Geothermal Energy Use, Country Update for Austria

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Keywords: Austria, Hydrogeothermal Use, Geothermal Energy, Geothermal Resources, Molasse Basin, Styrian Basin, Vienna Basin, Pannonian Basin, Eastern Alps, Shallow Geothermal Use, Ground Source Heat pump.

ABSTRACT

Since the late 1970s geothermal energy is used in Austria for heat generation leading to an average development of geothermal applications in an European comparison. Currently, installed capacities are at a level of 1.2 MW_{el} (electricity production), 95.1 MW_{th} (direct use) and around 1.000 MW_{th} (ground source heat pumps). As in many other European countries, the geothermal market is dominated by ground source heat pump systems (factor of some 1:10 regarding installed capacities). However, the share of geothermal energy in the installed renewables for heating is still very low (1.6%) and for renewable electricity production neglectable (<0.1%). This is due to a general low level of public knowledge of geothermal technologies, the lack of political will and a non-favourable legal framework.

Since 2016, the direct geothermal use (hydrogeothermal use) is again slightly increasing based on a new installation for agricultural use in Styria (Frutura Project) and the remarkable extension of the district heating project of Ried/Mehrnbach in the Upper Austria Molasse Basin. In the upcoming decade new district heating developments can be expected in the cities of Vienna and Salzburg. In general, district heating based on geothermal has proven to be economically successful so that the existing grids are being steadily expanded.

Ground source heat pump installations show annual growth rate of around 5% and a share of 24% on the heat pump market. The increasing demand on cooling and seasonal heat storage might offer further opportunities for enhancing the overall share of geothermal in the RES market in Austria.

1. INTRODUCTION

2.1 Geographical and socio-economic overview

Austria covers an area of 83,871 km² and has 8.9 million inhabitants (2019). Its surface is dominated by the Alps (62.8%) and the Bohemian Massif (10.2%) thus reducing the share of the densely populated lowlands to only 27%. Based on official numbers of 2017, the level of urbanization reaches 65.9% in Austria, compared to 74.8% as an average of the European Union. At a GDP of around 40.300 EUR per inhabitant (2019), Austria is one of the richest countries in the European Union.

The use of renewable energy sources (RES) has a long tradition in Austria. In 2016, the total end-user consumption of energy for all sectors reached 1,435 PJ at a RES share of 33.5% (Biermayr 2017). The highest portion of RES was reported for electric power production (71.7%), followed by housing (51.7%) agriculture (48.3%) and district heating (46.15). The lowest share was reported for traffic (8.7%). Due to favourable topographic conditions, hydropower is dominating the renewable electricity production (78.7%), followed by wind energy (10.3%) and biomass (6.2%). Although installed at two locations in Austria, geothermal electricity production has a neglectable share (<0.1%). The production of renewable heat is dominated by biomass (58.3%), followed by black liquors (12.7%) and solar thermal (4%). The share of geothermal heat production (direct use and heat-pump supplied) is estimated at around 1.6%.

In the context of the European Union, Austria is the leading country referring to the share of RES in electricity consumption, but just at position 10 of 28 regarding the share of renewable heat consumption (BMWFW 2017).

2.2 Geothermal settings

The geothermal conditions in Austria generally differ grossly between the Alpine region at the one hand and the main sedimentary basins (Molasse basin, Styrian Basin, Vienna and Pannonian Basin) at the other. As shown in Figure 1, elevated heat flow densities of more than 100 mW/m² can be observed in the eastern part of Austria (Pannonian Basin, Styrian Basin), which are related to crustal thinning at the Pannonian Basin. Local anomalies in the Molasse Basin (up to 90 mW/m²) and the Vienna Basin are associated with local to regional scale hydrothermal systems.

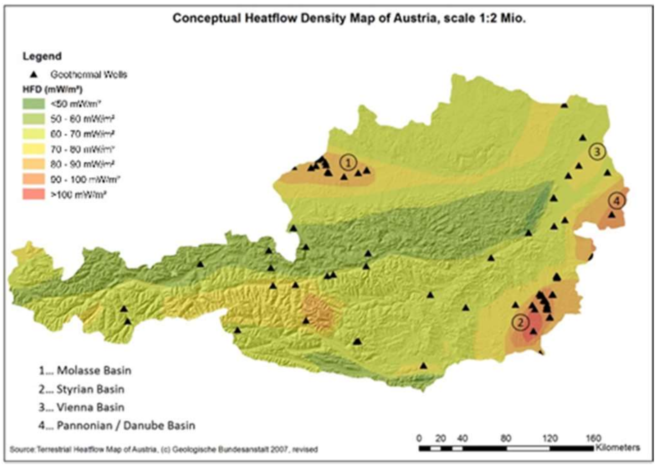

Figure 1: Conceptual heat flow map of Austria, displaying the location of geothermal wells.

Inside the Alpine Orogeny, the heat flow densities are generally lowered due to crustal thickening. Especially in the Northern Alps, long range infiltration systems of meteoric water lead to a further reduction of the heat flow density down to less than 50 mW/m². Elevated heat flow densities within the Alps only can be found in the area of the Central Gneiss due to radioactive heat production within this unit. Natural springs with temperature up to 46 °C are used for balneological purposes at Bad Gastein (Salzburg).

2.3 The role of geothermal energy in national Austrian strategies

Unfortunately, geothermal energy has not been playing a significant role in Austrian climate- and energy strategies until now. The Austrian National Renewable Energy Action Plan (AT-NREAP 2010) proposed the following measures for supporting the market diffusion of geothermal energy: (1) Feed-in tariffs of at least 7.5 €cent/kWh, (2) investment incentives of up to 30% for CAPEX greater than 35,000 € as well as (3) the re-use of abandoned hydrocarbon wells.

In fact, the feed-in tariff for geothermal electricity was reduced to 7.27€cent/kWh in 2018 and will further be reduced to 7.22 €cent/kWh in 2019 (ÖSET-VO 2018, BGBl. II Nr. 408/2017).

In 2018, the Austrian government defined a new strategy for climate mitigation and energy supply (#mission2030). Although again no specific goal or role was defined for geothermal energy use, the following aims of the strategy might be of relevance: (1) Expansion of heating grids linked to RES, (2) inclusion of storage into heating grids and use of waste heat, (3) re-use of abandoned hydrocarbon infrastructure.

Referring to the before mentioned strategy, the Austrian government is currently preparing a national Energy- and Climate Action Plan for the period 2021 to 2030 (BMNT, 2018). Geothermal technologies might contribute to the topics subsurface heat storage as well as decarbonized heating and cooling. A public stakeholder involvement process, which will be closed in autumn 2019, may offer a vital opportunity to strengthen the role of geothermal energy for the next decade.

2. DEEP GEOTHERMAL USE

2.1 General overview

The use of natural thermal waters (hydrogeothermal use) for balneological and energetic purposes has a long tradition in Austria leading to more than 70 geothermal projects and currently 135 km of drillings (see Table 1). After a period of extensive development in the 1990s and early 2000s, a period of reduced activities had to be observed (see also Figure 2). Since 2014, developments for the energetic use of thermal water slightly increased while balneological uses are stagnant.

In addition to numerous spas, 10 hydrogeothermal plants are currently operating in Austria. They are located in the Molasse Basin and the Styrian Basin. As shown in Figure 1 and Table 2, these regions offer the most favourable conditions for hydrogeothermal use regarding heat flow densities, aquifer capacities and groundwater chemistry. However, these two regions are quite extensively used and offer limited remaining reserves of around 100 MW_{th} according to Könighofer et al (2014).

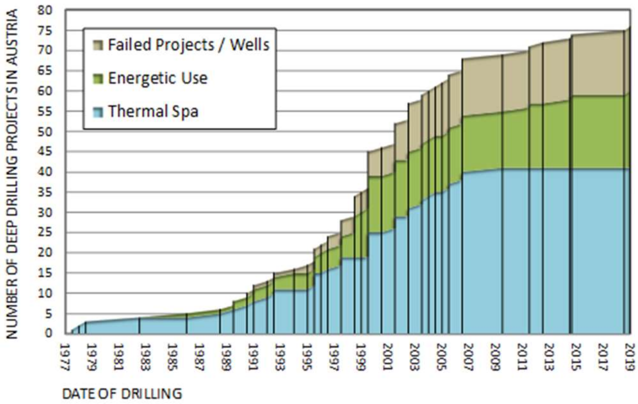

Figure 2: Geothermal drillings in Austria for the period 1977 - 2018.

Table 1: Geothermal drillings in Austria (period 1977 – 2018).

Unit	Total number of wells	Cumulative depth [m]
Styrian Basin	28	48 600 m
Upper Austrian Molasse Basin	14	30 828 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 and Upper Austroalpine Units (mainly crystalline rocks)	19	27 483 m
Pannonian Basin	1	860 m
Total	**77**	**135 178 m**

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 high subsidence rates. Locally confined enhanced heat-flow due to hydro-dynamic convection.	Several reservoirs in Austroalpine carbonate rocks; minor reservoirs in Miocene clastic sediments.	Central part: Not developed yet Southern part: balneological use

In contrast other hydrogeothermal regions in Austria like the Vienna Basin, the southern part of the Molasse basin in Upper Austria as well as the Molasse Basin in Lower Austria have not been developed yet and offer opportunities for future exploitation.

2.2 Research activities

Currently, research and exploration activities focus on the Vienna Basin and the Molasse Basin in Upper Austria and Bavaria.

Vienna basin

Since 2016, several 2D and 3D seismic exploration campaigns have been conducted in the framework of the GeoTief initiative (http://www.geotiefwien.at) in the eastern part of the city of Vienna. The energy supplier of Vienna intends to shift a significant share of the district heating supply to hydrogeothermal energy sources. The main exploration targets are Triassic carbonates, which belong to Austroalpine units, in depth ranges between 3,000 and >5,000 meters. In addition, Miocene conglomerates of the sedimentary fillings of the Vienna Basin in depths of 2,000 to 3,500 meters below surface represent a further target. As indicated in Figure 3, the structural position of the expected reservoirs is rather complex due to Alpine thrusting, thus increasing the possibility of failed projects.

Due to extensive hydrocarbon exploration in the past decades, the geothermal conditions in the Vienna Basin are rather well known as well as the presence of thermal water, which exhibits in most locations highly saline, connate conditions. Across the central Vienna Basin, occurrence of thermal fluids was observed in more than 50 exploration wells representing a thermal potential in the order of 160 to 460 MW_{th}.

The first commercial drillings are expected to be executed in 4 to 8 years.

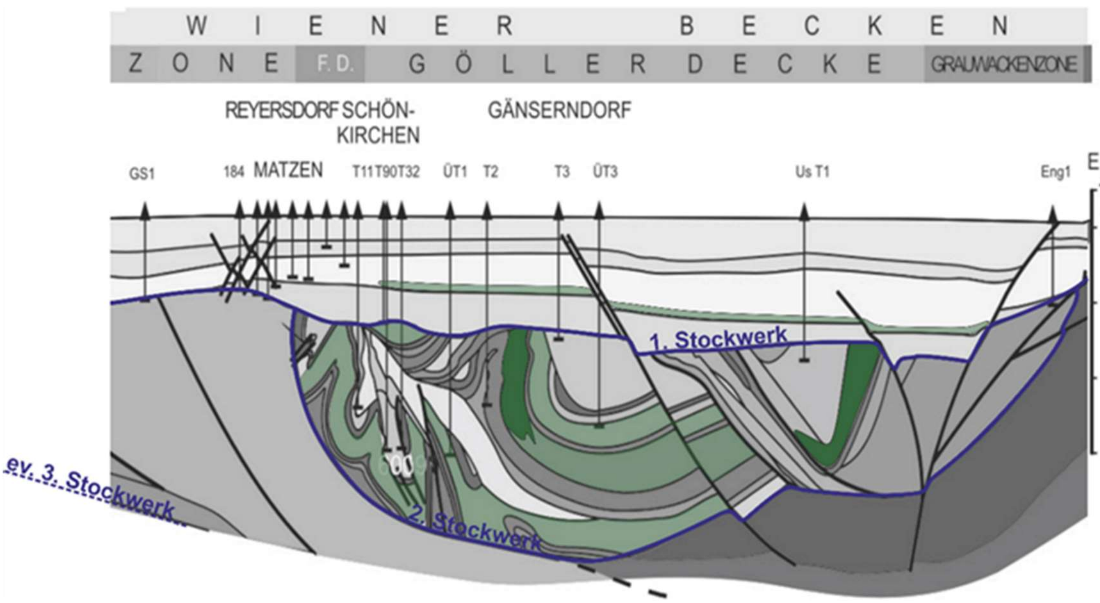

Figure 3: Cross section through the central Vienna Basin. Green coloured layers indicate estimated hydro-geothermal reservoirs. The cross section was taken from Wessely (2006).

Molasse Basin Upper Austria

Currently, two scientific studies (project OTTO, funded by the Austrian Academy of Science and a regional study directly funded by the authorities of Upper Austria and Bavaria, respectively), have their focus on the hydrodynamic systems of the Upper Jurassic (Malm) carbonates in the border region of Upper Austria and Lower Bavaria, an area already extensively used for balneological and energetic purposes. Both studies aim at evaluating existing concepts of the thermal water circulation systems in the Malm aquifer. Their results are intended to facilitate the management of the thermal water use in this sensitive region.

Within the project OTTO (2017 – 2020), more than 35 water samples have been collected at geothermal and hydrocarbon wells in Upper Austria and analysed for the chemical as well as hydro-isotopical composition. In addition, the project team investigated the hydrocarbon composition of the associated gas of geothermal wells.

Preliminary results indicate that the trapped thermal water might be older than assumed so far and is locally mixed with younger groundwater and interacting with present petroleum systems as a result of rather complex flow paths. The final results of the above-mentioned studies are expected in 2020 and 2021 respectively.

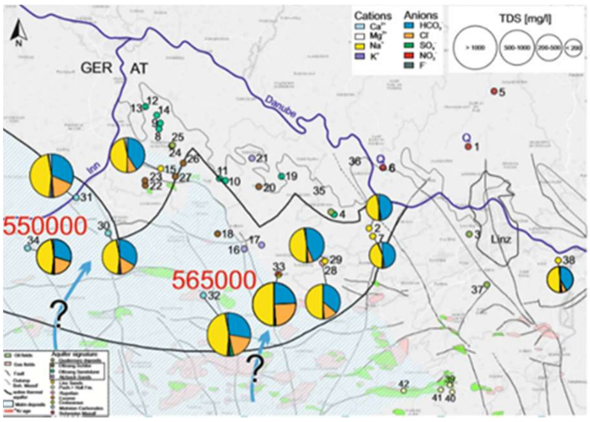

Figure 4: Chemical signature of water samples from geothermal wells in the border region between Austria and Germany, which were measured in the framework of the OTTO project (Gross et al., 2018).

2.3 Projects

Upper Austrian Molasse Basin

By the end of January 2019, the well Mehrnbach Th 3 was successfully finished at a depth of 2,592 m. This well is intended to enhance the production for the district heating network in the town Ried im Innkreis and the neighbouring village Mehrnbach which went into operation in February 2014. The encountered 200 m thick Upper Jurassic dolomite dominated sequence in Mehrnbach Th 3 is characterised by two distinct facture zones. A flow volume of 100 l/s is envisaged for the long-term pumping and reinjection test, which is scheduled for March and April 2019. Temperature at well head is expected as high as 105 °C. Upon implementation of Th 3 in the heating grid installed geothermal power at Ried-Mehrnbach will rise to 19 MW. Figure 5 shows a map with the location of the three wells and the geothermal plant.

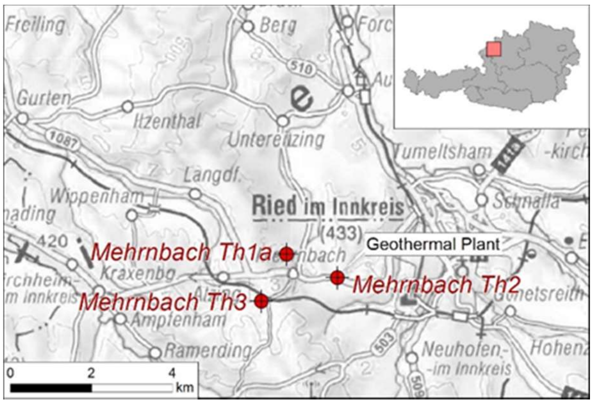

Figure 5: Site Mehrnbach (Upper Austria).

Styrian Basin

The geothermal greenhouse project Frutura went into operation in 2016. It is based on two wells which targeted Palaeozoic dolomites of the Basin floor of the Styrian Basin. The well Frutura GT 2, which has a MD of 3,300 m (TVD 3,188 m), allows for a production of 60 l/s at a temperature of 124.5 °C, the highest temperature so far of all geothermal wells in Austria. Geothermal fluid is a NaCl brine of 78 g/l, the accompanying gas is dominated by CO_2 (gas/water ratio: 12 : 1). Currently the gas is reinjected with the fluid in the well Frutura GT 1/1a (the "a" denotes a side track for geological reasons), but will be used for facilizing plant growth in the greenhouse (see Fig. 6) in a later stage of the project. The greenhouse area amounted to 17.5 ha by the end of 2018, the currently installed thermal power equals 15 MW.

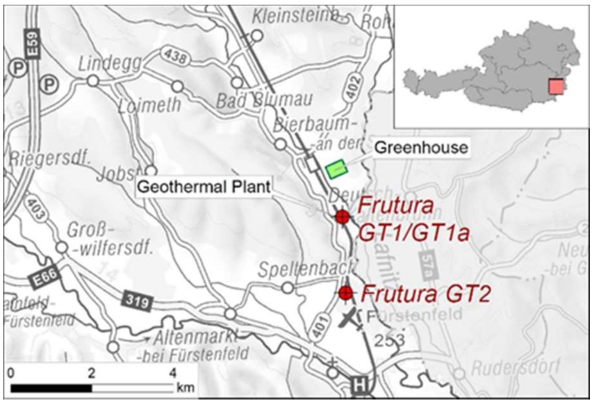

Figure 6: Map displaying the location of the Frutura wells, the geothermal plant and the green-house area.

2.4 Summary and outlook on the period 2019 - 2022

Based on reported numbers of 2018, deep geothermal reached a total installed capacity of 95.1 MW_{th} for direct heating (annual production 314.9 GWh_{th}) and 1.2 MWel (annual production 2.7 GWh_{el}) for electricity production. Currently, one installation in the Upper Austrian Molasse Basin (Ried im Innkreis) is expanded. Exploration is conducted in the Vienna basin and Bavaria Molasse Basin close to the Austrian border for a possible future supply of district heating systems in the metropolises Vienna and Salzburg. One geothermal exploration well, drilled 2018 in Carinthia was not successful.

In the upcoming 3 years no new installations for direct hydrogeothermal use may be expected. The extension of the existing installation in Ried im Innkreis is expected to raise the total amount of installed capacities in Austria in the range of 19 MW_{th}.

3. SHALLOW GEOTHERMAL USE

3.1 Market overview

The heat-pump market in Austria is still moderately growing at a rather high level of market diffusion.

It is currently dominated by air-based systems which had a market share of 72% in 2017 at a total of 18,994 sold units. The regressive trend started in 2008 leading to a reduction of earth coupled heat pumps from 60% to 24% regarding the installed systems in 2017.

The market share of water-water heat pumps was only 3.6% in 2017. Down hole heat exchanger saw an increase of 3.7% for systems in the power range <10kW: + 3.7% and 9.1% in the range >10 kW to <20 kW which is remarkable. For larger plants, however, sales figures declined by –9.6 % in 2017 thus following the negative trend of 2016 (-7.3%). The share of heat pumps based on borehole heat exchangers was 20.1% in 2017.

The total installed thermal power of earth coupled heat pumps by the end of 2018 can be estimated at 1.000 MW_{th}. This number is based on a thermal power of 840 MW for 2015 published by Goldbrunner & Götzl, 2016 and an annual growth rate of 53 MW_{th}.

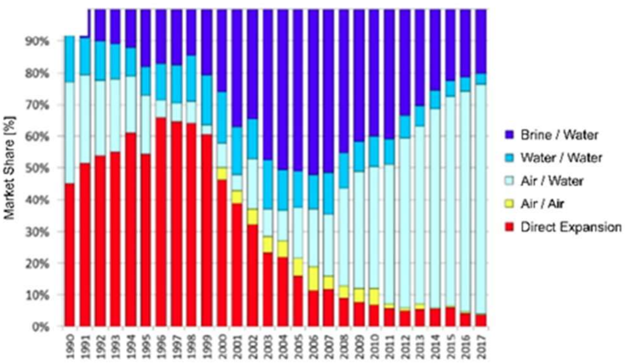

Figure 7: Development of the heat-pump market in Austria based on annual sales for the period 1990 – 2017 considering the different kind of heat sources. Taken from Biermayr et al (2018).

Actual market figures according to Biermayr et al. (2018) reveal that ground source heat pump systems still dominate the sector of large-scale installations (<50 kW total capacity of the heat pump) due to the technical and emission related limitations of air-based heat pump systems.

3.2 Research activities

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 ground groundwater use in urban areas calls for change of paradigm from individual ground source heat-pump systems to joint utilizations and integrative management approaches for city quarters and communities. 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.

3.4 Outlook on the period 2019 - 2022

Until now the ground source heat-pump market in Austria was dominated by individual (single building) use. Currently, the first joint uses in terms of low temperature heating and cooling grids are under development in Austria (e.g. urban development area “Viertel zwei +” in Vienna). The authors also see a rising interest in geothermal cooling and seasonal heat storage (especially combined heating and cooling) in the office building and urban housing sector. As the general level of awareness at investors and political decision makers in Austria on ground source heat-pump systems is rather low, the annual growth level with regard to installed capacities might be in the range of around 5% per year. This might change in case that large scale joint utilizations providing heating and cooling for low temperature heating and cooling grids might be further established on the Austrian market. Therefore, a future opportunity for the shallow geothermal use in Austria is given for large scale community utilizations with heat pump sizes of above 50 kW.

4. CONCLUSIONS

Austria represents a country with a long tradition on geothermal energy use and is still above European average regarding its application. Referring to reported figures from the Austrian operators in 2017 and 2018, direct geothermal use currently reaches 1.2 MW_{el} (2.74 GWh_{el} per year) for geothermal electricity production and 95.1 MW_{th} (315 GWh_{th} per year) for direct heat use. Different studies report proven geothermal reserves in the range of 700 to 1,000 MW_{th} for Austria with emphasis on the Vienna Basin. Hence, the degree of exploitation is still very low in Austria and future significant developments may be expected in the upcoming decade.

Concerning ground source heat-pump use, only estimations of the installed units based on sales figures of heat pump units indicate an average increase of 53 MW_{th} per year (gross production around 2.500 GWh_{th}

per year), which is mostly related to borehole heat exchangers.

Still, the level of awareness towards the use of geothermal energy is rather low in Austria. Hence, the share of geothermal heat production (direct use and heat-pump supplied) in the heat production heat is estimated around 1.6%. Currently executed research and communication activities in Austria aim at raising the awareness of political decision makers and investors, facilitate the access to information (development of web-based information systems) and provision of elaborated proposals to raise the efficiency of the legal framework. These activities aim to enhance the market diffusion of deep systems as well as ground source heat pumps. As the Austrian government is currently preparing an energy and climate strategy for the period 2021 to 2030 (BMNT 2018) this offers an opportunity to foster the integration of geothermal use into national strategies.

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Acknowledgements

The authors want to thank the operators of Austrian deep geothermal installations for providing the updated operational figures for 2018 and/or 2017.

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 electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2018	1.2	2.7		67.881	<0.1%	<0.1%
Under construction end of 2018						
Total projected by 2020	1.2	2.7				
Total expected by 2025	5	10				
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2018 (indicate exploration/exploitation if applicable):					Under development	
					Under investigation	

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commis-sioned	No of units	Status	Type	Total capacity installed (MW_e)	Total capacity running (MW_e)	2018 pro-duction (GWh_e/y)
Bad Blumau	Bad Blumau	2001	1	O	B-ORC	0.2	0.2	0.5
Altheim	Altheim	2000	1	O	B-ORC	1.0	1.0	2.2
total						1.2	1.2	2.7

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

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

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for 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 2018	75.7	224.7	17.0	69.6	69.0	218.4	2.4	20.6
Under construction end 2018								
Total projected by 2020								
Total expected by 2025	150	500						

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

Locality	Plant Name	Year commis-sioned	CHP	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GW_{th}/y)	Geoth. share in total prod. (%)
Altheim	Doublet Altheim*	2000	yes	No	11.2	11.2	27.9	100
Geinberg	Doublet Geinberg	1997	No	No	13.2	13.2	29.4	100
Simbach a. Inn / Braunau a. Inn	Doublet Simbach-Braunau	2003	No	No	10.0	42.3.	48.0	66
Obernberg	Doublet Obernberg*	2000	No	No	6.5	6.5	16.0	100
St. Martin im Innkreis	Doublet St. Martin	2002	No	No	8.5	29	31.7	60
Ried im Innkreis	Doublet Mehrnbach	2014	No	No	15.0	20	41.8	90
Haag am Hausruck	Doublet Haag	1996	No	No	1.0	1.0	7.1	100
Bad Blumau	Bad Blumau	2001	Yes	No	8.0	8.0	16.8	100
Bad Waltersdorf	Bad Waltersdorf*	1979	No	No	2.3	5.0	6.0	70
total					**75.7**		**224.7**	

* If 2017 numbers need to be used, please identify such numbers using an asterisk

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Fürstenfeld/Bad Blumau	Frutura	2016	no	17.0	17.0	69.6	100	Frutura
total				17.0	17.0	69.6		

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018 *	nA	~1,000	~2,500	~3,600	~53	24
Projected total by 2020	nA	~1,100	~2,700			

Table F: Investment and Employment in geothermal energy

	in 2018		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses	~5	nA	~10	nA
Shallow geothermal	~3.1	nA	~3.5	nA
total	**~8.1**		**~13.5**	

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	No	National research programs on energy KLIEN, FFG (https://www.ffg.at/)	
Financial Incentives – Investment	DIS (organized at a national level, funding agency KPC https://www.publicconsulting.at/)		DIS (organized via regional authorities)
Financial Incentives – Operation/Production	FIT: 7,22 €Cent/kWh	No	No
Information activities – promotion for the public	No	No	Guidelines on the licensing of new installations available; Technical guidelines provided by OEWAV (https://www.oewav.at/)
Information activities – geological information	No	No	Yes, web based information systems available in some regions of Austria Project GeoPLASMA-CE (www.geoplasma-ce.eu)
Education/Training – Academic	No	Yes	Yes
Education/Training – Vocational	No	No	Yes (training programs for installers and drillers)

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)