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Argentina Country Update

Abel Hector Pesce

SEGEMAR, Geothermal Department, Av. J. A. Roca 651, 8 Floor, Sect. "10" (1322), Buenos Aires, Argentina

apesce@minplan.gov.ar

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1. INTRODUCTION

Argentina continues producing a marked development of geothermal resources in recent years due to the discovery of new thermal areas associated with sedimentary basins which correspond to the conductive hydrothermal systems and progress in the research of high enthalpy thermal fields. This has allowed the development of new therapeutic (recreational complexes) that generate a new economic alternative for different regions of the country and an encouraging panorama is foreseen regarding the implementation of a power generating plant again. Figure 1 show projects of high enthalpy where investigations continued the advanced degree in low enthalpy. In this aspect it can be observed how projects whose studies begun in the last decade today are in exploitation or in development stage. The incorporation of new thermal areas where the pre-feasibility was completed marks the continued development of geothermal energy in Argentina. Even though the possibilities of power generation are favorable, as shown in some projects, by now it is necessary to continue working in order to create proper conditions that will allow the establishment of international companies, which in partnership with national companies, can move to development and production stages.

	Advance grade	Province	Project name	
High Enthalpy	Production (1)	Neuquén	Copahue with well	
	Development (2)	Neuquén	Domuyo	
		Jujuy	Tuzgle	
	Pre-feasibility (4)	San Juan	Los Despoblados	
		Santiago del Estero	Termas de Río Hondo	
		Mendoza	Los Molles	
			Peteroa	
Low Enthalpy	Development (10)	Córdoba	Chazón	Chaco-Paraná Basin
			Mar Chiquita	
		Corrientes	San Roque	
		Misiones	Wanda	
			2 de Mayo	
		Buenos Aires	Ramallo	
			Tigre	Salado Basin
			Navarro	
			Las Flores	
			Chascomus	
	Production (4)	Buenos Aires	Tapalqué with well	
			Dolores with well	
		Corrientes	Curuzú Cuatiá with well	Chaco-Paraná Basin
			Monte Casero with well	

Figure 1: Advance grade of thermal Projects in Argentina during the last five years

However, in a high enthalpy, continues studying new areas (Termas de Río Hondo) with very interesting perspectives. In low enthalpy, by its diversification in numerous thermal basins, the relative low investment of their projects compared to power generation, the short time in which occurs the return on investment and the orientation of the resource to the direct use (balneology), continues with a marked development of low temperature geothermal resources. The scenario remains encouraging, since in recent years, projects more advanced passed the production stage and eleven new areas (Figure 2), are being evaluated, characteristic that marks the continuous development of geothermal energy in the Argentina.

2. HIGH ENTALPHY: PROJECTS ORIENTED TO POWER GENERATION

During the last years, few advances have been produced in most of the geothermal fields oriented to power generation. Stands out on this scene, an old thermal known as Termas de Rio Hondo which is located in the province of Santiago del Estero (Figure 2) where possibility of electricity generation is presently being evaluated.

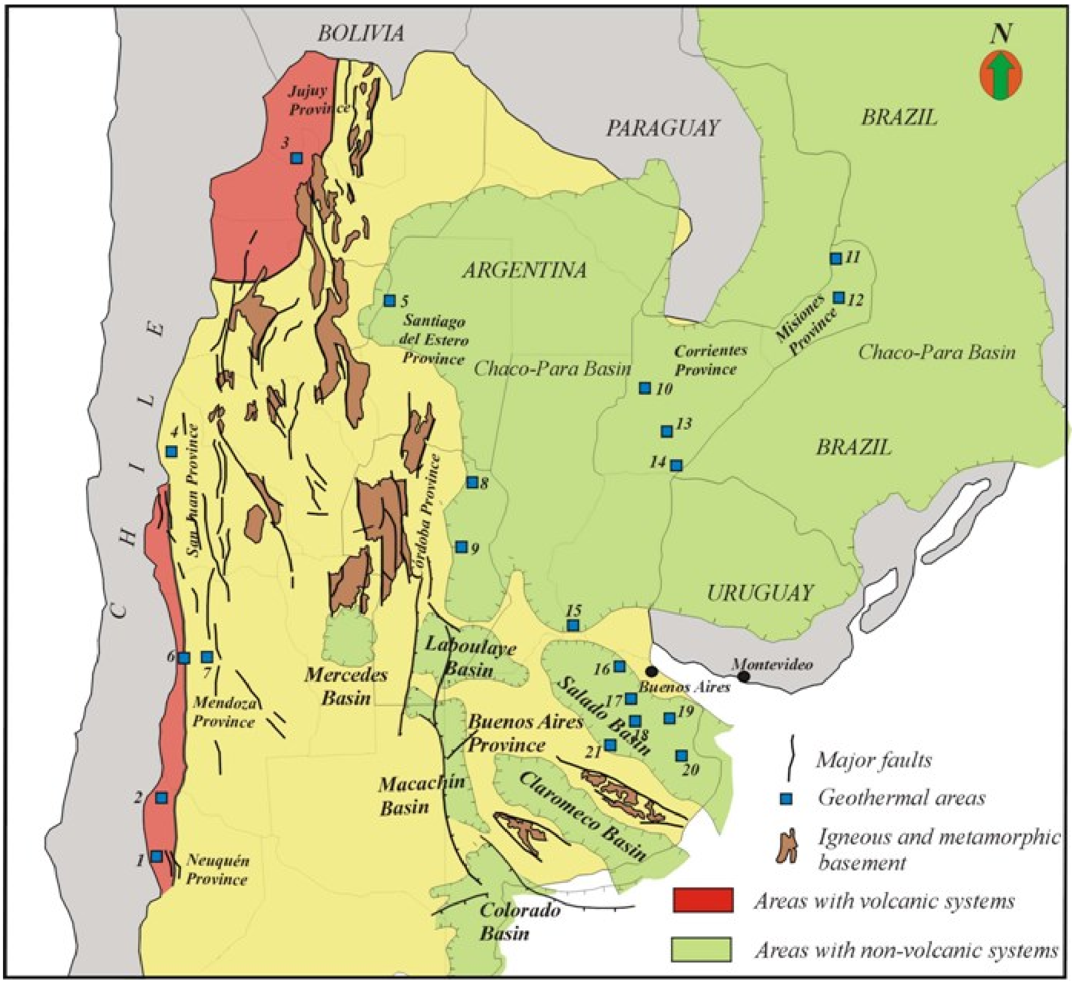

Figure 2: Distribution of thermal projects with different advance grade during the last five years: 1 Copahue, 2 Domuyo, 3 Tuzgle, 4 Los Despoblados, 5 Termas de Río Hondo, 6 Peteroa, 7 Los Molles, 8 Mar Chiquita, 9 Chazón, 10 San Roque, 11 Wanda, 12 2 de Mayo, 13 Curuzú Cuatiá, 14 Monte Casero, 15, Ramallo, 16 Tigre, 17 Navarro, 18 Las Flores, 19 Chascomus, 20 Dolores and 21 Tapalqué.

2.1 Copahue Geothermal Field

This field is located on the western border of Argentina and Chile in Neuquén Province (Figure 2). Five years ago it has been stated that a) the conclusion of the potential evaluation of the area indicated that it could generate electricity for 30 years, using the existing steam of approximately 1,200 m deep with a capacity of 30 MW as the generation size of the plant and b) government of the province of Neuquén, through the Agency for the promotion and the development of investments of the Neuquén (ADI-Nqn), was calling a public bid for private investors interested in building and operating a future plant for the generation of electrical power of 30 MW, with an investment of 100 million US dollars. The electric energy produced would be sold in the wholesale electricity market and transported through the already existing system of 33 kVa. The Canadian company Geothermal One was awarded with the tender, but in August of 2013 decided to withdraw. The company, according to the Secretary of Energy, explained the following three reasons: 1) the recovery of YPF, by the National State, which generated an uncertain panorama for the company, 2) the currency exchange control was one of the determining factors and 3) finally the impossibility of the transfer of utilities was the third argument. At the company withdrawal, ADI Nqn rescinded the contract and executed the guarantee that was presented by the company to do so.

2.2 Domuyo Geothermal Field

This geothermal field is located to the North of the province of Neuquén, 36° 48' south latitude and 70° 38' west longitude (Figure 2). Among the new studies made, it was emphasized an integral review of all the available information of the area (Pesce, 2013) where it presents an update of the geothermal model of the Domuyo area, and it is pointed out the need for a deep exploratory well in the high geothermal potential area identified by Pesce (1987). It would be followed by the study/analysis of the fluids, cuttings and cores collected from the well and by down-hole geophysical (resistivity, temperature, etc.) measurements. When these investigations are completed, one should have a better understanding of the system and will contribute with the objective of the province to award by a bid the thermal field to a private company. The winner of the lease would have the right to develop it, build power plants, and sell the electricity in the Argentine wholesale market. The Agency for the promotion and the development of investments of the Neuquén (ADI-Nqn) is making public national and international calls since later part of 2012 for the awareness of an exploitation contract of the Project without satisfactory results so far.

2.3 Los Despoblados Project

This thermal field is located in the northwest part in the province of San Juan (Figure 2). A Joint Venture formed by the Empresa de Energia Provincial de San Juan (EPSE), Geothermal Power Inc and Barrick Gold are evaluating their potential. They have carried out drilling five (5) wells at 300 meters deep and magneto telluric studies. The results showed values of the geothermal gradient to be a normal one, indications of active or extinct volcanism were not verified and it doesn't determine the reservoir existence in depth. It is considered, in function to the geophysical studies that the manifestations respond to hydrothermal convection systems, corresponding to low-temperature geothermal.

2.4 Tuzgle-Tocomar Project

This geothermal deposit is located in the southern center of the province of Jujuy (Figure 2) on the border with the province of Salta. Companies Andean Geothermal Power Inc., of Italian origin, with offices in Canada and the Vancouver, together with British Columbia own the rights to exploit this area. In recent years significant progress has not been made. Tuzgle-Tocomar geothermal field is located close to a deposit of lithium and potassium which requires large amounts of energy.

2.5 Peteroa and Los Molles Projects

Both projects are located to the southwest of the province of Mendoza, the first on the border with Chile and the second 150 km more to the east (Figure 2). The Geothermal One (Canadian) companies belonging to the Australian group Earth Heat together with Geo-energy (Argentina) begun with the first tasks of prospecting in both zones. Presently, they have stopped investigations.

2.6 Termas de Rio Hondo Project

In the area of Termas de Río Hondo, which is located on the border of center-west of the province of Santiago del Estero (Figure 2), where a strong anomaly of heat is found, studies began in order to evaluate its geothermal potential. Through a program that consists of 4 stages, ranging from the most expeditious and regional to greater detail, seeks to go reducing the uncertainty, to finally select the most promising area to define a deep exploratory well site. The program aims to assess the future possibilities of electricity generation, in a wide area, where there is a heat anomaly. It is interpreted that in the area there was a thinning of the continental lithosphere between 8 to 12 km (Febrer, et at 1982) and a fracturing that generated, an ascent of the asthenosphere and a regional geothermal gradient between 3.5 and 4 times higher than normal. The first stage geology, structure and geochemistry have been evaluated and using maps of heat curves the most promising area for the second stage was selected. Magneto telluric studies (MT) confirmed the established theoretical scheme. By 2D profiling it provided information of the lithostratigraphy and the bottom of the basin boundary. An area of low resistivity was defined which deepens up to 9.5 km, between two resistive areas that reflect the rise of thermal heat flow coming from the asthenosphere (Pesce, 2014). This information made it possible to delimit a zone more reduced, which has an area of 36 km2, where is planning the development of the next stage. The third stage, which is under execution, is intended to measure variations in the heat flow through gradient wells, to define the location of the deep exploratory well, which is considered to be made up to 2,000 meters in depth. Currently we are measuring temperature variations in 25 wells that have a depth of 100 meters, which were performed within the selected area.

3. LOW ENTALPHY: DIRECT USE-ORIENTED PROJECTS

Continue working with the evaluation and exploitation of the low temperature geothermal resources corresponding to the conductive hydrothermal systems. These are found in large sedimentary basins (Figure 2) which are in close proximity to the large population nucleus that define the city of Buenos Aires and Gran Buenos Aires (more than 20 million inhabitants), allowing to generate a sustainable development in the region. As it has been pointed out over the last 20 years (Pesce, 2000, 2001, 2002, 2005, 2010), the incorporation of thermal fluids into the production process in the region was, and continues to be, a multiplier element of development. Incorporating the geothermal resource, by conducting therapeutic recreational complex, the economic supply has been increased in many cities, located in the Mesopotamia and the Pampa Humeda of Argentina. The complex generated increased tourism, and this, greater well-being in cities i.e., by incorporating the natural geothermal resource that was in the basement of sedimentary basins, the economic equation in the region was modified in a positive way. In the past five years, fifteen (15) areas were worked. In four of these (Dolores, Tapalque, Curuzú Cuatiá and Monte Casero) drillings were carried out and surface facilities were installed, passing them to the stage of production. The first two are located in the province of Buenos Aires, in the area of the basin Cuenca del Salado and the other two, in the province of Entre Ríos in the Chaco-Paranense (Figure 2) basin.

Eleven (11) remaining areas are in development stage. There are five in the wide Chaco-Paranense, distributed in the following way; two (Wanda and 2 de Mayo) in the province of Misiones, one (San Roque) in the province of Corrientes and two (Chazon and Mar Chiquita) in the province of Córdoba (Figure 2). The remaining six (Tigre, Ramallo, Navarro, Las Flores, Chascomus and Pehuajó) are located in the basin Cuenca del Salado, in the area of Buenos Aires province (Figure 2).

4. PROJECTS IN PRODUCTION STAGE

Four new geothermal projects were incorporated into the production process during recent times which are described as follows:

4.1 Monte Caseros Project

It is located in the extreme south east of Corrientes Province (Figure 2), in the field of the Chacoparanense basin. In recent years a deep producing well (980 m) and construction of the Thermal Complex were made. The drilling, which is located in the Guarani Thermal Level, Member of the Paranense Thermal System (Pesce, 2005 and 2010) went through the two Sub-levels; Solari, (upper level) and Oberá. The sandstones of the upper level (F. Solari) have an approximate thickness of 106 meters and begin after crossing 364 m of basalts (F. Serra Geral). The sandstones of the lower level (F. Rivera) were found from the 600 m and have a thickness exceeding the 400 m. On the constructive aspect of drilling started at 20" up to 150 m, casing in 18" and cemented. Then drilling continues with a diameter of 17 ½ inches, completely passing basaltic package at 364 m, penetrating into sandstone between 364 m to 372 m (first thermal level). Once well is put into production, waters are emerging, with a pressure of 3 kg/cm2, with a flow rate of 140 m^3/h. Its chemical composition is of the Bicarbonate-Sodium type and it has an electrical conductivity (EC) of 850 µS/cm, pH between 8 and 8.5 and a temperature of 32°C. From the 372 m an exploratory drilling is executed with a 12 inch rock drill up to 1,035 m and geophysical profiling is made. With the logging results and litho logical profiles review the explanation of the second producer aquifer is established. A casing with 12-¾ inch steel pipe is made from 150 m to 600 m, cementation of the annular space is made between the formation and pipes. The final section between 980 m and 1,035 m is sealed in order to isolate the deep layers of high salinity, remaining a producer aquifer section from 596 m to 980 m. In the approximately 380 m of productive stretch 254 m of filter is placed, divided into seven sections, continuous-slot, 6-5/8 inches in diameter, with an aperture of 1 mm. The thermal water is Sulfated Chloride-Sodium type, has an electrical conductivity (EC) 7,100 µS/cm, a pH of 6.5, temperature of 38°C and 350 m^3/h flow rate and pressure of 2.5 kg/cm^2

4.2 Curuzú Cuatiá Project

It is located in South Central Corrientes province (Figure 2), in the area of the Chacoparanense basin. In recent years drilling took place that came up to 1,050 m, and building of the Thermal Complex started. Drilling went through basalt (F. Serra Geral) 647 m and 403 m in sandstones of the Rivera formation, which correspond to the Guarani Thermal Level, part of the Paranense Thermal System (Pesce, 2005 and 2010). The drilling, which was rotating with direct circulation of mud, began with an exploratory well of 8 inches between 0 m to 1,050 m depth with extraction of samples, to define the litho logical profile. Subsequently realized the geophysical shape up that allowed to determine the main characteristics of the drilling, which had the following steps. The exploration began from 0 to 37 meters in 26 inch, casing in 20 inches and later cemented of the annular space. Then the drilling continued up to 635 meters in 17 ½ inches, with casing at 14 inches and cemented. Drilling continued between 635 m up to 916 m 12-¾ inches pipe is made. Then we took down the pipe production, built in carbon steel and stainless steel and packer of 8-5/8 inch filters. The filters are positioned between 801 m to 901 m, with 5 m of decanting tube at the base until 906 m and cementation between 320 and 635 meters being completely isolated productive aquifer sections reclining in the basalts of the sands which correspond to the Rivera Formation. Thermal fluids, with a static level of 9.9 m above the mouth of the well, are Chloride-Sodium Sulfated type, with a flow of 150 m3/h, electric conductivity (C E) of 18,000 µS/cm, and a temperature between 40°C and 42°C (mesothermal) and a pH of 7.5.

4.3 Dolores Project

It is located in the east-center of Buenos Aires Province, in the area of the basin of El Salado (Figure 2). The basin covers an area of more than 50,000 km2 that extends part on the continental area, in the northern part of the province of Buenos Aires, and part into the sea, with a NW-SE direction. The basin of El Salado was formed by expansion of the crust related to the South Atlantic Ocean opening. It shows a typical geometry of extensional basin of Jurassic Lower Late-Cretaceous period on which lie the cretaceous and tertiary sediments. The basin was developed on an integrated basement Precambrian and Paleozoic metamorphic rocks, including quartzite, schist and gneiss. The stratigraphy sequence begins with the volcanic rocks of lower Cretaceous deposit of the Serra Geral formation. They are generally basaltic coulee with tholeitic composition. Then it continues with a strong deposit of sediments of continental origin of Cretaceous period (Zambrano and Urien, 1970). On these rests the formation General Belgrano, which consists of mostly sandy sediment, medium thickness grain of poor selection, of continental environment neritics of the Chilcas formation of Mastrichtian to Paleocen age, composed of gray-green, reddish and brown colored limonite. During the Eocene to low Oligocene period, continental sediments of Olivos Formation took place. It is constituted almost exclusively by sands of pin-white color, coarse-grained and scarcely conglomerated of continental fluvial environment. It continues with marine sediments from Paraná Formation. Its lithology consists of greenish-grey lime-arcilitas with interspersed sandy lenses. The sequence ends with continental sediments of Quaternary age that correspond to quartz sands deposit from Puelche formation. Geological and geophysical studies determined that thermal fluids can be found in the continental sediments of Olivos Formation, which in the area of Dolores city begin under 300 m. Besides, it was estimated that the drilling would reach 1,060 m deep. Drilling works were executed with petroleum equipment (Oil Well), rotation with injection and direct circulation of mud. Began in 17½ inch up to 35 m; casing at 14 inches and annular space cemented. Drilling continued in 12-1/4 inch until 200 m, in order to prepare the pumping chamber and continue with de-exploration drilling in 8-1/2 inch up to 1,060 m. Once drilling was finished, the well was shaped up throughout its whole development. It was established that the relevant aquifer is reached from 682 m, on sandy sediments fine to very fine with some loamy-clay inserts. 6 inch pipe was taken down between + 0.60 m sbp 200 m bbp (constituting the pumping chamber), followed by a pipe of exploitation of 4 inches, with two sections of pipe filter opening 0.5 mm between the 960 and 1,008 m. and between 1,023 and 1,059 m. Then we proceeded to the parts cementation. Thermal fluids are Chlorinated Sodium type with a high saline concentration 66,500 mg/l TDS, a pH of 7.00 and a temperature of 42°C.

4.4 Tapalqué Project

It is located in the northern center of the province of Buenos Aires, in the basin of El Salado (Figure 2) which is the second basin in importance where new thermal tourism health-oriented projects are being generated. In the previous World Geothermal Congress (Pesce, 2010) the lithostratigraphic characteristics of the region were described, the geo-electrical parameters, litho logical column from underground with the thickness of geologic formations that should go through by drilling to extract thermal fluids to surface facilities. The following is a brief summary of the drilling. This began in 17 ½ inches up to 30 m bbp, where we preceded with the 14 inch casing and cemented. We continued in 12¼ inch up to 200 m section that corresponds to the pumping chamber, where we proceeded with the 10 inch casing and cementing. Then continued drilling in 8 ½ inch to 441 m arriving to the basement. By geophysical shape up, three producer levels were defined and by sedimentologic studies (grading curves) settled the characteristics of the filter. The pumping test, established a flow of 80,000 l/h. The waters, which are semi-emerging, with a static level of less 50 m, are of the Chloride-Sulfated type; Calcium-Sodium. Have a temperature of 31°C (hypothermic), pH of 7.65 and total dissolved solids (TDS) 5,240 mg/l. Today, the first phase of the Therapeutic Thermal Complex has been completed.

5. PROJECTS IN DEVELOPMENT STAGE

In the new eleven projects which geothermal potential is being evaluated, geological and geophysical studies have been made in order to incorporate them into the production process, and depths of the producing aquifer units were determined. All of them, since are found in sedimentary basins, belong to the conductive hydrothermal systems, where must be drilled to arise fluids to surface facilities.

5.1 Chazón Project

It is located in South Central Province of Cordoba (Figure 2) in the area of the Chaco-Paranaense basin. A geological-geophysics model of the investigated area was established, with a column that from top to down presents six geo-electric units, which have a marked uniformity, both in the thicknesses of the layers as well as in the resistive values. The first layer corresponds to a slim bank (7-5 m) moderately resistive (30-20 Ωm) and that it probably corresponds to the unsaturated zone of the subsoil, composed of silt-Sandy to silt sediments. Then continues a thin geological unit (20-50 m, Ωm 7-9) of limonite and arcillitas that is allocated to the Pampa Formation, which rests on thin to thick sandstones of continental atmosphere that belong to the Puelche Formation (110-77 m; 10-13 Ωm). These units are supported by a strong sequence that varies between 530 and 572 meters thick (3.5 – 4.00 Ωm). It is considered that the upper part of this sequence would be arcillitas and silt arciliticos from Chaco Formation representing deposits of continental origin with intinsets of sea water. The bottom part probably corresponds to the Mariano Boedo Formation that is composed of fine to very fine sands from continental environment. This whole group rests on Serra Geral-Tacuarembo Formation which is integrated by feldespat thick sandstones with thin interspersed basalts (440-900 m.; 8.8-13.3 Ωm). As it arises from the bibliography and the various studies that were conducted in the Chacoparanense basin the Serra Geral-Tacuarembo pair, includes the thermal level of the basin. So it is considered, that from the 688 meters starts the thermal aquifer, in the field of study, which would extend to depths ranging between 1230 to 1600 meters. This episode was described in Pozo de YPF Ordóñez, (50 km to the north) where it has been possible to identify through cuttings and electric records, six basaltic flows separated between them by sedimentites. Each mantle thickness varies between 8 m and 92 m. It is considered that the final drilling depth could be between 950 to 1050 meters. Its waters are of the chloride-Sodium type, with marked salinity and the temperature would be in the order of 39°C to 41°C

5.2 Miramar Project

It is located in the northwest corner of the province of Cordoba, in the area of the Chacoparanense basin. Geothermal studies could have established a geological-geophysical model of the investigated area. Six geo-electrical horizons were determined to a depth of penetration of approximately 1,700 meters, locating thermal levels suitable to be exploited from the 850 meters. The first layer is a thin bench (8.0 m) moderately resistive (3.8 Ωm) and that it probably corresponds to the unsaturated zone of the subsoil, composed of silty to silty-sandy sediments.

Continue geological units of limonite and arcillitas (1.3 - 1.6 Ωm; 38 - 25 m) which is allocated to Pampa Formation , which rests on thin to thick sandstones of continental environment (5.4 – 8.3 Ωm; 134-160 m) that are allocated to the Puelche formation. Sediments, probably siltstones and clays of the Paraná Formation are at a lower level (2.0-3.6 Ωm; 178-233 m.) which would correspond to a reducing marine environment. These are supported by a strong sequence of 500 to 650 meters thick which is considered corresponding to arcillitas and arciliticos silt (0.78 - 0.95 Ωm) of the Chaco Formation, representing deposits of continental origin with insets of sea water. From 850 meters Serra Geral – Tacuarembo pair Formation is identified. Low resistivity of the basalts of the Serra Geral Formation (49.3 Ωm) is indicating presence of an inset between lava banks and continental sandstones. Typical event of a basin edge where the effusive cycle with the continental cycle combines. Therefore, from the lithoestratigraphycal interpretation it is considered that in the Miramar region from 850 meters begins an appropriate lithology that would indicate presence of a thermal aquifer. According to the geothermal study, it is considered that the final depth of drilling would be in the order of 950 meters. Waters would be of the chloride-Sodium type, with marked salinity and the temperature would be in the order of 39°C to 41°C.

5.3 Wanda Project

This project is located in Northwest sector of the Misiones Province (Figure 2) in the area of the basin Chacoparanense and nominated by a thick volcanic sequence integrated by multiple lay banks of the Serra Geral Formation. A thick lava sequence was established in the area of study, corresponding to the Paranense Thermal System of 940 m in thickness supported on sandstone of the F. Rivera, probably corresponding to the thermal Oberá sub-level. The sedimentary unit is of eolic origin and going towards its lower terms pass to deltaic and lacustrine fluvial deposits that contain abundant fresh water. The geophysical studies allowed distinguishing within the basalts of the Serra Geral Formation, four geo-electrical units that respond to different degrees of alteration and texture of the basalts. The first unit responds to thin banks (25.0 m) quite meteorized because of their greater exposure to atmospheric agents. True resistivity values are 144.30 Ωm, corresponding to a poorly developed soil. The second unit corresponds with a thin layer of basalt on the order of 65 meters, which is presented with a marked alteration. In this unit it is probably some pyroclastic interspersed and some level of water that decreased its resistivity value (171Ωm). A thick unit of 300 m of massive basalts continues, with a low fracturing degree and reliable resistivity in the order of 526 Ωm. The fourth layer is a powerful and well-defined electrical horizon, good lateral correlation and without noticeable facial changes. True resistivity values are around 356 Ωm and would be basalts with probable inset sands and aquifer sandstones. The average thickness of this unit is 557 m. The fifth geo-electrical unit would be represented by sandstones with a resistivity of the order of 75 Ωm, defining a low salinity aquifer environment. The roof of the sands, host of thermal aquifers, would be located below the 940 m of basaltic flows and it is estimated that approximately one hundred meters of depth, should penetrate into this sedimentary sequence. The aquifer would be of fresh water type, and can probably present a low mineralized with a temperature of the 39°C to 41°C.

5.4 2 de Mayo Project

The project is located in the centre of the province of Misiones (Figure 2) in the field of the Chacoparanenase basin and since it is found in the same geological environment as the Wanda Project, it has similar lithostratigraphic characteristics. The investigation also differentiated four units within the Serra Geral formation basalts, with different resistivity and thicknesses values and a fifth geo-electrical unit which is interpreted correspond to producing sandstones. The first geo-electrical unit corresponds to a slim body (15 m), local character, which has a very high resistivity value (540 Ωm) that would correspond to a very massive and compact basalt. Below this a second thin geo-electrical unit (15 to 20 m) is presented, of massive basalts bodies, without fractures with resistivity values of approximately 370 Ωm. The third unit corresponds to a thick sequence of 300 meters of altered basalts flows, with probable inset of piroclastitas or sandstone with some probable content of water (142 Ωm). The fourth electric horizon is a powerful body (657 m) that would not present sediments or piroclastitas. Resistivity values are of the order of the 415 Ωm corresponding to a massive and rather compact body. The fifth horizon with a resistivity of the order of 60 value Ωm, defines saturated sandstone in water of the Rivera and Tacuarembó Formations. Its resistive values are similar to those set forth in other studies carried out in the area. The roof of this unit is located below the 970 m and would be carriers of fresh waters of low salinity, with a temperature that would be around the 41°C.

5.5 San Roque Project

It corresponds to another project that is located within the Paranense Thermal System that is located in the west centre of the province of Corrientes (Figure 2), where the study made points out a marked lithological uniformity in its stratigraphic column. This begins with thin banks (5–10 m) moderately resistive (7-13 Ωm) that corresponds to the unsaturated zone of the subsoil, composed of silt-sandy to silty sediments. Then a unit (83-92 m) continues, which corresponds to medium to fine sandstones, partly limonite, from continental environment, which is awarded to the Ituzaingó and/or Pampa Formation. At a lower level (56-96 m) there are sediments, probably limonite and clays of the Paraná formation which would correspond to a regression marine environment. And in part Entre Rios Formation (14-18 Ωm). These are supported by a powerful sequence of 630-730 meters thick. It is considered that the upper part of this sequence would be arcillitas and silt arciliticos from Chaco formation representing deposits of continental origin with sea water (1.6-2.0 Ωm). The bottom part probably corresponds to the Mariano Boedo Formation that is composed of fine to highly fine sand of the continental environment. This whole rests on the Rivera - Serra Geral Formation pair found interdigitation. The vulcanite (F. Serra Geral) consist of an amount not well determined of sediments (F. Rivera) and tholeiitic basalts flows consists mainly of quartz, sometimes very silicified sandstone. The fissure character lavas, which are linked to the opening of the Atlantic Ocean, originated the basalts of the F. Serra Geral during the upper Jurassic and lower Cretaceous in a concomitant with the deposition of continental sediments of the Rivera Formation. Lithostratigraphic model developed in the area of San Roque is in concordant harmony with numerous geothermal studies and drillings carried out in the Chacoparanense basin. It is considered that among the 850 – 1,050 m deep is thermal aquifer integrated by thin banks of basalt with many medium to fine sandstones, with water storage. These would be of Chloride-Sodium type, with marked salinity and the temperature would be in the order of 39 to 41°C.

5.6 Ramallo Project

It is located to the north of the province of Buenos Aires (Figure 2) in the southern area of the Chacoparanense basin. The geological and geophysical studies carried out in the vicinity of the town of Ramallo were designed to determine the resistive units and its correlation with the geological formations to define the horizons with thermal fluids that can be exploited. The geo-electrical study allowed defining a very uniform environment in terms of thickness and resistive values. The first geo-electrical unit is considered as indicative of the deposits known as Pampa Formation composed by uniform banks of loess, which presents a thickness of 23 meters. True resistivity values range between 8 and 10 Ωm. The second unit is attributed to deposits of medium to fine sandstones from the Puelche Formation, which contains the aquifer of fresh water in the area. This feature is reflected in the true resistivity values (5.4 and 23.1 Ωm). The third geo-electrical unit is characterized by its great power which reaches the 567 meters and its very low resistive values (1.7 and 1.5 Ωm). This feature is expected viable since it represents the powerful sequence of green clay saturated with high saline content, from the Paraná Formation fluids. This geological unit relies on the Olivos Formation, in its upper part is integrated by silt and clay of marine origin, also saturated in salty water. This whole group of very low resistive values generates a very conductive horizon that acts as a layer screen. This characteristic weakens the response and obtaining accurate information of rock units that are located below it. Fourth and final geo-electrical unit (of which, the method does not allow to establish the base) is characterized by a higher true resistivity (10 Ωm) generating two geological hypotheses, but both are positive for the generation of thermal fluid. The first one is that we are in the presence of medium to fine sandstones corresponding to continental sediments of the lower part of the Olivos Formation. From this geological unit thermal fluids of Dolores Project are exploited. The second one, since the project is located in the basin border suggests that it may be in the presence of the pair Formation composed of basalts of the Serra Geral formation with sedimentary. This feature, with these resistivity values are presented in the Carlos Pellegrini and Diamante, projects that are currently in production and have thermal fluids with a considerable salinity, which greatly reduces the resistivity basalts. Studies indicate that thermal fluids that can be exploited could be found from the 750 to 800 meters. These would have a significant salinity, its chemical type correspond to the Chloride-Sodium and the temperature would be between 39° and 41°C

5.7 Navarro Project

This project is located in the northwest of the province of Buenos Aires, in the area of the basin of El Salado (Figure 2). El Salado basin was generated from a fracture of a basement, composed of Precambrian metamorfitas, in suprajurasics times or eocretacian, which was then filled by Cretaceous and Cenozoic continental and marine sediments with total thickness which can exceed the 7 km (Zambrano, 1971 and 1974) Padula and Mingramm, 1967; Padula, 1972; Bracaccini, 1972 and Zambrano and Urien, 1970). North and east boundaries of the basin of the Salado consist of direct failures, sometimes of several kilometers of vertical rejection. Above the basement we can find possible lower Cretaceous basaltic rocks or upper Jurassic in part, similar to those existing in the Chacoparanense basin. On the other hand, highlights the work of Yrigoyen (1975) that indicates the presence of basalts in the well of Conesa, in the northwest areas of the province. Also in geothermal studies carried on in the area of Ramallo and Chascomus (Pesce, in this work). According to Leinz (1949), these basic effusions have taken place when the region which was subjected to pressure pulsations efforts subject to traction by the continental drift. The area where the geo-electrical study took place, presents a marked uniformity, both in thickness and resistive values. The first geo-electrical unit corresponds to Pampeano Formation, age (40 to 35 m) Pleistocene that corresponds to continental deposits, eolic and reworked by other agents during all of the Quaternary period. The second geo-electrical unit would match the Puelche Formation. There are deposits of continental origin (88 to 62 m; 11-10 Ωm), more precisely fluvial which to the north of the region have great hydro-geological interest but in this area, its high salt content severely limits its use. The third geo-electrical unit this represented by the Paraná formation of marine origin (5-6 Ωm). This unit, between 170 and 240 m thick, present two faces: a top one made of very plastic clay and other underlying made of arcillaceous sands. The fourth and powerful geo-electrical unit (780 to 830 m) is considered that corresponds to two geological formations that have not been able to be differentiated (7 to 5.7 Ωm). It is interpreted as the vast majority this composed of Miocene sediments from the Olivos Formation of continental origin, which is very thick in the region. In its lower part could be Siltstone little consolidated, interspersed with clays and evaporites of gypsum and anhydrite of the Las Chilcas Formation. The fifth geo-electrical unit is considered that it would be made up of the Serra Geral Formation composed of basaltic lavas and interrelated with sediments of continental origin which were deposited at the same time in the region (46-43 Ωm). It is in this geological unit, which is considered that would act as a thermal aquifer. So it is considered that, from 1,000 to 1,100 meters starts the thermal aquifer, in the field of study. Low resistivity of the Serra Geral formation basalts is produced by intercalation between banks lava and continental sandstones. Typical event of a basin edge where the effusive cycle with the continental cycle combines. The final drilling depth should be between 1,100 and 1,200 meters. Its waters would be of the chloride-Sodium type, with marked salinity and the temperature would be in the order of 40 to 42°C.

5.8 Chascomus Project

It is located in the northeast of the province of Buenos Aires, on the northern shore of the basin of El Salado (Figure 2), with lithostratigraphic features similar to the Navarro project. The study established a tight geo-electrical model to the geological characteristics of the region and thus offer a very good safety of stratigraphy defined in the subsoil of Chascomus. Thus, the first geo-electrical unit geologically represents to the Pampa Formation, from Pleistocene age which has a thickness between 40 m and 60 m deep in the area. It is about continental, predominantly wind deposits (8.7 to 8.6 Ωm) and reworked by other agents throughout the Quaternary period. The second geo-electrical layer corresponds with the Ensenada Formation presenting a generally constant thickness (47 m and 37 m) and is represented by sediment composed of medium to fine saturated sand with low salinity water, probably brackish waters, which have an average of 12-11 resistivity Ωm. The third geo-electrical unit would match the Puelche Formation with an average thickness of 180 meters. It is about deposits of continental, more precisely fluvial origin is (6-8 Ωm) to the north of the region has great hydrogeological interest but that in this area, its salt content severely limits its use or application. The fourth geo-electrical unit is representing the formation unit of marine origin, known as Paraná Formation that has an average thickness of 410 meters. It is very possible that this unit presents two facies: a top one of very plastic clay and other underlying clayed sands. It is highly probable that resistive uniformity (1.9 to 1.7 Ωm) should be indicating a lithological uniformity of this formation, presenting a high salinity of the water saturation. The fifth geo-electrical unit finds geological correspondence with the interdigitation of the Serra Geral formation with sediments of continental origin which were deposited at the same time in the region. As it was pointed out, the opening of the basin of the Salado, which generated fracturing deep planes, allowed that the robes of basic lava would emerge. It is this unit which is considered that would act as a thermal aquifer. It is considered that the final drilling depth should be of the order of 1,100 meters. Its waters will be of the type Chloride-Sodium, with marked salinity and the temperature would be in the order of 40 to 42°C.

5.9 Tigre Project

It is located in the center-north of the province of Buenos Aires (Figure 2) and is located at the upper limit of El Salado Basin, where the basement blocks that generated it, are higher. By the geo-electrical study it depth and resistivity of deep horizons were determined carrier and its correlation with geological units, which allowed establishing a stratigraphic profile in the field of study. In the first few meters there are units performed as Pospampeano and Pampean, with very low thickness of an average of no more 30 meters. The Pospampeno presents resistive variations; clayey silts and silty sands (3, 65 Ωm) in some and others, with higher values, (12.75 Ωm) which correspond to toscas and calcareous silts compacted, used as artificial embankments. This set is supported on the roof of the sands of the Pampean presenting various resistive values (5.09-1.01 Ωm), which correspond to clayey silts and probably some collation of arenas that would raise the resistive value. To the third geo-electrical unit it is attributed the deposits of the Puelche formation, which occurs in the area with a very uniform thickness, (49.01 to 52.15 mm). The Puelche formation, which is of sandy lithology, has varied values of electrical resistivity, indicating the presence of salt water glasses (0.53 Ωm) brackish (3.02 Ωm) and fresh (7.91 (Ωm). The fourth geo-electrical unit has a marked thickness that varies between 250 and 342 meters, made up of very fine sand with silts and clays, saturated with fluids of varied salt content, which are reflected in the resistive values (2.5 Ωm and 4.1 Ωm). It is considered that at the top there is greenish gray clay interbedded with sands of the Paraná Formation and in its lower part, continental sediments of Miocene age of the Olivos Formation. The fifth unit is characterized by a true resistivity varying between 93.67 and 101.54 Ωm, where we were not able to determine its floor. These resistivity values are low for rocks of the basement floor of the sedimentary basin, whose composition is very hard metamorphic rocks. It is considered that belong to Serra Geral formation basalts, with sediments of continental cycle, as observed at the edge of the basin in numerous places. It is pointed out that the conditions of the area, did not allow the geo-electrical may have a greater opening that would allow reaching the basement. It is considered that at depths in the order of 400 meter thermal fluids would be found in sandstone interspersed among the basalts. These would be of Chloride-Sodium type with temperatures ranging from 29 to 31°C, with medium salinity.

5.10 Las Flores Project

It is located in the center-north of the province of Buenos Aires (Figure 2), and in the middle part of El Salado Basin, where it is estimated that the sedimentary thickness would be in the order of the six km deep. Geological and geophysical studies allowed defining a lithostratigraphic profile and establish the thermal fluid carrying geological unit. The first geo-electrical unit corresponds to Pampa formation, Pleistocene age. In the area; this unit would evolve between 20 m and 8 m depth. It is about continental, predominantly wind deposits (3.2 to 5.5 Ωm) and reworked by other agents during the entire Quaternary period. The second geo-electrical unit distinguished is awarded to the Puelche Formation with an average thickness of 45 meters. It is about deposits of continental origin, (9.19 Ωm) which to the north of the region have great hydrogeological interest, since it is a carrier of fresh water. The third geo-electrical unit that has thickness between 180 and 210 meters corresponds to the geological unit of marine origin (4.2 to 2.9 Ωm), known as Paraná Formation. This unit is characterized by two facies: a top one very plastic clay and other underlying argillaceous sands. It is very highly probable that resistive uniformity that was measured in the field, is indicating a lithological uniformity of this formation, presenting a high salinity of the water saturation. The fourth, and extensive, distinguished geo-electrical unit is interpreted that it corresponds to the Miocene sediments of the Olivos formation of continental origin, which has a very thick in the region (between 640 and 790 m). It consists almost exclusively of quartz sand, coarse grain and few conglomerates with pebbles of quartzite. It is this geologic unit where it is interpreted that there are thermal fluids that can be extracted by means of deep drilling. To the northeast, in the Dolores project, thermal fluids are being extracted, from a level something deeper of this geological unit. The fifth geo-electrical unit, which begins between the 820 and 1065 meters and has very low resistive values (1.01-3.4 Ωm), corresponds with the Las Chilcas formation, composed of abundant banks little consolidated limonite, interspersed with clays and gypsum evaporites. It is considered that drilling should not reach this geological unit. Therefore, studies indicate as interest level thermal sediments that are below the middle part of the Olivos Formation from the 700 m. In conclusion, it is estimated that drilling in the town of Las Flores, of approximately 980 m in depth would bring fluid thermal 38°C - 39°C, its chemistry composition would be between Chloride-Sodium waters and would present a medium to high grade salt.

CONCLUSION

It continues with a marked advancement degree in knowledge of geothermal energy, as in the start-up of new projects. In the high-enthalpy geothermal energy is driven to build and operate a future power generation plant of 30 MW called "Twins of Copahue" with an estimated investment of 70 million US Dollars. In low enthalpy were numerous projects that passed the exploitation stage in recent years, as well as new areas where the investigations have begun. The overview of geothermal energy in Argentina continues being encouraging, since this is a resource that is generating an interesting economic development in many regions of the country. The balance is positive however it is necessary to increase efforts to incorporate power generation, to the existing potential. In low enthalpy continues with a marked advancement degree in knowledge and exploitation of the geothermal resource. In this aspect, there were numerous projects that passed the exploitation stage in recent years, as well as new areas where the investigations have begun. The panorama of geothermal energy in Argentina continues to be encouraging, not only for the achievements, since these are generating an interesting economic development in many regions of the country, but that its weaknesses are also known.

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STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	0,67		37588	82953	11095	40330	1010	5732	173	432	31072	129477
Under construction in December 2014												
Funds committed, but not yet under construction in December 2014												
Estimated total projected use by 2030	30		230312	87334	5046	71523	4915	38421	5046	2336	56765	220637

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2014 if available, otherwise for 2013. Please specify which.

Locality	Power Plant Name	Year Commissioned	No. of Units	Status[1)]	Type of Unit[2)]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2014[3)] GWh/yr	Total under Constr. or Planned MWe
Copahue (NQ)	Copahue	1988	1	Not operating	Binary (Pilot)	0,67	0	0	0
Total			1			0,67	0	0	0
Total									

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being prod

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

1) I = Industrial process heat; H = Individual space heating (other than heat pumps)
C = Air conditioning (cooling); D = District heating (other than heat pumps)
A = Agricultural drying (grain, fruit, vegetables); B = Bathing and swimming (including balneology)
F = Fish farming; G = Greenhouse and soil heating
K = Animal farming; O = Other (please specify by footnote)
S = Snow melting

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality		Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
			Flow Rat	Temperature (^{o}C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
			(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Federación	(ER)	B-H	125	41	35			3.14		81.3	0.6
Concordia	(ER)	B	5	41	35			0.19		4.5	0.6
Villa Elisa	(ER)	B	3.3	38	33			0.1		2.3	0.6
Colón	(ER)	B	35.8	33	28			0.75		14.6	0.6
La Paz	(ER)	B	33.3	41	30			1.53		43.5	0.9
Villaguay	(ER)	B	8.3	41	28			0.45		12	0.8
Maria grande	(ER)	B	9.7	43	28			0.60		15	0.79
Gualeguaychu	(ER)	2B	5.5	33	28			0.41		3.3	0.9
Concordia	(ER)	2B	69	43	30			3.7		111	0.9
Basavilbaso	(ER)	B	19.5	42	35			0.57		15.70	0.87
Victoria	(ER)	B	12.5	37	30			0.37		11.54	0.99
Diamante	(ER)	B	4.72	47	35			0.24		6.33	0.84
San José	(ER)	B	3.33	36	33			0.1		1.32	0.42
Campo Timbo	(SFE)	B	18.06	36	32			0.30		8.44	0.89
Obera	(MIS)	B	44.4	51.3	33			3.4		111.1	1.04
Cerro Azul	(MIS)	O	10.56	32.3	20			0.54		12.98	0.76
Posadas	(MIS)	O	17.22	35	20			1.08		31.66	0.93
Uritorco	(CBA)	B	20	38	29			0.7		23	1.04
Cerro San Mar	(RN)	B	8.32	41	18			0.79		21.2	0.85
La Carrindang	(BA)	G	6.94	55	35					20.1	1
San Clemente	(BA)	B	8.9	41	35			0.22		5.54	0.8
Necochea	(BA)	B	2.2	37	35			0.1		0,58	1.18
Mar de Ajo	(BA)	B	11.67	38	35			0.15		4.35	0.92
Medanos	(BA)	B	33.3	74	50			3.35		1.1	0.25
Copahue	(NQ)	S	8.33	75	35			2		31.6	0.24
Gan Gan	(CHU)	F	8.8	21.5	18					3.1	1
Caimancito	(JY)	B	1.6	45	35			0.1		1.1	0.5
Aguas Calient	(JY)	B	1	45	35			0.1		4.7	0.45
El Sauce	(SAL)	B	7	35	30			0.14		2.1	0.45
Termas de Inti	(SAL)	B	0.5	60	35			0.1		0.7	0.45
Rosario de											
La Frontera	(SAL)	B	1	60	40			0.1		1.7	0.63
Incachule	(SAL)	B	7	45	35			0.29		3.2	0.35
Tocomar	(SAL)	B	1	55	35			0.1		1.3	0.35
Fiambala	(CAT)	B	2	53	33			0.16		1.9	0.4
Aguadita	(CAT)	B	0.1	30	25			0.1		0.01	0.4
Villavis	(CAT)	B	1	60	30			0.13		1.1	0.4
Llampa	(CAT)	B	1	30	27			0.1		0.2	0.4
Los Nacimien	(CAT)	B	1.5	36	30			0.1		0.5	0.4
Ojo de Villa Vis	(CAT)	B	6	24	22			0.1		0.7	0.4
La Copia	(CAT)	B	1	25	22			0.1		0.2	0.4
La Cienaga	(CAT)	B	2.5	24	22			0.1			
Vis Vis	(CAT)	B	7	31	25			0.18		0.4	0.4
La Soledad	(SGO)	B	15	41	35			0.38		19.6	1
Rio Hondo	(SGO)	B	1000	45	35			42		46.03	1

Santa Teresita	(LR)	B	3	42	35			0.1		2.81	0.8
Ambil	(LR)	B	5	27	25			0.1		0.8	0.4
La Laja	(SJ)	B	4	26	22			0.1		0.84	0.4
Guayaupa	(SJ)	B	0.5	27	22			0.1		0.11	0.4
Despoblados	(SJ)	B	1	75	35			0.17		0.8	0.15
San Crispin	(SJ)	B	2	57	33			0.20		0.6	0.15
Cajón de la Br	(SJ)	B	0.2	35	30			0.1		0.06	0.35
Rosales	(SJ)	B	4	40	30			0.17		2.1	0.54
Pismanta	(SJ)	B	7	43	35			0.23		5.53	0.43
Rio Valdez	(TdF)	B	18.1	37	32			0.32		5.6	0.47
Los Molles	(MZA)	B	2.5	41	35			0.1		1.6	0.25
Borbollon	(MZA)	B	1	24	22					0.08	0.48
Cacheuta	(MZA)	B	3.95	44	33			0.18		3.3	0.54
Carrillo	(MZA)	B	0.5	38	33			0.1		0.2	0.54
Alto Verde	(MZA)	B	0.5	23	21			0.1		0.08	0.33
Villavicencio	(MZA)	B	2	28	25			0.1		0.6	0.5
Copahue	(NQ)	B-H	1.76	58	35			0.17		25.34	0.48
Domuyo	(NQ)	B	2	65	35			0.29		4.05	0.48
El Quicho	(CBA)	B	45	38	33			0.94		10.5	0.24
Talacasto	(SJ)	B	12.5	26	22			0.16		2.6	0.4
Epulaufquen	(NQ)	B	1	65	35			0.13		0.7	0.25
Bahia Blanca	(BA)	H-B-G-F	1000	55	35			83.7		63.26	0.4
Larroude	(LP)	B	0.9	29	26			0.1		0.28	0.8
Monte Casero	(CO)	B	97.2	38	28			4.07		108.9	0.8
Curuzu Cuatia	(CO)	B	41.6	42	29			2.3		60.6	0.97
Dolores	(BA)	B	16.6	42	29			0.9		1.23	1.36
Tapalque	(B	B	22.2	31	25			0.55		14.9	0.86
TOTAL								165.54		1000.03	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2014

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W)
since projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	22.4	50	
District Heating [4]			
Air Conditioning (Cooling)			
Greenhouse Heating	21.48	40.1	
Fish Farming	7.03	13.1	
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting	1.36	31.6	
Bathing and Swimming[7]	96	820.59	
Other Uses (specify)	15.3	44.64	
Subtotal	163.57	1000.03	
Geothermal Heat Pumps			
TOTAL	163.57	1000.03	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)	2,5				2,5
Production	>150° C					
	150-100° C			15		12,45
	<100° C					
Injection	(all)					
Total				15		14,95

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	7		6			3
2006	7		6			5
2007	8		6			5
2008	8		8			7
2009	9		8			7
Total	39		34			27

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl. Surface Explor. &	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	4,8	1,2			70	30
2000-2004	1,5	3,5			85	15
2005-2009	5,3	6,5			80	20
2010-2015	6,5	15			80	20