A Prudent View of Geothermal Development in Italy by 2030

Paolo Conti[1], Giancarlo Passaleva[2] and Raffaele Cataldi[3].

[1] UGI/Italian Geothermal Union, Secretary; c/o University of Pisa /DESTEC; 2 Largo Lazzarino, 56122 Pisa, Italy

[2] UGI/Italian Geothermal Union, President; 20 Lungarno Colombo, 50136 Florence, Italy

[3] UGI/Italian Geothermal Union, Honorary President; 10 Via Il Sanguigno, 56124 Pisa, Italy

segretario@unionegeotermica.it

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ABSTRACT

The paper presents a prudent outlook on the possible development of geothermal applications in Italy for the next 15 years. We analyse the impact of current regulatory, technical, and economic constraints (e.g. the low oil cost) on the stall or stop of many initiatives in this field. Then, the minimum envision of geothermal growth up to 2030 is discussed for both electric generation and direct uses as a whole.

UGI, of course, hopes vividly that real development will outdo the minimum forecasts given in the paper: therefore, we will continue our actions aimed at addressing the geothermal development in the next future towards much more ambitious goals for both electric production and direct uses. The latter objectives are totally in line with the important potential of high and low-temperature resources of the country that are currently unexploited. In particular, the paper will stress how unconventional high-temperature systems might open much more important opportunities for electrical generation. Besides, we introduce the benefits of an integrated multi-source design methodology for moderate-to-low temperature projects.

1. BACKGROUND AND AIM OF THE PAPER

The accessible resource base (*ARB*) of geothermal energy in Italy within 5 km depth is in the order of 2 zettajoules ($2x10^{21}$ J); but some 30% only of them have a sufficiently high temperature, say > 90°C, enabling economic production of geothermal power at present costs. Maybe a fifth or a fourth of the fraction above is heat associated with high- or moderate-temperature hydrothermal systems, whereas 75-80% of the fraction is heat tied to the *unconventional geothermal systems* [1], no of which is economically harnessable today for power generation at the commercial scale.

However, regardless of the type of system, we can estimate that the geothermal resources (*RSS*) potentially extractable in Italy in the next 3-4 decades for both power generation and direct uses are in the order of 20 exajoules ($20x10^{18}$ J), which correspond to ~ 500 million of oil equivalent tonnes (MTOE) [2]. One third of such amount is heat a T > 150°C. This means that a small fraction only of the Italian high-temperature geothermal potential is economically harnessable at present costs.

A study carried out by UGI in 2011 to estimate the possible development of geothermal energy in Italy by 2030 (Buonasorte et al., 2011), which had been set up with two different growth scenarios (a rather prudent Scenario I, and an optimistic Scenario II), for reasons mostly related to the economic crisis that has hurt the country in the last 5-6 years, and also because of the short-sighted energy policy followed by the Italian institutions in the geothermal sector since many years, has proved that even the minimum targets indicated in the study for Scenario I are unattainable for both electric production and direct uses. In particular, the impossibility has become patent to carry out and finish before the second half of the next decade the systematic R&D Project proposed by UGI to establish the role of the *unconventional geothermal systems* in fostering substantially the geopower generation in Italy in the next decades (Cataldi et al., 2013/a).

This is why UGI has started few months ago, and plans to conclude by the end of this year, a new study to forecast on a more realistic base the possible development of the Italian geothermal resources. The study considers again two different scenarios (a very prudent one, and a hopeful one) with reasonable sure estimates until 2030, and with attempted projections by 2050.

Since the latter are still underway at present, this paper is based on the results of the first part of the study, and

[1] They include: EGS/HDR/HFR (more appropriately defined in recent years petrothermal systems), magmatic systems, supercritical fluids, submarine fumarolic fields, hot brines and geopressurized systems.

[2] For comparison we recall that the total Italian consumption of primary energy source in 2015 has been 160 MTOE.

will give the prudent estimates only of the expected geothermal growth in Italy by 2030. The growth figures shown here will thus offset the forecasts presented some three and half years ago at the previous EGC2013 (Cataldi et al., 2013/b)

2. GEOTHERMAL FRAMEWORK OF ITALY

The collision between the African and the European plates begun in the Upper Cretaceous (80-60 million years ago) and continued all through the Upper Miocene (15-10 million years ago), and the resulting Alpine-Appennine orogen in the last 10 million years, are the geological causes for the formation of the Italian territory, from the Sicily Channel in the South to the Alps in the North.

Moreover, beginning some 15 million years ago, the Tyrrhenian Sea started to open as a result of mantle arching in the south-western Mediterranean, accompanied by the rising of igneous material from partly deep and partly anatectic magma bodies. These geodynamic processes are still under way and are leading to: *i)* thinning of the crust; *ii)* formation of shallow intrusive bodies; and *iii)* volcanic activity in the southern Tyrrhenian Sea, in eastern Sicily, in central Sardinia, and in the western margin of the pre-Appennine belt, from Tuscany to Campania (Fig. 1).

As a result of all the above, favorable conditions formed in the south-western sector of the Italian territory, thus leading to the formation of a regional thermal anomaly (Fig. 2) with a number of local peaks mostly located in the southern Thyrrhenian Sea and in the pre-Appennine belt of central Italy.

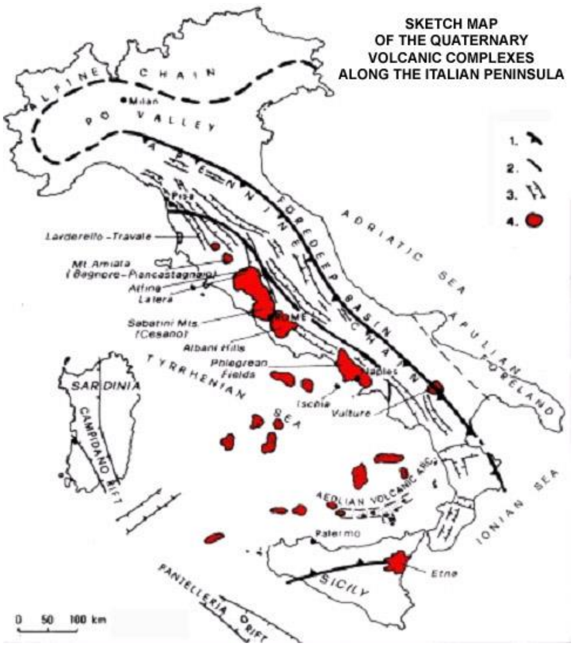

Figure 1: Geodynamic domains and recent volcanism of Italy.

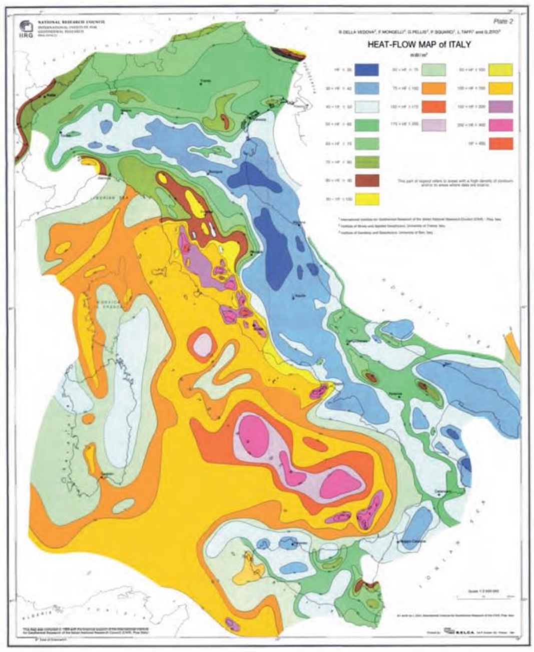

Figure 2: Heat flow map of Italy.

Figure 2 clearly evidences that two large sectors with different thermal regimes exist in the Italian territory:

- a western Appennine and Tyrrhenian sector, characterized by heat flow values of between 80 and 450 mW/m^2; and
- a northern/eastern/south-eastern and southern sector (Alps, Appennines, Adriatic-Ionian belt, Calabria and Sicily, with heat flow values of between 20-80 mW/m^2.

Moreover, intermediate values (100-150 mW/m^2) exist in the Sicily Channel with a peak in correspondence to the island of Pantelleria, and in Sardinia all through the Campidano graben. Here, three heat flow peaks are found :one in the South near Cagliari, one in the center to the West of Nuoro, and one in the North near Sassari. By comparing Figure 2 with Figure 1 one can realize that all the peaks above are located in correspondence to rift structures: the Pantelleria rift in the Sicily Channel, and the Campidano rift in Sardinia.

Recalling that all values above compare to the world average heat flow value of ~ 60 mW/m^2, we can conclude this geothermal outline of Italy by saying that specially favorable conditions could form locally in the western sector of the country as result of four concomitant factors: recent geodynamics, igneous and tectonic processes, anomalous thermal regime, and presence of impermeable complexes overlying permeable rocks with water circulation (confined aquifers). The combination in different way and with distinct values of these factors resulted in the formation of a variety of geothermal resources as illustrated in the categorization map of Figure 3.

The categorization is based on the cross-analysis of geodynamics at regional scale, magmatism, volcanotectonics, heat flow, temperature maps at 1-2 and 3 km depth, regional geology, hydrogeology, tectonics, lithology and lithostratigraphy, porosity and permeability of rocks, chemical and isotopic analyses of rocks and underground waters, and any kind of available data obtained from deep drillings. In short it can be said that:

- moderate-to-high temperature resources (T > 90 °C) within 5 km depth, potentially suitable for power generation, are found mainly in the pre-Appennine belt from Tuscany to Campania, in the volcanic islands of the Tyrrhenian Sea and of the Sicily Channel, in eastern Sicily, in central Sardinia and in correspondence to submarine volcanic structures of the southern Tyrrhenian;
- low-to-moderate temperature resources (T = 30-90 °C) at depth less than 2 km, suitable for most direct applications, exist in all areas mentioned above and in many other areas of continental and insular Italy;
- very low-to-low temperature resources (T = 10-30 °C), suitable for low-temperature applications by means of heat pumps, are found practically everywhere at very shallow depth.

Concerning in particular the use of terrestrial heat for direct applications, the priority areas with waters at T= 30-90 °C, hosted in phreatic or confined aquifers at relatively shallow depth, are those evidenced in fuchsia in Figure 4. These areas are located in some 15 % of the over 8000 Italian municipalities.

3. PAST DEVELOPMENT

3.1) Power generation

Its over one-hundred-years-old history is depicted in the diagram of Figure 5, with details for the most recent period.

It can be drawn from the details that the average yearly growth rates in the last 15 years are around 1.6 % and 1.4 %, respectively for the capacity installed and the production obtained. These values are in line with those observed in the previous 15 years, when the reinjection started of spent water in the Larderello field. Without that reinjection, and also without the improved efficiency of the new power units installed from 1990 approx. onward (Parri and Lazzeri, 2016), the annual growth rates mentioned above could not have happened. Consequently, they represent a reference base for possible future development of similar high-temperature hydrothermal systems.

The geopower production occurs in Tuscany only: in the Boraciferous Region (with plants installed at Castelnuovo V.C., Lago, Larderello, Montieri, Radicondoli, Sasso Pisano, Serrazzano, and Travale, for an aggregate capacity of 794.5 MW_e, and in the Mt. Amiata region (with plants installed at Bagnore and Piancastagnaio, for a joint capacity of 121 MW_e).

The 5.82 TWh generated in 2015 represents about 30 % of the total primary energy consumed in that year in Tuscany. It enabled saving 1280 kTOE, and avoiding 3880 kTonnes of CO_2.

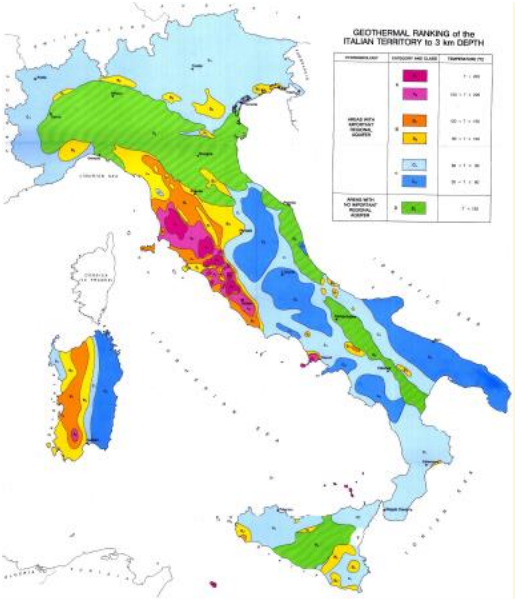

Figure 3: Geothermal ranking of the Italian territory.

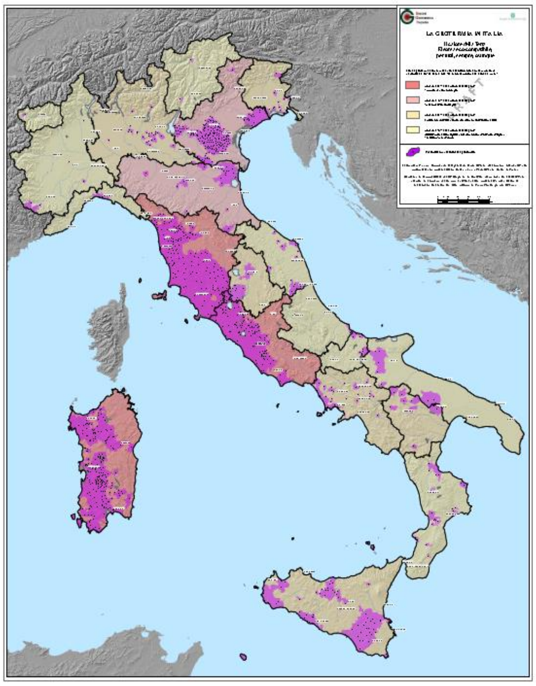

Figure 4: Priority areas for low-temperature resources.

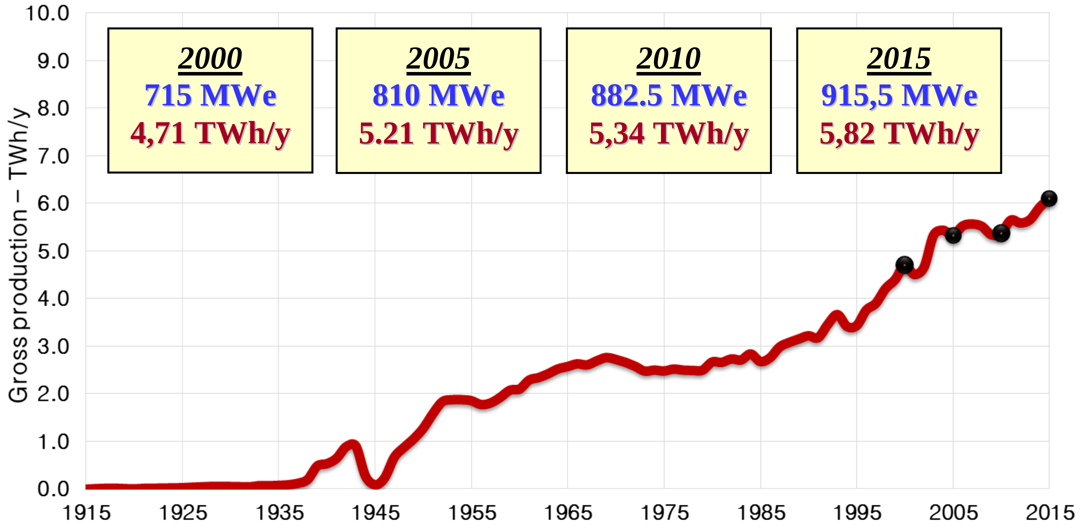

Figure 5: Power generation in Italy 1913-2015.

3.2) Direct uses (total, including heat pumps)

With regard to direct uses, we recall that hot geothermal waters have been used in Italy since prehistoric times for over 3,000 years. In particular, we cite two main development periods: the first one during the imperial period of Rome (1st B.C. - 4th cent. A.D.) with a widespread use of thermal balneology, and the second one between 1850 and 1920 with the intensive exploitation of hydrothermal minerals. References on direct applications of geothermal energy in Italy from Prehistory to the end of the second millennium can be found in Ciardi and Cataldi (2005).

Today, geothermal direct uses are continuously growing in both Italy and worldwide (Lund and Boyd, 2015). Ground-source heat pumps constitute the main technology to exploit and deliver geothermal heat, but important developments have been observed also in the DH sector, thermal cascade uses, and integrated multi-source systems (EGEC, 2014). The Italian situation in terms of application categories is in line with the rest of the World. Table 1 shows the status of the geothermal direct uses in Italy at the end of 2015.

Table 1: Summary table of geothermal direct heat uses as of 31 December 2015 in Italy.

Sector of application	*Capacity (MW_t)*			*Energy (TJ/yr)*		
	Total	**GSHPs**	**DHs**	**Total**	**GSHPs**	**DHs**
Space heating	716	514	137	4,445	3160	807
Thermal balneology	435	-	-	3,346	-	-
Agriculture uses	83	13	-	683	75	-
Fish farming	120	-	-	1,869	-	-
Industrial process heat + minor uses	18	4	1	156	25	10
TOTAL	**1,372**	**531**	**138**	**10,500**	**3,260**	**818**

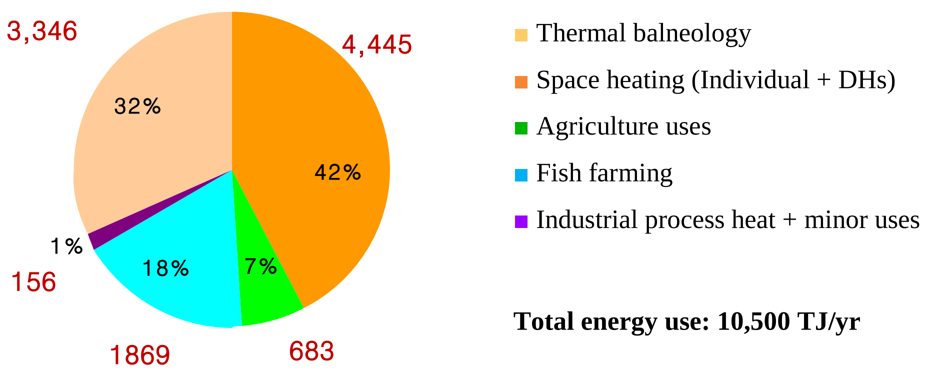

Figure 6: Share of geothermal energy utilization of direct uses in 2015 in Italy.

The total installed capacity exceeds 1,300 MWt, with a corresponding heat utilization of 10,500 TJ/yr. Space heating (DHs and individual systems) is the main sector of utilization in terms of both installed capacity (~ 52%) and energy use (~ 42%). Thermal balneology is the second sector (~32%), fish farming is the third one (~18%), and the rest (less than 10 %) is shared between agricultural applications, industrial processes, and minor uses. Ground-source heat pump systems exceed 500 MWt in terms of installed capacity, with a corresponding geothermal energy exploitation of more than 3,200 TJ/yr. GSHPs account for 39% of the total installed capacity and some 31% in terms of energy. DHs deliver about 8% of the total geothermal heat.

As above-mentioned, the development of the direct uses during the last years is mainly due to ground-source heat pump installations that have more than doubled their capacity: from ~250 MWt in 2010 to over 500 MWt in 2015. Similarly, Geo-DHs sector has grown from ~68 MWt in 2010 to over 138 MWt in 2015. Space heating has become the main sector of utilization thanks to the development of both GSHPs and DHs. Thermal balneology (the previous first sector of utilization) has slightly reduced its relevance because of the economic crisis that has reduced the number of customers and the overall wellness market. Further details on the evolution of geothermal direct uses in Italy are presented in Conti *et al* (2016).

3.3) Total geothermal vs. total energy consumption in 2015.

From points 3.1) and 3.2) emerges that, in 2015, geothermal heat (power generation+direct uses) totaled 1531 kTOE, displacing 4215 kTonnes of CO_2 emissions.

These figures must be considered in the light of the total primary energy consumed in Italy in 2015, which amounted to about 160 MTOE: 72% from fossil fuels (oil, gas, and coal), 22% from renewables and non-conventional sources (large and small hydro, wind, photovoltaic, biomass and geothermal), plus 6% from imported electricity. The share of aggregate renewables and non conventional energy sources climbed from 12% in 2010 to 22% in 2015 owing in part to the reduction of the total energy consumption (from 188 MTOE in 2010 to 160 MTOE in 2015) and in part to the impetus given to their development in the last 8-10 years.

Geothermal as a whole, in particular, grew from 1382 kTOE in 2010 to 1531 kTOE in 2015. Therefore, in this period, the contribution of the terrestrial heat to the total energy consumed in Italy rose from 0.73 to 0.95%. The increase is mostly owed to the reduction occurred in the consumption of the primary energy sources (from 188 MTOE in 2010 to 160 MTOE in 2015, as said above); however, also geothermal contributed in saving fossil fuels: power generation, growing from 1175 kTOE in 2010 to 1280 kTOE in 2015 (an average growth rate of about 1.7% per year), and direct uses rising from 207 kTOE in 2010 to 251 kTOE in 2015 (an average growth rate of 3.5% per year).

At any rate, the shares above (1.7 and 3.5 %, for power production and direct uses, respectively) lead to say that geothermal deployment from 2010 to 2015 has been rather poor as compared to the country's large geothermal potential, especially for direct uses.

4. ENVISAGED DEVELOPMENT

4.1) General

The new forecast study started by UGI a few months ago aims at giving the Italian government updated factual elements on the medium and long term deployment of geothermal energy in the country for power generation and direct uses.

Growth estimates by 2030, and attempted projections until 2050, are made on the basis of: *i)* Italy's geological setting and geothermal resources known or supposed to exist down to 5 km depth; *ii)* likely new increase in fossil fuel prices in the next years; *iii)* average annual growth rates occurred in Italy and worldwide in the last 30 years for power generation, and in the last 15 years for direct uses; *iv)* expected technological improvements in the extraction and use of the Earth's heat for any kind of energy application; and *v*) probable development at the commercial scale, for power production, of the *unconventional geothermal systems* in a "near future".

By "near future" we mean a flexible period of time, which may range from 3-5 years in few countries and for certain types of *unconventional system*, to 12-15 years in other countries and for different *unconventional systems*, depending also on other conditions at the global and local scale: world economy and energy costs, first of all.

For Italy, we feel that, regardless of the more or less encouraging results attainable by the experiments that have been started recently at Larderello in the framework of the *Descramble* Project[3], the possible deployment at the industrial scale of the *unconventional geothermal systems* depend on "when" the finalized R&D Project mentioned in a previous paragraph and outlined in the following Chapter 5, may start and be completed. In our study we hypothesize that the systematic, commercial production of electric energy from *unconventional systems* may hardly start before 2030. Therefore, we suppose that until 2030 geothermal-electric production will solely come from high- and moderate-temperature hydrothermal systems.

At any rate, all forecasts by 2030 and the projections until 2050, for both power generation and direct uses, are made by 5-years periods according to two different

[3] For a summary information on this Project see article by Bertani and Manzella (2016)

Table 2: Capacity installed and generation 2010-2015 with growth estimates by 2030 according to Scenario I and respective benefits, expressed in terms of crude oil annually saved and CO2 avoided.

Year	*2010*	*2015*	*2020*	*2025*	*2030*
Total installed capacity at December of each year (MW_e)	**882.5**	**915.5**	**960**	**1020**	**1070**
Average yearly increase of capacity compared to the previous 5-years period (% / year)	**1.7**	**0.7**	**1**	**1.2**	**1**
Total gross generation in each year (TWh/year)	**5.34**	**5.82**	**6.1**	**6.4**	**6.7**
Average yearly increase of production compared to the previous 5-years period (% / year)	**0.5**	**1.7**	**1**	**1.1**	**1**
Primary energy saved (KTOE / year)	**1175**	**1280**	**1342**	**1408**	**1474**
CO_2 avoided (kTonnes / year)	**3560**	**3878**	**4066**	**4266**	**4466**

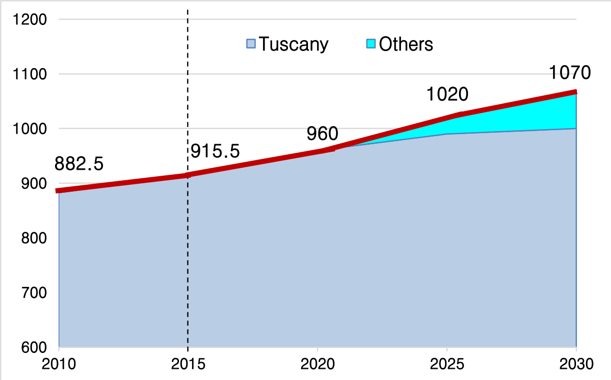

Figure 6: Increase of geothermal capacity in Italy (actual figures 2010 -2015, and forecasts 2020-2030, in **MWe**)

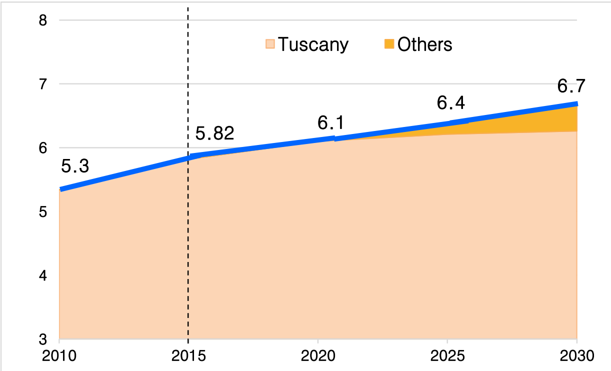

Figure 7: Increase of geothermal generation in Italy (actual figures 2010 -2015, and forecasts 2020-2030, in **TWh**)

growth scenarios based on the following summarized assumptions:

Scenario I: current economic trend, mature production technologies, and price of crude oil at source of 110 US $/bbl in 2020, and of 150 US$/bbl in 2030 [4] ;

Scenario II: economic trend driven by firm environmental policies, mature plus advanced production technologies, and price of crude oil at source of 150 US $/bbl in 2020, and 200 US$/bbl in 2030.

However, the estimates given in this paper refer to Scenario I only, till 2030, for both electric generation and direct uses.

4.2) Power generation

Based on the assumptions cited above, the growth estimate of geothermal-electric generation under Scenario I, with steps at December 2020-2025-2030 are shown in Table 1 and Figures 6 and 7.

Recalling that we have hypothesized by 2030 the exploitation of high- and moderate-temperature hydrothermal systems only (i.e. with no contribution from any *unconventional geothermal system*), and considering that we are speaking here of forecasts according to Scenario I, Table 1 and Figures 6-7, enable to say that:

- geothermal generation in the 15 years period 2016-2030 is expected to grow at moderate paces (1-1.2 % per year) totaling some 150 MWe additional capacity installed, with 0.9 TWh additional production as compared to the values of 2015;
- production in the 15 years 2016-2030 is expected to come mostly from Tuscany. However, starting likely from 2020 we hope that other Regions will come to the geothermal floor, the most probable of which are Latium, Campania, Sicily, and perhaps Sardinia. The contribution of the new Regions, however, will likely be no more than 70-75 MW_e.

In addition to the above, concerning the types of plants, we deem that, till 2030, all of them will be units of consolidated technology, mostly made by condensing turbines with sizes > 8-10 MW_e , and subordinately by binary-cycle units of different types, with sizes of between 1 and 5 MW_e. A few large units might be of the hybrid type (i.e multi-source supplied groups), similar to that recently installed by Enel at Cornia, a locality of the Boraciferous Regionn to the South of Larderello. At any rate, we expect that the great majority of such plants (if not all) will be supplied by high-to-medium temperature hydrothermal systems, at T > 120 °C.

[4] The average oil price at the source in 2015 was about 49.31 US $/bbl.

4.3) Direct uses (total, including heat pumps)

During the last decade, Italian direct uses have experienced a remarkable growth; both in terms of installed capacity and energy use. Despite of some methodological issues that are still affecting the statistics on direct uses (see Cataldi and Conti 2013, Conti *et. al* 2015 and Conti *et. al* 2016 for more details), we can estimate that, at the end of 2015, the installed capacity has reached the value of around 1,300 MWt (+33% with respect to 2010) and an energy use of about 10,500 TJ/yr (+21% with respect to 2010). The growth is mainly due to GSHP systems and geothermal district heating networks (+ 17%/yr and +7%/yr in terms of installed capacity, respectively). Also the other application sectors are expanding (e.g. industrial uses), however, the expected development for the next years seems related mainly to the space heating sector, particularly through GSHP systems.

In fact, as well-know, the high installation costs (including geo-source assessment and drilling costs) are the main drawback for the development of direct use applications. The achievable savings provided by a geothermal system should be sufficient to pay back the initial expenditure in a reasonable time; otherwise, the operator will choose another solution for his purposes. This is the reason why, currently, all the main direct applications are located within or close to the traditional geothermal areas (i.e. Larderello and Monte Amiata), where the existing geothermal infrastructures allow an easier and cheaper access to the geothermal resource with respect to a pure-new installation (i.e. new wells). The other great contribution to the total direct utilization of the geothermal energy comes from the balneology sector. It is widespread over the entire territory thanks to its intrinsic economic viability given by the remunerativeness of the wellness market. However, the latter sector seems to be close to a saturation in terms of exploitable thermal waters and no significant developments are expected for the next years.

We can figure out three main drivers for the development of the direct uses in Italy, namely: a) the exploitation of non-productive, but existing wells drilled for fossil fuels research in the past decades. Some of them could be recovered and converted in hot-water wells for direct use applications. In this way, it is possible to reduce the initial costs with a notable increase of the investment viability. The two existing geo-DH systems of Ferrara and Vicenza can be used as benchmark cases to endorse the exploitation of old research wells; b) as proven by the last ten-year evolution, the typical great and concentrated thermal demand of DHs represents a possible driver to create economies of scale, increasing the investment profitability. Otherwise, also considering the relative low price of other technological solutions and other energy sources, geothermal systems risk to be poor attractive; c) a novel design and management approach, based on a cost-benefit analysis and aimed at the concurrent reduction of the installation costs together with the optimization of the control during the system lifetime (Conti 2015). In this context, the geothermal system works in synergy with other sources of energy in order to maximize the viability of the overall project ensuring a constant exploitation of the geothermal resource during the system lifetime. A notable research activities are currently ongoing in these topics in order to find new design and management strategies for geothermal systems (see, for instance, Grassi *et al.* 2015).

In short, through the applications of the above-mentioned development drivers, we expect that Italian direct uses are going to evolve as shown in Fig. 8.

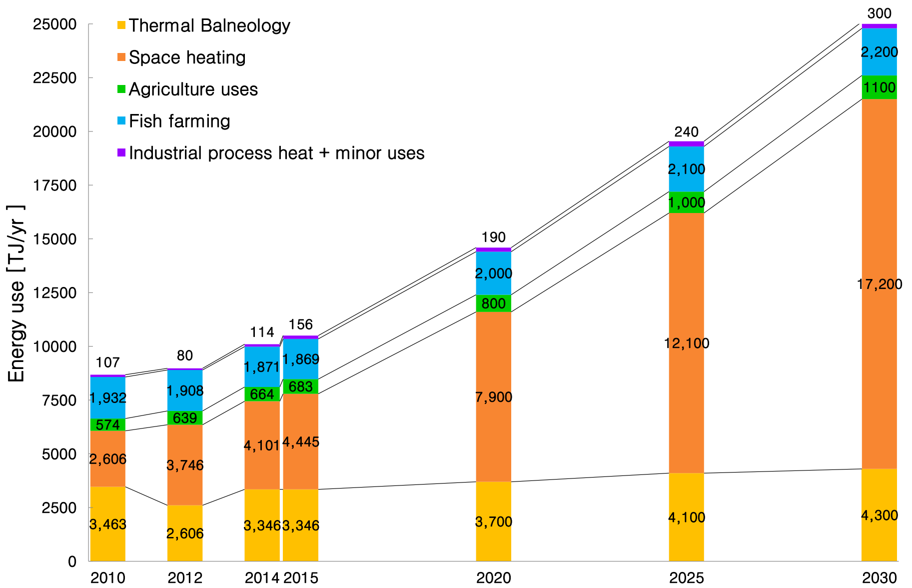

Figure 8: Development of the different sectors of direct uses in Italy (2010-2030).

Table 3: Summary of geothermal deployment in Italy 2016-2030 according to Scenario I

Use & Contribution	2015			2020			2025			2030		
Electrical energy	915.5 *MWe*	5.82 *TWh/a*	1280 *kTOE/y*	960 *MWe*	6.1 *TWh/a*	1342 *kTOE/y*	1020 *MWe*	6.4 *TWh/a*	1408 *kTOE/y*	1070 *MWe*	6.7 *TWh/a*	1474 *kTOE/y*
Direct uses (including GSHP)	1,372 *MWt*	10,500 *TJ/y*	251 *kTOE/y*	2,000 *MWt*	14,600 *TJ/y*	349 *kTOE/y*	2,800 *MWt*	19,500 *TJ/y*	466 *kTOE/y*	3,650 *MWt*	25,150 *TJ/y*	601 *kTOE/y*
Total geothermal	-	-	1,531 *kTOE/y*	-	-	1,691 *kTOE/y*	-	-	1,874 *kTOE/y*	-	-	2,075 *kTOE/y*
Geothermal contribution to primary energy consumption	-	-	0.96% (*)	-	-	1.06% (*)	-	-	1.17% (*)	-	-	1.30% (*)
CO_2 avoided (from total geothermal)	-	-	4215 *kTonn/y*	-	-	4388 *kTonn/y*	-	-	4568 *kTonn/y*	-	-	4720 *kTonn/y*

(*) Shares refers to a total final consumption of 160 MTOE recorded for 2015 and inferred estimations for 2020, 2025, and 2030 based on the expected concurrent presence of energy efficiency policies and a resumption of the economic growth .

4.4) Integrated geothermal development 2016-2030: geopower plus direct uses.

Duly taken into account the general considerations made in pagraph 4.1), and the data given and the comments made in paragraphs 4.2) and 4.3), the overall forecast of geothermal energy by December 2030, with its expected benefits, can be summarized as shown in Table 2.

The figures given in the first three lines of Table 2 point at the moderate but significant increase of the geothermal deployment in Italy even in the very prudent case of Scenario I, especially thanks to the direct uses. These, in fact, are expected to increase at an average rate of about 6 % per year. The much smaller increase of the electric generation (i.e. ~1.1%/year) is essentially owed to the limited perspectives of additional development of high- and moderate-temperature resources from hydrothermal systems in Tuscany, and to difficulties that are constraining the implementation of projects aimed deploying similar resources in Tuscany and in other Regions of Italy.

On the other hand, the aggregate extension of areas with high-to-moderate temperature hydrothermal systems is much less than 1500 km^2. Consequently, it would be of utmost importance to foster and enable development of high-temperature hydrothermal resources for power generation wherever possible, not only in Tuscany but also in other areas of Latium, Campania, Sicily and Sardinia. At any rate, we estimate that approximately half of the new 150 MW$_e$ capacity installable in Italy in the decade 2020-2030 be located in Regions other than Tuscany.

It is also patent from Table 2 that, even in the prudent Scenario I, the contribution of geothermal energy in saving many million tonnes per year of equivalent oil, and much more million tonnes of CO_2 per year is of a paramount importance.

5. A LOOK BEYOND 2030

As mentioned in previous chapters, the possibility to increase remarkably the geopower production of Italy by harnessing heat from high-to-moderate temperature hydrothermal systems within 5 km depth, is objectively hampered by the limited extension (<1500km^2) of its total surface area. Therefore, the only way to foster notably the possible increase in question is to verify the technical feasibility and the economic viability of harnessing resources tied to *unconventional geothermal systems*. Indeed, they exist widely in Italy and are spread over an aggregate area of some 50,000 km^2. It is an area 30-35 times larger than the max. 1500 km^2 said above for the high-to-moderate temperature hydrothermal systems.

Referring the reader to the paper by Cataldi et al. (2015) for location, geological characteristics, lateral and vertical variations, reciprocal interactions and other peculiarities of the *systems* in question, it is sufficient here to say that their first priority areas extend over 5000 km^2, and that their minimum extractable potential in the priority areas corresponds to 4000 MW$_e$ with a gross production of 25 TWh/year for 50 years. These are capacity and production additional to (not in substitution of) the capacity and production obtainable from high-to-moderate temperature hydrothermal systems. Thus, they would represent an actual increase, some 4 times higher than the power expected from hydrothermal systems alone.

“When” the afore-mentioned 50 years may start, however, is difficult to say, because it depends on when their technical feasibility and economic viability at the commercial scale can be proved in the peculiar geologic conditions of Italy, and compatibly with the specific situations of the country, featured by many local constraints. This why, UGI has proposed the execution of a special R&D Project finalized specifically to the Reconnaissance and Prefeasibility studies of the *unconventional geothermal systems* as a whole, to be set up and carried out in the framework of the unifying scope of a strategic energy Project of national interest. In this light, we have hypothesized that the Project should start before the end of this decade (or at the beginning of ‘20ies) and should be concluded by 2030 at most, with hopeful positive results.

In short, the activities envisaged for the Project would include:

- drilling of min.10-max.20 wells (each 4-5 km deep), located in min. 5-max.10 pilot sites (each with different geologic characteristics) so as to involve all types of *unconventional systems*. They would enable investigations of the conditions of different reservoir and determination of the physico-chemical characteristics of the hot fluid in each site;

- installation in at least three of those sites of a small power plant (1-3 MW_e each) in order to carry out sufficiently long production tests, investigate the reservoir performance in time, test the behaviour of the drilling materials and of surface equipment (casings, valves, pipes, etc.), put to test and tune up the components of the power units, economic studies, etc.

The cost of the Project would range (at present prices) between 200 and 400 million € depending mainly on the number of wells and number and size of the pilot power units. The duration of the Project would be 10 years, broken down in 4 phases to be implemented without gaps between them.

The essential idea of the Project has been disseminated within the Italian Earth Science community, receiving a large consensus. With this backstop, UGI is trying to promote the initiative at the institutional level aimed at fostering the preparation of a detailed Project Document. This would be the first (very low cost) phase of the four phases said above.

To conclude, should the Project in question be approved by the appropriate Italian Institution, carried out in about 10 years, and provide encouraging outputs by 2030 at most, the progressive increase in time of geothermal power would result in 2050 in about 2000 MW_e installed capacity according to Scenario I, of which almost half would be supplied by *unconventional geothermal systems*. This would represent a notable step ahead for the geopower generation in Italy.

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