Factors Affecting The Adoption of Solar PV Net Metering System: Case Study IESCO

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A Thesis Submitted to the Department of Software Engineering, Faculty of Engineering Sciences, Bahria University, Islamabad, in the partial fulfilment for the requirements of a Master's degree in Engineering Management

Approval Sheet

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Programme of Study:	MS Engineering Management		
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Abstract

Energy crisis in Pakistan is causing power outages that affects the household sector, industrial and commercial sector also the price of electricity is not stable and increases time to time. This energy crisis can be minimized by switching towards the renewable energy sources especially towards Solar PV system. Many countries around the world have switched towards solar PV systems due to its promising results but in case of Pakistan its adoption is very low even at microgeneration level. This study identifies the factors that affect the adoption of Solar on grid net metering-based systems both positively and negatively. Attributes of Rogers innovation diffusion model are used for understanding the adoption of Solar PV systems. Questionnaire was developed and distributed among 250 people who have the knowledge of net metering based solar PV system to gather data. Gathered data was then analysed using the SPSS software. Results shows that the initial cost of system is among the barriers that affect the adoption of net metering system negatively whereas relative advantage, compatibility and trialability has positive affect on the adoption of solar PV net metering system. Observability shows weak positive relationship. Adoption can be increased by working on the trialability and observability aspect of this technology and by decreasing the initial cost of system. The results of this study will have practical implications for Solar PV net metring-based system adoption in IESCO region.

Keywords: Solar PV Net Metering System, Technology Adoption, Innovation Diffusion Theory, Solar PV Adoption

Dedication

I dedicate this Thesis to my Parents and Siblings and thank them for their continuous support and motivation.

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I also dedicate this Thesis to my Teachers who guided me in completion of this Thesis.

Acknowledgments

All Praises are for Allah Almighty who gave me strength, patience and courage to complete this research.

I also express my sincere gratitude to my supervisor Engr. Bilal Ashraf Awan for mentoring and guiding me throughout this project.

I also thank my colleagues and friends who helped me throughout this research and motivated me as well.

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Chapter 1
Introduction

1.1. Introduction to Renewable Energy

Interest in Renewable Energy has increased with time and is greatly dependent on the perceived risks of using fossil fuels. Energy crises and the risk of running out of fossil fuel led to development of Renewable Energy technologies that could reduce the importance of fossil fuel and could also help in conserving the energy in an efficient way. In 1980s the risk associated with the occurrence of pollution due to usage of fossil fuel results in finding a way to avoid or remedy environmental damage form the fossil fuels extraction, processing and transport results in finding ways of burning fuel more efficiently, cleanly and without harming the environment. Nearly two decades ago risks associated with the CO_2 emissions and global warming have developed interests in Renewable Energy and its importance regarding the global warming [1].

Renewable resources include hydropower modern biomass, geothermal, solar energy, wind energy and wave tidal energy. Renewable Energy Sources (RES) supply 14% of the total world energy demand and their percentage increased a lot in the previous years. These energy sources are primary, domestic, and clean or inexhaustible energy sources. With the awareness among the people about the renewable sources it is expected that their share could increase very significantly from 30% to 80% till 2100. Fossil fuel is being dramatically consumed to such extent that this excessive fossil fuel consumption led to an increase in the rate of diminishing of its reserves around the world also it is a major cause of global warming as it produces carbon dioxide that change the environment resulting in increased health risks and threat of extreme global warming. Effective measures have now been taken all around the world especially in developed countries on political level to address the issue regarding global warming and its effects on human health and now society is moving with a great pace towards the Renewable Energy sources that are the potential alternatives for fossil fuel. Also, in developed countries decisions are made to reduce air pollution from vehicles, minimization of waste materials, conservation of native forests and planting more trees and the reduction of greenhouse gas emissions [2].

The most promising and easily useable renewable sources around the world are hydroelectric, photovoltaic (PV), and wind energy. Over the year's renewable energies have experienced one of the largest growths in percentage and is still growing around the world specially in developing countries but still Renewable Energy sources are comparable with the energy obtained from coal energy, but Renewable Energy are still below the percentage of natural gas and fossil fuel usage. The wind energy production at the end of 2018 is around 500GW whereas the Photovoltaic (PV) sector is growing at more than 30% per year [3].

1.2. Trends in Renewable Energy

In the field of solar energy systems, Germany has long been at the forefront of solar power and produced a total of 38.2 gigawatts (GW) in 2014. For understanding purpose, you can say that 1 GW is around the output of a large natural gas or nuclear plant, on several occasions Germany has produced about 50% of its daily energy needs from solar power, China is on the second number among the largest producers of solar energy, In China most photovoltaic products or solar panels is being installed in remote areas by giant solar farms that sell energy to utilities. China's drastic increase in solar power stems from the nations desperate need for electricity due to its enormous population but also due to air pollution crisis emerged in early years due to coal powered energy plants. In China government is aggressively encouraging the financial institutes to provide incentives for solar installations to support domestic solar power systems. Japan is on the third number in producing Renewable Energy through solar systems. Italy on the fourth and USA is on the fifth number. Few years ago solar power is considered as a niche market but these countries are proving that solar power is a legitimate alternate to replace fossil fuel, and is extremely environment friendly as it has no carbon emissions that could harm the environment [4].

With the advancement in the field of Renewable Energy sources RES, a new trend of microgeneration appears in the world. Microgeneration is the generation of heat and electric power by an individual on a small scale to meet their local needs of energy as supplements to traditional centralized grid connected power. Microgeneration technologies include Photovoltaic (PV) panels, micro wind turbines, solar water heaters, wood pellet boilers, geothermal heat pumps or combined heat and power units. Studies have shown that investment in microgeneration can be an economically valid way of reducing greenhouse

emissions and to reduce the cost of energy. Microgeneration has the potential to pay an important role in reducing overall energy demand and CO2 emissions in the residential sectors [5]. Out of all these microgeneration sources, solar PV systems has shown promising results as it works best under direct sunlight but also generates electricity under less favourable conditions. PV systems output basically depend on the amount of sunlight that fall on the surface of its panels and for this reason unshaded, south facing surfaces produce the best results. These photovoltaic power plants now a days plays a key role in the sustainable energy development and act as a major alternative of energy provision in remote areas where the electric grid cannot be reached. These small-scale PV systems can also be called as domestic solar PV systems or Low voltage (LV) photovoltaic power plants. In domestic applications these PV systems are mounted on the rooftop of buildings to obtain the direct sunlight for maximum generation of energy [6].

The latest trend emerged in microgeneration is net metering systems. Net metering systems allows residential and commercial customers who generate their local electricity from solar PV systems to sell the electricity they aren't using back into the grid at retail electricity rates [7]. Net metering has become a widespread policy in many countries for supporting the adoption of solar PV systems, it also allows customers to reduce their electric bills by offering their consumptions to electric grid. It also helped in jumpstarting the residential PV market [8].

In case of Developing country like Pakistan which has been facing energy crisis for the past few years due to increases in gap between the demand and supply of electricity. Government of Pakistan is promoting investment in the generation of small scale distributed Renewable Energy through the Alternative Energy Development Board (AEDB) based on net metering concept to compensate the issues of load shedding and power blackouts. The consumers who will supply energy to grids will either pay reduced utility bill or get paid for access energy exported to the grid. NEPRA in September 2015, issued its net metering regulations that allows the DISCOs in Pakistan to purchase excess units of electricity produce by the consumers and net them off against the units consumed from the grid [9]. Pakistan located on a map where natural renewable resources are in much excess that can be utilized to produce abundant amount of electricity through solar PV. In Pakistan daily solar irradiance ranges from 4.68kWh/m2 to 5.5kWh/m2 [10] daily and annual solar irradiance value is approximately 1990 to 2200 kWh/m2 [11] that can be utilized for

electricity generation. PV technology has proved itself as a useful way of generating electricity from solar irradiance and it can be used to supply electricity to remote areas [12].

1.3. Problem Statement

The current problem in case of Pakistan especially in case of IESCO is that the adoption of Net Metering system is very low and the factors that influence the adoption are unknown and due to low adoption towards Solar PV systems Pakistan is far behind from other countries in the filed of Solar Energy Generation despite having tremendous source of solar irradiance.

1.4. Research Questions

What are the factors that affect the adoption rate of net metering in Pakistan? Does the information about net metering system is easy to get? What are the cost concerns of people about this technology? What are the factors that are acting as barriers in the adoption of Net Metering system?

1.5. Research Objectives

Following are the main research objectives of this study:

1. To determine the factors that affect the adoption rate of net metering in Pakistan.
2. To determine the factors that are causing barriers in the adoption of net metering systems.
3. To determine the availability of sources to get Information about net metering systems.
4. To determine the cost concerns of the consumers.

Chapter 2
Literature Review

Renewable Energy is increasingly being recognized for its ability to offset rising and volatile energy prices, decrease carbon emission through reducing fossil fuel consumption, and decrease reliance on fuel imported from other countries that is often higher in cost as compared from conventional local sources.

2.1. Innovation and Diffusion of innovation

Innovation is basically the implementation of new ideas and features in the existing product to make it more competitive in the market with the change in time and it makes the outcome of the innovation a highly uncertain process. In general the greater the amount of changes performed in a product, the greater will be the uncertainty of how it will perform and how the market will react to the new innovation so the correlation between the amount of change and the degree of uncertainty has very important implications for the nature of appropriate innovation [13]. The main problem related to innovation is its diffusion in environment and how well the new innovation is adopted by the general population, for most of the innovation not everyone in the environment will adopt the innovation as the product introduced would not be the superior to existing forms or brands but sometimes the product is widely accepted by the environment [14].

According to Rogers diffusion is the process by which innovation is transmitted into environment, this transmission is through certain channels, and it takes time to be transmitted in population. Special type of communication that contains information about new ideas and products is being transmitted to population to increase its diffusion. Rogers also describe the innovation as the idea, practice, or product that is perceived as new by an individual. Perceived as new can also be expressed in terms of knowledge, persuasion or decision to adopt some technology [15].

2.2. Innovation Diffusion in Renewable Energies

Climate change issues, fluctuating price of oil and increasing awareness about environmental protection has highlighted the importance of Renewable Energy to reduce the greenhouse

emissions. Renewable Energy is an effective alternative to conventional energy sources with unlimited resources throughout the planet. Due to increase in the importance of Renewable Energy a lot of technological innovation has occurred in the field of Renewable Energy. Hydropower, Biomass Combustion, and geothermal energy are considered as the first generation of Renewable Energy technologies, and they have reached their maturity. Second generation technologies such as solar energy, wind power energy and modern forms of bio energy are currently rapid development stage and due to these innovated technologies, price of the system is very much lower than first generation technologies. Third generation technologies such as concentrated solar power, ocean energy, improved geothermal and integrated bio energy systems are in research and development stage. Penetration of Renewable Energy in environment is increasing but still it is limited and still it is unbearable to adopt for many households. Governments are making new policies in an effort to reduce the cost of 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 market [16].

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 boost in the innovation in Renewable Energy technology and it will reduce the carbon emission as well. Greater the per capita income and greater will be the innovation in this field, feed in tariff system also increases the 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 in the innovation and diffusion of technology in an environment [17].

The unsustainability of the conventional energy system needs to be addressed urgently to prevent the environment from greenhouse emissions, timeframe of twelve years was set to decrease the usage of fossil fuel by 50% to limit the global increase of temperature. Due to this timeframe researchers are doing research to find ways to increase the usage of renewable energies and to shift towards decarbonised energy system. Around the world policy makers 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 these system and to increase the diffusion

of these innovated energy systems. Solar PV systems were used in powering the space shuttles in 1970's era and after that they brought innovation in it and started the off grid isolated systems for a small market in 1980's and after further innovation and reduction in cost it was installed at public building rooftops at the end of 1990's. in the start of 21ist century it was also adopted by the 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 having suitable amount of solar irradiance, on the other hand wind energy was in R&D stage in 1970's, after some innovation in the design it was brought to the testing phase by installation of small wind turbines in 1980's and after further improvements it was brought to the general market in 1990's and 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 innovation of on grid systems in Solar PV, Commercial wind turbines, diffusion of these Renewable Energy sources is 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 [18].

2.3. Countries Leading in the Diffusion of PV

With the increase in worlds economic growth along with population, need of more energy has been seen in both developed and developing countries. With the increase in energy demand, Renewable Energy RE shows the promising results as it is the cleanest form of energy derived from nature and keeping nature less polluted. The environmental issue such as global warming is basically caused by 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 has gained attention worldwide and countries are making policies to reduce the green house emission (that includes carbon dioxide and methane), they also started shifting towards the alternate resources of producing the electric energy. Among many sources of sustainable energy, solar PV system shows the most promising results as an alternative for generation of electric energy. This is because energy generated from PV system is noiseless, no emission of carbon dioxide during generation, scale flexibility and simple operation and maintenance.

Solar PV system also gained attention around the world as an alternative source of generating energy [19].

Due to the quick development in PV industry and reduction in cost of panels, this industry established a sustainable development of energy system. All around the world laws regarding policies to implement PV systems and to shift from conventional energy to sustainable energy has been accepted and implemented without facing any kind of opposition. Many countries such as Germany, Japan, USA, and China are fighting technological war to gain the technological lead in this field by introducing and promoting programs to enhance the usage of PV system that will enhance the manufacturing capacity resulting in cost reduction and more importantly less dependent on conventional energy. These countries also introduced cost effective PV incentives and schemes to increase the adoption rate of this technology [19].

2.3.1. Diffusion of PV System in Japan

In case of Japan, natural disasters and nuclear disasters had a great effect local people and due to these issues they had to shift from the nuclear energy to alternative option that is Renewable Energy, so they shifted towards Renewable Energy to meet the demand of their people, their government has set a goal to reach 35% of RE generation by 2030. By 2013 Japan's production of Renewable Energy reached to 1,662,000 kW and this production of energy contains 1,559,000 kW of energy produced by using PV systems. They are planning to achieve 100% Renewable Energy by the end of 2050. Japanese government has also set a goal to reach the Renewable Energy generation of 28GW by the end of 2020 and they are planning to reach the generation of energy from PV system to 53GW by the end of 2030 [20]. Japan introduced many schemes and policies in order to shift towards Renewable Energy, this all started with sunshine program in 1981 with a target to produce 1.6% of total energy from Solar PV system till 1990 and then they raised 1.6% to 5% and set a new target of producing 7% of their energy from solar PV by the end of 1995. Their electric utility companies in 1991 started a project with a target to install 2.4MW of PV system by the end of 1995, they also introduced the buy back policy so companies can sell their surplus amount of energy to their local grid. By the end of 2011, Japan had total PV installed capacity of 1100MW [21].

For people to adopt this new technology, Japan introduced the new policies to increase the adoption rate of PV systems in 2009, that results in exponential growth of Japan's PV installed capacity. They also started the program to purchase the surplus energy form the consumers and added that into national grid. After introducing this policy almost 99% of PV system installed in japan were grid tied system and surplus amount of energy was added in national grid. They gave subsidy to people for installation of residential solar PV system so more people can adopt this technology [20].

2.3.2. Diffusion of PV System in Germany

One of the leading country in the field of RE is Germany with the highest production of energy by means of Renewable sources, they shifted towards the Renewable Energy sector after the oil crises in 1974 and after the incident of Chernobyl nuclear power plant and its radiation that polluted surrounding air, although it happened in Soviet state but the radiation level was so much high that it travelled to the German cities as well and it led them towards the Renewable Energy policy. German government started their path towards Renewable Energy with one goal i.e to increase the Renewable Energy generation and make the environment clean and eco friendly with enough energy to meet their needs. For the greater adoption rate towards the Renewable Energy, they introduced many laws such as electricity feed law and Renewable Energy law which played the key role in development of their Renewable Energy sector. These laws enabled them to purchase back the generated energy form the Consumers and also introduced schemes like loans and subsidies to support the production 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 in 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 3.5 GW per year [20].

In the introductory phase of this technology i.e solar PV systems, Germany introduced this technology in shape of a program called "1000 roofs program" in 1990's, they planned to install solar PV system 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 fulfil the energy demand of new users. The government of Germany gave full subsidy to the users of 1000 roof program to cover

the installation cost of rooftop solar PV systems. The program was a success and gained popularity in Germany and expanded in the form of 100,000 rooftops to drive the expansion of industry. This program invited the private companies to enter in this field and to lower the cost of PV installation. The private companies that participated in development of this field received a loan from government to invest in the development of this technology. This was also a successful program and it ended in 2004 with the 100,000 new rooftop PV systems consumers and they were all gird connected and due to this program success their market shifted from niche market and become market capable of mass manufacturing of solar PV systems. They also introduced a policy called as feed in tariff (FFT), this means that the consumers can sell the excess amount of energy back to grid and the units they produce will get higher price than the market price for next 20 year 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 it helped them in achieving lead position in terms of Renewable Energy production within a short span of time. Their market developed from 44MW in 2000 to 7.5GW in 2011 [21], and now according to the official site of Ministry of Economics and Energy Germany, they are producing 45GW of energy only from Solar PV systems [22].

2.3.3. Diffusion of PV System in China

In case of China, advancement in the field of solar began when China first successfully developed a solar cell by the aim of using it in space satellites back in 1968, they started using PV as the energy source on land back in 1973. Only eight PV companies and research institutes were present in China, and they were also purchased from US and Canadian firms, this was the situation between 1979 to 1992 and 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 the solar PV cells. Back in 1995, national scientific and technological commission (NSTC) of China drafted a document to introduce the outlines for reducing the green house emission and to focus on Renewable Energy especially Solar energy, this document also provided the road map to shift towards PV systems and also showed the plan for next five years and highlighted the development of PV cell modules and PV machinery. NSTC document also highlighted the importance of small-scale PV systems

and PV power stations and the other applications of Renewable Energy for the generation 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 became the member of world trade organization (WTO), and this acted as the catalyst for Chinese PV industry in terms of their growth as their product does not had to face foreign trade barrier. In 2005 they implemented a Renewable Energy act that demanded the grid tied systems and full purchase of renewable power form the private companies, in 2011, feed in tariff law was introduced in China which changed the demographic of 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 [23].

Back in 2016 China introduced the Renewable Energy law and pricing law by which there was reduction in taxes, a lot of financial resources support were given to the private sector and domestic consumer sector and many kinds of subsidies was given to the consumers in order to increase the adoption rate of PV systems, they introduced the feed in tariff of onshore wind and solar energy. China has also various resources of Renewable Energy and China is also working on the development of this sector, from 2006 to 2015 they have increased their solar capacity by 94.1% [24]. In the year of 2019, China has produced around 233.8 TWh of energy only from solar PV systems [25]. The goal of China is to achieve 45% energy from renewable resources and to achieve 80% reduction in carbon emission by 2050. the intermediate period between 2020 to 2030 will be the transition period for China's energy system as Renewable Energy will produce 25% of its total consumption and will replace the fossil fuel to some extent and by 2050 they plan to fully replace the fossil fuel by Renewable Energy as it will produce 2.6 billion tce (ton of standard coal equivalent) and accounting for the 40% of primary energy [24].

2.3.4. Diffusion of PV system in USA

Borchers in his study [26] discuss the adoption of wind and solar energy on farms in US, results suggest that the propensity to adopt is higher for livestock operations, larger

farms, operators with internet access, organic operations and newer farmers, with the help of net metering and interconnection policies designed to encourage the development of small scale generation units have shown results to increase the likelihood of farm solar and wind adoption. Among all the developed countries and their pursuit towards the leader of PV power generation country USA is also working towards the goal of achieving the title of Leader in the field of PV power Generation. In USA around 11% of its total Electricity generated in 2009 to 2010 by using the renewable sources of energy. In end of 2012 USA alone reached the installed Solar capacity of 7.2 GW and breached all previous records of PV installation. They installed more than 1033MW in California state, 710MW in Arizona, 415MW in New Jersey, 198MW in Nevada state, around 132MW in North Carolina, 129 MW in Massachusetts state, 109Mw in Hawaii State and 74 MW in Maryland state. The main factors that resulted in the adoption of PV system in case of USA includes Resolution of Trade Dispute, USA allowed the import of solar panels from China that reduces the cost of solar cells. The revolution of independent third party residential solar systems due to purchase back agreement and the availability of leases for residential solar systems and Private companies focus on Mega-Scale solar systems due to power purchase agreement. These are the main factors that increases the rate of adoption in USA, also the financing option played the vital role in adoption of technology, due to Modified Accelerated Cost Recovery System a lot of investors showed interest and invested their money in the field that increased the growth of market. Back in 2012 around 80% of PV systems installed in Colorado was based on financing model using the third-party investors. Almost every state of USA allowed the net metering for industrial and residential consumers so they could decrease their utility bills. This adoption towards solar PV systems allowed customers to sell their excess generated electricity and helped in reduction of bills up to 100%. It also created jobs opportunities in the local communities and provided jobs to many jobless persons [20].

According to latest report of FERC (Federal Energy Regulatory Commission) of USA that was published in June 2020, shows that the Renewable Energy that includes biomass, geothermal, hydropower, solar and wind energy in USA are dominating the USA Electric generation capacity in the first half of 2020. Report shows that in the first six months of 2020 the total new capacity added in national grid was 13,753 MW and 57.14% of new

added capacity was due to utilization of Renewable Energy resources. According to the report, Renewable Energy now shares 23.04% of USA total electricity generation capacity and it will expand in coming years. Out of 23.04% Renewable Energy 13.08% is the generating capacity of only solar and wind energy and share of solar energy alone is 3.79% that is four times greater than the last decade, the total USA Installed capacity is 1205.44 GW out of which only 45.74 GW is solar PV system [27].

2.4. Present Energy Situation in Pakistan

Energy generation is heavily dependent on fossil fuel in Pakistan. With the advancement in population and industrialization these conventional sources are not fulfilling the existing energy needs of the country and these sources are having an adverse environmental impact and are economically unsuitable to electrify remote areas. Due to dependence on fossil fuel to meet the energy demand of Pakistan, electricity prices are unstable and variations occur in them whenever the pries of oil in 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 increase of energy demand and crisis in Pakistan every year [28]. Independent power plants (IPPs) alone contribute around 50% of nations electricity generation in Pakistan, this is also a factor that contribute in the variation of electricity prices. These IPPs uses coal fired plants, oil and gas powered plants and they produce relatively expensive electricity [29]. 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 [28]. According to the annual report of NEPRA [30] 2018- 2019, 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.

After the advancement in Renewable Energy especially in Solar Energy in the past decades Pakistan's government is now making policies to shift from the 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 case of Pakistan

and requires new policies and implementation strategies to increase the transition rate, back in 2006, government of Pakistan introduced a RE policy and the aim of the policy was to shift from conventional energy resources to Renewable Energy resources by exploiting the indigenous resources such as wind and solar resources for Renewable Energy [28].

The most important factor that is essential for the generation of solar energy is the solar irradiance and Pakistan is one of those countries in world having the maximum solar 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^2 per year and sun shines for more than 300 days a year [12].

According to the world bank solar map of Pakistan shown in the figure 5 below, most of the cities of Pakistan are enriched with solar irradiance, Pakistan has around 4.5 to 6.3 kWh/m2 per day of solar irradiance and the total potential of solar energy is 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 potential of these renewable resources. Pakistan's energy sector could benefit from this huge abundance of solar energy to eradicate the short fall and to reduce the generation of conventional energy that has both environmental and economic effects. One of the reasons of the potential success of this technology is that the most of the rural areas and villages are far away from national grid and by installing this technology in these remote areas or villages will help the local communities and also saves the cost of transmission lines and their installations but due to the financial capabilities, improper infrastructure and absence of competition between companies to dominate the market are the significant obstacle in the path RE future in Pakistan [31].

Solar PV system shows the best results to transform from conventional energy to Renewable Energy and to electrify the rural areas as well but development in this field is very low especially in rural areas of Pakistan. NEPRA reported around 40,000 villages that do not have electricity access in the country, the role of government is in this particular field is not satisfactory and they haven't made any effective plans to harness the power of sun and to utilize it for our usage especially for the rural villages having no electricity, also the price of solar PV system is significantly high as compared to the developed countries due to the import duties on the import of solar panels and batteries as well, the high upfront cost is also

the major barrier in the development of this technology, also the customers especially household customers didn't received any subsidy on the installation of PV systems [32].

Solar energy shows the most promising results and it helps greatly in transformation from conventional to Renewable Energy generation as it is cheaper than oil, natural gas and coal and does not require much maintenance and has a great life span even compared with wind energy turbines. Also, for wind energy good wind speed is only available for 5 to 6 months but in case of solar energy solar radiation remains present around 300 days per year on average, by utilizing solar energy resources we can reduce the import of oil that could result in the reduction of electricity cost. By the construction of Quaid e Azam solar park and similar systems, awareness about solar energy has increased among the people but the total share of solar energy in our installed capacity is still around 2% that is very negligible, such policies should be implemented and introduced among people to increase the rate of adoption of this technology as this technology has a potential to solve energy problems in Pakistan in a short amount of time. Barriers that cause the low rate of adoption of this technology in Pakistan includes unawareness about market potential, initial costs are too high, limited government subsidies, no financial assistance from the third party sector, issues regarding the performance of system, no feed-in-tariff system, unreliable local technology, dependence on foreign technology for key parts and equipment, limited policies for adoption of technology, lack of awareness about solar energy especially in rural areas. These are the some of the barriers that are the main hurdle in the adoption of PV systems [33].

There are three main types of solar systems present currently in world, these are: off grid system, on grid system and hybrid system. Off grid system can also be called as stand-alone system and works independently without any connection with the main grid and the power generated is stored in batteries for backup purpose. On grid system was mainly used in industry but now the concept of residential on grid system has emerged around the world and in Pakistan as well, in on grid system energy generated is used by the consumers and extra power is fed into the grid and this system is only for the day time and consumers will use the grid supplied energy in night, this system does not require batteries for backup and hence it reduces the cost of batteries and its maintenance and results in reduction of cost of

total system. Third system is hybrid system is a combination of an on-grid system and off grid system, extra energy is stored in batteries and when the batteries are charged the remaining power feds into the grid. Among other renewable energies the solar system is most reliable among other energy resources and with the addition of net metering or by the installation of on grid system, energy can be fed back into the grid and helps in the reduction of utility bill, it also shows that by using solar gird tied system we can overcome the energy crisis [34]. In case of Pakistan, geographic location and climate offers a very high potential for solar energy applications. The solar resource assessment studies supports the country driven efforts to improve Renewable Energy resource awareness and exploitation due to the amount of solar irradiance present throughout the year [35]. PV solar system is a secondary source of energy in many countries worldwide as it contributes its parts in national grid but in Pakistan it is not yet drawn out at household levels, this is due to difficulty of using all appliances at a time and shortage of reliable batteries and solar panels, technicians are the causes of its less adoption [36].

Pakistan is suffering from acute shortage of electricity and fuel that has adverse effect on industrial and agricultural progress despite having around 2.9 million MW power that can be harnessed from solar radiations. Standalone PV systems application can save million in rupees that are currently being used on purchasing of conventional fuel to generate electricity through conventional ways [37]. Spokesperson of power division of the ministry of energy on may 7, 2019 claimed zero shortfall of electricity in the country and stated that the demand of electricity in country was 18,908 MW while they were producing 20,300 MW of electricity in 2019 [38] but the issue is still the cost of electricity and taxes applied on generated electricity, according to the rule book 2018-2019 of national transmission and dispatch company, 35,556 MW was the installed capacity in 2019 with the projected addition of 1,741 MW in financial year 2019-2020 [39]. According to the annual report of NEPRA for the financial year 2019-2020, around 27 new generation licenses were issued with the cumulative installed capacity of 2,338.14 MW, out of these 27 licenses 16 of them were issued to solar PV plants with the capacity of 621.43 MW. During this period 3,334 new net metering licences were issued to domestic consumers with the total installed capacity of 56.86MW out of which only 863 (9.99 MW) licenses of net metering were issued to IESCO region [40].

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. Moore and Benbasat [41] developed an instrument in their study to measure the adoption of technology using the attributes of rogers innovation diffusion model. Moore and Benbasat instrument was also been used by Marius Claudy [5] to measure the diffusion of microgeneration technologies, Al-Jabri and Sohail also used rogers diffusion model in their study [42], Tahir Masood also used rogers diffusion of innovation model in his study [43], I.U. Khalil [36] also used roger's model in his study to determine the solar PV adoption.

After analysing the previous studies and researches following are the Hypothesis that are deduced and needs to be verified in this study.

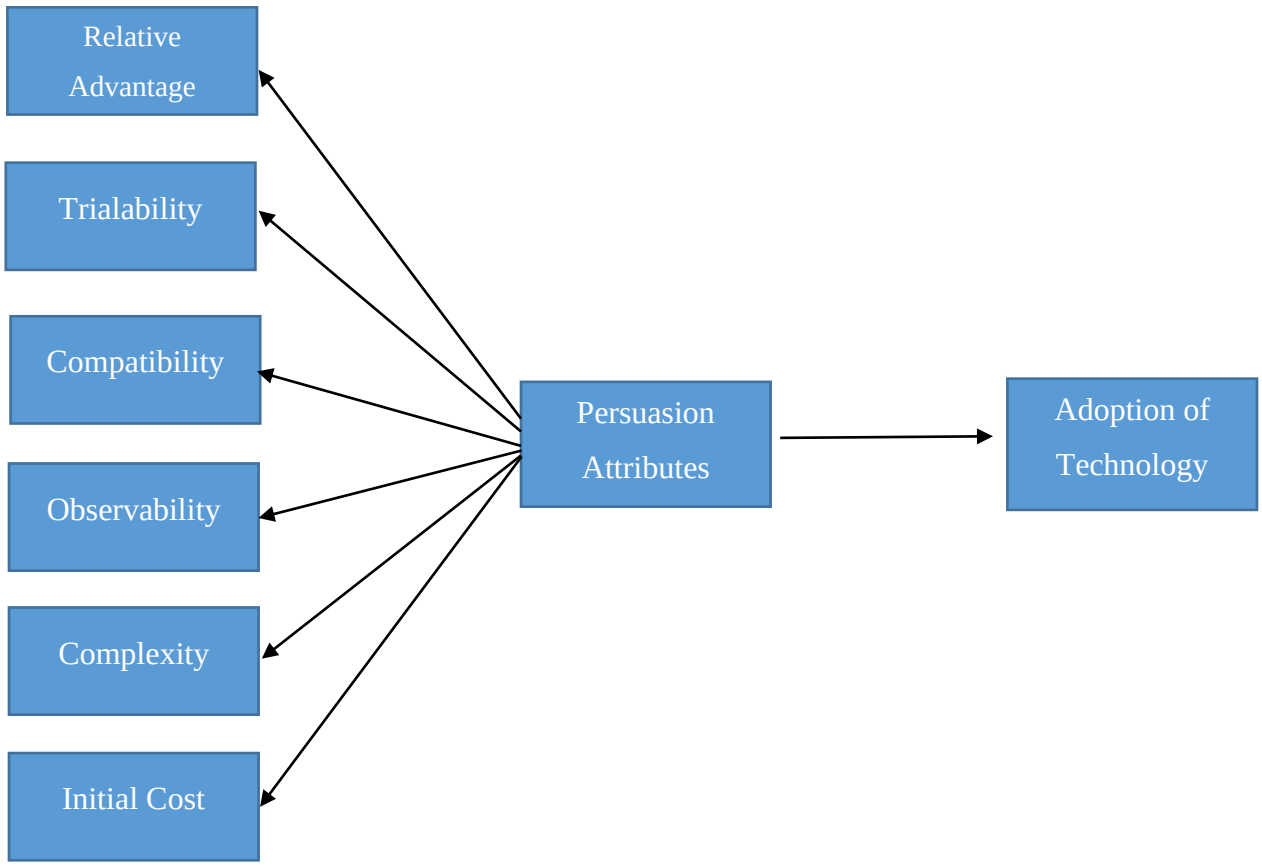
1. **H1: Relative Advantage will have a Positive impact on Net Metering Adoption**
2. **H2: Trialability will have a Positive impact on Net Metering Adoption.**
3. **H3: Compatibility will have a Positive impact on net Metering Adoption.**
4. **H4: Observability will have a Positive impact on Net Metering Adoption.**
5. **H5: Complexity will have a Negative impact on Net metering Adoption.**
6. **H6: Initial Cost will have a Negative impact on Adoption of Net Metering.**

2.5. Gap Analysis

In all the literature that was reviewed, we discussed the RE situation in China, USA, Germany, Japan we discussed their policies that increased the adoption rate of Solar PV systems, we observed that all these countries that are today in the leading row of RE energy generation countries have policies that support the adoption of this technology, they all have feed in tariff system, subsidies from the government for the consumers or the adopters of technology, in case of Pakistan all the papers that was read and quoted above shows that the adoption of solar PV system is very low in Pakistan due to barriers and the initial cost of the system but all the papers that discussed above had a strong focus on off-grid systems and its

economic analysis and implementation scenario and the potential of solar energy in Pakistan, none of them focused on On-Grid systems and why their adoption rate in Pakistan is very low despite having policies like feed in tariff system, solar financing systems, and the on grid system has low cost as compared to off grid systems and also they have very low maintenance cost as compared to off grid systems, this is the area where no study has been done to identify the factors that are affecting the adoption rate of Solar On-Grid PV System, so the main focus of this study will be to identify the factors that are causing barrier in the adoption of On-Grid Solar PV technology.

2.6. Theoretical Framework



Chapter 3

RESEARCH METHODOLOGY

To determine the factors that are causing barriers in the adoption of on grid systems we will use the diffusion of innovation model by Rogers, hence the solar energy technology provide innovative solutions for domestic consumers to produce the electricity. In this study we consider on grid solar PV systems as an innovation, according to Roger's theory technology is considered as innovation if it is perceived as new by an individual or an adopter of technology. The perceived newness of a technology for the individual determines his reaction i.e. either he is going to adopt or going to reject the technology. From the consumers point of view adoption of innovation process starts when an individual learned about an innovation's existence and gained more knowledge about the technology and its working [44].

3.1. The Innovation Decision Process Model

According to Rogers, the decision of an individual regarding an innovation is not an immediate act but its a complete procedure which consists of several steps that is linked with the time and comprises on several actions, the model of innovation consists of five stages:

1. **Knowledge**: It occurs whenever an person is introduced to the innovation that exists and the individual gains more knowledge about its functionality and advantages. In this step individual asks many questions about the innovation such as how it works, and why does it work, 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, this information seeking stage can also be occur at the persuasion and decision stage.
2. At the persuasion stage of the innovation decision process the individual that is seeking knowledge about the technology forms a favourable and unfavourable opinion towards the innovation, in this stage individual becomes more involved

psychologically with the innovation, he searches the new trends and ideas about the innovation, in this step important behaviours are where the individual is getting the information from, what message he get form the information and how he interprets the information that he received. Thus, selective perception is important in determining the behaviour of individual at this persuasion stage. Individual that is seeking the knowledge may apply the innovation mentally to its current and future situations in process of developing the attitude that may be favourable or unfavourable towards the innovation. All the innovation and their adoption carry some kind of uncertainty for the new adopters and in this persuasion stage individual also seek innovation evaluation information which also helps in the decreasing the uncertainty about the innovation for new adopters.

3. **Decision stage**: This process occurs when an individual gathered the knowledge about the innovation, persuasion of innovation, what information they get and what they intercepted from it, individual engages in these activities that lead him to the choice of adopting a technology or rejecting it, adoption of technology is the decision in which the individual made decision to make full use of an innovation as the best course of action available for the adopter and rejection is a decision of not adopting the technology. It is important to remember that the innovation decision process lead logically to a rejection of innovation and adoption of innovation nothing else, every stage in the process is a potential rejection point, rejection could be occur on the first step of acquiring knowledge about the innovation and it could also be occur prior to the decision of adoption and according to author rejection could be of two types i.e. active rejection which consists of considering adoption of the innovation but then deciding not to adopt it and passive rejection which consists of never really considering the use of innovation.
4. **Implementation stage**: Implementation process occurs when an individual puts an innovation into use or after deciding to adopt the innovation, individual acquired the innovation. Until the stage of implementation, whole innovation decision process was only the mental exercise, at this point in the innovation decision process, a certain degree of uncertainty still remains in the mind of individual even though the individual has made a decision to adopt previously, in this stage the individual seek

the knowledge of where to get the innovation, how to use it and what could be the potential operational problems may occur, so the process of acquiring the knowledge still takes place even at the implementation stage.

5. **Confirmation Stage:** Confirmation to adopt the technology occurs when an individual seeks reinforcement of an innovation decision already made but the individual may also reverse its decision of adopting the innovation when exposed to conflicting messages and information about the innovation.

The flow diagram of innovation decision process is drawn below in Figure .

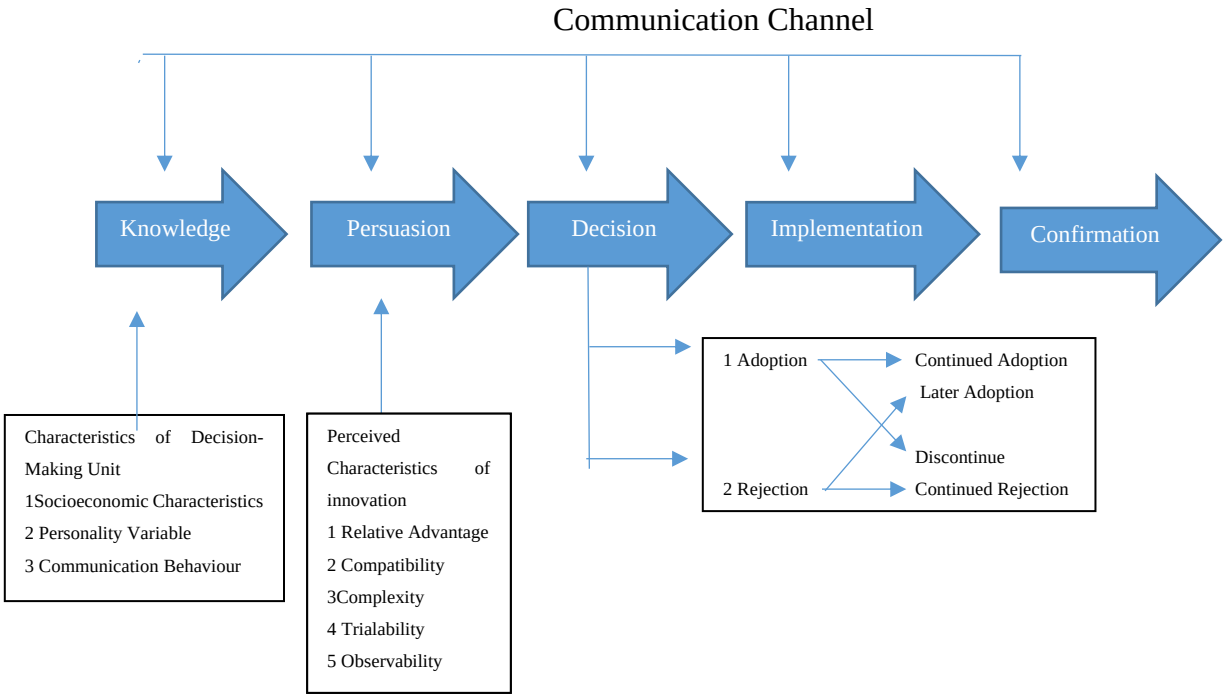


Figure 1: Model of Five Stages in Innovation Decision Process, Diffusion of Innovation [44]

3.2. Characteristics of Innovation

In this study our aim is to use the perceived characteristics of innovation of the persuasion stage to deduce our research, these characteristics of innovation and how they are perceived by the individuals helps to explain the adoption rate of innovation, the characteristics of innovation are as follow:

- **Relative Advantage** is the degree to which the innovation is perceived as better than the idea it is replacing. It could be [1]measured in the economic terms but the social prestige factors, convenience and satisfaction are also often important components. It does not matter that the innovation has great objective advantage what mainly matters is that the individual has perceived the innovation to be advantageous for his use, greater the perceived relative advantage of an innovation and greater will be the adoption rate of an innovation.
- **Trialability** is the degree to which an innovation may be experimented or used for the small amount of time; ideas that can be tried on the instalments plan will generally be adopted more quickly than innovations that are not divisible. Innovation that is trailable represents less uncertainty to the individual who is considering it for adoption.
- **Compatibility** is the degree to which an innovation is perceived as being consistent with the current values, past experiences and needs of the potential adopter of innovation. If the idea is not compatible with the existing values and social norms it will not be adopted rapidly as compare to the innovation that is compatible.
- **Observability** is the degree to which the results of an innovation are visible to others. If it is easier for individual to see the results of an innovation if it is easily observable, the more likely the innovation is to adopt, such visibility stimulates peer discussion of a new idea, as adopter can ask about the innovation evaluation information about that could help in making a decision.
- **Complexity** is the degree to which an innovation is perceived as difficult to understand and use, some innovations are readily understood by most of the members of the social society and other are complicated and will be adopted more slowly. In simple terms we can say that the ideas that are simple and easy to use are more likely to be adopted as compared to innovations in which the adopters has to develop a new skills and understandings to adopt the innovation.

In general we can say that the innovations that are perceived by receivers as having greater relative advantage, compatibility, trialability, observability and less complex will be adopted

more rapidly than other innovations, these are the most important characteristics of innovation in explaining the adoption rate of innovation [44].

Rogers model of innovation diffusion and the innovation characteristic have often been criticized of excluding some attributes that are important to measure the perception of adopters such as perceived initial cost of the innovation [45], this initial cost includes the cost of installation of system, infrastructure cost, some hidden cost such as building renovation, induction of new routes of wires and paint jobs after installation of system, so we also added the initial cost variable in our study.

Rogers defined the adoption as a decision to use the innovation at its full potential, in this study we are identifying the factors that affects the adoption of Net Metering. Many studies define adoption in terms of implementation, usage, utilization or satisfaction. In this study we will measure the adoption using the perceived Satisfaction as our dependent variable as it is widely used in studies. It also has a high degree of face validity and when the satisfaction related to the product is high one cannot deny the success of system [42].

3.3. Development of Questionnaire

The above-mentioned characteristics of innovation are the most common characteristics used to determine the adoption of innovation and these characteristics explains around 49 to 87 percent of variance in the rate of adoption of innovation. The innovations in which only individual is required to make decision have a greater rate of adoption as compared to the innovations where the decision depends on number of individuals like decision made in an organization [44]. In this study we are using the instrument developed to measure the perception of adopting an innovation. This instrument was developed by Moore and Benbasat in 1991 and it was developed to measure the perception of adopting an information technology innovation, hence this instrument is developed for information technology purpose [41] and in this study we are talking about solar technology so we can also use it in our research, this instrument was also adopted by Marius Claudy [5] about the diffusion of microgeneration technologies that also includes solar technology and it was also adopted by Ibrahim Al Jabari and Sadiq [42] in their study related to adoption of technology. This developed instrument is still in use and people use it in their research such as Kate Magsamen used it in her paper [46], Qian Lu used in [47] and Kawaljeet K. Kapoor in his study related to the adoption of Solar PV systems in [48] this shows that this model is still valid and people

use it in their studies from time to time. We extracted the questions used in measuring the variables relative advantage, compatibility, complexity, trialability and observability from [41] and modified it according to our need so we can use it to measure the adoption of net metering system in our study, we used 5 questions that are suitable for our study for relative advantage, 3 questions to measure the compatibility factor, 4 questions to measure the trialability, 3 questions to measure the complexity, 3 questions to measure the observability, 3 questions to measure the perceived initial cost of innovation was also added in this study and extracted the questions from the study of Marius Claudy [5]. For measuring the satisfaction we added 5 questions extracted and modified from [42] to make it compatible with our study.

3.4. Data Collection

Generally, there are two techniques used to gather the data for research purpose i.e. primary data collection and secondary data collection, when you are collecting the data for the first time for a specific topic then the collected data is called primary data and when u extracted data from the sources that already gathered data about a specific topic then it is called secondary data collection, in this study we are using the primary data collection technique, there are number of approaches to gather original data for a study, these approaches lies in the domain of primary data collection, first one is the observation approach, some of the important findings in research are gathered by observing the failures of different data collection methods, best way to collect data in observation approach is to observe and note down observations in a diary, note the factors affecting the certain change in experiment and other information regarding the experiment, second approach is the experimentation, it is the main tool in the physical research to gather data, in this approach main idea is to determine the effects of various factors on a certain variable by changing the factors in a controlled way and in controlled condition, this approach can be a reliable and efficient means of collecting data and can be used to verify theories. Next approach is the survey approach, this approach can be used to gather information from people, in this approach data can be calculated by asking question face to face or by sending the questionnaire through mail, this survey approach is the most widely used method of collecting data in business and management research, Interview approach is used to obtain qualitative data to understand in depth motivations for people's behaviour or feelings, face to face and telephonic interviews are the

main source of information in this approach, Diary approach can be qualitative or quantitative depending on the type of information that is recorded, this approach is not very much recommended for undergraduate or masters level research as it is time consuming, case studies are another approach of collecting primary data and they are generally used to study the certain phenomena is a particular settings, this method is very common in business research and when the analysis of an organization is required [49].

From all the approaches mentioned above for collect the primary data we will use the survey approach as our study aim is to determine the factors affecting the adoption of Solar PV net metering system and we are asking public to get their perception about this specific innovation, in conducting surveys critical points are the development of instrument or questionnaire, sample selection and administration while collecting data.

3.5. Sampling Technique

Sampling is a technique of selecting a suitable sample for the purpose of finding parameters or characteristics of the whole population. To do a research, one should know about the exact sample size that covers the whole population, whether the size is statistically justified and what method of sampling can be used in the study. There are only two sampling techniques i.e. probability and non-probability sampling. In probability sampling every element of population has an equal chance of being selected on the other hand if sample units are selected based on personal judgement, then the sample 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 [49], [50]. In this study we will be using the simple random sampling technique to gather our data as in this technique method of selection is specified, objective and each unit is selected with non-zero probability and every unit in the population has equal chance of selection.

3.5.1. Sample Size

Power and precision tool was used to measure the sample size for our study which is an empirical tool and is specially designed to measure the sample size. Two test correlation was used to interpret results in any direction, value of correlation i.e. 0.20 was extracted from the previous study of [41] and entered in the power and precision tool and it computed the sample size of 250 with 5% margin of error, 90% of studies would be expected to yields the

significant affect using this sample size of 250. The screen shot of sample size calculation is given below in figure 8.

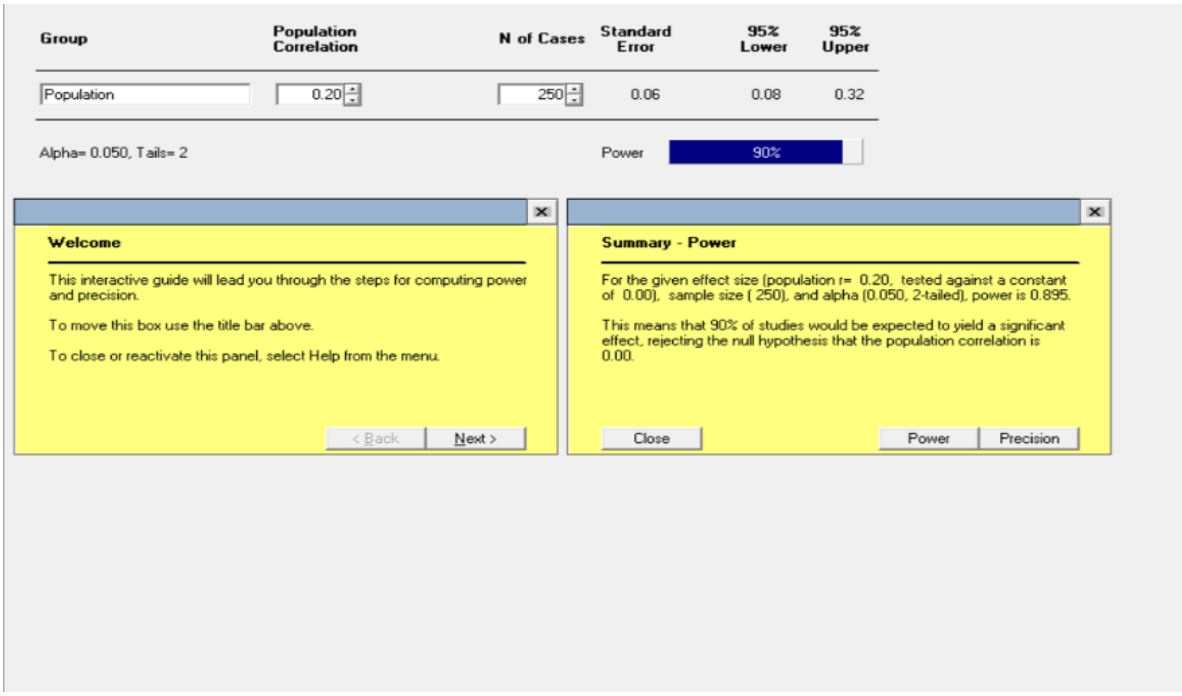


Figure 1: Sample Size Screen Shot from Power and Precision

3.6. Unit of Analysis

The entity that is under study is called as he unit of analysis. It is the 'who' and 'what' of research. It could be an individual, collections of individuals, to organizations, to geographic locations. It is a very important step in developing a methodology for research as it identifies the entity that is being studied [51]. In case of our research unit of analysis is the individual who has the decision-making power in his house.

3.7. Related Population

Our targeted population in this study are people that has the basic knowledge of Solar PV system and On Grid system, the term basic knowledge means that the person should have a knowledge about how PV systems works, knowledge about net metering system that how it works and cost of the system, they are the potential clients of Solar PV system and some point in their life they want to install PV system on their premises.

3.8. Collection of Data

Questionnaire that we have discussed was developed in Microsoft Forms and the link was sent to the population using social media platform, questionnaire we developed is a comprehensive questionnaire that asks various questions regarding the adoption of net metering, there are six variables that influence the adoption of this technology, there are total 30 items in this questionnaire including the questions about age, gender and knowledge about PV systems. All the responses are based on 5-point Likert scale with 1 being the strongly Disagree and 5 being the strongly agreed response and the statistical instrument used in this study is IBM SPSS to analyse the data and form our conclusion.

3.9. Data Analysis

The gathered data collected through survey was added in SPSS for result computation. Numerous tests were conducted to check the normality after that we checked the validity of data to check that our data is correct and has no unforeseen mistakes, after validity we checked the reliability, normality, correlation and performed the regression analysis on our data using SPSS. We checked correlation to make sure that all variables have a relation between each other, and regression was performed to determine the impact of independent variables on dependent variable.

Chapter 4
Results and Evaluation

This study identifies the factors that are affecting the adoption of net metering in IESCO region. Following results are determined by analysing seven variables and proposed hypothesis is tested by first analysing the statistical analysis. Data was collected using Questionnaires and then analysed by using the SPSS software to prove the relationship between variables. Analysis was taken at 5% level of significance. Out of seven variables 6 are independent variables and one is dependent variable i.e. Satisfaction. Every variable has various questions items in it and analysis was performed on each item which further calculates its means to compute a variable.

4.1. Descriptive Statistics

Descriptive Statistics tells us about the basic information of data, and it describes the data in most simple and meaningful way. In Descriptive Statistics we further find the central tendency of data and standard deviation of data. In central tendency we measure the mean, median mode of data, Skewness and Kurtosis of data as well. According to [52] Skewness and Kurtosis of data should be close to zero in ideal case but practically their value should be in range of -1.96 to +1.96.

Table 1: Descriptive Analysis

Variables	Minimum	Maximum	Mean	Median	Std. Deviation	Skewness	Kurtosis
RA	2.80	5.00	3.973	4.00	0.59430	0.135	-0.767
CAM	1.00	5.00	3.620	3.667	0.81488	-0.106	0.018
TRI	1.00	5.00	3.322	3.250	0.82068	-0.104	-0.243
COM	1.00	5.00	2.946	3.000	0.78688	-0.207	-0.285
IC	1.00	5.00	3.536	3.500	0.82292	-0.007	-0.257
OB	1.40	4.20	2.840	2.800	0.54671	-0.061	0.065
SA	2.00	5.00	3.880	3.800	0.61101	-0.116	-0.316

The minimum and maximum response value of Relative advantage is 2.80 and 5.00 and their standard deviation is 0.59430. Mean was calculated to be 3.973 and Value of Median is 4.00. Value of Skewness and Kurtosis is found 0.138 and -0.767 respectively and it shows that the data is normal.

The minimum and maximum response value of Compatibility is 1.00 and 5.00 and their standard deviation is 0.81488. Mean was calculated to be 3.620 and Value of Median is 3.667. Value of Skewness and Kurtosis is -0.106 and 0.018 respectively and it shows that the data is normal.

The minimum and maximum response value of Trialability is 1.00 and 5.00 and their standard deviation is 0.82068. Mean was calculated to be 3.322 and Value of Median is 3.250. Value of Skewness and Kurtosis is -0.014 and -0.243 respectively and it shows that the data is normal.

The minimum and maximum response value of Complexity is 1.00 and 5.00 and their standard deviation is 0.786. Mean was calculated to be 2.946 and Value of Median is 3.000. Value of Skewness and Kurtosis is -0.027 and -0.285 respectively, and it shows that the data is normal.

The minimum and maximum response value of Initial Cost is 1.00 and 5.00 and their standard deviation is 0.8229. Mean was calculated to be 3.536 and Value of Median is 3.500. Value of Skewness and Kurtosis is -0.007 and -0.257 respectively, and it shows that the data is normal.

The minimum and maximum response value of Observability is 1.40 and 5.00, their standard deviation is 0.546. Mean was calculated to be 2.840 and Value of Median is 2.800. Value of Skewness and Kurtosis is -0.061 and 0.065 respectively, and it shows that the data is normal.

The minimum and maximum response value of Satisfaction is 2.00 and 5.00, their standard deviation is 0.611. Mean was calculated to be 3.880 and Value of Median is 3.800. Value of Skewness and Kurtosis is -0.116 and -0.316 respectively, and it shows that the data is normal.

4.2. Psychometric Tests

In psychometric tests we find the reliability and validity of our data. In reliability analysis we find the Cronbach's alpha value of each variable and, we find the combined alpha value of all the variables. According to [53] Cronbach's alpha determines the internal consistency

between the items, Cronbach's alpha reliability coefficient ranges between 0 and 1 and there is no lower limit to the coefficient, greater the value is close to 1 greater will be the internal consistency between items. George and Mallery in their book [54] categorized the value of Cronbach's alpha, according to them:

- if the value of alpha is greater than 0.9 then its excellent.
- If the value of alpha is 0.8 it will consider as good
- If the value is greater than 0.7 it will be considered as acceptable
- If the value is greater than 0.6 it will be questionable
- If the value is greater than 0.5 it will be considered as poor value
- If the value is less than 0.5 the results will be considered as unacceptable.

In our analysis, Cronbach's alpha value of RA is 0.794, CA is 0.705, CO is 0.682, TR is 0.725, OB is 0.611, IC is 0.833 and SA is 0.763. Combined value of all the variables is above 0.8, all these values are mentioned below in the table and the combined alpha of all these variables are shown below in figure, these result shows that the data collected to perform research has good reliability.

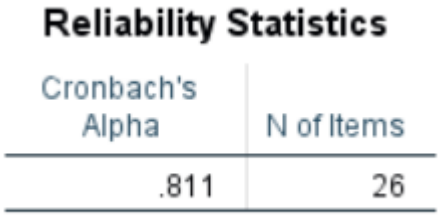


Figure 2: Combined Cronbach's Alpha Value

Variables	Cronbach's Alpha	Items
Relative Advantage	0.763	RA1, RA2, RA3, RA4, RA5
Compatibility	0.705	CA1, CA2, CA3
Trialability	0.725	TR1, TR2, TR3, TR4
Complexity	0.682	CO1, CO2, CO3
Initial Cost	0.660	IC1, IC2, IC3
Observability	0.833	OB1, OB2, OB3
Satisfaction	0.763	SA1, SA2, SA3, SA4, SA5

Table 2: Cronbach's Alpha Value of Variables

4.3. Normality Tests

Normality tests are basically used to authenticate the validity of data. In these tests we use different methods such as pi charts, bar charts, frequency charts, histogram, Q-Q plots, these all methods are visual representation of data and that can also explain that the data is normally distributed or not. Histogram and Q-Q plots are given below to verify the normality of collected data.

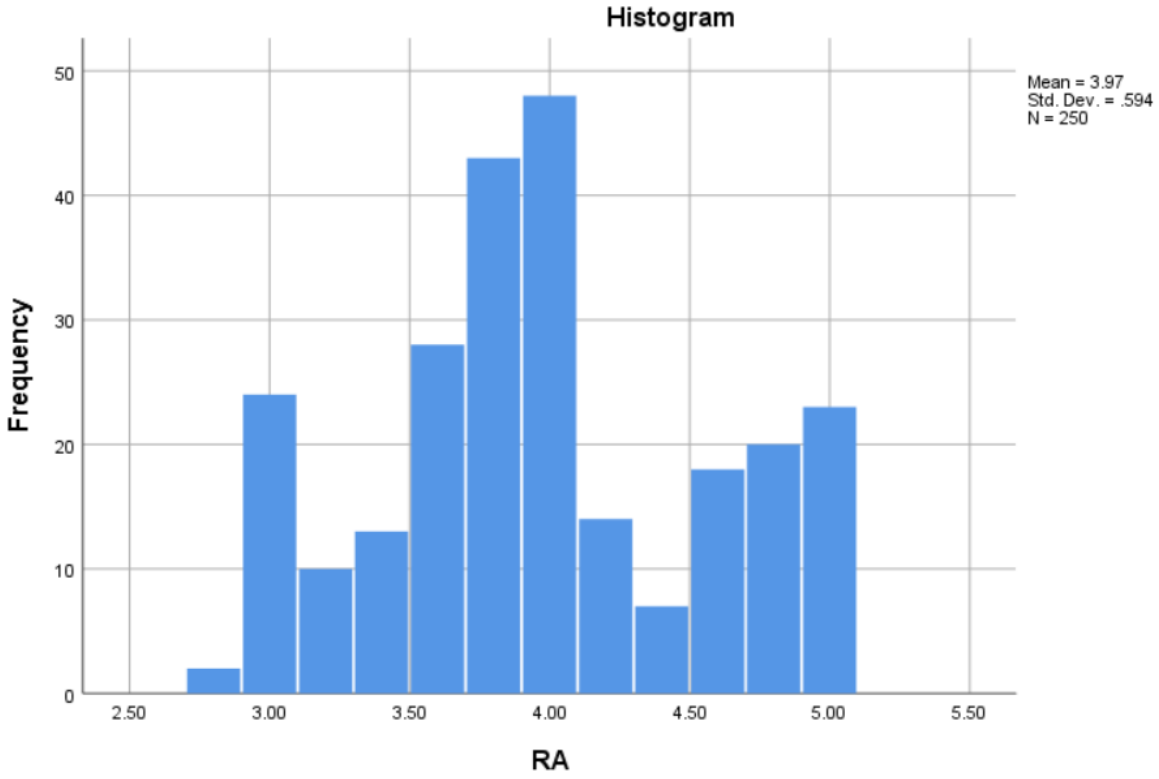


Figure 3: Graphical Representation of Relative Advantage Data through Histogram

Above figure shows the Histogram of independent variable RA, Histogram tells us about the distribution of collected data and through that we can predict the normality of data. The ideal histogram has smaller values at both ends and higher values at middle and forms the bell shape curve. RA data Histogram shows that the data is distributed between range 1 to 5, it also tells us about the collected sample size and measures the standard deviation of variable as well. The graph shows that the data is normal.

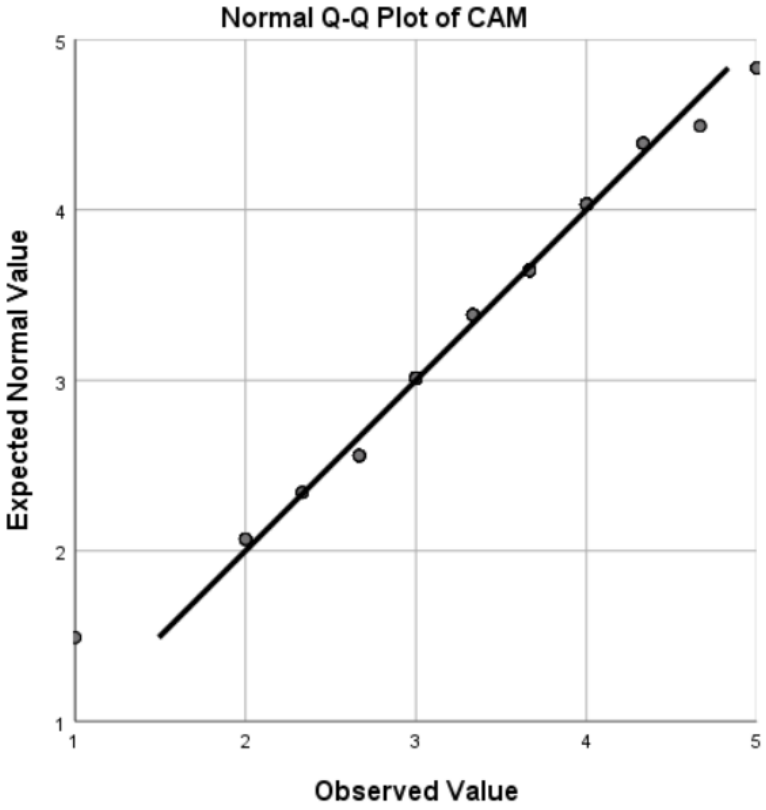


Figure 4: Q-Q Plot of Compatibility

In above figure we formed the Q-Q plot of independent variable CAM by using the SPSS software. Q-Q plot is also used as an alternative method to visualize the normality of data. In the ideal Q-Q plot there is a straight line that is the normal distribution line, and all the data should be plotted along it but in practical scenarios the closer the plots are from the line the more normal the data will be. In the above figure we can see that some plots are not online but closer to line and we can say that the data is normally distributed.

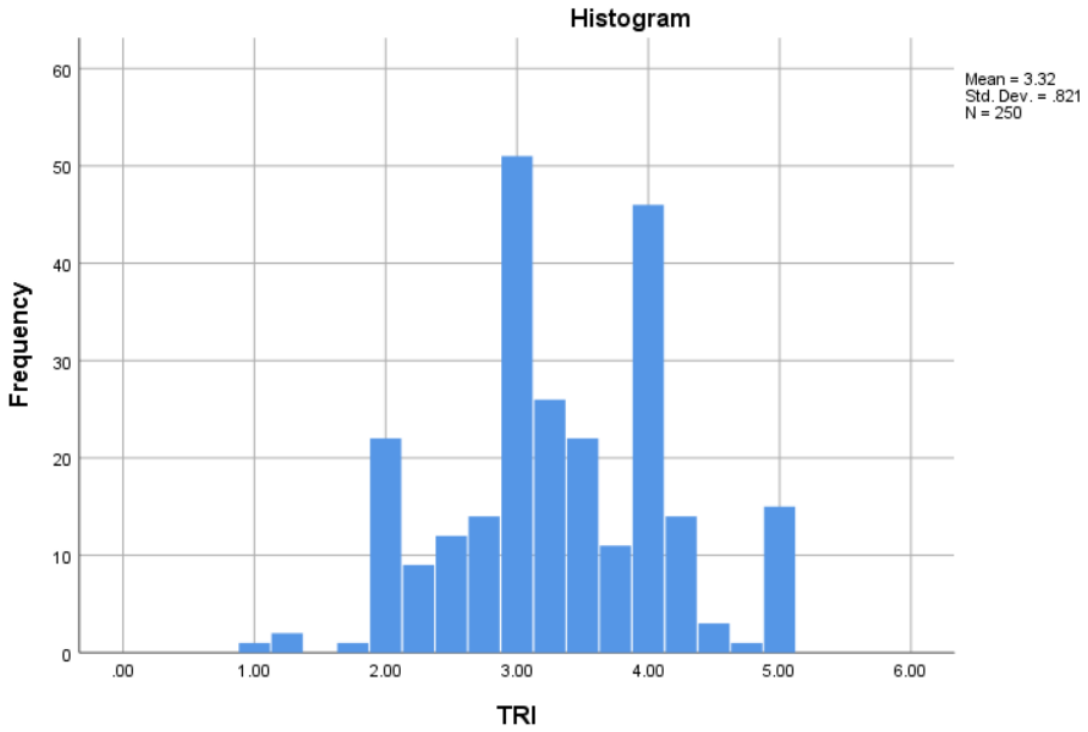


Figure 5: Graphical Representation of Trialability Data through Histogram

Above figure shows the Histogram of independent variable TR, Histogram tells us about the distribution of collected data and through that we can predict the normality of data. The ideal histogram has smaller values at both ends and higher values at middle and forms the bell shape curve. RA data Histogram shows that the data is distributed between range 1 to 5, it also tells us about the collected sample size and measures the standard deviation of variable as well. The graph depicts the shape of bell and which shows that the data is normal.

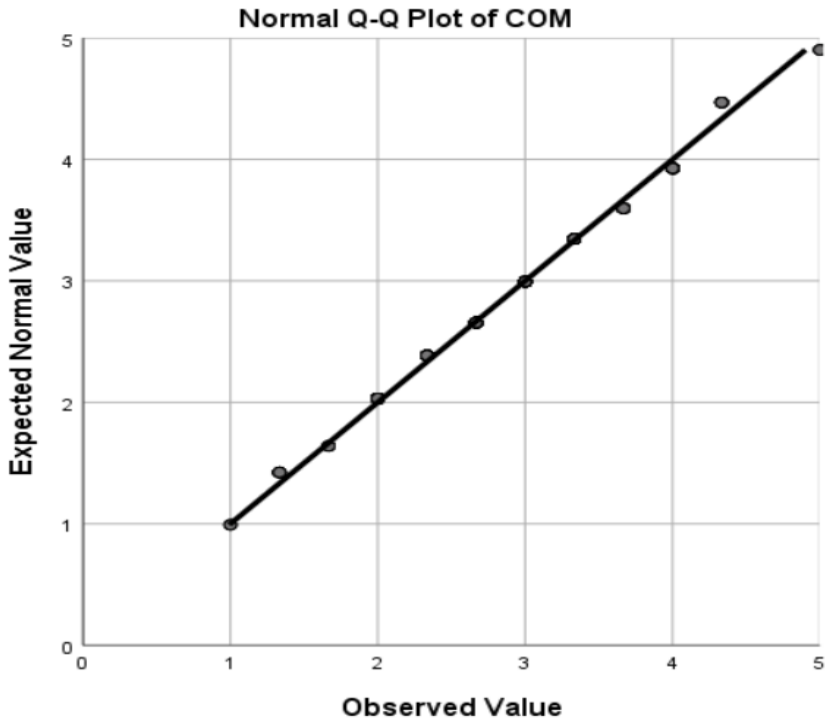


Figure 6: Q-Q Plot of Complexity Data

In above figure we formed the Q-Q plot of independent variable COM by using the SPSS software. Q-Q plot is also used as an alternative method to visualize the normality of data. In the ideal Q-Q plot there is a straight line that is the normal distribution line, and all the data should be plotted along it but in practical scenarios the closer the plots are from the line the more normal the data will be. In the above figure we can see that some plots are not on line but closer to line and we can say that the data is normally distributed.

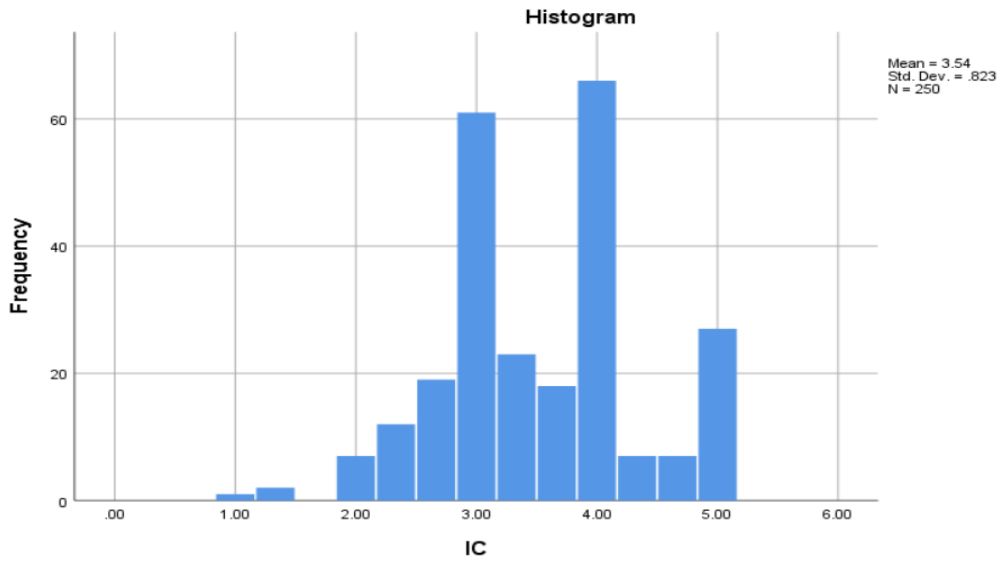


Figure 7: Graphical Representation of Initial Cost Data through Histogram

Above figure shows the Histogram of independent variable IC, Histogram tells us about the the distribution of collected data and through that we can predict the normality of data. The ideal histogram has smaller values at both ends and higher values at middle and forms the bell shape curve. RA data Histogram shows that the data is distributed between range 1 to 5, it also tells us about the collected sample size and measures the standard deviation of variable as well. The graph depicts the shape of bell, and which shows that the data is normal.

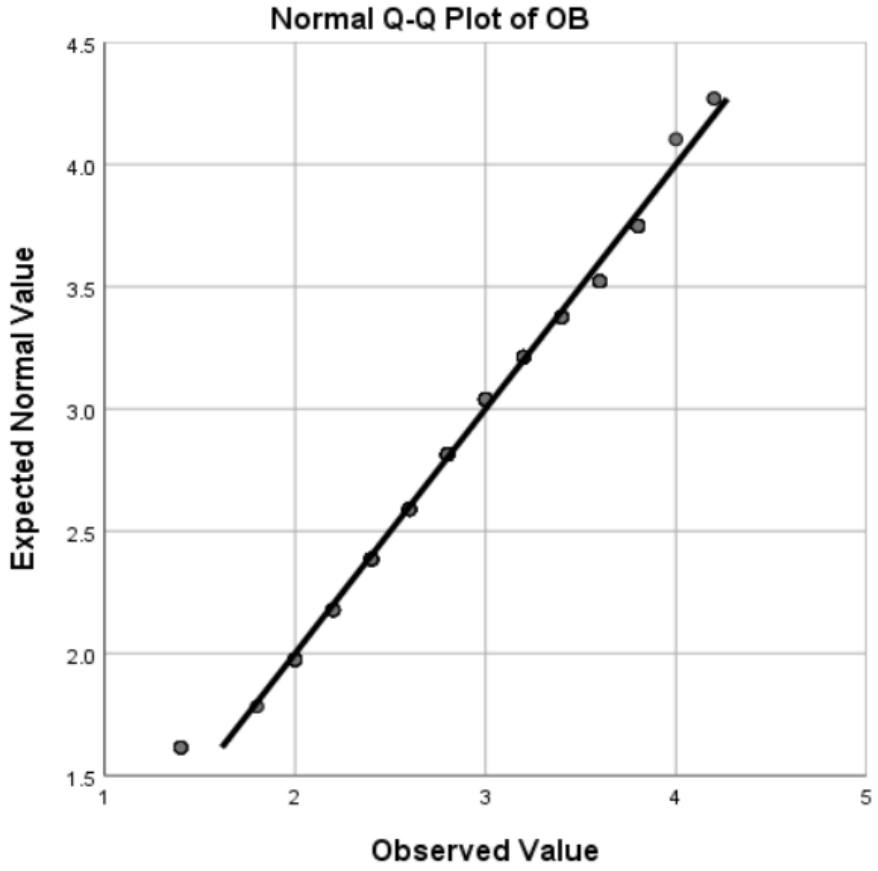


Figure 8: Q-Q Plot of Observability Data

In above figure we formed the Q-Q plot of independent variable OB by using the SPSS software. Q-Q plot is also used as an alternative method to visualize the normality of data. In the ideal Q-Q plot there is a straight line that is the normal distribution line and all the data should be plotted along it but in practical scenarios the more closer the plots are from the line the more normal the data will be. In the above figure we can see that some plots are not on line but closer to line and we can say that the data is normally distributed.

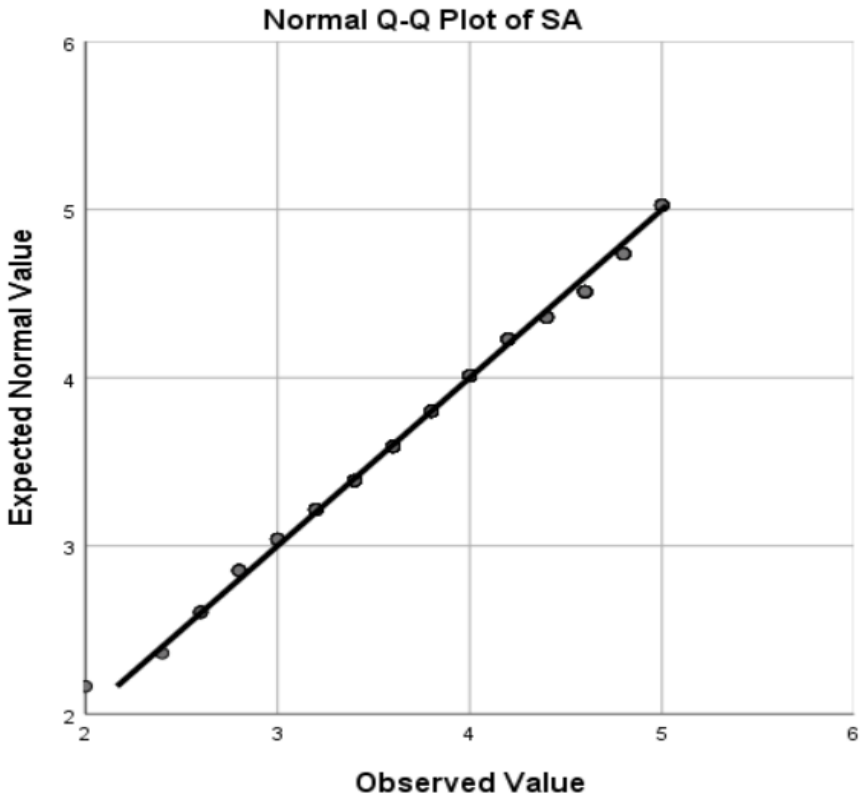


Figure 9: Q-Q Plot of Satisfaction Data

In above figure we formed the Q-Q plot of Dependent Variable Satisfaction by using the SPSS software. Q-Q plot is also used as an alternative method to visualize the normality of data. In the ideal Q-Q plot there is a straight line that is the normal distribution line and all the data should be plotted along it but in practical scenarios the more closer the plots are from the line the more normal the data will be. In the above figure we can see that some plots are not on line but closer to line and we can say that the data is normally distributed.

4.4. Correlation Analysis

Correlation analysis is performed on collected data to check the relation between the two or more variables. The value of correlation coefficient r is between -1 to 1, value near to 1 indicates the strong relation and the sigh indicates the direction of relationship, value greater than 0.5 to 1 considered as strong relationship, 0.3 to 0.5 value considered as moderate

relation, 0.1 to 0.3 considered as week relation between the variables [49]. If the two variables are scaled type, then we can apply the person R test on the data [55]. The correlation present in this study are two tailed correlation to get the clear information on the direction of relationship between variables. The results of Correlation analysis is given below in table.

C	RA	CAM	TRI	COM	OB	IC	SA
RA	1						
CAM	0.569**	1					
TRI	0.268**	0.631**	1				
COM	-0.136*	-0.160*	-0.322**	1			
OB	0.197**	0.150*	0.038	0.481**	1		
IC	-0.321**	-0.260**	0.073	0.314**	0.271**	1	
SA	0.742**	0.699**	0.411**	-0.075**	0.272**	-0.183**	1

Table 3: Correlation Analysis Data

* Correlation is Significant at the 0.05 level (2 Tailed)

** Correlation is significant at the 0.01 level (2 tailed)

It can be seen from table above that Dependent variable SA has a significant relation with all the independent variables, RA (relative advantage) has a strongest relation with SA (Satisfaction) with the correlation coefficient value of 0.742 it also shows that the relation between these two variables will be positive, CAM (compatibility) also shows strong relationship between SA and CAM with the correlation coefficient of 0.699 and their relation is also positive. TRI (trialability) has a correlation coefficient of 0.411 that shows that the relation between TRI and SA is moderate and has positive relation between them. OB (Observability) shows positive relation with SA with the correlation coefficient of 0.255 that shows that their relation is weak. IC (initial cost) and SA has weak relation, and their correlation coefficient is -0.183 which shows that their relation is negative that means change in one variable will affect the other variable inversely. Relationship between COM (complexity) and SA is also negative but is is insignificant with the correlation coefficient of -0.075.

4.5. Regression Analysis

Regression analysis is performed on data to find the relationship between variables and forming a model. It also tells us about the impact of independent variables on dependent variable. Regression analysis is performed using the ordinary least square technique. Multiple and simple regressions are carried out on data to prove our model. It is also used to predict the change in dependent variable when there is a change in independent variable. We will determine the relationship between dependent variable and independent variables, dependent will remain constant and independent variable will change alternatively. The general equation that determines the relationship between two variables is Y=X+B, where Y is dependent variable and B is independent variable.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.742[a]	.550	.548	.41076

a. Predictors: (Constant), RA

Model summary of relative advantage shows that the model is overall a good fit having R square value of .559 that means that there will be 55% change in dependent variable when we change the independent variable by 1%.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.699[a]	.488	.486	.43812

a. Predictors: (Constant), CP

Model summary of Compatibility shows that the model is overall a good fit having R square value of .488 that means that there will be 48% change in dependent variable when we change the independent variable by 1%.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.411[a]	.169	.166	.55816

a. Predictors: (Constant), TR

Model summary of Trialability shows that the model is overall a good fit having R square value of .169 that means that there will be 16.9% change in dependent variable when we change the independent variable by 1%.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.075[a]	.006	.002	.61053

a. Predictors: (Constant), CO

Model summary of Complexity shows that the R Square value is .006 that means there will be a change of 0.6% in dependent variable when we change the independent variable by 1%.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.272[a]	.074	.070	.58912

a. Predictors: (Constant), OB

Model summary of Observability shows that the model is overall a good fit having R square value of .074 that means that there will be 7.4% change in dependent variable when we change the independent variable by 1%.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.183[a]	.033	.030	.60191

a. Predictors: (Constant), IA

Model summary of Initial Cost shows that the model is overall a good fit having R square value of .033 that means that there will be 3.3% change in dependent variable when we change the independent variable by 1%.

4.6. Multiple Regression Analysis

To determine the change in dependent variable using this model we will perfom the multiple regression analysis, the purpose of this test is to determine the change in dependent variable when there will be change in all independent variables. Below table shows the result of multiple regression analysis.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.825[a]	.681	.673	.34927

a. Predictors: (Constant), IA, TR, OB, RA, CO, CP

Table shows that the model is a good fit having the R Square value of .683 which shows that there will be change of 68% when we wil change the independent variable by 1%. The only insignificant value in simple and multiple regression is the value of complexity which is supported by [42] that complexity can be insignificant in some cases depending on the population. Sometimes the population understands the technology or they gather information regarding the technology so sometimes it get insignificant.

Chapter 5
Discussion and Conclusion

5.1. Discussion

The purpose of this study to determine the factors that play a vital role in adoption of Net Metering in Pakistan specially in IESCO region. Our research addresses the questions based on adoption of innovation. Correlation between Relative Advantage and SA shows that they have positive relation between them, having the value of 0.747. Correlation value also tells that the relation is Strong between variables. Regression analysis also shows the positive relation between variables, R Square value show that there will be a 55% change in dependent variable if we change 1% in observability. The results also proved out Hypothesis. H1 that the Relative Advantage will have a positive impact on Adoption of Net Metering System.

Relationship between Compatibility and SA is also positive with the correlation value of .699 which shows that these two variables have strong relationship between them regression analysis also shows that thy have positive relation between them. R Square vale tells that there will be a change of 48% in satisfaction if we change 1% of compatibility. These results also support and proves our Hypothesis H2 that the compatibility will have a positive impact on adoption of net metering system.

In case of Trialability and SA correlation shows that they both have positive relationship between them and the strength of relation is strong having the correlation value of 0.411. regression analysis also shows that these two variables have positive relation between them. R square value tells us that 1% change in trialability will bring about 16.9% change in satisfaction. These results also support put Hypothesis H3 that the trialability will have a positive impact on adoption of Net Metering.

After correlation and regression analysis we can say that the Observability has a positive impact on adoption of Net Metering system with the correlation value of 0.272 that means they have a strong relationship, regression analysis between SA and OB shows that they have positive relationship between them. R square shows that there will be change of 7.5% change in if we change the observability by 1%. This result also supports our Hypothesis H4 that Observability have positive impact on adoption of Net Metering.

Correlation between Initial Cost and SA shows that the variables have negative relation between them with the correlation value of -0.183 and the relation is weak as well. Regression analysis shows that there will be 3.3% change in Adoption if we change the value of initial cost by 1% and it will affect positively. These results also prove our Hypothesis H5 that the initial cost will have a negative impact on Adoption of net Metering.

Correlation between Complexity and SA shows that the variables have no significant relation between them with the correlation value of -0.075 and the relation is insignificant. Regression analysis shows that there will be 0.6% change in satisfaction if we change the value of Complexity by 1% and that means it has no effect on SA. This results is unexpected but according to [42] this could happen and other authors have also reported about this. According to [42] it is possible that the population can learn about the technology as most of the population in our case are educated and mature enough to learn this technology and can afford this technology as well thus complexity has no significant effect on adoption of net metering proving our Hypothesis wrong.

5.2. Conclusion

This study concludes that the Relative Advantage, Trialability, Compatibility, Observability are the positive core components that have a positive impact on adoption of Net Metering. However, observability shows a weak relation and for increasing the adoption this factor should be addressed on every level. Other positive factors also need to be addressed on every platform and major campaigns regarding the awareness of this technology should be launched based on these positive factors to increase the adoption rate similarly the price of the system should be lower so wide majority of population can benefit from this technology, Complexity has no significant affect on adoption and the initial cost ha also weak relation that also needs to be addressed. Policies like subsidies and return of investment should be introduced to increase the adoption of Solar Net Metering System. Relative Advantage and Trialability shows higher affect on adoption and by specially working on these two factors as well as other factors adoption can be increased.

5.3. Recommendations and Future Work

All the positive factors need to be addressed on government level especially Observability factor should be addressed. Awareness regarding this technology should be conducted to

increase the adoption. When more people will hear about this technology then more will join and adopt this technology. Government should address these factors to increase the adoption of this technology. This study is purely based on the perception of individuals about the Solar Net Metering technology and to find the factors that influence the adoption rate of this technology. However, this study only focuses on the consumer side of this technology, and it does not investigate the policies of government regarding the adoption of this technology. Such kind of study should be done that identifies the factors that are causing barriers or supporting the adoption of Net Metring as it will really help in increasing the adoption of this technology in Pakistan.

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APPENDIX

Questionnaire

Factors affecting the adoption of Solar PV Net Metering System: Case Study IESCO.

Personal data (Confidentiality Guaranteed)

Gender	**Male**		**Female**		
Age	**18 - 25**	**26 -30**	**31 - 45**	**46 - 55**	**56 & above**

Please Tick the most appropriate option				
1	**2**	**3**	**4**	**5**
Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**

Statement	**1**	**2**	**3**	**4**	**5**
1. Do you know about Solar PV system					
2. Do you know about Net Metering System					
3. Do you Know about the working of Solar PV Net Metering System					
4. Installing a Net Metering system on your house would enables you to reduce your electricity bills. **(RA)**					
5. Installing a Net Metering system on your house gives you great control over your electricity bills.					
6. Installing a Net Metering system on your house would start your own the produc of electricity.					

7. Using a Net Metering system gives you control to sell excessive electricity to IESCO.					
8. Overall, you found Net Metering system advantageous in your lifestyle.					
9. To use a Net Metering system, it would not require significant changes in your existing daily routines. **(Compatibility)**					
10. Net Metering System would be compatible with your lifestyle.					
11. To use a Net Metering system, you don't have to change anything you currently do at home.					
12. You know where to get the information required for installing net metering system. (**Trialability)** **13.** You know where you could go for satisfactorily see various types working Net Metering system.					
14. You could draw on someone's experience who has already installed a Net Metering system.					
15. You have a great deal of opportunity to talk to various consumers of net metering system.					
16. Net Metering system is very complex system. **(Complexity)**					
17. Net Metering system would be very difficult to use.					
18. One requires a lot of information/knowledge for installing Net Metering system.					
19. You do not have the money to install a Net Metering system on your house. **(Initial Cost)**					
20. You would find it a financial strain to install a Net Metering system on your home.					
21. The initial cost of installing a Net Metering system on your house would be too high for you.					

22. I have seen others Installing net metering system on their house. **(Observability)**					
23. I have seen the net metering system in use at many locations.					
24. In my area one sees net metering systems on many roofs.					

Thank You!