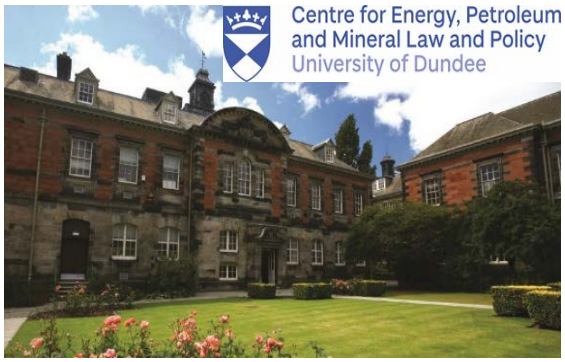
HOW TO ENHANCE RURAL ELECTRIFICATION REQUIREMENTS IN PERU: CAN SOLAR PV BE THE SOLUTION?



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ABSTRACT: *Rural Electrification has become an important target, specifically in non-developed countries such as Peru. Nonetheless, enhancing rural electrification is a challenging goal considering technical and economic constraints related to determining the best alternative to deploy electrification in isolated communities where getting access to their terrains is difficult. There are many possibilities to be deployed in order to meet rural electrification goals. The most popular is the one related to the extension of the existent grid. However, extending the grid is not always a possibility, specifically for isolated communities where this is not a cost-effective solution. Hence, this paper aims to asses rural electrification challenges, based on the Peruvian experience, in order to gain an understanding of how this market works and to determine whether Solar PV can be a useful technology for enhancing rural electrification goals.*

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ABBREVIATIONS

LCE	Electricity Concession Law, Decree Law 25844
MEM	Ministry of Energy and Mines
OSINERGMIN	Peruvian energy regulatory agency. This acronym stands for Supervisor Entity of the Investments on Energy and Mining.
PNER	Spanish acronym for Rural Electrification National Plan
RLCE	Rules for the Electricity Concession Law, Supreme Decree N° 9-93-EM
SEIN	Interconnected Electricity National System or National Grid
Solar PV	Solar Photovoltaic Technology

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1. Introduction

Peru is a developing country with a wide geographical diversity, which has led to face several issues in order to be able to meet energy demand requirements in rural areas. As of 2015, the electrification coverage in rural areas was about 78%, which means that there is still a 22% rate of rural electrification that needs to be covered.[2]

Furthermore, Peru has a very good potential to develop Solar PV and windfarms.[3] However, this potential has only been promoted for on-grid projects in Peru throughout four (4) auction process that has been held every two (2) years since 2009. Considering the abovementioned situations, the Peruvian government has enacted a regulatory policy in order to promote solar photovoltaic technology (Solar PV) as a source to be used to meet the demand requirements from rural areas. This is also due to the fact that Solar PV is a cheaper and effective alternative compared to the costs related to enlarge the national grid in order to reach those rural areas which demand for electricity have not yet been covered.

Considering the abovementioned, this research paper aims to address the effectiveness of Solar PV's ability to meet the demand for electricity in rural areas. In order to address this question, this research paper will go through a description of the requirements established in Peru's Rural Electrification National Plan. Once these requirements are clear, the next topic will be related to Solar PV Projects in Peru's rural areas. Specifically, this section will describe the auction process recently concluded, the obligations undertaken by the awarded company, the payment scheme and the technology to be implemented. Finally, this paper concludes with a discussion of whether Solar PV is the kind of technology that will allow Peru to meet its electricity demand requirements in rural areas.

2. The Relationship Between Distribution Activities and Rural Electrification

Most of the measures undertaken for enhancing rural electrification were related to the construction of distribution systems that allow rural areas to be connected to the existent grid, enabling the distribution concessionaire to deliver the energy demanded in such rural areas. Thereto, rural electrification policies aim to close the electricity gap from an on-grid

[2] PNER 2016-2015: Part 1. Section 4
[3] Cfr. Section 4 of this Research Paper

perspective. Given the on-grid approach of rural electrification policies, it is important to describe how distribution activity works in the electricity market in Peru.

Distribution activity involves energy transportation from substations or bus bars to final consumers throughout transmission lines of medium voltage to low voltage.[4] According to Peru's Electricity Concession Law, Decree Law 25844 (LCE), distribution activity has been declared a natural monopoly. Thereto, the distribution company has an exclusive right to operate on a given geographical area.[5] In order to perform distribution activities, a distribution company is required to obtain a definitive concession in accordance to what has been set forth in the LCE and Rules for the Electricity Concession Law, Supreme Decree N° 9-93-EM (RLCE).[6] Furthermore, distribution activities are performed under a regulated price.[7]

Energy retailing is also considered a part of distribution activities.[8] Thereto, distribution companies will sell energy directly to retail consumers. They can also provide energy to large consumers that have a demand in between 200 kV and 2.5 MW[9].

According to article 82 from LCE, distribution companies have an obligation to provide electricity service to those clients located under their concession area, as long as they have fulfilled the requirements and payments set forth under the regulation. However, this provision does not specifically include potential clients who are not connected to the national grid. In order to meet the demand of these clients, it will be required to build a distribution network so distribution companies can be able to deliver the electricity demanded. Nonetheless, this provision is only applicable for urban areas. There are no specific provisions for rural areas.

3. Rural Electrification: Demand for Electricity in Rural Areas in Peru

The economics that underlies the design of the electricity market relies on spreading high investment costs in between a maximised number of customers considering their location or

[4] SANTIVAÑEZ, Roberto. "Deregulation and Political Process: Regulatory Opportunism in Peru's Electricity Industry Reform. LL.M Thesis. University of Stanford. 2001. pp. 23-27.
[5] Cfr. Article 30, LCE.
[6] Cfr. Article 4, LCE.
[7] Cfr. Article 7, LCE.
[8] Cfr. Article 34, LCE.
[9] Cfr. Article 3, Supreme Decree N° 22-2009-EM

their energy consumption. Thereto, those customers should be able to demand and pay for the energy required in such a way so that electricity companies can recoup their investment.[10]

However, this market structure cannot be applied in rural areas, given that these markets usually have the following characteristics[11]:

(i) Rural populations are usually dispersed and have low consumption which results in high capital costs and investments with a very small investment return rate.

(ii) Low payment capacity of rural populations which prevent the expansion of the national grid to rural areas because it would be impossible to pay for that investment.

(iii) Rural consumers usually receive a low-quality electricity service given the lack of maintenance of the existent rural transmission lines.

Thereto, enhancing universal electrification becomes an almost impossible target to reach from an economic perspective. Notwithstanding, with the foregoing, access to electricity is a basic indicator of social development. Hence, enhancing electricity supply goals in rural areas is essential for introducing social and economic development to underprivileged rural populations.[12] It also *"[f]acilitates community services such as health and education (consumption use) and enables business entities to carry out professional activities (productive use) for rural populations"*[13].

As for any other rural area, Peru's rural population is characterised for (i) being distant and barely communicates with other communities, (ii) having a small electricity consumption, (iii) housing is dispersed within a town, and (iv) a high poverty rate among the population.[14] In order to enhance rural electrification in Peru, a set of policies and programs have been enacted by the government. Most of these programs aim to extend the grid or to provide a connection

[10] ZERRIFFI, Hisham. Rural Electrification. Strategies for distributed generation. Netherlands. SPRINGER Netherlands. 2011, p. 6.
[11] Ibid.
[12] RAHMAN, Mizanur, PAATERO, Jukka and LAHDELMA, Risto. *Evaluation of choices for rural electrification in developing countries: A Multicriteria Approach* in Energy Policy. Volume 59. 2013. p., 687.
[13] ALLIANCE FOR RURAL ELECTRIFICATION. Benefits of rural electrification. In: http://are.afd.website/benefits-clean-rural-electrification (accessed in 8 May 2016).
[14] PNER 2016-2025: Part I, Section 2.

to rural communities. Nonetheless, there are more recent measures which propose an off-grid solution for rural electrification.

In this section, this paper is going to provide a description of how rural electrification works in Peru and the goals that have been met so far for improving electrification in remote areas.

3.1. The Development of Rural Electrification in Peru

In 1992 was enacted LCE which promoted unbundling of the electricity industry looking for a more efficient development of the electricity market. Nonetheless, this act did not include specific provisions for rural electrification. As abovementioned, in 2006 the first specific act for rural electrification was approved. This established a set of measures in order to develop electricity projects that can make possible electricity provision in remote areas that were not connected to the national grid.[15]

Law 28749 and its regulation set forth as their objective to establish the regulatory framework required for the promotion and sustainable development of electrification in rural areas in Peru. Moreover, Regulation of Rural Electrification Law, enacted by Supreme Decree N° 25-2007-EM contains a list of principles that govern rural electrification activity. According to those principles, rural electrification projects are qualified as being a national necessity and public welfare and, for their development, coordinated action among governmental institutions is required. Likewise, it has been set forth the importance of introducing renewable energy technology to enhance rural electrification goals.[16]

The measures outlined in the regulatory framework aimed to close the electrification gap in rural communities by enlarging the existent grid or by building a distribution network that can allow rural communities to connect to a distribution company for obtaining electricity supply. In order to achieve such goal, the government will invest in building a set of systems classified as Rural Electric Systems that can include housing connections, distribution networks, transmission wires and generation plants.[17] Once these facilities are built and developed by the government, they are transferred to the local distribution concessionaires to operate so they can deliver energy to those rural areas where such facilities have been created.

[15] Ibid.
[16] Cfr. Article 3 of Supreme Decree N° 25-2007-EM.
[17] Cfr. Article 4 of Supreme Decree N° 25-2007-EM.

In addition, there are some provisions promoting the use of renewable energy technology for meeting rural electrification demand. According to these provisions, renewable energy projects will be encouraged in those places where it is not possible to enlarge the existent grid due to technical or economic constraints.[18]

From a more practical perspective and outside the regulatory framework for rural electrification, the Peruvian government has considered the following alternatives for meeting the demand of energy in remote or isolated locations, as follows[19]:

- The first alternative is to enlarge the grid.
- The second alternative is to use Solar PV for domestic use in those areas that have solar potential, such as in the highlands and the Amazon region.
- The third alternative is to use hydropower with a low installed capacity in those areas where there are water resources.
- The fourth alternative is to use wind power in those areas near the coast of Peru.

On the overall, these programs together with grid extension facilities have led to narrow the gap on rural electrification given that by 2015 the rural electrification rate was 78%. This proves how electrification rates have grown steeply, as it is shown in the following graphics[20]:

[18] Cfr. Article 80 of Supreme Decree N° 25-2007-EM.
[19] Cfr. PNER 2016-2025: Part 1. Section 4.
[20] PNER 2016-2015: Part 1. Section 4

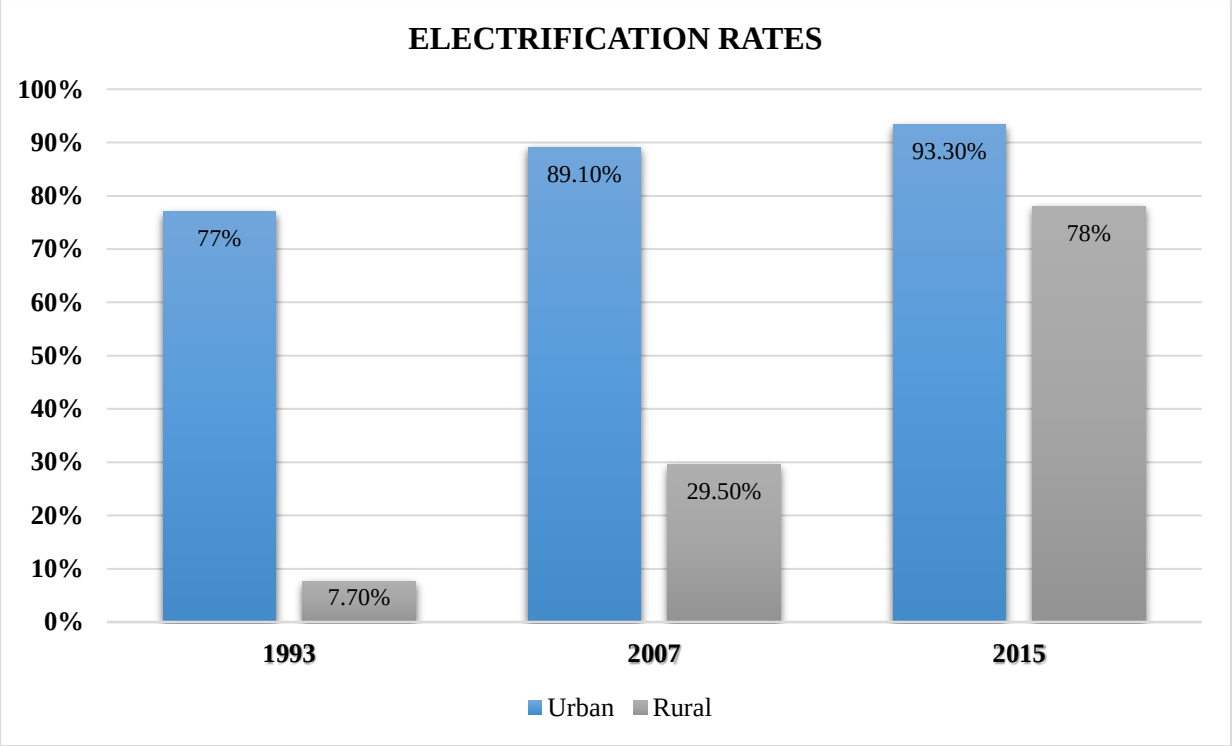

Figure 1. Electrification Rates
Source: PNER 2016-2025

According to these percentages, the rural electrification rate has grown 70.3% in 23 years, having a greater growth in between years 2007 and 2015 which corresponds to the starting year in which the rural electrification regulatory framework was enacted. Accordingly, this could mean that in order to meet enhance rural electrification demand, it was necessary to establish a set of rules that govern the actions needed to be taken by the Peruvian government. Nonetheless, there is still a rate of 22% energy demand need to be met.

3.2. Rural Electrification Plan in Peru

One of the most important measures under the rural electrification regulatory framework was the government's obligation of approving a Rural Electrification Plan or PNER which is a long-term management document with a lifespan of 10 years that should include policy, objectives, strategies, methodology, list of projects and financing sources aiming to organize in a long-term frame the development of rural electrification.

Basically, the PNER will establish the list of projects that should be implemented within a 10-year term. It will include a priority ranking of those projects based upon a criteria system. In

order to establish a ranking of projects, the Ministry of Energy and Mines (MEM) applies a point-system methodology which enables to grade each project. The criteria items are the following:[21]

- The lowest rural electrification rate in a specific location which will receive a top score of 5.0.

- The highest poverty rate on the area where the project would be located which will receive a top score of 2.5.

- The lowest subsidy rate required for household connection which will receive a top score of 1.0.

- The highest rate of household connection that can be obtained with a certain investment which will receive a top score of 0.5.

- The possibility of using renewable energy which will receive a top score of 1.0.

Once all these criteria are evaluated, MEM will determine which projects should be given priority and will set the time-frame required for developing the project. It should be noted that although the PNER is a long-term tool, it is required to be updated on a yearly basis.[22]

The latest version of PNER is the PNER 2016-2025 issued by virtue of Ministerial Resolution N° 579-2015-MEM/DM dated as of 1 January 2016. PNER 2016-2026 is composed of two (2) parts. Part 1 describes policy and strategies considered for determining the goals and investments to be made to enhance the supply of electricity in rural areas in Peru. PNER 2016-2015 also includes a list of the projects that have been executed by 2015 and a list of the projects to be implemented. According to the information obtained from this document, the projects that are being implemented are the following[23]:

(i) Rural electrification systems:

During 2015 there were 31 projects developed. These projects involved the building of new distribution facilities and for maintaining or enlarging the existent

[21] Cfr. Articles 12 and 13 of Supreme Decree N° 25-2007-EM.
[22] Cfr. Article 15 of Supreme Decree N° 25-2007-EM and PNER 2016-2025: Part 2, Section 11.
[23] PNER 2016-2015: Part 1, Section 4.

distribution facilities. Around 142,623 rural communities are going to benifit from the development of these projects.

(ii) Projects financed by the World Bank and other entities:

- FONER I: In 2007 the Peruvian government obtained a loan from the World Bank that was coupled with the donation made by some distribution companies and governmental funds. Altogether, this enabled the government to run a rural electrification project that made it possible to create 105,000 distribution connections and that ultimately benefited 446,000 rural inhabitants.

- FONER II: The Peruvian Government obtained a second loan that made it possible to keep working on the construction of distribution facilities and some renewable energy facilities, as well.

(iii) Renewable Energy Projects

Currently, the government has entered into six (6) contracts for developing household connection with Solar PV. It is expected to benefit around 6930 families from rural localities. In addition to this, the government implemented a massive program with Solar PV in order to provide electricity to 500,000 houses from isolated rural areas.

For enhancing the completion of the aforementioned projects within a time frame of 10 years, the government has considered that a total investment of US$ 1,272.07 million[24] will be required.[25]

3.3. How Rural Electrification is Funded?

The economic resources for financing rural electrification are the following[26]:

a. Public funds.

[24] The total amount in Peruvian National currency is S/. 4236,4 million. In order to convert this amount to dollar was used an exchange rate of 3.33.
[25] Cfr. PNER 2016-2025: Part 2, Section 11.2
[26] Cfr. Article 7 from Law 28749.

b. International funds.

c. The total amount of the fines imposed by the Peruvian energy regulatory agency (OSINERGMIN) to the electricity companies.

d. Up to 25% of the amount obtained from the privatisation of electricity companies.

e. An amount of 4% from profits obtained from generation, transmission and distribution companies that would be discounted from the income tax owed by these companies.

f. Donations.

g. Resources obtained from any agreement undertaken with regional or local governments, for the development of rural electrification.

h. Contributions made by the clients according to the rules established in the regulatory framework.

i. Any additional income that can be provided by MEM.

In addition, the regulatory framework for rural electrification also promotes private investment through Private-Public Partnerships[27]. In this cases, the Government will pay a subsidy to private investors for achieving any of the following: (i) Preparing feasibility studies for rural electrification projects, (ii) acquisition of equipment required for implementing rural electrification facilities and, (iii) construction of rural electrification facilities.[28]

It is important to mention that by means of Law 27510, the Peruvian government created the Electricity Compensation Social Fund which purpose is to benefit those users that have an electricity demand below to 100 kW per month.[29] This fund works under a cross-subsidy scheme given that it is financed by other electricity users with a larger demand. These users will be charged in their electricity bills with a surcharge that would be equivalent to a minor percentage of their electricity consumption.[30]

[27] Cfr. Article 66 of Supreme Decree N° 25-2007-EM
[28] Cfr. Article 67 of Supreme Decree N° 25-2007-EM
[29] Cfr. Article 1, Law 27510.
[30] Cfr. Article 2, Law 27510.

Currently, rural clients are paying around 20% of the monthly tariff and the rest is paid with the funds coming from the Electricity Compensation Social Fund. However, rural clients do not pay a fixed amount every month given that tariff for rural clients are calculated considering the characteristics of the facilities used for electrification and where they are located.[31]

4. Enhancing Rural Electrification Requirements in Peru by Using Solar PV

Peru has a great potential for developing Solar PV since the country benefits from a high annual irradiation level that ranges from 4.5 kWh/day in the amazon region up to 6.5 kWh/day in the south region.[32]

[31] TORRES LAM, José Eduardo. Electrificación en la zonas más vulnerables del país: Interview to Cesar Horqque, Head of the Rural Electrification Office from the Ministry of Energy and Mines. Revista Electricidad Peru: Energía y Minería. 5th Year. Ed. 16, 2013. p., 23.
[32] Ministry of Energy of Mines and National Service for Meteorology. Peru's Solar Energy Atlas. Lima. 2003. p., 17.

Figure 2. Solar Potential in Peru
Source: Deltavolt. Atlas Solar y Eólico. http://deltavolt.pe/phocadownload/radiacion_anual.jpg (accessed in 12 May 2016)

Although there is a preference for enhancing rural electrification goals by connecting rural communities to distribution facilities, it should be noted that this alternative does not cover or include isolated areas. Furthermore, when comparing grid extension to other alternatives, this

first alternative can be more expensive.[33] Thereto, given the country's specific circumstances, Solar PV becomes an excellent alternative for enhancing rural electrification demand.

4.1. What Has Been Achieved to Cover the Electricity Demand in Rural Areas with Solar PV?

The Peruvian government has been implementing a set of projects based on renewable energy in order to mitigate high costs related to the construction of electricity facilities to connect rural areas to the grid. As a matter of fact, even before Law 28749 was implemented, the Peruvian government launched Solar PV projects in several rural areas in Peru. Those projects were the following[34]:

(i) In between years 1996 and 2002, as part of an international cooperation project with the World Bank, 1523 Solar PV systems for providing electricity in rural areas and for connecting HF radios were installed. These facilities were implemented in 18 departments from Peru and it proved to be an excellent alternative for enhancing rural electrification where extend the grid to those areas was not possible. These Solar PV systems had a capacity of 50 kV and a voltage of 12V.

(ii) In 2007 there was held another international cooperation project which made viable the deployment of 4200 Solar PV systems in four Peruvian regions. In addition, 20 hybrid projects were also implemented. These hybrid installations were composed of one wind turbine with a capacity of 100W and a small Solar PV system with a capacity of 50W.

[33] The World Bank. The Welfare Impact of Rural Electrification: A Reassessment of the Costs and Benefits. Washington. 2008. p., 22.
[34] TORRES LAM, José Eduardo. *Op.cit.* p., 23.

Number of installed Solar Panels in Peru

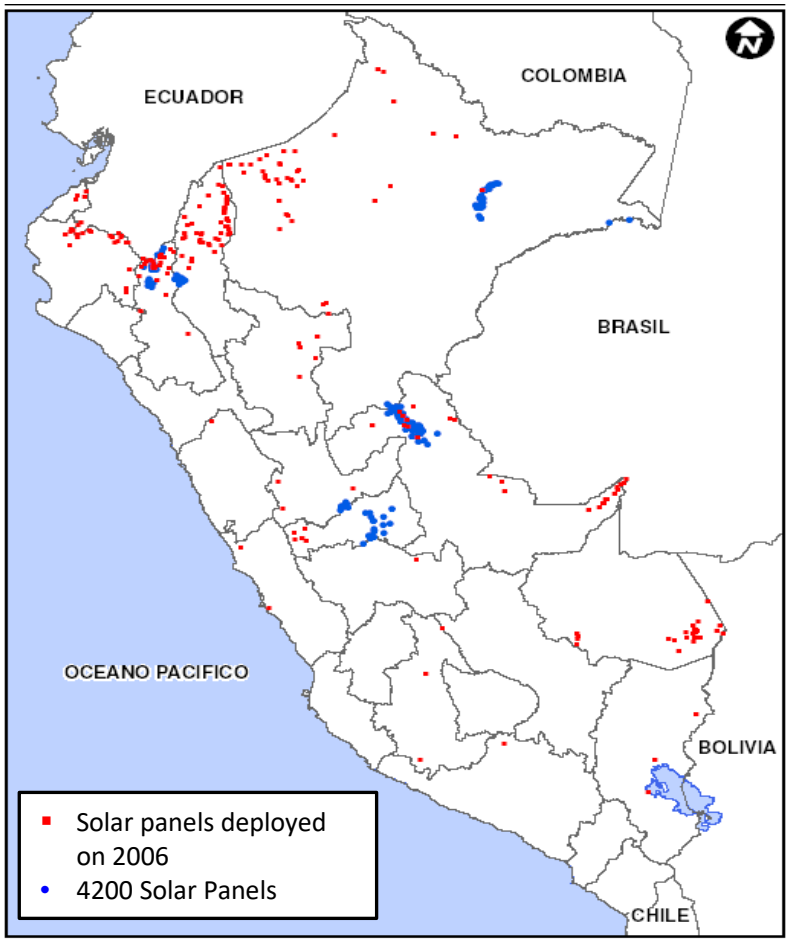

Figure 3. Number of Installed Solar Modules
Source: Rural Electrification General Office. Slide presentation: Rural Electrification in Peru. 2011.

(iii) In 2011 28 projects were implemented in the Amazon region in order to provide electricity supply for enabling the provision of communal services such as entertainment devices, computers, lighting, among others.

(iv) In that same year, the EURO-SOLAR program, as an initiative of the Cooperation Office of the European Union, was also implemented. This program purported to install 130 hybrid facilities composed by a wind turbine of 0.4V and a Solar PV panel of 1.0V for providing electricity for basic use by local families.

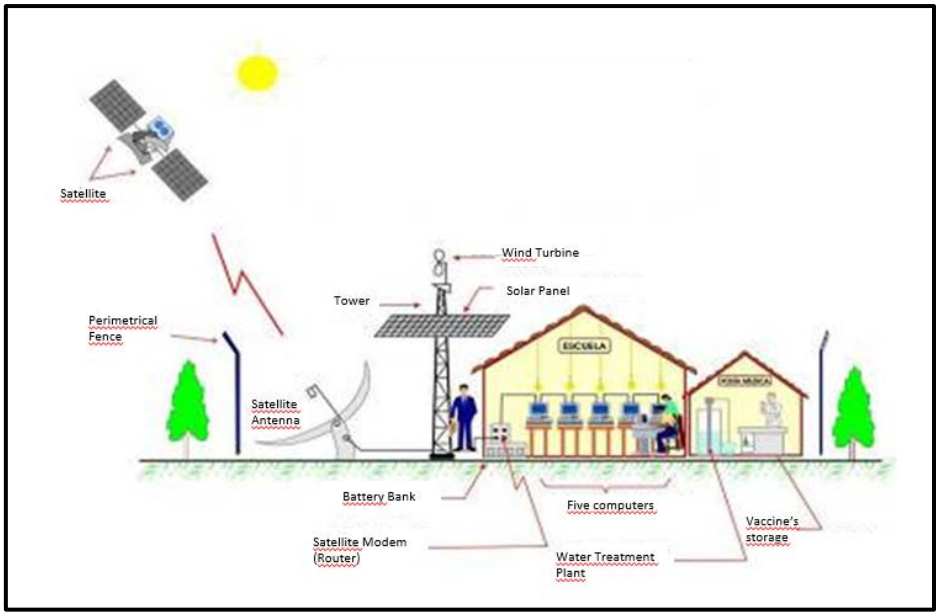

Figure 4. Hybrid facilities model
Source: Rural Electrification General Office. Slide presentation: Rural Electrification in Peru. 2011.

(v) Since 2012, the Rural Electrification Office from MEM has been developing Solar PV projects financed by the Peruvian government and the World Bank. Under these projects, 14,953 Solar PV systems will be installed, which will ultimately benefit around 66,000 people.

(vi) In 2013 the "Massive Program with Solar PV" project was launched to address electricity issues in isolated areas in Peru where it is unlikely that the electricity grid will be extended in the next ten (10) years. This program aims to provide electricity to around 500,000 homes. The characteristics and features of this program are going to be described in the next section.

4.2. Using Solar PV To Meet Demand Requirements in Rural Areas: Off-Grid Auctions

In June 2013, the Peruvian government enacted the Supreme Decree N° 20-2013-EM aimed to govern an off-grid auction system for allocating a set of agreements for the provision of Solar PV in isolated areas in Peru.[35] This auction system will make it possible for rural electrification to be provided by private investment. Furthermore, it will cover additional requirements for

[35] Cfr. Article 2 of Supreme Decree 20-2013-EM.

the provision of rural electrification such as quality of the service, operation and maintenance of the Solar PV facilities, among others. However, in order to make this service attractive to the private sector, the government is providing a subsidy to the awardees of the auction process.

In July 2013 the first auction process was launched which successfully concluded in November 2014. For allocation purposes, MEM decided to divide the national territory into three (3) sections: North, Centre and South. Under these sections were determined the isolated rural areas, seeking that the awardees would be able to provide Solar panels for around 500,000 homes.

For determining the awardees, each bidder is required to file an offer that will represent the tariff that they will charge for the provision of the Solar PV facilities. This price will include installation and operation and maintenance costs for Solar PV facilities to be installed. Those offers that not surpass the reference price set by OSINERGMIN will be awarded under the auction process.[36]

The proposed scheme for this program is to allocate the provision of electricity supply with Solar PV to private investors that will be required to install Solar PV facilities in rural areas. The payment for the service will be collected by the distribution concessionaire, which then will be required to deposit that money in a trust. This trust will have the funds to make payments to the awardees for the service provided. [37]

In the following sections will provide a brief description of how this new program works and what has been achieved up to now.

4.2.1. Contracts and Obligations Underlying the Auction

The purpose of the auction process is to determine, under competitive rules, the companies that can provide electricity supply by using Solar PV technology during a period of 15 years. Once OSINERGMIN chooses the most competitive offers, those awardees are required to enter into two specific contracts:

[36] Cfr. Article 13, Supreme Decree N° 20-2013-EM
[37] Cfr. Article 14, 15, 16 and 16, Supreme Decree N° 20-2013-EM

a. Investment Contract for Providing Electricity Supply with Solar PV[38]

The awardee or investor will enter into an investment contract with the Peruvian government for a period of fifteen (15) years counted from the commercial operation date of the Solar PV facilities.

Under this agreement, the investor undertakes the following obligations:

- Design, build, operate, maintain, and perform any power cut when necessary, replace any panel that can be damaged and to perform any other activity that can be required for the provision of electricity supply to the inhabitants of the rural area that was allocated to a specific investor.

- The Solar PV panels should preserve quality standards established in the Terms and Conditions of the auction process and in the regulatory framework.

- Set a construction schedule, including the commercial operation date for the project.

- Registration of all the potential clients located in their concession area. The clients to be registered would be those that do not have an electricity supply.

- Grant to the government two (2) performance bonds. One of them is for guarantying that the Solar PV facilities will be operating on the commercial operation date set forth in the construction schedule. The other one is for guarantying operation and maintenance activities and should be enforceable until the end of the investment agreement. The first performance bond will be for an amount of US$ 10 Million dollars and the second performance bond will be for an amount of US$ 2 Million dollars.

- By the end of the enforcement term of this Agreement, the investor shall transfer all the Solar PV facilities to the distribution concessionaire.

b. Service Contract for the Electricity Supply with Solar PV

[38] OSINERGMIN. Terms and Conditions for the Off-Grid Auction process 2013. Lima. pp., 50-101.

The Service Contract will be entered into the investor and the distribution concessionaire of the location where the Solar PV facilities will be installed. The investor will be in charge of providing electricity supply to the rural inhabitants and will be in charge of the operation of the facilities. Whilst, the distribution concessionaire will be the one performing the retailing activity, given that it has a direct relationship with the clients. Thereto, the service contract aims to set forth the provisions governing the relationship between the investor and the distribution concessionaire.

4.2.2. *Technology Requirements*

The Solar PV facilities will be required to have the following elements:

- Photovoltaic generator composed of 36 cells with a capacity of 86 Wp.
- Electronic load comptroller with a voltage of 12V.
- Battery with no liquid electrolyte of 12V which requires to have an indicator of the battery level.
- LED lamps of 10Watts and 600 lumens.

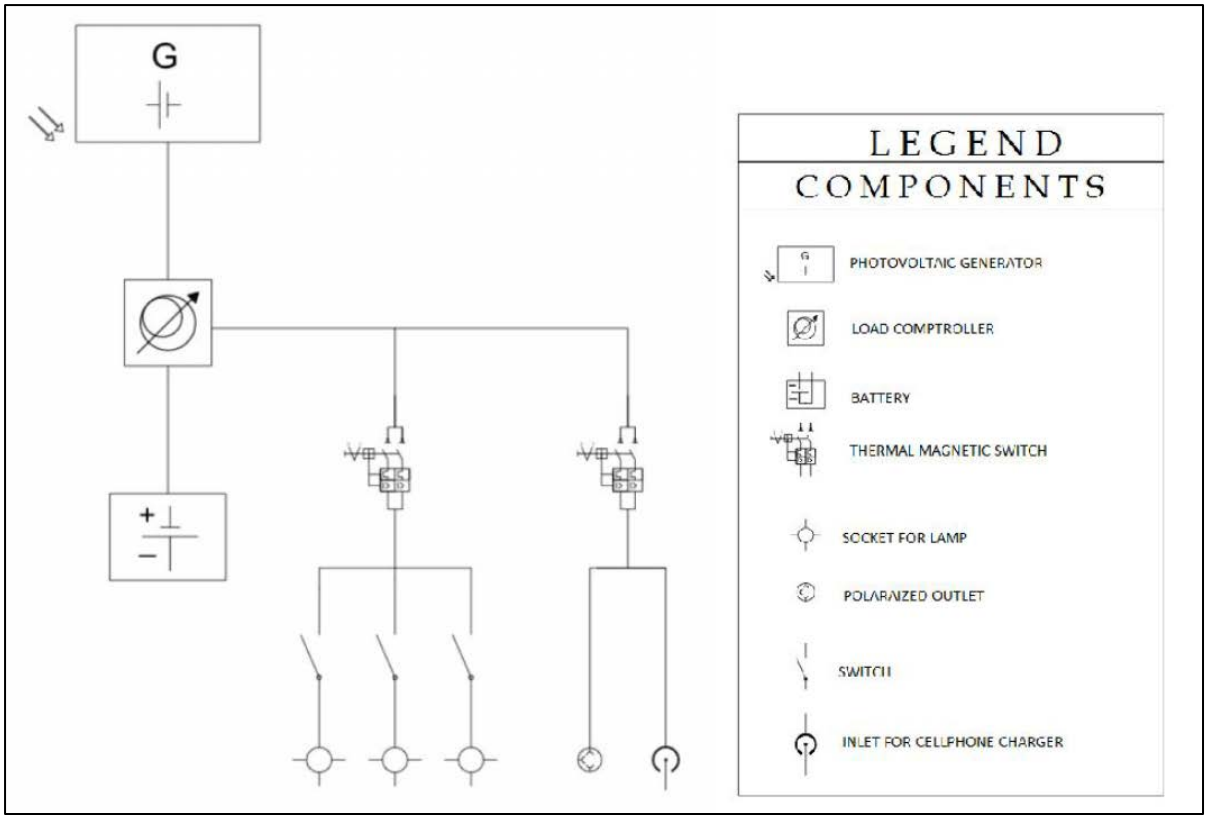

Figure 5. Technical requirements for Solar PV Modules
Source: Terms and Conditions for the Off-grid Auction 2013. p., 92.

4.2.3. Payment Scheme[39]

The investor will be paid according to the amount offered during the auction process. Said amount will be paid by a trust in which the tariff will be deposited. This will be charged to clients and the amounts collected from the Electricity Social Compensation Fund and other funds that will subsidise all the payments owed to the investor.

The distribution concessionaire will be in charge of collecting the tariff paid by the clients and the government will deposit the amounts obtained from compensation and social funds established for meeting the price to be paid to the investor.

According to the minute of the closing date of the auction process, the annual remuneration allocated is the following:

[39] Cfr. Articles 1, 14, 15, 16 and 16, Supreme Decree N° 20-2013-EM

Area	Bidder	Annual Remuneration (US$/Year)
North	Ergon Power S.A.C.	11,351,664.00
Centre	Ergon Power S.A.C.	8,860,950.00
South	Ergon Power S.A.C.	8,370,054.00

4.3. Expanding the Supply of Electricity in Rural Areas: Will Solar PV be a Solution to Meet Expansion Goals?

For the purpose of assessing this question, it is important to address the analysis from a technical, economic and policy point of view.

a. Technical aspect

From a technical perspective, the use of Solar PV for enhancing rural electrification in isolated areas represents a good solution considering the large potential that Peru has for the development of solar energy technologies.[40] As it was abovementioned, Peru has a radiation rate average of 5 kWh/day, which is among the highest radiation rates worldwide.

Furthermore, Solar PV also represents an excellent alternative for isolated areas where it is very unlikely that the grid can be extended in a short period. This alternative can help to shorten the electricity gap in less time.

One other aspect to be considered is that given the current regulatory framework that promotes Solar PV Off-Grid auctions, the quality of the electricity supply is being guaranteed. Other projects that have been deployed for enhancing rural electrification in Peru do not have a proper system that guarantees quality standards of the electricity being supplied. Furthermore, one current issue is the one related to the quality of connection facilities. Nonetheless, according to what has been mentioned in the previous section, this program involves the participation of private investors who will be in charge of operating and maintaining the Solar PV facilities.

[40] Alliance for Rural Electrification. The Peru Off-Grid Market in 12 pages: Players and Business Opportunities. p., 10 http://www.ruralelec.org/fileadmin/DATA/Documents/06_Publications/Market_intelligence/PERU_off-grid_market_12_pages.pdf (accessed on 13 April 2016)

Likewise, they are also obliged to meet the quality requirements set forth in the regulatory framework. This assures that clients will be provided with good-quality service.

b. Economic Aspect

From an economic perspective, providing electricity with renewable energy under an off-grid system can be cost-effective when the cost of grid connection is quite high. Regarding this issue, the World Bank has stated that *"the smaller the community and the further it is from the existent grid, the more expensive the connections are"*[41]. This means that Solar PV will be an excellent and competitive solution for isolated small communities. Hence, when rural electrification connections are required in larger communities, Solar PV may not be the most adequate solution.

In the Peruvian case, the use of Solar PV can have very good outcomes from an economic point of view when it used to provide electricity to isolated rural communities.

c. Policy aspect

From a policy perspective, although Peru does not possess a large regulatory framework for rural electrification, given the recent enforcement of the Supreme Decree N° 20-2013-EM, there is now a regulatory framework that adequately supports the Solar PV Off-Grid Auctions. This policy has established a set of terms that includes technical and economic aspects that are required for incorporating Solar PV for enhancing rural electrification needs.

Accordingly, considering the three (3) perspectives, Solar PV can be a useful technology for meeting electricity demand in those small communities that are far from the existent grid.

5. Conclusion

Rural Electrification has become an important target, specifically in non-develop countries, where meeting electrification goals has introduced a disparity between urban and rural areas. For instance, Latin American countries face a disparity of around 25% when comparing urban electrification to rural electrification.[42]

[41] The World Bank. Op. Cit. p., 22.
[42] ZERRIFFI, Hisham. Op. cit. p., 4.

However, enhancing rural electrification is a challenging goal considering technical and economic constraints related to determining the best alternative to deploy electrification in areas where seems to be impossible to construct distribution facilities due to the fact that communities are isolated and getting access to the terrains where these communities are located is difficult. Likewise, it can also be considered that the demand for electricity is minor in these communities rather than the electricity demand of urban areas.

Throughout the years, rural electrification has gain importance because of a social welfare concern. Governments have become aware of the importance of electricity in those areas given that it will help to improve incomes, community health and educational challenges. Considering the abovementioned situation, it has risen a concern of how to make it possible to provide electricity to rural areas.

There are many possibilities to be deployed in order to meet rural electrification goals. The most popular is the one related to the extension of the existent grid. However, extending the grid is not always a possibility, specifically for isolated communities where it is not cost-effective to provide electricity by enlarging the grid. In these situations, renewable technologies can be considered a better solution.

One of the most successful alternatives for rural electrification with renewable energy can be the use of Solar PV given that it allows for the providing of electricity to small rural communities located in difficult terrains. Furthermore, it can be a cost-effective alternative when comparing the costs related to enlarging the grid to the cost of deploying Solar PV modules in that same area. Nonetheless, it cannot be said that Solar PV can be a suitable alternative for all rural areas because in some specific situations implementing distribution facilities can be considered a better solution from an economic and technological perspective.

In the Peruvian case, there have been outstanding improvements regarding enhancing rural electrification. It is the government's concern to not only provide solutions for those rural communities that can be closer to the grid, but also to enhance rural electrification in isolated areas. In order to achieve such task, an off-grid auction process has been created seeking to engage private investment on rural electrification and to use Solar PV to provide electricity to those isolated communities. The specific results of this measure cannot be assessed yet given that this program has recently been developed. Nonetheless, it provides an excellent option for those small rural communities where access to electricity would otherwise be unavailable.

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