

# Why Say No to Solar Energy?

## *An Exploration of Residential Reluctance towards Solar Energy*

Ahmer Zaman Khan



Working Paper 04/2018



CREE – Oslo Centre for Research on Environmentally Friendly Energy  
acknowledges financial support from  
The Research Council of Norway, University of Oslo and user partners.

ISBN: 978-82-7988-258-9

ISSN: 1892-9680

<http://www.cree.uio.no>

## **Abstract in Norwegian:**

### - **Working Paper 04/2018**

Hvorfor si nei til solenergi? En undersøkelse av husholdningers skepsis til solenergi  
Ahmer Zaman Khan

Denne masteroppgaven undersøker årsaker til manglende bruk av solenergi som et middel til elektrisk backup under strømbrudd og for generell elektrisitetsproduksjon blant innbyggere i Punjab. En spørreundersøkelse ble gjennomført blant relativt velstående innbyggere i området, der svar fra 267 personer ble samlet inn og analysert. Mens bare 13 pst av respondentene oppga å ha installert solcellepaneler hjemme, svarte ytterligere 63 prosent av respondentene at de ønsket å gjøre det. Resultatene tydet på at manglende informasjon, mangel på tillit til leverandører av solcellepaneler og antatt høye kostnader representerte viktige hindringer for skifte til solenergi. Resultatene indikerte også en viss skepsis til påliteligheten av solenergi. Et flertall av respondentene fryktet å bli svindlet eller lurt hvis de kjøpte solcellepaneler. Mulige teoretiske forklaringer på resultatene diskuteres også i avhandlingen.

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**Masters in Economics**

**Department of Economics**

**University of Oslo**

**May 2018**

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## Abstract

The thesis explores the factors behind the lack of use of solar energy as a means of electricity backup during power outages and for general electricity production amongst the residents of Punjab-home to approximately 110 million people. A survey was conducted in which responses from 267 individuals were compiled and analyzed. The results suggested that people have low confidence in the dependability of solar energy. The respondents who preferred solar energy increased by 15% when the reliability of all electricity backup options (i.e. solar energy, generators, UPS systems and wind turbines) was assumed to be the same. A majority of the respondents feared being defrauded or deceived if they considered purchasing solar panels. The results also suggested that lack of information, lack of trust in solar panel providers and high cost of solar panels were a hurdle in making people shift to using solar energy, yet approximately 62.5% of respondents stated an interest in using solar energy. The results, possibly being a consequence of some behavioral economic phenomena such as status quo bias, sunk cost fallacy and present bias preferences were also discussed in the thesis.

## Preface

The process of conducting this research and writing the thesis was significantly more challenging than I had envisioned. Nevertheless, the journey has been overwhelming yet quietly pleasant. Stating that examining the results of the survey was interesting would be an understatement; however, it fueled my passion and motivation to carry on, go deeper in this research, and do my best with the scarce intellect I carry. Moreover, exploring elements which could help mitigate economic problems was the objective I carried before commencing with the process of working on my thesis, and I hope the findings of this study can be a basis for further research on the use of solar energy.

The completion of my paper would not be possible without my supervisor Professor Karine Nyborg, who has been inspiring, motivating and brilliant. I would also like to appreciate Mr. Humza Sajid, Mr. Waleed Malik, Mr. Haider Ali, Mr. Mansoor Ahmad and Miss Saba Malik for their respective efforts in supporting me for collecting data for my research. My thanks to Mr. Syed Haider Husnain Shah for his guidance regarding the functionality of solar panels. Thank you to all the respondents who took time out to answer the questionnaire and to everyone who helped me gather data. Thanks to Oslo Centre for Research on Environmentally friendly Energy (CREE) for granting me a scholarship to assist me in conducting my research. Finally, my humble gratitude to my family and friends who supported, motivated and believed in me while I pursued my ambition to complete my master's degree from the prestigious University of Oslo.

## Table of Contents

|  |    |
|--|----|
| Abstract .....   | iv |
| Preface .....  | v  |
| 1.1 Introduction .....   | 1  |
| 1.2 Background and Motivation for Research.....  | 2  |
| 2. Methodology: .....  | 8  |
| 2.1 Personal Interviews .....  | 8  |
| 2.2 Online Questionnaires .....  | 9  |
| 3. Costs, Benefits and Savings .....   | 11 |
| 3.1 Brief analysis of potential cost savings in shifting to solar energy for residential consumers and the economy ..... | 11 |
| 3.2 Cost and Benefit Analysis of Solar Panels and Its Alternatives.....  | 12 |
| 4. Discussion of Some Behavioral Economics Theories.....   | 20 |
| 5. Analysis of data collected in Punjab .....  | 23 |
| 5.1 Descriptive Statistics .....   | 23 |
| 5.2 Summary of Questionnaire Results (Selected).....   | 27 |
| 6. Discussion of some key findings .....   | 38 |
| 7. Limitations/Caveats of the research .....   | 41 |
| 8. Conclusion.....   | 42 |
| References .....   | 43 |
| Appendix .....   | 46 |

## 1.1 Introduction

Availability of sufficient electricity is usually an important element for the growth of an economy but it is also preferable that the source of electricity is cheap, clean and renewable. If countries shift resources towards renewable energy sources then they may be able to achieve cheaper energy, decrease emissions and reduce reliance on non-renewable energy sources. For low income countries (LICs), however, it is more complicated to invest in renewable energy given their lack of resources. For a country like Pakistan where scheduled power cuts (loadshedding) have been occurring between 6-12 hours a day during peak summer times, shortage of electricity has generated additional problems to the economy as businesses have been forced to shift, suffer competitively, and even shut down which underlines the significance of addressing this issue (Arshad & Ali, 2017). Generating expensive electricity, primarily through thermal energy (which produces high emissions), is also not helping the country's economic cause and a different direction would be helpful. Hence, by mobilizing the consumers of electricity to shift towards solar energy, it can assist the economy to reduce reliance on non-renewable energy and increase the composition of renewable sources, thus assisting in alleviating the country's energy crisis and produce power that is less damaging to the environment.

Since Pakistan has an abundance of sunlight during the year, the use of solar energy can be ideal and can allow the residents to consume cheap and clean energy. Despite the potential, there is low prevalence of solar energy usage in Punjab, as people give preference to Uninterruptible Power Supply (UPS) units and generators (see Figure 1), reasons for which I intend to explore (Arshad & Ali, 2017). Such preference of households in this region may seem rather peculiar, given the favorable climate conditions for solar energy in the region; thus, it requires a deeper understanding to determine what constitutes such preferences amongst the people of Punjab, and how they can be shifted from an inefficient to an efficient equilibrium of power generation.

Zhou, D., Shah, T., Jebran, K., Ali, S., Ali, A., Ali, A., & Abdullah (2017) conducted a research to explore the interest and public acceptance in using solar systems. They found in their paper that lack of information, lack of trust of solar panel providers and high cost of solar panels were a hurdle in making people shift to using solar panels. They also found that people are highly interested in using solar panels (nearly 81%), but the aforementioned hindrances are preventing the use of solar panels in Pakistan. Finally, they stated that government support could be the best way to promote solar energy. The researchers conducted a survey by drafting a

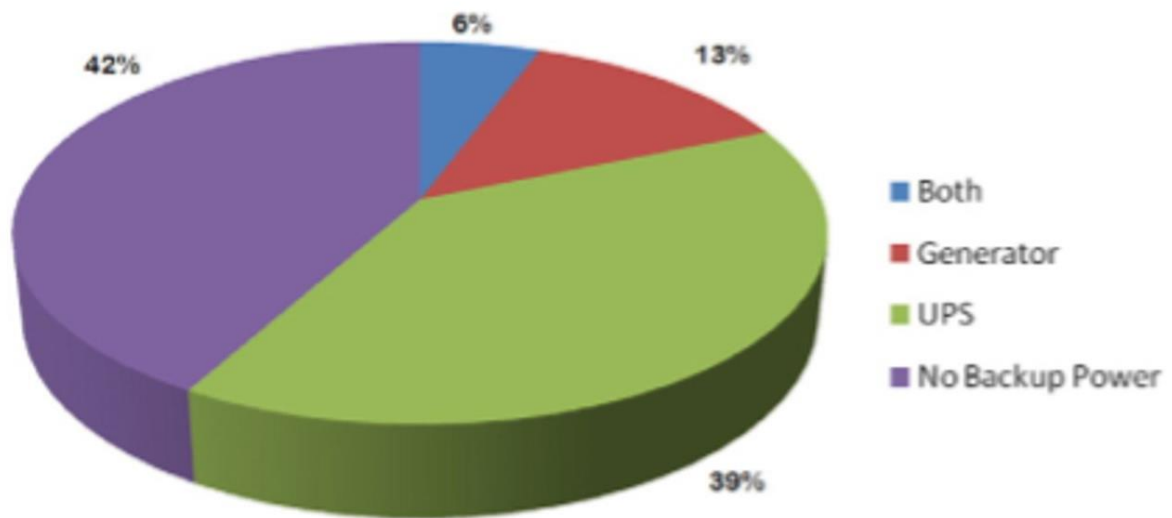
questionnaire and asking inhabitants of the northern part of Pakistan, primarily in the Malakand region. The language of the questionnaire was kept simple and without any complex terminology so that all the respondents could understand the content of the questionnaire (Zhou et al, 2017).

Therefore, I intend to understand what prevents the residents of Punjab, Pakistan's most developed and wealthy province, from investing in solar energy and try to understand it through the lens of behavioral economics. Is it lack of awareness? Is it due to financial constraints? Is there a resistance to change? Understanding and suggesting possible solutions is important for mitigating an energy crisis of a country of over 200 million people, enhance clean energy provision, and provide a blueprint for understanding the resistance by residential consumers in deploying resources towards solar energy in the whole of the Indian subcontinent.

## 1.2 Background and Motivation for Research

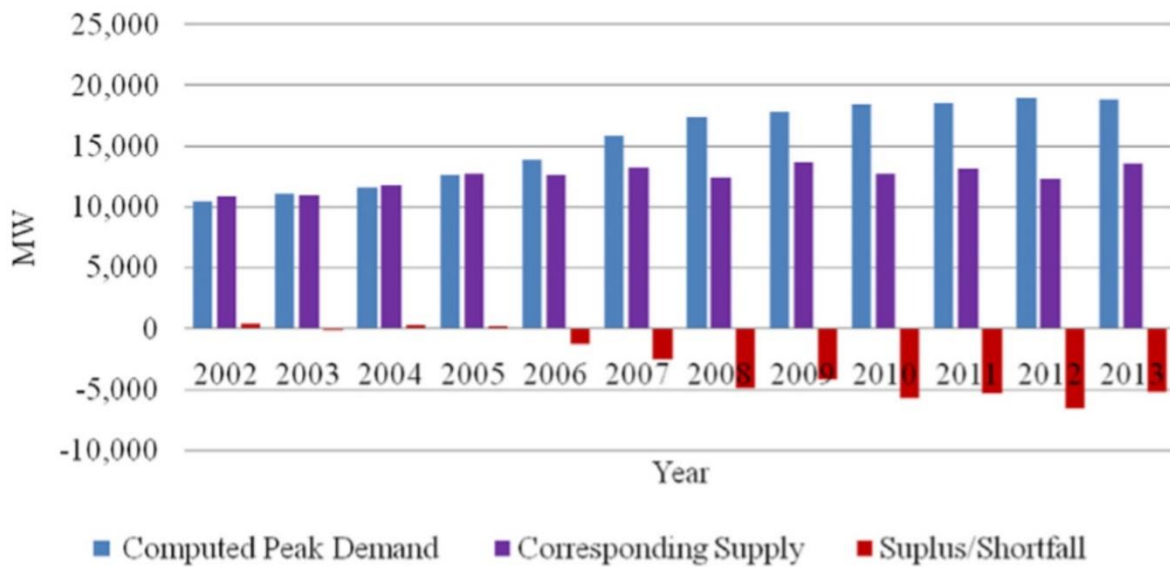
Pakistan has been engulfed in an electricity crisis since 2005 and it has led the country to suffer significant damage to the economy due to the resulting consequences of electricity shortage. For example, during 2012 and 2013, the lack of electricity impacted the country quite deeply and led to the country shedding 2% from the annual GDP growth (Pakistan Economic Survey 2012-13). Figure 2 below shows the peak demand and supply trends and the resulting surplus/shortfall of electricity in Pakistan during 2002 to 2013. The figure shows a shortage of more than 5,000 MW of electricity after 2010 (Khan & Abbas, 2016). The study by Khan and Abbas (2016) provided an idea of the economic impact as a result of electricity shortage in Pakistan which has been represented in figure 3. The economy seemed to be growing impressively and had a growth rate of approximately 9% during 2005; however, since the electricity crisis the manufacturing sector seemed to have been hit hard while the exports had been impacted significantly (Khan & Abbas, 2016). Overall, the graph shows a strong correlation between shortage of electricity and GDP growth, although the global financial crisis of 2008 could have also influenced the fall in GDP growth. Furthermore, Kessides (2012, p.271) underlines the magnitude of the problem of electricity shortage in the following way: 'Public protests against the blackouts have been widespread and riots have sometimes turned deadly. In some parts of the country, shopkeepers have threatened mass suicide to protest 18 to 20 hours of blackouts every day'.

Figure 1: Composition of alternative power sources in residential buildings in Pakistan in 2012



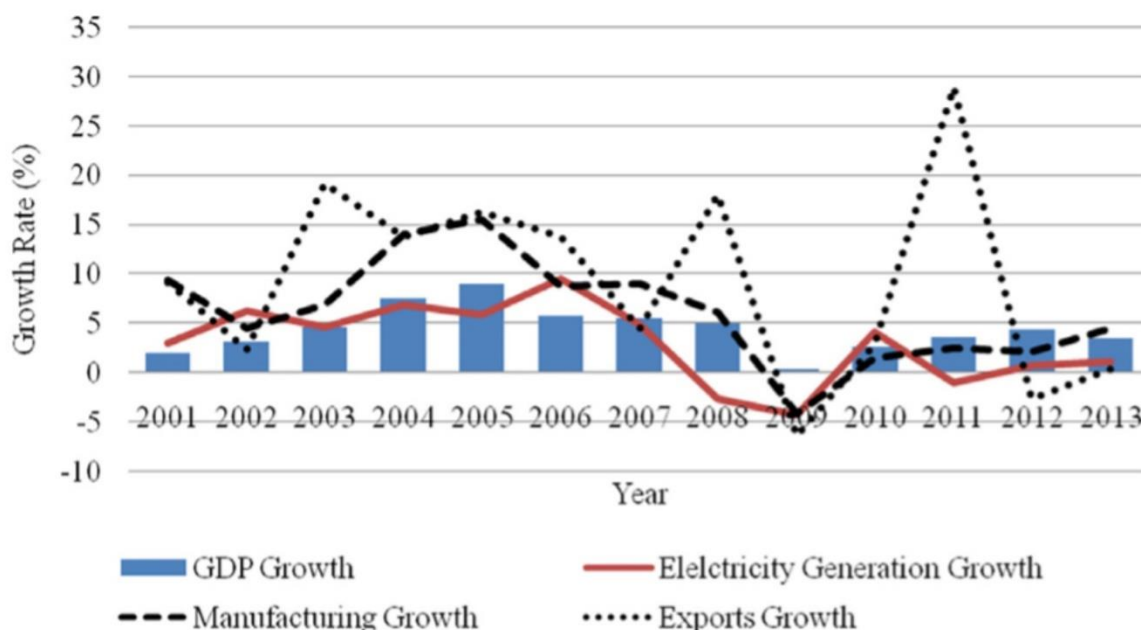
Source: (Arshad & Ali, 2017)

Figure 2: Peak demand and supply trends for electricity in Pakistan (in MW)



Source: (Khan & Abbas, 2016)

Figure 3: An estimate of the relation between growth rates of real GDP, industrial productivity, electricity generation and exports.



Source: (Khan & Abbas, 2016)

In order to eliminate the energy shortfall experienced by the country, the state would need to arrange sufficient resources to increase the supply of electricity within the state which may be challenging for a developing country like Pakistan that has meagre resources. The process of installing electrical grids is time consuming, expensive, and often contaminated with corruption (Malik, 2017). Alternatively, if the state can shift policy towards encouraging households who can afford solar panels to convert to renewable energy using their own resources, then Pakistan, or other countries alike that are suffering from energy shortfall, may be able to reduce its electricity deficit as the demand from the main electricity grid would be decreased and daily power outages can be reduced, or even eliminated, by cutting reliance over power stations. Thus, instead of focusing on installing large and expensive set-ups, the country could use incentives such as tax exemptions, subsidies, provision of cheap loans, or other methods that could propel households in Pakistan to shift their energy source from the main grid to solar energy, either completely or partly.

The aforementioned policy could be a quicker solution to the energy crisis that the country is facing and may also be beneficial in the long run (see Chapter 3.2). Thus, dependency on the electric power stations may be decreased and the state may have reduced need of large

investments for setting up extensive electricity power plants. Eventually, the reliance of electricity generation from fossil fuels, which was 67% as of 2015, can be reduced and the country could shift its electricity generating composition towards renewable energy (State of Industry Report 2015). The overall composition of electricity generation in Pakistan shows no projects of solar energy as of 30 June 2015, which can be viewed in figure 4 below.

*Figure 4: Installed Generation Capacity by Type in MW*

| As on 30 <sup>th</sup> June                               |                      | 2011          | 2012          | 2013          | 2014          | 2015          |
|---|----------------------|---------------|---------------|---------------|---------------|---------------|
| <b>HYDEL</b>  |                      |               |               |               |               |               |
| WAPDA Hydel   |                      | 6,516         | 6,516         | 6,733         | 6,902         | 6,902         |
| IPPs Hydel  |                      | 129           | 214           | 214           | 214           | 214           |
| <b>Sub-Total</b>  |                      | <b>6,645</b>  | <b>6,730</b>  | <b>6,947</b>  | <b>7,116</b>  | <b>7,116</b>  |
| % Share (Hydel Installed Generation Capacity)             |                      | 28.47         | 28.65         | 29.28         | 29.99         | 28.67         |
| <b>THERMAL</b>  |                      |               |               |               |               |               |
| GENCOs with PEPCO   |                      | 4,785         | 4,785         | 4,785         | 4,590         | 5,762         |
| KEL Own   |                      | 1,821         | 2,381         | 2,359         | 1,951         | 1,874         |
| IPPs  | Connected with PEPCO | 8,325         | 8,312         | 8,342         | 8,726         | 8,726         |
|   | Connected with KEL   | 252           | 252           | 252           | 252           | 252           |
| RPPs  | Connected with PEPCO | 353           | 0             | 0             | 0             | 0             |
|   | Connected with KEL   | 50            | 0             | 0             | 0             | 0             |
| CPPs/SPPs connected with KEL                              |                      | 324           | 239           | 203           | 200           | 200           |
| <b>Sub-Total</b>  |                      | <b>15,910</b> | <b>15,969</b> | <b>15,941</b> | <b>15,719</b> | <b>16,814</b> |
| % Share (Thermal Installed Generation Capacity)           |                      | 68.16         | 67.99         | 67.19         | 66.25         | 67.74         |
| <b>NUCLEAR</b>  |                      |               |               |               |               |               |
| CHASNUPP (I&II)   |                      | 650           | 650           | 650           | 650           | 650           |
| KANUPP  |                      | 137           | 137           | 137           | 137           | 137           |
| <b>Sub-Total</b>  |                      | <b>787</b>    | <b>787</b>    | <b>787</b>    | <b>787</b>    | <b>787</b>    |
| % Share (Nuclear Installed Generation Capacity)           |                      | 3.37          | 3.35          | 3.32          | 3.32          | 3.17          |
| <b>WIND</b>   |                      |               |               |               |               |               |
| Wind Power Plants connected with PEPCO                    |                      | 0             | 1             | 50            | 106           | 106           |
| <b>Sub-Total</b>  |                      | <b>0</b>      | <b>1</b>      | <b>50</b>     | <b>106</b>    | <b>106</b>    |
| % Share (Wind Installed Generation Capacity)              |                      | 0.00          | 0.00          | 0.21          | 0.45          | 0.43          |
| <b>Total Installed Generation Capacity of the Country</b> |                      | <b>23,342</b> | <b>23,487</b> | <b>23,725</b> | <b>23,728</b> | <b>24,823</b> |

*Source: State of Industry Report (2015)*

Meanwhile, in order to tackle loadshedding, the use of Uninterruptible Power Supply (UPS)<sup>1</sup> systems and diesel generators is most common in Pakistan (see Figure 1) despite the country having abundance of sunlight during the whole year (see Figure 5 and 6). I, therefore, hope to explore whether there are psychological resistances towards adopting solar energy as a means to tackle loadshedding as the use of generators and UPS systems continue to be the default method of tackling power outages in Punjab, given that the country is quite suitable for solar energy. Meanwhile, financial factors are expected to play a key role as well.

According to the research conducted by Zhou et al (2017) a significant number of the people taking part in the survey have a perception that solar panels in Pakistan are expensive. However, according to a quotation received from Mr. Syed Haider Husnain Shah, management consultant of *Baykee New Energy Technology Incorporated Company Limited*<sup>2</sup>, for a 3kVA solar system, an average household would require approximately PKR 401,000 (USD 3,468) as the upfront expenditure (see Table A11 in the appendix) which is considerably cheaper compared to the United States where households would require approximately USD 8,300 to USD 10,100<sup>3</sup> to setup a smaller sized system of 2.4kVA<sup>4</sup>. Therefore, the factors behind the lack of preference for the use of solar energy will be explored that could be used for future policy making which encourages residents to consider shifting to solar energy.

The lack of resources amongst households to invest in solar energy could be an element preventing its use since most people may be unable to afford it. Thus, the State Bank of Pakistan (SBP) has regulations in place for banks to disburse loans for the purpose of setting up renewable energy systems in both residential and commercial areas. The scope of the disbursement scheme is divided into two categories: systems within the range of 4KW to 1 MW for the residential or commercial user's own use or for supply to the distribution company, and for systems within 1MW to 50MW who have completed the required regulations setup by Alternative Energy Development Board (AEBD) and other relevant government department policies (State Bank of Pakistan, 2016). The duration of the loan can be extended up to 12 years while a grace period of another 2 years can be granted. The loan will have a fixed mark-up rate

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<sup>1</sup> Uninterruptible Power Supply is a machine which provides power to devices for a certain amount of time without stopping in case of power outages or other problems from the power sources (Suzuki, 2015).

<sup>2</sup> Personal communication, Haider Shah, Baykee New Energy Technology Incorporated Company Limited, 24-Oct-2017

<sup>3</sup> Prices taken from <https://www.solar-estimate.org/>

<sup>4</sup> Price of a 3kVA system was not available, thus price for a 2.4kVA (3kW) system has been compared.

of 6% for the entire duration of the loan. The percentage of initial investment is under the discretion of the loan disbursing bank, although it is usually between 10%-30% of the total investment.

Within a few months of the revision of the financing scheme for renewable energy by the State Bank of Pakistan, with the previous version being released in 2009, they had received 11 applications whereas during the previous 6 years there had been only 1 application obtained for renewable energy financing (Al-Bab Report, 2016). However, it is possible that most residential consumers may be reluctant to take up loans that they think are too hard to payback or are too expensive.

## 2. Methodology:

To answer my primary research question i.e. what prevents the residents of Punjab from using solar energy, I decided to conduct a survey in the region and explore the factors behind the low use of solar energy in the province. The data was collected through surveys conducted from the people of Punjab during January and February 2018 through personal interviews and online questionnaires. The questionnaires were primarily directed towards people who had a family income of at least PKR 50,000 (USD 450) per month, in order to obtain results from richer households that can potentially afford solar panels and they are not too financially constrained. However, no participant was refused and responses were also recorded and considered for people who had a lower family income.

### 2.1 Personal Interviews

The personal interviews were collected by traveling to various parts of the province such as Lahore, Gujrat, Gujranwala, Mandi Bahauddin and Sheikhupura. The personal interviews were conducted during two whole days: first day included traveling from Lahore to Gujrat and Gujranwala with 3 interviewers taking part, while the second day included traveling from Lahore to Mandi Bahauddin and Sheikhupura and also included 3 interviewers taking part in the activity. Since it was intended to obtain responses from people who were relatively wealthier, the interviewers conducting the interviews were asked to look for individuals who are likely to be rich in order to minimize responses from households that cannot afford such equipment, and have greater focus on those people who are more relevant for this survey.

The personal interviews were conducted in randomly picked out market places of the cities which were relatively crowded and were expected to contain relatively wealthier people. People were approached randomly and requested to spare a few minutes to answer some questions about solar panels for a university research. Most people welcomed the request while many people were suspicious of the interview and resisted responding to the questions until they were given an overview of the questions to be asked. The respondents seemed more and more calm as the interview progressed and became increasingly expressive as the subjects realized that the contents of the information they were asked were harmless to their business or occupations, and that the interviewer genuinely needed their opinion. There is a possibility that some responses might be biased since the samples were collected in January, when there is almost no loadshedding in the country, and people are not suffering from power outages, intense heat, and high electricity bills.

Since asking family income is a sensitive matter, and rather inappropriate at the start of the interview, it was the final question of the questionnaire in order to make the respondents realize that the purpose of the interview is genuinely academic and there is no ulterior motive involved. Rasmussen, Østergaard, and Beckmann (2006) suggested using large intervals for determining incomes of respondents in order to offend as few people as possible. Thus, income gaps of PKR 50,000 or PKR 100,000 were used. During the personal interviews, respondents were asked to personally (and discretely) tick the income bracket which pertained to them and place the form randomly in a file containing the rest of the questionnaires in order to maintain anonymity. It proved to be a successful strategy as apart from a small number of respondents, all of the interviewees agreed to follow the process. Such concern of privacy was not expected to be an issue for online questionnaires as those were completely anonymous.

There were a very small number of people who refused to answer questions; however, it was usually because they were busy with their work, or they were simply not interested in giving their opinions. The people who rejected responding did not seem to belong to any particular profile or location, and their refusal to answer was apparently not due to any special reason.

## 2.2 Online Questionnaires

The link to the online questionnaire was circulated through social media (primarily Facebook and WhatsApp). In order to avoid geographical and demographic bias in the responses, the link was shared on various forums and groups on social media, which was expected to provide responses from people having a diverse range of profiles. Furthermore, in order to prevent having excessive respondents from the same background, I also asked some friends from other parts of Punjab, especially from those cities which I was not planning on traveling to, for example Rawalpindi, Sargodha and Faisalabad, to share the link of the questionnaire with their friends thereby allowing me to obtain a diverse sample for the survey.

However, a majority of the responses came from Lahore (149) since it was the biggest and most developed city of the province, having over 11 million residents, therefore more number of people and more social media users. Another reason for the high number of responses from Lahore can be attributed to my own social media network being primarily from this city. Higher level of literacy in the city can also be a reason for the higher responses from Lahore, since it had been observed during the data collection process that people felt uncomfortable after seeing long, and perhaps complex, English statements as English is not their first language.

Respondents who were handed questionnaires to fill seemed less interested after seeing the language of the questions. Such reaction was observed considerably less in Lahore, possibly due to more familiarity with English, thus it is possible that the same lack of interest in the survey was shown by the people who were not from Lahore, as compared to those who belonged to this city.

The link of the questionnaire remained open between January and February 2018. On the other hand, more than 30 responses had to be omitted from the sample since they were either ‘non-serious responses’ or responses from people who were not from Punjab, even though the description with the link mentioned clearly that the questionnaire is only to be filled by residents of Punjab, Pakistan.

### 3. Costs, Benefits and Savings

#### 3.1 Brief analysis of potential cost savings in shifting to solar energy for residential consumers and the economy

Shifting to solar energy requires a one-time investment on the system but would then generate electricity without any running expenditure (see Table 1). However, if the cost of using solar energy is too high, or if it is cheaper to use the other available alternatives, then it may not be financially beneficial to invest in solar energy. Thus, I will explore the approximate cost of using the other alternatives: UPS systems and diesel generators, and compare it to solar energy. The efficient usage of the solar system would depend on the availability of sufficient sunlight, which in Pakistan's case is ideal throughout the year (see Figure 6). As the demand of electricity from the grid stations is reduced, the electricity deficit is lessened and the frequency of power outages during a day could be reduced.

Instead of investing millions on grid stations and then using fossil fuels to generate energy, the state can use resources to provide subsidies, discounts, tax breaks, or other incentives which leads to some households shifting their energy source to solar energy, hence vacating sufficient energy for the rest of the economy. Through this strategy, the country could indirectly be investing in reduction of emissions, since the composition of the economy's electricity generation might be moving away from non-renewable sources, while fuel importing economies would be able to reduce their reliance on imports. The economy and households would be spending less on electricity, and thus experience significant cost savings-the extent of which will be discussed in a subsequent subchapter.

Most interviewees who took part in the survey and who prefer UPS units did not seem to realize that although their UPS units are providing seamless backup energy during power outages, the source of energy is not free as they are still consuming the same energy from the main grid when the UPS batteries are being recharged. Residents may save costs if they use solar energy as a backup energy source when they experience power outages, instead of converting completely towards solar energy, which would require a considerably smaller system and much less investment compared to the quotation mentioned in table A11 in the appendix for a 3kVA solar system. In other words, households save money when there are power outages if they use solar energy as a source of a backup energy source.

### 3.2 Cost and Benefit Analysis of Solar Panels and Its Alternatives

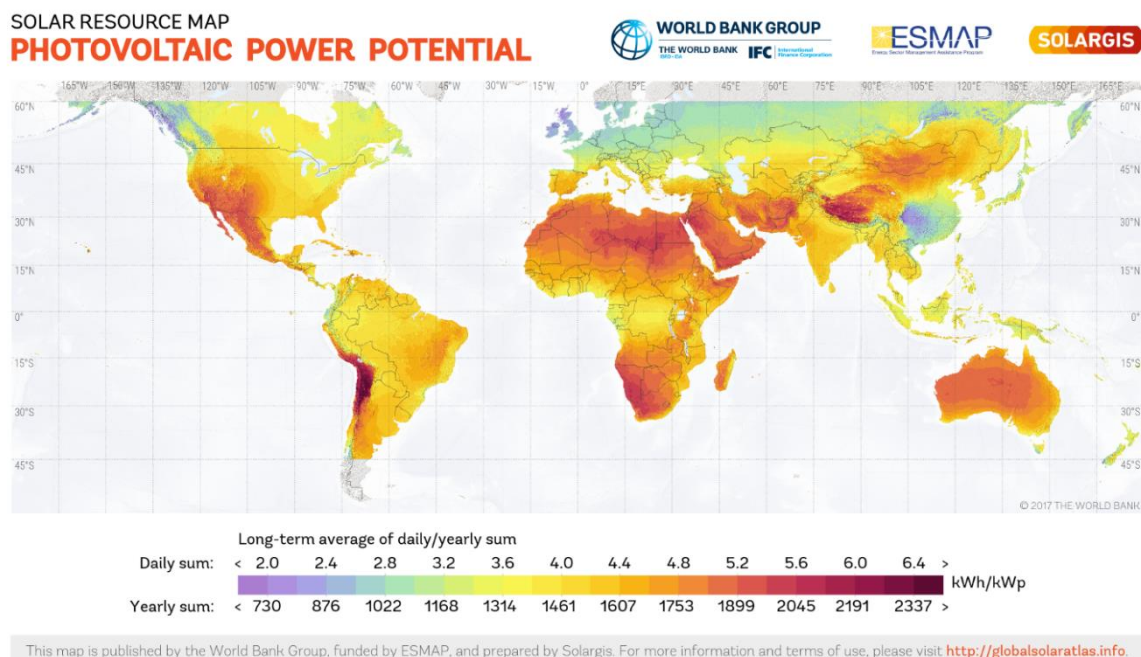
The constantly decreasing costs of photovoltaic cells is making solar energy considerably cheaper compared to the past, whereas the photovoltaic power plants in Germany are almost 80% cheaper than those built some years ago (Mayer, 2015). The cost of a 3kVA solar system for a Pakistani household would cost approximately PKR 401,000<sup>5</sup> (USD 3,500) (see Table A11 in the appendix) whereas the costs in the United States are much more expensive despite the 30% government subsidy on installation of solar plants (Matasci, 2018). Furthermore, the potential of using solar energy in Pakistan is amongst the best in the world according to Mr. Jamil Masud, who is an energy expert who helped draft Pakistan's national renewable energy policy. He stated while giving an interview to Reuters News that Pakistan's worst areas are better than Germany's best areas for solar energy generation (Khan, 2017). The photovoltaic power potential of all the countries in the world can be observed from figure 5 below (Global Solar Atlas, 2018). Electricity generation is also a major burden on the country's resources since Pakistan spent Rs.500 billion to subsidize electricity in 2012, which was more than half the country's budget deficit (Federal Budget, 2012).

The cost analysis, which I have conducted in Table 1 below, attempts to explore which is the cheapest option for electricity backup during power outages amongst UPS systems, diesel generators and solar energy. It attempts to explore whether it is economically beneficial for a household in Pakistan to use solar energy compared to other alternatives discussed in the analysis. The analysis provides an approximate expenditure which an average household may face while contemplating on which of the energy sources to invest in. A low discount rate of 1.5% and a high discount rate of 6% are used to obtain the present value of the costs. The latter value is used to explore the present value of using solar energy at the same rate at which loans are offered by the State Bank of Pakistan to buy solar systems which was discussed in section 1.2. If one disregards inflation and assumes there are no other fees for taking up a loan for purchasing a solar system, it would be beneficial to obtain a loan to buy a solar system if the present value of the costs of using solar energy at a 6% discount rate is less than present value of the costs of the alternatives. In the analysis, I have used an estimate of the costs incurred for investing and running a 3kVA backup system used for dealing with 4 hours of loadshedding each day for each alternative: Solar panels, UPS systems and diesel generators. Before presenting the table and the analysis, I will explain assumptions and how I arrived at the values.

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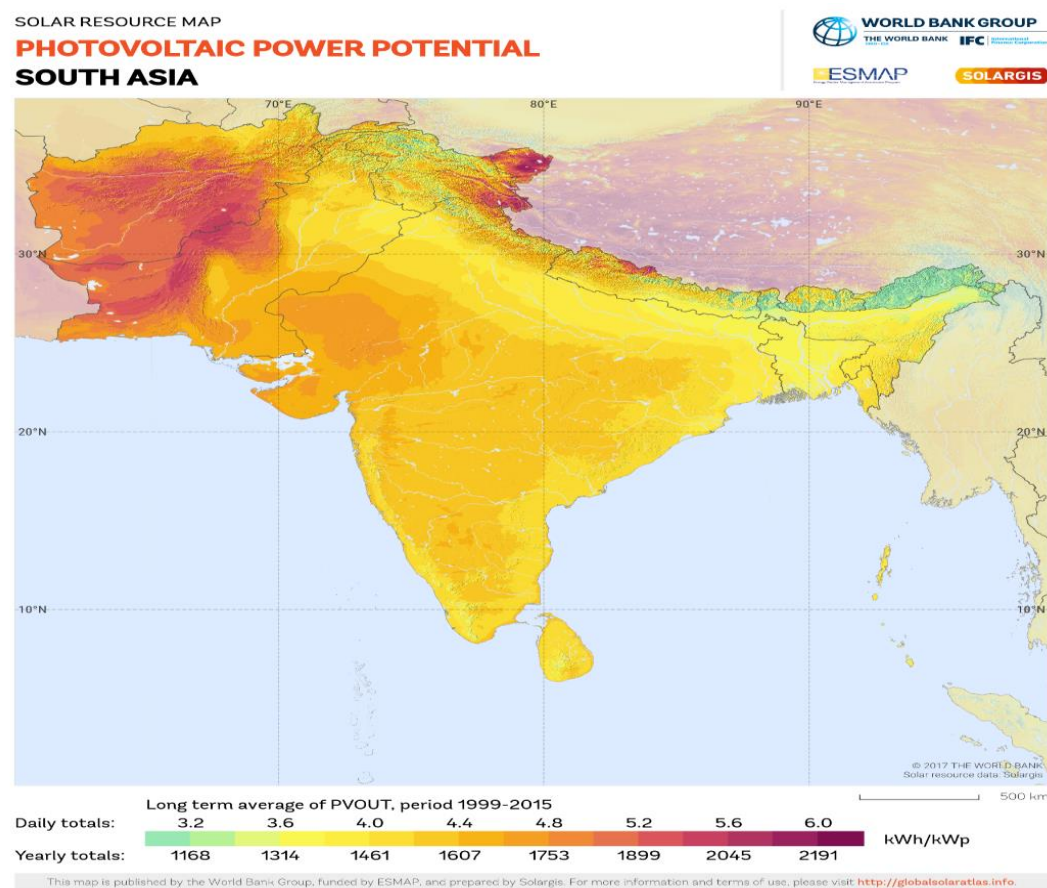
<sup>5</sup> Quotation mentioned is as of October 2017.

Figure 5: Photovoltaic power potential of all the countries in the world which shows how much solar energy potential each country possesses



Source: Global Solar Atlas (2018).

Figure 6: Photovoltaic power potential of South Asian countries



Source: Global Solar Atlas (2018)

For the analysis underlying Table 1, I take the following assumptions:

- I. There are 4 hours of power outages each day, hence each system is used to provide 4 hours of backup energy per day during power outages in the country
- II. For each source, we assume no maintenance costs (hence no battery replacements for UPS or solar systems) and no repairing costs.
- III. Diesel generators are assumed to have hourly running costs of PKR 75<sup>6</sup>.
- IV. Per unit (KWh) costs of electricity are assumed to be PKR 15<sup>7</sup>.
- V. In order to obtain a comparison of UPS systems with solar panels, I assume that the household consumes an average of 1 unit of electricity per hour, or 720 units a month. Thus, on average 120 units of loadshedding is experienced each month.
- VI. The power outages are not for a continuous period and would be according to the daily loadshedding schedule described in table A12 in the appendix. Thus power outages are spread out during the day so the UPS and solar batteries would have sufficient time to recharge. However, since the 3kVA system would require 4 (100 ampere) batteries of 12V each, it is expected that handling the load during power outages would not be a problem.
- VII. The electricity costs remain the same for the entire duration of the analysis, which means the electricity used to recharge by UPS batteries would remain constant for the entire duration of the analysis.
- VIII. There is an average of 8 hours of sunlight during a day, but 2 hours per day is lost for solar energy generation due to clouds or other factors. Eventually, solar panels provide 8 hours of energy in a day throughout the year: 6 hours via solar energy and 2 hours through battery backup during non-sunlight hours (see Table A12 in the appendix).
- IX. There is sufficient energy stored in batteries during the day to provide backup for power outages during non-sunlight hours in case of UPS systems and solar energy.

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<sup>6</sup> Since determining the actual diesel consumption is complicated and depends on various factors such as load, type of engine, size of engine and other factors, I have used a website of a US generator manufacturer that have designed a general formula based on average fuel consumption of various diesel engines (<http://www.hardydiesel.com/generator-fuel-consumption-calculator.html>). By entering the size of the diesel generator, I received the gallons per hour, which had then been converted to liters per hour. The average consumption liters per hour came out to be 0.76. The diesel price in Pakistan as of 1<sup>st</sup> March 2018 was PKR 98.45. Therefore, multiplying the diesel price with the per hour consumption i.e.  $98.45 \times 0.76$ , we have approximately PKR 75 as the hourly running costs for diesel generators.

<sup>7</sup> The per unit cost is taken from the schedule of electricity tariff from LESCO (Lahore Electric Supply Company) where I use the 'peak hour rate' of PKR 15 per unit for the whole day (See <http://www.lesco.gov.pk/3000063>).

X. Each alternative has a life span of 12 years<sup>8</sup>.

*Explanation of the values used in the analysis:*

*Diesel Generators:*

Determining the running costs of diesel generators is a complex process as it involves several factors such as the quality of the machine, load on the generator, size of generators and other factors. Therefore, to counter this problem, I use a website which calculates the hourly consumption of diesel per gallon (Hardy Diesel Generators, 2018). The following are the steps taken to attain the costing values of diesel generators:

1. As I am assuming a 3kVA system for each alternative, I convert kVA to KW (where KW is 0.8 times of kVA) which leads to 2.4KW.
2. The result of diesel per gallon used from the website gives me 0.2 gallons per hour.
3. Gallons is converted to liters, thus 0.2 gallons equals 0.76 liters<sup>9</sup>.
4. The price of diesel as of March 2018 was PKR 98.45, which I multiply with 0.76 to obtain hourly cost of running a diesel generator-PKR 75 (Pakistan State Oil Company, 2018).
5. Since the daily usage of each energy source is 4 hours, I multiply 4 with 0.76 and 98.45 which gives me a daily running cost of approximately PKR 300.
6. The daily cost of PKR 300 is used to calculate the respective yearly costs.
7. For the initial cost of a 3kVA diesel generator, the average price of 5 different brands were extracted from some online shopping websites in Pakistan: Yamaha (PKR 174,000), Homage (PKR 80,000), Firman (PKR 90,000), Elemex (PKR 153,000) and Jasco (PKR 91,500). The average price came out to be PKR 117,700<sup>10</sup>.

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<sup>8</sup> I take this time span since it is the maximum loan duration allowed by the State Bank of Pakistan and I can draw comparisons at the end of the loan duration (State Bank of Pakistan, 2016).

<sup>9</sup> To convert US gallons to liters, the following formula is used:  $L = \frac{US\ Gallons}{0.26417}$

<sup>10</sup> The sources of the prices are available in the appendix.

### *UPS Systems:*

To determine the running costs of the UPS system, we need to obtain the hourly consumption of electricity units and the cost per unit. The per unit cost is taken from the schedule of electricity tariff from LESCO (Lahore Electric Supply Company) where I use the 'peak hour rate' of PKR 15 per unit for the whole day (see <http://www.lesco.gov.pk/3000063>). From assumption V above, we assume that a household consumes an average of 1 unit per hour (720 units per month). We can thus obtain hourly running cost of UPS system by multiplying the number of units: 1, with the cost per unit: 15, which gives us PKR 15. As I am assuming that the daily power outage lasts for 4 hours, we can obtain the daily running cost of UPS systems by multiplying 15 with 4 which gives us PKR 60. The remaining yearly cost values can be obtained by multiplying the daily cost with the number of days.

### *Solar Energy:*

For the initial cost of the solar panel, I have used the quotation received from *Baykee New Energy Technology Incorporated Company Limited* for a 3kVA hybrid solar system (see Table A11 in the appendix). The running costs are all zero, based on my assumption that the batteries do not need to be replaced, there are no repairing costs incurred on any of the alternatives, and since electricity generation from solar panels does not cost anything. However, since solar panels can be used for 8 hours a day (see assumption VIII above), the household would save an extra 4 hours of electricity which would be in addition to the 4 hour loadshedding period. As per table A12 in the appendix, the household receives 6 hours of solar energy plus 2 hours of battery back-up during the night. Thus, the household would incur negative running costs for using solar energy beyond the 4 hours used to cover loadshedding since they would pay less for using electricity from the electricity supplying companies. In order to obtain the negative running costs for operating solar energy, I multiply the units consumed per hour, electricity cost per unit, number of hours of solar energy used beyond the loadshedding hours per day and number of days in a year. After conducting the calculations, I obtain the value of PKR 21,900.

Table 1: Cost Analysis between Solar Panels, Generators and UPS Systems<sup>11</sup>

|                                | <b>Initial Investment</b> | <b>Running costs per year</b>                                  | <b>Present value of total costs (initial investment plus discounted running costs) after 12 years, using a discount rate of 1.5%)</b> | <b>Present value of total costs (initial investment plus discounted running costs) after 12 years, using a discount rate of 6%</b> |
|--------------------------------|---------------------------|--|---|--|
| <b>Diesel Generator Backup</b> | PKR 36,800 <sup>12</sup>  | PKR 109,240 <sup>13</sup>                                      | PKR 1,191,537 + 36,800 =<br>PKR 1,228,337   | PKR 915,852 + 36,800 =<br>PKR 952,652  |
| <b>UPS Backup</b>              | PKR 112,700 <sup>14</sup> | PKR 21,900 <sup>15</sup>                                       | PKR 238,874 + 112,700 =<br>PKR 351,574  | PKR 183,606 + 112,700 =<br>PKR 296,306   |
| <b>Solar Energy Backup</b>     | PKR 401,000 <sup>16</sup> | PKR 0 <sup>17</sup> + (-21,900) <sup>18</sup><br>= PKR -21,900 | PKR -238,874 + 401,000 =<br>PKR 162,126   | PKR -183,606 + 401,000 =<br>PKR 217,394  |

The running costs of operating a diesel generator after 1 year would be PKR 109,240. However, after 12 years the present value of total costs (derived by adding the initial cost and the sum of discounted running costs) would go up to PKR 1,228,337 at a discount rate of 1.5% and PKR 952,652 if a discount rate of 6% is assumed. Using UPS systems would cost an average household PKR 21,900 per year if keeping within the assumptions quoted earlier but after 12

<sup>11</sup> For discounting, the following formula has been used:  $\sum \frac{Cost_t}{(1+r)^t}$ , where r is the discount rate, t is the year, and cost is the non-discounted running cost for the year.

<sup>12</sup> For the initial cost of a 3kVA diesel generator, the prices of 7 different brands (As of April 2018) were extracted from some online shopping websites in Pakistan and then their average was taken: EuroPower (PKR 43,000)<sup>12</sup>, Rigid (PKR 45,500)<sup>12</sup>, Rado (PKR 26,500)<sup>12</sup>, Hyundai (PKR 52,550)<sup>12</sup>, Elegant (27,500), QMB (PKR 30,000) and YIHU (PKR 32,500)<sup>12</sup>. The average price came out to be PKR 36,800.

<sup>13</sup> Liters of diesel consumed per hour (0.76)\*Price per liter of diesel (98.45)\*Number of hours of loadshedding per day (4)\*365

<sup>14</sup> For the initial cost of a 3kVA UPS system, the price of 3 different brands (As of April 2018) were extracted from some online shopping websites in Pakistan and then their average was taken: Homage (PKR 45,000), Emerson (PKR 74,000) and APC (PKR 139,000). The average price came out to be PKR 86,000. Whereas for the battery costs (of 100 amperes), the average of 4 different brands were taken from some online websites in Pakistan: AGS (PKR 7,300), Exide (PKR 7,000), Osaka (PKR 6,900) and Phoenix (PKR 5,500). The average price therefore comes out to be PKR 6,675. Since the system would have 4 batteries, I multiply the battery cost by 4 to obtain the total battery cost: PKR 26,700. Adding the cost of the UPS system and total battery costs, I get PKR 112,700. The sources of the prices are available in the appendix.

<sup>15</sup> Units consumed per hour (1)\*electricity price per unit (15)\*number of hours of loadshedding per day (4)\*365.

<sup>16</sup> See Table A11 in the appendix for cost break-up of the 3kVA solar system

<sup>17</sup> The value is zero since annual running cost to cover the loadshedding period is zero.

<sup>18</sup> Negative Running Cost = Units consumed per hour\*electricity price per unit\*number of hours of solar energy used beyond the loadshedding period per day\*365.

years the net present value would go up to PKR 351,574 at a discount rate of 1.5% and PKR 296,306 if a discount rate of 6% is taken. Finally, the annual running costs from using a solar system would be PKR -21,900 and after 12 years, the household's present value of total costs would be PKR 162,126 if a discount rate of 1.5% is assumed and PKR 217,394 at a discount rate of 6%.

However, if I alter assumption VIII and assume that the solar system is used for only 2 hours beyond the loadshedding period, then solar system would provide a negative cost of PKR 10,950 per year. If I use a discount rate of 1.5%, then solar system would have a present value of total costs of PKR 281,563 which would still be lower compared to UPS systems and diesel generators. Whereas if I use a discount rate of 6% then UPS systems has the lowest present value of total costs amongst the three alternatives but solar system still remains cheaper than diesel generators.

#### *Evaluation of the Cost Analysis*

By comparing the costs between solar panels, diesel generators and UPS systems, according to my calculations, it is beneficial for a household to use solar panels as it incurs lower costs compared to the other alternatives. We can observe that a regular household that invests in solar energy can expect to save significantly in the long run, albeit they would need to incur some initial investments. However, if we take higher discount rates it reduces the present value of running costs for UPS and diesel generators, which does not favor solar energy. In the case where solar energy is used for 4 hours beyond the loadshedding period, by taking a discount rate of 10.72% or higher the present value of total costs for solar energy becomes higher than UPS systems as per the values I have taken for my analysis. Whereas if we take a discount rate of 35.03% or higher, present value of total costs for solar energy becomes higher than diesel generators as per the values considered. Moreover, for the case where solar energy is used for 2 hours beyond the loadshedding period, solar energy becomes more expensive compared to UPS systems when using a discount rate of 5.18% or higher, whereas it becomes more expensive than diesel generators if we apply a discount rate of 31.81% or higher. Therefore, as long as a household can gather resources to invest in a solar system, for example through a loan, it would benefit in the long run.

Moreover, as discussed earlier the electricity provided to the people of Pakistan is largely subsidized. Hence, by switching to solar energy the social efficiency of electricity production would increase as well. As the cost of electricity for the household is lower than the real cost of production due to the extensive subsidies provided, by shifting to solar energy the household would benefit from getting a cheaper source of energy. Meanwhile the government would benefit since lesser subsidies would need to be offered to the consumers and emissions into the atmosphere would be reduced as well. Hence, given that the current electricity subsidies are kept unchanged, switching to solar energy may not only be better for the household but for the economy as well.

#### 4. Discussion of Some Behavioral Economics Theories

Despite solar energy being financially beneficial for households, there might be other factors preventing its use and thus becoming a hindrance for households. Apart from personal preferences determining the household's choice of backup for power outages, it is also important to discuss behavioral factors which could influence the choices of households. Below are brief discussions of some of the behavioral economic theories which may potentially influence a household's choice:

##### *Status Quo Bias*

Samuelson & Zeckhauser (1988) state that status quo bias exists when individuals prefer that their affairs stay the same by continuing with a decision previously made. They divide the explanation of the status quo bias into 3 parts: (i) cognitive misconceptions, (ii) rational decision making in the presence of transition costs or uncertainty, and (iii) psychological commitment stemming from misperceived sunk costs, regret avoidance or a drive for consistency.

In the case of solar energy, one of the practical concerns before opting to use solar panels would be to obtain knowledge about the product and the practicalities that are associated with using them, including financial costs, operational constraints, benefits of use, sustainability, etc. For consumers who are in process of making a purchasing decision, researching about the product can be a draining task. Thus, households might prefer to continue using their 'default' option and avoid investing time and effort in researching about a new available technology and simply use information they already have. As stated by Samuelson & Zeckhauser (1988, p.47): 'individuals display a bias toward sticking with the status quo' while choosing among alternatives, or that people tend to stick with a decision previously made. However, other households may not find it draining and would consider it as a trivial factor when formulating their costs of switching to solar energy.

##### *Sunk Cost Fallacy*

As purchasing generators or UPS systems for dealing with power outages requires considerable investment, households may not be willing to spend excessively once again. Using solar energy may be beneficial for the consumer, and the consumer may be aware of it, but they might avoid abandoning the previously used device since their investment would be 'sunk'. If the new equipment makes the old equipment redundant, then that would be a real cost to the consumer and a rational consumer may resist such a change unless it becomes necessary to change.

However, if the new technology is beneficial as soon as the consumer begins to use it even if the old technology may still be usable, then a rational consumer is likely to change to the new technology. Arkes & Blumer (1985, p.124) stated in their paper that ‘The sunk cost effect is manifested in a greater tendency to continue an endeavor once an investment in money, effort, or time has been made’. Therefore, if people have already spent large sums of money on UPS systems or diesel generators, then they might continue to use those devices even if they have a better option available such as solar energy, primarily to justify their previous investment.

### *Altruism*

Nyborg and Rege (2003) present four models for consumer preferences: Homo Oeconomicus, classical altruism, pure altruism and impure altruism. If we assume a homo oeconomicus consumer, then it is likely that the consumer will place low weight on factors such as environmental benefits that are provided to other people from shifting to solar energy. Meanwhile, a consumer that is an altruist will take into account the personal benefit received from shifting to solar energy as well as the relief obtained by the public. Hence, it is likely that an altruist will place a larger weight on environmental benefits of converting to solar energy, and this could influence their preference of back-up energy source.

### *Social Norms/Acceptance*

Social acceptance is also a factor which would depend on the social norms that exist around the household. Young (2015, p.359) defines social norms as ‘patterns of behavior that are self-enforcing within a group: Everyone conforms, everyone is expected to conform, and everyone wants to conform when they expect everyone else to conform’. Therefore, if a given household belongs to a society that gives high importance to environmental values and expects all members of the society to conform to that norm, then such household may place high weight on social acceptance in converting to solar energy. However, a household that does not face such circumstances may have lower or no weight on this factor when considering whether or not to shift to solar energy.

### *Present-Biased Preferences*

In the case of investing in solar energy, the investment activity must be done once and immediately while rewards would be obtained sometime in the future. In such cases, people tend to postpone costly actions when the benefits come in the future since people may be present-biased (Donoghue & Rabin, 1999). Donoghue & Rabin (1999, p.103) state about present-biased preferences: 'When considering trade-offs between two future moments, present-biased preferences give stronger relative weight to the earlier moment as it gets closer'. Thus, as the costs occur before the rewards, the individuals might be tempted to procrastinate and postpone the investment decision to the future. If one is not aware that they will eventually procrastinate, then they would be unaware that it would be more costly to procrastinate in the present. Therefore, people may not invest in solar energy because they prefer to postpone the costly decision to the future.

## 5. Analysis of data collected in Punjab

The data was collected from within the province of Punjab during January and February 2018 with 267 respondents taking part in the survey, where the samples were collected through social media and direct interviews. The following are results of some of the questions in the questionnaire, while the remainder of the results can be viewed in the appendix:

### 5.1 Descriptive Statistics

#### *Gender*

Table 2 shows the distribution of the number of men and women that took part in the survey. Approximately two-thirds of the responses are provided by men, primarily because most of the respondents while conducting personal interviews were men, and women were very scarce in the market places which were visited while conducting surveys in various cities. Most of the female responses were received from online questionnaires and majority of them belonged to Lahore.

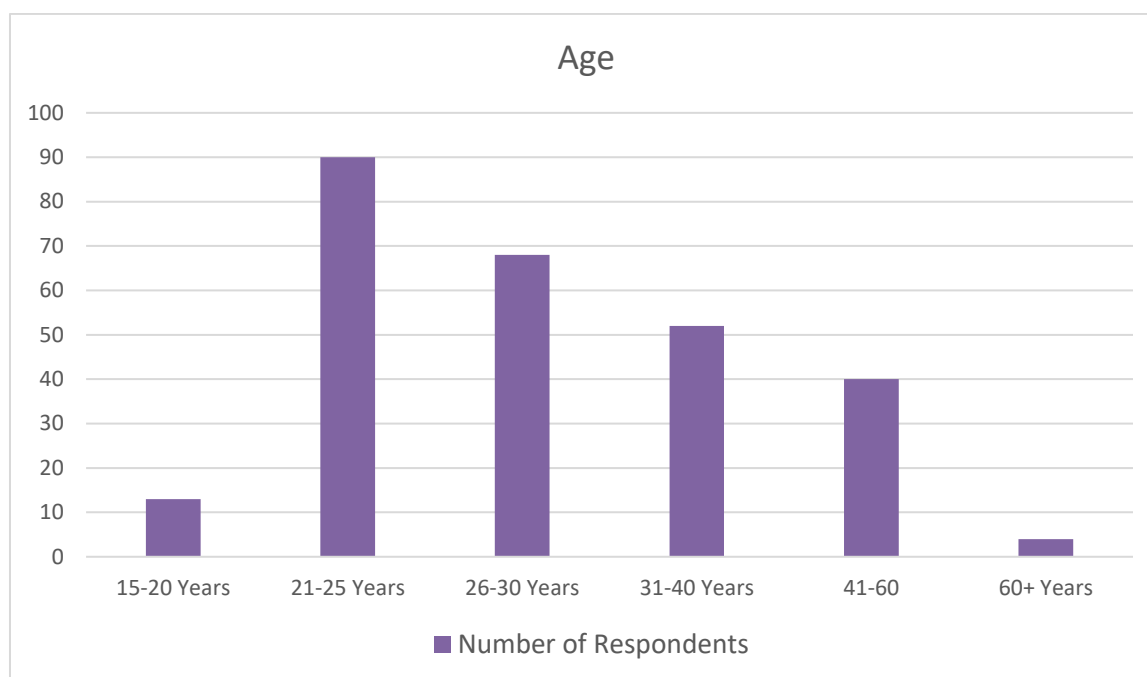
*Table 2: Gender*

| Gender | Frequency | Percentage |
|--------|-----------|------------|
| Male   | 179       | 67.04      |
| Female | 88        | 32.96      |
| Total  | 267       | 100.00     |

#### *Age of respondents*

From the figure below we can observe the age brackets of the respondents. People between the ages of 21 and 25 were the most common in the sample, which can be explained by more common use of social media by young people compared to the older generation. Similarly, the older the age bracket, the less are the number of respondents. It should also be noted that during the interview process, younger people were more enthusiastic about answering the questionnaires than older people. This has also contributed towards a higher involvement of younger people.

*Figure 7: Distribution of age of the respondents*



### *City*

The table below shows the distribution of the cities from which the respondents belonged to and the number of respondents from each city. As mentioned earlier, most of the respondents belonged to Lahore (149) as it is the biggest and most developed city of the province, hence a greater number of responses were received from Lahore. Higher level of literacy in the city may also be a reason for the higher responses from Lahore, especially through online questionnaires. Personal visits to cities such as Gujranwala, Gujrat, Sheikhupura and Faisalabad are the primary reason why the responses in these cities are higher compared to other cities. Responses from other parts of the province give a diversified sample; however, it is not plausible to consider the responses from respondents from these cities as representations of the whole city, especially the regions where the respondents are very few in quantity. However, obtaining responses from different regions should prevent regional biases and give a more complete overview of the data of the whole province.

*Table 3: Details of the number of respondents from each city*

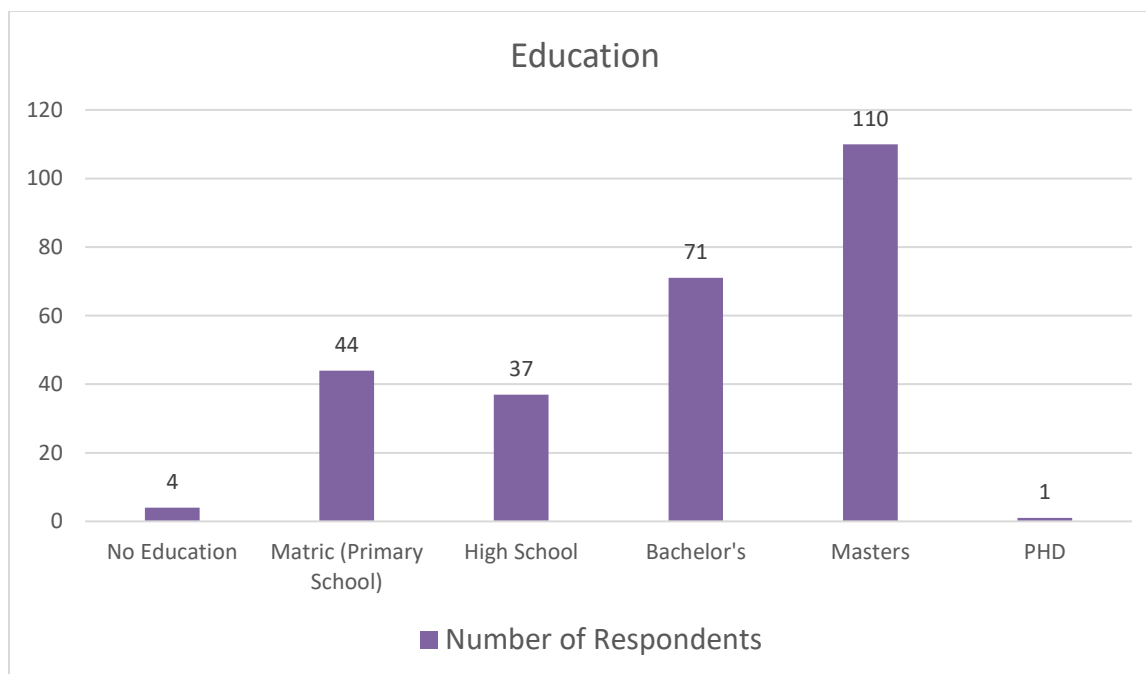
| Name of City    | Frequency | Percentage |
|-----------------|-----------|------------|
| Lahore          | 149       | 55.81      |
| Faisalabad      | 8         | 2.99       |
| Sargodha        | 4         | 1.50       |
| Gujranwala      | 32        | 11.99      |
| Gujrat          | 22        | 8.24       |
| Sialkot         | 1         | 0.37       |
| Sheikhupura     | 37        | 13.85      |
| Malakwal        | 1         | 0.37       |
| Mandi Bahauddin | 2         | 0.75       |
| Moradabad       | 1         | 0.37       |
| Multan          | 1         | 0.37       |
| Bahawalpur      | 1         | 0.37       |
| Okara           | 1         | 0.37       |
| Rawalpindi      | 6         | 2.25       |
| Wah Cantt       | 1         | 0.37       |
| Total           | 267       | 100.00     |

### *Education*

Figure 8 shows the educational attainment of the respondents taking part in the survey. More than 50% of the respondents had a bachelors or masters education while there was one respondent who had a PHD qualification. Majority of the respondents who had primary, high school or no education were those people who gave personal interviews, as such people are not expected to be very proficient or comfortable with the English language to understand the contents of the questionnaire which was circulated online. The interviewers translated the questions for people who were not comfortable with English, so it is possible that some respondents did not completely understand the meaning of the questions, or the interviewers were unable to accurately translate the contents of the questions. Finally, since this question was open ended in the questionnaire, most respondents wrote what they were studying or the type of degree they were doing, for example MBA, Masters, M.Phil., ACCA, BSc, BBA, etc.

The responses were eventually divided into 6 categories: Matric (Primary School), High School, Bachelor's, Master's, PHD and no education.

*Figure 8: Distribution of education of the respondents*



#### *Family Income:*

Table 4 below describes the composition of family income of individuals taking part in the survey, with the numerical values representing the following income brackets:

*Table 4: Family income of respondents*

| Values | Family Income Bracket (Per month) | Frequency | Percent |
|--------|-----------------------------------|-----------|---------|
| 1      | Less than PKR 50,000              | 27        | 10.11   |
| 2      | PKR 50,000 to PKR 100,000         | 68        | 25.47   |
| 3      | PKR 100,001 to PKR 150,000        | 66        | 24.72   |
| 4      | PKR 150,001 to PKR 250,000        | 33        | 12.36   |
| 5      | Greater than PKR 250,000          | 68        | 25.47   |
| 6      | Missing values                    | 5         | 1.87    |
| Total  |                                   | 267       | 100.00  |

More than 60% of the data obtained is from households whose monthly income is greater than PKR 100,000 (approximately USD 900), that is far greater than the average monthly consumption of households living in Pakistan which is approximately PKR 32,578 (Household Integrated Economic Survey, 2016). In order to justify that the amount of PKR 100,000 is sufficiently high for an average household to be able to afford solar panels, we can view figures from the cost benefit analysis in section 3, and we can also compare the averages of the incomes and expenditures of the richest households in the country. According to the research conducted by the Household Integrated Economic Survey (HIES), the average monthly consumption expenditure of the households falling in the 5<sup>th</sup> quintile in Pakistan is PKR 52,907 for the year 2015-16, while the average income of the same class of people is PKR 60,451 (Household Integrated Economic Survey, 2016). Furthermore, since most of the families in Pakistan live under a joint family system, it is possible that most families are able to combine resources collectively to make an extensive capital expenditure, which would make it easier for them to invest in solar panels. Finally, 5 people refused to provide family income which has been recorded as missing data.

## 5.2 Summary of Questionnaire Results (Selected)

*Table 5: Do you have solar panels installed at your home?*

| Responses | Frequency | Percent |
|-----------|-----------|---------|
| Yes       | 34        | 12.73   |
| No        | 233       | 87.27   |
| Total     | 267       | 100.00  |

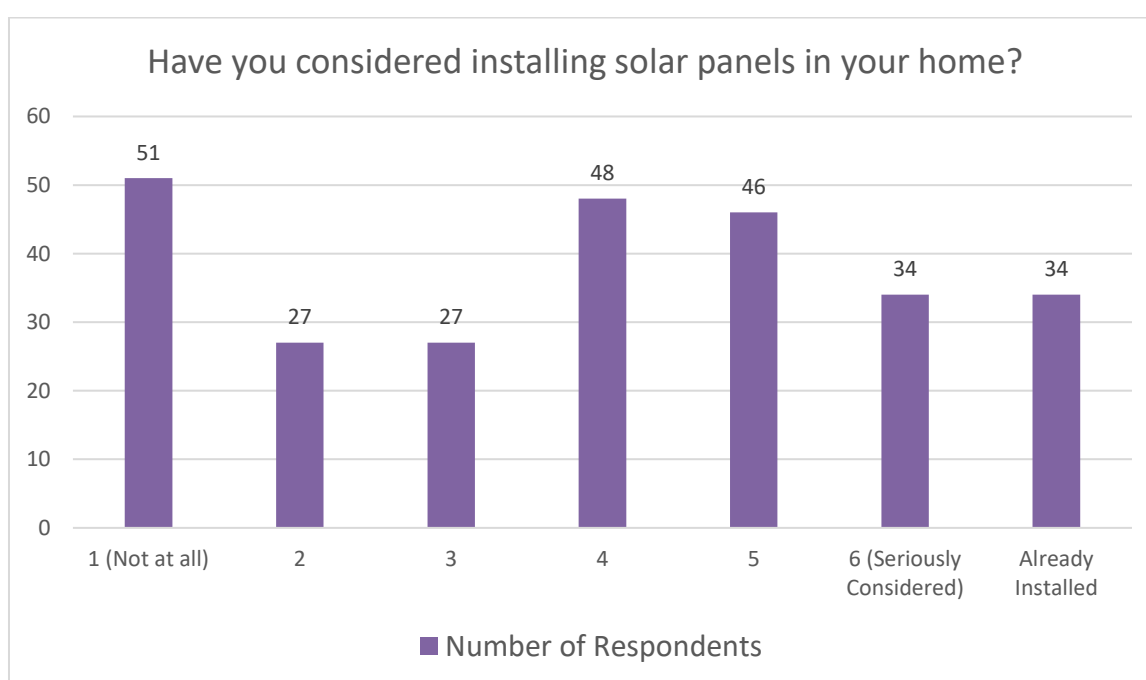
Amongst a total of 267 respondents taking part in the survey, only 12.73% of them are users of solar systems. Although power outages have been a common occurrence in the country recently, households have been reluctant to use solar energy and have primarily preferred using UPS systems or generators (see Figure 1).

*Table 6: Do you prefer installing solar panels in your home?*

| Values | Responses         | Frequency | Percent | Cumulative Percentage |
|--------|-------------------|-----------|---------|-----------------------|
| 1      | Yes               | 167       | 62.55   | 62.55                 |
| 2      | No                | 66        | 24.72   | 87.27                 |
| 3      | Already installed | 34        | 12.73   | 100.00                |
| Total  |                   | 267       | 100.00  |                       |

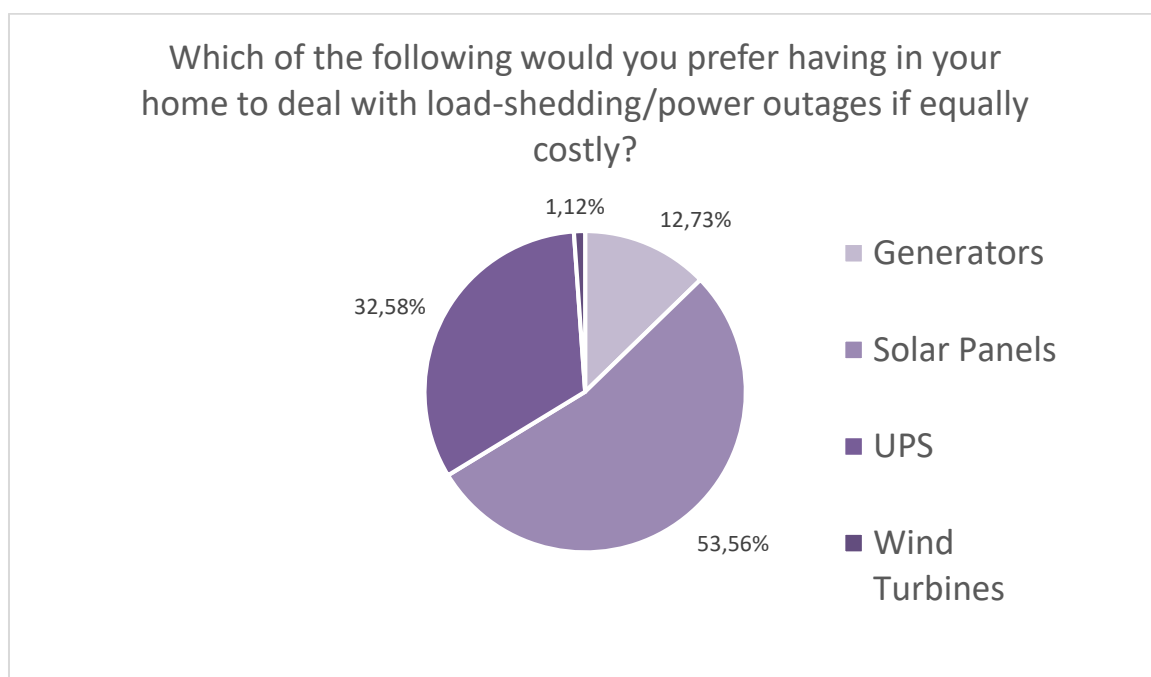
Table 6 shows that approximately 62.55% of the people report to prefer installing solar panels in their homes while approximately 25% of them prefer not to. The evidence suggests that a majority of respondents in the sample are interested in having solar panels in their homes, while approximately only 13% of the respondents have already installed solar panels in their homes. Moreover, as discussed earlier, approximately 60% of the respondents have a family income of more than PKR 100,000, which should presumably be sufficient to be able to afford a solar energy system in Pakistan. If most of the people in the sample can afford solar panels, and they also report to be interested in having this technology in their homes, it creates a valid question: Why do these households not shift to solar energy if they prefer to have it and they can afford it?

*Figure 9: Have you considered installing solar panels in your home?*



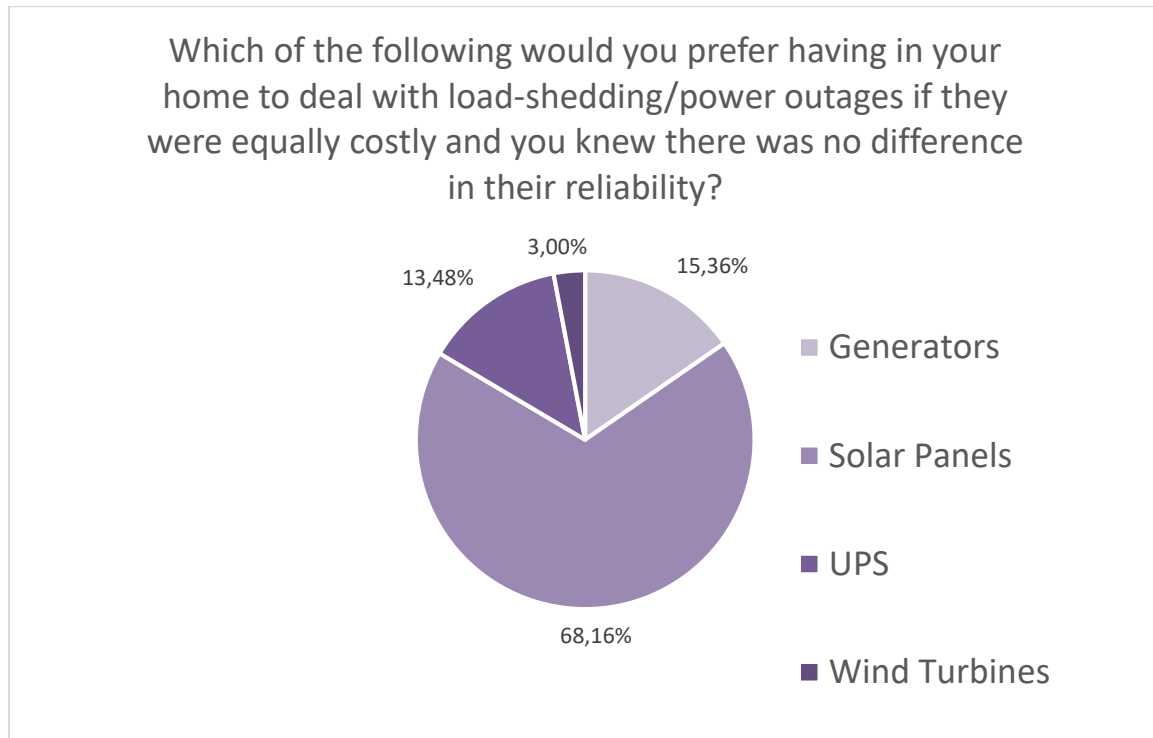
Respondents were asked to describe how seriously they had considered installing solar panels in their homes. Figure 9 above shows the distribution of answers received from the respondents regarding this question. There were 34 respondents who had already installed solar panels, while 51 people said they had not considered installing solar panels at all. Meanwhile, 34 people stated they are seriously considering installing solar panels.

*Figure 10: Which of the following would you prefer having in your home to deal with load-shedding/power outages if equally costly?*



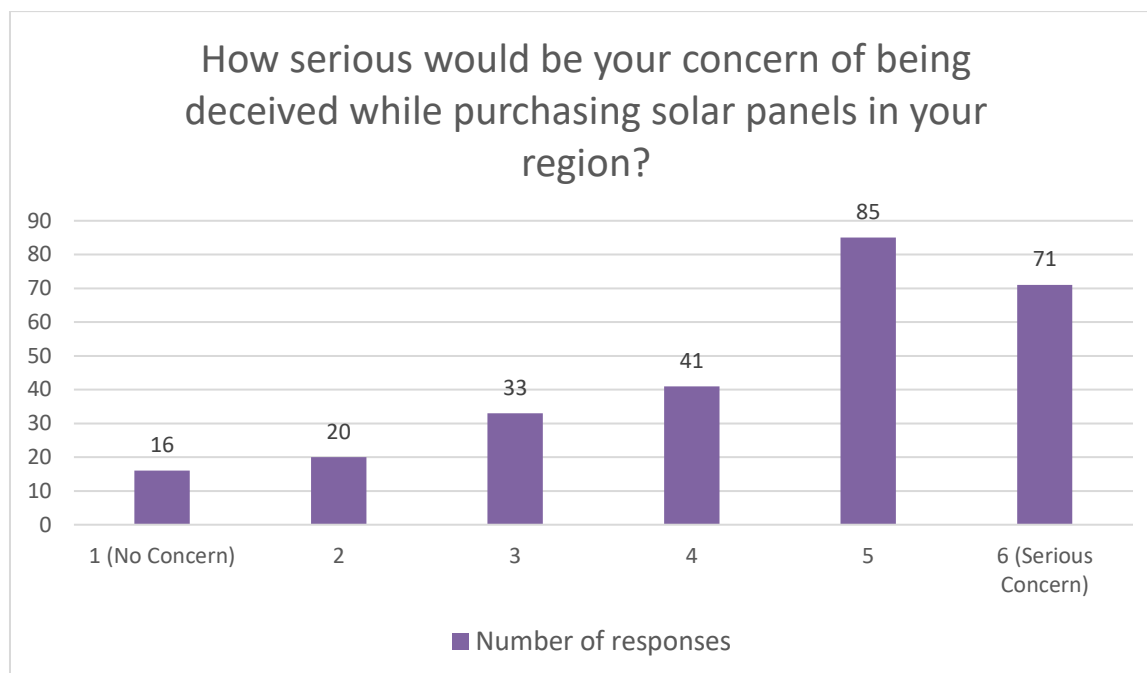
Respondents were asked which energy source they would prefer to deal with power outages if each option was equally costly. Solar panels were said to be preferred by 143 respondents (53.56%), while UPS systems were preferred by 87 respondents (32.58%). There were 34 people (12.73%) who stated preference for generators while only 3 people (1.12%) preferred to have wind turbines. The question did not mention explicitly whether the running costs are included or not, thus it is possible that some respondents assumed that running costs are included while others may have assumed that the question only refers to the capital expense.

*Figure 11: Which of the following would you prefer having in your home to deal with load-shedding/power outages if they were equally costly and you knew there was no difference in their reliability?*



Respondents revealed which energy source they would opt for if each alternative was equally costly and reliable. Approximately 15% people increased their preference to solar energy once the reliability factor was added, while 2.63% people had increased preference for generators. UPS systems was the only alternative which had reduced preferences amongst the respondents, as 19.1% fewer people preferred UPS systems once the reliability factor was controlled for. Furthermore, 5 respondents shifted preference to wind turbines.

*Figure 12: How serious would be your concern of being deceived while purchasing solar panels in your region?*

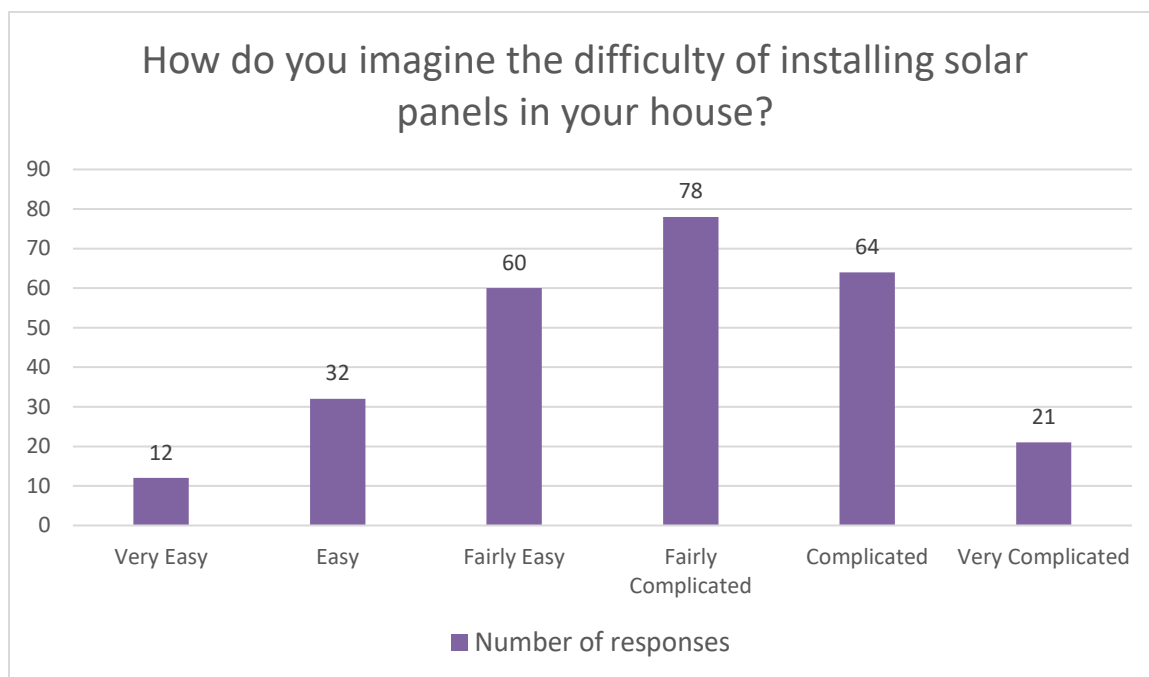


One of the factors which could be important in understanding the reluctance of people towards trying a different technology for their electricity needs could be the possibility of getting malfunctioning or inefficient products, and therefore facing the likelihood of having a large investment being wasted. Such a phenomenon is not surprising for a country which is ranked 117<sup>th</sup> out of 180 countries in the corruption perception index for 2017 according to Transparency International, whereas less corrupt countries like Denmark, Norway and Sweden were ranked 2<sup>nd</sup>, 3<sup>rd</sup> and 6<sup>th</sup> respectively (Transparency International, 2018). Therefore, it is essential to study the concern of potential customers of solar panels regarding the possibility of getting deceived.

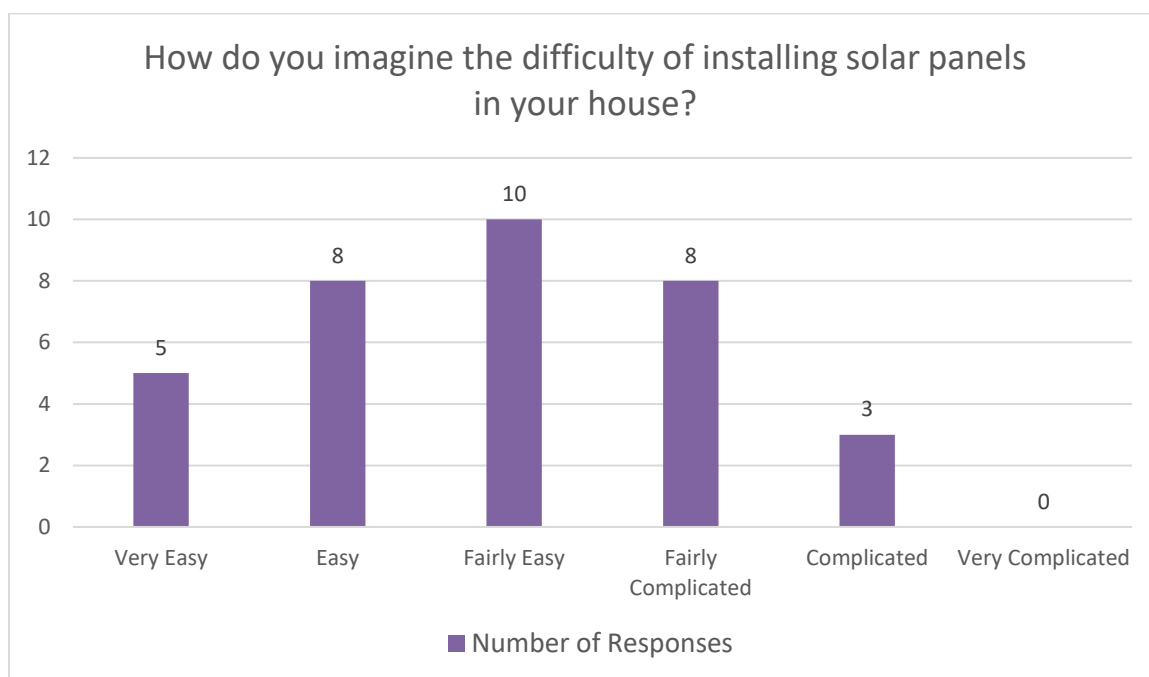
Figure 12 above shows the level of concern for being deceived for people if they would consider purchasing solar panels, where 1 states low level of concern and 6 states high concern for being deceived. As per the data collected, approximately 75% of the respondents claimed that they were rather concerned about being deceived if they decided to purchase solar panels from their region. It was a concern which was expressed by a significant number of interviewees who shared bad experiences faced by their friends or themselves where they were sold faulty products, or devices that were supposed to be of superior quality but instead they were given lower quality equipment. It may also give more reason to people who are risk averse to avoid considering this commodity and not go against the societal norms. Therefore, even if people

are interested in using this technology, they would be deterred by the prospect of being conned and having their investment wasted.

*Figure 13: How do you imagine the difficulty of installing solar panels in your house?*

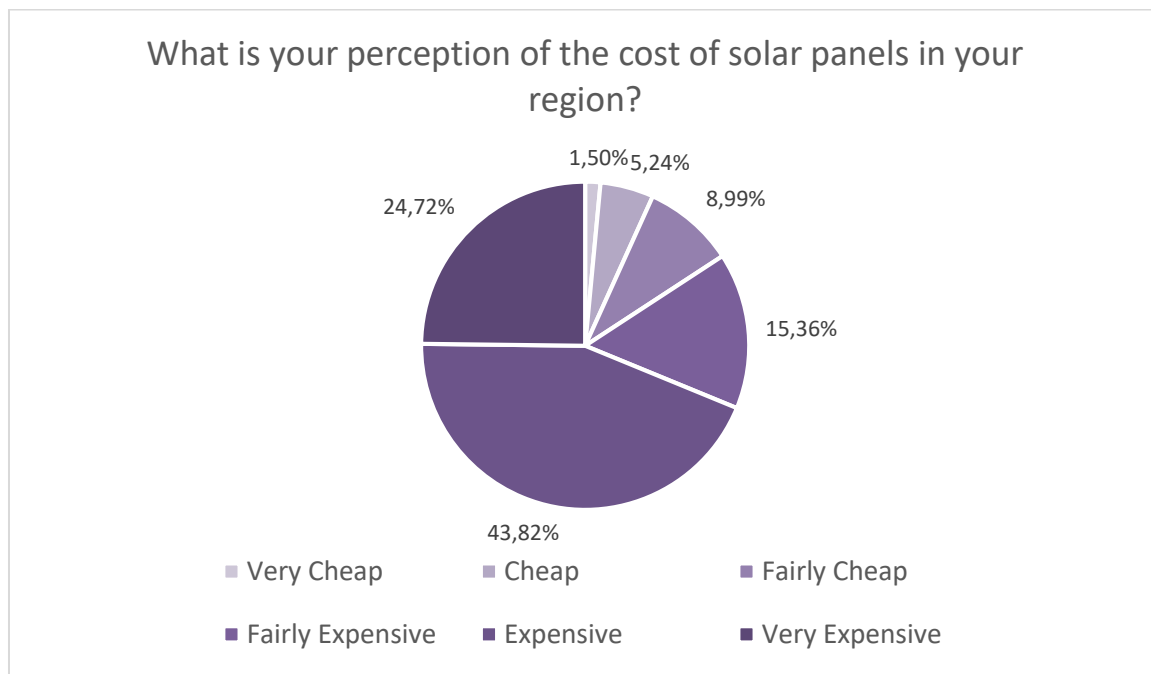


**Figure 14: Responses of people who had already installed solar panels regarding the difficulty of installing solar panels in their homes**



In order to understand whether there is any resistance to installing solar panels due to the difficulty of having them installed in people's houses, respondents were asked state whether they think it is complicated to install solar panels in their homes. As per figure 13, most of the respondents felt it is quite complicated, with more than 60% finding it rather cumbersome to have them installed in their homes, although the stated answers were simply the perceptions they carried in their minds. Moreover, it is apparent that many people feel that installing solar panels is not easy. However, while doing a further analysis of the same question, I have extracted the responses of the people who had already installed solar panels in their homes. Figure 14 shows that people who were already using solar panels did not find it too complicated to install solar panels in their homes. According to the data, none of the respondents thought the process was 'very complicated' while only 3 people thought it was complicated. However, 5 people felt it was very easy and 8 respondents stated that the process was easy. Finally, 10 and 8 people were of the opinion that the process was fairly easy and fairly complicated respectively.

*Figure 15: What is your perception of the cost of solar panels in your region?*



One possible reason for the reluctance of people moving towards solar energy is that people have a perception that solar panels are very expensive. The data above allows us to study the perceptions of people regarding the cost of solar panels in their region.

It is evident from the data that most people consider solar panels to be an expensive commodity. It could be due to lack of awareness or less knowledge amongst people that the costs of solar panels have decreased significantly during the past decade (Mayer, 2015). Nonetheless, as approximately 84% of the respondents feel that solar panels are expensive, it could be one of the hurdles in making people switch to this form of energy.

*Table 7: Are you aware of the experiences of your friends or family who used solar panels?*

| Values | Responses              | Frequency | Percent | Cumulative Percentage |
|--------|------------------------|-----------|---------|-----------------------|
| 1      | Mainly positive        | 133       | 49.81   | 49.81                 |
| 2      | Mainly negative        | 14        | 5.24    | 55.06                 |
| 3      | Not sure <sup>19</sup> | 120       | 44.94   | 100.00                |
| Total  |                        | 267       | 100.00  |                       |

According to the research conducted by Ahmed, Vveinhardt and Ahmad (2016), in Pakistani societies the word of mouth carries immense significance when consumers consider any purchasing decision. Another research conducted by Aslam (2011, p.497) stated about Pakistani consumers that: ‘consumers tend to rely on word of mouth for the purchase of everyday items as well as long-term goods. The people that seem to have an influence on the decision of the consumers the most are closed family, friends and acquaintances’. Therefore, since most people give high significance to the reviews and experiences of people they know before making an investment decision, it is important to understand whether family and friends of the respondents had positive or negative experiences with solar panels. As per the results, only 14 respondents claimed that people in their social circle had negative experiences with solar panels, whereas almost half the respondents stated that the experiences were mainly positive. The remaining answers were either neutral or were people who did not know anyone who had a solar system installed at their residence.

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<sup>19</sup> This response also includes people who were not aware of anyone who had solar panels installed in their homes.

*Figure 16: Would you be more unlikely or likely to install solar panels if your family/friends recommended it to you?*

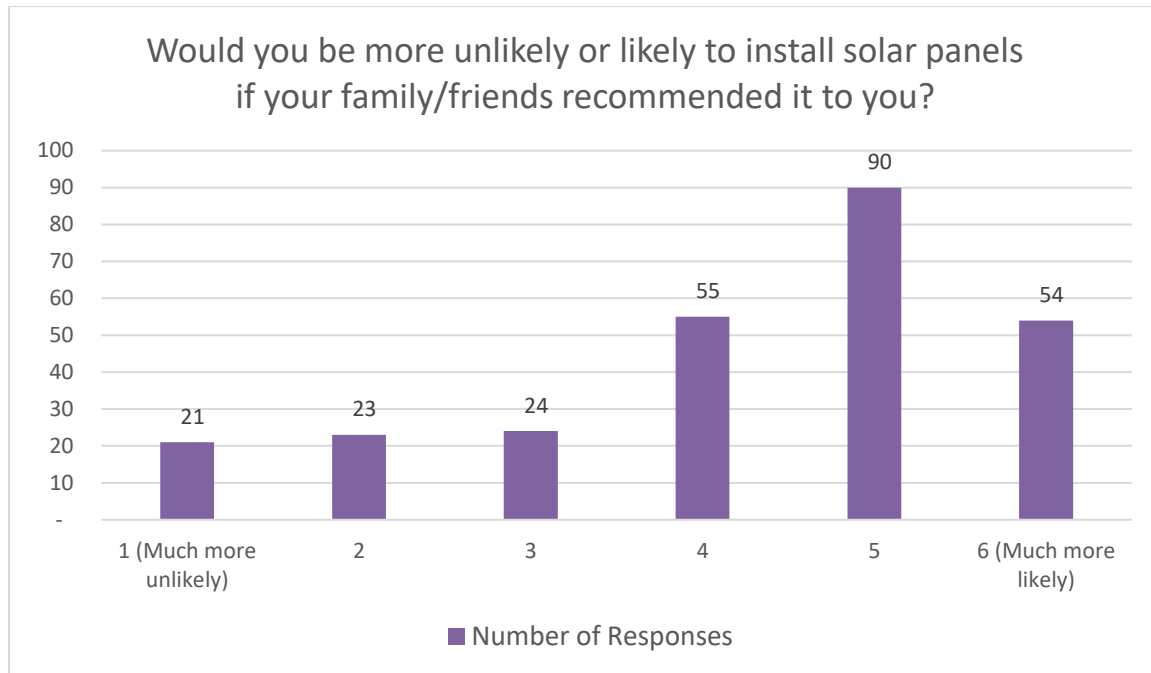


Figure 16 shows whether people are more likely to consider installing solar panels in their homes if the people they trust, particularly friends and family, recommend them to do so. The values closer to 1 suggests that they are less likely to consider using solar panels if their friends or family recommended it while values closer to 6 suggests that they are highly likely to do so. The responses from this question can also be supported by the research conducted by Aslam (2011) and by Ahmed, Vveinhardt and Ahmad (2016), which has been discussed earlier. Since most of the respondents reported that their friends and family had positive experiences with using solar energy, it is possible that there are some other elements preventing people from choosing solar energy.

*Table 8: Have you ever been requested or encouraged to install, or consider installing solar energy through any method?<sup>20</sup>*

| Responses | Frequency | Percent | Cumulative Percentage |
|-----------|-----------|---------|-----------------------|
| 1 (Yes)   | 108       | 40.45   | 40.45                 |
| 2 (No)    | 159       | 59.55   | 100.00                |
| Total     | 267       | 100.00  |                       |

Table 8 shows whether the respondents had ever experienced any pleas to shift to solar energy. Approximately 60% of the respondents stated that no one had ever asked them to shift to solar energy while nearly 40% of the respondents claimed that they have been asked to install solar panels in their homes. However, during some verbal exchanges, many of the respondents claimed that they had never seen any efforts from the government to encourage the public to use solar energy, while a significant number of them stated that they have barely ever seen any advertisements for solar energy.

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<sup>20</sup> The objective of this question was to ask whether they have experienced any campaigns or efforts from the government, or witnessed any advertisements from companies selling solar panels. However, the question did not clearly state this, and the interviewers did not make this clear to the interviewees while asking this question, and it is possible that some respondents may have taken into account the requests or pleas coming from family and friends regarding installation of solar panels. Thus, it is expected there would have been more 'No' responses if the question had been made clearer.

*Figure 17: Would you be more likely to install solar panels if some incentives (e.g. subsidies) were provided to you?*

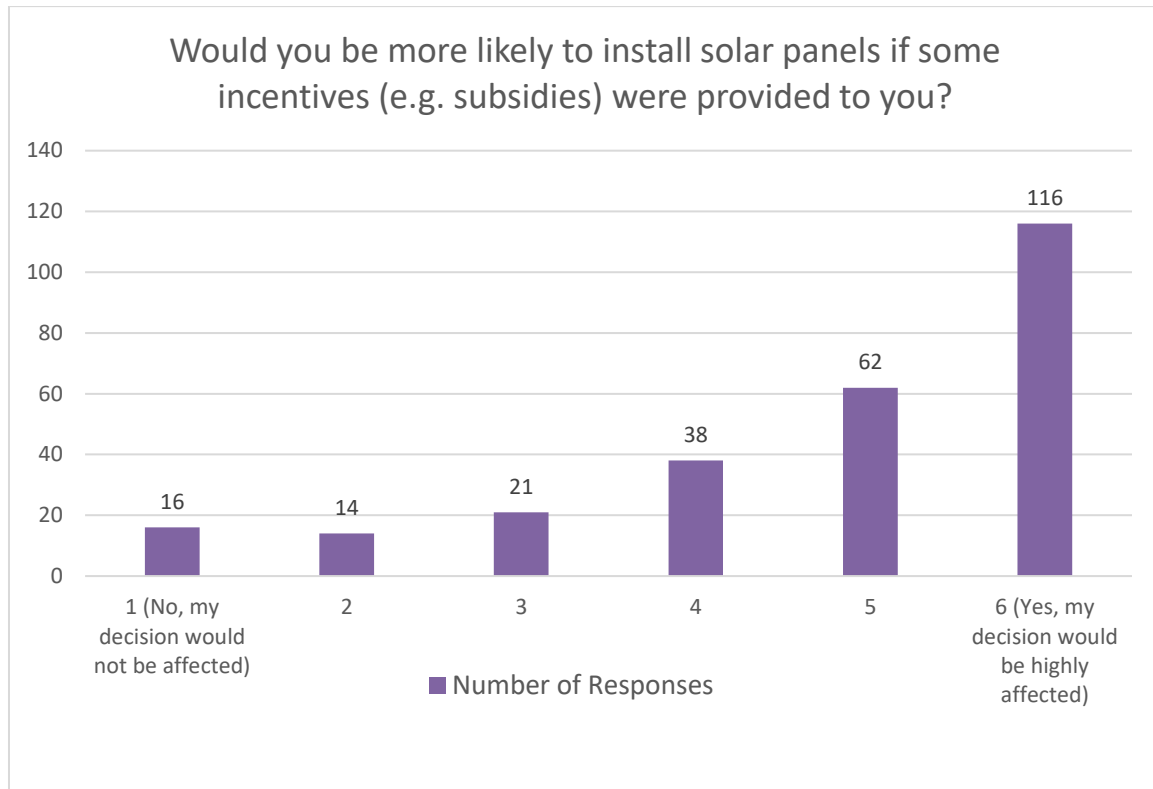


Figure 17 presents data regarding how likely people would be to install solar panels if some incentives, for example subsidies, are provided to them. Approximately 44% of the respondents stated that their decision would be highly affected if they are offered some incentives to install solar panels. Meanwhile, less than 20% stated that their decision would remain relatively unaffected.

## 6. Discussion of some key findings

The following are some of the key findings obtained from the survey:

1. People may seem to have low confidence in the reliability of solar panels. According to the results where subjects were asked ‘Which of the following would you prefer having in your home to deal with loadshedding/power outages if equally costly?’ nearly 53% responded that they would prefer solar panels. However, respondents were also asked ‘Which of the following would you prefer having in your home to deal with loadshedding/power outages if they were equally costly and you knew there was no difference in their reliability?’ For the latter question, support for solar panels jumped from nearly 53% to 68%. This suggests that people may be reluctant in using solar energy since they are not confident in its reliability.
2. Most people seemed hesitant to use solar energy since they fear being deceived or defrauded if they purchased solar panels in their region. As per the results, we can observe that a majority of the respondents have low confidence on the credibility of the type of solar system equipment they would receive in their regions. One respondent answered for the question ‘What is the primary reason for not installing to solar energy?’ by stating that “If you find me a credible supplier for solar energy in Gujrat, I will not wait a second to have it installed in my house”. The high corruption perception index of the country, which ranks poorly in 117<sup>th</sup> position out of 180 countries, may also be a factor that people are reluctant in making big investments unless they are satisfied that their investments are safe (Transparency International, 2017).
3. Respondents reported that they find solar panels expensive. They were asked about their perception about the cost of solar panels and nearly 84% of the respondents stated that they thought solar panels were rather expensive.
4. Most respondents prefer using solar panels in their homes. Nearly 72% (after removing the respondents who already had solar panels installed in their homes) of the respondents stated that they would prefer installing solar panels in their homes according to the results. However, only 34 of the 267 (12.73%) respondents had solar panels already installed in their homes. It is possible that this preference is due to environmental factors, as most of the respondents stated that they care about the atmosphere (see Figures A12 to A14 in the appendix).

5. Most of the respondents had the perception that the process of installing solar panels is difficult whereas a majority of the people who had already installed solar panels felt that the process was not difficult.
6. Getting incentives (such as government subsidies) would reportedly highly affect people's decisions to install solar panels. The results show that the respondents would be highly encouraged to install solar panels if some governmental support or other incentives were given to them.
7. People seem to have lack of information about solar panels. Apart from results from one of the questions where people seem to believe that installing solar panels is a tedious task, while conducting personal interviews I came across many people who were not aware of what solar panels were. Moreover, a large number of people seemed to be unaware of the advantages or disadvantages of solar panels whereas many people assumed that there are high maintenance costs associated with running solar panels. Some people felt there was no point in using solar panels instead of UPS systems, since 'both required batteries anyway'. Finally, most people were not aware that they could 'partially' convert their homes to solar energy, and that it was not necessary to invest in a solar system that would 'totally' convert their homes to solar energy.
8. The theory of status quo bias could explain why people are not willing to spend too much time and effort to research about solar energy and lack information about it. Since people do not have abundant knowledge about solar energy (as per one of the findings of the study), households may be less willing to invest excessive labor in carrying out research work regarding solar energy. Instead they may want to opt with the default option, namely UPS systems or diesel generators, as this may seem more convenient for them.
9. Households may be reluctant to purchase solar panels since their investment in alternative sources of energy is already 'sunk'. Despite 72% of the respondents preferring solar energy, they might not be willing to make another large investment since it would make their previous investment redundant.
10. The preference for solar energy amongst the respondents might be due to their altruistic nature. By observing figures A12 to A14 in the appendix, it is clear that a majority of the respondents are wary of the environment and they wish to have less pollution. If people's preference for solar panels is primarily due to environmental factors rather than financial or performance related factors, then the aforementioned figures could be one

of the elements which can explain why most people prefer to have solar panels in their homes.

11. If most of the society places great importance on the environment, then there might be pressure for other members of that group to convert to solar energy in order to comply with social norms, which could hence explain high preference for solar energy.
12. Present biased preferences could explain why people are not purchasing solar panels and delaying their purchasing decision, even though they state that they prefer to use them.

Some of the findings are in tune with the conclusion by Zhou et al (2017) where lack of trust in solar panel providers, high cost of solar panels and lack of information were the primary factors behind low usage of solar energy. Their study also found high interest in solar energy amongst the respondents (81%) while use of solar energy was not very common. Finally, they also stated that government support could influence people in using solar energy and that the respondents expect that the state should take the lead in its development.

## 7. Limitations/Caveats of the research

The following are some of the caveats of the research which must be considered while interpreting the results of the study:

1. The survey was conducted during January and February, which are one of the coldest months of the year in Pakistan and when loadshedding was not taking place in most parts of the country.
2. It is possible that some of the respondents failed to understand the questions completely, and hence gave an inaccurate response to some of the questions.
3. Some of the respondents may not have been serious in their responses, and could have given inaccurate answers.
4. During the personal interviews, it is possible that the some respondents gave false responses to some of the questions due to presence of other people around them, not being comfortable with answering questions to strangers, or other factors.
5. A higher number of responses from Lahore and lower participation of people from other parts of Punjab cannot adequately represent the whole of the province.
6. People may not have been honest while stating their family income since it is a sensitive matter.
7. It is possible that the interviewers were unable to accurately translate some of the questions to those respondents who were not comfortable with English.
8. The prices of the alternatives i.e. solar panels, diesel generators and UPS systems, may be outdated.
9. The respondents cannot be expected to be representative for people in Pakistan. One reason may be that the respondents were primarily rich, even though this was intentional, or perhaps because the online responses (which was gathered primarily from social media) might have been overrepresented from people with similar interests or backgrounds.
10. The study lacks statistical and regression analysis which may have helped to check whether some of the findings are significant or not. However, due to time limitations and work required to gather and compile data through questionnaires, it was not possible to carry out a statistical analysis of the data within the scope of the present thesis.

## 8. Conclusion

The survey was conducted in the Pakistani province of Punjab during January and February 2018. Data of 267 respondents was compiled and analyzed in order to understand what prevents the people of this region to use solar energy.

The responses suggested that even though a majority of the respondents (62.55%) prefer to have solar panels in their homes, most of them feel that the commodity is quite expensive and that the installation process is complicated. Approximately 69% of the respondents stated that they feel solar panels are ‘expensive’ or ‘very expensive’ while nearly 62% of the respondents stated that the installation process of solar panels is fairly complicated.

They also stated their concerns about being deceived if they purchased solar panels. Further, we can infer from the results that they have doubts about the reliability of solar energy. Lack of information about solar panels also seemed to be a factor behind the reluctance in using solar energy amongst the people of Punjab.

Government support in the form of subsidies or other benefits may support the use of solar energy, as a majority of the respondents stated that they would be more likely to install solar panels if some incentives were provided to them.

Status quo bias theory was one of the possible factors discussed which may explain this phenomenon as researching about solar panels requires time and effort, and people may feel comfortable by simply sticking with the ‘default’ option. Meanwhile, for the people who are already using some alternative energy source, they might not want to make their existing equipment redundant by investing in solar energy. The existence of the sunk cost fallacy may also be preventing the investment in solar energy by the households of Punjab.

The financial benefits of having solar panels, in comparison to the other alternatives, namely diesel generators and UPS systems, were also discussed where solar energy displayed significant cost savings against the other alternatives. Although the initial cost of installing a solar system is higher than the other alternatives discussed, i.e., diesel generators and UPS systems, a household would incur lower running costs in the long run by using solar energy compared to the other two alternatives discussed.

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## Appendix

Figure A1:

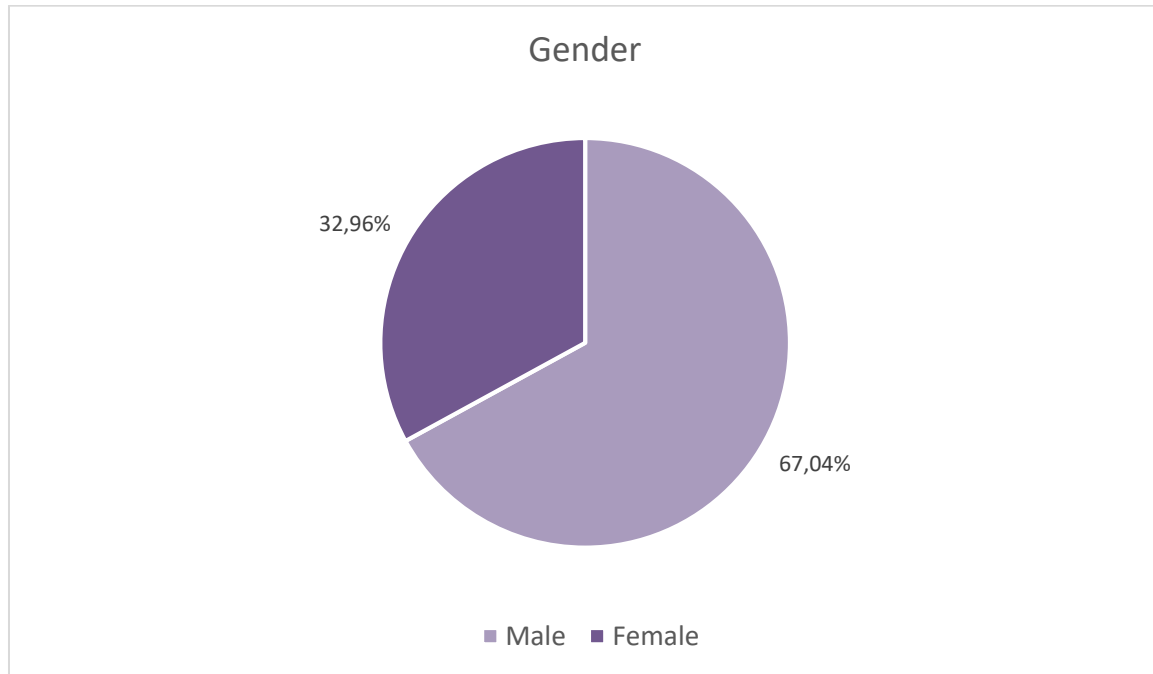
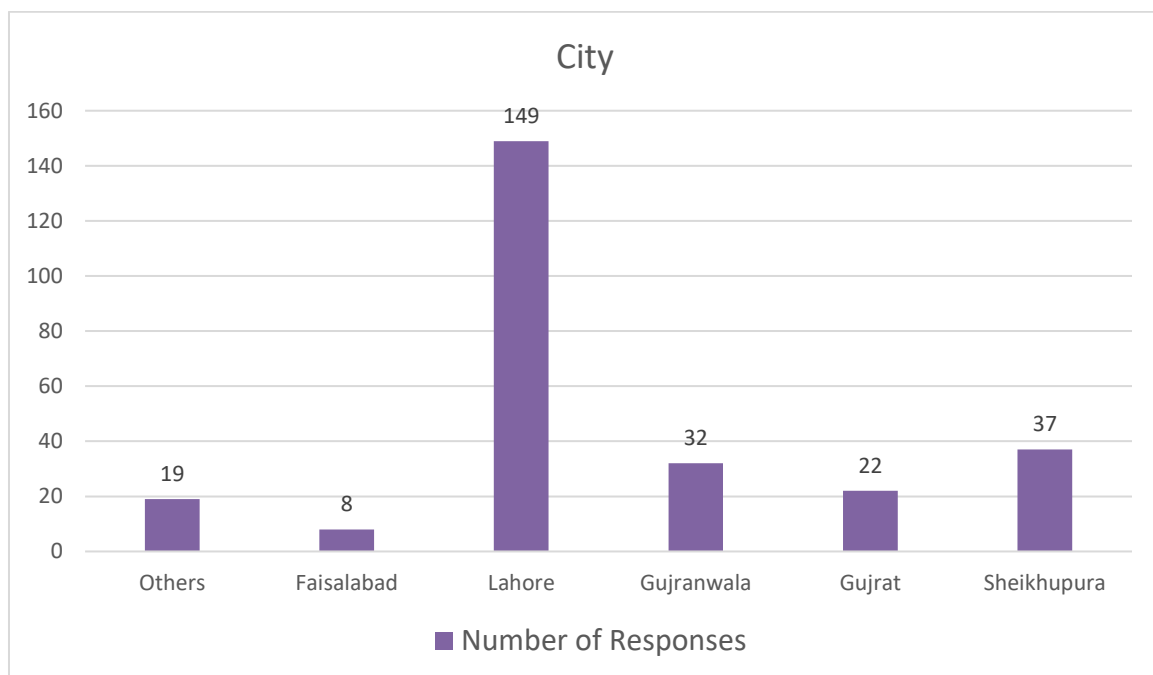


Figure A2:



*Table A1: Level of education of the respondents taking part in the survey*

| Level of Education | Frequency | Percentage | Cumulative Percentage |
|--------------------|-----------|------------|-----------------------|
| No Education       | 4         | 1.50       | 1.50                  |
| Matric (Primary)   | 44        | 16.48      | 17.98                 |
| High School        | 37        | 13.86      | 31.84                 |
| Bachelors          | 71        | 26.59      | 58.43                 |
| Masters            | 110       | 41.20      | 99.63                 |
| PHD                | 1         | 0.37       | 100.00                |
| Total              | 267       | 100.00     |                       |

*Table A2: Preferences of respondents if each power source was equally costly*

| Type of Energy Source | Frequency | Percentage | Cumulative Percentage |
|-----------------------|-----------|------------|-----------------------|
| Solar Panels          | 143       | 53.56      | 53.56                 |
| Generators            | 34        | 12.73      | 66.29                 |
| UPS Systems           | 87        | 32.58      | 98.88                 |
| Wind Turbines         | 3         | 1.12       | 100.00                |
| Total                 | 267       | 100.00     |                       |

*Table A3: Preferences of respondents if each power source was equally costly and reliable*

| Type of Energy Source | Frequency | Percentage | Cumulative Percentage |
|-----------------------|-----------|------------|-----------------------|
| Solar Panels          | 182       | 68.16      | 68.16                 |
| Generators            | 41        | 15.36      | 83.52                 |
| UPS Systems           | 36        | 13.48      | 97.00                 |
| Wind Turbines         | 8         | 3.00       | 100.00                |
| Total                 | 267       | 100.00     |                       |

Figure A3:

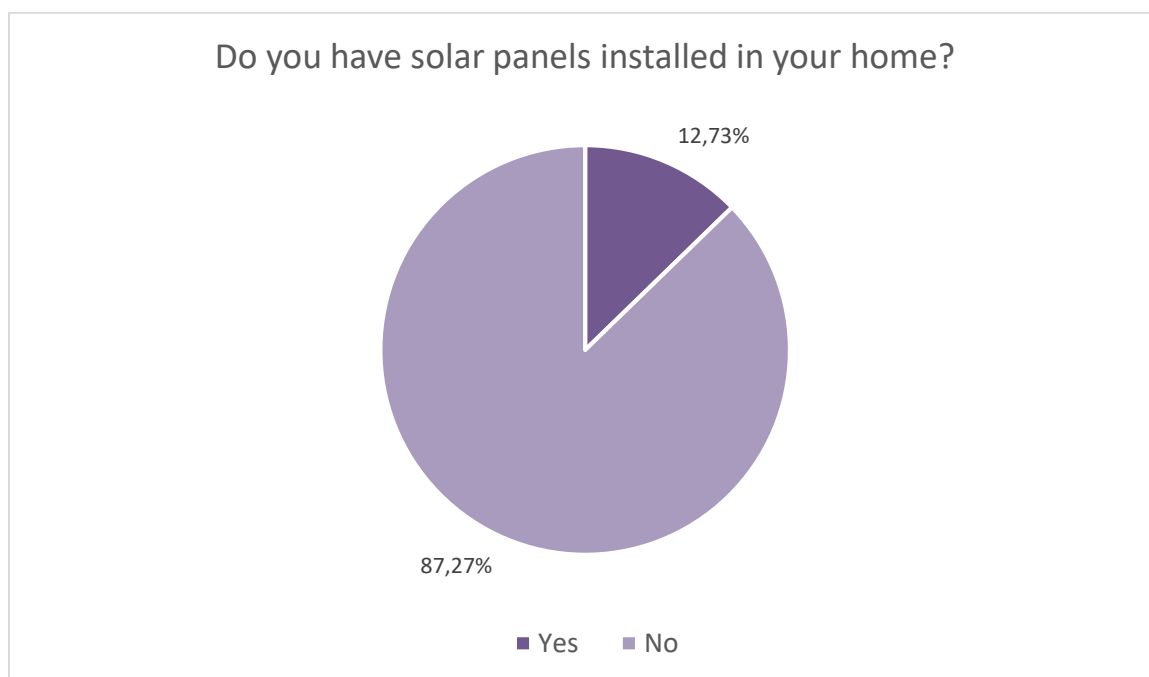


Table A4: Have you considered installing solar panels in your home?

| Responses                | Frequency | Percent | Cumulative Percentage |
|--------------------------|-----------|---------|-----------------------|
| 1 (Not at all)           | 51        | 19.10   | 19.10                 |
| 2                        | 27        | 10.11   | 29.96                 |
| 3                        | 27        | 10.11   | 41.20                 |
| 4                        | 48        | 17.98   | 59.18                 |
| 5                        | 46        | 17.23   | 76.40                 |
| 6 (Seriously Considered) | 34        | 12.73   | 90.26                 |
| Already Installed        | 34        | 12.73   | 100.00                |
| Total                    | 267       | 100.00  |                       |

Figure A4:

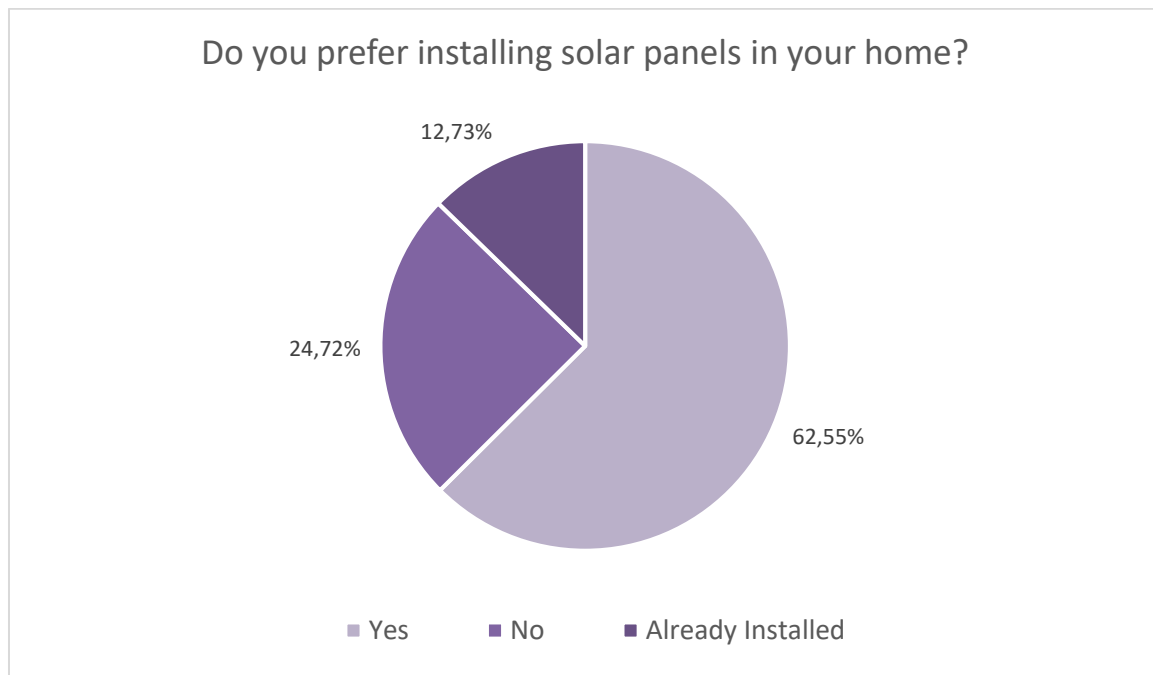


Figure A5:

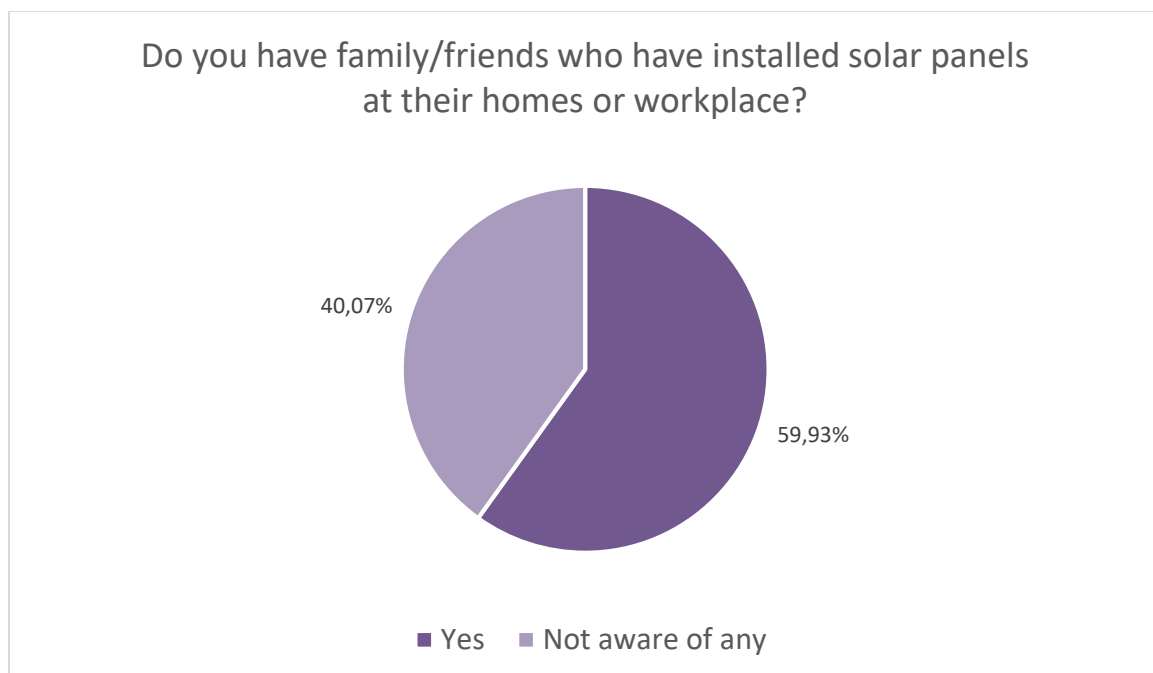


Figure A6:

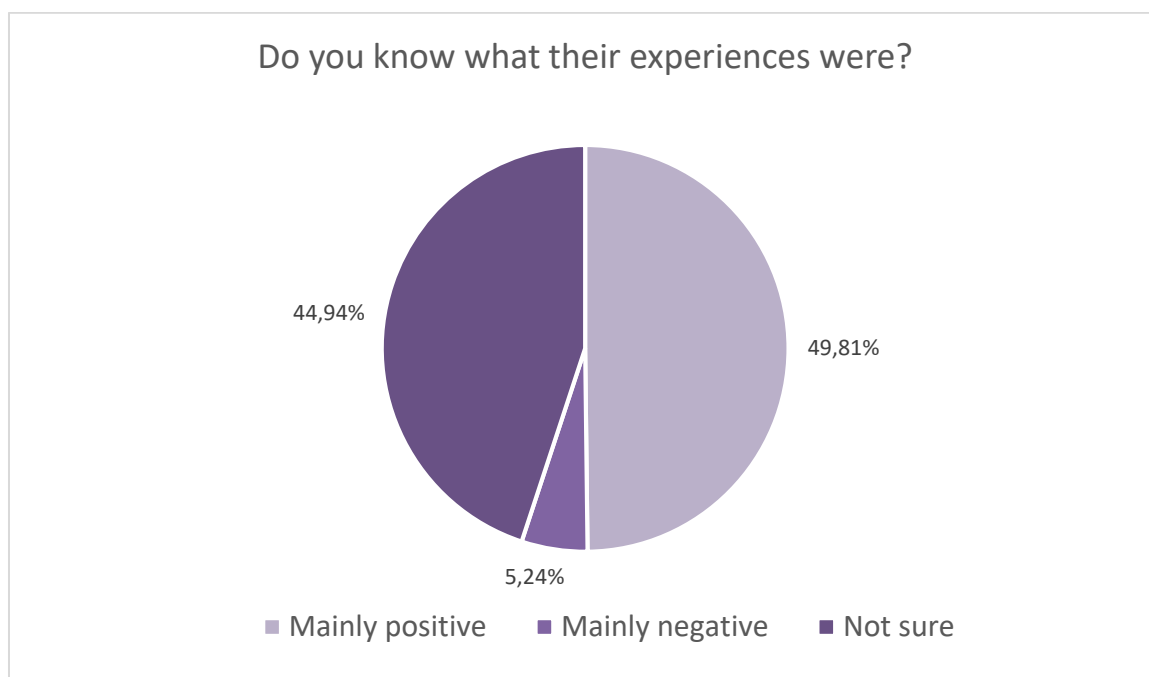
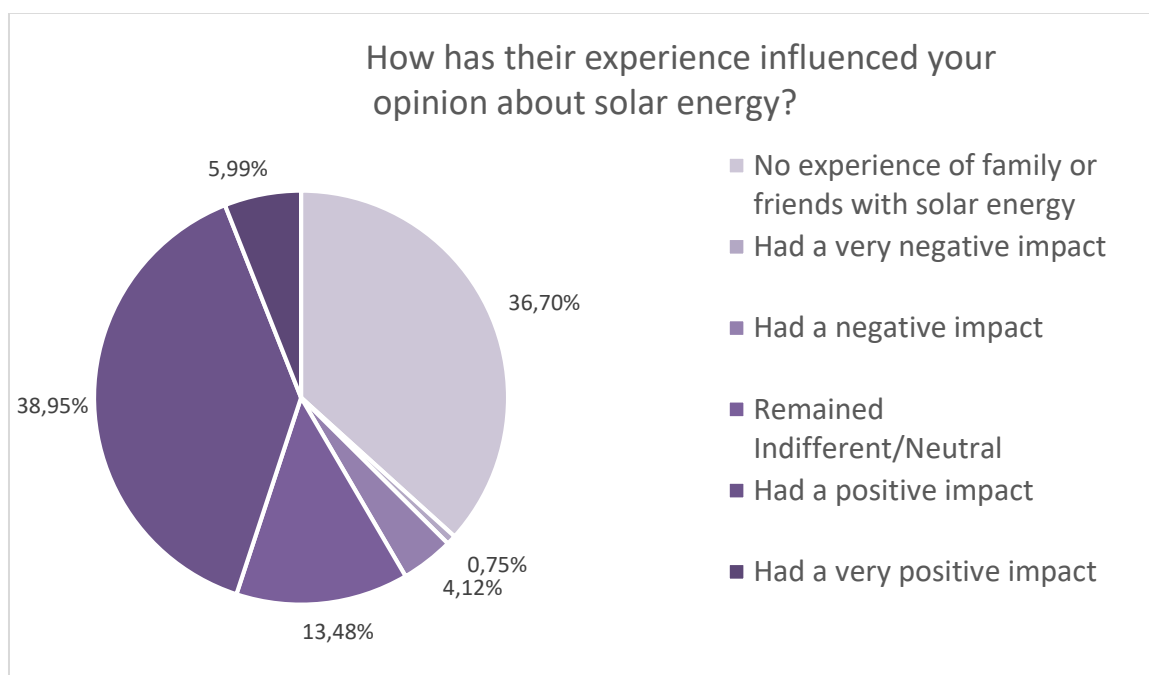


Figure A7:



*Table A5: How likely would be the respondents to consider installing solar panels in their homes if their family/friends recommended it to them*

| Values                 | Frequency | Percent | Cumulative Percentage |
|------------------------|-----------|---------|-----------------------|
| 1 (Much more unlikely) | 21        | 7.87    | 7.87                  |
| 2                      | 23        | 8.61    | 16.48                 |
| 3                      | 24        | 8.99    | 25.47                 |
| 4                      | 54        | 20.22   | 45.69                 |
| 5                      | 90        | 33.71   | 79.40                 |
| 6 (Much more likely)   | 55        | 20.60   | 100.00                |
| Total                  | 267       | 100.00  |                       |

*Figure A8: Would you be more likely to install solar panels if some incentives (e.g. subsidies) were provided to you?*

| Responses                                     | Frequency | Percent | Cumulative Percentage |
|---|-----------|---------|-----------------------|
| 1 (No, my decision would not be affected)     | 16        | 5.99    | 5.99                  |
| 2   | 14        | 5.24    | 11.24                 |
| 3   | 21        | 7.87    | 19.10                 |
| 4   | 38        | 14.23   | 33.33                 |
| 5   | 61        | 22.85   | 56.18                 |
| 6 (Yes, my decision would be highly affected) | 117       | 43.82   | 100.00                |
| Total   | 267       | 100.00  |                       |

Figure A9:

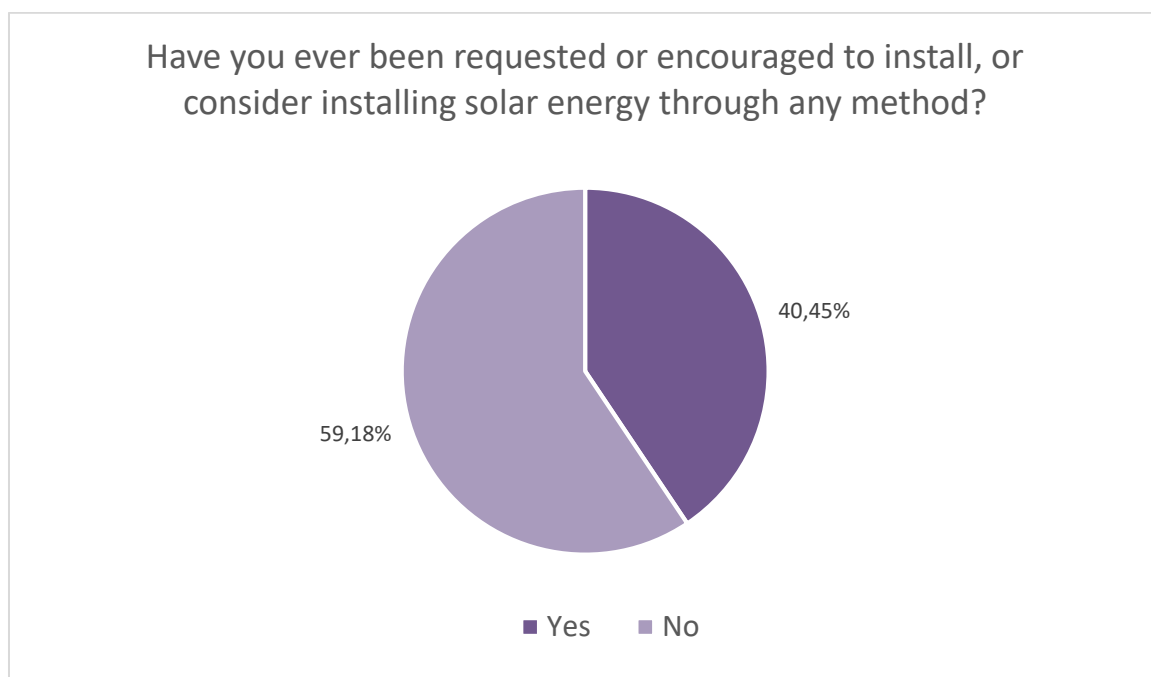


Figure A10:

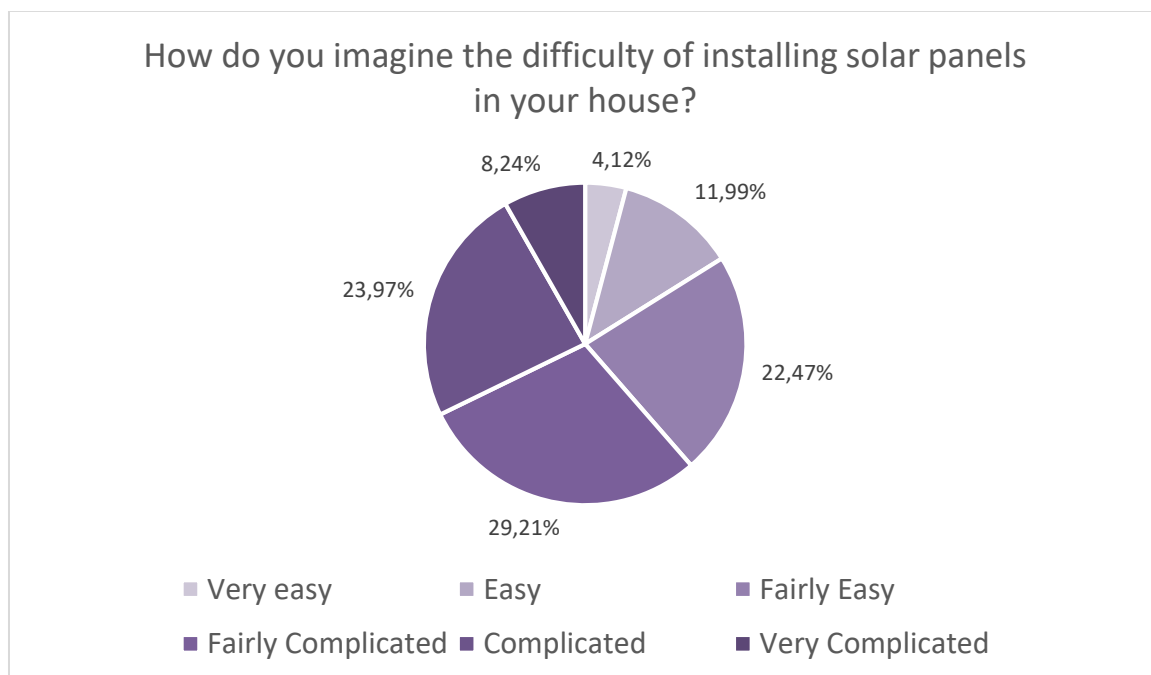


Figure A11:

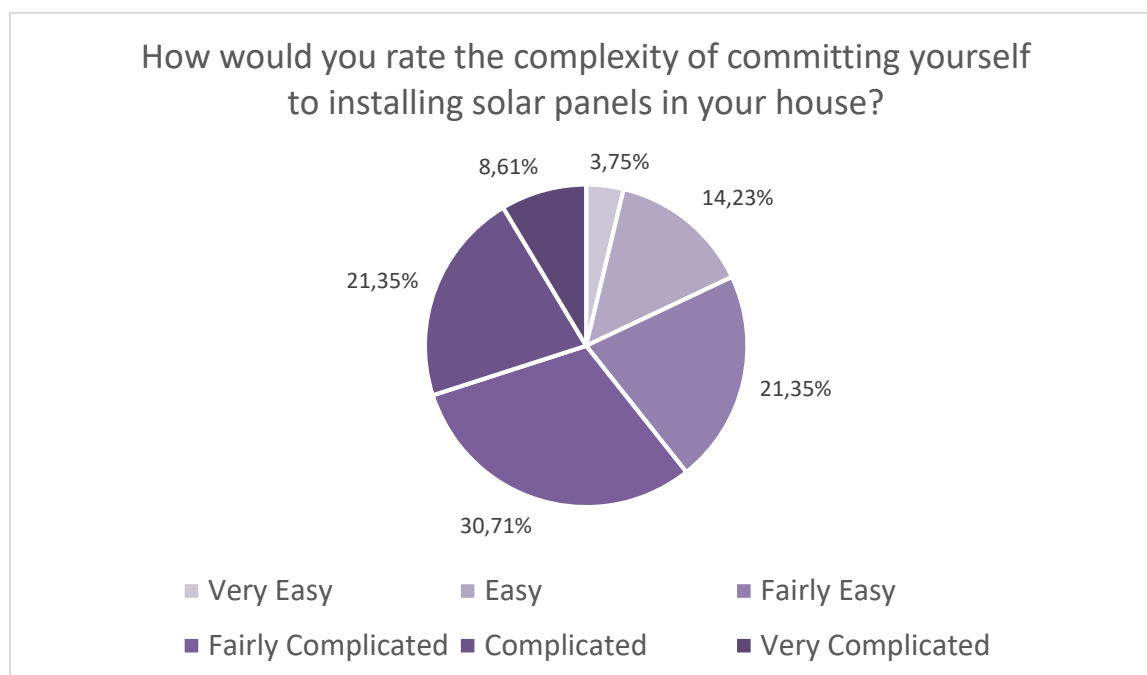


Table A9: Perception of respondents regarding the cost of solar panels in their region.

| Values | Perception of cost of solar panels | Frequency | Percent | Cumulative Percentage |
|--------|------------------------------------|-----------|---------|-----------------------|
| 1      | Very cheap                         | 4         | 1.50    | 1.50                  |
| 2      | Cheap                              | 15        | 5.62    | 7.12                  |
| 3      | Fairly cheap                       | 24        | 8.99    | 16.10                 |
| 4      | Fairly expensive                   | 41        | 15.36   | 31.46                 |
| 5      | Expensive                          | 117       | 43.82   | 75.28                 |
| 6      | Very expensive                     | 66        | 24.72   | 100.00                |
| Total  |                                    | 267       | 100.00  |                       |

*Table A10: Level of concern for respondents for getting deceived while purchasing solar panels in their region.*

| Values              | Frequency | Percent | Cumulative Percentage |
|---------------------|-----------|---------|-----------------------|
| 1 (No Concern)      | 16        | 5.99    | 5.99                  |
| 2                   | 20        | 7.49    | 13.48                 |
| 3                   | 33        | 12.36   | 25.84                 |
| 4                   | 42        | 15.73   | 41.57                 |
| 5                   | 85        | 31.84   | 73.41                 |
| 6 (Serious Concern) | 71        | 26.59   | 100.00                |
| Total               | 267       | 100.00  |                       |

*Figure A12:*

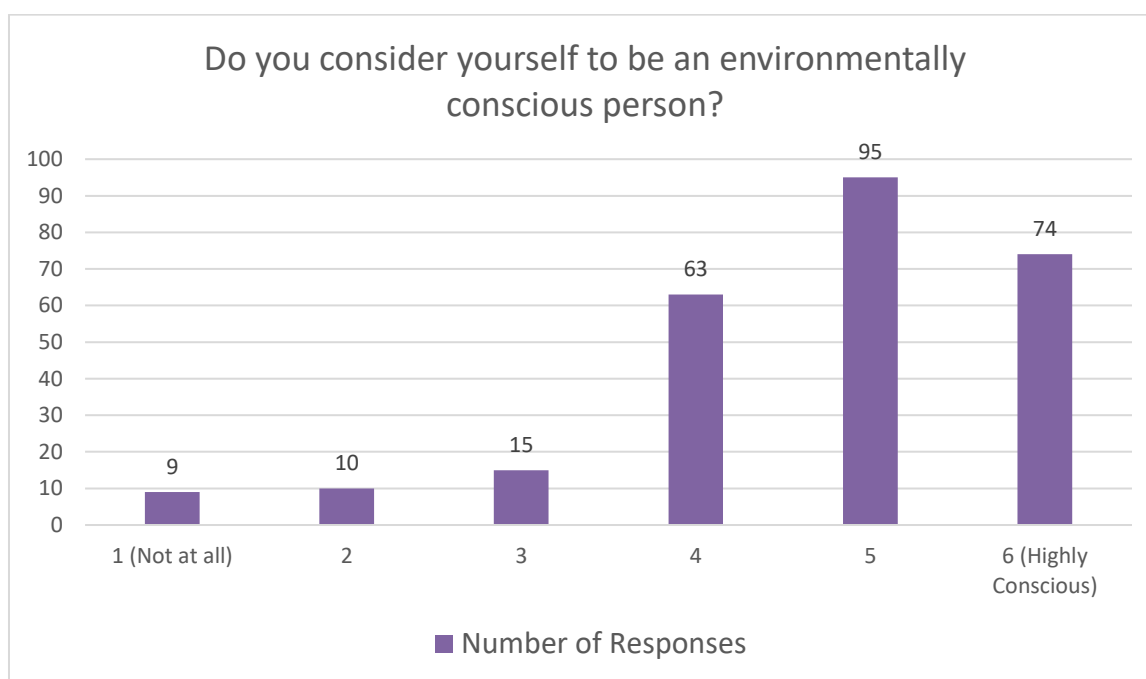


Figure A13:

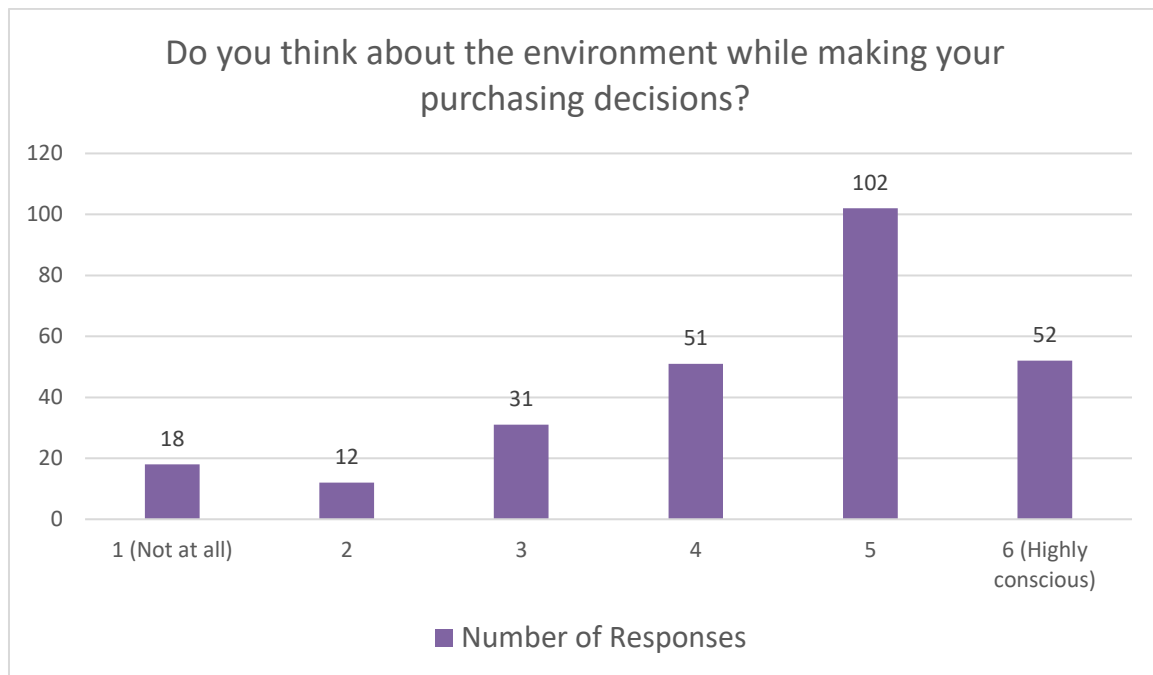


Figure A14:

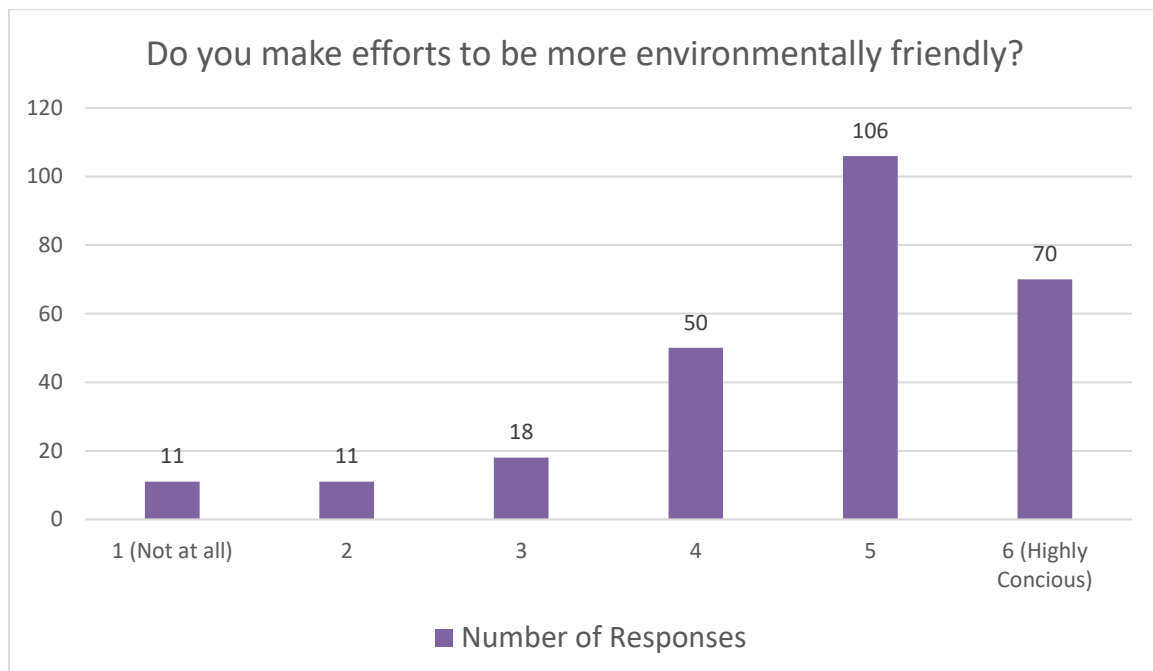


Figure A15:

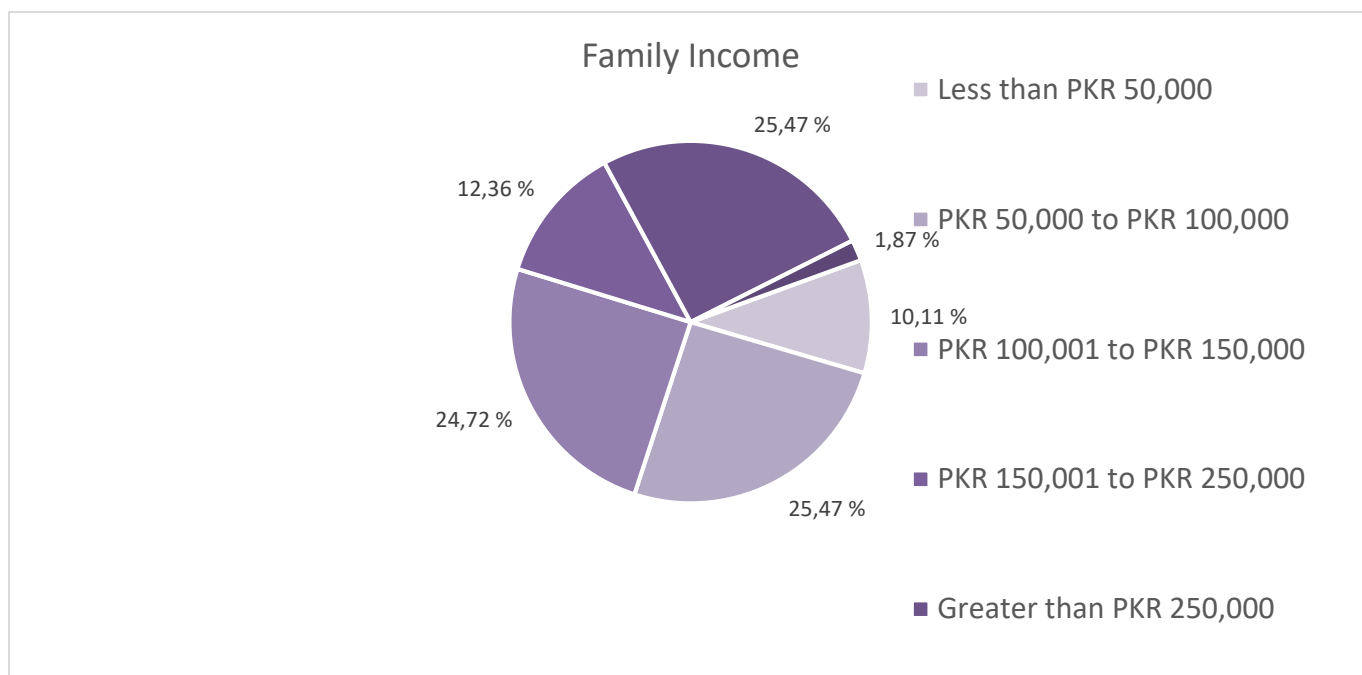


Table A11: Quotation for a 3kVA Hybrid Solar System Received from Baykee New Energy Technology Incorporated Company Limited (As of October 2017)

| 3kVA Hybrid PV System (Real-Time Sharing) w/ Backup                                    |   |                     |             |
|--|---|---------------------|-------------|
| #  | Description   | Unit(s)             | Price (Rs.) |
| 1  | Poly Crystalline PV Panels ( <i>CE Certified</i> )  | 12 Units            | 171 600     |
|  | Rating: <b>260Wp</b> (Make: Jinko Solar)  | (3.1kWp)            |             |
| 2  | <i>Low-Frequency, Transformer-based Pure Sine-Wave</i>  | 1 Unit              | 40 000      |
|  | <i>48V Hybrid Solar Inverter w/ MPPT Controller</i>   | (2,400W)            |             |
|  | <b>NK-Series 3kVA</b> Single-Phase  |                     |             |
| 3  | Galvanized Roof-Top Mounting - Standard<br><br><i>(MS Steel; Powder-Coated; Adjustable; Nut/Bolt Structure)</i>   | 3.1kWp<br><br>of PV | 31 200      |
| 4  | <b>Consumables and Installation</b><br><br><i>(Power Distribution Box, DC Wiring, Flexible Pipe, Thimbles, Copper Sleeve, Conduit &amp; Ducting, Heat-Shrink Covers, Wire Clips, MC &amp; Branch Connectors, Combiner Box etc.)</i> | As per Solution     | 28 080      |
| 5  | Deep-Cycle 12V Gel Series Batteries<br><b>48V @ 150Ah</b>   | 4 Units<br>(7+kWhr) | 115 200     |
| 6  | Rack for Battery Bank<br><br><i>(Pipe-based, Powder-coated, Air-Ventilated)</i>   | 1 Set               | 15 000      |
| 8  | Local Transportation and Delivery   | As per Actual       |             |
| GRAND TOTAL (PKR)*   |   | 401 080             |             |
| *Provided is a close estimate of the project total, subject to change based on survey. |   |                     |             |

Table A12: Daily Loadshedding Schedule for a Household in Punjab

|  |                |
|--|----------------|
|  | Sunlight Hours |
|  | Cloudy Hours   |

| Daily Loadshedding Schedule |            |                     |  |
|-----------------------------|------------|---------------------|--|
| Time                        | 1st Source | Backup              | Energy Source                                  |
| 00:00:00                    | Grid       | -                   | -  |
| 01:00:00                    | Grid       | -                   | -  |
| 02:00:00                    | Grid       | -                   | -  |
| 03:00:00                    | -          | UPS/Solar/Generator | UPS Battery Backup/Solar Battery Backup/Diesel |
| 04:00:00                    | Grid       | -                   | -  |
| 05:00:00                    | Grid       | -                   | -  |
| 06:00:00                    | Grid       | -                   | -  |
| 07:00:00                    | Grid       | -                   | -  |
| 08:00:00                    | Grid       | -                   | -  |
| 09:00:00                    | -          | UPS/Solar/Generator | UPS Battery Backup/Solar Energy/Diesel         |
| 10:00:00                    | Grid       | -                   | -  |
| 11:00:00                    | Grid       | -                   | -  |
| 12:00:00                    | Grid       | -                   | -  |
| 13:00:00                    | Grid       | -                   | -  |
| 14:00:00                    | Grid       | -                   | -  |
| 15:00:00                    | -          | UPS/Solar/Generator | UPS Battery Backup/Solar Energy/Diesel         |
| 16:00:00                    | Grid       | -                   | -  |
| 17:00:00                    | Grid       | -                   | -  |
| 18:00:00                    | Grid       | -                   | -  |
| 19:00:00                    | Grid       | -                   | -  |
| 20:00:00                    | Grid       | -                   | -  |
| 21:00:00                    | -          | UPS/Solar/Generator | UPS Battery Backup/Solar Battery Backup/Diesel |
| 22:00:00                    | Grid       | -                   | -  |
| 23:00:00                    | Grid       | -                   | -  |

#### Sources of Price of Batteries (100A) used for UPS Systems in Table 1:

Osaka: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/batteries/osaka/8499-osaka-v100z-15-plates>

Phoenix: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/batteries/phoenix/8530-phoenix-xp100r-11-plates>

Exide: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/batteries/exide/8440-exide-ex100-15-plates>

AGS: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/batteries/ags/8426-ags-gl100-12-volts-15-plates-lead-acid>

### **Sources of Price of 3kVA UPS Systems used in Table 1:**

Homage: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/inverters/homage/5915-homage-neon-hne-3009scc-3000va-2400watt-solar-inverter>

APC: [http://www.mega.pk/ups\\_products/17596/APC-SMC3000I-C-3000VA-LCD-230V-Power-Backup-UPS.html](http://www.mega.pk/ups_products/17596/APC-SMC3000I-C-3000VA-LCD-230V-Power-Backup-UPS.html)

Emerson: <https://homeshopping.pk/products/Emerson-UPS-Online-3000VA2400W-230V-PF-08-LCD-Tower-Standard-Backup-Price-In-Pakistan.html>

### **Sources of Price of 3kVA Diesel Generator used in Table 1:**

Yamaha: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/generators/yamaha/6122-yamaha-ef7200e-6-kva-generator>

Homage: <https://homeshopping.pk/products/Homage-Portable-Generator-HGR-60-KVA-G-6000-Watt-With-Wheel-Gas-Kit-Oil-Price-in-Pakistan.html>

Firman: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/generators/firman/10000-firman-fpg-9000-6.0kva-with-battery-&-gas-kit>

Elemex: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/generators/elemex/6099-elemex-sh6000dx-6.0kva-generator>

Jasco: <http://www.whatprice.com.pk/index.php/home-electrical/power-backup/generators/jasco/11035-jasco-fujigen-fg-7000-self-start-6.0kva-generator>

## Thesis Questionnaire

*\*All responses are anonymous, and data would only be used to conduct research on the proposed thesis topic.*

**Gender:**

- ☐ Male
- ☐ Female

**Age:**\_\_\_\_\_

**City:**\_\_\_\_\_

**Occupation:**\_\_\_\_\_

**Education:**\_\_\_\_\_

**Number of household members:**\_\_\_\_\_

(Please choose one response for each question)

1. Which of the following would you prefer having in your home to deal with load-shedding/power outages if equally costly?

Generators      UPS      Wind Turbines      Solar Panels      Other\_\_\_\_\_

2. Which of the following would you prefer having in your home to deal with load-shedding/power outages if they were equally costly and you knew there was no difference in their reliability?

Generators      UPS      Wind Turbines      Solar      Panels

Other\_\_\_\_\_

3. Do you have solar panels installed at your home?

- ☐ Yes
- ☐ No

4. Do you feel using solar panels for electricity generation would be beneficial for your household?  
If yes, state why:

\_\_\_\_\_

5. Do you feel using solar panels for electricity generation has drawbacks? If yes, state why:

\_\_\_\_\_

6. Have you considered installing solar panels in your home?

Not at all      1      2      3      4      5      6      Seriously considered

☐ Already installed

7. Do you prefer installing solar panels in your home?

☐ Yes

☐ No

☐ Already Installed

State reason for your stated answer: \_\_\_\_\_

8. What is the primary reason for not installing to solar energy?

\_\_\_\_\_

☐ Already installed

9. Do you have family/friends who have installed solar panels at their homes or workplace?

Yes      Not aware of any

10. Do you know what their experiences were? (Choose one to respond)

☐ Mainly positive

☐ Mainly negative

☐ Not sure

☐ Please

state

why: \_\_\_\_\_

11. How has their experience influenced your opinion about solar energy?

☐ No experience of family/friends with solar energy

☐ Had a very negative impact

☐ Had a negative impact

☐ Remained indifferent/neutral

☐ Had a positive impact

☐ Had a very positive impact

12. Would you be more unlikely or likely to install solar panels if your family/friends recommended it to you?

Much more unlikely    1       2       3       4       5       6       Much more likely

13. Would you be more likely to install solar panels if some incentives (e.g. subsidies) were provided to you?

No, my decision would not be affected    1       2       3       4       5       6       Yes, my decision would be highly affected

14. Have you ever been requested or encouraged to install, or consider installing solar energy through any method?

☐ Yes

☐ No

15. How do you imagine the difficulty of installing solar panels in your house?

Very Easy    Easy    Fairly Easy    Fairly Complicated    Complicated    Very Complicated

16. How would you rate the complexity of committing yourself to installing solar panels in your house?

Very Easy    Easy    Fairly Easy    Fairly Complicated    Complicated    Very Complicated

17. What is your perception of the cost of solar panels in your region?

Very Cheap    Cheap    Fairly Cheap    Fairly Expensive    Expensive    Very Expensive

18. How serious would be your concern of being deceived while purchasing solar panels in your region?

No concern    1       2       3       4       5       6       Serious concern

19. Do you consider yourself to be an environmentally conscious person?

Not at all    1       2       3       4       5       6       Highly conscious

20. Do you think about the environment while making your purchasing decisions?

Not at all   1   2   3   4   5   6   Highly conscious

21. Do you make efforts to be more environmentally friendly?

Not at all   1   2   3   4   5   6   Highly conscious

**Family Income:**

- ☐ Less than PKR 50,000
- ☐ PKR 50,000 to PKR 100,000
- ☐ PKR 100,001 to PKR 150,000
- ☐ PKR 150,001 to PKR 250,000
- ☐ Greater than PKR 250,000