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The soil thermal analysis in the neighbor of ground source heat exchanger of the heat pump

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Summary

The aim of this article is thermal behavior of ground source heat exchanger during the one year measured period. It represents soil temperature dependences on the depth under the terrain during the time. The ground source heat exchangers introduce a very interesting and important alternative source of energy which has a very good possibility for using not only in residential buildings in future.

In the article, daily, monthly and annual dependences of soil temperatures from particular sensors, placed in the system of ground source heat exchanger are analyzed.

Generally known rule that with the growing depth under the terrain the temperature of soil is less influenced by the weather conditions with the measured dates is validated. At the same time stands up the question, to which depth the soil is able to regenerate itself and when it cannot be revive by reason of big depth under the terrain.

Than it is necessary to consider the local conditions if it is better to use ground source heat exchanger or to make a borehole.

KEYWORDS: The ground source heat exchangers, temperature dependences, alternative energy, source of energy, alternative sources, the thermal behavior

ISSN 1582-3024

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1. INTRODUCTION

Nowadays, when the big requirement for saving energy is in need, there is a tendency to use natural and alternative sources of energy. The heat exchangers have a very good potential for using in residential housing and in large buildings as well in future. This article deals with soil thermal behavior in the neighbor of ground heat exchanger of the ground to water heat pump. The measurements are from one year period – from February to December 2007.

2. THE MEASURED SYSTEM DESCRIPTION

The measurements were made from February 2007 to December 2007 during all days in the interval one minute. This system is installed in the family house with overall heat loss aprox. 12kW. The energy demand for heating and hot water is covered by the ground to water heat pump. R404a is used in the ground heat exchanger like a cooling medium.

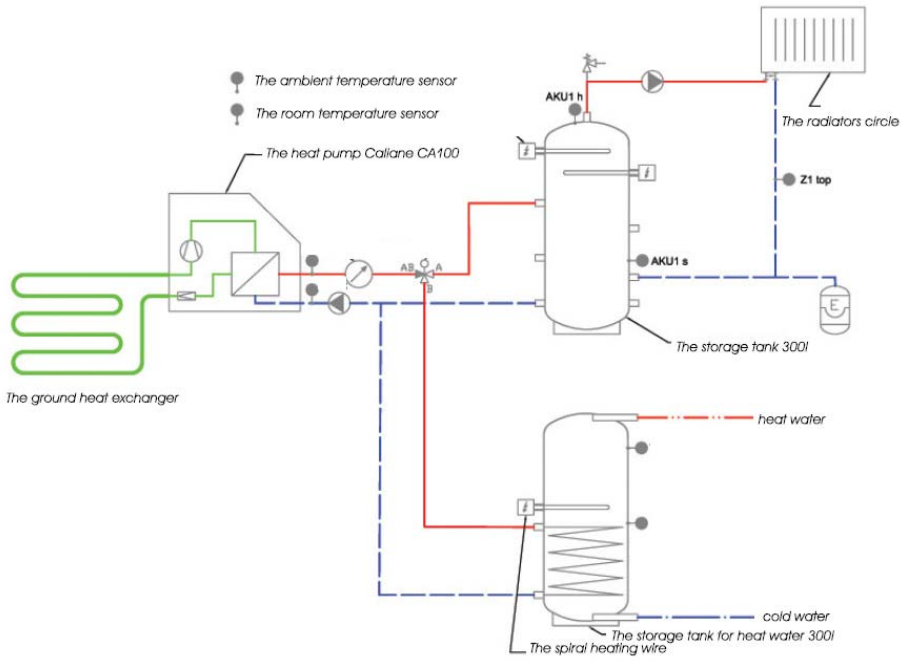

Figure 1. The system connection in the family house

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For the measurements the DS18B20 sensors were utilized (Dallas Semiconductor producer). These sensors work with thermal range -55°C to +125°C, with the accuracy $\pm$ 0,5°C for 10°C to +85°C.

15 sensors are placed in the different depth under the terrain, which are scanning the soil and piping temperature – viz. figure 2.

The AKU2h sensor is situated in 1,1m under the terrain and is screened from the ground exchanger by the polystyrene board to prevent the influence from piping to the soil.

The ground register is placed in the 1,1m under the terrain and is made from 5 piping loops. From the previous geological enquiry, the clay, cohesive and medium dry soil was found out.

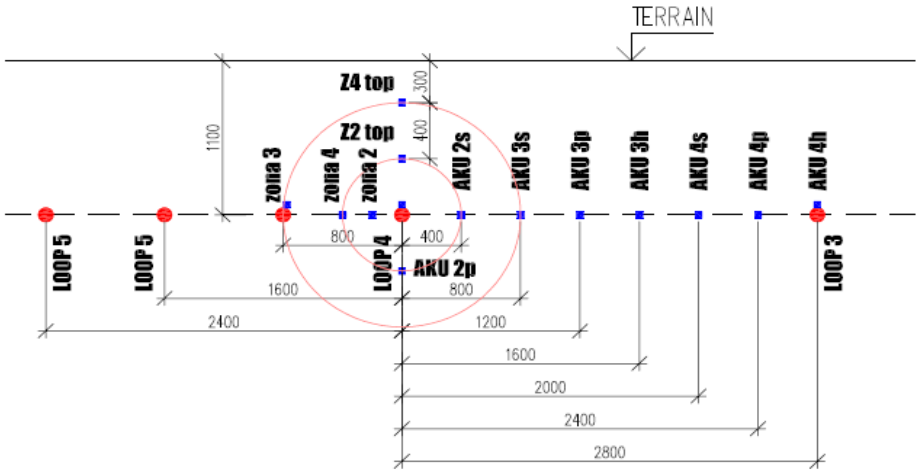

Figure 2. The situation of the used sensors

3. DATAS PROCESSING [1], [2], [3], [4]

Regarding to a large number of dates, from the ambient temperature, the coldest and the warmest month was determined. The coldest month in 2007 was December, the warmest one was June. As in the June the dates are not totally complete for next comparisons the July was studied.

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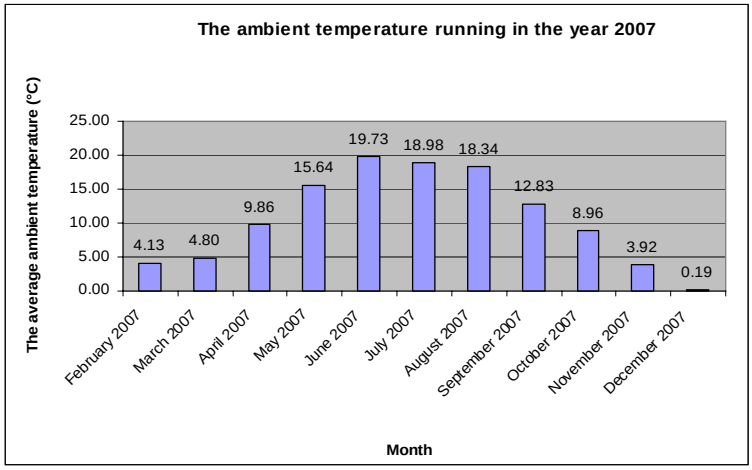

Figure 3. The average ambient temperatures in 2007

The next charge shows the temperature process in the soil during the reference day in the month (the 15 of July and the 15 of December). The dates are thinking from the sensors z4top, z2top and aku2h in these days. For the same level under the terrain, the temperature running is during the day almost constant. In July the warmest temperature can be observed in the depth 0,3m under the terrain, the most constant than in 1,1m under the terrain (aku2h sensor – screened sensor by the polystyrene board). In the December the highest temperature has the soil 1,1m under the terrain (the aku 2h sensor), the soil 0,3m and 0,7m under the terrain is more influent by the weather conditions.

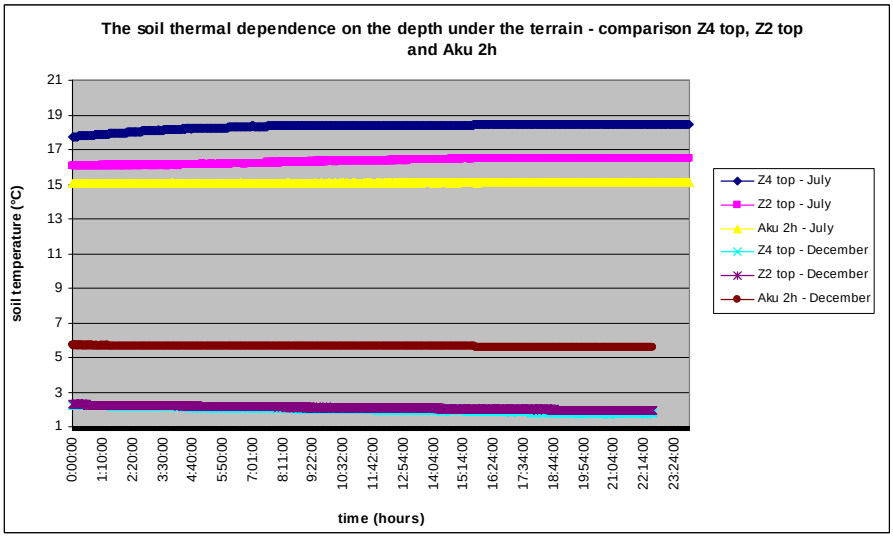

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Figure 4. The soil dependence on the depth under the terrain

Table 1. The daily average values of soil temperature in dependence on the depth under the terrain

	sensor Z2 top (°C)	sensor Z4 top (°C)	sensor Aku 2h (°C)	sensor Aku 2p (°C)
July 2007	16.33	18.32	15.07	14.85
December 2007	2.09	1.99	5.62	3.94

The soil daily running temperature in the dependence of the depth under the terrain and the sensor position, in the next charges is shown. The daily process of the temperature is based on the aku 2h and z4top sensors measurements. The temperature differences on the beginning and in the end of measured interval (24 hours) are almost negligible. From the sensor aku 2h in the day 14.07.2007 the difference is 0,04°C, for the day 15.07.2007 than 0,02°C. For the same days from the sensor z4 top these differences are higher and it is 1,13°C for the day 14. 07.2007 and 0,73°C for 15.07.2007.

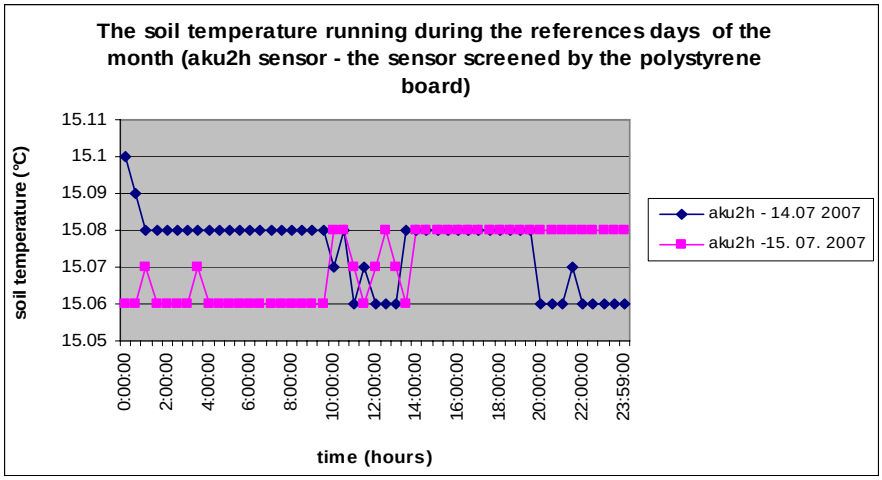

Figure 5. The soil thermal dependence on the depth under the terrain from aku 2h sensor

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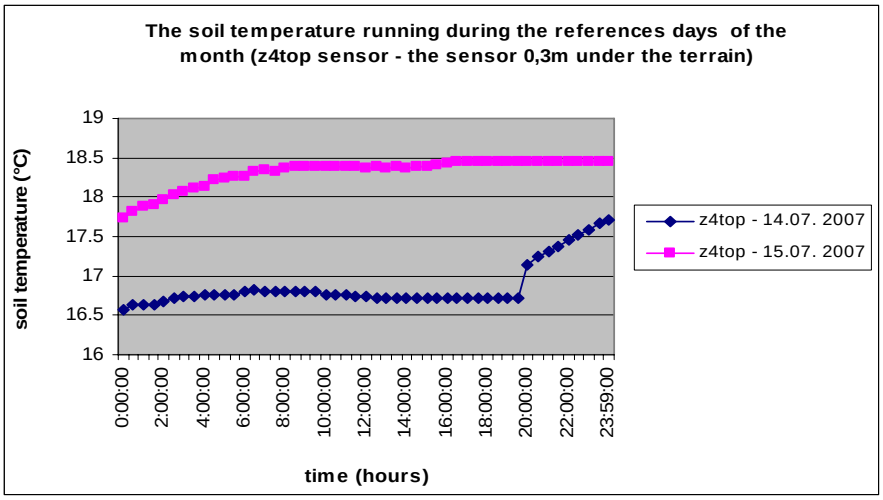

Figure 6. The soil thermal dependence on the depth under the terrain from z4 top sensor

How can be seen from these measured dates the most stable is the soil in the depth 1,5m under the terrain, because in this depth the soil is not so influent by the weather conditions.

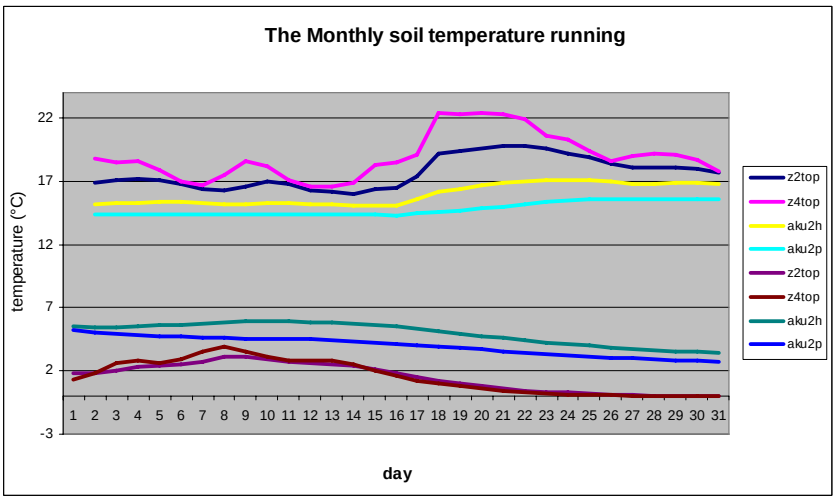

Figure 7. The monthly soil thermal dependences in June and in December

From the figure 7 can be seen the differences in the temperature divergence. The difference from the sensor z4 top is in frame 5°C, from aku 2p it makes the difference 1,5°C in the June. In the December, there can be observed the highest divergence in temperature from the 0,3m level under the terrain and it makes 4°C.

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The figure 8 shows the comparison between the soil thermal dependences during the June and December 2007. The differences can bee seen from the chart.

The maximal thermal differences in the month values during the year is between the dept 0,3m and 1,5m under the terrain, and it makes 5,91°C.

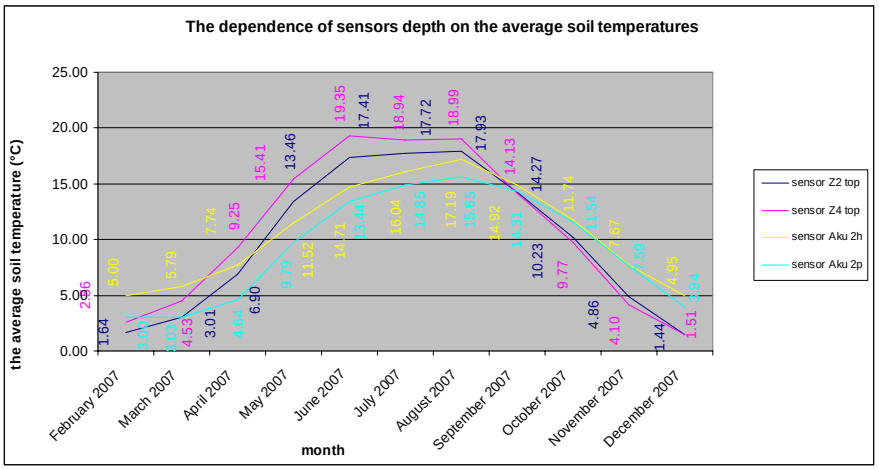
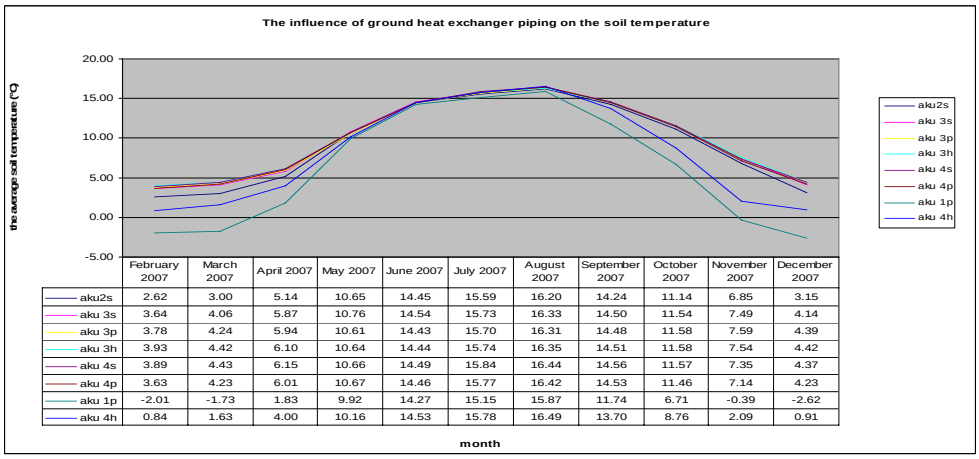


Figure 8. The year dependence of sensors position on the depth under the terrain

The soil temperature is influent by the ground heat exchanger piping with the cooling medium inside. From the next charge can be seen that this temperature is impressed only to the 0,4m length from this piping. In the higher distance from the ground register the soil temperature differences are almost negligible.



	February 2007	March 2007	April 2007	May 2007	June 2007	July 2007	August 2007	September 2007	October 2007	November 2007	December 2007
aku2s	2.62	3.00	5.14	10.65	14.45	15.59	16.20	14.24	11.14	6.85	3.15
aku 3s	3.64	4.06	5.87	10.76	14.54	15.73	16.33	14.50	11.54	7.49	4.14
aku 3p	3.78	4.24	5.94	10.61	14.43	15.70	16.31	14.48	11.58	7.59	4.39
aku 3h	3.93	4.42	6.10	10.64	14.44	15.74	16.35	14.51	11.58	7.54	4.42
aku 4s	3.89	4.43	6.15	10.66	14.49	15.84	16.44	14.56	11.57	7.35	4.37
aku 4p	3.63	4.23	6.01	10.67	14.46	15.77	16.42	14.53	11.46	7.14	4.23
aku 1p	-2.01	-1.73	1.83	9.92	14.27	15.15	15.87	11.74	6.71	-0.39	-2.62
aku 4h	0.84	1.63	4.00	10.16	14.53	15.78	16.49	13.70	8.76	2.09	0.91

Figure 9. The influence of register piping to the soil temperature

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4. CONCLUSION

From the previous dates follows the soil thermal dependences on the depth under the terrain. The generally known rule, that with the growing depth under the terrain the soil thermal dependence is less influent by the weather conditions is by the previous dates confirmed.

In the same time there is a question about the soil ability to revive itself. To which dept the soil can be during the summer regenerated. Than it is necessary to look over the climate conditions if it is better to make the ground heat exchanger or to prefer a borehole.

The special thanks are given to the company Regulus s.r.o, Do Koutů 1897/3, Prague 4 – Komořany, with its help was the measured dates obtained.

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ISSN 1582-3024