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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 730 000 HPs , of which 130 000 GSHPs (Sulpu 2016). HPs are replacing the earlier popular oil and electric heating systems in small houses and sometimes also district heating. The strongest growth has taken place in air-coupled HPs but also the increase of GSHPs was last year over 9000 units but not reaching anymore the historical top of 14 000 in 2011 (Fig. 1). After that the growth has been slower due to the common decline of economy and building activity. But still today over half of new small houses utilizes GSHP technology and an increasing number of big targets like office buildings, school houses, apartment houses, shopping centres, markets, hospitals take GSHPs for heating and especially 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 shallow geothermal (geoenergy) for heating but also for cooling.

The **largest installation** in Finland is in a logistics centre in southern part of Finland, 30 kilometers northward from Helsinki, with 150+150 closed-loop BHEs (two separate buildings) each 300 m deep (total 90 000 m). This energy field/installation has been provided by an advanced real-time fibre optic monitoring system designed by Geological Survey of Finland GTK and being in function since 2012.

The **first EGS - pilot project**, run by a private company St1Nordic Oy, and aiming to utilize geothermal energy from 6 – 7 kilometer`s depth for district heating with a thermal power of 40 MW , situated in the city of Espoo, was started 2015 with a core sample boring up to 2 km`s depth into the crystalline granitoidic bedrock. This hole was made for research purpose only. The boring of the final production holes is planned to start during springtime 2016, and the first hole be finalized in a half year.

It looks today that **energypiles** for storing and extracting of geoenergy, heat and cold, may have a growing role in future, especially in areas of thick Quartenary clayey sediments.

The publication of the first Finnish **geothermal energy potential map by** GTK (Fig.2) is believed to give an extra jump forward in utilizing GSHPs.

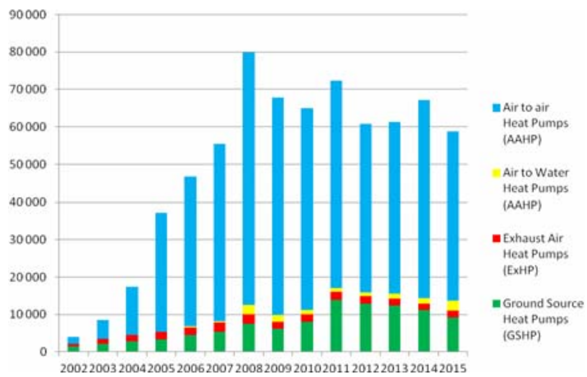

Figure 1: Total number of HPs in Finland in years 2002-2015. (Sulpu, 2016)

1. GEOLOGICAL conditions in Finland

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 increasing need of free cooling during summertime. Bedrock preserves summer heat until winter/spring and enough cold from winter over summertime. 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 is 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. For example 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. To reach 100 Celsius, depths from 6 to 8 km are required (Kukkonen 2000).

This means that no EGS systems have not been so far economically attractive but the present on-going pilot in Espoo city hopefully will show the real economic and technical possibilities to utilize geothermal deep heat in Finland.

On the other hand the cool bedrock is very suitable for (free) cooling which makes the geoenergy system more profitable. The heat from cooling is transferred back to bedrock increasing the heat capacity. In Finland all geothermal energy so far comes from shallow geothermal energy sources, from the uppermost layers/skin (150-300 m) of the crust. GSHPs are used for heating. Free circulation through wells without GSHPs works in most cases for cooling.

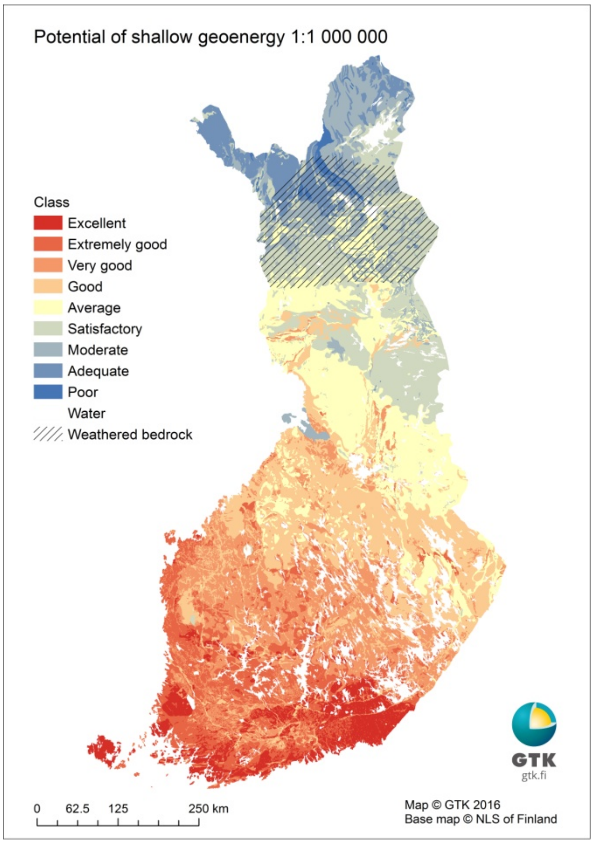

Figure 2: Geothermal energy potential map from Finland (GTK, 2016).

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. Some new innovative Finnish co-axial exchangers have emerged and under trial. Well depths are typically 150-300 m, with a tendency to go deeper down to 400 m. Spacing between single wells is 20m +/- and geometry mostly rectangular.

Today many of the large systems are hybrid renewable energy systems consisting of two or more 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.There are moreover some hybrids especially in the city areas, which utilize geothermal energy together with district heating for single houses. So the building is coupled also to district heating grid.

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.

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 understood 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. 3)

Figure 3: 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 bank 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. 4). Also resources are focused on research, especially to theoretical behaviour and modelling of an single energy well as well as multi hole storage systems, and for determining the thermal properties of bedrock from layer to layer using fiber optic thermometers combining TRT- method and called DTRT- test. Moreover large installations/hybrid systems including real-time monitoring and steering of energy uptake from a field are under active research. Some trials with bentonite grouting have been run.

Figure 4: The Finnish thermal response test unit (TRT) in operation at urban building area. Photo I. Martinkauppi

3. CONCLUSIONS

Geothermal energy or geoenergy (as called in Finland) has taken remarkable jumps forward during the last five years. The HP boom started with air-coupled HPs, still prevailing and most sold, but the trend is shifting today more and more to GSHPs both in small house as well as in large projects. The future seems positive and geoenergy takes 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.

In the year 2014 the total energy consumption for space heating (houses) in Finland was 77 TWh of which HPs deal is about 7 %, and of which GSHPs produce about 5-6 %.Last year 2015 the increase given by HPs is estimated to be 1 TWh (Sulpu 2016).

In common close to 40 % of the used energy is produced today by renewable sources. The target set by our government by 2020 is 38 % which was passed last year.

REFERENCES

Kallio, J., Leppäharju, N., Martinkauppi, I. and Nousiainen, M.Geoenergy Research and its utilization in Finland. *Geological Survey of Finland, Special Paper 49, 179-185, 2011.*

Kukkonen, I.T. Geothermal energy in Finland. *Proceedings World Geothermal Congress 2000, Kyushu* – Tohoku, Japan, May 28 – June 10, (2000), 277 – 282.

SULPU (Finnish heat pump association), 2016. <www.sulpu.fi>

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

Table B: Existing geothermal power plants, individual sites

There are no geothermal power plants in the country

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

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

There are no geothermal district heating plants so far but one pilot project is going in southern Finland

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2015		
	Number	Capacity (MW_{th})	Production (TWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2015	130 000		5	9200		>50
Projected total by 2018	160 000		6			

Table F: Investment and Employment in geothermal energy

	in 2015		Expected in 2018	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power				
Geothermal direct uses				
Shallow geothermal	350 (HPs)	2000	550 (HPs)	2500
total	**350**	**2000**	**550**	**2500**

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D			DIS
Financial Incentives – Investment		DIS	DIS, LIL
Financial Incentives – Operation/Production			no
Information activities – promotion for the public			Yes, mostly by entrepreneurs/companies, municipalities, cities
Information activities – geological information			Available from GTK
Education/Training – Academic			Some university courses
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