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ITALY COUNTRY UPDATE REPORT 1995-1999

Guido CAPPETTI, Giancarlo PASSALEVA and Fabio SABATELLI
Erga – Enel Group - Via Andrea Pisano, 120 - I-56122 Pisa, Italy
E-mail: cappetti.guido@enel.it; passaleva.giancarlo@enel.it; sabatelli.fabio@enel.it

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ABSTRACT

The development of geothermal activities in Italy over a five-year period (1995-1999) is outlined in this paper. Geothermal resources in Italy are mainly used to produce electricity. The first industrial power plant dates back to 1913; since then geothermal installed capacity has increased, reaching 788.5 MW as of January 2000. Electricity generation peaked to an unprecedented maximum of 4.4 billion kWh in the year 1999. Several new power plants, totalling 280 MW, have been installed in the last five years and are now operating in the Larderello and Mount Amiata areas. Some of these units replaced older plants no longer in operation. The first commercial power plant outside Tuscany, exploiting the Latera water-dominated reservoir situated in Northern Latium and with an installed capacity of 40 MW, has recently been commissioned. Direct uses of geothermal resources have also increased, reaching a peak capacity of 325 MW, with an annual energy use of 3800 TJ. Over the last five years, 35 wells have been drilled, totalling 106,500 metres. Most of these new drillings have been of deep wells. Investment in geothermal research, development and utilisation exceeded US$ 700 million, most of which (well over 90%) is directed at electricity generation.

1. THE LIBERALISATION OF THE ELECTRICITY MARKET IN ITALY

Like many other countries, Italy has experienced the liberalisation process of the electricity market over the last few years. In Italy this sector used to be largely under Enel's control.

Enel was set up in December 1962 and began operating as the State Electricity Company when about 1250 electrical companies and small firms were nationalised. Its specific objectives were to complete the electric grid and adjust the price and supply of electricity to the needs of a country with a growing economy.

In January 1991 the production of electricity by Non Utility Generators was liberalised and encouraged. Enel was subsequently transformed into a joint stock company, which was fully owned by the Ministry of Treasury, by an act of Parliament on 11 July 1992, as part of a government programme aimed at privatising large public utilities. The company's name was changed to Enel S.p.A., i.e. a joint stock company (Società per Azioni, or S.p.A. for short).

In line with the European Directive (EC/96/92) relating to the creation of a single market for electric energy in Europe, on 19 February 1999 the Italian government approved a decree law defining the basic rules for the new organisation of the Italian electric power industry. According to one of the new regulations, no individual operator will be allowed to generate or import more than 50% of the domestic overall consumption of electric energy as from 1 January 2003. In order to comply with this new legislation, Enel S.p.A. will have to sell around 15,000 MW of its current generating capacity to other operators.

Under the same law, as from the year 2001, all operators (importers and producers of electricity from non renewable sources) will have to feed a quota produced from renewable sources into the grid the following year. The quota is initially, i.e. from the year 2002, set at 2% of the total energy produced or imported exceeding 100 GWh (excluding cogeneration, auxiliary consumption and exports).

Applied to the Italian market, the 2% quota corresponds to about 5 billion kWh, an amount large enough to spur the market effectively, considering that it must be obtained only from plants that begin production or are re-powered (for the additional capacity only) after the law has come into effect.

The conceived mechanism provides a great deal of flexibility: operators are allowed to meet their obligations either by generating directly or by purchasing from others some or all of the "green" energy necessary, or simply their rights (as in the spirit of the "green certificates").

Updating the 2% quota in subsequent years, in keeping with international commitments designed to reduce CO_2 emissions, is envisaged according to agreements to be stipulated between the Ministries of Industry and of Environment.

In compliance with the decree law, Enel S.p.A. has developed a new corporate structure. It now co-ordinates and is at the helm of a number of independent joint stock companies, each responsible for activities regarding generation, the ownership of the transmission grid, distribution and supply of captive clients, supply of eligible clients, etc.

The current and planned (2005) electricity generating capacity and production in Italy is summarised in Table 1. Whereas geothermal data are updated to 1999, the data regarding other sources refer to the year 1998.

At present, the Enel Group is the leader in the generation, transmission, distribution and supply of electricity in Italy. In 1998, Enel produced approximately 73% of total Italian electricity output (about 247 TWh), 78.6% from fossil fuels, and supplied 93% of the electricity to customers (Figures 1, 2 and 3). As for the power supplied, the Enel Group ranks third out of the twenty-nine OCSE countries.

Over the past few years, Enel's primary objective has been to prepare for the liberalisation of the energy market. This aim has been achieved by significantly reducing costs, re-organising activities, improving both efficiency and competitiveness, encouraging business diversification directed at power-related sectors, as well as by focusing on customer expectations.

The Enel Group is thus diversifying its activities, enhancing its assets and its expertise in other sectors, such as telecommunications, public lighting, power production from waste, natural gas and water supply.

In compliance with the privatization process, a substantial amount of Enel's shares has been sold through an IPO, followed by share negotiations that started on 2 November 1999 in Milan and New York.

2. ERGA: A COMPANY DEDICATED TO RENEWABLE ENERGY SOURCES

In response to the growing demand for renewable energy, recorded in recent years as a result of commitments signed by many governments directed at reducing CO_2 emissions, a new company, Erga S.p.A., fully owned by the Enel Group, was set up on 1 October 1999.

This company draws its strength from Enel expertise and experience in geothermal, small-hydro, wind and solar power generation.

A combination of power plants and facilities built by Enel provides Erga with a solid base in the field of electricity generation from renewable energy sources. The company will maintain and operate 1560 MW of output capacity solely

from renewable resources: its production plants include 273 mini-hydro, 31 geothermal, 4 wind parks and 3 solar grid connected photo-voltaic facilities, with a combined yearly expected output of about 8 billion kWh, the electricity requirement of 4 million Italian households.

Today, Erga is one of the world's leading companies in this segment of the market. Its mission is to develop energy generation from renewable sources, both in Italy and abroad, maximising its economic significance through the efficient use of power plants, the identification of new renewable resources, the technological development and the proficient use of its human, technical and financial resources.

Its production of "green energy" is thus in line with the requirements of the Kyoto Agreement concerning the reduction of greenhouse gas emissions and the promotion of a sustainable energy development.

3. GEOTHERMAL POWER GENERATION

Commercial power generation from geothermal resources began in Italy in 1913 with a 250 kW unit, marking the beginning of this new industrial activity.

Power generation stayed at modest levels until 1938 but since then it has risen rapidly and continuously, interrupted only in 1944 by events occurring during World War II (Figure 4). The Italian experience of electricity generation from endogenous fluids remained the sole example in the world until 1958, when the first power generation unit was installed in Wairakei (New Zealand). In the same year more than 1900 GWh of electric energy was produced in the Larderello area with an installed capacity of 300 MW.

On 31 December 1999, the total installed capacity in Italy amounted to 788.5 MW, of which 38 MW are classified as "reserve units", used only during the scheduled maintenance operations of other plants, while 3,5 MW are classified as "retired". The 1999 energy generation reached 4403 GWh. Comparative figures as of January 1995 were an installed capacity of 625.7 MW and a generation of 3436 GWh (Allegrini *et al.*, 1995). Additional units totalling 390 MW will be installed over the next five years, 245 MW of which will replace old units that have been in operation for many years and are to be decommissioned (229 MW), while 145 MW will be related to new field developments.

The positive results of deep exploration and reinjection programmes, which began in the late 1970s (Barelli *et al.*, 1995; Bertini *et al.*, 1995 and Cappetti *et al.*, 1995), have made it possible to reassess the field potential of geothermal areas and to plan both development programmes (involving additional wells and power plants) and renewal programmes (replacement of old units with new ones, characterised by higher efficiency and lower environmental impact).

Detailed data on the installed capacity, the electricity generation of each unit and the planned development are shown in Table 2. The main features of geothermal fields in operation are described below.

Larderello (Tuscany). The explored area is about 250 km^2, where 180 wells produce some 830 kg/s of superheated steam at pressures between 2 and 15 bars and temperatures ranging between 150°C and 260°C. The non-condensable gas content ranges from 1 to 15% by weight.
The installed capacity is 547 MW, with 27 units (2 of which are reserve units).

Since the late 1970s, reinjection and deep exploration programmes were started in this area with the aim of sustaining or increasing steam production. The reinjection of the steam condensate back into the reservoir, in the most exploited areas, has been very successful and has increased both the reservoir pressure and steam production. The deep exploration programme has demonstrated the presence of permeable layers, within the metamorphic basement, up to depths of 3000-4000 m, with reservoir pressure and temperature increasing with depth, up to values of 70 bar and 350°C. The fluid within the deep reservoir is still superheated steam and is characterised by a high content of volatile chloride. Specific treatment plants have been installed to avoid corrosion problems inside the wells and also in the surface equipment (gathering system and turbines).

Travale-Radicondoli (Tuscany). The explored area covers approximately 50 km^2; 15 wells produce about 140 kg/s of superheated steam at pressures ranging from 8 to 14 bars, with temperatures of 190°C to 250°C. The non-condensable gas content is in the range of 4 and 8% by weight. The installed capacity is 90 MW with 5 units in operation.

In the same area deep exploration showed the existence of permeable layers within the metamorphic basement, at the same depths and with fluid thermodynamic and chemical characteristics very similar to those found in the Larderello area. Based on the data collected from the deep drillings, it can be said that the Larderello and Travale-Radicondoli areas belong to the same deep geothermal system: at the depth of 3000 m, the 300°C isotherm contour line includes both areas, with a total extension of about 400 km^2.

Based on the positive results of deep exploration wells recently drilled in the southern margin of the field (a single well drilled in 1999 can produce about 70 kg/s of superheated steam), a development programme has been planned in this new area involving the drilling of additional wells and the installation of new units totalling 60 MW: the first 20 MW unit will be in operation in March of the current year.

Monte Amiata (Tuscany). This area includes two geothermal fields: Bagnore and Piancastagnaio. They were discovered in the late 1950s and early 1960s, with wells producing from the shallow carbonate reservoir. The deep exploration programme in both these fields has been very successful and has revealed the presence, inside the metamorphic basement underlying the shallow carbonate reservoir, of fractured layers at depths ranging from 2500 to 4000 m. This deep reservoir is water-dominated, with a hydrostatic pressure of around 200 bars at 3000 m of depth and temperatures of 300-350°C. The produced fluid is a two-phase mixture that is separated at wellhead at 20 bars; the gas content in the steam ranges from 8 to 15% by weight.

The installed capacity in the Piancastagnaio field is 91.5 MW, with 5 units on line; the first 20 MW unit in the Bagnore field started operation in December 1998 and the second unit, of the same size, will be on line in 2002.

Latera (Latium). This field is located in the Monti Volsini volcanic region of northern Latium. The water-dominated reservoir, chiefly made up of carbonate and carbonate-siliceous formations, is characterised by temperatures of 190-240°C, with typical values around 210°C. The wells produce a two-phase mixture with a TDS content of about 10-12 g/l (mainly alkaline chlorides and, to a lesser extent, alkaline earth bicarbonates) and a gas content around 4-5% by weight (with 98% of CO_2). In this area 5 productive and 4 reinjection wells are available and the construction of the power plant (installed capacity 40 MW) and of the relevant gathering system was completed in 1999. This plant, the first of its kind, features an advanced generation scheme, based on a double flash cycle with the upstream removal of NCG by means of a direct-contact reboiler (Sabatelli and Mannari, 1995). Bottoming binary units (5 MW) are being installed.

Power plants operation. The small capacity of geothermal units (the maximum installed capacity is 60 MW), their number, areal distribution and the comparative simplicity of the equipment determined the decision to use plant automation and remote control systems to ensure maximum operating economy. Currently, all the installed power plants are remotely controlled from a "Remote Control Station" located in Larderello, where 12 operators work on a continuous turnover shift.

This remote system provides increased plant operation safety, allowing the automatic monitoring of many parameters, while making it possible to take operational decisions, e.g.:

- to remote control (including shutdown and restart) and supervise the power plants;
- to carry out power plant operation in safety and efficiency conditions;
- to have a total visualisation of the state of the plants, of each unit and of the HV electric line;
- to analyse information coming from the power plants (signals, alarms, measurements).

The plants are also protected by a security system, which detects unauthorised entries by warning the shift operator at the "Remote Control Station".

4. DIRECT HEAT UTILISATION

The lack of economic incentives for the direct use of geothermal heat prevented the research and development of low-temperature resources and made it difficult to develop new projects using fluids already available.

In Italy, the vast majority of geothermal development is based on steam-dominated reservoirs, so waste streams with high enough temperatures are not generally available. Under these circumstances, heat has to be supplied by means of geothermal steam subtracted to the electricity generation; the subsequent loss of generation has to be charged to the heat user, resulting in increased costs, especially when the electricity produced with that steam benefits from the state subsidies for RES.

Despite this, some progress has been made over the last five-year period. The district heating of many villages in the Larderello area (Montecerboli, Serrazzano, Lustignano, San Dalmazio and Sasso Pisano) accounts for the largest amount among the new applications, even if the unit capacities are quite small. These plants are fed by steam supplied by Erga and operated by local municipalities. In Larderello, the local swimming pool has re-opened after many years of closure and features a brand-new geothermal heating system fed and operated by Erga. New greenhouses have been built in the Radicondoli area, fed by Erga and operated by a private entrepreneur. Finally, an industrial plant for the transformation of dairy by-products has been built in Carboli, in the southernmost part of the Larderello field, and is also fed by steam supplied by Erga.

On the other hand, some existing greenhouses in Castelnuovo V.C. have been dismantled; most importantly, the Vicenza district heating system has been converted from geothermal to natural gas. This was made possible by introducing other endothermic motors in addition to the ones previously coupled to the heat pumps. Under the present scheme, made more convenient by subsidising generated electricity, the motors are coupled to generators and their waste heat feeds the district heating network. This example fully demonstrates how economical incentives can be effective in promoting one energy source rather than another.

The present status of the direct utilisation of geothermal heat is shown in Tables 3 and 5.

The recent start-ups of geothermal power plants in the water-dominated fields of Bagnore and Latera will make available large quantities of waste heat in these sites. Specific projects (district heating and greenhouses respectively) have already been planned. In the Piancastagnaio field, in addition to the greenhouses fed by the high-NCG steam coming from a back-pressure unit in operation, the district heating of the village is planned to use water coming from wells tapping the deep reservoir and separated at wellhead.

5. DRILLING

Over the last few years, drilling activity has progressively decreased from 35,000 m in 1995 to around 11,000 m in 1999. During this period, a total of 33 wells were drilled specifically for the electricity generation, with depths generally between 2,000 and 4,000 m. Ten of these newly drilled wells are exploratory, and they have made it possible to verify the extension of the productive areas beyond the boundaries of fields already under exploitation. Only one well, drilled within the framework of a direct-use project, has been abandoned due to lower than expected temperatures.

The summary of the drilling activity carried out is given in Table 6.

6. PERSONNEL AND INVESTMENTS

The number of professional personnel allocated to geothermal activities has remained almost unvaried in the last five years, with only a minor decreasing trend shown in Table 7.

Overall investment is slightly lower compared with the peak reached in the previous five-year period, as shown by Table 8. This reduction reflects both the already mentioned contraction of drilling activity and the generalised equipment cost reduction experienced in the Italian market.

REFERENCES

Allegrini, G., Cappetti, G. and Sabatelli, F. (1995). Geothermal development in Italy: Country update report. *World Geothermal Congress*, Florence, Italy, May 18-31, 1995. Proceedings, vol. 1, pp. 201-208.

Barelli, A., Cappetti, G. and Stefani, G. (1995). Results of deep drilling in the Larderello- Travale/Radicondoli geothermal area. *World Geothermal Congress*, Florence, Italy, May 18-31, 1995. Proceedings, vol. 2, pp. 1275-1278.

Cappetti, G., Parisi, L., Ridolfi, A. and Stefani, G. (1995). Fifteen years of reinjection in the Larderello - Valle Secolo area: Analysis of the production data. *World Geothermal Congress*, Florence, Italy, May 18-31, 1995. Proceedings, vol. 3, pp. 1797-2000.

Bertini, G., Cappetti, G., Dini, I. and Lovari, F. (1995). Deep drilling results and updating of geothermal knowledge of the Monte Amiata area. *World Geothermal Congress*, Florence, Italy, May 18-31, 1995. Proceedings, vol. 2, pp. 1283-1286.

Sabatelli, F. and Mannari, M. (1995). Latera development update. *World Geothermal Congress*, Florence, Italy, May 18-31, 1995. Proceedings, vol. 3, pp. 1785-1789.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICTY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Wind, Solar, Biomass and Waste)		Total	
	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr	Capac-ity MWe	Gross Prod. GWh/yr
In operation in January 2000	785	4403	54530 *	207970 **	20255 *	47365 **	—	—	615 *	1466 **	76185	261204
Under construction in January 2000	105						—	—				
Funds committed, but not yet under construction in January 2000	285						—	—				
Dismantling	229						—	—				
Total projected use by 2005	946	5900	53600	241300	20600	55000	—	—	2200	8700	77300	310900

* January 1999
** Production 1998

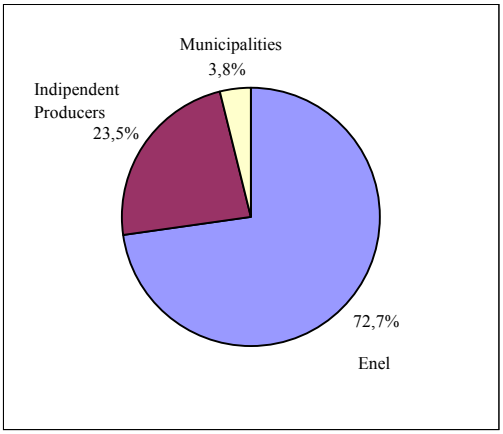

Figure 1: Electricity Generation in Italy (1998)

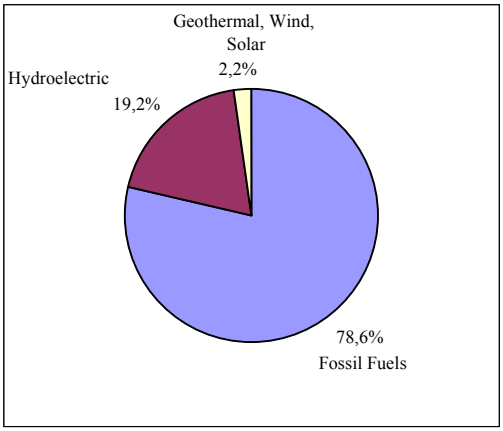

Figure 2: Enel Electricity Generation (1998)

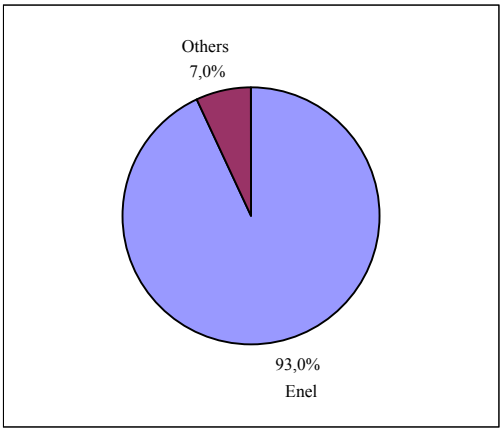

Figure 3: Electricity Distribution in Italy (1998)

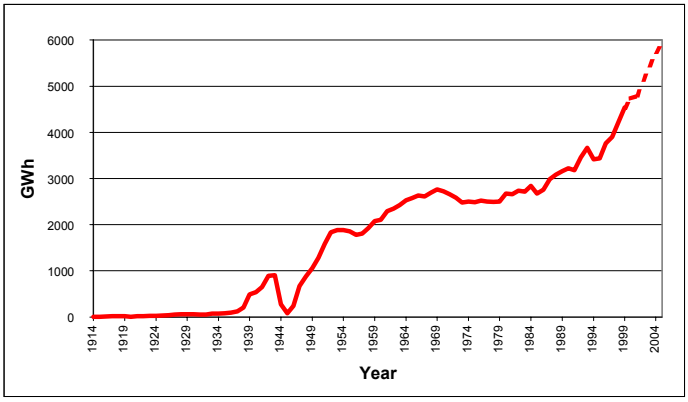

Figure 4: Yearly geothermal power generation

TABLE 2. UTILISATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 1999

[1] N = Not operating (temporary), R = Retired. Otherwise presently operating.

[2] 1F = Single Flash; 2F = Double Flash; H = Hybrid; D = Dry Steam; D* = Steam with entrained water separated at wellhead; B = Binary (Rankine Cycle)

Locality	Power Plant Name	Year Commissioned	No. of Units	Status[1]	Type of Unit[2]	Unit Rating MW$_e$	Total Installed Cap. MW$_e$	Annual Energy Produced 1999[3] GWh/yr	Total under Constr. or Planned MW$_e$
Larderello	Valle Secolo	1991	2		D	60	120	890.7	
	Farinello	1995	1		D	60	60	401.3	
	Gabbro	1969	1		D	15	15	109.2	
	Nuova Gabbro		1		D	20			20
	Castelnuovo V.C.	1946	1 1	 N	D D	11 11	22	45.6	
	Nuova Castelnuovo		1		D	20			20
	Serrazzano	1957 1957 1975	1 1 1	N	D D D	12.5 12.5 15	40	159.9	
	Nuova Serrazzano		1		D	60			60
	Nuova Sasso	1996	1		D	20	20	117.8	
	Le Prata	1996	1		D	20	20	118.4	
	Monterotondo	1958	1		D	12.5	12.5	54.6	
	Nuova Monterotondo		1		D	10			10
	San Martino	1985	2		D	20	40	208.6	
	Nuova San Martino		1		D	40			40
	Lago	1960	1 1 1	 N	D D D	6.5 12.5 14.5	33.5	45.3	
	Nuova Lago		1		D	10			10
	Lagoni Rossi 3	1981	1		D	8	8	48.4	
	Cornia	1987	1		D	20	20	123.4	
	Cornia 2	1994	1		D	20	20	138.5	
	Molinetto 2	1982	1		D	8	8	53.4	
	La Leccia	1983	1		D	8	8	56.1	
	Nuova Molinetto		1		D	20			20
	Carboli 1	1998	1		D	20	20	141.6	
	Carboli 2	1997	1		D	20	20	127.6	
	Selva 1	1997	1		D	20	20	39.6	
	Selva 2		1		D	20			20
	Monteverdi 1	1997	1		D	20	20	33.9	
	Monteverdi 2	1997	1		D	20	20	106.6	
	Sesta		1		D	20			20
SUBTOTAL			36				547	3020.5	220
Travale-Radicondoli	Radicondoli	1979	2		D	15	30	204.8	
	Nuova Radicondoli		1		D	40			40
	Pianacce	1987	1		D	20	20	137.1	
	Rancia	1986	1		D	20	20	128.1	
	Rancia 2	1988	1		D	20	20	142.3	
	Travale 3		1		D	20			20
	Chiusdino 1		1		D	20			20
	Travale 4		1		D	20			20
SUBTOTAL			9				90	612.3	100
Mt. Amiata	Bagnore 2	1962	1	R	D	3.5	3.5	-	
	Nuova Bagnore 2		1		1F	5			5
	Bagnore 3	1998	1		1F	20	20	153.3	
	Bagnore 4		1		1F	20			20
	Piancastagnaio 2	1969	1		D	8	8	36.4	
	Bellavista	1987	1		D*	20	20	105.2	
	Piancastagnaio 3	1990	1		D*	20	20	156.2	
	Piancastagnaio 4	1991	1		D*	20	20	154.8	
	Piancastagnaio 5	1994	1		D*	20	20	150.4	
	Piancastagnaio 6-7		1		D*	40			40
SUBTOTAL			10				111.5	756.3	65
Latera	Latera	1999	2 2		2F B	20 2.5	40	13.6	 5
SUBTOTAL			4				40	13.6	5
TOTAL			59				788.5	4402.7	390

TABLE 3. UTILISATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 1999

[1] I = Industrial process heat; H = Space heating & district heating (other than heat pumps); C = Air conditioning (cooling); B = Bathing and swimming (including balneology); A = Agricultural drying (grain, fruit, vegetables); G = Greenhouse and soil heating; F = Fish and animal farming; 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. (°C) - outlet temp. (°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. (°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

[5] Capacity factor = [Annual energy use (TJ/yr) x 0.03171]/Capacity (MWt)

Locality	Type[1]	Maximum Utilisation					Capacity[3]	Annual Utilisation		
		Flow Rate	Temperature (°C)		Entalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		kg/s	Inlet	Outlet	Inlet	Outlet	(MWt)	kg/s	TJ/yr	Factor[5]
Piancastagnaio	G	17.52	97	50	2200	209	34.88	8.79	551.98	0.50
Larderello Industria	I	5.60	160	95	2780	398	13.34	1.89	141.99	0.34
Larderello villaggi	H	1.95	160	95	2780	398	4.64	0.56	42.07	0.29
Larderello impianti sportivi	B	0.50	200	80	2860	335	1.26	0.05	3.98	0.10
Larderello SCL	I	3.91	200	80	2860	335	9.88	2.37	188.74	0.61
INACASA Larderello	H	0.29	180	70	2755	293	0.72	0.06	4.66	0.21
Montecerboli	H	1.39	180	80	2800	293	3.49	0.28	22.14	0.20
Serrazzano	H	0.79	180	80	2800	293	1.98	0.11	8.70	0.14
Lustignano	H	0.28	180	80	2800	293	0.70	0.03	2.37	0.11
San Dalmazio	H	0.28	180	80	2800	293	0.70	0.03	2.37	0.11
Castelnuovo V.C.	H	2.74	105	70	2200	293	5.23	0.97	58.34	0.35
Sasso Pisano	H	0.99	110	70	2640	293	2.33	0.24	17.77	0.24
Isolver	I	0.07	117	70	2650	293	0.17	0.01	0.74	0.14
Az. Agr. Castelnuovo	G	1.32	105	70	1000	293	0.93	0.66	14.72	0.50
Az. Agr. Castelnuovo	G	2.80	70	30	—	—	0.47	1.35	7.12	0.48
COSVIG	F	0.31	105	70	2685	293	0.74	0.08	6.04	0.26
Az. Agr. Lago Boracifera	G	0.70	125	100	2730	419	1.62	0.17	12.39	0.24
Monterotondo M.mo	H	0.95	170	70	2750	293	2.33	0.40	31.00	0.42
Ecomilk Carboli	I	1.89	185	70	2755	293	4.65	0.27	20.97	0.14
Le Serre Radicondoli	G	0.71	185	70	2755	293	1.75	0.17	13.20	0.24
Ferrara	H	129.61	98	68	—	—	16.27	58.13	230.02	0.45
Abano Terme	B/H	580.00	78	37	—	—	99.50	200.00	1081.58	0.34
Montegrotto Terme	B/H	470.00	75	37	—	—	74.73	170.00	852.07	0.36
Battaglia Terme	B/H	110.00	64	37	—	—	12.43	40.00	142.45	0.36
Galzignano	G	30.30	58	40	—	—	2.28	15.00	35.61	0.50
Civitavecchia (Pantani)	G	238.00	52	30	—	—	21.91	58.19	168.86	0.24
Canino	G	7.80	40	35	—	—	0.16	1.96	1.29	0.26
Bagno di Romagna	H	25.00	40	18	—	—	2.30	15.02	43.59	0.60
Acqui Terme	H	9.50	70	35	—	—	1.39	5.98	27.61	0.63
Rodigo	G/F	10.57	60	18	—	—	1.86	5.97	33.07	0.56
Totale							324.64		3767.44	

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 1999

[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 enthalphy (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)

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 1012 J/yr)	Capacity Factor[3]
Space Heating[4]	135.41	1528.69	0.36
Air Conditioning (Cooling)	—	—	—
Greenhouse Heating	64.93	821.71	0.40
Fish and Animal Farming	1.67	22.57	0.43
Agricultural Drying[5]	—	—	—
Industrial Process Heat[6]	28.04	352.44	0.40
Snow Melting	—	—	—
Bathing and Swimming[7]	94.59	1042.03	0.35
Other Uses	—	—	—
TOTAL	324.64	3767.44	0.37

[4] Includes district heating

[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 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 (specify)	
Exploration	(all)	10	1			34.6
Production	>150° C	23				68.6
	150-100° C					
	<100° C					
Injection	(all)	2				3.3
Total		35	1			106.5

TABLE 7. 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) Contributied Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
1995	40	20	25	—	—	91
1996	40	20	25	—	—	91
1997	30	20	20	—	—	91
1998	30	20	20	—	—	89
1999	30	20	15	—	—	84

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (1999) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling Million US$	Field Development Including Production Drilling & Surface Equipment Million US$	Utilisation		Funding Type	
			Direct Million US$	Electrical Million US$	Private %	Public %
1985-1989	106	273	7	127	99	1
1990-1994	104	483	5	199	99	1
1995-1999	70	498	4	154	99	1