CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Determining the Factors Influencing Adoption of Solar Energy Solutions using SEM Approach

by

Abdullah Multazim

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"I dedicate this thesis to my parents, whose unwavering love, support, and encouragement have been my driving force throughout my academic journey. Their sacrifice and dedication to my education have inspired me to strive for excellence and to never give up on my dreams. This achievement would not have been possible without their guidance and belief in me

To my wife, who has been my rock, partner, and best friend through thick and thin. Your support and encouragement have been invaluable and have carried me through the most challenging moments. Your understanding and patience have made this journey so much easier. I am truly grateful to have you by my side.

And to my precious children, Muhammad bin Abdullah and Mahrosh Fatima, who bring joy to my life every day. Your innocence and pure love have reminded me of the importance of cherishing the little things in life. Thank you all for being a part of my life and for making this journey so meaningful. This thesis is as much yours as it is mine."

CERTIFICATE OF APPROVAL

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(Abdullah Multazim)

Abstract

Pakistan is a country with abundant solar energy potential, yet the adoption of solar energy solutions remains low. The purpose of this study is to determine the factors that influence the adoption of solar energy solutions in Pakistan. To achieve this, the study uses a combination of the Theory of Planned Behavior (TPB) and revised Technology Acceptance Model (TAM) constructs. Specifically, the study focuses on the attitudes, subjective norms, and perceived behavioral control from TPB and the initial cost, financial incentives, and comparative advantages from revised TAM.

The study employs a survey-based research design and collects data from 308 respondents who are currently using solar energy solutions or have the intention to adopt them in near future. The study uses Structural Equation Modeling (SEM) approach to analyze the data along with exploratory factor analysis (EFA), confirmatory factor analysis (CFA), composite reliability, and discriminant validity tests to assess the reliability and validity of the TPB and revised TAM constructs.

The findings of the study reveal that attitudes, subjective norms, initial cost, financial incentives, and comparative advantages have a significant impact on the adoption of solar energy solutions in Pakistan. Specifically, a positive attitude towards solar energy solutions, favorable subjective norms, the availability of financial incentives and comparative advantages, and the initial cost are essential factors in predicting the adoption of solar energy solutions. However, the study finds that perceived behavioral control was not a significant predictor of adoption behavior in the context of Pakistan.

The study makes several contributions to the literature on technology adoption and solar energy solutions. Firstly, the study provides empirical evidence of the applicability of the TPB and revised TAM constructs in predicting technology adoption behavior in the context of Pakistan. Secondly, the study identifies the key factors that influence the adoption of solar energy solutions in Pakistan, which can be useful for policymakers, solar energy solution providers, households, and businesses looking to adopt solar energy solutions. Thirdly, the study demonstrates the importance of financial incentives and comparative advantages in promoting

the adoption of solar energy solutions, which can guide the development of policies and interventions aimed at increasing the adoption of solar energy solutions in Pakistan.

One of the key findings of this study is that the initial cost of adopting solar energy solutions has a negative impact on adoption behavior. This is not surprising, as the initial cost is often cited as one of the primary barriers to the adoption of renewable energy solutions, especially in developing countries like Pakistan. The high upfront cost of installing solar panels or other renewable energy systems can be prohibitive for many households and businesses, especially those with limited financial resources. This highlights the need for policies and interventions that can help to reduce the cost of adopting solar energy solutions, such as subsidies, tax incentives, and financing mechanisms. By addressing the issue of initial cost, policymakers can help to promote the adoption of renewable energy solutions and contribute to the country's energy security and environmental sustainability goals.

Overall, the study provides a comprehensive understanding of the factors that influence the adoption of solar energy solutions in Pakistan, which can guide future research and policy decisions in this area. The findings of the study have important implications for the promotion of renewable energy sources in Pakistan and can help the country to reduce its reliance on fossil fuels and mitigate the adverse effects of climate change.

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Abbreviations

AEDB	**Alternative Energy Development board**
AT	**Attitude**
CFA	**Confirmatory Factor Analysis**
EC	**Environmental Concerns**
EFA	**Exploratory Factor Analysis**
FI	**Financial Incentives**
ITSE	**Intention to Adopt Solar Energy Solutions**
IC	**Initial Cost**
MI	**Modification Indices**
NEPRA	**National Electric Power Regulatory Authority**
PBC	**Perceived Behavioral Control**
PV	**Photo Voltaic**
PCA	**Principal Component Analysis**
RE	**Rebewable Energy**
SE	**Solar Energy**
SEM	**Structural Equation Modeling**
TAM	**Technology Acceptance model**
TPB	**Theory of Planned Behaviour**
TRA	**Theory of Reasoned Action**

Chapter 1

Introduction

1.1 Overview

The growing reliance on Renewable Energy (RE) sources in recent decades can be attributed to two primary factors. The first is the rapid depletion of non-renewable fossil fuel sources, coupled with the detrimental environmental effects of their use. The second is the desire to shift to an energy future that is more sustainable and less damaging to the environment. By investing in renewable sources, such as wind, solar, and hydroelectric power, we can reduce our dependence on carbon-heavy fossil fuels and reduce the global carbon footprint. Secondly, the fluctuating fossil energy prices and often observed: "Energy crisis" has also instigated the search for utilizing renewable sources for energy production. Fossil fuel consumption has significantly contributed to global warming, with the release of carbon dioxide drastically altering the environment and increasing the risks of health problems, as well as the potential for drastic increases in temperature. Effective measures have now been taken worldwide, especially in developed countries to address the issue of global warming and its effects on human health. Policies and legislation have been made to reduce air pollution from vehicles, minimize waste materials, conserve native forests, plant more trees, and reduce greenhouse gas emissions [1]. Due to the adverse effects of using fossil fuels, developed countries are quickly transitioning to renewable energy sources which are seen as viable alternatives. Renewable energy sources offer a number of beneficial advantages over conventional energy sources, from environmental sustainability to long-term cost savings. Renewable

energy sources are clean and inexhaustible. With the growing public awareness about renewable energy sources, it is expected that their share in world energy production would increase very significantly. Different methods of RE have been adopted by humans in the past few years. Hydropower, Biomass Combustion, and geothermal energy are considered the first generation of Renewable Energy technologies, and they have reached their maturity. Second-generation technologies including solar energy, wind energy, and contemporary kinds of bioenergy are now in the early stages of development. Concentrated solar power, oceanic tidal energy, and better geothermal and integrated bioenergy systems are examples of third-generation technology. These technologies are still in the initial phases of development. Renewable Sources Of energy (RES) provide 14% of total global energy utilization, and their share is predicted to upsurge in the future years. With growing public awareness about renewable sources, it is expected that their share would increase very significantly from 30% to 80% by 2100 [2]. With advances in the domain of renewable energy sources RES, a new trend of microgeneration arises throughout the world. It is the production of heat and electricity on a small scale by an individual to fulfil their local energy demands as a complement to typical centralized grid-connected power. Investing in renewable energy sources such as photovoltaic (PV) panels, micro wind turbines, solar water heaters, wood pellet boilers, geothermal heat pumps, and combined heat and power systems has been proven to be an effective way to reduce greenhouse gas emissions and lower energy costs. It has the ability to significantly reduce overall energy demand and Carbon intensity in the residential market [3].

Out of all these RE sources, solar PV systems have shown promising results as it works best under direct sunlight but also generates electricity under less favourable conditions. The PV system's output depends on the amount of sunlight that falls on the surface of its panels and for this reason, unshaded, south-facing surfaces produce the best results. These solar power plants currently play an important part in the development of sustainable energy and serve as a major alternative to energy provision in distant places where the electric grid cannot be accessible. These small-scale PV systems are also known as residential solar PV systems or low voltage photovoltaic power plants. In domestic applications, these PV systems are mounted on the rooftop of buildings to obtain direct sunlight for maximum

generation of energy [4].

Domestic solar PV Panels have a big potential in developing nations like Pakistan, which has been experiencing an energy crisis for the past several years due to a rise in the gap between demand and supply of electricity. To compensate for load shedding and power outages, the government of Pakistan is encouraging investment in the generation of small-scale distributed renewable energy through the Alternative Energy Development Board (AEDB), which is based on the net metering idea. Consumers who give energy to grids will either pay a lower utility bill or be compensated for access to energy exported to the grid [5]. Over the years renewable energies have experienced one of the largest growths in percentage and are still growing around the world, especially in developing countries. The utilization of renewable energy sources is comparable to the power received from coal energy, but it is still less than the proportion of natural gas and fossil fuel consumption [6]. Therefore, consumer behaviour in terms of renewable energy adoption or non-adoption must be addressed. Many research models, such as Rogers' innovation theory the planned behaviour theory, and the technology acceptance model, have been used to analyse the customer's purpose in the adoption of new technology.

This research focuses on solar PV systems as an invention, as well as their uptake and acceptability in society. According to Roger's view, technology is deemed innovative if it is regarded as a novel by a person or a technology adopter. The apparent newness of technology impacts the individual's attitude, i.e., whether to embrace or reject the technology. Adoption of the innovation process begins when a consumer learns about the existence of an invention and receives more understanding about the technology and how it works. An individual's choice about innovation is not a quick action, but rather a whole operation that consists of multiple steps that are linked with time and involve several acts; the innovation model consists of five phases: Knowledge, persuading, choice, application, and validation stages[7]. Researchers have been using Rogers's Theory for predicting the consumer's choice in the field of renewable energy adoption [8] and this theory is also used in analyzing mobile banking [9].

The theory of reasoned action (TRA), contained two variables: attitude and subjective standards. A positive or negative feeling in a relation to reaching a goal

was defined as an attitude, while subjective norms are the representation of the individual's ability in reaching goals [10]. In 1980, 'Ajzen' refined and expanded this idea further into the theory of planned behaviour. This extension added one major predictor, perceived behavioural control. This research model has been applied to consumers' behaviour towards online shopping [11].

In 1980, the Theory of Planned Behavior (TPB) was derived from the Theory of Reasoned Action to assess an individual's intention to engage in a behaviour at a specified time and location. This hypothesis was meant to explain all actions over which humans have control. The theory of planned behaviour is basically based on a hypothesis that ties beliefs to conduct and focuses on subjective standards, attitudes, and perceived behavioural control. The Theory of Planned Behavior predicts the chance that an individual will intend to engage in a given behaviour. It explains the components that contribute to a specific behavioural purpose. It focuses on the community's behavioural intent, which is determined by attitude. It has been used to identify habits and intentions for a variety of concerns such as smoking, health care, and so on. According to the hypothesis, attitude, subjective norms, and perceived behavioural control are all related to behavioural intentions. TPB is already being used in Pakistan to analyse factors influencing the uptake of renewable energy [12]. This theory is used to analyze the intention to visit Malaysia for medical facilities [13]. Another theory named as "Technology acceptance model" comprises two main variables: Perceived ease of use and Perceived usefulness [14]. These factors influence customers' motivation and perception of how to adapt to new technologies. The moment at which individuals believe that any technology may improve their health is referred to as perceived utility. The degree to which individuals assume that utilizing new sophisticated technology is referred to as perceived ease of use. Environmental usefulness (protection of the environment and natural resources), economic usefulness (cost reduction), and social usefulness are the three aspects that comprise PU (putting out your share to society). Uncertainty (fear or doubt that technology will fail to operate) and humiliation (perceived lack of inconvenience while utilizing) comprise perceived ease of use. This model is previously used to identify the public perception of technology adoption [14]. For research objectives, such as in the adoption of mobile banking the theory of planned behaviour and the Technology Acceptance Model

has also been combined [15]. The differences and similarities can be integrated and research results can be further improved using the constraints of the two theories.

1.2 Problem Statement

The low adoption rate of renewable energy systems, particularly PV solar energy solutions, in Pakistan, is hindering progress towards achieving energy sustainability, and the factors influencing customer behavior towards adopting such systems are relatively unknown or not adequately addressed. Therefore, this research thesis aims to investigate the variables that impact the acceptance of renewable energy systems in Islamabad.

The study will identify the challenges and barriers hindering the adoption of renewable energy systems and explore the potential policy solutions and incentives to promote sustainable energy practices in Pakistan. The findings of this research will provide valuable insights for policymakers, energy practitioners, and researchers interested in promoting renewable energy adoption in developing countries.

1.3 Research Objectives

The primary study goal of this thesis is to identify and combine two distinct research models, TPB and TAM. Hypothesis are generated using these two research methodologies to explore the customer's intention towards renewable energy resources. The variables influencing the adoption of renewable energy sources, particularly solar PV energy systems, were investigated, and the following research questions were derived from the study goals.

1.4 Research Questions

The following are the main research questions of this study:

- What are the factors that are acting as barriers to the adoption of the renewable energy system?

- Does the information about the RE system easy to get?
- What are the cost concerns of people about solar energy technology?
- What is the perceived usefulness of using renewable energy sources?

1.5 Scope of the Reseach

Solar energy is a promising alternative to traditional energy sources and is critical for achieving sustainable development. However, despite the numerous benefits of solar energy solutions, adoption rates remain low in Pakistan. Understanding the factors that influence the adoption of solar energy solutions is crucial in promoting sustainable energy use.

This thesis aims to identify and analyze the factors that influence the adoption of solar energy solutions using the Structural Equation Modeling (SEM) approach. Additionally, this study integrates two widely used frameworks, the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB), to provide a more comprehensive understanding of the factors that influence solar energy adoption. The study seeks to investigate the relationships between the constructs of TAM and TPB in the context of solar energy adoption and identify the direct and indirect effects of environmental, economic, social, and technological factors on adoption.

The study will use a quantitative research design, collecting data from potential adopters of solar energy solutions through an online and in-person survey questionnaire. The collected data will be analyzed using the SEM approach, integrating TAM and TPB models to provide a more accurate prediction of the adoption of solar energy solutions.
The study will contribute to the existing literature by providing valuable insights into the factors that influence the adoption of solar energy solutions, and the integration of TAM and TPB models in explaining the adoption of solar energy solutions will expand the current understanding of technology adoption. The results of the study can be used by policymakers, solar energy providers, and potential adopters to promote sustainable energy use.

1.6 Methodology

The purpose of this particular study is to conduct an investigation into the various elements that are acting as obstacles to the adoption of renewable energy source systems. To achieve this aim, a comprehensive review of existing literature has been carried out, and as a result, two established research models, the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB), have been merged to form the basis of this study [16]. In terms of methodology, a quantitative approach has been utilized to gather and analyze data for this research.This study investigates the elements that are causing impediments to the adoption of renewable energy source systems. Following a thorough examination of the literature, two research models, TAM and TPB, have been combined [16]. The quantitative method has been used. In this study consumers' adoption of solar energy solutions is investigated. A quantitative research method will be used and a questionnaire designed keeping the hypothesis's aspects in context. [15] [17]. The questionnaire will be circulated in society using online platforms.

The results of the questionnaire are analyzed using structural equation modelling [18] and the results are analyzed accordingly. Fig 1.1 shows the methodology adopted in the study.

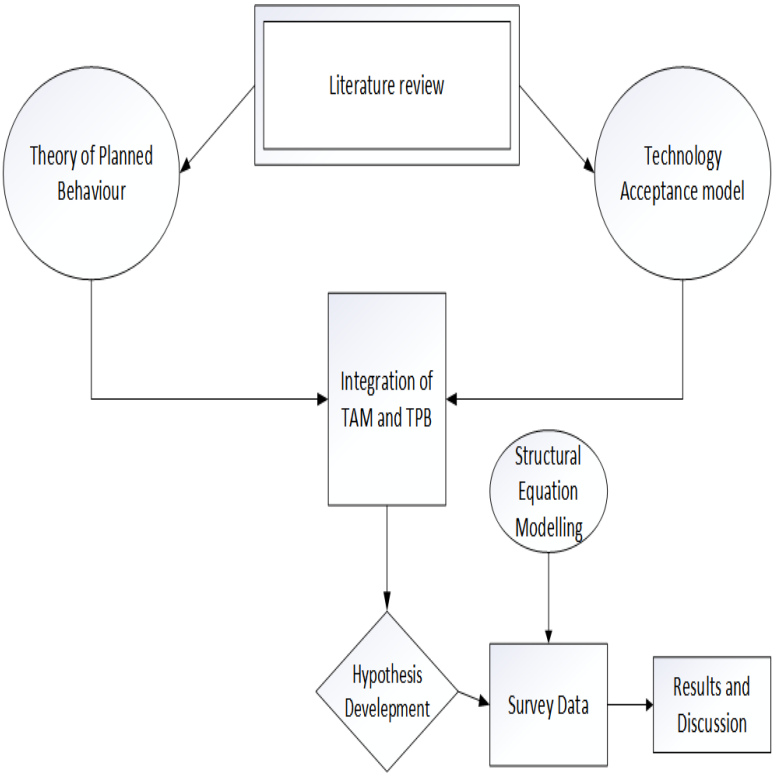

FIGURE 1.1: Methodology

1.7 Thesis Outline

Following is the road map of the research thesis in a logical manner and a brief introduction of all chapters.

Chapter 1

This chapter provides an overview of the topic, its background, purpose, aim, and objectives. It briefly explains the topic along with the scope of the research. Also, it signifies the research topic and its usefulness to society.

Chapter 2

Literature review creates a relationship of purposed work with existing knowledge. It consists of a general review of scholarly knowledge that includes: past research papers, journal articles, annual reports, books, a thesis, and any other related material concerned with renewable energy usage and the behavioural intention of the consumer. It also contains a detailed review of theories associated with the research topic and structural equation modelling. In short extensive literature review from past research is covered in this chapter.

Chapter 3

This chapter covers the extensive procedures and processes used in this research to ensure correct outcomes. The primary data was obtained using proper instruments, and the data were analyzed using structural equation modelling. It also goes into great detail on study design, hypothesis building, and questionnaire development. The approach describes all of the research efforts in detail.

Chapter 4

This chapter provides an in-depth analysis of the data obtained through a questionnaire. Various statistical techniques and methods have been utilized for the proper analysis of the data. A concise, clear, and well-structured discussion, providing a comprehensive overview of the results and their significance for the field has been presented.

Chapter 5

In the concluding chapter, the key results of the study are highlighted, and the research question is answered based on the findings. Here are some key elements that are discussed in the conclusion. Based on the study's results and limitations, provide recommendations for further research.

Chapter 2

Literature Review

The review of the literature will concentrate on solar energy solutions and the acceptance of solar energy solutions in society. This chapter will explain all the concepts involved in the research study related to energy generation and the behaviour of consumers in the adoption of RE source of generation.

In the first section, the introduction of RE technology is explained as how the energy transition took place from burning wood to solar PV systems and innovation in PV solar systems. It describes all the history and future impacts of RE innovations. In the next section trends of solar energy will be studied around the world i.e. the amount of RE usage in other countries especially the neighbouring countries of Pakistan and countries that are dominating in the field of PV energy systems.

This section covers RE development and will provide insight into the possibilities of RE systems in Pakistan in comparison to the rest of the world.

The third section will give a detailed description of theories associated with analyzing the consumer's behaviour towards an innovation. It includes all the previous work done by using old research models such as Roger's theory of innovation, Theory of planned behaviour, Theory of reasoned action and technology acceptance model. In this section innovation and diffusion of innovation in society are explained. It will explain consumers' behaviour intention and the involved constructs in the adaptation of RE. As each theory has different criteria defined to analyze consumer behaviour. This thesis analyses the best integration of two theories and a hypothesis will be formulated keeping all the aspects of RE.

Renewable energy includes any source of energy that can be renewed in a relatively short period of time, such as wind, biomass, geothermal, and, most importantly, solar energy. Renewable energy is rapidly being acknowledged for its capacity to balance rising and variable energy prices, reduce carbon emissions by lowering fossil fuel usage, and reduce dependency on fuel imported from other nations, which is frequently more expensive than traditional local sources [19].

It's important to go back into history and investigate where it exactly started and where it stands at the moment and what will be the future in the coming years. So far, the world has seen three distinct energy shifts. The first change was the substitution of coal for wood as a raw energy source. Oil supplanted coal as the major energy source throughout the second transition. There is a worldwide commitment to the third transition to replace fossil fuels with renewable energy. Predominantly solar energy is considered the latest development in renewable energy sources and is considered an innovation.

In today's world, there exist three predominant classifications of solar systems that are in use: off-grid systems, on-grid systems, and hybrid systems. These categories represent different approaches to solar energy utilization, and each has unique features and benefits depending on the specific needs and circumstances of the user. also known as standalone systems, operate independently without any connection to the main grid, and the power generated is stored in batteries for future use. The Ron-grid grid system was primarily used in industry, but the concept of a residential on-grid system has emerged around the world and in Pakistan as well. In the on-grid system, energy generated by the consumers is used, and excess power is fed into the grid; this system is only for the day, and consumers will use grid-supplied energy at night; this system does not require batteries for backup, lowering the cost of batteries and their maintenance.

The third approach is a hybrid system, which is a combination of an on-grid and an off-grid system in which surplus energy is stored in batteries and the leftover power is supplied into the grid when the batteries are charged.

Among other renewable energy resources, the solar system is the most reliable, and with the addition of net metering or the installation of an on-grid system, energy can be fed back into the grid and helps in the reduction of a utility bill; it also shows that by using a grid-connected system, we can overcome the energy crisis [20].

2.1 Renewable Energy Solutions as an Innovation

Innovation is the incorporation of new ideas and features into a current product in order to make it more competitive in the market as time passes, making the outcome of the innovation a very unpredictable process. In general, the more changes made to a product, the higher the uncertainty about how it will perform and how the market will react to the innovation, hence the relationship between the quantity of change and the degree of uncertainty has significant consequences for the nature of suitable innovation [2]. The main problem related to innovation is its diffusion in the environment and how well the innovation is adopted by the general population, for most the innovation not everyone in the environment will adopt the innovation as the product introduced would not be superior to existing forms or brands but sometimes the product has widely accepted the environment [21].

2.1.1 Characteristics of Innovation

This study used the perceived attributes of innovation in the persuasion stage to draw conclusions about our research. These attributes of innovation and how people perceive them can assist to explain the adoption rate of innovation. The attributes of innovation are as follows:

2.1.1.1 Relative Advantage

Relative Advantage is one of the characteristics of innovation, referring to the degree to which an innovative product or service is seen to be better than the existing alternatives. Relative Advantage measures the value of innovation relative to the existing alternatives in the market. It is an important consideration for entrepreneurs, as a relatively more advantageous product or service is likely to have higher adoption and success [22]. Relative Advantage measures how much better the innovative product or service is compared to the current alternatives. This comparison can be made on almost any criteria, from price to performance.

A product or service with a high Relative Advantage can significantly increase customer satisfaction and drive adoption.

2.1.1.2 Trialability

Trial ability refers to the ease with which a new product or service can be tested or tried out before full adoption. It is an important factor in the diffusion of innovation, as it influences the willingness of individuals and organizations to try out new products and services. The trial ability of an innovation is often a key factor in determining its success, as individuals and organizations are more likely to adopt new products and services that they can easily test and evaluate before making a full commitment. It can be influenced by a variety of factors, including the cost and availability of the product or service, the ease of use, and the level of risk involved in trying it out [23]. For example, a new technology that is inexpensive, easy to use, and poses a low risk to the user is more likely to be trialable than one that is expensive, complex, and poses a high risk. It is important for organizations to develop and commercialise new products and services, as it can help guide product development decisions and marketing strategies. By focusing on making their innovations trialable, organizations can increase the chances of success for their new products and services, as users and customers are more likely to try them out and ultimately adopt them.

2.1.1.3 Compatibility

Compatibility refers to the extent to which a new product or service fits with existing values, needs, and experiences.
It is an important factor in the diffusion of innovation, as it influences the willingness of individuals and organizations to adopt new products and services [24]. The compatibility of an innovation is often a key factor in determining its success, as individuals and organizations are more likely to adopt new products and services that are compatible with their existing systems, processes, and behaviours. It can be influenced by a variety of factors, including the alignment with existing values, the ease of integration with existing systems and processes, and the compatibility with existing behaviours and habits. For example, a new technology that is

compatible with existing values and systems, and that requires minimal changes to existing processes and behaviours is more likely to be compatible than one that requires significant changes or disruptions [25]. It is important for organizations to develop and commercialise new products and services, as it can help guide product development decisions and marketing strategies. By focusing on making their innovations compatible with existing systems, values, and behaviours, organizations can increase the chances of success for their new products and services, as users and customers are more likely to adopt them.

2.1.1.4 Observability

Observability refers to the extent to which the benefits and results of a new product or service can be easily observed or noticed by others.
It is an important factor in the diffusion of innovation, as it influences the willingness of individuals and organizations to adopt new products and services based on the experiences of others [26]. The observability of an innovation is often a key factor in determining its success, as individuals and organizations are more likely to adopt new products and services that they can see being used and delivering benefits to others. It can be influenced by a variety of factors, including the visibility of the product or service in use, the availability of demonstrations or demonstrations of the product or service, and the willingness of early adopters to share their experiences and results. For example, a new technology that is highly visible and easily demonstrable is more likely to be observable than one that is less visible or difficult to demonstrate.It is important for organizations to develop and commercialise new products and services, as it can help guide product development decisions and marketing strategies. By focusing on making their innovations observable, organizations can increase the chances of success for their new products and services, as users and customers are more likely to adopt them based on the experiences of others.

2.1.1.5 Complexity

Complexity refers to the level of difficulty or challenge involved in using or adopting a new product or service. It is an important factor in the diffusion of innovation,

as it influences the willingness of individuals and organizations to adopt new products and services.

The complexity of an innovation is often a key factor in determining its success, as individuals and organizations are more likely to adopt new products and services that are easy to use and understand. It can be influenced by a variety of factors, including the level of skill required to use the product or service, the number of steps involved in the process, and the complexity of the user interface [27]. For example, a new technology that is easy to use and requires minimal skill is less complex than one that requires extensive training or a high level of expertise. It is important for organizations to develop and commercialise new products and services, as it can help guide product development decisions and marketing strategies. By focusing on reducing the complexity of their innovations, organizations can increase the chances of success for their new products and services, as users and customers are more likely to adopt them if they are easy to use and understand.

In general, we may state that innovations viewed by receivers as having more relative benefit, compatibility, trialability, observability, and being less complicated will be accepted more swiftly than other innovations; these are the most essential features of innovation in understanding the pace of innovation adoption. Rogers defines diffusion as the process by which innovation is communicated into the environment; this transmission occurs through certain routes and takes time to reach the population.

The concept of communication aimed at promoting the spread of innovative ideas and goods to the general public is known as innovation dissemination. It involves sharing information about new and innovative products, services, or concepts with a broader audience, with the aim of encouraging their adoption and use. This process often involves various forms of communication, such as advertising, marketing, public relations, and social media, to raise awareness and generate interest in these new ideas or goods.Innovation can also refer to an individual's perception of a novel concept, activity, or product.

This perception is often influenced by a range of factors, including personal values, beliefs, and experiences. When individuals perceive something as new or innovative, they may be more open to learning more about it and considering its potential benefits. [28].

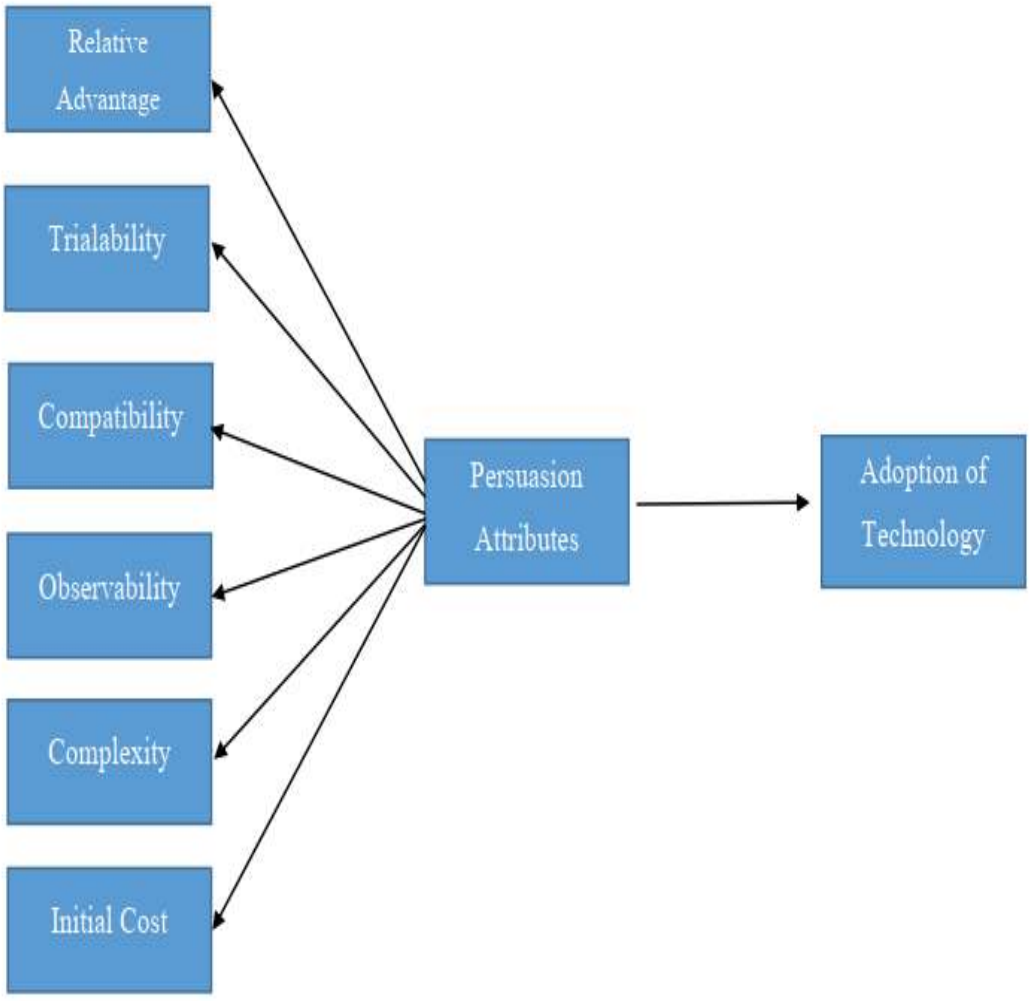

FIGURE 2.1: Characteristics of innovation (adopted from [28])

2.2 Renewable Energy as Innovation

Climate change issues, fluctuating prices of oil, and increasing awareness about environmental protection have highlighted the importance of Renewable Energy to reduce greenhouse emissions. Renewable Energy is an effective alternative to conventional energy sources with unlimited resources throughout the planet. As the importance of renewable energy has grown, so has technical innovation in the industry. Hydro, biomass combustion, and geothermal power are considered the first generations of renewable energy sources, and they have attained maturity. Second-generation technologies, such as solar energy, wind power energy, and new

forms of bioenergy, are now in the early stages of development, and the price of the system is significantly lower than that of first-generation technologies. Third-generation technologies such as solar concentrated power, ocean energy, enhanced geothermal, and integrative bioenergy systems are in the phase of research and development. Penetration of Renewable Energy in the environment is increasing but still, but it is limited and still, and it is unbearable to adopt for many households. Governments are making new policies to reduce the cost of the system and to make its diffusion at a greater rate, as a result of these policies tradeable energy certificates feed-in tariff systems and tax credits kind of concepts are introduced in the market [29]. Climate change issues can be addressed through rapid technological innovation in Renewable Energy, but some factors influence the growth of innovation in this field, these factors include feed-in tariff system, electricity from RE, per capita income, and R&D. By installing the electricity generation from RE plants there will be a boost in the innovation in Renewable Energy technology will reduce carbon emissions as well. The greater the per capita income and greater will be the innovation in this field, feed-in tariff system also increases innovation as more people will adopt this technology and more development will occur in this field. In short, we can say that policies also contribute to the innovation and diffusion of technology in an environment citeemodi2015influencing. The unsustainable conventional energy system needs to be addressed urgently to prevent the environment from greenhouse emissions, the time frame of twelve years was set to decrease the usage of fossil fuels by 50% to limit the global increase in temperature. Due to this timeframe, researchers are researching to find ways to increase the usage of renewable energies and to shift towards decarbonized energy system. Around the world policymakers are making policies so innovation in the field of clean energy can be made possible, they are also making policies to improve the production of this system and to increase the diffusion of these innovative energy systems. Solar PV systems were used in powering the space shuttles in the 1970s era and after that, they brought innovation in it and started the off-grid isolated systems for a small market in the 1980s and after further innovation and reduction in cost it was installed on public building rooftops at the end of the 1990s. At the start of 21st century, it was also adopted by households and private building owners due to further reduction in cost through more innovation in technology and now it is adopted by almost every country that has a suitable amount of solar irradiance,

on the other hand, wind energy was in the R&D stage in the 1970s, after some innovation in the design, it was brought to the testing phase by the installation of small wind turbines in the 1980s and after further improvements, it was brought to the general market in the 1990s after that, it was adopted by many countries and many innovations in designs made it more efficient and profitable. These advancements are all because of the new trends and innovations in these fields such as the innovation of on-grid systems in Solar PV, Commercial wind turbines, and diffusion of these Renewable Energy sources are also supported by policies of different countries that invested heavily in the R&D of these technologies and made it possible for people to adopt these systems [30].

2.3 Analysis of Solar energy Solutions usage Worldwide

With the increase in world economic growth along with population, the need for more energy has been seen in both developed and developing countries. With the increase in energy demand, Renewable Energy RE shows promising results as it is the cleanest form of energy derived from nature and keeps nature less polluted. Environmental issue such as global warming is caused by an excess amount of carbon dioxide which is produced in the process of electric power generation, and it has a significant role in climate change. In recent years, this global warming and environmental issue have gained attention worldwide and countries are making policies to reduce greenhouse emissions that include carbon dioxide and methane, they also started shifting toward alternate resources for producing electric energy. Among many sources of sustainable energy, the solar PV system shows the most promising results as an alternative to the generation of electric energy. This is due to the fact that the energy provided by the PV system is noiseless, emits no carbon dioxide during generation, has scale flexibility, and is simple to operate and maintain. A solar PV system has also gained popularity as an alternative energy source across the world [31].

Due to the rapid expansion of the PV sector and the reduction in the cost of

panels, the industry built a sustainable development of energy systems. Laws governing the implementation of PV systems and the transition from conventional to renewable energy are in place all over the world. Sustainable energy has been adopted and deployed without any objection. Many countries, including China, Germany, Japan, the United States, and others, are engaged in a technical arms race to outperform others in this sector by proposing and advocating initiatives to increase the use of photovoltaic (PV) systems, which will increase production capacity, lower costs, and, most importantly, reduce reliance on fossil fuels. These countries also implemented cost-effective PV incentives and strategies to enhance the rate of PV adoption of this technology [31].

Germany is one of the leading countries in the field of RE, with the highest production of energy from renewable sources. They shifted towards the Renewable Energy sector after the 1974 oil crisis and the incident of the Chernobyl nuclear power plant and its radiation that polluted the surrounding air; although it occurred in the Soviet state, the radiation level was so high that it travelled to German cities as well, leading them to the Renewable Energy sector. German government started its path towards renewable energy with one goal i.e. to increase Renewable Energy generation and make the environment clean and ecofriendly with enough energy to meet their needs. They adopted various legislation, such as the electricity feed law and the Renewable Energy law, to increase the adoption rate of renewable energy, which played an important part in the growth of their renewable energy sector. These rules allowed them to buy back the generated energy from consumers and also implemented programs such as loans and subsidies to encourage the generation of renewable energy. The National Renewable Energy action plan of Germany in 2010 projected that Germany will generate 38% of its annual generation through renewable sources and add it to the national grid by the end of 2020, and they also set a goal to increase this percentage to 50% by 2030, and their total cumulative solar PV capacity is around 52 GW by the addition of 3.5GW per year [32].

In the introductory phase of this technology i.e. solar PV systems, Germany introduced this technology in the shape of a program called the “1000 roofs program” in the 1990s, they planned to install all solar PV systems on 1000 roofs of domestic consumers so they can gain more experience in solar installation and also to make the system compatible with the usage of domestic consumers and make it more

compatible to fulfill the energy demand of new users.

The German government subsidized the installation of rooftop solar PV systems for users of the 1000 roof programmer. The program was a success and gained popularity in Germany and expanded in the form of 100,000 rooftops to drive the expansion of the industry.

This program invited private companies to enter this field and lower the cost of PV installation. The private companies that participated in the development of this field received a loan from the government to invest in the development of this technology. This was also, a successful program and it ended in 2004 with 100,000 new rooftop PV systems consumers they were all girds connected and due to this program's success, their market shifted from a niche market and become a market capable of mass manufacturing solar PV systems. They also introduced a policy called feed-in tariff which means that the consumers can sell the excess amount of energy back to the grid and the units they produce will get a higher price than the market price for the year and 20 years beyond the installation date, this opens a new door for firms and investors to invest their capital in solar PV to gain the profits, this was the key point in developing industry that is now among the biggest solar market around the world. They renewed the feed-in tariff in 2000 and increased its per unit rate and which helped them in achieving the lead position in terms of Renewable Energy production within a short period. Their market developed from 44MW in 2000 to 7.5GW in 2011, and now according to the official site of the Ministry of Economics and Energy Germany, they are producing 45GW of energy only from Solar PV systems [33].

In the case of China, advancement in the field of solar began when China first successfully developed a solar cell with the aim of using it in space satellites back in 1968, they started using PV as the energy source on land back in 1973. Between 1979 and 1992, just eight PV enterprises and research institutions were present in China, and they were also bought from US and Canadian corporations. At that time China was not capable of designing and manufacturing turnkey production lines and manufacturing equipment that can be used for the mass manufacturing of solar PV cells. Back in 1995, the national scientific and technological commission (NSTC) of China drafted a document to introduce the outlines for reducing greenhouse emissions and to focus on Renewable Energy especially solar energy. This document also presented a road map for the transition to PV systems, as

well as a five-year plan that highlighted the development of PV cell modules and PV equipment. The NSTC statement also emphasized the necessity of small-scale PV systems, PV power plants, and other Renewable Energy applications for the creation of clean energy. They also gave permission to private industry and firms to take part in the development of PV market and product and by this point, a lot of technology was imported to China followed by entrepreneurial activities. By the end of 2001, China had become a member of the World Trade Organization (WTO), which functioned as a spur for the Chinese PV industry's expansion because their product no longer had to face global trade hurdles.

In 2005 they implemented a Renewable Energy act that demanded the grid-tied systems and full purchase of renewable power form private companies, in 2011, feed-in tariff law was introduced in China which changed the demographic of the Chinese PV market as more people started to adopt this technology and there was an exponential rise in PV installation. Entrepreneurs entering this field to gain more profit, local and central government policies providing the firms lands, capital and institutional advantages were the main internal factors that gave rise to the Chinese PV market [34].

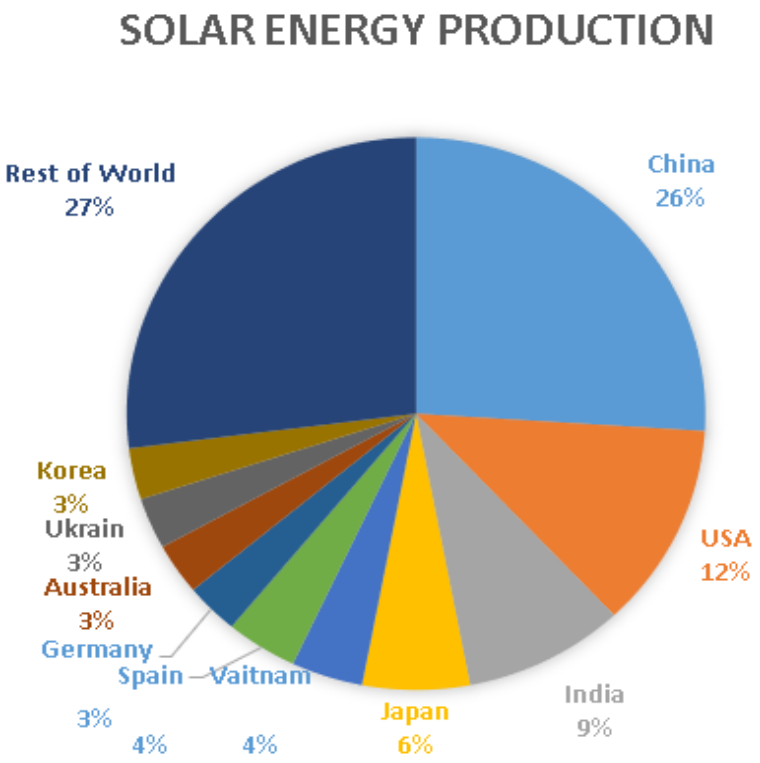

FIGURE 2.2: Solar energy Production (adopted from [17])

2.4 Energy Situation in Pakistan

In Pakistan, fossil fuels are highly relied upon for energy production. With the expansion of population and industrialization, these conventional sources are no longer meeting the country's present energy demands, and they have a negative environmental effect and are economically inadequate for electrifying rural locations. Due to dependence on fossil fuels to meet the energy demand of Pakistan, electricity prices are unstable and variations occur in them whenever the price of oil in the international market increases apart from the variable prices of oil, increase in population and poor energy policies and lack of innovation in terms of technological advancement results in an increase of energy demand and crisis in Pakistan every year [35].

Independent power plants (IPPs) solely produce roughly 50% of the national energy output in Pakistan; this also a role in the volatility of electricity costs. These IPPs employ coal-fired facilities, as well as oil and gas-powered units, to provide rather costly energy [33]. Also, one of the main factors in the crisis of energy in Pakistan is the distribution and transmission losses, around 20% of the energy is wasted due to transmission and distribution losses because of in efficient lines and distribution systems [35].

According to the annual report of NEPRA [36]. Pakistan has increased it installed capacity to 35,000 MW but still around 63.96% of installed capacity is thermal energy that includes, oil, gas, and coal-powered plants, the total Solar PV installed capacity according to the report of NEPRA is 1.3% i.e, around 400MW.

2.5 Advancement of Solar Energy Solutions in Pakistan

After the advancement in Renewable Energy particularly Solar Energy in the past decades Pakistan's government is now making policies to shift from conventional energy to Renewable Energy and the government is trying to reduce its dependency on fossil fuels, the transition from conventional energy to Renewable Energy is very slow in the case of Pakistan and requires new policies and implementation

strategies to increase the transition rate. Back in 2006, the government of Pakistan implemented a renewable energy strategy with the goal of shifting from conventional energy resources to renewable energy resources by utilizing indigenous resources such as wind and solar resources for renewable energy [35].

The most significant aspect in the creation of solar energy is solar irradiance, and Pakistan is one of the nations in the world with the highest sun irradiance throughout the year. Sun shines around 7 to 8 hours in many parts of the countries and this shows the potential of solar energy in Pakistan, also Pakistan has solar irradiance of around 2200 kW/m$\hat{2}$ per year and the sun shines for more than 300 days a year [37].

The majority of Pakistan's cities have access to solar irradiance, which ranges from 4.5 to 6.3 kWh/m$\hat{2}$ per day and has a total capacity of around 2.9 million MW. Several studies have been conducted to explore the renewable resources of Pakistan such as wind and solar energy and to explore the relevant areas having the potential for these renewable resources. Pakistan's energy sector could benefit from this huge abundance of solar energy to eradicate the shortfall and to reduce the generation of conventional energy that has both environmental and economic effects. The potential success of this technology in Pakistan is hindered by certain obstacles. These include a lack of financial resources, inadequate infrastructure, and a lack of competition between companies to dominate the market. However, it could be beneficial for rural areas and villages which are far away from the national grid, as it would help the local communities, and also reduce the cost of transmission lines and their installations [38].

Solar PV systems are the best way to transform from conventional energy to Renewable Energy and to provide electricity to rural areas, however development in this field is very low. According to NEPRA, there are around 40,000 villages in Pakistan without electricity. The government has not made any effective plans to harness the power of the sun in these rural areas. Additionally, the cost of the solar PV system in the country is significantly higher than in developed nations, and customers, particularly households, don't receive any subsidies on the installation of these systems. This high upfront cost is a major barrier to the development of this technology [39]. Solar is proving to be a viable alternative to traditional sources of energy such as oil, natural gas, and coal due to its low cost and minimal maintenance requirements. Its life cycle is even longer than a wind turbine.

Additionally, solar radiation is more consistent throughout the year compared to wind speed, which is only available for five to six months a year. By utilizing solar energy resources, the reliance on oil imports to generate electricity can be diminished significantly, resulting decrease in cost. The Quaid-e-Azam solar park and other similar systems have been successful in raising awareness of solar energy, however, its share in the installed capacity is still quite small at only 2%. Policies should be implemented and enforced to encourage more people to adopt this technology, which can quickly solve Pakistan's energy problems. The low adoption rate of this technology in Pakistan is largely due to a lack of knowledge about its market potential, high initial costs, a lack of government subsidies and financial assistance from the third-party sector, concerns over its performance, the absence of a feed-in-tariff system, dependence on foreign technology for essential parts and equipment, inadequate policies for its adoption, and a general lack of awareness about solar energy, particularly in rural areas. The high potential for utilizing solar energy in Pakistan is evidenced by its geographic location and climate. Various studies conducted to assess the availability of solar resources have provided valuable insight into how and why renewable energy can be beneficial in the country, as there is a plentiful amount of solar irradiance naturally occurring here year-round [40]. In many countries worldwide, PV solar systems are a major contributor to the national electricity grid. However, the use of these systems in households in Pakistan has not yet been fully realized. This could be due to the lack of reliable batteries, solar panels, and technical knowledge that makes it difficult to use a solar system to its full capacity [41].

2.6 Theories to Determine the Adoption of Technology

To understand the obstacles impeding the adoption of on-grid and off-grid solar energy systems, the various theories, such as the Theory of Diffusion of Innovation (Rogers 1995), the Theory of Reasoned Action (TRA), the Theory of Planned Behavior (TPB) and the Technology Acceptance Model (TAM) have been studied and analyzed.

Solar energy technology is an innovation in the way people can produce electricity in their homes. It is considered an innovation because it is perceived as new by those who use it. According to Roger's theory, for technology to be considered an innovation, it must be perceived as new by the individual or adopter of the technology. The level of the newness of the technology will then determine whether the individual will adopt it or not. From the consumer's perspective, the adoption of innovation begins when the individual becomes aware of the technology and learns more about how it works. The individual may then decide to purchase and install a solar energy system in their home. After the purchase and installation of the system, the individual will then be able to benefit from the use of the free renewable energy source, which can be used as an alternative to more traditional energy sources. Individuals may also benefit from additional features of solar energy technology. For example, some systems may come with battery storage capabilities that allow users to store excess energy produced by the system, which can be used in the case of a power outage or when energy prices are high. Solar energy systems also tend to require minimal maintenance, as they do not require fuel and have few moving parts. This can save money on energy bills in the long run. The research will use the constructs of two theories, TAM and TPB, to discover the factors influencing adoption, and will form a relationship with different variables and evaluate the results using structural equation modelling. The hypotheses we explored for our study work are briefly described here.

2.6.1 Roger's Theory of Innovation

According to Rogers [42], the diffusion of innovation the decision of an individual regarding innovation is not an immediate action but it's a complete procedure which consists of several steps that are linked with time and comprise several actions, the model of innovation consists of five stages [43]:

2.6.1.1 Knowledge

It occurs whenever a person is introduced to the innovation that exists and the individual gains more knowledge about its functionality and advantages. In this

step, the individual asks many questions about the innovation such as how it works, why it works, what is the innovation and its functionality, once the individual learned about the innovation and its working and other knowledge about the innovation then the awareness about the innovation motivates the individual about the adoption of this technology [43], this information seeking stage can also occur at the persuasion and decision stage.

2.6.1.2 Persuasion Stage

The persuasion stage is an important part of the innovation adoption process and involves the individual seeking knowledge about the technology and forming a favourable and unfavourable opinion towards the innovation [42]. In this phase, individuals become more involved psychologically with the innovation, researching new trends and ideas related to it. In this stage, it is important to consider the individual's sources of information and how the messages received are being interpreted. The concept of selective perception or people's ability to interpret information in line with their existing beliefs can play an important role in determining the individual's behaviour. Furthermore, the individual may apply the innovation mentally to current and future situations, in the process of developing an attitude towards the innovation that may be either favourable or unfavourable [44]. Finally, innovation adopters may also seek evaluation information that helps to reduce uncertainty surrounding the innovation and can inform their decisions on whether to adopt or not.
This can help individuals to make an informed decision about whether to pursue the innovation and make the switch.

2.6.1.3 Decision Stage

The innovation-decision process is a series of steps an individual goes through before deciding whether to adopt or reject a new technology. It starts with the individual gaining knowledge about the innovation and its features, as well as how it compares to existing solutions.
This information may come from various sources such as advertisements, reviews, recommendations from friends or colleagues, and hands-on experience with the

technology. Next, the individual engages in persuasive activities, such as considering the advantages and disadvantages of the technology and evaluating its compatibility with their current needs and practices[44].

During this stage, the individual also considers the costs and benefits associated with the adoption of the technology, including the monetary, social, and psychological costs, as well as the benefits it may bring in terms of increased productivity, efficiency, and overall satisfaction. Once the individual has evaluated the technology and determined that it meets their needs, they make a decision to either adopt or reject it.

Adoption refers to the decision to use the technology as the best available option, whereas rejection means not using it. It is important to note that rejection can occur at any stage of the innovation-decision process. For example, the individual may reject the technology simply by not having enough knowledge about it, or by being unable to afford it. On the other hand, they may actively consider adopting it but then decide not to due to perceived risks, lack of compatibility with existing practices, or any other factors. Rejection can also be either active or passive. Active rejection involves the individual considering the adoption of the technology but then deciding not to, while passive rejection refers to the individual never seriously considering the technology in the first place.

2.6.1.4 Implementation Stage

The implementation process occurs after the individual has made the decision to adopt a new technology and has acquired it. Up to this point, the innovation-decision process has been purely a mental exercise. However, even after making the decision to adopt, a certain degree of uncertainty may remain in the individual's mind. During the implementation stage, the individual seeks to acquire knowledge about how to use the technology and what potential operational problems may arise [45].

This may involve researching the best place to acquire the technology, learning how to set it up, and familiarizing themselves with its features and capabilities. It is important to note that the process of acquiring knowledge continues even after the individual has acquired the technology.

This is because there may be aspects of the technology that are unclear or unknown

until it is put into actual use. The individual may also encounter operational problems that require further research and understanding in order to be resolved.

2.6.1.5 Confirmation Stage

The confirmation stage of the innovation-decision process refers to the point at which an individual seeks reinforcement for the decision to adopt a new technology. At this stage, the individual may look for additional information that supports their decision to adopt, such as feedback from others who have used the technology or positive reviews and testimonials. However, the individual may also reverse their decision to adopt the technology if they are exposed to conflicting information or messages about the innovation [46]. This could come from sources such as negative reviews, warnings from others about potential problems, or the individual's own experience with the technology after implementation.

In the confirmation stage, the individual reassess the decision to adopt the technology and determines whether they still believe it is the best option. If they encounter conflicting information, they may decide to abandon the technology and look for alternative solutions. For measuring the adoption of technology, many studies have used roger's innovation diffusion model, the advantage of using this model is that it can be used to measure any technological innovation.

This model has been used by many authors in their numerous studies of different topics on different technologies. This model has been used to investigate the factors influencing home solar PV adoption [8]. In this study, the authors applied Rogers' theory of innovation to find out the factors that contribute to the adoption of solar PV energy. According to the theory, innovations that have greater relative advantage, compatibility, trialability, observability and lower complexity will be adopted quicker; however, the relative advantage is not absolute, but it relies on the perception and necessity of solar PV among households. The research was based on a questionnaire designed using the constructs of Rogers's theory of innovation and was circulated among the households of Lahore. After examining the results, it was discovered that the diffusion of innovation is not a simple process. From an adoption perspective, the high cost of installing solar panels was identified as a major hindrance. To address this obstacle, the government could potentially set

up a financial institution to provide assistance for prospective adopters. Furthermore, no efforts the adoption solar PV systems will be effective until households are fully aware of the advantages and disadvantages. The research uncovered that the diffusion of solar PV systems in Lahore is not an easy process. The cost of these systems appears to be the most influential factor from an adoption perspective, regardless of their clean and eco-friendly characteristics. As a result, their implementation is impeded by their expensive upfront costs.

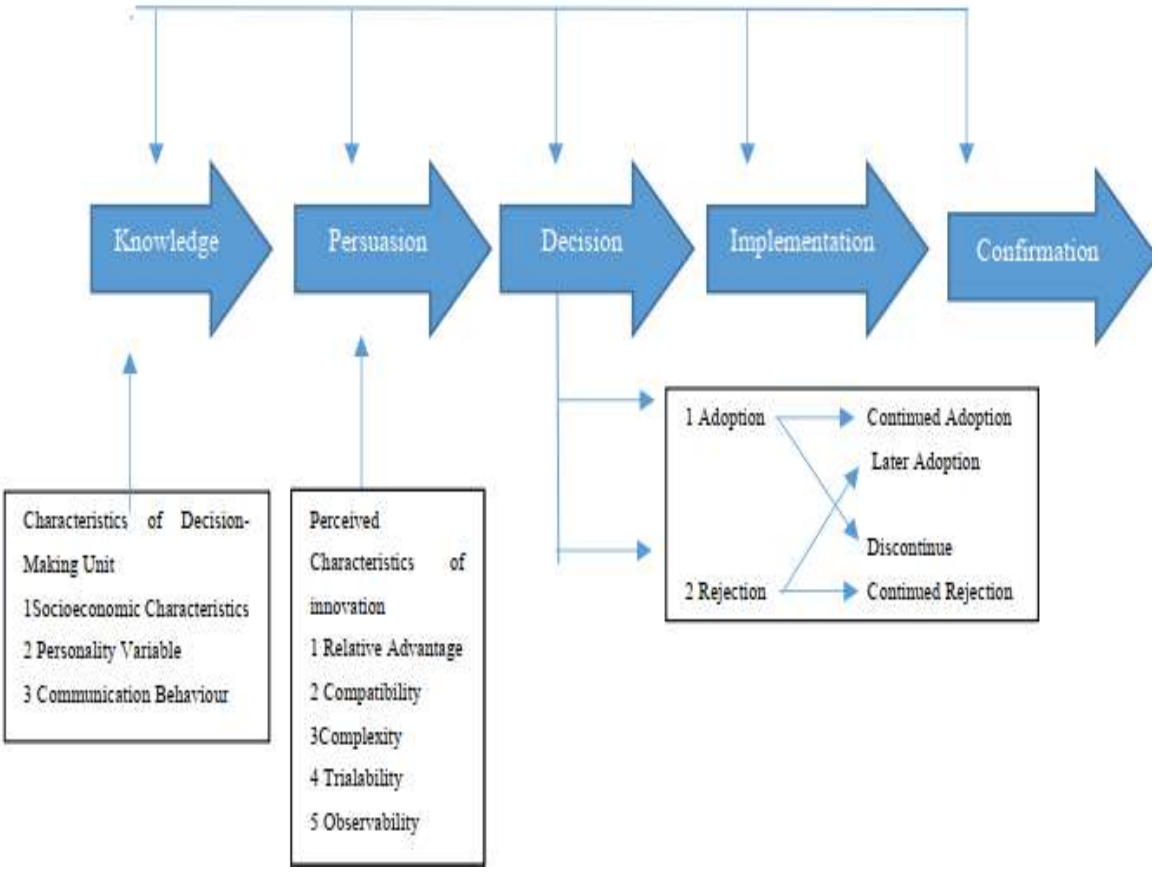

FIGURE 2.3: Solar Energy Usage (adopted from [17])

2.6.2 Technology Acceptance Model

In 1985, Fred Davis developed the Technology Acceptance Model (TAM) to explain and predict how users interact with technology. It proposed that user motivation,

based on external stimuli such as the technology's features and capabilities, intimates how technology will be used. TAM is a model that helps gain insights into how users adopt and accept technology [47]. The proposal puts forward that user drive towards utilizing technology can be illustrated by three aspects, which are attitude, perceived ease of use and perceived usefulness. It highlights that the sentiment of a consumer is fundamental in deciding whether to accept or reject technology. The two primary TAM components, perceived usefulness (PU) and perceived ease of use (PEOU) are declared to have an effect on consumer behaviour and attitude towards adopting new technology

2.6.2.1 Perceived Usefulness

Perceived Usability (PU) refers to the degree to which people perceive that technology can be used to enhance their lifestyle. It encompasses three elements: environmental usefulness (i.e. protecting the environment and natural resources), economic usefulness (i.e. reducing costs), and social usefulness (i.e. contributing to the community). Additionally, PU refers to the degree to which people believe that using the new technology would be easy.

Environmental usefulness: In order to ensure a high quality of life for ourselves and future generations, it is essential that we properly manage the environment. This includes taking care of the air we breathe, the food we consume, and the water we drink all of which are fundamental elements provided by the environment that are essential for our daily lives. Its protection is very important for living in the adoption of any technology the consumer keenly observes the usefulness for the environment and readily accepts the innovation if it's improving the environment and not causing any major destruction.

Economical usefulness: It is a major variable in decision making consumers think twice before spending money on innovation. There are always risk concerns associated while adopting new technology and its economical usefulness as well. Social usefulness: Another important concept in this model is about the social usefulness of a product or a technology, as humans are termed as social animals, this concept is always present in the mind if the adoption of innovation affects social life in a positive manner or not [48].

2.6.2.2 Perceived Ease of Use

PEOU encompasses two elements of uncertainty: fear or doubt that technology will not work as expected, and embarrassment about perceived inconvenience when using it. Uncertainty relates to a lack of knowledge about the potential outcomes of a particular situation. It can refer to estimates of future events, to physical measurements which have already been taken, or to the unknown. When there is incomplete information, uncertainty naturally arises: therefore, the adoption of new technology is always accompanied by an element of uncertainty.

Psychometric scales are used to measure perceived ease of use and perceived usefulness. These scales prompt individuals to answer questions related to the research's context. The responses obtained from these prompts can be used to gauge a person's internal beliefs and assess the research.

The Technology Acceptance Model has been employed to identify the factors that affect the adoption of solar PV technology in Pakistan [49]. This research explores the factors that affect households' perception of the purchase of PV technology in Pakistan. Tam was analyzed using a structural equation model which partitioned it into two second-order sub-constructs (PU and SU). The PU sub-construct was further broken down into social, economic, and environmental usefulness, while the SU sub-construct was broken down into discomfort and insecurity. Two additional moderating variables, policy and propaganda, were also included in the research [50].

The adoption of PV technology has been found to reduce excessive Carbon dioxide levels. This increased demand for PV technology can be attributed to various factors, such as technology acceptance, government policies, investments and favourable regulations for RE technology. The two main constructs associated with this phenomenon are PEOU, a second-order construct which better explains the phenomenon and insecurity and discomfort. Insecurity refers to distrust of a particular technology and the perception that it will not function properly, while discomfort is associated with a perceived lack of control over the technology.

The study [49] revealed that a relationship exists between the exogenous and endogenous variables in the study, leading to the rejection of all hypotheses. Furthermore, the empirical results showed that Perceived Usefulness (PU) had an impact on consumer attitudes towards the adoption of solar PV technology in Pakistan.

Through the use of Partial Least Squares-Structural Equation Modelling (PLS-SEM), the results showed that both PU and Perceived Ease of Use (PEOU) had a positive effect on consumer attitudes, which eventually affected consumer intention to adopt solar PV technology. The reliability and validity tests of the measurement model thus confirm these findings.

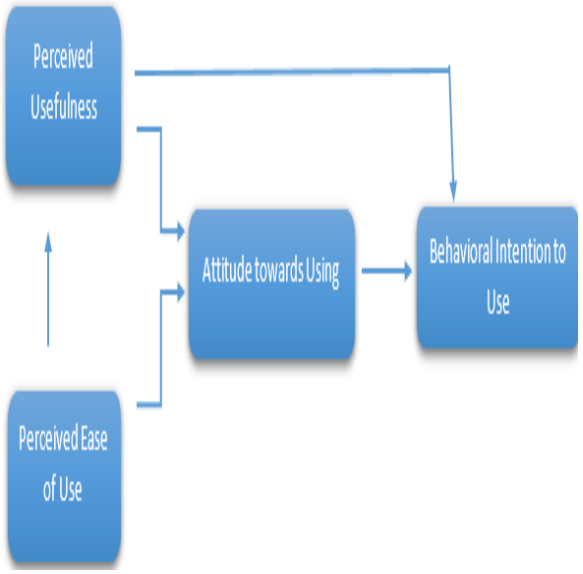

FIGURE 2.4: Technology acceptance model (adopted from [49])

2.6.3 Theory of Reasoned Action

In this theoretical model, a person's conduct might be predicted by taking into account his purpose as well as his views about the given activity. One of the most prevalent ideas is the Theory of Reasonable Action [51], which is about one aspect that impacts behavioural intention and a person's attitudes about that activity. defined "attitude" as an individual's assessment of an item, "belief" as a relationship between an object and some attribute, and "action" as a result or goal. Attitudes are emotional in nature and are founded on a set of beliefs about the target of conduct (e.g.: online banking is convenient). A second aspect is the individual's subjective norms of how they view their immediate community's attitude toward specific activity (e.g., peers use internet banking and it's a status symbol to have one). It proposed that attitude toward actual conduct and subjective norms connected with behaviour might influence behavioural intention.

It defined attitude as either good or negative sentiments about carrying out the

actual conduct. In mathematical terms, a person's attitude toward an activity may be assessed by adding the total of salient beliefs about executing that specific behaviour and an appraisal of the consequences [52].

They also defined subjective norms as the majority of people's perceptions of what others believe. Subjective norms (SN) can be described as the total of a person's normative ideas that are perceived expectations of other people or society. As a result, the behavioural intention might be estimated using the formula given, with A as a measure of attitude toward the behaviour and SN as a subjective standard.

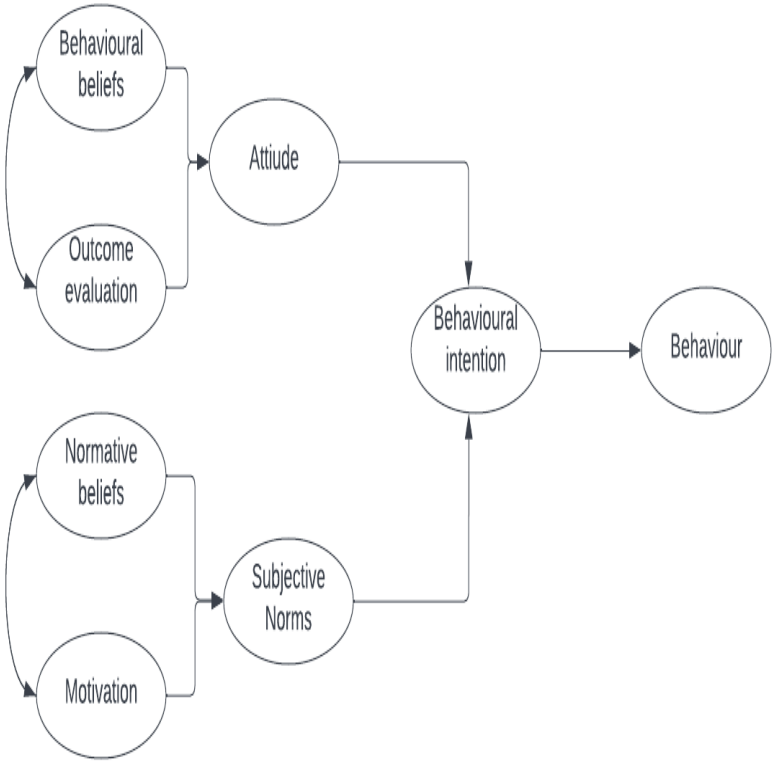

FIGURE 2.5: Theory of reasoned action (adopted from [49])

2.6.4 Theory of Planned Behavior

The Theory of Planned Behavior (TPB) is a cognitive social theory that attempts to explain and predict human behaviour by examining its cognitive antecedents. The theory suggests that an individual's intentions and behaviours are determined by their attitude toward the behaviour, their subjective norms, and their perceived behavioural control. According to the TPB, an individual's attitude towards a behaviour is their evaluation of the behaviour, positive or negative; their subjective norms are the perceived social pressure to engage or not in that behaviour; and

their perceived behavioural control is the extent to which they believe they can or cannot perform the behaviour. Based on these three variables, an individual's intention to act in a certain way can be predicted. The TPB has been used to explain a variety of human behaviours, such as quitting smoking, eating healthy, and exercising regularly [35].

The Theory of Planned Behavior (TPB) is a psychological model that attempts to explain and predict the likelihood of individuals engaging in certain behaviour. The model was created by researchers in 1980 and is based on the idea that beliefs, social norms, and perceived control of behaviour all contribute to an individual's intention to undertake an action. The three main components of the theory are attitude, subjective norms, and perceived behavioural control. Attitude refers to an individual's positive or negative feelings toward performing a behaviour. Subjective norms refer to an individual's beliefs about what is expected and accepted by significant figures in their life. Perceived behavioural control represents an individual's confidence in their ability to succeed at a given behaviour.

The TPB has been used to analyze and predict various behaviours, including health service utilization, smoking, and others [53]. Attitudes can be thought of as a set of internalized reactions or judgments toward particular objects, people, or events. They are formed over time through a person's experiences and can be positive, negative, or neutral. Attitudes are very influential as they can affect a person's opinion or even behaviour. In psychology, attitudes are considered to be important predictors of a person's behaviour and can be used to predict how individuals will respond in certain situations.

2.6.4.1 Attitude

The amount of as a set of internalized reactions or judgments toward particular objects, people, or events. They are formed over time through a person's experiences and can be positive, negative, or neutral. Attitudes are very influential as they can affect a person's opinion or even behaviour. In psychology, attitudes are considered to be important predictors of a person's behaviour and can be used to predict how individuals will respond in certain situations.

2.6.4.2 Subjective Norms

it refers to a person's beliefs about how the people around them think they should behave. It is based on the perceived opinions and beliefs of the people around them and can be affected by the values and attitudes of the society and culture in which they live. Subjective norms are a form of social influence; they can influence individuals to behave in a certain way or to resist certain behaviours. They can also play a role in how people evaluate their own behaviour and judge the behaviour of others.

2.6.4.3 Perceived Behavioral Control

It is the belief that a person has over their ability to successfully complete a task or behaviour. This belief is subjective and based on personal experience and current environmental factors. It can be affected by a person's past success or failure in similar tasks and the availability of resources or support to help them succeed [54]. Perceived behavioural control may be low in tasks that seem difficult to complete or require a lot of time and resources, while it may be higher in tasks that are simpler or that a person feels they have a good understanding of. Ultimately, perceived behavioural control influences how likely a person is to attempt a behaviour, making it an important factor in predicting behaviour.

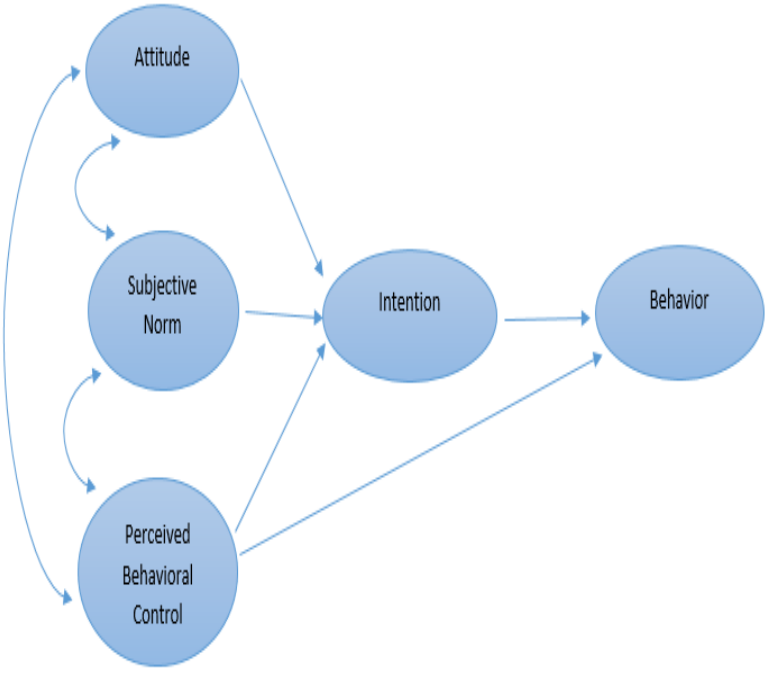

FIGURE 2.6: Theory of planned behavioural (adopted from [35])

This theory has been used in identifying the factors involved in the adoption of PV in five cities of Pakistan [12]. External variables, such as perceived risks, self-efficacy, and openness to technology, were added to this study model, along with the original TPB model, to explore consumers' perceptions of solar PV advantages, solar PV cost, and societal norms. The perceived danger has a detrimental impact on consumer acceptance. Customers' perceptions of the likelihood of safety and security issues, as well as the repercussions, were used to calculate perceived risk. Reasonably, perceived danger may have a detrimental impact on residents' willingness. Perception of self-efficacy reflected "a person's evaluation of how simple or difficult it is to undertake a certain action". Individuals thought they have the necessary skills, resources, or chances to successfully implement new technologies. The notion of self-efficacy is important and has favourably affected customer uptake. The third component was receptivity to technology which was described as "whether customers test new technologies or remain with established ones". We investigated household attitudes by assessing their readiness to embrace solar PV. Residents of all five provincial capitals were included in the study's target population (Lahore, Peshawar, Quetta, Gilgit, and Karachi). The urbanization tendency has been progressively increasing as the Pakistani government seeks to develop provincial capitals and make them the country's major areas. The bulk of the country's population is migrating from rural regions to the country's main cities in quest of better employment, education, and healthcare. These province capitals reflect the country's distinctive characteristics in terms of economic, energy, and resource structure, and energy consumption in these capitals is growing day by day.

The self-administered questionnaire was divided into two sections: one for profiling and another for the items utilised to evaluate each construct. There were six questions in Section A regarding gender, age, marital status, education, family income, and employment. Section B had 39 questions, including seven regarding belief in solar PV advantages, social norms, and self-efficacy and five about solar PV cost and perceived risk. Four questions were posed concerning technological openness and the desire to embrace solar PV. Items in Section B were graded on a seven-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) (strongly agree). SEM was performed with SPSS and AMOS version 26 to evaluate the study hypotheses and model that were considered. When assessing the

link between multiple factors, SEM is a practical approach that gives trustworthy and solid data. A validity and reliability test was performed on the measurement model. There were two types of validity tests: convergent validity (as assessed by average variance extracted (AVE)) and discriminant validity (as measured by AVE) [12].

The investigation results approved that purchasers' readiness to take on daylight-based PV is fundamentally affected by their convictions about its advantages Consumers can embrace solar PV on the off chance that they can see the genuine benefits of utilizing it over non-inexhaustible assets. Being harmless to the ecosystem innovation, sun shine-based PV has the capability of diminishing fossil fuel byproducts; be that as it may, studies looking at purchasers' eagerness to embrace PV innovation are restricted.

This study focused on this exploration gap by combining novel variables (saw risk, self-viability, and receptivity to innovation) with existing elements (accepted practice, sunlight-based PV cost, and conviction of sun-oriented PV benefits) in the reasonable structure of TPB to thoroughly investigate the purchaser's reception component.SEM was used to analyse information gathered from Pakistan's common capitals.

The examination discoveries uncovered that accepted practices, the impression of self-viability, and conviction about sunlight-based PV help emphatically impacted purchaser readiness to embrace sun-oriented PV. Then again, saw risk and sunlight-based PV costs adversely impacted purchasers' eagerness. Curiously, receptiveness to innovation had an inconsequential effect.

2.7 Integration of TAM and TPB

The literature review depicts that researchers have been modifying and decomposing the research modes according to the requirements [12],[55]. The integration of two research models is also performed by the researchers to get better results by investigating the consumer's behaviour. And below is one of the explained examples.

The study focuses on customer acceptance of internet banking. Over the last

10 years, internet banking has emerged as maybe the most advantageous online business application. Though a few previous research projects have focused on the factors that influence the reception of data innovation or the Internet, there is limited precise work that captures both the success factors (positive variables) and the opposition factors (negative variables) that encourage clients to engage in internet banking.

The paper investigates [16] and coordinates the different benefits of internet banking to frame a positive variable named apparent advantage. Also, drawing from the apparent gamble hypothesis, five explicit gamble features - monetary, security/protection, execution, social and time risk are incorporated with apparent advantage as well as coordinated with the innovation acknowledgement model (TAM) and hypothesis of arranged conduct (TPB) model to propose a hypothetical model to make sense of clients' goal to utilize internet banking.

The outcomes demonstrated that the goal to utilize internet banking is unfavourably impacted basically by the security/protection risk, as well as a monetary gamble and is decidedly impacted mostly by seen advantage, mentality and perceived value. The ramifications of coordinating apparent advantages and perceived risks into the proposed web-based financial reception model are talked about[16].

With the rapid advancement of Internet innovation, internet banking has assumed a significant and focal part in the e-payment region, providing an online transaction platform to help a wide range of internet business applications such as web-based shopping, online sale, online stock trading, and so on. Regardless, despite the fact that web-based banking offers many advantages, for example, faster exchange speed and cheaper dealing with costs, a sizable number of clients will not use such administrations due to vulnerability and security worries.

In this way, comprehending the purposes behindhand this opposition would be valuable for bank executives in creating systems pointed toward expanding web-based financial use. Shoppers have shown hesitance to finish basic on online purchases principally because of chance worries and, subsequently perceived risk is placed as a noticeable obstruction to purchaser acknowledgement of web banking. Contrasted with online buys, the reception of on web banking reception is ordinarily more complicated, as it starts an enduring connection between the customer and internet banking administrations. There is a great deal in question for

customers as they mull over going into a business relationship with far-off, unremarkable online banking administrations.

Despite the fact that customer view of the dangers of taking on internet banking has been concentrated on by numerous specialists the seen risk variable has just been demonstrated as a solitary build, which neglects to mirror the genuine qualities of seen risk and make sense of why purchasers oppose such financial administrations. To give a more profound comprehension of the apparent dangers of embracing web-based banking, a more in-depth investigation of the qualities of the apparent dangers. We separated apparent gambles into five classifications: execution, monetary, time, social and security/ protection gambles, as estimated by Jacoby and Kaplan [56], all together to explain which risk types are more significant in this discipline.

Though a few survey projects have concentrated on the elements that affect the reception of data innovation or the Internet for as long as a decade, there is restricted observational work which catches the achievement variables or positive elements of internet banking to assist with framing an essential plan. In this review, other than regrettable elements, we investigate and incorporate the benefits of web-based banking to foster an indicator named apparent advantage to clear up and foresee clients' goals for embracing web-based banking.

TAM is a variation of the hypothesis of anticipated action (TRA) and was for the most part intended for exhibiting user acknowledgement of data innovation. This model proposes that framework usage is straightforwardly resolved by the behavioural expectation to use, which is therefore impacted by users' attitudes toward using the framework and the framework's apparent utility. Perceived usability also influences behaviour and perceived usefulness. Perceived usefulness, which represents a person's strong belief in the use of the invention, will be beneficial in enhancing execution. define perceived usefulness as an individual's primary conviction that utilizing the innovation will liberate them from effort [57].

The appeal of this paradigm is that it is both precise and restrictive, while yet demonstrating a broadly anticipated force of innovative application. These determinants are also straightforward to understand for framework developers and may be specifically considered during system precondition analysis and subsequent framework development phases. These elements are common in innovation utilization situations and can be used broadly to address the acknowledgement issue.

The TPB's eventual TRA endeavour has shown success in predicting and making sense of human behaviour across multiple information developments. According to TPB, an individual's honest approach in doing certain tasks is directly impacted by their social expectations and is therefore decided by their disposition, emotional standards, and perceived behavioural constraints toward performing the way of behaving. Behavioural intention is a measure of how willing one is to make effort when acting out specified behaviours. Attitude (AT) describes a person's favourable or negative judgement of the activity under consideration. Furthermore, good or negative conduct directly influences the strength of the manner of acting and thoughts about the appropriate outcome.
Subjective norm (SN) communicates the apparent hierarchical or prevailing difficulty of an individual who expects to play out the conduct being referred to. In other words, the subjective norm is compared to regularizing views about others' assumptions. It might be represented as an individual's normative belief about a certain referent weighted by their motivation to comply with that referent. Perceived behaviour control (PBC) reflects an individual's perception of the ease or difficulty of carrying out the activity in question.
It is about convictions regarding the presence of control elements that may help or hinder their performance of the behaviour. Control convictions about resources and possibly open doors are therefore the main determinant of perceived behavioural control and may be represented as control beliefs weighted by the apparent force of the control component in question.
Overall, based on TRA's efforts, TPB is intended to eliminate the limitations of the original model in controlling behaviour over which individuals have little volitional control. TPB varies from TRA in that it includes the component of perceived behaviour control.

Although previous research has recognised TAM as a conservative and powerful model, it only uses three components to make sense of social goals: client mindset and two attitudinal beliefs (perceived utility and perceived ease of use). In any event, a client's behaviour aim will be influenced by several factors, such as the opinions of other relevant people (subjective norms). Furthermore, regardless of whether clients have significant areas of strength to act out a behaviour, they cannot do so without the necessary assets and abilities (perceived behavioural

control).TPB fills this gap; nevertheless, while TPB captures the occupations of people, hierarchical persons, and social effects on behaviour goals, it does not reveal to us which attitudinal convictions would affect a client's disposition toward the expectation.TAM's attitudinal convictions may serve as mindset reference points for TPB, and as a result, they are vital approaches. Furthermore, the precise results suggest that the combination of TAM and TPB has high logical power, which might pave the way for the inclusion of other innovation recognition models. For example, consider data innovation acceptance research [58] has produced a slew of competing models, including innovation diffusion theory, social cognitive theory, expectation confirmation model, and theory of reasoned action, each with its own set of acknowledgement determinants. It is hoped that this research will help other studies that coordinate competing models to generate unified ones.

In another study [59] in a developed country, an empirical integration of a technological acceptance model with the theory of planned behaviour is used to forecast e-procurement uptake. The emphasis on the supply chain has directed managers' attention to the value-added potential of cutting-edge technology, which mostly comprises the internet and e-services. Procurement is an important participant in the value chain since it often tackles one of the most expensive items in a company's expenditure structure. E-procurement denotes the use of data and communication parts of online innovation for acquiring materials and administrations and managing their inflow into the organisation. E-obtainment encompasses six sorts of exercises: e-requesting, e-maintenance repair work, web-based enterprise resource planning, e-sourcing, e-tendering, e-reverse auctioning/e-auctioning, and e-informing. e-procurement has evolved significantly, transitioning away from a focus on obtaining the lowest supplier prices or reduced margins. Instead, its aim is to reduce costs and receive savings for both buyers and sellers alike, by controlling material and administrative costs [59]. Moreover, e-procurement has minimized the time and cost involved in issuing purchase orders, placing orders, and establishing terms in contracts.

The adoption of e-procurement systems is usually decided by boards and managers of organizations, who are well-versed in the alternatives and consequences of using such a system. However, this decision-making process can overlook important considerations such as user acceptance of the system. Through this study, we seek to evaluate the role of various factors which could potentially influence the

intention to use e-procurement systems.

The purpose of this study is to explore the factors that impact the intention to use e-procurement systems by combining TPB and TAM. This research furthers the theoretical understanding of behaviour leading to e-procurement adoption and also offers practical implications to e-procurement system developers and purchasing managers. Strategies and tools are recommended to incentives purchasing personnel to get on board and adopt e-procurement systems.

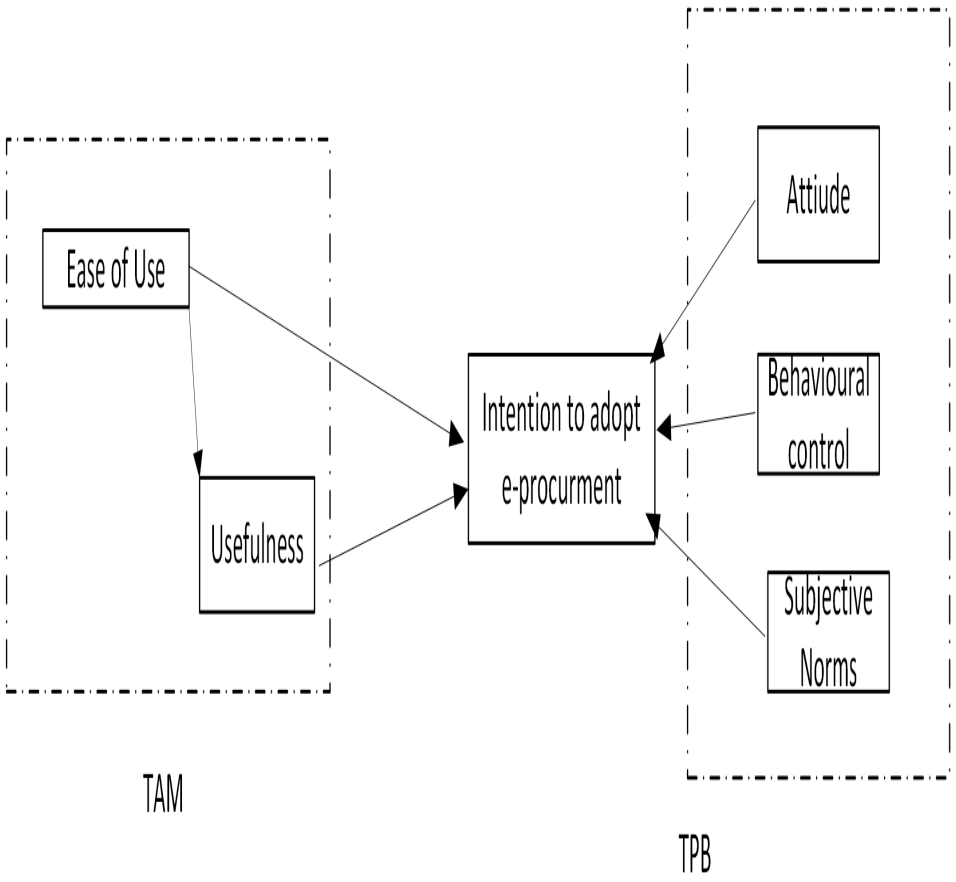

FIGURE 2.7: Integration of TAM and TPB fore-procurment (adopted from [59])

According to TAM and TPB, attitude toward using a given framework is a crucial factor of the aim to use that framework, which results in actual usage behaviour. The primary explanation is that individuals make decisions in a safe and efficient manner depending on the information available to them. Because the purpose of this article was to investigate the effects of TAM and TPB variables on the goal of e-obtainment reception, a self-regulated survey was used to target purchasing/supply chiefs and officials in organisations that had not yet used e-acquisition.

Following the survey distribution, a letter seeking the internal progress of the evaluation was faxed to all participating organisations. Respondents were encouraged to complete the surveys individually and submit them to allocated office secretaries, from whom the results were obtained.

The objective of this study was to propose an integrated model for predicting and understanding the intention to use e-procurement technology. To achieve this goal, the study combined the constructs of the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB), in order to provide a more comprehensive assessment of both the technical and social aspects of e-procurement innovation. In order to evaluate the reliability and validity of the proposed model, accurate data was collected through a field survey. The study aimed to provide a more nuanced understanding of the factors that influence the acceptance and usage of e-procurement technology in organizational contexts. By combining two established theoretical frameworks, the study sought to offer a more robust and holistic approach to studying the complexities of technology adoption in the context of e-procurement. The findings of this investigation can have important implications for practitioners and policymakers seeking to promote the effective implementation and use of e-procurement technology in organizations.The estimated model demonstrates that the hypothetical constructs have adequate consistency and validity, while the SEM was checked to throw a tantrum for precise information.

The study findings reveal that the social objective toward e-acquirement innovation is not fixed by the client's manner and is influenced by seeming usefulness and SN. Overall, the results demonstrate that the suggested model has strong illustrative power and confirms its robustness in anticipating customers' desires to use e-obtainment innovation, with good observational support. This is especially important for merchants, specialists, and customers of e-acquisition innovation for framework expansion and execution.

TAM and TBP integration has also been used to determine customer intent to adopt electronic money, commonly known as smart money [60].

The study's goal is to determine the factors that influence attitudes toward and intentions to utilize electronic money, which includes smartphone apps. The integration of TAM and TPB is used to study the elements that influence the public's inclination to utilize electronic money as a method of transaction. TAM attitudes and intentions are influenced by two primary predictors: perceived usefulness and

perceived simplicity of use. TPB is a model that predicts customer interest or intent to engage in a behaviour or action.TPB is a refinement of the Theory of Reasoned Action (TRA).

In the development of information technology, there are three major predictors affecting individuals' intentions to perform a behaviour: attitude toward behaviour, subjective norms of behaviour, and perceived behavioural control. Both theories are widely used as predictors for acceptance and to know the behaviour of an information technology object, either separately or combined.

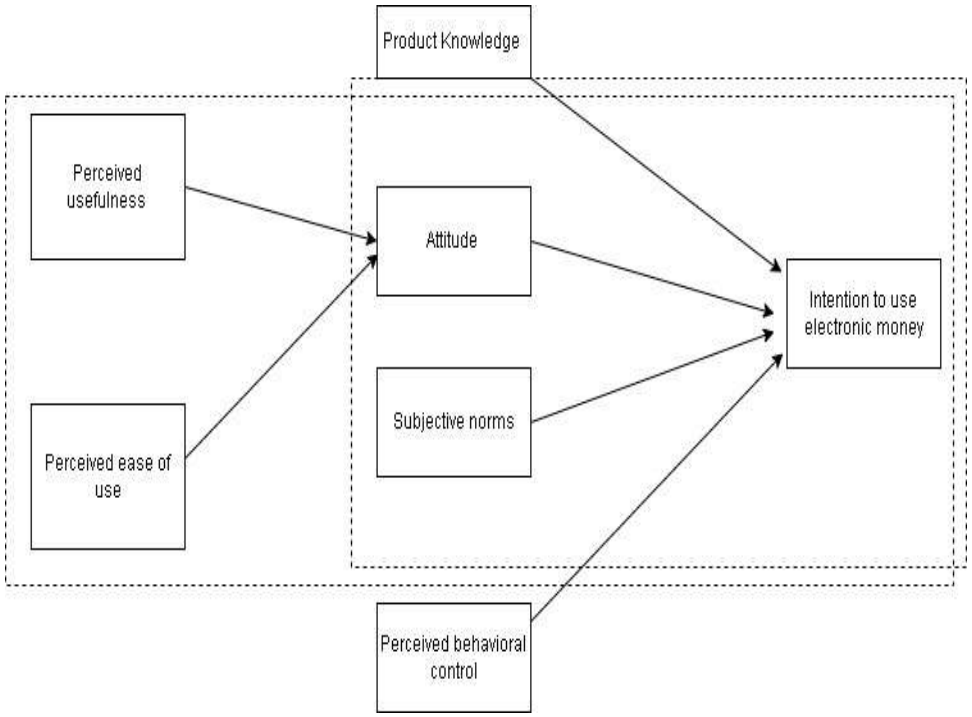

FIGURE 2.8: Integration of TAM and TPB for Intention to use electronics money (adopted from [60])

In this research, a descriptive quantitative technique was employed, as well as a survey and a cross-sectional investigation. To test the hypothesis, this research model has 7 hidden variables and 38 indicator observable variables. Seven factors are assessed with instruments in the form of a questionnaire with questions that serve as indicators. Measurements of each indicator were taken using a Likert

scale of 1 to 5, where 1 indicates strongly disagree and 5 indicates strongly agree, with the exception of product knowledge indicators, where 1 indicates an incorrect response and 5 indicates a correct answer. Cell phone-based electronic cash the first late smartphone instrument was acquainted as contrasted different financial products and chip-based electronic cash [60]. As a generally new item, a tremendous advancement system turns into a need. Cash withdrawal though not a card in an ATM is the most predominant pointer variable that pulls the premium of respondents as a consequence of substitution experience, but information connecting with this component stays uncommon. Partaking in promotions will speed up information connecting with these decisions to customers.

After conducting a thorough literature review, it has become apparent that a more comprehensive approach to analyzing consumer behavior can be achieved by integrating multiple research models. In light of this, the current research has sought to identify the various factors that are impacting the adoption rate of solar energy systems by integrating the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB). By combining these two established research models, this study aims to provide a more comprehensive and nuanced understanding of the factors that are causing barriers in the adoption of solar energy photovoltaic (PV) solutions.

The primary objective of this research is to identify the key obstacles that are hindering the widespread adoption of solar energy PV systems. By employing a combined TAM-TPB model, this study will examine the various factors that are influencing the attitudes, intentions, and behaviors of potential users towards solar energy technology. By identifying the specific barriers to adoption, this research aims to inform policymakers and stakeholders about the challenges that must be addressed to facilitate the greater uptake of renewable energy solutions. The integration of the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB) in this study represents a novel and effective approach to understanding the multifaceted factors that are shaping consumer behavior towards solar energy technology. By offering a more comprehensive analysis of the barriers to adoption, this research has the potential to make a valuable contribution to the development of strategies and policies aimed at promoting the widespread adoption of renewable energy systems.

Chapter 3

Research Methodology

This chapter introduces a study approach that will be used by the following chapter to analyse and report on the links between the adoption of solar energy solutions and the many structures involved. This chapter covers the extensive procedures and processes used in this research to ensure correct outcomes.
The main data was obtained using proper apparatus, and the data was analyzed using statistical methods. This chapter focuses on the conceptual framework, sample characteristics, study design, and numerous tests that are used.

3.1 Conceptual Framework

The primary goal of this study is to comprehend the link between consumer behaviours and the adoption of solar energy solutions, particularly in the context of Islamabad/Rawalpindi. As noted in the literature review, few theories are utilised to predict consumer behaviour [61] (already explained in the literature review) among the Theory of planned behaviour and Technology acceptance are most in use.
TPB explains three dimensions, namely Attitude (AT), Perceived behavioural control (PBC), and Subjective norms (SN), but provides little insight into the cost, environmental issues, utility, and advantages of usage.
The Technology Acceptance Model, on the other hand, contains two core constructs: perceived utility (PU) and perceived ease of use (PEOU) and does not

identify users' attitudes or subjective standards.

To address the shortcomings of both study models, researchers combined them to develop a complete model. Chinglee et.al [62], [16] have integrated these research models to investigate the factors involved in the "adoption of internet banking". In another study, Amohgelem et al.[56] used an integrated model in identifying factors involved in "E-procurement". In another research Heddy et al [55] used the integrated model to study the adoption of "Electronic money in society".

To make the research more viable both models were integrated as there was no research on the adoption of solar energy solutions in Pakistan using an integration of these two research models. The basic model of TBP was used while the constructs of TAM are redefined. The main emphasis of TAM is on technology's usefulness, and researchers have further subdivided this construct for detailed analysis. Khalid et.al [63] in their research "Evaluating Consumers' Adoption of Renewable Energy" redefined usefulness in terms of financial Incentives, relative advantage and economical concerns, and used Perceived ease of use as defined in the TAM. In his research relative advantage was coinciding with environmental concerns. To make the research more comprehensive and overcome the shortcoming of Khalid et.al [58] relative advantage was redefined as comparative advantage CA and aspects related to the real-life usefulness of solar energy solutions were added as per the Pakistan context.

The high cost of implementation is a major barrier to the widespread adoption of solar energy technology in developing countries like Pakistan. This financial obstacle often limits access to the necessary resources for installing and maintaining solar energy systems, making it difficult for individuals and organizations to transition to renewable energy sources. The cost of solar energy technology is a crucial factor that must be considered in any efforts to promote its adoption in developing countries. Therefore, it is important to develop policies and strategies that address this challenge and make renewable energy systems more accessible and affordable for those who need them most. By overcoming financial barriers, more people will be able to take advantage of the benefits of solar energy, such as reduced energy costs and greater energy independence.

To address this concern, an external construct, namely, "initial cost," has been included in the Technology Acceptance Model (TAM). This additional construct provides a more comprehensive understanding of the financial concerns of potential

users. In total, six constructs have been employed, consisting of three constructs from the Theory of Planned Behavior (TPB) and three redefined constructs from the Technology Acceptance Model.

These six constructs are thoroughly explained below to provide a more detailed insight into their relevance and importance in this study.

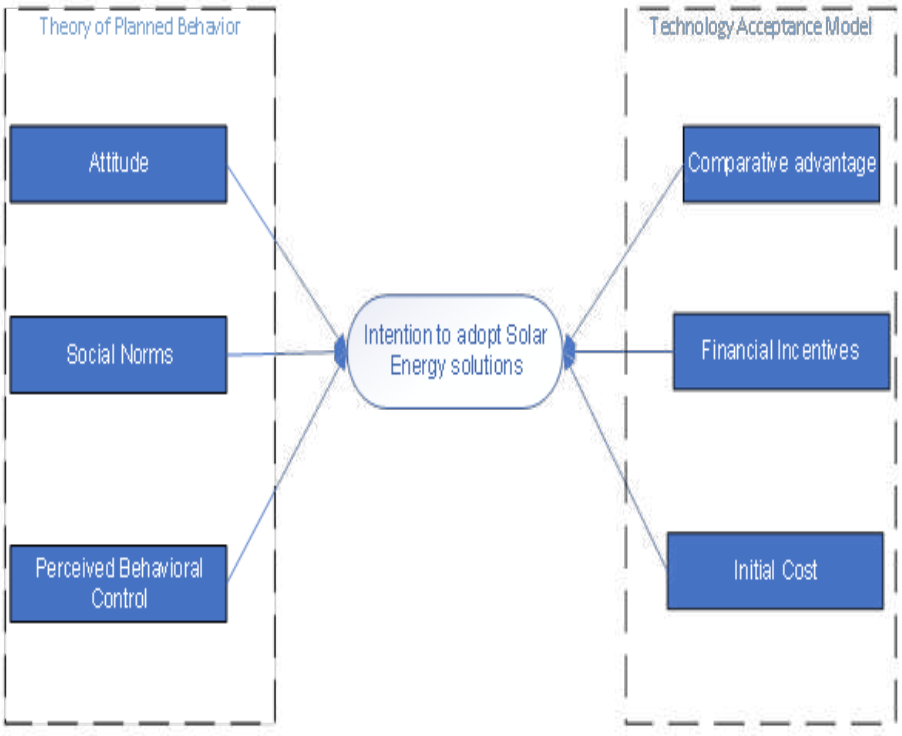

FIGURE 3.1: Research Framework

3.2 Development of Research Hypotheses

The current study attempts to incorporate the Theory of Planned Behavior (TPB) [64] and Technology Acceptance Model (TAM) [65] to measure customers' willingness to embrace solar energy solutions.

As a result, the hypotheses established in this study include key components from

each of these theories. The hypotheses employed in this study are explained in the next section.

3.2.1 Attitude (AT)

TPB places a strong focus on "Attitude" and regards it as a key factor in determining customer intentions. "The degree to which a person has a favourable or negative opinion or appraisal of the action in issue is commonly characterized as an attitude" [66]. A distinction can be made between different kinds of attitudes. Most of the attitudes are developed rather than innate. There are several types of attitudes that may be distinguished. The majority of attitudes are learned rather than natural. The advantages and perceived downsides of technology drive both optimistic and pessimistic perspectives. Ahmad et al. [67] assessed popular approval of solar photovoltaic technology. Their findings suggested that customer attitudes have a substantial effect on PV technology adoption. Poier et al. [68] emphasized the relevance of attitude in their research on PV technology adoption in Germany. It was also shown that attitude is favourably related to consumers' intention to use less energy. Furthermore, attitude played a significant role in the acceptance of RE among homeowners [69]. In light of the TPB's postulation and the empirical data available in the literature, the first hypothesis connected to "Attitude" has been developed as follows

H1: Consumers' attitude has a positive impact on the adoption of solar energy solutions.

3.2.2 Subjective Norms (SN)

Subjective norms are a person's views of societal influences to do or refrain from performing a behaviour. It is a theory of planned behaviour construct that is described as an individual's sense of societal pressures to do or not execute an action. Subjective norms are based on a person's opinions about what is essential or desirable to key individuals in their life, such as family, friends, or coworkers. Subjective norms are thought to help forecast an individual's conduct. Subjective

norms (SN), also known as normative opinions and social norms, are another fundamental pillar of TPB. SN is defined as "the seeming social pressure to perform or not execute the activity" [66]. They determine whether prominent persons or organisations would applaud or criticize the given conduct. Individuals opinions are crucial, and societal pressure to comply with such opinions has a considerable impact on consumer behaviour. It has been proposed that subjective norms impact behavioural intention [64]. This is because, in general, the more social pressure there is to engage in specific conduct, the stronger the behavioural intention [66]. Several experimental studies have reinforced this idea by demonstrating that SN is a strong predictor of the desire to engage in an action[69],[70],[71].In a survey of homeowners, while exploring the intention to purchase a solar energy system, Korcaj et al.[70] observed that SN greatly impacts RE adoption in a survey of homeowners while investigating the desire to acquire a solar energy system. As a result, taking into account the TPB's postulation and the empirical data available in the literature, the second hypothesis concerning "Subjective Norms" has been developed as follows:

H2: Subjective norms have a positive impact on the adoption of solar energy solutions.

3.2.3 Perceived Behavioral Control (PBC)

Perceived behavioural control refers to a person's belief in their capacity to manage their own conduct. It is a construct of the theory of planned behaviour and is described as an individual's assessment of their ability to control their conduct given the resources at their disposal. It is a cognitive construct that may be divided into two categories: self-efficacy and control beliefs. Self-efficacy is the idea that one is capable of reaching a specific goal or outcome. Control beliefs are views about the existence of resources and other circumstances that can help or hinder behaviour performance. Perceived behavioural control is a key component of the theory of planned behaviour, and it is thought to have a role in anticipating an individual's behaviour. Another key TPB component is perceived behavioural

control (PBC), which measures the degree of control one has over his or her behaviours [66],[64]. Rather than concentrating on the amount of genuine control a person has over behaviour, the TPB focuses on the amount of surface control a person has over the behaviour - known as perceived behavioural control (PBC). As discussed by Ajzenn [66], "PBC relates to people's knowledge of the ease or difficulty of completing the conduct of interest". PBC is founded on the rationale that when an individual has control over a component that influences their decision to engage in an activity, they are more likely to do so. Individuals will not display a specific behaviour if they have little to no control over it. In the TPB, perception of control is employed rather than real control since it is easier and sometimes more accurate to measure. It has been demonstrated empirically that it is a reliable alternative for genuine control [64]. Wang et al. [72] PBC was found to be a strong predictor of behavioural intention. In their investigation of consumer intent to install solar panels, they discovered that PBC was the most significant element. Perri et al. [71] discovered that PBC impacts the intention to use renewable energy. As a result, the authors indicated that it is critical to boost PBC over solar adoption intention by reducing perceived barriers to increasing the adoption rate of solar energy solutions. Given the TPB hypothesis and the setting of this investigation, it was expected that:

H3: Perceived behavioural control has a positive impact on the adoption of solar energy solutions

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3.2.4 Financial Incentives (FI):

The extent to which a product or technology might have useful effects on the life of the users is called its perceived usefulness [73]. TAM asserts that the intention of a customer to use or reject any technology depends on its perceived usefulness. Usefulness, however, is a broad term and encompassed several dimensions such as financial benefit, environmental conservation or comfort, etc. Recently, Bilal et.al [55] used alternative variables to measure perceived usefulness such as Financial Incentives (FI), Relative Advantage (RA), and Environmental Concerns (EC). The present research also utilizes the constructs developed by Bilal et.al [55] and uses

Financial Incentives (FI), Environmental Concerns (EC) and Comparative Advantage (CA) to measure the usefulness of solar energy solutions. Usefulness is often measured in terms of the monetary value of a product or technology and FI plays a pivotal role in the diffusion of technology in society. FI is used around the world to promote the adoption of solar energy solutions for its sustainable growth [74]. Although renewable energy resources are free the equipment required to extract energy from them requires high initial costs. In the case of solar energy solutions, equipment such as PV panels and inverters etc. require a high initial cost. In order to enhance the affordability of such solutions, Governments devise policies that allow easy loans through commercial banks [75]. This incentive helps in the diffusion of solar energy solutions in society. In addition to loans, other measures such as "on-grid net metering (feed-in-tariff)" allows solar energy users to reduce their electricity bill by selling the surplus power generated back to power suppliers. This new trend has positively affected the users' intention to the adoption of solar energy solutions. Fowler et.al [76] also assert that subsidies and tax reliefs have a very positive impact on the adoption of solar energy solutions. Thomas et.al [77] have also explained the different schemes and initiatives of Governments in the promotion of solar energy solutions. Based on this empirical evidence, the fourth hypothesis is formulated as:

H4: Financial incentives have a positive impact on the adoption of solar energy solutions.

3.2.5 Comparative Advantage (CA)

Environmental and climate change issues have dominated headlines throughout the world in recent decades. The use of hydrocarbons for energy generation has had disastrous consequences for the environment and civilization.

Efforts are being made to meet energy needs using renewable sources rather than fossil fuels. The extent to which households are aware of environmental issues and how concerned they are about them is described as environmental concerns. Growing public understanding of environmental protection has considerably boosted environmental concerns [78]. Pakistan is listed in the ten most affected countries by climate change [79]. EC is very important from the Pakistani context and seriously

needs to be addressed [80]. The energy produced through renewable sources has a significantly lower impact on the environment as compared to traditional fossil fuel-based energy production. With the expanded worldwide consciousness of the arising and existing environmental concerns, purchasers are progressively becoming concerned and focused on settling these issues. M. Irfan et.al [78] explained how users are progressively becoming aware of the influence of their utilization habits on climate change. Therefore, consumers with serious EC show a tendency towards the reception of environmentally friendly power production [81].

Solar energy solutions are considered a powerful initiative to mitigate climate change issues and solve environmental concerns [82]. Despite attempts to maintain sustainable surroundings, progress in tackling environmental challenges such as climate change is gradual [83]. Thus, understanding the consumer's intention to use renewable energy requires a grasp of the idea of environmental concern. Consumers that have a good attitude about "Environmental Concern" are more inclined to choose solar energy solutions. The comparative advantage in technology adoption is the degree to which a certain invention outperforms current technology. Solar energy solutions compete with traditional power supply sources in a variety of ways, including ease of installation, continuous power delivery, and low maintenance costs [84].

Domestic solar PV solutions have a big potential in developing nations like Pakistan, which has been suffering an energy crisis for the past several years due to a rise in the gap between demand and supply of power. Apart from supplying energy it also gives consumers independence of living. Pakistan's transmission lines are outdated and need maintenance frequently and which causes power outages regularly. With solar energy solutions, consumers can efficiently manage power outages. This comparative advantage makes solar energy solutions more effective in Pakistan [85]. A greater comparative advantage associated with solar energy solutions facilitates its adoption rate. With all the empirical evidence it has been hypothesized as below:

H5: Comparative advantage positively impacts the adoption of solar energy solutions.

3.2.6 Initial Cost (IC)

There are several advantages to employing solar energy solutions; however, switching to solar energy solutions is not feasible owing to different factors involved in its adoption [86].The adoption of solar energy solutions may be a realistic alternative in Pakistan's current economic climate, where fuel and energy costs are quickly growing. Recently, the government of Pakistan has begun to encourage the use of solar-powered household and commercial micro-generation [87]. However, previous research indicates that the most significant barrier to the adoption of solar energy solutions in many nations is the initial cost. The high initial cost of solar energy systems is a hindrance to their adoption [88].

In the instance of solar energy solutions, Fadlallah et al.[89] discovered a negative relationship between the cost and adoption of solar energy solutions. The authors calculated that the cost of solar PV was still higher than the cost of the government's basic electricity supply. In the adoption of solar energy solutions, most of the customers are concerned about their monetary value [90]. In another study, it was confirmed that consumers are discouraged by the high costs of solar energy installation [91]. Based on these findings, the sixth hypothesis was formulated as:

H6: Initial cost negatively impacts the adoption of solar energy solutions.

3.3 Questionaire Development

In this research, the measurement scale is in the English language used with the same phrases in different research studies. The spelling and syntax errors were carefully checked before circulating the questionnaire. the questionnaire was divided into two parts. part-1 consists of demographic questions that include age, income, education, and gender. The privacy of all the respondents is assured.

Part-2 consists of questions related to the hypothesis. A five-value likert scale is used where 1=Strongly agree and 5=Strrongly disagree. An extensive literature review is used to identify the required measurable items for the present research. In this regard, the research work of Kardooni et al. [92] was consulted, and its items were used to measure the Attitude of consumers toward the adoption of SE solutions. The work of Tanveer et al.[93] was considered, and its scale items

associated with Social norms were extracted. The research study of Irfan et. [94] was chosen to identify the items for Perceived behavioural control. The research of Ru et al.[63] was used to identify the scale items associated with Initial cost and its relation with the adoption of SE solutions. The scale items for Comparative advantage were determined from a research study of Wal et al.[55] and Ahmad et. al [95]. Based on these literature findings, a comprehensive questionnaire was developed for this study (attached in Appendix-A).

3.3.1 Unit of Analysis:

The entity that is under study is called the unit of analysis. It is the 'who' and 'what' of research. It could be an individual, a collection of individuals, organizations, or geographic locations. It is a very important step in developing a methodology for research as it identifies the entity that is being studied. In the case of our research unit of analysis is the individual who has the decision-making power in his house.
The population targeted in this study comprises individuals who possess a fundamental understanding of Solar Photovoltaic (PV) systems and On Grid systems. The term "basic knowledge" in this context refers to individuals who are familiar with the functioning of PV systems and are aware of the associated costs. These individuals are considered as potential clients of Solar PV systems, and it is likely that they have a desire to install a PV system on their premises at some point in the future.

It is important to note that the criteria for inclusion in this study are focused on individuals who possess a certain level of familiarity with PV systems. This ensures that the data collected from the study participants is informed by a basic understanding of the technology and is therefore more likely to provide insights into the factors that are influencing their attitudes and behavior towards solar energy. As such, the study seeks to target individuals who are likely to have a vested interest in the adoption of solar energy and are thus more likely to provide meaningful insights into the challenges and barriers that are affecting the uptake of renewable energy solutions.

Overall, by focusing on individuals with a basic knowledge of PV systems, this study aims to provide valuable insights into the factors that are impacting the adoption rate of solar energy solutions among potential clients. This information can be used to inform the development of strategies and policies aimed at promoting the uptake of renewable energy systems and accelerating the transition towards a more sustainable energy future.

3.3.2 Sampling Technique

Sampling is a technique of selecting a suitable sample for the purpose of finding parameters or characteristics of the whole population. Two kinds of research, qualitative or quantitative are generally done in such exploratory research studies. When the research is mainly based on qualitative analysis and there is no need for a statistical tool, then that is purely qualitative research. This research is quantitative research because the data were collected through a questionnaire by respondents and analyzed through different statistical tools to get empirical results. In the beginning, 50 questionnaires were established as a target. It was supposed that the population sample will be representing the entire population of Islamabad/Rawalpindi which will assist to produce the required results from the sample statistics. The quantitative method is used so as to approach a large measure of the population. Therefore, in this study quantitative method is used to achieve quality data. The size of a sample can vary depending on the research being conducted. In general, the larger the sample size, the more reliable the results will be. However, there is also a trade-off between sample size and resources, as larger sample sizes require more resources and can be more expensive. Therefore, the sample size must be determined based on the research goals, available resources, and the desired level of accuracy There are only two sampling techniques i.e. probability and non-probability sampling [96]. In probability sampling every element of the population has an equal chance of being selected on the other hand if sample units are selected based on personal judgments, then the sampling technique is called a non-probability sample. There are different ways of collecting the data from the defined sample and among them is simple random sampling.

3.3.2.1 Subject to Item Ratio

It is an approach used in statistical sampling to create a representative sample from a population. It is a way of obtaining a sample in which the proportion of items in the sample is similar to the proportion of items in the population. This sampling method is used when there is a need to determine the proportions of different items within the population. The subject-to-item ratio method is based on the assumption that the population of items is composed of larger numbers of one item than of others. The sampling process begins with the selection of a representative sample from the population. This sample should be representative of the entire population, meaning that it should be composed of elements that have similar characteristics to the population as a whole. Once the sample is selected, the population is then divided into two groups: those that are similar to the sample group and those which are not similar. Each group is then assigned a weighting value which is used in the selection process. The weights based on the characteristics of the sample group are used to determine the number of items from each group which are to be included in the sample. The subject-to-item ratio method can be used in many different types of data collection. The ratio can also be used to determine proportions in other settings such as market research, political polls, and product usage. In conclusion, subject-to-item ratio sampling is a method of obtaining a sample that is representative of the population. It is a good sampling technique when the population is composed of a larger number of items than others. It is especially useful for surveys that measure the proportions of different types of people in a population, such as race, gender, age, and income. In this research subject to item ratio sampling technique was used, first of all, a pilot study was conducted using a smaller sample size before the start of the actual research. Costello et.al [97] found that no specific criteria have been followed in behavioural studies, as one-sixth of the researchers apply 2:1 and 20% of the researchers apply 5:1 subject to item ratio our sample size after removing the invalid responses is 308 i.e. more than 5:1 which is very sufficient enough to apply data analysis.

3.4 Data Analysis

The data was gathered on the foundation of a Likert-type 5-point scale which fluctuated from the questionnaire distributed to 350 individuals the survey questionnaire was designed in the English language and was distributed online among the participants. Respondents, easily understand and feel comfortable with the Likert scale. All variables of this study are measured with a five-point Likert scale as follows: 1= Strongly Agree, 2= Agree, 3= Neutral, 4= Disagree, 5= Strongly Disagree. The reliability and validity were tested with the help of Cronbach's Alpha technique. The acceptance range of it is 0.7 and all the measurements disclosed the score. the reliability and validity were established. None of the respondents faced any kind of difficulty in understanding the questionnaire as all of them graduated from university and the writing of the questionnaire is simple. The questionnaire discussed was developed in Microsoft Forms and the link was sent to the population using social media platforms, the questionnaire developed is a comprehensive questionnaire that asks various questions regarding the adoption of solar energy solutions, there is a total of 24 items in this questionnaire including the questions about age, gender and knowledge about PV systems. The gathered data collected through the survey was analyzed using SPSS and AMMOS and hypotheses are tested using Structural equation modelling. Numerous tests are conducted and are explained below respectively:

- Composite reliability.
- Discriminant validity
- Exploratory factor analysis.
- KMOs and betrays test of sphericity.
- Confirmatory factor analysis.
- Model fitness.
- Structural equation modelling.
- Path analysis.
- Hypothesis testing.

Chapter 4

Results and Discussion

The suggested theory's measurement and structural model were examined using structural equation modelling (SEM) and confirmatory factor analysis (CFA). To discover the underlying factors in the observed data, an exploratory factor analysis (EFA) was performed, and discriminant validity was verified to determine that the factors were different. The EFA results revealed that the data could be reduced to seven underlying factors, which were labelled as factor 1 (Attitude), factor 2 (Social Norms), factor 3 (Perceived Behavioral Control), factor 4 (Intention to Adopt Solar Energy), factor 5 (Comparative Advantage), factor 6 (Financial Incentives), and factor 7 (initial cost). All of the factor loadings were significant. The CFA findings showed that the measurement model suited the data well, with a good model fit index (CFI) of 0.92, a root mean square error of approximation (RMSEA) of 0.06, and a chi-square in the acceptable range. The factor structure was likewise compatible with the idea. The SEM findings demonstrated that the structural model provided an adequate fit to the data, with a CFI of more than 0.90 and an RMSEA larger than 0.07. SPPS and AMMOS software was utilised for data analysis. SPSS (Statistical Tool for the Social Sciences) is a robust statistical software package for data analysis and insight generation. AMOS, on the other hand, is specifically designed for structural equation modelling (SEM) which is a powerful statistical technique for testing complex hypotheses about relationships between multiple variables. It offers a variety of estimation techniques, including maximum likelihood and weighted least squares, which enables researchers to test different models and select the best-fitting one.

Furthermore, AMOS has a graphical interface that allows users to create path diagrams and visualize the relationships between variables in a model, making it easy to understand and interpret the results.

4.1 Demographic Data Analysis

Demographic data analysis is the study of population characteristics such as age, gender, education level, income, and other factors. It helps in understanding the population's composition and its characteristics.Demographic data is collected through surveys and censuses, and the data collected is then analyzed to identify patterns, trends, and relationships. For convenience, a scale or range is often used to collect information about demographic variables such as age. For example, age may be collected using a range of categories such as 18-24, 25-34, 35-44, etc. This allows for easy categorization of the data and helps in the analysis of the demographic information. The information obtained from demographic data analysis can be used for a variety of purposes such as market research, planning and policy-making, and decision-making.

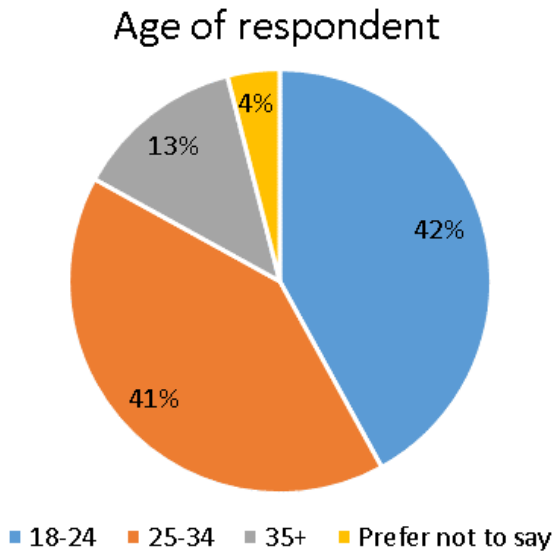

FIGURE 4.1: Age of Respondents

For this study, both genders provided data for this study without hesitation after being assured of the confidentiality of their identities and ages. Female replies in Pakistan have generally been low. Females have made significant contributions to

education and work during the previous two decades. In this study, the feminine side showed a healthy reaction. A dichotomous scale is used to assess two levels or categories, and it was employed in this survey to measure gender. The male side received 63.5% of the answers, while the female side received 36.5%.

Education is an important sector and a major component of the economy which ensures the prosperity of the nation. It is an important dimension of demographics. Education is the right of every citizen of the country as it opens up new avenues of success in order to take competitive advantage at national and international levels. The diverse nature of qualifications was part of this research to avoid biases in data collection. A nominal scale was used to identify the qualification, age and income level of the respondent.

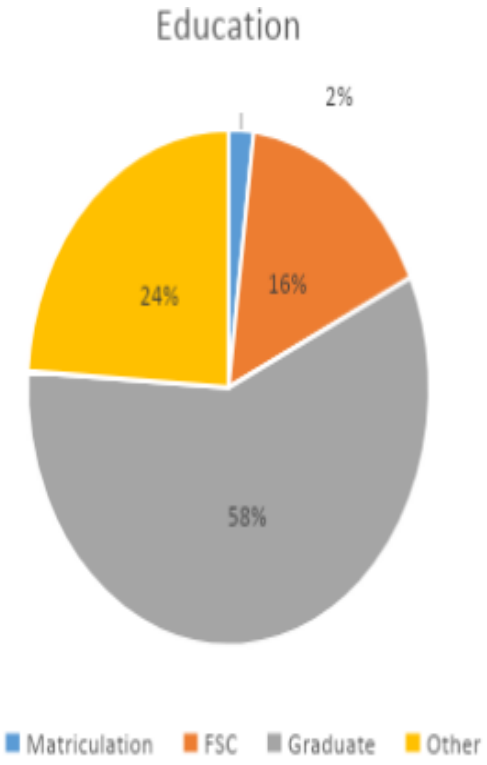

FIGURE 4.2: Education of Respondents

In various quantitative research studies, the income level of respondents has emerged as a crucial variable. This is due to the fact that a respondent's income level can significantly influence their level of extrinsic motivation, which is the drive to complete a survey for external rewards or incentives. A nominal scale was also used to measure.

TABLE 4.1: Composite Reliability

Constructs	Composite Reliability	AVE	Cronbach Alpha
AT	0.85	0.59	0.92
SN	0.78	0.53	0.81
PBC	0.71	0.45	0.77
ITSE	0.86	0.67	0.90
CA	0.85	0.85	0.92
FI	0.76	0.52	0.75
IC	0.699	0.54	0.73

4.2 Composite Reliability and Discriminant Validity

When assessing psychometric measurements, it is critical to evaluate composite reliability and discriminant validity. The degree to which many indicators of the same construct measure the same underlying concept is referred to as composite dependability. The degree to which two separate conceptions do not measure the same underlying construct is referred to as discriminant validity. Combining these two concepts allows researchers to assess the accuracy of a measure and its ability to reflect meaningful differences between groups. When assessing composite reliability, it is important to use a variety of items or indicators that are thought to measure the same underlying construct. This can be done through a factor analysis, and by examining the correlation coefficients of each indicator. If the correlation coefficients between the indicators are high, this suggests a strong relationship between the items in measuring the same underlying construct and high composite reliability. When assessing discriminant validity, it is important to examine whether two different constructs are in fact differentiable. One way of doing this is through a discriminant analysis, where differences between the two variables are examined. If the variables are not significantly different, then the two constructs are not distinct and have low discriminant validity. These two concepts are essential for assessing the accuracy of a psychometric measure and are important for interpreting the results [98]. They give a better understanding of how an instrument measures what it is supposed to measure and distinguishes it between various groups. Assessing composite reliability and discriminant validity correctly can assist to guarantee that the outcomes of a psychometric measure are accurate and relevant [99].

TABLE 4.2: Discriminent Validity

	AT	SN	ITSE	CA	FI	IC	PBC
AT	0.768						
SN	.595**	0.7348					
ITSE	.547**	.498**	0.8202				
CA	.669**	.489**	.592**	0.9236			
FI	.463**	.511**	.394**	.547**	0.7238		
IC	.399**	.319**	.361**	.551**	.373**	0.7378	
PBC	.644**	.640**	.509**	.533**	.527**	.375**	0.6752

Composite reliability is the average of the reliability coefficients for all of the component items (e.g., items on a survey) that make The average of the reliability coefficients for all of the component items (e.g., survey items) that make up a composite measure is known as composite reliability. The composite reliability is used to assess the composite measure's validity. A composite dependability rating of at least.70 is generally regarded as satisfactory. Discriminant validity is a sort of construct validity that determines if a measure properly reflects what it purports to measure while not measuring anything else. It may be assessed by looking at the correlations between two or more measures; if the two measures are meant to measure separate constructs, the correlation should be low. If the correlation is strong, it indicates that the measures are evaluating the same concept and that all of the results were over the threshold [100].

4.3 Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) is a statistical method that aims to identify the underlying relationships between a large set of variables. The goal of EFA is to identify a smaller number of factors, which are latent or unobserved variables that explain the majority of the variation in the observed variables. The factors can be thought of as groupings of variables that are highly correlated with one another. EFA is commonly used as a preliminary step before conducting more advanced statistical techniques such as Confirmatory Factor Analysis (CFA) or Structural Equation Modeling (SEM). By reducing the number of variables and identifying patterns or groupings among them, EFA provides a simplified view of the data that can be useful for further analysis.

EFA is an iterative process that involves selecting a suitable factor extraction

method, specifying the number of factors to extract, rotating the factor solution, and evaluating the factor solution to determine the best fit for the data.

The results of EFA can be used to guide hypothesis testing, and hypothesis generation, or to provide a summary of the data for descriptive purposes. In other words, it is used to investigate the structure of connections between variables. EFA is a sort of multivariate data analysis that allows researchers to investigate the structure of a data set by finding variables' connections [101]. EFA uses multiple techniques to uncover patterns in data, one of which is PCA. PCA is a statistical method used to analyze relationships between multiple variables. It aims to reduce the complexity of a large dataset by transforming a set of correlated variables into a smaller set of uncorrelated variables known as principal components.

The objective of PCA is to identify patterns in the data that explain the maximum amount of variation in the original dataset. In other words, PCA helps to simplify the data by identifying the most important variables that explain the majority of the variation in the dataset, reducing the number of variables while still preserving the information that is essential for analysis. The use of PCA in EFA allows for the identification of the underlying factors that explain the relationships between the variables in a dataset. The eigenvalues and eigenvectors of a data covariance matrix are calculated during the PCA procedure. Eigenvectors are the directions in the data space that maximise the variance of the data, and eigenvalues are the percentage of variance explained by each primary component.

The principal components are then ranked in order of the magnitude of the eigenvalues, with the principal component having the largest eigenvalue being the first principal component and so on. By using an EFA, researchers can learn more about the factors that make up and how those factors are related [102].

This can be used to better understand and predict behaviour. EFA is an important tool for understanding the structure of a data set and how the variables are related. It can help researchers to identify important dimensions, clusters, and patterns within the data set. We began with intensive EFA to have a better knowledge of the interaction between structures and their components.

Exploratory Factor Analysis (EFA) can be performed using statistical software like SPSS. EFA begins with the creation of a correlation matrix of all the variables in the dataset.

This matrix depicts the relationship between each variable pair. Following that, a factor extraction approach, such as principal component analysis (PCA) or common factor analysis (CFA), is used to discover the underlying components that account for the majority of the variance in the data [103]. These factors are then rotated, using techniques such as varimax, to make the factor loading more interpretable. Varimax is a technique used in exploratory factor analysis (EFA) to rotate the factor matrix. Rotation's purpose is to simplify the factor structure and make the factor loading more understandable. Varimax rotation is a method for constructing a collection of factors with high loading on a limited number of variables by maximizing the variance of the squared loading in each factor. The varimax rotation technique is designed to produce factors that are more easily interpretable and more easily distinguished from one another.

Once the factors have been identified and rotated, the factor loading can be examined. The factor loading shows the relationship between each variable and each factor. A variable with high loading on a factor is considered to be strongly related to that factor.

After identifying the factors, the next step is to name the factors based on the variables that have high loading on them. For example, a factor with high loading on variables related to income, education and occupation might be named "socio-economic status."

In this research, the environmental concerns and relative advantages of solar energy technology were combined into a single factor called comparative advantage. It is worth noting that the use of Exploratory Factor Analysis (EFA) is a data reduction technique rather than a confirmatory technique. Its primary purpose is to identify patterns and correlations in the data that can be further explored and confirmed through other methods such as Confirmatory Factor Analysis (CFA) or Structural Equation Modelling (SEM).

Therefore, the results of EFA should be interpreted with caution, and further research is required to confirm and validate the findings. By employing rigorous statistical methods such as CFA and SEM, researchers can more accurately and reliably identify the underlying factors that influence the adoption and usage of solar energy technology, and develop evidence-based policies and interventions to promote its uptake.

TABLE 4.3: Rotated Component Matrix

	Component						
	1	2	3	4	5	6	7
AT1	0.757						
AT2	0.778						
AT3	0.772						
AT4	0.766						
SN1		0.654					
SN3		0.765					
SN4		0.779					
ITSE1			0.806				
ITSE2			0.846				
ITSE3			0.808				
CA1				0.788			
CA2				0.759			
CA3				0.806			
CA4				0.814			
CA5				0.638			
CA6				0.704			
FI1					0.747		
FI2					0.842		
FI3					0.552		
IC1						0.521	
IC2						0.904	
PBC1							0.593
PBC2							0.662
PBC3							0.76

4.3.1 The Kaiser-Meyer-Olkin (KMO) Test

The Kaiser-Meyer-Olkin (KMO) test is a statistical tool used in factor analysis to assess the suitability of a dataset for factor analysis. The test evaluates the proportion of variance among all the variables that might be common or shared. The KMO test measures the degree to which the variables in a dataset are related to one another, and it ranges from 0 to 1. A value close to 1 indicates that the data is suitable for factor analysis, while a value close to 0 suggests that the data is not suitable for factor analysis.

The KMO test is usually used in combination with Bartlett's test of sphericity,

which measures the strength of the correlation between variables. The KMO test calculates the ratio of the total variance explained by common factors to the total variance of the dataset, and this result is used to determine whether a dataset is suitable for factor analysis. The KMO test is an important step in the factor analysis process, as it helps researchers determine whether a dataset is appropriate for factor analysis or if another method of analysis should be used. If the KMO statistic is low, it may be necessary to modify the dataset. The KMO test can also be used to evaluate the appropriateness of a factor analysis model [104]. The KMO test computes the ratio of total variance explained by common components to the total variance in the dataset. If the resultant statistic is near one, the data can be factored. If it is near to zero, factor analysis should not be used to examine the data. The following formula is used to calculate the test: KMO = (total variation explained by common factor/dataset total variance) $\times$ 100.
The KMO test is a critical stage in factor analysis that can assist researchers in determining if a dataset is acceptable for factor analysis. If the KMO statistic is low, the dataset should be modified or another technique of analysis should be used. The KMO test may also be used to determine the suitability of a factor model analysis.

4.3.2 Bartlett's Test of Sphericity

It is a statistical test employed to determine if the correlation matrix of a collection of variables is an identity matrix. This test is commonly used in the context of factor analysis and multivariate analysis to guarantee that the data are acceptable for the analysis. The test is also known as the homogeneity of variance test. The test is predicated on the premise that the correlation matrix is an identity matrix. If this condition is broken, the correlations across all variables are not the same, and the data is not appropriate for factor or multivariate analysis. To run the test, the correlation matrix is compared to an identity matrix.
If the correlation matrix is not an identity matrix, the test can be performed to assess if the discrepancies between the correlation matrix and the identity matrix are statistically significant. If the discrepancies between the two matrices are statistically significant, the correlation matrix is not an identity matrix, therefore

TABLE 4.4: KMO and Bartlett's Test of Sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.942
Bartlett's Test of Sphericity	Approx. Chi-Square	5202.002
	df	276
	Sig.	.000

the data is not appropriate for factor or multivariate analysis. Bartlett's Test of Sphericity is a valuable technique.

4.4 Confirmatory Factor Analysis(CFA)

Confirmatory Factor Analysis (CFA) is a statistical technique used to assess the fit of a suggested model of connections among a collection of observable variables to the data. CFA seeks to ascertain the suitability of the suggested model, which is represented by a collection of factor loadings and a covariance matrix, for the given set of data. Confirmatory factor analysis (CFA), a development of exploratory factor analysis (EFA), is used to investigate the underlying organization of a collection of observed variables, i.e., to determine if the seen variables represent a more limited set of latent, or unobserved, variables. CFA is frequently used in combination with SEM (structural equation modelling). It is a statistical approach used to examine hypothesized correlations between observed variables [105]. The approach assumes that the observed variables may be classified into underlying constructs or components. To perform a CFA, researchers must first identify the factors that have been observed and their predicted correlations. The data is then evaluated to see how closely the variables are connected to one another. The analysis results are then used to assess the sufficiency of the hypothesized relationships. The model is then tested for fit using a variety of fit indices, including the chi-square statistic, the root mean square error of approximation (RMSEA), the standardized root mean square residual (SRMR), and the comparative fit index (CFI). These fit indices indicate how well the model matches the data, with values around 1 suggesting a stronger fit [62]. Once the model has been tested for fit, the factor loading can be examined to determine which variables are most strongly related to each factor. A variable with high loading on a factor is considered to be strongly

related to that factor. It is crucial to remember that CFA is a confirmatory approach that should be utilised after exploratory techniques such as Exploratory Factor Analysis (EFA) have been used to uncover patterns in the data. CFA allows for testing specific hypotheses about the relationships among variables, and it is less sensitive to outliers and non-normality than EFA [106]

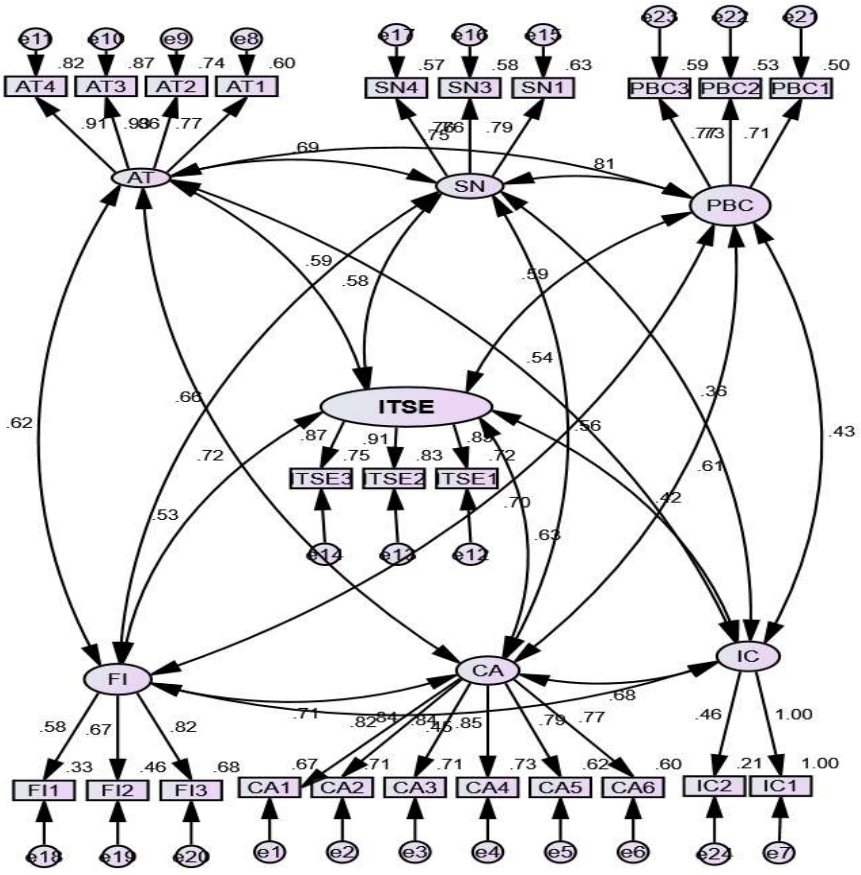

FIGURE 4.3: Standardize Factor Analysis

4.4.1 Confirmatory Factor Analysis (CFA) and the Goodness of Model Fit

Confirmatory Factor Analysis (CFA) is a thorough statistical approach used to verify the factor structure of observable constructs. The CFA determines whether

or not a link exists between observable variables and their underlying latent variables. The dependability of each individual concept employed in the study model is validated using CFA. A large body of evidence from the literature on the model's goodness of fit yields a diverse set of fit indices and information about their relevance to behaviour [106],[107]. The absolute fit indices are used to determine how well a prior model supports the sample data Macdonal et al. [108] and demonstrates which alleged model is the best and superior match. The fit indices values collected give fundamental information about the suggested theory to fit the data. Absolute fit indices assess a model's overall fit to data, independent of the number of parameters in the model. Incremental fit indices, on the other hand, measure the improvement in a fit that occurs when a certain set of parameters is added to the model. Absolute fit indices are used to assess the overall quality of a model, whereas incremental fit indices assess the contribution of single parameters or sets of parameters to the overall fit of the model. The absolute fit indices calculations provide more accurate results than the incremental fit indices calculations and do not require a comparison to a baseline model in order to determine the model's fit. Absolute fit indices include the Chi-square test, GFI, AGFI, RMR, SRMR, and RMSEA, which allow researchers to measure the fitness of their models in a more accurate and meaningful way. No single structural model can be deemed the "best" to accurately describe the effectiveness and acceptance of a single statistic test Hair, et al. [62]. There is still disagreement surrounding the reporting of fit indices to rely on. Nonetheless, a literature review suggested that at least four incremental and absolute fit tests should be validated to assess the model's fitness. Chi-Square is used to compare observed and predicted data in a population. It expresses the difference between observed and predicted values as a chi-square statistic. It is used to evaluate the independence of two categorical variables, the quality of fit of an actual distribution to an expected distribution, or the homogeneity hypothesis in a contingency table. The Chi-Square value is a standard statistic for analysing and quantifying the overall fitness of a model. It assesses the size of the divergence between the sample and fitted covariance matrices. The chi-square statistic is sensitive to big and small sample sizes, therefore researchers should utilize additional statistics in addition to the Chi-Square statistic [109]. Because of the vast and small sample sizes, as well as the various measurement procedures utilised, the suggested value of the Chi-Square statistic stays as high

as 5.0 [110] and low as 2.0 The Root Mean Square Error of Approximation is another key metric used to measure model fit (RMSEA). The number of estimated parameters in the model also affects the RMSEA indices. The RMSEA fit value varies from 0.05 to 0.10, indicating a reasonable to poor fit [111]. Researchers believe that an RMSEA range of 0.08 to 0.10 indicates a moderate fit, whereas less than 0.08 indicates a strong match of the measurement model.

4.4.1.1 Goodness-of-Fit Statistic (GFI)

This test determines how well a particular model or distribution matches a set of observations. It calculates the difference between observed and predicted frequencies in a sample and is used to examine if a hypothesized distribution is a sufficient representation of the observed data. Is an alternative to the Chi-Square test for calculating the ratio of variance calculated by the estimated population covariance. When the Chi-Square value is exaggerated owing to the sample size issue, the GFI assists in determining the fitness of the measurement model. GFI indices have a value ranging from 0 to 1. Large sample size raises the value of GFI owing to an increase in the number of parameters [112]. The acceptable extent of GFI is 0.90 to 0.95.

4.4.1.2 Adjusted Goodness of Fit Index (AGFI)

in structural equation modelling (SEM), the adjusted goodness of fit index (AGFI) is a metric used to gauge how well a given model fits the data in general. It changes the goodness of fit index (GFI) to account for the number of model parameters, providing a more accurate assessment of model fit. AGFI values near 1 indicate a strong match between the proposed model and the data, while values less than 0.9 indicate that the model may need to be modified or altered.

4.4.1.3 The Root Mean Square Residual

the Root Mean Square Residual (RMSR) is a measure of a model's fit to data. It reflects the average difference between the observed and anticipated values of the model. The RMSR is determined by taking the square root of the mean of

the residuals (observed values minus projected values) and dividing it by two. A low RMSR number indicates a good match between the model and the data, whereas a high RMSR value indicates that the model should be changed. The RMSR is a model fit statistic that is often used in regression analysis. It is also a component of other model fit statistics such as the R-squared value. The square roots of the difference between the residuals of the sample covariance matrix and the predicted covariance model are known as the Root Mean Square Residual (RMR) and Standard Root Mean Square Residual (SRMR). The computed RMR number is sensitive to the scales used with changing items in a questionnaire, such as (some questions may range from 1 - 5 while others range from 1 - 7), making RMR difficult to understand [108]. The SRMR value ranges from 0 to 1.0, and the well-fit model value should be less than.05 but can be as high as 0.08 in some cases.

4.4.1.4 Normed Fit Index (NFI)

The Normed Fit Index (NFI) is a measure of how well a structural equation model (SEM) fits the data. It returns a number between 0 and 1, with values near 1 indicating a good fit between the model and the data.
The NFI is determined as the difference between the goodness of fit index (GFI) and an adjusted GFI divided by the difference between 1 and an adjusted GFI. The modified GFI takes into consideration the number of model parameters, whereas the GFI is a measure of the overall fit of the model to the data.
It is incremental fit indices 'sensitivity to sample size and is not suggested for small sample size [106]. NFI can sometimes exceed 1 and become difficult to understand. However, given a sufficient sample size, the fit NFI value varies.80 to.95.

4.4.1.5 Comparative Fit Index (CFI)

it compares the observed covariance matrix of a model to the covariance matrix implied by the model. A CFI value of 1.0 shows a perfect fit between the model and the data, while values greater than 0.9 are typically regarded to indicate a good match. CFI is frequently used in SEM because it is less sensitive to sample size than other goodness of fit measures and offers information on both the overall

fit of the model and the fit of individual parameters.

It is an upgraded variant of NFI incremental fit indices. CFI, like NFI, implies that all latent variables are uncorrelated but are not affected by sample size. CFI reporting is superior to NFI reporting since it is more robust in nature and produces better results. The CFI value spans from 0 to 1, with a cut-off value of 0.90 deemed preferable closer to 1[113].

4.5 Adjusted CFA

By analyzing the modification indices of the initial CFA model, researchers can identify potential areas for improvement and adjust the model accordingly to achieve better results. Modification indices are particularly useful in identifying specific sources of model misfit that may be addressed through parameter adjustments. This iterative process of adjusting the model and reviewing modification indices can help to improve the overall fit of the CFA model and enhance its ability to accurately represent the underlying data. As such, modification indices are a valuable tool in CFA research for improving model fit and ensuring the validity of study findings.t[114]. They indicate the improvement in a model fit that would result from adding or freeing specific parameters in the model. In CFA, modification indices are computed for each parameter in the model, such as factor loadings, residual variances, and covariances between indicators.

When conducting Confirmatory Factor Analysis (CFA), researchers can use modification indices to identify potential improvements to the model. High modification indices indicate that adding or freeing a specific parameter could improve the model's fit. To utilize modification indices in CFA, researchers typically run an initial model and then review the modification indices for that model. A recommended approach is to correlate the error terms with high parameter change values, and then make adjustments to the model accordingly. This iterative process can help to enhance the model's overall performance. As a result, this approach is often considered a best practice in CFA.

Below is the adjusted CFA model and all values lie in the recommended criteria [115].

TABLE 4.5: Model Fitness

Fit Indices	Initial results	Adjusted Values	Recommended Criteria
Chi Square	567.379	481.155	Acceptable
Df	232	228	Acceptable
CMIN/Df	2.44	2.11	1-3
RMSEA	0.71	0.61	0.8
GFI	0.95	0.95	0.9
SRMR	0.057	0.051	0.8
TLI	0.92	0.94	0.9
NFI	0.84	0.91	0.9

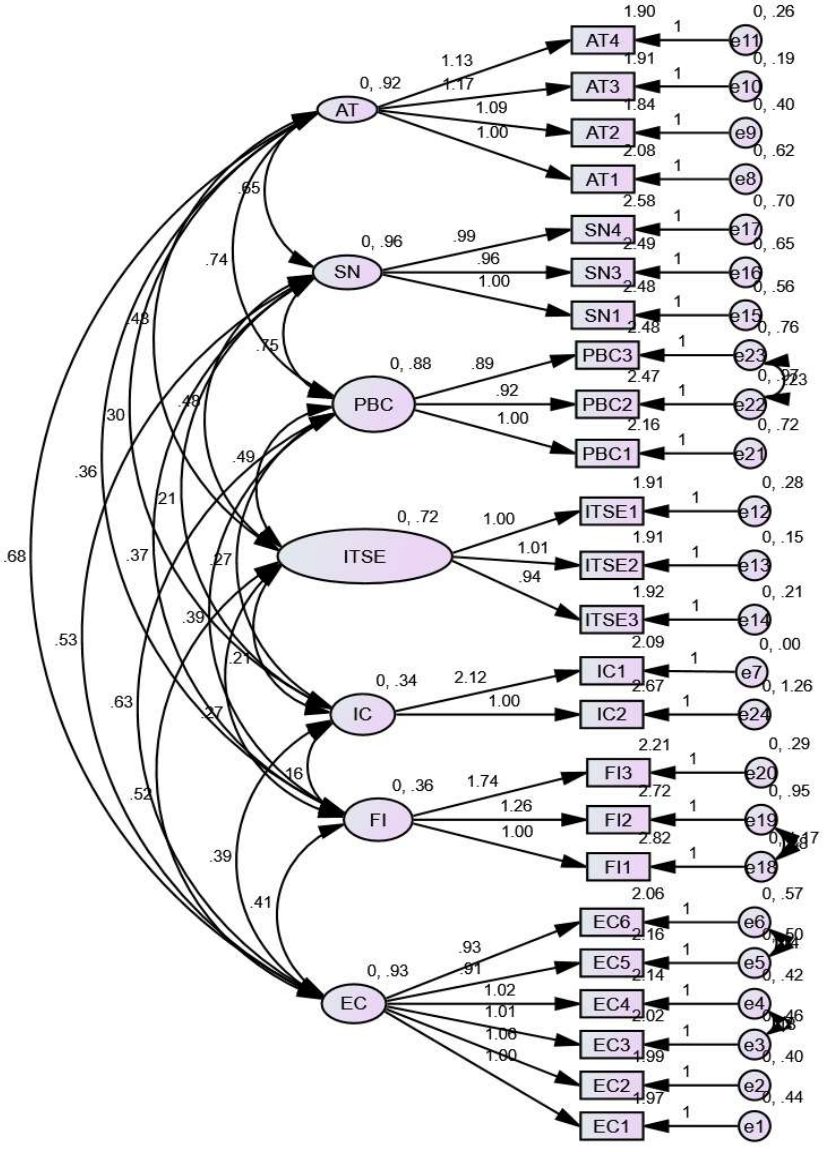

FIGURE 4.4: Adjusted CFA model

4.6 Structural Equation Modelling

SEM is a statistical tool for examining the correlations between numerous variables and testing hypotheses regarding their underlying links. It is a multivariate analytic tool that enables researchers to examine complicated correlations between variables and establish links between observable and latent variables.SEM is commonly used to evaluate ideas and hypotheses concerning the origins of diverse occurrences in domains including psychology, sociology, education, and others.

It offers a versatile and powerful method for assessing the connections between variables and testing ideas about the underlying mechanisms behind a collection of data. SEM incorporates the properties of both regression and factor analysis, and it represents the relationships between variables using a combination of observable and latent variables. SEM data can provide valuable insights into the causal linkages between variables and can assist researchers in better understanding the underlying processes and mechanisms of the action in a particular event.

SEM is a multivariate statistical approach that is based on the factor analysis model that allows researchers to evaluate the correlations between several variables at the same time.

SEM is a method that combines confirmatory factor analysis (CFA) with route analysis to estimate both measurement and structural models. Path analysis is used to test the structural model, which analyses the links among the latent variables, whereas CFA is used to test the measurement model, which assesses the fit of the observed variables to their underlying latent variables.

In SEM, the measurement model is used to evaluate the dependability and validity of the observed variables. The consistency of the measurement is referred to as reliability, while the correctness of the measurement is referred to as validity. The measurement model is defined by specifying the connections between the observed variables and the latent variables, which are supposed to be the observed variables' underlying sources. The unobserved latent variables are inferred from the observable variables. One of the benefits of SEM is that it may estimate both measurement and structural models at the same time. This is significant because measurement inaccuracy might generate bias in structural model estimates.

SEM may also estimate latent variables, which are unseen and inferred from observable variables. This is significant because latent variables are frequently the

underlying sources of observed variables and can give a more accurate picture of the underlying construct under investigation.

Another benefit of SEM is that it enables for the simultaneous testing of several hypotheses. This is significant because it enables researchers to test several hypotheses at the same time, saving time and money. Below is a complete approach for hypothesis testing and path analysis.

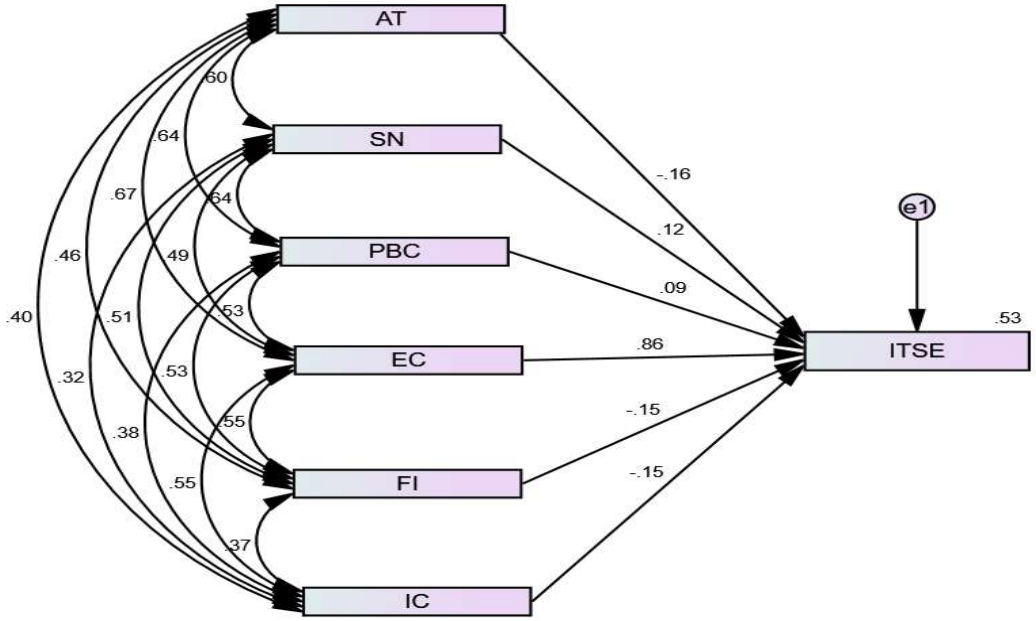

FIGURE 4.5: SEM Model

4.6.1 Path Analysis

SEM (structural equation modelling) is an effective tool for examining complicated interactions between several variables. Path analysis, which is used to investigate

direct and indirect effects among variables in a causal model, is an essential component of SEM. A causal connection in path analysis is a link between two variables in which a change in one variable (the independent variable) causes a change in the other variable (the dependent variable). In the route diagram, the direction of the causal link is depicted by an arrow going from the independent variable to the dependent variable. In our study, for example, the six constructs (AT, SN, PBC, FI, IC, and CA) already specified in the methodology are regarded as independent variables, with a desire to use solar energy solutions as the dependent variable. The route diagram's arrow would point from independent factors to dependent variables. The first step in carrying out a route analysis is to define the model. This is accomplished by drawing a route diagram, which is a visual depiction of the variables in the study's relationships. The route diagram is made by connecting the variables with arrows, with the direction of the arrow denoting the direction of the causal effect. Following the specification of the route diagram, the parameters of the model are estimated using a sample of data. This is often accomplished through the use of a technique known as maximum likelihood estimation, which is a method for determining the parameter values that maximise the likelihood of the observed data presented in the model. The generated estimates reveal the strength of the correlations between the variables as well as the relevance of the impacts. Following the estimating process, the model's fit to the data must be evaluated. This is done by comparing the actual covariance matrix to the predicted covariance matrix, which is based on the model's estimated parameters. Fit indices such as the chi-square, CFI, RMSEA, GFI, NLI, and others are also used to assess how well the model fits the data. A good fit suggests that the model is consistent with the data. After fitting the model, we may investigate the direct and indirect effects of one variable on another. This is accomplished by examining the route coefficients, which reflect the magnitude of the impacts. The path coefficients may be used to identify the model's most essential variables as well as the factors that have the greatest influence on the outcome variable. Positive path coefficients represent a direct influence, whereas negative path coefficients represent a negative effect. The magnitude of the route coefficients can be used to calculate the effect's intensity. The research initially creates a hypothesis on the link between the independent and dependent variables in hypothesis testing utilizing path coefficient values. By determining the route coefficient between the

TABLE 4.6: Hypothesis Testing

Hypothesis	Structural path	Beta Coef	p-value	Conclusion
H1	AT → ITSE	.075	***	Acceptable
H2	SN→ITSE	.099	***	Acceptable
H3	PBC→ITSE	.014	0.23	Rejected
H4	CA→ ITSE	.117	***	Acceptable
H5	FI→ ITSE	.064	***	Acceptable
H6	IC→ITSE	.704	***	Acceptable

two variables, the hypothesis is tested. The hypothesis is accepted if the path coefficient is significant (at a preset alpha level). The hypothesis is rejected if the path coefficient is not significant

4.7 Hypothesis Testing

The beta coefficient (also known as the standardised path coefficient) is a measure of the strength and direction of the association between two variables in path analysis. It is comparable to a correlation coefficient, except in route analysis it is used to evaluate causal links between variables.

A positive beta number implies a positive correlation between the two variables, implying that if one variable grows, so does the other. A negative beta value implies a negative correlation between the two variables, implying that if one measure rises, the other tends to fall.

The beta value's magnitude reflects the strength of the link between the two variables. A beta number near one implies a strong positive association, whereas a beta value near one suggests a strong negative link. A beta value around zero denotes a weak association. To assess the significance of the beta value, compare it to a null value (typically zero) to see if there is a statistically significant association between the two variables in the issue. If the test yields a p-value less than the selected significance threshold (e.g. 0.01), an alternative hypothesis (i.e. a link exists) might be accepted. Below are the results of our research hypothesis:

The SEM model matched the data well, with Chi-square, CFI, and RMSEA values in the acceptable range, showing that the model accurately represents the connections between the variables under consideration. Out of six hypotheses,

five were approved and one hypothesis (H3) was rejected. The path coefficients indicated a significant positive link between Initial cost and intention to use solar energy solutions, with a beta value of 0.704 and a significance level of p.01. This is consistent with prior research and implies that Initial cost has a considerable influence on solar energy solution adoption. The findings of a hypothesis test are used to assess whether there is sufficient evidence to reject the null hypothesis and accept the alternative hypothesis, or if there is insufficient evidence to support the alternative hypothesis. The alternative hypothesis is accepted if the p-value is less than the level of significance. This suggests that there is evidence to show a difference or link between the variables under consideration. If the p-value is larger than the level of significance, there is insufficient evidence to support the alternative hypothesis. The following results were inferred and supported by the literature based on the p-value.

4.7.1 Relationship between AT and ITSE

Attitude and desire to adopt solar energy solutions are two critical components for a successful transition to renewable energy solutions in society. Attitude is a person's proclivity to generate an emotional opinion or feeling about something. The intention is an individual's resolve to undertake a specific activity in a specific scenario. The link between mindset and desire to embrace solar energy solutions is complicated and multifaceted. According to the findings of a literature study, when someone has a positive attitude about a certain issue, they are more likely to embrace or apply solar energy solutions. Positive opinions toward solar energy solutions are frequently motivated by environmental and economic concerns, as well as personal preferences. People who have a negative attitude about solar energy solutions may not follow through on their goal to use these solutions. At the same time, once an individual decides to use solar energy, their attitude about these solutions is likely to improve. This is because having the aim to embrace solar energy solutions will likely lead to greater study and learning about these solutions, enhancing one's awareness and appreciation of the numerous benefits of solar energy solutions. This, in turn, will most likely lead to an even more favourable attitude toward these solutions. According to the study, having a good

attitude about solar energy solutions is a major component in predicting the desire to embrace these solutions. At the same time, having the intention to implement these answers might lead to a more optimistic mindset.

This emphasizes the significance of both attitude and intention in the effective adoption and implementation of solar energy solutions. Our study findings are quite compatible with previous research work, and as indicated in our results, the beta value of 0.075 has proven that our research hypothesis is acceptable

4.7.2 Relationship between SN and ITSE

The link between social norms and the intention to use solar energy solutions is complicated, and considerable study has been done in this area. Social norms can impact both positive and negative intentions to use solar energy solutions. Positively, societal norms can serve to foster an environment conducive to the adoption of solar energy solutions. When their friends, family, and peers are using solar energy, people are more likely to do the same. Local efforts such as community solar farms and bulk purchase schemes can make it easier for individuals to switch to solar. Negatively, societal norms might lead to consumers being suspicious of the advantages and cost reductions offered by solar energy solutions. People generally take their signals from their surroundings, and if the people around them are not supportive of solar energy solutions, they are less likely to embrace them. Furthermore, some people may be socially pushed not to employ solar energy solutions, either due to a perceived lack of expertise or the belief that solar is a luxury rather than a need.

Overall, societal norms have a substantial impact on people's willingness to accept solar energy solutions. People will be more inclined to embrace solar energy solutions if a more supportive environment is created and any negative incentives are removed. Individuals may also utilize their personal networks to raise knowledge about the benefits of solar energy solutions, resulting in a more positive societal norm.

As depicted from the previous research work in the literature review [116] the results of our research were also consistent and proved that social norms have an influence on the willingness to use solar energy solutions.

4.7.3 Relationship between PBC and ITSE

Perceived behaviour control (PBC) is a construct that expresses an individual's belief in their capacity to conduct an activity. It is one of the primary drivers' theories of planned behaviour (TPB), which holds that an individual's intention to do behaviour is impacted by their attitudes about the conduct, subjective norms, and perceived behavioural control. The hypothesis-tested findings in this study revealed that there is no statistically significant association between these two variables since the p-value (0.23) is bigger than the beta value (0.099). This might be due to a number of factors, including a lack of information or expertise about solar energy, a lack of perceived advantages or cost-effectiveness of solar energy, or a perceived lack of control over the decision-making process. It is vital to remember that there is no link between PBC and the plan to implement a solar energy solution. This is not to say that PBC has no influence on intention. It may also imply that attitudes, subjective standards, and perceived rewards and costs are more relevant in deciding intention. Furthermore, variables such as a lack of access to solar energy solutions, a lack of government subsidies, or a lack of information about the potential benefits of solar energy can all have an impact on the link between PBC and the desire to implement a solar energy solution.

4.7.4 Relationship between CA and ITSE:

Solar energy has several comparative advantages when compared to other forms of energy, which make it an attractive option for adoption. As the technology and economies of scale improve, the costs of solar energy are becoming increasingly competitive with traditional forms of energy [80]. Once installed, solar energy systems require very little maintenance and have a long lifespan, resulting in low operational costs. Solar energy systems can be easily scaled up or down to meet the energy needs of a particular location or application. Solar energy is a renewable and sustainable source of power that has gained significant attention in recent years as a potential solution to environmental concerns related to fossil fuel use. Solar energy has the primary benefit of being a clean, non-polluting energy source that emits no greenhouse gases or other pollutants [117]. As a result, it is an appealing choice for decreasing carbon emissions and tackling climate change [106]. Our

research results also infer the same relation of CA with ITSE. The beta value explains the same. The beta value of 0.14 depicts that when the CA will increase the Intention to adopt solar energy solutions will increase.

4.7.5 Relationship between IC and ITSE

The initial cost refers to the monetary charges incurred while purchasing and installing a solar energy system. The initial cost and intention to use a solar energy solution have a negative connection [118]. This is due to the fact that high initial prices might make solar energy systems less cheap and practicable for individuals and businesses, lowering their intention to adopt a solar energy solution. The initial cost of adopting solar energy in Pakistan can vary based on a number of factors, including the size of the solar energy system, the technology employed, and the location of the installation. However, due to the high import tariff on solar panels and other components, the absence of economies of scale, and the lack of a well-established solar energy sector, the cost of solar energy systems in Pakistan is comparatively expensive in comparison to other nations. The cost of a 1 kW solar energy system in Pakistan ranges from PKR 150,000 to PKR 250,000, according to research by the Pakistan Alternative Energy Development Board (AEDB). A bigger system, such as a 10-kW solar energy system, can cost between PKR 1.5 million and PKR 2.5 million [119]. It's also worth mentioning that large upfront prices might reduce the perceived benefits of solar energy systems, since people may not understand the financial benefits of adopting a solar energy solution if they can't pay the upfront charges. Furthermore, large initial expenses might reduce the perceived control of adopting a solar energy system, since users may lack the financial resources to cover the upfront charges. For example, if a person perceives that the cost of acquiring and installing a solar energy system is too expensive, this may reduce their perceived advantages and perceived feasibility of adopting a solar energy solution, and hence their intention to adopt a solar energy solution. In conclusion, the relationship between initial cost and the intention to adopt a solar energy solution is strongly related to each other and it's one of the main obstacles to the adoption of solar energy solutions, particularly in Pakistan. As evident from the literature and verified through research results, a beta value

of 0.75 proves the fact that initial cost has a very strong negative relation with ITSE.

4.7.6 Relationship between FI and ITSE

Financial incentives are government or corporate policies or initiatives that give financial rewards to those who use solar energy. Tax credits, rebates, grants, and low-interest loans are all examples of incentives. The association between financial incentives and the inclination to use solar energy is favourable.

This is due to the fact that financial incentives may lower the price of solar energy systems, making them more affordable for people and businesses. Financial incentives can improve the perceived advantages and perceived feasibility of adopting a solar energy solution, which in turn can raise the desire to adopt a solar energy solution by lowering the costs of solar energy systems.

Furthermore, financial incentives can improve the desire to adopt a solar energy solution by offering access to low-interest loans or grants, which can make it simpler for individuals to finance the initial expenditures of solar energy systems. Furthermore, financial incentives can raise public awareness and knowledge about the benefits and costs of solar energy systems by providing information and education [116]. On the contrary, if financial incentives are not available or are not appealing enough, this can reduce the perceived benefits and feasibility of adopting a solar energy solution, potentially leading to a decrease in intention to adopt a solar energy solution. The beta value of 0.064 depicts that a very weak relationship exists between FI and ITSE.

Chapter 5

Conclusion and Recommendations

This chapter will describe the outcomes of the results and the developed hypothesis, as well as provide a thorough insight into how the research thesis was concluded and recommendations for the future. Furthermore, the strength, limits, and recommendations will be examined at the end.

5.1 Strengths of the Research

The research theories employed in this thesis are the Theory of Planned Behavior (TPB) and the Redefined Technology Acceptance Model (R-TAM). The TPB is a theory that explains human behaviour in terms of the intentions that precede it. The TPB defines conduct as being determined by an individual's attitudes, subjective standards, and perceived behavioural control. The TPB was utilised in this study to better understand the aspects that impact an individual's intention to employ solar energy solutions. The study looked at the link between attitudes about solar energy, societal norms around solar energy adoption, perceived power over the decision to embrace solar energy solutions, and the desire to use solar energy solutions. TPB and R-TAM are both widely used and accepted in the field of technology adoption research. They provide a framework for studying the elements that impact technology adoption intentions and may be used to drive

the design of interventions to enhance technology adoption. The incorporation of these theories in this study provides a comprehensive understanding of the factors that influence people's intentions to use solar energy solutions. Exploratory factor analysis, confirmatory factor analysis, and structural equation modelling are used in this study to test complex relationships between multiple constructs and to identify causal relationships between them. This study takes into account a variety of constructs, including attitude, social norm, perceived behavioural control, comparative advantage, initial cost, and financial incentives, to provide a comprehensive understanding of the factors that influence the intention to adopt solar energy solutions. Given the continuous worldwide drive for clean energy alternatives, the study topic of solar energy adoption is particularly relevant and contemporary. The findings of this study have significant theoretical implications for our understanding of the factors that influence the adoption of solar energy solutions, and they can help to inform the development of policies and programs to increase the adoption of solar energy solutions. The study employed established measures for each component, increasing the data's reliability and validity. The research thesis is well-written, and the results are presented in a clear and concise manner, allowing readers to easily understand and interpret the findings.

5.2 Recommendations

Several recommendations can be made based on the findings of this research to increase the adoption of solar energy solutions:

According to the study, people with have a positive attitude toward solar energy are more likely to use solar energy solutions. As a result, it is critical to educate people about the potential benefits of solar energy, which include cost savings, environmental benefits, and energy independence.

Individuals who perceive social support for solar energy adoption are more likely to intend to use solar energy solutions. As a result, it is critical to encourage people to talk about solar energy adoption with their friends and family, as well as to provide opportunities for people to learn from others who have already adopted solar energy solutions.

The research infers that individuals who perceive control over the decision to use

solar energy are more likely to want to use solar energy solutions. As a result, it is critical to provide individuals with accurate information about the costs and feasibility of solar energy systems, as well as the resources they require to make sound decisions about solar energy adoption.

The study discovered that the initial cost of solar energy solutions is a significant barrier to their adoption. As a result, it is critical to developing policies and programmes that can reduce the initial costs of solar energy systems and make them more affordable to individuals and businesses.

According to the study, financial incentives are positively related to the intention to use solar energy solutions. As a result, it is critical to provide individuals and businesses with financial incentives such as tax credits, rebates, grants, or low-interest loans.

5.3 Future Direction of Research

Future studies on the question of solar energy adoption might go numerous different paths. Some possible research areas include:

This study employed a cross-sectional design, which makes establishing causality impossible. A longitudinal study would aid in determining the direction of causality between variables and understanding how the intention to implement solar energy solutions changes over time. The study used a sample of participants from a specific geographic location, the findings may not apply to other populations or cultures. Future research could look into the factors that influence people's intentions to use solar energy in different countries, regions, or cultures. As previously stated, this study only looked at a small number of characteristics that impact people's intentions to use solar energy. To further understand the elements that impact the desire to embrace solar energy solutions, future studies might incorporate other variables such as personal values, political opinions, and risk perceptions. As in this study, two research models were combined; additional mediation or moderating effects can be added for further analysis. This analysis presupposes the presence of financial incentives for solar energy adoption. However, financial incentives may not be available or appealing enough in particular

places or populations, which may impact the desire to embrace solar energy solutions. Future research should look into the role of financial incentives in various contexts and how they can be made more appealing and accessible. Future studies might look at the effectiveness of interventions aimed at increasing the use of solar energy solutions in the actual world. This could include a social evaluation of net metering and hybrid systems. Government policies and programs aimed at promoting the adoption of solar energy solutions, as well as an examination of the barriers and facilitators to the implementation of these interventions, must be considered. The research framework can also be used to determine customer intentions in a similar field, such as the adoption of electric vehicles, and the research model can be extended by incorporating another research theory that may yield better results.

5.4 Conclusion

The research presented in this thesis integrates two widely used research models, namely TAM and TPB to investigate the factors that affect consumers' behaviour in adopting solar energy solutions. In this regard techniques such as EFA, CFA and SEM have been utilized for the analysis of the primary data obtained through questionnaires. The following main conclusions can be drawn from this work:

• Consumers' attitudes positively affect the adoption of solar energy solutions.

• Social norms have a positive influence on consumers' intention to adopt solar energy solutions.

• The study also discovered that initial cost is a key obstacle to the adoption of solar energy solutions since high initial prices might make solar energy systems less cheap and practicable for consumers. This emphasises the necessity of adopting laws and initiatives that might reduce the initial costs of solar energy systems and make them more accessible to consumers and businesses.

• Comparative advantage enhances the solar energy solution adoption.

• It was also inferred that financial incentives promote the adoption of solar energy adoption in society and policymakers must initiate such steps.

Overall, this study provides a better understanding of the factors that influence people's intentions to use solar energy solutions, and it can help to shape policies

and programs to increase solar energy adoption. It is important to note that the findings of this study are limited to the sample context and may not apply to other populations. Future research should strive to repeat this study in diverse circumstances and cultures in order to validate the findings and broaden their applicability.

	Constructs
	Attitude
At1	I intend to use Solar energy solutions as often as necessary.
At2	I find solar electricity to be a major source of electricity in the future.
At3	I intend to continue using solar energy solutions in future.
	Subjective Norms
SN 1	The majority of people who are important to me encourage me to use solar PV energy solutions.
SN 2	Those who have my best interests at heart would prefer that I purchase solar PV energy solutions.
SN 3	Neighbor participation motivates me to utilize Solar energy solutions.
	Perceived behavioral control
PBC 1	It is entirely up to me to start using solar energy.
PBC 2	I think that I have the resources, knowledge, and ability to use solar energy solutions.
PBC 3	I think that using solar energy solutions would be entirely within my control.
	Initial cost
IC 1	Solar PV installations require a high up-front cost.
IC 2	I find that Solar energy solutions are more expensive compared with conventional energy.
IC 3	I find the purchase of Solar energy solutions a good investment for the future.
	Financial incentives
FI	Easy loans are available to acquire Solar energy solutions.
FI	Government subsidizes Solar energy solutions.
FI	Cost of electricity bill can be reduced by "Net Metering" option.
	Comparative Advantage
CA 1	Solar energy solutions will offer competitive benefits in my life.
CA 2	Solar energy solutions will reduce dependency on conventional energy sources.
CA 3	Hybrid solar energy solution will make my life independent of power outages.
CA 4	I am anxious about environmental problems caused by fossil fuel-based energy
CA 5	The excessive use of fossil fuels is the reason for climate change.
CA 6	Solar energy solutions may lead to a better and clean environment.
	Intention to Adopt solar energy solutions
ITSE 1	I have the intention to adopt Solar energy solutions.
ITSE 2	I will encourage others to adopt solar energy solutions.
ITSE 3	I will make efforts to install/upgrade solar energy solutions in future.

Appendix

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