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Austria – Country Update

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ABSTRACT

Four deep geothermal boreholes have been drilled between 2010 and 2014 with a total length of 12.3 km. One borehole in the Styrian Basin was not yet completed in May 2014. A district heating scheme was established at Ried im Innkreis in the Upper Austrian Molasse Basin. Geothermal production started here in February 2014.

The electrical power production from geothermal declined in the period 2010–2014. The plant in Simbach-Braunau was dismantled.

The number of ground source heat pumps shows a steady increase since 2010. 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

Austria (area 83,871 km², 8.5 million inhabitants in 2014) is subdivided into different geological units which differ greatly in their hydrogeological properties and their geothermal conditions. Approximately two thirds of the Republic's area is covered by the Eastern Alps which reach a maximum elevation of nearly 4,000 m and are less prospective in terms of geothermal resources.

Use of deep geothermal energy mainly takes place in the Molasse Basin of Upper Austria and to a minor extent in the Styrian Basin. Figure 1 shows the location of the 75 wells finished by Mid 2014. Their total length is 126 km. The number of new deep wells in the reporting period 2010 – 2014 is 5 with a total length of 15.6 km.

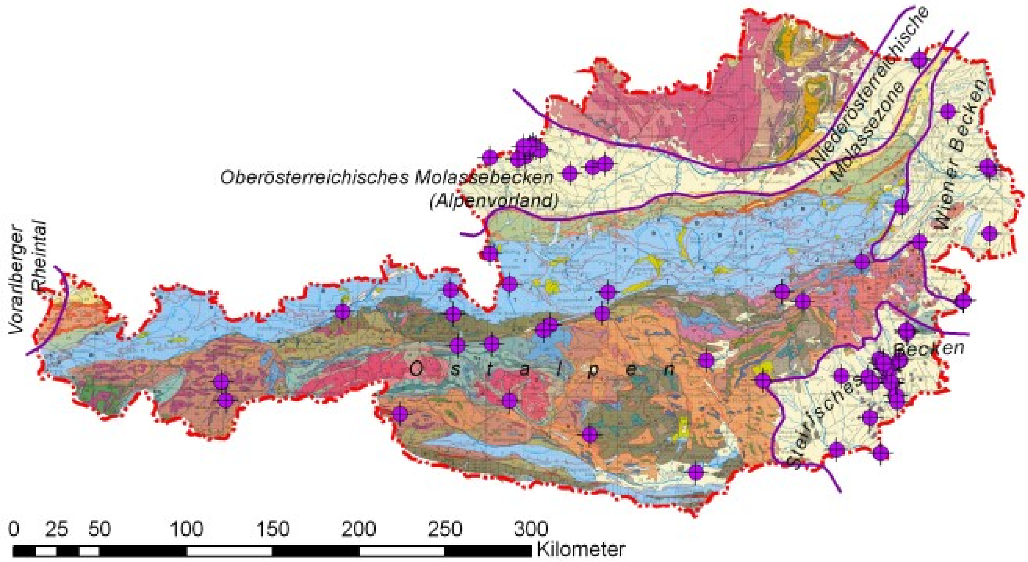

Figure 1: Geothermal exploration wells in Austria.

Table 1: Deep Geothermal Drillings in Austria and number of new wells since 2010.

Tectonical unit	Total number of wells	No. of new wells 2010 - 2014	Total length of new wells [m]	Total length of all wells [m]
Styrian Basin	28	2	6,578	48,100
Upper Austrian Molasse Basin	13	2	4,810	28,236

Vienna Basin and Lower Austrian Molasse Basin	8	1	4,223	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:	75	5	15,611	129,221

2. DEEP GEOTHERMAL

2.1 Balneology

Balneological use of thermal water has a very long tradition in Austria dating back until Roman times (e.g. Baden west of Vienna, Warmbad Villach, federal country Carinthia and Bad Gastein, federal country Salzburg). At these locations natural warm springs are utilized. The highest temperature (47 °C) of naturally outflowing springs is found in Bad Gastein (ZÖTL & GOLDBRUNNER, 1993). In the 1970s some abandoned oil exploration wells were used for the production of thermal waters. Examples of such developments are the Spa resorts of Loipersdorf and Waltersdorf in the Styrian Basin. The economic success of these resorts boosted several exploration and drilling projects not only in the deep basins but also in the Eastern Alps. A considerable number of wells tapped thermal water in crystalline rocks. Fig. 2 shows the location of the 27 spas based on successful geothermal drillings. They were all built after 1970 and represent a major economic factor in the region.

The balneological use equals 10 MWth.

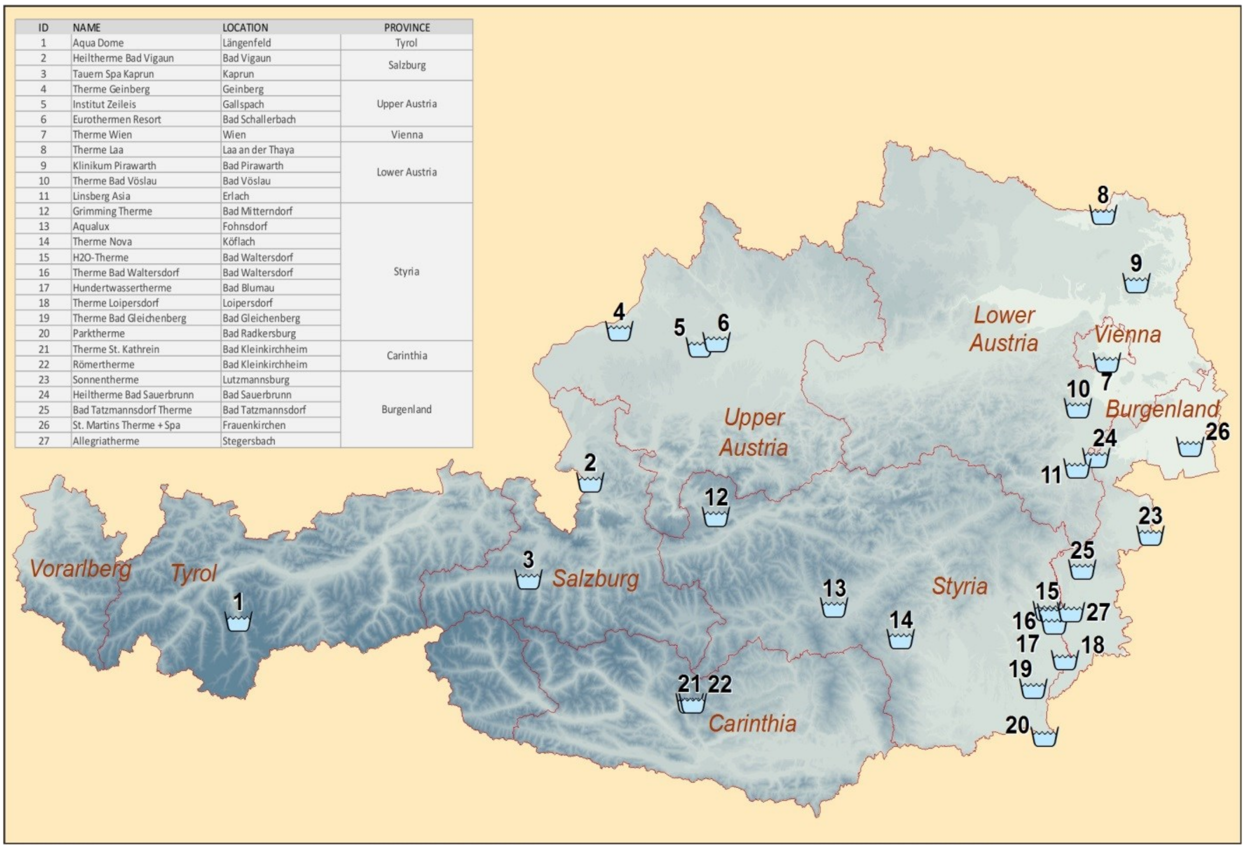

Figure 2: Locations of spas based on deep drillings.

2.2 Vienna Basin

The Vienna Basin is regarded as a prospective area for geothemal energy as the basin is locally more than 5,500 m deep. Suitable structures extend to the eastern part of Vienna. In Vienna (1.77 million inhabitants in 2014) there is a distinct compulsion to replace conventional energy for district heating by alternative energy including geothermal.

The Miocene basin fill is underlain by allochthonous and subthrust floors. The different nappes of the Northern Calcerous Alps are composed of thick carbonate rock units (e.g. Hauptdolomit and Wettersteindolomit) which are regarded as aquifers for thermal water.

The main tectonic elements of the Vienna Basin are shown on the basis of a SW – NE longitudinal profile. The NW – SE trending Leopoldsdorf fault which crosses the city area of Vienna separates the carbonate units on the up-thrown block in the west from the down-thrown block in the east Fig. 3).

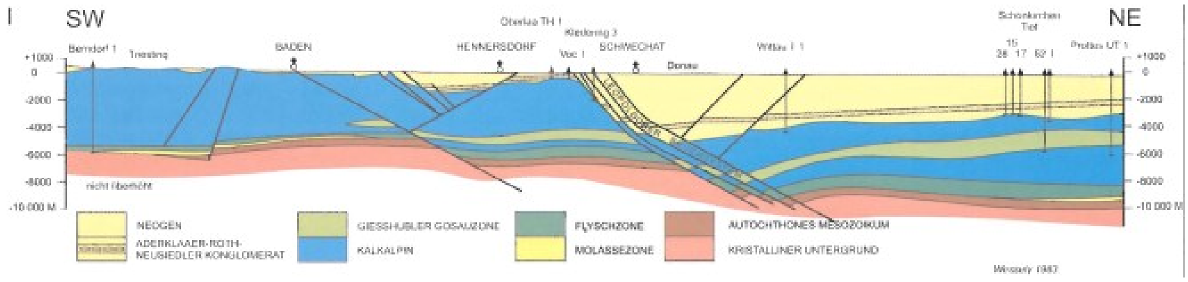

Figure 3: Geologic cross section Berndorf – Baden – Oberlaa – Schönkirchen (WESSELY, 2006).

At the down-throw block the permeable carbonate rocks are lowered to 3,000 to 6,000 m below surface, their bottom can be expected in a depth range of more than 8,000 m (WESSELY, 2006). The aquifer contains NaCl-water with a TDS of 150 g/l; temperatures can be expected in the range between 100 °C and 215 °C (WESSELY, ibid).

The geothermal project "Aspern-Eßling" was intended for the heat supply of the urban development area "airfield Aspern" situated in the eastern part of Vienna and covering a surface area of 240 ha. The required thermal power for heating and cooling is as high as 18 MW for the first stage and 39 MW for the second stage of the development with a completion by 2020.

In 2012 the first drilling labeled "Eßling Thermal 1" was sunk. It targeted fractured dolomites (Hauptdolomit) of the basin floor at a depth of 3,400 to 3,450 m. The end depth of the borehole was planned at 5,000 m; production temperatures of more than 140 °C were expected.

The bore met sediments of the Tertiary basin filling of the Vienna basin with a stratigraphic span form Pannonian to Karpatian. The profile agreed well with those of the surrounding oil and gas exploration wells. While entering the basin floor at a depth of 3,298 m the borehole tapped Middle Triassic limestones instead of the expected Upper Triassic (Norian) dolomites which form the preneogene basement in a hydrocarbon exploration well some 2,500 m apart from the location. It turned out that the limestones in Aspern-Eßling Th1 which had an apparent thickness of 235 m belong to a nappe ("Klippe") overlapping a small syncline of limnic Cretaceous beds (Gosau). The Gosau sediments consisted of marlstones, argillaceous marlstones and calcareous marlstones. 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°. The structural conditions and the lithology resulted in increasing drilling problems which forced to give up drilling operation at 4,224 m MD. After an unsuccessful test of the Middle Triassic limestones the well was abandoned.

The drilling showed that the alpine basin floor in this area is dominated by small-scale structures which are not revealed by the existing seismic data and geological models. This proves the need of extensive 3D-seismic surveys.

2.3 Upper Austrian Molasse Basin

The Upper Austrian Molasse Basin is so far the most developed geothermal area in Austria. The main aquifer is in Upper Jurassic (Malmian) dolomites and limestones bearing low mineralized (TDS < 1.2 g/l) sodium bicarbonate chloride waters. Temperatures up to 130 °C can be achieved. Currently 7 geothermal district heating projects are in operation including the new development at Ried im Innkreis (geothermal doublet Mehrnbach; Fig. 4).

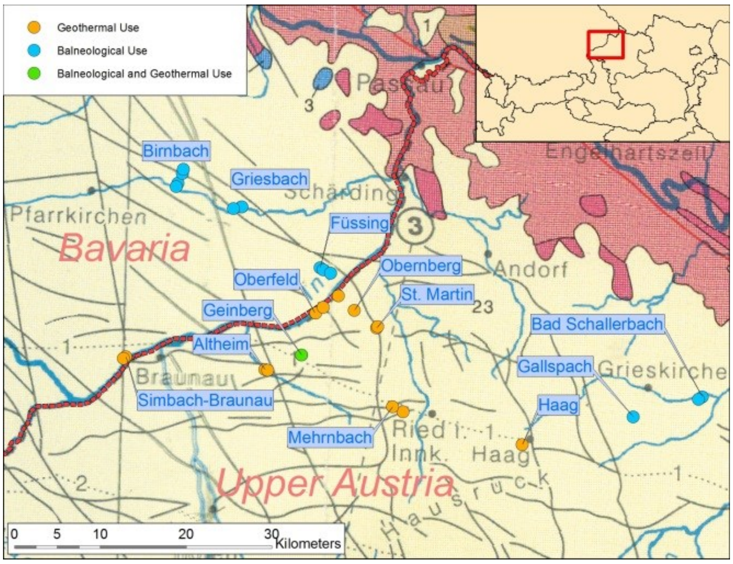

Figure 4: Geothermal wells and wells for balneological use in the Upper Austrian / Bavarian border region.

For the period 2006 to 2010 data on the geothermal use are available (Table 2). For the Simbach-Braunau plant data on the geothermal use are available up to 2013 for the (Table 2 and 3). The share of geothermal energy in the annual work is 66 - 77% at Simbach-Braunau. This is all the more remarkable, however, since the wellhead temperature is 80.5 °C, the temperature in the district heating system is 110 °C at the maximum. The number of full load hours is above 4,000 h/a. This is a proof of the base load capacity of geothermal energy. In summer 2014 a stronger pump will be installed in the production borehole Simbach-Braunau Th 2 to increase the flow volume from 80 to 90 l/s thus increasing the geothermal power to more than 10 MW to meet the demand of the permanently growing net which currently represents a total installed thermal power of nearly 40 MW.

The installed ORC unit was dismantled in 2013 due to problems with the cooling cycle which did not allow continuous operation of the plant.

Table 2: Geothermal heat supply of Upper Austrian geothermal projects (2006 – 2010).

Geothermal Heat supply [MWh]		2006	2007	2008	2009	2010
Altheim						
	District heating	27,368	25,134	27,807	28,380	28,580
	ORC	1,585	1,056	860	1,029	?
Geinberg						
	Total	32,271	29,564	30,469	29,952	30,475
	100/70 °C	9,182	6,153	7,140	7,392	7,038
	70/40° C	19,158	19,783	19,359	18,208	18,979
	< 40°C (green house)	3,931	3,628	3,970	4,352	4,458
Obernberg						
	Total	-	7,584	10,290	10,935	11,800
Haag						
	Total	5,460	4,500	5,547	5,904	5,974
Simbach-Braunau						
	Total	61,105	57,557	58,273	59,642	64,317
	Geothermal	40,451	42,477	42,569	42,179	46,142
	Fraction of geoth. [%]	66	74	73	71	72
St. Martin						
	Total	26,179	26,438	29,168		
	Geothermal	14,998	14,850	17,547	18,658	18,984
	Fraction of geoth. [%]	57	56	60		

Data in Table 2 were taken from KNEIDINGER et al., 2012.

Table 3: Geothermal heat supply of Simbach-Braunau (period 2011 – 2013).

Geothermal Heat supply [MWh]		2011	2012	2013
Simbach-Braunau				
	Total	59,424	61,946	65,024
	Geothermal	45,552	44,278	48,018
	Fraction of geoth. [%]	77	71	74

A geothermal district heating project in the district town Ried im Innkreis (11,400 inhabitants in 2013) was established 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 (seen on the right edge of the profile in Figure 5) which has a vertical displacement of some 800 m. Based on seismic measurements and results of neighbouring boreholes top of Malm was expected at approximately 2,500 m. After encountering Malmian limestones at a depth of only 1,765 m it had to be recognized that the bore had landed on the up-thrown block of the Ried fault. 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 and tapped the Malm aquifer at 2,354 m and 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 crystalline basement at 2,598 m. The horizontal displacement at end depth was some 300 m.

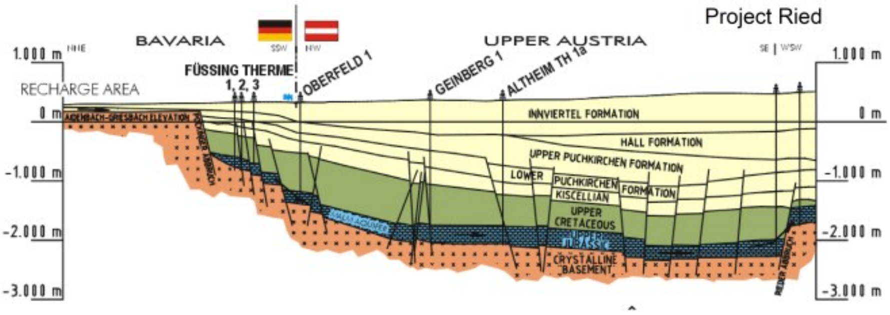

Figure 5: Cross section showing the geological position of the geothermal project Ried (after GOLDBRUNNER, 2000).

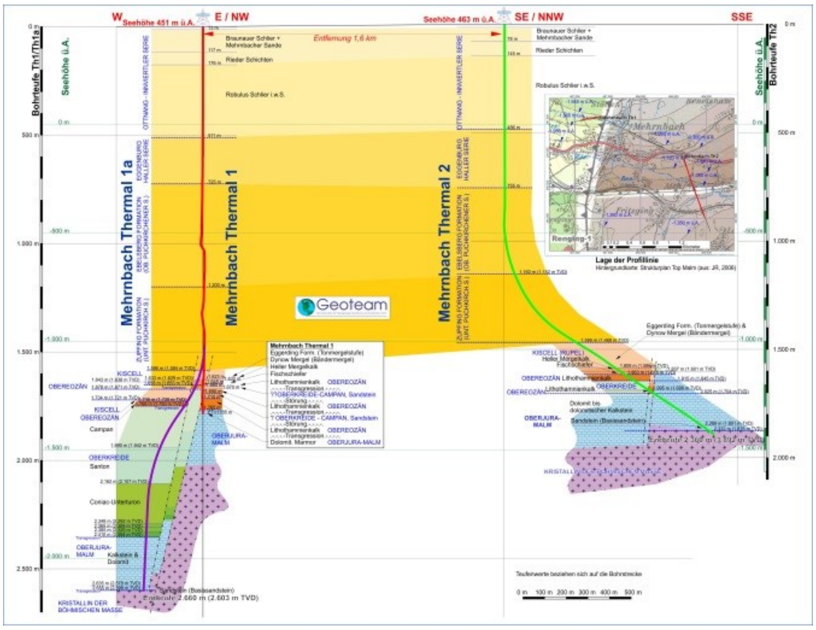

Figure 6: Doublet Mehrnbach, geological profile.

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 from the outset 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 carstified dolomites and dolomitic limestones and 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. 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. For the time being about 5 MW were produced. For the next winter period some 7 MW are expected.

In the geothermal project Geinberg the flow was increased from 30 l/s (artesian production) to 52 l/s by installing an electrical submersible pump thus increasing the installed thermal capacity of the geothermal cascade to 13.2 MW.

2.4 Styrian Basin

The approximately 4 km deep Neogene Styrian Basin, the westernmost subbasin of the Pannonian Basin System is located at the southeastern border of the Alpine orogen. It has an elongate shape of about 100 km in length and 60 km in width. The Styrian Basin is subdivided by the N-S trending Middle Styrian Swell in a deep Eastern Styrian and a shallower Western Basin. Therefore geothermal drilling activity focuses on the Eastern Basin which is separated from the Western Pannonian by the SW-NE trending South Burgenland Swell (Fig. 8).

The basement is formed of different tectonic units (Penninic, Austroalpine Crystalline, Graz Paleozoic). The Graz Paleozoic comprises thick carbonate sequences which show good aquifer properties due to brittle tectonics and locally carstification.

Geothermal gradients range between 3K/100 m and 5K/100 m (Fig. 7). The lower values reflect the proximity of the wells to recharge areas.

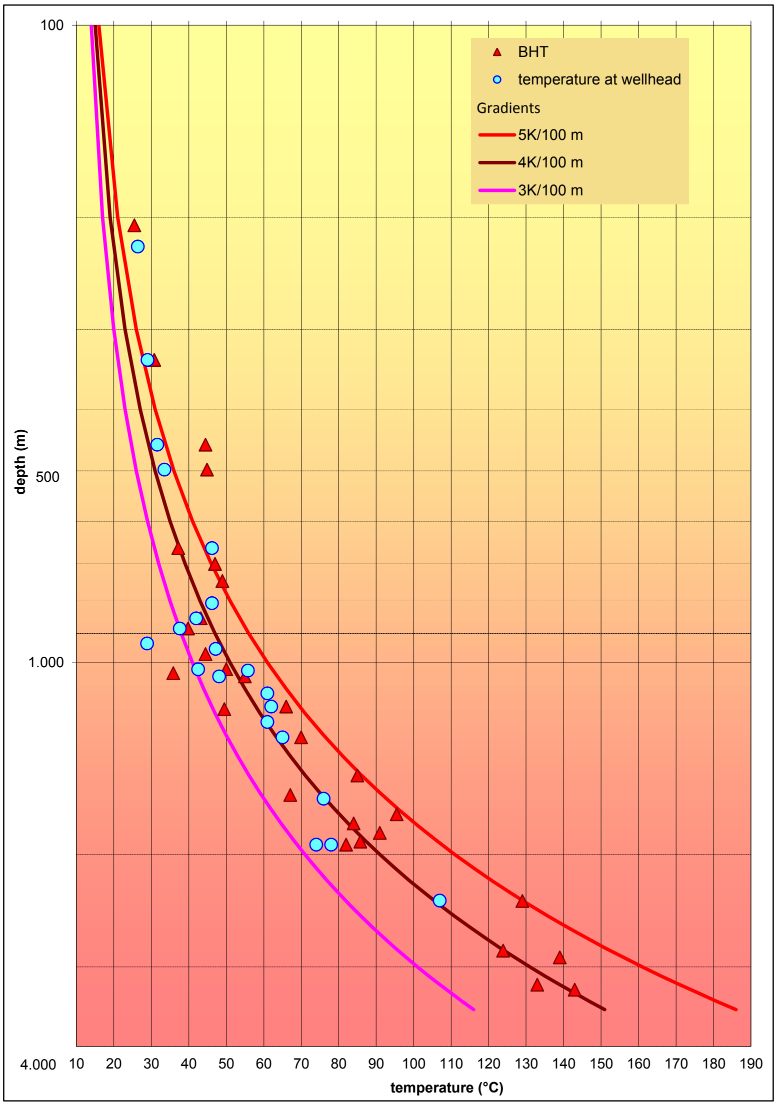

Figure 7: Depth temperature relation of wells of the Styrian Basin.

Table 3: Geothermal projects in the Styrian Basin.

Project	Use	Flow Rate [l/s]	T_{in} [°C]	T_{out} [°C]	Capacity [MW]
Sebersdorf/Waltersdorf	B	2,5	33	30	0.03
Bad Waltersdorf	D, B, G	22	63	28	3.2
Bad Blumau	E, D, B	20	110	50	5.0
Loipersdorf	B	4	61	30	0.5
Bad Radkersburg	B	5	70	30	0.8

B = balneology, D = district heating, G = greenhouse, E = power production.

The geothermal district heating project at Fuerstenfeld was abandoned due to continuing reinjection problems (sand-stone aquifer). The district heating net is now powered by a biomass plant.

2014 two boreholes intended for the thermal heat supply of greenhouses (project Frutura; see fig. 8) with 23 ha of glasshouses are drilled some 4 km south of Bad Blumau where geothermal energy is used for power generation and heating since 13 years. They target the aquifer in the dolomites and limestones of the pre-Neogene basin floor. The first well (GT1) was teminated by the end of March. It met the dolomitic aquifer at 2,875 m MD and reached an end depth of 3.279 m. Extrapolated BHT is 143 °C. First pumping tests showed that production temperatures > 120°C are likely.

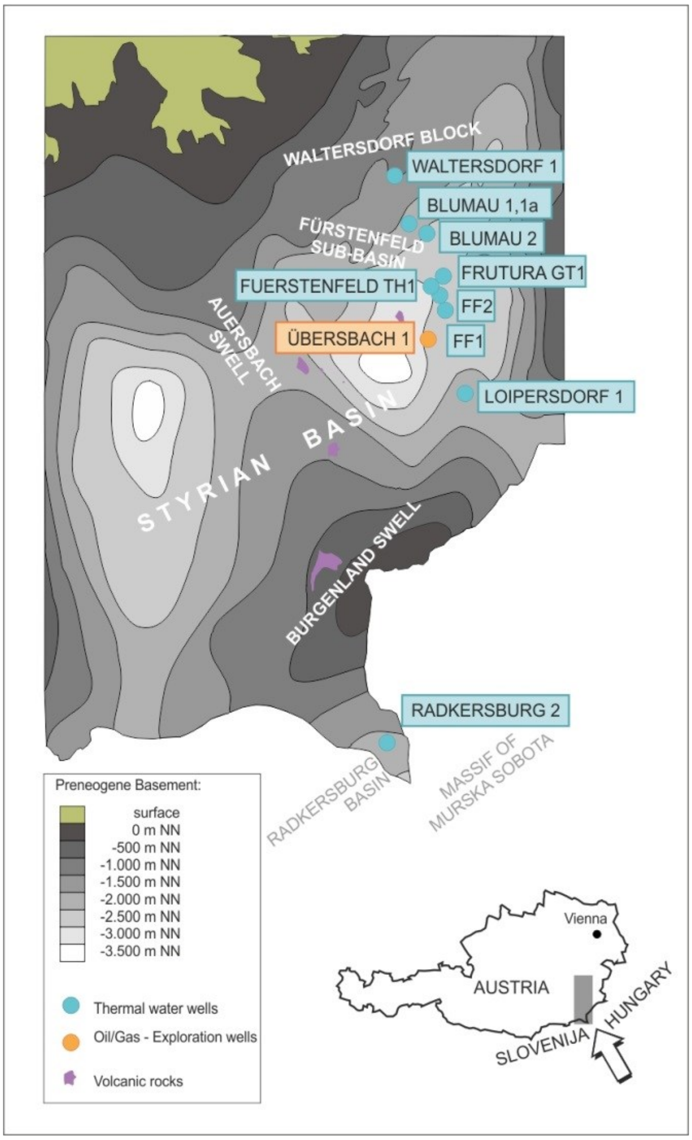

Figure 8: Map of the Eastern part of the Styrian Basin.

The second well of the geothermal doublet was finished by end of July 2014 reaching the total depth of 3,300 m. First pumping tests showed excellent aquifer properties.

2.5 Eastern Alps

Since 2006 no drilling activity was encountered in the region of the eastern Alps. The reason is the lack of new projects focusing on Spas or thermal resorts following the worldwide financial crisis.

The Spa at Kaprun (some 100 km south of the capital town Salzburg; Fig. 2, #3), which is so far the last realized project, was opened in December 2010. The resort area comprises some 20,000 m². The geothermal drilling reached an end depth of 684 m, the filter section was set between 300 and 559 m. The main water bearing zones are in fractured calcareous shists and dolomitic marble.

3. SHALLOW GEOTHERMAL

The number of ground source heat pumps shows a steady increase since 2010. The total number of units is estimated as high as 70,000 having a capacity of 840 MWth and 1,386 GWh/yr. This represents an increase since 2010 of 20,000 units and 240 MWth. The numbers are based on sales figures provided by heat pump suppliers.

The total length of drillings for DHE in Austria was determined at 2,800 km (MACHO, 2011).

The largest installation is the heating and cooling supply for the distribution centre of the company FRONIUS at Wels, Upper Austria. It covers a total length of 40 km of DHE.

4. CONCLUSIONS

The use of deep geothermal energy is dominated by district heating projects which all are situated in the Molasse Basin of Upper Austria. Not least, it was the economic success of the Simbach Braunau geothermal project that another geothermal district heating went into operation at the beginning of 2014. The geothermal cascade at Geinberg underwent a significant expansion.

Electrical power production from geothermal is declining in Austria. The plant at Simbach Braunau was dismantled because of cooling problems. New developments are not very likely due to lacking public support.

The number of ground source heat pump projects increased by 40 % since 2010 and further growth is expected. The growth rates, however, will decrease due to increasing competition from air heat pumps.

REFERENCES

Goldbrunner, J.: Hydrogeology of Deep Groundwaters in Austria.- Mitt.Österr.Geol. Ges., 92 (1999), 281 – 294, Wien, 2000.

Kneidinger, Ch., Goldbrunner, J. & A. Shirbaz: Wasserwirtschaftliche Bewertung der Thermalwassernutzungen im Oberösterreichischen Molassebecken. Berichtszeitraum 2006 – 2010.-Report (2012), 24 p., 8 att.

Macho, A.: Erdgekoppelte Wärmepumpen in Österreich, ihr Beitrag zum Energieaufkommen.- Thesis, University of Applied Sciences Pinkafeld, 146 p, 2011.

Wessely, G.: Geothermische Nutzung.- in: G. Wessely: Niederösterreich. Geologie der Österreichischen Bundesländer.- 307 – 310, Vienna (Geologische Bundesanstalt) 2006.

Zötl, J. & J.E. Goldbrunner (Ed.): Die Mineral- und Heilwässer Österreichs. Geologische Grundlagen und Spurenelemente.- 324 p, Wien-New York (Springer), 1993.

STANDARD TABLES

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2014	1.25	2.2	7,064	16,014	13,350	47,836.4	-	-	2,535	6,863	22,950.26	70,716.4
Under construction in December 2014	0	0	-	-	800	2,866.6	-	-	49	132.7	849	2,999.3
Funds committed, but not yet under construction in December 2014	0	0	2,102	4,765	4,586	16,432.8	-	-	417,5	1,130.4	7,105.5	22,328.2
Estimated total projected use by 2020	2	4	9,166	20,779	16,980	60,843.6	-	-	3,001.5	8,129.9	29,149.5	89,749.5

TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (please specify)
D = Dry Steam

3) Data for 2014 if available, otherwise for 2013. Please specify which.

Locality	Power Plant Name	Year Commissioned	No. of Units	Status 1)	Type of Unit 2)	Total Installed Capacity MWe*	Total Running Capacity MWe*	Annual Energy Produced 2014 3) GWh/yr	Total under Constr. or Planned MWe
Altheim	Altheim	2002	1		B-ORC	1.0	0.5	1	
Simbach-Braunau	Simbach-Braunau	2009	1	R	B-ORC	0	0	0	
Bad Blumau	Blumau	2001	1		B-ORC	0.25	0.2	1.2	
Total			2			1.25	0.7	2.2	

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2014 (other than heat pumps)

1) I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

2) Enthalpy information is given only if there is steam or two-phase flow

3) Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

4) Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^oC) - outlet temp. (^oC)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154

5) Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% of capacity all year.

Note: please report all numbers to three significant figures.

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (^oC)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Altheim	D	76.8	105	70			11.2	60	277.0	0.78
Geinberg	D, B, G, I	49.9	103	40			13.2	40	332.4	0.80
Simbach a. Inn/Braunau a. Inn	D	77.6	81	53			9.1	60	221.6	0.77
Obernberg	D	19.4	80	55			2.0	10	33.0	0.52
St. Martin im Innkreis	D	38.8	90	55			5.7	30	138.5	0.77
Ried im Innkreis	D	38.8	85	65			3.2	30	79.1	0.77
Haag am Hausruck	D	9.7	70	50			0.8	6	15.8	0.62
Bad Blumau	D, B, O	19.8	110	50			5.0	17	134.5	0.86
Bad Waltersdorf	D, B	21.7	63	28			3.2	15	69.2	0.69
TOTAL		352.5	787.0	466.0			53.4	268.0	1,301.2	

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2014

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

2) Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

3) Report the COP = (output thermal energy/input energy of compressor) for your climate

4) Report the equivalent full load operating hours per year, or = capacity factor x 8760

5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or Water Temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
No detailed information available; a total number of some 70,000 installations can be assumed by 2014 based by sales figures.								
TOTAL								

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 (TJ = 10^{12} J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 (MW = 10^6 W
projects do not operate at 100% capacity all year

Note: please report all numbers to three significant figures.

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]	50.4	1,255	0.79
Air Conditioning (Cooling)			
Greenhouse Heating	1.8	29	0.51
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]	1.2	17	0.46
Snow Melting			
Bathing and Swimming[7]	10	247	0.78
Other Uses (specify)			
Subtotal	63.4	1,548	
Geothermal Heat Pumps	840	4,990	0.19
TOTAL	903.4	6,538	

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1]	(all)					
Production	>150° C					
	150-100° C		4			12.3
	<100° C					
Injection	(all)					
Total			4			12.3

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Progran
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	2		2	4		5
2011	2		2	4		5
2012	2		2	4		5
2013	2		2	4		5
2014	2		2	4		5
Total	10	0	10	20	0	25

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2014) US$

Period	Research & Development Incl. Surface Explor. &	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	44.3	6	19	3	59	41
2000-2004	24.2	1.8	1.5		60	40
2005-2009	14.3	0.9	1.5		60	40
2010-2015	30.0	1.2	1.0		60	40