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Geothermal Energy Use, Country Update for Finland

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ABSTRACT

In Finland a huge growth in the amount of HPs started from the year 2005 with less than 100 000 HPs up to today`s 540 000 HPs. The strongest growth has taken place in air-coupled HPs but also in GSHPs the yearly increase has been tens of % with the record of 72% in 2012 (Fig. 1). Today over half of new small houses utilizes HP technology and an increasing number of big targets like office buildings and shopping centres markets take GSHPs for heating and cooling of spaces. A clear trend is toward large GSHP installations but still today domestic systems are growing fastest and > 50 % of new small houses takes geothermal heating/cooling. The largest installation is in a logistics centre in southern part of Finland with 150 BHEs, each 300 m deep (total 45 000 m). This energy field/installation has been provided by an advanced real-time fibre optic monitoring system designed by Geological Survey of Finland GTK.

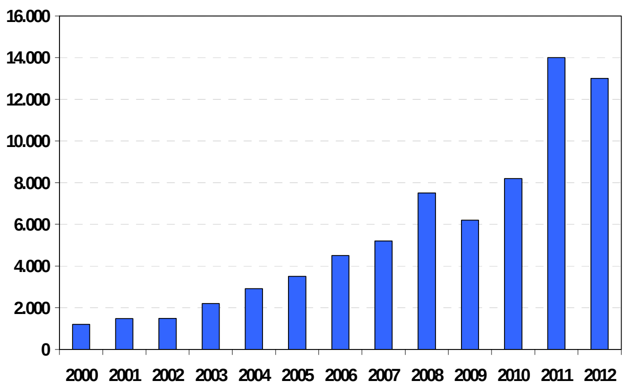

Figure 1: Total number of GSHPs in Finland in year 2000-2012. (Sulpu, 2013)

1. GEOLOGICAL CONDITIONS IN FINLAND (SHALLOW GEOTHERMAL)

The Finnish bedrock/crust consists of Pre-cambrian, (Archean) crystalline, metamorphosed ”thick” , cool craton, consisting of granitoids, migmatites, gneisses and schists with smaller areas of younger sandstones. Only 3 % of land is exposed as outcrops. Brittle deformation by fractures and cross-zones, filled with moving ground-water (reservoirs), gives favourable conditions for geoenergy exploitation. Low average temperatures of ground, around the year (2 – 8 Celsius) give good chances for free cooling during summertime. Bedrock preserves summer heat until winter and cold from winter until summer. The bedrock is covered by Quarternary (< 10 000 yrs) sediments, clays, silts, fluvial sands, moraines, mires. Thickness of these are typically a few meters (2-6 m), sometimes > 30 m(– 50 - 60m and more). Over 9% covered by water (lakes, rivers).

All Fennoscandian Shield low enthalpy area. The geothermal gradient is usually 8-15 K/km. The low gradient is due to the Precambrian geology, with a very thick lithosphere (150-200 km). The average thermal conductivity of Finnish rocks is 3.24 W/(m K) (Kallio & al 2011). Thermal conductivity is controlled by the mineral composition, texture and porosity of the rock and movements of groundwater. Typically maximum ground temperatures at the depth of 300 m are around 10 – 12 Celsius in southern Finland. As examples in the Pyhäsalmi ore mine (central Finland) , in the depth of 1450 m, the temperature is about 22 °C. At Outokumpu, area (eastern Finland) in the depth of 2500 m, the temperature is 40 °C.

This means that no EGS systems are economically possible. On the other hand bedrock is very suitable for (free) cooling which makes the whole system more profitable. The heat from cooling is transferred back to bedrock increasing the heat capacity. In Finland all geothermal energy comes from Shallow Geothermal Energy sources, from the uppermost layers/skin (150-300 m) of the crust, and GSHPs are always needed for heating. Free circulation through wells without HPs works in most cases for cooling.

2. TECHNOLOGIES IN USE

Only closed loop BHE-systems are in use with alcohol (ethanol) based fluid circulating in exhangers (pipes/wells). The exchanger is typically a single or double U pipe with typical diameter between 32-40 mm . Well depths are 150-300 m and spacing between single wells typically 20m +/- and geometry rectangular. Today most of the large systems are hybrid renewable energy systems consisting of two or more renewable energy sources (geo-/bio-/solar.).In summer surplus heat from air conditioning (cooling) is transported into e-wells ” loading” the field for winter uptake, making the rock act as an Underground Thermal Energy Storage (UTES), in this case as a BTES. Often hybrid systems for peak loads are used and welcome

The used drilling technique is Down Hole Hammer (DHT) and no grouting is needed/used so far but will be tested especially for the groundwater areas. There are moreover some hybrids especially in the city areas, which utilize geothermal energy together with district heating. So the building is coupled also to district heating grid. Planning, calculating and modelling of large geothermal installations are typically based on TRT – measurements and other local on –site research, and it is also recommended for all planners to use experts for this work. The value of this research has been accepted more and more as a necessary and basic back-ground work for a successful final result. It gives the needed empirical planning parameters. Geological Survey of Finland GTK utilizes also DTS-method as a routine method in its services for planners, (Fig. 2)

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Figure 2: Distributed temperature system (DTS) measurements with fibre optic cable. Photo by I. Martinkauppi

2.1 R&D CHALLENGES

The R&D (theoretical+applications) in Finland is mostly run by GTK. It has very comprehensive geological and geophysical data collected during tens of years. All Finland has been covered by air borne geophysics. GTK has also two mobile TRT-vans/units for in-situ surveys (Fig. 3). Also resources are used for research, especially to theoretical behaviour and modelling of an single energy well as for modelling of large installations/hybrid systems including real-time monitoring and steering of energy uptake from a field.

Figure 3: The first Finnish thermal response test unit (TRT) in operation at an industrial building area. Photo I. Martinkauppi

3. CONCLUSIONS

Geothermal energy or geoenergy (as called in Finland) has taken long jumps forward during the last five years. The HP boom started with air-coupled HPs, still prevailing, but shifting today more and more to GSHPs both in small house as well as large projects. The future seems positive and geoenergy is taking even greater share from the renewable energy palette. The governmental target to be set for the year 2020 is now 8 TWh representing about 10% of the energy needed for heating of houses. With the present trend this figure will be surpassed. Last year (2012) the total consumption for space heating in Finland was 95 TWh. Today about 30 % of the used energy is produced by renewable sources. The target set by 2020 is 38 %.

REFERENCES

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Tables A-G

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

*Geothermal power plants are not available in the country.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

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

*Geothermal district heating plants are not available in the country.

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

*Geothermal district heating plants are not available in the country.

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

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (TWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	90 000		3 – 4	13 000		< 50
Projected by 2015	130 000		4 – 5			

Table F: Investment and Employment in geothermal energy

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses				
Shallow geothermal	400 (HPs)		1000 (HPs)	
total	**400**		**1000**	

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D			DIS
Financial Incentives – Investment			DIS, LIL (HPs 20 % of investment`s value)
Financial Incentives – Operation/Production			no
Information activities – promotion for the public			Yes, mostly by entrepreneurs/companies
Information activities – geological information			Available from GTK
Education/Training – Academic			Not yet
Education/Training – Vocational			Yes by separate courses

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