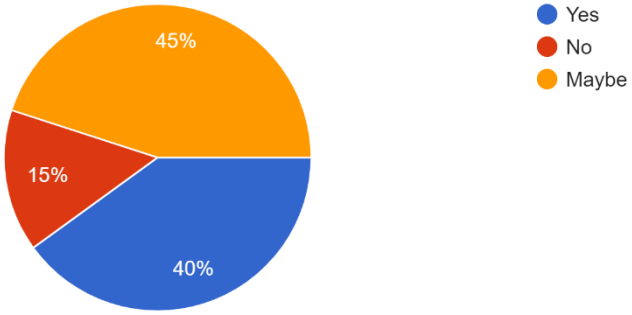

Figure 8 Participants interested in investing in solar panels

CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS

Conclusion

Throughout this study, the researcher was able to come to several conclusions that are to be explained in this section.

One of the main findings was that there was a low awareness rate of households who knew the benefits of implementing solar panels in their houses. Through observations it was found out that most households tried to manually save their electricity consumption by using less of the electricity to save on costs. However, it came to show that although this was done, they were at a disadvantage as they had to ration their consumption and it affected their day-to-day activities. Most households did complain about the fact that they face a lot of power cuts throughout certain days, which leave them with no other option but delay their work.

It was also observed that most households do receive proper sunlight throughout the day but haven't gone through with the installation of solar panels due to various reasons, including not knowing proper companies, high costs, as well as lack of knowledge. For these reasons, participants were provided with a leaflet explaining the benefits as well as methods they could opt to if they chose to go ahead with implementing solar systems. This was seen as a beneficial step as a high percentage of participants were willing to consider going ahead with this investment.

Overall, a deductive approach was selected over an inductive research approach mainly because this study was done within a time span of 3 months, whereas in an inductive approach there is no shortage of time to complete the study, and it is associated with a risk factor. In an inductive research the researcher uses observations and tests in order to develop a theory whereas a deductive approach tests an existing theory and confirms or rejects the hypothesis created, which was more suitable for this study. It assisted the researcher to formulate a hypothesis and test it in different ways, and examine the outcome and modifying it as needed. The researcher was able to compare statistics of previous electricity consumption of the country and how it was affected by the pandemic situation, as well as develop a hypothesis on how solar energy could help solve issues of pollution and be an eco-friendlier solution to generating electricity.

When it comes to the research methodology, a pragmatism approach was selected over realism and positivism. This is a more practical approach to looking and dealing with issues and experiences and guides to actions are judged against the outcomes of the research rather than abstract principles. On the other hand, selecting a survey as the research strategy was a lot beneficial for the researcher over methods such as case studies. In a survey the researcher identifies that participants answer questions that are administered through interviews and questionnaires. This is a more reliable method an is comparatively more valid as the questions are constructed properly.

Having open ended questions allows the participants to provide a wider variety of responses although this could be difficult to statistically analyze. Case study methods on the other hand involve in-depth studies of individuals or groups that lead to hypotheses, which are relatively accurate predictions, and thereby was not suitable for the current study. Using a mixed method, the researcher was thereby able to get both quantitative and qualitative data in order to make more accurate and fair conclusions. It was also identified that most participants were more comfortable with filling in questionnaires, rather than being interviewed. In this way, the researcher was thereby able to understand the relationship between increasing electricity bills to the number of households and the reasons for not going ahead with this solution by now. According to the details gathered, the researcher was able to make recommendations for future improvements to be made on the research.

In conclusion this research met the objectives of understanding the impact off AI, and how weather predictions are useful when it comes to solar panels, as well as finding ways in which people will benefit off this concept by getting the maximum out of the energy saved. The study further answered the research questions brought up earlier and the researcher was able to make the most of the time and resources available in order to come to a proper conclusion.

Limitations

One of the main limitations faced by the researcher when conducting this study was not being able to collect data from a larger sample. This was mainly due to having to follow the health and safety precautions set because of the pandemic situation and risks around the country. Due to this a smaller sample was selected and the research was conducted on an assumption that the responses given by participants were of fair nature. On the other hand, analyzing data

mainly through Google Forms is also a limitation, and other methods of data analyzing tools would've given the researcher better and accurate results.

Future improvements and recommendations

The present study helped the researcher find the relationship between number of households, income earners and current electricity bills, which were projected at an increasing rate. It was also evident that most households were willing to consider switching to this method of energy generation, but most were concerned due to the costly investment. For future improvements, the researcher or future researchers interested can make sure they approach participants with different installment plans that could well fit the likings of the households. This would help in order to provide households with a clear picture on how they'll be able to manage costs effectively.

On the other hand, in future researches, the researcher recommends the research to also be done on households who already have solar panel facilities. This will be done in order to identify whether they too face and would like to add on whether prediction and energy conservation features to their existing panels. Moreover, the researcher can select a random set of participants and implement this solution in hopes of proving through reduced electricity bills that this solution would bring the households a lot of advantages when incorporated with weather prediction facilities, and get input from the households on their new opinions. This will give a better idea on the views and opinions of not only new customers but ones who already exist in the market. The researcher will be able to then be able to work on improvements and changes to be made before introducing this concept to the households of Sri Lanka.

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Annexures

1.20. Annexure 1 - Questionnaire

Computing Research Project - The conservation of Solar Energy by incorporating AI

A study conducted using solar panels in households of Sri Lanka.

* Required

Number of households? *

- ◯ 1 - 3
- ◯ 4 - 6
- ◯ More than 6

Number of Income earners in household? *

- ◯ 1
- ◯ 2
- ◯ 3 or more

Current electricity bill value? *

- ◯ Rs.3,000 - Rs.5,000
- ◯ Rs.5,000 - Rs.7,500
- ◯ Rs.7,500 - Rs.10,000
- ◯ Over Rs.10,000

Do you usually find ways to reduce your electricity bill? *

- ◯ Yes
- ◯ No

Would you say that your area of residence is mostly sunny? *

- ◯ Yes
- ◯ No

Do you already have solar panels installed at home? *

- ◯ Yes
- ◯ No

Do you have a proper idea on the benefits of using solar energy? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Are you willing to know more information regarding the use of solar energy? *

- ◯ Yes
- ◯ No

Will you be interested in investing in solar panels anytime soon? *

- ◯ Yes
- ◯ No
- ◯ Maybe

Why haven't you already opted to using solar panels?

Your answer

Submit