PRESENT SITUATION OF CEOTHERMICS IN MEXICO

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INTRODUCTION

Up to present geothermal resources in Mexico are utilized to produce electrical energy. There are some places where superficial geothernial resources are used for tourist or therapeutic purposes. and some studies have been made regarding use of the separated waters or the waste heat for industrial purposes in Mexicdn geothermal fields. However, exploration and development activities are focused on use of geothermal resources to produce electricity.

Even though recent changes in Mexican law permit private investment for building and operating power plants, the Comision Federal de Electricidad (CFE, Federal Commission for Electricity) remains as the public utility in charge of the electrical energy service. The CFE is directly responsible for exploration, development and commercial use of geothermal energy to produce electricity, although development, construction and operation of geothermal projects by private companies are already permitted.

This report includes the present and planned exploration and utilization of Mexican geothermal energy to generate electricity in the period from 1990 to 1994. It is divided into exploration and drilling activities, installed capacity and generation, and evolution of the geothermal professional personnel and investments, including the appropriate tables.

EXPLORATION ACTIVITIES

Kegional geothermal assessment in Mexico was completed in 1987, when 92% of the whole territory had been covered. The remaining 8% has no geothermal potential because of its tectonically stable location. By 1987, 545 thermal localities had been identified, which grouped dround 1380 individual hot points including hot springs, hot water shallow wells, hot soils, fumaroles, etc. By 1990, **42** geothermal zones had been located; in those zones, pre-feasability studies (geology, fluid geochemistry and geophysics) had been conducted in varying stages (Hiriart, 1990).

From 1990 to 1994 detailed geological studieswere made in the following geothermal zones: Las Tres Virgenes in the State of Baja California Sur (hydrology, tectonics, stratigraphy, volcanology), El Ceboruco-San Pedro in the State of Nayarit (hydrology, tectonics, volcanology), Araro in the State of Michoacin (detailed stratigraphy), Pathe in the State of Hidalgo (tectonics), Santa Rita in the State of Jalisco (detailed mapping), Domos de Zitacuaro in the State of Michoacán (detailed mapping), and Bahia Concepción in the State of Baja California Sur (detailed mapping).

Based upon these geological surveys. it was decided in two of those areas (Santa Rita and Domos de Zitácuaro) to stop exploration, at least for the moment. This was because in Santa Rita all rhyolitic domes were much older than anticipated, and in Domos de Ziticuaro there is an outcropping metamorphic basement whose fracturing, and hence it5 probable permeability, seems to be very low.

Geophysical surveys in the same period were carried out in: Las Tres Virgenes (magnetotelluric, seismology), El Ceboruco-San Pedro (magnetotelluric, thermometry with shallow slim holes, aero-magnetometry, gravimetry), Araro (magnetotelluric. thermometry with shallow slim holes), and Laguna Salada in the State of Baja California (magnetotelluric, gravimetry, thermometry in shallow slim holes, seismology).

TABLE 1. INFORMATION ABOUT GEOTHERMAL LOCALITIES

[1] Main type of reservoir **rock.**

[2] Total dissolved solids (TDS) in water before flashing. v for vapor dominated.

[3]
N = Identified geothermal locality. but **no** assessment information available.
R = **Regional** assessment.
P = Pre-feasability studies.
F = Feasability studies (reservoir evaluation and engineering studies)
U = Commercial utilization.

			Rock[1]	TDS[2]	in January, 1995	Res. temp (°C) Estimated	Measured
El Ceboruco-San Pedro, Nay.	21.0	105.0	Andesites	–	P	–	112
Laguna Salada, B.C.	32.5	115.5	Sandstones(?)		P	–	120
Santa Rita, Jal.	20.5	102.5	Volcanic	–	P	160	–
Bahia Concepción, B.C.S.	27.0	112.0	Volcanic	–	P	–	–
Domos de Zitácuaro, Mich.	19.5	100.0	Metamorphic	–	P	–	–

These are the main studies and explored zones in Mexico during the past five years, all of them made by CFE with its own technical exploration staff or by contracting private Mexican companies. Based on these data, Table 1 was prepared. In this table only those zones whose status changed since 1985 or 1990 are included, as well as zones not included in the same tables of the former update reports (Alonso, 1985; Hiriart, 1990). So, some zones like Santa Rita, Domos de Zitacuaro and El Ceboruco-San Pedro changed from R (regional assessment in 1990) to P (pre-feasability studies in Table 1), while other zones like Laguna Salada and Bahia Concepción were not been mentioned in the former reports.

Beside these geological and geophysical studies, exploration activities in 1990-1994 included drilling of thermal gradient and exploratory wells in some new geothermal zones. In Table 2 those exploratory and thermal gradient wells drilled in that period in the Araró, El Ceboruco-San Pedro, Las Tres Virgenes. Laguna Salada, Pathé and Las Derrumbadas geothermal zones, are listed. Eight deep exploratory wells had been drilled, and four more were in progress, when this report was written. Also, 12 thermal gradient wells were drilled in the Araro and El Ceboruco-San Pedro zone,.

wells drilled in the geothermal fields in production.

As Table 3 shows, in the Cerro Prieto geothermal field (see Figure 1 for location) 13 wells were drilled in 1990, 12 in 1991, 7 in 1992, 2 in 1993, and 4 in 1994 (one more being in progress). Among the 39 wells in that field, there are 33 production and 6 injection wells, giving a total amount of 75,465 drilled meters. If we consider that in January, 1990, there were in Cerro Prieto 185 wells representing 415,356 meters (Hiriart, 19901, there are now 224 wells adding up to 490,821 meters. So, over the last five years the number of wells has increased by 21%, and the drilled meters increased by 18% in that field.

It is worth while to mention that, from those 33 production wells in Cerro Prieto, 21 –including well 624, in progress– have been drilled and are being operated by a private Mexican company, which has signed a contract with the CFE to supply around 15% of the whole steam required by the geothermal units. Recently the contract was enlarged to supply up to 30% of the present whole steam.

In the Los Azufres geothermal field (Figure 1) only four wells were drilled in 1990-1994, all of them for exploratory

TABLE 2 WELLS DRILLED FOR EXPLORATORY PURPOSES IN NEW GEOTHERMAL ZONES FROM 1990 TO 1994
(Do not include thermal gradient wells less than 100 m deep)

1) Type of well:
T = Thermal gradient or other scientific purpose. E = Exploration

2) Total flow rate in kg/s, at given wellhead pressure (WHP) in bar.

Locality and State	Year drilled	Well Number	Type of Well[1]	Total Depth (m)	Max. Temp. (°C)	Fluid Enthalpy (kJ/kg)	Flow Rate[2]	WHP
Araró, Mich.	1991	Z-3	E	1350	118			
	1991	GZ-4	T	200	72			
	1991	cz-5	T	114	79			
	1991	GZ-6	T	201	47			
	1991	GZ-7	T	200	36			
	1991	GZ-8	T	123	26			
El Ceboruco-Domo San Pedro, Nay.	1992	cc-1	T	157	43			
	1992	cc-2	T	124	27			
	1992	CC-3	T	200	43			
	1992	GC-4	T	187	48			
	1992	cc-5	T	198	37			
	1993	GC-6	T	496	31			
	1993	GC-7B	T	414	23			
	1994	CB-1	E	2801	112			
	1994	CB-2	E	1700	120			
	1994	CB-3	t	1911	180			
Las Tres Virgenes, B.C.S	1991	LV-2A	E	1291	240			
	1994	IV-3	E	2150	260			
	1994	LV-1	F	in progress	?			
Laguna Salada, B C	1994	ELS-1	t	2396	125			
	1994	ELS-2	E	1777	112			
	1994	ELS-3	E	in progress	?			
Pathé, Hgo.	1994	EP-1	E	in progress	?			
Las Derrumbadar. Pue.	1994	ED-2	E	in progress	?			

Results of the deep drilling in Araró, including a former deep well (named as Z-2) drilled in 1982 exhibiting low temperature, led stopping of the exploration in this zone. This decision was taken because Araro seems to be a fossil hydrothermal system, now extinct, as shown by its present low temperatures and its intense high temperature hydrothermdl alteration at depth.

DRILLING ACTIVITIES

Wells drilled for geothermdl purposes in Mexico between 1990 and 1994 are included in Tables 2 and 3. Wells in Table 2 have been mentioned already. In Table 3 are reported those

purposes, giving a total of 5,734 meters. Presently, there are in this field 68 geothermal wells, representing 104,859 drilled meters.

In the Los Humeros geothermal field (Figure 1) two deep wells (H-3 and H-341 and seven shallow slim holes were drilled. The latter ones had hydrological objectives, to sample and measure the shallow aquifer in the field. The deep wells add up 3,555 meters and, thus, there are now 35 geothermal wells and 75,952 drilled meters.

At the present time, four deep exploratory wells are being drilled in the geothermal zones of Las Tres Virgenes, Laguna

Salada, Path6 and Las Derrumbadas (see Figure 1 for location). Two of the wells are slim hole type (in Path6 and Las Derrumbadas).

Las Tres Virgenes is a Quaternary volcanic complex, composed of three North-South aligned volcanoes. Well LV-2 and its deviation, named LV-2A, found interesting temperatures (Table 2) but low permeability. Well LV-3 is probably the first producer well (its production is being assessed at moment) and a third well (LV-1) is being drilled.

El Ceboruco is a Quaternary strato-volcano located in a wide graben (the Tepic Graben) within which other volcanoes and domes, like the Domo San Pedro, have been formed. The two first wells found low temperatures, hut the third (CB-3) presents a good temperature (Table 2).

Laguna Salada is a tectonic basin 35 km to the west of Cerro Prieto (Figure 1), where two first wells, known as ELS-1 and ELS-2, recorded low temperatures (Table 2). Well ELS-3 is now being drilled.

Besides the wells in Pathe and Las Derrumbadas, one deep exploratory well is scheduled to be drilled in each one of the geothermal zones of Caldera de Acoculco and Los Negritos (Figure 1). Two more exploratory wells will be drilled at the

TABLE 3. *WELLS* DRILLED FOR ELECTRICAL USE OF GEOTHERMAL *RESOURCES* FROM 1990 *TO 1994*
(Do **not** *include thermal gradient wells less than 100 m* **deep)**

1) Type of well:

T = Thermal gradient or other scientific purpose. E = Exploration. P = Production. I = Injection

2) Total flow rate in kg/s, at given wellhead pressure (WHP) in bar.

Geothermal field	Year drilled	Well Number	Type oi Well"	Total Depth (m)	Max. Temp (°C)	Fluid Enthalpy (kJ/kg)	Well Output[2]	
							Flow Rate	WHP
Cerro Prieto	1990	E-60	P	2128	310	1444	40.7	28.2
	1990	101	I	1366	253	–	–	–
	1990	102	P	2000	312	2072	15.2	24.1
	1990	E-61	P	1620	307	1432	41.3	28.2
	1990	103	P	1950	322	2031	36.3	51.6
	1990	104	I	1600	254	–	–	–
	1990	301	P	1300	290	1382	36.5	34.5
	1990	105	P	1700	310	1143	27.6	12.5
	1990	302	P	1330	285	1356	34.9	34.1
	1990	303	I	1337	278	–	–	–
	1990	107	P	1550	315	1156	29.0	20.0
	1990	106	P	1600	301	1156	23.9	12.1
	1990	E-56	P	2860	311	1524	39.5	58.2
Cerro Prieto	1991	600	P	2030	325	2131	20.8	29.4
	1991	601	P	1936	323	1143	40.0	21.0
	1991	603	P	1916	295	1528	14.6	20.0
	1991	605	P	1860	310	1847	21.0	26.6
	1991	602	P	2030	276	1327	38.0	34.8
	1991	607	P	2080	319	1809	14.7	27.0
	1991	604	P	2040	320	1922	19.8	29.6
	1991	606	P	1966	330	1750	18.2	28.4
	1991	609	P	2158	312	2282	14.5	20.7
	1991	608	P	2040	335	1545	22.0	27.2
	1991	611	P	2140	325	1625	12.1	20.3
	1991	613	P	2038	330	1512	21.2	19.3
Cerro Prieto	1992	615	P	2153	315	2315	15.5	26.9
	1992	610	P	2030	340	1796	41.5	48.2
	1992	617	P	2315	330	2428	18.2	29.8
	1992	612	P	2030	330	1813	29.4	32.4
	1992	I-2	I	1400		–	–	–
	1992	I-1	I	1251			–	–
	1992	202	P	2675	320	1704	22.5	32.7
Cerro Prieto	1993	108	P	1640	310	1767	16.1	22.1
	1993	619	P	2543	325	1628	52.7	52.4
Cerro Prieto	1994	614	P	2948	330	1528	54.5	53.7
	1994	616	P	2703	330	1541	31.5	26.9
	1994	618	P	2883	330	1637	47.9	58.94
	1994	I-5	I	2319	–	–	–	–
	1994	624	P	in progress	330	–	–	–
Los Azufres	1990	A-58	E	2054	110		–	
	1990	A-58D	E	1660	100	–	–	
	1991	A-59	E	905	220	696.9	11.85	15.15
	1991	A-60	E	1115	220	–	–	
Los Humeros	1990	PCH-1	T	301				
	1990	PGH-2	T	327				
	1990	VP-1	T	206				
	1991	PGH-3	T	262				
	1991	PGH-4	T	330				
	1991	PGH-5	T	282				
	1991	PGH-7	T	363				
	1993	H-3	E	1755	317	–	1.81	3.11
	1994	H-34	P	1800	300	2606.8	2.34	7.15

northwestern portion of Los Azufres during 1995

In conclusion, there are in Mexico, up to the present, 356 deep wells drilled for electrical use of geothermal resources, excluding thermal gradient and shallow slim holes. These wells give a total amount of 715,090 drilled meters. These figures include wells in La Primavera geothermal field, and in the Las Derrumbadas and San Marcos zones (Hiriart, 1990).

INSTALLED CAPACITY AND ELECTRICAL GENERATION

A detailed status of the geothermal-electric installed capacity in Mexico is presented in Table 4, divided into three geothermal fields in production: Ccrro Prieto, Los Azufres and Los Humeros (Figure 1).

in the Cerro Prieto geothermal field there arc 9 power units in operation, grouped into three sections: CP-I, CP-II and CP-III. There is a fourth section, known as Cerro Prieto IV (CP-IV), in which same successful exploratory wells have been drilled. No unit is installed in that section yet, although an minimum potential of 80 MWe has been estimated based on mathematical modelling.

Present installed capacity in Cerro Prieto is 620 MWe, the same as reported in 1990. Energy produced in 1993 was 5,021 .0 GWh, which represents an average rating of 573.2 MWe and a plant factor of 92.4%. in 1988 the average rating was 555.3, equivalent to 89.6% (Hiriart, 1990); so, there was a more efficient utilization of the same units, particularly Unit 5 of CP-I, which increased its plant factor from 40% to 67%.

As Table 4 shows, installation of eigth units with 168 MWe in total is planned at Cerro Prieto between 1996 and 1988. All of them are planned to be constructed by means of contracts of BLT type (Build, Leasing, Transfer), and some could be installed and operated by private investors or developers. There are no units in construction by the moment.

In the Los Azufres geothermal field 12 power units are operating: 9 back-pressure units 5 MWe each, one single flash unit of 50 MWe (Tejamaniles Unit), and two binary units of 1.5 MWe each. The latter ones are the first binary plants operating in Mexico, and were installed by end of 1993. Thus. present installed capacity in Los Azufres is 98 MWe. Inasmuch as 80 MWe were reported in operation in 1990 (Hiriart, 1990), Los Azufres presents an increase of 22.5% in its installed capacity.

Energy produced in Los Azufres during 1993 was 643.2 GWh, with an average rating of 75.2 MWe and a plant factor of 77.3%, considering the actual date of the initial operation of the binary units. The average plant fdctor in 1988 was similar (75.8%).

Six units, 20 MWe or 25 MWe each one, are planned to be installed in Los Arufres by 1997 and 1998 (Table 4), also by means of BLT contracts.

In the **Los** Humeros geolhermal field seven back-pressure units, 5 MWe each, are now in operation. In 1990 there were no installed units, although units 1, 2, 3 and 4 were reported in construction (Hiriart, 1990). Energy produced in Los Humerus in 1993 was 212.4 GWh, with an average raling of 26.3 MWe and an average plant factor of 85.8%; however, these figures do not include Unit 6, whose operation started in February, 1994. One experimental small (3 MWe) unit is planned in Los Humeros to be installed in 1996, in a cascade arrangement with an existing back-pressure unit. Also two units, 20 MWe each, are planned by 1999.

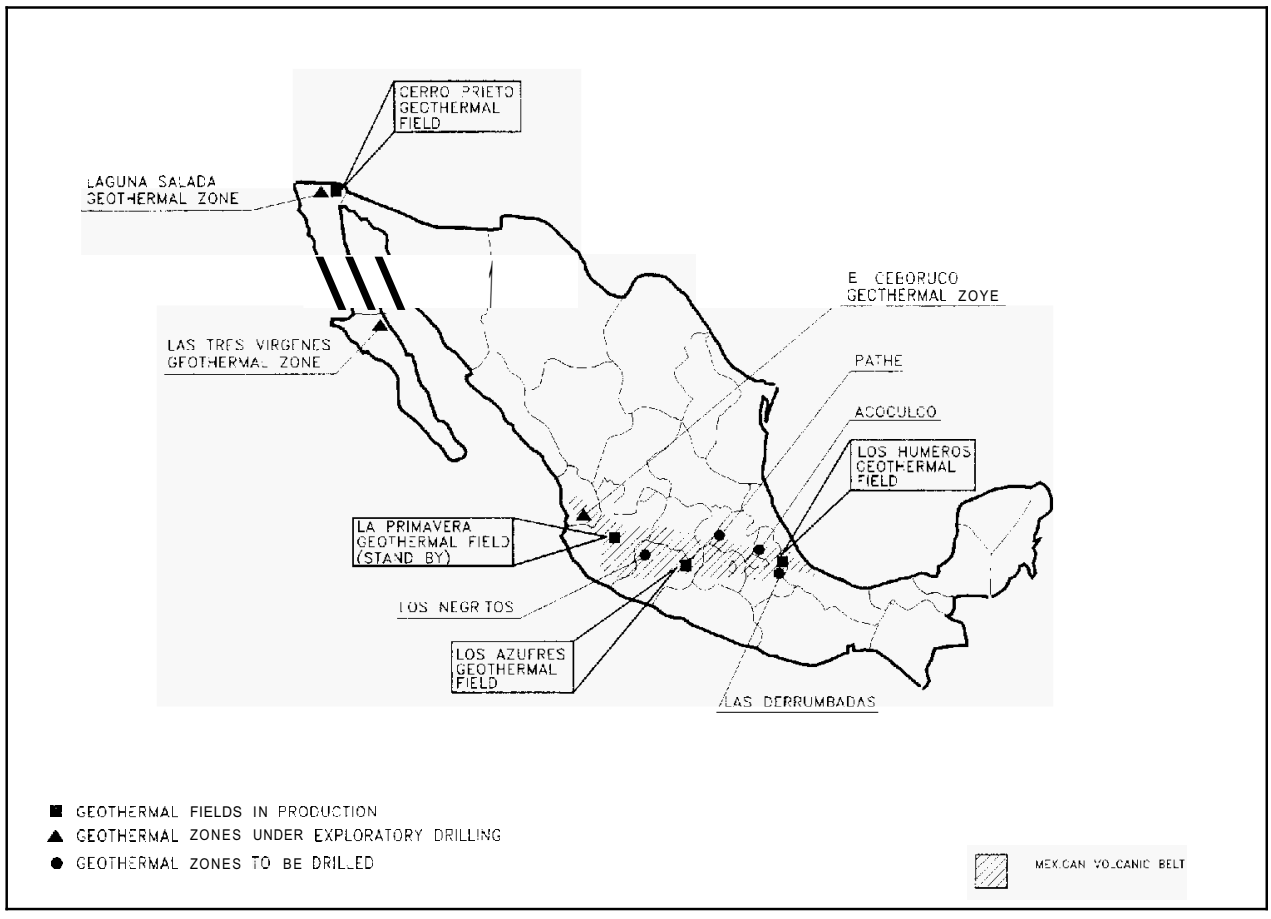

Figure *1* - Geothermal fields **and** geothermal zones under exploration in Mexico

TABLE 4. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRICAL GENERATION IN DECEMBER, 1994

[1] Statui: O = Operation P = Planned

[2] Type of unit: 1F = Single flash 2F = Double flash B = Binary BP = Back-pressure

[3] Data for 1993.

Geothermal field	Power Plant Name	Year Com-misioned	No. oi Units	Status[1]	Type of Unit[2]	Unit Rating MWe[3]	Total ins-talled Cap. MWe	Annual Production GWh/yr[3]	Total Planned MWe
Cerro Prieto	CP-I U-1	1973	1	O	1F	32.7	37.5	286.7	
	u-2	1973	1	O	1F	36.2	37.5	316.7	
	u-3	1979	1	O	1F	30.9	37.5	270.3	
	u-4	1979	1	O	1F	36.3	37.5	318.1	
	u-5	1982	1	O	2F	20.2	30.0	176.6	
	U-6	1997	1	P	1F	–	25.0	–	25.0
	u-7	1996	1	P	–	–	3.0		3.0
	CP-II U-1	1986	1	O	2F	109.3	110.0	957.6	
	u-2	1987	1	O	2F	100.3	110.0	878.8	
	u-3. U-4	1997	2	P	1F	–	50.0	–	50.0
	CP-III U-1	1986	1	O	2F	99.2	110.0	868.8	
	u-2	1987	1	O	2F	108.1	110.0	947.4	
	u-3.u-4	1997	2	P	1F	–	40.0	–	40.0
	CP-IV U-1, u-2	1998	2	P	1F	–	50.0	–	50.0
Los Azufres	U-1	1982	1	O	BP	4.7	5.0	41.5	
	U-2	1982	1	O	BP	5.0	5.0	43.7	
	u-3	1982	1	O	BP	4.7	5.0	41.1	
	u-4	1982	1	O	BP	5.0	5.0	44.1	
	u-5	1982	1	O	BP	4.9	5.0	42.8	
	U-6	1986	1	O	BP	4.9	5.0	43.1	
	(Tejamaniles) U-7	1988	1	O	1F	32.0	50.0	280.0	
	u-8	1989	1	O	BP	4.9	5.0	43.3	
	u-9	1990	1	O	BP	4.9	5.0	43.2	
	u-10	1992	1	O	BP	4.2	5.0	18.1	
	U-11	1993	1	O	B	–	1.5	2.0	
	u-12	1993	1	O	E	–	1.5	0.5	
	Maritaro U-1, U-2	1997	2	P	1F	–	40.0	–	40.0
	El Chino U-1, U-2	1997	2	P	1F	–	40.0	–	40.0
	Nopalitos U-1, U-2	1998	2	P	1F		50.0	–	50.0
Los Humeros	U-1	1990	1	O	BP	4.8	5.0	41.8	
	u-2	1990	1	O	BP	4.2	5.0	36.9	
	U-3	1991	1	O	BP	4.7	5.0	41.4	
	u-4	1991	1	O	BP	3.7	5.0	32.7	
	u-5	1992	1	O	BP	4.7	5.0	41.0	
	U-6	1994	1	O	BP	–	5.0	–	
	u-7	1993	1	O	BP	4.2	5.0	18.5	
	U-8	1996	1	P	–	–	3.0	–	3.0
	u-9. u-10	1999	2	P	1F	–	40.0	–	40.0
La Primavera	U-1, u-2	1997	2	P	BP	–	10.0	–	10.0
	U-3, u-4	1999	2	P	1F	–	40.0	–	40.0
TOTAL						674.7	753.0	5876.6	391.0

In the fourth Mexican geothermal field, La Primavera (Figure 1), where two back-pressure units, 5 MWe each one, were reported in construction in 1990 (Hiriart, 1990), there was no activity in 1990-1994. Even though 13 geothermal wells have been drilled since 1988, six of them with good production, those two units were finally installed in Los Humeros, because of the lack of environmental permits and licenses in La Primavera. However, 50 MWe are planned to be installed in this field by 1996 and 1999 (Table 4).

Therefore, Mexico has at present an installed geothermal-electric capacity of 753 MWe (Table 5). In 1990, 700 MWe were reported as the installed capacity (Hiriart, 1990), so there was an increase of 7.6% during the last five years. This represents a very slow rate, much lesser than the growth rate of total electric capacity in Mexico, which was around 30% in the same period. In fact, installation of new geothermal units in 1990-1994 was limited to those which were in construction by 1990, plus the referenced two experimental binary units.

Electrical installed capacity based upon fossil fuels (hydrocarbons and coal) had an increase of 34%. raising from 16,085 MWe in 1990 to 21,565 in 1994 (Table 5). This increase is sligthly lesser than the anticipated in 1990, when the projected use by 1995 was estimated in 22,425 MWe (Hiriart, 1990).

The hydroelectric installed capacity has increased by 14.5%, by raising from 7,764 MWe in operation in 1990 to 8,891 MWe in 1994 (Table 5). This last figure coincides practically with the projected use estimated in 1990, which was 8,839 MWe (Hiriart, 1990).

In 1990 there were no nuclear-electrical plants in operation in Mexico, although 675 MWe were reported under construction. Now, installed capacity based on nuclear plants is 675 MWe, with another 675 MWe under construction, all of them at the Laguna Verde power plant (Table 5).

Total electrical installed capacity in Mexico is, therefore, 31,884 MWe by August, 1994 (Table 5), being slighly less than anticipated in 1990 (33,564 MWe; Hiriart, 1990). Geothermal-electric capacity represents 2.4% of that total, while in 1990 represented almost 2.9%. This decrease is due, of course, to the above mentioned different growth rates of geothermal and total

	Capacity MWe	Gross prod. GWh/y	Capacity MWe	Gross prod. GWh/y	Capacity MWe	Gross prod. GWh/y	Capacity MWe	Gross prod. GWh/y	Capacity MWe	Gross prod. GWh/y
In operation	753	5,867	21,565	89,522	8,891	26,235	675	4,931	31,884	126,565
Under construction	0		1,400		9,350		675		3,010	
Funds commited, but not yet in construction	391		959		2,632		0		3,718	
Total projected use by 2000	1144		23,924		12,018		1,350		38,352	

electrical capacities in 1990-1994.

Electricity produced by geothermal plants in Mexico was 5,877 GWh in 1993 (Table 5), while in 1988 was 4,661 GWh (Hiriart, 1990). So, there was an increase of 26% during these five years, which reflects a substantial improvement in the efficiency of the installed geothermal plants, especially in Cerro Prieto as was mentioned before.

In 1988 total electrical energy produced in Mexico was 105,905 GWh, from which geothermal electricity represented a percentage of 4.4 (Hiriart, 1990). while in 1993 those 5,877 GWh represented a 4.6% of the total electricity produced in that year (Table 5). Therefrom, even though the installed geothermal capacity decreased from 2.9% to 2.4% of the total electrical capacity between 1990 and 1994, the electricity production of geothermal plants had a relative increase from 4.4 to 4.6% of the total production of electricity in Mexico in a similar period.

In Table 5 an additional 391 geothermal MWe are reported with funds commited but not yet in construction. This figure is composed of 168 MWe planned in Cerro Prieto, 130 MWe planned in Los Azufres, 43 MWe planned in Los Humeros and 50 MWe planned in La Primavera (Table 4). In La Primavera a potential of 75 MWe has been estimated by mathematical modelling.

Table 5 shows, also, the total electrical capacity projected in Mexico by 2000. This is estimated in 38,252 MWe, which represents an increase of 20% as compared to the present capacity. This means an annual growth rate of 4%, much lesser than the actual rate in the past five years (which was around 6%). This estimated rate could be greater, and in such a case the excess would be supplied with thermal plants based upon fossil fuels.

PROFESSIONAL PERSONNEL AND INVESTMENTS

TABLE 6. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES

(Restricted to personnel with a University degree)

(1) Government
(2) Public utilities
(3) Universities
(4) Paid foreign consultants
(5) Contributed through foreign aid programs
(6) Private industry

Year	Professional Man Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1990	0	195	40	0	0	18
1991	0	196	38	0	0	15
1992	0	198	38	0	0	20
1993	0	200	38	0	0	20
1994	0	202	39	0	0	19

In Table 6 the personnel with an university degree allocated only to geothermal activities is reported, and their changes in the last five years. In governmental agencies, at least since the middle of 1990, there were no professional personnel exclusively allocated to geothermics.

Data from public utilities refer only to CFE, in particular to the Cerencia de Proyectos Geotermoeléctricos (the geothermal division of CFE), whose professional personnel have remained practically the same, after the substantial decrease ocurred between 1988 and 1989 (Hiriart, 1990). Data in the third column of Table 6 includes also research centers, like the Instituto de Investigaciones Electricas (IIE, Electrical Research Institute), whose personnel remains without major changes.

TABLE 7. TOTAL INVESTMENTS IN GEOTHERMICS

(All data in 1994 million dollars)

1) Research and Development, including surface exploration and exploratory drilling
2) Field development including production drilling and surface equipment.
3) New exchange rate for Mexican currency: N$ 3.0 x 1 USD.

Year	R & D (1)	Field Develop. (2)	Utilization		Funding Type
			Direct	Electric	
1990	6.20	42.22		48.42	Public
1991	8.62	36.36		44.96	Public
1992	5.73	58.20		63.93	Public
1993	7.03	64.66		71.69	Public
1994	5.46[3]	44.17[3]		49.63[3]	Public

Personnel of private industries is estimated, and includes that from drilling or consultant companies allocated mainly, but not only, to geothermal activities, whose number seems to be practically the same as during 1990-1994.

Table 7 presents total investments in geothermics, valued in 1994 American dollars, for years 1990 through 1994. Total annual investment is reported under Electrical Utilization, and is separated into Research and Development and Field Development items, as was required. All funds are of public type, and the reported figures refer to CFE's investments. Data from former years were not available.

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