Geothermal Energy Use, Country Update for Lithuania

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ABSTRACT

Due to peculiar geological conditions (the West Lithuanian geothermal anomaly is the most intensive one in the East European Platform) utilisation of geothermal energy is expedient in Lithuania.

Analysis of geological setting and parameters of major geothermal aquifers (Cambrian, Lower Devonian, Middle Devonian) enable to estimate the productivity of the geothermal well doublet in middle Lithuania. It is defined that the Cambrian geothermal aquifer is highly promising for the district heating purposes.

The geothermal modelling indicates that temperature 150^{0}C can be met at the depth of 4.2-5.0 km in the southern part of West Lithuania. This area is considered a prospective target for development of the EGS/HDR systems for production of electric power. The area is as large as 2,200 km^2.

The information on operation of Klaipėda geothermal demonstration plant (KGDP) and the growth of installed capacity of ground-source heat pump systems are also presented in this paper.

Two case studies are discussed as good practice examples in Lithuania:

first, comparison of Heat pump system with Gas boiler system both installed in the same single family house;

second, the installation of geothermal heating and cooling system (with 0.8 MW capacity) in the Solar energy technology center located in Vilnius.

1. INTRODUCTION

The Lithuanian GDP was increasing fast during the period 2000-2008, but dropped in year 2009 – (-14,8%) and increased again by 1,3 %, 5,9 %, 3,6 % in year 2010, 2011, 2012, respectively.

Lithuania inherited energy sector based on foreign primary energy (crude oil, natural gas, coal). In year 2010 Lithuania's dependence on imported fossil fuel was 79,4 % and at the same time the contribution of RES in final energy consumption was 15,2 %.

So it is clear why the main goal of the National Energy Independence Strategy (NEIS) (National 2012) is to ensure Lithuania's energy independence before the year 2020 by strengthening Lithuania's energy security and competitiveness. On 26th of June, 2012 the NEIS was approved. In this Strategy it is stated that until year 2020: *"Lithuania will progressively increase the use of renewable energy sources (henceforth – RES) in the production of electricity and heating as well as in the transport sector. The state will aim to reach the target of no less than 23% of renewable energy in final energy consumption, including no less than 20% of renewable energy in the electricity sector, no less than 60 % in the district heating sector and no less than 10 % in the transport sector. Clear conditions of support to RES will be introduced, giving preference to the most economically and technically feasible solutions of renewable energy."*

2. GEOLOGICAL SETTING AND GEOTHERMAL POTENTIAL

2.1. Major Deep Deothermal Aquifers of Lithuania

2.1.1. Geological setting and major aquifers

Lithuania is located in the eastern part of the Baltic sedimentary basin overlying the western margin of the East European Craton of the Early Precambrian consolidation.

The basin was initiated in Cambrian and manifested protracted subsidence that continued till Quaternary. As a result the basin contains a number of aquifers. The oldest Cambrian geothermal aquifer, representing the basal part of the sedimentary pile, is composed of quartz sandstones with rare siltstones and shales. The aquifer is of up to 60-80 m thick and 1-2 km deep in the prospective area. The second potential geothermal aquifer is represented by the Lower Devonian sands and sandstones comprising shales and siltstones that compose about 35% of the section. It is of up to 160 m thick and occurs at the depth of about 1 km in the prospective west Lithuanian area. The third prospective geothermal aquifer is represented by the Middle Devonian sandy package of up to 220 m thick and about 700 m deep. It is composed of quartz and feldspar-quartz sandstones and sands with subordinate shales and siltstones. The other aquifers defined in the geological section of Lithuania are of much smaller thickness and are of low geothermal potential.

2.1.2 Parameters of major geothermal aquifers

Cambrian sandstones show significant variations in the reservoir properties across Lithuania. Some systematic westward decrease of the porosity from 25% to 16% is reported at depths interval of 400-1800 m. Bellow the depth of 1800 it drastically reduces to 5%. The gas permeability is around 0.5-1 D at depths of 400-1800 m, and sharply decreases from 10-1 D to 10-5 D at greater depths. The decrease in the reservoir properties is basically controlled by late diagenetic quartz cementation. The chemical composition of the water also changes dramatically from the east to the west. The water salinity ranges from 0.5 g/l to 200 g/l. The temperature of the formation water changes from 15^{o}C in the east to 70-90^{o}C in West Lithuania (Fig. 1). A prospective area for district heating, exceeding 30^{o}C, encompasses Central and West Lithuania.

The Lower Devonian geothermal aquifer has much better reservoir properties, but is characterised by lower temperatures. The sands and sandstones of the aquifer is about 26%, the permeability is in the range of 0.5-4 D. The water salinity ranges from 0.2-0.5 g/l to 40-90 g/l in the west. Temperatures exceeding 30^{o}C were measured in a number of wells in West Lithuania. The maximum temperatures reach 45-50^{o}C (Fig. 1).

The third large-scale geothermal aquifer is related to the Middle Devonian sandstones and sands that have similar reservoir properties (average porosity 28%, permeability 0.5-4 D). The formation water is less mineralised; salinity ranges from 0.2-0.5 g/l in the east to 10-20 g/l in the west. Temperatures exceeding 30^{o}C (up to 32^{o}C) are reported from only the westernmost part of Lithuania.

The western part of Lithuania is characterized by anomalous heat flow. It provides most favourable conditions for utilization of the Earth's heat for district heating in Lithuania and is best investigated. Yet, Middle Lithuania has good geothermal prospects despite of the lower heat flow compared to West Lithuania. The geothermal studies of recent years were scoped on the re-evaluation of the geothermal potential of Middle Lithuania (Sliaupa and Kezun 2011). It basically relates to much better reservoir properties of the oldest Cambrian geothermal aquifer, while Lower Devonian temperatures are too low. In West Lithuania, the Cambrian aquifer has very low geothermal potential due to low porosity and permeability of sandstones that is accounted to severe late diagenetic quartz cementation controlled by high temperature and pressure and specific lithological fabric. The recent studies show that middle Lithuanian Cambrian aquifer has the largest geothermal capacity.

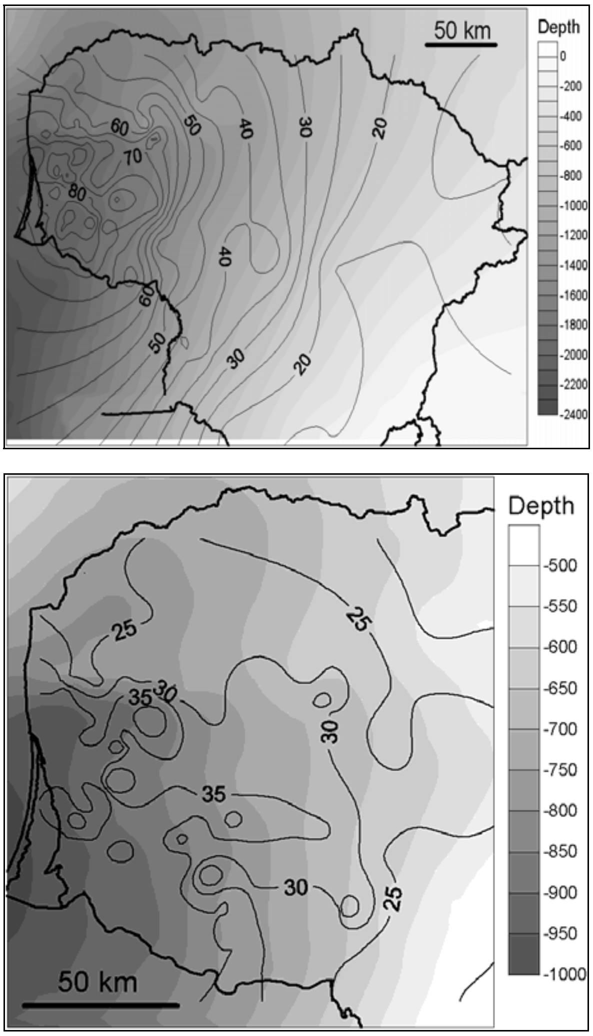

Figure 1. Temperatures (contour lines, ^{o}C) and depths of top (grey scale, m) of Cambrian (upper figure) and Lower Devonian (lower figure) geothermal aquifers

The temperature of the Cambrian aquifer increases from 35^{o}C (the accepted lower economic temperature limit) to more than 50^{o}C, increasing with the depth to the west (Fig. 2a). The effective thickness of the Cambrian aquifer in Middle Lithuania ranges within 15–58 m, the average porosity of sandstones being 13–20% and permeability 370 mD (Fig. 2b, 2c). The best reservoir properties are documented in the southern half of Middle Lithuania due to lithological specifics.

The productivity of the geothermal well doublet is estimated to be as high as 53–175 m^3/h in the southern part of Middle Lithuania, while attaining only 16–43 m^3/h in the north (Fig. 3a). These variations of the productivity control the geothermal potential of the wells.

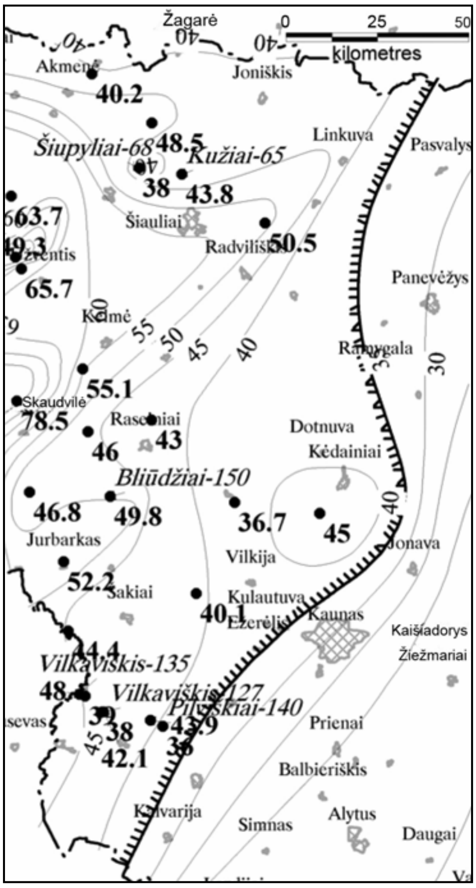

Figure 2a. Temperatures of Cambrian reservoir, Middle Lithuania. Thick line marks 35 °C isotherm. Wells referred to in the text are marked

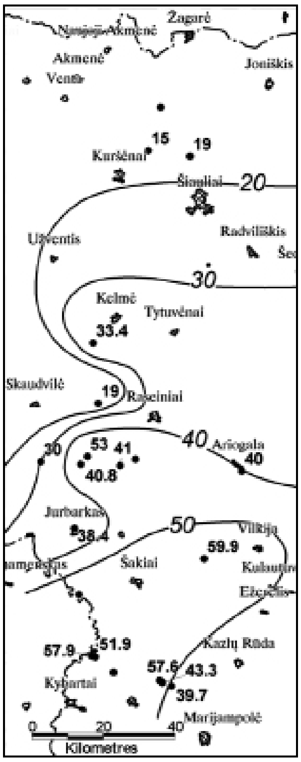

Figure 2b. Effective thickness (m) of Cambrian reservoir, Middle Lithuania

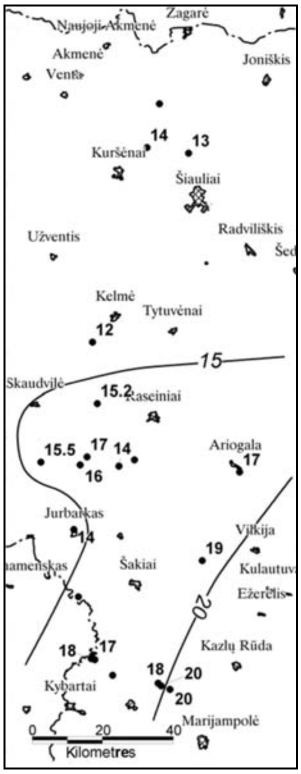

Figure 2c. Average porosity (%) of Cambrian sandstones in wells, Middle Lithuania

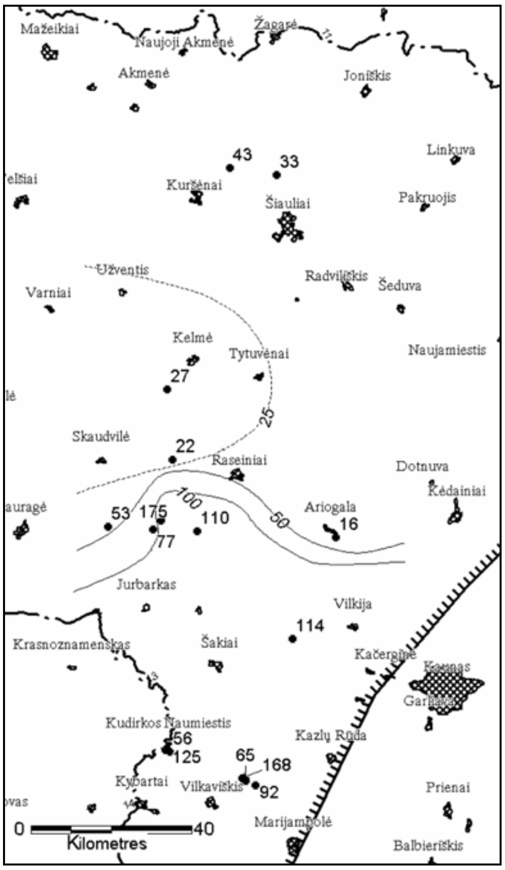

Figure 3a. Productivity (m^3/h) of geothermal well doublet (40 bar well head pressure) in Middle Lithuania

The geothermal potential of the well doublet varies from 0.44 MW to 1.37 MW in the northern area and ranges from 1.69 MW to 6.02 MW in the south (Fig. 3b). The highest geothermal potential is suggested in Vilkaviškis town area and should be considered the priority target for development of the geothermal district heating system in Middle Lithuania.

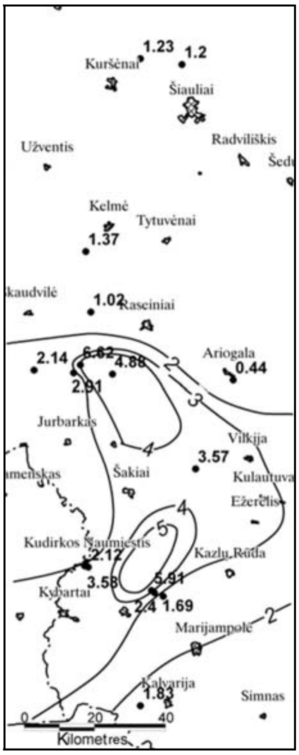

Figure 3b. Heat potential of geothermal well doublet in Middle Lithuania

The Cambrian formation water is characterised by a high salinity (98–130 g/l). It is of NaCl type. The thermochemical modelling indicates that gypsum precipitation should be expected in a geothermal system using high salinity water (~130 g/l) in the south, while carbonates and hydroxides may precipitate in less saline water in the north (~100 g/l) (Fig. 4a, 4b). Accordingly, a special chemical treatment will be required to maintain the geothermal systems. Pyrite may precipitate, essentially in a case of bacterial activity.

One/two doublet installations exploiting the Cambrian geothermal water may cover the basic needs of central heating of towns (except Šiauliai) of middle Lithuania. It is therefore concluded that the Cambrian geothermal aquifer is highly promising for the district heating in Middle Lithuania.

2.2. Geothermal Electric Power Production Opportunities

Lithuania is situated in the western periphery of the East European craton overlain by the Baltic sedimentary basin. The heat flow systematically increases from 38 mW/m^2 in the east to more than 90 mW/m^2 in the west. Accordingly the most favourable conditions for utilisation of the geothermal energy are related to the western part of the country.

The basement is covered by 2 km thick sediments in the prospective area of West Lithuania. The temperatures do not exceed 100^{o}C at the top of the crystalline basement, therefore the prospects of the geoelectric power production are related to the deeper parts of the basement. The anomalous heat flow of west Lithuania is likely related to mantle processes, while short-wavelength variations are primarily accounted to the lithological variations.

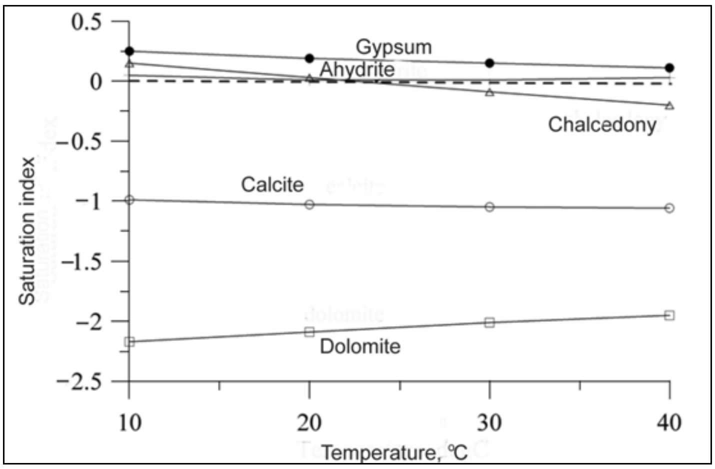

Figure 4a. Temperature vs saturation index of different mineral phases of Cambrian formation water, well Pilviškiai-140 (PHREEQC modelling), South Middle Lithuania

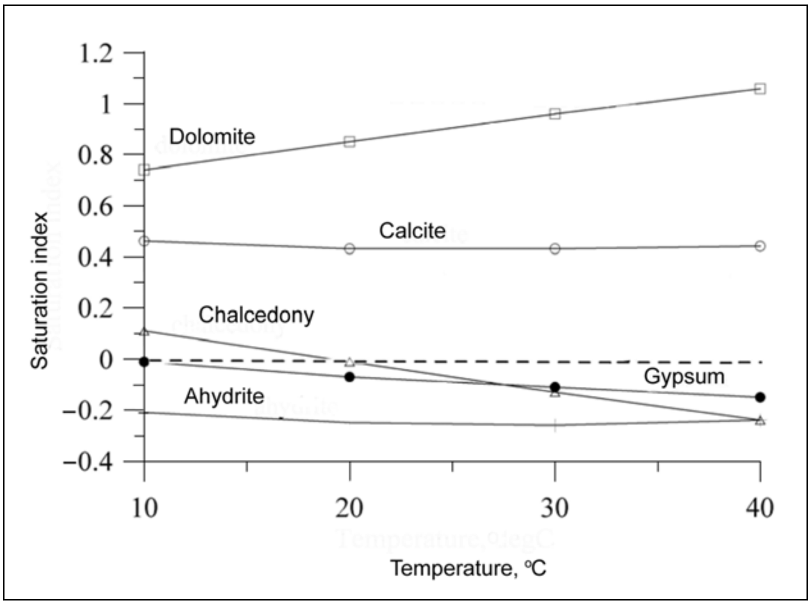

Figure 4b. Temperature vs saturation index of different mineral phases of Cambrian formation water, well Kužiai-65 (PHREEQC modelling), North Middle Lithuania

The basement is dominated by Palaeoproterozoic granulites of about 1.8 Ga age. A number of Mesoproterozoic granitoid intrusions were identified. They were established in the cratonic setting about 1.5 Ga. A specific feature of those bodies is a high heat production in the range of 4-18 μW/m^3. As a consequence, the most intense heat flow anomalies are confined to hot granite intrusions. Those are viewed as the potential targets for EGS/HDR systems for production of electric energy combined with a district heating (Sliaupa et al. 2005). The geological background is very similar to that of the Australian geothermal areas.

The geothermal modelling indicates that temperature 150^{o}C can be met at the depth of 4.2-5.0 km in the southern part of West Lithuania (Fig. 5). This area is considered a prospective target for development of the EGS/HDR systems for production of the electric power. The area is as large as 2,200 km^2.

So far, no implementation activities were initiated in Lithuania. The consortium of the interested parties for the development of the geolectric power was established in Lithuania a few years ago that incorporates business and scientific institutions. The well triplet system is expected to produce 3.5 MWe gross energy. The high exploration risk is considered as the main barrier for initiation of those activities. The basement is covered by 2 km thick sediments. The fault zones are of low amplitudes (up to 50 m); the identification of the fractured zones is very difficult. Besides, there is little information on the tectonic stress field in Lithuania that is one of the basic parameters in definition of the geothermally prospective fractured zones.

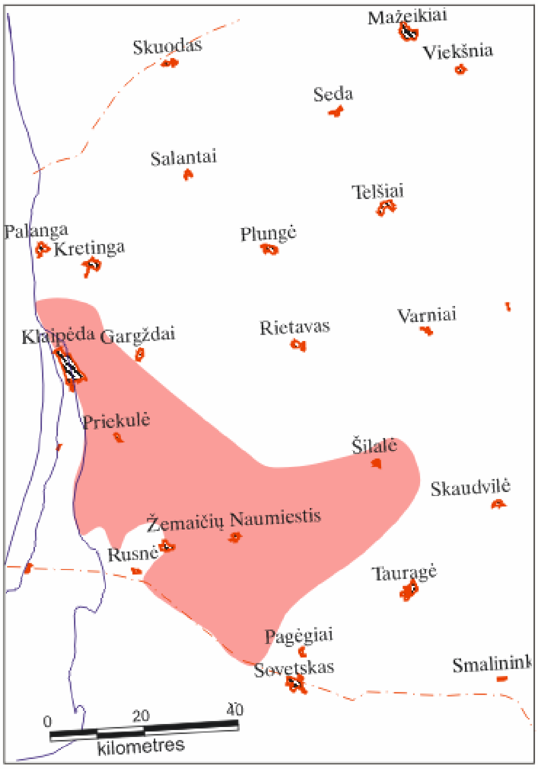

Figure 5. Prospective area for geoelectrical power production, west Lithuania. Isotherm 150^{o}C is modelled as deep as 4.2-5.0 km in the area

3. GEOTHERMAL UTILIZATION

3.1. Klaipeda Geothermal Demonstration Plant (KGDJ)

Usage of geothermal resources for district heating started at 2000 in Klaipeda. The absorption heat pumps use lithium bromide (LiBr) solution. Low-temperature geothermal heat is extracted from geothermal water of the Devonian aquifer. Plant capacity is confirmed by the State Commision – 35 MW_t (geothermal part – 13,6 MW_t). (In detail the operation of Klaipeda geothermal demonstration plant was described in papers (Zinevicius et al. 2003 and Zinevicius and Sliaupa 2010)).

The heat production of KGDP in the period from 2010 to 2012 was more or less stable (Fig. 6).

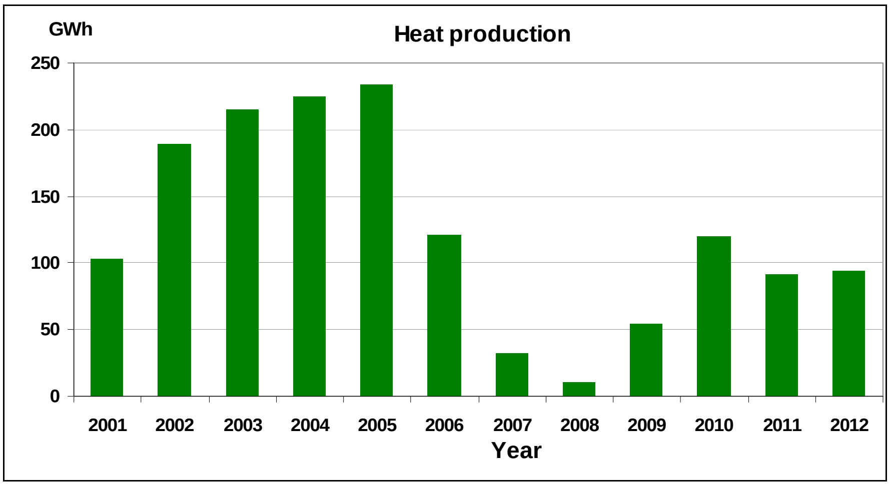

Figure 6. Heat production

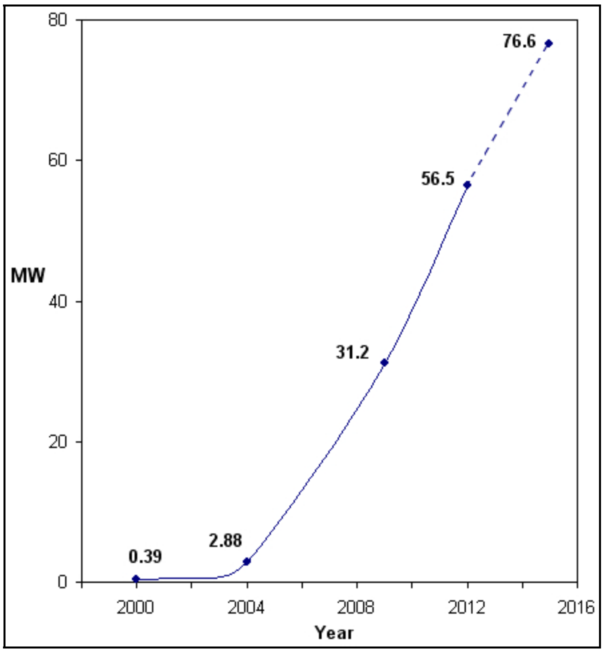

Figure 7. Total capacity of small-scale GSHP systems

3.2. Small-Scale Ground Source Heat Pump Installation

The number of small-scale ground source heat pump systems in Lithuania is growing. For today we have near 4500 installations thanks for such private enterprises as: UAB ”Ekoklima”, UAB ”Naujos idėjos”, UAB “Tenko Baltic”, UAB “EES”, UAB “Vilpra”, UAB ”Ekokodas”, UAB “Steltronika”, UAB “Geoterminis šildymas”, UAB “Alropa”, UAB ”Ogeo”, UAB ”Ardega”, UAB ”Monvilas”, UAB ”Bremena”, UAB “Kauno hidrogeologija”, UAB ”Šilumos mašinos” and UAB ”Aqua Jazz”. Total installed capacity – more than 50 MW (Fig. 7).

4. LEGAL BASIS

A great amount of hopes were concentrated on the Law on Energy from Renewable Sources, which passed the Seimas (Parliament) on the 12th of May, 2011 (Law 2011). In this document are fixed very important statements influencing geothermal energy utilization development in Lithuania:

Article 3. *Promotion of renewable energy resources usage development.*

2. Usage of renewable energy resources is promoted by using fixed support scheme which consists of one or few promotion measures.

As promotion measures are considered:

9) support by investment to RES technologies.

Article 5. *Competence of Government*

2. Government or its authorized institution:

13) defines RES usage in buildings requirements and order of their implementation

15) sets the certification order for RES technologies installation specialists.

Article 11. *Competence of National control commission for prices and energy*

3) sets the reduced tariffs for electricity consumed by heat pumps (that have accounting of electricity passing to compressor).

Article 25. *Procurement of heat energy produced from RES.*

2. Heat supplier (operator) must procure all heat energy, which is cheaper as own produced, from RES and delivered by independent heat producers, whose heat production equipment is connected to heat transfer network, except cases, when heat amount produced from RES by independent heat producers exceeds the demand of consumers connected to heat supply system.

***Article 26.** Promotion of heat pumps usage.*

Investments to heat pumps in accordance with the requirements fixed in Article 47 part 3 of present law and investments necessary for their implementation are promoted by order fixed in eighth paragraph of present law.

Taking advantage of such support form prevents from possibility to use promotion measure fixed in Article 11 item 3 of present law.

***Article 42.** The use of means of RES development programmes.*

2. The means of National RES development programme are used:

6) for implementation of projects directed to geothermal energy utilization.

***Article 45.** Qualification and certification of RES technologies installers.*

4. In established order RES technologies installers must be certified:

3) installers of geothermal systems and heat pumps.

***Article 47.** Requirements for particular equipment.*

3. Support schemes for heat pump and their installation are applicable if heat pumps correspond to criteria setled by Decision of EC 2007/742/EC on 09 November 2007, which defines eco criteria applicable for labelling of electrical, gas or absorbtional gas heat pumps.

6. Close loop geothermal systems installed in household with capacity less than 30 kW and off need of boring wells are under registration without requirement for the exploitation licence.

5. GOOD PRACTICE EXAMPLES

5.1. Single Family House: Heat Pump or gas boiler?

In such countries as Sweden, Switzerland, France, Germany, Austria Ground Source Heat pumps (GSHP) already are a routine option for residential houses. In countries of East Europe – Lithuania, Latvia, Estonia – GSHP market development now shows evident growth rates, but society is still faced with the lack of information, especially from economical point of view.

So, the aim was to compare Heat pump system with Gas boiler system, both installed in the same single family house.

The measurement and registration of systems operational data during three heating seasons provided a possibility to calculate the running costs and to compare the systems from economical point of view.

5.1.1. Installation for investigations and methodology

The Heat pump (heating capacity – 13,0 kW, power – 2,6 kW, refrigerant – R407C) and Gas boiler (capacity-24 kW) were installed for heating purpose and investigations in single family house (180 m^2) located in suburb Kaunas, Kaunas region, Lithuania (Fig. 8). The main component of ground side GSHP system is heat collector. Installed collector consists of 8 loops made from plastic pipes (polythene PA, D32x3).

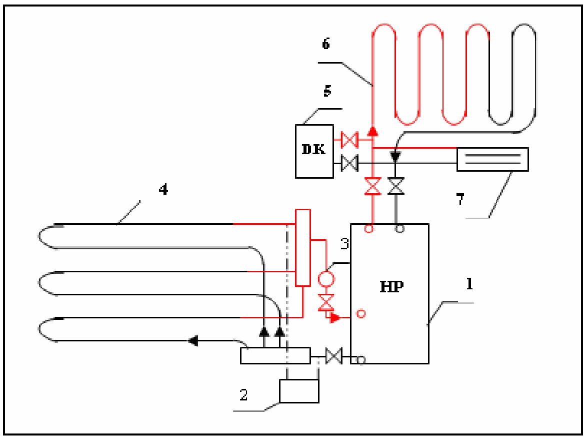

Figure 8. The heating scheme with two systems – Heat pump and Gas boiler (1-Heat pump, 2-Temperature meter, 3-Water flow meter, 4-Horizontal ground heat exchanger, 5- Gas boiler, 6- Floor heating, 7-Fancoil).

Inside of loops we have mixture of water and antifreeze liquid (approx. 400 litres) which freezing temperature is (-12^{0}C). For the heat collector the top earth layer was removed, the pipes are laid (in the depth of 1,8 meters), and the soil (loam) is distributed back over the pipes.

The main component of building side heat pump system is also heat exchanger which consists of tubes (diameter 12 mm, temperature 25-30^{0}C) installed in a floor and cowered by concrete and tiles. The pressure inside the soil collector and inside the floor heating system was 0,8-1,25bar. Indoor temperature during the heating season was kept 18-22^{0}C, and the outside temperature along the heating season changes from (-10^{0}C) up to (+12^{0}C).

When Heat pump was in operation, the Gas boiler was switched off and vice versa. The fancoil may be used in case of need to raise indoor temperature in a short time.

The measurement and registration once per 24 hours of temperatures (of water flows in loops, also indoor and ambient), volumes (of water circulating (m^3/h) and natural gas used), pressures (in loops) and electricity consumption – gave possibility to calculate the operating costs and coefficient of performance (COP) of the heat pump over heating season.

5.1.2. Results

The change of ambient temperature and the soil temperature changes were fixed from October to April.

The average ambient temperature was -4,64°C. The electricity consumption within the month of the HP was 732 kWh or 24 kWh per day. The COP was 3,95.

When heating season started the temperature of the soil was 12-13^{0}C and the lowest ambient temperature was from minus 10 and highest up to 12^{0}C.

The soil temperature goes down with the time because the heat was constantly taken off from the soil.

The temperature decrease of the soil was not less than 0^{0}C. It shows that the soil and the fluid which is inside the pipes buried in the soil have no possibility to freeze. When the Heat Pump for weekend was switched off, the room temperature went down from 20-22^{0}C to 15-17^{0}C, and the temperature of the soil went up 1-2^{0}C. The Gas Boiler consumed 24,46m^3 of natural gas per day (Fig. 9).

The calculations (carried out using the prices of the natural gas, electricity and equipment of year 2012) show that operation cost of Heat pump system is 494.9 EUR/year, whereas that of Gas boiler system - 3735,1 EUR/year.

The comparison of foreseen expenses set for each year in the duration of 10 years of exploitation (in case of same operation cost every year) for each system separately is presented in Table 1.

Installation costs. Private investment: the total cost of Heat pump heating system is – 9372 EUR; the total cost of Gas boiler heating system is – 1100 EUR.

In the first year we have a sum of investment and operation costs. During next years the expenses are rising due to operation costs. The total expenses per 10 years for Gas boiler system is 2,61 time higher than for Heat pump system.

More details on this case study in (Aleksandravicius T.A. 2012).

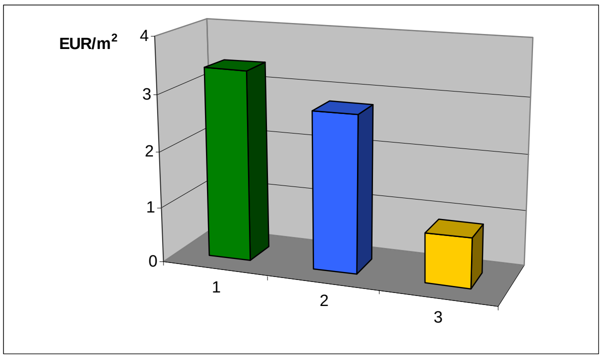

Figure 9. Costs of Gas boiler and Heat pump systems operation. (1-Gas boiler, 3,4 EUR/m^2; 2- Gas boiler switched off for 6-8 hours per night, 2,8 EUR/m^2; 3-Heat pump, 0,885 EUR/m^2)

5.2. Geothermal Heating and Cooling System Industry

One of the largest geothermal heating and cooling system in Lithuania (0.8 MW) has been installed in the Solar energy technology center (SETC) located in Vilnius (Fig. 10).

Figure 10. Solar energy technology centre

In the beginning of 2011, at the early-project stage, the first TRT (Thermal Response Test) in Lithuania

Table 1: Comparison of expenses of Boiler system and Heat pump (HP) system

	Operating cost per year									
	1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year	9th year	10th year
Boiler investment 1100 EUR	4835,1	8570,2	12305,3	16040,4	19775,5	23510,6	27245,7	30980,8	34715,9	38451
HP investment 9372 EUR	9866,9	10361,8	10856,7	11351,6	11846,5	12341,4	12836,3	13331,2	13826,1	14321

was done and the project started from the EED (Earth Energy Design) simulation model.

Ventilation and technology processes are required to maintain a certain microclimate in Solar Technology Center building. To have the most efficient use of geothermal heat have been designed and installed Low temperature (heating water temperature up to 40 ° C) ventilation air heaters, and underfloor heating system (Fig. 11)

Figure 11. Underfloor heating system

Heating, cooling and ventilation systems can be operated with one freely programmable control system, which is connected to the Internet. This enables to connect to the building's engineering systems from any part of the world to see their work and to change the settings.

The purpose of the established Geothermal heating/cooling center (Thermal center) - to generate heat and cold from different sources and distribute to consumers. There are 109 wells (with PE D40 "U" probes 150 m deep) installed under the building. Wells and heat pumps (12 units of 70 kW capacity (0/35 C) *"Stiebel Eltron WPF 66")* are connected by a pipeline in which circulates coolant - propylene glycol. Glycol passed through the wells warms up to 12 ° C; the heat pumps is cooling glycol to 5 ° C and warming up the water to 40 ° C transfers the heat to the building Thermal center. Then, taking into account the needs of users of the building, the warm water is directed to the floor heating or air heating systems. In summer, the system is used for production technology lines and for space cooling. High thermal resistance of the building and choice of a modern geothermal heating in winter and cooling in summer helps to save energy costs.

The first heating season building monitoring indicates a truly high coefficient of performance (COP) equal to 5.8 .

While investment in the geothermal heating system was approximately 4 million. LTL (1 EUR = 3,4528 LTL), calculated payback time - 3.5 years.

The heat used in SETC is absolutely "green" because the electric energy required for the heat pumps operation is supplied from PV modules. Geothermal and solar energy utilization in SETC will reduce carbon dioxide emissions by 400 tons / year in comparison with the case of district heating (burning of natural gas).

6. CONCLUSIONS

1. There are two (Cambrian and Lower Devonian sandstones) major geothermal aquifers that can be exploited for district heating in Lithuania. The most prospective area is related to geothermal anomaly of West Lithuania.

2. The reservoir properties of Cambrian reservoir are, however, rather low in West Lithuania, that accounted to pervasive quartz cementation of sandstones.The reassessment of the geothermal resources unravelled favourable heat production conditions in central Lithuania, that is characterised by higher Cambrian reservoir properties. The geothermal potential of a well doublet varies from 0.44 MW to 6.02 MW. The mineral (carbonates, gypsum) precipitation due to high water salinity should be taken into consideration while designing the geothermal stations.

3. The geothermal modelling indicates that temperatures as high as 150^{o}C can be met at the depths of 4.2-5.0 km in the crystalline basement in the southern part of West Lithuania that provides opportunities for electric power generation using EGS technologies. There is, however, high exploration risk related to identification of prospective fractured zones in the basement.

4. In the period from 2004 to 2012 it is evident growth in the number of small-scale ground source heat pump installations – up to 57 MW in year 2012. This result is reached mainly due private initiative.

5. Real financial support from the Government to geothermal development is expected with the implementation of Law on Energy from Renewable Sources approved in year 2011.

6. If in the short run Gas boiler system installed in the single family house seems more financially attractive – in the long run (10 years) it requires 2,6 time higher expenses.

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Tables A-G

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

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 DH Plants		Geothermal heat in agriculture and industry		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)
In operation end of 2012	35	93,9	-	-	-	-
Under construction end of 2012	-	-	-	-	-	-
Total projected by 2015	35	94	-	-	Tests	Tests

* Estimated values, more under consideration

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

Locality	Plant Name	Year commiss.	Is the heat from geo-thermal CHP?	Is cooling provided from geo-thermal?	Installed geotherm. capacity (MW_{th})	Total installed capacity (MW_{th})	2012 geo-thermal heat prod. (GWh_{th}/y)	Geother. share in total prod. (%)
Klaipėda	Klaipėda Geothermal Demonstration Plant	2004	No	No	13,6	35	93,9	23,3

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

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012	4387	56,5	141,3*	511	7,5	
Projected by 2015	5600	77	192			

* estimated using practical data

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	0,01	20	0,35 (in 2013)	20 (in 2013)
Shallow geothermal	3,6*	112		
total	**3,61**	**132**		

* estimated

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	-	DIS	DIS (~ 20 000 EUR, foreign)
Financial Incentives – Investment	-	DIS	DIS (%)
Financial Incentives – Operation/Production	-	-	-
Information activities – promotion for the public	Yes	Yes	Yes
Information activities – geological information	Yes	Yes	Yes
Education/Training – Academic	Foreseen	Yes	Yes
Education/Training – Vocational	No	No	No

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