Geothermal Electricity, Country Update for Italy

Massimo Montemaggi, Paolo Romagnoli and Ruggero Bertani

Enel Green Power, Via A. Pisano 120, Pisa, Italy

massimo.montemaggi@enel.com

Keywords: Italy, geothermal, electricity, Larderello, mnt. Amiata

1. INTRODUCTION

In Italy the electricity generation is only in Tuscany, whereas direct uses are scattered all along the country, mainly for bathing and district heating purposes. An overview of the activity carried out in 2012 will be presented in this paper. (Cappetti et al., 2010; Cappetti et al., 2005).

The total installed capacity reached the historical maximum of 875 MWe, with 34 units and a production of 5,235 GWhe. The heat delivered to direct uses is 3,500 GWhth from 1,000 MWth, half of the installed capacity being used by heat pumps.

A new Incentive Law have been approved for the remuneration of the geothermal electricity.

2. CURRENT STATUS OF GEOTHERMAL ELECTRICITY

All the plants in operation are located in Tuscany, in the two productive poles of Larderello/Travale and Mount. Amiata (see figure 1); all the plants are owned and operated by Enel Green Power

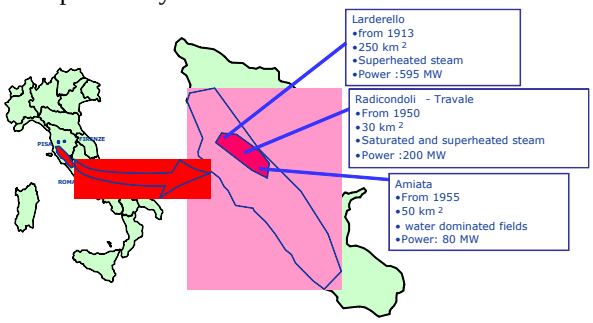

Figure 1: geothermal areas in Italy

As of 31 December 2012, the following figures have been achieved:

- **Wells in Operation**: 308 for production, 69 for reinjection and 107 as reserve or field control; 96 wells have depth greater than 3 km.
- **Gathering Systems**: 207 km of steam lines, 298 km of reinjection pipes.
- **Power Plants**: 34 power units, 4 of 60 MW, 3 in the range 20-40 MW, 3 old units below 15 MW, and the majority (24) is with the standard unified design of 20 MW.
- **Capacity**: the installed capacity of 875 MWe is unevenly split in the two poles: Larderello/Travale with 795 MWe of dry steam units, and Mount Amiata, where in the water dominated field 80 MWe of flash plants have been installed. The total operating capacity is 766 MWe, achieving a production of 5235 GWhe in 2012.

In 2012 important renovation activities have been carried out on three plants, and one old 8 MW unit (Piancastagnaio 2) has been retired.

A new small additional binary unit (commissioned in the early 2013) on the separated water stream for Bagnore 3 has been completed.

Enel Green Power business plan for Italy is strongly focused on the geothermal development on Tuscany, with several new projects, as highlighted in figure 2: a new 40 MW plant in Bagnore; exploration in the new leases, surrounding the Larderello and Mount Amiata areas, aimed to identify an exploitable geothermal fluid with temperature suitable for binary power plant.

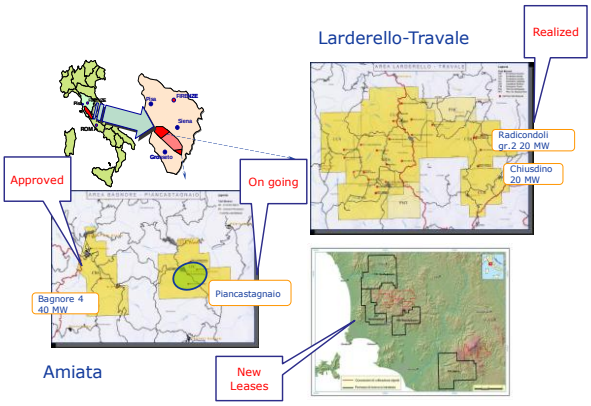

Figure 2: Planned Enel Green Power activities

Figure 3 presents an artistic view of a typical Tuscany geothermal landscape: after more than 100 years of exploitation Larderello field is still able to provide a sustainable development (see figure 4).

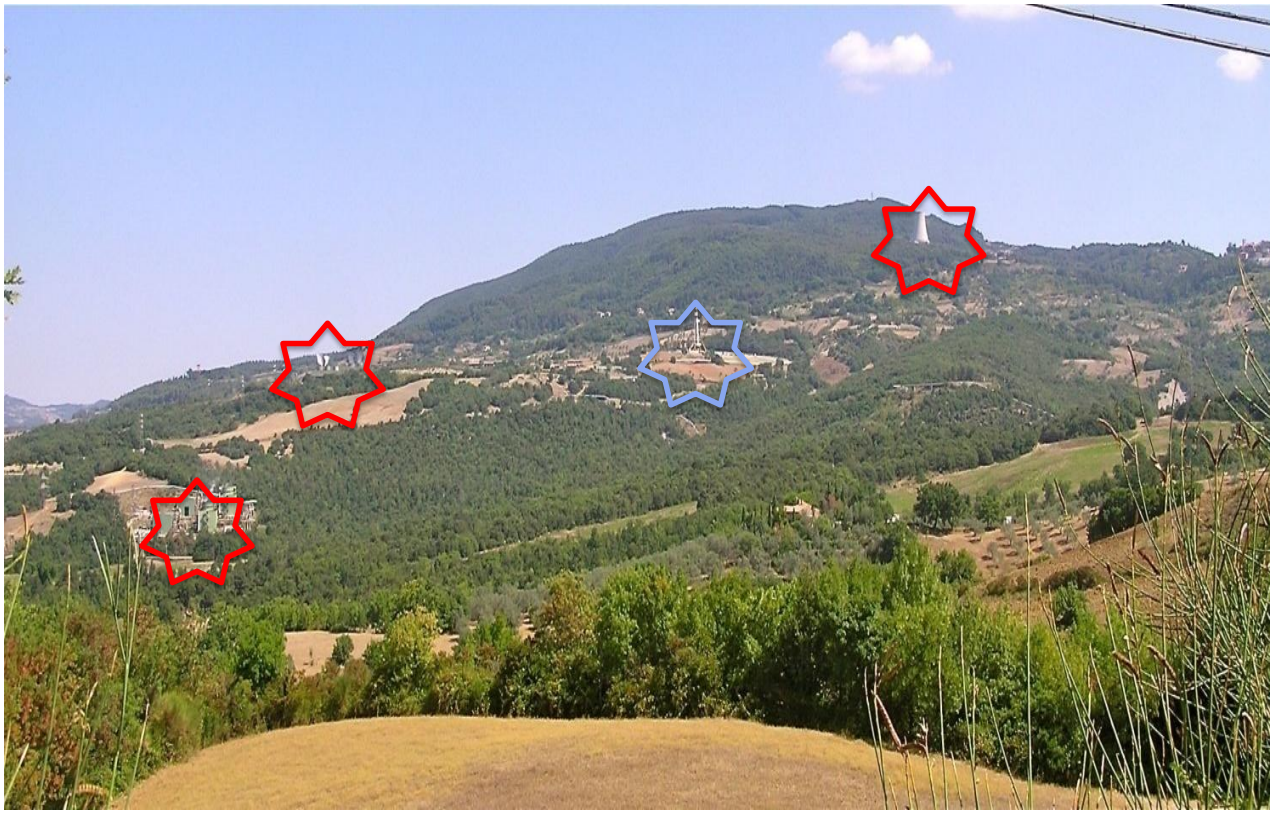

Figure 3: 90 MW in a snapshot: Carboli, San Martino & Monte Rotondo and a new well in drilling phase

Figure 4: Historical trend of Electricity production in Italy

2.1 Drilling Activities

In the year 2012, the following drilling activities have been carried out in Tuscany by Enel Green Power drilling unit:

- Four new wells, with depth 2.1 km, 3.9 km, 4.3 km and 4,4 km.
- Two piezometric wells of 200 m each.
- Seven work-over/deepening.

The total number on meters drilled in 2012 in all the wells reached the value of 16 km.

3. AVOIDED EMISSIONS

The contribution of geothermal energy to the fossil fuel saving (in toe) in Italy is not negligible, as in the following table I, The avoided emissions of carbon dioxide is highlighted in table II.

Table I: saving factor of geothermal energy in Italy

Geothermal energy produced	GWh/yr	Savings factor [toe/ GWh]	Fossil fuel savings [toe]
Geothermal power produced	5.235	253	1.324.455
Geothermal heat produced	3.500	127	443.437
TOTAL	**8.815**		**1.767.892**

Table II: avoided CO2 emissions

Description	GWh/yr	Total CO2 savings by substitution of gas/ oil/ coal in tonnes [t CO2]
Geothermal power produced	**5.235**	
CO_2 savings for natural gas [kg/MWh]	193	**1.010.355**
CO_2 savings for oil [kg/MWh]	817	**4.276.995**
CO_2 savings for coal kg/MWh]	953	**4.988.955**
Geothermal heat produced in 2011	**3.500**	
CO2 savings for natural gas [kg/MWh]	97	**339.490**
CO2 savings for oil [kg/MWh]	409	**1.431.459**
CO2 savings for coal kg/MWh]	477	**1.669.452**

3.1. Environmental/Acceptability Aspects

The strong interaction occurring between geothermal activities and the territory of Tuscany, a region so important for its landscape and touristic attractions, has placed a serious hindrance to developing new high enthalpy projects, specially on Mount Amiata area.

As an important investment for reducing the odor emissions in H_2S of the Italian power plants, Enel Green Power installed 20 abetment systems (AMIS plant, figure 5), of patented original design, with very good results in improving the local acceptance of the geothermal development (Sabateli et al, 2009).

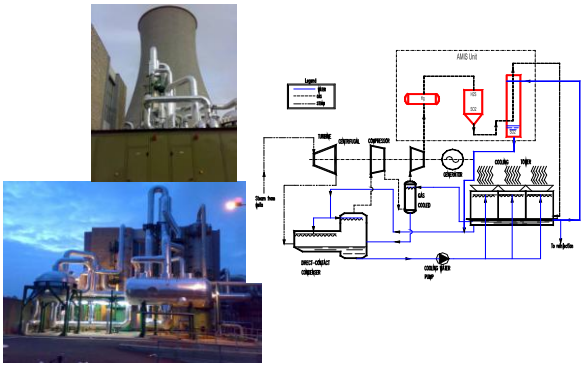

Figure5: the Enel Green Power AMIS system

Aiming at the retrieval of a constructive and mutually beneficial relation with the territory, Enel has set going a number of initiatives with the intent of achieving a reduction of environmental drawbacks and an increase of

acceptability. New design solutions have been envisaged to reduce the noise and visual impact of drilling pads, gathering systems and power plants.

4. MARKET DEVELOPMENT AND STIMULATION

4.1 New law for Geothermal Electricity tariff

Geothermal energy is included in the national energy strategy to reduce greenhouse gas emission.

The Italian policy give a support to the development of renewable resources using a different approach, in terms of tariff, accordingly with the size of the plants, through a new law on incentives for renewable electricity, in force since July 2012.

The incentives will apply only to a limited number of plants, to be officially shortlisted. It is possible to bid for a lower incentives in order to enter into the RES quota. This process can be penalizing in case of great number of plants asking the incentives, but it is unlikely to foresee some problem in the short future, being the quota high enough for geothermal.

For plant acknowledge as fully innovative, with a non-commercial technology, it is recognized an all inclusive tariff of 200 €/MWh up to the fluid temperature of 150°C; the incentive will be reduced accordingly with a linear formula from 200 €/MWh at 151°C down to 137 €/MWh at 235°C.

The standard tariff is in three levels:

- Plant below 1 MW is 135 €/MWh;
- Plants between 1 MW and 20 MW is 99 €/MWh;
- Other plants is 85 €/MWh.

An additional premium is for plants with special technologies:

- 30 €/MWh for total reinjection plant (zero emission);
- 30 €/MWh for the first 10 MW installed in a new area, without existing plants;
- 15 €/MWh for plants with H_2S and Mercury abatement of at least 95% of the emission;

4.2 Royalties

The "Exploration Permit" holder must pay out 325 €/km^2 of annual lease. The "Mining Lease" holder must pay out 650 €/km^2 of annual lease. In case of medium-low enthalpy resources, the above-mentioned values are the maximum (they could be lower).

For electrical power generation, the "Mining Lease" holder must pay out (only for plants greater than 3 MW power):

- 13 € for each MWh generated to Municipalities on whose territory the "Lease" are included.
- 19.5 € for each MWh generated to Regions on whose territory the "Lease" are included.

4.3 Liberalization

A new Law liberalized the access to the geothermal market, opening the possibilities for new player to enter into the geothermal business, asking the concession of an "exploration lease" to the regional authority. In a couple of years only several new leases have been requested, in many different Italian regions, as shown in figure 6.

The total number of new request is around 120. It is foreseeable an impressive development and increase of the geothermal electricity in Italy in the near future.

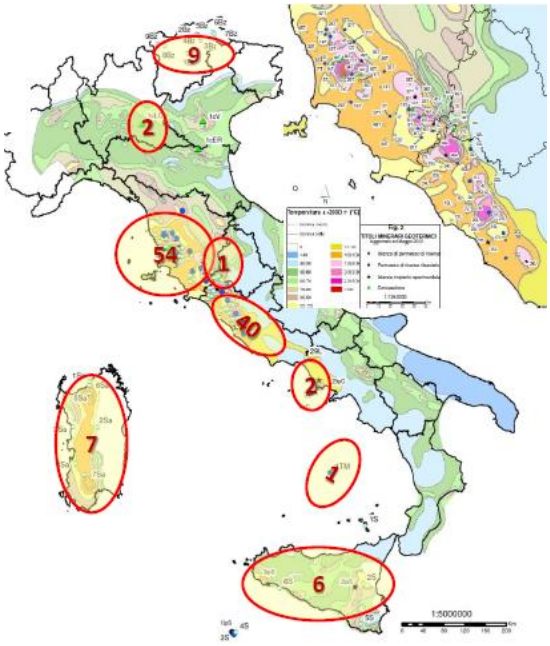

Figure 6: new geothermal requested leases in Italy

5. CONCLUSIONS

After more then 100 years of exploitation, Larderello is still alive and able to keep a sustainable production, through the deep drilling and reinjection programs.

In the second productive pole on Mt. Amiata, the local opposition from committees against geothermal energy is slowing down the large potential development of the Bagnore area, despite the indirect benefit of district heating and greenhouses system of Floramiata, one of the largest complex in Europe. However the entire approval process is finally competed, and the construction of the new plant is ready to start.

New zones have been opened to the geothermal research in Tuscany and other regions, targeting fluids suitable for electricity production through binary cycles, in the medium enthalpy levels.

The new incentive law is not enough for sustaining an important investment in the geothermal sector, even if the Italian resource is much more generous than other countries.

Without a modification of the present incentive scheme, it is unlikely to have good perspectives of development in medium-long term, even if the geothermal energy, due to its base-load capability, can be considered as an high valuable resource of the electrical system in any country, but specially in Italy, where the solar PV and wind are strongly increasing their market segment.

REFERENCES

Buonasorte G., Cataldi R., Franci T., Grassi W., Manzella A., Meccheri M. and Passaleva G.: Previsioni di crescita della geotermia in Italia fino al 2030 - Per un Nuovo Manifesto della Geotermia Italiana -, Ed. Pacini, Pisa, (2011), 108 pp.

Cappetti, G. Romagnoli, P. and Sabatelli, F.: Geothermal power generation in Italy 2005-2009 update report. Proceedings, World Geothermal Congress, Bali, Indonesia, April 25-30 (2010).

Cappetti, G. and Ceppatelli, L.: Geothermal power generation in Italy 2000-2004 update report. Proceedings, World Geothermal Congress, Antalia, Turkey, April 24-29 (2005).

Sabatelli, F., Mannari, M. and Parri, R.: Hydrogen sulphide and mercury abatement: development and successful operation of AMIS technology, Transactions GRC, (2009)

Tables A-B

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country (2011)		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012	874.5	5,235	118,443	302,570	1%	2%
Under construction end of 2012	41					
Total projected by 2015	915					

Table B: Existing geothermal power plants, individual sites[1]

Locality	Plant Name	Year COD	No of units	Status	Type	Total inst. Cap (MW_e)	Total run. Cap. (MW_e)	2012 product. (GWh_e/y)
Larderello	Nuova Larderello	2005	1	O	D	20	15	115.2
Larderello	Farinello	1995	1	O	D	60	46	399.6
Larderello	Valle Secolo	1991	1	O	D	60	57	436.0
Larderello	Valle Secolo	1992	2	O	D	60	57	417.1
Larderello	Nuova Castelnuovo	2000	1	O	D	14.5	14	122.0
Larderello	Nuova Gabbro	2002	1	O	D	20	19	139.6
Larderello	Nuova Molinetto	2002	1	O	D	20	17	94.8
Larderello	Sesta 1	2002	1	O	D	20	17	46.7
Larderello	**TOTAL**		**8**			**274,5**	**242**	**1,771**

[1] In the case of major renovation of the plant, in the COD column there is the indication of a second year.

Locality	Plant Name	Year COD	No of units	Status	Type	Total inst. Cap (MW_e)	Total run. Cap. (MW_e)	2012 product. (GWh_e/y)
Radicondoli	Travale 3	2000	1	O	D	20	19	6.7
Radicondoli	Travale 4	2002	1	O	D	40	39	309.2
Radicondoli	Pianacce	1987	1	O	D	20	18	98.3
Radicondoli	Rancia 1	1986 2012	1	O	D	20	18	86.9
Radicondoli	Rancia 2	1988 2012	1	O	D	20	18	90.6
Radicondoli	Nuova Radicondoli	2002	1	O	D	40	38	288.7
Radicondoli	Nuova Radicondoli	2010	2	O	D	20	17	153.7
Radicondoli	Chiusdino 1	2010	1	O	D	20	18	147.3
Radicondoli	**TOTAL**		**8**			**200**	**185**	**1,182**
Lago	Selva 1	1999	1	O	D	20	19	102.6
Lago	Nuova Lago	2002	1	O	D	10	10	80.5
Lago	Monteverdi 1	1997	1	O	D	20	16	143.6
Lago	Monteverdi 2	1997	1	O	D	20	16	100.9
Lago	Cornia 2	1994	1	O	D	20	14	98.8
Lago	Nuova Monterotondo	2002	1	O	D	10	8	40.1
Lago	Carboli 1	1998	1	O	D	20	19	96.7
Lago	Carboli 2	1997	1	O	D	20	19	86.6
Lago	Nuova San Martino	2005	1	O	D	40	36	308.9
Lago	Nuova Lagoni Rossi	2009	1	O	D	20	15	72.2
Lago	Nuova Sasso	1996	1	O	D	20	15	85.5
Lago	Sasso 2	2009	1	O	D	20	17	116.9
Lago	Le Prata	1996 2012	1	O	D	20	15	93.7

Locality	Plant Name	Year COD	No of units	Status	Type	Total inst. Cap (MW_e)	Total run. Cap. (MW_e)	2012 product. (GWh_e/y)
Lago	Nuova Serrazzano	2002	1	O	D	60	47	341.4
Lago	**TOTAL**		**14**			**320**	**266**	**1,768**
Bagnore	Bagnore 3	1998	1	O	1F	20	20	160.9
Bagnore	Binario	2013	1	N	B-0RC	1	1	N/A
Bagnore	Bagnore 4		1		1F	20	20	N/A
Bagnore	Bagnore 4		2		1F	20	20	N/A
Piancastagnaio	Piancastagnaio 2	1969	1	R	1F	8	6	N/A
Piancastagnaio	Piancastagnaio 3	1990	1	O	1F	20	19	134.3
Piancastagnaio	Piancastagnaio 4	1991	1	O	1F	20	17	116.9
Piancastagnaio	Piancastagnaio 5	1996	1	O	1F	20	17	102.0
Piancastagnaio	**TOTAL (in operation)**		**4**			**80**	**73**	**514**
TOTAL (in operation)			**34**			**874,5**	**766**	**5,235**

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other