Summary of EGC 2019 Country Update Reports on Geothermal Energy in Europe

Burkhard Sanner

EGC 2019 Country Update Report Coordinator,
European Geothermal Energy Council EGEC aisbl, 2, place du champ de mars, 1050 Brussels, Belgium

country.updates@europeangeothermalcongress.eu

Keywords: geothermal potential, geothermal power, geothermal direct use, geothermal heat pumps, policy, country update.

ABSTRACT

The European status of geothermal energy use by the year 2018 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 2960 MW_{el} installed capacity. The installed capacity of geothermal heating from medium to low temperature sources exceeds 10'600 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), there is still substantial growth, and a capacity of at least 26'900 MWth was achieved by the end of 2018, distributed over about 1.9 Mio GSHP installations.

32 country update reports were submitted (see table 1 at the end of this paper). The overall growth since the reporting for EGC 2016 is steady, with the notable exception of an increase of almost 29 % in installed geothermal power generation capacity, mainly due to activities in Turkey, where installed capacity has almost doubled to about 1280 MW_{el} at the end of 2018. In general, the statistical approach and classification as adjusted over the last reporting periods has proven suitable; again, in some cases this results in decrease in one category and increase in others.

1. INTRODUCTION

In most countries in Europa, geothermal energy is firmly established on the heat market, with shallow geothermal energy (GSHP) used in virtually all of Europe. Direct use of deep geothermal resources is more regionally concentrated, due to its dependence upon suitable geological settings, and is mainly used in the East/South-East of Europe, France, Germany, and some more. Recent development in Belgium and the Netherlands is very encouraging for increased direct use of geothermal energy. Geothermal power generation still is centred in few countries, with only Iceland, Italy and Turkey having substantial shares of geothermal power in the national electricity mix. Nevertheless, the list of geothermal power countries in Europe is steadily growing longer, with Croatia and Hungary as new entries since EGC 2016.

For the heating sector, the deep and shallow energy production combined still could reach the target for 2020 set forth in the Ferrara Declaration (EGEC, 1999), but additional efforts might be needed to actually achieve this. The installed electric power generation capacity from geothermal has almost reached the 2020-value already in 2018, due to the massive growth of geothermal power plants in Turkey, with about doubling of the installed capacity compared to three years ago. 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 typically represent the status in the year prior to the respective event.

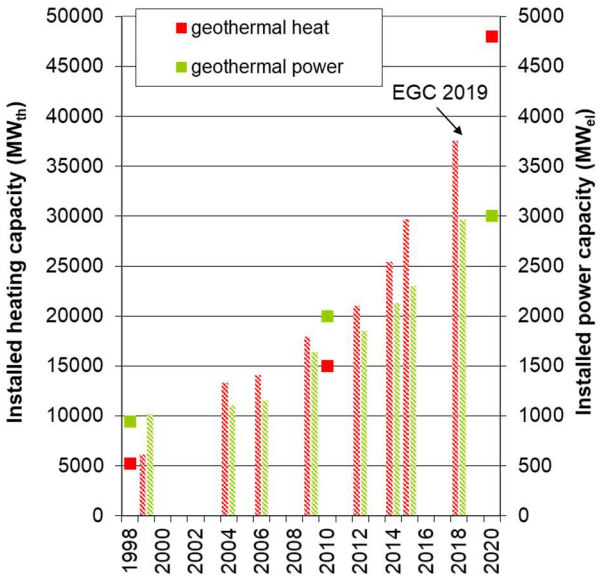

Figure 1: Comparison of installed capacity after Ferrara Declaration of 1999 (squares), and reported values (hashed columns).

The growth of geothermal electricity is also reflected in the shares the different sectors have in installed capacity in Europe. As can be seen in figure 2, the share of power generation capacity increased from 6.0 % to 7.3 % over three years, while deep geothermal direct use decreased in relation from 27.1 % to 26.2%. The largest share of about 2/3 of all capacity installed falls to shallow geothermal plants, almost stable above 66 %.

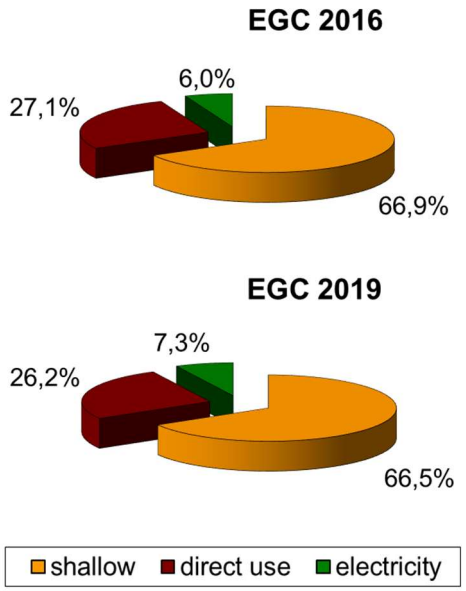

Figure 2: Share of installed capacity in the three geothermal sub-sectors in Europe as reported at EGC 2016 and EGC 2019

2. GEOTHERMAL POWER PRODUCTION

The implementation of geothermal power in Europe at the end of 2018 is listed in table 2, at the end of this paper. The number of countries having operational geothermal power plants slightly increased to ten, a number expected to further rise to 17 by 2025 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 3 shows the development as reported at the various WGC and EGC events since 1995, and the forecast to 2025. In electricity, the minimum target of the Ferrara declaration for the year 2020, set to 3000 MW_{el}, was almost met already in 2018 (cf. figure 1), and will most likely be surpassed in 2020. Due to many new installations, the average load factor is down to ca. 70 % in 2018, but can be expected to rise again once all plants are in full, routine operation with start-up problems fixed. And as in the past, some individual plants can report values of almost 100 %.

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 Turkey, the extraordinary growth over the last three years is apparent, and this country meanwhile has surpassed Italy, the previous leader in Europe. Installed capacity is steady on a high level in Italy, while annual production even slightly increased – a sign of higher load factors and improved availability of the plants. Iceland has not provided figures for EGC 2019, however, a stable, high-level installed capacity can be assumed; reporting for Iceland is expected for WGC 2020, to be held in Reykjavik next year. The interesting development in Turkey and Germany is shown separately in figure 5, highlighting the strong, seemingly exponential increase in geothermal power production in Turkey The improvement in load factor in Germany had a very positive effect on power production; statistical inaccuracies might be the reason for the anomaly in the values from EGC 2013 / WGC 2015.

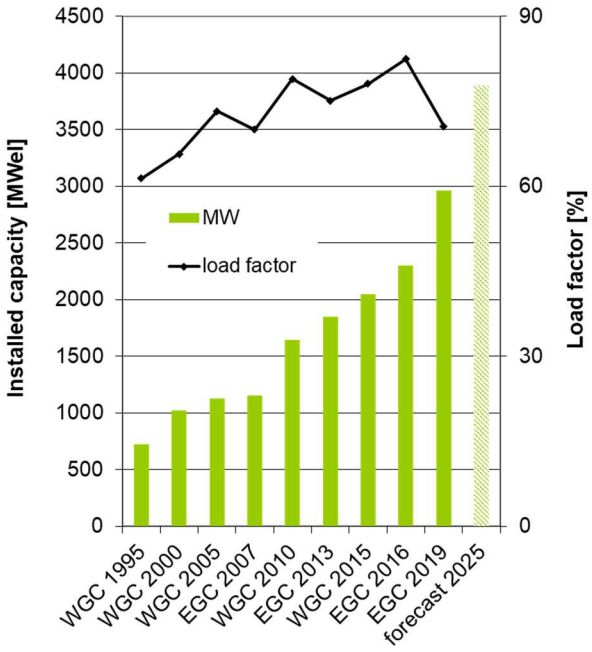

Figure 3: Installed capacity and average load factor for geothermal electricity in Europe as reported at various events, and forecast of installed capacity to 2025.

Figure 6 shows the installed capacity for the different countries as reported at EGC 2013, 2016 and 2019, and the values expected to be reached by 2025. It can be seen from this figure that the huge potential that EGS might offer (cf. Geoelec, 2013) is not reflected in the growth expectations up to 2025. Most reported and expected geothermal power production is based on the currently available high enthalpy resources and low-to-medium-temperature binary power plants. The growth beyond 2025 might look different; however, a massive development exercise for EGS would be required to make it happen.

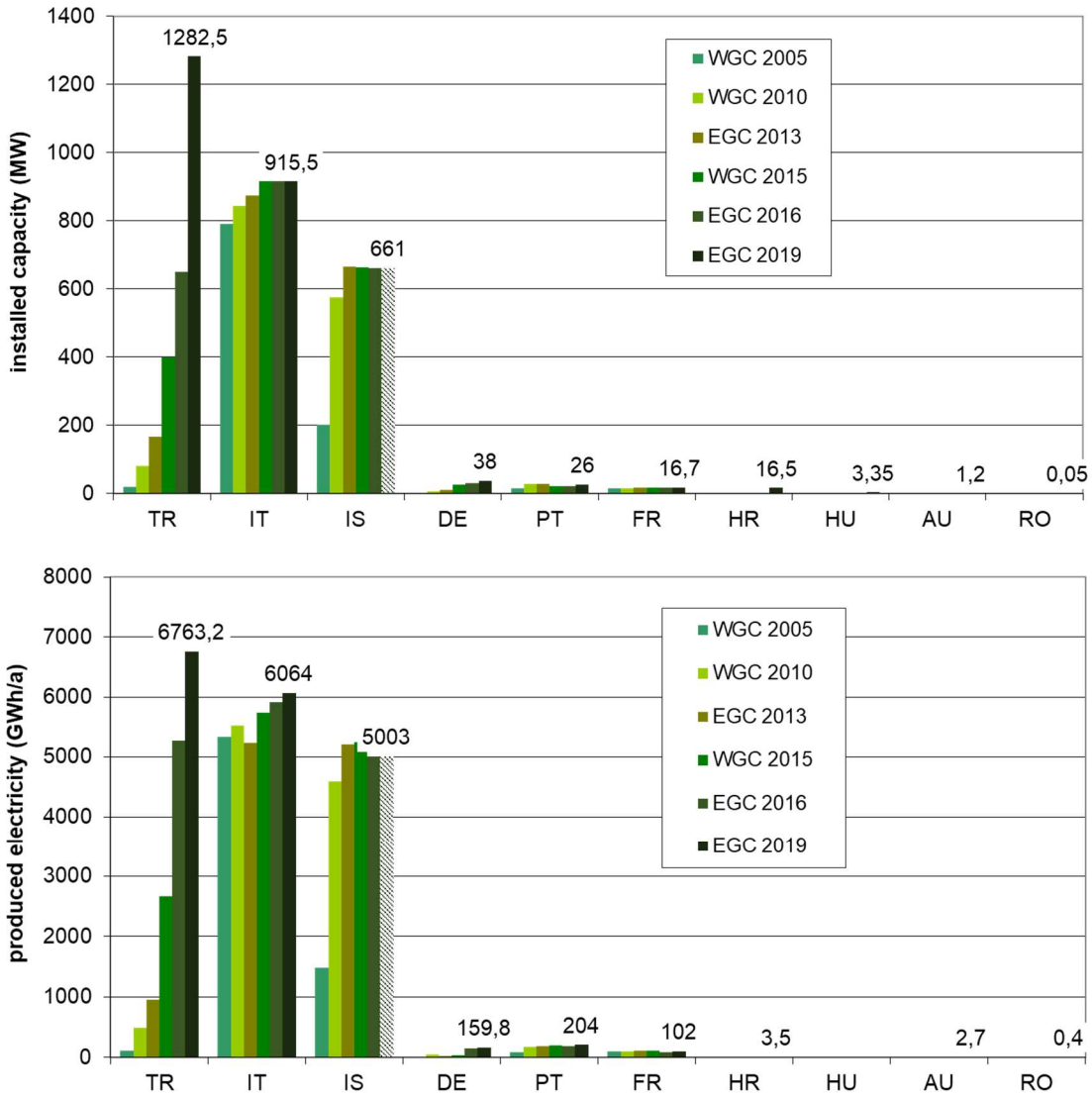

Figure 4: Installed geothermal power (top) and annual production (bottom) in Europe after country update reports since WGC 2005.

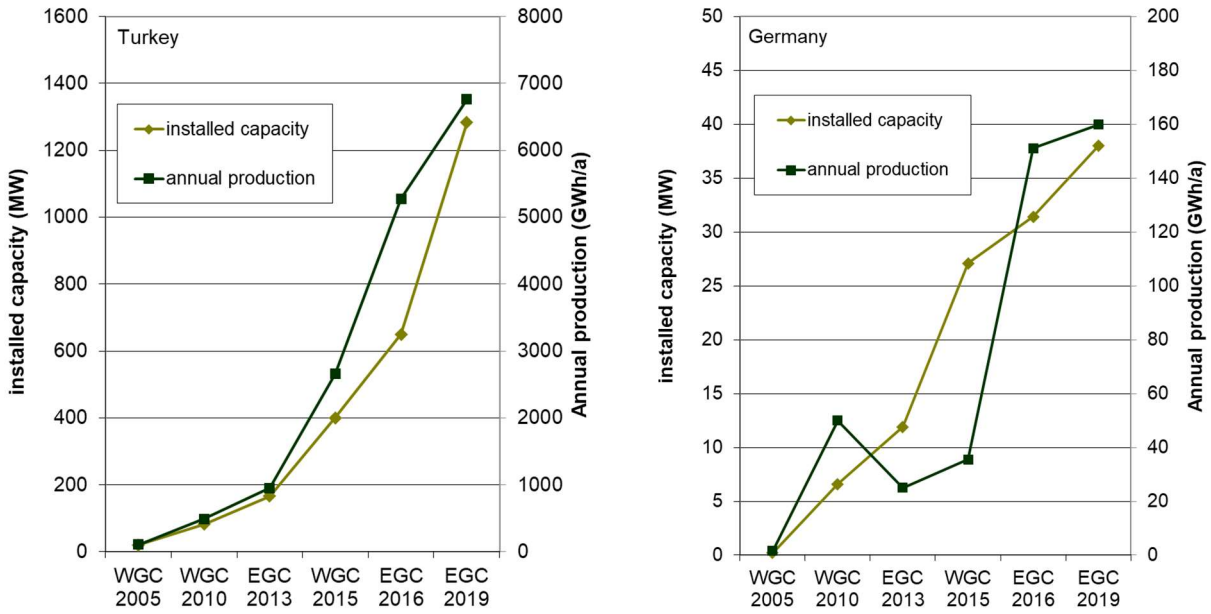

Figure 5: Development of installed geothermal power and annual production in Turkey (left) and in Germany (right), after country update reports since WGC 2005.

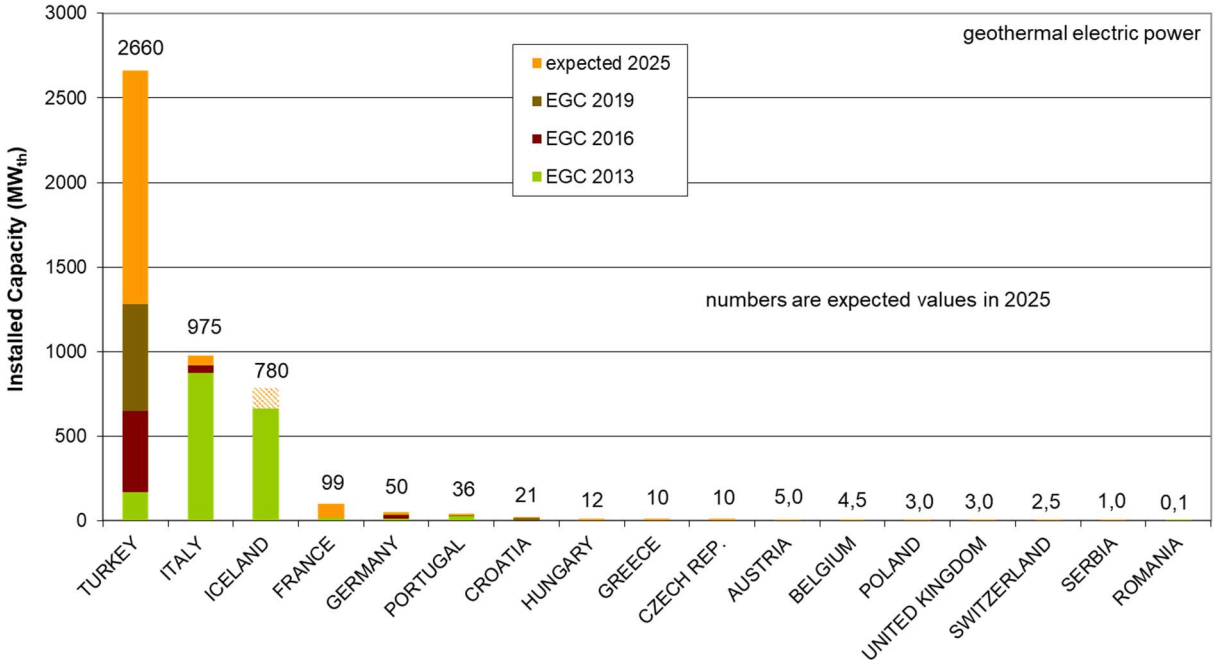

Figure 6: Installed geothermal power in Europe 2012-2018, after EGC 2013, 2016 and 2019, and reported expectations towards 2025.

3. GEOTHERMAL DIRECT USES

The reporting according to different types of use as attempted since EGC 2013 has proven feasible. With the adjustments as made for EGC 2016 kept also this time, a meaningful distinction between district heating and other type of use could be made (cf. remarks on country report tables at the end of this text). Even the amount of geothermal heat used in spas and balneology was mostly reported, albeit being difficult to determine. Figure 7 shows three examples of the distribution into the different sectors, highlighting the big differences that can be found. In Hungary, about 40 % of the geothermal heat goes to agriculture etc., and a quarter each to district heating and balneological applications, respectively. In Italy, heat for individual buildings and other applications is in the lead, with district heating accounting for only 11 %. In Germany 85 % of geothermal heat goes into district heating, and the rest mainly to balneology.

The reported values for 2018 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, Hungary, Slovakia and the Netherlands 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, Germany and Romania, district heating is the main use of geothermal heat.

Figure 9 is a synopsis of the values reported at EGC 2013, EGC 2016 and EGC 2019, and the forecast for 2025. 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, while Iceland definitely is the champion in geothermal coverage of national heat demand. Some countries report a substantial growth, which might be partly due to reporting of non-DH uses for the first time. The Netherlands, having had the lead in relative growth at EGC 2016 with 65 % per year, this time still has a remarkable value of about 62 %..

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 (cf. figure 2). The shallow geothermal share did increase from 63 % reported at EGC 2013 to >66 % in reporting for EGC 2016 and EGC 2019. It enjoys the widest deployment among European countries; the data for 2018 from the individual countries are summarised in table 4 at the end of this paper.

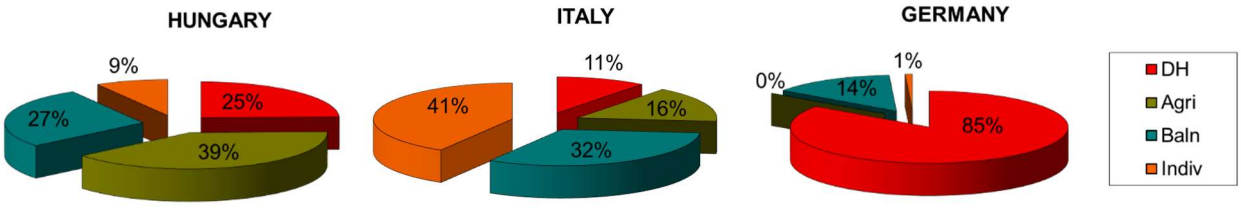

Figure 7: Share of installed capacity in district heating, agricultural uses, balneology and individual buildings in geothermal direct use in Hungary, Italy and Germany.

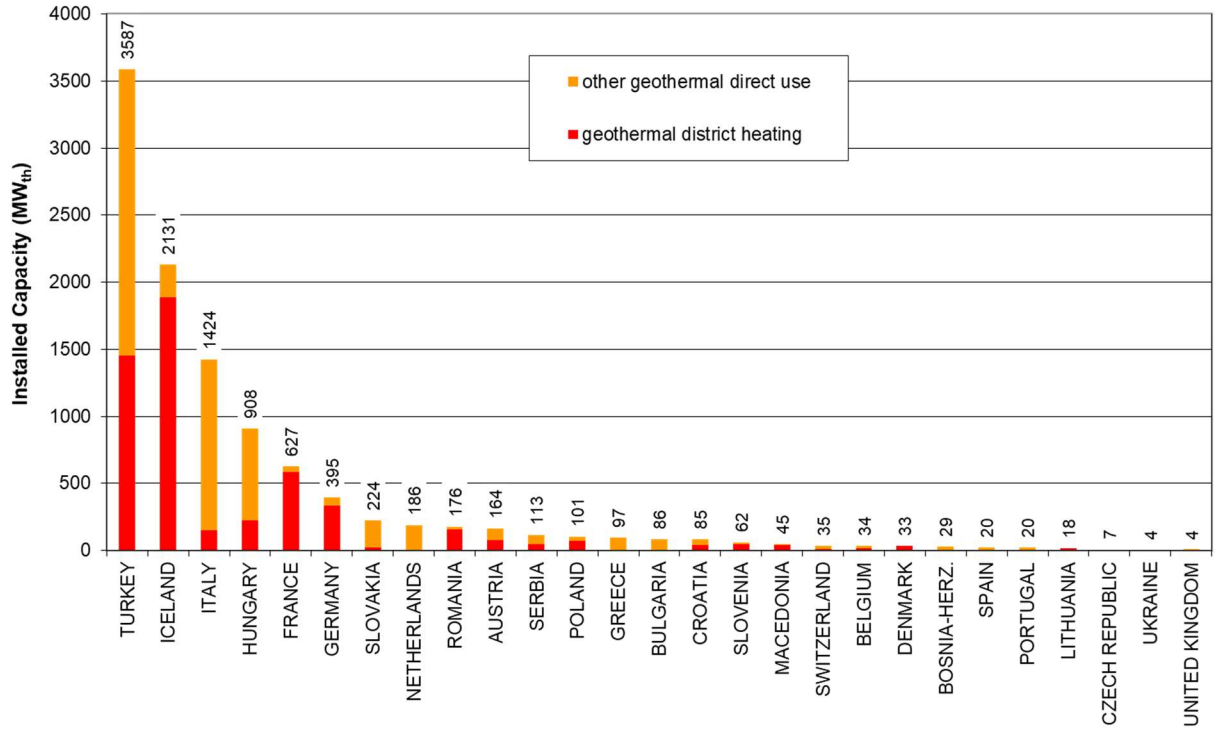

Figure 8: Installed capacity in geothermal direct use in Europe 2018, showing the share of district heating in the total direct geothermal use

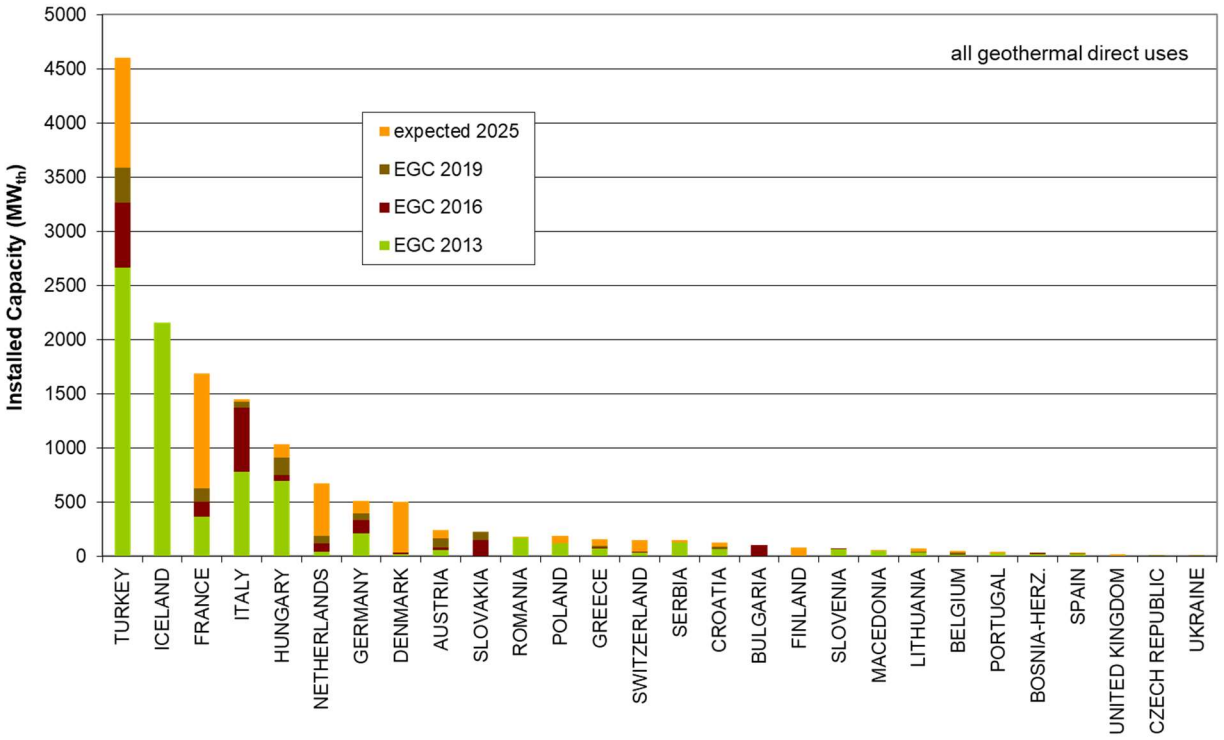

Figure 9: Installed capacity in geothermal direct use in Europe 2012-2015, after EGC 2013, 2016 and 2019, and reported expectations towards 2025.

The total number of geothermal heat pumps installed in Europe is close to 1.9 Mio units. The leader by far is Sweden, in particular when considering the number of less than 10 Mio inhabitants. Germany with a much larger population of almost 82 Mio comes in second, with about 2/3 of the number of Swedish GSHPs. Other important countries with more than 50'000 installations are France, Finland, Switzerland and Austria. Figure 10 shows the numbers of installed heat pumps 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 UK and Poland lead with a high ratio of new installations, exceeding 10 %. For countries with a large number of existing installations it is more difficult to achieve a high ratio of new sales, of course. Hence the value of 6.2 % of the stock achieved in Germany in 2018 is remarkable. The revised federal incentive programme (MAP), improved from mid-2015 on, and some regional incentives have lead to a reverse of the downward curve in the last three years; the full account of market development for GSHP in Germany is shown in figure 11. The sales in France had dropped drastically to only 1.9 % of the stock in the report three years ago at EGC 2016, and did decrease further to just 1.7 % now. Sweden lost the first place in annual sales numbers for the first time in an EGC report, with just 13'990 new units in 2018. Because in Northern Europe heat pumps with high capacity are among the sales, the newly installed capacity in Sweden in 2018 is similar to that in Germany, with about 250 MW each. The ratio of sales in respect to the existing stock in Sweden is 2.4 %, a value almost equal to that of Switzerland, the other European country with a high density of GSHP.

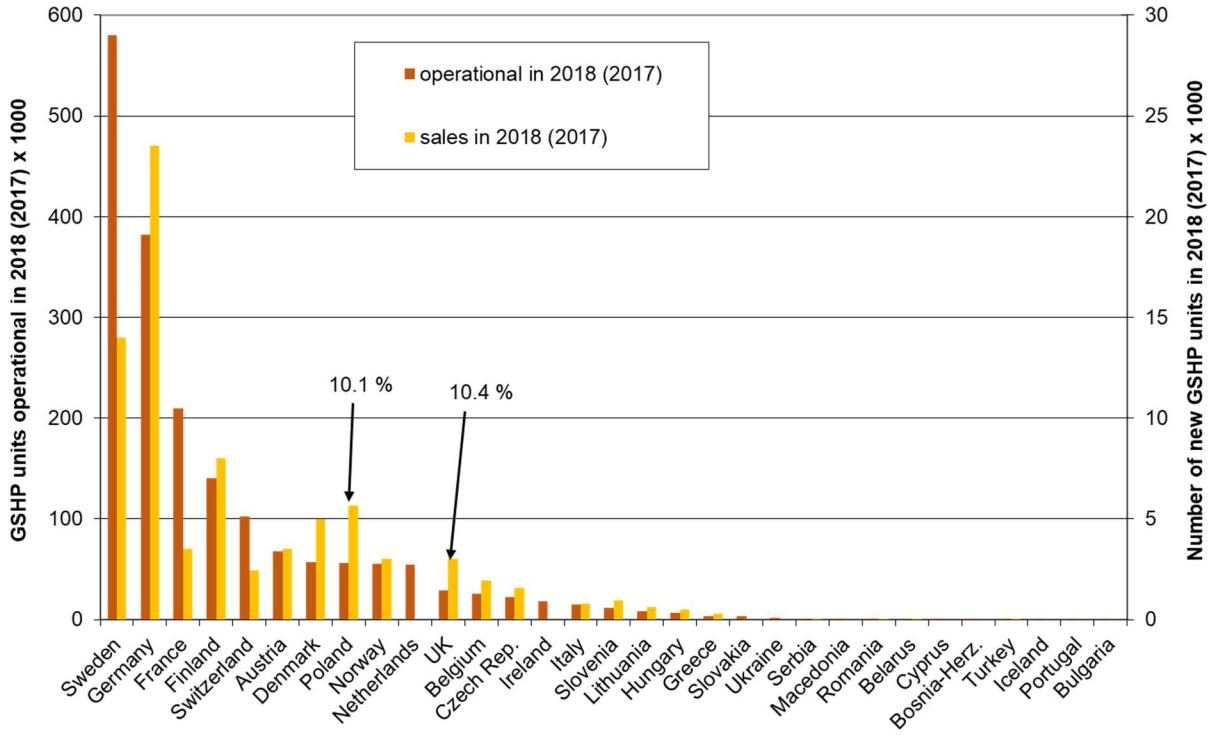

Figure 10: Total number of GSHP and sales in 2018 (some countries 2017) as stated in EGC 2019 country update reports; the ratio of sales in relation to existing installations is highlighted for Poland and UK.

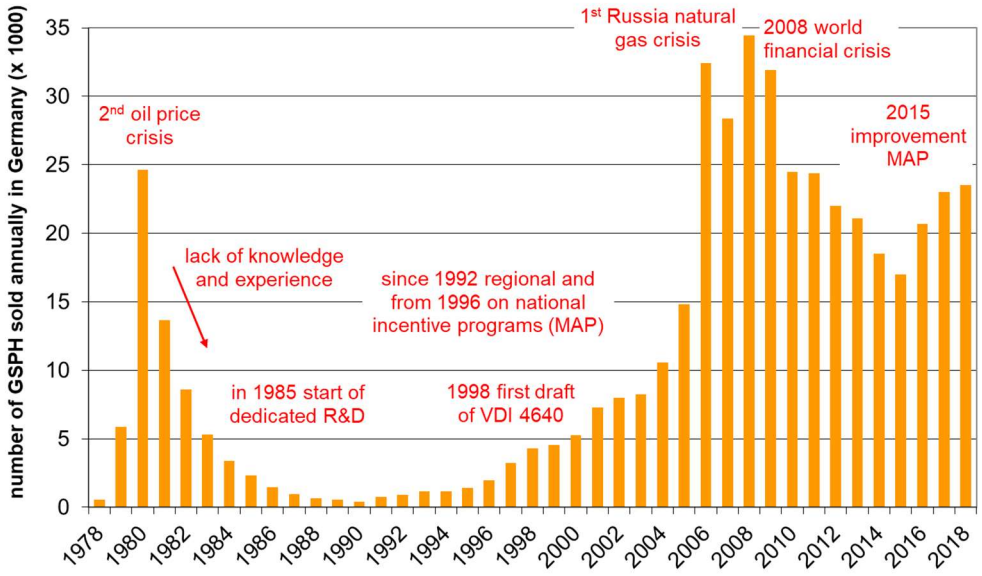

Figure 11: Development of GSHP-sales in Germany over 40 years, with drivers for growth and decrease (after data from BWP).

The reasons for the differences among the countries are manifold and can be attributed to energy prices, incentives, regulation, awareness, knowledge, but also active salesmen and installers, or to a kind of market saturation as might be encountered in Sweden and Switzerland.

The recent development and future perspectives for shallow geothermal in Europe can be seen from figure 12, where data from EGC 2013 and EGC 2016, the current values, and the expectations towards 2020 are shown in comparison. Sweden is again the country leading by installed capacity, followed by Germany, Finland, France and Switzerland. The Netherlands have shown a very dynamic development in the past years and are, together with Norway, among the countries with more than 1 GW_{th} of installed shallow geothermal capacity. Shallow geothermal energy is used also in some countries that did not report to EGC 2019 (Luxembourg can serve as a small, but interesting example here, with good growth and some large installations), and we can state that there is virtuallyt no country in Europe without some shallow geothermal installation.

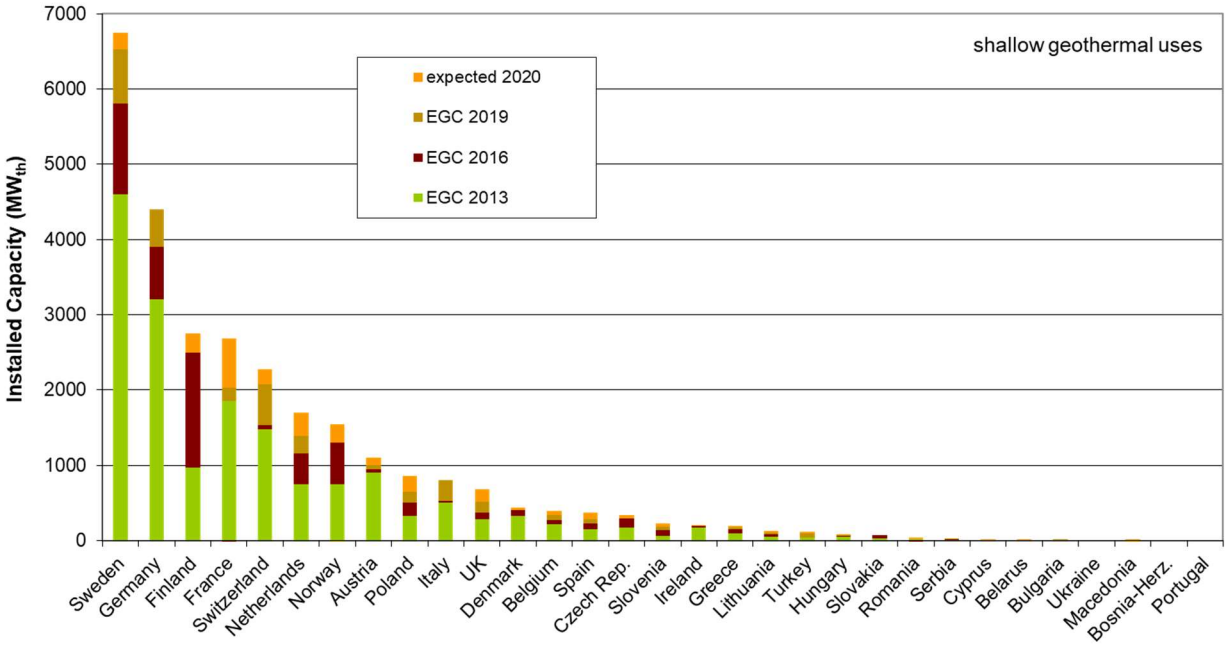

Figure 12: Installed capacity in geothermal heat pumps in Europe after EGC 2013, 2016 and 2019, and reported expectations towards 2020

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 11.5 billion € in 2018.

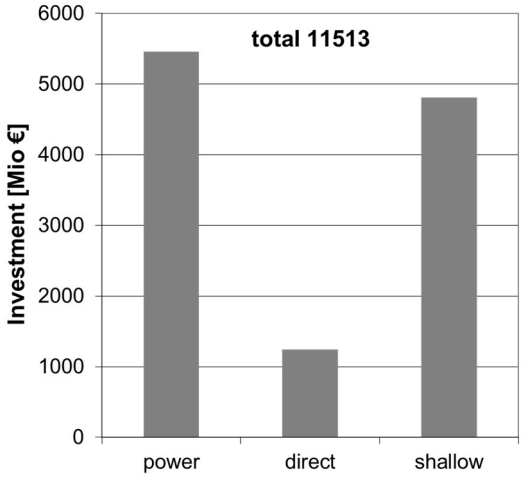

Figure 13: Investment in the different fields of the geothermal sector (only 24 of 32 countries reporting)

At EGC 2016 only 4.5 billion € where reported, albeit with some substantial players (Italy and Germany) missing. Nevertheless, the more than doubling of the number is breathtaking, and it is mainly due to the heavy investment in geothermal power in Turkey, reported to be 5.2 biliion € alone. Investment in geothermal power thus surpassed the traditional leader, shallow geothermal, this time.

For employment, we can state that at least 34'000 persons work in the geothermal sector, somewhat less than reported for EGC 2016 (36'000 persons). The shallow geothermal sector definitely dominates the workforce (fig. 14), with about 20'000 persons in Sweden, Germany and Finland alone. For geothermal power, Turkey is leading with 2000 persons. The true number of geothermal personnel in Europe will be definitely higher, considering the limited number of countries reporting, and partial sectoral reporting only in some cases.

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

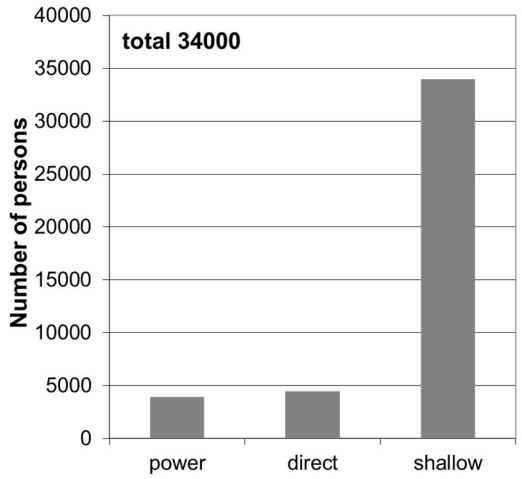

Figure 14: Number of persons working in the different fields of the geothermal sector (only 24 of 32 countries reporting)

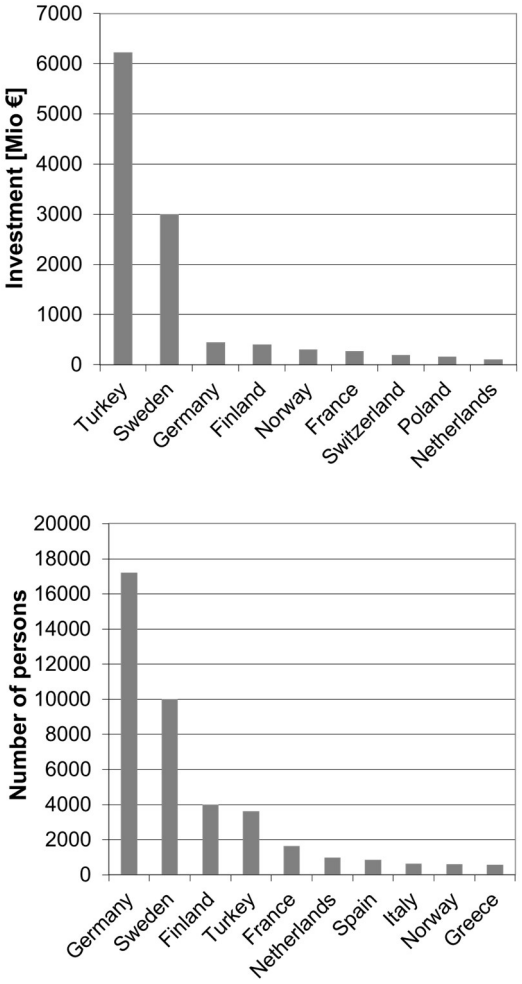

Figure 15: Total geothermal investment for countries with more than 100 Mio €/a (top) and personnel in countries with more than 500 geothermal workers (bottom)

6. CONCLUSIONS

In geothermal power, Turkey has strengthened its position as a new leader with very dynamic development, while the previous 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 did slightly increase to over 49 %. The distribution in individual countries can vary widely, as was discussed in chapter 3. The shallow geothermal sector has a steady development, with poor sales numbers in some countries (France), saturation on high level in others (Sweden, Switzerland), a good recovery of sales numbers in Germany, and high relative growth in places like Poland and the UK.

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 about 25 years. Thus the author encourages all readers to also study the individual country update reports that are part of the EGC 2019 proceedings.

REFERENCES

Antics, M. and Sanner, B.: Status of Geothermal Energy Use and Resources in Europe, *Proc. EGC 2007*, Unterhaching (2007), paper #082, 1-8

Antics, M., Bertani, R. and Sanner, B. (2013): Summary of EGC 2013 Country Update Reports on Geothermal Energy in Europe, *Proc. EGC 2013*, Pisa (2013), paper keynote-1, 1-18

Antics, M., Bertani, R. and Sanner, B. (2016): Summary of EGC 2016 Country Update Reports on Geothermal Energy in Europe, *Proc. EGC 2016*, Strasbourg (2016), paper K1, 1-16

Bertani, R. Geothermal Power Generation in the World, 2010–2014 Update Report. *Proc. WGC 2015*, Melbourne (2015), paper #01001, 1-19

EGEC: Ferrara Declaration / Dichiarazione di Ferrara. *EGEC Business Seminar Ferrara,* Brussels (1999), 1-2, www.egec.org

Geoelec: A prospective study on the geothermal potential in the EU, *D2.5, Geoelec*, Brussels (2013), 1-97

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

Acknowledgements

The author of this summary likes to sincerely thank all contributors to the country update reports for EGC 2019 (see table 1), who devoted considerable time and effort to research, verify and write the individual country papers. These papers, as available in the proceedings of EGC 2019, give a detailed account of geothermal resources, regulatory framework, actual use and potential future development in the individual countries, and enabled the author of this summary to once again endeavour in painting the overall picture of the development in Europe.

Remarks on the tables in the country reports

Here the comments on how tables A-G in the individual country update reports should have been filled in, as a reference to fully appreciate these data:

The tables A-G are intended for assisting in the comparison of the development in the countries. Please fill in as much detail as you have (where applicable). If there are no numbers, use estimations (please mark them as *est*.) or just simple words like many, more, few. In particular for tables F and G, just yes or no might be appropriate.

Explanation to tables A and B: "*Under Investigation*" comprises prefeasibility studies and exploration, incl. test drilling, typically up to 3 years; "*Under Development*" means resource development (drilling), engineering and construction, until routine operation starts

Explanation to tables C, D1 and D2: 'Geothermal district heating or district cooling' (Geothermal DH plants) is defined as the use of one or more production fields as sources of heat to supply thermal energy through a network to multiple buildings or sites, for the use of space or process heating or cooling, including associated domestic hot water supply. If greenhouses, spas or any other category is among the consumers supplied from such network, it should be counted as district heating and not within the category of the individual consumer. In case heat pumps are applied in any part of such a network, the also should be reported as district heating and not as geothermal heat pumps. An exception is for distribution networks from shallow geothermal sources supplying low-temperature water to heat pumps in individual buildings; systems of this kind should be reported in table E. For table D2, please give information on large systems only (>500 MWth); installations with geothermal source temperatures <25 °C and depth <400 m should be reported in table E.

Spas and pool are difficult to estimate and are often over-estimated. For calculations of energy use in the pools, be sure to use the inflow and outflow temperature and not the spring or well temperature (unless it is the same as the inflow temperature) for calculating the energy parameters, as some pool need to have the geothermal water cooled before using it in the pools.

Explanation to table E: 'Shallow geothermal' installations are considered as not exceeding a depth of 400 m and (natural) geothermal source temperatures of 25 °C. Installations with geothermal source temperatures >25 °C and depth >400 m should be reported in table D1 or D2, respectively. Distribution networks from shallow geothermal sources supplying low-temperature water to heat pumps in individual buildings are not considered geothermal DH *sensu strictu*, and should be reported in table E also.

Explanation to table F: Expenditures in installation, operation and maintenance, decommissioning. For personnel, only direct jobs: Direct jobs – associated with core activities of the geothermal industry – include "jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration". For instance, in the geothermal power sector, employment created to manufacture or operate turbines is measured as direct jobs.

Table 1: EGC 2019 country update reports.

Author(s)	Country
Goldbrunner, J., Goetzl, G.	Austria
Dubanevich, M., Zui, V.	Belarus
Lagrou, D., Petitclerc, E., Hoes, H., Dupont, N., Laenen, B.	Belgium
Samardžić, N., Hrvatović, H., Skopljak. F.	Bosnia and Herzegovina
Hristov, V., Deneva, B., Valchev, S., Benderev, A.	Bulgaria
Živković, S., Kolbah, S., Škrlec, M., Tumara, D.	Croatia
Michopoulos, A., Zachariadis, T.	Cyprus
Dědeček, P., Šafanda, J., Tym, A.	Czech Republic
Erbs Poulsen, S., Bjørn, H., Mathiesen, A., Nielsen, L. H., Vosgerau, H., Vangkilde-Pedersen, Th., Ditlefsen, C., Røgen B.	Denmark
Kallio, J.	Finland
Boissavy, C., Henry, L., Genter, A., Pomart, A., Rocher, P., Schmidlé-Bloch, V.	France
Weber, J., Born, H., Moeck, I.	Germany
Papachristou, M., Arvanitis, A., Mendrinos, D., Dalabakis, P., Karytsas, C., Andritsos, N.	Greece
Nádor, A., Kujbus, A., Tóth, A.	Hungary
Pasquali, R., Hunter Williams, T., Blake, S., McAteer, J.	Ireland
Manzella, A., Serra, D., Cesari, G., Bargiacchi, E., Cei, M., Cerutti, P., Conti, P., Giudetti, G., Lupi, M., Vaccaro, M.	Italy
Šliaupa, S., Zinevičius, F., Mazintas, A., Petrauskas, S., Dagilis, V.	Lithuania
Popovska-Vasilevska, S., Armenski, S.	Macedonia
Provoost, M., Albeda, L., Godschalk, B., van der Werff, B., Schoof, F.	Netherlands
Kvalsvik, K.H., Midttømme, K., Ramstad, R.K.	Norway
Kępińska, B.	Poland
Nunes, J.C., Coelho, L., Martins Carvalho, J., do Rosário Carvalho, M., Garcia, J.	Portugal
Gavriliuc, R., Rosca, M., Cucueteanu, D.	Romania
Oudech, S., Djokic, I.	Serbia
Fričovský, B., Černák, R., Marcin, D., Blanárová, V., Benková, K., Pelech, O., Fendek, M.	Slovakia
Rajver, D., Lapanje, A., Rman, N., Prestor, J.	Slovenia
Arrizabalaga, I., De Gregorio, M., De Santiago, C., García de la Noceda, C., Pérez, P., Urchueguía, J.F.	Spain
Gehlin, S., Andersson, O.	Sweden
Link, K., Siddiqi, G., Lupi, N.	Switzerland
Mertoglu. O., Şimşek, Ş., Başarir, N., Paksoy, H.	Turkey
Curtis, R., Law, R. Busby, J., Adams, C.	United Kingdom
Morozov, Y., Barylo, A.	Ukraine

Table 2: Geothermal Electric Power in Europe in 2018.

	2018 installed capacity	2018 electricity produced	2018 load factor	Inst. cap. expected 2025
	]MW_{el}]	[GWh_{el}/yr]	[%]	[MW_{el}]
Austria	1.2	2.7	25.7	5
Belgium				4.5
Croatia *	16.5	3.5	2.4	20.8
Czech Republic				10
France	16.7	102	69.7	98.7
Germany	38	159.8	48.0	50
Greece				10
Hungary	3.35		0.0	12
Iceland **	*661*	*5003*	*86.4*	
Italy	915.5	6064	75.6	975.5
Poland				3
Portugal	26	204	89.6	36
Romania	0.05	0.4	91.3	0.05
Serbia				1
Switzerland				2.5
Turkey	1282.5	6763.2	60.2	2658
UK				3
Total	2960.8	18302.6	average 70.6	3890.05

* low load factor due to plant operation starting late in 2018

** values for 2015

Table 3: Geothermal Direct Use in Europe in 2018.

	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]
Austria	75.7	224.7	17.0	69.6	2.4	20.6	69.0	218.4
Belgium	17.0	14.6	7.0	0.1			10.0	14.4
Bosnia-Herz.			0.8	0.1	11.7	12.0	16.5	47.2
Bulgaria			3.5	15.7			82.3	586.1
Croatia	42.3	44.7	6.5	10.	24.0	15.3	12.6	12.1
Czech Rep.	6.6	21.0						
Denmark	33.0	98.7						
France	586.2	1651.67	24.0	110.0	17.0	21.0		0.0
Germany	334.5	893.37			56.8	474.6	3.3	9.6
Greece			53.1	69.8	42.0	69.7	1.7	3.9
Hungary	223.4	635.7	358.1	803.1	249.5	745.5	77.2	83.1
Iceland *	1890.0	6651.0	60.0	228.0	72.0	420.0	109.0	377.0
Italy	149.0	237.0	229.0	791.0	456.0	972.0	590.0	1031.0
Lithuania	18.0	34.1						
Macedonia	42.6	106.0	2.8	12.5				
Netherlands			186.0	1011.0				
Poland	74.6	250.4	4.0	6.0	12.0	35.0	10.0	25.0
Portugal	2.1	15.0			17.1	85.9	1.0	7,0
Romania	158.0	300.0	8.0	50.0	10.0	12.0		
Serbia	47.7	153.8	11.6	62.5	36.7	186.3	16.8	78.0
Slovakia	21.9	41.0	45.3	74.9	107.7	301.0	49.0	69.2
Slovenia	46.9	124.4	8.7	25.0	4.3	6.4	2.5	4.9
Spain	2.9	2.4	14.9	26.2	2.6	14.6		0.0
Switzerland	11.9	35.7			23.2	129.8		
Turkey	1453.0	4600.0	820.0	2900.0	1205.0	6307.0	109.0	477.0
UK	3.0	14.8			0.6	3.0		
Ukraine	0.9				3.0			
Total	5241	16150	1860	6266	2351	9832	1160	3044

* values for 2015

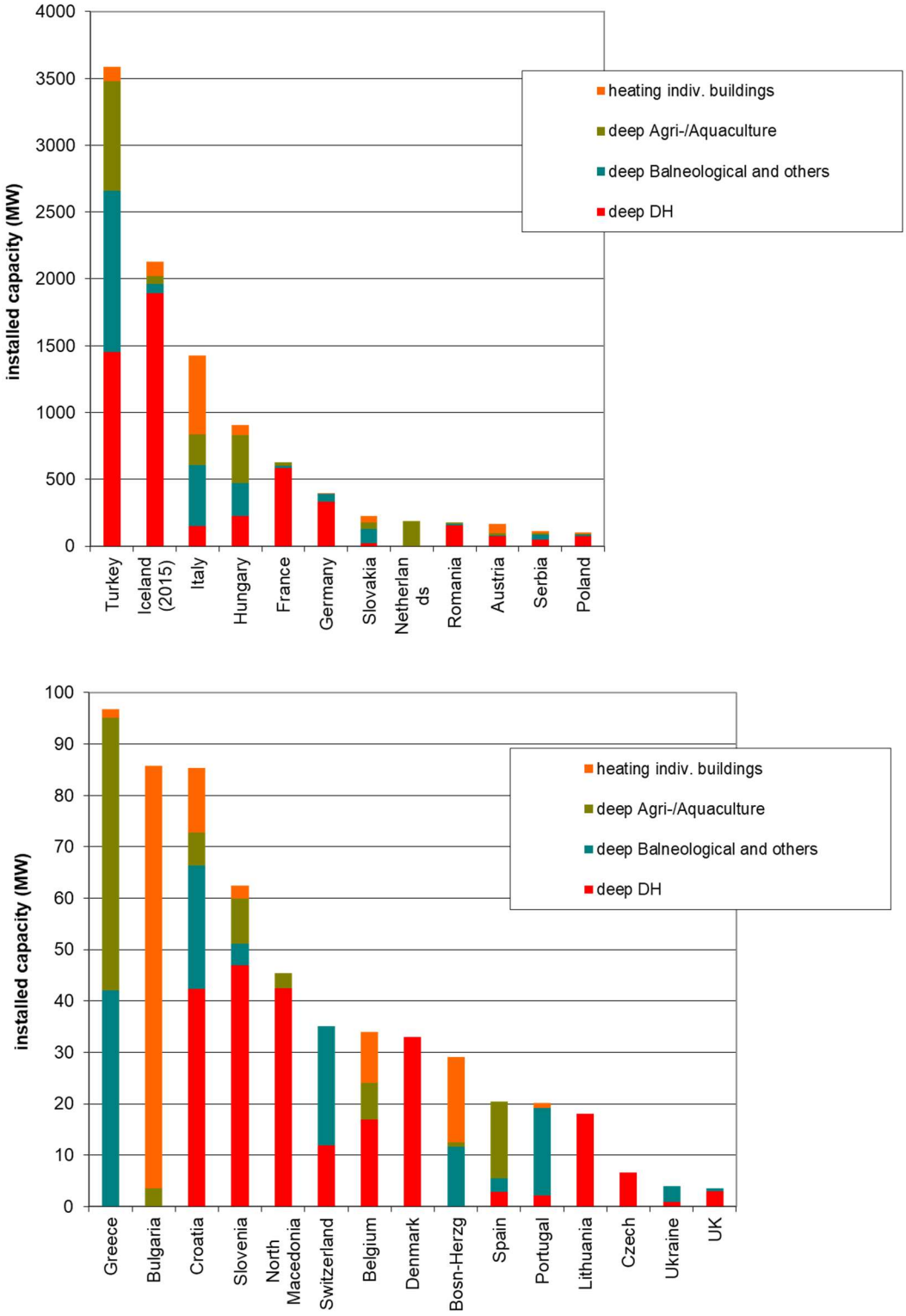

Figure 16: Visualisation of data on installed capacity from table 3, countries with high installed capacity (top) and countries with capacity <100 MW (bottom).

Table 4: Ground Source Heat Pump Use in Europe in 2018.

Country	Number of GSHP	Capacity [MW_{th}]	Production [GWh_{th}/year]	kW_{th} per unit	Full-load hours per year
				Data calculated by author of summary	
Austria	*83000*	1000.0	2500.0	*12*	*2500*
Belarus	250	9.0	7.0	*36*	*778*
Belgium	25622	338.6	544.4	*13*	*1608*
Bulgaria	8	5.5	14.8	*690*	*2671*
Cyprus	175	10.2	19.0	*58*	*1863*
Czech Rep.	22740	300.0	450.4	*13*	*1501*
Denmark	40000	400.0	597.7	*10*	*1494*
Finland	140000	3000.0	6000.0	*21*	*2000*
France	210000	1980.0	3360.0	*9*	*1697*
Germany	382000	4400.0	6600.0	*12*	*1500*
Greece	3300	175.0	383.0	*53*	*2189*
Hungary	6500	72.0	144.0	*11*	*2000*
Iceland *	70	1.0	5.0	*14*	*5000*
Ireland	18092	200.0	260.3	*11*	*1301*
Italy	15000	745.0	1270.0	*50*	*1705*
Lithuania	8729	110.2	255.0	*13*	*2314*
Macedonia	500	1.3	10.5	*3*	*8400*
Netherlands	67820	2775.0	3052.0	*41*	*1100*
Norway	55000	1023.0	4103.0	*19*	*4011*
Poland	56000	650.0	860.0	*12*	*1323*
Portugal	54	0.7	0.9	*12*	*1340*
Romania	307	19.0	40.0	*62*	*2105*
Serbia	1000	15.6	34.4	*16*	*2204*
Slovakia	3012	78.1		*26*	*0*
Slovenia	11770	185.0	260.64	*16*	*1408*
Spain	*16000*	192.7	289.04	*12*	*1500*
Sweden	580000	6520.0	22950.04	*11*	*3520*
Switzerland	102520	2077.8	3610.44	*20*	*1738*
Turkey	146	100.5	880.4	*688*	*8760*
UK	28800	520.0	936.0	*18*	*1800*
Ukraine	1500	18.0		*12*	*0*
Total	1’880’304	26923	59438	*average 21* **	*average 2250* **

* valus for 2015

** in calculation of average unit size, Bulgaria and Turkey have not been considered, and for full-load hours North Macedonia was not included.