ECONOMIC PERFORMENCE OF NETMETERING AND NET-BILLING: AN ANALYSES OF NEPRA RULES AND REGULATION

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CERTIFICATE

This is to certify that this thesis entitled: **"ECONOMIC PERFORMANCE OF NET-METERING AND NET-BILLING: ANALYSES OF NEPRA RULES AND REGULATION"** submitted by **Mr. Saadat Ali** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Health Economics.

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Author's Declaration

I **SAADAT ALI** hereby state that my MPhil thesis titled "**Economic performance of Net metering and Net-billing: Analyses of NEPRA rules and regulations"** is my own work and has not been submitted previously by me for taking any degree from the Pakistan Institute of Development Economics or anywhere else in the country/world.

At any time if my statement is found to be incorrect even after my Graduation the university has the right to withdraw my MPhil degree.

SAADAT ALI

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May the Almighty God, Allah SWT blesses and guide us to the straight path.

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ABSTRACT

Pakistan has massive potential to produce solar energy and in the future solar energy can immensely contribute into energy mix. Mainly, the solar deployment is promising for future energy as its feasibility assessment can reduce the energy import bill and the country energy demand. Pakistan introduces distribution generation facility under net metering rules regulation for small scale solar system. Around 58% of electricity produced in the region from fossil fuel and only 2.4% from renewable energy although the country blessed with RE potentials.

The tariff rate of electricity consumption is highest in Pakistan due to the dependency of energy production on fossil fuel. And the cost of small-scale solar energy production reached to the grid parity. The DG facility under net metering scheme in Pakistan allow the solar system users to produced own electricity. The DG facility users can get two type of incentives, that is, energy compensation and monetary compensation for export energy to grid, only if the DG facility fulfil the criteria of net metering rules regulation. In the literature net metering and net billing are loosely describe as a net metering scheme or DG facility under net metering scheme. Both the schemes allow the customer to export excess electricity to the national grid. Under net metering scheme the consumers get energy compensation while under net billing support the consumers financially for excess electricity export to the grid.

The study assessed both the incentive of DG facility under net metering rules regulation as a net metering and net billing scheme in Pakistan. The energy production software has been used in the study, climatological data base and by putting the technical and financial parameters to estimate the technical and economic performance of solar modules under net metering and net billing schemes. The result indicated that the net metering scheme provide high rate of returns if the household goes for energy compensation, and can reduce his electricity bills up to zero and consume exported electricity in the next month. On the other hand, net billing has attractive rate of returns to invest on solar system. But slightly lower than net metering. Despite the fact that, rules and regulation are settled for DG facility in Pakistan where the customer have dis-incentive to go for monetary benefits. The net metering rules regulation has implemented by NEPRA. Further, the dissertation results that the government policy is more balanced and encouraging for investment on solar system up to certain level and the net export billing of DG facility should be smooth to attract the participants to invest on rooftop solar photovoltaic system

Key words: explained

PV system: Photovoltaic system energy production software

KWP: kilo watt peak. Electricity unit during peak time

KWh: kilo watt hours

NEPRA: national electric power regulatory authority

DISCOs: distribution companies

ICC: Install capital cost per watt peak, the energy cost of per watt from solar

Tilt angle: the angle between solar penal and sunlight

Azimuth or inclined plane: the angle of the solar plant place with west and east

Module degradation: the energy losses of solar penal due to use of the technology.

String inverter: it uses to convert direct current to alternative current

STC: standard test condition which the control variable effect the current flow or performance of the system

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Many developed and developing countries are in the process of boosting their national energy supplies with renewable energy sources. Due to the variety of national policy for promoting renewable energy to achieve target goals, the focus in the past has been to increase the deployment of renewable energy technologies on a utility scale. In the present time the small scale photovoltaic system has expanded to the users of small-scale RE solar systems for the individual and domestic sectors. Some Southeast Asian states have undergone rapid-economic growth in the past few decades, and their goal is to strike a balance between rapid-economic growth and long-term sustainable development goals. The national political agenda has slowly begun to shift towards low carbon economic development. These country's Pakistan, Indonesia, Malaysia, Philippines, Singapore and Thailand have presented a policy designed to encourage domestic households for investment on renewable energy and increase the use of small scale solar system in the region. However, they have designed different policy choices to improve the adoption of rooftop-solar photovoltaic systems. Due to the continuous decreasing the cost of solar Photovoltaic system and the high monetary benefit commitment of feed in tariff attract the users to solar schemes, the framework and policy choices of each country are convergent towards the solar system is incentive to consume the energy for self-consumption. Pakistan are also in the list where the distribution generation facility is performing the same as the other country under net metering arrangement.

In the early year Indonesia announced a net metering framework to achieve the energy demand in the region (Yosiyana., 2016). Thailand dropped their feed-In tariff scheme and Malaysia following the net metering arrangement and Thailand following a self-consumption policy (Kokchang., et al.

2017). the Philippines presented a net metering and net billing framework (Pacudan., 2018); Singapore adopted a net-settlement policy (authority 2017). These countries are trying to enhance their experience of using solar photovoltaic system under net metering scheme. The economic and social well-being of a country depends to a large extent on the availability of affordable electricity for all strata of society. In Pakistan, a large part of this decade has been overly troubled due to the inability to obtain sufficient affordable power generation capacity and inefficient T&D transmission and distribution service.

In the case of Pakistan, the demand for energy increases by more than 9% annually. Energy demand is expected to increase 8 times by 2030 and 20 times by 2050 (Hamid., 2015). In addition to all other developing countries, Pakistan is also experiencing rapid economic growth. In order to meet its massive burden on electricity demand, Pakistan hopes to expand its power network so that it can be fill the electricity gap between supply and demand. Because the country's continuous and increasing rate of population, the electricity stock lags behind the demand. Because of this huge embarrassment, a huge load shedding occurs in summer for ten to twelve hours in urban areas. And similarly this issue is more problematic in rural areas which is sixteen to eighteen hours' load factor (Irfan., et al. 2019).

However, in the past few years, due to the production of a large amount of power generation capacity in Pakistan has been upgraded significantly, but the cost of electricity for both government and end consumers has increased due to various reasons, such as high transmission and distribution losses, circular-debt, a massive volume of payments, low-recovery, money-depreciation, fuel costs, underutilization of efficient power-plants etc. Transmission and distribution losses of electricity in Pakistan have reached an unprecedented level causing a huge burden of circular debt of around Rs.2150424 million on fiscal position of the country (NEPRA., 2020). Considering the above electricity issue in Pakistan power sector, the government is encouraging small scale

renewable energy distribution generations (DG) by promoting investment through alternative energy development board (AEDB) on the basis of net-metering framework.

The concept of net-metering, incentivized self-consumption scheme, is an encouraging and cost-effective mechanism adopted by many countries around the world to reduce power sector issues. This mechanism running under two frameworks, net-billing and net-metering, is utilized to encourage the adoption of net-metering scheme (Pacudan., 2018). Incentivized self-Consumption scheme that contains net-metering and net billing frameworks is roughly defined in the literature as net-metering scheme. The main differences between net metering and net billing schemes have been pointed out by (Sarasa-Maestro., et al. 2016), and (SWD Commission 2015) in both-cases where the solar Photovoltaic energy is consumed first by households for self-consumption and the excess electricity is exported to the national grid. However, net metering provides energy compensation for excess generation, while net billing offers a monetary compensation to the solar energy generators (Sarasa-Maestro., et al. 2016).

1.2 overview of net metering performance in Pakistan

Distribution generation facility (DG) refers to the electricity produced from solar and wind through net metering scheme as a consumer choice where the customer is allowed to generate his own electricity from 1KW to 1MW. In this process initially, the energy is used for self-consumption and the excess energy is exported to the national grid to get energy compensation. In order to maximize the use of alternative renewable energy (ARE) technology, NEPRA announced its rule and regulations (alternative and renewable energy Regulations on Distributed Power Generation) and Net Metering scheme on September 1, 2015. These regulations provide a framework for net metering installations that use solar and wind energy to generate electricity with a capacity up to 01 megawatts.

Under net metering rules the customer can install up to 250kwh per license according to the feedin tariff set by the authority (NEPRA. 2015). In the fiscal year 2020-21, a total of 8,417 net metering licenses were issued, with a total installed capacity of 145.881 megawatts. The discowise details of the net- metering licenses is shown in the following Table 1:

Table. 1: Net metering licenses and energy capacity in kWh of all Disco's from 2016-21

	2016-17		2017-18		2018-19		2019-20		2020-21	
All **Disco's**	**Lic.**	**Capacity kwh**	**Lic.**	**Capacity Kwh**	**Lic.**	**Capacity kwh**	**Lic.**	**Capacity kwh**	**Lic.**	**Capacity kwh**
IESCO*	49	1,008.96	114	1,732.81	377	3,849.07	863	9,990	1,976	24,439
PESCO	0	0	2	37.56	10	96.6	131	3,200.84	525	6,064
TESCO	0	0	0	0	0	0	0	0	0	0
GEPCO	3	11	31	1190.37	56	908.64	134 4,	720	433	11,138
LESCO*	36	468.2	142	3,204.43	348	7,154.44	886	14,980	2,170	41,126
FESCO	2	305	13	217.6	24	258.17	152	3,960.00	564	14,879
MEPCO*	10	470.57	7	251.96	47	1,129.94	166	4,300	876	17,928
HESCO	0	0	0	0	1	10.08	6	220	11	951
SEPCO	0	0	0	0	1	964.91	5	469	7	136
QESCO	0	0	0	0	1	6.18	1	20	4	326
KE*			28	288.4	253	4,270.21	730	12,240	1,357	23,885
BTPL	6	52.95	13	84.79	48	490.62	204	2,140	221	1,862
DHA-XII	0	0	0	0	1	10.4	56	630	273	3,147
Total	**106**	**2,316.68**	**350**	**7,007.92**	**1,167**	**19,149.30**	**3,334**	**56,869.84**	**8,417**	**145,881**

Source: NEPRA. (State of industrial report 2021)

According to the Electric Power Act 1997, the NEPRA issued the Net-metering rules and regulations in September 2015 by the endorsement of Federal-Government. The certified

Pakistan's power distribution-companies (DISCOS) are allowed to purchase surplus electricity units generated by consumers from solar and wind at rate of off-peak tariff of the respective discos.

Table-1 shows the growth of net metering is mainly led by three key discos, namely K-Electric (KE), Islamabad Power Supply Company (IESCO) and Lahore Power Supply Company (LESCO). Other large discos such as Multan Power Company (MEPCO), Faisalabad Power Supply Company (FESCO), Peshawar Power Supply Company (PESCO), and Gujranwala Power Company (GEPCO) lag behind in power distribution. Several others like Sukkur Power Company (SEPCO), Hyderabad Power Supply Company (HESCO) have issued less than twenty licenses each in the last six years. Quetta Power Supply Company (QISCO) have issued only 6 licenses in the last six years. Moreover, the Tribal Area Power Supply Company (TESCO) has not yet engaged in distributed power generation (NEPRA, 2021) likewise the low rate of licenses issued by discos also pointed out due to long registration processes and constrained in the processes by(Saleh 2020). Multan Electric Power Company (MEPCO) has partially adopted net-metering system in Pakistan and has reported a positive feedback (Hassan., et al. 2020).

1.3 Problem statement

According to given information, there is no study on the policy effectiveness between net-metering and net-billing in Pakistan. Therefore, there is an essential need to study net-metering framework in its entirety in Pakistan and the main hurdles in its mass adoption. It is also important to examine the policy effectiveness of incentives between net-metering and net-billing mechanisms. This study is aimed at studying this policy gap in the NEPRA Rules and Regulations policy with respect to the incentive provided in self-consumption scheme and evaluate the cost-effectiveness between the incentive structure of energy compensation and monetary compensation from the household prospective.

The current study separately analyzes the monetary compensation through net-billing and energy compensation through net metering mechanism in order to explore the effectiveness of each scheme to boost the usage of rooftop solar Photovoltaic schemes in Pakistan. And fill the policy gap to over-come the issues facing consumers in net-metering schemes and help investors to choose between net-billing and net-metering based on economic analysis

1.4 Research Problem

Based on the narrative of problem statement mentioned above, I am narrowing my research problem into "**Economic performance of Net-metering and Net-billing: Analysis of NEPRA rules and regulations of Pakistan**" and have operationalized my topic into following research questions and objectives**.**

1.5 Research question

(i) How does the existing net metering scheme perform compared with alternative net billing scheme?

(ii) What is the impact of net metering policy on the growth of investment in rooftop solar photovoltaic system?

1.6 Objectives of the study

The main focus of this study is to analyze the net-metering rules regulation enforced in Pakistan for customer who's installing distribution generation facility under net metering rules regulation announced by the Pakistan (National Electric Power Regulation Authority) NEPRA in 2015. Under net metering rules the residential household invest in rooftop solar photovoltaic system. The energy produced from PV system is first used by the household for self-consumption and the excess energy is exported to the national grid. Later, the exported energy is sent back to consumer

to consume it during off-peak hours when the PV system becomes unable to meet the household electricity demand as an energy compensation on the same tariff rate equal to retail tariff through net metering scheme. The program introduced in Pakistan is a net metering scheme fairly a net billing framework. Net billing is part of the net metering framework in Pakistan where the compensation for exported electricity is granted in monetary form to the consumer instead of energy compensation. If the DG (PV system) meets up the household electricity demand and the distribution generation (DG) achieves net export bill, then the DISCOS will have to pay the household at the rate of off-peak hours set by the NEPRA. The policy aims to facilitate and incentivize households to invest in solar photovoltaic system within the rules and regulations adopted by NEPRA.

- To estimate the Economic performance of net metering framework, compare with net billing scheme as an incentivized self-consumption scheme in Pakistan.
- To evaluate the effect of net metering policy on the growth of investment in solar photovoltaic system.

1.7 Explanation of Key Concepts/Terms

1.7.1 Distribution generation facility /DG facility

Distribution generation (DG) refer that electricity produce from solar and wind under Net metering is consumer choice policy where the customer allows to generate own electricity through (solar and wind) from 1KW to 1MW. And first the energy uses by own and the excess energy export to the notional grid to get energy compensation. Feed in tariff scheme refer to where the household generate electricity from solar or wind and the exported energy export to the grid from solar system that the utility is given money per kwh at rate which set by the respective discos. And the self uses or self-consumption scheme allow the customer to generate has own electricity and consume it by

self while the incentivized self-consumption scheme where the customer can use the electricity for self-consumption and the excess energy can transfer to the national grid to get energy compensation during offsite hours or when the solar system unable to work. (Couture T., 2010)

1.7.2 Net Metering

Net metering, the electric meter used to rotate and record the net energy in both directions energy Consumption from the national grid and net metering connect the DG facility to grid. Where the household able to export excess electricity to the grid and use it during offsite hours when the DG facility are unable to fulfill the household demand. Net metering give energy compensation with same rate of tariff with retail rate.

1.7.3 Net-Billing

Under net billing the owners get monetary compensation by injection solar energy to the national grid.

1.8 Originality

This will be the first study to analyze NEPRA rules regulation regarding Distribution generation (DG) under net-metering policy and the technical comparison of economic performance of net metering and net billing mechanisms can promote the use of renewable energy and attract customer to invest in the rooftop solar photovoltaic system in Pakistan. This study will provide valuable policy insights to reduce power sector issues with deep understanding between net metering and net billing scheme.

1.9 Organization of the study

The organization of the study is the first chapter present the introduction of the study and overview of the net metering scheme, problem of the study, objectives and key words. Second chapter explained about the previous studies globally and specifically in Pakistan net metering scheme. Chapter third present the methodology and data as well as technique for the analysis. Chapter fourth present the estimation and result with detail methodology which used. Using energy production softer PVsyst where which we can measure the technical performance of solar panels and by putting key parameter to estimate the economic analysis of different project scheme. Chapter fifth express the results of the study and discussion. Chapter sixth present the qualitative part of the study where revive the present policy of the net metering and existing material document and then were conducting focused interview with energy expert and policy expert of NEPRA and AEDB, the other group re the net metering user perspective. Chapter seventh present the conclusion and policy recommendation.

CHAPTER 2

LITRERATURE REVIEW

2.1 Literature Review

The literature has been captured on the economics of net metering scheme. The large number of studies have been explored with the purpose to analyze the economic performance of solar PV system under net metering and net billing schemes. In the literature net metering and net billing scheme are roughly use as a net metering scheme. In both schemes the household produced has own electricity from solar penal and first the energy uses for self-consumption and the excess electricity export to the grid. The solar system under net metering scheme gives energy compensation while net billing gives monetary compensation to the solar system users or whose install rooftop solar system.

2.2 Globally literature on net metering

The Net metering systems were first adopted in the United States, where solar and wind energy was synchronized with the grid electricity. The system is put in place for renewable energy users because they are interested in using all the electricity generated at different times according to their needs. In 1981, the first state to approve a net metering license process was in Minnesota the solar or wind electricity users are willing to produced its own electricity due unavailability of electricity (Doris., et al. 2009). Furthermore, many distribution organizations are proceeding solar net metering mechanisms to the small scale level. Some states in the United States of America and Japan have implemented net metering schemes in domestic level, where they produced the electricity for self-consumption rather than use the electricity from the national grid. On the other

hand, Germany is usually known for its vigorous implementation of total capacity of net-metering plans. As well as are trying to improve has solar technology over the region (Vikas., et al. 2018).

In 2013 with the cooperation of Cyprus energy regulation Authority (CERA), Cyprus has begun to implement a net metering scheme. And starting campaign for implementation of net metering scheme (Nikolaidis and Charalambous 2016). There are feasibility study was conducted on the installation of photovoltaic solar panels on the rooftop solar PV system in Maldives, and they concluded that the solar PV system has great potential in reducing the use of diesel generators and fuel imports as well as it can minimizing power generation costs and helping to alleviate the energy crisis (Shafiullah., et al. 2018). The interest behind this policy was to promote the rooftop solar system installation in Cyprus as a sign of clean and friendly environment with the possibility of cheapest energy production in the region. After the first promotion of the net metering arrangement in Cyprus, due to the interest and simplicity of the net metering policy provided by Cyprus. The rooftop solar photovoltaic system installations have started to become popular on an individual basis. in Cyprus, located in the Eastern Mediterranean region, which has the largest potential for solar and photovoltaic irradiation in Europe (Nikolaidis and Charalambous 2016). In India, Maharashtra was the first state to use net metering. The first two-way meter was installed at Verdean Industries Ltd. By Tata Power Company. After that, in Vatic-Nagar district office are introduced the net metering scheme. Some other projects are also effectively installed by Rooftop-Urja-company, namely Telangana 3kw net solar metering system, Karnataka 15kw net solar metering system and Karnataka 10kW net solar metering system(Redfield and Redfield 2010).

Number of countries introduced the net metering framework such as Indonesia, Malaysia, Philippines, Singapore and Thailand have presented a policy designed to encourage domestic households for investment on renewable energy and to increase the use of small scale solar system in the region. However, they have designed different policy choices to improve the adoption of

rooftop-solar-photovoltaic systems. Due to the continuous decreasing the cost of solar Photovoltaic system and the high monetary benefit commitment of feed in tariff which attract the users to install solar schemes, the framework and policy choices of each country are convergent towards the solar system has incentive to consume the energy for self-consumption

In the early years Indonesia announced a net metering framework to achieve the energy demand in the region (Yosiyana., 2016). Thailand dropped their feed-In tariff scheme and Malaysia following the net metering arrangement and Thailand following a self-consumption policy (Kokchang, et al. 2017). The Philippines presented a net metering and net billing framework where the solar energy users have choice according to their interest and need. both the schemes allow the solar users to produced its own electricity first use the electricity for self-consumption and then export the access electricity to the national grid. The solar PV system users under net metering scheme they get the energy compensation which mean they can consume the exported electricity to the grid when the solar system is unable to meet the demand of the household. On the other hand the solar system users under net billing scheme they get monetary compensation which mean that they can sale the exported electricity to the national grid according to tariff rate sited by distribution (Pacudan., 2018); Singapore adopted a net-settlement policy (authority 2017). These countries are trying to enhance their experience by using solar photovoltaic system under net metering scheme. The economic and social well-being of a country depends to a large extent on the availability of affordable electricity for all strata of society

Integrated building photovoltaic (DIPV) systems are a promising solution for on-site production of clean electricity. In a DIPV system, photovoltaic panels must replace building envelope products, and if embedded photovoltaic modules are removed, they must be replaced with suitable conventional building products. However, there is another type of photovoltaic system classification, called photovoltaic products connected to buildings (BAPV). These products are not

DIPV, or they do not know how the products are installed. However, it is important here that both DIPV and BAPV systems are related to the de-carbonization of the energy system, whether it is related to the general energy system or the energy needs of buildings.

In the previous studies, there are many studies investigating the performance of DIPV systems in a variety of configurations (Kamalnathan., et al. 2002). (Gaillard., et al. 2014), (Lau, Sanvicente et al. 2012), (Yang and Athienitis 2015), (Agathokleous and Kalogirou 2018), and (Zogou and Stapountzis 2011). but there are fewer studies related to large-scale building-level research (Kuhn, Erban et al. 2021) argued that the Different technical design schemes for DIPV systems are proposed where they analyzed the technical performance of solar system.

(Kyritsis., et al. 2019)The performance of the DIPV system in the building is studied under the net metering scheme. The Studied the DIPV system as an important step towards green buildings.

(Aristizábal., et al. 2017) The performance of the 6 kilowatt DIPV system in university buildings was investigated and it was concluded that the university saved US11, 022 per year due to the operation of this photovoltaic system.

(Heesen., 2021) The performance of rooftop photovoltaic systems was investigated in 'the Netherlands, Belgium, Luxembourg, Germany, France and Italy. The DIPV system has important advantages, such as using the surface available on the exterior wall or roof of the building to replace building components, which can balance the cost, generate electricity on site and replace electricity that could have been purchased. When the system uses the available surface on the exterior wall or roof of the building to replace building components, it can balance the cost and generate electricity on site.

A comparative study by (Tan and Chow., 2016) of feed-in tariff (fit) and power grid measurement schemes in Malaysia, considering the 100kWp solar photovoltaic system on the UCSI university campus. The analysis is based on a simulation model and found that the cost savings of measuring and adjusting the net monthly energy bill were 4.91% and 3.51%, respectively, and the return on investment of measuring and adjusting the net solar photovoltaic system implementation was 11.5 to16.1 years, respectively. Another comparison between fit and net measurement schemes is proposed, and net purchases are proposed by (Yamamoto., 2012).

(Guillén et al., 2014) Studied the impact of different applications of net metering and rate design on cross-subsidies, cost recovery and policy objectives for residential consumers. The design and economic analysis of an independent rooftop solar photovoltaic system for a hotel building in India were carried out by (Shukla et al., 2016) The conclusion is that the annual final output value of 2.86kWh/kWp is an indicator that the installation of independent systems in India is a technically feasible energy solution even for urban areas, government buildings and hotels. In addition, it was concluded that although the initial installation of the system is very high, since the expected life of the system is about 25 years, it is beneficial and suitable for long-term investment. In addition, the Government also recommends that the Government provide financial support to subsidize the procurement and installation of rooftop solar photovoltaic systems, making them a popular choice and promoting this energy solution.

Another study regarding a roof PV system in India is performed by (Kumar, Gupta et al. 2019) In terms of performance, energy loss and degradation prediction. The estimated annual capacity factor, performance ratio and system power loss are 16.72%, 77.27% and 26.5%, respectively percent, %.

(Brito, Freitas et al. 2017) Investigated the potential of outer walls for the photovoltaic potential of Mediterranean cities. Annual analysis shows that the photovoltaic potential of roofs and facades exceeds the local demand for non-basic loads, and can contribute 50-75% of the total electricity demand, and the recovery period is less than 10 years when only rooftop photovoltaic systems are considered. (Sedghisigarchi 2009) Investigated the technical and financial aspects of residential solar systems

2.3 Net metering scheme in Pakistan

National Electricity Regulatory Authority (NEPRA) announced officially the distribution Generation facility and Net Metering Regulations on September 1, 2015. According to these regulations, the customers who's connected three phase line can get benefits to install solar system under net metering scheme

In Pakistan, net metering is the first policy mechanism of the Renewable Energy Act 2006. Fully implemented. Section 8.4.2 EEG 2006 Provide technically sound and non-discriminatory information by distributing to the end users, DISCO enters into net metering agreements with eligible end users who will install renewable energy system (NEPRA., 2015)

The study carried out by (Qamar., et al. 2016) where the study discussed, the Potential hurdles to the promotion of Pakistan's net metering policy. One of the main obstacles is the unwelcome response of utility companies. There is a lack of technically trained persons and equipment required for local production and installation of network metering systems. Another setback of this policy is the lack of public awareness. Residential consumers ignore their net metering opportunities.

Net-metering schemes is one of the achievable options that residential consumers can get benefits from solar energy in the region. The study estimates the threshold of single building where the billing system of whole building is based entirely on the usual housing supply tariffs. With frequent use of local services, it was found that net-metering coverage is desirable at a determining cost of the maximum solar energy potential (50 KW). From the point of view of the total demand of the entire residential building, there is a critical cost (80 kilowatts) of solar power. Effectively annual financial savings can be obtained by exceeding this threshold (Waqas U R., 2017).

Solar energy through net-metering technology has many important advantages, such as better voltage regulation, reduced transmission and distribution losses, increased power availability, reduced consumer complaints, and reduced load on utility networks. The mechanism by which the solar grid metering scheme supplies additional energy to the distribution network clearly shows that the two-way energy flow (from the utility grid to the consumer side, and vice versa) is beneficial to consumers and energy systems due to its various advantages. The case study found that the more solar power under net metering mechanism supplies to the utility grid in Pakistan, It will reduced the supply demand gap of electricity (Hassan., et al. 2020).

In the case of Pakistan, the demand for energy increases by more than 9% annually. Energy demand is expected to increase 8 times by 2030 and 20 times by 2050(Hamid., 2015). In addition to all other developing countries, Pakistan is also experiencing rapid economic growth. In order to meet its massive burden on electricity demand, Pakistan hopes to expand its power network so that it can be fill the electricity gap between supply and demand. Because the country's continuous and increasing rate of population, the electricity stock lags behind the demand. Because of this huge embarrassment, a huge load shedding occurs in summer for ten to twelve hours in urban areas. And similarly this issue is more problematic in rural areas which is sixteen to eighteen hours load factor (Irfan., et al. 2019).

There is no work on the cost competiveness of net metering and net billing scheme in the light of current policy. And analysis of NEPRA rule regulation. This will be the first study to analyze NEPRA rules regulation regarding Distribution generation (DG) under net-metering policy and the technical comparison of economic performance of net metering and net billing mechanisms can promote the use of renewable energy and attract customer to invest in the rooftop solar photovoltaic system in Pakistan. This work will give us clear picture of incentive which provide in the net metering policy in Pakistan. The study captured the incentive which provide in policy to the net metering users, the study analyzed where the net meter users have benefit to go. The study captured, give clear direction to users and also give positive outcome of the given policy.

The demand for energy in Pakistan has increased due to a high rate of population growth, estimated at 3% per year, with a median age of just over 22 years. Population growth has led to increased urbanization, a significant increase in the number of automobiles, and some industrial development. As a result of this growth, the country's energy demand has grown by more than 9% annually (Irfan et al., 2019). Based on current government policies and the use of the energy mix, total energy demand in 2018 is expected to reach approximately 400 TWh by 2030 (Raza et al., 2022). The use of fossil fuels such as coal, natural gas, oil, liquefied natural gas, and petroleum gas has grown to meet the growing demand from the country's energy sector (Musa et al., 2018; Liu and Xu, 2021; Tahir et al. ., 2021)

CHAPTER 3

DATA AND METHODOLGY

3.1 Introduction

This chapter presents the research methodology and data. Section 3.2 explains the research strategy. Section 3.3 explains the research strategy and presents the methodology in detail. Section 3.6 explains data types and sources as well as source of estimation technique in detail.

3.2 Research strategy

A research strategy is a plan adopted to answer research questions. This is a procedural framework, which determines the philosophical point of view of the research and the choice of data collection and analysis methods. In order to achieve the goals of this research, we use a mix-approach. Mixed method of research is defined as "inquiry or methods that combine or associate qualitative and quantitative forms." It involves philosophical hypotheses, the use of qualitative and quantitative methods, and the mixing of the two methods in research"(Creswell and Clark 2017).

Qualitative research is inductive in nature and is used to explore and understand the meaning that people give to social problems. The quantitative method tests the objective theory by studying the relationship between variables. This type of analysis has to test the hypotheses of the theory deductively.

The first objective of the study which is to estimate the economic performance of net metering framework compare to alternative net billing scheme are estimated with the help of quantitative method by using the secondary data in energy production software PV-system model. The second objectives of the research are analyzed through qualitative methods, which involves evaluating the

net metering rules regulation of NEPRA. The study also conducted a semi-structured interview with officials from NEPRA and AEDB and users of net-metering scheme along with the analysis of NEPRA net-metering Rules and Regulation documents.

3.3 Methodology and Research Design

The research design of the study describes and presented the methodology for measuring and evaluation of cost competitiveness of solar system and its economic performance of the different system in Pakistan initially the study estimates the energy production of the rooftop solar system following the technique and methodology presented in (Pacudan., 2016) and (Saheb-Koussa, Haddadi et al. 2009) respectively. The study considering the regional climatological data and the plant configuration data use in the estimation. The irradiation data export from climatological database by applying the metronome program. The database uses long-term data sets to estimate the yearly, monthly, daily, hourly values are available in the data base. The variable use in the study as (radiation, temperature, precipitation, and sunshine). Mostly the project researchers and solar energy expert in the industries using the metronome program source to estimate the energy yield in the project. The metronome database consists of more than 8,000 global meteorological stations and 5 geostationary satellites, as well as internationally standardized aerosol climatology and data from 1991 to 2010 (RE Energy., 2018). By sitting a pacific location and taking regional climate data using energy production software PVsyst through PV module to estimate seasonal pattern. And the energy yield or energy production in the plant. In estimation the solar (photovoltaic) PV system energy production, the study uses typical Canadian solar penal (semi-mano crystalline) solar PV modules and string inverter available in the market. The technical performance of solar PVsyst module estimate based on three size of semi-mano crystalline photovoltaic modules. (See section 4.1 chapter#4)

Secondly we calculate the amount of energy which household use for self-consumption as well as the excess energy which export to the grid from DG facility or solar system. The study take a domestic electricity consumer with his daily load profile of 50kwh per day and 1500kwh per month of energy consumption were consider in the analysis to calculate the amount of energy for own consumption and the amount of energy export to the national grid. (See section 4.2 chap#4)

Then we review electricity retail tariff rates and its generation charges. For the analysis we take monthly and yearly electricity consumption with daily profile of a typical household and tariff set by the respective DISCO's. (see section 4.3 ch#4)

To estimate the cost of project for estimation we take the install generation cost, which is already offer in the market. Then we take the price of average cost per watt peak. Which is already available in the market by conducting market survey. The per watt peak installation cost include the following key variables such as cost of PV equipment, generation license cost, solar system consultant cost, grid connection cost, and transportation cost, (See section 4.4 ch#4)

3.4 Levelized cost of energy LCOE

The procedure used in estimation of levelized cost of energy/electricity. (LCOE) is the efficient method to measure the net average cost of electricity generation which produced from solar system and evaluate to compare the cost of different generation technology. The LOCE is refers to calculate the electricity cost of generation for generator over the period of time where the value fixed income deliver the system over the life time of the install system to reached the project to breakeven point or the system payback period (Commission 2015), (Campoccia., et al. 2009) and (M. 2018). The LOCE are roughly designed as the discounted of the total generation cost of electricity divide by the discounted of total amount of energy produce by the solar system over the life of the asset (see section 4.5 ch#4) Equation:

$$LCOE = \frac{\sum_{n=0}^{PL} \frac{TC_n}{(1+dr)^n}}{\sum_{n=1}^{PL} \frac{TQ_n}{(1+dr)^n}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: TCn, represents the total cost, in n years; TQn represents energy generation, in n years; n represents the year; PL, represents the project life; dr represents the discount rate.

3.5 Economic performance of net-metering and net-billing

Net metering

Estimate the economic performance of net metering using the same data in PV system the model as follow

$$ScP = rtP \ldots\ldots\ldots\ldots (2)$$

$$ExPNB = rtP \ldots\ldots\ldots\ldots (3)$$

$$Rn = (rtP, n * TQ, n) \ldots\ldots\ldots\ldots (4)$$

Where: ScP= self-consumption price, rtp= electricity retail price, ExpNM= export tariff, TQ=the amount of export and self-consumption electricity, n=period of time or given year, Rn= the total income receiving each year in the net-metering arrangement,

For both schemes under net metering and net billing equation 2 is valid, which show that the opportunity cost of electricity for self-consumption is equal to the utility retail tariff or price. Equation 3 show the export energy under net metering is equal to the electricity of retail price while equation 4 show us the total income (revenue) of the project at any given year in the net metering scheme. See (section 5.2.1 chapter 5)

Net billing:

We estimate the economic performance of net billing using the technical performance of PV system and put information find in estimation chapter the model as following. (See section 5.2.2, chapter 5)

$$ScP = rtP \dots \dots \dots \dots . (2)$$

$$ExPNB = OPrtP \dots \dots \dots \dots . (5)$$

$$Rn = (rtP, n * QScNB, n) + (OPrtP, n * ExPNB, n) \dots \dots \dots . . (6)$$

3.6 Data collection

Data collection is a method by which researchers collect relevant information to solve research problems or test hypotheses or theories and ultimately evaluate the results. In fact, there are two main sources of data collection, including primary and secondary sources of information. The choice of each data collection method depends on the objectives of the research. In addition, we will use these two sources for our research purposes.

3.6.1 Primary data

Primary data will be collected with the help of focus group interviews from relevant government ministry, energy expert and NEPRA officials. However, the study draws policy analysis through content analysis of NEPRA Rules and Regulations policy document.

3.6.2 Secondary data

The study used the climatological database and the Metronome program to collect secondary data on variables such as radiation, temperature, precipitation, and sunshine. Metronome is the main sources of simulation data sets which is mostly applying in the solar photovoltaic industry-annalist and project researchers in the analysis of renewable energy projects. The metronome database consists of more than 8,000 global meteorological stations and 5 geostationary satellites, as well as internationally standardized aerosol climatology and data from 1991 to 2010 (department 2018). The database uses long-term data sets to estimate minute and hourly value, monthly average values, and annual sums of several climate parameters (which is radiation, temperature, precipitation, and solar time).

3.6.3 Data availability

The study uses the climatological database and the Metronome program to export radiation data in the PVsyst software for the purpose of analysis.

The database uses long-term data sets to estimate minute and hourly value, monthly average values, and annual sums of several climate parameters such as (radiation, temperature, precipitation, and sunshine). Metronome is one of the sources of simulation data sets used by the solar photovoltaic industry and project researchers in the analysis of solar projects. The metronome database consists of more than 8,000 global meteorological stations and 5 geostationary satellites, as well as internationally standardized aerosol climatology and data from 1991 to 2010(department 2018). Further discussed in chapter 4

3.6.4 Technique for analysis

To simulate energy production in industry, we will use energy production software PVsyst. (Pacudan., 2018), and (Klise., 2010) Where they comparing the performance of software packages for solar energy production used by industry stakeholders, they came to the conclusion that the components of the radiation model of the assessment tool consistently perform and predict similar arrays with the similar climate data. In terms of total electricity production, the performance of the best efficient modeling tools exceeds 9%. The most conservative modeling tool. The software packages evaluated are PVWatts (PVwatt 2017), Solar Advisor Model (model 2017), PV-Design Pro (model 2017), PV*SOL (design 2017) and PVsyst (Couture., et al. 2014).

(PVsyst 2022) We use the PVsyst software in the analysis to assess the cost competitiveness and technical performance of solar modules.

3.8 Method of Analysis

The first part of the analysis will present the methods for assessing the price competitiveness of a roof-top solar photovoltaic system in Pakistan, as well as the estimated rates needed to motivate households to participate in solar photovoltaic arrangement as part of the electricity net metering, and net billing policy. The second part of the analysis will present the methods and data used to estimate the cost of the energy i.e., levelized cost of energy (LCOE). In addition, the method will be used to assess the level of incentives required for participation, net metering, and net-billing scheme.

The qualitative part of the research will be analyzed with the help of inductive thematic analysis. Inductive codes include theoretical analysis, which helps to eliminate explanations that are in the opposite order of explanations (Strauss., 1990). Analyze qualitative data by classifying data into

topics and concepts and establishing associations between these concepts. For content analysis, the analysis will be drawn by integrating the data into the encoding. The specific focus will be on research issues, and the background and theoretical construction will be carefully incorporated. By plotting the similarities and differences between the data, the text can appear and be written in narrative form and tabular form.

The qualitative study is organized in the response of participant. The open-ended questionnaire was design to asked with concern energy expert in power sector, they have knowledge that how the existing net metering rule regulation and its performance in the country. As well as the net metering incentive provided to users as under consideration. The study we design in to three group-A with energy expert as policy regarding and the Group-B with net metering user regarding net metering incentives satisfaction and Group-C a random interview with discoes.

Semi-structured interviews are usually open-ended, which provides flexibility. By asking the questions asked in the given order, it is easy to compare respondents, but this may be limited. Less structuring can help you see patterns while at the same time allowing comparisons between respondents.

The participants of semi structure interview took interest during interviews and they were feel pleasurable to tell about the net metering, unpopularity of net metering, type of incentives to the end users, and discussed about the existing rule for net metering. And the other hand the net metering users who's has net metering experience in practicality of net metering, and consumer side satisfaction are discussed.

CHAPTER 4

ESTIMATIONS

Introduction

This chapter describe and present the economic performance and cost competitiveness of rooftop solar photovoltaic system in Pakistan. Section 4.1 presents the methodology and energy-yield in PV system estimation. Section. 4.2 explains how much the energy use by a typical household and how much energy export to the grid. Section. 4.3 explains the tariff on electricity and described its component. 4.4 section presents the cost of the projects in detail**s.**

4.1 Estimation of the Electricity production in rooftop PV system

To estimate energy production of rooftop solar PV systems following the methodology described in(Pacudan., 2016), and (Koussa., 2009), which takes into account the regional climate data and plant configuration. The study uses the climatological database and the Metronome program to export radiation data in the PVsyst software for the purpose of analysis.(PVsyst., 2022)

The database uses long-term data sets to estimate minute and hourly value, monthly average values, and annual sums of several climate parameters such as (radiation, temperature, precipitation, and sunshine). Metronome is one of the sources of simulation data sets used by the solar photovoltaic industry and project researchers in the analysis of solar projects. The metronome database consists of more than 8,000 global meteorological stations and 5 geostationary satellites, as well as internationally standardized aerosol climatology and data from 1991 to 2010 (RE Energy 2018).

A specific location N33.73^{o}, E73.18^{o} and 574 meter above from sea level in bhara kahu Islamabad was taken as the location for metrological data to be used in the analysis to find the metrological

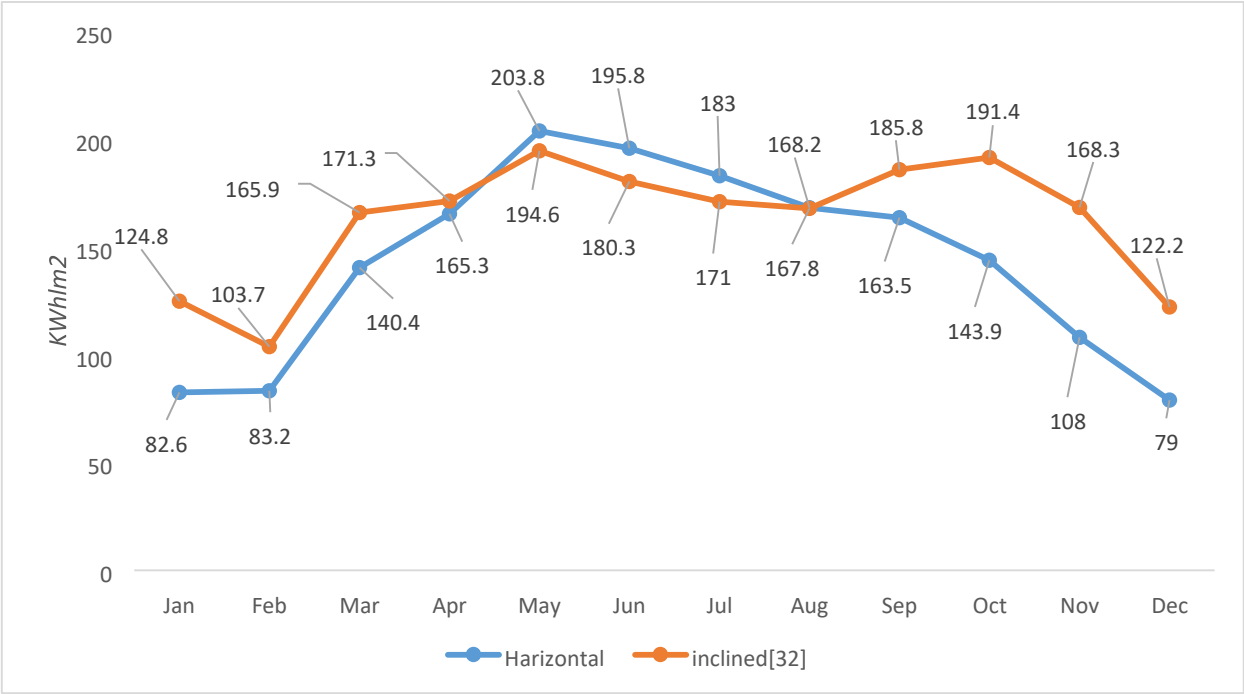
condition of irradiation in the selected location. The yearly sum of global horizontal irradiation (GHI) of the study location is 1717kwh/m^2.

Figure-1 shows the irradiation of GHI over the years. The seasonal pattern of irradiation is the highest during spring and lowest at the end of summer which are the longest solar days. During the monsoon with high cloudy days it directly affects the irradiation negatively. However, the GHI increases in the autumn explained by the dry seasonal day and later it declines in August until December. On the other hand, we observed the same inclined irradiation for the study. The annual sum of irradiation on inclined plan is greater than horizontal plane as well as the inclined plane has high GHI value before April and in between August to December.

To simulate energy production, we use the energy production software. (Yates 2010.) Where they compared the performance of software packages for solar energy production used by industry stakeholders, they came to the conclusion that the components of the radiation model of the assessment tool perform consistently and predict similar arrays with the similar climate data. In terms of total energy production, the performance of the models used in PVsyst software is 9% most efficient than other conventional modeling tools. The software packages evaluated are PVWatts (PVwatt 2017), Solar Advisor Model (model 2017), PV-Design Pro (model 2017), PV*SOL (design., 2017) and PVsyst (Rickerson W., 2014), (PVsyst., 2022)

The above mansion software is mostly used for solar energy project to assess the cost competiveness of the technology as well as to technical performance. Our used pv syst energy production software for economic analysis in the study.

Figure. 1: Annual Average of solar irradiation at a selected site location N33.73, E73.18



In estimating the solar PV energy production or energy yield, we used the Canadian (semi-monocrystalline) of solar PV module and string inverter (delta) available in the market. String inverter convert (DC) direct current received from solar penal to (AC) alternative current. For case study we take three size of PV modules of (3kwp, 6kwp and 10.5kwp) to simulate and observed the different export scenario in the analysis. Table-A show us the key input parameter were use in the analysis.

In the process of PV simulation, the plane angle of solar PV penal (module) is fixed to face south and inclined at 32^{o} which is the maximum sun light or irradiation collected by the solar penal in selected location of Bara kahu Islamabad. And the PV module produce Direct current DC from sun light and convert it into alternative current AC through a string inverter.

The PVsyst software simulate endogenously the model and estimate the technical losses based on specified parameters in the [case study in table 2 and table 3] as well as the study exogenously estimate the energy losses due to the model degradation and plant availability. We take 1% of annual degradation with 99% of plant availability with the reference of manufacturer, guarantees.

Table. 2: key input parameter uses in Pv syst software

Module Coordination			
Module tilt angle/ inclined angle	32°		
Azimuth-angle	0°		
PV-Module string inverter formation			
Size of install modules	3.0 KWp	6 KWp	10.5 KWp
1.Module-type	smi-mano crystalline	smi-mano crystalline	smi-mano crystalline
2.Number of modules (NOM)	12	26	42
3.Nominal capability of modules (NCM)	250 Wp	250 Wp	250 Wp
4.Number of modules per string (NMS)	12	13	14
5.Total strings in parallel (TSP)	1	2	3
6.Inverter capability (IC)	2.8 KWAC	5.8KWAC	4.75KWac
7. Connect inverters (CI)	1	1	2
8.Installed inverter capability (STC)	2.8 KWAC	5.8 KWAC	9.5KWAC

Based on climatic condition, physical and technical characteristic and under the above assumption the PVsyst-model estimated the following.

1. Annual energy production or energy yield per year of each solar penal

2. Specific energy production or yield factor, yield-factor refer to the total energy produce per kilo watt peak KWp in the installed solar system. There are Various factor effects the specific energy production or yield factor such as weather condition, location, model type (PV module), and model orientation. Model orientation refer to the angles of solar penal to the sun light (Tongi., 2017)
3. Performance ratio, [PR] show us the overall performance of installed system over the year where the perfect system produces energy per watt peak. Under standard test condition [STC] in PVsyst, standard test condition can specify the energy produce in watt peak under the assumption sited in the energy production System (Paghasian., 2011)

Table. 3: Technical performance of solar PV system

Peak Power	**KWp**	**3.0 KWp**	**6 KWp**	**10.5 KWp**
Irradiation on horizontal-plane	kWh/m^2	1717	1717	1717
Irradiation on inclined-plane	kWh/m^2	1776	1776	1776
Plant-availability	percent	99	99	99
First Year Performance				
Energy produced (after inverter)	KWh/year	4195	9437	14156
Overall yield factor/specific energy prod	kWh/kWp/year	1398	1402	1384
Energy production average per day	kWh/kWp/day	3.83	3.43	3.95
Overall-performance ratio				
Performance ratio per years	percent	71.1	71.1	71.1
Electricity production per year (average 25 years)	kWh/year	3896	9123	13563
Total production for 25 years	kWh	97400	228075	339075
Overall yield-factor	kWh/kWp/year	1398	1402	1384
Overall performance ratio	percent	69.6	69.5	69.1

The table 3 show us the technical performance of the Photovoltaic [PV] model of three sizes were taken in the analysis. The performance of solar photovoltaic system estimated by the PVsyst software. The solar photovoltaic model of first year production and the average of 25-year electricity production are estimated and its performance ratio with the installed capacity of 3KWp. 6KWp and 10.5KWp are shown in table-3. Furthermore, the same technical parameter specification, and metrological condition were used for solar system. The performance ratio of all three sizes are identical under using the same specification.

4.2 To Estimate the household Electricity consumption and export to grid

Within the existing net metering rules regulation in Pakistan the distribution companies DISCOS aims to promote the energy generation and its consumption from rooftop solar photovoltaic system and allow them to export the excess electricity to the grid from distribution generation (DG) facility. The grid net off the exported electricity units from DG facility and incorporate it in the next billing cycle or can get monetary benefit at the rate of off-peak tariff set by national electric power regulation authority NEPRA (2015)

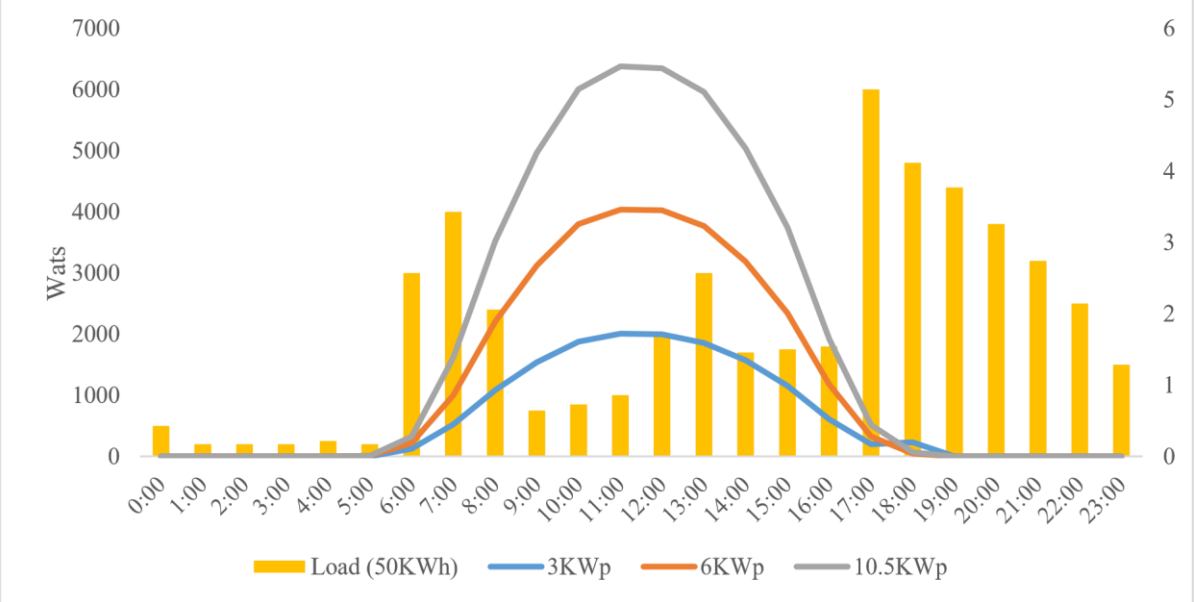
For estimating the amount of energy consumption and export to the grid from DG facility. We take a typical average income family with its daily electricity demand of 50kwh (1500 kWh) per month. The normal daily electricity profile presented in fig-2. This profile is built on the primary data by conducting a side survey. Which show in Table-B where monthly, daily averages, daily fluctuation and seasonal variation in electricity consumption of the household are noted. The study design questionnaire presented in (appendix A-01). The current study used the average load of the typical household electricity consumption of 50 kwh per day and 1500 kwh per month was take in to consideration in the analysis.

Table. 4: Household information and electricity consumption

typical household	Building area m^2	number of bedroom	number of person	Residents	Amount of electricity in kwh	
					daily	monthly
A	150	6	8	4 kids' school 3 adult work and 2 not working	50kwh	1500kwh

The household daily consumption of electricity with 50 kWh per day and (1500 kWh per month) in the daily profile, there are three times are peak demand of the household electricity consumption take into account during day time demand at around 6-oclock in the morning at noon and 5-oclock at evening. The highest peak demand happens in the evening time, the household energy demand in morning and the afternoon up 5 o'clock his consumption could be supported by the rooftop solar photovoltaic system.

Figure. 2: A typical household daily electricity consumption and Generation of solar PV system



In fig-2 show us the average daily production of PV solar module where as we take three different sizes in the study ($3KW_p$, $6KW_p$ and $10.5KW_p$) and estimated through PVsyst (energy production

software) and represent above in the figure. By using 19 years of worldwide irradiation data sits in the process of PVsyst module simulation for the period of 365 days. The system presents the hourly average energy production of each solar module in PV system for a typical year.

Within this time period the fig-2 shows the daily electricity production and consumption from solar PV system. The electricity production curve of solar photovoltaic system represents the average daily electricity production capacity of each PV module. The area under energy production curve and below from the household electricity demand or load profile represent the energy consume by the household from solar system. The reaming area where the energy production curve above from the household electricity demand and under the production curve than the excess energy can be export to the national grid.

By installing 3kw solar system with average daily production of 12.67kwh per day, from which around 83% of electricity would be used for self-consumption. If the household installed 6kw system with average daily production of 24.1kwh per day and 10.5kw with average daily production of 39.81 kwh from which 58% and 32% electricity will be used for self-consumption respectively.

4.3 Estimate the electricity generation and tariff rates

Under the Distribution generation facility and net metering schemes the opportunity cost of electricity is equal to the retail tariff rate which domestic household paying to the retail company DISCOs. The Islamabad electricity supply company (IESCO) tariff rate in Pakistan which take in to account. The average electricity tariff rate for domestic household with 1500KWh per month electricity consumption in 2022 is RS: 24.33 (US$ 0.12165) per KWh (IESCO 2022).

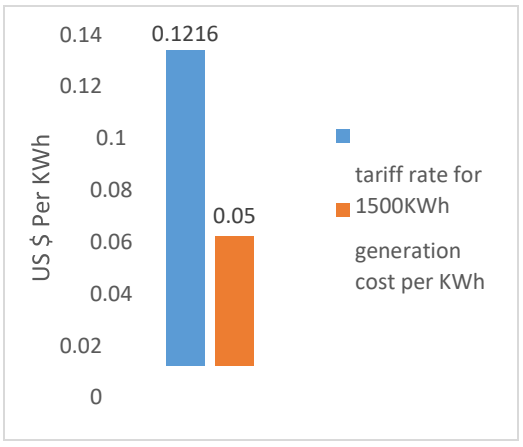
The tariff rate of IESCO for residential electricity consumption

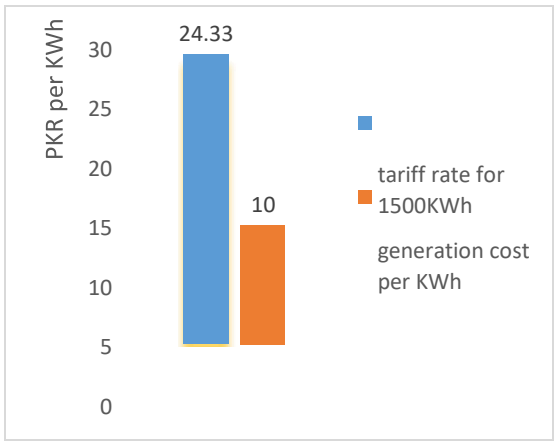
IESCO general supply tariff for residential household			Consumption
unit KW	tariff per KWh		
1 t0 100	9.42		
101 to 200	11.74		
201 to 600	13.83		
601 to 700	21.23		
above 700	24.33		
for sanction load 5kW and above		peak tariff 24.33	off-peak tariff 18.01

source: IESCO tariff guidance

Under the implemented rules and regulation, the electricity export, as a stipulated form, for export electricity the compensation rate is fixed by the distribution companies. In 2022 the average generation charges RS: 10PKR, (US$0.050) per KWh which is represent around 41.1% of the total electricity retail tariff. The following are the average tariff of electricity and the cost electricity production of per KWh. The tariff rate for 1500 KWh. expressed US$ and PKR in fig-3

Figure.3: The average tariff rate of typical household electricity consumption 1500kwh per month





4.4 To Estimate the cost of project

Globally the install cost of rooftop solar photovoltaic system and solar technology rapidly decline over the previous years. Mostly the install price for large scale PV system are below US$1(IEA 2016). Over the years, the cost of solar PV innovation has a pattern of decline is seen globally, which is due to Mechanical, and technological advancement of the solar system and reduced costs of raw-material. Therefore, the install capital cost ICC of solar PV system fluctuates from US$ 0.5 to US$ 0.9/Wp. (Khatri 2022)

In the case of Pakistan, Pakistan import the PV Solar penal and equipment's from other countries. That the install capital cost is PKR 150, (US$0.75) per watt peak W_P (Khatri 2022). For confirmation the install cost we design a case study on basis of interview which was conducted with solar installers and solar system users. To capture the market value of installation cost of rooftop solar PV system, per watt peak (Wp) is around PKR 150, (US$ 0.75) after averaging the collected information and conclude that the average installs capital cost of per watt peak Wp PKR 150. The capital cost of solar system contains net metering licenses cost, installer cost, solar equipment cost, designing and engineering cost, grid connection cost, and transport cost. The case study questionnaire presented in the (appendix A-02)

4.5 To Estimate the levelized cost of energy [LCOE]

The (LCOE) is the efficient method to measure the net average cost of electricity generation which produced from solar system and evaluate to compare the cost of different generation technology. The LOCE is refers to calculate the electricity cost of generation for generator over the period of time where the fixed value of income delivers by the system over the life time of the install system to reached the project to its breakeven point or the system payback period (SWD., 2015), (Campoccia A., 2009.), and (M., 2018). The LOCE are roughly designed as the discounted of the

total generation cost of electricity divide by the discounted of total amount of energy produce by the solar system over the life of the asset Equation:

$$LCOE = \frac{\sum_{n=0}^{PL} \frac{TC_n}{(1+dr)^n}}{\sum_{n=1}^{PL} \frac{TQ_n}{(1+dr)^n}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where: TCn, represents the total cost, in n years; TQn represents energy generation, in n years; n represents the year; PL, represents the project life; dr represents the discount rate.

Weighted average cost of capital (WACC):

$$\text{WACC} = \frac{Es}{Es+Ds} * Ec + \frac{Ds}{Es+Ds} * Dc * (1-T)$$

Es is equity share, Ec is the cost of equity, Ds is debt share and Dc debt cost and T is the income tax rate. The selected project assumes own funded; the household bear the total financing of the project. So the debt part will be equal to zero.

The study used only capital cost and O&M cost. The weighted average cost of capital (WACC) before the tax were used as a discount rate in the study. Operation and maintenance O&M cost are considered one percent of the total install cost. Decommissioning and additional cost was not under consideration in the estimation. And taking 25 years of project period are taken in the case of Pakistan. For easiness we take the own funded system and the debt were not considering in the analysis. The current inflation rate of May, 2022 used and weighted average cost of capital used is discount rate which can efficiently calculate the risk free factor. Because the investor is mostly interested to recovered at least his capital. Additional key parameter of the study below in Table5

Table.5: Cost and financial parameters

cost parameter	**economic parameter**
install cost: 150PKR, (US$0.75)Per Wp	Own funded 100%
Operational cost (O&M): 1% of capital cost	tax rate 30%
	inflation rate 12.50% MAY, 2022
Others	Return on equity =8.75%
PV-project workable life time 25year	

"Note: that the install cost and other parameter were taken base on ((Khatri 2022)), as well as conducted a market survey in the select area, with PV installer, stockholder and installed pv system users. The average install price per Wp 150PKR (US$0.75)"

From above mentioned methodology and using the given information to estimate LCOE for selected three size of PV Solar system through energy production software PVsyst. The installed cost of 150 PKR (US$0.75) were taking in the estimation of three different solar modules of 3KW, 6KW and 10.5 KW with install cost of 150 PKR (US$0.75) per watt peak (WP) to estimate LCOE of each module. Based on technical parameter and the given costs, the LCOE result are the following: with install cost 150PKR (US$0.75) three size of PV modules (3kw, 6kw and 10kw) the cost of per kWh estimated is 12.31 PKR (US$0.050), 12.41 (US$0.050), and 12.60(US$0.050), are the same LOCE with same install price, financial parameters and technical parameters. The technical performance of three different module presented in (table- 2).

Does the above calculated number matter in the protective of household? Of course yes it does matter depend on the monthly consumption of electricity of household. By looking the number there's clear economic benefits for household to use the energy generated from solar pv system. If the household fulfill the net metering criteria as mention for all customer to install solar system.

The given policy of net metering in Pakistan converging the solar user on small level to use the energy for self-consumption rather than to sell the solar energy. In both cases the household have economic benefits as we discussed in detail below.

The estimated number of solar pv system may be different from region to region due to weather conditions, irradiations and PV modules, dust areas. Generally, the estimated number or the cost of per KWH are acceptable and related to the literature generated numbers. According to Economic point of view the solar generated energy has couple of benefits regard environmental pollution. Decrease the secretion of CO2. And can decrease the energy shortages, can contribute to decrease the load on national grid. Also can make the country self-made energy country to save the country from circular debt. As many researchers mentioned that the geographical have enough capacity to generate electricity from solar.

The following chapter of the study focused to analyze the incentive provide in net metering policy to their users. With deep technical analysis

To determine the attractiveness of solar photovoltaic system as well as cost competitiveness in Pakistan. The LCOE of solar PV system generation electricity unite compare with the electricity retail tariff rate which the consumer paying to the distribution company as DISCO's. The cost of energy production is much better than the cost of energy consumption is deemed appropriated. The small scale project connects with low voltage level to the distribution network, which oppose the large scale project which are mostly connected with medium or high voltage level to the grid network

CHAPER 5

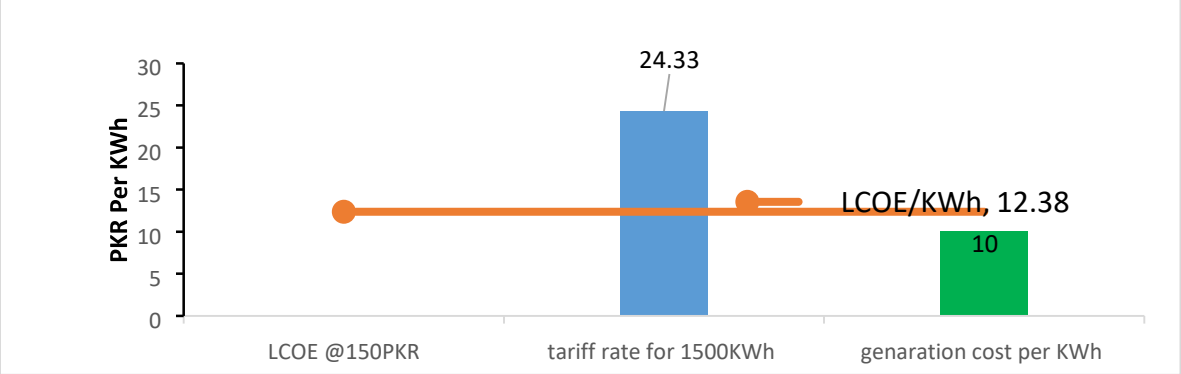
RESULTS AND DISCUSION

5.1 Grid parity and fuel parity

To determine the attractiveness of solar photovoltaic system as well as cost competitiveness in Pakistan. The LCOE of solar PV system generation electricity unite compare with the electricity retail tariff rate which the consumer paying to the distribution company as DISCO's. The cost of energy production is much better than the cost of energy consumption is deemed appropriated. The small scale project connects with low voltage level to the distribution network, which oppose the large scale project which are mostly connected with medium or high voltage level to the grid network.

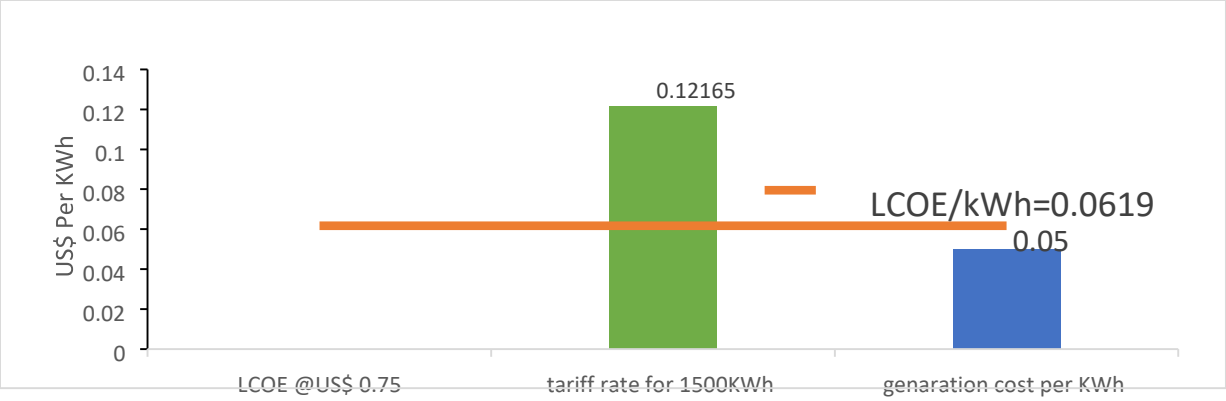
When the LCOE of the installed technology (PV system) is equal to retail average prices which the consumer paying to the (DISCO) that mean the technology (PV system) said to be the system reach to 'grid parity'. And if the LCOE is equal to the average cost of grid energy generation mean that the solar system achieved fuel parity (IEA 2016).

Figure. 4: *T*he average tariff rate for 1500 KWh and Generation Cost Vs LCOE



Expressed in pakistani rupies PKR.

Fig. 4: The average tariff rate for 1500 KWh and Generation Cost Vs LCOE



Expressed in US$ dollar: US$1=200 PKR

The LCOE of solar photovoltaic PV system are above the average energy production cost of grid generation. Hence the opportunity cost of self-consumption of electricity from solar photovoltaic system is equal to the retail tariff or unit price. The IESCO's regular monthly tariff rate for 1500KWh consumption are shown in fig-4(IESCO 2022).

In figure-4 we compared the cost of per kilo watt hours of solar pv system, the verge retail tariff rate of per kwh and the cost of grid power generation per kwh. Which indicate that the small scale solar PV System has almost cross the fuel parity (when the electricity cost of solar system equal to grid generation prices) and still below from grid parity (when the electricity cost of solar system equal to the retail tariff rate) in Pakistan. Mean that the average generation cost of grid power in Pakistan is 10PKR, (US$0.05) per KWh, the cost of hydro power generation was not take into account in analysis. And the other hand the average tariff rate for 1500kwh of monthly consumption for a typical household in Pakistan is 24.33pkr (US$0.12165). The install cost of solar PV system per Wp (watt peak) in Pakistan is 150PKR (US$0.75). So the LCOE with install cost of 150PKR (US$0.75) per Watt peak [Wp] is 12.33pkr (0.0619) per KWh, which is below from the average tariff rate of 1500kwh per month consumption based on IESCO tariff rate. The peak hour's tariff rate is 24.33 (US$0.12165) and off peak tariff 18.11(US$0.09055) till Jun 2022.

The result specifies that base on present retail tariff and the solar PV system install prices, the household have efficient incentive to invest on the rooftop solar photovoltaic system in Pakistan. And get energy benefit according to the household electricity monthly load. The net metering rules and regulation allow the household to install the solar system more than 1.5 time of the original load or his monthly electricity demand.

5.2 Household incentive under alternative policy

The distribution generation facility under net metering arrangement in Pakistan are well designed mechanism where the household have incentive to get benefits. The current study estimates the net metering incentive separately to compare the performance of each incentive which provided to the customer in the net metering scheme by NEPRA.

5.2.1 Household incentive under Net-metering scheme

As we discussed earlier under the net metering arrangement the household get energy compensation, meant that the household generate electricity from solar PV system, first consume it by self and the excess electricity export to the respective grid. The grid gives back the energy to the household during off time of PV system as per the required. The household incentive under net metering scheme the opportunity cost of electricity for self-consumption (ScP) is equal to the average utility retail price (rtP) in (equation 2). ($ExPNM$) the opportunity cost of energy export to the grid under net metering is equal to the retail price (Equation 3). The total revenue of the project at any given year present in (equation 4)

$$ScP = rtP \dots \dots \dots \dots . (2)$$

$$ExPNM = rtP \dots \dots \dots \dots . (3)$$

$$Rn = (rtP, n * TQ, n) \dots \dots \dots . . (4)$$

Where: ScP = self-consumption price, rtP = electricity retail price, $ExPNM$ = export tariff, TQ =the amount of export and self-consumption electricity, n =period of time or given year, Rn = the total income receiving each year in the net-metering arrangement,

The assumption for both schemes under net metering and net billing equation 2 is valid, which show that the opportunity cost of electricity for self-consumption is equal to the utility retail tariff or price. Equation 3 show the export energy under net metering is equal to the electricity of retail price while equation 4 show us the total income (revenue) of the project at any given year in the net metering scheme.

Under net metering arrangement the economic performance of solar photovoltaic system based on the above assumption is shown in (table-6, fig 5). the result show that the existing solar PV system install cost and the retail tariff rate of electricity for the selected three sizes of solar PV system give positive economic benefits to the household with daily electricity consumption. The household daily profile discussed see (fig 2). The internal rate of retune (IRR) of the three install PV system is greater than the weighted average cost of capital (WACC). Net metering scheme allow the customer to oversize the system up to a certain level

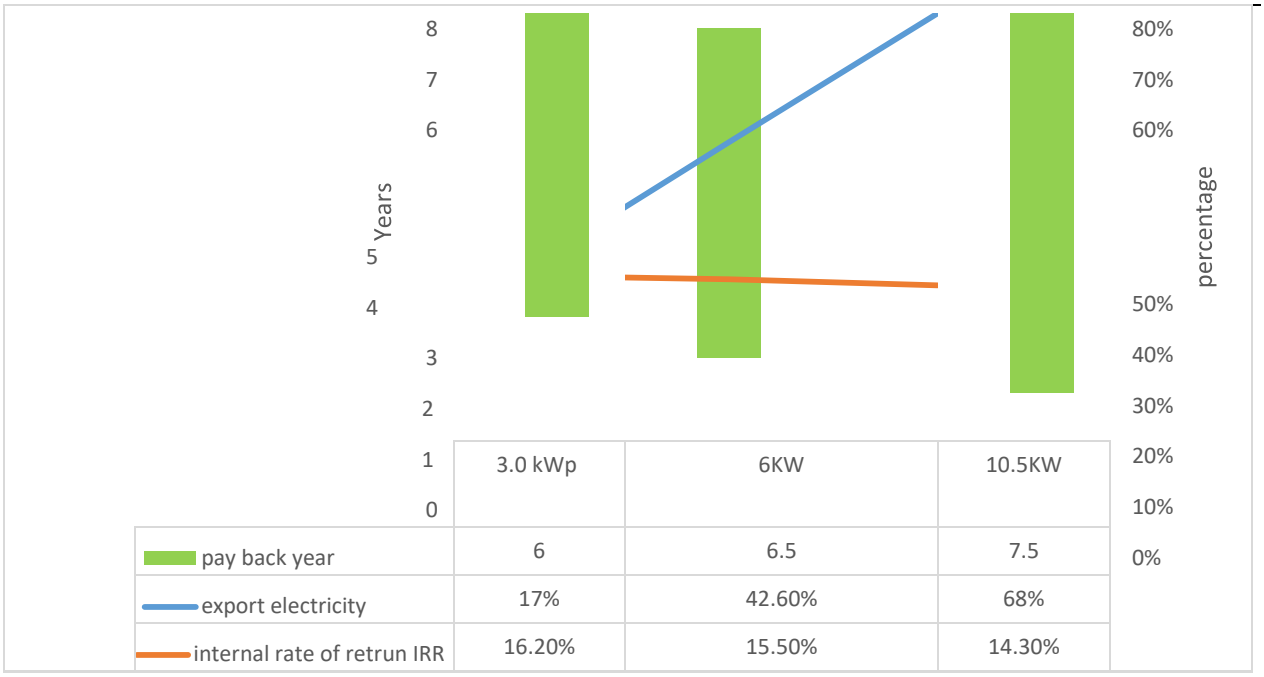
The result also indicates that the economic performance under net metering scheme the internal rate of return IRR is decrease its due to the install cost of capital and slightly higher than the net billing arrangement its due the export tariff under net metering is equal to the retail tariff rate. The payback period very from system sizes and install cost.

Table.6: Economic performance of Net- metering scheme

Module	export electricity	internal rate of return IRR	Pay-back year
3.0 KWp	17%	16.20%	6
6KWp	42.60%	15.50%	6.5
10.5KWp	68%	14.30%	7.5

Note that weighted average cost of capital 8.75%

Figure.5: Economic performance of Net-metering scheme



Note: the weighted average capital cost: WACC=8.7%

5.2.2 Household incentive under Net billing scheme

Under net billing scheme household get monetary compensation, meant that the household generate electricity from solar PV system, first consume it by self and the excess electricity export to the respective grid. The distribution company give money at rate of off-peak retail unit price determine by NEPRA. The off-peak tariff rate of electricity determines by NEPRA which is applicable for all distribution generation facility to sale the electricity to DISCOs (NEPRA., 2015) The household have same incentive under net billing scheme showed in (equation 2). The opportunity cost of electricity for self-consumption (ScP) is equal to the utility distribution or retail price (rtP) of DISCO. The ($ExPNB$) Opportunity cost of export electricity under net billing

scheme to grid is equal to off-peak retail tariff ($OPrtP$) as fixed by NEPRA in Pakistan. (Equation 5). The project revenue at any given year present in (Equation 6) whereas ($QScNB$), ($ExPNB$) indicate the energy for self-consumption, as well as the amount of electricity export to the grid under net billing scheme.

$$ScP = rtP \dots \dots \dots \dots . (2)$$

$$ExPNB = OPrtP \dots \dots \dots \dots . (5)$$

$$Rn = (rtP, n * QScNB, n) + (OPrtP, n * ExPNB, n) \dots \dots \dots . . (6)$$

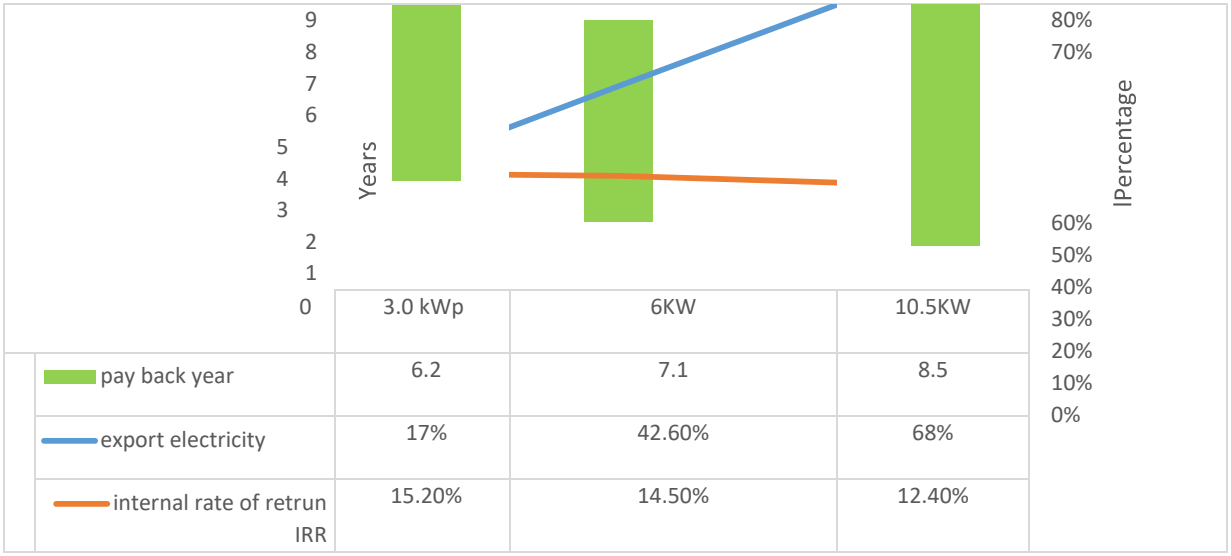
The economic performance under Net billing arrangement the result estimated of each PV system with same install price as shown in (table-7, fig-6). the result shows that the economic performance under Net billing scheme is positive and the IRR are slightly lower than net metering scheme its due to the export tariff rate is off peak tariff rate sited by NEPRA which is lower than the premium retail tariff rate as the household paying to DISCO's. But the generation cost of electricity produce from solar PV system is lower than off peak retail tariff rate. The monetary compensation under net billing scheme can attract the household to invest on rooftop solar PV system. The payback period is almost identical of each system. The IRR under net billing are still attractive as compare with net metering scheme. However, the household can achieve high economic-benefit when the system covers day-time electricity demand.

Table. 7: Economic performance of net billing scheme

	export electricity	internal rate of return IRR	Pay-back year
3.0 kWp	17%	15.20%	6.2
6KWp	42.60%	14.50%	7.1
10.5KWp	68%	12.40%	8.5

Note that the weighted average cost of capital =8.75%

***Figure. 6**:* Economic performance of net billing scheme



Note: the weighted average cost of capital: WACC=8.7%

5.2.3 Sensitivity Analysis

The technical and financial parameter were taken into account in the sensitivity analysis to detect the key risk in both schemes. From the household side the following factor-significantly influence the feasibility of PV system. Such as install capital cost (ICC), Operational cost and maintenance Cost (O&M), energy production or yield factor (YF), model yearly degradation (MYD), Electricity retail tariff (ERT) and export electricity tariff (EXT).

The study uses three indicators in the sensitivity analysis to compare the economic performance of the PV system under net metering and net billing scheme. The Internal rate of retune (IRR), the levelized cost of electricity (LCOE) and the pay-back period of each module to assess the key risk of profitability of the project, also identify the effect on the LCOE and the pay-back period by changing the above parameters.

The sensitivity analysis results are shown in table-8. The over-all result indicates that by changing the (ICC increase 10%), (O&M increase by 10%), (YF increase by 5%), (increase MYD),

(decrease annually electricity tariff), (decrease export tariff for net metering), (increase export tariff for net billing). The IRR of both schemes are not significantly deviate from base line except under net billing scheme by changing the export tariff rate from off-peak to peak tariff rate the IRR reach to net metering base line.

The LCOE affected by increasing (ICC and O&M) it increase the price of per KWh, and by increasing the annual generation production or (YF) It positively affect the LCOE. The other parameters are not significantly affect the LCOE.

The pay-back period of each project fluctuate between 6 to 10 years.

Under Net metering scheme as we discussed previously, that the IRR with install capital cost of 150 PKR (US$ 0.75) per watt peak are slightly higher than net billing scheme. Almost both policy framework has the same household incentive to get benefits. As Net metering dealing in energy compensation while Net billing dealing in monetary compensation under incentivized selfconsumption scheme. The net billing has monetary attraction as people can attract to invest in rooftop solar PV system. According to distribution generation facility in Pakistan under net metering arrangement where the customer have choice to avail the both type of incentive. The net metering rules regulation are designed by the government where the household have more benefit in energy compensation rather than the monetary compensation. If the household are trying to get monetary benefits than they have to fulfil the criteria which mention in net metering rules regulation document.

Table.8: Sensitivity analysis

	Internal rate of return IRR (%)			Levelized cost of energy (LCOE) PKR			pay-back years		
	3kW	6KW	10kW	3kW	6kW	10kW	3kW	6kW	10kW
Net Metering Scheme									
i. IRR with install cost150pkr(US$0.75)	16.2	15.5	14.3	12.3	12.4	12.3	6	6.5	7.5
ii.Increase install capital cost (ICC)by 10%	15.2	14.2	13.3	14.11	14.8	14.8	7	8	9.6
iii. Increase the O,M cost by10%	16.2	15.5	13.3	14.11	14.8	14.8	7	8	9.6
iv. Generation output by 5% yield-factor(YF)	15.5	14.4	14.3	10.1	10.1	10.1	5.5	6	6.7
v. increase (from 0.5% to 2%)yearly degradation (MYD)	15.9	14.9	13.6	12.1	12.1	12.1	5.5	6	7
vii. Decrease Electricity tariff (from 3% to 1%)	15.8	14.8	14.3	12.2	12.3	12.3	6.2	6.8	7.5
vii. decrease export tariff to off-peak tariff)	16.2	15.5	14.3	12.3	12.3	12.3	6.2	6.8	7.5
Net Billing Scheme									
i. IRR with install cost 150pkr(US$0.75)	15.2	14.5	12.4	12.3	12.4	12.3	6.2	7.1	8.5
ii. Increase install Cost by 10%	14.2	13.2	11.1	14.11	14.8	14.8	7	8.5	10
iii. Increase the O,M by10%	15.6	14.5	11.1	14.11	14.8	14.8	7	8.5	10
iv. Generation output by5% (yield factor)	14.2	13.4	10	10.1	10.1	10.5	5.7	6.5	7.9
v. increase (from 0.5% to2%) yearly degradation	15.2	13.9	11.2	12.1	12.1	12.1	5.7	6.5	7.3
vi. decrease Electricity tariff (from 3% to 1%)	14.6	13.8	11.9	12.2	12.3	12.3	6.5	7.3	8.5
vii. Increase export tariff equal to retail tariff (peak)	15.7	15.5	14.3	12.3	12.3	12.3	6	6.5	7.5
NOTE: weighted average capital cost WACC= 8.7%									

This chapter present the analysis of NEPRA rule regulation of net metering, as well as discuss qualitative part of the study based on the existing studies and document, and as well as taking focused groups interviews.

6.1 Net metering scheme and regulation in Pakistan

National Electricity Regulatory Authority (NEPRA), (Alternative and Renewable Energy) announced distribution Generation and Net Metering Regulations on September 1, 2015.

According to these regulations, the DG system owner generate electricity from solar and wind (1KWp up to 1MWp) to meet their own need and get paid for excess electricity exported to the national grid, after getting licensed from the concern utility. Based on these regulation there's no monetary benefit are given to the DG system owners for annul exported energy to the grid (NEPRA., 2015). Later the NEPRA changed the name of DG system to DG facility and allow the small scale customers to install up to 25KWp DG facility without license directly from all DISCO. Islamabad electricity supply company IESCO one of the ten disco which provides the electricity to customers of Islamabad. For economic analysis we used the IESCO electricity tariff rate for proposed net metering scheme.

In Pakistan, net metering is the first policy mechanism of the Renewable Energy Act 2006. Fully implemented. Section 8.4.2 EEG 2006 Provide technically sound and non-discriminatory information by distributing end users, DISCO enters into net metering agreements with eligible end users who will install renewable energy systems (2015).

6.2 Distribution generation (DG) under net metering in Pakistan

Distribution generation (DG) refer that electricity produce from solar and wind under Net metering is consumer choice policy where the customer allows to generate own electricity through (solar and wind) from 1KW to 1MW. And first the energy uses for self-consumption and the excess energy export to the notional grid to get energy compensation. In order to maximize the use of

alternative renewable energy (ARE) technology, NEPRA announced (alternative and renewable energy Regulations on Distributed Power Generation) and Net Metering on September 1, 2015. These regulations provide a framework for net metering installations that use solar and wind energy to generate electricity with a capacity of (1KW to 1MW) megawatts.

6.3 General rule for net metering:

1. Under the net metering scheme, the DG install single meter or two separate meters. Bothe the single meters and two separate metering measure the net energy. In the case of single meter shall be capable to measure the flow of electricity in to bidirectional.
2. The Distribution generation DG system that connected to the DISCO's have fulfill all the safety requirement and assure safe and reliable operation of the DG system. Which have been approved by the authority.
3. The Net Energy Metering Facility, at the Distributed Generator's expense, shall meet all security and safety necessities that are essential to guarantee protected and dependable operation of the DG facility when connected to the DISCO's Distribution generation facilities and that have been accepted through the Authority**.**
4. The household can install the small scale solar system under net metering according the household load profile. The size of the solar system up 1.5 time more of the load profile
5. DG facility available for those who's connected to three phase distribution line

6.4 Billing rules for net metering

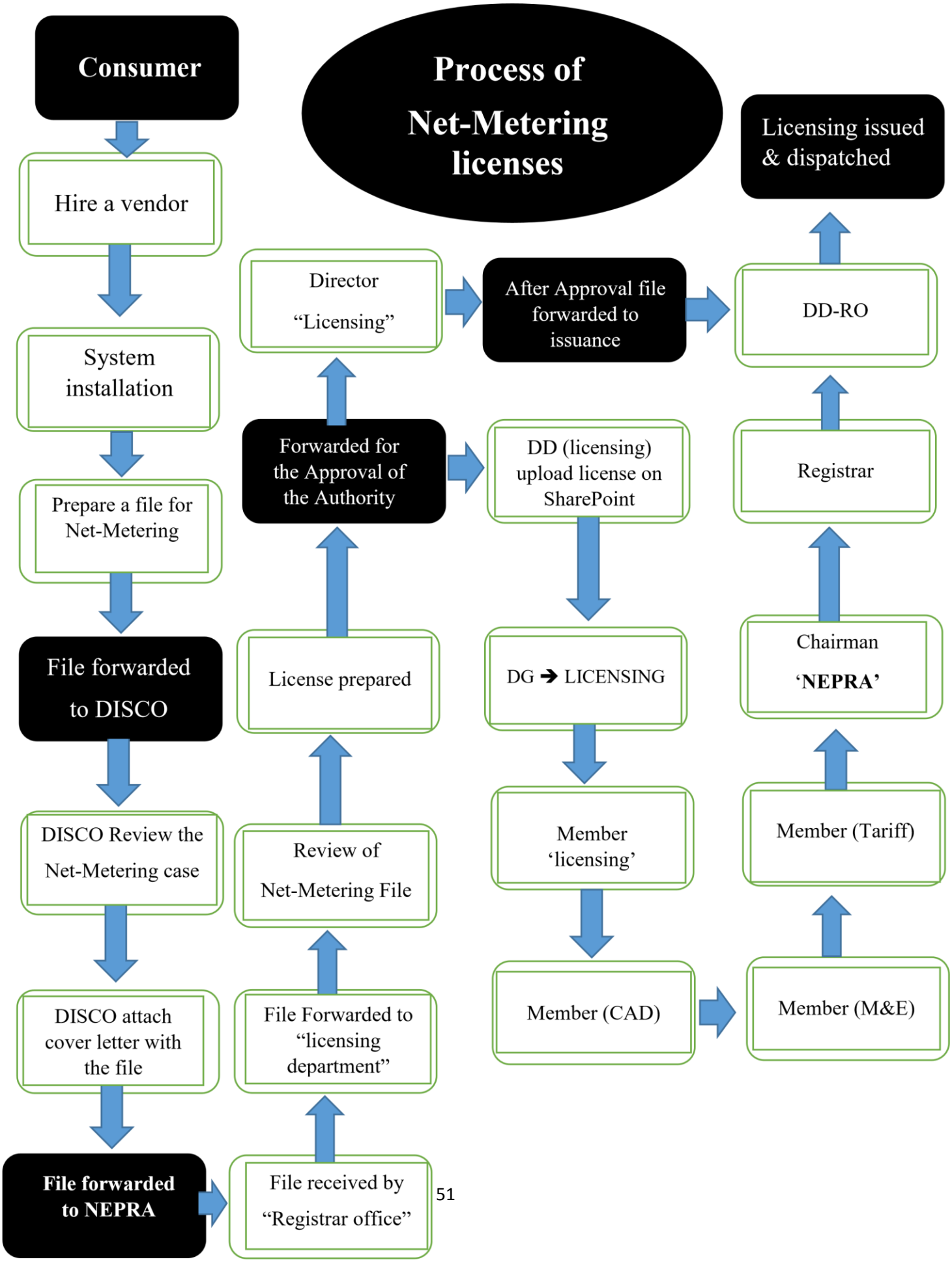
During the end of each billing cycle after the connection date of DG facility to the DISCO's. DISCO's shall net-off the kWh exported by DG system against the kWh supplied by DISCO's. If the kWh supplied by DISCO's exceed DG system shall be billed at the retail tariff rate. If the kwh exported by DG system exceed the DISCO's than the net kwh shall be credited to DG system in next billing cycle for future consumption or shall be paid to DG system at off-peak tariff rate accordance to the applicable tariff of DISCO when the DG facility receiving net export bill consistently three months.

Net metering licensing procedures

The national electric power regulation authority allows the all discos to engaged the small scale net metering users directly from the respective discos there is no need for license up 25 kilo watt. Above 25KW solar user must need to take license from the NEPRA.

The household who's connected to three phase distribution line they're eligible to apply for license if they install more than 25 kilo watt otherwise less than that, they can directly concern to respective disco.

All the financial burden will be covered by the installer and also promised for upcoming maintenances of the system. The legal procedure of license re shown in following diagram.


Process of Net-Metering licenses
Consumer
Hire a vendor
System installation
Prepare a file for Net-Metering
File forwarded to DISCO
DISCO Review the Net-Metering case
DISCO attach cover letter with the file
File forwarded to NEPRA
File received by "Registrar office"
File Forwarded to "licensing department"
Review of Net-Metering File
License prepared
Forwarded for the Approval of the Authority
Director "Licensing"
After Approval file forwarded to issuance
DD (licensing) upload license on SharePoint
DG ➔ LICENSING
Member 'licensing'
Member (CAD)
Member (M&E)
Member (Tariff)
Chairman 'NEPRA'
Registrar
DD-RO
Licensing issued & dispatched

6.5 Qualitative analysis

The qualitative analysis gives us a clear picture with key information about the estimated result which discussed in the above section. The qualitative study is organized in the response of participant. The open-ended questionnaire was design to asked with concern energy expert in power sector, they have knowledge that how the existing net metering rule regulation and its performance in the country. As well as the net metering incentive provided to users as under consideration. The study we design in to three group-A with energy expert as policy regarding and the Group-B with net metering user regarding net metering incentives satisfaction and Group-C a random interview with discoes.

6.5.1Semi-structure interview

Semi-structured interviews are usually open-ended, which provides flexibility. By asking the questions asked in the given order, it is easy to compare respondents, but this may be limited. Less structuring can help you see patterns while at the same time allowing comparisons between respondents.

The participants of semi structure interview took interest during interviews and they were feel pleasurable to tell about the net metering, unpopularity of net metering, type of incentives to the end users, and discussed about the existing rule for net metering. And the other hand the net metering users who's has net metering experience in practicality of net metering, and consumer side satisfaction are discussed.

Each group of the study divided in sub parts and each sub part have different question asking from participants.

6.5.2 Group-A response of Energy expert

The current Net metering framework give incentive to the customer through energy compensation that the customer consumes exported electricity during offsite hours or when solar PV system are not working or shall be paid at off-peak tariff rate. But still the framework unpopular except few DISCO's. What type of incentive need for net metering scheme to attract the customer to invest on solar system? Your own opinion of net metering. What is your views on net billing scheme? As there any need for awareness program. How if the government subsidize net metering scheme through low interest rate loan.

"*The aim of net metering rules was initiated by NEPRA to reduce the customer has electricity bills which they pay to the discos. And allow them to produce own electricity for self-consumption. And export the access electricity to the grid through net metering mechanism. Under the net metering rules, the customer can install who's connected with three phase line and each customer allow to install 1.5 times more of has electricity load mean that if the house hold load 3kw they can install 4.5kw. Rules no 2 the net metering billing procedure where they allow the customer to get paid for excess electricity. If the household electricity demand is fulfilling by the solar system. But the criteria for paid electricity by discos to customer, as follow if the customer export electricity continually three months then the discos will have paid at off-peak tariff rate to the DG facility it the end of the year if the customer at least one month lesser then the deal will start from start again and the previous export electricity the customer will get back in the form of electricity."*

"Though by relaxing the rules can improve net metering mechanism from three phase to single phase where the customer allows to install the solar system under net metering mostly in rural area they are connected with single phase. Relax 1.5 times of load section condition to a certain

limit. The payment procedure should need to be smooth for customer whose export electricity to grid each month.

Unpopularity of net metering as fact that the NEPRA allow all discus to manage directly the small scale net metering customer up to 25kw so the main role for popularity of small scale net metering depend on discos where they have authority to encourage the customers but inside discouraging of discos and the unawareness of net metering to public re the reason of unpopularity of net metering scheme in Pakistan. So the discos should need to simplified the net metering procedure"

"*The net billing scheme as the type of incentive which is already introduced in net metering scheme. It can be further reform by making separate arrangement for accounting of net metering and net billing of export energy from distribution generation facility. If the existing net metering billing procedure should make smooth, then ultimate objective of net metering can be achieving. And the other hand net metering rules formulate where the customer have more benefit to use the energy rather than paid. So by relaxing net billing procedure will cough the customer due to its monetary attraction"*

"*Our opinion on net metering is very positive initiative and has contributed significantly from its inception. It can produce better result if the DISCO's work proactively in the matter.*

Net metering should be more beneficial in rural area where the users required electricity and face with load shading there is a need for different rule for rural and urban. For big cities there should be a maximum limit to which net metering should be allowed"

"Yes there is need for awareness program. People don't know the benefits of net metering they need to educate. People have benefit by using the energy for self-consumption rather than export to the grid. They can reduce has bills which they pay to the discos. According to study finding the customer have benefits.

There is need for subsidize the scheme through low interest rate loan. Especially middle class people whose need small scale system which face with financial constrain during installing the system."

6.5.3 Group-B with net metering users

According to the net metering rules what is your experience by installing solar system under net metering scheme. Are your satisfied from your solar system? It can fulfill your day time electricity demand. Did your sale electricity to grid? What is the cost of per kWh, how much decrease your monthly bill which you pay to the discos? Did you receive net energy export bill from discos? What is your own opinion on net metering scheme?

"*Yes, solar system is one of the most reliable sources and the net metering scheme allow us to produce has own electricity for self-consumption. The present solar system fulfills the day time demand when the weather condition is optimal or during sunny days the system can produce extra electricity which export to the grid and consume it back during off-sit hours or when the system unable to produce electricity. The monthly bill deceases up to 70%, 80% be in peak season it almost above 90%. The household have energy compensation and they also offer paid for export electricity when the distribution generation produce extra power consistently three-month billing cycle completion the discos then pay to the distribution generation facility or solar generator. But for most the system cannot fulfill this criterion due the rules the DG system user almost able to*

reduce has monthly bills. It because the discos allow you to install the system as your monthly consumption load. So the customer is restricted. Mostly net metering users focusing to reduce the monthly bills and fulfill energy requirement."

"yes overall the solar system install cost are high which mostly people unable to install the system and those whose financial better they can install and the yearly maintenance cost are almost lower in small scale system if the government support customer financially through low interest rate loan, then the customer whose connect with three phase line they can avail the system and can get benefit. The per kWh cost in solar system are very cheaper than the retail tariff rate if the system working in optimal condition with reliable equipment's than 6 to 7 rupees cost per kwh. But if the other factors effect then may be the cost will increase up to 10 or 12 rupees. Systematically cost are around 12 rupees per kWh in the practicality it should be change according to the system size cost weather condition etc."

"*If the objective solar users are to decrease monthly bills rather than sale the electricity than household have sufficient incentive to install small scale system according to the respective load. And get energy compensation through net metering scheme. And the other hand the monetary compensation will insufficient incentive in the existing net metering rules regulation. If the authority makes smooth the billing procedure, it will have attracted more participant over the country. The restriction for single phase and the load section also effects the popularity of net metering. In the rural area where mostly need for electricity where they are unable to install the system during three phases connect they mostly connect with single phase*"

Group 6.5.4 with discoes.

As we know that the net metering scheme is one of the prominent scheme for cheapest electricity generation over the world. Many countries are trying to generate electricity with clean environment. As we can see Pakistan is also experience in the solar projects and NEPRA allow all discos to manage directly from discos whose want to install small scale solar system up 25KWp. The customer under this range will no required for any approval, the respective discos will manage it directly. What are the main reason of unpopularity of net metering in Pakistan? What is your opinion on the given outcome of the study is the study helpful for customer prospective? Do NEPRA need to relax the net metering rules for net billing? What if the customer allows to install solar scheme whose connect with tow phase distribution line rather than three phase?

"*according the given finding of the study is well analyzed the incentives of the net metering policy, a very deep and comprehensive study give a clear picture to customer that where to go. If they interested to minimized their electricity bill rather than sell the electricity to discos so the study well matches with the government policy of net metering. On the other hand, if they go for selling the extra energy to the discos, then given policy may not allow the customer to fulfil the criteria. Because the authority allows the customer to install the solar system based on their monthly electricity expenditure. They customer can install 1.5 time greater than their monthly consumption"*

"the main reason of unpopularity of net metering is no public awareness, high cost installation, quality of raw martials. There is need to subsidize the solar system on small scale rather than to relax the rules regulation. Tow phase customer cannot allow to install the system because the transmission and distribution loses in Pakistan is almost on the peak, the distribution line cannot support it may increase the loses factors, only three phase customer can install safe system. Tow phase is also the reason but people can allow to install off grade solar system"

“net billing is part of net metering in Pakistan other country may follow that a separate system but the given net metering policy support net billing scheme, if the customer receives net export bill consistently three-month billing cycle the disco will pay but under given policy solar system may not be fulfilling these criteria”

“our own opinion regarding net metering scheme is one of best solution for energy crises, because Pakistan have the much more capacity of sunny day. It is good for city people who connect with three phase line. Those who are not connect to three phase line they must need go for off grade solar system”

CHAPTER 7

CONSCLUSION AND POLICY RECOMMENDATION

7.1 Conclusion

Pakistan have efficient solar potential in the region and the future solar energy can huge contribution in the energy mix in Pakistan. Mainly the solar deployment is promising for future energy as its feasibility assessment can reduce the energy import bill and the country energy demand.

The residential household under net metering rules regulations in Pakistan, the popularity of the current net metering and its increasing trend of the participants have been unnoticed earlier except few DISCO's are performing very well as compare to other. It's due to Pakistan import the PV system equipment from other country. And the small-scale PV system in the country almost reach to grid parity in the country with install cost of 150PKR (US$ 0.75) per Wp.

The selected three size of PV module (3kwp, 6 kwp and 10.5kwp) with install cost of 150pkr under the given metrological condition and financial parameters. The estimated levelized cost of electricity LCOE is 12.3pkr (US$0.060) per kwh, whereas the household electricity consumption above 300kwh, above 200kwh per month have an average retail tariff 21.23pkr, 13.83pkr per kwh respectively compare with LCOE is12.33pkr which mean that the middle class household have sufficient incentive to invest on the rooftop solar system in Pakistan.

Net metering and net billing scheme are roughly pronounced is a net metering scheme. Both frameworks allow the distribution generation (DG facility) customer to produce own electricity

using (wind or solar) resource and export surplus energy to the national grid. In net metering scheme the household get energy compensation for export electricity. And allow them to use the electricity during offsets hours or when the DG facility or PV system are not working, or insufficient to satisfy the household electricity demand. And the other hand the net billing scheme the household compensate financially for export electricity. In the case of Pakistan for export electricity the off-peak tariff rate is set by the authority NEPRA under the net metering scheme as a name of net export billing. Where the net metering user can sale the electricity if they GD facility fulfil the criteria.

This study focused on net metering framework and its policy incentive to the net metering participants. In terms of whole management control from policy perspective. We separately compare the energy compensation and monetary compensation as discussed earlier as a net metering and net billing scheme. The three sizes of (3KWp, 6KWp and 10.5KWp) solar PV module was selected in study. With a typical household electricity consumption of 50kwh per day (1500kwh per month) and has daily profile load was considering in the analysis. The power export to the grid as 17%, 42.6% and 68% by each system sizes respectively.

The net metering scheme the IRR yield slightly higher than net billing scheme. It's due the policy design to disincentive the household to oversizing the system. In both scheme the IRR is greater than weighted average cost of capital (WACC; 8.75%). as shown in (table-5).

Table. 5: The IRR yield under net metering vs net billing:

module sizes	3kwp	6kwp	10.5kwp
IRR Yield under Net metering scheme	16.20%	15.50%	14.30%
IRR Yield under Net billing scheme	15.20%	14.50%	12.40%

The result indicate that the household can get benefits from both schemes comparatively the IRR are low under net billing scheme but still attractive as the system compensate financially the participant's. Lower the system size has yield high IRR under net billing scheme. This policy

design in a manner where the household cannot over size the system. And the net metering allow the household to over the system size up to certain level. The DG facility under net metering scheme in Pakistan have both type of incentive provides where the customer can benefit. The IRR of net metering are higher if the household are willing to get only energy compensation rather than monetary compensation. Because the net metering rules are design where the net metering user couldn't able to meet the net export billing criteria to get monetary compensation. The household can decrease its own electricity bill under net metering which they are paying to the DISCO by using solar energy.

7.2 Policy Recommendation

Despite improving the capacity of power generation in the country, the issues persist and increase day by day. There is a strong need for effective policy debate to target the power sector with viable and economic policy options. This study analyzes the net metering incentive under the rules regulation of NEPRA. Our effort is to propose an effective incentive structure for promoting and popularizing the use of net-metering in the country

This study analyzed the cost competitiveness of solar photovoltaic system under the current net metering rules regulation. The current net metering rules regulation are consistent with energy compensation while the type of incentive which provided to the DG facility users or solar system users as the form of energy compensation and net export billing which as explain net billing scheme. We estimate separate the scenarios of incentive as net metering and net billing scheme both the scheme gives benefit to the household but the restriction of net metering rules regulation adversely effects in the case of net billing scheme. By reviving the existing rules regulation of net metering and the study result as well as the qualitative part of the study indicate that the net

metering gives optimal benefit to the customer or DG users in Pakistan. The following are policy recommendation to improve the exiting net metering mechanism in the country.

- Net metering performs dually incentive to the household as an energy compensation as well as monetary compensation. There is need for making smooth the net billing procedure under net metering arrangement. It will attract the participant toward net metering scheme.
- The net metering scheme are need to promote in the rural areas where the discos can encourage net metering users if the single-phase users allow to install the small scale system rather than three phase distribution line than the net metering will be gaining popularity in the country.
- There's need for subsidies to the net metering scheme to a certain level through low interest loan. As well as people awareness programs regarding net metering are necessary.

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APENDEX A-01

The questioner uses for capturing the house daily electricity consumption profile where we compare it with the DG facility that to estimate the energy consume by the household and how much the energy can be export to grid

Questionnaire for Household electricity consumption profile and average monthly load [profile]

Name…….. Gender:…….

Address:…… Contact no:……..

Q1. Are you connecting with three phase electricity transmission distribution line [YES], [NO]

Q2. What are the area of your house in meter ……

Q3. What is your monthly load of electricity consumption in units or Kw……..

Q4. Number of persons in the house, kids [ ], adult [ ],

Q5. Number of person employed [ ].

Q6. Number of person unemployed [ ].

Q7. What are the peak time of electricity consumption in day time? Early

morning [ ], noon time [ ], evening time [ ]

APENDEX A-02

This questionnaire uses for calculating the install cost of capital per watt peak of solar system in Pakistan.

Questionnaire for finding Cost of per watt peak in the market

Name…….. Gender:…….

Address:…… Contact no:……..

Q1. How many type of SOLAR MODULES and inverter are available?

Q2. What are the price of per solar module?

Q3. What are the installation cost per watt peak?

Q4. What are total cost of per watt peak?

Q5. What are the operation and maintenance cost per year?

APENDEX A-03

Questionnaire for QUALITATIVE ANALYSIS.

Pakistan institute of development economics (PIDE) Islamabad.

Group-A with energy expert [part 1]

Q1. The current Net metering framework give incentive to customer through energy compensation that the customer consumes exported electricity during offsite hours when PV system are not working or shall be paid at off-peak tariff rate. But still the framework unpopular except few DISCO's. What type of incentive need for net metering scheme to attract the customer to invest on solar system?

Q2 net billing framework performing the same as net metering scheme but it compensates the customer financially, that the export electricity shall be paid at rate of distribution utility generation cost or off-peak retail tariff rate. What is your view on this alternative?

Q3 how if the government subsidize small scale scheme through low interest rate loan? Is there any need for public awareness program regarding net metering?

Q4. What is your own view about the current net metering policy?

Group-B with net metering users [part 2]

According to the net metering rules what is your experience by installing solar system under net metering scheme.

Q1 Are you're satisfied from your solar system?

Q2 Does the solar system can fulfill your day time electricity demand. Did your sale electricity to grid?

Q2 How much decrease your monthly bill which you pay to the discos. What are the cost of per kWh?

Q3 Did you receive net energy export bill from discos?

Q4 What is your own opinion on net metering scheme?

Group-C with DISCOS authorities. [Part 3]

As we know that the net metering scheme is one of the prominent scheme for cheapest electricity generation over the world. Many countries are trying to generate electricity with clean environment. As we can see Pakistan is also experience in the solar projects and NEPRA allow all discos to manage directly from discos whose want to install small scale solar system up 25KWp. The customer under this range will no required for any approval, the respective discos will manage it directly.

Q1 What are the main reason of unpopularity of net metering in Pakistan?

Q2 What is your opinion on the given outcome of the study is the study helpful for customer prospective?

Q3 Do NEPRA need to relax the net metering rules for net billing?

Q4 What if the customer allows to install solar scheme whose connect with tow phase distribution line rather than three phase?

Q5 what is your comment on the given finding of the study?

Q6 share your own opinion regarding net metering in Pakistan