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Geothermal Power Generation in Italy 2010-2014 Update Report

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ABSTRACT

This paper presents an overview on the development of the Enel Green Power activities carried out in the five-year period 2010-2014. In Italy, the geothermal resources are mainly used for electricity generation and all of the plants in operation are located in Tuscany, in the two "historical" areas of Larderello-Travale and Mount Amiata.

In the year 2013, with an installed capacity of 875.5 MW (767 MW efficient capacity), the gross electricity generation reached 5.7 billion kWh, which represents the new record of electricity produced from geothermal resource in Italy; in 2014 one additional unit (Bagnore 4) is being realized, increasing the capacity up to 914.5 MW.

In the Larderello-Travale area the positive results of the deep drilling and a careful resource management with reinjection programs and chemical stimulation made it possible to increase the steam production, despite the long and intensive exploitation history. Five additional units were thus installed in the period 2009-2013 with a total capacity of 100 MW, of which only 40 MW represents a net capacity increase, while 60 MW replaced old units, decommissioned because obsolete.

In the Mount Amiata area, after many years in which all activities have been stopped due to pending acceptability problems from local communities, in 2012 Enel Green Power obtained permission to resume drilling and construction activities. In the timeframe of 2012-2013 three additional units were thus installed with a total capacity of 60 MW to replace old units and some new wells have been drilled successfully.

In 2013, Enel Green Power installed the first binary power plant in Italy (Gruppo Binario Bagnore3 – 1 MW) which is located in Bagnore Geothermal Field (Mount Amiata) and uses the liquid phase after the primary flash of geothermal fluid. In 2015, Cornia 2 power plant will be upgraded adding a biomass fired boiler, allowing superheating of geothermal steam. This upgrading will increase the output power from 12 MW to 17.3 MW.

During 2009–2013, thirty-one wells were drilled in the whole geothermal area, totaling about 100,000 meters, and 26 AMIS plants (the H_2S and Hg abatement technology developed and patented by Enel) were installed and are currently in operation.

Since 2011, Enel Green Power has begun new exploration activities in areas adjacent to the existing exploitation leases, with the main purpose to find a medium-high enthalpy fluid suitable for the production of electricity (temperature higher than 150°C).

1. THE ELECTRICITY MARKET IN ITALY AND ENEL GREEN POWER

In the year 2012, the electricity needs in Italy reached 342.4 billion kWh, with a domestic contribution of 87.4%, while a relevant 12.6% was imported.

The electricity generation capacity and production data in Italy as of 2012 are summarized in Table 1. As regards the 299 TWh of domestic electricity generation, 72.7% comes from fossil fuels, 14.7% from hydro and 12.6% from geothermal, biomass, wind and solar (Figure 1). Even if the contribution of geothermal electricity generation is only 1.9% of the whole Italian generation, it covers about 33% of the electricity needs in Tuscany, giving a substantial contribution to the green energy generation.

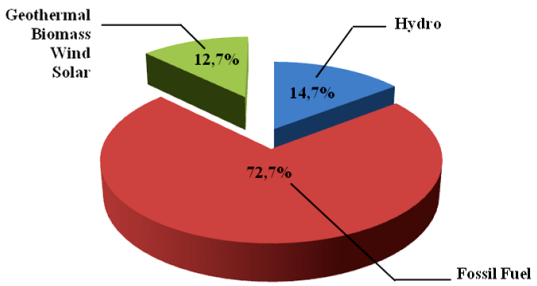

Figure 1: Electric domestic generation in Italy (2012).

According to the Bill Law issued on July 2012, starting from January 1, 2013 new power plants with a capacity exceeding 1MW, will no longer be granted with "Green Certificates" but with an "Incentive Fee" similar to an all-inclusive fee decreased by zonal price of energy to which additional premiums can be added.

In 2013, the average market price of electricity was approximately 6.3 Eurocent/kWh. The value of the net kWh generated from new or recent geothermal power plants awarded with "Green Certificates" is around 14.3 Eurocent/kWh, while with a new "Incentive Fee" was 9.9 Eurocent/kWh (under 20 MW installed capacity) or 8.5 Eurocent/kWh (over 20 MW installed capacity).

1.1 Enel Green Power

Enel Green Power Spa (EGP), established in December 2008, is the Enel Group Company that develops and manages energy generation from renewable sources at a global level, with a presence in Europe, the Americas and Africa.

At present, Enel Green Power has an installed capacity of 8,943 MW, produced by over 750 plants in 16 countries, with an annual production of 25 TWh from a generation mix that includes wind, solar, hydro, geothermal and biomass meeting the energy consumption of over 8 million families and avoiding about 16 million tons of CO_2 emissions per year.

2. GEOTHERMAL POWER GENERATION: CURRENT STATUS AND DEVELOPMENT

The historical trend of electricity generation from geothermal resources in Italy is given in Figure 2, where two different increase phases are shown: the first one in the period from 1930s to the mid 1970s, related to the development of the shallow carbonate reservoir, with well depths up to about 1,000 m; the second one from the beginning of the 1980s up to now, when the fluid production has been increased thanks to the positive results of the deep drilling activity and to the artificial recharge of the depleted shallow reservoirs by means of the reinjection of water and condensed steam.

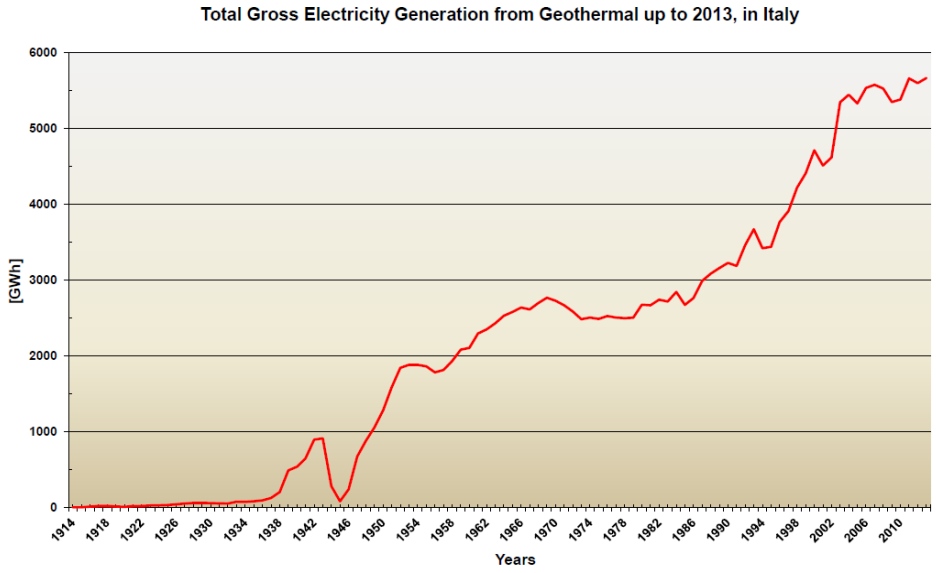

Figure 2: Historical trend of electricity generation from geothermal resources in Italy.

During the year 2013, with an installed capacity of 875.5 MW, the electricity gross generation has picked up to 5,659 GWh. The complete list of the power plants in operation is given in Table 2; taking into account the real operating conditions of the plants in the different areas (pressure, temperature, non-condensable gas content in the steam), the total running capacity is 767.4 MW.

In 2010, two new 20 MW units in Travale/Radicondoli area (Nuova Radicondoli GR2 e Chiusdino 1 – Figure 3) were built. Between 2012 to 2013 six units have been renovated because of their outdated technology: one in Larderello area (Le Prata – Figure 4), two in Travale /Radicondoli area (Rancia and Rancia 2 – Figure 5) and, all the three Piancastagnaio area power plants (Piancastagnaio 3, Piancastagnaio 4 and Piancastagnaio 5). This fact has led to an increase in performance that, together with the geothermal field maintenance, allowed to achieve a new record for electricity production from geothermal sources in the year 2013.

Figure 3: Chiusdino 1 (20MW) power plant.

Figure 4: LePrata (20MW) power plant.

Figure 5: Rancia (20MW) and Rancia 2 (20MW) power plants.

Also in 2013, the first geothermal binary power plant (Gruppo Binario Bagnore3) (Figure 6) in Italy was installed as an upgrade to Bagnore 3 power plant; this has led to an increase of 1 MW installed capacity on this group. Two new 20 MW units (Bagnore 4) are currently under construction and will be commissioned by the end of 2014, increasing the total installed capacity from 875.5 MW as of December 2013 to 914.5 MW as of December 2014.

Figure 6: Gruppo Binario Bagnore (1MW) power plant.

In 2015 Enel will built the first Geothermal - Biomass combined power plant in Italy at Cornia 2 power plant with an increase of the output power from 12 MW to 17.3 MW, with an overall plant efficiency improvement.

All of the geothermal power plants are remotely controlled and operated from a Remote Control Station located in Larderello, where 12 people work in round the clock shifts (24/7), thus ensuring a continuous overseeing. In this way, every plant operating parameter can be monitored and analyzed and it is also possible to shut down and restart any unit from the Remote Station. This solution has allowed for better plant operation, at the same time dramatically reducing operating costs.

2.1 Plant for Hg and H2S abatement (AMIS)

Enel developed and patented a proprietary technology, named "AMIS" (Abbattimento Mercurio e Idrogeno Solforato- mercury and hydrogen sulfide abatement). The AMIS system allows the removal of substances such as mercury and hydrogen sulfide present in the non-condensable gases of geothermal fluid. The process involves a stage of catalytic oxidation, by which the H_2S is selectively converted to SO_2. Thereafter, the SO_2 produced is absorbed in the water of the cooling circuit, through a packed column. Also the mercury, which is present in the geothermal fluid can be removed by adsorption on fixed beds of sorbents with specific yields of over 95% (Sabatelli et al., 2009).

In May 2010, the Resolution of Country Council 344/2010 provides that, in order to obtain the renewal of the emissions permits, all the geothermal power plants are equipped with the latest technologies, including AMIS plants and high efficiency demister. As of May 2014, 26 AMIS groups are in operation and 8 are under construction, providing each power plant with this technology.

In 2013, the averaged availability of AMIS plants (hours of operation vs hours of operation of the associated power plant) exceeded 90%, with only 1-2 outages per thousand of operating hours.

3. GEOTHERMAL FIELDS UPDATE

All of the Italian geothermal fields in exploitation for electricity generation are located in Tuscany (Figure 7): Larderello, Travale/Radicondoli, Bagnore and Piancastagnaio (the two latter being located in the Mt. Amiata area).

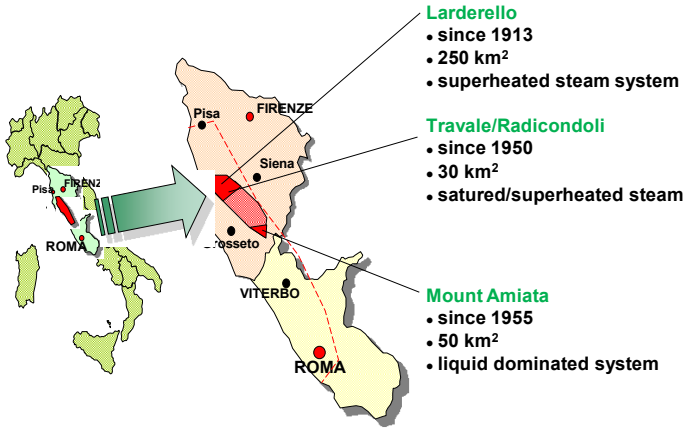

Figure 7: Location of the geothermal fields in Italy.

The activities carried out over the last five years have been concentrated both in Larderello-Travale and in Mount Amiata areas. Each area is characterized by a different type of mining activity depending on the geothermal reservoir characteristics and the level of exploitation. Therefore, while the activity in the Larderello-Travale areas are being targeted at field management optimization to reduce and contrast the natural decline, in the area of Monte Amiata was carried out development activities to increase electricity generation. Since 1980, in order to increase the productivity of individual wells after drilling and to preserve it during their production life, some stimulation techniques have been developed and are currently being implemented. The aim of these techniques is to improve the permeability of fractured zones and to reduce or eliminate the formation damage (skin factor) by means of acid stimulation (Scali et al., 2013). With the experience gained during the operation and maintenance of the wells, different causes of well damage (formation or wellbore) have been identified and different techniques aimed to the recovery of the original productivity have been studied and implemented. Only in this way Enel Green Power experience in geothermal field management, gained over decades, allowed obtaining positive results in a continuously increasing number of cases.

3.1 Larderello

The explored area is about 250 km^2, where 200 wells produce superheated steam at pressure between 2 and 18 bars and temperature ranging from 150°C to 270°C. The non-condensible gas content ranges from 1 to 15% by weight. The installed capacity is 594.5 MW as of December 2013, with 23 units in operation. The area of Larderello has been exploited since the beginning of the 1900s and resource sustainability is ensured through two main strategies for the management of the reservoir: reinjection and deep drilling. Since the late 1970s, the reinjection of the steam condensate back into the shallow carbonate reservoir formation has been highly beneficial, especially in the most depleted area (Valle Secolo) and made it possible to increase the reservoir pressure and, accordingly, the steam production (Cappetti et al., 1995). The deep exploration program showed the presence of permeable layers within the Metamorphic Basement, up to 3,000 – 4,000 m depth, with reservoir pressure and temperature increasing with depth up to 7 MPa and 350°C (Barelli et al., 1995, 2000; Bertani et al., 1995; Cameli et al., 2000).

An important activity that is going on in this area is the empowerment of an existing geothermal power plant named Cornia-2 by using biomass; the existing geothermal power plant (rated 19 MW) is running at reduced capacity (13.7 MW) and steam parameters and original thermal cycle are suitable for biomass firing integration using local biomass (Figure 8).

The project consists of a geothermal integrated biomass power plant composed of a superheater boiler for geothermal steam with combustion grate supplied by local forest woodchip, agricultural residues or special crops. This example represents the first innovative geothermal integrated biomass power plant in the world and allow an increase of about 5 MW electric.

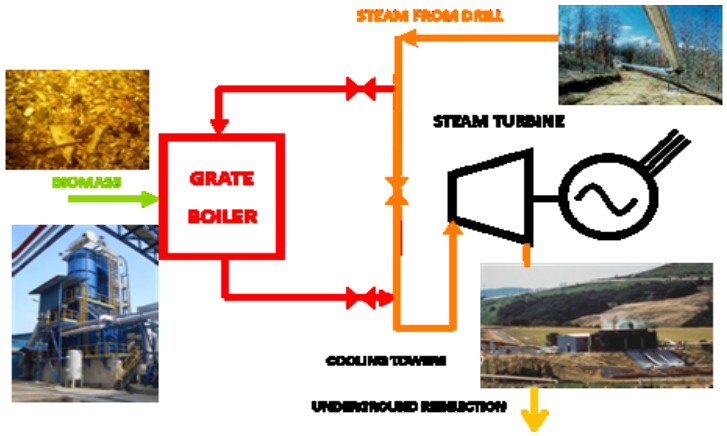

Figure 8: Geothermal integrated Biomass power plant.

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3.2 Travale/Radicondoli

The explored area covers approximately 50 km^2; 29 wells produce superheated steam at pressure ranging from 8 to 20 bars and temperature of 190-250°C. The non-condensible gas content is in the range of 4 - 8% by weight. The installed capacity is 200 MW with 8 units in operation. The deep exploration, performed in previous years, showed also in this area the presence of permeable layers within the Metamorphic Basement, which resulted at the same depths and with the same reservoir temperature and pressure as in the Larderello area. Moreover, some of the deep wells (at depths of about 4,000 m) showed the presence of productive layers also in the Granite underlying the Metamorphic Basement. It must be pointed out that the deep drilling activity proved that the two old and shallow fields of Larderello and Travale/Radicondoli represent the "outcropping" of a unique, wide and deep (3,000-4,000 m) geothermal system, with an extension of about 400 km^2. At a depth of about 3,000 m, the same temperature and reservoir pressure was found (300-350°C and 6-7 MPa) both inside the field and in the marginal areas.

On the basis of the positive results of the deep exploration program, the drilling activities have continued even in the last five years with 10 new production wells that have allowed to find new steam and reduce the natural decline of the field. To reduce the mining risk and to identify the main potential drilling targets, make-up wells are located on the basis of a joint accurate interpretation of the well data and seismic 3D surveys. In order to better understand the correlation between steam production and granite, in-depth analysis of petrography, geochemistry and geophysical log is currently under development (Casini et al., 2015)

The intensive exploitation of the Travale/Radicondoli geothermal field caused a change in the thermodynamic properties of the fluid; the lowering of the pressure induced by the extraction of fluid determined an increasing overheating by heat mining process. Therefore there is an ongoing testing for reinjection into the deep reservoir to investigate the possibility to reduce the field natural decline through the evaporation of water injected.

3.3 Mount Amiata

Two geothermal fields are located in this area: Bagnore and Piancastagnaio. They were discovered between the late 1950s and the early 1960s, with wells producing steam from the shallow carbonate reservoir. In the late 1970s, a deep exploration program was begun and the results were very successful in both of these fields, revealing the presence of fractured layers at depths ranging from 2,500 to 4,000 m inside the Metamorphic Basement underlying the shallow carbonate reservoir (Bertini et al., 1995). This deep reservoir is liquid-dominated, with a pressure of around 200 bars and a temperature of 300-350°C at 3,000 m depth (Bertini et al., 1995). The produced fluid is a two-phase mixture that is separated at wellhead at 20 bars; the non-condensible gas content in the steam ranges from 6 to 8% by weight. Higher values occur in the steam produced from the shallow carbonate reservoir that feeds a back-pressure unit and is condensed downstream to supply heat for a large greenhouse complex in Piancastagnaio.

From between 2012 to 2013 all the three units in the Piancastagnaio area (Piancastagnaio 3, Piancastagnaio 4 and Piancastagnaio 5) have been renovated because of their outdated technology. At the same time several mining operations (both workover of an existing well and new drillings) were conducted with the aim to find new geothermal fluid to ensure the full load on the power plants. A total of more than 120 t/h was retrieved equal to an increase of 50% compared to the total steam extracted from the Piancastagnaio area.

In 2013, there was installed the first geothermal binary power plant (Gruppo Binario Bagnore3) in Italy as upgrade of Bagnore 3 power plant; this has led to an increase of 1 MW installed capacity on this group. This new unit is based on an ORC cycle using the normal pentane as the secondary fluid. This unit is fed by a secondary flash steam at low pressure which is obtained from the partial evaporation for expansion of the liquid phase output from the primary flash (20 bar). The operating conditions of temperature and pressure of the secondary flash are monitored in such a way as to avoid the phenomena of scaling due to the possible deposition of the salts contained in the geothermal fluid. Two new 20 MW units (Bagnore 4) are currently under construction and will be commissioned at the end of 2014; the steam flow rate needed to feed the two new units (about 260 t/h) will be obtained from the drilling of two new deep wells (4,000 m) and the workover of two existing wells currently non-productive because damaged.

As of December 2013, the total installed capacity is 81.0 MW, with 5 units on line. One additional 40 MW unit, called Bagnore 4, is under construction and will be commissioned in December 2014 (Figure 9 and Figure 10).

Figure 9: Bagnore 4 (40MW) power plant rendering.

Figure 10: Bagnore 4 (40MW) power plant.

3.4 New exploration leases

Since 2011, Enel Green Power has begun an exploration activity in areas adjacent to the existing exploitation leases. In particular EGP acquired 4 different exploration leases (Figure 11*)* for a total of approximately 1000 km^2, two in the north-western part of Larderello (Montebamboli and Montegemoli), one in the southern part of Travale/Radicondoli (Boccheggiano) and the last one on the south-west edge of the geothermal field of Piancastagnaio (Murci).

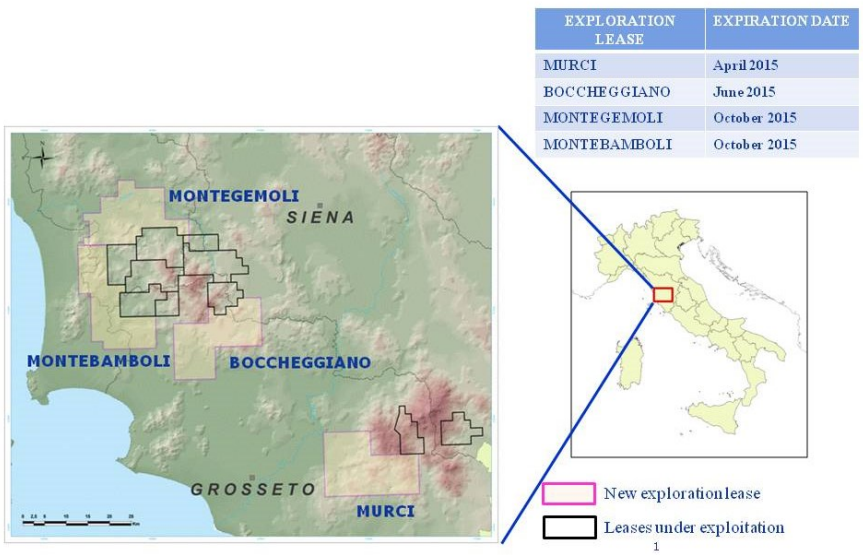

Figure 11: New exploration leases

All these leases are considered as brown fields with the main purpose to improve the knowledge of the area to understand the possibility of finding a medium-high enthalpy fluid suitable for the production of electricity (temperature higher than 150°C). Until today a surface exploration (2D Seismic and MagnetoTelluric surveys) has been conducted whose interpretation has been used to locate some slim holes and wells for the next phase of deep exploration. Currently all the required permissions and have been completed and mining activities will begin during 2014.

4. DRILLING

In the period 2010 - 2014 a total of 25 wells were drilled in Italy, for a total drilled depth of 64.9 km. Eighteen of these wells are make-up wells drilled in Larderello (7) and Travale/Radicondoli (10) fields and they are relevant to the maintenance programs to contrast natural decline of geothermal production. In Mount Amiata area, the first two production wells of the development program are drilled. The other three drilled wells are relevant to the reinjection/injection program. Also three wells for monitoring the shallow aquifers (piezometers) are drilled in Mount Amiata area, as a prescription for the construction of the new production Bagnore-4 (under construction).

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

5. PERSONNEL AND INVESTEMENTS

The number of professional personnel allocated to geothermal activities is given in Table 7.

The overall investments are shown in Table 8; the values are lower than in previous five-year period due to the delay of development projects caused by the already mentioned environmental and acceptability problems.

The investment data reported in the previous article were evaluated according to a different method of accounting. It were revised to make them consistent with those of the period 2010-2014.

6. CONCLUSIONS AND FUTURE PROSPECTS

In response to the growing demand for renewable energy a new company, Enel Green Power, fully owned by Enel Group, was established in December 2008 with the aim to develop and manage the energy generation from renewable resources both in Italy and abroad. At present, this company is the world leader in this sector, with 25 TWh per year produced in sixteen countries of Europe and American continent.

This paper presents an overview on the development of the Enel Green Power activities carried out in the five-year period 2010-2014 in Italy. Over the last five years thanks to the Green Certificates it has been possible to get a development of the geothermal source. Now with the new bill the income from the energy sale will be reduced. This significant incentive reduction is likely to penalize investments in new exploration and in fields characterized by a lower productivity per well.

Despite this, in addition to six units that have been renovated because of their outdated technology, two new units were installed in 2010 (Nuova Radicondoli GR2 20MW and Chiusdino 20MW), one new unit will be commissioned in the year 2014 (Bagnore 4 40MW) and in 2015 Cornia 2 power plant will be upgraded by a biomass fired boiler allowing superheating of geothermal steam, with a total capacity of 85.3 MW.

The total installed capacity as of December 2013 was 875.5 MW and the gross electricity generation picked up to the value of 5,659 GWh/y, which represents about 25% of the electricity needs of Tuscany, the region where all geothermal fields in operation are located. The total installed capacity will reach 920.8 MW by the end of 2015.

A deep exploration program including 3D seismic surveys and eleven exploratory wells 3,000-4,000 m deep was completed in the Larderello-Travale/Radicondoli area with positive results, but the strong interaction occurring between geothermal activities and the territory, taking into account that we operate in Tuscany, has placed serious hindrance to the development of new projects.

In the shallow and most depleted areas of the geothermal field, different strategies for the optimization of resource management have been put in place (reinjection, chemical stimulation) to increase the steam production and reduce natural decline.

Aiming at the retrieval of a constructive and mutually beneficial relation with the territory, Enel Green Power has set 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.

An innovative plant for the abatement of mercury and hydrogen sulfide (called AMIS) was designed by Enel and 26 abatement plants were installed and are now in operation.

On the basis of the programs already in progress, an increase of 85.3 MW of the installed capacity for the period 2010-2015 can be regarded as a reasonable target.

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STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2012 December 2014	882.5 915.5	5,592 5,740	81,734.2	217,561	20,207.6	43.854	-	-	28,341*	32,269	131,165.3	299.276
Under construction in December 2014	40	27										
Funds committed, but not yet under construction in December 2014												
Estimated total projected use by 2020												

* This value is the Efficient Capacity

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2014

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

[2] 1F = Single Flash; 2F = Double Flash; 3F = Triple Flash; D = Dry Steam; B = Binary (Rankine Cycle); H = Hybrid (explain); O = Other (please specify); D* = Steam with entrained water separated at wellhead

Locality	Power Plant Name	Year Commissioned	No. of Units	Status[1]	Type of Unit[2]	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2013 GWh/yr	Total under Constr. or Planned MWe
Larderello									
	Valle Secolo	1991	2		D	120	110.6	873.7	
	Farinello	1995	1		D	60	52.4	420.3	
	Nuova Larderello	2005	1		D	20	16.6	129.8	
	Nuova Gabbro	2002	1		D	20	19.1	150.8	
	Nuova Castelnuovo	2000	1		D	14.5	14.9	120.5	
	Nuova Serrazzano	2002	1		D	60	47.5	367.0	
	Nuova Sasso	1996	1		D	20	14	75.4	
	Sasso 2	2009	1		D	20	16.7	120.9	
	Le Prata	1996	1		D	20	18	147.7	
	Nuova Monterotondo	2002	1		D	10	8	53.4	
	Nuova San Martino	2005	1		D	40	36.2	311.3	
	Nuova Lago	2002	1		D	10	10.9	87.8	
	Nuova Lagoni Rossi	2009	1		D	20	12.7	79.3	
	Cornia 2	1994	1		D	20	12	99.8	
	Cornia 2 Biomasse								5.3
	Nuova Molinetto	2002	1		D	20	14.5	101.6	
	Carboli 1	1998	1		D	20	15.4	84.2	
	Carboli 2	1997	1		D	20	15.4	114.3	
	Selva	1997	1		D	20	18.3	119.6	
	Monteverdi 1	1997	1		D	20	17.8	151.8	
	Monteverdi 2	1997	1		D	20	15.6	80.9	
	Sesta	2002	1		D	20	13.9	73.1	
Subtotal			22			594.5	500.5	3763.2	5.3
Travale-Radicondoli									
	Nuova Radicondoli	2002	1		D	40	39.5	288.8	
	Nuova Radicondoli GR 2	2010	1		D	20	19.4	162.4	
	Pianacce	1987	1	N	D	20	14.1	2.1	
	Rancia	1986	1		D	20	19.1	162.0	
	Rancia 2	1988	1		D	20	19.1	154.5	
	Travale 3	2000	1		D	20	16.5	92.3	
	Travale 4	2002	1		D	40	38.9	329.7	
	Chiusdino 1	2010	1		D	20	19.4	151.1	
Subtotal			8			200	186	1342.9	
Mt. Amiata									
	Bagnore 3	1998	1		1F	20	19.9	172.8	
	Gruppo Binario Bagnore3	2013	1		B	1.0	1	1.4	
	Bagnore 4								40
	Piancastagnaio 3	1990	1		D*	20	20	130.7	
	Piancastagnaio 4	1991	1		D*	20	20	104.6	
	Piancastagnaio 5	1994	1		D*	20	20	143.6	
Subtotal			5			80.99	80.9	553.1	40
Total			**35**			**875.5**	**767.4**	**5659.2**	**45.3**

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2010 TO DECEMBER 31, 2014 (excluding heat pump wells)

[1] Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)	10				33.8
Production	>150° C	10				19.5
	150-100° C					
	<100° C					
Injection	(all)	3				1.2
Total		23				54.5

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

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

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	15		10			70
2011	15		10			71
2012	15		10			73
2013	15		10			74
2014	15		10			72
Total	**75**		**50**			**360**

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
2005-2009	212	227		436	100	
2010-2014	56	420		521	100	