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RESEARCH RESULTS OF THE EFFECTIVENESS OF THE HEAT OBTAINMENT FROM THE GROUND IN WINTER SEASON

Summary

In the period between December 2011 and March 2013, there were conducted the research on the acquisition and processing of the heat from the ground with usage of the vertical heat exchangers and heat pump with capacity of 8 kW. The daily heat production yield amounted to 0.486 GJ and lack of thermal regeneration in spring-summer period of the exploited deposit in winter time for two years (2012 and 2013) did not cause any significant reduction of the heat obtained from the ground. And the difference in the amount of heat generated by the heat pump did not affect the temperature of the heated area.
***Key words**: energy, heat, heat pump, livestock building, calorifics*

WYNIKI BADAŃ EFEKTYWNOŚCI POZYSKIWANIA Z GRUNTU CIEPŁA W OKRESIE ZIMY

Streszczenie

W okresie od XII 2011 do III 2013 r. prowadzono badania nad pozyskiwaniem i przetwarzaniem ciepła z gruntu wykorzystując pionowe wymienniki ciepła i pompę ciepła o mocy 8 kW. Dzienny uzysk wyprodukowanego ciepła wyniósł 0,486 GJ, a brak regeneracji termicznej w okresie wiosenno-letnim eksploatowanego złoża zimą przez dwa lata (2012 i 2013) nie spowodował znacznej redukcji pozyskiwanego ciepła z gruntu. A różnica w ilości generowanego ciepła przez pompę ciepła nie wpłynęła na temperaturę ogrzewanych pomieszczeń.
***Słowa kluczowe**: energia, ciepło, pompa ciepła, budynek inwentarski, ogrzewnictwo*

1. Introduction

The heat pumps are devices enabling the acquisition of heat from various sources, applicable to industrial processes and home heating systems. Increasing energy prices demand the search for cost-efficient and effective solutions of energy generation. The heat pump has a high potential for efficient sourcing of cheap energy from renewable sources [2]. The heat pump in a system with ground heat exchanger (GSHP-ground source heat pump) as a basic source of energy for heating or cooling, uses solar heat accumulated beneath the soil surface. This system provides high efficiency of the air conditioning rooms – the ground provides low temperature for cooling systems and high temperatures for heating ones, moreover ensures a stable temperatures with fluctuations smaller than changes in air temperature [14, 15]. The ground is a good heat accumulator, since all year it retains relatively uniform temperatures between 7 and 13°C (at a depth of 2 m).

GSHP systems are widely distributed and used in residential and office architecture. In recent years all over the world it has been observed a steady increase in the number of installations of this type ranging from 10% up to 30% per year [1]. Working activity of the heat pump is based on a reversed thermodynamic cycle, forcing the flow of the heat from the region of lower temperature to the area of higher temperature. The heat pump for power supply uses electricity, however it is about ¼ of the total energy produced by this device. Normally the pump delivers three or four times more of the heat in comparison with the electricity input into the drive system. The device and the installation of the whole system for the heat extraction from a natural center, is characterized by high investment costs compared to conventional heating systems, but low maintenance costs of the system with a heat pump and ecological benefits, provide reliable and environmentally friendly method of building heating on over 20 years [9]. Absorption of the heat from the ground takes place with the aid of proper ground heat exchangers located in the ground boreholes reaching the depth of 200 m (vertical heat exchangers) or distributed over a large area at a depth of 1-1.5 m (horizontal heat transfer). Heat exchangers operate in a closed system, and usually the circulating factor collecting the heat from the ground is water solution of glycol. The heat transfer through the ground heat exchangers is strongly dependent on thermal properties of the soil. Composition and type of the soil can vary considerably, not only in the particular area, but also can differ alongside the depth of the borehole. The efficiency of heat exchange depends on thermal properties of the soil surrounding the heat exchanger. Therefore, when designing the ground heat exchangers it is important to effectively determine the soil thermal properties [7]. In the literature, there are numerous research papers on effectiveness [6, 8] and profitability of heat pump systems. [5, 10] reported that the heat pump in system with ground source heat pumps (GSHP) are an attractive alternative for conventional heating and cooling systems due to their higher efficiency of energy use. The Authors' study clearly indicate that GSHPs are economically beneficial also in cooperation with conventional heating or cooling devices.

The efficiency of heat pump systems and ground source heat pumps is related to the temperature of the lower source - the higher the temperature the higher the efficiency of the entire system. Increasing of the ground thermal efficiency is made through the regeneration of the ground with a heat from solar collectors [11, 16] or cooling the buildings in the summer [3].

Research of Hanuszkiewicz-Drapała [4] on functioning of ground, complex horizontal-vertical heat exchanger showed that in second heating season the amount of heat absorbed from the ground was slightly lower in comparison with first season. And the reason was the lack of complete heat recovery of the ground in the summer. The author states that heat regeneration of the ground, which raises the heating energy is essentially important and affects the proper functioning of the heating system in the coming years.

2. Research aim and research hypothesis

The research aim is to analyze the thermal performance of the vertical ground heat exchangers in set with a heat pump and verification of the efficiency of heat acquisition from the ground without current regeneration of ground heat potential consisting of additional heat "dump" from summer working solar panels.

The research hypothesis was that in case of winter exploitation of the vertical ground heat exchangers, there is no need of deposit regeneration in the summer with usage of heat from another heat sources - such as solar panels. Justification of this hypothesis is related to the fact that the Earth has a large enough heat potential and few months exploitation of the limited space around the vertical heat exchanger should not disturb this potential or reduce its value to such an extent that could have a negative impact on heat acquisition in subsequent heating seasons.

3. Research problem

1. Does 2-year long acquisition of heat from the ground without deposit current regeneration in summer have an effect on heat input during subsequent heating seasons?
2. What is the efficiency of heating system that acquires heat from the vertical ground heat exchangers?

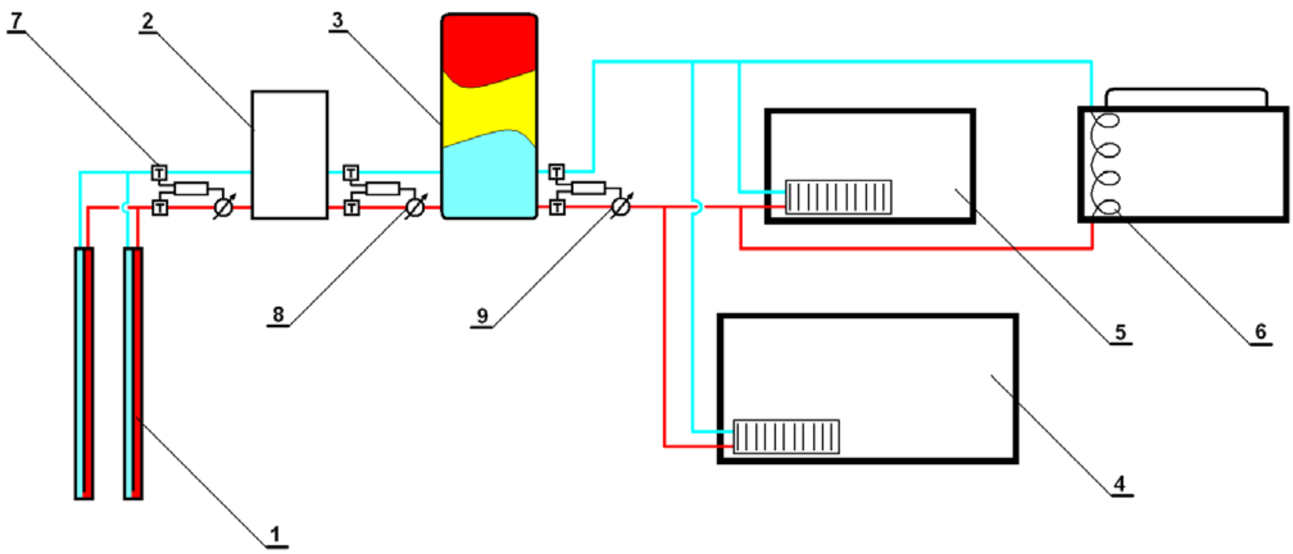
4. Methodology

The applied research methodology was used during the measurements and studies in the period 2011-2012 and described by Szulc and Łaska [12]. The research site was located in the ITP in Poznan in the renewable energy laboratory "Ekobudynek" ("*Ecobuilding*") with dimensions of 12 m x 6 m having walls made of sheet filled with 10 cm layer of styrofoam. It consisted of the heat pump Vitocall 200 Viessmann 8 kW, storage tank with capacity of 200 dm^3, two geothermal boreholes of 70 m deep each. The heat meters were installed at the entrance and exit of the heat exchanger (geothermal borehole) and in the installation carrying the hot water to the radiators in a heated building. The heated room was a cellar with a capacity of about 125 m^3, as well as "Ekobudynek" equipped with 6 radiators. The studies were conducted in the period from 12th December 2011 to 14th February 2012 and between October 2012 and March 2013. The analysis of the results was developed using appropriate formulas and presented as a printout of the Excell 2010 spreadsheet.

Determination of the coefficient of performance (COP) defining the energy efficiency of the operated system was obtained as a quotient of the gained heat (GJ) in relation to incurred energy expenditure (kW; GJ).

5. Research results

Table 1 presents selected measurement results of exploitation research taken in winter (between 10th October 2012 and 29th March 2013) demonstrating the efficiency, productivity and the repeatability of working characteristics of buildings heating system with a heat from vertical ground exchangers and heat pump support. For comparison, Table 2 shows already published [13] research results from winter period between 12th December 2011 and 14th February 2012.



Source: own research / Źródło: badania własne

Fig. 1. Block scheme of tested installation: 1 – vertical heat exchangers; 2 – heat pump; 3 – buffer tank; 4 – heated basement in research building; 5 – renewable energy laboratory; 6 – micro biogas plant; 7, 8, 9 – heat meters

Rys. 1. Schemat blokowy badanej instalacji: 1 – pionowe wymienniki ciepła; 2 – pompa ciepła; 3 – zbiornik buforowy; 4 – ogrzewana piwnica budynku naukowego; 5 – pracownia energii odnawialnej; 6 – mikrobiogazownia; 7, 8, 9 – ciepłomierze

Table 1. Selected measurement results from the period between 10.10.2012 and 29.03.2013

Tab. 1. Wybrane fragmenty wyników pomiarów z okresu 10 X 2012 do 29 III 2013 r.

		Geothermal boreholes			Buffer tank				Basement		Heat pump					
Date	Air temp. (°C)	Air temp. inside (°C)	Heat meter (GJ)	Daily heat gain (GJ)	Daily heat gain (GJ)	T1 (°C)	T2 (°C)	ΔT (K)	Air temp. (°C)	Radiator temp. (°C)	T_1 (°C)	T_2 (°C)	ΔT (K)	Daily amount of heat (GJ)	Daily electricity consump. (kWh)	COP
19.11.2012	3	21	147,365		0,239	39,5	23,1	16,4	18	25	40,8	34,9	5,9	0,52	58,2	2,482
20.11	5	14	147,412	0,047	0,066	27,16	17,94	9,22	12,5	17,5	30,7	25,1	5,6	0,103	16,8	1,703
21.11	3	22	147,591	0,179	0,236	39,44	30,28	9,16	12	16	53,1	53,0	0,1	0,47	68,2	1,914
22.11	2	21	147,824	0,233	0,243	41,62	36,64	4,98	19	32	42,6	36,5	6,1	0,513	61,5	2,317
23.11	1	19	148,062	0,238	0,217	39,4	34,93	4,47	17	29	40,4	34,4	6	0,523	62,4	2,328
24.11			148,297	0,235	0,228	38,42	31,45	6,97						0,524	63,4	2,296
25.11			148,532	0,235	0,228	39,82	32,71	7,11						0,524	63,4	2,296
26.11	0	20	148,768	0,236	0,23	39,58	34,84	4,74	18	30	40,5	34,6	5,9	0,524	63,4	2,296
27.11	5	22	149,002	0,234	0,233	40,62	35,60	5,02	18,5	31	41,6	35,6	6	0,519	62,6	2,303
28.11	6	23	149,236	0,234	0,25	40,99	35,79	5,2	18,5	31	41,8	35,9	5,9	0,532	65,2	2,267
29.11	3	20	149,464	0,228	0,243	36,20	34,08	2,12	17	27	37,0	33,9	3,1	0,506	59,7	2,354
30.11	1	18	149,712	0,248	0,286	37,85	32,64	5,21	18	26	38,6	32,7	5,9	0,526	58,3	2,506
12.01.2013			160,479	0,259	0,274	33,1	26,98	6,12						0,514	50,7	2,816
13.01			160,738	0,259	0,274	32,45	26,24	6,21						0,514	50,6	2,822
14.01	-7	10	160,998	0,26	0,275	29,12	23,42	5,7	11	19	30,1	24,1	6	0,514	50,7	2,816
15.01	-7	11	161,263	0,265	0,27	31,00	25,55	5,45	12,5	21,5	31,8	25,9	5,9	0,519	49,9	2,889
16.01	-7	12	161,518	0,255	0,281	30,31	24,28	6,03	11,5	20,5	31,1	25,0	6,1	0,504	49,3	2,840
17.01	-9	11	161,778	0,26	0,287	30,37	25,00	5,37	12	21	31,2	25,3	5,9	0,513	50,2	2,839
18.01	-7	11	162,038	0,26	0,279	30,16	24,66	5,5	12	20	31,0	25	6	0,512	49,5	2,873
19.01			162,300	0,262	0,266	28,95	23	5,95						0,512	49,0	2,902
20.01			162,562	0,262	0,266	28,21	22,98	5,23						0,512	49,1	2,897
21.01	-11	8	162,825	0,263	0,267	27,96	22,59	5,37	11	18,5	28,9	22,9	6	0,512	49,1	2,897
22.01	-11	9	163,094	0,269	0,263	28,43	22,97	5,46	11	18,5	29,4	23,4	6	0,513	46,9	3,038
23.01	-10	10	163,356	0,262	0,262	30,37	25,05	5,32	12,5	21	31,3	25,2	6,1	0,509	48,7	2,903
24.01	-9	11	163,614	0,258	0,259	30,75	25,33	5,42	12,5	21	31,5	25,6	5,9	0,510	50,0	2,833
25.01	-12,5	7	163,875	0,261	0,253	28,06	23,35	4,71	12	19,5	29,1	23,2	5,9	0,509	49,0	2,885
26.01			164,135	0,26	0,254	29,54	23,5	6,04						0,509	49,5	2,856
27.01			164,395	0,26	0,253	31,28	25,14	6,14						0,509	49,5	2,856
28.01	-1	14	164,655	0,26	0,254	33,6	27,44	6,16	13	24	33,7	27,8	5,9	0,509	49,4	2,862
11.02	-3	14	168,082	0,25	0,278	31,88	25,87	6,01	12	22	32,5	26,8	5,7	0,503	52,7	2,651
12.02	-4	12	168,334	0,252	0,272	31,57	25,82	5,75	13	22	32,3	26,5	5,8	0,524	50,9	2,860
13.02	-3,5	14	168,588	0,254	0,29	32,28	26,62	5,66	12	22,5	33,0	27,1	5,9	0,511	51,7	2,746
14.02	-2	15	168,835	0,247	0,287	33,62	27,83	5,79	12	23	34,3	28,5	5,8	0,506	52,7	2,667
15.02	-2	15	169,079	0,244	0,285	33,3	27,30	6	13	23	33,9	28,2	5,7	0,503	52,9	2,641
16.02			169,329	0,25	0,29	32,8	26,58	6,22						0,511	52,7	2,693
17.02			169,579	0,25	0,29	32,79	26,9	5,89						0,511	52,7	2,693
18.02	-3	14	169,829	0,25	0,29	32,68	27,07	5,61	13,5	22,5	33,4	27,6	5,8	0,512	52,7	2,699
19.02	-3	14	170,08	0,251	0,277	32,40	26,79	5,61	13	22	33,1	27,2	5,9	0,511	52,2	2,719
20.02	-4	13	170,33	0,25	0,283	29,48	25,33	4,15	11	20	32,2	26,1	6,1	0,511	52,1	2,724
21.02	-6	12	170,584	0,254	0,278	30,87	25,3	5,57	12,5	21	31,6	25,7	5,9	0,509	50,1	2,822
22.02	-6	11	170,842	0,258	0,272	30,46	24,92	5,54	12	20	31,2	25,3	5,9	0,517	50,8	2,827
23.02			171,094	0,252	0,276	31,49	25,41	6,08						0,511	51,1	2,778
24.02			171,346	0,252	0,276	32,87	26,91	5,96						0,511	51,1	2,778
25.02	0	15	171,599	0,253	0,277	33,01	27,4	5,61	13	23	33,7	27,9	5,8	0,511	51,1	2,778
26.02	-0,5	16	171,842	0,243	0,283	33,66	27,86	5,8	12	23	34,3	28,5	5,8	0,505	52,9	2,652
27.02	1	16	172,086	0,244	0,283	34,13	28,46	5,67	13,5	24	34,8	29,0	5,8	0,510	53,5	2,648
28.02	0	16	172,324	0,238	0,287	34,1	28,44	5,66	14	24	34,8	29,0	5,8	0,503	54,4	2,568
1.03	0	15	172,565	0,241	0,282	33,68	28,18	5,5	15	23	34,3	28,5	5,8			
2.03			172,799	0,234	0,272	32,93	26,97	5,96						0,492	52,4	2,607
3.03			173,033	0,234	0,272	32,72	26,66	6,06						0,492	52,4	2,610
4.03	-1	14	173,268	0,235	0,271	32,83	27,61	5,22	13,5	24,5	33,6	27,9	5,7	0,492	52,5	2,603
5.03	4	10	173,301	0,033	0,202	27,23	8,80	18,43	12,5	6	29,3	22,6	6,7	0,164	23,8	1,914
6.03	2	21	173,505	0,204	0,176	46,97	38,08	8,89	12,5	8	47,3	41,8	5,5	0,424	60,2	1,956
7.03	2	9	173,531	0,026	0,034	10,3	9,52	0,78	11,5	7	10,6	10,5	0,1	0,075	15,9	1,310
8.03	-2	17	173,739	0,208	0,14	43,95	33,94	10,01	10	5	44,4	38,5	5,9	0,493	64,8	2,113
9.03			173,927	0,188	0,128	44,18	34,9	9,28						0,472	65,0	2,017
10.03			174,115	0,188	0,128	43,12	33,98	9,14						0,472	65,0	2,017
11.03	-7	16	174,303	0,188	0,127	43,26	33,07	10,19	9	3	43,7	37,9	5,8	0,471	65,1	2,010
12.03	-5	17	174,499	0,196	0,124	44,23	34,26	9,97	9	5	44,5	39,0	5,5	0,487	66,8	2,025
13.03	-5	18	174,689	0,19	0,118	44,26	34,13	10,13	9,5	4	44,6	39,0	5,6	0,474	65,4	2,013
14.03	-10	17	174,888	0,199	0,119	37,84	29,13	8,71	10	4	39,1	33,0	6,1	0,462	59,0	2,175
15.03	-4	16	175,078	0,19	0,115	41,19	30,73	10,46	10	4	42,1	36,1	6	0,449	58,7	2,125
16.03			175,261	0,183	0,111	42,88	31,45	11,43						0,453	62,2	2,023
17.03			175,447	0,186	0,111	43,08	31,98	11,1						0,453	62,2	2,023
18.03	-4	16	175,627	0,18	0,112	43,82	32,28	11,54	8	2	44,3	38,5	5,8	0,453	62,3	2,020
19.03	-3	16	175,817	0,19	0,112	44,27	32,61	11,66	9	4	44,7	38,9	5,8	0,478	66,4	2,000
20.03	-2	19	175,996	0,179	0,108	46,43	34,75	11,68	10	5	46,7	41,2	5,5	0,475	69,5	1,898
21.03	-3	19	176,171	0,175	0,104	45,86	34,11	11,75	9	4	46,3	40,8	5,5	0,463	67,4	1,908
22.03	-4	18	176,347	0,176	0,105	45,32	33,35	11,97	9	3	45,5	40,0	5,5	0,479	69,8	1,906
23.03			176,536	0,189	0,1	44,09	33,1	10,99						0,460	62,2	2,054
24.03			176,725	0,189	0,1	42,73	32,48	10,25						0,460	62,2	2,054
25.03	-3	18	176,914	0,189	0,1	41,61	31,03	10,58	9	3	42,6	36,5	6,1	0,459	62,3	2,047
26.03	-4	18	177,093	0,179	0,096	44,62	32,59	12,03	8	2	45,1	39,2	5,9	0,449	62,5	1,996
27.03	-2	18	177,266	0,173	0,094	43,82	31,68	12,14	7	2	44,5	38,8	5,7	0,447	63,6	1,952
28.03	-0,5	19	177,442	0,176	0,095	44,63	32,7	11,93	7	3	45,2	39,4	5,8	0,453	64,8	1,942
29.03	-1	20	177,607	0,165	0,093	46,8	34,12	12,68	8,5	3	47,1	41,5	5,6	0,450	66,9	1,868
Mean	-1,0	16,3	-	0,231	0,239	35,9	29,2	6,6	14,2	21,4	36,9	31,2	5,7	0,486	54,498	2,465
Min.	-13,0	7,0	-	0,026	0,007	10,3	8,8	0,0	7,0	2,0	10,6	10,5	0,1	0,048	10,9	1,212
Max.	12,0	25,0	-	0,269	0,321	47,0	38,1	18,4	20,0	32,0	53,1	53,0	8,1	0,600	69,900	3,038
St. deviation	5,241	4,221	-	0,042	0,064	5,658	4,651	2,598	3,364	8,585	5,936	6,006	1,138	0,093	10,351	0,364

Source: own research / Źródło: badania własne

Table 2. Selected measurement results from the period between 12.12.2011 and 14.02.2012 [13]
Tab. 2. Wybrane fragmenty wyników pomiarów z okresu 12 XII 2011 do 14 II 2012 r. [13]

	Amount of pumped glycol (m^3)	Momentary power (kW)	Water flow ($m^3 \cdot h^{-1}$)	Temp. T_1 (°C)	Temp. T_2 (°C)	ΔT (K)	Time (h)	Electricity consump. meter (kWh)	Heat meter (GJ)	Daily amount of heat (GJ)	Daily electricity consump. (kWh)	COP
25.I.2012	8299,42	6,20	0,9	37,6	31,4	6,2	50736	21623,3	209,857			
26.I.2012	8320,93	6,39	0,897	35,4	28,8	6,2	50760	21681,1	210,399	0,542	57,800	2,539
27.I.2012	8342,60	6,28	0,888	32,8	26,7	6,1	50784	21735	210,942	0,543	53,900	2,723
28 I 2012	8364,28	6,30	0,889	34,5	28,4	6,1	50808	21783,866	211,482	0,540	48,866	2,979
29 I 2012	8385,95	6,31	0,89	29,9	23,7	6,2	50832	21832,732	212,022	0,540	48,866	2,979
30.I.2012	8406,96	6,34	0,888	28,4	22,2	6,2	50856	21881,6	212,564	0,542	48,868	2,990
31.I 2012	8428,32	6,46	0,891	29,3	23	6,3	50880	21928	213,105	0,541	46,400	3,138
1.II.2012	8449,79	6,24	0,884	27,9	21,7	6,2	50904	21974,3	213,649	0,544	46,300	3,162
2.II.2012	8471,22	6,31	0,889	27,9	21,7	6,2	50928	22019,8	214,194	0,545	45,500	3,222
3.II.2012	8492,68	6,38	0,890	29,3	23,1	6,2	50952	22065,1	214,727	0,533	45,300	3,164
4 II 2012	8514,40	6,28	0,891	31,4	25,3	6,1	50976	22110,6	215,263	0,536	45,500	3,169
5 II 2012	8536,00	6,31	0,888	30,5	24,2	6,3	51000	22155,9	215,805	0,542	45,300	3,218
6 II 2012	8557,70	6,25	0,890	29,4	23,3	6,1	51024	22201,6	216,343	0,538	45,700	3,167
7 II 2012	8579,38	6,30	0,888	28,9	22,8	6,1	51048	22247,1	216,883	0,540	45,500	3,192
8.II.2012	8599,73	6,39	0,891	29,8	23,6	6,2	51072	22292,6	217,41	0,527	45,500	3,115
9.II.2012	8621,48	6,27	0,896	32,5	26,5	6	51096	22341	217,945	0,535	48,400	2,979
10.II.2012	8642,63	6,34	0,892	28,4	22,3	6,1	51120	22387,6	218,481	0,536	46,600	3,096
11.II.2012	8664,30	6,35	0,896	30,9	24,8	6,1	51144	22433,93	219,014	0,533	46,330	3,096
12.II.2012	8685,98	6,30	0,894	31,1	24,9	6,2	51168	22481,43	219,552	0,538	47,500	3,051
13.II.2012	8707,05	6,35	0,897	32,6	26,5	6,1	51192	22526,0	220,080	0,528	44,570	3,184
14.II.2012	8728,56	6,23	0,896	34,0	27,9	6,1	51216	22577,3	220,621	0,541	51,300	2,847
Mean	8514,255	6,313	0,892	31,071	24,895	6,157	50976,0	22108,565	215,254	0,538	47,700	3,051
min.	8299,424	6,197	0,884	27,900	21,700	6,000	50736,0	21623,300	209,857	0,527	44,570	2,539
max.	8728,555	6,464	0,900	37,600	31,400	6,300	51216,0	22577,300	220,621	0,545	57,800	3,222
St. deviation	123,661	0,056	0,004	2,190	2,177	0,074	138,391	268,201	3,101	0,005	3,236	0,172

The conducted research clearly showed that average daily heat gain from two geothermal boreholes amounted 0.486 GJ where heat pump support was approximately 47.5% (0.255 GJ). This value confirmed research results from the first winter period (2011-2012), when the daily yield of heat produced was 0.538 GJ with 49.44% share of the heat pump (0,272 GJ). The difference in the amount of heat produced per day in 2011-2012 and 2012-2013 amounted 0.052 GJ which is a value lower of 9.66% in comparison with previous year. Despite this, the average air temperature in heated rooms in the first heating period was only 12.9°C, and in the second one 14.2°C. Average air temperatures outside were statistically comparable and amounted in the examined periods respectively -1.28°C and -1.0°C, so could not be a significant factor having a considerable effect on the temperature inside the heated area.

The average temperature of the heated second room - renewable energy lab – in investigated period amounted 16.3°C, and during the first winter period – 12.51°C.
However, the most important indicator is the fact that both after first and second winter heating period, there was no thermal ground recovery (recommended in the period from spring to autumn), making a heat-dump from another heat source, which usually is a liquid solar collector. Moreover during spring-summer period (between 2nd April and 28th August 2012) was further exploitation of vertical heat exchangers, so the ground deposit could not have a chance to be regenerated. These actions were intentional and targeted, in order to prove the initial hypothesis saying that in case of heat extraction from the ground there is no need for thermal regeneration of the ground in the summer [13]. The obtained results of 2-year research confirm this hypothesis.

In winter time 2012-2013 additionally was installed third point receiving the heat generated - the installation heating the gas path of the container micro biogas plant located in ITP – Poznań branch - Figure 2.

Photo R. Szulc

Fig. 2. Additional heat transfer – container micro biogas plant
Rys. 2. Dodatkowy odbiór ciepła – mikrobiogazownia kontenerowa

6. Conclusions

Based on the conducted research and obtained observations the following conclusions have been raised:

1) The daily yield of the heat produced was 0,486GJ.
2) Lack of thermal regeneration during spring-summer period of the deposit exploited in winter time for two years did not cause a significant reduction of heat obtained from the ground. And the difference in the amount of heat generated by the heat pump did not affect the temperature of heated area.

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