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Country report on geothermal direct uses in Italy 2005-2010

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ABSTRACT
After describing the criteria followed for the revision of data published in previous years, the paper presents the comparative development of direct uses in Italy in the period Dec. 2005-Dec. 2010, broken down into five sectors of application: space heating & cooling, thermal balneology, agricultural uses, fish farming, and industrial processes.

The development is summarized in the following table. It shows the total energy consumed in 2005 and 2010, highlighting the fraction produced by means of geothermal heat pumps. The table also displays the total thermal capacity installed at Dec. 2005 and 2010, and the respective fractions attributable to GHPs.

Year	*2005*		*2010*	
Categories of utilization	**(a)** Final energy consumption (TJ/year)	**(b)** Fraction of **(a)** obtained by GHPs (TJ/year)	**(c)** Final energy consumption (TJ/year)	**(d)** Fraction of **(c)** obtained by GHPs (TJ/year)
Space heating &cooling	2100 (26%)	*700 (82%)*	4750 (38%)	*1450 (85%)*
Thermal balneology	3400 (41%)	//	4200 (33%)	//
Agricultural uses: greenhouses & other	1140 (14%)	*100 (12%)*	1500 (12%)	*150 (9%)*
Fish farming	1360 (17%)	//	1800 (14%)	//
Industrial processes & other	200 (2%)	*50 (6%)*	350 (3%)	*100 (6%)*
Total heat consumption	**8 200 (100%)**	**850 (100%)**	**12,600 (100%)**	**1 700 (100%)**
Installed capacity (MW_t)	**650**	**215**	**1000**	**500**

1. AVAILABLE DATA, PROCESSING METHODOLOGY AND YEARS OF REFERENCE

The preparation of a country report on direct uses of geothermal energy in Italy has always been, and still is, a demanding task because: *i)* geothermal operators are not bound by law to specify in their annual reports quantitative figures on all direct uses, especially those at low and very low temperature; *ii)* a national office entrusted with gathering operating figures on each and all sectors of direct uses of the Earth's heat did not exist till very recent times[1]; and *iii)* the data provided by operators to the public office concerned, and made available to the public, are often an aggregation of inhomogeneous, incomplete and incoherent data, sometimes related to different direct applications. This makes the unbundling of data, their aggregation into coherent utilization groups, and their processing a very difficult task.
Therefore, when an author realizes that the data obtained from public offices are not consistent with one another and not complete, he/she is obliged to proceed with additional searches for data from many operators in the hope that the material on which he will base his/her work may reach a minimum level of reliability. At any rate, it is always necessary to make estimated evaluations for a number of figures.

Processing available data represents another important issue. In fact, even though direct uses of geothermal energy can be grouped into homogeneous sectors (see para. 2.1), each sector has different characteristics, resulting in the need to devise an appropriate calculation methodology for each sector. This means that when the energy balances are calculated by general and simple equations, with no indication of the specific conditions of each sector, summing their heat sub-totals to obtain the total heat used in a given year in a given country is implicitly a rough procedure, often affected by notable errors.

[1] Decree no.28 of the Italian Ministry of Economic Development, issued on 14 Jan. 2012 and published on 14 Feb. 2012, actually gives general instructions on the methodology of gathering operating data, including those on direct uses of geothermal energy, and assigns to GSE (a company, controlled by the Italian Ministry of Economy and Finance entrusted with paying economic incentives and promoting the production of energy from renewable sources) the task to gather such data. Detailed regulations on how to collect specific data on the different energy sources identified in the Decree in question, however, have not been issued yet; thus, it is very unlikely that the Decree may become fully operative within 2013. This means that better information and detailed figures on direct uses of the Earth's heat in Italy will not be available until the end of 2014, if not 2015.

Concerning in particular geothermal heat pumps, it is known that both their coefficient of performance (COP) and thermal capacity are influenced by the temperature level of the source. At a unitary load ratio, the same equipment provides different values of thermal energy depending on the local thermal state of soils and rocks forming the heat source. Therefore, with no explanation of the working parameters (temperature levels of the evaporator and of the condenser), comparisons between two or more heat pumps are hard to make. This is why international (ISO) and European (EN) technical standards have been issued to give specific instructions on how to determine the test conditions for the rating of heat pumps.
Apart from the above, the operating data of heat pumps provided in Italy by operators and private users rarely specify working hours per year, useful ΔT, and other elements needed to calculate the net energy consumed[2]; other times, when a combined heat-producing system is used, those data are often provided in an aggregate form, together with aeraulic and/or hydraulic pumps which have nothing to do with geothermal resources.
Similar considerations could be made for all sectors of direct uses; but this is not the place to deepen the point. However, an example of the methodology devised by UGI to calculate the energy balance of the Italian spa system can be found in another paper presented at this Congress (Cataldi and Conti, 2013).

The situation outlined above occurs unfortunately not only in Italy but also in many other countries of the world, so that preparing continental or global reports on geothermal direct uses always requires a demanding effort of interpretation and processing of available data, which is difficult even when the most skilled experts on direct uses are entrusted with the task. Despite such effort, national data presented for many of the almost 80 countries in the world harnessing geothermal heat for direct uses (and then also the aggregate global or continental data published in the above-said reports) generate a number of doubts that the same authors do not fail to stress (Lund et al., 2010).

To lessen this inconvenience while processing data on direct uses in Italy, three years ago UGI started a clarification work on the type of information that operators should provide to the relevant institutions. Hence, two of the points on which UGI recently focused its attention are:

a) grouping direct uses into established sectors of application, as described in para. 2.1 below;

b) allocating the thermal energy extracted from the subsoil through geothermal heat pumps (i.e. the *net energy*) to the application sectors which actually use it, and not to a separate autonomous sectors totally independent of any real utilization.

As to the latter point, it is worth recalling that grouping together geothermal heat pumps in a specific sector independent of any type of actual utilization was an almost general practice by all authors till a few years ago. In this way, heat pumps seemed to be a kind of utilization sector, rather than an electromechanical tool used to extract an additional amount of thermal energy that would otherwise remain trapped *in situ* below the Earth's surface. However, since the heat supplied by geothermal heat pumps for a given application sector is just a fraction of the total energy consumed in that sector, we have decided to include it within its own application sector, and to highlight its contribution as a share of the total energy used in the sector concerned.

Points **a)** and **b)** have already been brought by UGI to the attention of the institutions in charge of energy matters in Italy, accompanied by suggestions for their inclusion into the regulations dealing with the type of data that geothermal operators should provide to the public offices authorized to gather them. UGI hopes that both points will be accepted soon.

Concerning the years of reference, attention must be paid to the fact that, at least in Italy, data on yearly operation in the different sectors of direct uses are mostly provided by operators to the competent offices, and released by the latter to the public, two years after the end of each fiscal year. Thus, UGI decided to consider for its reports on direct uses the only data available two years before writing the relevant paper. This is why, for this country report, we will stop our analysis at the end of 2010, and will limit our remarks to the advancement made in the 5-year period Jan. 2006-Dec. 2010.

For such period, the data given in this report are taken mostly from a study published by UGI in Dec. 2011 (Buonasorte et al., 2011), on the basis of which another paper has been prepared for this Congress to depict the forecasted development of geothermal energy in Italy until 2030 (Cataldi et al.,2013).

2. DIRECT USES 2005-2010

2.1) Main groups of application

To facilitate comparisons with the data published in past years, or with those that will be published in future years, UGI decided to group direct uses in Italy in the following main sectors of utilization:

- space conditioning (heating & cooling);
- thermal balneology [3];
- agricultural uses (greenhouses, pasteurization of milk products, and other agricultural uses);
- aquaculture (fish farming and other animal breeding, and hydroponics); and
- industrial processes, plus other minor uses.

With other minor uses in the last group we mean all those uses that, though having had little or no application in Italy so far, might however find a certain development in the future, such as: snow melting and de-icing of urban roads and sidewalks, snow melting of cycle-tracks, defrosting of highways, seasoning of valuable timber, sterilization of textiles by natural steam, washing carpets with thermal water, and other possible minor uses related to industrial activities.

[2] *Net energy* is to the part of geothermal energy tapped from subsoil through GSHPs and made available for practical use.

[3] Beauty care centers or beauty farms, fitness clubs, and other facilities not using hot natural fluids are excluded.

2.2) Revision and consolidation of data at Dec. 2005

The data published for 2005 by Borghetti et al. (2005), used for reference by all Italian authors (for instance Buonasorte et al., 2007) and abroad, were revised by UGI in 2011 during its study on forecasts of geothermal development in Italy till 2030 (Buonasorte et al., 2011).
The new data reflect the different and wider use recorded in 2005 for geothermal heat pumps and spas as compared to the values published previously (Borghetti et al., 2005). Information on such wider use and different data were obtained in late 2009 and 2010, based on the details given below.

a) Geothermal heat pumps

They had reached in 2005 a total installed capacity [4] of 215 MW_t with a production of about 850 TJ/year. As a consequence, compared to 150 MW_t and 650 TJ/y estimated for 2005 by Borghetti et al. (2005), there is a positive difference of 65 MW_t and almost 200 TJ/y, respectively.

However, UGI feels that a fraction (probably a small one, but difficult to evaluate) of both higher capacity installed and energy obtained through geothermal heat pumps in 2005 may correspond in part to substitution of old thermal plants fed by natural hot fluids mostly in the field of district heating. Therefore, the difference of capacity installed and energy obtained by means of geothermal heat pumps cannot be added entirely to the total capacity (610 MW_t) and heat consumed (~7550 TJ/yr) in direct uses as indicated for 2005 by the authors cited above.

In this light, UGI estimated that the additional fraction of capacity installed and energy consumed owing to the greater development of geothermal heat pumps in 2005 may have been some 40 MW_t and no more than 50 TJ/year, respectively.

b) Thermal balneology

A study carried out by UGI in 2009 (Cataldi et al., 2010) on the mass and energy balance of Italian spas suggested that the statistics reporting the amount of natural thermal energy consumed yearly in this sector did not include the heat utilized by the over 500 thermal pools existing inside or outside the spas and used for therapeutic purposes in Italy. And since the energy in question is contained in hot waters supplied directly to the pools by wells or thermal springs, it does not involve any increase of thermal capacity installed, but results in a notable increase of thermal energy used.

As a consequence, duly taking into account the sizeable amount of water used by the over 500 thermal pools mentioned above, UGI estimated that they consumed in 2005 an aggregate amount of energy in the range of 600-650 TJ/year. This energy can be added entirely to the total heat reported by Borghetti et al. (2005) for the overall direct uses in 2005.

c) Revised figures 2005

In short, based on the new data obtained for geothermal heat pumps and thermal balneology as said in points ***a)*** and ***b)*** above, UGI estimated that in 2005 we had in Italy higher values of installed capacity for some 40 MW_t (attributable to additional heat pumps alone), and of energy consumed by direct uses for 650 TJ/year approx. (due mostly to thermal pools and subordinately to the additional capacity of heat pumps said before).
As a result of the above, the updated totals of direct uses in 2005 are those shown in the last two lines of Table 1, i.e.: 650 MW_t of capacity installed, and 8200 TJ/year of heat used. Out of these totals, 215 MW_t of capacity installed, and 850TJ/year of heat consumed are owed to geothermal heat pumps. Table 1 also shows the totals of heat consumption estimated by UGI for each utilization sector of direct uses, accompanied by the respective fraction of energy produced by geothermal heat pumps.

The following can be noted from this table:
- thermal balneology was by far the first sector in 2005, followed at notable distance by space heating & cooling;
- the latter, however (ranking 3rd after fish farming in previous years), had experienced a rather fast growth between 2000 and 2005;
- geothermal heat pumps, which had grown very slowly in the 990s till the first years of this century, started to grow rapidly between 2003 and 2005, mainly in the sector of air conditioning;
- the above-said pumps, however, with 33% of total capacity (215 vs. 650 MW_t), contributed as little as 10% to the total in terms of geothermal energy used (850 vs. 8200 TJ/y).

2.3) Revision and consolidation of data at Dec. 2010

The situation discussed for 2005 in points ***a)*** and ***b)*** of paragraph 2.2) explains why UGI had to revise also the data predicted in previous years for the growth of direct uses in 2010 (Barbier et al., 2006, and Buonasorte et al., 2010), published by UGI members on behalf of UGI between 2006 and early 2010. The new situation for 2010 reconstructed very recently is as follows.

a) Geothermal heat pumps

The total installed capacity of heat pumps amounted in 2010 to 500 MW_t, and not to 260 MW_t, as previously published. Therefore, an additional amount of about 600 TJ/year of energy was used in 2010 (see page 48 of Buonasorte et al., 2011).

b) Thermal balneology

According to the estimation published in the same paper quoted above, the heat utilized in 2010 by the over 500 thermal pools operated in Italy for therapeutic use was estimated to be in the range of 1000 TJ/year.

[4] Currently, no actual information about rating conditions of heat pump capacity is available. The values evaluated by UGI are related to the nominal size used as reference by traders. This may cause ambiguity because while thermal capacity is referred to the condenser, the consumption of energy refers to the geothermal fraction tapped from an underground source through the evaporator. As mentioned elsewhere in this paper (Chapters 1 and 7), UGI is already working on a methodology for collecting and analyzing data on geothermal heat pumps.

However, as said for 2005, also in this case such additional energy does not involve any increase of installed thermal capacity, because the hot water from thermal springs or deep wells directly supplies the pools in question, without help by intermediate thermal equipment.

Table 1: Direct uses in Italy 2005 according to data revised by UGI

Sector of application	(a)Total thermal energy consumed (TJ/year)	(b)Fraction of (a) obtained by GHPs (TJ/year)
Space heating & cooling	2100 (26%)	700 (82%)
Thermal balneology	3400 (41%)	//
Agricultural uses (greenhouses, etc.)	1140 (14%)	100 (12%)
Aquaculture [5]	1360 (17%)	//
Industrial processes and other	200 (2%)	50 (6%)
Total energy (TJ/year)	**8200 (100%)**	**850 (100%)**
Total installed capacity, (MW_t)	**650**	**215**

c) Revised figures 2010

As a consequence of points ***a)*** and ***b)*** above, the forecasts made by Buonasorte et al. (2010) for direct uses 2010 (i.e. some 930 MW_t and 11,000 TJ/year) must be increased by approx. 70 MW_t of capacity and 1600 TJ/y of energy.

To conclude, the updated figures for the situation in 2010 are: 1000 MW_t of total capacity installed (out of which 500 MW_t of heat pumps), and 12,600 TJ/year of total energy consumed (of which 1700 TJ/y attributable to heat pumps). Such figures are shown in Table 2, with details on each of the five main utilization sectors considered. The figures given in Table 2 enable us to make the following remarks:

* space heating & cooling, which ranked second after thermal balneology in 2005 with 2100 TJ/yr, grew at fast paces from Jan. 2006 to Dec. 2010, resulting in an average growth rate of over 17% per year. Thus, this sector became in 2010 the first sector after thermal balneology;
* aquaculture, mostly thanks to fish farming, was in 2010 the third sector, at notable distance, though, from thermal balneology, and slightly above agricultural uses, fourth;

[5] For aquaculture too, just as for balneology, both thermal capacity and energy consumption are related to the temperature drop between the inlet and outlet temperature of pools or ponds. Capacity (MW_t) depends on the maximum flow rate of water that can be supplied by wells or springs. Energy consumption (TJ/y) depends on the total volume of water used during a given year. In the publication by Buonasorte et al. (2011), and thus also in this paper, the inlet temperature level is taken to be that of the average outlet temperature of the feeding water at well head or spring mouth. On the contrary, for the outlet temperature, we have assumed that the water remains in the relevant pool or pond for a relative long span of time, so that it is possible to approximate its outlet temperature with the average annual air temperature of the site concerned (for Italy, in general, such average annual temperature is 15 °C).

* industrial uses remained the least developed sector in absolute terms. However, their annual growth rate during the 5-year period 2005-2010 was important: over 12%/yr, as can be seen by comparing figures in Tables 1 and 2;

Table 2: Summary of direct uses in Italy 2010, according to data revised by UGI

Sector of application	(a)Total thermal energy consumed (TJ/year)	b)Fraction of (a) obtained by GHPs (TJ/year)
Space heating & cooling	4750 (38%)	1450 (85%)
Thermal balneology	4200 (33%)	//
Agricultural uses (greenhouses, etc.)	1500 (12%)	150 (9%)
Aquaculture [6]	1800 (14%)	//
Industrial processes and other	350 (3%)	100 (6%)
Total energy (TJ/year)	**12,600 (100%)**	**1700 (100%)**
Total installed capacity, (MW_t)	**1000**	**500**

* in the period under review geothermal heat pumps more than doubled their contribution to space heating & cooling. Nonetheless, their share of total energy in other sectors remained poor or null (see comparative Tables 1 and 2);
* on the other hand, the above-said pumps, with 50% of total capacity installed (500/1000 MW_t), contributed little to the total energy used by all direct applications (1700 vs. 12,600 TJ/y, which corresponds to 13.5% only of the total).

3. COMPARATIVE DEVELOPMENT OF DIRECT USES 2005-2010

Comparative data 2005-2010 (taken from Tables 1 and 2, respectively) are summarized in Table 3 and Figures 1-2 for each sector of utilization, in terms of both energy used and share of the total. Table 3 and Figures 1-2 also show the contribution of heat pumps in each sector.

In addition to the specific remarks made in previous paragraph for the situation of direct uses at the end of 2005 and 2010, Table 3 and Figures 1-2 allow us to make the following summary considerations for the 5-year period Jan. 2006-Dec. 2010:

* total increase of direct uses in the period in question reached the notable average annual growth rate of 9%, both in terms of capacity installed (from 650 to 1000 MW_t) and energy utilized (from 8200 to 12,600 TJ/y);
* space heating & cooling became the first utilization sector of direct uses, growing from 26 % in 2005 to 38% in 2010 of the total energy used;
* all other sectors too increased in absolute terms in the 5-year period Jan. 2006-Dec. 2010. Nonetheless, with the only exception of industrial processes with the only exception of industrial processes (which were not very significant due to their small development level), the growth rates of the three other sectors ranged between 4 and 6% per year;

[6] Same specifications as in footnote 5.

* geothermal heat pumps doubled in terms of heat used (from 850 to 1700 TJ/y) and more than doubled (from 215 to 500 MW_t) in terms of capacity installed, with average growth rates of 15 and over 18%/y, respectively.
However, considering that heat pumps were still in the early development stage in 2005, such notable growth rates (especially in terms of installed capacity) should not be taken as significant indicators of their market growth after 2010;
* in the period under review, heat pumps were employed in three sectors only of direct uses: space heating & cooling, agricultural applications, and aquaculture, with shares in the range of 85, 9 and 6 % respectively of the 1700 TJ/year of total energy supplied by them in 2010.

Table 3: Geothermal heat used in Italy for direct applications in 2005 and 2010

Year	***2005***		***2010***	
Categories of utilization	**(a)** Final energy consumption (TJ/year)	**(b)** Fraction of **(a)** obtained by GHPs (TJ/year)	**(c)** Final energy consumption (TJ/year)	**(d)** Fraction of **(c)** obtained by GHPs (TJ/year)
Space heating & cooling	2100 (26%)	*700 (82%)*	4750 (38%)	*1450 (85%)*
Thermal balneology	3400 (41%)	//	4200 (33%)	//
Agricultural uses: greenhouses & other	1140 (14%)	*100 (12%)*	1500 (12%)	*150 (9%)*
Fish farming	1360 (17%)	//	1800 (14%)	//
Industrial processes & other	200 (2%)	*50 (6%)*	350 (3%)	*100 (6%)*
Total heat consumption	**8,200 (100%)**	**850 (100%)**	**12,600 (100%)**	**1,700 (100%)**
Installed capacity (MWt)	**650**	**215**	**1000**	**500**

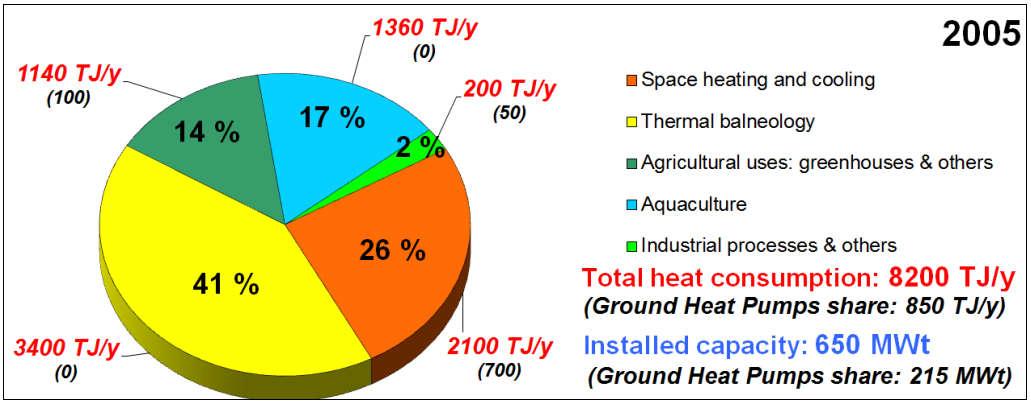

Fig. 1: Share of different utilization sectors in total heat used for direct applications in 2005

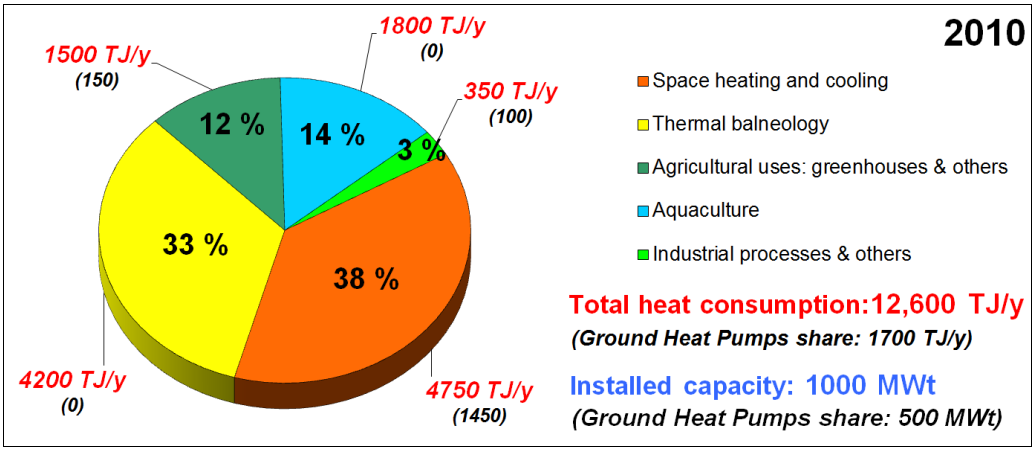

Fig. 2: Share of different utilization sectors in total heat used for direct applications in 2010

Regarding differential increase occurred between the different sectors of direct uses from Jan. 2006 through Dec. 2010, reference can be made to Figure 3.

It can be seen that the two sectors with the fastest annual growth rate were in that period space heating & cooling and industrial processes (17.5% and 12.2%/yr, each), followed by aquaculture (~5.9 % /yr), agricultural uses (~ 5.7%/yr), and thermal balneology (~ 4.4 % /yr).

Finally, though evaluation of capacity factor for each specific sector is impossible with the data available at present, it should be stressed that the overall average capacity factor of direct uses was around 40 % both in 2005 and 2010.

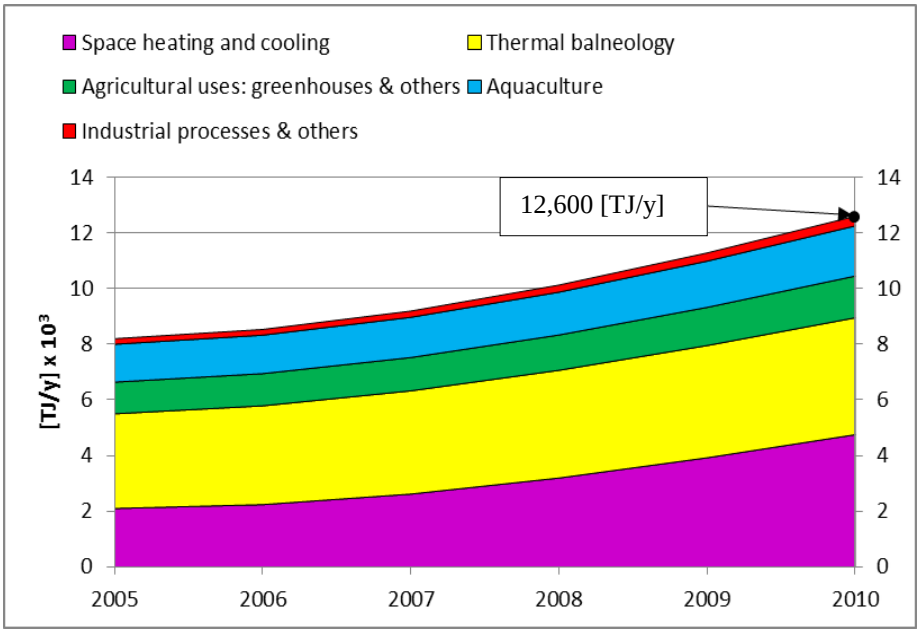

Fig. 3: Development 2005-2010 of the different sectors of direct uses in Italy

4. REGIONAL DISTRIBUTION OF DIRECT USES AT DEC. 2005 AND DEC. 2010

Figures 4 and 5 clearly show that, out of the twenty Italian administrative Regions, Veneto, Tuscany and Campania are the three main Regions using terrestrial heat, amounting together to almost three fourths of the total in 2005, and to two thirds in 2010.

However, the other seventeen Regions evidence aggregately a rising trend (from 28 to 34 % of the total in the 5-year period under review), mostly owing to district heating.

This points to the fact that the direct use of the Earth's heat is slowly taking root in many new places in Italy, mainly in the sector of air conditioning.

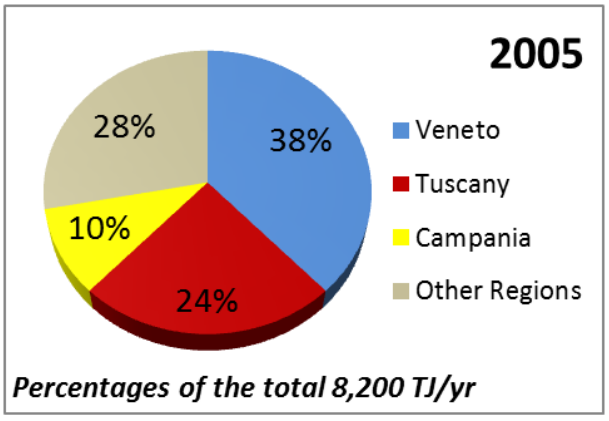

Fig. 4: Regional distribution of direct uses in 2005

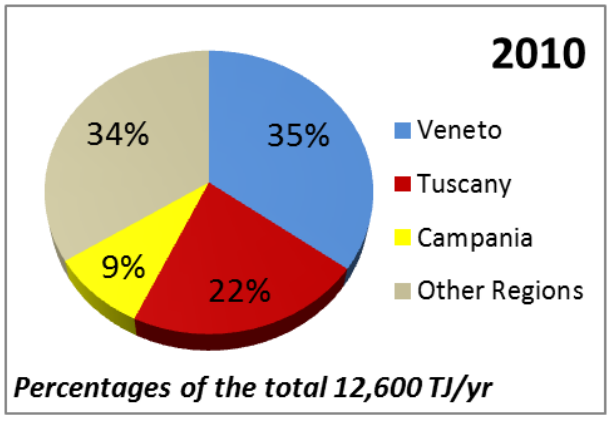

Fig. 5: Regional distribution of direct uses in 2010

5. MAIN SECTORAL PROJECTS OF DIRECT USES

In a concise report like this, a detailed list of all projects cannot be given; therefore, we will limit ourselves to mentioning the most important projects with a few essential data.

Detailed information on each of the projects described below can be found in the relevant references quoted.

Space heating and cooling

Ferrara (Emilia-Romagna)

This is the best known example of district heating in Italy fed by geothermal energy, active since 1987. Its distribution network extended in 2010 for about 53 km, supplying heat and hot water to 780 households approx. Also a retail center of 26,000 m^3 is cooled by means of an absorption refrigerator.

The total volume of space heated & cooled in 2010 was over $5.3x10^6$ m^3. The generation system consists of: a geothermal well (water temperature ≈ 100 °C), a waste-to-energy plant, a heat recovery steam-generator and 14 back-up boilers. Thermal capacity of the water produced by the well in question is 14 MW_t, which delivers 238.3 TJ/yr of energy.

In short, thanks to the use of geothermal energy only, the project in question in 2010 saved 5.7 kTOE and avoided 18.3 ktonnes of CO_2 emitted into the atmosphere (AIRU, 2011).

Milan: Canavese and Famagosta districts (Lombardy)
A 15 MW_t groundwater heat pump (GWHP) has been in operation since 2009 as a generator for heating the Canavese district. The system utilizes a total flow rate of 300 l/s (1080 m^3/h) tapped from three shallow wells at T ~ 15 °C. The heat pump work together with three auxiliary boilers and three reciprocating gas engines used as cogenerators of heat and electricity. The latter are also used to supply energy to the compressor of the heat pump. A total volume of over $9.3x10^5$ m^3 was heated in 2010, also thanks to 15 TJ/yr provided by the GWHP. In that year 356 TOE were thus saved, corresponding to 1.15 ktonnes of avoided CO_2 emissions (Carella et al., 2012).

Moreover, in 2011, a heating system similar to that described above was inaugurated in the Famagosta district, whose project outline and initial operating data can be found in a paper presented at this same Congress by Spadoni et al.(2013).

Milan: Lombardy hall (Lombardy)
"Palazzo Lombardia" is the new headquarters of the Lombardy Region, where 3,000 people work. The heating system consists of three GWHPs and three back-up boilers. Cooling for air conditioning in summer is obtained thanks to the reversibility of such equipment. Total GWHP capacity is 3x2150 kW_t in the heating mode, and 3x4000 kW_t in the cooling mode.
The geothermal circuit is of the open loop type. A total flow rate of 320 l/s (1152 m^3/h) of water at ~14 °C is provided by eight 50-m deep wells.
The nominal COP of the whole system is about 6, whereas the seasonal COP is about 4.5 and the seasonal Energy Efficiency Ratio (EER) about 6.
In winter, heat production is estimated at 45 TJ/yr (12.6 GWh), while in summer 54 TJ/yr (15 GWh) of "cooling energy" are provided for air conditioning.
In the heating mode, the system saves 1 kTOE and 3.5 ktonnes of CO_2 (Porro and Piemonte, 2012 and 2013).

Boraciferous Region (Tuscany)

- Projects in operation: Municipalities of Castelnuovo V.C., Monterotondo M.mo and Pomarance.

In the Larderello and surrounding areas of Tuscany, where most of geothermal power generation is concentrated, direct use of geothermal heat is very widespread. In the three Municipalities in question, 12 district heating networks and 32 individual heating systems exist, supplied by heat exchangers fed with natural steam from Enel Green Power' deep wells.

About 4750 users and a volume of 1.42 million cubic meters of urban flats are served by a total installed thermal capacity of 42.5 MW_t with 257 TJ/yr of thermal energy consumed. In this way, 6.1 kTOE/y and 19.7 ktonnes of CO_2/yr are saved.

- Projects under construction: Municipalities of Chiusdino, Monteverdi M.mo, Montieri and Radicondoli. Also these projects are based on the use of natural steam from Enel Green Power' deep wells.

Due for completion within a couple of years or so, they will provide heat to over 1700 users, saving 3.2 kTOE/yr of primary energy and 8.8 ktonnes of CO_2/y.

- Projects envisaged: Municipalities of Massa M.ma and Volterra

They are at present at the level of pre-feasibility study, investigating two main alternatives of heat supply: from natural hot water tapped from shallow aquifers (possibly integrated with heat provided by geothermal heat pumps), or from natural steam supplied by deep wells located some kilometers away from the respective towns.

- *Monte Amiata region (Tuscany):* Municipality of Santa Fiora

This is the most important district heating system fed by geothermal energy in southern Tuscany, with a total installed capacity of 15 MWt. Some 97.1 TJ/y of thermal energy are provided by the system to heat 240,000 m^3 of buildings and meet the heating needs of about 800 users. Over 2.3 kTOE were saved in 2010, with 7.5 ktonnes of displaced CO_2 emissions.
Detailed and recent information on the geothermal heating systems mentioned above for the Boraciferous and Mt. Amiata regions can be found in the papers by Burgassi A. (2012), Nati (2011), and Parri (2011).

Thermal balneology
There are almost 150 active spas in Italy, but the most frequently attended ones are located in four Regions only: Veneto, Tuscany, Latium, and Campania, from North to South.
An overall analysis of Italian spa systems, including the related water and energy balance at regional level, can be found in Cataldi and Conti (2013); but for the purposes of this paper a few data on each of the four main Italian spa systems are given below.

Euganean district (Veneto): Municipalities of Abano, Galzignano, Montegrotto and Teolo
The energy consumed in this district represents the major fraction of the Earth's heat used in the whole Italian spa system. The volume of hot water used in the Veneto Region (~ $35x10^6$ m^3 of prevailingly natural hot water produced in 2010 by many tens of deep wells at a temperature of 38-74 °C) represents in fact more than one third of the total volume of hot water used for thermal balneology in Italy. Of the above-said volume, at least 80% is attributable to the spas of the Euganean district alone where about 1600 TJ/yr were consumed in 2010. This energy corresponds to some 76 kTOE saved and about 240 ktonnes of avoided CO_2 emissions.

Montecatini Terme (Tuscany)
This spa system represents over 40% of the energy consumed by the balneological sector of Tuscany.
Over $6x10^6$ m^3 of water with an average temperature of 30 °C were used in 2010.
The share of geothermal energy consumed in this system is around 53 TJ/yr, corresponding to about 8 kTOE of primary energy saved and 27 ktonnes of CO_2 emissions avoided.

Terme dei Papi (Latium)
Due to their historical interest and modern refurbishment, this spa (with water at T = 49-58 °C) is visited by over one million people/yr, using together over $6x10^6$ m^3/yr.
This corresponds to some 260 TJ/yr, resulting in more than 14 kTOE/yr of primary energy saved and about 46 ktonnes of CO_2/yr displaced.

Ischia (Campania)
The spas of this island represent the majority of the whole balneological sector in southern Italy. Over $8x10^6$ m^3 of hot water at T = 45-100 °C (with an average of ~70 °C), produced by more or less deep wells, were in fact used in 2010 by its over 80 cure stations.
This value corresponds to some 400 TJ/yr of energy consumed in 2010, saving 17 kTOE and displacing 53 ktonnes of CO_2 approx.

Agricultural uses (greenhouses)
Piancastagnaio (Tuscany)
Owned by Floramiata Co. and heated by geothermal energy, these facilities extend over 230,000 m^2. Their core-business is based on tropical ornamental plants, grown in a wet environment at T = 25-30 °C. Such temperature value was assured until July 2011 by natural steam exhausted by Enel's Piancastagnaio 2 power plant; afterwards, as a result of the modernization made by Enel Green Power of the whole Piancastagnaio geothermal power generation system, the heating method of the greenhouses in question was modified. Therefore, at present, a minimum quantity of steam is spilled from the collector of the Piancastagnaio 3 power plant, and (by means of a heat exchanger located near the greenhouses) the same temperature of 25-30 °C is obtained.
The thermal capacity installed at Dec. 2010 was about 35 MW_t, providing the greenhouses with 391,5 TJ/y of thermal energy. This made it possible to save 9.35 kTOE/y, with 30.1 ktonnes of avoided CO_2 (Parri, 2011).

Radicondoli (Tuscany)
Three geothermally-heated greenhouses owned by the "Parvus Flos" cooperative exist in the territory of this municipality, which are used to produce mostly selected vegetables (basil and other), with subordinate flowers.
Instead of traditional boilers, the heating system uses a heat exchanger supplied by steam from one of Enel Green Power's pipelines. In 2010, a heat exchanger with a nominal capacity of 2 MW_t provided the greenhouses with around 31.5 TJ/yr of thermal energy, saving some 0.75 kTOE and displacing 2.4 tonnes of CO_2 emissions.
The use of geothermal energy in a rather cold climatic area (as the territory in question is) resulted in a notable reduction of production costs (Rosetti and Ferri, 2009).

Industrial processes
Larderello (Tuscany)
The major direct application project in this sector is the one developed by *Società Chimica Larderello*, a company specialized in the production of boric products.
Steam spilled from the gathering system of the Larderello 3 power plant is passed through appropriate heat exchangers in order to keep a constant temperature in the pipelines carrying the products to the factory, and in the silos where boric compounds are stored.
At Dec. 2010, a total capacity of 9.9 MW_t was installed, with 96.5 TJ/yr of thermal energy consumed. This corresponds to 2.3 kTOE/y saved, and to 7.4 ktonnes of CO_2 avoided (Chiacchella, 2009).

6. FORECASTS 2010-2015

The increase in direct uses envisaged by Dec. 2015, together with their respective savings in terms of oil consumed and emissions of CO_2 avoided, are summarized in Table 4 under two different growth Scenarios.
Detailed information on the future geothermal growth in Italy, with projections by 5-year periods until 2030 and relevant comments can be found in another paper presented at this Congress (Cataldi et al., 2013).

Table 4: Forecast development of direct uses in Italy by 2015, including energy produced by means of heat pumps

Year	*2010*	*2015*
SCENARIO I		
Installed capacity *(MW_t)*	1000	1560
Gross geothermal energy *(TJ/y)*	12,600	17,930
Oil saved (*kTOE/y)*	300	430
Avoided CO_2 emissions *(kTonnes/y)*	800	1120
SCENARIO II		
Installed capacity *(MW_t)*	1000	1630
Gross geothermal energy *(TJ/y)*	12,600	19,040
Oil saved (*kTOE/y)*	300	460
Avoided CO_2 emissions *(kTonnes/y)*	800	1200

7. CONCLUDING REMARKS AND PROPOSAL

The international geothermal community is invited to consider the following final remarks that UGI presents here in view of improving the compilation of future country reports on direct uses. In fact, the information related to direct utilization of geothermal energy has so far been rather inhomogeneous and not sufficient at all to formulate sure statistics. Moreover, evaluation of the accuracy of such statistics is hard to make for everybody because the elements needed to determine the uncertainty of the data given in each report most of the times do not exist.
In short, not only in Italy, but also in many other countries of the world, the experts entrusted with the task of processing national or global figures on direct uses have been obliged to offset the incompleteness and inhomogeneity of data with their best personal estimations.
This means that, even though we recognize and commend the effort made till now by many authors to address such inconveniences, most of the data published so far on direct uses (including those published by UGI, of course) cannot be taken as firm references.

As said in section 1 of this paper, UGI has been working for some years to improve the gathering of operating data and the processing of the relevant figures in each sector of direct uses in Italy. The work carried out so far in this field consists of two blocks of activity: the first, to systematically collect and revise operating data every two years approx.; and the second, to develop an appropriate methodology to process the data available in each application sector of direct uses. Each sector, in fact, owing to its particular utilization conditions, needs its own processing approach.
At the end of this work (not before 4-5 from now, we suppose) we hope to obtain more homogeneous and comparable statistics on direct uses in Italy.

On the other hand, we feel that the same methodological problems and difficulty in data processing exist in any country of the world where geothermal energy is used for direct applications. As a consequence, we think that, to speed up the achievement of the common objective to get comparable data and reliable statistics on direct uses, a coordinated effort should be made at the world scale.

In this light, UGI hopes that the international geothermal community will promote the setting-up of an *ad hoc* working group on the methodological approach for collecting and processing data on direct uses, under the IGA umbrella as soon as possible.
To this end, UGI is available to give its contribution.

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APPENDIX

During the editing period of the congress , the organizing committee requested to the authors an integration of the data presented in the paper. Table A.1 was added according to the availability of information. The table refers to geothermal district heating plants operating in Italy in 2010. The values in Table A.1 represent a breakdown of the data presented in Table 2 and Table 3.

Table A.1. Geothermal district heating (DH) operating in Italy in 2010.

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	Geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Castelnuovo V.C. (PI)[1]		1986			7.3	7.3	23.1	100 %
Sasso Pisano (Castelnuovo V.C.,PI)[1]		1996			2.3	2.3	5.9	100 %
Montecastelli Pisano (Castelnuovo V.C. ,PI) [1]		2010			2.9	2.9	1.4	100 %
Monterotondo M.mo (GR) [1]		1994			2.3	2.3	9.7	100 %
Larderello (Pomarance, PI) [1]		1988			0.7	0.7	1.2	100 %
Lustignano (Pomarance, PI) [1]		1996			0.7	0.7	1.0	100 %
Montecerboli (Pomarance, PI) [1]		1995			3.5	3.5	6.6	100 %
Pomarance (PI) [1]		2003			11.6	11.6	13.2	100 %
San Dalmazio (Pomarance, PI) [1]		1999			0.7	0.7	1.1	100 %
Serrazzano (Pomarance, PI) [1]		1996			2.0	2.0	3.3	100 %
Pomarance (PI) [1]					3.3	3.3	2.6	100 %
Pomarance (PI) [1]							0.7	100 %
Santa Fiora (GR) [1]		2005			15.1	15.1	27.0	100 %
Ferrara[2]		1987		YES	14.0	154.5	66.2	35.1 %
Morbegno (SO) [2]		2006			2.8/3.7	31.7	1.8 / 2.4	3.6% / 5%
Bagno di Romagna (FC)[3]		1983			1.4/1.6	7.6	1.9 / 2.2	28% / 32%
Milano[2,4]	Canavese	2007 (GeoDH since 2010)			10.0/15.0	73.2	2.5 / 4.1	6% / 10%
Total					**80.7/86.8**	**319,4**	**167.3 / 169,8**	

Note: When GSHPs feed the DH, two value of thermal power and thermal energy are presented in the table: the first one refers to the evaporator, while the second one refers to the condenser; (evaporator / condenser).

Data courtesy of: [1]Enel Green Power, [2]AIRU, [3]Soggetel, [4]A2A Calore & Servizi