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Geothermal Energy Use, Country Update for Austria

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ABSTRACT

During the current time period only one new geothermal project was carried out in Austria. For the very successful Frutura project (highest production temperature in Austria so far) two deep geothermal boreholes have been drilled in the Styrian Basin in 2014 with a total length of 6.5 km for the thermal heat supply of greenhouses.

The electrical power production from geothermal declined in general. The ORC unit at Simbach-Braunau has been dismantled.

The city of Vienna is currently developing a comprehensive exploration concept for hydrogeothermal utilization in the greater Vienna area. Resuming of drilling operations is not expected before 2020.

The number of ground source heat pumps still shows a steady increase. The total number of units based on DHE is estimated as high as 70,000 having a capacity of 840 MWth and 1,386 GWh/yr based on sale figures provided by heat pump suppliers.

1. INTRODUCTION

Deep geothermal exploration in Austria (area 83,871 km², 8.7 million inhabitants in 2015) mainly takes place in the Molasse Basin of Upper Austria and the Alpine–Carpathian intra-mountainous basins (Styrian Basin; to a minor extent in the Vienna Basin) and the Pannonian/Danube Basin (Figure 1).

While the first balneological applications can be traced back until Roman times (e.g. Baden near Vienna or Warmbad Villach, Carinthia), hydrogeothermal utilization for heating purposes has commenced in the late 1970s at Bad Waltersdorf (Styrian Basin) and Geinberg (Upper Austrian Molasse Basin). Table 1 lists the deep drilling projects in Austria for the period 1977 to 2015. During the time period between 1986 and 2005 a remarkable development in the field of geothermal drilling projects took place in Austria with its focus on the Styrian Basin and the Upper Austrian Molasse Basin. In the 1990s drilling activity also comprised the Eastern Alpine region, mainly for balneological purposes associated to skiing resorts. The complex alpine tectonics and the lack of reliable results of geophysical survey caused a significant number of non-successful drilling projects in this area (Figure 2).

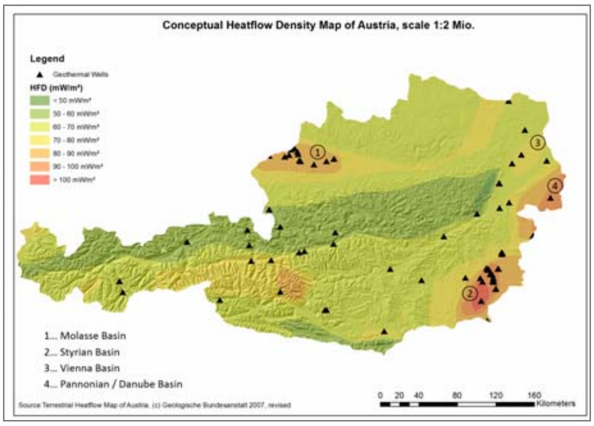

Figure 1: Overview on the deep wells and thermal springs in the Terrestrial Heatflow Density Map of Austria.

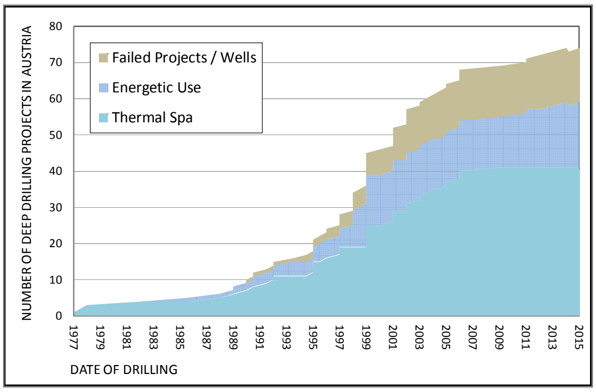

Figure 2: Geothermal drillings in Austria for the period 1977 - 2015.

In the beginning of the geothermal utilization in Austria mainly abandoned hydrocarbon wells were used for development of hydrogeothermal projects. Intense exploration for hydrothermal energy started in Austria in the 1990s after joining the European Union, where the access to EU funding boosted many projects which have been resting on the shelf for many years.

Since 2005 a period of moderate development to stagnation is observed for both, balneological as well as technical/industrial use. As for balneology, this trend is caused by a market saturation in the well-developed balneological regions of Austria (Styria, Burgenland and Upper Austria). Climate change and the resulting reduction of snow coverage in Alpine ski resorts led to an increased exploration activity in this region due to Economic pressure. Only a few of the successful bores lead to the development of spa and leisure resorts (Längenfeld in Tyrol and Kaprun in Salzburg).

Table 1: Geothermal drillings in Austria (period 1977 – 2015).

Unit	Total number of wells	Cumulative depth [m]
Styrian Basin	28	48.100 m
Upper Austrian Molasse Basin	13	28.236 m
Vienna Basin and Lower Austrian Molasse Basin	8	12.605 m
Northern Calcareous Alps and Upper Austroalpine Units (mainly carbonate rocks)	7	14.802 m
Lower, Middle and Upper Austroalpine Units (mainly crystalline rocks)	18	24.618 m
Pannonian Basin	1	860 m
Total	**75**	**129.221 m**

Considering direct use for heating purposes, Austria has lost its leading role in central Europe from the late 1990s and moved to the mid-table of direct geothermal use in Europe. In addition, the current legal and financial framework in Austria hinders a significant development in that field. In contrast to many other European countries like Germany or the Netherlands, the legal framework in Austria was not adapted in order to establish geothermal claims or to provide sound incentives for development of market. As a consequence of this, the total installed capacities of direct use are more or less stagnant since 2005, whereas windfarms, solar plants and photovoltaic systems boomed due to financial state subsidies. Moreover, the exploration well for a large-scale district heating project in Vienna, drilled in 2013, was not successful from a hydrogeological point of view (see chapter 2.3). As consequence an extensive exploration program was started in order to assess the complex tectonic setting of the Pre-Neogene subsurface of the Vienna Basin to minimize the drilling risks.

Regarding Enhanced Geothermal Systems, no activities can be reported for Austria. EGS is currently far behind the political scope. This also holds true for use of hydrogeothermal resources for the generation of electric power, which is currently at a feed in tariff level of 7,43 Cent per kWh (source: OESET-VO 2016).

The current state of shallow geothermal use will be discussed in chapter 3.

2. HYDROGEOTHERMAL USE

2.1 General Overview

The general geothermal conditions in Austria are affected by the Alpine orogeny and its tectonic implications as well as by the influence of the crustal thinning in the Pannonian Basin and its Subbasins. As shown in Figure 1, the well-developed regions of direct hydrogeothermal use in Austria coincide with enhanced terrestrial heat flow and wide spread reservoirs systems. The most relevant hydrogeothermal regions in Austria are outlined in Figure 1 and roughly characterized in Table 2.

Table 2: Overview of hydrogeothermal regions in Austria.

Region	*Geothermal Settings*	*Hydrogeological Settings*	*Current Use and Future Options*
Molasse Basin (Upper Austria)	Enhanced heat-flow due to hydro-dynamic convection	Wide spread reservoir system of low mineralization (Upper Jurassic Malm system) in the central and northern part. Poorly known reservoir (Malm) in the southern part at higher level of mineralization.	Well developed in the northern part of the reservoir system, southern part not used yet.
Molasse Basin (Lower Austria)	Locally confined enhanced heat-flow due to hydrodynamic convection	Locally confined carbonates (Upper Jurassic Malm system) and wide spread clastic reservoirs (Middle Jurassic Dogger); enhanced mineralization.	Not developed yet due to low density of users. single balneological use.
Styrian Basin	Regionally enhanced heat-flow due to thinning of the crust and hydro-dynamic convection	Locally confined Miocene (clastic) and Devonian (carbonatic) reservoirs; varying degree of mineralization.	Well developed for most reservoirs.
Vienna Basin	Moderate heat-flow due to deposition of sediments. Locally confined enhanced heat-flow due to hydro-dynamic convection.	Several reservoirs in Austroalpine carbonate rocks; minor reservoirs in Miocene clastic sediments.	Not developed yet due to non-success of a large scale project.

The individual balneological projects in the Austrian share of the Pannonian Basin as well as in various Alpine regions are generally not linked to wide spread or significant hydrogeothermal reservoirs and will not be discussed in this paper.

In the following subchapters, the most relevant hydrogeothermal regions will be presented based on selected projects and studies.

2.2 Molasse Basin

Project Geomol

The recently accomplished transnational project GeoMol (2013–2015), financed by the ERDF program Alpine Space, aimed at the description and visualization of subsurface geo-potentials in the Molasse basin and its pre-tertiary subsurface in various regions between France and Austria (www.geomol.eu). Unfortunately, the share of the Molasse basin covered by the Czech Republic could not be included for administrative reasons related to the funding program.

Based on published geological data (cross-sections, maps and formation tops observed in wells) and interpreted seismic data from the hydrocarbon industry, geological 3D models have been established for 11 significant stratigraphic units (Diepolder, 2015).

Based on the geological models a conductive 3D geothermal model of the trans-boundary focus region at Upper Austria and Upper Bavaria has been generated using the software code FEFLOW. The model considered annual mean surface temperatures and the basal heat-flow density derived from Przybycin et al (2014).

Figure 3 shows an example of the elaborated temperature models based on a combined geological and geothermal cross-section through the Molasse basin in Upper Austria. The light blue line represents the base of the Upper Jurassic Malm carbonates (JU). The Figure clearly shows a convection driven positive temperature anomaly at the Jurassic and Cretaceous units leading to enhanced geothermal conditions. The most favourable conditions (modelled reservoir temperatures slightly above 100 °C) have been modelled in the area of the currently developed hydrogeothermal project Ried-Mehrnbach.

Project Ried Mehrnbach

The geothermal district heating project Ried-Mehrnbach in the district town Ried im Innkreis started in 2011 and was presented for the first time in the last country update (Goldbrunner and Goetzl, 2013).

Two wells of the geothermal doublet (Mehrnbach Th 1/1a and Th 2) were drilled to the Malm aquifer in the period of 2011 to 2013.

Mehrnbach Th 1/1a targeted the down-thrown block of the Ried fault and tapped the Malm aquifer (in a side-track) at 2,354 m and penetrated the whole thickness (245 m) of Malm carbonate rocks (limestones and dolomites), some 20 m of Basal Sandstone and finally reached the top of the crystalline basement at 2,598 m.

The second well (Mehrnbach Th 2) was situated at the up-thrown block of the Ried fault some 1,300 m apart from Mehrnbach Th 1/1a. The bore encountered the Malm carbonate rocks at a MD of 2,026 m (TVD 1,704 m) and penetrated some 263 m (147 m) of fractured and carstified dolomites and dolomitic limestones. It entered the crystalline basement at 2,332 m MD (1,876 m TVD).

From October to December 2012 a combined pumping and reinjection test was performed using Mehrnbach Th 1/1a as a production well and Mehrnbach Th 2 for injection. The production temperature was 105 °C at a flow rate of 64 l/s. Upon detection of pressure reductions in Bavarian balneological wells some 16 km from Mehrnbach the function of the boreholes was reversed now using Mehrnbach Th 2 as production well and Mehrnbach Th 1/1a for reinjection.

The trial operation of the geothermal doublet started in February 2014 (Goldbrunner, 2015). Due to a high acceptance the district heating project is economically successful. The targeted installed thermal power for the project is as high as 28 MW. Preparatory work began in early 2016 to sink a third well at the end of the year to hedge the geothermal production.

2.3 Styrian Basin

Project Frutura

Since the previous country update in 2013 only one large geothermal project was carried out in Austria. The project Frutura intended the heat supply of greenhouses (24 ha of greenhouses) and was developed with great success in the Eastern Styrian Basin (Goldbrunner, 2015). In 2014 two boreholes were drilled some 4 km south of Bad Blumau, where geothermal energy is used for power generation and heating since the year 2000.

Both boreholes targeted the aquifer in the dolomites and limestones of the pre-Neogene basin floor. The first well (Frutura GT1; Figure 4) met the dolomitic aquifer at 2,875 m MD and reached an end depth of 3,279 m. Extrapolated BHT is 143 °C.

The second well of the geothermal doublet (Frutura GT2) was finished by end of July 2014 reaching the total depth of 3,300 m. First pumping tests showed excellent aquifer properties for this well. With this knowledge it was decided to perform a side-track in the well GT 1 to cope with the high transmissivities of well GT 2. The operation was being prepared by VSP measurements which revealed the structural situation thus enabling to tap similar transmissivities in GT1a as in GT2.

A production and reinjection test of three months in winter 2014/2015 demonstrated the suitability of the doublet for the heat supply of the greenhouse project. The associated CO_2 (gas-water ratio 12:1; flow volume water 60 l/s) will be partly used for growing tomatoes.

2.4 Vienna Basin

As described in detail in the last country update 2013 (Goldbrunner and Goetzl 2013), the non-successful hydrogeothermal well Essling Thermal 1 led to a new understanding of the complex tectonic situation at the Austroalpine units, located at the basement of the Vienna Basin in the eastern city aere of Vienna. The geological results from the well Essling Thermal 1 (see also Goldbrunner & Goetzl 2013) were used to elaborate a new tectonic concept for the basement of the Vienna Basin in this region. The complex tectonics of the Pre-Neogene subsurface is shown in Figure 5.

It is assumed, that the northern frontier of the so called "Goeller" nappe system allocated to the Austroalpine units, which bears the most relevant hydrothermal reservoirs, is split into several blocks. These are separated by softer but impermeable rocks (e.g. Gosau sediments or anhydrites and clays of the Werfen Unit). Figure 3 also shows the drilling path of the geothermal well Essling Thermal 1/1a, which tightly missed the Hauptdolomit reservoir (unit 20 in Figure 3) and remained in tight Gosau sediments (unit 13 in Figure 3).

2.5 Estimation of the total hydrogeothermal potential in Austria

In the past years several studies have been performed in order to estimate the hydrogeothermal potential in Austria. The reported potentials are given in different levels of precision. For comparison reasons all reported potentials were assigned to the nomenclature of the Canadian Geothermal Reporting Code (Deibert et al 2010).

The internal project "OMV-Thermal" (funded by OMV AG, 2010 – 2012) aimed at the estimation of the hydrogeothermal potential in the Vienna Basin and its adjacent regions including the Molasse zone in Lower Austria. The Geological Survey of Austria was analysing "Measured Resources" based on observed inflow of thermal water in hydrocarbon exploration wells. The observed water inflow was assigned to geological units and converted to an estimation of Measured Resources based on assessed reservoir parameters. Finally, the calculated single resources per well were summarized to geological units.

The project "Transenergy" (Interreg Central Europe, 2011 - 2013) investigated technical hydrogeothermal potentials at different levels of confidence based on geological models and wellbore information based on hydrocarbon exploration for the Vienna Basin. In total 5 hydrogeothermal reservoirs have been identified predominately consisting of Mesozoic carbonates of the Austroalpine nappe systems. In addition, two clastic Miocene reservoirs have been identified for hydrogeothermal use. One clastic reservoir is located in the Austrian part of the Vienna Basin (Aderklaa conglomerate), the other reservoir is located in Slovakia (Ottnangian deltafront sediments). At Transenergy, the highest level of confidence is represented by the so called "Measured Resources", which were derived by sum-up of observed thermal water inflow and related reservoir parameters at hydrocarbon exploration wells in the Vienna Basin. Further information on the outcomes of Transenergy can be found at http://transenergy-eu.geologie.ac.at.

In 2013 an internal study at the Geological Survey of Austria was performed in order to estimate the hydrogeothermal potential at the level of "Inferred Resources" for the city of Vienna. The estimation of resources was applied on 6 hydrogeothermal plays inside the city of Vienna. All plays are represented by carbonates located inside the Mesozoic Austroalpine nappe systems. The estimation of Inferred Resources was basing on assumed heat recover factors in the range between 1% (worst case scenario) and 15% (best case scenario) and different levels of a technical reference temperature (between 55°C and 90°C).

The project "GeoEnergie2050" (KLIEN - Klima- und Energiefonds des Bundes, project no. 834451, 2012 - 2014) gives a conservative estimation of the available potentials by applying a source – user matching approach. Reservoirs which fulfill general hydrogeothermal criteria (e.g. minimum temperatures and minimum transmissivity) were matched with the surface heat demand. The calculated hydrogeothermal potential has to be understood as a matched capacity and reflects the estimated heat demand on the surface based on the existing infrastructure. Different outcasts have been made for 2020 and 2050 assuming different maximum drilling depths (<6.000 meters until 2020 and >6.000 meters after 2020). In this paper the estimated potential has been taken from the matched capacity of well-known reservoirs (so called "realistic potential") for 2020. Further information about this project can be found in Könighofer et al (2014).

Table 3 shows the summarized hydrogeothermal potentials at the different levels of confidence. Those different studies delivered total hydrogeothermal potentials for the prospective regions between at least 264 MW_{TH} (only Vienna at Inferred Resources level) and at least 668 MW_{TH} (Vienna Basin and Molasse zone in Lower Austria at Measured Resource level). A quite conservative calculation of the Probable Reserves only accounting for the estimated future heat demand of existing settlements delivered a total hydrogeothermal potential for Austria of 451 MW_{TH}. None of the above mentioned studies has quantified the hydrogeothermal potential for the production of electric power.

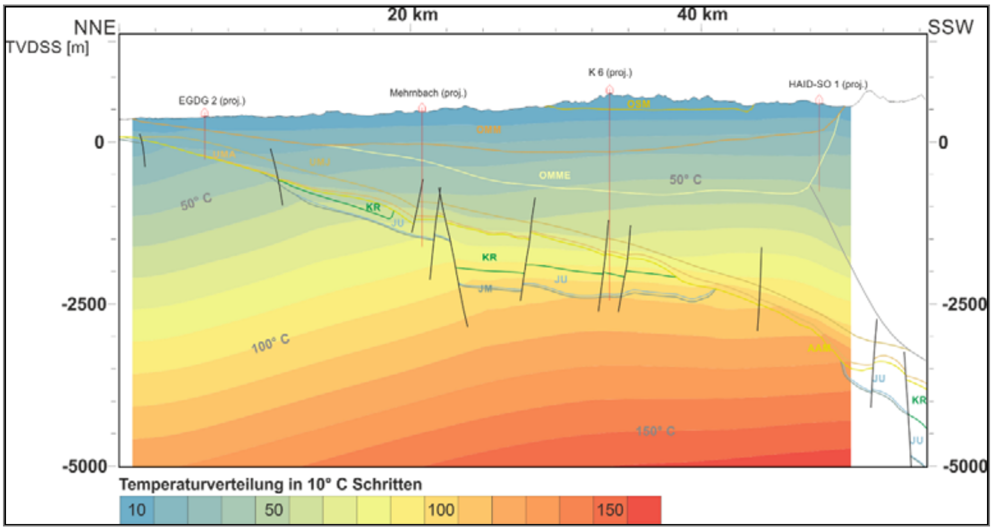

Figure 3: Combined geological – geothermal cross section through the Molasse basin in Upper Austria.

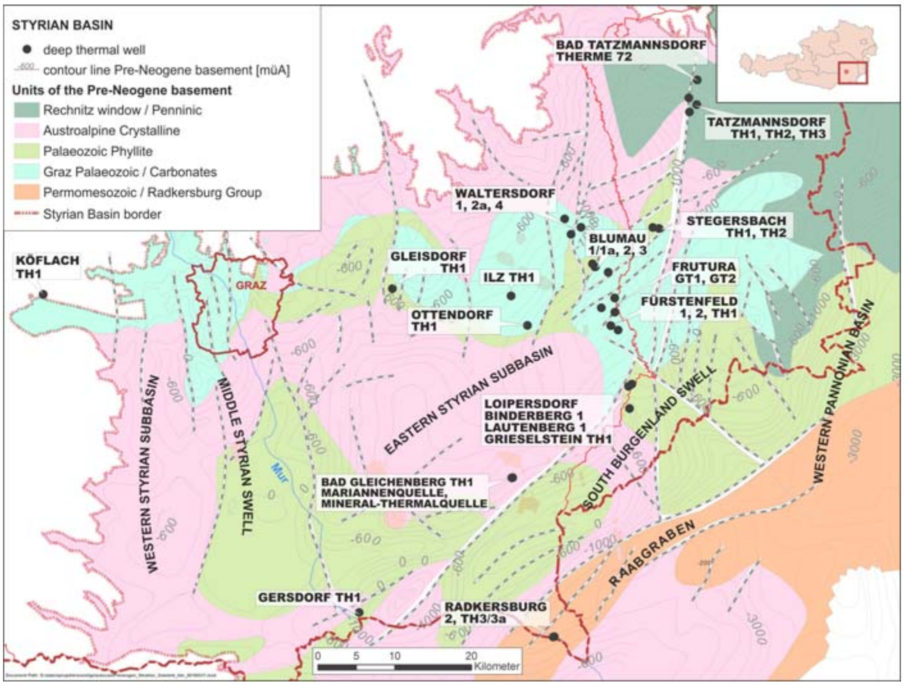

Figure 4: Styrian Basin: structural map of the Pre-Neogene basement map and deep thermal wells.

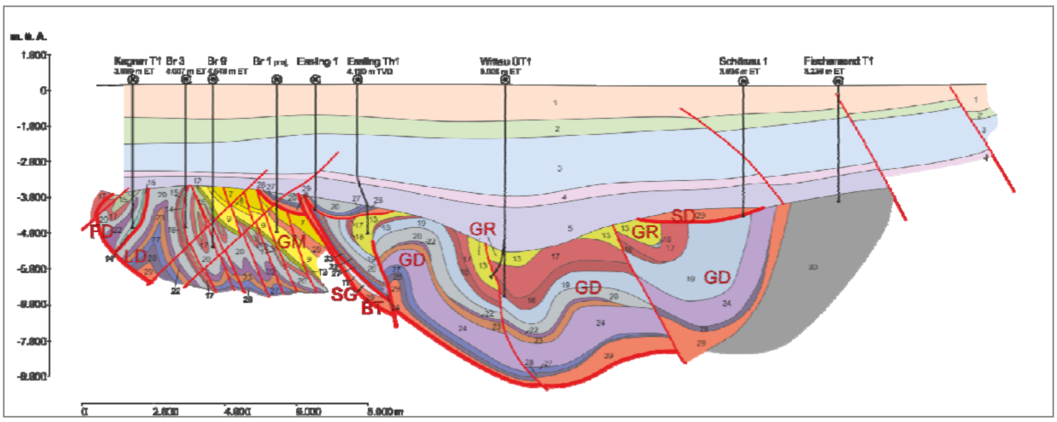

Figure 5: Geological cross-section through the Vienna Basin at the eastern part of the city of Vienna (taken from Elster et al 2016). The main targets are represented by carbonates (Hauptdolomit, index “20” and Wetterstein Dolomit, index “24”). In addition, the clastic Aderklaa conglomerate unit (index “4”) is also suitable for hydrogeothermal use.

Table 3: Comparison of the estimated hydrogeothermal potential in prospective regions in Austria, taken from different previous studies.

Estimated hydrogeothermal potential (MW_{TH})				
Study	OMV-Thermal (2010 - 2012)	Transenergy (2011 - 2013)	Geol Survey of Austria (2013)	GeoEnergie 2050 (2012 - 2014)
Resource level	Measured Resources	Measured Resources	Inferred Resources	Probable Reserves
Molasse Zone				
Upper Austria	n.a	n.a	n.a	105
Salzburg	n.a	n.a	n.a	82
Lower Austria	168	n.a	n.a	81
Total	**>168**	**n.a**	**n.a**	**268**
Vienna Basin				
City of Vienna	n.a.	n.a	264	42
Total	**500**	**450**	**264**	**168**
Styrian Basin				
Total	**n.a**	**n.a**	**n.a**	**15**
Total Sum	**>668**	**>450**	**>264**	**451**

2.6 Outlook on 2016 - 2019

Vienna Basin

After the non-success of the hydrogeothermal well "Essling Thermal 1" the city of Vienna is currently developing a comprehensive exploration concept for hydrogeothermal utilization in the greater Vienna area. Future hydrogeothermal wells are not expected before 2020.

3. SHALLOW GEOTHERMAL USE

The heat-pump market in Austria is still moderately growing at a rather high level of market diffusion. In the year 2014, in total, around 230.000 heat pumps are installed, whilst some 140.000 are used for heating purposes. The annual sale of heat pumps for heating purposes is at a level of almost 20.000 pieces. In 2014, the share of sold heat-pump systems used for combined cooling and heating use is around 39% for small scale heat pumps (capacity 10 – 20 kW) and decreases to level of 24% for large scale systems (>50 kW). As shown in Figure 6, Air - Water heat-pump systems (pale blue bars) are having the largest share (~63%) in the annual sales. These systems replaced brine based heat pump systems as market leader in the year 2011 (Biermayr et al 2015).

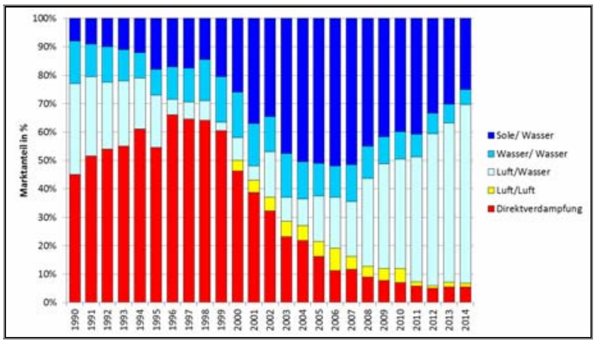

Figure 6: Historical development of the heat-pump market in Austria (annual sales) considering the different kind of heat sources. Taken from Biermayr et al (2015), p. 170.

Air – water based heat pumps systems are currently dominating the small capacity heat pump uses (<20 kW), primarily applied at private heating. At increasing capacities, the share of brine- or groundwater based heat pump systems continuously increases.

At the moment, scientific research in Austria is focusing on web based information systems and on low temperature heating and cooling grids based on geothermal sources in urban areas. The increasing intensity of thermal groundwater use in urban areas calls for change of paradigm from individual ground source heat-pump systems to joint utilizations. This in turn may influence licensing procedures (including a possible adaption of the legal framework) as well as monitoring strategies for the assessment of thermal conditions at near surface groundwater bodies below cities.

4. CONCLUSIONS

In the period between 2013 and 2016, we report only a very low increase of the installed geothermal capacities at both, shallow geothermal as well as deep (hydrogeothermal) methods. Considering hydrogeothermal use, the current legal framework and public incentives do not support a significant increase of the market share. In addition, the currently existing low prices for fossil fuels also hinders investment in direct geothermal use.

The current energy-economic framework may also lead to a decrease of heat pump utilizations. Possible implications may be seen after receiving the market data from 2015. In the small capacity private heating sector, unfortunately a replacement of ground source heat pump systems by air based heat pump systems has to be observed for several years now. The reason for this is given by the lower investment costs. In case of enhanced future electricity costs, which may be a consequence of increasing market share of renewable energy sources, the market share of air-water heat pump systems may decrease due to lower efficiency and higher electricity consumption.

REFERENCES

Biermayr P., Eberl M., Enigl M., Fechner H., Kristöfel C., Leonhartsberger K., Maringer F., Moidl S.,

Schmidl C., Strasser C., Weiss W. and Wopienka E.: Integrative Energietechnologien in Österreich – Marktentwicklung 2014, *Berichte aus Energie und Umweltforschung 11/2015*, Bundesministerium für Verkehr, Innovation und Technologie, Wien, (2015)

Deibert L., Hjartarson A., McDonald I., McIlveen J., Thompson A., Toohey B. and Yong D.: The Canadian Geothermal Code for Public Reporting, Reporting of Exploration Results, Geothermal Resources and Geothermal Reserves, 2010 *Edition 2010*, The Canadian Geothermal Code Committee, Calgary, (2010).

Diepolder, G. (editor in chief) and the GeoMol Team.: GeoMol – Assessing subsurface potentials of the

Alpine Foreland Basins for sustainable planning and use of natural resources, *Project Report*, LfU, Augsburg, (2015).

Elster, D., Goldbrunner J.E., Wessely G., Niederbacher P., Schubert G., Berka R., Phillipitsch R. and Hörhahn Th.: Thermalwässer in Österreich, Geologische Bundesanstalt, Wien, (2016).

Goldbrunner J.: Austria – Country Update.- *Proceedings*, World Geothermal Congress 2015, Melbourne, Australia, 19-25 April 2015 (2015).

Goldbrunner, J.: Neue Geothermiebohrungen im Steirischen Becken.- bbr 10-2015, 64 – 70, 2015.

Goldbrunner, J.: Oberflächennahe Geothermie in Österreich.- in Handbuch Oberflächennahe Geothermie, Hg. M.J. BAUER, W. FREEDEN, H. JACOBI & Th. NEU.- Springer Verlag (in Druck) (2016).

Goldbrunner J.E. and Goetzl G.: Geothermal Energy Use, Country Update for Austria, *Proceedings*, European Geothermal Congress 2013, Pisa 3 – 7 June 2013 (2013).

Könighofer K., Domberger G., Goldbrunner, J., Füreder J. & G. Burgstaller: Hydrothermale Energiepotenziale.- EuroHeat & Power, 11, November 2014

Kamyar H.: Verteilung der Untergrundtemperaturen an Beispielen der Bohrlochtemperatur (BHT) – Messungen in den RAG – Konzessionen, Oberösterreichs und Salzburgs, (Molasse-Flyschzone), *phD Thesis*, University of Vienna, (2000).

Leblanc, Y., Pascoe, L.J., and Jones, F.W.: The temperature stabilization of a borehole, *Geophysics*, **46**, Tulsa, (1981).

Przybycin A., Scheck-Wenderoth, M, and Schneider, M.: The 3D conductive conductive thermal field of the Northern Alpine Foreland Basin – Influence of the deep structure of the adjacent European Alps, *Geophysical Research Abstracts*, **16**, EGU2014-2942-2, (2014).

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2015 *	1.25	2.2		50,875		0.003
Under construction end of 2015	0	0				
Total projected by 2018	0	0				
Total expected by 2020	2	4				
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2015 (indicate exploration/exploitation, if applicable):						

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commissioned	No of units **	Status	Type	Total capacity installed (MW_e)	Total capacity running (MW_e)	2015 production * (GWh_e/y)
Altheim	Altheim	2002	1	O	B-ORC	1.0	0.5	1
Bad Blumau	Blumau	2001	1	O	B-ORC	0.25	0.2	1.2
Total						**1.25**	**0.7**	**2.2**

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** In case the plant applies re-injection, please indicate with (RI) in this column after number of power generation units

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 MW_{th}); installations with geothermal source temperatures <25 °C and depth <400 m should be reported in table E.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for individual buildings		Geothermal heat in balneology and other **	
	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)
In operation end of 2015 *	72.5	272.5	2	4.6			2.4	20.6
Under construction end 2015			10					
Total projected by 2018								
Total expected by 2020								

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** Note: 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.

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commissioned	CHP **	Cooling ***	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 production * (GW_{th}/y)	Geoth. share in total prod. (%)
Altheim	Doublet Altheim	2000	yes	No	12	18	28.6	100
Geinberg	Doublet Geinberg	2000	No	No	13.2	7.1	92.3	100
Simbach a. Inn / Braunau a. Inn	Doublet Simbach-Braunau	2003	No	No	9.3	40.7	46.1	7
Obernberg	Doublet Obernberg	2000	No	No	6.5	6.5	16	100
St. Martin im Innkreis	Doublet St. Martin	2002	No	No	5.7	29	38.5	60
Ried im Innkreis	Doublet Mehrnbach	2014	No	No	15	5	22	80
Haag am Hausruck	Doublet Haag	1996	No	No	1	5	6	100
Bad Blumau	Bad Blumau	2001	Yes	No	7.5	7.5	18	100
Bad Waltersdorf	Bad Waltersdorf	1979	No	No	2.3	5	5	70
Total					**72.5**	**123.8**	**272.5**	

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** If the geothermal heat used in the DH plant is also used for power production (either in parallel or as a first step with DH using the residual heat in the brine/water), please mark with Y (for yes) or N (for no) in this column.

*** If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

Table D2: Existing geothermal direct use other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling **	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 pro-duc-tion * (GWh_{th}/y)	Geoth. share in total prod. (%)
Total							

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

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.

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2014 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2014 *	~144.553	~1,500	~2,000	5,128	~70	36%
Projected total by 2018	~150,000	~1,900	~2,500			

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table F: Investment and Employment in geothermal energy

	in 2015 *		Expected in 2018	
	Expenditures ** (million €)	Personnel (number)	Expenditures ** (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses				
Shallow geothermal				
total				

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** Expenditures in installation, operation and maintenance, decommissioning

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	no	O – R&D funding programme “Energie der Zukunft”, FFG – Österreichische Forschungsförderungs- Gesellschaft	no
Financial Incentives – Investment	DIS	DIS	DIS ~6,5 Mio EUR
Financial Incentives – Operation/Production	FIT ~7,43 Cent/kWh	no	no
Information activities – promotion for the public	no	no	EU-Project TESSe2b (2016 – 2020): storage of thermal energy in combination with the use of shallow geothermal energy. EU-Alpine Space project GRETA (2016 – 2018): Application of shallow geothermal systems in Alpine infrastructure.
Information activities – geological information	no	no	R&D activities for public information systems in Salzburg
Education/Training – Academic		Lectures Goldbrunner at TU Graz, University of Salzburg, University of Applied Sciences Pinkafeld and Vienna	
Education/Training – Vocational	no	no	Various training courses for planners and instasllers provided by federation of drilling engineers (VOEBU) and Austrian Water and Waste Management Association (OEWAV)

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)