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Performance and Economic Analysis of Grid-connected Residential PV DG Systems under Net Metering in Pakistan

Muhammad Usman Afridi
Department of Electrical Energy System Engineering
USPCAS-E, University of Engineering and Technology,
Peshawar mafridi1@asu.edu /usman.afridi.ned@gmail.com

Tanvir Ahmad
Department of Energy Management and Sustainability
USPCAS-E, University of Engineering and Technology,
Peshawar
tanvir.ahmad@uetpeshawar.edu.pk

Rizwan Kamal
Department of Electrical Energy System Engineering
USPCAS-E, University of Engineering and Technology,
Peshawar
rkrizwan891@gmail.com

Inzamam ul Haq
Department of Electrical Energy System Engineering
USPCAS-E, University of Engineering and Technology,
Peshawar
iulhaq@asu.edu

Abdul Basit
Department of Electrical Energy System Engineering
USPCAS-E, University of Engineering and Technology,
Peshawar
abdul.basit@uetpeshawar.edu.pk

Abstract
In Pakistan, the National Electric Power Regulatory Authority (NEPRA) in 2015 has introduced net metering incentive, which allows the distributed generation systems of photovoltaic (PV) and wind (from 1kWp up-to 1MWp) to sell excess units of electricity to the grid, and net them off against the units consumed from the grid. The objective is to proliferate and facilitate the use of renewable energy resources for green energy production and also to counter the electricity crisis prevalent in the country. This paper presents a detailed performance and economic analysis of residential consumers of one of the distribution companies in Pakistan, Islamabad Electric Supply Company (IESCO), having solar distributed generation (DG) systems of 3kW, 5kW, and 10kW with net metering. Using HOMER Pro®, a micro grid optimization software, a detailed economic and performance analysis has been performed. Economic analysis includes the net present cost (NPC), levelized cost of electricity (LCOE), internal rate of return (IRR), return on investment (ROI), and simple payback period of the system. Results indicate that as the generation capacity of DG is increased, the LCOE and payback period is reduced while IRR and ROI is increased, which signify the usefulness of net metering policy for the customers. Performance analysis include energy sold to and purchased from the grid, and monthly average electrical production of the DG systems. Finally, some recommendations are made for any further work in this area.

Keywords Net metering; Distributed Generation; Photovoltaic; LCOE; NPC; IRR; ROI.

1. INTRODUCTION

1.1. Renewable Energy around the world:

The focus on renewable energy production has been enormous in the past few decades. With the already visible effects of global warming, and the depleting conventional sources for power production, different countries have formulated different policies regarding power production using renewable energy resources. Fig. 1 shows how the progress in renewable energy sector has been made and how the world is looking

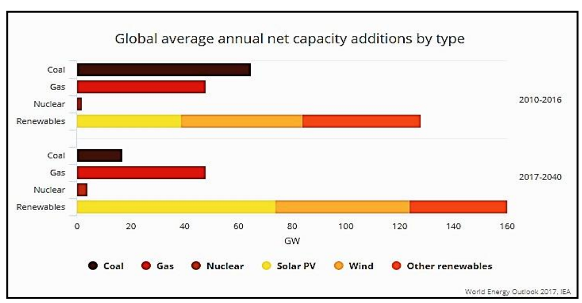

Fig 1. Current and projected global average annual net capacity additions by type.

towards renewable energy sources [1]. It is also evident from the figure that solar energy has the most potential in the production of green energy.

1.2. Solar resource potential in Pakistan:

Location of Pakistan is favorable for solar radiation. The sun shines for major part of the day, for about 7 to 8 hours daily in various parts of the country. Moreover, solar energy is available for around 2300–2700 hours annually and the sun shines for more than 300 days [2]. On average, Pakistan receives 2400 kWh/m^2 of Solar Irradiance per year [3]. Solar maps of Pakistan have been formed by US National Renewable Energy Laboratory which indicates that many regions in the country have high solar irradiance averaging 5-7 kWh/m^2 per day [4].

1.3. Net metering in Pakistan:

The Pakistani government has taken steps for the promotion the solar PV market, including loans for PV modules, rooftop PV setups and endorsement of the utilization of grid-connected solar PV, to proliferate the renewable energy usage in the country. Introducing net-metering in 2015, NEPRA issued its regulations for net-metering allowing the distribution companies (DISCOs) in the country to purchase excess units of electricity produced by the consumers through wind and solar power(1 kWp up-to 1 MWp), and net them off against the units consumed from the grid. It is a huge development, which can not only counter the energy shortage but also help in the reduction of bills by selling the extra electricity to the grid [5]. Net metering policy functions by installing a bi-directional meter which can spin in both directions. It spins forward when power is drawn from the grid by customer (i.e., consuming more energy than they are generating), and backward when energy is being sent back to the grid (i.e., using less energy than they are generating). The customer is only billed for the net electricity used [6].

Currently, the net metering policy has been implemented at all the distribution companies but its installation has been limited to some of the DISCOs. As on 28th June 2018, Islamabad Electric Supply Company (IESCO) has commissioned or installed 171 Net Metering Systems, Lahore Electric Supply Company (LESCO) 178, Karachi Electric Limited (K-Electric) Electric 29, Faisalabad Electric Supply Company (FESCO) 15, Gujranwala Electric Power Company (GEPCO) 34, Multan Electric Power Company (MEPCO) 17 and Peshawar Electric Supply Company (PESCO) 2 [7]. In these net metering systems, 98 percent of DG systems are solar PV based. Thus from these numbers, one can conclude that the net metering system installation in different DISCOs is increasing at a fast rate and becoming popular with the passage of time.

2. METHODOLOGY:

In this research, the focus has been on the ‘prosumers’ of IESCO, as it was the first electrical distribution company which started installation of net metering facility to the consumers in Pakistan. Consumers with generation facility are also called ‘prosumers’ because they are able to sell to and consume electricity from the grid. In this research, residential consumers with solar PV DG systems of 3kW, 5kW and 10kW has been considered because the consumers with that capacity were most recurring in IESCO. Economic and performance analysis has been performed which is explained below.

2.1 Economic Analysis:

Extensive economic analysis has been performed of the systems which includes the following costs.

2.1.1 Lifecycle cost (LCC): The overall system cost of a system for a given period is the lifecycle cost. It consists of the system installation, replacement, operation and maintenance minus the salvage cost. It is represented by Eq. 1 below [8].

$$LCC = C_{int} + C_{rep} + C_{OM} - C_{salvage} \quad (1)$$

Where C_{int} is the installation cost of the system, consisting of installation of PV, inverter, etc. C_{rep} is the replacement cost of any given component in the system. In this research, the replacement of inverter after 15 years of it lifetime is taken into account. C_{OM} is the maintenance and operation cost of the system and is taken as 1% of the initial system capital cost [8]. $C_{salvage}$ is the cost of a project during its end.

The lifetime of PV panels is taken as 25 years where as that of inverter is taken as 15 years.

2.1.2 Net Present Cost (NPC): The present value of all the individual costs of the system spent over the lifetime, excluding the present value of all the revenue it earns in its life time is the net present cost (NPC) of system. In HOMER Pro®, the total NPC is calculated by the addition of total discounted cash flows in each year over the lifetime of the project (T). NPC is determined by Eq. 2 [9]

$$NPC = \sum_{t-1}^{T} \frac{C_t}{(1+r)^t} - C_0 \quad (2)$$

Where C_t is net cash inflow during the period t, C_o is the total initial investment cost, 'r' is the discount rate, and 't' is time period.

2.1.3 Levelized Cost of Electricity (LCOE): The levelized cost of electricity refers to the life cycle cost over the amount of energy produced in a given year. Eq. 3 shows the expression for finding LCOE [8].

$$LCOE = \frac{LCC}{\sum_1^n E_{ann}} \quad (3)$$

Where E_{ann} is the total electrical energy produced per year and n is the total number of years.

2.1.4 Payback Period: The payback period tells us about the recovery of the capital investment cost of the project. It is shown by Eq. 4 below [8].

$$T_{payback} = C_{int}/(C_{bill} - C_{net_{bill}} \quad (4)$$

In the above equation, $T_{payback}$ is the payback period in years, C_{int} is the total initial cost of the project, C_{bill} is the electricity billing without the PV system and C_{net_bill} is the electricity billing under net metering system. The payback period is one of the important parameters as it attracts potential 'prosumers' based on how quickly their cost is returned after installing the system.

2.1.5 Internal Rate of Return (IRR): Internal rate of return is a mathematical tool used in the capital budgeting to find out the profitability of potential investments [10]. Internal rate of return is found out from the same equation as that of NPC, which is,

$$NPC = \sum_{t-1}^{T} C_t/(1+r)^t - C_0 \quad (5)$$

From the above Eq. 5, the value of 'r', which is the discount rate, will be the IRR of that project.

2.1.6 Return on Investment (ROI): ROI is a performance indicator, used in evaluation of the efficiency of a given investment or to compare many different investments. The result can be expressed in terms of a percentage or a ratio.

The return on investment is determined from the Eq. 6 [11].

$$ROI = \frac{G_i - C_i}{C_i} \quad (6)$$

Where G_i is the gain from investment and C_i is the cost of investment.

2.2 Performance Analysis:

Performance analysis includes the monthly average electric production by DG systems. It also includes the energy purchased from and sold to the grid by the DG systems.

2.3 Simulation Tool:

All the simulation results have been obtained with the help of HOMER Pro®. HOMER Pro®, a micro-grid software by HOMER Energy, is a tool for optimizing micro-grid design in all areas, from remote off-grid utilities to grid-connected utilities. HOMER (Hybrid Optimization of Multiple Electric Renewables), helps in evaluating design for both on-grid and off-grid power systems. It simulates energy systems, provides sensitivity analysis and shows system configuration optimized by cost. HOMER uses all the different input variables, for example different components of a system, availability of energy resources, temperature data, wind speed, solar radiation, variation in costs, etc. and helps in evaluating many possible system configurations. The best optimized system is sorted on the net present cost of the project. Furthermore, economic results like levelized cost of electricity, present worth, annual worth, etc. of the system are obtained. Simulation results are also displayed in a wide variety of graphs and tables that can be evaluated on their technical and economic merits.

2.4 System Configuration:

In this research, extensive analysis of the residential ‘prosumers’ of IESCO, having solar PV DG systems of 3kW, 5kW and 10kW with net metering facility have been performed. The load profiles of the prosumers have been obtained from the electricity bills, and the average load has been fed in to HOMER Pro® for analysis.

2.4.1 Daily solar radiation and temperature in Islamabad: As the focus of this research are the prosumers of IESCO, the daily solar radiation and the temperature required for the PV system in the city of Islamabad have been obtained through HOMER Pro® as shown in Fig. 2(a) and (b). The daily average annual solar radiation, indicated by the blue line in Fig. 2(a) is 4.96 kWh/m^2/day. The annual average temperature is 18.05 C^o in Islamabad.

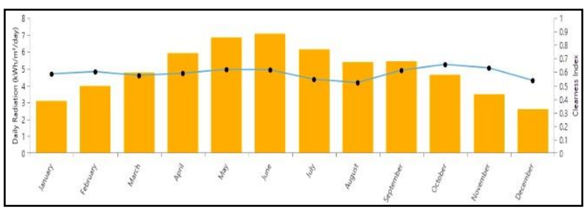

Fig. 2(a) Daily solar radiation in Islamabad

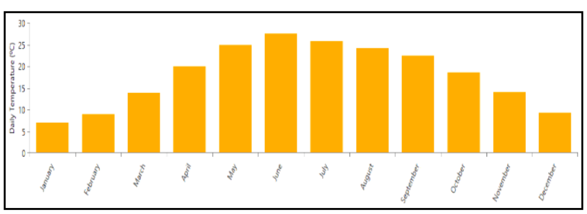

Fig. 2(b) Daily temperature in Islamabad

2.4.2 Tariff Details: The tariff rates play a vital role in the billing system under net metering and thus the economic analysis of DG systems. Table 1 shows the peak and off-peak timings and cost of electricity (COE) for the residential consumers of IESCO [12], [13].

Table 1. Peak and Off-Peak Timings and Electricity Rates in Pakistan

Season	Peak	Off-Peak
Mar - May	6 PM - 10 PM	Remaining 20 hours
Jun - Aug	7 PM - 11 PM	-do-
Sep - Nov	6 PM - 10 PM	-do-
Dec - Feb	5 PM - 9 PM	-do-
General Supply Tariff-Residential		
COE (Rs/kWh)	16.63	9.30

Under net metering regulations of 2015 in Pakistan, a prosumer can sell back the electricity to the grid at the off-peak rate. In HOMER Pro®, there is a net-metering option for which the tariff details, peak and off-peak timings have been specified as shown in the Fig. 3.

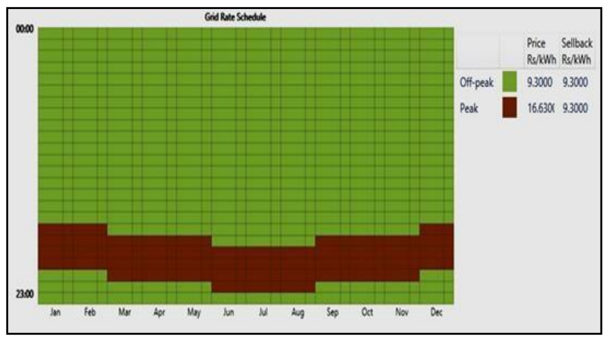

Fig 3. Grid rate schedule specified in HOMER Pro.

2.4.3 System Design: All the input parameters shown in Table 2 and Table 3 have been specified for the economic analysis of all the DG systems under focus in this research in HOMER Pro®. Battery backup has not been considered in these DG systems. The reliability of the grid has been assumed to be perfect for this research, i.e. no power outages or scheduled load-shedding of electricity.

Table 2. Common Input Parameters of all DG Systems

Sr. No	Nominal discount rate (%)	6.00		
1	Expected Inflation rate of the project (%)	5.00[14]		
2	Project lifetime (years)	25		
3	System fixed O&M cost (Rs/year)	O&M costs have been taken as 1% of the initial capital cost		
4	Component	Derating Factor	Efficiency	Lifetime
I) Solar Panels		80%	--	25 years
II)Inverter		--	95%	15 years

The derating factor in Table 2 is a scaling factor which HOMER Pro considers for the PV module output to include the output variations in the real world conditions, as compared to the conditions in which PV module was rated [15].

Table 3. Different Cost Parameters for DG Systems.

System	PV Cost (PKR)	Inverter Cost (PKR)	O&M Cost/ year PKR	Civil Cost (PKR)	Install Cost (PKR)
3kW System	180,000	118,878	3,300	12,000	21,000
5kW System	300,000	118,878	4,500	20,000	33,600
10kW System	600,000	153,301	8,483	25,000	70,000

In Table 3, the PV cost of Grade 1 solar module has been taken as PKR 60/watt, according to market rates in Pakistan as of 20 August, 2018. Install cost includes the amount charged by vendors for installing PV system, which is PKR 7/watt. The civil cost includes the cost of mounting structure for PV systems.

2.4.4 System Schematics:

The schematics for 3kW, 5kW and 10kW DG systems designed in HOMER Pro software have been shown in Fig. 4(a), 4(b) and 4(c).

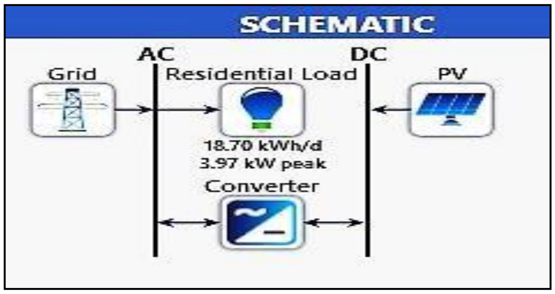

Fig 4. (a) Schematic of 3kW DG system.

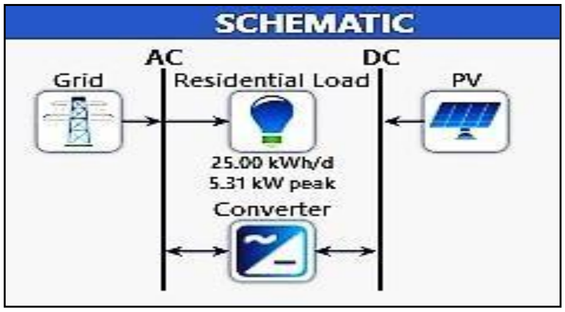

Fig 4. (b) Schematic of 5kW DG System.

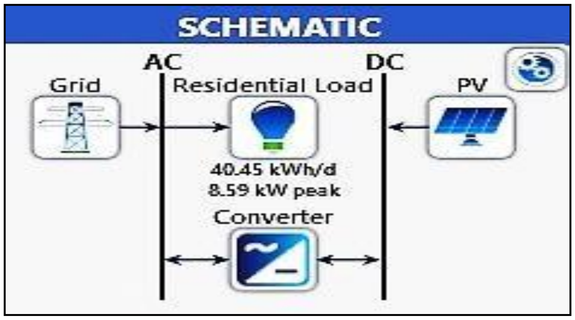

Fig 4. (c) Schematic of 10kW DG System.

A 3kW system, with 3kW PV system, and 5kW- 3 phase inverter, connected with the grid has been shown in Fig. 4(a). According to net metering regulations 2015 in Pakistan, a 3-phase inverter is required for the connection. As 3kW-3phase GoodWe (GW) inverters were not available in the market, therefore a 5kW-3Phase inverter was connected to the system. A residential load of 18.70 kWh/day with 3.97 peak load is connected to the system.

Similarly, a 5kW DG system, with 5kW PV, and 5kW-3phase GW inverter, connected with the grid is shown in Fig. 4(b). An average residential load of 25.00 kWh/d with 5.31 peak load has been connected to this system. Also, a 10kW DG system, with 10kW PV and 10kW-3 phase GW inverter, connected with the grid is shown in Fig. 4(c). A residential load of 40.45 kWh/d with 8.59 kW peak is connected to this system.

3. RESULTS AND ANALYSIS

The simulation results of the mentioned DG systems have been obtained through HOMER Pro, which are explained as follows.

3.1 3kW DG system:

The cost summary for the project lifetime of 3kW DG system is shown in Fig. 7(a). The capital cost includes the cost of 3kW Solar PV and 5kW-3phase GW inverter. The replacement cost for inverter after 15 years is also indicated. Other cost, indicated by red color in graph, shows the fixed O&M cost for the DG system. The light blue color in Fig. 7(a) indicates the operation cost of the grid, which includes the electricity purchased from the grid by the DG system throughout its lifetime. The salvage cost is mainly the cost of inverter after replacement at the end of project lifetime.

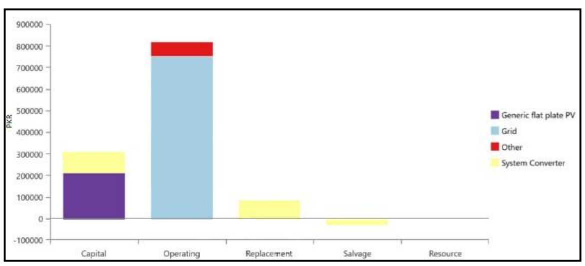

Fig 7. (a) Cost Summary for 3kW DG System

Fig. 7(b) shows the monthly average electric production by 3kW DG system. The result indicates that the generic flat plate PV production is 4,924 kWh/yr., while the grid purchases are 4,097 kWh/yr.

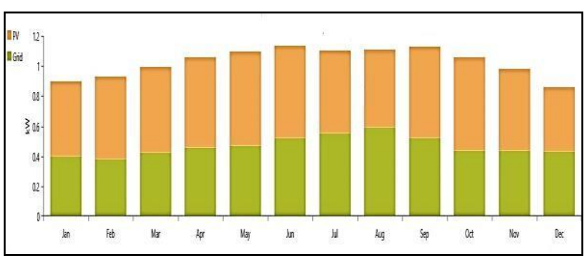

Fig 7. (b) Monthly Average Electric Production by 3kW DG System

The energy purchased from the grid by 3kW DG system is shown in Fig. 8(a). The results indicate that the maximum energy purchased from the grid is in the month of August, which is 438 kWh with peak demand of 4kW.

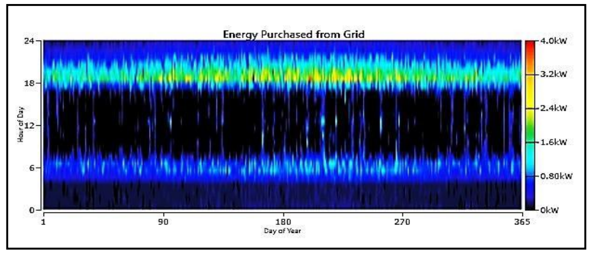

Fig 8. (a) Energy purchased from the Grid by 3kW DG system

The energy sold to the grid by 3kW DG system is shown in Fig. 8(b). The results indicate that the maximum energy sold to the grid is in the month of October, because of higher solar radiation and less electrical load. 196 kWh energy is sold to the grid in that month.

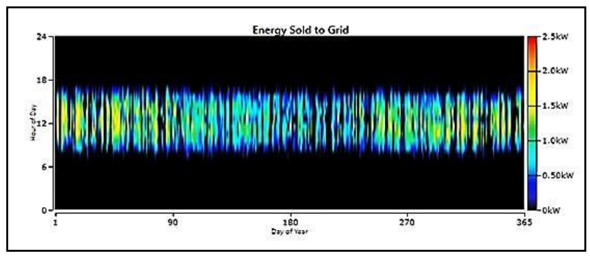

Fig 8. (b) Energy Sold to the Grid by 3kW DG system

3.2 5kW DG system:

The cost summary for 5kW DG system, during its life time is shown in Fig. 9(a). The capital cost indicates the cost of 5kW PV and 5kW-3phase GW inverter. Other costs have already been explained earlier.

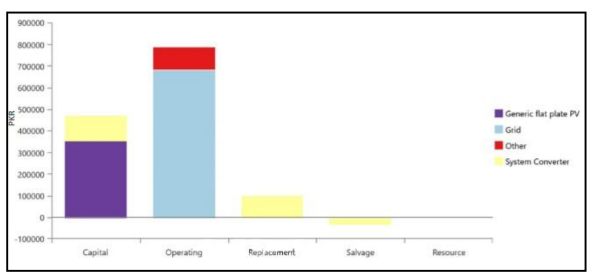

Fig 9. (a) Cost summary for 5kW DG system

The monthly average electric production by 5kW DG system is shown in Fig. 9(b). The generic flat plate PV production is 8,207 kWh/yr., whereas the grid purchases are 5,290 kWh/yr. The load demand in this case is more, that's why grid purchases are more as compared to 3kW DG system.

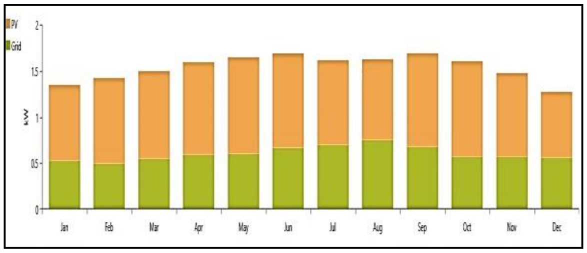

Fig. 9(b) Monthly average electric production by 5kW DG system

The energy purchased from the grid for 5kW DG system is shown in Fig. 10(a). The results indicate that the energy purchased from the grid is highest in the month of August, which is 561 kWh, with peak demand of 5kW during evening time i.e. after 6:00 pm.

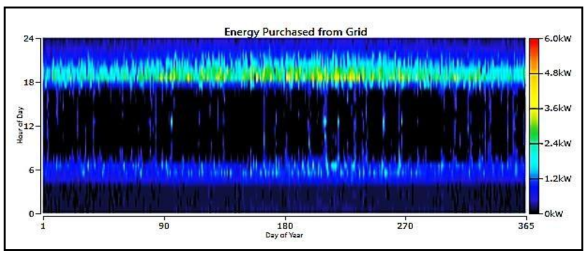

Fig. 10(a) Energy purchased from the grid by 5kW DG system

The energy sold to the grid by 5kW DG system is shown in Fig. 10(b). The results show that the highest amount of energy sold to the grid is during the month of October which is 395 kWh.

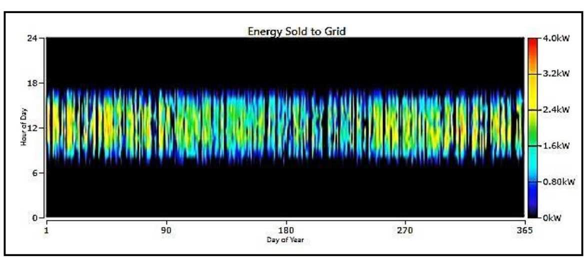

Fig. 10(b) Energy Sold to the grid by 5kW DG system

3.3 10kW DG system:

The cost summary for 10kW DG system is shown in Fig. 11(a). The capital cost includes the costs of 10kW PV system and 10kW 3-phase GW inverter. Other costs have already been explained.

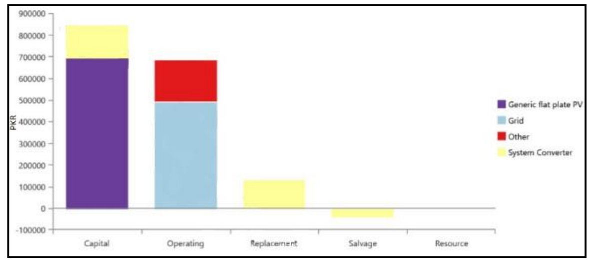

Fig. 11(a) Cost summary for 10kW DG system

Fig. 11(b) shows the monthly average electric production by 10kW DG system. The generic flat plate PV production is 16,415 kWh/yr., while the grid purchases are 8,309 kWh/yr. In this case, energy purchases is maximum as compared to the previous DG systems because of higher load demand but electric production from PV is also greater because in this case 10kW PV system is installed.

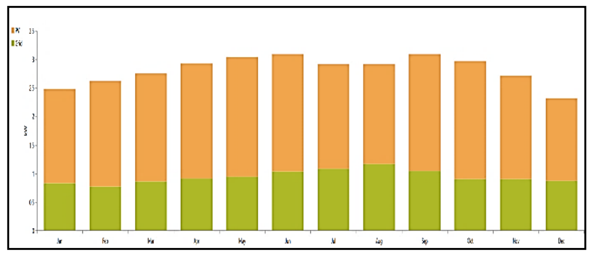

Fig. 11(b) Monthly average electric production by 10kW DG system

The energy purchased from the grid by 10kW DG system has been shown in Fig. 12(a). The results indicate that the highest amount of energy purchased from the grid is 873 kWh in the month of August with peak demand of 8kW.

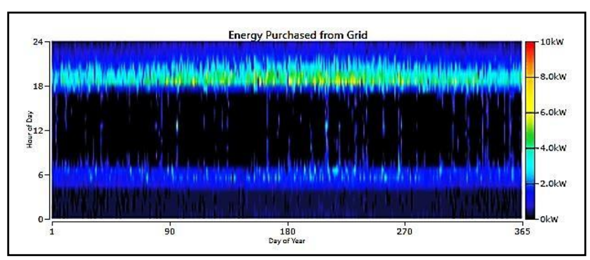

Fig. 12(a) Energy purchased from the grid by 10kW DG system

Fig. 12(b) shows the energy sold to the grid by 10kW DG system. Results show that highest amount of energy sold to the grid is during the month of October, which is 906 kWh.

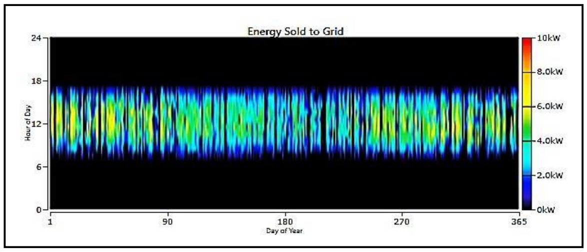

Fig. 12(b) Energy sold to the grid by 10kW DG system

3.4 Cost summary:

Table 4 shows the cost summary of the DG systems under focus for this research.

Table 4 Cost Summary of the DG Systems.

Metric	System Value		
	3kW	5kW	10kW
Total NPC	Rs1.23M	Rs1.33M	Rs1.62M
Levelized COE	Rs6.31	Rs4.58	Rs3.06
Return on Investment (%)	8.2	10.7	12.6
Internal rate of return (%)	11.6	14.4	16.4
Simple payback(year)	7.62	6.51	5.85
Metric	**System Value without DG & Net Metering**		
Total NPC	Rs1.79M	Rs2.39M	Rs3.90M
Levelized COE	Rs11.2	Rs11.2	Rs11.2

The results in Table 4 indicate that as the DG system size is increased, the value of ROI, as well as the IRR is increased. The increase in percentage of ROI means that this is a positive development and therefore the extent of return (benefit) is more as compared to the investment. Therefore, more the capacity of DG system, more will be the benefit for the investor. The higher value of IRR indicates that the project is more feasible. Thus as the capacity of DG is increased, the feasibility for the project is increased.

On the other hand, the value of the LCOE is reduced, and the simple payback period is also reduced. The reduction in the LCOE means that the consumer will now pay less bill per unit per month. As indicated from the results in Table 4, for 5kW DG system, the bill will be Rs4.58 per unit with net-metering, and without net-metering, a consumer will have to pay Rs11.2 per unit. The reduction in the simple payback period means that it will take less time in recovering the full cost of investment of a given project, thus more the capacity of DG system, less will be the payback period. It can be deduced from the table that net metering can greatly reduce the costs of electricity of the prosumers.

The non-net metering customers can have a slight disadvantage because they have to subsidize the prosumers, in order to compensate for the relief provided by the utility to the prosumers. This problem can be countered by formulating flexible net-metering policy, which can benefit all the customers of a utility [16]. Moreover, other benefits associated with net-metering and PV DG systems like strengthening the distribution grid, increasing the stability of the grid and reducing the frequency of maintenance and up gradation of the power distribution system grid, it becomes a tangible benefit to the utility as well as the customers of that utility [6].

4. CONCLUSIONS AND FUTURE RECOMMENDATIONS

Net metering is an extremely important incentive introduced by NEPRA for the proliferation of DG systems in Pakistan. It can not only help in production of green energy, but also in countering electricity crisis in Pakistan. Moreover, as is evident from the economic analysis, net metering is an extremely attractive policy which can greatly reduce the electricity prices of DG owners.

Further work in this area can be carried out by taking into account the sensitivity analysis on different parameters (for example weather, sunshine) of different regions in the country to check the feasibility of net-metering in these regions. The reliability factor of grid can be added while doing analysis because the grids in different parts of the country have different reliability settings, like power outages, scheduled load-shedding, etc. Moreover, a detailed analysis of commercial and industrial DG systems with net metering facility can be performed for finding out the feasibility of net-metering in these sectors. Technical analysis of DG systems can be performed by taking into account different kinds of solar modules and inverters and finding out their effect on the system.

NOMENCLATURE

NEPRA	National electric power regulatory authority.
DG	Distributed generation.
PV	Photovoltaic.
kWp	Kilowatt peak.
MWp	Megawatt peak.
IESCO	Islamabad electric supply company.
NPC	Net present cost.
LCOE	Levelized cost of electricity.
IRR	Internal rate of return.
ROI	Return on investment.
LCC	Life cycle cost.
kWh	Kilowatt hour.
DISCOs	Distribution companies.
O&M	Operation and maintenance.
COE	Cost of electricity
PKR/Rs	Pakistani rupee.
GW	GoodWe inverter

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REFERENCES

[1] World Energy Outlook, 2017 https://www.iea.org/weo2017/,19 March 2018.

[2] M. A. Chaudhry, R. Raza, and S. Hayat, "Renewable energy technologies in Pakistan: prospects and challenges," Renewable and Sustainable Energy Reviews, 13(6-7): 1657-1662 (2009).

[3] T. Ilahi, M. Abid, and T. Ilahi, "Design and analysis of thermoelectric material based roof top energy harvesting system for Pakistan," in Power Generation System and Renewable Energy Technologies (PGSRET), 1-3 (2015).

[4] M. Amer and T. U. Daim, "Selection of renewable energy technologies for a developing county: a case of Pakistan," Energy for Sustainable Development, 15(4): 420-435(2011).

[5] Zahir, A., S.A. Khan, and A. Naseem. Feasibility analysis of grid tied PV system based on net-metering incentive for a developing country: A case study of Pakistan. in 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM). 2017.

[6] Poullikkas, A., G. Kourtis, and I. Hadjipaschalis, A review of net metering mechanism for electricity renewable energy sources. Vol. 4. 2013. 975-1002.

[7] Distributed generation—net metering license http://www.nepra.org.pk/Lic_netmetering.htm, 03 June 2018.

[8] Yatim, Y., et al. Tecno-economic analysis of PV module selection for residential BIPV with net metering implementation in Malaysia. in 2017 IEEE 15th Student Conference on Research and Development (SCOReD). 2017.

[9] Net Present Cost (HOMER Pro 3.11) https://www.homerenergy.com/products/pro/docs/3.11/net_present_cost.html, 20 June 2018.

[10] Compare Economics (HOMER Pro 3.11) https://www.homerenergy.com/products/pro/docs/3.11/compare_economics.html, 20 June 2018.

[11] Return on Investment (HOMER Pro 3.11) https://www.homerenergy.com/products/pro/docs/3.11/return_on_investment.html, 05 June 2018.

[12] Tariff Guide for IESCO http://www.iesco.com.pk/index.php/customer-services/tariff-guide,03 June 2018.

[13] Peak/Off-peak timings in Pakistan. http://www.lesco.gov.pk/3000063, 03 June 2018.

[14] Inflation rate in Pakistan https://www.statista.com/statistics/383760/inflation-rate-in-pakistan/, 01 June 2018

[15] PV Derating factor (HOMER Pro 3.11) https://www.homerenergy.com/products/pro/docs/3.11/pv_derating_factor.html, 17 August 2018.

[16] Eid, C., et al., The economic effect of electricity net-metering with solar PV: Consequences for network cost recovery, cross subsidies and policy objectives. Energy Policy, 2014. 75: p. 244-254.