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THE RENEWABLE ENERGY MARKET

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Study

PERU'S RENEWABLE ENERGY MARKET

FIT LIMA

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1. OVERVIEW

Peru is a country whose electricity generation matrix has traditionally been low in carbon emissions, due to the importance of hydroelectric generation. Despite this, Peru continues to have significant energy challenges, to which Renewable Energy Resources (RER) can contribute greatly. For this reason in 2008, the Peruvian State issued Legislative Decree 1002 that promotes investment for the generation of electricity with the use of Renewable Energy Resources (RER)[1].

In 2008, the year in which the promotion of non-conventional renewable energies began, energy production with RER represented less than 0.01% of the total energy produced by the Interconnected Electrical National System (SEIN). However, due to the awarding of new RER projects, this percentage has increased. The Minister of Energy and Mines, Mr. Francisco Ismodes, projected renewable sources will generate 15% of Peru's energy matrix by 2030[2].

EVOLUTION OF ENERGY PRODUCTION WITH RER
(% of the total)

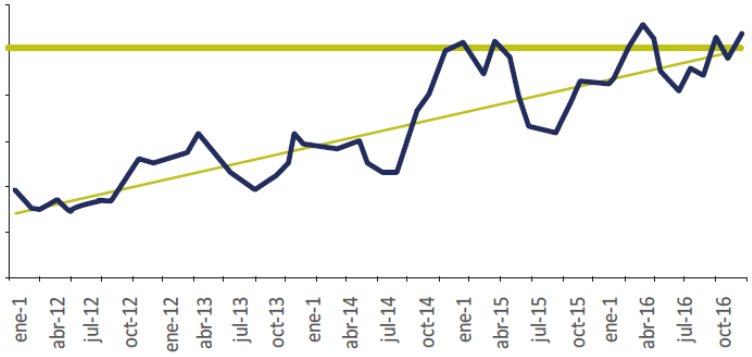


Chart 1: extracted from MINEM and OSINERGMIN. Elaborated by GPAE - OSINERGMIN

Despite the low costs associated with the use of solar and wind energy, in 2018 only 4% of Peruvian energy production came from unconventional renewable energy resources (RER)[3]. It is important to mention that between 2010 and 2017 the cost of solar energy fell by 73%; and that of wind energy by 40%, mainly due to technological progress[4].

[1] Information extracted from OSINERGMIN, Energías renovables: experiencia y perspectivas en la ruta del Perú hacia la transición energética
[2] Information extracted from El Comercio, https://elcomercio.pe/economia/opinion/marchas-contramarchas-promocion-energia-renovable-ines-vazquez-noticia-595517
[3] Information extracted from Semana Económica, https://semanaeconomica.com/article/sectores-y-empresas/energia/341962-spr-ya-no-necesitamos-una-estructura-que-brinde-precios-por-encima-del-mercado/
[4] Information extracted from Semana Económica, https://semanaeconomica.com/article/sectores-y-empresas/energia/339673-generadoras-ya-preparan-proyectos-de-energia-renovable-ante-cambio-normativo/?ref=a-arc

In November 2018, the Ministry of Energy and Mines (MINEM) published a draft Supreme Decree amending Article 110 of the Electricity Concessions Law Regulation, to recognize the Firm Power[5] of wind and solar power plants in the country. Recognizing Firm Power for wind and solar energy means mainly eliminating a regulatory barrier that would enable these technologies to compete on equal terms with traditional electricity generation (thermal and water), to supply clean and cheap energy to users of the regulated and free markets. Its recognition will encourage competition in the sector and, most likely, the construction of numerous renewable plants in Peru. The ministry continues evaluating the norm, after receiving the comments of relevant actors of the sector[6].

2. ELECTRICITY PRODUCTION

In Peru, electricity generation has historically been concentrated in conventional water sources. However, the country's energy matrix has changed in the last two decades. From 1997 to 2003, the share of hydroelectric production was on average 89.7%. From the start of the Camisea Project in 2004, electricity production with natural gas increased, reaching a maximum share of 48% in 2014. It was later reduced by the entrance of the RER plants, whose contribution to total electricity production in 2018 was 7.2%. It should be noted that, although the share of energy generated by hydroelectric plants has decreased compared to the beginning of the year 2000, in absolute terms it has continued to increase due to the fact that total electricity production has a positive growth trend[7].

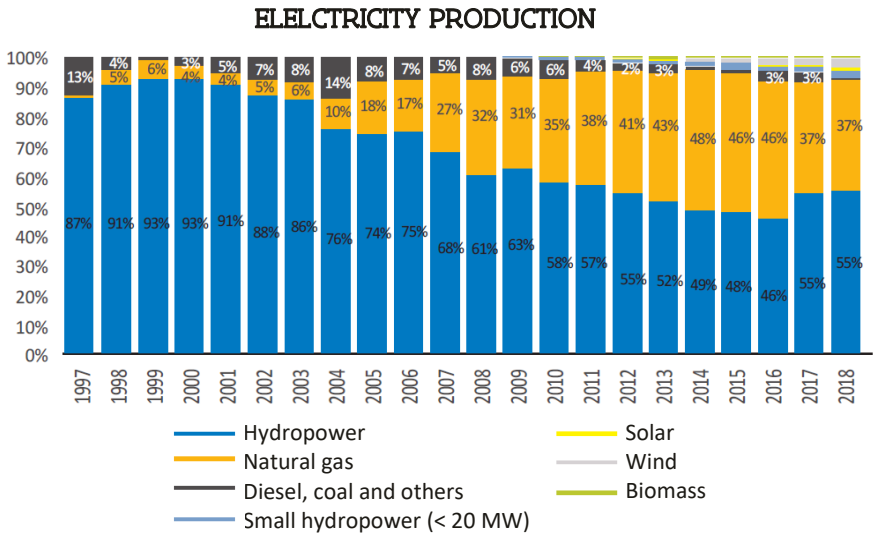


Chart 2: extracted from COES (2019). Elaborated by GPAE-Osinergmin

[5] Potencia firme: plena capacidad de operación eléctrica
[6] Information extracted from Semana Económica and Revista Energia, https://semanaeconomica.com/article/sectores-y-empresas/energia/318346-mem-propone-una-modificacion-regulatoria-que-impulsara-las-energias-renovables/?ref=a-ari
https://revistaenergia.pe/energias-renovables-momento-de-tomar-accion/
[7] Information extracted from OSINERGMIN, Energías renovables: experiencia y perspectivas en la ruta del Perú hacia la transición energética

According to the Committee for Economic Operation of the National Interconnected System (COES)[8], 8.5% of the electricity production in 2019 was generated by renewable energy sources.

ELELCTRICITY PRODUCTION BY ENERGY SOURCE 2019

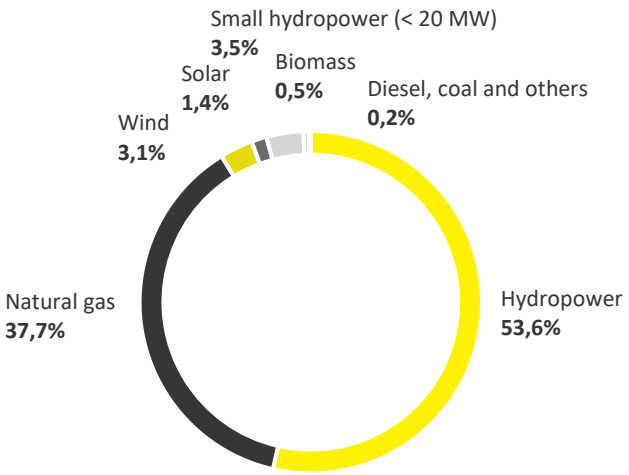


Chart 3: extracted from COES (2019)

3. RENEWABLE ENERGY SOURCES

Peru has a great potential for the generation of electricity based on renewable energy resources. According to the document "Elaboración de la nueva matriz energética sostenible y evaluación ambiental estratégica, como instrumentos de planificación" conducted by the Inter-American Development Bank (IDB) in 2012, the total generation capacity from renewable energy resources by 2040 is expected to be 4,321 MW, which represents 17.3% of the total installed capacity. It is also important to mention that in order to achieve this power, an investment of approximately USD 8 757 million would be required[9].

INSTALLED CAPACITY RER TO 2040

Renewable energy source	Potential (MW)	%
Geothermal energy	1 500	34.7%
Wind energy	1 342	31.1%
Biomass	623	14.4%
Small hydroelectric plants	496	11.5%
Solar energy	360	8.3%
Total	**4 321**	**100%**

Table 1: extracted from the Inter-American Development

[8] Information extracted from the Annual Statistics conducted by COES, https://www.coes.org.pe/Portal/areas/Publicaciones/documentos/capitulo01.htm
[9] Information extracted from MINEM, http://www.minem.gob.pe/minem/archivos/file/DGEE/eficiencia%20energetica/publicaciones/guias/Informe_completo_Estudio_NUMES.pdf

3.1 SOLAR ENERGY

Peru has a great potential for solar energy, thanks to its geographical and climatological characteristics. The greatest potential for solar generation in Peru is found in the northern and southern parts of the country[10]. The average annual radiation of Peruvian regions oscillates between 3.3.kWh/m^2 and above 6.0 kWh/m^2 annually, being Ancash, Arequipa, Lambayeque, Moquegua, Puno and Tacna, the regions with the highest average, and hence, being the regions with the most potential[11].

According to the Renewable Power Plants Map 2019 conducted by COES, Peru has seven solar plants with photovoltaic technology in the regions of Arequipa (2), Moquegua (4) and Tacna (1)[12].

3.2 WIND ENERGY

According to the Wind Atlas of Peru developed by the MINEM in 2016, Peru has an excellent wind resource. Its estimated wind power potential is 20 493 MW[13]. The coasts of Piura, Lambayeque and some areas of La Libertad stand out. The departments of Ancash, Lima and Arequipa also stand out, but the department with the most wind power is Ica[14].

USABLE WIND POTENTIAL IN PERU

Region	Usable wind power potential (MW)
Piura	7 098
Lambayeque	7 017
Ica	2 280
Arequipa	1 020
La Libertad	921
Cajamarca	891
Ancash	708
Lima	429
Amazonas	129
Total	**20 493**

Table 2: MINEM, extracted from Wind Atlas of Peru 2016

According to the Renewable Power Plants Map 2019 conducted by COES, Peru has five solar plants with photovoltaic technology in the regions of Ica (3), La Libertad (1) and Piura (1)[15].

[10] Information extracted from Andina, https://andina.pe/agencia/noticia-peru-tiene-mayor-potencial-generacion-solar-las-zonas-norte-y-sur-772634.aspx
[11] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[12] Information extracted from COES, https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica2019#
[13] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[14] Information extracted from OSINERGMIN, https://www.osinergmin.gob.pe/empresas/energias-renovables/energia-eolica/que-es-la-energia-eolica
[15] Information extracted from COES, https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica2019#

3.3 HYDROPOWER

This kind of energy is possible thanks to three big water sources: the Atlantic basin, the Pacific basin and the Titicaca basin. According to the Hydropower Potential Atlas developed by the MINEM in 2011, the usable hydropower potential is 69 445 MW, with a greater participation of the Atlantic basin (87%)[16].

USABLE HYDROPOWER POTENTIAL IN PERU

Basin	Usable hydropower potential (MW)
Atlantic	60 627
Pacific	8 731
Titicaca	87
Total	**69 445**

Table 3: MINEM, extracted from Hydropower Potential Atlas 2011

In Peru, small hydroelectric plants are those with an installed capacity less than 20MW[17]. According to the Renewable Power Plants Map 2019 conducted by COES, Peru has 29 small hydroelectric plants, located in the departments of Lima (8), Junín (6), Cajamarca (5), Ancash (3), Puno (3), Huánuco (2), Arequipa (1), and Piura (1)[18].

3.4 BIOMASS

Peru has significant potential for untapped biomass waste that can be converted into energy. According to a study on the availability of agricultural residues, it has been estimated that 13 types of crops produce sufficient quantities of residues for the production of electricity. Those crops generate approximately 31 million tons of waste that are then burned or left in the fields[19].

ANNUAL AVAILABILITY OF WASTE, 2005-2011 AVERAGE

Crops	Waste (tons)
Sugar cane	18 967 989
Rice	4 172 540
Hard yellow corn	2 904 397
Palm fruit	1 499 188
Starchy corn	915 928
Corn corn	599 802
Cotton	572 083

[16] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[17] Information extracted from OSINERGMIN, https://www.osinergmin.gob.pe/empresas/energias-renovables/energia-mini-hidraulica/que-es-la-energia-mini-hidraulica
[18] Information extracted from COES, https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica2019#
[19] Information extracted OSINERGMIN, Energías renovables: experiencia y perspectivas en la ruta del Perú hacia la transición energética

Asparagus	499 400
Coffee	337 486
Wheat	251 682
Barley	236 006
Grapes	34 265
Olive	22 027
Total	**31 012 793**

Table 4: extracted from Mitigation Momentum (2015)

There are three major regions where biomass presents an interesting potential to be used for medium energy purposes and great power: the northern coast (sugarcane bagasse, rice husk, hydrobiological waste); the high jungle (coffee husks, forest residues); and the low forest (forest residues). According to the report "Sustainable energy production from biomass waste in Peru" (NAMA proposal November 2015) the potential of biomass in Peru is estimated between 450 to 900 MW. In Lambayeque, Lima and Loreto, sugar cane contributes a substantial share to the total waste-to-energy generation potential. In Junín, primary energy is almost exclusively related to cotton, whereas in Amazonas, Puno and Tacna, residues from rice can be an important source of energy[20].

According to the Renewable Power Plants Map 2019 conducted by COES, Peru has 6 biomass plants, located in the departments of Lima (4), Piura (1) and Ancash (1)[21].

3.5 GEOTHERMAL ENERGY

There is great potential for this energy in the volcanic chains of southern Peru[22]. Based on the Master Plan for the Development of Geothermal Energy in Peru conducted by the Japan International Cooperation Agency (JICA) in 2012, there is a geothermal potential close to 3 000 MW[23].

Peru has more than 156 identified geothermal areas, more than 200 hot water runoffs, many vents and some geysers with temperatures near the 100°C (212°F). The greatest geothermal potential of Peru is found in six geothermal regions: Cajamarca, Huaraz, Churín (Lima, Pasco and Huánuco), Central Zone (Huancayo, Huancavelica and Ayacucho), Volcanic Zone (Ayacucho, Apurimac, Arequipa, Moquegua and Tacna), Puno and Cusco[24].

According to Brendan Oviedo, president of the Peruvian Society of Renewable Energy, in addition to wind and solar energy, there is great potential in geothermal energy, especially in the south of the country. The development of projects of this type takes a little longer due to the fact that exploratory excavations have to be done. However, unlike wind or solar energy, geothermal can operate 24 hours a day. Currently

[20] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[21] Information extracted from COES, https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica2019#
[22] Information extracted from OSINERGMIN, https://www.osinergmin.gob.pe/empresas/energias-renovables/energia-geotermica/que-es-la-energia-geotermica
[23] Information extracted from JICA, https://openjicareport.jica.go.jp/pdf/12048567.pdf
[24] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y

their costs are a bit high, but technological advances can reduce them, as happened with wind and solar energy[25].

According to the Committee for Economic Operation of the National Interconnected System (COES), to December 2019 Peru has 47 renewable power plants[26]. The following map shows where each of those power plants are located:

[25] Information extracted from Semana Económica, https://semanaeconomica.com/article/sectores-y-empresas/energia/341962-spr-ya-no-necesitamos-una-estructura-que-brinde-precios-por-encima-del-mercado/
[26] Information extracted from COES, https://www.coes.org.pe/Portal/publicaciones/estadisticas/estadistica2019#

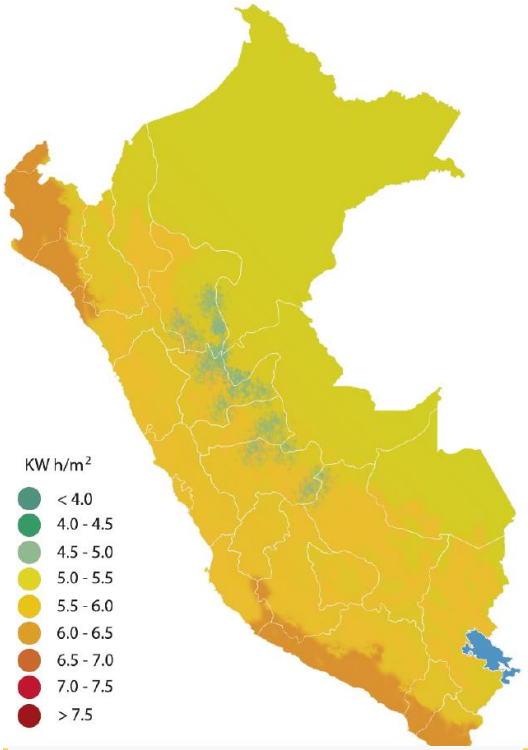
RENEWABLE POWER PLANTS MAP 2019

Image 1: extracted from COES (2019)

Peru has a huge capacity for electricity generation with renewable energy. The following images show Peru's Renewable Energy Potential Maps:

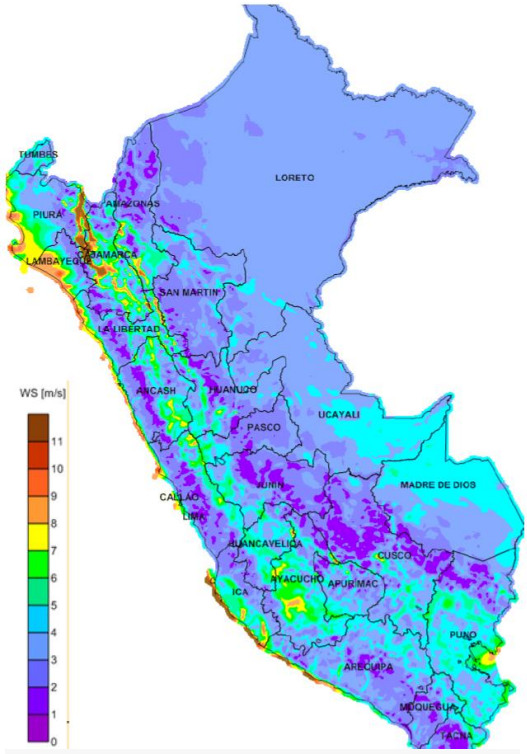
PERU'S RENEWABLE ENERGY POTENTIAL[27]

SOLAR POTENTIAL



Based on the Solar Power Atlas 2003, the solar potential of Peru varies according to the zone:
Highland: 5.5 - 6.5 kWh/m²
Coast: 5.0 - 6.0 kWh/m²
Jungle: 4.5 - 5.0 kWh/m²

WIND POTENTIAL



Based on the Wind Atlas 2016, the wind power potential of Peru is **20 493 MW2**.
In 2017 there was 236 MW of wind power. With the entry of Wayra I (126 MW), the wind potential throughout the SEIN raises to 362 MW.

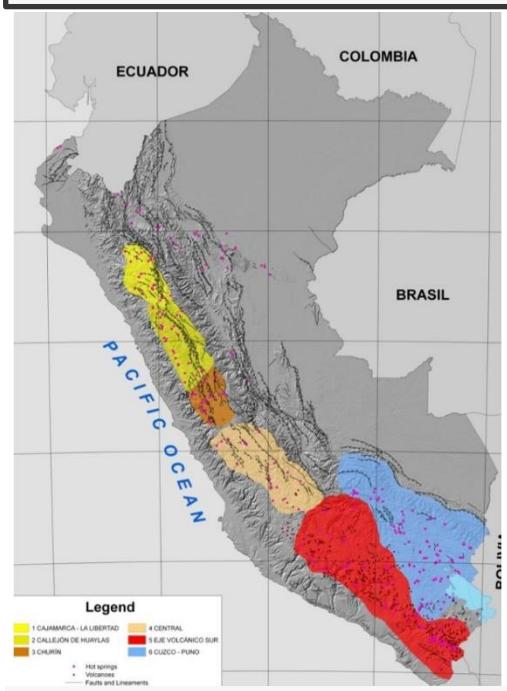
Image 2: Images extracted from MINEM, Panel: Aspectos regulatorios de las energías renovables en el Perú

[27] Information extracted from MINEM, Panel: Aspectos regulatorios de las energías renovables en el Perú

HYDROPOWER POTENTIAL

Based on the Hydropower Potential Atlas 2011, the usable hydropower potential is **69 445 MW**

GEOTHERMAL POTENTIAL



Based on the Master Plan for the Development of Geothermal Energy in Peru 2012, there is a geothermal potential close to **3 000 MW**

BIOMASS POTENTIAL

According to the report "Sustainable energy production from biomass waste in Peru" (NAMA proposal November 2015) the potential of Biomass in Peru is estimated between **450 to 900 MW**

Image 3: Images extracted from MINEM, Panel: Aspectos regulatorios de las energías renovables en el Perú

4. RENEWABLE ENERGY AUCTIONS

In Peru, the promotion of renewable energies is carried out through auctions administered by the Supervisory Agency for Investment in Energy and Mining (OSINERGMIN). An auction is a market mechanism that has an explicit set of rules for the allocation of resources and where the prices are based on the bids (offers) submitted by the participants. The rules of an auction define the winner, the payments and the behavior of the participant during the auction process. Based on the renewable law, enacted in 2008, at least one auction should be held every two years[28].

For purposes of these auctions, the MINEM states an energy objective to be reached by each kind of energy source. The main incentives for these auctions are that the awarded corporations have priority on the supply and sale of electricity by the COES, priority on the access to distribution and transmission grids and long term stable prices determined by auctions[29].

Regarding the bid selection process (Procedimiento de adjudicación de la subasta RER on-grid)[30], the four main steps are:

1. Bids are sorted by price offered, starting with the lowest. Bids exceeding the maximum price established by the regulator are rejected.
2. If the total energy (MWh) offered is less than the required energy, it is awarded.
3. The maximum price is revealed only if the required energy was not fully covered and if there were offers that exceeded the maximum price.
4. If the energy offered exceeds the required energy, it is verified if there is a partial award (only if the price offered is below the maximum price).

BID SELECTION PROCESS

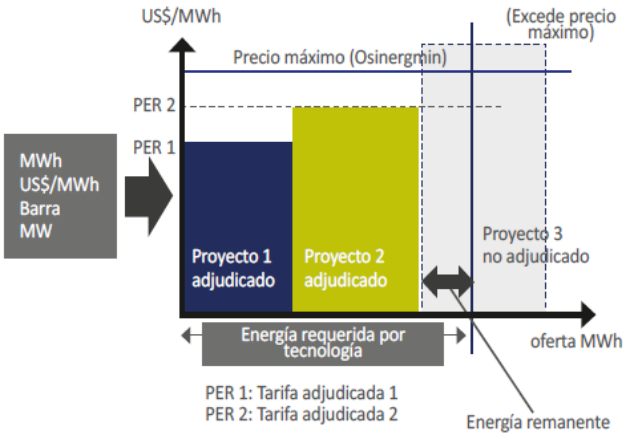


Image 4: Images extracted from OSINERGMIN. Elaborated by OSINERGMIN.

[28] Information extracted from OSINERGMIN, La industria de la energía renovable en el Perú: 10 años de contribuciones a la mitigación del cambio climático
[29] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[30] Information extracted from OSINERGMIN, La industria de la energía renovable en el Perú: 10 años de contribuciones a la mitigación del cambio climático

The image above shows that projects 1 and 2 will be awarded since they offer prices below the maximum price set by OSINERGMIN and their energy offered is less than that required. In this case, the maximum price is revealed since the energy required has not been fully covered. A partial award of Project 3 is not considered because its price exceeds the maximum price set. In the event that the auction is declared partially deserted, it must be reconvened within a period of no more than 30 days after said declaration in order to complete the energy required. On the other hand, if it is declared totally deserted, a new process is called[31].

It is important to mention that the conditions for the auctions are established by the MINEM and the process is hosted by OSINERGMIN, which also sets the maximum prices and calculates the applicable premium annually[32].

From 2009 to today, four RER auctions have been held for the Interconnected Electric System (SEIN) and one off-grid RER auction[33]. The following table provides a summary of all four RER auctions hosted by OSINERGMIN, in which a total of 64 projects were awarded:.

SUMMARY OF THE RENEWABLE ENERGY AUCTIONS IN PERU FOR ON-GRID POWER

Main characteristics			First Auction (2009-2010)	Second Auction (2011)	Third Auction (2013)	Fourth Auction (2016)
Projects	Projects submitted		56	25	24	131
	Projects awarded		27	10	14	13
Energy (GWh)	Required		4 380.0	1 981.0	1 620.0	1 750.0
	Offered		3 810.0	2 894.2	1 763.7	19 650.6
	Awarded		1 971.6	1 152.7	1 277.9	1 739.2
Prices (USD/MWh)	Solar	Average price offered	243.3	186.3	-	57.4
		Minimum awarded	215.0	119.9	-	48.0
		Average awarded price	221.1	119.9	-	48.1
	Wind	Average price offered	89.7	75.4	-	50.5
		Minimum awarded	65.5	69.9	-	37.8
		Average awarded price	80.4	69.9	-	40.4
	Biomass	Average price offered	63.6	71.3	-	77.0
		Minimum awarded	52.0	100.0	-	77.0
		Average awarded price	63.5	100.0	-	77.0
	Hydropower	Average price offered	60.0	55.6	59.6	47.3
		Minimum awarded	55.0	47.4	50.5	44.0
		Average awarded price	60.0	53.2	56.4	46.3

Image 5: extracted from OSINERGMIN. Elaborated by GPAE - OSINERGMIN.

[31] Information extracted from OSINERGMIN, La industria de la energía renovable en el Perú: 10 años de contribuciones a la mitigación del cambio climático
[32] Information extracted from Peru Oil & Gas Investment Guide 2019 – 2020, conducted by E&Y
[33] Information extracted from OSINERGMIN, Energías renovables: experiencia y perspectivas en la ruta del Perú hacia la transición energética

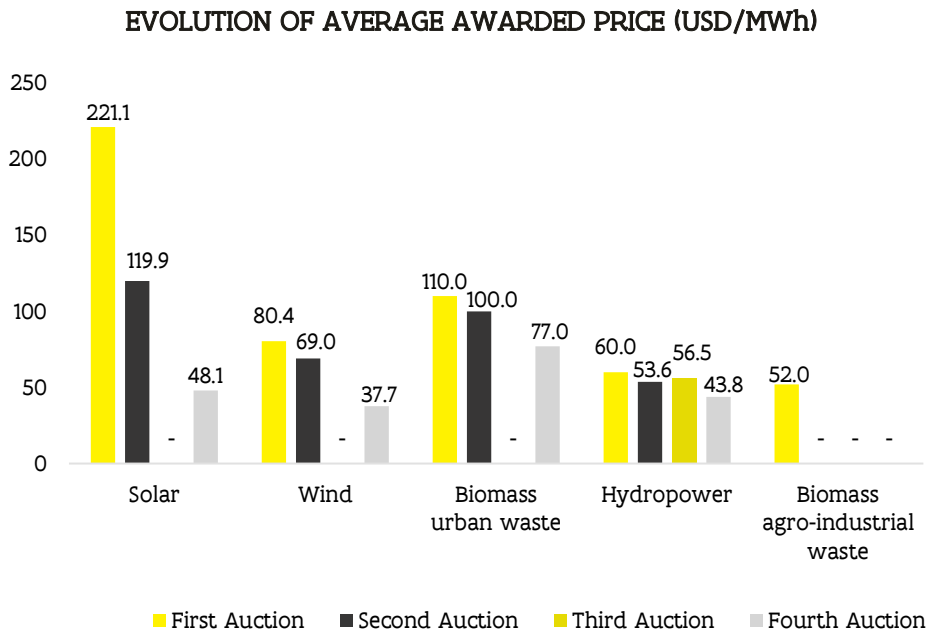


Chart 4: extracted from OSINERGMIN. Elaborated by GPAE - OSINERGMIN)

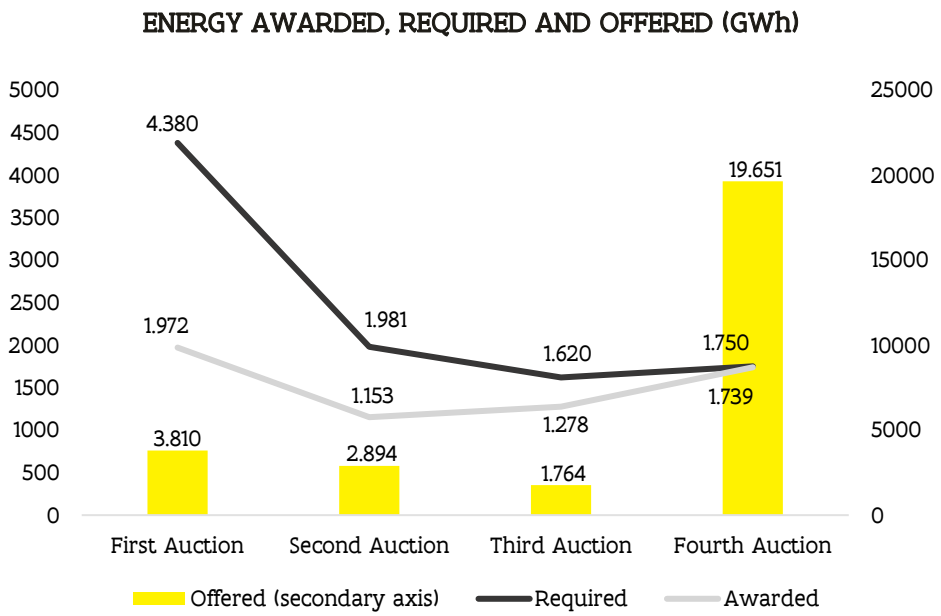


Chart 5: extracted from OSINERGMIN. Elaborated by GPAE - OSINERGMIN)

For more information related to auctions, please review the following link:
http://www.osinergmin.gob.pe/empresas/energias-renovables/subastas

5. RELATED INSTITUTIONS

- MINISTRY OF ENERGY AND MINES (MINEM)
  T.: (+511) 411 1100
  http://www.minem.gob.pe/
  Address: Av. las Arte Sur 260, San Borja

- SUPERVISORY AGENCY FOR INVESTMENT IN ENERGY AND MINING (OSINERGMIN)
  T.: (+511) 219 3400
  http://www.osinergmin.gob.pe/
  Address: Calle Bernardo Monteagudo 222, Magdalena del Mar

- SNMPE NATIONAL SOCIETY OF MINING, OIL AND ENERGY (SNMPE)
  T.: (+511) 215 9250
  http://www.snmpe.org.pe/
  Address: Francisco Graña 671, Magdalena del Mar

- PERUVIAN SOCIETY OF RENEWABLE ENERGIES (SPR)
  https://spr.org.pe/
  Address: Avenida Manuel Olguin 335 Of 1302, Surco

- COMMITTEE FOR ECONOMIC OPERATION OF THE NATIONAL INTERCONNECTED SYSTEM (COES)
  T.: (+511) 611 8552
  http://www.coes.org.pe/portal/
  Address: Calle Esquilache 371 oficina 1301, San Isidro

6. RELATED EVENTS

- CONGRESO ENERGÍA (PERUVIAN ENERGY SUMMIT)
  https://congresoenergiaperu.com/

- EXPO ENERGÍA PERÚ
  https://www.expoenergiaperu.com/

- PERÚ ENERGÍA
  https://peruenergia.com.pe/

7. SOURCES OF INFORMATION

OSINERGMIN

- http://www.osinergmin.gob.pe/empresas/electricidad/publicaciones
- http://www.osinergmin.gob.pe/empresas/energias-renovables/introduccion-energias-renovables/que-son-las-energias-renovables
- http://www.osinergmin.gob.pe/empresas/energias-renovables/tecnologias-rer/introduccion
- http://www2.osinerg.gob.pe/EnergiasRenovables/contenido/IntroduccionEnergiasRenovables.html
- https://www.osinergmin.gob.pe/seccion/centro_documental/Institucional/Estudios_Economicos/Libros/Osinergmin-Energia-Renovable-Peru-10anios.pdf
- https://www.osinergmin.gob.pe/seccion/centro_documental/Institucional/Estudios_Economicos/Libros/Osinergmin-Energias-Renovables-Experiencia-Perspectivas.pdf

MINAGRI

- http://www.minagri.gob.pe/portal/45-sector-agrario/recurso-energetico/337-energia-renovable

SNMPE

- https://www.snmpe.org.pe/informes-y-publicaciones/boletin-estadistico-mensual/electrico/
- https://www.snmpe.org.pe/informes-y-publicaciones/boletin-estadistico-mensual/electrico/5491-boletin-estadistico-mensual-electrico-febrero-2019.html

MINISTRY OF ENERGY AND MINES (MINEM)

- http://www.minem.gob.pe/_detalle.php?idSector=6&idTitular=638&idMenu=sub115&idCateg=350
- https://foroenergia.com.pe/downloads/9.%20Rosendo%20Ramirez.%20AspectosRegulatorios-RER-DGEE-MINEM-201118.pdf
- http://dger.minem.gob.pe/

COES

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