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DEVELOPMENT OF GEOTHERMAL ENERGY AND FACTORS THAT AFFECT ITS UTILIZATION IN PERU

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ABSTRACT

The objective of this paper is to demonstrate the potential of geothermal resources in Peru, the barriers which limit its development, and to propose actions that could promote the development of geothermal energy in Peru through the improvement of geothermal energy and Renewable Energy Resources legislation, to improve the mechanisms that encourage investment for the development of geothermal projects, training of human resources in geothermal energy, and action management of the central government, regional governments, and all the entities that are involved in these processes.

1. LEGAL BASIS

There are several laws and decrees that apply to geothermal development in Peru:

- Law Nº 26848, Organic Law of Geothermal Resources;
- Supreme Decree Nº 019-2010-EM, which approves the Regulation of the Organic Law of Geothermal Resources;
- Decree-Law Nº 25844,Electric Concessions Law;
- Supreme Decree Nº 009-93-EM, Regulation of the Electric Concessions Law;
- Legislative Decree Nº 1002, Promotion for the investment in the generation of electricity through the use of renewable energy; and
- Supreme Decree Nº 012-2011-EM, Regulation of Generation of Electricity through Renewable Energy.

In the aforementioned regulations, the role is established for the State and the private sector to execute any electrical activity in general and particularly renewable energy within which geothermal energy is considered.

To develop geothermal energy, we have established the granting licenses for the exploration of geothermal resources and the granting of concessions for the exploitation of these resources. The exploration consists of a period of three years. In the first phase (which lasts for two years), superficial studies must be done and in the second phase (which lasts for one year), at least three wells with a depth of 1000 meters must be drilled. An environmental study should be approved and a sub-surface fee must be paid in order to enter this phase.

2. BACKGROUND

An overview of the history of geothermal exploration in Peru can be summed up as follows:

- 1970: development began on the project "Assessment of Geothermal Potential of Peru" by the Geological Survey of Peru (INGEOMIN), currently INGEMMET, undertook studies to explore geologically and geochemically the geothermal manifestations, in order to assess the true geothermal potential of the country.
- 1979–1986: Geothermal recognition studies were conducted in southern Peru to identify the areas of interest.
- 1986: Geochemical investigations were carried out between the departments of Tacna and Moquegua with technical assistance from the International Atomic Energy Agency (IAEA) and the United Nations.
- 1994: The geovolcanic study and systematic inventory of geothermal manifestations of the Tutupacalot were performed.
- 1995: An evaluation study was performed in hydrothermal areas in Pampas de Kallapumaand surrounding areas.
- 1996: "Analysis of geochemical data from geothermal areas in the South East of Peru" was conducted with the support of the Electrical Research Institute (IIE) of Mexico.
- 2007-2009: Geothermal explorations of two pilot projects were developed with Japanese cooperation to build geothermal plants: Calientes and Borateras fields.
- 2009-2012: The Master Plan for Geothermal Energy Development was developed with support from JICA (Japan).

The pre-feasibility studies conducted by the international consulting firm West Japan Engineering Consultants in the Borateras and Calientes geothermal fields, located in the south of the country consisted of geological, geochemical, and geophysical exploration, and an engineering evaluation of both fields and demonstrated that they have considerable potential and that the former is within an Regional Reserve Area and the second is partially inside it.

The second investigation that was done was the Master Plan for Development of Geothermal Energy in Peru.It goal was to formulate a master plan to mark the path of development of geothermal energy in Peru, develop a database of potential geothermal resources, perform an economic evaluation, plan optimal development for the generation of electricity, and transfer of technical knowledge to the staff of the counterpart by the same consulting firm through international technical cooperation with the Japan International Cooperation Agency (JICA), whose final report was submitted in May of this year.

3. THE ROLE AND SIGNIFICANCE OF GEOTHERMAL ENERGY

The importance of geothermal energy consists of the following:

- Geothermal energy is not part of the current energy matrix in Peru, but according to the Law of Renewable Resources, is an important alternative for generating electric power, and this is complemented by the Geothermal Energy Act and its Regulations.
- Geothermal energy is important but it is still not a priority given that Peru has other alternatives for energy from renewable sources such as hydroelectric generation.
- It is important to provide training to human resources so that the country is technically capable of developing geothermal energy.
- Due to the sustainable economic growth that Peru is experiencing, which in turn generates increased demand for electric power in the economic sectors, geothermal energy will contribute to diversify the energy matrix from a new renewable energy resource in order to achieve a supply of energy within a framework of sustainable development.

- The goal is to be self-sufficient in the production of energy and have an energy sector with a minimal environmental impact and low carbon emissions, allowing savings on fuel or non-renewable resources such as oil and natural gas in electricity production.
- Potential sources of geothermal energy are being identified, which when added to the existing promotional regulatory framework(which is designed to attract private investments in energy) will make possible the construction of power plants based on this technology.
- An important aspect of geothermal energy is its variety of uses, not only in power generation but for heating and other uses of geothermal heat.

The advantages are:

- There is an explicit regulation for geothermal energy, although for the moment it is only intended for the production electric power.
- There is great geothermal potential and a master plan that directs investment in identified areas.
- There is active private sector participation in the exploration of geothermal resources, something that requires a large and high risk initial investment.
- There is a Geological Metallurgical Mining Institute (INGEMMET) that has preliminary prospective studies, which guide the actors in the development of geothermal energy.

The disadvantages are:

- The slow pace of the environmental authority in defining the environmental instruments to be developed for Phase II of the exploration, which involves drilling.
- The lack of more knowledge in some state entities regarding the scope of geothermal energy. This causes development geothermal development in areas that are within national reserves or protected areas to not receive support. Among these entities we have the National Water Authority, the National Service of Protected Areas, and corresponding entities of regional governments, among others.
- The non-participation of the State in the direct management of the development of a geothermal project, mainly in the drilling phase.
- Lack of skilled professionals in geothermal energy and non-existence of a specialty in this area within Peruvian universities.

4. CURRENT STATUS OF GETHERMAL DEVELOPMENT

4.1 Status of the electrical sector in Peru

Geothermal development is not present in the energy matrix because it is only in the exploration stage. There have been three auctions of energy from Renewable Energy Resources (RER) which currently consists of generating from solar origin and the first wind farms are expected to be installed this year.

At present the total installed capacity of the country is 10,900 MW, of which about 32% is hydroelectric. Also, the total energy production is 43,400 GWh, of which 55% is hydropower. Geothermal development is not present in the energy matrix because it is only in the exploration stage. The distribution of effective power potential is shown in Figure 1.

4.2 Geothermic potential in Peru

The final report of the Master Plan for Development of Geothermal Energy in Peru developed with the support of JICA concludes that Peru has abundant geothermal resources, with an estimated potential of 2 860 MWe situated in different geothermal fields, mostly located in the southern part of the country.

Moreover, that plan shows the following results: selection and determination of sequence of development for 10 promising fields for geothermal development, geological and geochemical information and detailed estimate of the potential in these fields, analysis of demand and transmission network to establish geographical position and time of the entry of geothermal plants, prediction and evaluation of environmental impact and geothermal development database.

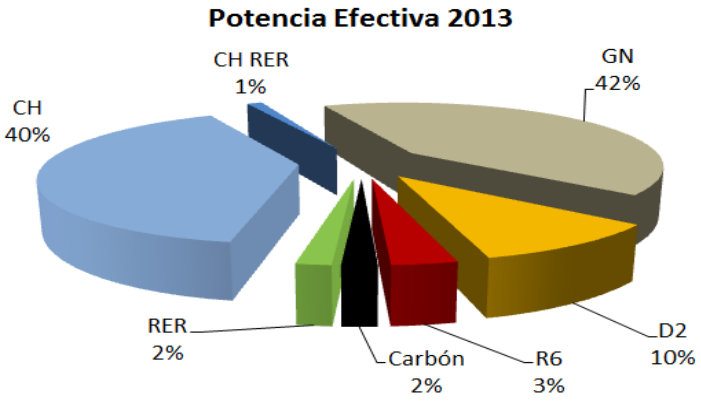

FIGURE 1: Effective power potential in 2013

The Master Plan has divided the country into six regions, from the geothermal potential point of view as indicated in the map presented in Figure 2.

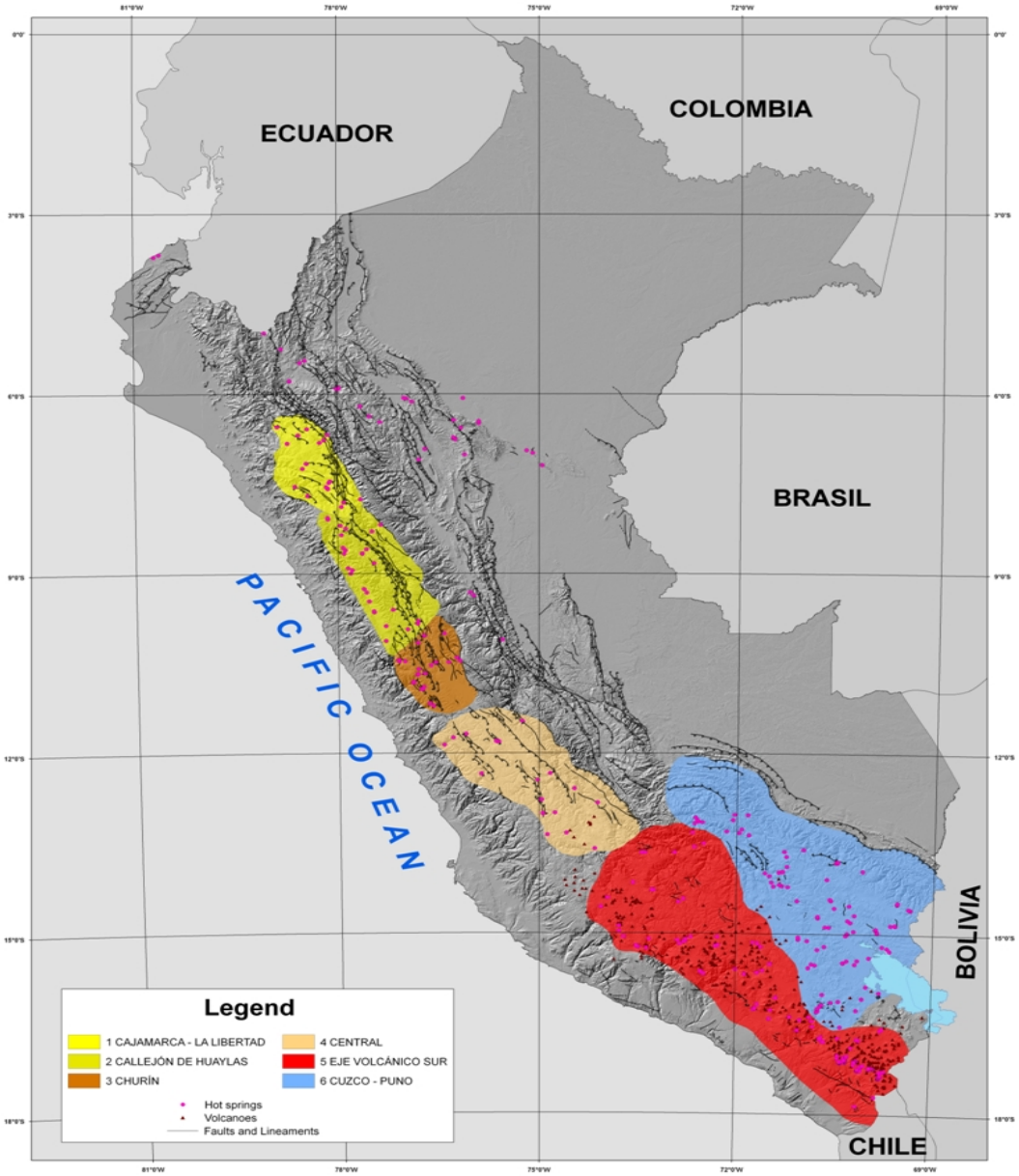

FIGURE 2: The six geothermal regions of Peru as delineated in the Master Plan

Considering the regions presented in the map, the geothermal potential is distributed as shown in Figure 3.

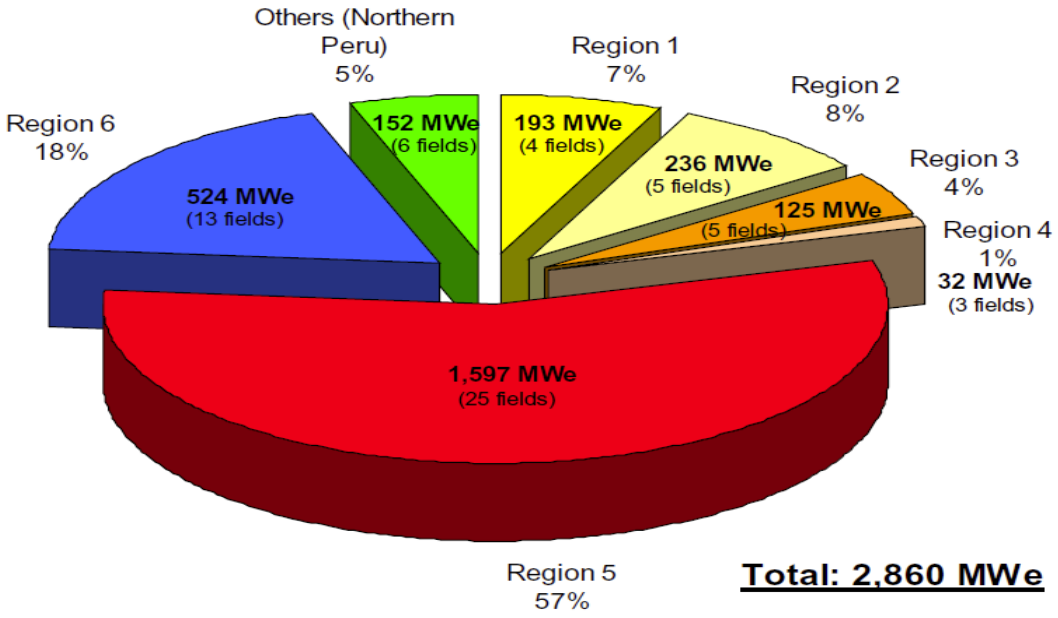

FIGURE 3: Geothermal electricity generation potential of the six geothermal regions of Peru

4.3 Granted geothermal licenses

Currently, only the private sector is participating in the development of geothermal generation and to date, 32 licenses have been granted for the exploration of geothermal resources to the following companies: Magma Energía Geotérmica Perú (Magma Geothermal Energy Peru), Hot Rock Perú S.A. (Hot Rock Peru Inc.), Eco Energy Perú S.A.C. (Eco Energy Peru Inc.), and Andes Power Perú S.A.C. (Andes Power Peru Inc.), Geotérmica Quellaapacheta Perú S.A. (Quellaapacheta Geothermal Peru Inc.), Enel Green Power Perú S.A. (Enel Green Power Peru Inc.), and EMX Geothermal Perú S.A.C. (EMX Geothermal Peru Inc.). For further information on individual licenses, see Appendix I.

5. BARRIERS TO THE DEVELOPMENT OF GEOTHERMAL ENERGY

The following barriers are present to geothermal development in Peru:

- The initial investment cost to build a geothermal generation plant (exploration and drilling phase) is too high compared to other sources of as well as the price of energy at Bus Bar cost (which affects the final rate) that prevents the State from providing financial resources to build a geothermal plant, leaving it to the private sector.
- The risk involved in finding resources and high initial cost of geothermal development itself could possibly prevent further development by the private sector, therefore it is necessary to consider other options such as improvements to the existing legal framework.
- Consultation with indigenous communities or peoples, pursuant to the Prior Consultation Act, will mean a delay in the development of geothermal resources exploration, and more so at the operation stage because it is a new experience and because of the politicization of community social sectors.
- The environmental license for geothermal projects does not clearly define what type of environmental study must be developed for Phase II of the exploration when drilling should be carried out, nor for the exploitation stage. Added to this time it takes for approval of the environmental study that is determined by the corresponding entity.

- The location of geothermal fields within protected areas or conservation areas prevent their development, as is the case Calientes field within the Regional Conservation Area Vilacota-Mauri, and Boraterasfield that affects a part of this area.
- The absence of a strong human resource base capable of developing geothermal energy, such as the lack of specialists in the exploration and exploitation of geothermal resources, and insufficient exchange of information between government institutions.
- No criteria have been established for technical evaluation regarding the methodology, parameters and standards.
- Lack of awareness of the benefits of geothermal energy development in the country on the part of the authorities of the Central, Regional, and Local Governments.

6. POLICIES TO INCREASE THE USE OF RENEWABLE ENERGIES

One of the objectives of the Government is to encourage the use of non-conventional renewable sources in electricity production, so much so that auctions are conducted every two years to cover 5% of demand with renewable energy, but geothermal energy has not participated yet.

Within this, the government has set a target for 2019 for 5% of the energy demand to be supplied by renewable energy, including geothermal energy.

The policies that the government can propose to promote the use of renewable energies in general and geothermal energy in particular are as follows:

- Adopt TUPA (Single Text for Administrative Processes) in the Ministry of Energy and Mining in the processing of geothermal licenses.
- Strengthen the organizational structure of the state in the development of geothermal energy.
- Initiate the process for the definition of environmental instruments for geothermal activities before the environmental authority.
- Initiate the process for the compatibility of geothermal projects in regional conservation areas or protected areas.
- Regulate the process of prior consultation established by Law No. 29785, Law of the right to prior consultation with indigenous or local peoples, recognized in the Convention No. 169 of the International Labor Organization and the Regulations approved by Supreme Decree No. 001-2012-MC in order to do it in the shortest possible time if it is required.
- Approve the list of goods and supplies required by the holders of geothermal licenses, in coordination with the Ministry of Economy and Finance.
- Disseminate the results of the Master Development Plan from Geothermal Energy Peru, prepared under the auspices of JICA.
- Review the regulation for promotion of renewable energy and consider improving them further for better development of geothermal energy (percentage share of renewable energy, time limits for renewable energy auctions, etc.).
- Review the regulation of geothermal energy to introduce the improvements necessary to encourage geothermal projects.
- Promote training courses on geothermal energy at the national level, especially in the southern region of the country.
- Promote the creation of a geothermal engineering specialty with the help of national universities and the College of Engineers of Peru.
- Enter the geothermal projects into a future Energy Auctions for Renewable Energy Resources to ensure the sale of energy to the rate awarded.
- Have an energy matrix that is diversified, competitive, and with emphasis on renewables and energy efficiency.
- Encourage private investment in the development of renewable energy, such as the

exploration and exploitation of geothermal energy by providing economic and tax incentives (with no guarantee in Phase I and exemption from taxes on imported supplies, anticipated recovery of VAT).

7. CONCLUSIONS

From the previous discussion, the following can be concluded:

- Geothermal energy in the country is at an early stage of its development by the private sector, who have the responsibility to continue investing despite the risk this poses.
- Geothermal energy is not a priority in the country's energy matrix, since it has other resources such as hydroelectricity, but it is important because of its multiple uses.
- The main barrier to the development of geothermal energy is the high risk and a significant initial investment in the drilling phase, which results in high rates in relation to other renewable resources.
- An important policy of the government would be the support the development of geothermal energy in the initial phase.
- Peru has great geothermal potential in the southern part of the country according to the Master Plan for the Development of Geothermal Energy, which was developed with support from Japan.
- The main geothermal fields are located in regional reserve areas, and therefore, regional governments should reconsider the priorities of development in relation to natural resources and the needs of their people and country.

APPENDIX I: License holders to geothermal resources in Peru

Nº	Licensee	Zone (Geothermal field)	Location	Directorial resolution	End of studies
1	ANDES POWER PERÚ S.A.C.	TUTUPACA	Tacna	010-2011-EM/DGE (2011.03.18)	2015.07.12
2	ECO ENERGY S.A.C.	GERONTA II	Ayacucho	027-2011-EM/DGE (2011.05.19)	(*)
3	ECO ENERGY S.A.C.	UMACUSIRI I	Ayacucho	028-2011-EM/DGE (2011.05.19)	(*)
4	ECO ENERGY S.A.C.	UMACUSIRI II	Ayacucho	029-2011-EM/DGE (2011.05.19)	(*)
5	ECO ENERGY S.A.C.	GERONTA I	Ayacucho	030-2011-EM/DGE (2011.05.19)	(*)
6	ECO ENERGY S.A.C.	PINAYA I	Puno	002-2011-EM/DGE (2011.02.04)	(*)
7	ECO ENERGY S.A.C.	PINAYA II	Puno	003-2011-EM/DGE (2011.02.04)	(*)
8	ECO ENERGY S.A.C.	PINAYA III	Puno	036-2011-EM/DGE (2011.05.19)	(*)
9	HOT ROCK PERÚ S.A.	RUPHA	Ancash	006-2011-EM/DGE (2011.02.12)	2015.03.01
10	GEOTÉRMICA QUELLAAPACHETA PERÚ S.A.	QUELLAAPACHETA	Moquegua	031-2011-EM/DGE (2011.04.06)	2015.03.01

Nº	Licensee	Zone (Geothermal field)	Location	Directorial resolution	End of studies
11	HOT ROCK PERÚ S.A.	CHOCOPATA	Puno	012-2011-EM/DGE (2011.03.18)	2015.03.01
12	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	LORISCOTA	Moquegua Puno	022-2011-EM/DGE (2011.04,13)	2015.02.01
13	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	CRUCERO	Moquegua Puno	025-2011-EM/DGE (2011.04.13)	2015.02.01
14	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	PASTO	Tacna Moquegua	034-2011-EM/DGE (2011.07.15)	2015.12.28
15	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	SARA SARA	Ayacucho y Arequipa	055-2011-EM/DGE (2011.09.14)	(*)
16	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	PANEJO	Moquegua	060-2011-EM/DGE (2011.09.14)	2015.12.11
17	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	ATARANI	Tacna Moquegua	076-2011-EM/DGE (2011.09.22)	2015.12.24
18	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	SUCHE	Tacna	092-2011-EM/DGE (2011.11.30)	(*)
19	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	TUTUPACA NORTE	Tacna Moquegua	091-2011-EM/DGE (2011.11.30)	(*)
20	HOT ROCK PERÚ S.A.	TURU	Arequipa Cusco	099-2011-EM/DGE (2011.12.05)	2015.07.05
21	HOT ROCK PERÚ S.A.	ACHUMANI	Arequipa	217-2012-EM/DGE (2012.10.17)	2016.02.22
22	ECO ENERGY S.A.C.	PINAYA I V	Puno	239-2012-EM/DGE (2012.12.12)	(*)
23	ECO ENERGY S.A.C.	PINAYA V	Puno	240-2012-EM/DGE (2012.12.12)	(*)
24	ECO ENERGY S.A.C.	PINAYA VI	Puno	249-2012-EM/DGE (2012.12.18)	(*)
25	ENEL GREEN POWER PERÚ S.A.	CARMEN	Ayacucho	009-2013-EM/DGE (2013.02.07)	(*)
26	HOT ROCK PERÚ S.A.	HUISCO	Ayacucho	010-2013-EM/DGE (2013.02.15)	2016.08.20
27	ENEL GREEN POWER PERÚ S.A.	CHILATA	Moquegua	067-2013-EM/DGE (2013.04.19)	(*)
28	EMX GEOTHERMAL PERÚ S.A.C.	TAMBOCHACA	Pasco	074-2013-EM/DGE (2013.04.26)	(*)
29	EMX GEOTHERMAL PERÚ S.A.C.	PUMAHUIRI	Ayacucho	075-2013-EM/DGE (2013.04.26)	(*)
30	EMX GEOTHERMAL PERÚ S.A.C.	SENGATA	Ayacucho	076-2013-EM/DGE (2013.04.26)	(*)
31	EMX GEOTHERMAL PERÚ S.A.C.	COROPUNA	Arequipa	146-2013-EM/DGE (2013.05.26)	(*)
32	MAGMA ENERGÍA GEOTÉRMICA PERÚ S.A.	PINCHOLLO LIBRE	Arequipa	278-2013-EM/DGE (2013.07.07)	(*)

1 Transfer RD 061-2013-EM/DGE, Pub. 12-04-2013

(*) Awaiting for approval of the instrument of the environmental management document accrediting that it is not necessary (DS Nº 015-2013-EM)