The technological acceptance of using Solar Energy Systems in Cairo, Egypt

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1. Introduction

1.1 Background

Since the industrial revolution, anthropogenic activities like burning fossil fuels and rapid urban density, which directly affect the average global temperature, have led to an increase in greenhouse gas concentrations. Dialogues about the causes and repercussions of this phenomenon, together with worries about energy demand and consumption, have grown in recent years and are now a major topic of discussion in many international dialogues (Da Guarda et al., 2020). Moreover, climate change has become a key challenge for the society which urges the world to think of mitigation measures for the effects of global warming that are crucially needed. One way of mitigating the effects of climate change is through making our energy systems more sustainable (Da Guarda et al., 2020).

Adding clean and renewable energy to the mix of energy sources can help cut down on the use of fossil fuels and greenhouse gas emissions (Da Guarda et al., 2020). For example, through solar energy systems in terms of using technologies such as solar panels, the effects of climate change such as harmful emissions are found to be reduced. Hence implementing these systems is said to contribute to facing this societal challenge and the attempts of mitigating its effects. Although there have been great latest efforts from Egypt in supporting sustainable development which can be inspiring, Egypt's potential and resources are not yet fully utilized which piqued my curiosity (Transforming Egypt's Energy Market, n.d.-b).

Assessing how potential technology is viewed as useful is a logical approach to encourage sustainable development. It is advised to investigate technological acceptability since it would be a suitable method for assessing the acceptance of solar panel technology. So, what is technological acceptance exactly and why is it relevant? Technological acceptance is defined as the degree to which people are eager to use and adapt a new technology or innovation (Davis, 1989). There are several models that are used to explain the factors that influence individuals' attitudes and intentions to use a new technology such as technological acceptance model (TAM) which will be elaborated on throughout the paper (Venkatesh et al., 2003). The use of technological acceptance's factors in the TAM made it much easier to analyze and draw conclusions from the study of the perception of the use of solar panel technology in Egypt because the TAM specifically addresses the areas of concern that help to adequately address the research question.

Consequently, Egypt as a country has been chosen to study closely to examine the country's current status of technological acceptance towards installing solar panels. What has been done and what hasn't been done yet was sorted out by reading literature reviews and gray literature. However, there are many obstacles that prevent this evolution from moving more quickly, including the lack of technology adoption in traditional societies like Egypt. The Egyptian government has demonstrated interest by supporting initiatives like EGYPT-PV, which promotes knowledge of such technologies and exposes them to the public (Transforming Egypt's Energy Market, n.d.-b). Apart of this, there are not any current articles or literature reviews that is able to shed the light on the technological acceptance of installing solar energy systems in Cairo Egypt which has been a motivation for conducting this study.

In order to use solar energy for placing solar panels on people's homes, the motivation to investigate the technological acceptance of solar energy was subsequently generated. There are several reasons to why this study is selected along with the chosen country. Firstly, there are several papers that highlight the fact that main components of a successful energy transition include studying the perceptions of renewable energy and technological acceptance (Sütterlin & Siegrist, 2017). In addition to this the lack of study on the acceptance of solar energy systems in Cairo, Egypt piqued my curiosity in learning more about this subject. Finally, reports have shown the huge potential Egypt has for adopting solar energy systems and using it as a renewable energy source which shows that the solar energy in Egypt is not utilized to its full potential (Renewable Energy Outlook: Egypt, 2018). All these reasons triggered conducting this study and looking more into the technological acceptance of the public in Cairo Egypt and filling the research gap.

The focus of the discussion is on implementing solar panels in homes particularly located in Cairo Egypt as a mean on technological adoption. The purpose of this study is to gather information and carry out research to determine whether solar energy usage and integration of solar panels are thought to be technologically acceptable. To be more specific, the perceptions of people regarding the installation of solar panels in their houses will be the emphasis. This study also tries to determine how people view it and any potential implementation opportunities. Several influences of problems could be mitigated by implementing integrated solar energy systems by using solar panels such as climate change, energy security, environmental protection, and cost savings (Polatidis & Haralambopoulos, 2007). Nevertheless, the technological acceptance of using solar energy is an important topic because the successful adoption of renewable energy technologies depends on the support of both the local communities and stakeholders(Polatidis & Haralambopoulos, 2007).

The reason behind the significance of this study is that it is the first to examine the technological acceptance of putting solar energy systems into practice by installing solar panels in households in Cairo Egypt. By doing so, the study will be able to inform future researchers about how the subject is perceived and move them one step closer to putting these systems into practice.

The technological acceptance of using solar energy systems is an important consideration in the planning and implementation of renewable energy projects (Moharram et al., 2022). According to the electricity vision of Egypt in 2035, energy is produced up to 42 percent through different renewable energy sources (Moharram et al., 2022). PV modules is envisioned to produce 22 percent of the total electricity production which is more than half of the total renewable energy sources. Thus, this shows the great potential and the huge contribution of PV energy systems to the energy production and hence highlights the importance of this study. Moreover, by engaging with local communities and addressing their concerns, renewable energy projects can gain greater acceptance and support, leading to more widespread adoption of clean energy sources. Hopefully, it will encourage some members of the public to learn more about the options and potential uses of renewable energy in the future and to see the long-term advantages of doing so.

1.2 Problem Statement

As the world is directing more to sustainable development, naturally people tend to be interested in using solar energy systems as the importance of their implementation is peaking due to the global energy crisis (Polatidis & Haralambopoulos, 2007).

The main issue that this study is trying to solve is that Egypt has resources like the sun that, if used properly and through solar energy systems, would provide renewable energy while minimizing emissions. This could subsequently lead to aiding in sustainability development, the environment as a whole, and ultimately the climate change. Inspecting the technological acceptance from instance of implementing solar panels would be a huge step forward to get an overview of how this technology is perceived. This makes it easier to study and thus creates a more solid pathway for industries along with the government to be interested in implementing them. Since technological acceptance measures a handful of several factors that investors would surely find them insightful such as perceived ease of use, environmental awareness and perceived affordability, studying the technological acceptance has been a very attractive subject to assess. Additionally, the lack of research on my home country's technological acceptance of implementing such systems is the problem this paper is attempting to address in order to help in understanding the country's status with regard to energy systems and to serve as inspiration for future work in this area. In fact, Egypt has recently made significant investments in both large- and small-scale solar energy. Additionally, there is a growing demand for small-scale solar technologies. (Egypt PV, 2023).

Additionally, technological acceptance of renewable energy technologies is influenced by social and cultural norms, economic factors, and other factors (Polatidis & Haralambopoulos, 2007). Understanding the acceptance of installing solar energy systems is crucial for promoting renewable energy sources and achieving a sustainable future. (Von Wirth et al., 2018).

1.3 Research Objectives and Questions

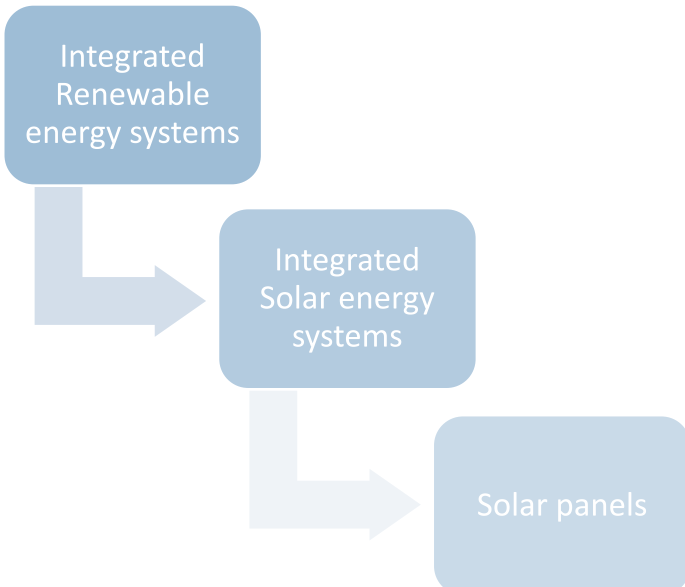
For renewable energy projects to be implemented, technological acceptance is essential. Hence, the objective of this research is to identify how people perceive these systems specifically solar energy systems in Cairo Egypt.

The questions that this research aims to answer as follows: What is the level of technological acceptance of the use of solar panels in Cairo, Egypt? To answer this research question, several sub-questions need to be answered first: What are the public perceptions of people in Cairo towards ease-of-use, usefulness, environmental awareness, and affordability? How do these perceptions affect the level of technological acceptance of people in Cairo?

2. Literature review

To gain the full picture and respond to the research topic, it was essential to look at and study certain areas. This was done so that a thorough examination of the crucial elements that must be provided in order for this research study to be powered could be made. To get to a major part of this research, which explains the significance and operation of solar panels, these research fields make multiple pauses. It was discovered that solar panels are a component of the energy systems that will be discussed in this area of the literature study after extensive investigation. The link between integrated renewable energy systems (IRES), integrated solar energy systems (ISES), and solar panels is depicted in the following diagram.

Figure 1
The relationship between IRES, ISES and solar panels.



2.1 Integrated Renewable Energy Systems (IRES)

Integrated renewable energy systems are created to enhance effectiveness, cut costs, and lessen environmental impact by utilizing the benefits of various renewable energy sources (Von Wirth et al., 2018). IRES are energy systems that combine two or more renewable energy sources into a single system to deliver a dependable and affordable energy supply (Von Wirth et al., 2018). To lessen dependency on fossil fuels and cut greenhouse gas emissions, IRES utilization is growing in popularity. In this study, the focus will be on solar energy specifically as per the huge potential this type of renewable energy has in the location that was selected (Moharram et al., 2022).

Solar, wind, hydro, geothermal, and biomass are the most prevalent renewable energy sources employed in integrated renewable energy systems (IRES) (Von Wirth et al., 2018). In order to suit particular energy needs, these sources are frequently put together in various configurations. A system might, for instance, combine solar and wind energy to supply energy at various times of the day or year, or it might combine solar and hydro energy to supply energy both during the day and at night (Polatidis & Haralambopoulos, 2007). To develop a more dependable and sustainable energy supply, these sources can be blended and included into an integrated renewable energy system. Additionally, photovoltaic solar panels are frequently utilized to produce power using renewable solar energy (Moharram et al., 2022). Among integrated renewable energy systems (IRES), integrated solar energy systems are a crucial subset.

2.2 Integrated Solar Energy Systems

Integrated solar energy systems (ISES) are becoming more prevalent and garnering greater attention as renewable energy technologies become more accessible over time. Tan et al. (2016) claim that these technologies provide a reliable and sustainable energy source that can assist lessen dependency on conventional fossil fuels and lessen the negative effects.

Many technologies are integrated in ISES with the intention of producing and storing solar powered electricity. Such systems are often referred to as “hybrid solar energy systems” or “solar plus storage systems” (Majlan et al., 2018). Moreover, these systems typically consist of solar photovoltaic (PV) panels, battery storage, and an inverter that transforms the DC electricity generated by the PV panels into AC power that can be utilized to power appliances and gadgets in a home or company (Majlan et al., 2018).

The intriguing thing about integrated solar energy systems is that they are designed to provide consistent and reliable power even when the sun is not shining (Zhang et al., 2019). The solar panels are powered by sunlight during the day, and any additional energy is stored in the battery system for later use. The home or business is powered by the stored energy at night or when there is little solar energy output (Tan et al., 2016).

Integrated solar energy systems may also incorporate other parts like charge controllers, monitoring systems, and backup generators in addition to the solar panels, battery storage system, and inverter (Zhang et al., 2019). These systems can be connected to the grid or used as standalone units that run independently to satisfy the unique energy requirements of a building or residence (Zhang et al., 2019).

Photovoltaic (PV) electricity can be integrated significantly into the national utility grid thanks to a network called solar-grid integration (Nwaigwe et al., 2019c). This is a significant technological achievement since it improves building energy balance, improves PV system economics, lowers operating costs, and adds value for both utilities and consumers. Due to a growing need for alternative, clean energy sources, solar-grid integration is becoming widespread practice around the world (Nwaigwe et al., 2019c).

It is not unexpected that Egypt receives a significant amount of solar energy. Egypt receives 3,050 hours of sunlight on average each year, ranging from 1970 to 3200 kWh/m2 for direct normal irradiations and 2000 to 3200 kWh/m2 for yearly total solar irradiance (Moharram et al., 2022). "Egypt therefore has extraordinary solar resources that can be used for a wide range of solar energy systems and businesses, including the construction of photovoltaic (PV) or concentrated solar power (CSP) plant establishments” (Moharram et al., 2022). This has acted as another motivation to study the technological acceptance of installing solar energy panels in homes/rooftops.

2.3 Solar Energy in Egypt

Egypt as per its geographical location is believed to be a top destination for renewable energy projects due to its large landmass, favorable climate, and strong winds (Bissada, 2022). The market for equipment for renewable energy sources could be worth billions of dollars (Bissada, 2022). To meet rising demand and transition to a more ecologically friendly and diverse electrical sector, the Egyptian government is aware of the need for a sustainable energy mix. The importance of renewable energy is emphasized in the 2035 Integrated Sustainable Energy Strategy, which expands on earlier programs (Bissada, 2022).

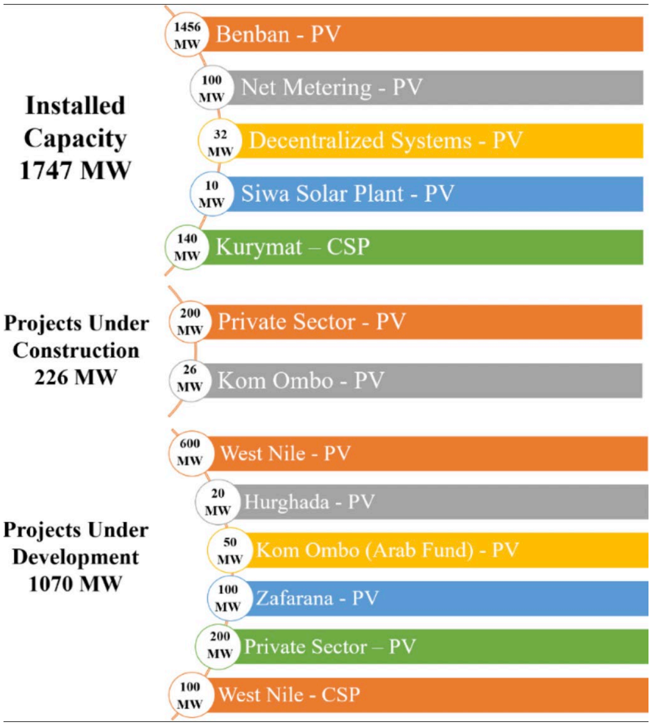
By 2022 and 2035, Egypt aims to generate 20% and 42% of its electricity from renewable sources, respectively, with wind contributing 14%, hydropower 1.98%, photovoltaic (PV) 21.3%, wind 14%, concentrated solar power (CSP) 5.52%, and conventional energy sources accounting for 57.33%. It is noticeable that PV has the highest overall percentage compared to the reset of the renewable sources hence, this was a driver to focus on it specifically in this study (Bissada, 2022).

By implementing small, decentralized, grid-connected Photovoltaic (PV) systems with an easily replicable and scalable system design in homes and small- and medium-sized businesses, UNDP, and the government hope to lower the barriers to increasing power generation. This initiative is known as the award-winning "Egypt-PV" project (Transforming Egypt's Energy Market, n.d.-b).Solar panels are a sensible investment that can lower electricity bills while providing dependable power for families and businesses." Over 40 initiatives enabled the setup of 129 solar system plants in 15 governorates, which installed capacity of 11 MWp, with 17.6 GWh/year electricity in different factories, hotels, commercial and admin buildings, houses, educational facilities etc." (Transforming Egypt's Energy Market, n.d.-b). The New Administrative Capital, which installed 16 MWp over 52 government buildings in the new metropolis, has also received technical support from the project. Through projects like these, the awareness of such technologies increases and therefore contributes to the technological acceptance of the public (Egypt PV, 2023).

The supreme council for energy has approved a revised version of this plan that will represent energy generated from renewable sources at a rate of 33 percent by 2025, 48 percent by 2030, 55 percent by 2035, and 61 percent by 2040. This strategy is thought to be quite upbeat. Most of this capacity is anticipated to be provided by the private sector. According to Egypt's Solar Atlas, with 2,000 to 3,000 kWh/m2/year of direct solar radiation, Egypt is a "sun belt" nation. From north to south, the sun shines for 9 to 11 hours per day, with rare days having clouds (Bissada, 2022).

Global Solar Atlas estimates that Egypt has a solar energy capacity of 74 billion MWh annually (n.d.). Projects utilizing solar energy have long been recognized as being profitable. The estimated quantity is considerably higher than Egypt's present electricity output (Mazlan et al., 2016) Moharram et al., 2022). Following the response from the Ministry of Electricity and Renewable Energy, numerous solar energy collection and generation projects have been constructed, or are in the process of being constructed, to gather solar energy and generate electrical power using a variety of solar energy technologies (The Ministry of Electricity and Renewable Energy, n.d.), as shown in Figure 2 (Moharram et al., 2022).

Figure 2
Solar power projects in Egypt (Moharram et al., 2022).

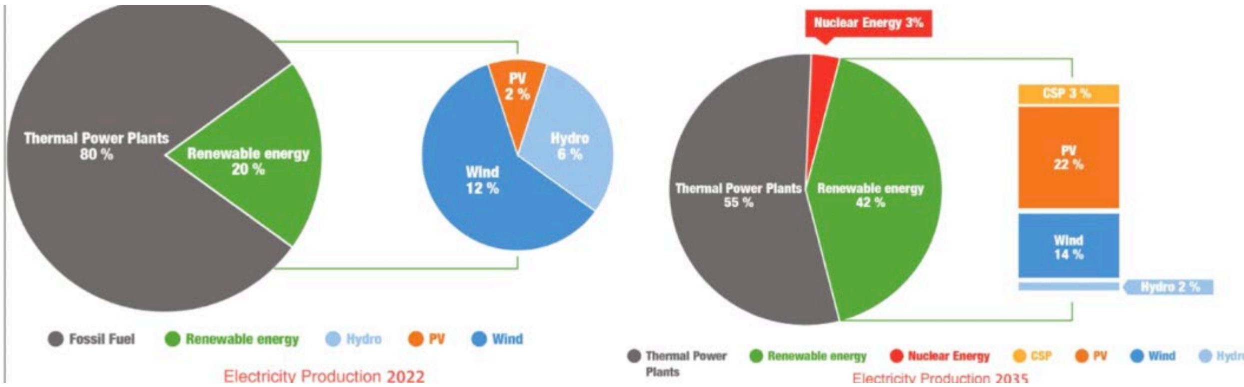


The Beneban Solar Park, the Siwa Solar facility, and the Kuraymat Concentrated Solar Power (CSP) facility are Egypt's three largest solar energy projects. It can be noticed that implementing PV modules in the private sector is still under development and construction which spikes a question as into why this the case with all the capacity Egypt is has from weather resources to start such practices. This triggers this research as into whether the public is aware of Egypt's energy status, potential options to invest in to encourage clean energy for a more sustainable and environmentally friendly country (Moharram et al., 2022).

In 2009–2010, 4% of the energy used for primary energy generation came from renewable sources, with hydropower (3%) and wind power accounting for the bulk of this 1%. The percentage of electricity produced by renewable energy sources will rise to 20% by 2022 and to 42% by 2035, according to the Egyptian government's plan. Solar energy generates 25% of the power generated by renewable energy sources, with wind energy providing the remaining 14%, as shown in Fig. 1. In the near future, it is anticipated that the private sector will provide most of these abilities. The New and Renewable Energy Authority (NREA) and the Ministry of Electricity and Renewable Energy (MERE) jointly issued a presidential proclamation designating 28 areas, as shown in Fig. 3 [(أهداف الطاقة المتجددة - هيئة الطاقة الجديدة والمتجددة, n.d.), to provide resources for the development of large-scale renewable energy initiatives. (Moharram et al., 2022).

Figure 3

Electricity Production future classification (Moharram et al., 2022).



These renewable energy options can be combined and integrated into an integrated renewable energy system to create a more reliable and sustainable energy source. About 19.2 GW of total electricity will be produced in 2021 by renewable energy sources. The government must encourage the output of renewable energy to reach 62.6 GW by 2034/2035, (*Renewable Energy Outlook: Egypt*, 2018) with goals of 50.5 GW in 2029/2030 and 62.6 GW in 2034/2035. The World Energy Outlook estimates that by 2035, renewable energy will generate 42% of all Egyptian power. The capability of installed renewable energy over time is shown in Fig. 4. (Moharram et al., 2022).

Figure 4
The evolution of Egypt's renewable energy capacity in GW (Moharram et al., 2022).

Type of Power Station	2009/10	2021/22	2029/30	2034/35
Hydro	2.8	2.8	2.8	2.9
Wind	0.5	13.3	20.6	20.6
PV	0.0	3.0	22.9	31.75
CSP	0.0	0.1	4.1	8.1
Total	3.3	19.2	50.5	62.6

2.4 Limitations of Implementing Solar Energy Systems

A big part of the limitations of implementing solar energy systems is the lack of awareness that people have on the technology itself. It is generally believed that customers who have more information about new technologies are more likely to adopt them ("Impact of Perceived Ease of Use, Awareness and Perceived Cost on Intention to Use Solar Energy Technology in Sri Lanka," 2020). It's crucial to remember that public opposition to solar energy systems can also hinder their uptake.

The possibility that individuals will desire to adopt a technology greatly declines when they are misinformed or do not fully comprehend it. This can be explained by the fact that a new technology's likelihood of being accepted is significantly decreased by ignorance (Zografakis et al., 2010). Furthermore, utilizing new technologies sometimes involves additional costs, which may not be convenient for clients, especially if they are unaware of the advantages of the technology. It's interesting to note that the study published in the Research Publishing Academy (RPA) journal Journal of International Business and Management (JIBM) highlighted the significance of perceived cost as "the single most important factor that influences consumer adoption of innovation."

Customer must find new technologies affordable compared to alternatives for them to be adopted. If the cost is perceived as being too high, consumers might not find it feasible to embrace a new technology (JIBM-RPA, n.d.). Given that perceived affordability is one of the TAM model's four main criteria, these results support the decision to use it. This will be examined in more detail in order to find out more about how the public in the selected sample group feels about technology. Implementing renewable energy systems helps address some of the most important environmental challenges, such as climate change, and provides a variety of additional benefits as well. However, due to the region's favorable atmosphere, Cairo, Egypt strongly encourages the usage of solar energy systems as one of the renewable energy sources.

This is confirmed by a study of the country's 2035 energy goal, which calls for a 22 percent dependence on solar energy—more than half of the nation's overall dependence on renewable energy sources (Moharram et al., 2022). This emphasizes how crucial it is for the nation to adopt solar energy systems.

2.5 Technological Acceptance in Egypt

The purpose of this study is to evaluate the technological acceptance of solar panels in Cairo, Egypt. The following paragraphs will examine the literature study that outlines the key factors for examining Cairo's technological acceptability as well as how people who live there feel about adding solar panels to their homes. This study seeks to better understand Cairo attitudes and perceptions concerning solar energy systems by evaluating these variables.

The acceptance of these chances was not addressed in a study that offered energy prospects and views on energy difficulties in Egypt (Rezk, 2019). A different framework was created to research the use of renewable energy in floating hotels, using Egypt as a case study. The results of this study, which even though it wasn't focused on solar energy systems, showed the potential of deploying solar panels on floating hotels and prompted more investigation into whether solar energy systems would be accepted in Egypt, especially in Cairo (Rezk, 2019b). This study offered insightful analysis for analyzing the technological acceptance of solar panel installation in Cairo residents' homes.

A thorough examination of renewable energy sources, including their technologies, difficulties, and suggestions, was also deemed to be instructive. Additionally, this study emphasized Egypt's enormous potential for solar energy due to its highest daily normal irradiance values in North

Africa, which range from 2000 to 3200 kilowatt per meter squared per year and an average of 9 to 11 hours of sunshine per day (Salah et al., 2022).

According to the examined literature, Egypt has a significant opportunity to adopt solar energy systems because of favorable meteorological conditions, for example (Rezk, 2019b). To learn more about how the public views these technologies, particularly solar energy systems, more research is encouraged and recommended (Rezk, 2019b). These results emphasize the necessity for more research into the public's comprehension and acceptance of solar energy systems in Egypt.

After some investigation, it was discovered that not a single work directly addressed and elaborated on the issue of Cairo Egyptians' acceptance of solar energy systems, which leaves a knowledge gap and suggests a potential subject of study. As a result, in this proposal, the literature review uncovers this knowledge gap, which will be thoroughly filled in the following sections using the methodology of choice.

The effectiveness of the switch to renewable energy depends on the community's (local) acceptance of it, particularly as many nations change their energy policies to focus on decarbonization (Cousse, 2021). It's interesting to note that new research contends that people's opinions and choices towards solar energy may be swayed by the favorable symbolic connotations associated with this technology, thus producing skewed risk assessments (Siegrist and Sütterlin, 2014). This discovery has generated interest in future research into how the public views renewable energy technology, which are frequently greeted with hostility at the local level but are typically well-received nationally (Sütterlin & Siegrist, 2017; Huijts et al., 2012; Wüstenhagen et al., 2007).

A growing variety of elements are being investigated to better understand their influence on the public's acceptance of technology, which has been the subject of scholarly study (Gupta et al., 2012). Socio-psychological components that are used to assess attitudes have advanced over time, reflecting more recent ideas in this area. There is little information on the role of public perception and community acceptance of renewables for developing and growing economies, including the MENA countries (Hanger et al., 2016), even though traditional determinants like perceived danger, perceived reward, trust, guilt, knowledge, individual differences, and attitude continue to be important (Gupta et al., 2012). In this paper, the TAM theory will be to identify the technological acceptance of implementing solar energy in Egypt. This theory will be elaborated on in the next chapter.

Among other things, cultural, societal, and economic norms can all influence how well solar energy systems are received (Sütterlin & Siegrist, 2017). Solar panel utilization may raise worries, even though most people support and have good opinions toward renewable energy (Sütterlin & Siegrist, 2017). A successful energy transition requires not only overcoming enormous technical challenges, but also public and technological acceptance (Sütterlin & Siegrist, 2017). Participating local communities in the design and construction of renewable energy system projects is crucial to boosting acceptance and support. Furthermore, spreading knowledge about these systems' advantages, such as lower energy costs and better air quality, might increase public adoption of technology (Polatidis & Haralambopoulos, 2007).

As a result of the thorough literature review, the knowledge and research gap in the case of Cairo, Egypt, was successfully discovered. The knowledge gap in this study was determined to be the technological acceptance of installing solar panels on homes. To address this precise gap, no prior research has been conducted.

3. Conceptual Framework

Although they can be related in some instances, public acceptance and technological acceptance are two separate concepts that will be defined explicitly in chapter 3. In simple words, public acceptance includes the level of support or approval that a particular innovation, policy, or idea has among members of the public or a specific target audience (Devine-Wright, 2007).

To determine peoples' perceptions of new technology or a pressing societal issue, for instance, surveys, focus groups, or social media analysis can be used to estimate popular approval (Devine-Wright, 2007). There are several factors that contribute to the acceptance of the public which include personal factors such as age and gender along with psychological factors that include political beliefs and perceived impacts (Devine-Wright, 2007).

Technological acceptance, on the other hand, often touches on the degree to which people are willing to use and adopt a new technology (Yang, 2021). It typically focuses on how useable and useful the technology itself people is rather than how feel about technology. The acceptance of technology can be influenced by its usability, perceived value, and user attitude. (Taherdoost, 2018). This idea is frequently discussed in relation to professional or organizational contexts where the effective adoption of new technology can raise output and efficiency.

In this study, the focus is on analyzing the level of technological acceptance of a specific target group in Cairo, Egypt and how they perceive solar energy systems specifically installing solar panels in homes. The study of technological acceptance was chosen precisely because the findings of this research perfectly match the criteria for measurement in the framework for technological acceptance. Public approval and social acceptance were also taken into consideration, however some research, described in section 3.1, revealed that they are not entirely consistent with the aim of the study. In other words, this study aims to look at factors such as usefulness and affordability of installing a technology like solar panels, social and public acceptance are not quite fit for the framework and the research issue that should be addressed.

3.1 Acceptance

Since acceptance is a major part of this study, understanding exactly what acceptance is, its types and its significance is very essential to have a clear overview of the whole study. Acceptance as a term has been attempted to get defined several times in different papers. Consequently, the proposed definition of acceptance by the paper Koirala et al. (2018) is as follows: When members of a public unit (such as a nation, community, organization, or family) have a favorable attitude, intention, behavior, and, where appropriate, use towards a proposed or existing technology or socio-technical system (Koirala et al., 2018).

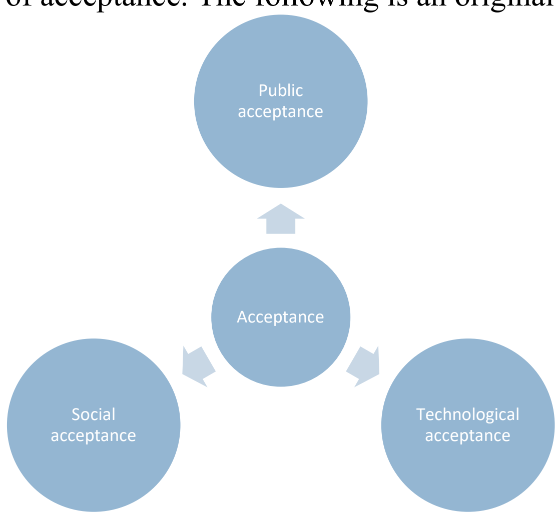
According to this definition, acceptance first suggests the development or proposition of a technological artifact or socio-technical system (Koirala et al., 2018). The idea of approval could then be reduced to its most basic meaning, which would be the absence of an oppositional reaction. However, acceptance can also refer to stronger, more positive qualities like attention, support, and even admiration (Koirala et al., 2018). Because developers need the acceptance, the readiness to accept, and the actual use of their developments by external individuals and decision units, acceptance is frequently regarded as one of the key aspects of societal reactions to energy technologies (Koirala et al., 2018)

Acceptance is only one aspect of the larger phenomenon of how people, groups, and societies interact with energy developments, even if we agree that acceptance is the key psycho-social component in the process of diffusion of energy technologies (Upham et al., 2015). In essence, acceptance involves dynamic, multi-dimensional processes that are not only masked using a single word, but also seen from various angles as the result of or a component of several processes (Upham et al., 2015).

One could contend that the word "acceptance" is troublesome and difficult to get rid of. As stated by Batel (2017) in the article, "If we keep focusing on this term - whether intentionally or unintentionally - we are not only perpetuating the normative top-down perspective on people's relations with energy infrastructures, but we are also potentially ignoring all the other types of responses to those, such as support, or uncertainty, resistance, apathy, among others". Acceptance, however, is undoubtedly at least slightly more neutral in its attribution of cause and more general in its breadth of application, despite being in many ways similarly simplistic in its obscuring of objects and processes (Batel, 2017).

Figure 5

The three relevant types of acceptance. The following is an original figure.



There are different types of acceptance which include, public acceptance, social acceptance, and technological acceptance as shown in figure 5(Devine-Wright, 2007;Vacas et al., 2020;Venkatesh et al., 2003). It is necessary to know the difference between these types of acceptances to avoid confusion as both public and social acceptances are related concepts it has slightly different meanings.

Public acceptance refers to the level of approval or support that a particulate policy, decision, or action receives from the public or society at large (Schumacher, 2019). It can usually be measured through various indicators such as opinion polls, media coverage, or public protests (Veenstra & Koole, 2018). Public acceptance considers elements including how people perceive, hold opinions about, act, and value the innovation in question (Devine-Wright, 2007). The level of acceptance or approval that a given behavior or action obtains from a particular group or community within society is referred to as **social acceptance** (Vacas et al., 2020). In summary, social acceptance is more concerned with the attitudes and behaviors of subgroups within society, whereas public acceptance is more concerned with the broader perception of society (Vacas et al., 2020). This group may be based on factors such as race, ethnicity, religion, gender, sexual orientation, or other shared characteristics (Vacas et al., 2020).

Technological acceptance refers to the degree to which people are willing to use and adopt a new technology or innovation and this is the most optimum type of acceptance found for this study (Davis, 1989). There are several theories and models of technological acceptance that explain the factors that influence individuals' attitudes and intentions to use a new technology such as technological acceptance model (TAM) which will be mentioned in the next paragraph (Venkatesh et al., 2003). The use of technological acceptance's factors in the TAM made it much simpler to analyze and draw conclusions from the study of the perception of solar panel technology in Egypt because the TAM addresses the precise areas of concern that help to adequately address the research question.

To measure this technological acceptance of the public, several theories were reviewed to find the most suitable one for this study. The next paragraph explains the two theories that were considered for this study. The selected is further explained in section 3.2 along with the reasons for adopting it for this study in the same section.

Two main theories were reviewed which are 1. Technological acceptance model theory and 2. Social acceptance theory. Social acceptance theory focuses on attitude, social and personal norms as well as perceived behavioral control and intention (Upham et al., 2015). It also emphasizes on the fact that the social psychology mainly focuses on theories of planned behavior and norm activation risk perception, environmental concern, values, norms, behavior, and social representations (Upham et al., 2015). This theory includes approaches that are categorized according to the disciplines such as economic, social, psychology and cultural theory. Although the social acceptance theory is relevant, the technical acceptance model theory which will be elaborated further in the next section was found to be more optimum for this study as we are tackling the solar energy system technology specifically.

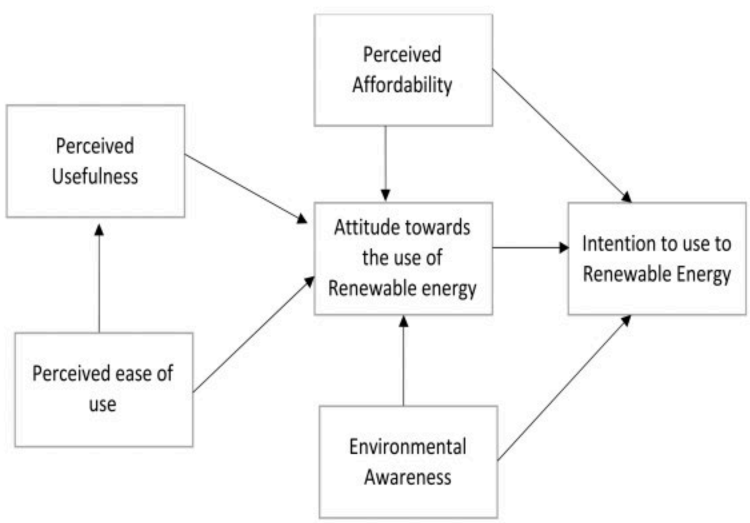
3.2 Technological Acceptance Model Theory

Public knowledge of the problem and the value of using renewable energy has increased because of studies on public opinion. Understanding how consumers feel about and intend to use renewable energy is essential given the increasing demand for it on a global basis.

The most well-established and fundamental paradigm for technology acceptance was developed by Davis and is called the technology acceptance model (TAM) (Carter, 2005). The theory of reasoned action (TRA) and the theory of planned behavior were combined to create the TAM (TPB). According to Ducey and Coovert (Ducey & Coovert, 2016), the TAM demonstrates that a person's attitude toward a particular technology or innovation and their subsequent desire to adopt that technology are significantly influenced by their beliefs regarding the perceived usefulness and ease of use of that technology. According to Azjen and Gilbert Cote (Yang, 2021), one of the main determinants of a person's intention to utilize technology is that person's attitude toward technology.

The TAM is founded on the hypothesis that users' acceptance of a technology is influenced by two variables: perceived utility and perceived usability. While perceived ease of use refers to the user's perception that utilizing the technology will be simple and require little effort, perceived usefulness refers to the user's opinion that a technology will improve their job performance (Dudgey and Coovert (2016). According to Bandar and Amarasena (2018b), customer perceptions of perceived ease of use are influenced by their views on the installation, regular use, upkeep, and recycling of new technology. The most significant predictor of a person's goals or behaviors, according to (Verma et al., 2018), is attitude. An individual's attitude toward the behavior in issue can be either positive or negative, according to Fishbein and Ajzen. (Yang, 2021) This research will demonstrate how perceived affordability and environmental consciousness together can affect how renewable energy is accepted in Egypt. Thus, in addition to the TAM's original variables, the research also considers perceived affordability and environmental awareness. **Figure 6** depicts the hypotheses that were derived from the TAM's initial version (Yang, 2021).

Figure 6
The Technology Acceptance Framework (TAM) (Yang, 2021)



In summary, the Technological acceptance theory (TAM) is a widely used model that explains how users come to accept and use a new technology. The theory suggests that users' acceptance depends on their perceived usefulness and ease of use of the technology, as well as other factors such as social influence and perceived risk (Yang, 2021).

TAM was found to be most relevant and tailored to this study. Through the survey, the four indicators were measured, which are perceived usefulness, perceived affordability, perceived ease of use and environmental awareness. All of these elements are thought to influence both the intention to use renewable energy and the attitude about its use. The four indicators include perceived usefulness, perceived ease of use, environmental awareness, and perceived affordability How valuable the technology being tested is to the consumers is mostly determined by perceived usefulness. The user's perception of how simple it is to interact with and use technology is measured by this factor. Additionally, perceived affordability measures how cost-effective it is for the consumer to employ the given technology. The last factor to consider reflects the user's knowledge of his surrounds and the environment: his level of environmental awareness.

It is crucial to emphasize the fact that this approach has some drawbacks as well, which should be considered. One of TAM's limitations is the variable that refers to client behavior, which must be evaluated using subjective criteria like behavioral intention and interpersonal influence (Malatji et al., 2020). Social influence, on the other hand, refers to the subjective norm in which a person is influenced by "word of mouth" from a coworker (Malatji et al., 2020b). Another drawback of TAM is the inability to accurately quantify the underpinnings of behavior in an observed study due to numerous subjective factors, such as societal values and conventions, personal characteristics, and personality traits (Shahzad et al., 2018)(Hayes et al., 2018).In other words, even though the idea might be accurate in theory or for personal use of invention, it might not necessarily be accurate or trustworthy in a professional setting(Malatji et al., 2020b).

Perhaps it is useful to emphasis on the difference between perception and technological acceptance to provide more clarity. Although they are related, perceptions and technological acceptance are two different ideas. People's perceptions are essentially how they interpret and comprehend information in light of their beliefs, values, and experiences (Davis, 1989b). A number of variables, including cultural background, individual prejudices, emotions, and cognitive ability, can affect how people perceive things (Venkatesh et al., 2003b). For instance, while some people may view new technology as exciting and helpful, others may view them as a risk to their privacy or ability to keep their jobs. In conclusion, perceptions can affect how well a technology is received, but they are not the same thing. While technological acceptance is more objective and impacted by variables that are frequently out of an individual's control, such as the availability and cost of technology, perceptions are subjective and based on personal experiences Venkatesh et al., 2003b) (Davis, 1989b).

4. Research Design

The research is divided into steps to see the flow of the work. The main idea of this research is to explore the technological acceptance of using solar energy systems in Cairo Egypt. This paper aims to study the current state of awareness of the public of ISES and how people in Cairo are interested in the implementation of these systems. Additionally, this study provides us a better understanding of public opinion and pointers on how to motivate people to utilize solar energy systems in order to have more sustainable energy and thereby help create a society that is more ecologically conscious. The nature of the research perspective was established to identify the acceptance of such technologies the possibilities of integrating solar panels specifically in Cairo. Since Cairo is Egypt's capital and has the most residents, it was especially chosen for this study. This indicates that a sizable population has various perspectives on the technology, therefore confronting Cairo would result in a variety of research findings. Cairo serves as a primary representative of Egypt because it is the capital city with the highest population. Additionally, I originally come from Cairo, Egypt, which increases my connections with people who would be interested in taking part in this research compared to other cities in Egypt, making it simpler to contact people to answer the question. Last but not least, Cairo, Egypt is home to many large solar energy installation projects like EGYPT PV, which provides this research a head start by starting in the same location.

The explanation of the research framework is the following (see also figure 7): First, Literature review about ISES in Cairo Egypt was done to establish a conceptual framework for the scope of the project. After that a literature review of TAM theory was obtained to understand concepts involved with technological acceptance of the energy systems in Egypt specifically. The next step was to create surveys to get information from residents of the chosen area to better understand their level of knowledge, their acceptance of the topic, and how willing they are to execute it. Following analysis of the data gathered, conclusions will be drawn from surveys, scientific literature, and gray literature. Finally, conclusions and correlations were made using the data analysis findings in accordance with the TAM that was chosen. These results included assessments of the degree to which solar energy deployment was technologically acceptable, and practical suggestions were made to support the process of adoption.

Figure 7

Methodology of this research

4.1 Literature Review

Some of literature review was done as shown previously on the current energy status in Cairo Egypt. This literature includes academic literature, grey literature, public reports, and governmental reports. My search strategy was first to gather articles and journals using keywords such as: technological acceptance, Egypt, Solar energy systems using Scopus. After that the content was filtered out through reading the abstract and selecting the relevant ones. The reports were specifically searched for to gather specific information about the country's current energy status.

To tackle the research question completely it is essential to have a clear understanding on two components of this study which is the level of solar energy systems acceptance technology in Egypt and the definition of technological acceptance. It is often confusing as the use of social and technological acceptance is sometimes interchangeable. To make sure the study is clear, both terms were explained and defined to avoid confusion.

In addition to this, technological acceptance as a concept was researched along with the different theories of it that were considered to find the optimum one for this study. After some research TAM was found to be the best theory for this framework and hence verified and used. There are four indicators to TAM which were studied and measured through literature review and surveys for verification. These indicators were found to be those four:1. Perceived usefulness, 2. perceived ease of use, 3. Environmental awareness and 4. perceived affordability. These indicators are the underlying main concepts the survey would attempt to verify and measure.

4.2 Survey

The survey was designed in a way to get a clear idea of the identity of the participant, such as his gender, age, level of education and occupation. Quantitative data collection is an approach to be applied as it aligns with this study's main aim which is to measure the level of technological acceptance of a specific technology, which in this case is solar energy systems. Having said that, distributing a survey was an optimum way to collect the data required to answer the research question and provide us insights of the public's perceived technology implementations. The previous claim applies because surveys give the researcher the opportunity to gather both a large number of responses and an array of stakeholder perspectives.

Implementing integrated energy management system is necessary to minimize the grid usage while depending on more environmentally friendly and sustainable energy sources such as solar energy. Through these questions, strong conclusions were done that helped in forming a clear idea on the factors that contribute to the patterns and attitudes of individuals towards the perceived technology implementation. The technology that was referred to in the survey was the solar PV panels that are installed on the roofs of houses. The survey was distributed to university students, different residential compounds, gyms, and other public places to make sure the data collected includes the biggest selection of individuals of different age and professions in Cairo Egypt. It targeted people 18 years old and above to have a big amount of data to analyze. This fortunately gave us insights on how willing the public is to integrate renewables and the future potential of relying on possibly on renewable energy fully in the future. The survey was then passed around through a link or a QR code to which the participant can scan and access it with ease. This study concentrated on the unanswered problems about the social and technological implications of implementing integrated solar energy systems, such as solar energy. Along with this question, potential answers to what other factors that make the public lean towards these solutions.

The aim of this survey was to get data to answer the main research question along with the sub questions. For instance, these questions include: What is the level of technological acceptance of solar energy systems in Cairo, Egypt? The main target was to have from 100- 150 for as a sample size for this study for a reliable and valid data as calculated by the sample size calculator, which will be elaborated on in the next section. To be exact, 132 responses in total were gathered, which is within the targeted calculated range, throughout the whole process.

The questions that were included in the survey(refer to the appendix for survey questions) were formulated depending on the four indicators that are mentioned as a part of the TAM. Moreover, the main concern of the question was to retrieve the perceptions of residents of Cairo on usefulness, ease-of-use, affordability, and environmental awareness of solar energy systems. Based on these responses, I was able to establish a clear level of technological acceptance.

The Likert scale is primarily a psychometric scale frequently used in surveys-based research. Although there are various forms of rating scales, it is the most extensively used method of sizing replies in survey research (Joshi et al., 2015). There are different types of LIKERT scales, 7 point and 5-point scale. Strongly disagree, disagree, slightly disagree, either agree or disagree, somewhat agree, and agree are examples of responses on a 7-point Likert scale used to measure agreement, while responses on the scale are also used to measure frequency and satisfaction. 5-point scale is the same idea as the 7 points but with 5 responses.

In the conducted survey, the 5-point Likert scale was selected to narrow down the responses to be just enough to carry on the required analysis. For this research, the research units are individuals that live in Cairo Egypt. The surveys were strictly distributed to these individuals. The limitation of this research is not being present in the research area to notice behaviors and specific situations that might occur during taking surveys.

The total number of individuals who took the survey was 132 in total, all of them living in Cairo, Egypt. 62 females and 70 males to be exact. 53% are male and 46% female Which is almost but not equal. The main set aim was to get 100-150 responses to help have an idea about where the technological acceptance of solar panels in Cairo, Egypt stands. By using a sample size calculator, the population of Cairo was inserted which is 22million, along with an 80 percent confidence level of the response and 6 percent +/- margin of error. The sample size was then calculated to be 114 responses or more. The sample size used was 132 which is more than the calculated one and hence acceptable for this study.

The use of mean values was then done and calculated to determine levels of acceptance of the respondents for each indicator. To determine if an indicator is above or below the average, the mean value of the mean values for each indicator was determined. By comparing the mean values of all 4 indicators, it was much simpler to respond to the research question of this paper. These numbers reflect whether the majority of people have a positive or negative opinion of each indicator. The mean value was calculated through an online calculator and the values were recorded for each question and afterwards to each indicator. The average mean value was calculated for each indicators using its corresponding mean values of its relevant questions respectively. By calculating the average mean value of each indicator, value was generated for each one to show the acceptability of each one. Finally, a final mean value was calculated using the same method to give a final overview of all four indicators in this study collectively. In the next section, a table will be provided to clearly show each question with its corresponding mean value for clarity.

4.3 Data Analysis

There are four indicators of the TAM model that are be considered in this study to further look into the technological acceptance of the people as mentioned previously in section 3.2. The four indicators will be tested through questions in the survey to answer the research questions and sub questions.

These indicators were found to be those four:
1. Perceived usefulness
2. Perceived ease of use
3. Environmental awareness
4. Perceived affordability

For data analysis, the results of the survey are compared and analyzed to draw conclusions. Microsoft excel was used as a qualitative data tool for this study for analyzing the collected data via the distributed survey. Descriptive statistics was used which focused on describing the selected sample to draw predictions and conclusions about the population based on the findings within the sample.

The main research question is: What is the level of technological acceptance of integrating solar energy in the energy systems in Cairo, Egypt?

Table 1
Sources of the Research Perspective

Research Question	Data Required	Methods
What are the public perceptions of people in Cairo towards ease-of-use, usefulness, environmental awareness, and affordability?	Public perceptions towards the above-mentioned indicators usefulness, ease of use, environmental awareness, and affordability.	Survey, Literature review
How do these perceptions affect the level of technological acceptance of people in Cairo?	Public perception towards adopting new technology such as solar panels in their homes.	Survey, literature review

Note. The above table demonstrates the research questions and sub questions, methods of research and theories used to answer them.

Ethical Approval

A few steps were carried out to prevent ethical issues. The survey includes the reason for conducting this research along with the time required to fill it out in the introduction part. A clear statement was included to make it clear that the participants are free to respond to all or none of the questions. The participants' privacy in the survey was treated with the utmost respect. Participants signed a` consent form in the survey's final section to confirm their free will and provide permission to utilize the results for scholarly research.

The data collected through the survey will remains only with the researcher and not one else has access to it. Ethical considerations were done right after the thesis proposal was accepted and reviewed to enable the data collection and survey distribution phase.

5. Findings

This chapter is about all the findings that were gathered through the survey. A description of the sample is also touched on along with the survey results. First the survey results are stated followed by the sample description and followed by adding the results of each question in the survey with its corresponding graph such as bar graphs for reference. The section is concluded by the last part which includes the survey details section which sums all the conclusions of the survey responses together by quantifying the data collected through studying the mean value of each question and comparing them through an answering scale which will be discussed thoroughly in this section.

5.1 Survey results

The questionnaire consists of 2 different parts,

- Questions in the first part are for gathering "personal and basic information" of participants which was mainly 8 questions.
- The second part were questions related to the four indicators, which are ease of use, affordability, perceived usefulness, and environmental awareness.

The scales implemented were customed made according to the questions. For instance, for usefulness, the 5 options varied from not useful at all, slightly useful, moderately useful, very useful, and extremely useful. The same applies to ease of use and the other 3 indicators of technological acceptance.

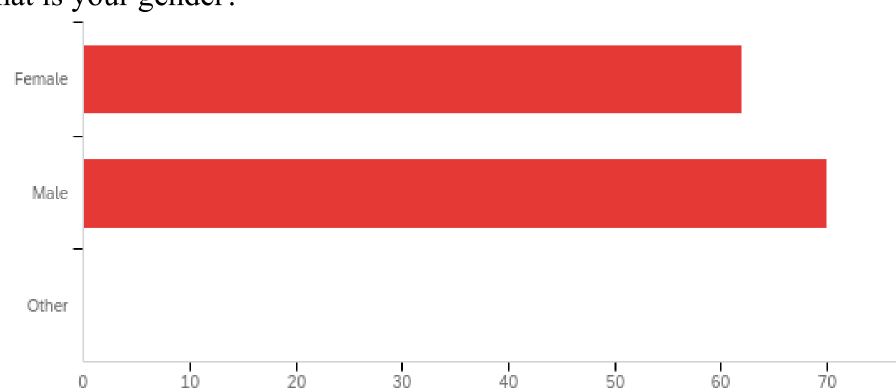
5.1.1 Sample description

The sample was sufficient to give conclusions according to the formula used to calculate the number of responses required. There was a good mix or responses in terms of genders and age which aided in the analysis of this research to be well rounded and fair as much as possible. In this section, the survey results are displayed in graphs to help visualizing and analyzing the data collected and draw conclusions.

Figure 8

The bar chart shows the result of question 1

Q1 - What is your gender?

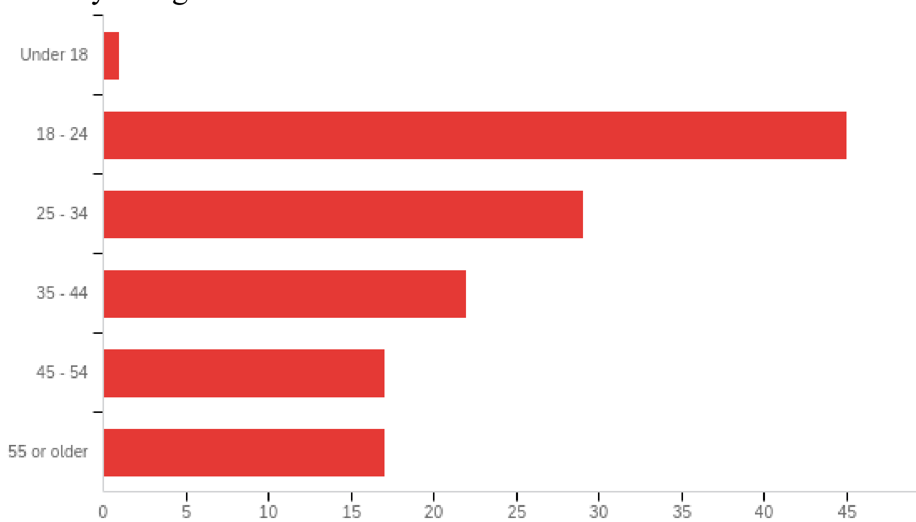


The number of respondents concerning the age groups was not evenly spread which affected the results and quality of responses. Although they were not exactly equal, there was quite a mix of respondents from different age groups. The highest percentage of people taking the survey were between the ages of 18 and 24, and they were 34 percent of the total respondents and 45 people in total. Participants were mostly between 18 and 24 of age which around 34%, followed by the next category up to 34 which is 22%, and then the following category between 16 percent 12%, and 13%. The rest belonged to the rest of the age groups. The first two questions were asked to know more about the sample size that is been used to help in drawing conclusions and logical explanations later on.

Figure 9

The bar chart shows the result of question 2

Q2 - What is your age?



The survey results are divided into two parts. The first part tackles general information about the respondents' backgrounds and the second one is about the four indicators of technological acceptance. The questions of the survey revolved around the four indicators as mentioned previously in the conceptual framework according to the Technological acceptance Framework, the four factors which were looked into. The four indicators were measured, which are perceived usefulness, perceived affordability, perceived ease of use, and environmental awareness. As all of these elements are thought to influence both the intention to use renewable energy and the attitude about its use. The last few questions were general questions regarding the respondents' thoughts on such technologies about the environment and GHG emissions.

In this part after the general questions, the survey was designed to test the awareness of the respondents regarding the topic of technology of installing solar panels. The five questions included in this part are questions 4 to 8. (Refer to the appendix for the questions).

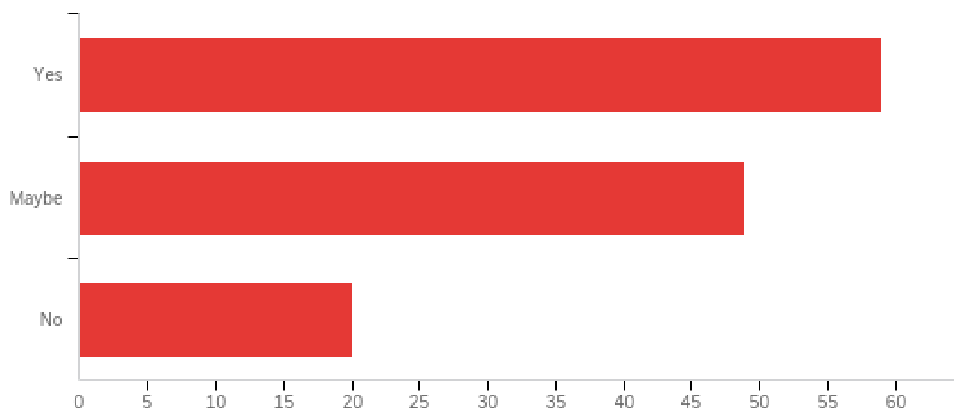
The results of these questions were very interesting and were helpful to conclude later on in the next section. For question number 4 only 8 people out of the 132 respondents have solar panels installed at home. This is quite a very small number compared to the total number of responses which triggered deeper analysis. This question shows that only 6% installed Solar panels which indicates the need to promote the use of renewable energy in the domestic sector and there is awareness of the importance of solar panels it's to contribute to sustainable development in Egypt.

For question number 5, the biggest percentage of people answered “yes” to the consideration of installing solar panels.45 percent said yes, 38 percent answered maybe, and 15 percent answered not as shown in the bar chart below. With the consideration of solar panels it was greatly responded that they will be considered with the percentage of 46% and probably 38% Meanwhile it was rejected by 15.6%. This result shows that there is good awareness of solar panels and it's important to be used at homes.

Figure 10

The bar chart shows the result of question 5

Q5 - Have you ever considered installing solar panels at your home?

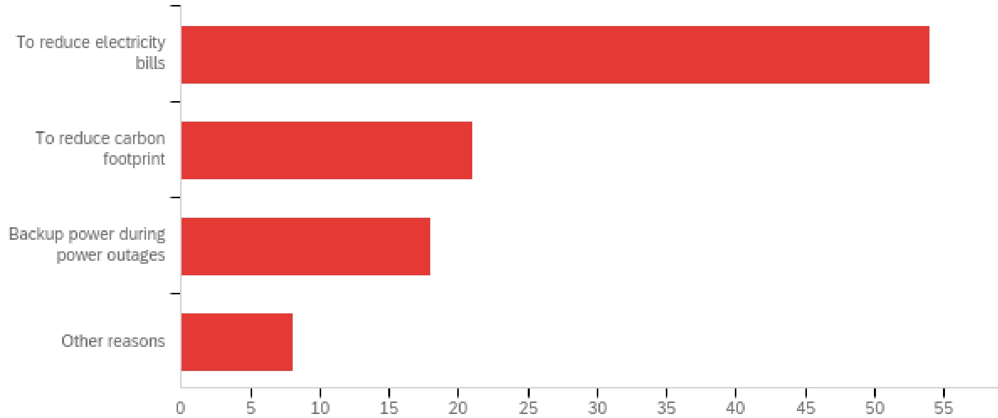


For question 6, the majority of the people who said they are considering installing solar panels, their reasoning was to reduce electricity bills. The results show that's economic impact to reduce the electricity bill has the most influential factor with 53% followed by any deduction of the carbon footprint with 20% which shows that environmental awareness should be enhanced. A good amount of almost 18% is also considering solar balance as a backup during power outages.

Figure 11

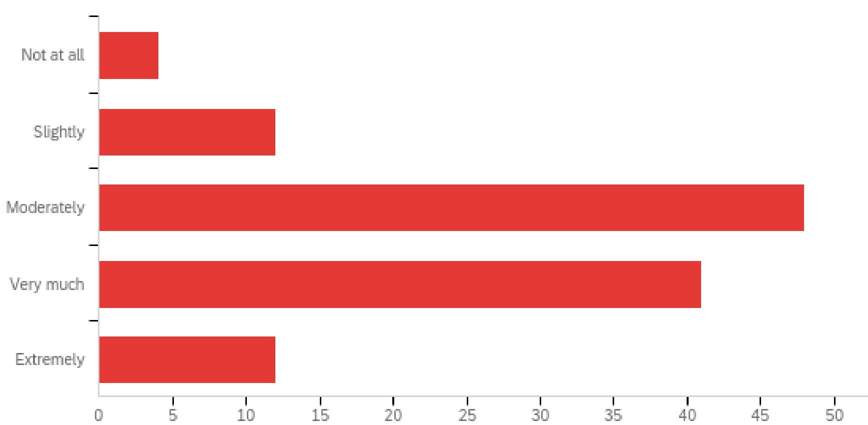
The bar chart shows the result of question 6

Q6 - If you answered "yes" to question 5, what are your reasons for considering installing solar panels at your home?



Regarding question 7, the majority responded that they think that solar electricity can fulfill everyday electricity requirements moderately. Fortunately, most of the participants believe that solar energy is reliable, and they can depend on which is showing clearly as moderately dependent 41% and very much by 35%. This means that they don't have a strong opinion on whether it can fulfill their needs or not. This can either be a result of their lack of knowledge regarding the effectiveness of installing solar panels at home or that they are still not convinced about the performance of those solar panels.

Figure 12
The bar chart shows the result of question 7
Q7 - To what extent do you believe solar electricity can fulfill your everyday electricity requirements?



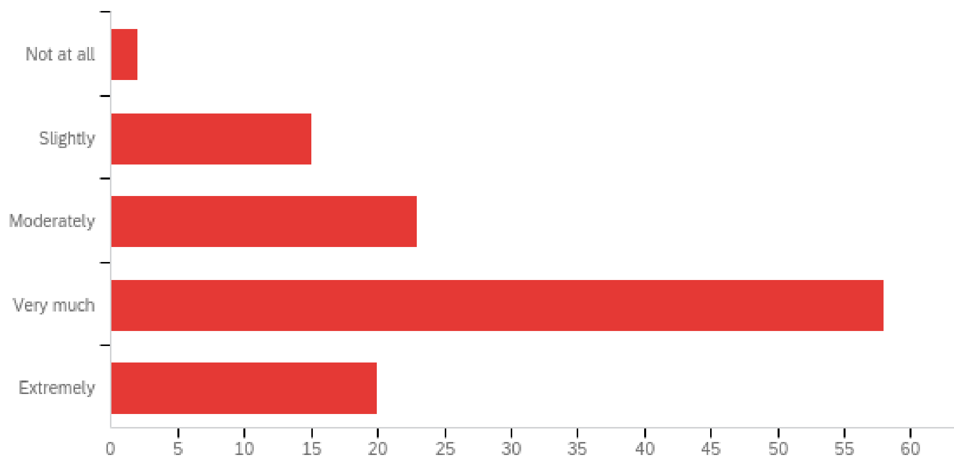
The last question (question 8) of the first part was testing the respondent's awareness of the link between using solar panels at home and the reduction of GHG emissions. 57 people answered very much and 20 people answered extremely, which is 65 percent of the total number of respondents. Most of the opinions think that the installation of solar panels good contributes to reducing GHG and affects climate change, which gives adequate awareness of environmental issues

This is a very promising number as it indicates that the respondents do realize the link between these two things. The four indicators that were focused on and tested as mentioned before are perceived usefulness, affordability, ease of use, and environmental awareness.

Figure 13

The bar chart shows the result of question 8

Q8 - How much do you think installing solar panels at home could contribute to reducing GHG emissions and address climate change?



Questions 7 and 8 are the last two questions before focusing on the four indicators. These two questions support in drawing conclusions later on as the responses provide an idea about the general level of awareness of the respondents in terms of crucial important topics such as climate change in terms of rising technologies which in this case is specifically solar panels. Additionally, they relate their views on how using a more sustainable source of energy relates to their everyday electricity needs.

5.1.2 Perceived usefulness

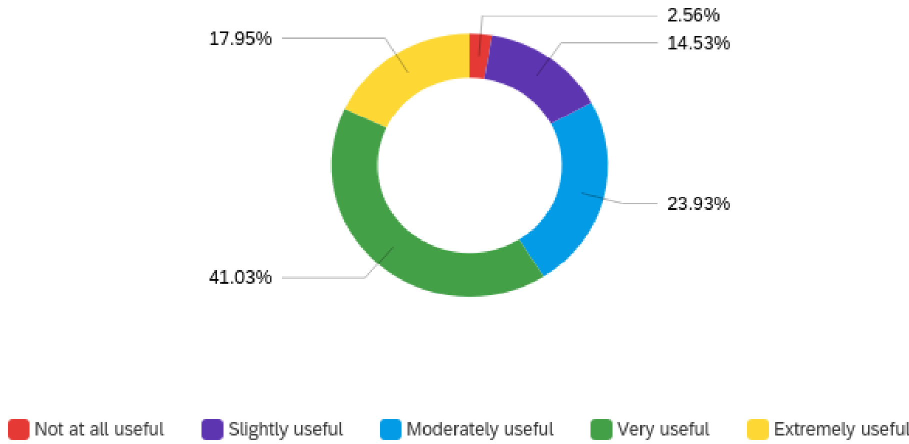
There were two questions that tackled this indicator which are: How do you feel about the usefulness of solar panels at home in your daily life activities? And do you think installing solar panels is more useful than using regular energy systems?

For the first question, more than 50 percent agreed that it is either very useful or extremely useful to use solar panels at home in their daily life activities. 29 percent of the respondents answered moderately useful, which reflects their uncertainty about the usefulness of the technology. Again, most of the participants feel that it is very useful to utilize solar panels in daily activity, this also promotes implementing solar panels in Egypt

Figure 14

The bar chart shows the result of question 10

Q10 - Perceived Usefulness: Do you think installing solar panels is more useful than using regular energy systems?

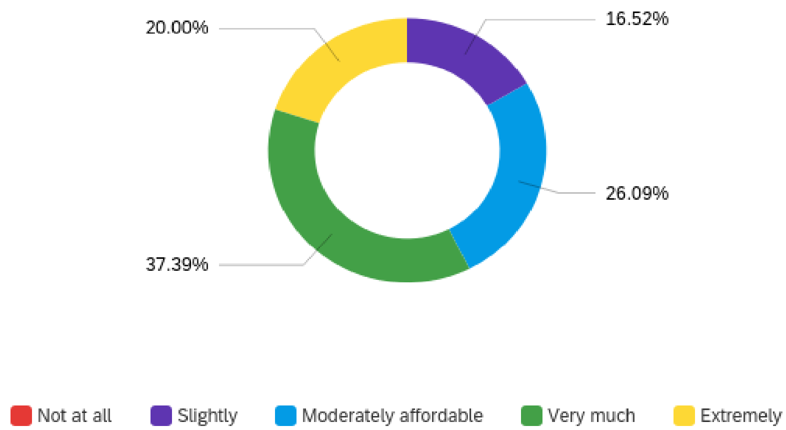


For the second question, the question was added to get an idea about how useful the respondents think of installing solar panels compared to using regular energy systems. 18 percent of the respondents answered extremely useful, and 40 percent of the respondents answered very useful. Both of these makeups more than 50 percent of the responses, which indicates that it is fairly perceived as useful compared to regular energy systems. All in all, perceived usefulness was found to have positive feedback according to the responses to the relevant questions, Hence, this in practice means that a big portion of the respondents agree that installing solar panels is useful.

5.1.3 Affordability

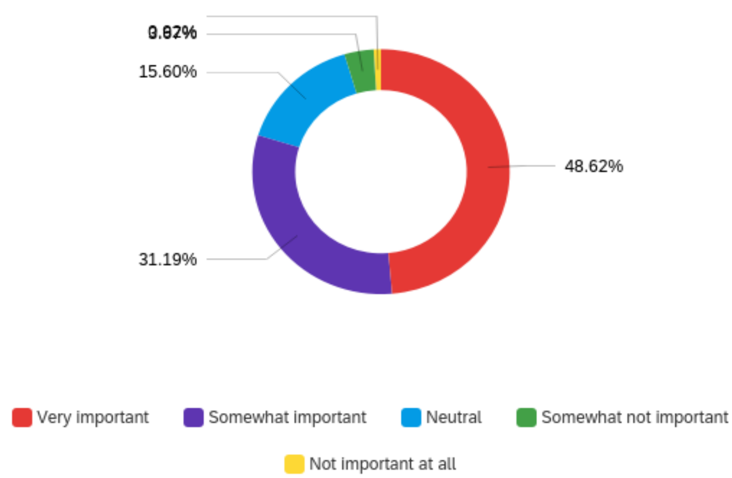
There were three questions included in the survey to tackle the indicator "Affordability". Questions were designed to track people's thoughts on solar panels regarding energy bills and the importance of their costs in general. The three questions included in this part are questions 11 to 13. (Refer to the appendix for the questions)
As shown in Figure 14, for question 11, the majority answered that installing solar panels at home would be very useful in terms of lowering energy bills. The next highest percentage was moderately useful. Most of the participants think that solar panels when lower their energy bills very much which has a significant economic impact on the family budget.

Figure 15
The bar chart shows the result of question 11
Q11 - Affordability: Do you think installing solar panels at home would lower your energy bills?



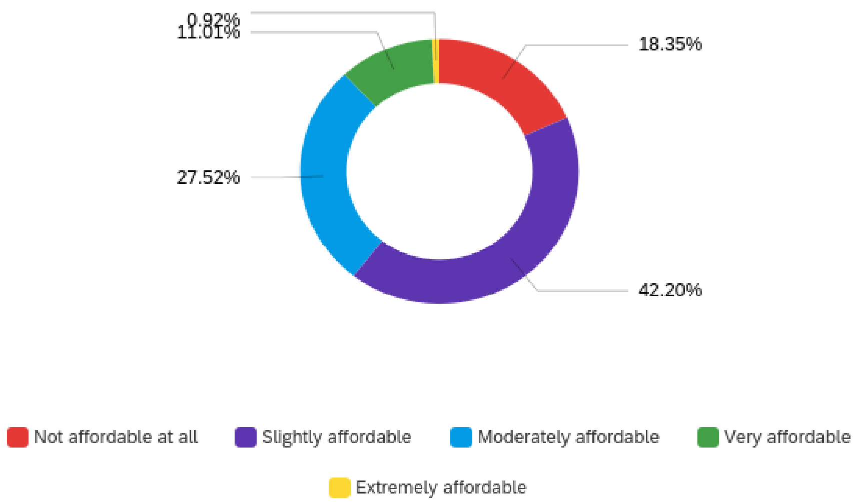
For question 12, the question was written to test the importance of the affordability of installing solar panels to the respondents.52 people answered very important, and 34 people answered somewhat important. This is 86 people out of 131 which is more than 50 percent of the total number of respondents. This could be portrayed in the corresponding chart.

Figure 16
The bar chart shows the result of question 12



The last question was whether the respondents think installing solar panels is affordable or not. Only one person answered extremely affordable. The highest percentage belonged to the answer slightly affordable at 42 percent which is 46 respondents. It is also crucial to consider the upfront cost of installing solar panels, as this is something that most participants worry about, as well as the participants' financial resources, as most of them believe they are only just able to purchase solar panels. This indicates that the majority of them do not believe it to be affordable, which will help support the conclusions reached in the next section.

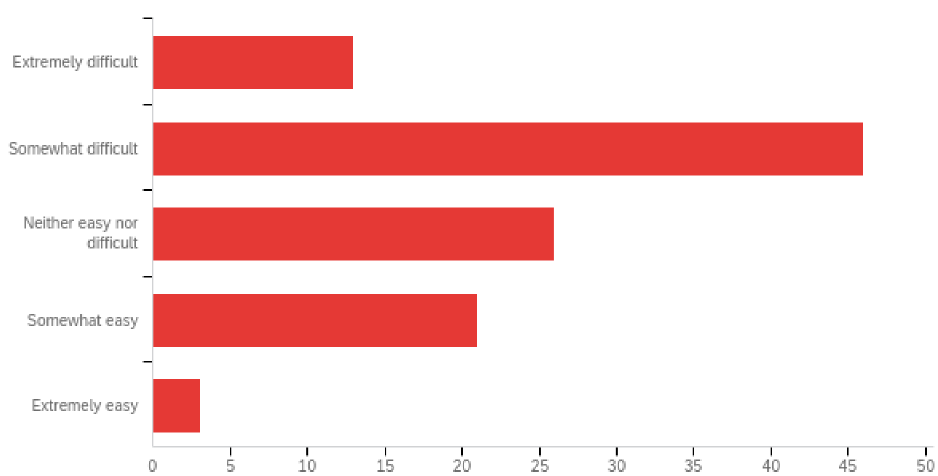
Figure 17
The chart shows the result of question 13
Q.13 Do you think installing solar panels is affordable?



5.1.4 Ease of use

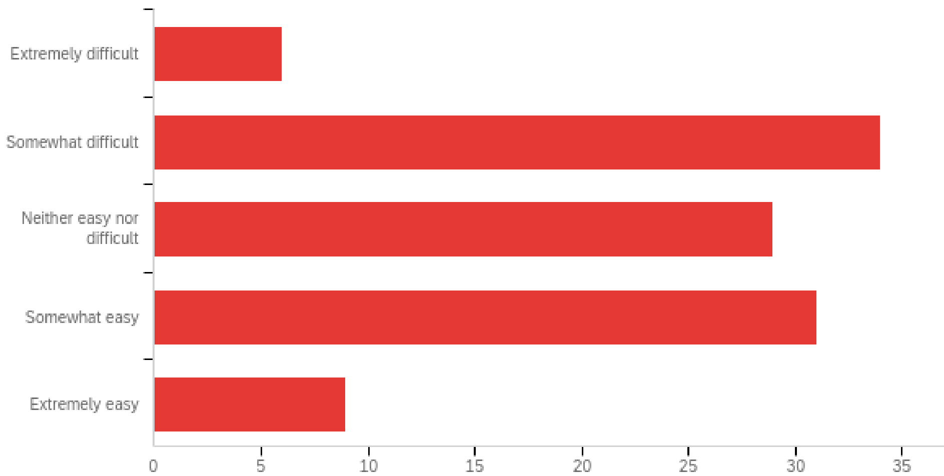
This section of the survey, which examined the ease of installing solar panels in homes, consisted of three questions. For this one, the responses were fascinating. The first question was: How easy is it for you to install solar panels at home? 45 people answered somewhat difficult, which was the highest cluster.13 people selected extremely difficult. This is a significant number of responses saying that this section of the population thinks it is hard to install solar panels at home.

Figure 18
The bar chart shows the result of question 14



The next question was how easy it for you is to use solar panels at home. This question was also very interesting as there were almost equal votes for three contrasting opinions, somewhat difficult and somewhat easy, and neither easy nor difficult. For this, they consider how challenging it is to use solar panels at home, as well as how challenging it is to install them.
They believe there are certain technical challenges or impediments to using new technology, and they require some support from the professionals, if not training. This represents a division in the respondents' attitude and understanding to produce such diametrically opposed viewpoints as illustrated in the graph below.

Figure 19
The bar chart shows the result of question 15



The third question in this section was: How easy do you think installing solar panels at home will be from a technical perspective? From a technical perspective, 38 percent voted somewhat difficult while 9 percent voted extremely difficult. On the other hand, 26 percent voted neither easy nor difficult which is the second highest percentage.

Figure 20
The bar chart shows the result of question 16

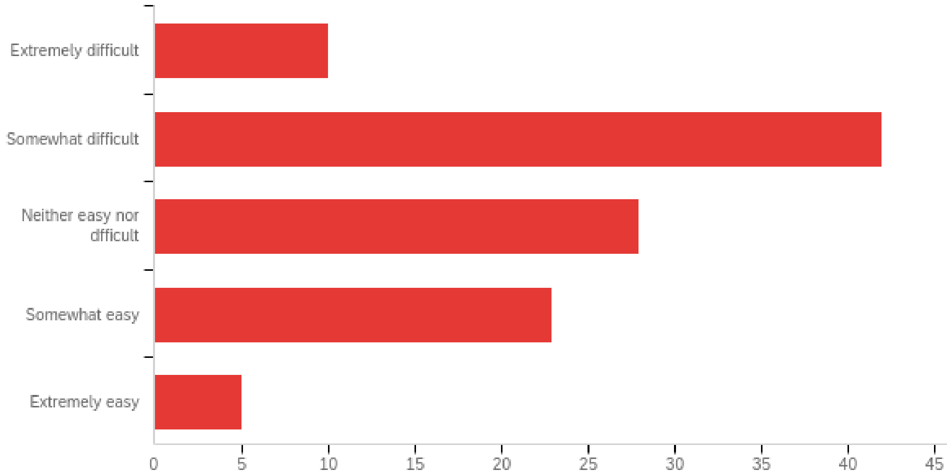
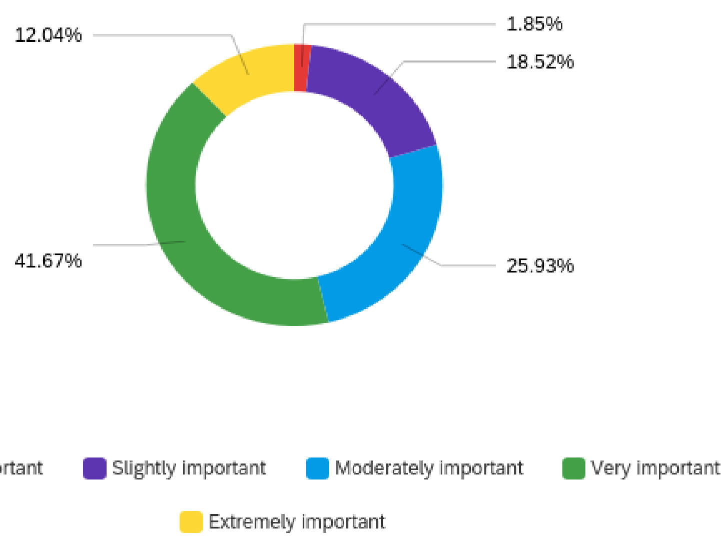


Figure 14: The above bar chart shows the result of question 16

5.1.5 Environmental awareness

The last section was for Environmental awareness included the rest of the questions such as How important is environmental sustainability in your technology usage? The majority voted very important 42 percent and 12 percent extremely important as shown in figure 21.

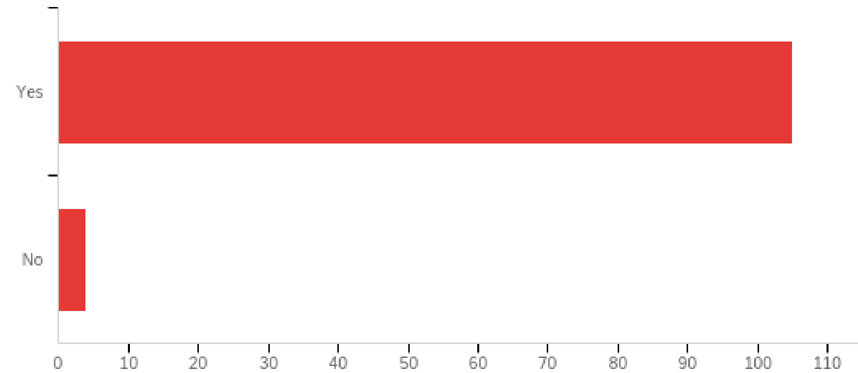
Figure 21
The chart shows the result of question 17



The next question was: Do you think installing solar panels can help in promoting environmental sustainability? 96 percent selected yes while the rest selected no.

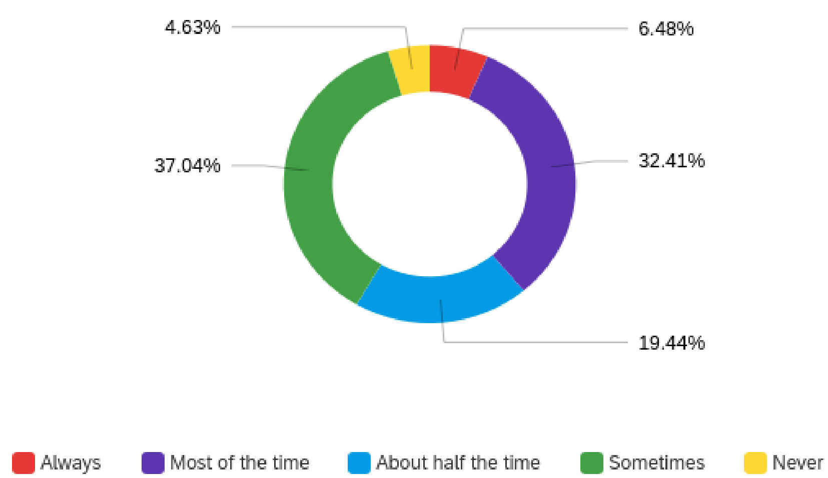
Figure 22

The bar chart shows the result of question 18



Finally, the last question that was related to environmental awareness is as follows: Q20 - How often do you consider the environmental impact of technology when making installing/ purchasing decisions? The percentages indicate that the respondents are somewhat aware of the environmental impacts of their purchasing decisions. The second highest percentage was most of the time of 32 percent. A very small percentage was of 4.7 percent the ones who said never.

Figure 23
The chart shows the result of question 20



5.2 Survey Results' Summary

To gather information from Cairo residents who are 18 years of age or older, a survey with questions was used as the quantitative data-gathering approach. As mentioned previously, the 5-point Likert scale method was used in this survey to focus such that there was just the right number to continue with the necessary analysis.

Only eight people out of the 132 people who did the survey have solar panels installed at home. This means that the technology is not yet popular in Egypt, or the people are not very convinced about using it. Therefore, this indicates that the technology is not yet implemented in Cairo which shows the importance of the emphasis of this study to the community of Cairo. Regarding the consideration of installing solar panels, 45 percent said yes, they are considering, 38 percent answered maybe, and 15 percent answered no. Hence, this shows that people are either considering or to yet sure about the decision they should make regarding installing solar panels.

To draw conclusions and answer the research question, the results of the survey had to be quantified and along with studying the mean value of each question. The mean value is included in the table below. The mean value of the mean values for each indicator was calculated to get a single number for each one to show whether it is above the average or below the average. These numbers indicate whether the majority of people think of this indicator positively or negatively and by comparing all 4 indicators' mean values, it was much easier to answer the research question of this paper. In the tables below are the mean values of the questions along with the answer scale.

The majority of the participants were between the age groups of 18-24 and 24-34. (45 and 29). This means that almost half of the participants are considered young and therefore it is important to keep this factor in mind, meaning that this is what the new generations' perceptions are. Moreover,41 percent of the respondents think that solar electricity can moderately fulfill their everyday electricity requirements. This means to this question was 3.38, which indicates that the majority of the responses lean towards the positive side of the spectrum of the fulfillment of electricity requirements. Some factors that might affect the results where conclusions could be drawn are the gender of the participant and his/her age.

For the general questions, the mean values were 3.38 and 4.65. This means that the Responses were considered positive in a way, and their mean value combined is 4.015, which is again a positive number. The scaling positive and negative are just explanations for the number found through the survey to help in viewing and comprehending the data.

Table 2

Question	**Mean**	**Answer scale**
Q7. To what extent do you believe solar electricity can fulfill your everyday electricity requirements?	3.38	1=not at all (Negative) 5= extremely (Positive)
Q8. How much do you think installing solar panels at home could contribute it	4.65	1=not at all (Negative)

reducing GHG emissions and address climate change?		5=extremely (Positive)
Q9 - Perceived Usefulness: How do you feel about the usefulness of solar panels at homes in your daily life activities?	3.6	1=not at all useful (Negative) 5=extremely useful (Positive)
Q10 - Perceived Usefulness: Do you think installing solar panels is more useful than using regular energy systems?	3.57	1=not at all useful (Negative) 5=extremely useful (Positive)
Q11 - Affordability: Do you think installing solar panels at home would lower your energy bills?	3.61	1=not at all (Negative) 5=extremely (Positive)
Q12 - Affordability: How important is the cost of installing solar panels to you?	1.77 (3.23)	1=very important (Negative) 5=not important at all ((Positive)
Q13 - Affordability: Do you think installing solar panels is affordable?	2.34	1=not affordable (Negative) 5=extremely affordable((Positive)
Q14 - Ease of Use: How easy is it for you to install solar panels at homes?	2.59	1=extremely difficult (Negative) 5=extremely easy (Positive)
Q15 - Ease of Use: How easy is for you to use solar panels at home?	3.03	1=extremely difficult (Negative) 5=extremely easy (Positive)
Q16 - Ease of Use: How easy do you think installing solar panels at home will be from a technical	2.73	1=extremely difficult (Negative) 5=extremely easy (Positive)
Q17 - Environmental Awareness: How important is environmental sustainability in your technology usage?	3.44	1-not at all important 5=extremely important
Q18 - Do you think installing solar panels can help in promoting environmental sustainability?	1.04	1=yes 2=no
Q19 - How difficult do you think the frequency of maintenance would be after installing solar panels at home?	2.59 (2.41)	1=not difficult 5=extremely difficult
Q20 - How often do you consider the environmental impact of technology when making installing/ purchasing decisions?	3.01 (1.99)	1=always 5=never

The table shows all the mean values for the corresponding questions along with the answer scale for the relevant selected questions. The mean value for questions 7 and 8 is 4.015. This shows that these questions are positively perceived by the respondents. In other words, they believed that installing solar panels may significantly reduce GHG emissions while also meeting your daily electrical needs.

Perceived usefulness, Affordability, Ease of Use & Environmental Awareness

For the perceived usefulness, the mean values were 3.6 and 3.57, and combined the mean value was 3.585, which is close to 5 which therefore means that it is a positive value. The questions considered for perceived usefulness were questions 9 and 10 and for affordability were 11,12 and 13.
The table above shows the mean value of the answers of all four indicators including perceived usefulness and affordability. For affordability, the numbers were pretty low, as for question 12 on how important it is, the mean value was 1.77 where 1 was very important. This shows that the affordability of the technology plays a major role in the interest of the people to implement it or not. When question 13 was asked which looked at whether the respondents think installing solar panels is affordable, the mean value was 2.34, which is leaning more towards not affordable. Although the mean value of this section (affordability) combined is 2.57, which is slightly above the average of 2.5, it is still quite low, and hence recommendations should take place to enhance the numbers, perhaps even look at policies that Cairo has or could potentially work on in terms of incentives to help in further spreading the acceptance of this technology more.

For ease of use, the mean values for each of the 3 questions were not high, as the average of the mean value was 2.78 which is slightly higher than the average but yet still very low. This shows that the ease of use is somehow acceptable but needs to work on further. On the other hand, for environmental awareness, similarly, the total mean value was above the average but also not that high, 2.61. The questions considered for ease of use were questions 14,15 and 16. Additionally, the questions considered for environmental awareness were questions 17 to 20.

Table 3

Table 3 shows the average mean value for all the questions of each indicator correspondingly merged.

Indicator	**MEAN VALUE**
Perceived usefulness	3.585
Affordability	2.57
Ease of use	2.78
Environmental awareness	2.61

Final mean value: 2.88

The results of these values show that there are indicators more developed than others. In general, all mean values for each one was more than the average but, this shows that since they were not too high, there is room for improvement and work to be done. The values are all above 2.5 which means results are mainly positive, yet by comparing the numbers in Table 4, some indicators are more positively perceived by the respondents such as the perceived usefulness of installing solar panels compared to the affordability indicator.

6. Discussion

The results from the previous section, which show all relevant percentages and numbers, are extremely captivating. These results lead to a number of conclusions and observations, which are provided in this section.

Firstly, the cost of installation is one of the great concerns of the respondents when faced with questions regarding installing solar panels. It was noticed that the initial cost of solar panel installation is concerning most of the participants. Cost of installation and maintenance in addition to technical competency of technicians are concluded to be the main challengers to widely install solar panels. In addition to this, technical support is suggested to provide low-cost training for solar panel users or technicians to overcome the technical difficulties in the installation and maintenance of solar panels to promote and support the technology.

The cost of installation and maintenance are not the only obstacles that the respondents touched on. Most of the respondents think that maintenance would be moderately difficult or slightly difficult which is also addressing the needs of the technician's competencies. Maintenance of installed solar panels is thought to be difficult in their opinion as well. If the issue of maintenance is resolved, a lot of people are expected to consider installing solar panels more. This could be done through providing free services by the government to encourage people living in Cairo to install them. The support from the Egyptian government in the form of incentives and programs has recently grown quickly. This has been a major contributor to the Egyptian solar market's explosive expansion (Egypt Solar Energy Market Insights, n.d.).

For instance, to assist developers of utility-scale solar projects, the Egyptian Electricity Utility & Consumer Protection Regulatory Agency (Egyptera) authorized additional incentives for net metering and self-consumption solar power systems in March 2022. Before COP27 in November 2022, these incentives were agreed to promote investments in the renewable energy sector (Egypt Solar Energy Market Insights, n.d.). These previous points are examples of how the support of the government could impact the solar market in Egypt.

The focus on economic impact (cost reduction in energy bills) can be considered as great motivation to install more solar panels and thus positively impact environmental sustainability. Moreover, most of the participants consider the importance of the environmental impact and sustainability in technology usage when making technological decisions. Most of the participants, or nearly all of them think that solar panels can help improve environmental sustainability which is very promising. Additionally, most of the participants think that environmental sustainability is very important in technology usage as per Q17 and almost all of them think that it can promote environmental sustainability as per Q18.

There is a great potential to promote Environmental sustainability through the usage of solar panels at homes in Egypt particularly in urban areas (which is expected to have more need for Solar Panels). This research looks at people living in Cairo Egypt, but perhaps for future work, it would be very helpful to look at urban areas and their technological acceptance of using solar panels for several reasons. The use of solar panels in these urban areas would be helpful as some areas don't have a connection to the grid for electricity. To help the community, policymakers could be contacted to see what can be done to promote the technology to provide electricity alternatives for the ones who don't have access to it. In addition to this, policies could be revised to make sure that they effectively support the interested parties in implementing the technology as means to support an environmentally friendly practice. Incentives could be suggested for the policymakers to be provided for the interested individuals and studied to encourage the installation of solar panels. As previously mentioned, there are extensive efforts from the Egyptian government to support the solar market. Consequently, urban areas could be brought to their attention through organizations to direct their focus to support them in adopting this technology.

Awareness is a huge factor in the technological acceptance of solar panels, so therefore raising awareness of what it is exactly that it provides, the means of its installation, how beneficial it is, and to what extent would it impact the environment would definitely make a difference in how people perceive this technology and their willingness to adopt it and to work with it.

The TAM model was all in all a suitable model to use as it has a lot of strengths that were noticed while using it in this study. These strengths include the fact that it's a simple model. There were no major difficulties faced in understanding and applying the model to this study. In addition to this, the model mainly focuses on the user's perception of a specific technology, which was very fitting to our study as the main point of the study was to study the acceptance of installing the technology (solar panels) at home. Needless to say, the TAM model has very high applicability to different types of user populations, industries, and technologies which results in it being a versatile model.

Although there are various strengths to the model, there were also several weaknesses that were encountered while using the model in this study. As mentioned previously a drawback of TAM is the inability to accurately quantify the underpinnings of behavior and observed study due to numerous subjective factors, such as societal values and conventions, personal characteristics, and personality traits (Shahzad et al., 2018)(Hayes et al., 2018).In other words, even though the idea might be accurate in theory or for personal use of invention, it might not necessarily be accurate or trustworthy in a professional setting(Malatji et al., 2020b).This was observed through the hands on experience with the model while analyzing the results of the survey. TAM was noticed to neglect the influence of the other factors minus the four variables considered. In simple terms, considering the function of emotions like trust or fear can significantly influence consumers' behaviors towards the technology while examining the technological acceptability of technology like solar panels. The mentioned factors are believed to be very effective factors however the Tam model does not directly account for them. Another weakness that was noticed in the TAM model limited consideration of context. To elaborate on this weakness, the model does not fully address the influence of contextual factors. Examples of these factors include cultural differences and technological infrastructure. All in all, there are strengths and weaknesses to each model, however, models are usually compared to find the most suitable one for the study to acquire the best and most reliable results possible.

Although there were a few alternative frameworks that were considered as mentioned previously, they were found to be not fit as well the chosen TAM. To clarify these alternative frameworks and to make sure the best one was chosen, their definitions were given in details in the conceptual framework to explain the differences between each one. These frameworks include public acceptance and social acceptance. Social acceptance is more concerned with the behaviors of subgroups within society (Vacas et al., 2020).

Since we are dealing with a technology (installing solar panels at homes) the TAM was shown to test the most relevant factors and concepts to be able to answer the research question and support the success of this study. Another theory that was considered for application is the social acceptance theory. The social acceptance theory focuses on theories of planned behavior and social representations (Upham et al., 2015). This theory incorporates methodologies that are grouped by academic fields including economic, social, psychological, and cultural theory. The technical acceptance model theory, which will be further discussed in the following section, was determined to be more appropriate for our study because we are explicitly addressing solar energy system technology, even though the social acceptance theory is still applicable.

The findings of this study, which demonstrate that installing solar energy systems like solar panels in Egypt is encouraged, were not unexpected because they were supported by earlier work. Through different frameworks, it was previously concluded that there is a high potential for deploying solar panels on floating hotels, and this prompted more investigation into whether solar energy systems would be accepted in Egypt, especially in Cairo (Rezk, 2019b). This study offered insightful analysis for analyzing the technological acceptance of solar panel installation in Cairo residents' homes.

In addition to this, another study emphasized Egypt’s enormous potential for solar energy due to its highest daily normal irradiance value in North Africa (Salah et al., 2022). This complies with the results of the survey as the technological acceptance mean’s average was above average which indicates that the responses regarding the four factors are off positive perceives.

7. Conclusion

Technological acceptance of installing solar panels in Cairo Egypt was not an easy concept to measure due to the handful of factors involved in the concept along with the huge population which affects the sample size required. By dividing the survey into parts to tackle specific areas, the survey was able to shed light on the perspective of the respondents along with their perceptions regarding the four main factors of technological acceptance of this technology. The technological acceptance model framework was the most suitable and relevant model that could be used to tackle areas of research to answer the research question and to extract the required information to draw concrete observations and conclusions.

In conclusion, this paper aimed to study the level of technological acceptance of installing solar panel at homes in Cairo Egypt. The main inspiration for this study was that through research and literature review, enormous potential in Egypt's solar market was found. Although the potential of the solar market is huge, solar energy was found to be not yet fully utilized by solar panels. The proper utilization of solar energy systems would consequently affect sustainable development and the environment as a whole and ultimately affect climate change in Egypt. The problem that this paper attempted to address is to help in understanding the status of the country about ISES and thereby provide a well-researched studies with valuable findings along with some inspiration for future work in this area.

Egypt has recently made considerable investments in solar energy on both a major and small scale. Additionally, there is a steady growth in the market for small-scale solar energy systems (Egypt PV, 2023). The goal of the study was to compile a survey of the literature on solar energy generally and in Egypt, as well as other studies on the acceptance of new technologies. Since the TAM addresses the precise areas of concern that help in providing a sufficient response to the research question, using the indicators of the TAM made the study of perceptions of solar panel technology in Egypt much easier to analyze to and to draw conclusions from. This contributed to the adoption of technological acceptance.

Qualitative data was found to be the best way to gather the required information for this study's motivation. The survey was designed to tackle specific areas and answer some questions by people living in Cairo, Egypt to test their technological acceptance of installing solar panels at home according to the four factors. The survey was done, and the results were deeply analyzed to conclude and some recommendations for future research.

The research question along with the sub-questions were answered through the conducted literature review and the analysis of the survey. The main research question was "What is the level of technological acceptance of solar energy systems in Cairo, Egypt?". To answer it, the final mean value of the indicators was 2.88 which shows that the level of technological acceptance of solar energy systems in Cairo Egypt is above average, yet there is room for improvement to boost the level of technological acceptance as well as to spread awareness to promote this technology. In order to get to the research question's answer, several sub-questions were required to be answered first which are as follows: What are the public perceptions of people in Cairo towards ease-of-use, usefulness, environmental awareness, and affordability? How do these perceptions affect the level of technological acceptance of people in Cairo? The public perceptions of people in Cairo towards the different four indicators varied according to the survey responses that were distributed among different people of different age groups and backgrounds. Out of all four indicators which are ease of use, perceived usefulness, affordability, and environmental awareness, perceived usefulness had the highest mean value. This means that the respondents think that installing this technology would be useful for their daily activities in a great way. The perceptions affect the level of technological acceptance of people as all of them contribute to adopting the technology or not as mentioned in previous chapters. Finally, to answer the research question, the final mean value of the indicators was 2.88 which shows that the level of technological acceptance of solar energy systems in Cairo Egypt is above average, yet there is room for improvement to boost the level of technological acceptance as well as to spread awareness to promote this technology.

Some limitations of this study are that I was not physically in Egypt, so I depended fully on reaching the respondents online, through distributing the survey to online groups and pages. Another limitation is that in the survey, it wasn't set that all questions should be answered. This might have affected the results are the number of responses for each question varied. Although this might not be a big number of responses, the variety of the age of the respondents gives us a quite sufficient response to analyze. The number of responses could be increased for future work to have more reliable data by increasing the confidence level percentage to more than 80 percent to analyze. This change would result in a bigger calculated sample size and therefore the data set that will be analyzed and dealt with along with the responses collected would be on a larger scale.

In addition to this, it was noticed that almost half of the participants are considered young (between the age groups of 18-24 and 24-24), which therefore has definitely steered the results to the new generations perceptions, rather than an exactly balanced proportional one corresponding equally to each age group.

Recommendations for future work would be to look for more factors and trace them with the responses to the survey and the 4 indicators. Further analysis could be done by relating factors such as the level of education to the responses of the indicators to conclude how the level of education could affect the perceived technological acceptance of technology such as solar panels at homes. Another recommendation would be to increase the sample size of the required responses to increase the confidence rate and decrease the error margin of the study.

In addition to this, policies could also be studied, and perhaps contact policymakers in the country to promote the technology to encourage more people to adopt it as it is helpful in the long term for the environment and GHG emissions. All in all, this study highlighted that there is a lot of potential in this sector, and there is a great interest in this technology in Cairo, Egypt. There is room for more progress in the market for the installation of solar panels, but it is a good starting point for many future works to put solar energy into good use and to help reduce the negative environmental impact of GHG emissions. The main contribution of this paper is that it provides new empirical insights into the technological acceptance of solar panels. It also combines a big chunk of literature review and grey literature that was done in the past along with quantitative analysis related to the implementation of solar panels in Egypt, which would be very beneficial and a concrete start for future researchers who are interested in this topic. Finally, this paper provides an overview of solar energy in Egypt concerning the technology of solar panels which is one of a kind as this has not been in the past in other papers.

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APPENDIX

Survey

I am a student from the master's program in Environmental & Energy Management at the University of Twente (The Netherlands). The purpose of this survey is to understand the technological acceptance of people living in Cairo with regards to installing solar panels at home. Technological acceptance refers to the willingness of individuals or groups to use and adopt new technologies. It is a measure of how open people are to using new devices, applications, or systems in their daily lives or work.

This research study aims to know how you perceive technology in terms of usefulness, affordability, ease of use, and environmental awareness. Participation in this survey is completely voluntary and anonymous. Your answers will only be used for this research and will not be shared with other parties. It will take approximately 10-15 minutes to complete the survey. If you participate in this survey, you consent to the use of the questions you answered within the study. To take part in this survey, you must be resident Cairo, Egypt and above the age of 18 years old Your participation contributes to a better understanding of the technological acceptance. of solar energy systems in Cairo. This survey consists of two parts. The first part general information. Part two is about your personal opinion on installing solar panels at home. Please answer the following questions to the best of your ability. Thank you in advance for your time and contribution to this survey.

Hereby, I say that I have read the above consent form and agree with it.

Yes

No

1.What is your gender?

- Female
- Male
- Other

2.What is your age?

- Under 18
- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 or older

3.Do you live in Cairo?

- Yes
- No

4.Do you currently have solar panels installed at home?

- Yes
- No

5.Have you ever considered installing solar panels at your home?

- Yes
- Maybe
- No

6.If you answered "yes" to question 5, what are your reasons for considering installing solar panels at your home?

- To reduce electricity bills
- To reduce carbon footprint
- Backup power during power outages
- Other reasons

7.To what extent do you believe solar electricity can fulfill your everyday electricity requirements?

- Not at all
- Slightly
- Moderately
- Very much
- Extremely

8.How much do you think installing solar panels at home could contribute to reducing GHG emissions and address climate change?

- Not at all
- Slightly
- Moderately
- Very much
- Extremely

9.Perceived Usefulness: How do you feel about the usefulness of solar panels at homes in your daily life activities?

- Not at all useful
- Slightly useful
- Moderately useful
- Very useful
- Extremely useful

10. Perceived Usefulness: Do you think installing solar panels is more useful than using regular energy systems?

- Not at all useful
- Slightly useful
- Moderately useful
- Very useful
- Extremely useful

11.Affordability: Do you think installing solar panels at home would lower your energy bills?

- Not at all
- Slightly
- Moderately affordable
- Very much
- Extremely

12.Affordability: How important is the cost of installing solar panels to you?

- Very important
- Somewhat important
- Neutral
- Somewhat not important
- Not important at all

13.Affordability: Do you think installing solar panels is affordable?

- Not affordable at all
- Slightly affordable
- Moderately affordable
- Very affordable
- Extremely affordable

14.Ease of Use: How easy is it for you to install solar panels at homes?

- Extremely difficult
- Somewhat difficult
- Neither easy nor difficult
- Somewhat easy
- Extremely easy

15.Ease of Use: How easy is for you to use solar panels at home?

- Extremely difficult
- Somewhat difficult
- Neither easy nor difficult
- Somewhat easy
- Extremely easy

16.Ease of Use: How easy do you think installing solar panels at home will be from a technical perspective?

- Extremely difficult
- Somewhat difficult
- Neither easy nor dfficult
- Somewhat easy
- Extremely easy

17.Environmental Awareness: How important is environmental sustainability in your technology usage?

- Not at all important
- Slightly important
- Moderately important
- Very important

Extremely important

18.Do you think installing solar panels can help in promoting environmental sustainability?

- Yes
- No

19.How difficult do you think the frequency of maintenance would be after installing solar panels at home?

- Extremely difficult
- Slightly difficult
- Moderately difficult
- Very difficult
- Extremely difficult

20.How often do you consider the environmental impact of technology when making installing/ purchasing decisions?

- Always
- Most of the time
- About half the time
- Sometimes
- Never