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Status of Geothermal Energy Use and Resources in Europe

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ABSTRACT

The European status of geothermal energy use is presented. The situation varies from country to country according to the geothermal technology that best suits the available natural resource. The spectrum varies from power generation from high enthalpy resources (Iceland, Italy, Greece, Turkey), to direct use of hydrothermal resources in sedimentary basins (France, Germany, Poland, Italy, Hungary, Romania, and others). Shallow geothermal is available everywhere and is mostly harnessed by ground source heat pump installations.

Geothermal power generation in Europe currently stands at 1060 MW installed capacity, surpassing fast the target of 1000 MW set forth for 2010 by the White Paper from 1997 (Eurobserv'ER, 2005). The target value of 2000 MW for 2010 from the Ferrara Declaration (EGEC, 1999) seems not out of reach.

Geothermal heating from medium to low temperature source installed capacity exceeds 6600 MW_t and has a increasing trend of about 50 MW_t per year. This growth rate could lead to a doubling of the forecast capacity of 5000 MW_t by 2010 set forth by the White Paper (Eurobserv'ER, 2005).

Shallow geothermal energy, ground source heat pumps (GSHP), installation growth rate is even more spectacular, and a capacity of 8000 MW_t could be reached if 10% growth per year is maintained (Rybach, 2006).

Summing up, geothermal energy scored well in Europe and has an enormous potential. For the heating sector, the deep and shallow energy production combined is bound for exceeding even the ambitious target of 15000 MW_t set forth in the Ferrara Declaration (EGEC, 1999).

1. INTRODUCTION

Geothermal Energy is energy stored in the form of heat beneath the surface of the solid earth. This definition became official in Germany (VDI 4640) and it has been adopted by the European Geothermal Energy Council (EGEC).

Geothermal energy has been used for many centuries in Roman and Ottoman baths, for district heating in France during the Middle Ages, and for extracting various borate compounds at Lardarello, Italy, starting in the 1700s. More recently, extensive direct heat utilization projects have been undertaken in many European countries, and electric power developed extensively in Italy and Iceland. Geothermal heat pumps became extensively used in Austria, Switzerland, Germany and Sweden.

Geothermal energy can be reclaimed in two different ways: in the form of electricity and the form of heat. Each type of utilisation is distinguished by different technologies and applications.

Europe has significant geothermal resources both in volcanic and sedimentary basin evironment (fig. 1). The distribution of geothermal heat flux (fig. 2) matches mainly that picture, and also outlines the main macrotectonic features of the continent.

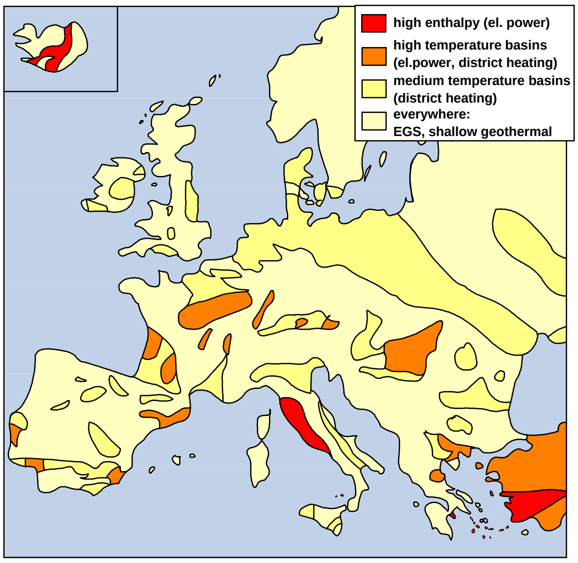

Figure 1: Main basins and geothermal resources of Europe

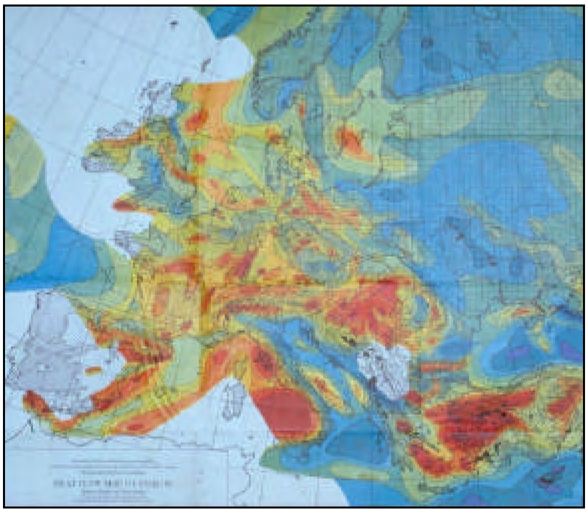

Figure 2: Geothermal heat flow density map of Europe, from Cermak & Rybach (1979)

According to a study carried out by SHELL that investigates the temperatures at 5000 m depth (fig. 3) it can be observed that on the whole territory of the continental Europe there are favourable temperature anomalies, especially throughout the large basins.

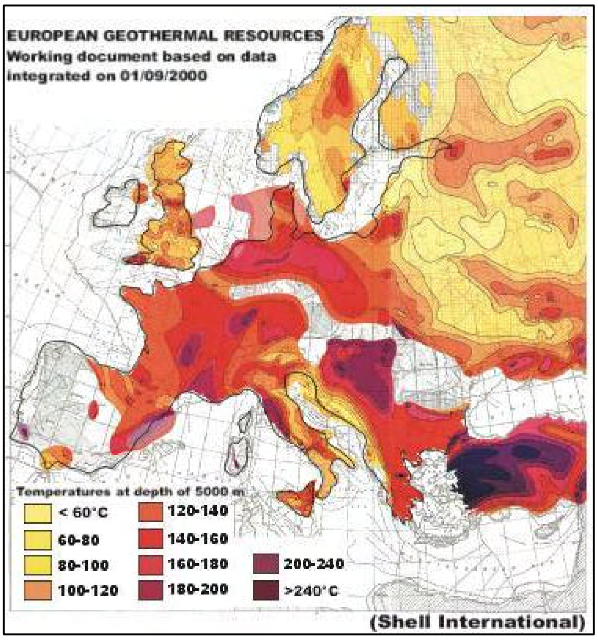

Figure 3: Temperature distribution at 5000 m depth (source SHELL)

The Scientific Committee of EGC2007 launched, in early January 2007, a request to the representatives of European Geothermal Organisations to supply the most recent data on the status of geothermal development of their respective countries. A total of 10 country review papers were received at the date of compiling the present paper.

To bridge the gap, other data from Eurostat, from the World Geothermal Congress(WGC 2005), the European Heat Pumps Association (EHPA; sales figures), the European Geothermal Energy Council (EGEC) and Eurobserv'ER were used. An excellent summary with respect to geothermal heating and cooling is presented in the Deliverable 2 report of the K4RES-H project.

We distinguish the geothermal heating and cooling production with heat pumps from the other direct heat use applications. In some statistics geothermal energy is limited to the deep applications only, excluding heat pumps. The classification of Renewable Energy sources preferred by EGEC is shown in fig. 4.

2. THE EUROPEAN ENERGY CONTEXT

The EU is the world's largest energy importer, relying on imports for 50% of its energy needs. With an energy demand forecast likely to grow by 1-2 % a year, that figure will over the coming 20-30 years rise to 70%. Yet Europe's energy needs are growing slowly relative to other parts of the world, so it must increasingly compete for energy resources.

Climate change has pushed renewable energy up the agenda too, and Europe is investing particularly in wind and solar energy and also biofuels. Europe is the main driver behind efforts to establish a global carbon market, with its pioneer EU emissions trading Scheme, although it suffered a severe credibility blow when the carbon price plummeted last year because member states had negotiated greater emissions allowances than those needed by their industries.

On climate change, the EU is committed by the Kyoto protocol, to reducing greenhouse gas emissions by 8% below the 1990 level in 2008 -2012. Its emissions trading scheme is the key measure, but others include an energy efficiency action plan which aims at a 20% energy consumption cut by 2020, with cost savings of € 200-€1,000 for an average household and reducing CO_2

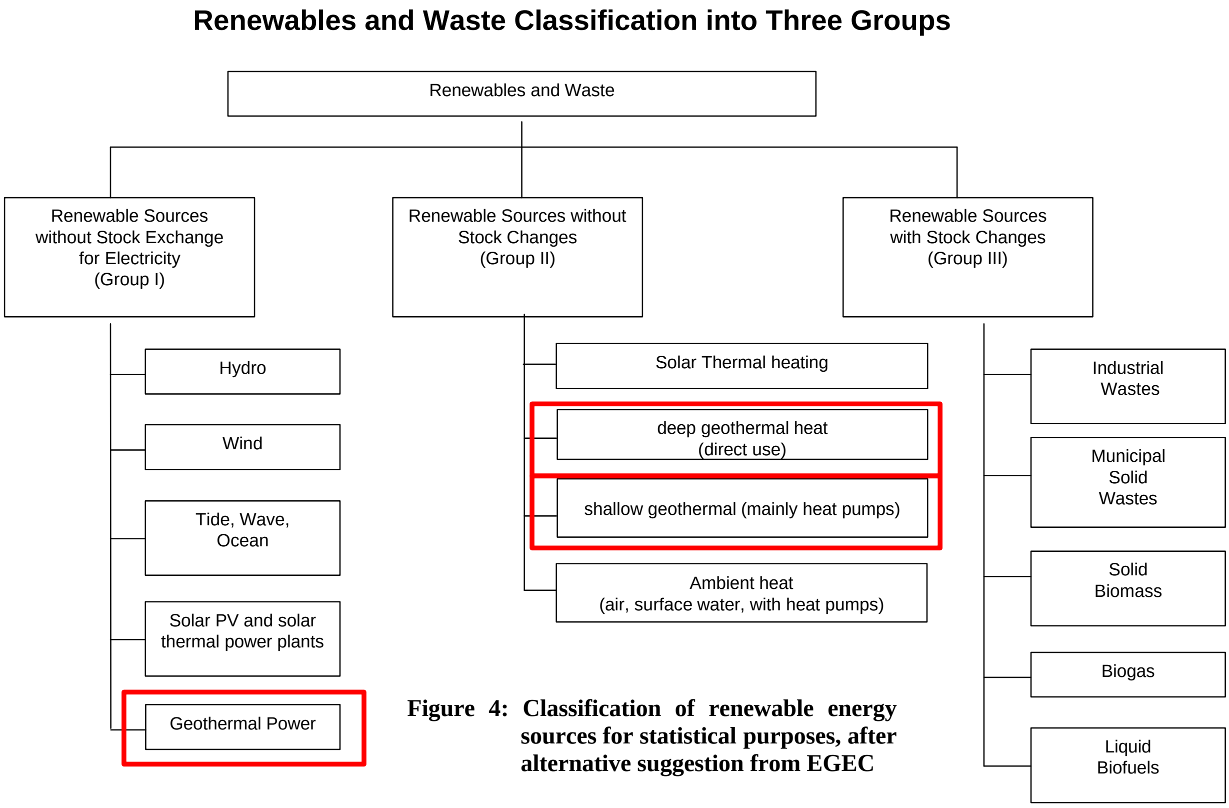

Figure 4: Classification of renewable energy sources for statistical purposes, after alternative suggestion from EGEC

emissions by 780 Mtonnes. And the Renewables Directive, introduced in 2001, aims to double the share of renewables in electric power production from 6% to 12% by 2010. The Energy Review also calls for a 20% cut in emissions by 2020, which the EU would increase to 30% would other developed countries signed up to do the same.

The Commission's comprehensive energy package at the start of this year included a "road map" on renewables, with a target of reaching 20% by 2020. The EU's energy strategy is being driven by three imperatives – to ensure security of supply, to ensure competitive energy prices for european business and to reduce the climate change impacts of its energy use. Its central aim is therefore to create a genuine single energy market, and to integrate many of its near neighbors into it (Europe's World, 2007).

3. GEOTHERMAL POWER PRODUCTION STATUS

In some regions of Europe geothermal power plants already substantially contributes to an environmentally friendly and sustainable energy supply, using existing technologies of exploiting steam and hot water reservoirs. This is done mainly in Italy, and on the Azores and other islands of volcanic origin in Europe including, last but not least, Iceland. In Iceland, geothermal energy will be one of the two pillars upon which a fully Renewable Energy supply will be built. In South-East Europe, Turkey and the Caucasian region further huge, yet unexploited, reservoirs may contribute to a sustainable energy supply.

Geothermal power in Europe is provided mostly by Italy (5200 GWh/yr), followed by Iceland (1500 GWh/yr). The status of geothermal power production is presented in table 1. Distribution of installed capacities is given in fig. 5.

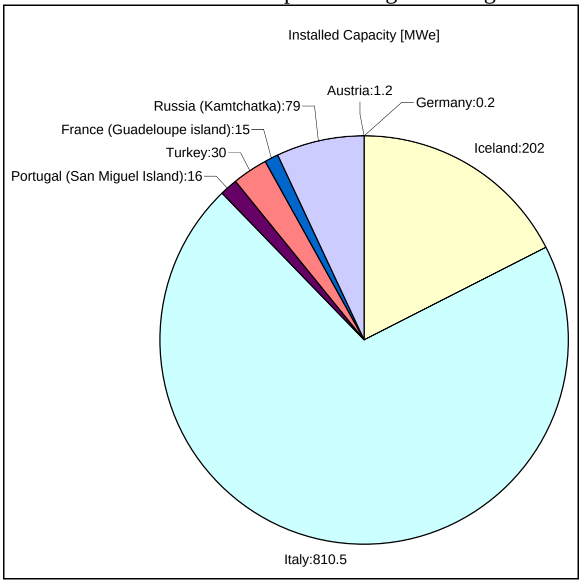

Figure 5: Distribution of installed geothermal power capacities

Table 1: Geothermal power production in Europe (from Bertani 2005, Rybach 2006) updated with available data May 2007

Country	Installed Capacity [MWe]	Running Capacity [MWe]	Annual Energy Produced [GWh/y]	Number of Units	% of National Capacity	% of National Energy	2007 DATA
Austria	1.2	1.1	3.2	2	Negligible	Negligible	
Germany	0.2	0.2	1.5	1	Negligible	Negligible	
Iceland	202	202	1483	19	13.7	17.2	
Italy	810.5	711	5200	32	1.0	1.9	X
Portugal (San Miguel Island)	16	13	90	5	25*	n/a*	
Turkey	30	30	108	2	Negligible	Negligible	X
Total in Europe proper	**1059.9**	**957.3**	**6885.7**	61	-	-	
France (Guadeloupe island)	15	15	102	2	9*	n/a*	
Russia (Kamtchatka)	79	79	85	11	Negligible	Negligible	X
GRAND TOTAL	**1153.9**	**1051.3**	**7072.7**	**74**	-	-	

*) Local capacity (Azores islands, Guadeloupe)

Austria has two power plants using binary technology, one at Blumau (0.2 MWe started up in 2001) and the other at Altheim (1 MWe started up in 2002; this plant uses condenser cooling from river water).

In *Germany*, geothermal power generation is done through the use of binary cycle technology. Since November 2003, a ca. 0,2 MWe pilot power plant using this process is exploited at Neustadt-Glewe and another twenty megawatts (4 or 5 power plants) is currently in the planning and construction stage, chiefly in Southern Bavaria. The most advanced project is that of Unterhaching. This small city, located to the southwest of Munich, has a 122°C hot water deposit at a depth of 3446 meters depth with a mean flow rate of 150 l/s. The considered system consists of a 41 MW_t combined heat and power (CHP) plant that could be able to develop an electrical capacity of 3.5 to 4 MWe (Eurobserv'ER, 2005).

Geothermal electricity production in *Iceland* has increased significantly since 1999, with the installation of new plants in Svartsengi, Krafla and Nesjavellir, up to the present value of 202 MW. An additional 30 MW single flash unit at Nesjavellir is at an advanced stage of construction (Ragnarsson, 2005; Gunnlaugsson, 2003).

Italy, which celebrated in 2004 the centenary of its first geothermal installation (Larderello in 1904), hosts the two main high temperature geothermal deposits in Europe (810.5 MWe out of 1059.9 MWe). Italy's geothermal installations are concentrated around three sites: Larderello (563 MWe), Travele-Radicondoli (160 MWe) and Monte Amiata (88 MWe). Italy installed 10 new power plants over the last five years with a total capacity of 264 MW (Eurobserv'ER, 2005 and Buonasorte et al, 2007).

In *Portugal*, exploitation of geothermal energy to produce electricity has been developed on the volcanic archipelago of the Azores, or more precisely on the Sao Miguel Island. This island has five geothermal power plants achieving a total capacity of 16 MWe, one on the Pico Vermelho site (3 MWe) and 4 binary cycle power plants on the Ribeira Grande site (13 MWe). These power plants supply 25% of Sao Miguel's needs in electricity. A new 10 MW power plant is currently under construction. It will replace the old Pico Vermelho power plant soon. A high temperature geothermal field has also been identified on Terceira Island. A drilling programme has been set up with the view of installing 12 MWe to supply 50% of the island's needs (Eurobserv'ER, 2005).

The electricity generation in *Turkey* has been increased to 30 MWe with the addition of the Aydin-Salavatli binary cycle geothermal power plant, adding a 10 MWe installed capacity to the existing Kizildere geothermal power plant (20 MWe installed capacity) (Mertoglu et al, 2007).

France started up its second geothermal power plant in 2004 on the Bouillante site, i.e. an additional 10 MW (14.7 MWe in total), that could produce an additional 72 GWh per year. Furthermore, the Bouillante 3 feasibility study, launched in 2003, could result in a third power plant with more than 10 MWe capacity. In metropolitan France, the experimental Soulz-sous-Forêt deep geothermal energy programme continues. The first phase of the project (1999-2004) that consisted in constructing a high-depth heat exchanger (well drillings, stimulation) was accomplished as scheduled. The second phase of the project (2004-2007) should permit construction of a 5 to 6 MW pilot unit. Would tests prove conclusive, a 25 MW industrial prototype could be built in 2010 (Eurobserv'ER, 2005).

In *Russia*, geothermal power production is located in the Kamchatka Peninsula and Kuril Islands. At present, three stations are in operation in Kamchatka: Pauzhetka geothermal power plant (11 MWe installed capacity) and two Severo-Mutnovka geothermal power plants (12 and 50 MWe respectively). Another geothermal power plant of 100 MWe is being commissioned on the same site. Two small geothermal power plants are in operation in Kuril's Kunashir Island, and Iturup Island, with a installed capacity of 2.6 MWe and 6 MWe respectively (Svalova, 2007).

Hungary is also considering electric power production from geothermal energy. The national oil company MOL plans installations for 12-14 MWe within the next years. First well tests have been finished early in 2007 at the drilling site in Iklódbördoce (Kujbus, 2007).

4. GEOTHERMAL DIRECT USES STATUS

Heat supply from geothermal energy in Europe is primarily achieved by using hot water from deep aquifers for district heating, etc., or in a large number of small to medium shallow geothermal plants. Shallow geothermal also supports the use of solar energy for heating, through underground storage of solar heat from summertime until its use in winter, and offers many other opportunities addressing long-term thermal energy storage.

There are other direct uses of geothermal energy such as fish farming (aquaculture), greenhouse heating, crop drying and, last but not least, balneology. Balneology in many countries may have a significant, comparable to space heating, thus upgrading the geothermal input (fig. 6).

The largest geothermal district heating systems within Europe can be found in the Paris area (France), Austria, Germany, Hungary, Italy, Poland, Slovakia and Turkey. Other countries enjoy a substantial number of interesting geothermal district heating systems.

The situation of geothermal direct use is presented in table 2. This table summarises all types of utilisations. The growing awareness and popularity of geothermal (ground-source) heat pumps had the most significant impact on the data.

Figure 7 shows the distribution of the installed capacities according to their respective use.

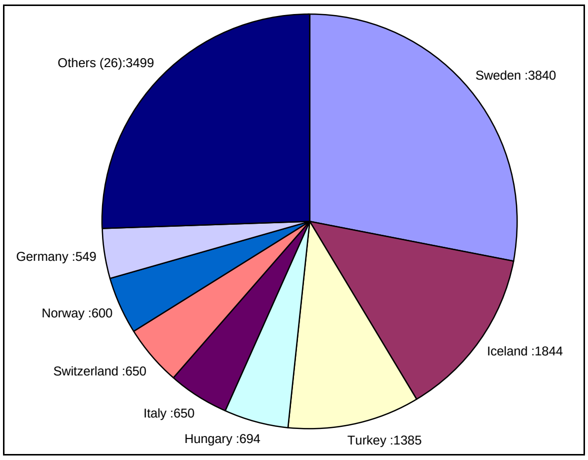

Figure 6: Geothermal direct use capacity distribution in Europe (MW_t).

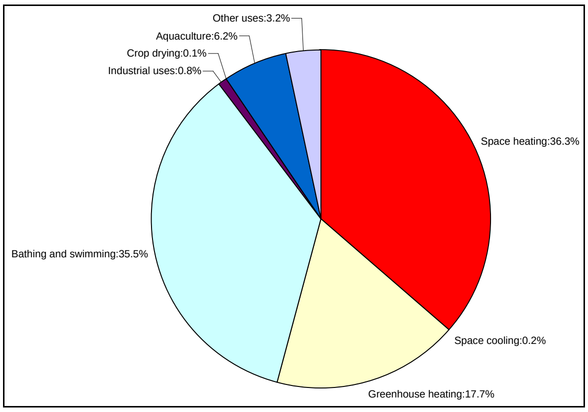

Figure 7: Distribution of geothermal energy direct use

Short summary of direct use country wise provided by the available country updates:

Albania: The paper represents a summary of the important geothermal fields: Kruja, Ardenica and Peshkopia. The paper reveals that there are many thermal springs and wells of low enthalpy, with temperatures up to 65.5°C, in the country (Frasheri, 2007). Many abandoned oil and gas wells are being investigated for geothermal direct heat use. Thus, there are many possibilities for direct-use, especially for hotel and spa heating to develop the tourist industry. Five locations are reported using geothermal waters for bathing and balneology with a combined installed capacity of 9.6 MWt and an annual energy use of 8.5 TJ.

Germany: At present, 140 geothermal installations for direct use of geothermal energy are operating in Germany.

The installed capacity of these plants amounts to roughly 177 MW_t. The installations comprise centralised heating units (district heating), space heating in some cases combined with greenhouses, and thermal spas. Most of the centralised plants are located in the Northern German Basin, the Molasse Basin in Southern Germany, or along the Upper Rhine Graben. In addition to these large-scale plants there are numerous small- and medium-size decentralised geothermal heat pump units (ground coupled heat pumps and groundwater heat pumps). Their installed capacity exceeds 775 MW_t. By the end of 2006 direct thermal use of geothermal energy in Germany amounted to a total installed thermal capacity of 952 MW_t.

Table 2: Geothermal direct use in Europe (after Lund, 2005, Rybach, 2006) updated with available data May 2007

Country	Capacity MWt	Use TJ/yr	Capacity Factor	2007 Data
Albania	9.6	8.5	0.03	X
Austria	352.0	2229.9	0.20	
Belarus	2.0	13.3	0.21	
Belgium	63.9	431.2	0.21	
Bulgaria	109.6	1671.5	0.48	
Croatia	114.0	681.7	0.19	
Czech Republic	204.5	1220.0	0.19	
Denmark	330.0	4400.0	0.42	
Finland	260.0	1950.0	0.24	
France	308.0	5195.7	0.53	
Georgia	250.0	6307.0	0.80	
Germany	952.0	6060.0	0.18	X
Greece	74.8	567.2	0.24	
Hungary	694.2	7939.8	0.36	
Iceland	1844.0	24500.0	0.42	
Ireland	20.0	104.1	0.17	X
Italy	650.0	8000.0	0.39	X
Lithuania	21.3	458.0	0.68	
Macedonia	62.3	598.6	0.30	X
Netherlands	253.5	685.0	0.09	
Norway	600.0	3085.0	0.16	
Poland	210.0	1108.0	0.16	X
Portugal	30.6	385.3	0.40	
Romania	145.1	2841.0	0.62	
Russia	308.2	6143.5	0.63	X
Serbia	88.8	2375.0	0.85	
Slovak Republic	187.7	3034.0	0.51	
Slovenia	49.6	729.6	0.47	
Spain	22.3	347.2	0.49	
Sweden	3840.0	36000.0	0.30	
Switzerland	650.0	5500.0	0.23	X
Turkey	1385.0	24000.0	0.53	X
Ukraine	10.9	118.8	0.35	
United Kingdom	10.2	45.6	0.14	
TOTAL	**14114.1**	**158734.5**	-	-

The exact number of GSHP units presently installed in Germany is unknown since no national statistics are available. However, based on the number of heat pump sales in Germany, an estimation may be carried out. According to sales statistics (BWP 2007) about 28,600 small decentralised unites have been newly installed in 2006, a doubling of sales compared to the previous year. The mean installed geothermal power of each of these units typically varies from 8-15 kW_t, with an average of about 10-12 kW_t. (Schellschmidt et al., 2007)

Greece: Some developments have been completed in the whole sector of geothermal energy in Greece. New geothermal fields have been located, studied and reported. The installed capacity in the country for the direct utilization of geothermal energy is approximately 75 MW_t (Fytikas, et al., 2005). About half of this capacity is for thermal spas (in a few cases combined with space heating) and heating of open and closed pools. Two recent trends in Greece include the reduction in greenhouse and soil heating, even thought the latter showed a considerable increase in the previous five years, and the diversification of the uses. New uses include fish farming, spirulina growing and vegetable and fruit dehydration. Earth coupled and groundwater (or seawater) heat pumps have shown a significant increase in the past five years, amounting to 19 large capacity units totalling 1.0 MW_t and producing 5.8 TJ/yr of thermal energy, with other smaller units contributing for a grand total of 4.0 MW_t and 39.1 TJ/yr. Interesting direct-use applications are soil heating for growing asparagus, covering about 12 ha; a tomato dehydration plant which has produced more than 15 tonnes of “sun-dried” tomatoes since 2002; a desalination plant on Kimolos Island; and cultivation of a green-blue algae *spirulina* utilizing the geothermal waters for both the heat and dissolved CO_2. Electricity production has not seen any progress, except the actual deep drilling of Public Power

Corporation (P.P.C.) in NW part of Lesvos Island, in search for a high enthalpy field.

Direct uses have not undergone any development mainly due to the new legislation which has been finalized at 2005, and some applications for district heating are still pending. GSHP exhibited a rapid development due to the change of legislation. (Hatziyannis, 2007).

Ireland: Subsurface temperature data were compiled from 81 boreholes up to 2500 m depth. These reviews of the Republic of Ireland and Northern Ireland, indicate a regional increase in temperatures at 500m depth from 18ºC in the south to 30ºC in the north. At 1000m depth from 20°C to 60°C. At 2500 m from 30ºC to 95ºC to the north. At 5km depth they vary from 60ºC in the south to 150ºC in the north. These results indicate significant geothermal resources with the potential for commercial development (Jones et al., 2007).

Italy: Despite their wide application opportunities, the direct uses have raised scarce interest so far in Italy, except thermal balneology which has continued to grow at a sustained pace. However, we should also mention that, because of the increase in price of oil products, the Italian institutions and some public investors have started to pay attention in the last few years at the renewable and non-conventional energy sources, including geothermal energy. In fact, utilization in 2006 of the latter source is roughly doubled as compared to the situation in prevailing 1999-2000: present capacity stands at 650 MW_t for the plants supplied by natural heat vs. about 325 MW_t, which makes approximately 39% annual capacity factor vs. 37%, and a total production of 8000 TJ/y vs. 3800 TJ/y.

Concerning geothermal heat pumps in particular, it is estimated that their total capacity as of December 2006 was nearing 150 MW_t, with about 600 TJ/year of thermal energy produced. This corresponds to some 23 % of the total installed thermal capacity, and to approx. 7.5% of the energy produced, a still unsatisfactory value as compared to their wide application possibility. Nonetheless, we should stress that the use of this technology has started to take root, as proven by a number of initiatives completed or underway in several towns of northern and central Italy. The most significant of these initiatives are two urban district heating projects using heat pumps supplied by phreatic or surface waters at temperature below 15 °C. The first of these projects is being implemented at Milan, and the second at Bergamo, both in Lombardy (Buonasorte et al., 2007).

Macedonia: There are 18 known geothermal fields in the country with more than 50 thermal springs, boreholes and wells with hot water. These discharge about 1000 l/s water flow with temperatures in 20-79 °C range. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l. All thermal waters in Macedonia are of meteoric origin. The heat source is the regional heat flow, which in the Vardar zone is about 100 mW/m^2 and crust thickness 32 km. (Popovski et al., 2007).

Poland: According to data updated January 1st, 2006, the installed thermal power of all geothermal plants in Poland (including heat pumps) amounted about 210 MW_t and the annual heat generation was at the level of 1 108 TJ/year (tab. 1.5.1). Total installed power, in the three groups of installations, exceeds 210 MW_t. Almost half of that figure (over 101 MW_t) is supplied by geothermal energy whereas the remaining 110 MW_t originates from gas, oil and electricity. These traditional energy carriers are applied to drive absorption pumps (gas), compressor pumps (electricity) and peak load sources (gas and oil boilers) as well as heat/power cogenerators (gas). Despite the described geothermal installations, several other projects are at various stages of development. In many localities studies and preliminary works are executed, which aimed utilising geothermal energy. A wide spectrum of applications is contemplated: from space heating through balneotherapy and recreation to agriculture, gardening and fish farming.

Russia: Geothermal resources are used for heat supply of several cities and settlements on Northern Caucasus and Kamchatka addressing a total of population 500’000. In addition, in some regions of the country geothermal heat is used for greenhouses with an equivalent area of 465000 m^2. The most active geothermal development is in Krasnodar territory, Dagestan and in Kamchatka. (Gadzhiev et al., 1980, Kononov et al., 2000). Approximately half of the energy is used for space heating supply of dwellings and industrial buildings, one third to greenhouse heating, and about 13 % - for industrial processes. Thermal waters are used in approximately 150 health resorts and 40 factories for bottling mineral water (Svalova, 2007).

Switzerland: The key achievement of Switzerland is still in the use of shallow geothermal resources by ground-coupled heat pumps. An evaluation of available global data reveals that Switzerland occupies a prominent world-wide rank in installing and running geothermal heat pump systems (Rybach, 2005). There is an obvious growth in installing borehole heat exchangers for GSHPs over the years 1998-2006; in 2006 close to 1000 kilometers have been drilled for borehole heat exchangers. Geothermal heat pumps are now increasingly and soon routinely used for heating as well as for cooling (Rybach and Minder, 2007).

Turkey: Turkey is the fifth country in the World in operating geothermal direct use applications. Most of the development is achieved in geothermal direct-use applications with 117’000 residences equivalence geothermal heating (983 MW_t) including district heating, thermal facilities and 1 million m^2 geothermal greenhouse heating. Geothermal water is used in 215 spas for balneological purposes (402 MW_t). Engineering design of nearly 310,000 residences equivalence geothermal district heating has been completed. By summing up all these geothermal utilizations, the geothermal direct use installed capacity is 1385 MW_t by April 2007 in Turkey. Main geothermal district heating system applications are Izmir-Balcova, Izmir-Narlidere and Izmir-Medical Faculty Campus of Dokuz Eylül University, Afyon-city center, Afyon-Sandikli, Kirsehir-city center, Kütahya-Simav, Ankara-Kizilcahamam, Balikesir-Gönen, Nevsehir–Kozakli, Manisa–Salihli, Agri-Diyadin, Denizli-Sarayköy, Balikesir-Edremit, Balikesir-Bigadiç and Yozgat-Sarikaya geothermal district heating systems (Mertoglu, 2007).

5. THE FUTURE OF GEOTHERMAL DEVELOPMENT IN EUROPE

On January 10, 2007, the European Commission released an “energy package” including a renewable energy roadmap. Currently, the European Commission prepares a plan on how to divide this renewable energy share over individual member states. In this respect, a new directive is under preparation to foster renewable energies in all sectors, and by that eventually replacing the existing directives on RES for electricity and on biofuels by years 2009-2010.

The European Renewable Energy Council, with the help of EGEC, published the Renewable Energy Technology Roadmap. Within this document, for geothermal energy development in Europe, the roadmap shown in fig. 8 is suggested.

systems, and dissemination of successful approaches from some countries to the whole EU

- Further increase of efficiency of ground source heat pumps, optimised system concepts, application of advanced control systems, improved components and materials (compressors, refrigerants, pipes, etc.)
- Construction of new district heating networks, and optimisation of existing networks and plants, in particular in East/South Eastern Europe and Turkey

Table 5: Renewable Electricity Installed Capacity Projections

TYPE OF ENERGY	2000 EUROSTAT	2004 EUROSTAT	Annual growth rate 2000-2004	PROJECTION 2010	Annual growth rate 2004-2010	PROJECTION	Annual growth rate 2010-2020
1. Wind	13.2 GW	33.6 GW	26.3	80 GW	15.6	180 GW	8.5
2.Hydro	93 GW	107.5 GW	3.7	113 GW	0.8	120 GW	0.6
3. PV	0.18 GW_p	0.86 GW_p	47.8	8 $GW_p{}^3$	45.0	52 $GW_p{}^3$	20.6
4.Biomass	9.5 GW_e	13.1 GW_e	8.6	25 GW_e	11.2	50 GW_e	7.2
5.Geothermal	0.6 GW	0.66 GW	2.4	1 GW	7.2	2 GW	7.2

Table 7: Renewable Heat Generation Projections

TYPE OF ENERGY	2000 Eurostat	2004 Eurostat	AGR 2000-2004	Projection 2010	AGR2004-2010	projection 2020	AGR 2010-2020
Biomass for heat	44.7 Mtoe	48.4 Mtoe	2.0%	65 Mtoe	5.0%	105 Mtoe	4.9%
Solar thermal	0.38 Mtoe	0.68 Mtoe	15.6%	2 Mtoe	19.7%	12 Mtoe	19.6%
Geothermal	0.66 Mtoe	1.5 Mtoe	22.8%	4 Mtoe	17.7%	8 Mtoe	7.2%

Figure 8: Tables from EREC´s Renewable Energy Roadmap to 2020 (www.erec.org)

To achieve the targets, beside economic incentives, research and technical development is required on the geothermal sector. Technology evolution can be expected in both sectors, power and heat, and towards increasing the usable geothermal potential, improving plant efficiency, and decreasing installation and operational cost.

In the geothermal power sector, the main new developments can be expected concerning:

- Improved energy conversion efficiency for geothermal power plants, adapted to the reservoir temperatures on site, for conventional turbines as well as for ORC, Kalina, etc.
- Successful demonstration of EGS (Enhanced Geothermal Systems) on key sites like Soultz-sous-Forêts, France, and dissemination of the technology to other sites and regions
- Increased overall efficiency in geothermal CHP
- Improvement of exploration methods, installation technologies, and system components (pumps, pipes, turbines, etc.)

The future development of the geothermal heating and cooling sector is bound to achieve:

- Improved site assessment (incl. GIS-systems), exploration and installation, also for shallow
- Increased application and innovative concepts for geothermal energy in agriculture, aquaculture, industrial drying processes, etc.
- Demonstration of new applications like de-icing and snow melting on roads, airport runways, etc., sea-water desalination, and geothermal absorption cooling.

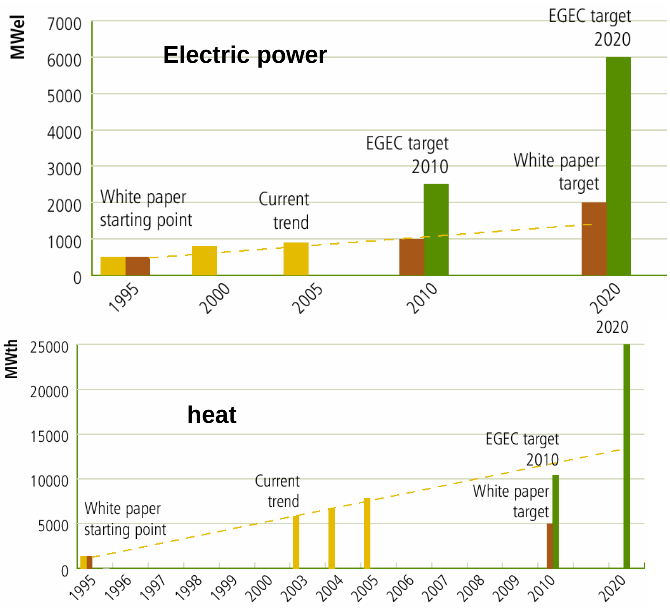

Figure 8: Comparison of current trend with targets

Also non-technical development is of paramount importance, comprising administrative and legal clarity, suitable infrastructure in form of machines and skilled labour, information to the public, etc. For the legal and regulatory background, a process has been started in 2005 out of the geothermal and geological community; this action is know as the "Kistelek Process", after the small South-Hungarian town where the first meeting took place (see the "Kistelek Declaration", for download at www.egec.org).Currently the activity is continued through a EU-supported project called GTR-H (Goodman, 2007).

REFERENCES

Bertani, R.: World Geothermal Generation 2001-2005: State of the art. *Proceedings*, World Geothermal Congress 2005, Antalya, Turkey, Apr. 24-29, (2005).

Buonasorte, G., Cataldi, R., Passaleva, G.: Geothermal Development in Italy: From Present to Future. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Cermak, V. and Rybach, L. (eds.): Terrestrial Heat Flow in Europe. 328 p, Berlin 1979 (Springer)

EGEC: Ferrara Declaration / Dichiarazione di Ferrara. EGEC Business Seminar (1999). www.egec.org

EGEC: Best available statistical data on Geothermal energy, for each EU-25 country, including a description of the sources, their accuracy, and recommendations to improve their quality. K4RES-H Deliverable 2 Report, June (2006). www.erec.org

EGEC: Geothermal Heating and Cooling Action plan for Europe. K4RES-H brochure, January (2007). www.erec.org

EREC: Renewable Energy Technology Roadmap up to 2020. January (2007). www.erec.org

Eurobserv'ER: Eu and Worldwide Geothermal Energy Inventory. *Systemes Solaires*, 170, Barometre Geothermie, December (2005).

Europe's World: The Broad Thrust of Europe's Energy Strategy, *Europe's World*, Spring 2007, pp. 108-109.

Frasheri, A.: Scenarios for Integrated and Cascade Use of Geothermal Energy of Low Enthalpy in Albania. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Goodman, R. et al.: GTR-H - Geothermal Regulations in Europe, the Kistelek process. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Gunnlaugsson, E.: The Use of Geothermal Energy-Example from Iceland-, *International Workshop* in Possibilities of Geothermal Energy Development in the Aegean islands, 5-7 September, (2002)

Hajto, M.: Poland Country Update (draft). *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Haztziyannis, G: Update of the Geothermal Situation in Greece. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Jones, G. L, Goodman, R., Pasquali, R., Kelly, J. G, O'Neill, and N. Slowey, E.: The Status of Geothermal Resource Development in Ireland. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Kujbus, A.: MOL Geothermal Power Plant Project - New Segment in the Hungarian Geothermal Exploration *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Lund, J. W., Freeston, D. H., Boyd, T. L.: World-Wide Direct Uses of Geothermal Energy. *Proceedings*, World Geothermal Congress 2005, Antalya, Turkey, Apr. 24-29, (2005).

Mertoglu, O., Mertoglu, F. M., Bakir, N., Kaya, T.: Recent Geothermal Activities and Developments in Turkey and Projections for the Year 2013. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Popovski, K., Popovska Vasilevska S., Micevski, E., Naunov, J.: Macedonia Country Update 2007. First Signs of Recovery. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Ragnarsson A.., Geothermal Development in Iceland 2000-2004. *Proceedings* World Geothermal Congress, Antalya, Turkey, April 24-29, (2005).

Rybach, L., Minder, R.: Swiss Country Report. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Rybach, L.: Status and Prospects of Geothermal Energy in Europe – and achievements in Switzerland. *Presentation* held at the Institute of Energy Economics, Tokyo, Japan, 12 October (2006).

Sanner, B.: Overview: Geothermal Energy in Europe. *Presentation* held at 1st International Conference: Geothermal Energy in Eastern Europe. RENEXPO Centrals and South-East Europe, Budapest (2007).

Schellschmidt, R., Sanner, B., Jung, R., and Schultz, R.: Geothermal Energy Use in Germany. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).

Svalova, V.: Complex Use of Geothermal Resources. *Proceedings*, European Geothermal Congress 2007, Unterhaching, Germany, 30 May-1 June (2007).