Impact Assessment of Net Metering for Residential Photovoltaic Distributed Generation in Peru

David Humpire Mojonero*, Alberto Rios Villacorta**‡, Jaime Luyo Kuong***

*Faculty of Mechanical Engineering, Universidad Nacional de Ingeniería, Lima 25, Peru

** Faculty of Sytems, Electronics and Industrial Engineering, Universidad Técnica de Ambato

*** Faculty of Mechanical Engineering, Universidad Nacional de Ingeniería, Lima 25, Peru

(dhumpirem@uni.pe, a.rios@uta.edu.ec, jluyok@uni.edu.pe)

‡ Corresponding Author; Alberto Rios Villacorta,

Tel: +90 312 123 4567, Fax: +90 312 123 4567, a.rios@uta.edu.ec

Received: 05.10.2017 Accepted:12.12.2017

Abstract- The integration of distributed generation is based on legal and regulatory mechanisms which provide the technical and economic conditions of energy exchange with the electricity distribution network. In Peru, the definition of regulatory mechanisms and technical-economic conditions of connection of distributed generation are under discussion and development. This paper evaluates the technical-economic impact of integration mechanism called *net metering* on the end-user and the electricity distribution company (DSO), by connecting photovoltaic (PV) systems to the distribution network of the Arequipa City. The evaluation from residential end-user, connected to the low-voltage grid and associated with tariff BT5B, it is in terms of the installed PV power in kWp and the greater expected economic benefit, in terms of optimum values for consumption range. The evaluation from DSO, is made based on purchase energy blocks to the wholesale market to distribute regulated users. In addition, has been used indicators such as the self-consumption rate, coverage rate and impact about billing. The results find that *net metering* provides a strong economic incentive for the installation of PV systems by the residential user of higher energy consumption, a payback time of 6 years, considering that in the region analysed there are high level of solar irradiation. Consequently, end-users with low energy consumption will have less incentive to become prosumers, due to the existence of subsidized rate. The DSO would experience a reduction in the sustainability of its business, due to the injection of energy to the distribution network with a higher price than spot market.

Keywords Distributed generation, Photovoltaic system, Incentive mechanisms, Net metering.

1. Introduction

The electricity supply is one of the key factors for competitiveness, economic growth and productivity of a country. Worldwide, non-conventional renewable sources are of great interest for energy supply, mainly for diversification of the energy matrix, technology lower prices, security of supply and reduced environmental impact. In 2016, electricity generation obtained from renewable sources covered 24.5% of the final energy consumption in the world. Renewable sources installed capacity was 2017 GW. In 2015, electricity generation from renewable sources covered 23.7% of global electricity consumption [1].

In recent years, solar photovoltaic (PV) power generation has had high growth, reaching a global installed capacity of 290.8 GW by 2016, equivalent to more than 10 times the existing installed PV power one decade ago. China leads with 77.9 GW, 42.9 GW in Japan, 42.4 GW in the US, 41.1 GW in Germany, in Italy 18.9 GW, 11.5 GW in the UK, 7.1 GW in France and 5.5 GW in Spain. Currently, China, Japan and the United States lead the increase in installed PV power, with 34.5, 8.6 and 14.8 GW respectively. European Germany, France, Italy and Spain countries only integrated 1.5, 0.6, 0.4 and 0.1 GW respectively last year. By 2016, electricity generation by PV systems supplied 1.5% of global electricity consumption. In Europe, it covered about 4% of electricity consumption. The countries that cover a greater percentage of their electricity demand with PV installations are Italy, Greece and Germany, with quotas of 7.3, 7.2 and 6.4% respectively [2].

In Peru, since 2008 promotes large-scale electricity generation by renewable energy resources (RER), as wind, solar, geothermal, biomass and hydroelectric installations under 20 MW [3]. The auction mechanism and priority clearance has allowed RER electricity generation gradually become an economically very competitive technology. At the last auction, held in 2016, prices for renewable generation imposed worldwide record. PV technology achieved a 78% reduction in the price of energy offered regarding the first auction in 2010.

In Peru, due to the absence of a regulatory framework for the promotion of distributed generation, it has not yet made possible the formation of a competitive market for PV generation in the electricity distribution systems. It is important to indicate that in Peru there are large geographic areas with exceptional solar resources. For example, the southern regions of Peru have a specific solar potential higher than 2,000 kWh/kWp compared to European countries like Germany, France, Italy and Spain, which have a lower solar potential in the range of 900 - 1300 kWh/kWp, but paradoxically have significant power installed in residential PV systems [8].

Some European countries such as Germany and Spain have a regulatory framework for incentives through tariffs *Feed in Tariff (*FiT), contract up to 25 years, differentiated by type and size of installation. In Spain until 2011, for PV installations below 100 kWp capacity it was paid a FiT of 575% of the average rate and larger facilities at 100 kWp up to 300% of the average rate, prompting the installation of 650 MW to 2007 and demand for connections up to 12000 MW. Later, in 2011, the FiT rates were eliminated in Spain. Currently the Spanish government is working on the development of *net metering* scheme. In Germany, the PV self-consumption is encouraged by FiT rates to systems with an installed capacity below 10 kW and a payment of € 0.1328 / kWh. Italy, since 2005, applied the FiT rates up to 0.208 € / kWh for installations 3 kWp, which since 2013 have been replaced by the net metering mechanism. In California, Arizona and Hawaii, the predominant mechanism for *net metering* limit for installing power 1000 kW, associated with an average payment for photovoltaics between 0.12 and 0.16 US$/ kWh for 20 years. In Table 1 described a comparison of the mechanisms shown in different countries.

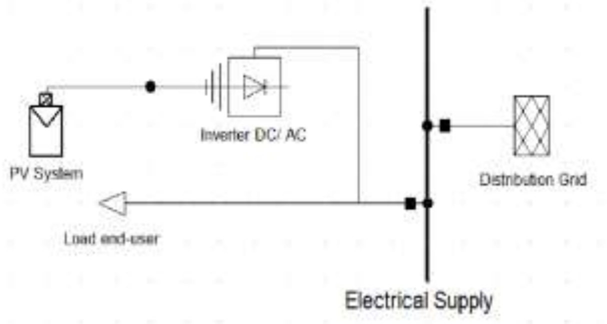

Fig 1. Grid connected PV system

Table 1. Incentive mechanisms distributed PV generation

Geographic region		Incentive Mechanism	Detail
Caribbean	Barbados	Net Billing [2]	Residential: Limit capacity 10 kW, connected capacity <= 10% of peak demand
Latin America	Brazil	Net Metering [2, 22]	Residential and commercial 75 kW, and mini-generation 5 MW
Latin America	Chile	Net billing and self-consumption [15]	Limit capacity 100 kW
North America	Mexico	Net metering [11]	Residential: up to 10 kW to 500 kW and Commercial
North America	USA	Net Metering [11]	Limit capacity of 1000 kW. There is particular conditions by State
Europe	France	FiT[4,5]	kW ranges in [0-3], [3-9], [9-100], [100-12000]
Europe	Germany	FiT and self-consumption [4,5]	kW ranges [0-40], [40-1000], [1000-10000]
Europe	Italy	FiT (Inactive), Net metering (Active) [4,5]	kW ranges in [0-3], [3-9], [9-100]
Europe	Spain	FiT - Inactive[4,5]	kW Ranges [<100], [> 100]

This article focuses on assessing the impact of *net metering* as an incentive mechanism for the integration of PV systems for end-users, connected to the low voltage grid with rate BT5B- *Flat Rate Price*; also the analysis of the price of energy injected into the grid, considering the sale of the whole volume of energy produced under the scheme shown in Fig. 1.

Due to the rapid decrease in photovoltaic technology costs, FiT mechanisms are being re-evaluated and reformulated. Several countries are in a transition towards the net metering like promotion mechanism. In this study for Peru, net metering is considered as an incentive to distributed photovoltaic generation.

The Fig. 2 shows the stages of the analysis developed.

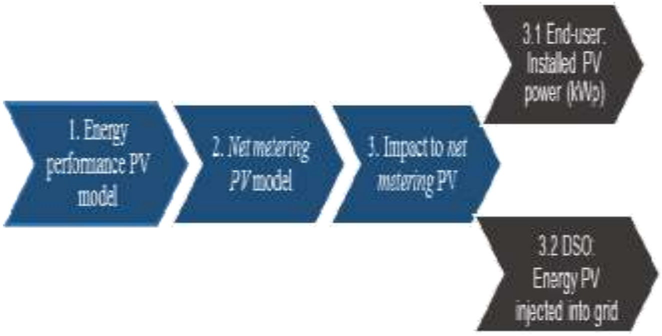

Fig. 2 Scheme of Methodology

2. RER Distributed Generation Promotion Mechanism

The integration of RER distributed generation, particularly PV systems are based on the implementation of FiT mechanisms applied mainly in Germany, France and Spain, representing 60% of the market by 2012. Self-consumption mechanisms and *net metering* represent 14% applied in Italy and in different states of the USA. More modern mechanisms as net billing are applied in Chile and Japan. In addition to incentives such as capital grants, tax reduction and renewable portfolios- RPS standard [4, 8, 22].

In [4, 5] presents benchmarking promotion mechanisms as the FiT in France, Germany, Greece, Italy and Spain relative to *net metering*, based on indicators payback and VPN of photovoltaic projects. In [6] FiT rates and evaluates the importance of evolution in the European market. The mathematical formulation of various forms of *net metering* is presented in [7], indicating that Spain had high rates FIT development that promoted the photovoltaic market in residential installations. The effects of *net metering* under the perspective of the grid and impact assessment on the costs of recovery infrastructure and cross-subsidies between users explained in [8]. In [9, 19] is performed a comparison of *net metering* and FiT schemes established in Cyprus with tariff Time of Use-TOU. In [10] FiT performs comparison, *net metering* and net purchase and sale, based microeconomic models, showing that if the retail price of photovoltaics has the same purchasing value of the network, the mechanisms do not vary. In [11] evaluates the *net metering* focusing on saving billing of California users. Optimization models installed capacity of photovoltaic system of prosumer under FiT rates are evaluated in [12, 13, 14] with the aim of reducing costs throughout the lifetime of the system using the VPN indicator, besides considering the environmental aspect function. In [20] is performed the technical and economical optimization using the HOMER software. In [21] is performed the effect of the deployment of distributed PV generation penetration due to the lower purchase of energy from the PJM wholesale electricity market. Different net metering models in India are explained in [23], in function to the customer and the PV technology. In [15, 16] the mechanism *net metering* and *net billing* is explored in the residential sector in Chile. It is demonstrated that due to the abundant solar resource in the north of the country, photovoltaic projects are economically attractive without government subsidies

3. Methodology

The methodology of this article is organized as follow:

Energy performance model of the PV system

The energy performance ratio- *PR*, which expresses the ratio of the real energy efficiency with respect to energy efficiency theoretically possible, independently of the orientation of the PV installation [17], is represented using the following formula:

$$PR = \frac{Epro_i/Pp}{Irr_i/Gstc} \tag{1}$$

Where $Epro_i(kWh)$ is the energy produced with the $Pp(kWp)$ installed power, $Irr_i\ (kWh/m^2)$ is the global horizontal irradiance, $Gstc\ (kW/m^2)$ is the irradiation measured under standard conditions.

Then energy production corresponds:

$$Epro_0 = \frac{Pp\ Irr_i\ PR}{Gstc} \tag{2}$$

The PVWatts model by NREL (National Renewable Energy Laboratory) estimates the value of Performance Ratio of PV systems connected to the network considering various factors. Key factors include: the efficiency of the photovoltaic inverter DC/AC, the level of losses in the wiring and environmental conditions. In Table 2 the parameters and factors for calculating energy production in this study are shown.

Table 2. Technical parameters

Performance Ratio (%)	PR	85.0
Conductivity wires efficiency (%)	ncc	97.0
Inverter efficiency (%)	ninv	95.0
Lost by environmental conditions (%)	np	5.0
Annual degradation rate (%)	d	1.0
Analysis period (years)	T	20

Scheme net metering model

Based on the model proposed in [15], the *net metering* scheme compensates the energy injected to the same economic value than the energy consumed. It is considered that under this scheme the user intends to generate the same amount of energy (*Net zero energy* is building with a balance zero between demand and production energy) [18] and the optimal installed PV power intended to minimize the deviation between the generated energy and demanded at each instant of time, *t*. Fig. 3

$$min\{err\,(Pp) = \sum_{t=\Delta}^{i}\left(Ebase_t - Epro_t\,(Pp)\right)^2 \tag{3}$$

Where $Ebase_t(kWh)$ is energy consumed without PV project.

If an error of 0 is defined, then the size of the system is defined by:

$$Pp = \frac{\sum_{t=\Delta}^{i} Ebase_t}{PR \cdot \sum_{t=\Delta}^{i} HSE} \tag{4}$$

Where $HPS = \sum_{t=\Delta}^{i} HSE$ is equivalent peak sun hours measurement standard conditions. And HSE, equivalent sunshine hours.

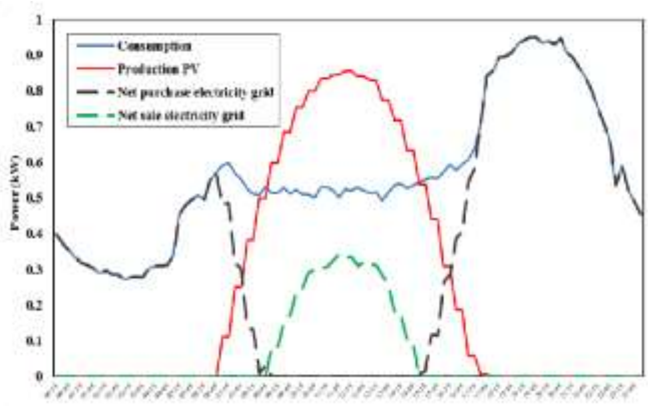

Fig. 3 Typical profiles of electricity consumption and PV production.

The benefits under this scheme, depending on the weighting factor *k* is expressed as follows.

$$k = \frac{p_{ventaFV}}{p_{BT5B}} \tag{5}$$

$$BenNetMet = \sum_t^i Epro_t\,(k\ p_{BT5B}) \tag{6}$$

Where $p_{ventaFV}\left(\frac{US\$}{kWh}\right)$ is the retail price of photovoltaics and $p_{BT5B}\ \left(\frac{US\$}{kWh}\right)$ is the energy price for the end user.

If it included in the analysis, calculating the residential integration PV rate, depending on the k factor, defined as the minimum expected rate energy user, enabling it to profit.

$$pbt5b_{intfv} = \frac{f_{Ainv}\ Cpp}{Ebase_t - Ecom_t + Even_t\ k} \tag{7}$$

Where f_{Ainv} is the annuity factor investment, $Cpp\,(US\$)$ the investment cost of the photovoltaic system, $pbt5b_{intfv}\left(\frac{US\$}{kWh}\right)$ is the integration PV rate, $Ecom_t\,(kWh)$ is energy purchased from the network and $Even_t\,(kWh)$ energy sold to the grid.

The proposed model presents the impact evaluation of the integration of PV systems on the distribution company, considering the sale price of PV energy to the grid and comparing it with the energy purchase value of the distributor to the wholesale market to supply its customers [10].

$$ImpactDSO = \sum_t^i Even_t\ (k\ p_{BT5B} - p_{em}) \tag{8}$$

Where $p_{em}\left(\frac{US\$}{kWh}\right)$ is the energy price in the wholesale market.

The following indicators for comparison of distributed PV generation projects are defined.

➢ Self-consumption rate: Represents the ratio of energy produced and consumed instantaneously between total generation.

$$\alpha = \frac{Epro_t - Even_t}{Epro_t} \tag{9}$$

➢ Coverage rate: Represents the relationship between the energy generated and consumed in the base case or without project.

$$\beta = \frac{Epro_t}{Ebase_t} \tag{10}$$

➢ Payback time: Years of economic recovery of the initial investment in the project.

$$P/B = \frac{C_{Fp}}{BenNetMet} \tag{11}$$

➢ Billing rate Impact: Ratio of economic impact to the distributor by energy billing without project.

$$\frac{ImpactDSO}{Billing_{S/P}} = \left|\left(\frac{ImpactDSO}{Ebase\ p_{BT5B}}\right)\right| \tag{12}$$

Supply and demand energy data of the case study

For this work, the study is focused in the Arequipa region, located in the south of Peru. Solar resource information is estimated according to information from the NASA-SolarGis database. It is also considered that the installation has an optimum tilt angle in the cover housing. The specific production of PV generation is 2300 kWh/kWp. Fig. 4

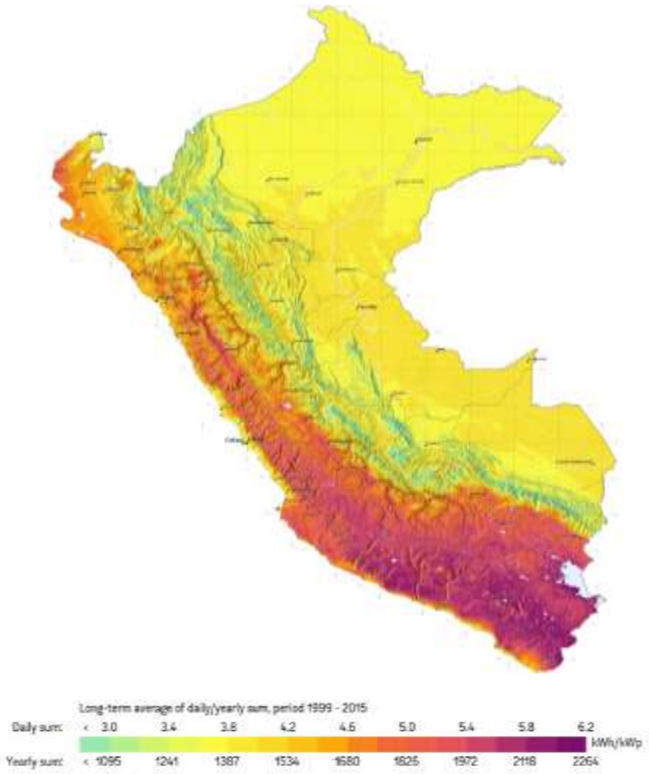

Fig.4 Photovoltaic Generation Potential Estimated in Peru. Source: Solar resource database and photovoltaic simulation software 2016 Solargis.

The power consumption profile characteristic is extracted from the load market studies analysed and shown in terms of the relationship between the instantaneous demand and peak demand, Fig. 5.

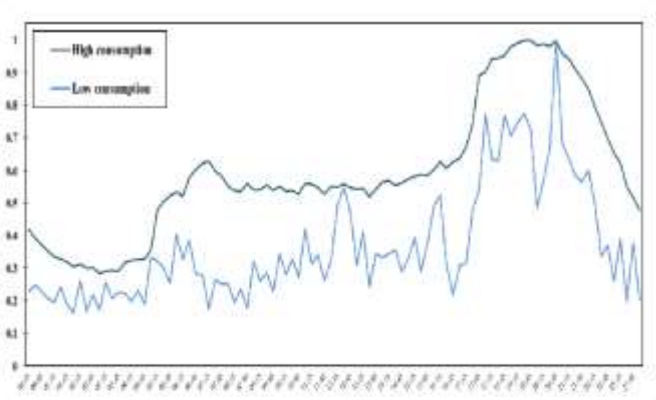

Fig. 5 Energy demand profiles p.u. (Pinstataneous/Pmax). Source: Estudios de Caracterización de Carga – SEAL ST2 2013.

Table 3 shows typical monthly consumption, depending on the range of consumption. The high consumption users, more than 150 kWh/month, have a higher load factor 0.59 and low consumption less than 150 kWh/month, it is estimated with a load factor of 0.37.

Table 3. Energy consumption data by consumer range

Consumption range kW.h/month	Average consumption kW.h/month
< 1 : 30>	11.7
< 31 : 100>	70.9
< 101 : 150 >	119.0
< 151 : 300 >	192.3
< 301 : 500 >	350.2
< 501 : 750 >	566.5
< 751 : 1000 >	834.3

In Peru, the electricity rates for residential end-user are constant in the day - *flat rate price*- and reflect the added cost of generation, transmission and distribution of electricity. Fund for Electricity Social Compensation (FOSE) in Peru is a cross-subsidy between residential users, which allows the reduction rate in users with consumption less than 100 kWh/month, financed by an increase in the rate of users with consumption more than 100 kWh/month. Table 4 shows energy prices to end users and without involvement of FOSE.

Table 4. Rates range consumption in US$/kWh

<0:30> kWh / month	<31: 100> kWh / month	> 100 kWh / month	Without FOSE
0.119	0.147	0.163	0.158

4. Results

In this section, are shown the results of evaluation of the introduction of *net metering* mechanism as an incentive to promote residential PV distributed generation. The analysis are presented in Arequipa city, a representative city in southern Peru because of its high level of solar irradiation.

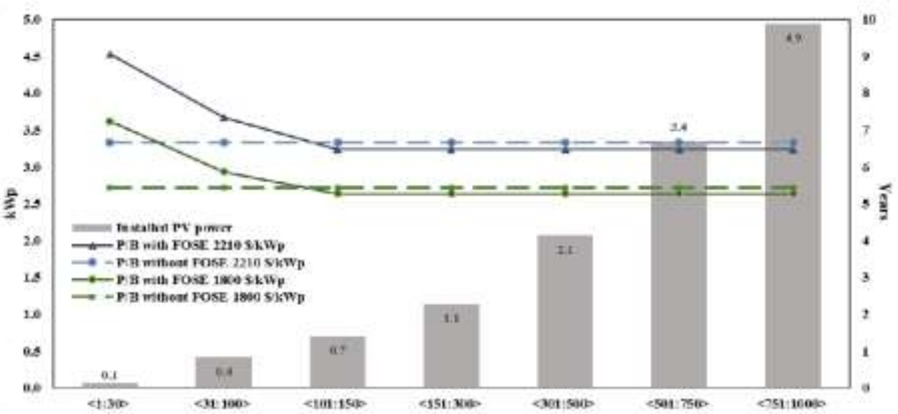

Fig. 6 Optimal installed PV power and P/B for consumption range

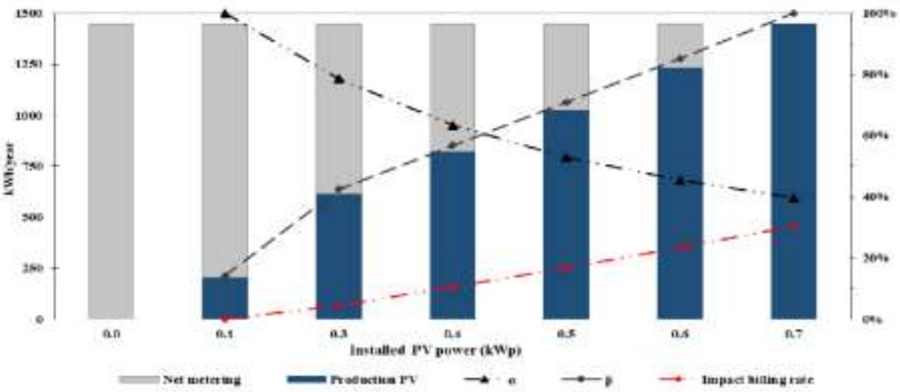

Fig. 7 Impact of installed PV power. End-user consumption <100-150> kWh/month

In Fig. 6, it has been considered the cost of current investment in PV systems 2210 US$/kWp and the projected cost 2020 1800 US$/kWp. It is shown that the installation of PV systems, due to the effect FOSE, presented reduced economic benefits for users of lower consumption. Residential users, with less than 30 kWh/month consumption, require a facility with a capacity below urged 0.1 kWp with a payback (P/B) between 7 and 9 years. Residential users with consumption in the range of 30 to 100 kW.h/month, with optimum 0.42 kWp photovoltaic system recover their investment between 6 and 7.5 years. Residential users with more than 100 kWh/month consumption have a lower P/B between 6.5 and 5.3 years for photovoltaic systems between 0.7 and 4.9 kWp, respectively. In Fig. 7 corresponds to the PV power impact to the user, in the consumption range between 100 and 150 kW.h/month. It is determined, depending on the installed PV power, self-consumption rate, coverage rate and billing rate impact. For optimal installed PV power 0.7 kWp, determined above, Fig. 6, with a coverage factor of 100%, is self-consumption rate 40% of the energy produced from the PV system, and by default 60% of the energy produced is injected into the electricity distribution network, causing an impact of 31.7% of economic losses due to the injected energy has a value above the wholesale electricity market. The decrease of the installed PV system power, reduce the coverage rate, increases self-consumption rate and default, it reduces the energy injected into the network. As the installed PV power is reduced also reduces the economic impact on the electricity distributor, reaching zero for capacities less than 0.2 kWp.

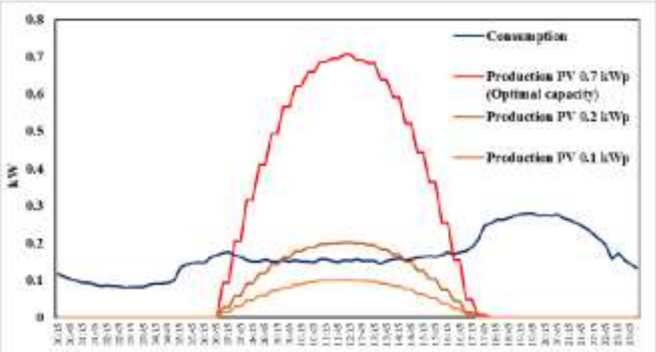

Fig. 8 Profiles of electricity consumption and PV production for different installed power.

Fig. 8 shows the matching of supply and demand curves. The high value of the indicator of self-consumption rate and low coverage rates for PV systems of small power up to 0.3 kWp, is explained by the reduced value of the installed PV system power relative to demand. PV production tends to be locally consumed and reduce injection solar energy to the network, a default lower energy demand user.

For residential user, described in the preceding paragraph, and optimal installed PV power of 0.7 kWp, annual balance of PV energy production and energy consumption is 0, because defined a coverage rate of 100%. For the months of highest irradiation, October to march, production is greater than consumption, otherwise the months from April to August. It demonstrated that a period of annual analysis on *net metering* allows adequately compensate the production and consumption of electricity, Fig. 9

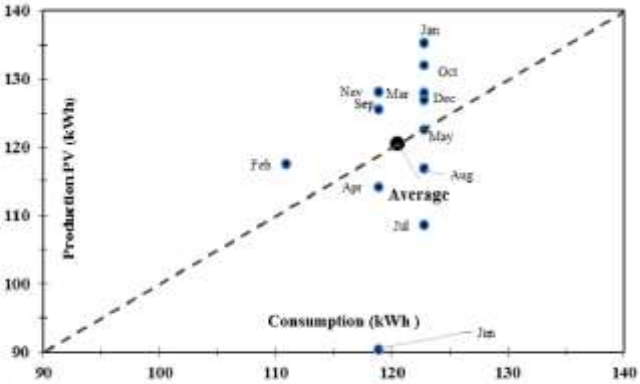

Fig. 9 Consumption vs. Production PV monthly - 'Net Energy Zero Building'

Indicator assessment impact on billing for optimal capacity of residential users, with less than 30 kWh/month consumption, has a value of 43.5%. Residential users with consumption between 30 and 100 kWh/month, 35.3% and impact users with increased consumption to 100 kWh / month at 30.5%. Table 5. As demonstrated in Figure 7, lower installed PV power reduces the impact on the electricity distributor.

Table 5. Impact on the DSO of PV energy system injection with optimum capacity.

Consumption range, kW.h/month	ImpactDSO/Billing S/P (%)
< 1 : 30>	43.5
< 31 : 100>	35.3
< 101 : 150 >	31.7
< 151 : 300 >	30.5
< 301 : 500 >	30.5
< 501 : 750 >	30.5
< 751 : 1000 >	30.5

With the result values of Table 5; 35% on average, and under the unlikely event that there is a penetration of PV distributed generation 10% of the total market demand, the impact of economic losses distributor be estimated 3.5% $(35\%\frac{impact}{user} * 10\%\, user)$. The market has analysed a total demand of 3,000 GWh/year, which means that 10% penetration of distributed PV generation is the installation of about 130 MWp *Roof Mounted PV System*. An unlikely scenario, which would involve an impact lower 3.5% on DSO.

Reducing the impact on the distribution company, according to *equation (9)* requires the selling price of PV energy tends to balance the wholesale market price p_{em}. Reducing the impact on the distributor, in turn, reduces the incentive to residential users to install PV systems.

In Fig. 10, under a mechanism *net billing* a factor $k<1$, in which the whole volume of PV energy is sold, according to *equation (5)* the value $k * p_{BT5B}$, the economic viability of the installation PV systems through a residential integration PV rate for each value *k*, defined as the estimated value of the minimum rate for a project to be economically attractive for prosumers.

For an investment cost of 2210 US$/kWp, it is observed that the *net billing* mechanism, with $k = 1$ factor - equivalent to *net metering* - is attractive for users with greater than 30 kWh/month consumption. Reduction *k* factor reduces user benefits. Only users with more than 100 kWh/month consumption may recover the investment, up to a factor *k* equal to 0.9. For an investment cost of 1800 US$/kWp, the *net metering* would be suitable for all ranges of consumption. The *net billing* mechanism would be feasible with *k* factors between 0.8 and 0.7, for users with power consumption between 30 and 100 kWh/month and more than 100 kWh/month, respectively. Values *k* factor less than 0.7 does not produce incentives to PV distributed generation any residential user.

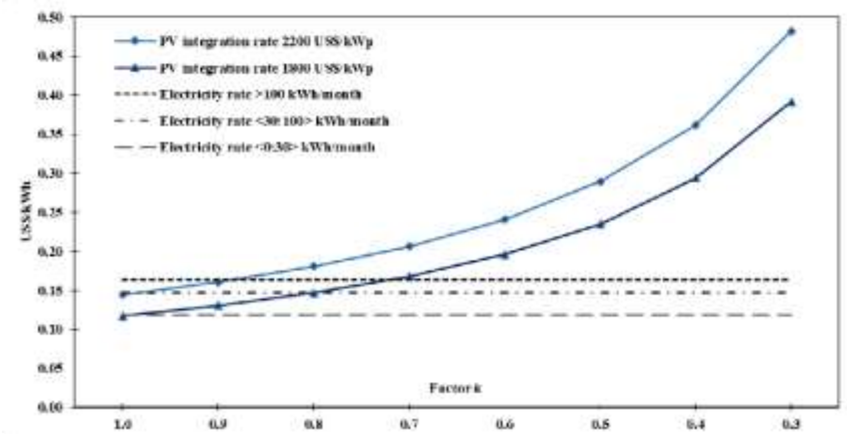

Fig. 10 PV integration rate for each sale factor *k*.

5. Conclusions

This article has presented the assessment of the technical-economic impact of *net metering* mechanism for the particular conditions of the residential electricity market in Peru. The application of this mechanism would result in high economic incentive for integrating photovoltaic systems users with increased consumption to 100 kWh/month with installed power ranging from 0.7 to 5 kWp, which for each range would cover all consumer energy demand annual. FOSE effect reduces the economic incentive for users with less than 100 kWh/month consumption; therefore, from the perspective of promoting the integration of residential PV systems should consider the reformulation or elimination of this subsidy.

The continued decline in costs of photovoltaic technology by 2020 will allow any user to integrate residential solar home systems profitably under the *net metering* mechanism. Likewise, the evaluation mechanism *net billing* per total volume should be considered for technology costs lower than 1800 US$/kWp, since it has been shown that the mechanism of promotion *net billing* has less impact on the distributor and retail user incentive would be equated with reducing technology costs.

For electricity distribution company, the integration of residential photovoltaic systems with installed power lower than those calculated would be easily implemented, considering impact per user ranges less than 35%.

In a next research, the impact of net billing scheme promotion and self-consumption in the residential user incentive for investment in photovoltaic systems and the sustainability of the business chain in the electricity sector will be evaluated

References

[1] REN21. (2017). Renewables 2017 Global Status Report.

[2] Mayer, J. N., Simon, P., Philipps, N. S. H., Schlegl, T., & Senkpiel, C. (2015). Current and future cost of photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems (Fraunhofer ISE, Study on behalf of Agora Energiewende, Freiburg, 2015).

[3] Legislative Decree 1002 (2008). Promoting investment for electricity generation using renewable energy.

[4] Dusonchet, L., & Telaretti, E. (2015). Comparative analysis of economic support policies for PV Solar most representative in the EU countries. Renewable and Sustainable Energy Reviews, 42, 986-998.

[5] Campoccia, A., Dusonchet, L., Telaretti, E., & Zizzo, G. (2014). An analysis of feed'in tariffs for PV Solar representative in Six Countries of the European Union. Solar Energy, 107, 530-542.

[6] Pyrgou, A., Kylili, A., & Fokaides, PA (2016). The future of the Feed-in Tariff (FiT) scheme in Europe: The case of photovoltaics. Energy Policy, 95, 94-102.

[7] Dufo-Lopez, R., & Bernal-Augustine, JL (2015). A comparative assessment of net metering and net billing policies. Study cases for Spain. Energy, 84, 684-694.

[8] Eid, C., Guillen, JR, Marin, PF, & Hakvoort, R. (2014). The economic effect of net-metering electricity Solar PV With: Consequences for network cost recovery, cross subsidies and policy Objectives. Energy Policy, 75, 244-254.

[9] Andreas Poullikkas. (2013). A comparative assessment of net metering and feed in tariff schemes for residential PV systems. Sustainable Energy Technologies and Assessments 3: 1-8.

[10] Yamamoto, Y. (2012). Pricing residential electricity from photovoltaic systems: A comparison of feed-in tariffs, net metering, and net purchase and sale. Solar Energy, 86 (9), 2678-2685.

[11] Darghouth, NR, Barbose, G., & Wiser, R. (2011). The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California. Energy Policy, 39 (9), 5243-5253.

[12] Ren, H. Gao, W., & Ruan, Y. (2009). Economic optimization and sensitivity analysis of photovoltaic system in residential buildings. Renewable energy, 34 (3), 883-889.

[13] Mondol, JD, Yohanis, YG, & Norton, B. (2009). Optimizing the economic viability of grid-connected photovoltaic systems. Applied Energy, 86 (7), 985-999.

[14] Bernal-Augustin, JL, & Dufo-López, R. (2006). Economical and environmental analysis of grid connected photovoltaic systems in Spain. Renewable energy, 31 (8), 1107-1128.

[15] Varas, T., Carmona, M. C., Ferrada, P., Fuentealba, E., Lefranc, G., & Crutchik, M. (2016). Evaluation of incentive mechanism for distributed generation in Northern Chile. IEEE Latin America Transactions, 14(6), 2719-2725.

[16] Watts, D., Valdés, MF, Jara, D., & Watson, A. (2015). Residential PV development potential in Chile: the effect of net metering and net billing schemes for grid-connected PV systems. Renewable and Sustainable Energy Reviews, 41, 1037-1051.

[17] Standard, B. (1998). Photovoltaic system performance monitoring-Guidelines for measurement, data exchange and analysis. BS EN, 61724.

[18] Sartori, I., Napolitano, A., & Voss, K. (2012). Net zero energy buildings: A consistent definition framework. Energy and Buildings, 48, 220-23.

[19] Christoforidis, G. C., Chrysochos, A., Papagiannis, G., Hatzipanayi, M., & Georghiou, G. E. (2013, October). Promoting PV energy through net metering optimization: The PV-NET project. In Renewable Energy Research and Applications (ICRERA), 2013 International Conference on (pp. 1117-1122). IEEE.

[20] Srivastava, R., & Giri, V. K. (2016). Techno-Economical Analysıs of Grid Connected PV System For A Universıty In Indıa. International Journal of Renewable Energy Research (IJRER), 6(2), 535-540.

[21] Diefenderfer, P., Prescott, E. R., & Jansson, P. M. (2015, November). Energy and capacity values for distributed PV in PJM. In Renewable Energy Research and Applications (ICRERA), 2015 International Conference on (pp. 1265-1268). IEEE.

[22] Aktas, A. Z. (2015, November). A Review and comparison of renewable energy strategies or policies of some countries. In Renewable Energy Research and Applications (ICRERA), 2015 International Conference on (pp. 636-643). IEEE.

[23] Thakur, J., & Chakraborty, B. (2015, November). Smart net metering models for smart grid in India. In Renewable Energy Research and Applications (ICRERA), 2015 International Conference on (pp. 333-338). IEEE.