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Outlook on Geothermal Power Development in Italy by 2050: Up or Down?

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ABSTRACT

From 1985 to 2013, geothermal power grew in Italy at an average rate of 2.4% per year thanks to the exploitation of high-temperature hydrothermal systems within 5 km depth by using conventional technologies, mostly condensing power plants supplied by steam or water-dominated reservoirs. However, these types of systems with T > 100 °C within 5 km of depth are found in only a few areas of the country which aggregately extends over 1,500 km^2. Thus, an objective limit exists to increasing Italian geothermal generation by harnessing hydrothermal systems only.

A study published by Unione Geotermica Italiana (UGI – Italian Geothermal Union) in December 2011 concluded that by limiting development to such systems, geothermal electricity in Italy would attain in 2030 no more than 1,500 MW$_e$ and 9 TWh/yr; however, should the technology of unconventional geothermal systems (UGS) become commercially mature for power production by 2025, the figures above might increase in 2030 to a maximum of 2,000 MW$_e$ and 12 TWh/yr. In such case, the UGS would give a contribution to total Italian geothermal generation in 2030 of more than 25 %.

A more recent study made by UGI on the possible growth of geothermal power in Italy by 2050 pointed out that by only harnessing hydrothermal systems in the above-said 1,500 km^2 of high-temperature areas, with no contribution from UGS, the moderate increase envisaged for the future would vanish around 2030 and a gradual decrease would then begin, resulting in ~1,200 MW$_e$ installed capacity and ~7.5 TWh/yr produced by 2050. On the contrary, should UGS become technically mature around 2025 and their commercial exploitation start for power production, they would counterbalance abundantly the decreased production from hydrothermal systems, and the combined generation from hydrothermal systems plus UGS would reach in 2050 some 3000 MW$_e$ and 18 TWh/yr. Out of these totals, ~1800 MW$_e$ and ~10.5 TWh/yr would belong to UGS alone. It is thus patent that the long-term increase of geothermal power in Italy largely depends on the technical-economic feasibility to exploit geothermal systems other than traditional hydrothermal systems.

After describing shortly the geological characteristics of the UGS, where they are found in Italy, and the estimated overall extension on land and offshore of their first order priority areas (4,000-10,000 km^2), an estimation is given of the aggregate potential for power generation from UGS in such areas: 200-500 GWye. For plants operated at full load for 50 years and 6000 hours/yr, this range of values corresponds to 4000-10,000 MW$_e$ of installed capacity and 25-60 TWh/yr of power generation.

Finally, a proposal by UGI is outlined for the execution of a large-scale R&D Project targeted at UGS as a whole. The general program of such Project would include drilling of 10-20 wells at 4-5 km depth, located in geologically different sites, and the installation of 3-5 pilot plants. The duration and cost of the Project are estimated to be 9-10 years and 200-400 M€, respectively.

Only this type of Project, we think, may create the technical pre-requisites necessary in Italy to start harnessing the sizeable energy potential of unconventional geothermal systems. In this way only, we feel, the country's geothermal power development can be directed towards a stable rising trend, with the figures given above for 2050 representing a step only of much more important long-term targets.

1. INTRODUCTION

Detailed information on the forecasts made by UGI for the development of geothermal power generation in Italy by 2030 under two different growth scenarios are to be found in Buonasorte et al. (2011); but for the purpose of this paper, the summary data shown in Table 1 are sufficient. The figures in parentheses for Scenarios I and II represent the possible contribution, at December 2030, of geothermal systems other than hydrothermal ones at T > 90 °C within 5 km depth, i.e. the share of the whole group of systems collectively called Unconventional Geothermal Systems (UGS) in the totals. These systems are described in the following paragraph.

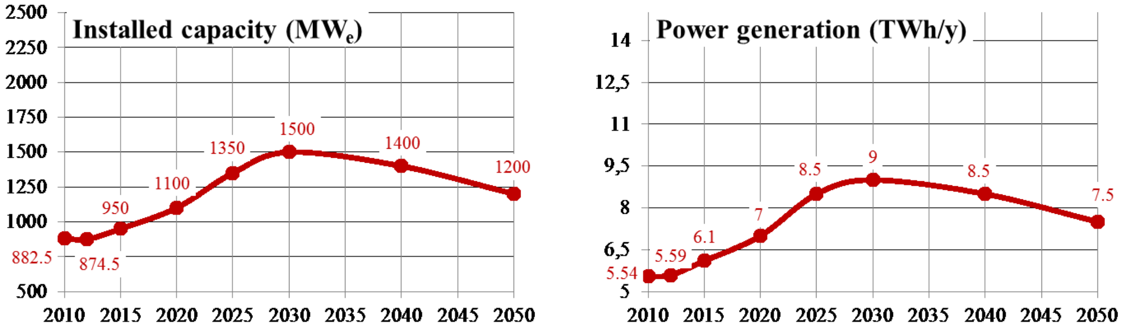
The hypothesis made by Buonasorte et al. (2011) on the development of UGS is that at least one of the UGS should reach by 2025 the technological maturity and the cost-effectiveness necessary for their industrial exploitation. In this case, their share in total geothermal power generation by 2030 would range between 10 and 25 % approx.

Table 1: Summary forecasts of geothermal power generation in Italy: 2010-2030

Year		***2010***	***2030***	
Power generation			***SCENARIO I***	***SCENARIO II***
Installed capacity	**(MW$_e$)**	**882.5**	**1500** ***(150-200)***	**2000** ***(400-500)***
Gross generation	**(TWh/yr)**	**5.34**	**9.4** ***(1-1.4)***	**12.0** ***(2.5-3)***

After the forecasts mentioned above, UGI conducted in early 2012 a preliminary study on the possible development of geothermal power generation from 2030 to 2050, by exploiting all possible high-temperature resources from hydrothermal systems at T > 90 °C within 5 km depth, and from first order priority areas of unconventional systems; for the latter it was assumed that one or more UGS could reach no later than in 2025 the economic attractiveness necessary for their industrial development. Therefore, the expected contribution of the two groups of resources (from hydrothermal systems alone, and from any kind of UGS found in the first order priority areas only) have been analyzed separately.

For the development based on high-temperature hydrothermal resources only, starting from the data given in Table 1 for the best possible Scenario 2010-2030, the estimated development till 2050 is shown in Figures 1a and 1b.



Figures 1a-1b: Development of installable capacity and producible energy until 2050 by harnessing hydrothermal systems only, according to the best possible growth scenario.

We call attention on the fact that the aggregate surface extension of the areas with high-temperature resources (T>90 °C within 5 km depth) does not exceed 1,500 km^2, and that the most important of them are located in Tuscany where they have undergone exploitation for about four decades in certain cases, and for over one century at Larderello and surrounding zones. Thus, objective limits prevent a notable increase of the development of such types of resource.

As a consequence, considering that the amount of water obtainable by condensing the steam exhausted from power plants is limited (approximately 25% of the total fluid extracted from production wells) and that there is no possibility to use river waters to resupply artificially the geothermal reservoir, and taking also into account the economic limits for deeper drillings and the local or environmental constraints existing in some areas of possible interest, we feel that within some 15 years from now (if not before), a decreasing trend in geothermal power generation from high-temperature hydrothermal resources is likely to start.

Should this occur, the long-term future of Italian geothermal electricity would undergo an irreversible slow decline. Nonetheless, we feel that this possibility could be offset if one or more of the above-said unconventional geothermal systems came on stage in the meantime.

2. UNCONVENTIONAL GEOTHERMAL SYSTEMS: GEOLOGICAL CHARACTERISTICS

Unconventional geothermal systems (UGS) is a term proposed by Cataldi (2008) to designate collectively those high-temperature systems at T > 150 °C which are endowed with a huge quantity of heat, but are still far from the technological maturity needed for economic development for power generation. They include: HDR/HFR/EGS, magmatic systems and submarine fumarolic fields, supercritical fluids, geopressurized systems, and hot brines. Their geological characteristics can be summarized as follows.

2.1 Enhanced Geothermal Systems (EGS): Formerly Called Hot Dry Rocks (HDR) and Hot Fractured Rocks (HFR)

EGS are buried complexes of compact rocks of any nature, characterized by poor permeability due to closed fissures, or fractures almost totally sealed by fossil hydrothermal circulation. They can be found in any situation of thermal regime, with normal, moderate or high heat flow values. Therefore, by lacking convective movements of natural fluids their temperature at depth depends almost solely on the local geothermal gradient. In certain areas, their permeability at a given depth may change laterally from very low to moderate and high, or vice versa; in this way such systems (as a function of the local thermal regime) may fade into high or moderate-temperature hydrothermal systems, or vice versa (Figure 2).

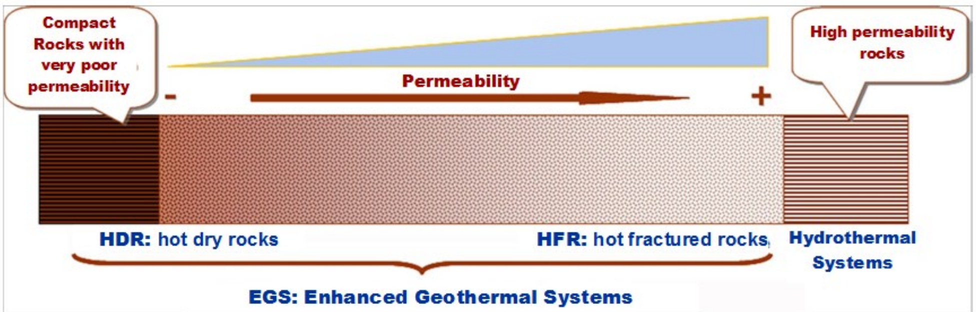


Figure 2: Conceptual diagram showing how, depending on permeability, Enhanced Geothermal Systems may fade gradually from Hot Dry Rocks to Hot Fractured Rocks, and from the latter to Hydrothermal Systems. (after Cappetti, 2009, with small graphic changes).

2.2 Magmatic Systems and Submarine Fumarolic Fields

Magmatic systems are rock complexes of any type overlying active igneous bodies located at a relatively shallow depth (< 5-6 km), where fluid temperature in the reservoir is controlled by the temperature at the top of the underlying magma chamber (Figure 3).

Different techniques have been conceived to harness yet a small fraction of the huge quantity of heat flowing up from such bodies, depending on whether the reservoir is a naturally fractured formation, or a man-made volume of permeable rock created inside the overlying rock complex. At any rate, none of these techniques have been developed so far.

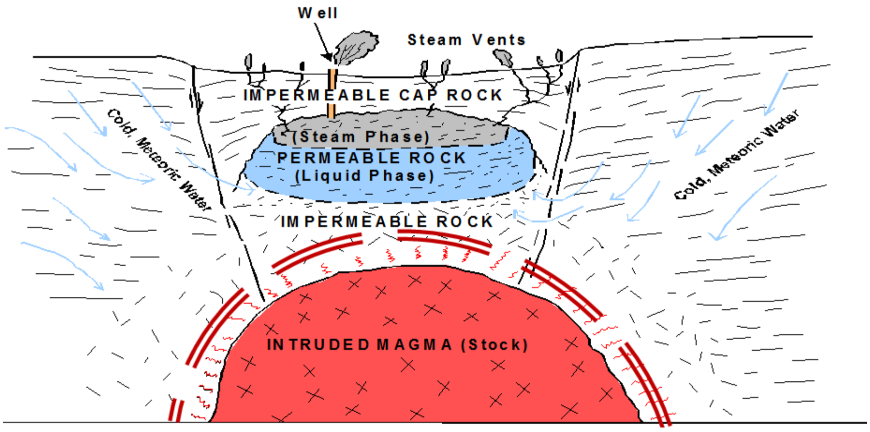


Figure 3: Model of a magmatic system overlain by a high-temperature hydrothermal system characterized by liquid and steam phases, which may form under these conditions.

Magmatic systems may be associated with a new group of systems controlled by active volcanism occurring at the floor of oceans and seas in many places on Earth. They are evidenced by submarine hydrothermal plumes and vents at the piedmont of volcanic seamounts and ranges of active volcanoes. Seafloor fumarolic fields can thus form (Figure 4), whose fluid temperature may reach many hundreds degrees °C.

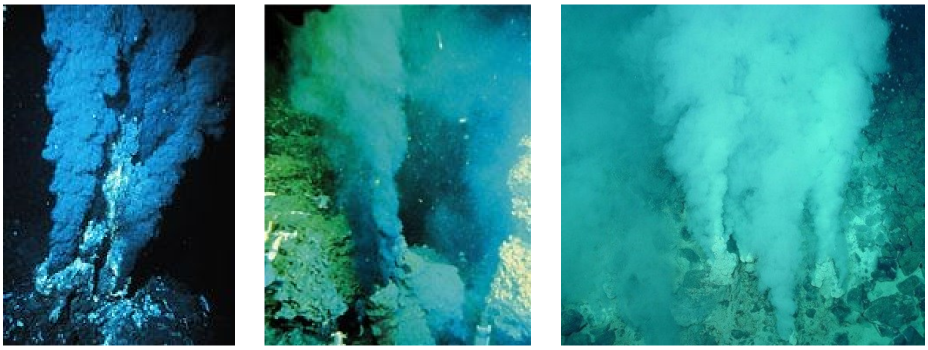


Figure 4: Different views of submarine fumarolic vents. (from left to right: Black smoker, eastern margin of Mid-Atlantic Ridge; Black smoker, southern margin of the Galapagos trench; the "Champagne" fumarolic field, NW Eifuku volcano, Marianes trench). (after Wikipedia: hydrothermal submarine vents).

These manifestations have been studied for over 20 years for scientific purposes (Humpfris et al., 1995); however, in very recent years they have also received attention from applied geothermalists as a possible source of energy for power generation. In fact, the minimum technical potential estimated for this type of resource is, according to Hiriart et al. (2010), in the range of 1,000,000 MW_e. For a full-load capacity and 8000 hours/yr of operation of power plants, this value corresponds to over 200,000 billion kWh of power generation for 25 years. A huge amount of energy which, however, is still far on the horizon.

2.3 Systems with Supercritical Fluids

For the formation of supercritical fluids, a confined reservoir with very high pressure and temperature (over 220 bar and 374 °C for water) is required; therefore, at a relatively shallow depth (e.g. less than 5 km) they may exist only in areas characterized by very high temperature gradient and heat flow values. As a result, the energy concentration of supercritical fluids is also very high with a heat content (enthalpy) several times higher than that of superheated steam, as is the case of the steam-dominated fields of Larderello and The Geysers. In areas of very strong thermal anomaly, supercritical fluids may contain corrosive chemicals.

However, it should be stressed that fluids in the supercritical state have not been documented so far in any geothermal field under exploitation in the world; nonetheless, they are likely to exist below high-temperature fluids associated with magmatic and hydrothermal systems, with a gradual transition from the subcritical state to the supercritical state.

2.4 Hot Brine Systems

Hot Brine Systems are particular types of hydrothermal systems where, for several reasons (probable mixed genesis of the water in the system, lateral sealing of the reservoir caused by changes occurred in the original hydrogeological setting of the system and/or by self-sealing due to hydrothermal scaling, poor supply of young meteoric water, and mostly because of slow convective circulation in an almost closed environment at high temperature), the original waters contained in the reservoir underwent a long process of saline concentration until reaching the content of an actual brine (TDS >10 g/l).

Therefore, to be harnessed for power production, the fluids of these systems require costly chemical treatments and special generation plants. At the same time, though, they give the opportunity to extract valuable chemicals, which (from the economic viewpoint) are sometimes much more attractive than the producible electric power.

2.5 Geopressurized Systems

In most cases, these are geologically-young (<10 My) clastic complexes, usually sands, not yet totally diagenesized, with good permeability due to primary porosity, forming confined aquifers at depths generally over 3 km. The water pressure in these aquifers is controlled mostly by the lithostatic pressure of the overlying formations, and not by the normal hydrostatic pressure; moreover, in regions subject to compression stresses a lateral component of the pressure is added to the vertical one (Figure 5). As a result, the fluid pressure in the aquifer usually reaches values in the range of many hundreds atmospheres. In some cases, however, the same conditions are found in confined aquifers hosted by completely diagenesized rock complexes with low permeability.

All geopressurized systems form in regions with weak thermal anomaly, so that the temperature of the fluids in the reservoir depends on average-to-low values of the local geothermal gradient.

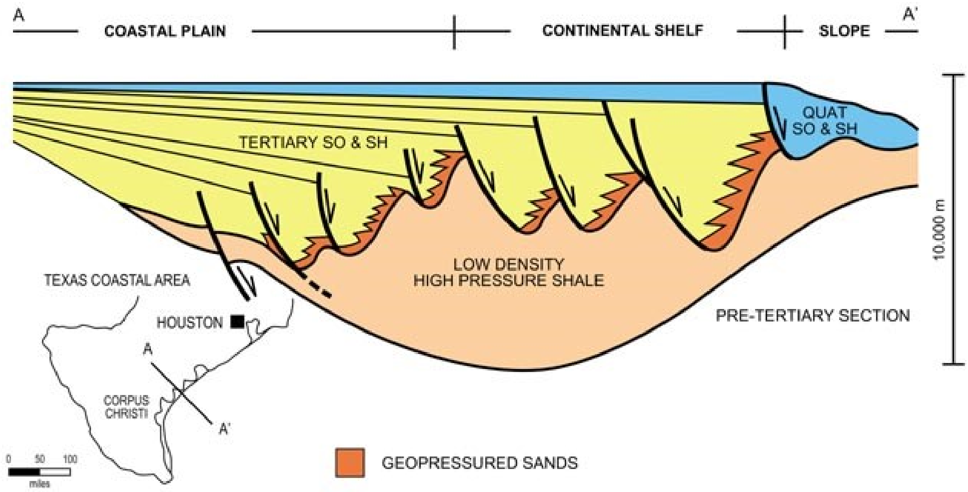


Figure 5: Cross section of a geopressurized system in the geological setting of a coastal area of the Gulf of Mexico, some 300 km SW of Houston, Texas (USA) (after a lecture given by Lund, 2007)

Apart from the above, it should be stressed that the water in the confined aquifers almost always contains sizeable amounts of organic gas and/or oil, which increase notably the economic value of the thermal energy extractable from a given geopressurized system.

3. LOCATION AND LAYOUT OF UNCONVENTIONAL GEOTHERMAL SYSTEMS IN ITALY

All types of systems described above are found in Italy: those with T > 200 °C within 5 km depth are located almost solely in the western and southern Tyrrhenian sectors of the country whereas geopressurized systems (T < 200°C within 5 km depth) are located mostly in the eastern sectors of the Italian peninsula. For each type of system in question, the following main locations of the UGS may be indicated (Figure 6).

HDR/HFR/EGS

- two small areas in NE Italy, one near Merano and the other near Padua (Trentino-Alto Adige and Veneto);
- deep formations of the Larderello, Travale-Radicondoli and Mt. Amiata geothermal fields and nearby areas (Tuscany);
- some sectors of the Volsini-Sabatini-Albani volcanic district (Latium);
- a rather large area N-NW and S-SE of the two groups of locations indicated above (Tuscany and Latium);
- some deep features of the Phlegraean Fields and of the Vesuvius volcanic district near Naples (Campania);
- two relatively small areas NE and E-SE of Naples (Campania and Lucania);
- two areas in Sicily, one in the Etna-Hyblaean Mts. to the west of Catania, and the other SW of Palermo (Sicily); and
- the Campidano graben and the area N-NW of it (Sardinia).

Magmatic systems and submarine fumarolic fields

- central sectors of the Volsinian and Sabatinian volcanic systems (Latium);
- internal sectors of the Phlegraean Fields-Ischia volcanic province, and peripheral areas of the Vesuvius volcanic district (Campania);

– volcanic islands of the southern Tyrrhenian Sea: Aeolian archipelago (Lipari, Vulcano, Stromboli, Panarea, etc.; Sicily - Figure 7);
– volcanic submarine ridges of the southern Tyrrhenian Sea: Marsili, Vavilov, Magnaghi, Palinuro, and other (Sicily - Figure 7); and
– Pantelleria island and submarine volcanic structures of the Sicily Channel (Ferdinandea, Nerita, and other; Sicily - Figure 7).

Supercritical fluids

– bottom reservoir layers of the Larderello, Travale-Radicondoli and Mt. Amiata geothermal fields, below 5 km depth (Tuscany);
– bottom reservoir layers of the Phlegraean Fields-Ischia volcanic province below 4-5 km depth (Campania); and
– deep layers below 4-5 km depth of the main volcanic islands of the Aeolian archipelago: Lipari, Vulcano and possibly other (Sicily).

Hot brines

– Cesano geothermal field, below 2 km depth (Latium);
– western sector of the Phlegraean Fields-Ischia volcanic province below 2 km depth (Campania);
– main volcanic islands of the Aeolian archipelago (mainly Lipari and Vulcano) and of Pantelleria, below 3 km (Sicily).

Geopressurized systems

– large areas of the Lower Po River Valley (Emilia-Romagna);
– some coastal sectors of the Adriatic Sea (Emilia-Romagna and Marches);
– Bradano graben (Lucania-Apulia); and
– Caltanissetta trough (Sicily).

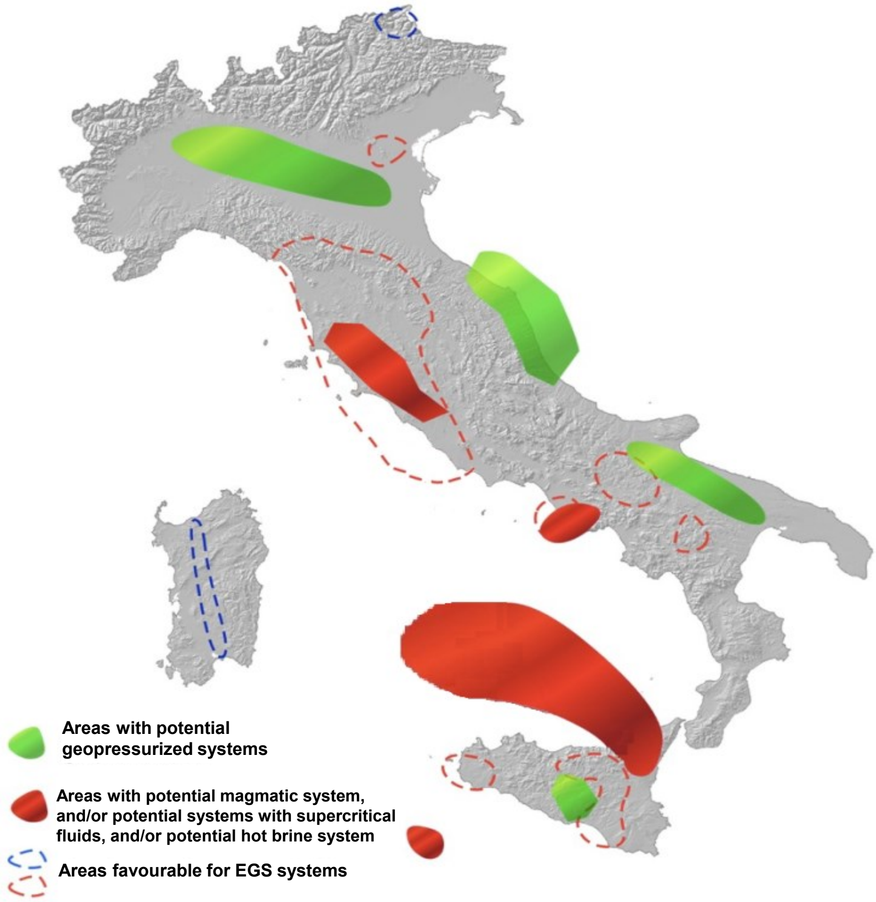


Figure 6: Favorable areas for projects of unconventional geothermal systems (after Buonasorte et al., 2011- Fig. 39-, with small graphic changes).

Figure 7: Location of superficial and main submarine volcanic structures in the southern Tyrrhenian Sea and in the Sicily Channel (after Wikipedia: submarine volcanoes in southern Italy)

The above list and Figure 6 clearly show that in several cases some types of UGS with T > 200 °C within 5 km depth are present in the same area. This means that some UGS may coexist in the same area: high-temperature hydrothermal systems above and one or more types of UGS below, at greater depths.

Moreover, there are reasons to speculate that in some cases different types of systems (hydrothermal ones and one or more of the UGS described above) pass gradually with depth from one type to the other, and may interfere laterally with each other, or lie in partial coalescence.

Furthermore, it is almost sure that in certain cases, hydrothermal systems and one or more of the UGS in question fade laterally into each other as shown in Figure 2 for the EGS, resulting in a kind of heteropy of facies.

Under these circumstances, it is impossible today in Italy: i) to define the surface extension of each UGS; ii) to evaluate their reservoir volume in each area; iii) to assess the energy potential in situ of each system; iv) to quantify the extractable resources in each area; and v) to carry out surface and subsurface surveys aimed at specific exploration of a single UGS.

As a consequence, based on the present-day knowledge of the deep geological conditions of Italy, quantification of the high-temperature heat harnessable from UGS for power generation in the long term cannot be made separately for each system. This means that, for the time being at least, the evaluation of the in-situ and extractable potential of UGS should be made aggregately as a unitary group and concurrently.

As regards to the aggregate extension of UGS (land plus marine areas), Figure 6 allows us to say that it is in the range of 50-60,000 km^2; i.e. 35-40 times higher than the maximum extension of hydrothermal systems at T > 90 °C alone. This indirectly points at a total potential extractable from UGS that is notably higher than the residual resources harnessable from high-temperature hydrothermal systems only.

4. PRIORITY AREAS AND MINIMUM ENERGY EXTRACTABLE FROM UGS

Out of the aggregate extensions given above (50,000-60,000 km^2), under a combination of more or less favorable geological conditions, three levels of interest areas can be singled out, which represent different orders of priority for their development. In starting such development, preference should be given, to the first order priority areas.

4.1 Extension of the First Order Priority Areas

Taken together, such areas with their minimum surface extension were estimated by UGI as follows:

– on land:	2000 - 5000 km^2
– on coastal and off-shore areas:	3000 - 5000 km^2
Total	*5000 -10,000 km^2*

4.2 Resources at T ≥ 200 °C Potentially Extractable from the First Order Priority Areas

– from land areas:	100 - 200 GWyr (e)
– from coastal and off-shore areas:	100 - 300 “ “
Total	*200 - 500 GWyr (e).*

4.3 Power Generation Potentially Obtainable from UGS Priority Areas

Assuming a 50-year utilization time with plants operated at full load for 6000 hours/yr on average, the capacity which might be installed, and the power generation which might be obtained from the energy potential said in section 4.2) would be:

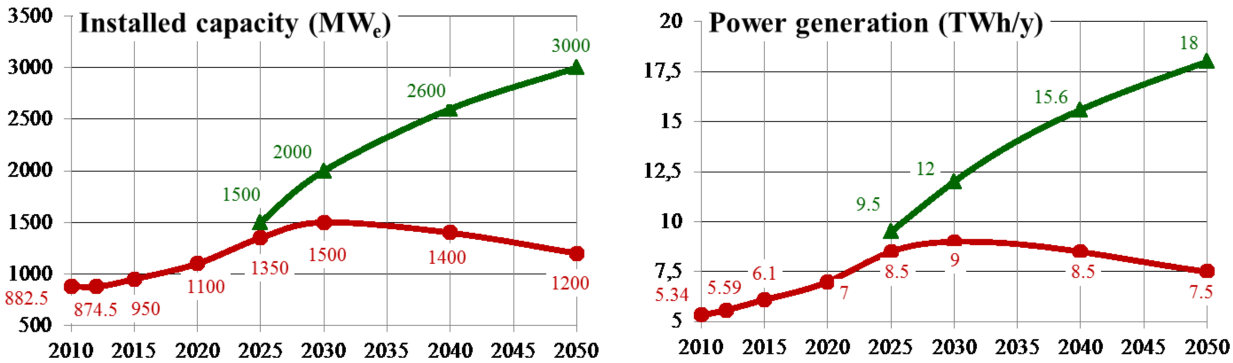
– capacity: 4000 - 10,000 MW_e ;
– power generation: 25 - 60 TWh/yr.

These values include the 500 MW_e and 3 TWh/yr maximum indicated in Table 1 for the contribution of UGS by 2030. They are in addition to (not in substitution of) the capacity and power obtainable from high-to-moderate temperature hydrothermal systems. To make the comparison easy, it is worth recalling that the capacity installed and the electricity produced in 2010 (882.5 MW_e and 5.34 TWh/yr - see Table 1) are the result of the exploitation of high-temperature hydrothermal systems only at Larderello, Travale-Radicondoli and Mt. Amiata in Tuscany.

It can be noted that the energy potential of UGS first order priority areas alone is much higher than the potential needed to supply the 500 MW_e given above and to produce the 3 TWh/yr maximum indicated for Scenario II in Table 1.

4.4 Foreseeable Contribution of UGS to Power Generation in Italy by 2050

The contribution depends mainly on the date when the 50-year period (assumed in section 4.3) may start; but in this regard we can make a single hypothesis only, subject to the implementation of the R&D Project described in Section 6 below. On this hypothesis, the start may happen around 2025 and the development technology of at least one UGS may become mature by 2030. In this case, the contribution of UGS to power generation in Italy 2030-2050 would correspond to the area defined (for capacity and power generation, respectively) by the two curves (green (upper) and red (lower)) of Figures 8a and 8b.



Figures 8a- 8b: Development of installable capacity and producible energy till 2050 by harnessing hydrothermal systems according to the best possible scenario, jointly with one or more UGS/Unconventional Geothermal Systems.

These figures illustrate that harnessing one or more UGS from 2025 onwards would enable not only to offset the foreseeable decline of geothermal generation from hydrothermal systems after 2030, but also to increase notably the total geopower production of Italy, with a sustained upward trend for subsequent decades.

5. R&D PROJECT TO MAKE THE COMMERCIAL EXPLOITATION OF UGS MATURE IN ITALY. A PROPOSAL BY UGI

5.1 Foreword

Should the future development of the Earth's heat in Italy be based on the application of presently mature technologies only, we could envisage:

– for direct uses: a rather optimistic future, with a maximum target in the range of 90,000 TJ/yr by 2030. This would correspond to an actual increase of ~ 9 times the value at December 2012 (~10,000 TJ/yr) as revised by Conti et al. (2014);

– for power generation: a rather narrow development road-map, with a maximum target of 9.5 TWh/yr by 2030 (see Table 1).

There are several reasons explaining why we envisage such a limited target of power generation by 2030. The most important of them are: i) the limited extension of the areas with high-to-moderate temperature hydrothermal systems within 5 km depth (~1,500 km^2 in the overall country, as discussed before) and ii) the high generation costs of the residual resources likely existing in the productive layers between 3 and 5 km depth.

As a consequence, more ambitious targets for geothermal power production by 2030 can only be set by seeking the initial development of one or more UGS, which (as described in sections 3 and 4) widely exist in Italy on land and offshore. However, since the time needed for the most promising UGS to reach technological maturity is 7-8 years at minimum, their appealing development prospects at the industrial scale should be promptly put on the agenda and tackled with a unitary vision.

5.2 UGI's Proposal to Speed Up the Exploitation of UGS

To prepare the technical-scientific grounds for industrial development of the huge amount of heat associated with unconventional geothermal systems, UGI has proposed the implementation of a special R&D Project focused on UGS, with the following objectives:

– asses the technical feasibility and economic viability of harnessing the Earth's heat for power production at industrial scale by using advanced technologies under the specific geological conditions of Italy;

– quantify the energy extractable from UGS as a whole, and estimate the resources harnessable from each (or some) of them, if possible;

– single out the most promising priority areas where initial geothermal power generation projects at industrial scale might be developed as soon as possible.

5.3 Outline of the Project Program

Drilling of a minimum of 10 to a maximum of 20 deep wells (each of 4-5 km depth), located in a minimum of 5 to a maximum of 10 geologically different sites. These wells should investigate the geological conditions of the reservoir in each site and analyze the chemical characteristics of the fluids in the reservoir of all UGS.

In at least three of the aforesaid sites, a pilot geothermal power plant should be installed in order to carry out long-term production tests, identify the fluid production trend over time, assess the behavior of the reservoir, test the materials (casing, pipes, etc.) for well construction and machinery under actual operating conditions, and tune up the mechanical components of power plants.

5.4 Timing and Duration of the Project

Three main phases of work can be hypothesized:

– first phase: preparation of a Project Document, including planned works and activities, selection of drilling sites, definition of the technical profile of the wells, analysis of technical costs, evaluation of possible external costs, outline of external benefits, preparation of the organizational chart and of any other document needed for the approval of the Project. Based on this Project Document, the official approval by the institution(s) concerned should be obtained, the operational work should be organized, and the initial work contracts awarded. The duration of this phase is in the range of 2 years starting from the "green light" given to the preparation of the Project Document in question.

– second phase: execution of works, including any kind of field, lab, and office work. Most activities should be carried out in parallel and approximately in the same periods of time in the different project sites. They should be coordinated by the project management structure directly reporting to the main national institution acting as Project leader. The expected duration of this phase is 5-6 years starting from the authorization to begin field work.

– third phase: mainly office work, including processing of data and results obtained in the different work sites, quantification of extractable resources, selection of areas where to locate the first UGS projects, singling out priority sites for implementation of such initial projects, drafting the final report, submission of the draft report to the main national institution acting as Project leader, revision and printing of the final report. The duration of this phase is some 2 years starting from the end of field and lab work.

The Project is hoped to start no later than 2015. After that, if the different phases are developed in timely continuity, the total duration of the Project is estimated to be 9-10 years.

5.5 Preliminary Estimation of Project Costs

A first tentative estimation indicates that, at present prices, the total cost of the Project may range from 200 to 400 M€, depending mainly on the number and depth of wells (min. 10 - max. 20, at depths of 4-5 km), and on the number and size of pilot generating units (min. 3 - max. 5, each with a capacity of 1-1.5 MW_e). An accurate evaluation of costs can be made only on the basis of the actual work to be identified in the Project Document.

6. SUMMARY AND CONCLUSIONS

The long-term future of geothermal power generation in Italy cannot be based on the sole development of moderate-to-high temperature hydrothermal resources existing within 5 km depth in the very limited aggregate area of no more than 1,500 km^2. In fact, probably around 2030 ± 5 years, an irreversible decline of the annual geo-power generation is likely to occur.

Under this condition, the only way we see to counter this probable decline and to increase the national geothermal power is to harness a fraction of the huge quantity of high-temperature heat associated with unconventional geothermal systems (UGS), of which Italy is richly endowed. To do this, however, considering the unique and extremely diversified geological conditions of Italy, as well as the existing numerous local and environmental constraints, we think that the only way to proceed is the execution of a large R&D Project focused specifically on UGS as a whole, to be completed before the above-said decline starts appearing.

The core of the program of such Project should consist of a minimum of 10 to a maximum of 20 wells (each at 4-5 km depth), and a minimum of 3 to a maximum of 5 pilot plants. The total cost would be in the range 200-400 M€, and the duration 9-10 years, starting possibly no later than in 2015.

With this in mind, taking into account the important technical-scientific outcome expected from the implementation of the Project, UGI has widely disseminated the idea of the Project within the Italian earth science family in general and the geothermal community in particular, always obtaining a large consensus in principle.

Such consensus, however, is only part of the elements needed to build awareness, among energy planners and inside the institutions involved in energy dealings, of the risk that the country runs by founding the development of geothermal power generation in Italy on exploitation of hydrothermal systems only. It is thus imperative that institutions and energy decision-makers grasp the importance of the R&D Project proposed by UGI, aimed at laying the technical-scientific foundations required to harness a fraction of the huge quantity of heat associated with UGS; this with a view to significantly increasing geothermal power generation in future decades. In this framework, but to the extent of its possibilities, UGI will do its best to promote and build awareness of the above-mentioned risk.

Moreover, when the idea of developing the Project is accepted in principle at political level, UGI will be happy to give its contribution in drafting the Project Document and, subsequently, during execution of the works, to provide technical-scientific skills and expertise in all fields related to research and experimentation of unconventional geothermal resources.

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