SOME NEW INITIATIVES FOR DIRECT GEOTHERMAL UTILIZATION IN ITALY

Pier Domenico Burgassi[1], Maurizio Gentili[1], Raul Toneatti'

[1]ENEL S.p.a. -DPT-VDT/G - Via Andrea Pisano 120,56122 - Pisa (Italy)

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ABSTRACT

The promotion activities of the non-electrical uses of geothermal energy carried out by the ENEL Demonstration Centre of Castelnuovo Val di Cecina include initiatives ranging from the recovery of associated chemicals contained in geothermal fluids to the use of geo-heat for ago-industrial applications. This paper describes the present situation of the projects in which ENEL is involved and provides details about the most recent achievements.

1. INTRODUCTION

ENEL Società per azioni is the main Italian electric company which has the concession for the production, distribution and sale of electrical energy in Italy. It is also the sole Italian geothermal company actively involved in the direct exploitation of geo-heat for electric generation.

Special emphasis is also given to the direct uses of geo-heat in order to cover all the various applications of the geothermal resources, especially when the temperature of geothermal fluids is too low to be of any practical use for the generation of electricity .

In this field ENEL works according to the following criteria:

- the promotion of the direct uses of geo-heat to demonstrate that low temperature geothermal fluids, generally considered of little market value, can be of commercial interest, especially when found in the vicinity of potential users. To this end, a special Center was established in 1983 at Castelnuovo Val di Cecina, Tuscany,
- the study of new technologies of exploitation (i.e., research activities, carried out also in collaboration with other Institutes and Universities),
- the participation in the design and/or construction of various plants for direct exploitation,
- the utilization of geo-heat for the heating of buildings, warehouses and workshops belonging to ENEL,
- the sale of geo-heat and byproducts (CO_2 and salts) to various users.

2. PROJECTS

Tables 1, Table 2 and Fig. 1 summarize the situation of the projects in which ENEL is engaged at the date of preparation of this paper.

Table 1. Direct geothermal utilization by type of use.

Type	Thermal Power (MW_t)	Energy Use (TJ/yr)
District Heating	46.241	554.61
Ind. process heat	10.86	238.27
Greenhouses	70.696	764.85
Fish Farming	0.72	7.55
CO_2 Supply	8 t/h	
Salt Extraction	50,000 t/yr	

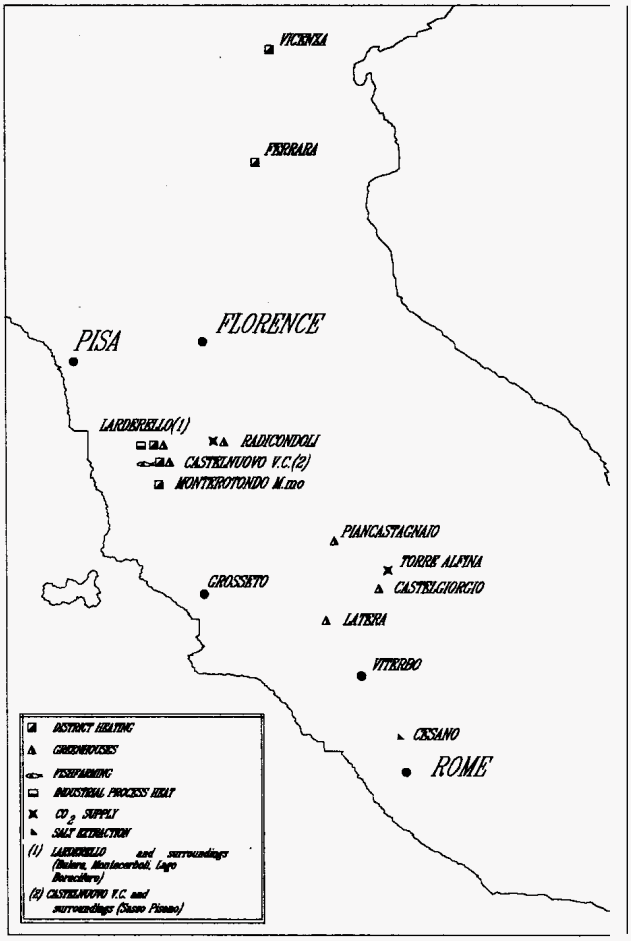


Figure 1 - Location map

Table 2. Distribution of the direct geothermal utilization in the Italian Regions.

Italian Region	Thermal Power (MW_t)	Energy Use (TJ/yr)
Tuscany	92.567	1148.9
Umbria	4.35	27.2
Umbria		
Emilia	9.29	167.4
Emilia		167.4
Venetia	4.88	83.7
Latium	17.43	138.1

It is worth stressing that, in most cases, ENEL responsibility is limited to the design, the construction and the operations of that part of the plant which supplies heat to the customer.
Due to tradition and availability of resources, the heat supplies in operation are mostly concentrated in Tuscany (72 % of the power and 73 % of the total energy): now, however, new projects concerning new areas (Lazio and Umbria) are **also** under construction **or** planned.
In the Tables below (from Table 3.1 to Table 3.27) are **listed** the detailed cards referring to each heat supply.

Table 3.1

Location:	LARDERELLO
Municipality & Province:	POMARANCE - PISA
Type of Use:	District heating
Client:	Local Municipality
Thermal Power (peak):	0.74 MW_t
Fluid:	STEAM
Inlet Temperature:	180 "C
Outlet Temperature:	70 °C
Flow rate (peak):	0.30 kg/s
Energy use per year:	6.11 TJ
Remarks:	In operation from 1988

Table 3.2

Location:	LARDERELLO
Municipality & Province:	POMARANCE - PISA
Type of Use:	District heating (buildings, warehouses, workshops)
Client:	ENEL S.p.a.
Thermal Power (peak):	13.31 MW,
Fluid:	STEAM
Inlet Temperature:	160 °C
Outlet Temperature:	95 °C
Flow rate (peak):	5.60 kg/s
Energy use per year:	141.80 TJ
Remarks:	In operation from1904

Table 3.3

Location:	MONTECERBOLI
Municipality & Province:	POMARANCE - PISA
Type of Use:	District heating
Client:	Local Municipality
Thermal Power (peak):	3.48 MW_t
Fluid:	STEAM
Inlet Temperature:	200 °C
Outlet Temperature:	80 °C
Flow rate (peak):	1.40 kg/s
Energy use per year:	29.29 TJ
Remarks:	Under construction

Table 3.4

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C. - PISA
Type of Use:	District heating
Client:	Private ownership
Thermal Power (peak):	0.037 MW_t
Fluid:	STEAM
Inlet Temperature:	117 °C
Outlet Temperature:	70 °C
Flow rate (peak):	0.016 kg/s
Energy use per year:	0.37 TJ
Remarks:	In operation from 1986

Table 3.5

Location:	SASSO PISANO
Municipality & Province:	CASTELNUOVO V.C. - PISA
Type of Use:	District heating
Client:	Local Municipality
Thermal Power (peak):	2.03 MW_t
Fluid:	STEAM
Inlet Temperature:	105 °C
Outlet Temperature:	70 °C
Flow rate (peak):	1.00 kg/s
Energy use per year:	12.55 TJ
Remarks:	Under construction

Table 3.6

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C - PISA
Type of Use:	District heating
Client:	Private ownership (two lodges)
Thermal Power (peak):	0.034 MW_t
Fluid:	STEAM
Inlet Temperature:	160 °C
Outlet Temperature:	90 °C
Flow rate (peak):	0.02 kg/s
Energy use per year:	0.21 TJ
Remarks:	In operation from 1994

Table 3.7

Location:	MONTEROTONDO M.mo
Municipality & Province:	Monterotondo M.mo - Grosseto
Type of Use:	District heating
Client:	Local Municipality
Thermal Power (peak):	1.85 MW_t
Fluid:	STEAM
Inlet Temperature:	95 °C
Outlet Temperature:	70 °C
Flow rate (peak):	2.63 kg/s
Energy use per year:	16.91 TJ
Remarks:	In operation from 1994

Table 3.8

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C. - PISA
Type of Use:	District heating
Client:	Local Municipality
Thermal Power (peak):	5.37 MW_t
Fluid:	STEAM
Inlet Temperature:	105 °C
Outlet Temperature:	70 "C
Flow rate (peak):	7.6 kg/s
Energy use per year:	50.24 TJ
Remarks:	In operation from 1987

Table 3.9

Location:	LARDERELLO
Municipality & Province:	POMARANCE - PISA
Type of Use:	District heating
Client:	ENEL S.p.a.
Thermal Power (peak):	4.64 MW,
Fluid:	STEAM
Inlet Temperature:	160 °C
Outlet Temperature:	95 °C
Flow rate (peak):	1.95 kg/s
Energy use per year:	41.85 TJ
Remarks:	In operation from 1904

Table 3.10

Location:	LARDERELLO
Municipality & Province:	POMARANCE - PISA
Type of Use:	Swimming pool
Client:	ENEL S.p.a.
Thermal Power (peak):	0.58 MW_t
Fluid:	WATER
Inlet Temperature:	78 "C
Outlet Temperature:	27 "C
Flow rate (peak):	2.7 kg/s
Energy use per year:	4.18 TJ
Remarks:	In operation from 1994

Table 3.11

Location:	VICENZA
Municipality & Province:	VICENZA
Type of Use:	District heating
Client:	Az.de Industriali Municipalizzate
Thermal Power (peak):	4.88 MW_t
Fluid:	WATER
Inlet Temperature:	67 °C
Outlet Temperature:	25 °C
Flow rate (peak):	27.75 kg/s
Energy use per year:	83.70 TJ
Remarks:	In operation from 1990

Table **3.12**

Location:	FERRARA
Municipality & Province:	FERRARA
Type of Use:	District heating
Client:	AGEA
Thermal Power (peak):	**9.29** MW_t
Fluid:	WATER
Inlet Temperature:	**100** °C
Outlet Temperature:	60 °C
Flow rate (peak):	**55.6 kg/s**
Energy use per year:	**167.40** TJ
Remarks:	In operation from **1989**

Table **3.13**

Location:	LARDERELLO
Municipality & Province:	POMARANCE - PISA
Type of Use:	Industrial process heat
Client:	Private ownership
Thermal Power (peak):	**10.86 MW,**
Fluid:	STEAM
Inlet Temperature:	**200 °C**
Outlet Temperature:	80 °C
Flow rate (peak):	4.30 kg/s
Energy use per year:	238.27 TJ
Remarks:	In operation from 1967

Table **3.14**

Location:	BULERA
Municipality & Province:	POMARANCE - PISA
Type of Use:	Greenhouses & Dismct Heating
Client:	Private ownership
Thermal Power (peak):	0.79 MW_t
Fluid:	STEAM
Inlet Temperature:	148 °C
Outlet Temperature:	**90** °C
Flow rate (peak):	**0.40** kg/s
Energy use per year:	14.64 TJ
Remarks:	Under construction

Table **3.15**

Location:	BULERA
Municipality & Province:	POMARANCE - PISA
Type of Use:	Greenhouses
Client:	Regional Administration
Thermal Power (peak):	1.51 MW_t
Fluid:	STEAM
Inlet Temperature:	120 °C
Outlet Temperature:	40 °C
Flow rate (peak):	1.00 kg/s
Energy use per year:	18.71 TJ
Remarks:	In operation from 1986

Table **3.16**

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C.- PISA
Type of Use:	Greenhouses
Client:	Ita. Agric.Forest Res.Ministry
Thermal Power (peak):	**10.92** MW_t
Fluid:	STEAM
Inlet Temperature:	105 °C
Outlet Temperature:	70 °C
Flow rate (peak):	1.33 kg/s
Energy use per year:	14.64 TJ
Remarks:	In operation from 1958

Table **3.17**

Location:	CANALINO
Municipality & Province:	CASTELNUOVO V.C.- PISA
Type of Use:	Greenhouses
Client:	Ita. Agric. Forest Res.Ministry
Thermal Power (peak):	**0.46** MW_t
Fluid:	WATER
Inlet Temperature:	70 °C
Outlet Temperature:	30 °C
Flow rate (peak):	2.80 kg/s
Energy use per year:	7.11 TJ
Remarks:	In operation from 1993

Table **3.18**

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C.- PISA
Type of Use:	Greenhouses
Client	ENEL S.p.a.
Thermal Power (peak):	**0.046** MW_t
Fluid:	WATER
re:	70 °C
ture:	60 °C
	1.10 kg/s
Energy use per year:	**0.41 TJ**
Remarks:	In operation from **1958**

Location:	PIANCASTAGNAIO
Municipality & Province:	PIANCASTAGNAIO- SIENA
Type of Use:	Greenhouses
Client:	Private ownership
Thermal Power (peak):	**34.86 MW_t**
Fluid:	WATER
Inlet Temperature:	**97 °C**
Outlet Temperature:	50 °C
Flow rate (peak):	**17.5 kg/s**
Energy use per year:	**435.24** TJ
Remarks:	In operation from **1984**

Location:	RADICONDOLI
Municipality & Province:	RADICONDOLI - SIENA
Type of Use:	Greenhouses
Client:	Private ownership
Thermal Power (peak):	8.71 MW_t
Fluid:	WATER
Inlet Temperature:	120 °C
Outlet Temperature:	65 °C
Flow rate (peak):	37 kg/s
Energy use per year:	96.25 TJ
Remarks:	Not in operation

Table **3.21**

Location:	LAGO BORACIFERO
Municipality & Province:	Monterotondo M.mo - Grosset
Type of Use:	Greenhouses
Client:	Ita. Agric. Forest Res.Ministry
Thermal Power (peak):	1.62 MW_t
Fluid:	STEAM
Inlet Temperature:	125 °C
Outlet Temperature:	100 °C
Flow rate (peak):	0.70 kg/s
Energy use per year:	12.55 TJ
Remarks:	In operation from 1960

Table **3.22**

Location:	LATERA
Municipality & Province:	LATERA - VITERBO
Type of Use:	Greenhouses
Client:	Private ownership
Thermal Power (peak):	17.43 Gcal/h
Fluid:	WATER
Inlet Temperature:	85 °C
Outlet Temperature:	35 °C
Flow rate (peak):	83 kg/s
Energy use per year:	138.10 TJ
Remarks:	Under construction

Table 3.23

Location:	CASTELGIORGIO
Municipality & Province:	CASTELGIORGIO - TERNI
Type of Use:	Greenhouses
Client:	Local Municipality
Thermal Power (peak):	4.35 Gcal/h
Fluid:	WATER
Inlet Temperature:	80 °C
Outlet Temperature:	40 °C
Flow rate (peak):	26 kg/s
Energy use per year:	27.20 TJ
Remarks:	Under construction

Table 3.24

Location:	CASTELNUOVO Val di Cecina
Municipality & Province:	CASTELNUOVO V.C.- PISA
Type of Use:	Fish farming
Client:	Private ownership
Thermal Power (peak):	0.72 MW_t
Fluid:	STEAM
Inlet Temperature:	105 °C
Outlet Temperature:	70 °C
Flow rate (peak):	0.3 kg/s
Energy use per year:	7.55 TJ
Remarks:	In operation from 1993

Table 3.25

Location:	TORRE ALFINA
Municipality & Province:	Acquapendente - VITERBO
Type of Use:	CO_2 Supply
Client:	Private ownership
Flow rate (peak):	4 t/h
Remarks:	In operation from 1993

Table 3.26

Location:	RADICONDOLI
Municipality & Province:	RADICONDOLI - SIENA
Type of Use:	CO_2 Supply
Client;	Pnvate ownership
Flow rate (peak):	4 t/h
Remarks:	Under study

Table 3.27

Location:	CESANO
Municipality & Province:	CESANO - ROMA
Type of Use:	Salt extraction
Client:	Private ownership
Yearly production:	50,000 t/yr
Remarks:	Under study

3. GUIDELINES OF ENEL S.p.a. PROJECTS FOR DIRECT UTILIZATIONS

The main guidelines adopted by ENEL S.p.a. in the last few years are the following:
- optimization of the existing plants from the engineering and environmental point of view (e.g., improvement of the insulation, the collection of condensed fluids and their re-injection);
- utilization of the wells neglected in the past due to their precarious conditions or to the discontinuity of the energy source (e.g., well n.86 for the Heat Station of Castelnuovo V.C., shallow wells and natural manifestations of Pelaghi for the Heat Station of Sasso Pisano);
- utilization of the available resources in non-traditional areas (Latera, Castelgiorgio);
- extraction of gases and salts contained in the geothermal fluids (Torre Alfina, Travale and Cesano);
- updating of contract stipulations to match the new company organization of ENEL and adjustment of the rates to the actual market values;
- research of new customers in those areas where abundant resources are available, *so* as to increase the utilization rate **of** the heat-supply plants and, therefore, to reduce their amortization cost.

4. SOME CONCRETE CASES

An example of the optimization of an existing plant is that of the present Heat Station of Castelnuovo Val di Cecina (see flow diagram Fig. 2).
Built in **1987,** the Heat Station was fed with steam coming from the steam network of the Castelnuovo geothermoelecmc power plant.
The changes and improvements carried out in 1994 and 1995 increased the thermal capacity by 30 % with a reduction of the operation costs of the same amount and a 60 % recovery of fluid suitable for electric generation.
These changes and improvements are the following:
- complete utilization of the water of the "Sperimentale 2" well,
- use in cascade of fluid coming from other thermal users (the heat exchangers fed by "N.°86" and "Niccolini" wells),
- utilization of the hot water at the temperature <60 °C (after the heat exchanger for dismct heating) to feed additional greenhouses by means **of** fan coil and underground pipeline,
- utilization for heat purposes the fluid suitable for electric generation **only** during the peak demand,
- modifications of the regulating system in order to avoid disposal **of** steam to the atmosphere.

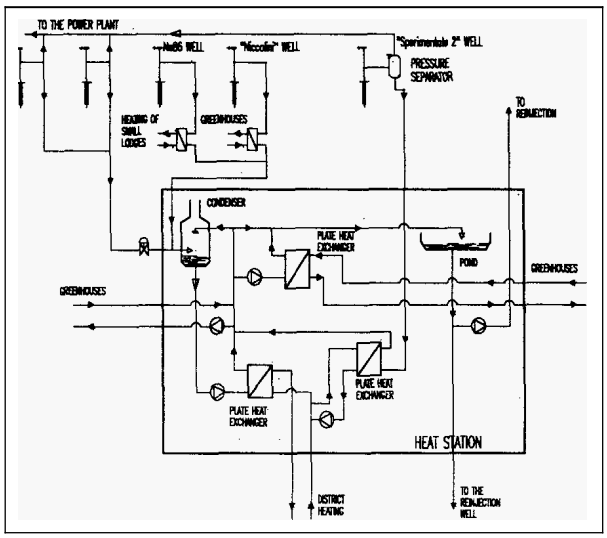
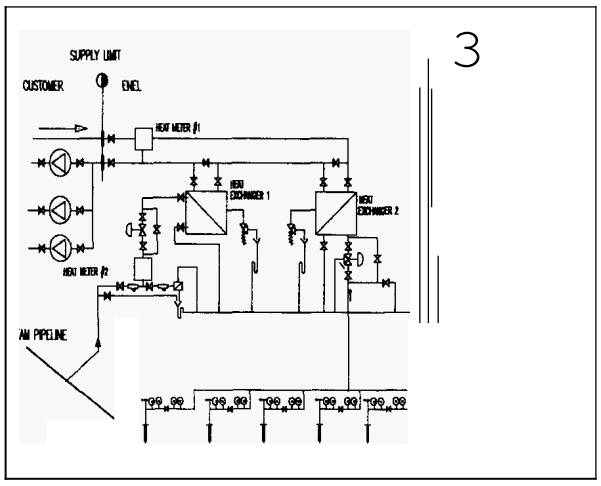


Fig.2 - Flow diagram of the Castelnuovo Val di Cecina Heat Station.

An example of utilization of a resource neglected in the past is the exploitation of some shallow wells drilled for chemical purposes over fifty years ago and later abandoned, because of their low and discontinuous flow rate and the extremely bad condition of their wellheads. These shallow wells are being used to feed the Sasso Pisano Heat Station now under construction.
The project consisted of
- reparing of the damaged wellhead in order to make possible the production of low pressure steam from the shallow wells;
- conveying the steam toward a shell and tube heat exchanger;
- conveying the high pressure steam from the steam network feeding the geothermal power plant **of** Sasso Pisano to a second shell and tube heat exchanger in order to satisfy the heating peak demand (see flow diagram Fig.3);
- gas disposal and reinjection of the condensed fluids.



An example of the utilization of a resource known since **1975,** but usable only by employing advanced technology, is the Castelgiorgio plant.
The plant was designed to produce electricity and heat, using a medium temperature highly scaling geothermal fluid (140 **"C).**
The scaling of calcium carbonate is inhibited by injecting **at** the bottom of the well a chemical product (already **been** tested **by** ENEL in Italy and Turkey), by means of a capillary **tube.**
The geothermal production of electricity will be carried out with a *binary* cycle plant **(1,300** kW **nominal** rate). The **gas will** be disposed through a 50 meter **tall** stack which **will** ensure its dispersion in the atmosphere.
The residual water at **95** "C will feed the heat exchanger which will supply treated hot water to **20,000** m^2 of greenhouses (Fig. **4).**

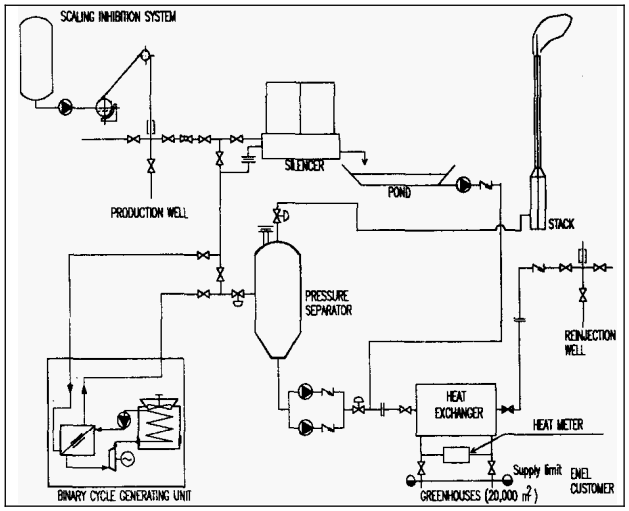


Fig. **4-** Flow diagram of the Castelgiorgio plant

5. CONCLUSIONS

The large availability of terrestrial heat in southern Tuscany **and** northern Latium is not a sufficient condition for the diffusion of the direct use of geothermal energy.

The main obstacles **are:**
- the **high** investment costs of the plants for the heat supply and utilization,
- the low utilization rate of these plants,
- the unfavorable location **of** the resources as regard to the highways and railways lines,
- the competitiveness **of** traditional fuels, the extensive distribution network of natural **gas** already **partially** operative in the geothermal areas.

An improvement of this situation **will** be **obtained** only by planning **on** a wide scale both the projects and the regulations. The former consists of the concentration and diversification of the users, and it **has** to be developed in agreement with the **local** administrations [Regions, Provinces, Municipalities], with the aim to increase the utilization rate of the heat supply plants and therefore to decrease the cost of the energy sold to the final user (private and public).
The latter is connected with a new State regulation, extending also to the direct use of terrestrial heat the subsidies which are provided for the generation **of** elecmcity from alternative sources.

REFERENCES

Leoni, P. (1992). ***Geothermal dismct heating and air conditioning plant in Vicenza.*** Report for the **1992** German-Italian Conference on Renewable Energies, Freiburg, Germany. pp. **118-121.**

Sommaruga, C., Verdiani, G. **(1994).** ***Geotermia: principi, metodi di ricerca, di produzione e di utilizzazione con particolare riguardo alla situazione Italiana.*** Nuova Italia Scientifica - Roma - Italy (in press)

Allegrini, G., **(1976).** ***Non electric uses of endogenous fluids at Larderello.*** Report for the **1976** Simposio Internacional Sobre Energia Geotermica en America Latina. **pp. 393-409**

Cataldi, R., Ferrara, G.C., Palmerini, C.G., Sabatelli, F., **(1990).** ***Comparative Progress Report 1985-1989 and Projections*** *on* ***Future Development of Geothermal Energy Italy.*** Report for the **1990** International Symposium **on** Geothermal Energy - Hawaii. **14** pp. **147-161.**

Allegrini, G., Cappetti, G., Sabatelli, F. **(1995).** ***Geothermal Development in Italy: Country update report.*** Report for the **1995** World Geothermal Congress, Florence, Italy. (in press)