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Summary of EGC 2016 Country Update Reports on Geothermal Energy in Europe

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ABSTRACT

The European status of geothermal energy use by the year 2015 is presented. The situation varies from country to country according to the geothermal technology that best suits the available natural resource. The opportunities range from power generation from high enthalpy resources over direct use of hydrothermal resources in sedimentary basins to shallow geothermal applications available everywhere, and mostly harnessed by ground source heat pump installations.

Geothermal power generation in Europe currently stands at about 2050 MW_{el} installed capacity. The installed capacity of geothermal heating from medium to low temperature sources exceeds 9200 MW_{th}, of which about half is used in district heating. Concerning shallow geothermal energy (ground source heat pumps – GSHP and Underground Thermal Energy Storage – UTES), the installation growth rate is impressing, and a capacity of at least 22'900 MW_{th} was achieved by the end of 2015, distributed over more than 1.7 Mio GSHP installations.

This year, 33 reports were submitted (see table 1 at the end of this paper). It is apparent that the overall growth since the reporting for WGC 2015 is only gradual, but there are interesting individual developments to be noticed. In general, the statistical approach and classification is better defined now, and in some cases this results in decrease in one category and increase in others. For the first time tables for underground thermal energy storage (UTES) were devised and sent to selected countries, as an experiment; you can see the result in the reports from the Netherlands and Sweden.

1. INTRODUCTION

Geothermal energy is firmly established on the heat market in Europe, and still has an enormous growth potential. Geothermal power generation currently is established in few countries only, and the threshold of 1 % of national power generation is surpassed just in three European countries: Iceland, Italy, and Turkey.

For the heating sector, the deep and shallow energy production combined is well on track to reach the targets set forth in the Ferrara Declaration (EGEC, 1999), while the installed electric power generation capacity from geothermal sources is slightly behind the expectations from the end of the last Millennium. Figure 1 shows the comparison of the values from the Ferrara Declaration with the reported values from WGC and EGC events, assuming the reported values represent the status in the year prior to the respective event.

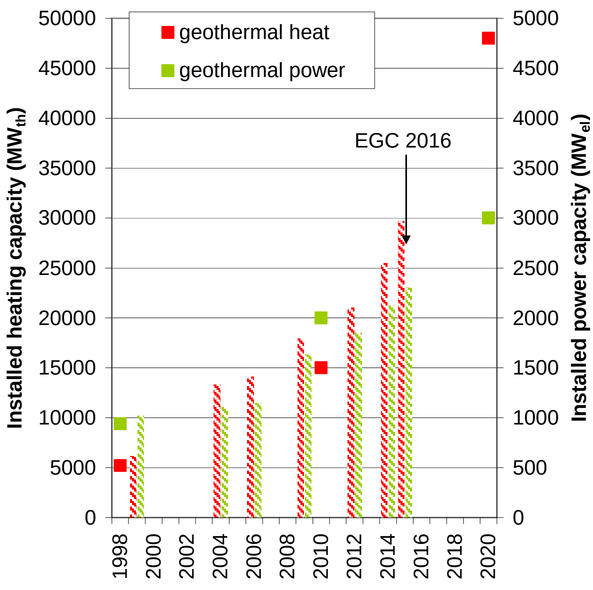


Figure 1: Comparison of installed capacity after Ferrara Declaration of 1998 (squares), and reported values (hashed columns)

2. GEOTHERMAL POWER PRODUCTION

The implementation of geothermal power in Europe at the end of 2015 is listed in table 2, at the end of this paper. Eight countries have geothermal power plants running, a number expected to rise to 18 by 2020 as to the data given in the reports.

Geothermal electricity production in Europe is growing further, both in the traditional high-enthalpy areas, and in the low-medium temperature resources through the extensive utilization of binary plants technologies. Figure 2 shows the development as reported at the various WGC and EGC events since 1995, and the forecast to 2020. In electricity, the minimum target of the Ferrara declaration for the year 2020 might just be met (cf. figure 1). The average load factor is increasing also, having achieved values above 75 %. Single plants report values of almost 100 %. In table 2 the values per country are listed; as of 2015, Turkey is leading with a value of 92.6 %. The rather poor average load factor in Germany of the past periods, being a result of teething problems in new binary plants and of the fact that most of the early plants are part of district heating schemes and need to share the geothermal resource with the heat supply, has improved considerably and reached about 55 % in 2015.

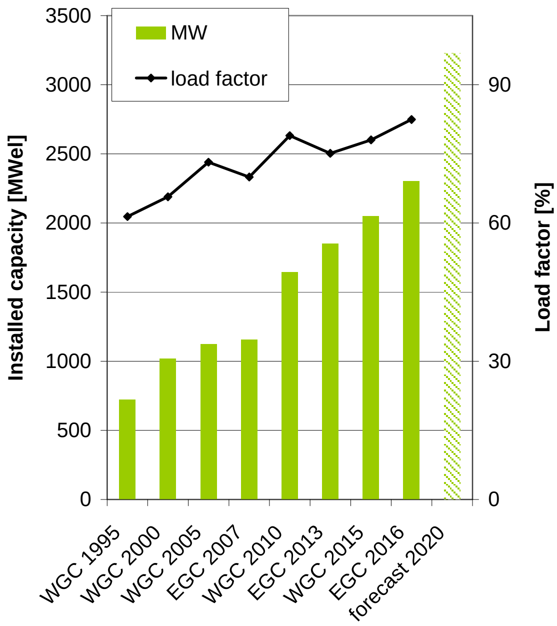


Figure 2: Installed capacity and average load factor for geothermal electricity in Europe as reported at various events, and forecast of installed capacity to 2020.

Geothermal power still is a marginal contributor to the national electricity networks, as the values in figure 3 show. In large countries like France and Germany, even geothermal power production in the order of 100 GWh/a does not lift geothermal over the threshold of 1 %. The only country with a substantial geothermal share is Iceland, where more than a quarter of the national electricity production comes from geothermal sources, followed by Turkey and Italy. In Turkey, now new on 2nd rank, geothermal power plants of slightly less than 1 % of the countries electric production capacity allow for about 2.5 % of national production (calculated using OECD figures).

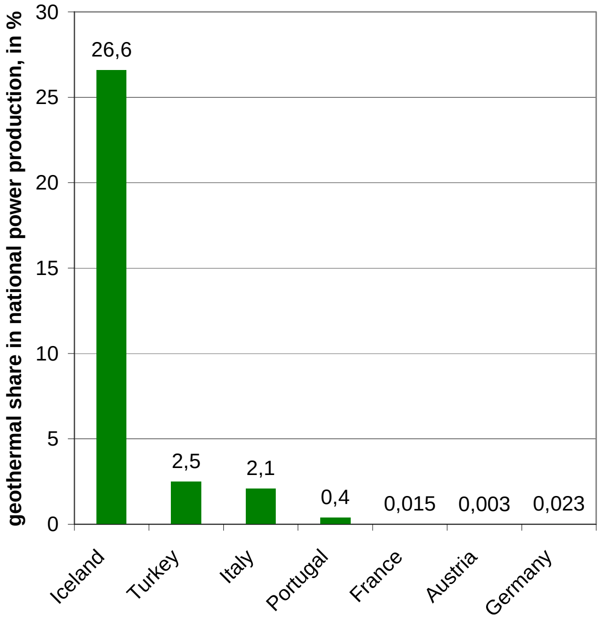


Figure 3: Share of geothermal power in the national electricity production in some countries

The development of installed capacity and annual production in the currently producing countries is shown in figure 4 for the time since the reporting of WGC 2005. In Italy, a steady growth of installed capacity on a high level is seen, while annual production shows some slight variations. The main growth in Iceland was from 2005 to 2010, with installed capacity stable since 2012, also on a high level. The most interesting development is in Turkey and Germany, and figure 5 shows these two countries separately. The improvement in load factor in Germany, as mentioned earlier, had a very positive effect on power production. However, also statistical inaccuracies might have contributed to the fluctuations 2010-2015.

Finally for the power chapter, figure 6 shows the installed capacity for the different countries as to the end of 2012 (EGC 2013) and 2015 (EGC 2016), and the values expected to be reached by 2020. Turkey had the highest increase in the last 3 years with about 480 MW_{el} installed new, and is about to take the lead in Europe with more then 1 GW in 2020, if all current expectations come true. It can be seen from this figure that the huge potential that EGS might offer (Geoelec, 2013) is not yet reflected in the national targets until the end of this decade. Most of what is reported this year is based on the currently available high enthalpy resources and low-to-medium-temperature binary power plants. The growth up to 2030 and 2040 might look different; however, a massive development exercise for EGS would be required to make it happen.

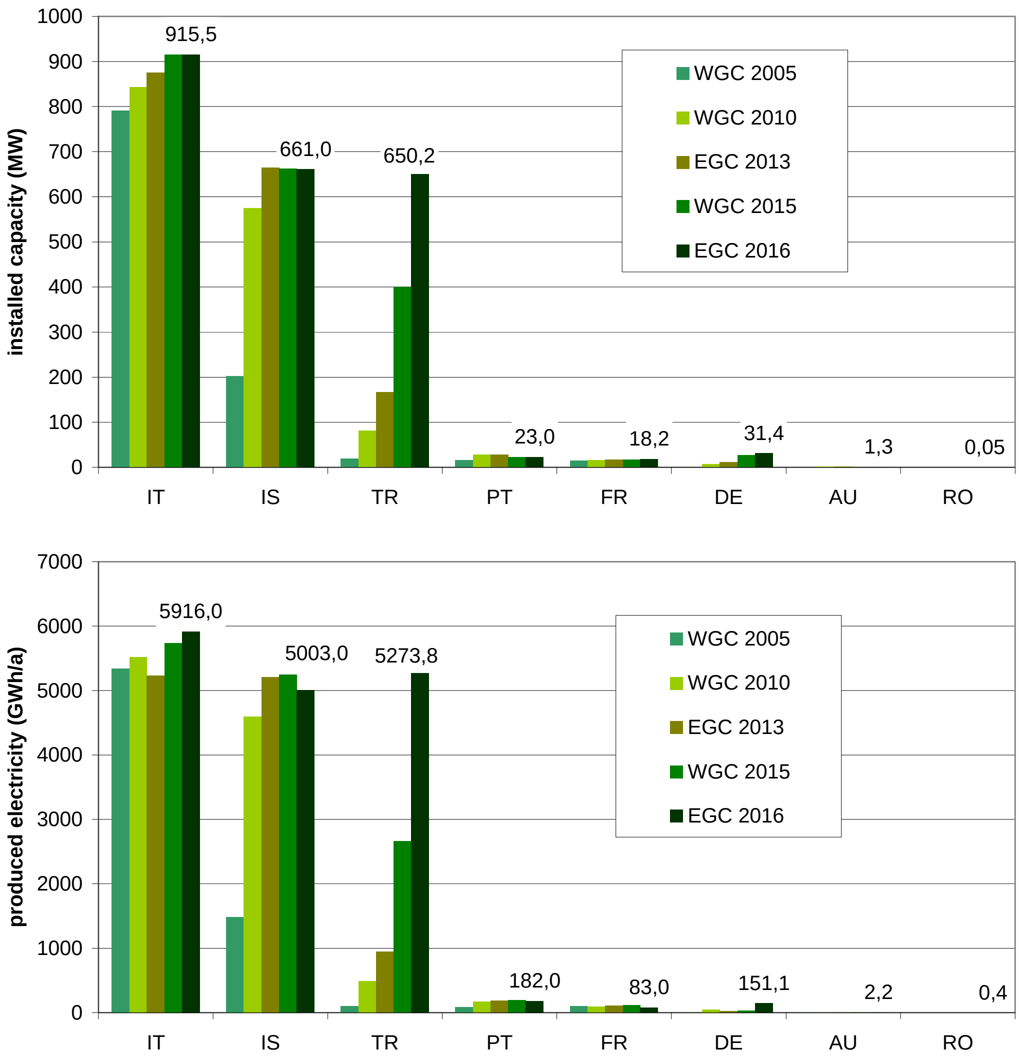


Figure 4: Installed geothermal power (top) and annual production (bottom) in Europe after country update reports since WGC 2005

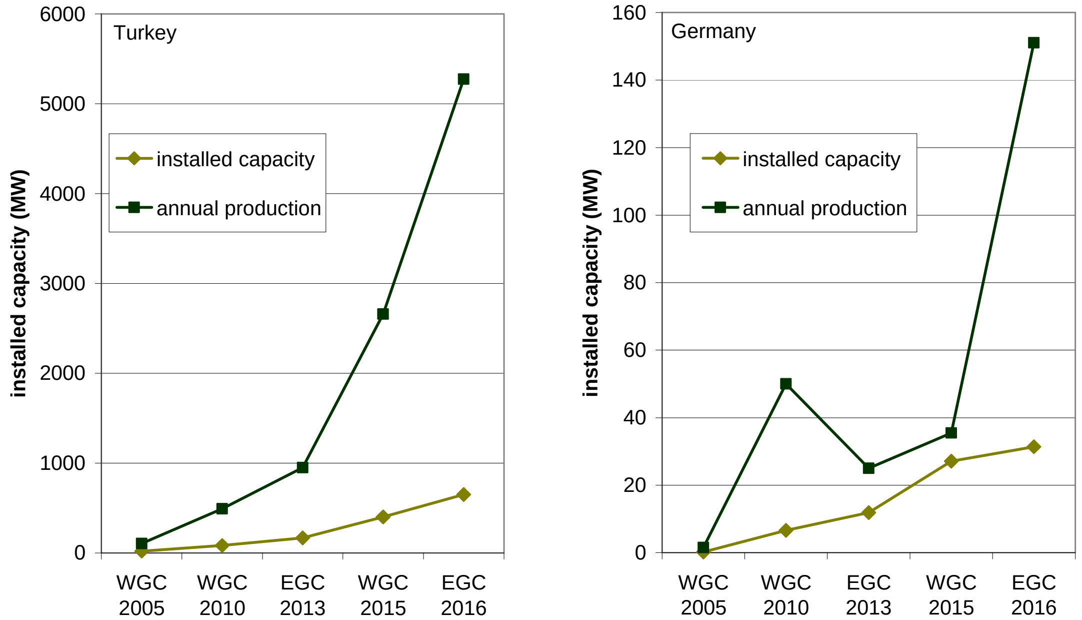


Figure 5: Development of installed geothermal power and annual production in Turkey (left) and in Germany (right), after country update reports since WGC 2005

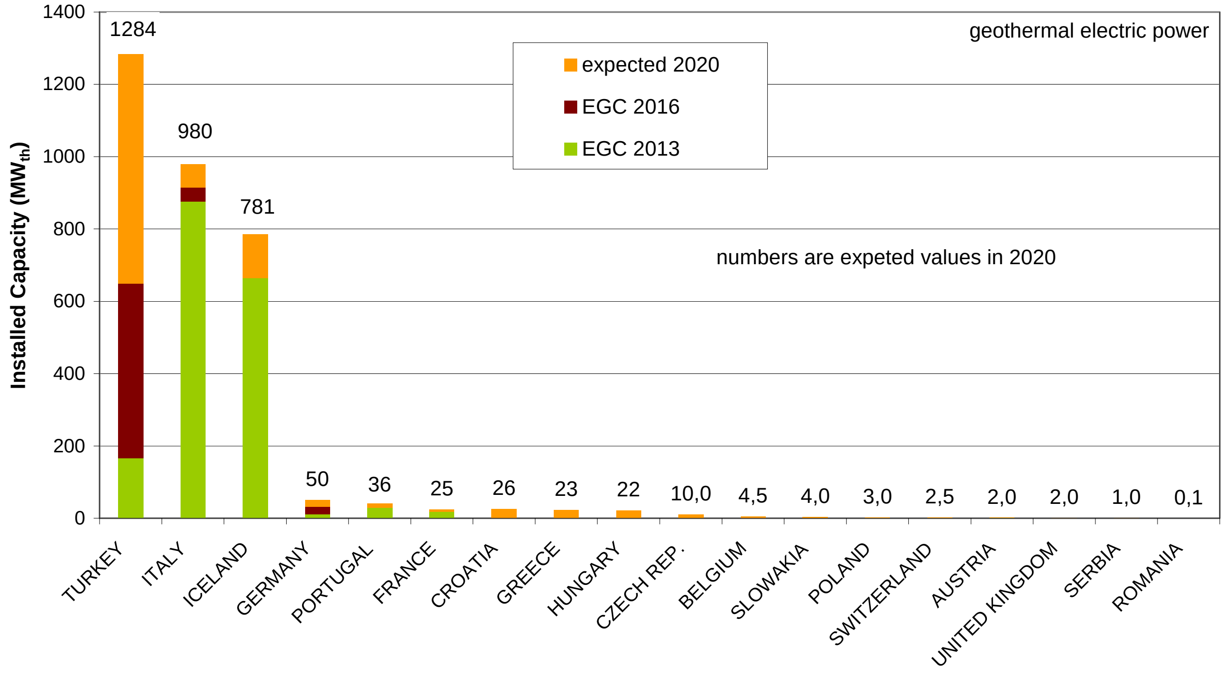


Figure 6: Installed geothermal power in Europe 2012-2015, after EGC 2013 and EGEC 2016, and reported expectations towards 2020

3. GEOTHERMAL DIRECT USES

In the past, the reported geothermal energy used as heat was mainly the share used in district heating and in some of the agricultural uses. In particular the amount used in spas and balneology is difficult to determine and was often not reported. Already in EGC 2013 an attempt was made to better quantify this sector, and the tables have been improved slightly for EGC 2016. Figure 7 shows the distribution into the different sectors for a few selected countries, highlighting the big differences that can be found. In Hungary, almost half of the geothermal heat goes to agriculture etc., and a third to balneological applications. In Italy, heat for individual buildings and other applications is in the lead, while district heating dominates the consumption in Iceland with almost 90 % and in Germany with 85 %.

The reported values for 2015 for each country are listed in table 3 at the end of this paper. Figure 8 shows the total values for each country and the share of geothermal district heating thereof. Some countries like Turkey, Italy or Hungary have a high share of other direct uses and would be much undervalued if only geothermal district heating is considered. In other countries, like Iceland, France and Germany, district heating is the main use of geothermal heat.

Figure 9 is a synopsis of, the values reported at EGC 2013 for 2012 and at EGC 2016 for 2015, and the forecast for 2020. Compared to past reports, the expectations for the future are much less ambitious, probably a result of the general economic situation and of more realistic forecasting. Turkey is the leader in total amount, Iceland of course champion in geothermal coverage of heat demand, and the Netherlands top in relative growth (65 % per year).

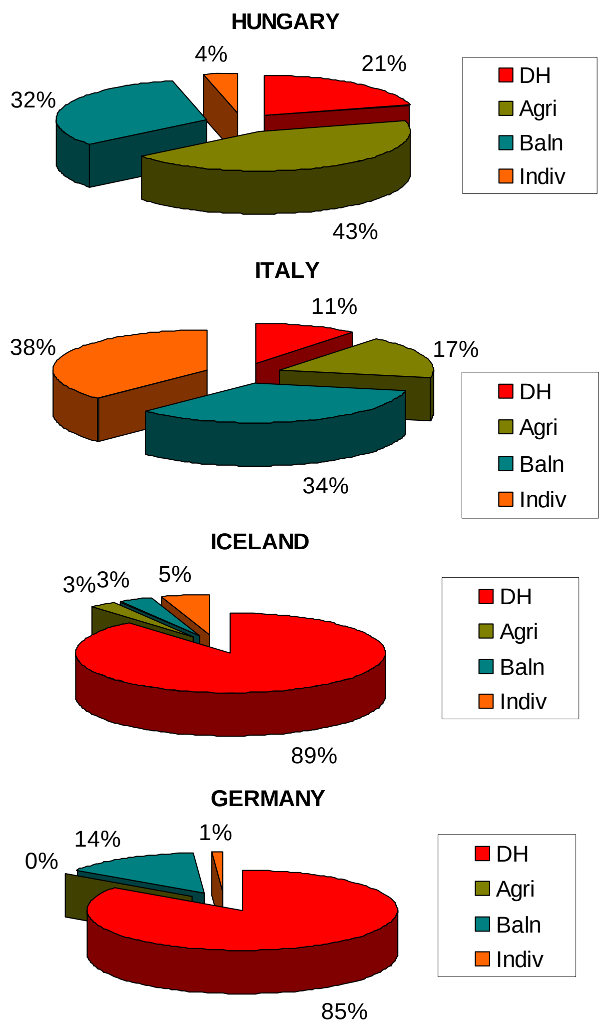


Figure 7: Share of installed capacity in district heating, agricultural uses, balneology and individual building in geothermal direct use in Hungary, Italy, Iceland and Germany

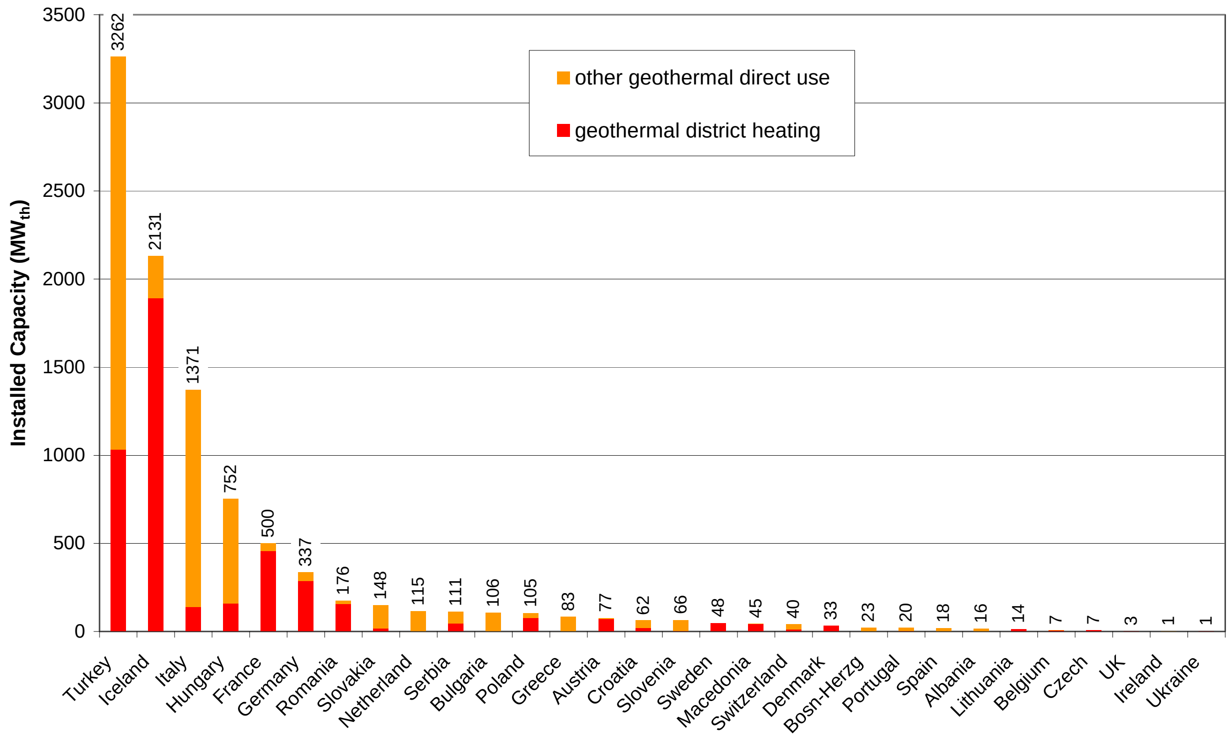


Figure 8: Installed capacity in geothermal direct use in Europe 2015, showing the share of district heating in the total direct geothermal use

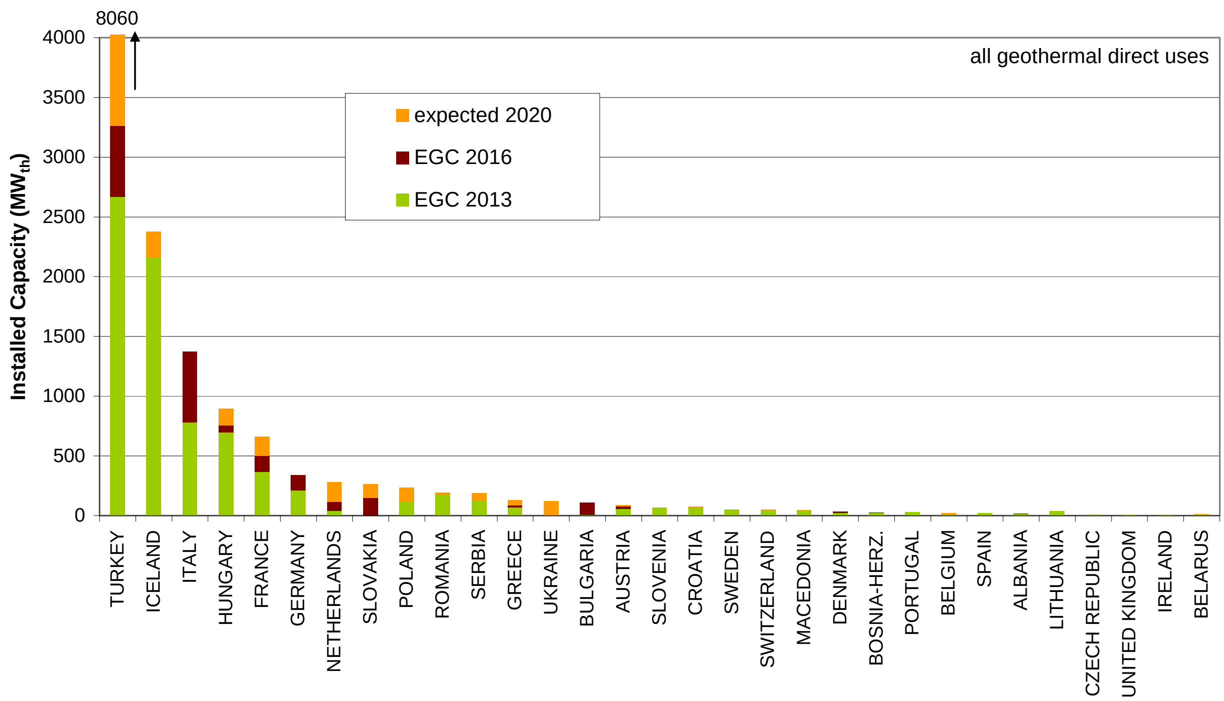


Figure 9 Installed capacity in geothermal direct use in Europe 2012-2015, after EGC 2013 and EGEC 2016, and reported expectations towards 2020 (EGC-2016-values for Denmark from WGC 2015)

4. SHALLOW GEOTHERMAL APPLICATIONS

In terms of number of installations, installed capacity and energy produced this is by far the largest sector of geothermal energy use in Europe (figure 10. The shallow geothermal share did increase from 63 % reported at EGC 2013 to 67 % in the current reporting. It enjoys the widest deployment among European countries; the data for 2015 from the individual countries are summarised in table 4 at the end of this paper.

The total number of geothermal heat pumps installed in Europe exceeds 1.7 Mio units. The leader by far is Sweden, in particular when considered the number of less than 10 Mio inhabitants. Germany with a much larger population of almost 82 Mio comes in second, with less than 2/3 of the Swedish GSHP number.

Other important countries with more than 50’000 installations are France, Austria, Finland, Switzerland and Norway. Figure 11 shows the numbers of installed heat pump per country, compared to the annual sales (not all countries reported the sales number). The number of new installations per year is typically about 3-6 % of the existing stock, with some noteworthy exceptions as highlighted in figure 10. The sales in France recently dropped drastically and now achieved only 1.9 % of the stock, while other countries have a high ratio of new installations, in a few cases exceeding 10 %. The reasons for the differences are manifold and can be attributed to energy prices, incentives, regulation, awareness, knowledge, and active salesmen and installers.

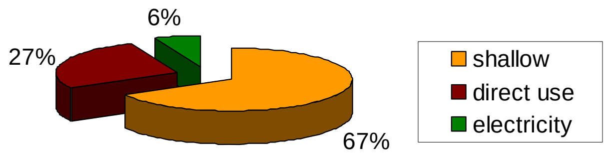


Figure 10: Share of installed capacity in the three geothermal sub-sectors in Europe as of 2015

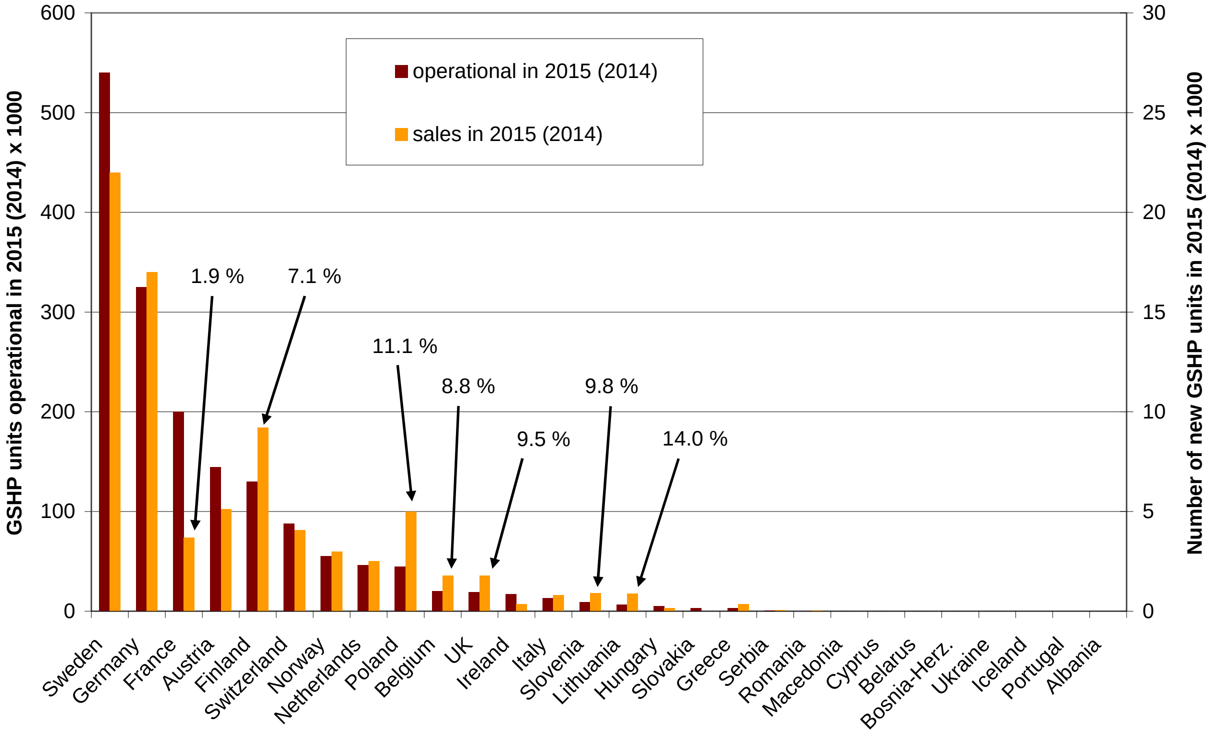


Figure 11: Total number of GSHP and sales in 2015 (some countries 2014) as stated in EGC 2016 country update reports; the ratio of sales in relation to existing installations is highlighted for some countries

For EU statistical purposes, the renewable (geothermal) contribution of geothermal heat pumps to the heat produced should be calculated according to the EU Directive 2009/28/EC “Renewable Energy”, Annex VII, by the equation:

$$E_{RES} = Q_{usable} * (1 - 1/SPF)$$

E_{RES}	*renewable energy (in GWh)*
Q_{usable}	*estimated total usable heat (in GWh)*
SPF	*seasonal performance factor*

In March 2013, the EC has issued the necessary rules for applying this formula, prepared by Eurostat (Decision 2013/114/EU). Also default input values are given in that document, for three different climate zones (cold, average and warm). It is hoped that, geothermal statistics will become easier inside the EU (and in the rest of Europe) with this regulation, urging the national statistical offices and Eurostat to provide data as to Directive 2009/28/EC. However, currently only a few countries fully comply with this rules. For instance, often the distinction within the heat pump sector (aerothermal / geothermal) is not made, and only numbers for heat pumps in general are published. Hence the activity of relevant associations (e.g. BWP in Germany or RGS in Romania) still is required to collect data matching the needs of the industry, and it will take some more time until we can just download such data from the national and European statistics.

The recent development and future perspectives for shallow geothermal in Europe can be seen from figure 12, where data from EGC 2013, the current values, and the expectations towards 2020 are shown in comparison. The largest amount of newly installed capacity from EGC 2013 to EGC 2016 was in Finland, surpassing even the numbers for Sweden, the country leading by installed capacity. Shallow geothermal energy is used also in some countries that did not report to EGC 2016 (Luxembourg can serve as a small, but interesting example here, with good growth and some large installations), and we can state that there is almost no country in Europe without some shallow geothermal installation.

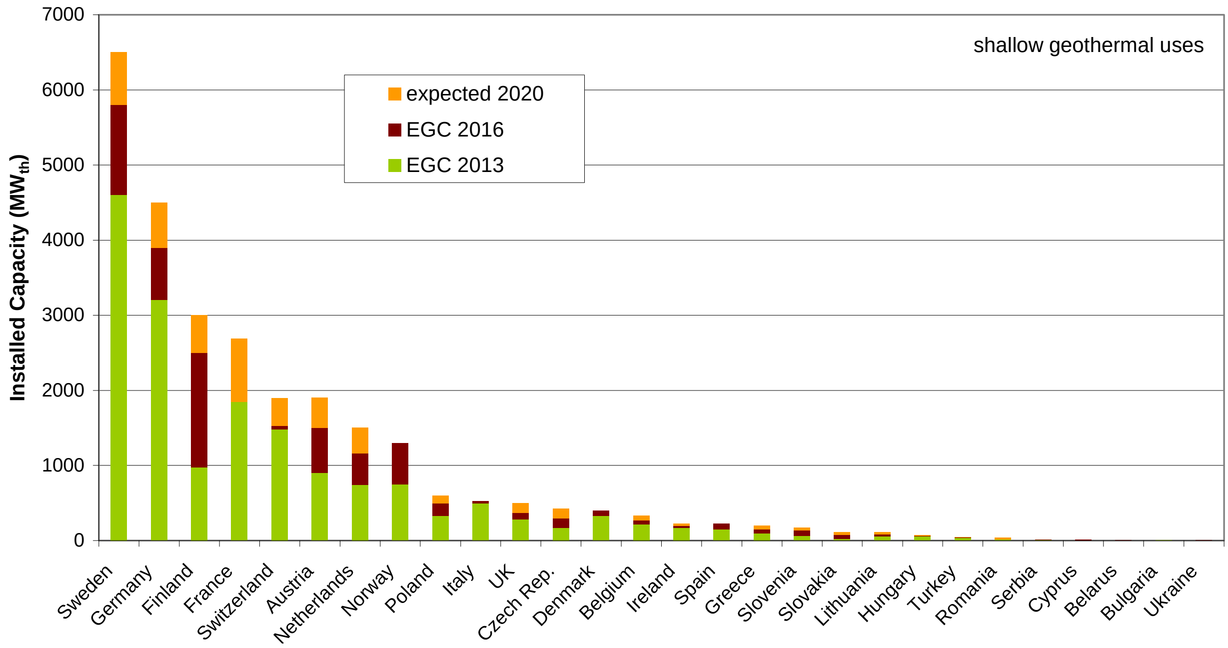


Figure 12: Installed capacity in geothermal heat pumps in Europe 2012-2015, after EGC 2013 and EGEC 2016, and reported expectations towards 2020 (EGC-2016-values for Denmark from WGC 2015)

5. MARKET SITUATION

Not all countries reported on the financial aspects and manpower requirement of the geothermal market. Hence the numbers given here should be considered as a minimum only. Investment in geothermal energy was at least 4.53 billion € in 2015. This is .about 750 mio € less than reported for EGC 2013; a part of that might be explained by the missing number from Germany this time, and included in EGC 2013. As some major players like Italy and, as said, Germany are missing, the true investment values in Europe will be definitely higher. This also might contribute to the high investment (in relative terms) in the shallow sector (fig. 13), as this is dominated by Sweden.

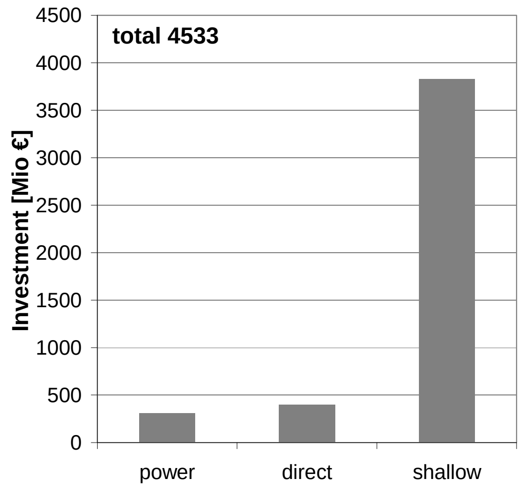


Figure 13: Investment in the different fields of the geothermal sector (only 20 of 33 countries reporting)

The extrapolation to 2018, based on the same reporting countries only, amounts to ca 7.17 billion €, an increase of about 58 % (higher than the predicted increase of 30 % from 2012-2015 in the EGC 2013 reports). However, this is mainly due to a very high increase in Turkey. The forecast in other countries apparently is much more cautious this time.

For employment, we can state that at least 36’000 persons work in the geothermal sector. This is somewhat higher than reported for EGC 2013 (31’800 persons), however, the distribution now is quite different, with the shallow sector dominating also the workforce (fig. 14), and work in direct use projects much reduced. However, the situation is not fully comparable, with much lower numbers reported for Turkey in EGC 2016 than for EGC 2013. In general, the definition of persons working in geothermal seems in need of clarification. As was said already for investment, the true number of geothermal personnel in Europe will be definitely higher, considering to the limited number of countries reporting.

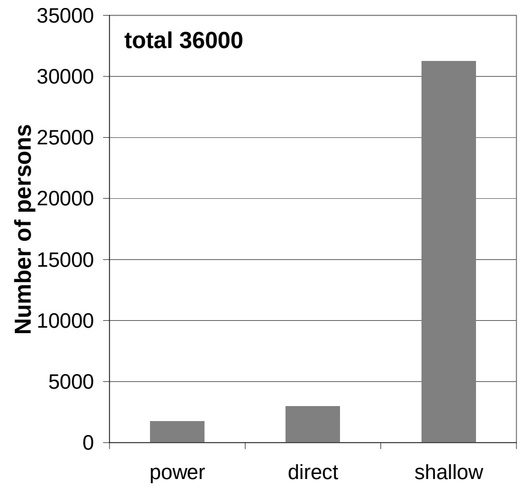
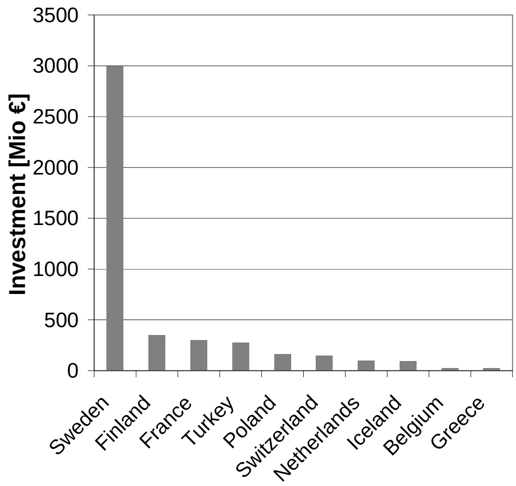


Figure 14: Number of persons working in the different fields of the geothermal sector (only 20 of 33 countries reporting)

The breakdown of investment and personnel per country is shown in figure 15 for the larger reporting countries.



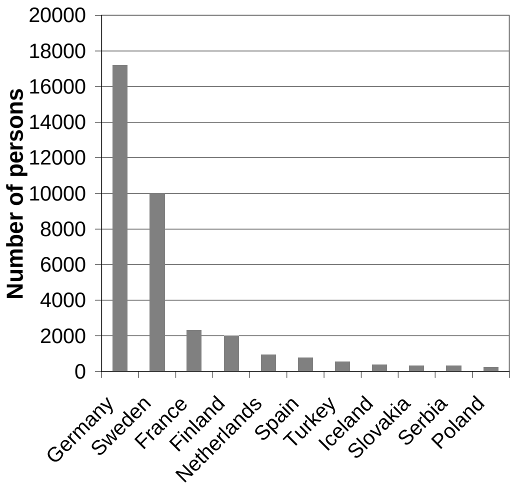


Figure 15: Total geothermal investment for countries with more than 20 Mio €/a (top) and personnel in countries with more than 200 geothermal workers (bottom)

6. CONCLUSIONS

After years of steady growth and high interest in new projects in the first decade of the Millennium, the signals now are more on consolidation.

In geothermal power, Turkey has emerged as a new leader with very dynamic development, while the current top countries Iceland and Italy now only have a small growth, albeit on high total level. The players from these countries hence are active elsewhere in the world to develop new geothermal projects and to transfer their experience.

For direct uses, some countries have a good development in the agricultural sector, in particular the Netherlands and Hungary. District heating is growing, but much work here also goes into refurbishment and "repowering" of existing plants. The share of district heating in all direct use still is about 47 %, with balneology taking another quarter of the total (fig. 16). The distribution in individual countries can vary widely, as was discussed in chapter 3. The shallow geothermal sector has a varied development, with problems in some countries (France), consolidation on high level in others (Sweden, Germany), and high relative growth in places like Finland, Poland and Lithuania.

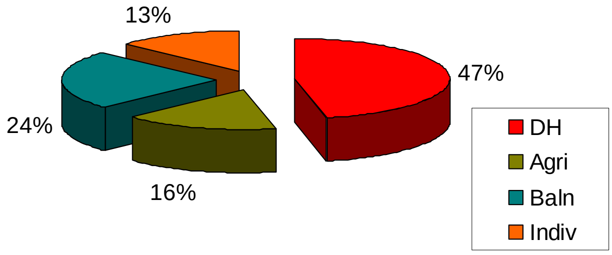


Figure 16: Share of installed capacity in district heating, agricultural uses, balneology and individual building in geothermal direct use in Europe

The country update reports for WGC and EGC still serve an important task, as national statistics cannot (yet?) deliver the data and insights requested. Documents like the EGEC Market Report are intended for use in industry (and limited in availability, e.g. for members only). The individual country updates and summary reports are a source open to everybody, and a fixture in the geothermal scene since more than 20 years.

The authors of this summary wish to thank all contributors who committed their time to collection and interpretation of data in their countries, some of them for many years now, and in particular those who endeavoured on that challenge for the fist time! The names are listed in table 1, and we encourage all readers to also study the individual country update reports that are part of the EGC 2016 proceedings.

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Lund, J.W. and Boyd, T.L.. Direct Utilization of Geothermal Energy 2015 Worldwide Review. *Proc. WGC 2015*, Melbourne (2015), paper #01000, 1-31

Table 1: EGC 2016 country update reports.

Author(s)	Country
Frasheri, A.	Albania
Goldbrunner, J. and Goetzl, G.	Austria
Zui, V. Dubanevich, M. and Vasilionak, E.	Belarus
Petitclerc, E., Laenen, B., Lagrou, D. and Hoes, H.	Belgium
Samardžić, N. and Hrvatović, H.	Bosnia and Herzegovina
Benderev, A., Hristov, H., Hristov, V. and Berova-Andonova, A.	Bulgaria
Živković, S., Kolbah, S. and Škrlec, M.	Croatia
Michopoulos, A. and Zachariadis, T.	Cyprus
Dědeček, P., Šafanda, J. and Tym, A.	Czech Republic
Kallio, J.	Finland
Boissavy, C., Rocher, P., Laplaige, P. and Brange, C.	France
Weber, J., Ganz, B., Sanner, B. and Moeck, I.	Germany
Papachristou, M., Mendrinos, D., Dalampakis, P., Arvanitis, A., Karytsas, C. and Andritsos, N.	Greece
Nádor, A., Kujbus, A. and Tóth, A.	Hungary
Ragnarsson, A.	Iceland
Pasquali, R., Jones, G.L., Burgess, J., and Hunter Williams, T.	Ireland
Conti, P., Cei., M. and Razzano, F.	Italy

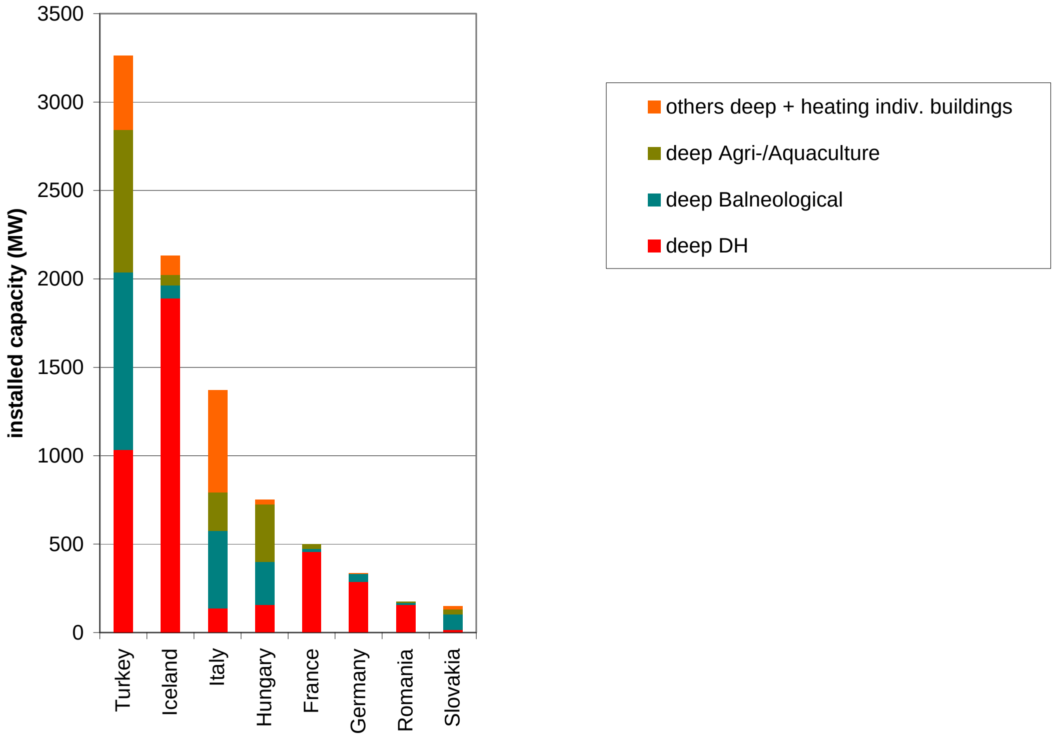
Author(s)	Country
Zinevicius, F., Sliaupa, S., Mazintas, A. and Dagilis, V.	Lithuania
Popovska-Vasilevska, S., Armenski, S. and Stefanovska, C.	Macedonia
Bakema, G. and Schoof, F.	Netherlands
Midttømme, K., Henne, I., Kocbach, J. and Kalskin Ramstad, R.	Norway
Kępińska, B.	Poland
Nunes, J.C. Coelho, L., do Rosário Carvalho, M., Garcia, J., Cerdeira, R. and Martins Carvalho, J.	Portugal
Gavriliuc, R., Rosca, M., Polizu, R. and Cucueteanu, D.	Romania
Oudech, S., Djokic, I. and Radomir, S.	Serbia
Fendek, M., Fendekova, M., Fricovsky, B. and Blanarova, V.	Slovakia
Rajver, D., Lapanje, A., Rman, N. and Prestor, J.	Slovenia
Arrizabalaga, I., De Gregorio, M., García de la Noceda, C., Hidalgo, R. and Urchueguía, J.F.	Spain
Gehlin, S. and Andersson, O.	Sweden
Link, K., Rybach, L., Wyss, R. and Imhasly, S.	Switzerland
Mertoglu. O., Şimşek, Ş., and Başarir, N.	Turkey
Curtis, R., Law, R. and Adams, C.	United Kingdom
Morozov, Y. and Barylo, A.	Ukraine

Table 2: Geothermal Electric Power in Europe in 2015.

	2015 installed capacity	2015 electricity produced	2015 load factor	Inst. cap. expected 2020
	]MW_{el}]	[GWh_{el}/yr]	[%]	[MW_{el}]
Austria	1.25	2.2	20.1	2
Belgium				4.5
Croatia				25.6
Czech Republic				10
France	18.2	83	52.1	25
Germany	31.4	151	54.9	50
Greece				23
Hungary				22
Iceland	661	5003	86.4	781
Italy	916	5916	73.8	980
Poland				2-4
Portugal	23	182	90.3	36
Romania	0.05	0.4	91.3	0.05
Serbia				1
Slovakia				4
Switzerland				2.5
Turkey	650.2	5273.8	92.6	1284
UK				1-4
Total	2300.6	16611.5	average 82.4	3256

Table 3: Geothermal Direct Use in Europe in 2015.

	Geothermal DH Plants		Geothermal heat in agriculture		Geothermal heat in balneology		Geothermal heat in other and indiv. Bldg.	
Country	Capacity [MW_{th}]	Production [GWh_{th}/yr]	Capacity [MW_{th}]	Production [GWh_{th}/yr]	Capacity [MW_{th}]	Production [GWh_{th}/yr]	Capacity [MW_{th}]	Production [GWh_{th}/yr]
Albania					11.7	23.7	4.5	5.9
Austria	72.5	272.5	2.0	4.6	2.4	20.6		
Belarus								
Belgium	6.1	16.7	0.9	1.3				
Bosnia-Herz.					12.5	29.3	10.4	53.3
Bulgaria			3.8	13.2	100.3	379.5	1.5	6.1
Croatia	19.5	51.2	6.5	39.0	22.2	47.8	13.8	
Czech Rep.	6.5	25.0						
France	456.0	1175.0	26.6	110.0	17.0	21.0		
Germany	285.0	689.6			48.3	400.0	3.3	9.5
Greece			39.7	170.7	42.0	69.7	1.7	5.0
Hungary	157.2	353.7	325.6	732.6	241.6	724.8	28.0	63.0
Iceland	1890.0	6651.0	60.0	228.0	72.0	420.0	109.0	377.0
Italy	138.0	227.0	221.0	752.0	435.0	929.0	577.0	1008.0
Lithuania	13.6	34.0						
Macedonia	42.6	106.0	2.8	17.0				
Netherlands			115.0	667.0				
Poland	76.2	277.1	3.1	3.7	26.0	73.0		
Portugal	2.1	14.9			17.1	85.9	1.0	7.1
Romania	158.0	300.0	8.0	50.0	10-0	12.0		
Serbia	45.9	161.0	11.6	62.4	36.7	186.3	16.8	78.0
Slovakia	16.2		27.3		87.7		16.6	
Slovenia	3.6	6.1	14.4	34.5	17.9	34.5	29.8	61.9
Sweden	48.0	140.0						
Switzerland	11.1	26.1			29.1	224.1		
Turkey	1033.0		804.3		1005.0		420.0	
UK	2.0	14.0			0.6	3.0		
Ukraine	0.9							
Total	4517	13107	1688	6145	2239	8988	1233	2963



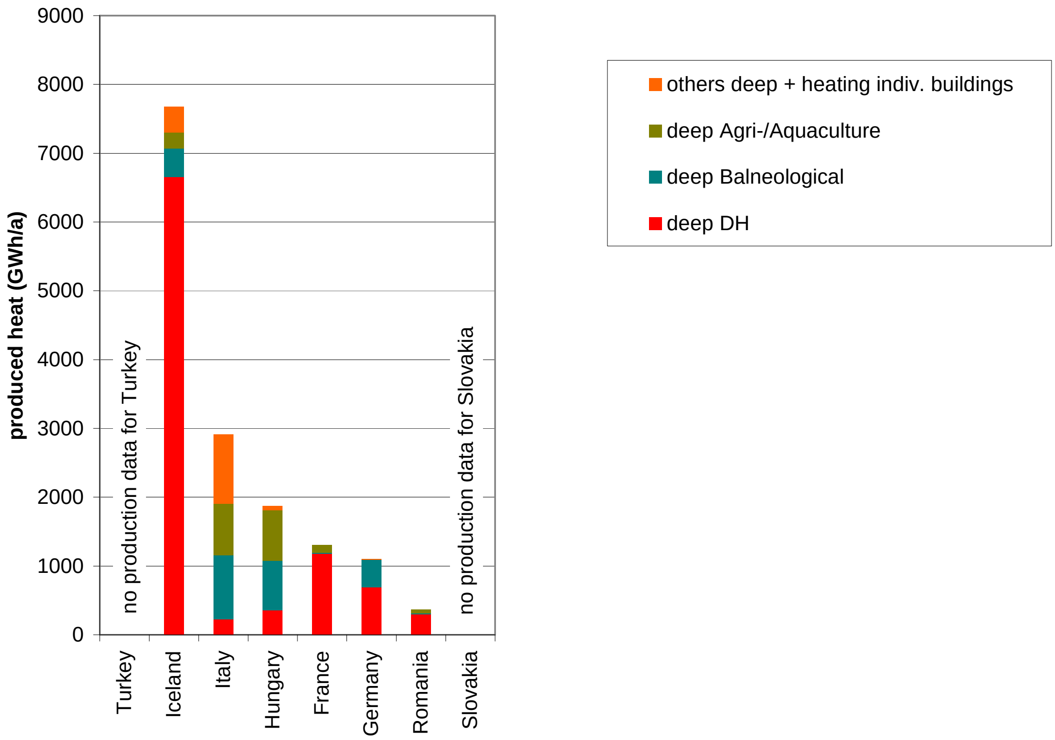


Figure 17: Visualisation of data on installed capacity and produced heat from table 3, countries with high usage

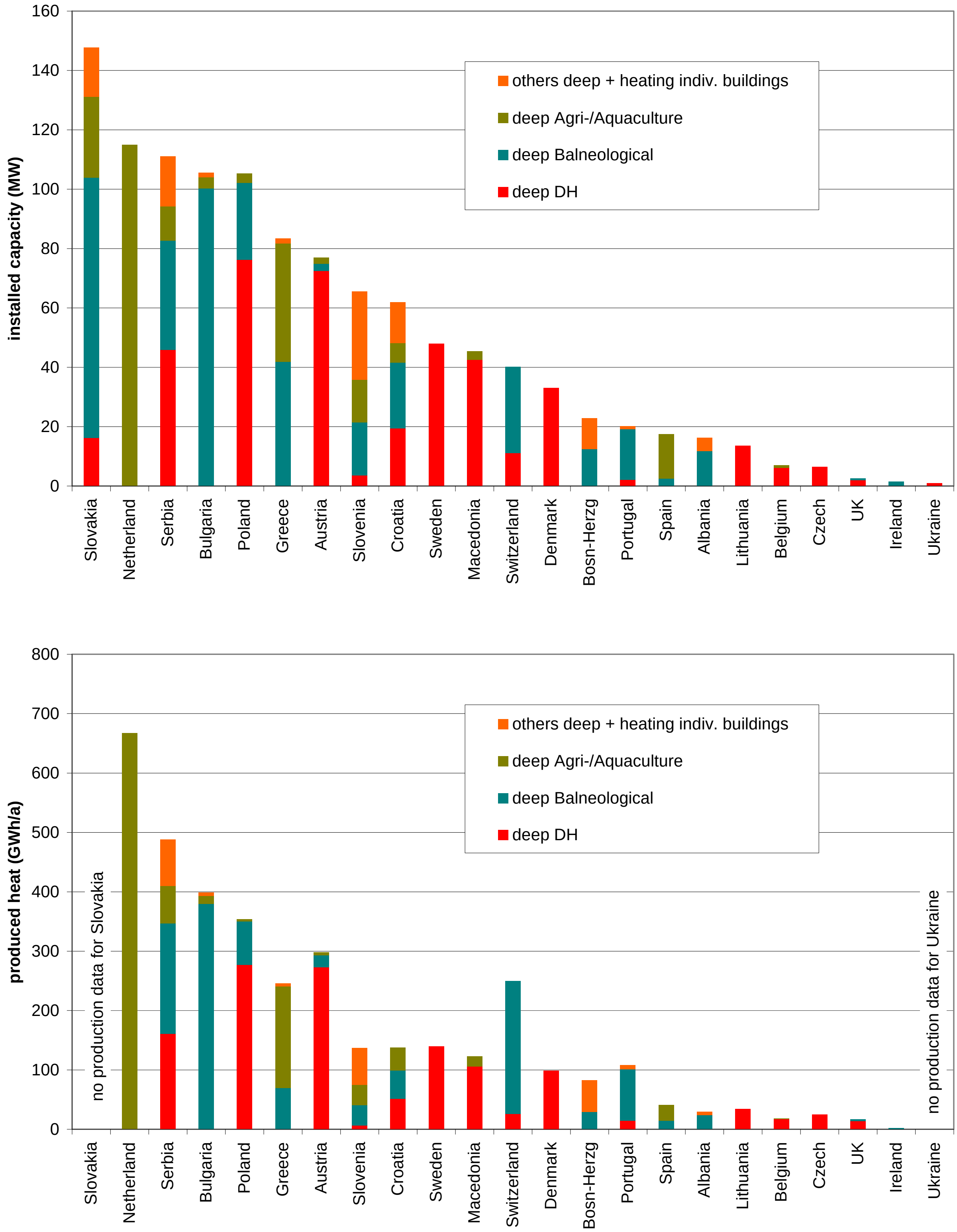


Figure 18: Visualisation of data on installed capacity and produced heat from table 3, countries with low usage (values for Denmark from WGC 2015)

Table 4: Ground Source Heat Pump Use in Europe in 2015.

Country	Number of GSHP	Capacity [MW_{th}]	Production [GWh_{th}/year]	kW_{th} per unit	Full-load hours per year
				Data calculated by authors of summary	
Albania	106	4.5	5.84		*1299*
Austria	144’553	1500.0	2000.0	*10,4*	*1333*
Belarus	150	7.0	3.6	*46.7*	*510*
Belgium	20’372	269.7	431.8	*13,2*	*1601*
Bosnia-Herz.	150	2.0	3,7	*13,3*	*1850*
Cyprus	170	10.0	19.0	*58.8*	*1900*
Czech Rep.	18’300	300.0	450.4	*16.4*	*1501*
Denmark	*40’000*	*400.0*	*597.7*	*10.0*	*1494*
Finland	130’000	*2500.0*	5000.0	*19.2*	*2000*
France	200’000	1800.0	3060.0	*9.0*	*1700*
Germany	325’000	3900.0	5704.0	*12,0*	*1463*
Greece	3000	148.0	197.0	*49.3*	*1331*
Hungary	5500	61.0	122.0	*11.1*	*2000*
Iceland	70	1.0	5.0	*14.3*	*5000*
Ireland	17’195	191.0	252.0	*11,1*	*1319*
Italy	13’200	531.0	906.0	*40.2*	*1706*
Lithuania	6396	81.8	193.0	*12.8*	*2359*
Macedonia	200	*2.5*	*4.2*	*12.5*	*1668*
Netherlands	45’986	1160.0	3400.0	*25.2*	*2931*
Norway	55’000	1300.0	2296.3	*23.6*	*1766*
Poland	45’000	500.0	714.0	*11,1*	*1428*
Portugal	54	0.65	0.87	*12.0*	*1340*
Romania	307	19.0	40.0	*61.9*	*2105*
Serbia	827	12.8	28.2	*15.5*	*2199*
Slovenia	9350	136.6	203.4	*14.6*	*1489*
Spain		225.0	315.0		*1400*
Sweden	540’000	5800.0	20100.0	*10,7*	*3466*
Switzerland	88’215	1531.7	2385.3	*17.,4*	*1557*
Turkey		42.8			
UK	19’000	370.0	665.0	*19,5*	*1797*
Ukraine	134	5.2		*38.9*	
Total	1’712’848	22891.4	49366.4	*average 22.2*	*average 1809*

Data in *italics* calculated by the authors of the summary
Data for Denmark from WGC 2015

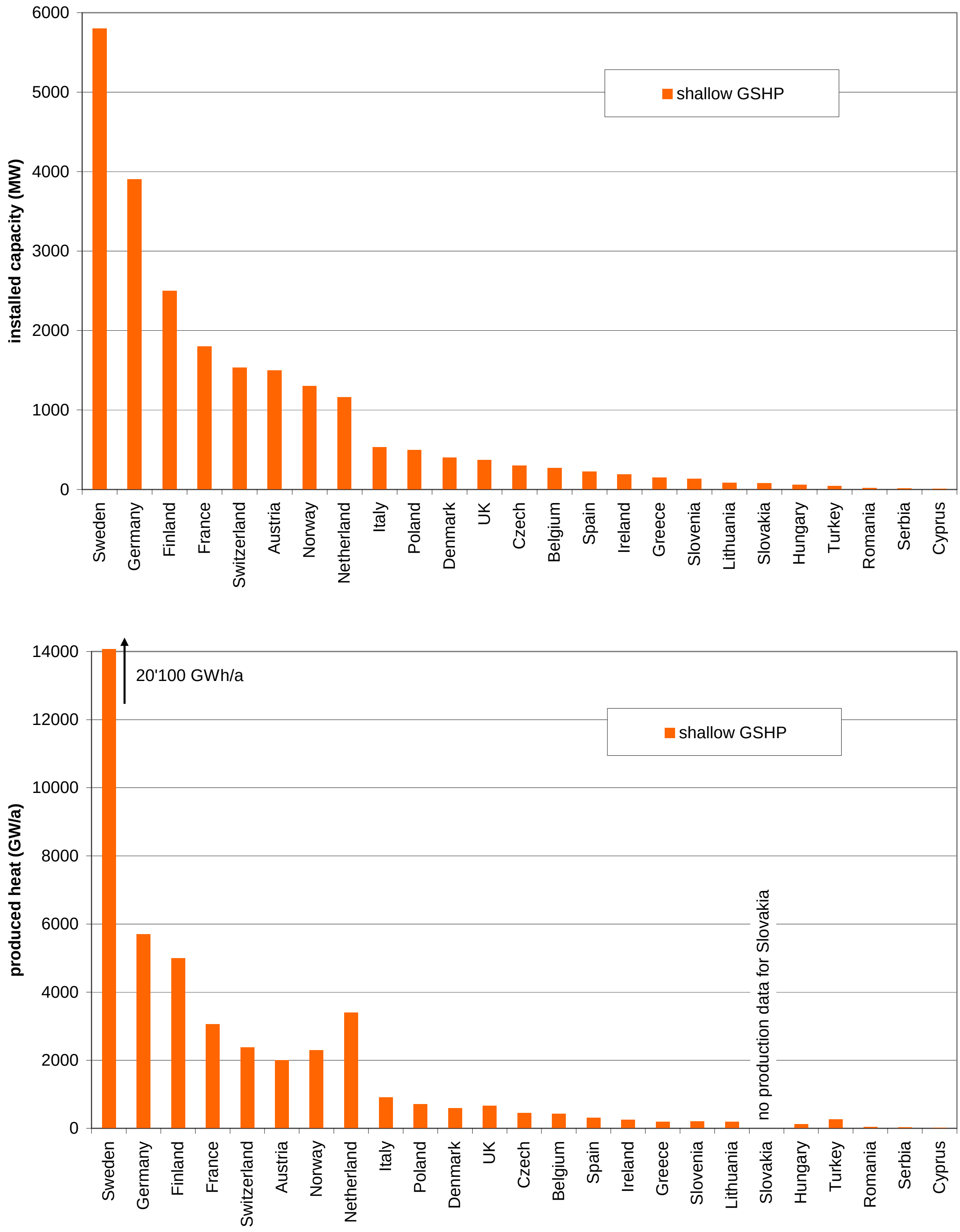
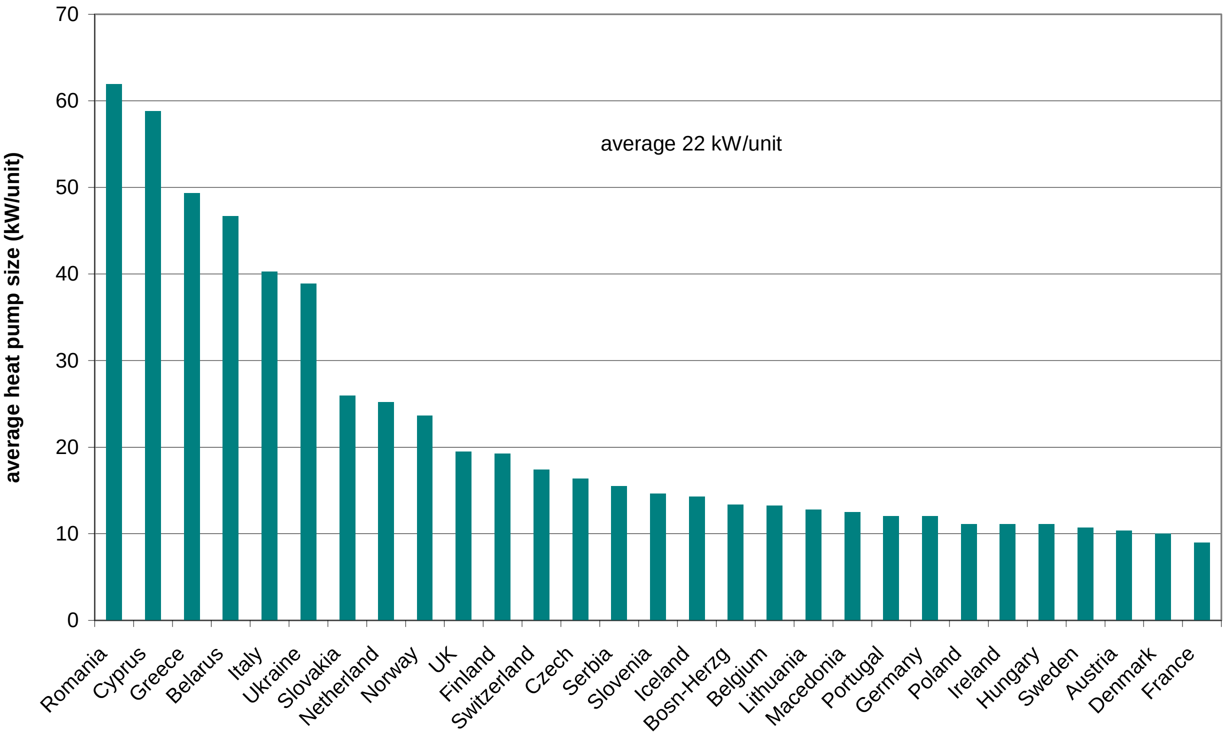


Figure 19: Visualisation of data on installed capacity and produced heat from table 4 (values for Denmark from WGC 2015)



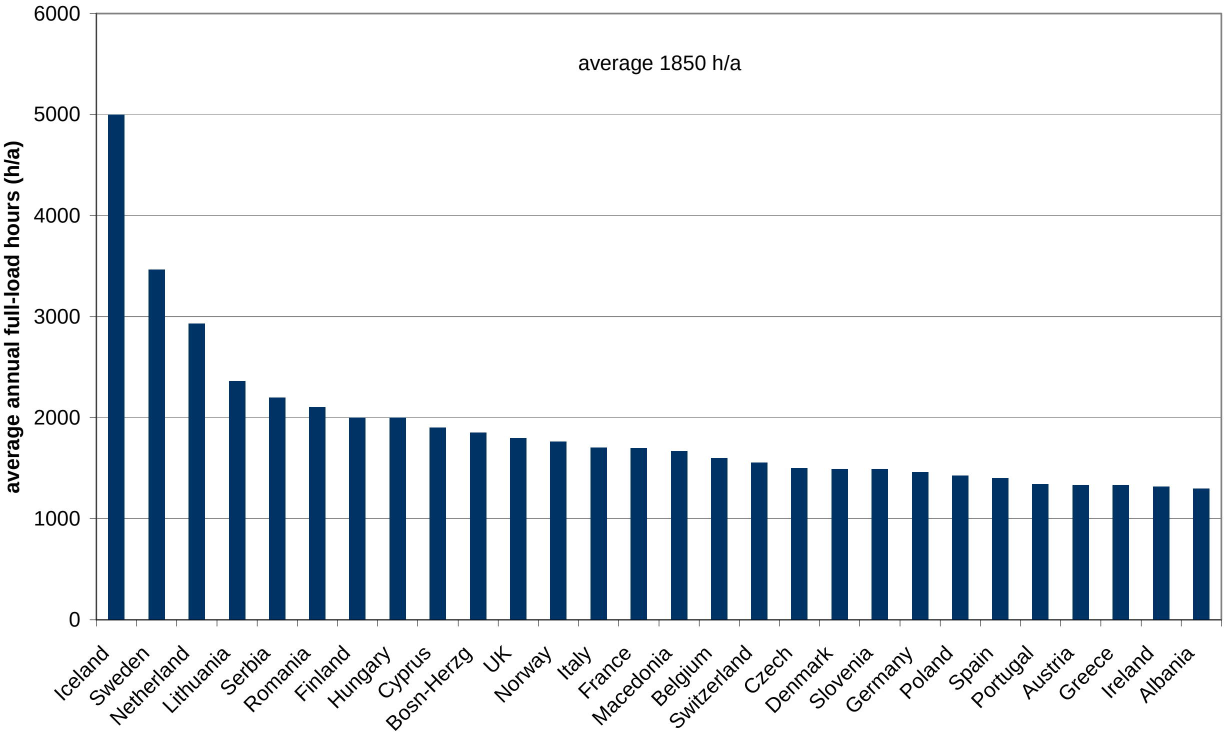


Figure 20: Average heat pump size (top) and annual full-load hours (bottom) for ground source heat pumps

- **concerning the size, there is no clear distinction of “unit”, being either a single heat pump, or several heat pumps installed together in one plant; this may account for the rather large “unit” size in some countries**
- **as to the full-load hours, a certain correlation with climate in the different regions of Europe can be seen, however, other factors seem to influence this parameter also**