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Geothermal Energy Use, Country Update for Austria

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ABSTRACT

In general Austria exhibits moderate to favourable conditions for hydrogeothermal use considering several basin areas with either widespread aquifers or enhanced geothermal conditions. In this context utilization of natural thermal water has long-term tradition in Austria. Geothermal energy supply has commenced in the late 1970s and was boosted in the time period between 1985 and 2005. Since then hydrogeothermal development has been on a modest level. The main barriers of a further geothermal development in Austria are given by a very moderate federal funding scheme (e.g. feed-in tariffs).

Recent geothermal activities in Austria have focused on 2 projects in the Upper Austrian Molasse (Ried im Innkreis) and on the Vienna Basin (Aspern-Essling). While parts of the Upper Austrian Molasse Basin are yet well-developed in terms of hydrogeothermal use, the Vienna Basin has not been developed yet, although remarkable hydrogeothermal resources of more than 500 MW_{th} have been assessed in recent studies.

1. INTRODUCTION

Deep geothermal exploration in Austria (area 83,871 km², 8.49 million inhabitants in 2012) 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).

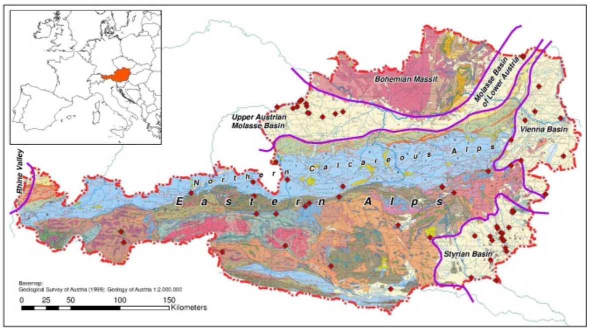

Figure 1: Overview on the deep wells and thermal springs in Austria.

Geothermal utilization has a several decades of year-long tradition in Austria. 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 2012. 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 mainly for balneological purposes associated to skiing resorts comprised also the Eastern Alps. The complicated structural conditions and the lack of authoritative results of geophysical exploration led to a significant number of non-successful drilling projects (Figure 2).

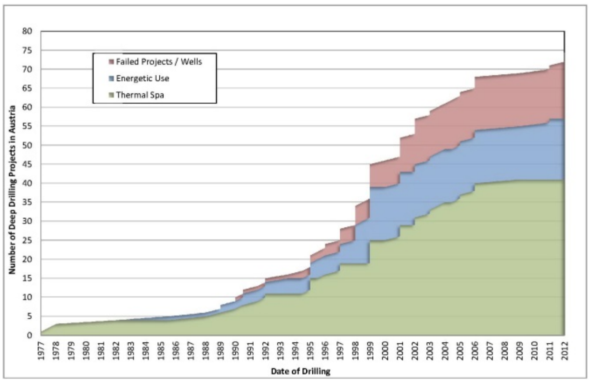

Figure 2: Geothermal drillings in Austria for the time period 1977 – 2012.

In the first phase of geothermal utilization abandoned hydrocarbon wells played an important role for the 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.

In the period 2005 – 2010 hydrogeothermal exploration and development was on a modest level in Austria (GOLDBRUNNER, 2010). In 2011 two projects for hydrogeothermal district heating have been launched in Austria (Ried im Innkreis in the

Upper Austrian Molasse Basin and Aspern-Essling in the Vienna Basin).

Table 1: Geothermal drillings in Austria (period 1977 – 2012).

Unit	Total number of wells	Cumulative depth [m]
Styrian Basin	26	41,522
Upper Austrian Molasse Basin	13	28,236
Vienna Basin and Lower Austrian Molasse Basin	8	12,605
Northern Calcareous Alps and Upper Austroalpine units (mainly carbonate rocks)	7	14,802
Lower, Middle and Upper Austroalpine Units (mainly crystalline rocks)	18	24,618
Pannonian Basin	1	860
Total	**73**	**122,643**

2. GEOTHERMAL SETTINGS

2.1 General Overview

In general Austria exhibits varying thermal conditions which are influenced by the Alpine Orogeny and by the neighbouring Pannonian Basin (see also Figure 3). Considering the terrestrial heatflow density (HFD) the lowest ranges can be found in the Northern Calcareous Alps. As a consequence of crustal thickening due to Alpine thrusting and massif inflow of fresh surface waters observed HFD values are lowered down to <50 mW/m².

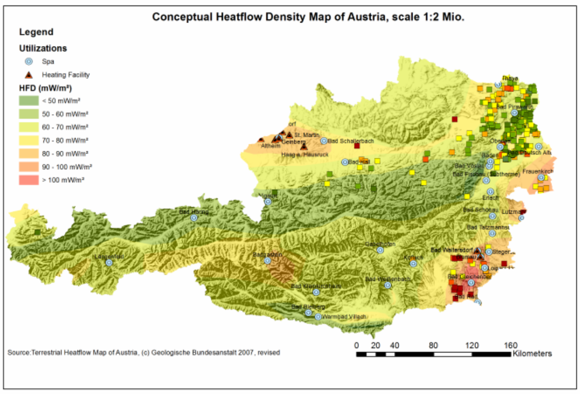

Figure 3: Terrestrial Heatflow Density Map of Austria at scale 1:2 Mio. (revised version of Goetzl 2007). Coloured squares represent derived HFD values at deep drillings.

In opposite clearly elevated geothermal conditions are given at the Eastern part of Austria, especially at the south-eastern Styrian Basin, exhibiting HFD values of more than 100 mW/m². These favourable conditions are related to a significant geothermal anomaly at the Pannonian Basin due to lowered lithospheric thickness. Recently executed joint modelling and interpretation of HFD data from Austria, Hungary, Slovakia and Slovenia in the course of the Interreg IV project Transenergy (GOETZL et al, 2012b) showed, that the highest HFD values are located at the margin areas of the Western Pannonian Basin.

The geothermal conditions at the Austrian parts of the Molasse Basin can be described as average to slightly elevated (70 - 80 mW/m²). Regions of enhanced terrestrial heatflow densities are associated to regional hydrothermal flow systems predominately located at basement reservoirs (Malmian limestones and Dogger sandstones). These local to regional scale anomalies can be found both in the western part of Austrian Molasse (Upper Austrian Molasse Basin) and the eastern margin of the Molasse Basin close to the transition zone to the Vienna Basin (Lower Austria).

The geothermal conditions at the intra-mountainous regions of the Eastern Alps are quite heterogenic and not entirely investigated yet due to the lack of deep drillings. In general moderate to slightly lowered conditions (50 – 70 mW/m²) have to be assumed referred to the crustal build-up. Locally to regionally confined enhanced HFD values (>70 mW/m²) are associated to hydrothermal systems (e.g. Bad Gastein) and excess heat resulting from denudation of deeply buried crustal blocks (e.g. Tauern Window area).

2.2 Vienna Basin

Project Aspern Essling

In 2012 the first drilling named Essling Thermal 1 for the geothermal district heating project of Aspern (eastern district of the Austrian capital Vienna) took place. It targeted fractured dolomites in the basin floor of the Vienna Basin which is formed there by rocks of the Goeller nappe of the buried Northern Calcareous Alps. The Norian Hauptdolomit of the Goeller nappe which can attain a thickness of more than 1,000 m exhibites suitable aquifer properties as shown in some boreholes in the surrounding of the location. The end depth of the borehole was scheduled at appr. 5,000 m thus providing temperatures as high as 140 °C.

To a depth of 3,398 m sediments of the Tertiary basin filling of the Vienna Basin with a stratigraphic span form Pannonian to Karpatian have been sunk. The encountered geology showed only a small departure from the forecast. When entering the basin floor the borehole came in limestones of Middle Triassic age instead of the expected Upper Triasssic (Norian) dolomites. Later it turned out that the limestones which had an apparent thickness of 235 m belong to a nappe ("Klippe") overlapping a small syncline of limnic Gosau beds (Cretaceous). The Gosau consisted of marlstone, argillaceous marlstone and calcareous marlstone. The top of this formation was met at a measuring depth of 3,694 m. From top to bottom the dip of the strata steepened from 40° to more than 70°. These bedding conditions resulted in increasing drilling problems which forced to give up the drilling section at a MD of 4,224 m.

By structural interpretation of FMI and VSP measurements an adapted geological model was established which forecasted top of Hauptdolomit at a depth of approx. 4,500 m. After problems occurred during side-tracking of the borehole the client decided to give up the drilling project. The decision was motivated by the apprehension that yet another liner had to be set when drilling problems would continue. In such a case the reduction in diameter would limit the flow volume as a production casing has to be installed because of the high salinity of the geothermal fluids (TDS 150 g/l, NaCl).

2.3 Upper Austrian Molasse Basin

The geothermal district heating project Ried im Innkreis in the Upper Austrian Molasse Basin was implemented 2011 – 2013.

The first well (Mehrnbach Th 1) of the geothermal doublet was intended to reach the Malm aquifer at the down-thrown block of the Ried fault which has a vertical displacement of some 800 m. Based on seismic measurements and results of neighbouring boreholes top of Malm was expected at appr. 2,500 m. After encountering Malmian limestones at a depth of only 1,765 m it had to be recognized that the bore landed on the up-thrown block of the Ried fault.

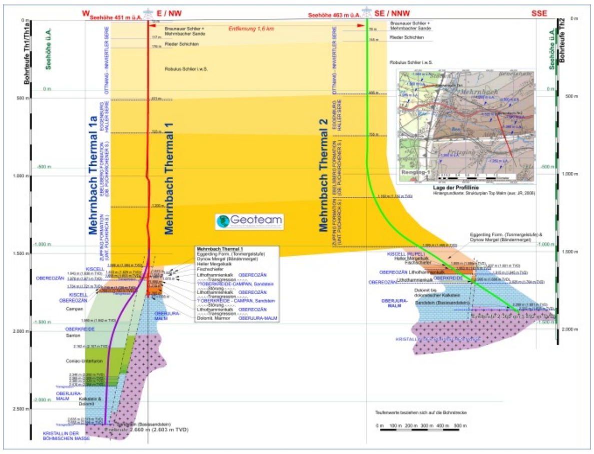

Figure 4: Doublet Mehrnbach, geological profile

After plugging back the borehole was side-tracked to reach the down-hole block of the Ried fault. A deviation of only 65 m at the level 1,765 m was sufficient to leave the up-thrown block. Mehrnbach 1a cut across some 600 m of Upper Cretaceous mainly pelitic sedimentary rocks, tapped the Malm aquifer at 2,354 m, penetrated the whole thickness (245 m) of Malm carbonate rocks (limestones and dolomites) and some 20 m of Basal Sandstone and finally tapped the top of the cristallinic basement at 2,598 m. The horizontal displacement of the borehole at end depth was some 300 m.

The second well (Mehrnbach Th 2) was situated at the up-thrown block of the Ried fault some 1,300 m apart from b/h Mehrnbach Th1/1a. It was designed as a deviated borehole with a KOP at 825 m an inclination of 58° and an azimuth of 160°. The bore encountered the Malm carbonates at a MD of 2,026 m (TVD 1,704 m) and penetrated some 263 m (147 m) of fractured and karstified dolomites and dolomitic limestones. It entered the crystalline basement at 2,332 m MD (1,876 m TVD). The good aquifer properties of the Malmian rocks were exhibited by continuing mud losses (up to 24 m³/h) at a mud weight of 1.02 kg/dm³. In contrast Mehrnbach 1/1a had only small mud losses.

From October to December 2012 a combined pumping and reinjection test was performed using Mehrnbach 1/1a as a production well and Mehrnbach 2 for injection. The production temperature was 105 °C at a flow rate of 64 l/s.

As the first stage of extension of the district heating loop has already been established delivering of geothermal heat will start in early September 2013.

2.4 Styrian Basin and Pannonian Basin

In 2012 a geothermal project for the heat supply of glasshouses (27 ha) was launched in the Fuerstenfeld Basin. It targets the main thermal aquifer of the Styrian Basin formed by Paleozoic fractured dolomites. The end depth of the production borehole will be 3,600 m, expected temperatures are > 130 °C. The first drillings will start by the end of 2013.

3. HYDROGEOTHERMAL RESOURCES AND CURRENT USE

For the period 2005 to 2010 data on the geothermal use in the Upper Austrian Molasse Basin have been compiled by KNEIDINGER et al., 2012 (see Table 2).

In recent times geothermal resource assessment has focused on the eastern parts of Austria in several studies with a clear emphasize on the Vienna Basin and its vicinity. Based on hydraulic well tests performed at hydrocarbon exploration drillings as well as based on numerical modelling hydrogeothermal resources in the range of around 600 MW_{th} have been identified for the central Vienna Basin and the very eastern margin of the Molasse Basin in Lower Austria (GOETZL et al, 2012a). Despite of the identified relevant hydrogeothermal resources the investigated region faces limitations due to a quite low density of settlement except for the eastern part of Vienna. The total hydrogeothermal resources at the eastern districts of Vienna have recently estimated in the range of 200 – 300 MW_{th} for 4 different carbonate reservoirs at the basement of the Vienna Basin. Despite of the fact, that the first hydrogeothermal exploration well Essling Thermal 1 has not been successful the eastern districts of Vienna offer remarkable hydrogeothermal resources, which can play an important role in the future energy supply of Vienna.

Considering petro-thermal energy supply no exploration or research activities have been conducted in Austria yet.

4. CONCLUSIONS

The last years saw only limited drilling activity in Austria. This is mainly due to the fact that power production is not economic because of very low public feed-in tariffs. Secondly a growing saturation is to be recognized in Spa development.

However, there are still regions in Austria, which can be developed for hydrogeothermal use in Austria exhibiting significant resources. Above all the Vienna Basin as well as the eastern margin of the Molasse Basin has to be pointed out, where no hydrogeothermal utilization has been installed yet. Nevertheless further hydrogeothermal resources may also be assumed for Upper Austrian Molasse basin outside of the already developed areas as well as for the Styrian Basin. Due to the observed enhanced HFD the latter listed region may gain importance in future for petro-thermal utilization in case of economic feasibility, which is not given yet in Austria considering the actual feed-in tariffs.

5. OUTLOOK ON 2013 - 2015

The failure of the Aspern-Essling deep drilling has brought some setback. It has to be concluded that large-scale 3D seismic surveys are essential to develop the geothermal potential of the Vienna Basin which is estimated as high as 300 MW only for the eastern part of Vienna.

Until 2015 hydrogeothermal resources will also be assessed and re-evaluated for the Malmian limestone reservoirs in Upper Austria at the recently launched Interreg IV project Geomol (http://geomol.eu). Focus will be set on the hydraulic characterization of a ridge zone separating low mineralized thermal waters at well-developed regions from brine reservoirs south of the ridge.

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Table 2: Geothermal heat supply of Upper Austrian geothermal projects (period 2005 – 2010)

Geothermal heat supply [MWh]		2005	2006	2007	2008	2009	2010
Altheim							
	District heating	27.369	27.368	25.134	27.807	28.380	28.580
	ORC [Mw_{el}]	916	1.585	1.056	860	1.029	?
Geinberg							
	Total	31.542	28.953	26.190	28.667	29.409	28.580
	100/70 °C	8.705	9.182	6.153	7.140	7.392	7.038
	70/40° C	18.759	19.158	19.783	19.359	18.208	18.979
	< 40°C (green house)	4.078	3.931	3.628	3.970	4.352	4.458
Obernberg							
	Total	7.584	?	7.584	10.290	10.935	11.800
Haag							
	Total	5.434	5.460	4.500	5.547	5.904	5.974
Simbach-Braunau							
	Total	58.263	61.105	57.557	58.273	59.642	64.317
	geothermal	39.221	40.451	42.477	42.569	42.179	46.142
	fraction of geoth. [%]	67	66	74	73	71	72
St. Martin							
	Total	25.966	26.179	26.438	29.168	?	?
	geothermal	14.774	14.998	14.850	17.547	18.658	18.984
	fraction of geoth. [%]	57	57	56	60	?	?

Tables A-G

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

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2012	2	2.2		81,400		0.003
Under construction end of 2012	0					
Total projected by 2015	2	2.2				

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commiss.	No of units	Status	Type	Total inst. Capacity (MW_e)	Total running cap. (MW_e)	2012 product. (GWh_e/y)
Altheim	Altheim	2002	1	O	B-ORC	1.0	0.5	1
Simbach - Braunau	Simbach Braunau	2009	1	R	B-ORC	0.6	0	0
Bad Blumau	Blumau	2001	1	O	B-ORC	0.25	0.2	1.2
total						**1.85**	**0.7**	**2.2**

Key for status:		Key for 1type:			
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

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 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)
In operation end of 2012	51.5	158.8	2	4.6	2.4	20.6
Under construction end of 2012	15					
Total projected by 2015	66.5	205				

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

Locality	Plant Name	Year commis s.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Altheim	Doublet Altheim	2000	yes	No	12	18	28.6	100
Geinberg	Doublet Geinberg	2000	No	No	5.1	7.1	24	100
Simbach a. Inn / Braunau a. Inn	Doublet Simbach-Braunau	2003	No	No	9.3	40.7	46.1	77
Obernberg	Doublet Obernberg	2000	No	No	5.3	5.3	11.8	100
St. Martin im Innkreis	Doublet St. Martin	2002	No	No	5	29	18.9	60
Haag am Hausruck	Doublet Haag	1996	No	No	5	5	6	100
Bad Blumau	Bad Blumau	2001	Yes	No	7.5	7.5	18	100
Bad Waltersdorf	Bad Walters-dorf	1979	No	No	2.3	5	5.5	70
Total					**51,5**	**117.6**	**158.9**	

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

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012		~900				
Projected by 2015						

Table F: Investment and Employment in geothermal energy

No data available

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D			
Financial Incentives – Investment			
Financial Incentives – Operation/Production	FIT	RC (1 project)	
Information activities – promotion for the public	No	Activities planned	Yes, Project Geopot (2008 – 2010) assessing spatial capacities for shallow geothermal use. Further activities planned.
Information activities – geological information		Activities planned (Geothermal Atlas of Austria).	Activities planned (Web-portal for shallow geothermal use in Austria).
Education/Training – Academic			
Education/Training – Vocational			

Key for financial incentives:

DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota