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ARGENTINA COUNTRY UPDATE

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ABSTRACT

I) INTRODUCTION

The degree of progress of the knowledge of the geothermal resources in the last five years in Argentina expands the trends already settled at the beginning of the decade. The direction pointed then was that the research and development lines on both the low and high enthalpy fields should be oriented towards the direct use of the geothermal fluids in order to produce development. For this reason, the use of thermal fluids in farming or industrial establishments, or in multiple use endeavors is encouraged. Also, in many areas of the country, particularly in those with low development there are thermal manifestations and productive activities demanding relatively low thermal levels. This is the case of house heating or animal berthing, farm-industry activities, greenhouses, balneology, etc.. The utilization of these fluids could contribute to improve the life standards in those places.
The studies, undertaken in different areas of Argentina, allowed a clear understanding of the geothermal potential of the country and gave place to the exploitation of some of the low temperature thermal fields.
In this period, the National Geothermal Plan is an important element, which the Argentine Geological and Mining Survey, through the Department of Geothermy, is carrying out.

II) NATIONAL GEOTHERMAL PLAN

It is well known that the geothermy has relevant social and economic implications, a well as the fact that it can offer interesting development possibilities. Although it is well known that a good understanding of the magnitude of this resource has been achieved, also it is known there is much to be done in order to evaluate its potential. From the economical view-point, it could be said it is a virgin field, and for most of research institutions it has been neglected, in spite of its importance. For this reason, the need of a National Geothermal Plan raised to encourage a take-off in accordance with the importance the Geothermy deserves.

The National Geothermal Plan has the following specific objectives:

- To enlarge the knowledge of the thermal resources of the country.
- To develop the Thermal Cartography of Argentina.
- To systematize information by means of catalogues and directories.
- To establish an adequate legal framework in order to generate an economic take-off.

The strategy established to carry out the Plan is characterized by an integrated work scheme including the different actions to be performed in order to achieve the goals already stated. In accordance with this criteria, the following work lines were established:

- Program of Geothermal Studies
- Program of Geothermal Sheets
- Systematization of the information
- Development of a legal framework

Geothermal Studies Program

Designed to evaluate the geothermal potential and to plan its rational exploitation, by means of economically feasible endeavors. It includes reconnaissance studies to be performed in the chosen areas, aimed at enlarging knowledge and defining new thermal areas. Geothermal Potential Studies, in order to establish the magnitude of the resource (Geothermal models)will be performed in the previously chosen areas as well as the Studies of Economic Applications of the Geothermal Fluids, in order to define the economic endeavors.

Geothermal Sheets Program

The Program has the specific objective of developing the geothermal cartography of Argentina. It was designed in order to cover, by means of different kinds of maps, the main geothermal aspects of the country to make available the base information allowing adequate utilization of the resource. They are:

- The Map of Geothermal Manifestations of Argentina.
- The Geothermal Sheets of Argentina.
- The Provincial Geothermal Maps.
- The Maps of Geothermal Basins and Thermal Areas with Economic Potential.

Data Systematization

An important mission of the State, to make the information elaborated become public domain, is the promotion of data and knowledge. Therefore the Catalogue of Thermal Manifestations of Argentina. Also the Directory of geothermal opportunities, having a general scenario of feasible geothermal projects, is under preparation.

Development of a Legal Framework

Aimed at promoting a rational exploitation of the geothermal resources, to encourage investments and to produce development, a suitable legal framework is being elaborated. Therefore, an adequate legal instrument will make the exploitation of the resource predictable allowing the economic take-off of gheothermy.

III) GEOTHERMAL DEVELOPMENT OF NORTHEAST OF ARGENTINA

A remarkable development was produced in the last few years in Northeast Argentina where six new thermal areas related to low enthalpy fields were evaluated (Figure 1), triggering exploitation of four recreational therapeutic complexes, producing a new economic activity in the region. In this areas there is a huge sedimentary basin, Chaco-Parana Basin, that due to its characteristics and extent (Northwest Uruguay, Southern Brazil and Northeast Argentina), becomes a major hydric reserve with an important geothermal potential.

A lower aquifer is constituted by glacial-marine deposits of Permian age, bearing salty water (up to 18,900 µS/cm), belonging to the Sachayoj-Charata-Chacabuco Formations. An upper one is formed by Triassic- Upper Jurassic eolian sandstones, with high quality clear water (500 to 1,300 µS/cm) hosted in the Rivera-Tacuarembó Formations.

Both aquifers are located within an epicratonic basin having intermediate to low geothermal gradients, in the surroundings of 2° C/100 m, that, up to the present, have produced water at temperatures of about 45º Celsius.

The Chaco-Paraná Basin, is an ancient epicratonic basin located on the River Plate Craton-Brazil Massif Unit, cratonized towards the end of the Brazilian Cycle, during proterozoic times. The origin of the basin is related to a slow regional subsidence, as shown by the large extension of fine eopaleozoic sediments overlaying the crystalline basement. The basin analysis determined that the Sachayoj-Charata-Chacabuco Aquifer, in its northern section, has a maximum thermal potential with temperatures of 80º C at –1,800 m while in the Rivera-Tacuarembó Aquifer, an area where the maximum thermal potential with temperatures of 55º C at –1,100 m was delimited.

The discovery of thermal waters at 43º C by means of a drilling 1,260 m deep and the opening of the first thermal center in January, 1997 in Federación city, Entre Rios Province, triggered a new economic activity, thermal tourism, that produced among other things a hotel industry growth; from accommodation for 132 to 807 people in 1997 and a total of 197,284 visitors in the last summer season (1998, 1999).

Up to present six deep wells have been drilled in the region, in Federación, Concordia, Villa Elisa, Gualeguaychú, Colon and Concepción del Uruguay cities (Figure 2). Well depths range from 1,000 to 1,500 m. They are artesian wells with flow rates varying from 12 to 135 m^3/h and temperatures between 30º and 46º C. This region has a high potential for the development of tourism as well as other economically feasible direct use endeavors. Up to now, four therapeutic-recreational complexes using thermal fluids have been developed.

IV) NEW APPLICATIONS OF DIRECT-USE IN ARGENTINA:

Villa Elisa Thermal area: Balneology.

The thermal area is located 4 km northwest of Villa Elisa City, Entre Rios Province, 360 km from Buenos Aires City. The well, 1,032m deep, reached an artesian aquifer level in glacial-marine deposits of Permian age between 942 and 1032 m b.w.h.. The natural surging well, with a flow rate of 12 m^3/h, has a temperature of 40,2º C at the well head. From chemical point of view water correspond to Sodium-Chloride type with pH of 7.7. The concentration of total dissolved solids (14,400 mg/l) indicate a strong mineralization and the electric conductivity (18,900 µS/cm) allows to classify them as salty waters. A thermal therapeutic center was developed, in which the high mineralization of waters confers them excellent properties for specific balneotherapeutic treatments.

Colón Thermal Area: Balneology.

The thermal area is located in Colón City, Entre Rios Province, 320 km from Buenos Aires City. The well 1,502 m deep reached an artesian acquifer level in eolian sandstones of Triassic Jurassic age. The aquifer can be considered as surging confined. Essays conducted during 72 hours showed a highest flow rate of 135 m^3/hour. Water correspond to slightly alkaline (pH of 8.5), sodium bicarbonate type with a moderate mineralization. The electric conductivity value of 1,180 µS/cm, relates them to fresh waters. A thermal complex with several pools, showers, and resting and recreation places was developed.

Federación Thermal Area: Balneology

This thermal area is located in Federación City, Entre Rios Province, 480 km from Buenos Aires City. The well, 1,260 m deep, reaches artesian aquifer levels in Triassic-Upper Jurassic sandstones, with abundant fresh waters. The well is surging naturally with a flow rate of 450 m^3/h, having a temperature at the well head of 43º C. The chemical type of these waters correspond to sodium-chloride-bicarbonate type, with a pH of 7.8, and an electric conductivity of 1253 µS/cm. The thermal waters complex has a large park (9 hectares), five open pools with water at different temperatures, an indoor one with hydromassage and a Spa have been built.

Concordia Thermal Area: Balneology

The thermal area is located in Concordia City, Entre Rios Province, 438 km from Buenos Aires City. The well 1,179 m deep, reached artesian acquifer levels of the Rivera-Tacuarembó Formation, eolian sandstones dated Triassic-Upper Jurassic. High quality fresh waters at 46°C, belong to the sodium-bicarbonate type, with moderate mineralization, pH of 7,9 and electric conductivity of 583 µS/cm. In a large forested area, thermal baths with four pools at different temperatures, recreation places and restaurants has been developed.

Copahue-CaviahueThermal Field: Snow Melting

Fluids of the Copahue-Caviahue thermal field are used for heating the streets and roads allowingaccess to the Copahue Village, and to world-wide known thermal center with capacity to supply 2,500 thermal baths a day. The thermal center is located in the Copahue Thermal Field at 37º 50' S y 71º 05' W, at 1.170 km to the south-south-west of Buenos Aires (Figure 2), at 1,900 meters above the sea level, very close to the international border between Argentina and Chile. Until last year, the Village could only work from December to April since the winter storms could cumulate up to four meters of snow on the streets of the village. Since the first days of April 1998 the hotels and the health center can host guests thanks to a streets heating system powered by geothermal steam that prevents the snow from cumulating along some 17 blocks of Copahue Village.

The streets heating system (a radiant panels system) consists of a coil-shaped piping included in the concrete extending along the streets of the thermal center that when the geothermal steam condensed supplies heat to the ground and raises its temperature.
The steam is produced by the COP-4 geothermal well, located in the most important productive area of the geothermal field and is transported *via* a vapor pipeline with a total extension of 2.396 meters.
In order to distribute the vapour through the Copahue Village, a perimetrical concrete channel, with a length of 1,880 m, was built surrounding the radiant panel system in the village and, to heat all the streets, 618 heating plates of the radiant panel were built.
The steam is distributed along the village at a pressure of 8 bar and 178º C by means of a main pipe, reducing as flow rates decrease to smaller diameters. Every 50 heating plates, 150 linear meters, a control and pressure reducing station was installed, with an automatic pressure-regulating valve, and blocking and by-pass spherical valves.
From the secondary distribution pipe, each coil is fed. The condensate goes to a recollection line, transporting it to the natural streams of the region.
The mean consumption of steam for street heating is of 37 kg/h per panel, totaling 22.866 kg/h for the whole project. Under snow and wind storms up to 90 km/h the panels remain clean with surficial temperatures between 10 and 20º C.

Bahía Blanca-Pedro LuroThermal Basin: Shrimp farming, greenhouse heating, Balneology

In the southern border of the Buenos Aires Province there is a large thermal basin, Bahia Blanca-Pedro Luro, with an anomalous geothermal gradient (56º to 82,5º C), produced by a thinning of the earth crust (between 24 and 26 km) and deep basement structures created during the Atlantic Ocean opening. The Cretaceous-Cenozoic sedimentary basin is characterized by surging aquifers levels at different depth: an upper level, 530 to 570 m deep with temperatures ranging from 55º to 60º C and a deeper one, from -660 to -890m with temperatures from 65º and 85º C. Several feasible projects have been planned, using the fluid in many different economical applications in this thermal basin, among them, those oriented towards greenhouse (Carrindanga Project), shrimp farming (Cerri Project)and therapeutical-recreational projects (Medanos).

Cerri Project: Shrimp Farming

The General Cerri Area has very favorable conditions for the development of a Shrimp farming project using sea water and thermal fluids. The thermal fluids would enable to establish suitable environmental conditions to obtain the optimal growth of the chosen specie.
The pilot plant is located south of General Cerri, Buenos Aires Province, in the upper leg of the sea estuary of Bahia Blanca, strongly affected by tidal variations.
The ground covers more than six hectares and is located away from the flood zone. At 1,200 meters of the chosen area, a thermal well producing clear water at 58º C with a surging flow rate of 40 m^3/hour, being the chemical type of the water CO_3H-Cl-Na. The semi-intensive farming method was selected, which is the most popular nowadays, is the most reliable and has the highest revenue ratio. The pilot project has a hexagonal pool, excavated in the ground, a depth of 1,5 m and 1 hectare. A hydraulic floodgate would be used for the hydric change and fans, in order to produce currents to avoid physic-chemical stratification of the water (Temperature, salinity, pH). The sea water intake would be made through a channel connected to the estuary during high tide. Three schemes to heat the pool were designed, each one offering different heating alternatives . In all the cases , the water first enters the mixture pool where it reaches the proper temperature. The specie chosen for farming is the *Penaeus Monodon,* the most commonly used all over the world, and with high commercial value. Its natural environment is the sandy or muddy sea bottom, at temperatures ranging from 23º y 31º C , it easily adapts to low salinity (16 a 24 ppm) and is feeds with a complement constituted by fish and agricultural products, very cheap in the area.
Concluding, the Bahia Blanca Area, by means of thermal fluids, could develop a shrimp breeding industry, that would allow it to enter a very demanding, international competitive market. The use of geothermal waters is a low cost element that would reverse a natural situation and generate a production with interesting perspectives.

Carrindanga Project: Greenhouse Heating

The use of greenhouses geothermally heated, in areas of marginal weather such as Bahia Blanca region, would enable higher competition as it allows to vary the soil use pattern, to reach new markets, increase yielding, decrease production and infrastructure costs, decrease the percentage of lost in the harvests and an increase in the commercial classification of the product.

The area chosen for this project is located 5 km from Bahia Blanca City, comprises a six hectare ground having a deep artesian well that produces 25 m^3/h at 57° C of drinking water quality. From the well, water is delivered directly to a settling tank with different outputs for different uses, among them house and greenhouse heating and to feed a 600,000 liters tank for cooling and storage of water.
The temperature of water at the intakes for both the greenhouse and the houses are between 32º and 35º C. The heating of the house is performed by radiant floor
by means of a pipe network. At the thermal fluid intake a fluid/distilled water heat exchanger was placed due to a low content of carbonate in the fluid.
Two greenhouses 40 m long were built having four naves 6 m wide each. They have mobile glass structure, with aspersion watering and semi-superficial heating system. The cultivation method consists of canopies placed on benches made of grooved timber of 40 x 60 cm and are heated at the roots. The canopies have seeds and branches of interior and outdoors (bushes, ornamental, aromatic, forestry) plants, also flowers and horticultural plants.
The canopies allow plants to germinate in a shorter time since it is possible to control parameters such as humidity and temperature. In a regular process in the Bahia Blanca area, it takes a month for a sprout to achieve its optimal root and foliation development for a definitive transplantation, while by controlling the mentioned parameters the time is shortened by a 50% with the following benefits:
Direct: the productive cycle is most efficient since the seed-planting can be programmed, namely the production operation, for example tomatoes can be harvested out of season.

Indirect: since plant development per square meter can be programmed, production and sales can be scheduled in advance.

Médanos Project: Balneology

In the last few years, Health tourism has had a significant development in our country. The success of the Integral health Spas, both locally and internationally is relevant. In the Medanos city, 45 km from Bahia Blanca City there is an endeavor oriented towards therapy and recreation using thermal fluids surging at a temperature of 74º C and a quite significant flow rate of 2.000 l/minute. The well reaches a depth of -1,174 meters and the waters are Cl-Na with low construction and a good income capability is expected.

Area Termal Gan Gan

In the Gan Gan geothermal area (Figure 2), in the center of Chubut Province (42º 25´South, 68º 18´ West), 1700 km south of Buenos Aires, a project using thermal waters for the trout breeding is under construction. In this area, very cold and windy place with a annual mean temperature of 12º C , thermal waters are taken from three A recent project oriented towards snow melting was developed in the Copahue-Caviahue Thermal Field, in which thermal fluids are used to heat a radiant panel system. It consists of a pipe included in concrete, extending along the streets of the Copahue Thermal Village, where geothermal steam circulates and when condensing supplies heat to the ground and raises its temperatursprings (estimated flow rate of 32,000l/hour) at a temperature of 21.5º C . These fluids are bicarbonate sodic, with a pH of 7,4 and a conductivity of 434µS/cm. The fluid is transported to the breeding pools by means of propylene pipes. Faster growth and optimal commercial size are achieved in a shorter time by using thermal fluids in cold weather species.

SUMMARY OF DIRECT USE PROJECTS

At present, 134 direct use endeavors with an annual installed capacity of 25,7 MWt exist (Table 1). Balneology prevails (52,7%) representing an annual installed capacity of 13,56 MWt. Other endeavors are domestic use (24,6%) with an installed capacity of 6,33 MWt, house heating (4,6%) equivalent to 1,17 MWt, greenhouse heating (4,5 %) with an installed capacity 1,14 MWt, aquaculture (1,5%) equivalent to 0,38 MWt, industrial uses (6,7%) of 1,72 MWt and snow melting (5,4%) corresponding to 1,4 MWt.

- Thermal fluids for hot water supply are being used in eight sites. Four of them are located in the Bahia Blanca-Pedro Luro Basin, Buenos Aires Province. one in Federación, Entre Rios Province and another one in Domuyo, Neuquén Province (figure 2), The last two ones are in north-west Argentina

- There are five house heating endeavors. Four of them in Bahia Blanca-Pedro Luro Basin and the other one in Domuyo. Among the first four, the Galería Plaza (Plaza Shopping Mall) is worth mentioning, it corresponds to a twelve store building where the geothermal fluid is used for heating as well as hot water supply.

- There are three greenhouse heating developments in the Bahia Blanca-Pedro Luro thermal Basin and one in Cacheuta thermal field, Mendoza Province. The last one is a small endeavor supplying vegetables to the guests in balneological hotel. Regarding acquaculture, there are two projects being undertaken, one in the Bahia Blanca-Pedro Luro Basin, where gold fish and frog are being farmed and the other in the Gan Gan thermal area, Chubut Province, where thermal fluids are used to farm trout. Gan Gan area is located in a very cold and windy region where the fluids are captured from three warm springs (at 21,7º C) and are transported by means of polypropylene pipes to the breeding and farming pools. Faster growth and optimal commercial size are achieved in a shorter time by using thermal fluids.

- Two industrial applications are developed in the Bahia Blanca-Pedro Luro thermal Basin. One is a pasta factory, remarking the use of thermal fluids in their advertisements, and the other uses geothermal fluids to wash wool (59º C).

- A recent project oriented towards snow melting was developed in the Copahue-Caviahue Thermal Field, in which thermal fluids are used to heat a radiant panel system. It consists of a pipe included in concrete, extending along the streets of the Copahue Thermal Village, where geothermal steam circulates and when condensing supplies heat to the ground and raises its temperature.

CONCLUSSIONS

The general analys geothermal resources in Argentina in the last five years are indicating a steady growth of the utilization of the geothermal fluids. At present, the evaluation stage is being completed to start with the exploitation of the resource with a increase in the direct use of the fluid. The thermal offer is constantly growing and at the same time, the transfer of the resource to private companies is encouraged. The direct use of the geothermal resources is considered to contribute to the development of the regional economies, through farming or industrial establishments, or multiple use endeavors.

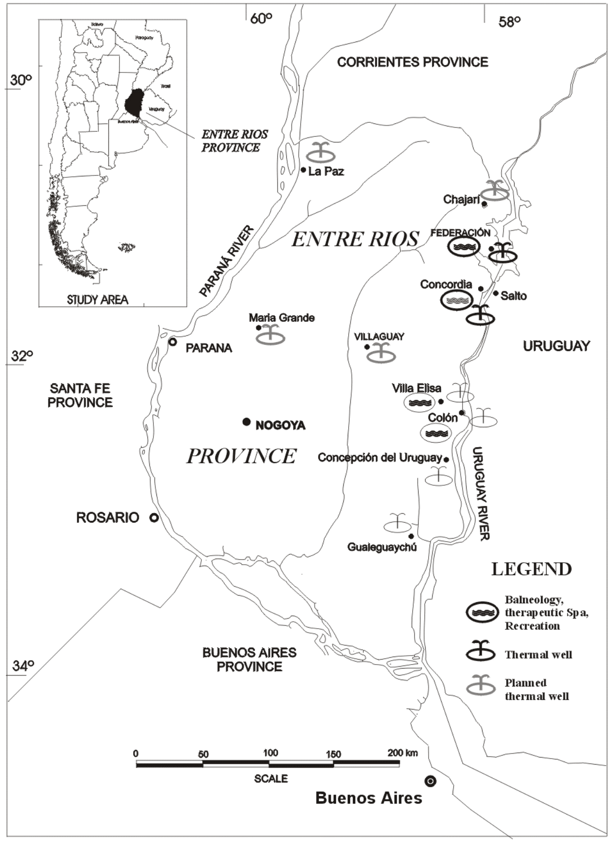

Figure 1. Geothermal development in northeastern Argentina.

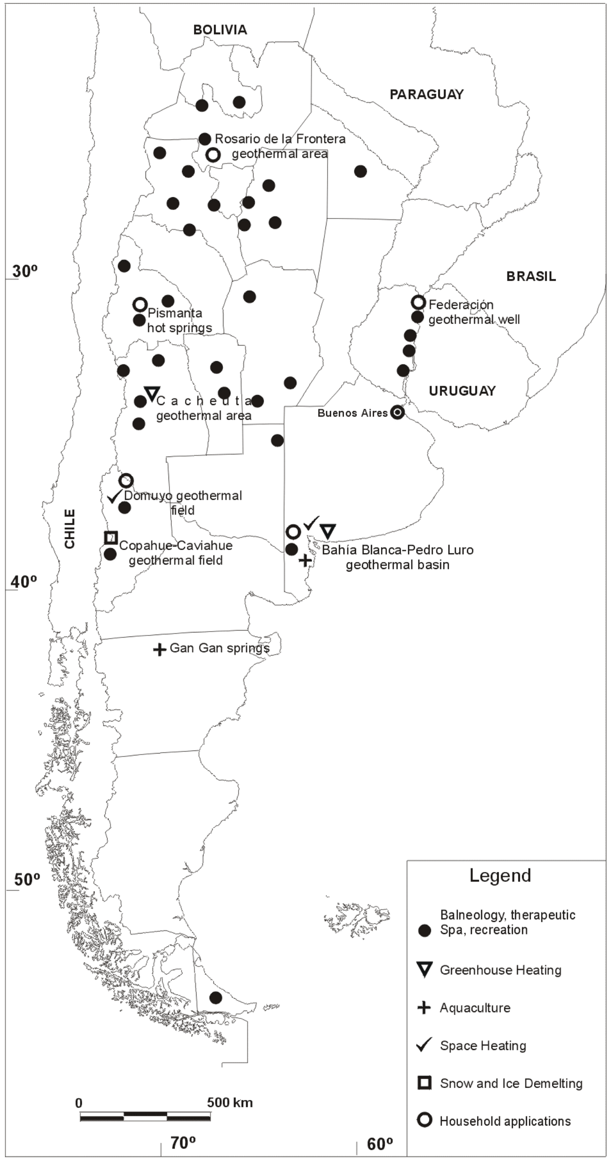

Figure 2. Geothermal areas and direct uses of geothermal resources in Argentina.

Establishments-quantity	Installed Capacity MWt	Energy TJ/year	Oil barrels equivalent/ year	Cost of o.b.e. at U$S 18/barril
Balneoterapy – 112	13,56122	260,39622	44.472,9	$ 800.512,07
% Direct use	52,7%	58,0%		
Domestic use - 8	6,32813	101,12753	17.271,5	$ 310.887,04
% Direct use	24,6%	22,5%		
House heating - 5	1,17764	13,16282	2.248,1	$ 40.462,27
% Direct use	4,6%	2,9%		
Greenhouses – 4	1,14466	28,74101	4.908,6	$ 88.355,84
% Direct use	4,5%	6,4%		
Aquaculture – 2	0,38392	5,37624	1.301,2	$ 16.527,69
% Direct use	1,5%	1,2%		
Industrial applications-2	1,72339	18,46653	3.153,9	$ 56.769,94
% Direct use	6,7%	4,1%		
Snow melting - 1	1,39411	21,97454	3.753,0	$ 67.554,30
% Direct use	5,4%	4,9%		
Total – 134	25,71307	449,24489	77.109,2	$ 1.381.069,15

Table 1. Direct uses, installed capacity in MWt and oil barrel equivalents.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Eolic		Total	
	Capa-city MWe	Gross Prod. GWh/y	Capa-city MWe	Gross Prod. GWh/y	Capa-city MWe	Gross Prod. GWh/y	Capa-city MWe	Gross Prod. GWh/y	Capa-city MWe	Gross Prod. GWh/y	Capa-city MWe	Gross Prod. GWh/y
In operation in January 2000	0.67	0	9972	36662	9160	31787	1018	9000	12	16	20162	77465
Under construction in January 2000	0	0	-	-	-	-	-	-	-	-	-	-
Funds committed, but not yet under construction in January 2000	0	0	-	-	-	-	-	-	-	-	-	-
Total projected use by 2005	0.67	0	12700	47519	11600	41201	1018	9000	15	21	25333	97741

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF DECEMBER 1999

Locality	Power Plant Name	Year Com-missioned	Number of units	Status	Type of Unit	Unit Rating MWe	Total Installed Capacity MWe	Annual Energy Produced 1999 GWh/yr	Total under Constr. or Planned MWe
Copahue (NQ)	Copahue	1988	1	Not operating	Binary (Pilot)	-	0.67	0	0
Total			1				0.67	0	0

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF DECEMBER 1999

Locality	Type	Maximum Utilization					Capacity	Annual Utilization		
		Flow Rate	Temperature (C)		Enthalpy (kJ/kg)			Ave. Flow	Energy	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	Rate (kg/s)	(TJ/yr)	Factor
Federacion (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
Colon (ER)	B	35.8	33	28 (*)	-	-	0.75	-	14.6	0.6
Gualeguaychu (ER)	B	-	-	-	-	-	-	-	-	0
Concepcion del Uruguay (ER)	B	-	-	-	-	-	-	-	-	0
La Carrindanga (BA)	G	6.94	55	35 (*)	-	-	0.58	-	20.1	1
Medanos (BA)	B	33.3	74	50 (*)	-	-	3.34	-	1.1	0.25
Copahue (NQ)	S	8.33	75	35 (*)	-	-	1.39	2 (*)	31.6	0.24
Gan Gan (CHU)	F	8.8	21.5	18 (*)	-	-	0.13	-	3.1	1
Caimancito (JY)	B	1.6	45	35 (*)	-	-	< 0.1	-	1.1	0.5
Laguna de la Quinta (JY)	B	2 (*)	40	35 (*)	-	-	< 0.1	-	1.4	0.5
Aguas Calientes del Tuzgle (JY)	B	1 (*)	45	35 (*)	-	-	< 0.1	-	4.7	0.45
Banos 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
Aguaditas (CAT)	B	< 0.1	30	25 (*)	-	-	< 0.1	-	0.01	0.4
Villavil (CAT)	B	1 (*)	60	30 (*)	-	-	0.13	-	1.1	0.4
Llampa (CAT)	B	1 (*)	30	27 (*)	-	-	< 0.1	-	0.2	0.4
Los Nacimientos (CAT)	B	1.5 (*)	36	30	-	-	< 0.1	-	0.5	0.4
Ojo de Villa Vil (CAT)	B	6	24	22 (*)	-	-	< 0.1	-	0.7	0.4
La Coipa (CAT)	B	1 (*)	25	22 (*)	-	-	< 0.1	-	0.2	0.4
Termas de la Cie-naga (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	-	19.8	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

TABLE 3. (CONT.)

Locality	Type	Maximum Utilization					Capacity (MWt)	Annual Utilization		
		Flow Rate (kg/s)	Temperature (C)		Enthalpy (kJ/kg)			Ave. Flow Rate (kg/s)	Energy (TJ/yr)	Capacity Factor
			Inlet	Outlet	Inlet	Outlet				
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
Corral de Piedra (SJ)	B	1	25	22 (*)	-	-	< 0.1	-	0.17	0.5
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
Cajon de la Brea (SJ)	B	0.2	35	30 (*)	-	-	< 0.1	-	0.06	0.35
Rosales (SJ)	B	4	40	30 (*)	-	-	0.17	-	2.1	0.54
Rodeo (SJ)	B	6	37	30 (*)	-	-	0.18	-	-	-
Pismanta (SJ)	B	7	43	35 (*)	-	-	0.23	-	5.53	0.43
Rio Valdez (TdF)	B	18.1	37	32 (*)	-	-	0.38	-	5.6	0.47
Cerro Campanario (MZA)	B	5	51	35 (*)	-	-	0.38	-	-	-
Banos del Azufre (MZA)	B	48	39	35 (*)	-	-	0.80	-	-	-
Los Molles (MZA)	B	2.5	41	35 (*)	-	-	< 0.1		1.6	0.25
El Sosneado (MZA)	B	7.53	33	28 (*)	-	-	0.16	-	-	-
Puente del Inca (MZA)	B	15.67	34	-	-	-	-	-	-	-
Borbollon (MZA)	B	1 (*)	24	22 (*)	-	-	-	-	0.08	0.48
Cacheuta (MZA)	B	3.95	44	33 (*)	-	-	0.18	-	3.3	0.54
Cerrillo (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-H	2 (*)	65	35 (*)	-	-	0.29	-	4.05	0.48
Taco Ralo (TUC)	B	30 (*)	40	35 (*)	-	-	0.63	-	-	-
Roque Saenz Pena (CH)	B	-	-	-	-	-	-	-	2.37	1
Tanti Viejo (CBA)	B	-	-	-	-	-	-	-	0.12	0.48
San Marcos Sierra (CBA)	B	-	-	-	-	-	-	-	-	-
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
TOTAL							142		380.14	

(*) estimation

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF DECEMBER 1999

Locality	Ground or water temp (C)	Typical Heat Pump Rating or Capacity (kW)	Number of units	Type of Unit	COP	Equivalent Full Load Hr/Year	Thermal Energy Used (TJ/yr)
-	-	-	-	-	-	-	-
Total			0				0

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF DECEMBER 1999

Use	Installed Capacity (MWt)	Annual Energy Use (TJ/yr)	Capacity Factor
Space Heating	22.4	-	-
Air Conditioning (Cooling)	0	0	-
Greenhouse heating	21.48	-	-
Fish and Animal Farming	21.03	-	-
Agricultural Drying	0	0	-
Industrial Process Heat	0	0	-
Snow Melting	1.39	31.6	0.24
Bathing and Swimming	75.7	-	-
Other Uses	0	0	-
Subtotal	**142**	-	-
Geothermal Heat Pumps	0	-	-
TOTAL	**142**	-	-

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 1995 TO DECEMBER 31, 1999

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other	
Exploration	(all)	0	0	0	0	0
Production	> 150°C	0	0	0	0	0
	150-100 °C	0	1	0	0	1.4
	< 100 °C	0	7	0	0	8.7
Injection	(all)	0	0	0	0	0
Total		0	9	0	0	10.1

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES
(Restricted tO personnel with a University degress)

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1995	25	-	13	1	3	22
1996	7	-	4	-	-	22
1997	6	-	4	-	-	25
1998	5	-	4	-	-	25
1999	6	-	4	-	-	26
Total	49	0	29	1	3	120

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (1999) U$S

Period	Research & Development Incl. Surface Expl. & Exploration Drilling Million U$S	Field Development Incl. Production Drilling & Surface Equipment Million U$S	Utilization		Funding Type	
			Direct Million U$S	Electrical Million U$S	Private %	Public %
1985 - 1989	4.0	2.0	-	0	0	100
1990 - 1994	7.2	3.7	-	0	30	70
1995 - 1999	4.8	1.2	-	0	70	30