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Geothermal Energy Use in Lithuania

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ABSTRACT

Lithuania contains large hydrogeothermal resources confined mainly to major Cambrian and Lower Devonian siliclastic reservoirs comprised by up to 2 km thick sedimentary pile of the Baltic sedimentary basin, covering the Early Precambrian crystalline basement of the East European Craton. So far, one district heating geothermal power plant is operating in the city of Klaipeda located on the Baltic Sea shore. Several priority targets were defined for further development of the hydrogeothermal objects that are characterized by exceptionally favorable geological conditions in west Lithuania containing the thickest sedimentary cover (maximum depths) and highest intensity heat flow anomaly.

Geothermal balneology is seen as the parallel important application of the geothermal reservoirs. There are a number of resorts chained along the Baltic Sea shore in Lithuania. They are, however, heavily seasonal-dependent crowded during the summer season while abandoned during the rest of the year that causes economic-social misbalance of the area. Yet, the shore zone is characterized by the largest hydrogeothermal resources. Three prospective reservoirs were defined and assessed, i.e. Middle Cambrian, Lower Devonian and Middle Devonian sandstones that are obtained at different depths which, in turn, control the temperatures and chemical composition of the formation water; respectively, about 150 g/l and 70 to 80°C, 70-90 g/1 and 35 to 40°C, 15-30 g/1 and 25 to 30°C. It led to some initiatives of the realization of the geothermal balneology objects along the Baltic Sea shore zone (e. g. Kretinga—Palanga area).

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

As good practice examples in Lithuania – two case studies are discussed:

First - the residential countryside house with a novel geothermal heating system is presented. The heat pump system (with coaxial ground heat exchanger) is operating with a solar collector. The summer heat accumulated in the soil around the vertical borehole is utilized during the first part of winter, whereas since February the solar collector is connected up in order to source higher potential heat for the geothermal heat pump. The water accumulation volumes are used for solar heat collecting.

Second - the installation of geothermal heating and cooling system (with 140 kW capacity) in the building of "WURTH LIETUVA", UAB logistics center located in Ukmerge district.

1. INTRODUCTION

A positive Lithuanian gross domestic product (GDP) dropped in 2009, by (-14.6%), but increased again by 1.5%, 6.1%, 3.5%, 3.5% in the period from 2010 to 2013, respectively. In 2012 the contribution of "clean" fuel to the primary energy balance was 22%, natural gas – 36%, oil and oil products – 34%, coal and peat – 3%, (Energy, 2012), (Figure 1).

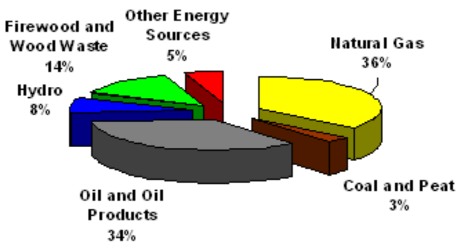


Figure 1. The structure of Primary energy balance in year 2012.

2. GEOLOGICAL SETTING AND GEOTHERMAL POTENTIAL

2.1 Aquifers of Lithuanian sedimentary cover

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 (Kepezinskas et al., 1996). It was formed in the Cambrian. It is a rather unique basin as sedimentary layers of all geological periods ranging in the age from Cambrian to Quaternary are present in the sedimentary cover which is accounted to protracted subsidence history. Lithuania is located on the eastern flank of the basin. The thickness of the sedimentary pile changes from 200 m in the southeast to 2,300 m in Western Lithuania (Figure 2).

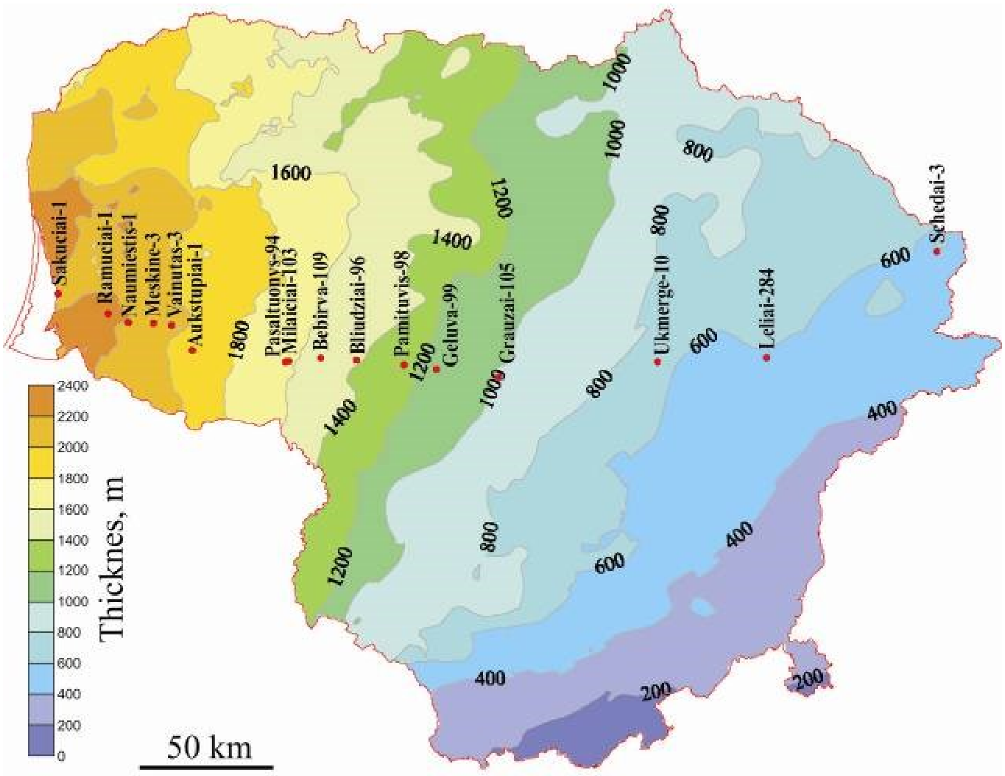


Figure 2: Thickness of sedimentary cover of Lithuania. Wells indicated in profile are shown (Figure 3).

Different lithologies are defined in the sedimentary cover owing to the changing sedimentation environment. As a result, the sedimentary pile of Lithuania represents alteration of different size carbonaceous and sandy aquifers and shaly aquitards. Three major geothermal aquifers are defined, referred to as Cambrian (30-70 m thick), Lower Devonian (up to 160 m thick), and Middle-Upper Devonian (about 220 m thick) dominated by sands and loosely cemented sandstones with subordinate shales and siltstones (Figure 3). A number of smaller-scale aquifers are defined in the upper part of the geological section, e.g. Upper Devonian dolomite and sandy layers (Pliavini, Stipinai, Kruoja, Zagare dolomites of 5 to 20 m thick, Muri-Svete and Ketleri sands of 15-35 m thick), Upper Permian dolomites and limestones (10-35 m thick), Jurassic sands with clays (up to 100 m thick), Cretaceous chalk and sand (up to 200 m).

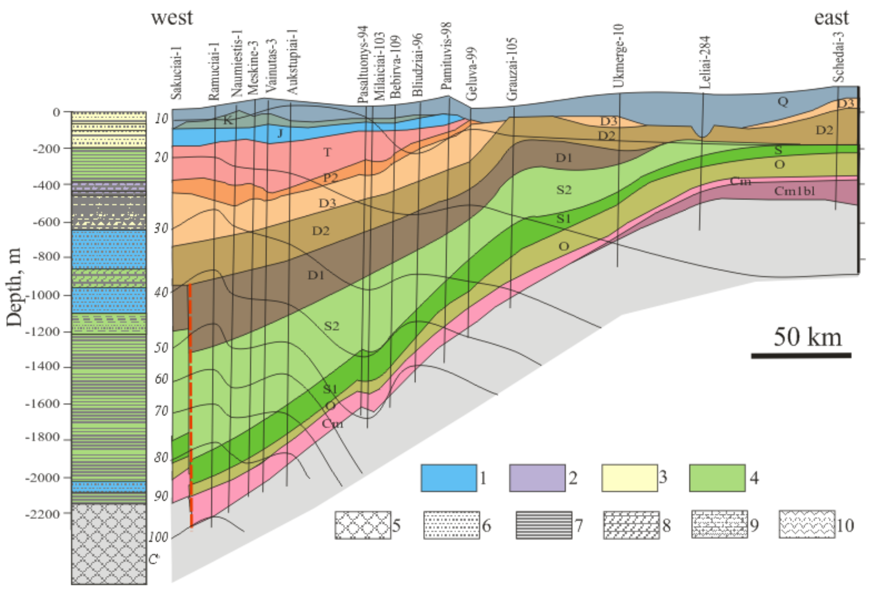


Figure 3: Geological cross section west-east of Lithuania. Isotherms are shown. Lithological profiles are indicated on the left. 1-major aquifer, 2-subordinate aquifer, 3-intercalation of aquifers and aquitards, 4-aquitard, 5-crystalline basement, 6-sand / sandstone, 7-clay – shale, 8-marlstone, 9-carbonates, 10-gypsum.

2.2. District heating potential

The heat capacity of different layers is also highly variable owing to the different reservoir properties, thickness, and temperature (Figure 3). The latter parameter is controlled by depth and heat flow intensity which is twice as high in western Lithuania (70-80 mW/m^2) as that in eastern Lithuania (40-50 mW/m^2). The highest temperature close to 100^{o}C is registered in the Middle Cambrian sandstones of southwest Lithuania. The effect of the difference of heat flow intensity is well illustrated in the profile of isotherms presented.

Such a variability of geothermal aquifers provides different opportunities for their utilisation in Lithuania. The main prospects are related with central heating of exploitation of hot water of three major geothermal aquifers mentioned above. So far, only one district heating installation is operating in Klaipeda in western Lithuania (see below). Aquifers of temperature exceeding 35^{o}C are considered as potential formations for district heating applications. The Cambrian geothermal aquifer covers the largest (29,800 km^2) area in Lithuania (Figure 4). There is a number of potential towns for geothermal district heating installations. The most prospective area is confined to a temperature range of 35-65^{o}C. A dense quartz cementation, dramatically reducing reservoir properties of Cambrian sandstones, occurs at higher temperatures, while the average porosities are in the range of 22-15% within the 35-65^{o}C temperature interval. The assessment of the geothermal resources reveal that 1-2 well doublets (except Siauliai town) are needed to cover the heating needs of individual towns. The well doublet extracted heat potential is estimated to range from 0.5 to 6.5 MWt. The depth of potential varies from 1 km in middle Lithuania to 2 km in western Lithuania.

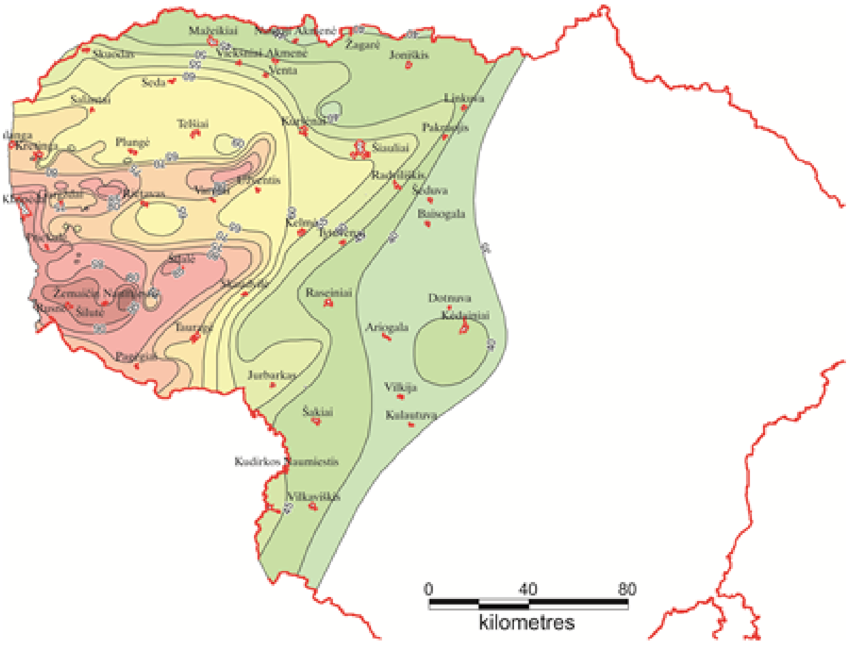


Figure 4: Distribution of temperatures >35^{o}C of Cambrian geothermal aquifer. Potential towns for district heating are indicated.

The prospective area of the Lower Devonian geothermal aquifer covers a much smaller part (810 km^2) of Lithuania due to shallower depths (~1 km) (Figure 5). Temperatures are in the range of 35-50^{o}C in the prospective area. It is characterised by very high reservoir properties (average porosity 26%, permeability is of 2 up to 4 Darcy (D)). Klaipeda geothermal power station exploits 38^{o}C hot water from this reservoir. Potential customers are such towns as Silale, Silute, Pagegiai, Rusne, and Priekule. The extracted heat potential of a well doublet is in the range of 4-9 MWt.

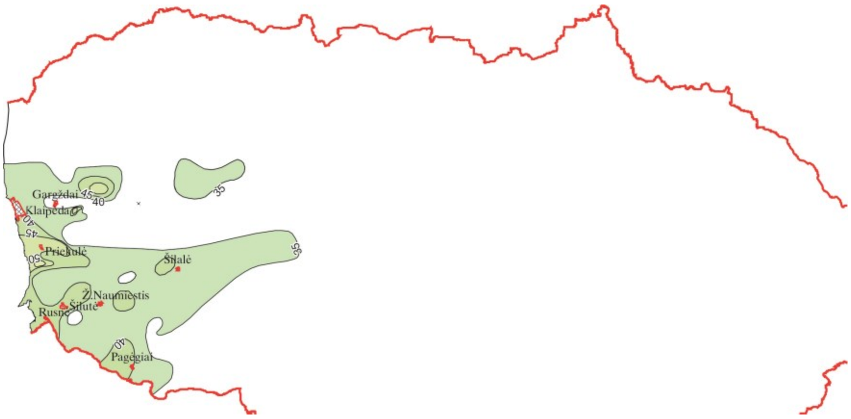


Figure 5: Distribution of temperatures >35^{o}C of Lower Devonian geothermal aquifer. Towns potential for district heating are indicated.

2.3. Potential of alternative utilisation of geothermal aquifers

The geothermal aquifers provide alternative ways of utilisation of hot water. There is a growing interest in geothermal balneology in Lithuania. Several mineral water resorts (Druskininkai, Birstonas, and Likenai) are located in middle Lithuania that is characterised by shallow setting of low temperature aquifers. The main prospects are related to the Baltic seaside area. The seaside resorts are subject to considerable seasonal variations; crowded during the summer season and abandoned during rest of the seasons. The establishment of geothermal facilities should play a buffering role to some extent. The seaside is characterised by very good geological conditions. There are a number of geothermal-mineral water aquifers in the sedimentary section (Figure 6, 7). The uppermost is about 200 thick and part of the section is comprised of potable water. The saline water occurs below the regional-scale Triassic shaly aquitard. The Upper Devonian dolomitic aquifers have 4-8 g/l salinity and 15-25°C temperature that is suitable for drinking mineral water application (depths 200-500 m). The underlying large Upper-Middle Devonian sandy aquifer contains 15-35 g/l and 20-30°C temperature (depths 500-800 m). It is considered one of the most prospective geothermal balneological formations along with the large Lower Devonian aquifer 60-90 g/l and 25-45°C in western Lithuania. The lowermost Cambrian aquifer is characterised by 50-85°C temperature and 120-200 g/l salinity.

Establishment of the first geothermal balneological facility located close to the famous Palanga resort town is in progress. The Upper Devonian dolomite aquifers are planned to be utilised for drinking mineral water supply, while the Lower Devonian sandy aquifer provides high salinity hot water for body treatment and also provided to the heating system.

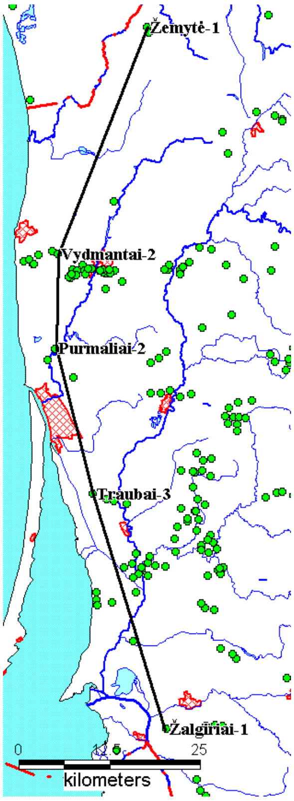


Figure 6: Wells drilled to the Cambrian reservoir and linen of Hydrogeological cross-section along the Baltic Sea shore.

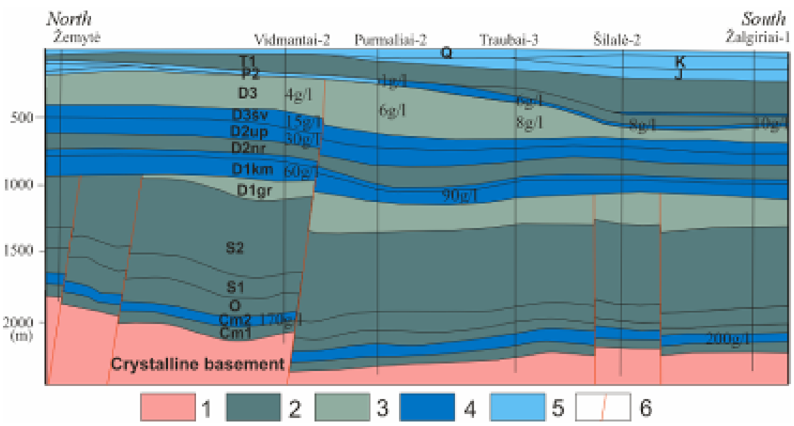


Figure 7: Hydrogeological cross-section along the Baltic Sea shore. Salinity of aquifers is indicated. Symbols: 1-crystalline basement, 2-shaly aquitard, 3-shaly aquitard with subordinate carbonate aquifers, 4-saline aquifer, 5-potable water aquifer, 6-fault.

3. GEOTHERMAL UTILIZATION

3.1. Klaipeda Geothermal Demonstration Plant (KGDP)

The usage of geothermal resources for district heating started in 2000 in Klaipeda. The absorption heat pumps use a lithium bromide (LiBr) solution. Low-temperature geothermal heat is extracted from the geothermal water of the Devonian aquifer. The plant capacity is confirmed by the State Commission at 35 MWt (geothermal part – 13.6 MWt). (The operation of the KGDP was described in detail in papers (Zinevicius et al. 2003) and (Zinevicius and Sliaupa 2010)). KGDP is still solving difficulties of injection and struggling in the market, as a result, operation in only during the heating season.

The heat production of KGDP in the period from 2010 to 2012 was more or less stable (Figure 8).

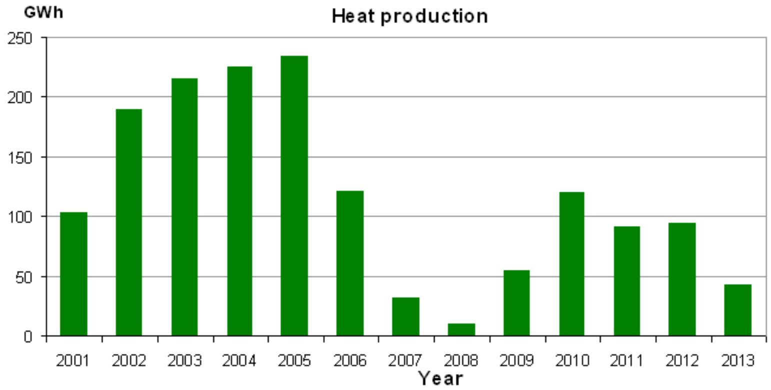


Figure 8: Heat production of KGDP in the period from 2000 to 2013.

3.2. Installation of Small-Scale Ground Source Heat Pumps (GSHP)

The number of small-scale ground source heat pump systems in Lithuania is growing. At present, we have near 5,500 installations thanks to such private enterprises as: JSC Ekoklima, JSC "Naujos idejos", JSC "Tenko Baltic", JSC "EES", JSC "Vilpra", JSC "Ekokodas", JSC "Steltronika", JSC "Geoterminis sildymas", JSC "Alropa", JSC "Ogeo", JSC "Ardega", JSC "Monvilas", JSC "Bremena", JSC "Kauno hidrogeologija", JSC "Silumos masinos", JSC "Aqua Jazz". Lithuanian Geothermal Association is proud for its legal bodies, such as: JSC "Donasta", JSC "Airr", "VVS Montavimo grupe". The total installed capacity is more than 70 MWt (Figure 9).

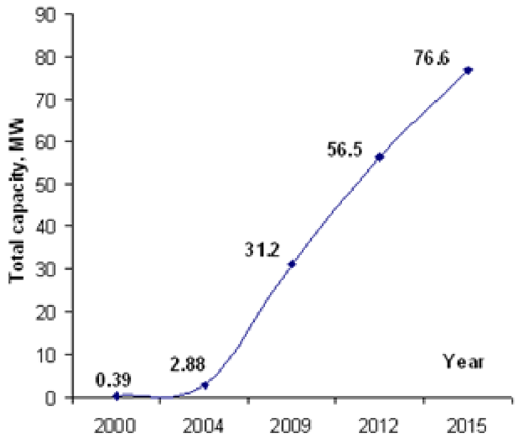


Figure 9: Total capacity of small-scale GSHP systems.

3.3. Opportunities of Geothermal Electric Power Production

The geological background in the southern part of western Lithuania is very similar to that of the Australian geothermal areas. The most intense heat flow anomalies are confined to the 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 geothermal modelling indicates that temperatures of 150^{o}C can be met at the depth of 4.2-5.0 km. The area is as large as 2,200 km^2. The well triplet system is expected to produce 3.5 MWe gross energy.

4. LEGAL BASIS

The **Law on Energy from Renewable Sources** passed the Seimas (Parliament) on the 12th of May, 2011 (Law 2011). In this document are fixed important statements influencing geothermal energy utilization development in Lithuania. In:

Article 3. *Promotion of Development of the Use of Renewable Energy Sources* – the support of the Use of Renewable Energy Sources - the support of investments in renewable energy technologies is considered.

Article 5. *Remit of the Government* – it is fixed that the Government or an institution authorized by the Government shall establish the procedure for implementing the requirements for using the renewable energy sources in buildings and implementing these requirements; also establishs the procedure for certifying the fitters of installations for production of energy from renewable sources.

Article 11. *Remit of the National Control Commission for Prices and Energy* (NCCPE) – NCCPE shall establish preferential rates for electricity used for the operation of heat pumps (with accounting of electricity supplied to the compressor).

Article 42. *Use of Funds of Programmes for Funding the Development of the Use of Renewable Energy Sources* – funds shall be used for implementation of projects for the use of geothermal energy for energy production.

Article 47. *Requirements for Individual Installations* - Support schemes shall apply to heat pumps and their installation provided that the heat pumps meet the criteria specified by Commission Decision 2007/742/EC of 9 November 2007 establishing the ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps (OJ 2007 L 301, p.14); also closed-loop geothermal systems whose installed capacity is less than 30 kW and which are intended for households shall be registered without an authorization for operation.

The main goal of the **National Energy Independence Strategy (NEIS)** (National, 2012) is to ensure Lithuania's energy independency before year 2020 by strengthening Lithuanian energy security and competitiveness. The NEIS sets a number of tasks. For the electricity energy sector, which has a crucial impact on the country's energy independence, the task is: full integration into the European Energy Systems. The main activities in this direction are:

- Completion of the Lithuanian – Swedish power link NordBalt in 2015, and
- Start-up of the Lithuanian – Polish power link Lit Pol Link1 in 2015 and extension of this link in 2020; also the completion of extra Lithuania – Poland, cross-boarder power connection (Lit Pol Link 2), (Figure 10).

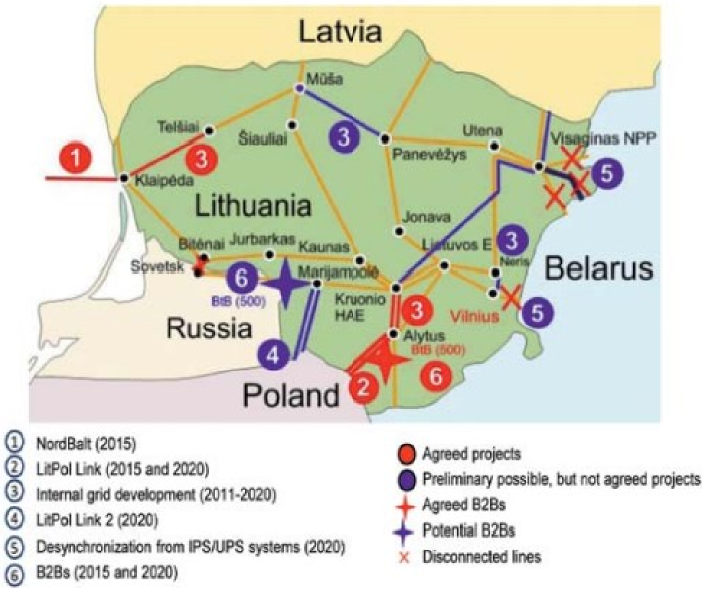


Figure 10: Vision of Lithuanian electricity system operation with European continental network in the synchronous mode.

Most of the energy sources used in Lithuania are imported; thus special attention is paid to renewable energy sources (RES) – target for RES is: no less than 20% of renewable energy in final energy consumption. In 2011, Lithuania produced 1,097 GWh from RES and in 2020 it is expected to produce 3,675 GWh (or 25% of total electricity consumption), (Figure 11).

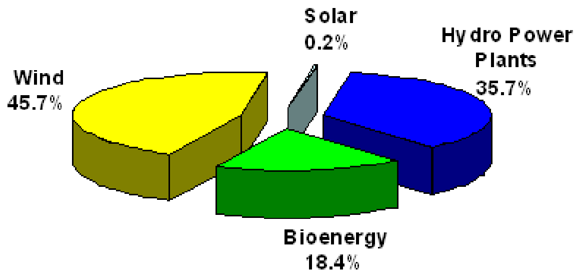


Figure 11. Electricity production from RES in 2012.

5. GOOD PRACTICE EXAMPLES

5.1. Residential heat pump with seasonal heat accumulation around borehole.

The growing development of heat pumps in Lithuania is conditioned by the present situation in the energy market. The spectrum of installed heat pumps varies from family water heating systems (in the whole country) to high powered heat pump plants for district heating purposes (in Klaipeda city).

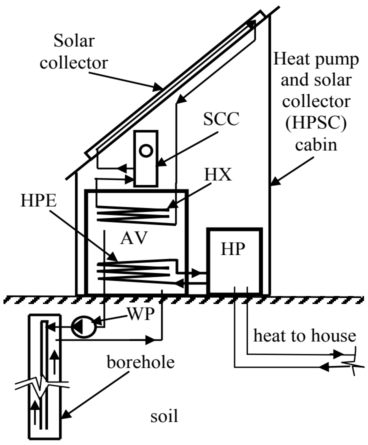
Residential heat pumps with vertical borehole heat exchangers have advantage compared to other means of low potential heat absorption in cool climate regions.

It is evident in recent years the increase of scientific publications outlining both the advantages of such heat pumps as well as their disadvantages. One of the identified disadvantages is the heat transfer problem while absorbing the heat from soil. Other aspect of this problem is the internal heat transfer between the in-and-out vertical flows. This transfer reduces the total effectiveness of the exchanger irrespective of its type. Coaxial and double U-type borehole heat exchangers are slightly more effective compared to the usual U-type exchanger (Nagano K. et al., 2006).

Yet another disadvantage of vertical borehole heat exchangers is related to the heat inertia of soil. Geothermal heat flux from depth is low compared to the amount of the absorbed heat around the borehole; due to that, the soil temperature there decreases from year to year (Rybach L. and Eugster, 2002). This reduces both effectiveness and capacity of the system. The problem is partially solved by the reverse heat pump, which directs the heat absorbed from the building during the summer season to the soil. The problem could be fully solved also by delivering summer heat to the soil via solar collectors. However, in this mode the borehole heat exchangers operate even worse because of greater temperature difference between in-and-out vertical flows and therefore greater internal heat transfer.

The good practice example is presented while solving the problem of heat supply into the soil. Coaxial borehole heat exchanger functions cyclically supplying a large amount of heat to the bottom of the boring with 125 m depth by central duct. The higher heat capacity of the exchanger is the lower comparative loss of effectiveness due to internal heat transfer. The heat pump system is more costly because additional volume of heat carrier and the high-power circular pump is necessary.

The additional volume of heat fluid AV (Figure 12, Figure 13 and Figure 14) is approximately equal to the volume of the coaxial borehole heat exchanger. When the fluid temperature reaches the set-point value, the water pump is switched rapidly on to counterchange fluids of both volumes. Therefore the warm fluid is moved to the very bottom of the borehole and then fills the borehole volume. Then the water pump is switched off and fluid cools down while heating the soil uniformly. Counterchange of heating liquids means high capacity of heat transfer from additional volume to volume of borehole.



Intensive

Figure 12: Scheme of the residental heat pump with seasonal heat accumulation in soil around the borehole (HP - heat pump assembly; AV - additional volume; HX - heat exchanger of solar collector; HPE - heat pump evaporator; SCC – solar collector controler; WP - water pump).

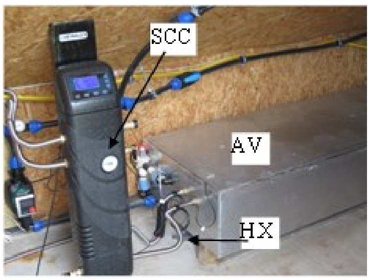


Figure 13: Additional volume (AV) and controller of solar collector (SCC) in HPSC cabin.

Figure 14: HPSC cabin and countryside house.

The capacity of internal heat transfer, meanwhile, remains almost the same, so overall heat transfer losses because of internal transfer are much lower. Effectiveness of the presented heat exchange system oversteps 85%, comparing to the 70% of conventional system of the borehole heat exchangers (Nagano K. et al., 2006).

The main result of this good practice example is economical. Due to higher effectiveness of the heat exchange system (additional volume AV, higher capacity water pump and as a result – more efficient borehole heat exchanger) the same heat capacity could be reached with a decreased, by 20%, borehole depth or by approximately 24 m with the actual depth of the borehole at 122 m. It should save the sum of 830 EUR while expenses for the additional volume, higher capacity water pump, installation, etc. took 240 EUR. Thus, overall saving of 590 EUR could be stated as a practical result.

The increase in the coefficient of performance of the actual heat pump system with seasonal heat accumulation around the borehole will be determined after several years of testing and comparison with the results which are obtained without accumulation.

5.2. Installation of geothermal heating and cooling system (140 kW capacity) in the building of logistics center.

Storage spaces of large area and height in Lithuania usually are heated by forced air heating systems, as in other European countries. Spaces are heated only during working hours. This heating mode is aceptable for cheap investments, but it needs, as a rule, fossil fuel, mainly natural gas.

A new approach has been applied at the construction of the logistic center “Wurth Lithuania” by design company “STELTRONIKA”. The heated area of the considered building area is 5,200 m^2 and a volume of 42,000 m^3. Alternative engineering solutions have been integrated for space heating and cooling of the warehouse and administrative parts by contractor company “DONASTA”: The floor heating system is embedded in the 20 cm jointless concrete slab laid directly on the ground, with 5 m insulation around the perimeter, and a shallow geothermal plant consisting of two units STIEBEL ELTRON WPF66 heat pumps (total capacity 134 kW, in accordance with EN 14511/BO/W35), using 16 boreholes of 150 m deep with “U”-type PE D40*3.7 probes. Fan coils of casestte type are applied for cooling (in passive cooling mode) of the office part. Total investments – 251,000 EUR. The scheme of installation is shown in Figure 15, the general view in Figure 16, and details of installation in Figure 17. According to the commitment with the customer, the heating and cooling expenses shall not exceed the 10,000 EUR/year at electricity price of 0.13 EUR/kWh.

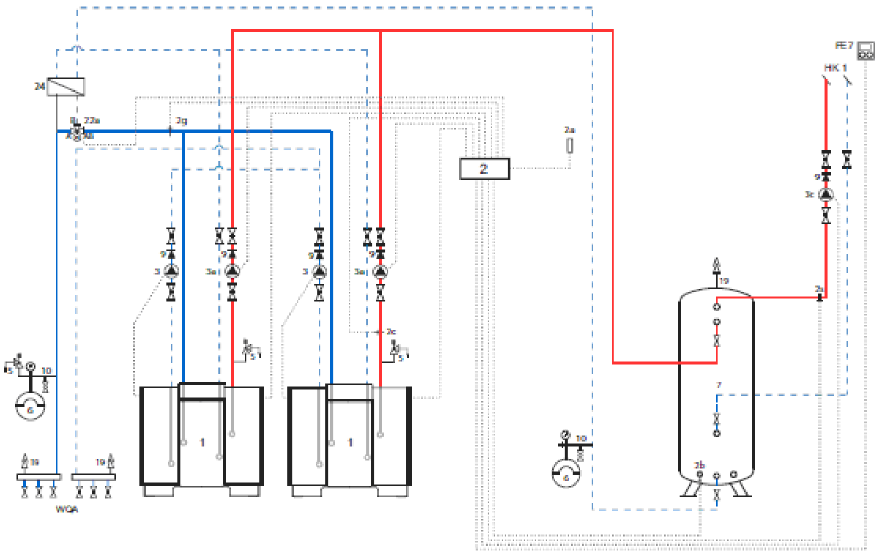


Figure 15: Scheme of heating equipment installation (1 – heat pump, 2 – control unit WP MW, 3 – circulating pumps, 7 – buffer cylinder).

Figure 16: The view of the logistic center.

Figure 17: The view of floor heating system installation in the logistic center.

The results of the first year of operation are discussed below.

The heating season of 2013/2014 was relatively warm and is characterized by 3,200 degree-days instead of average annual value of 3,870. Heating in the building started in October 2013, before the finalizing of the construction work. The temperature in the office was settled at 21^{o}C, in the space of stock premise at 18.5^{o}C. The supply water temperature of heating system in the office did not exceed 30^{o}C, and 28^{o}C in the stock. Stable indoor temperatures wwere maintained according to the normal heating curve algorithm, additionally adjusting the temperature in every room by thermostatic valves of floor heating system. The average temperature of glycol in the shallow geothermal probe was at least 4^{o}C. The heat pump system was automatically shut down at average 3 days outdoor temperature 14^{o}C (20/04/2014).

The results of the heating season according to the internal energy meters:

Production of thermal energy by heat pumps: 178.8 MWh; Consumption of electricity by heat pumps 29.5 MWh; COP 6.06 (without energy for circulation pump, which was equal to 1,166 working hours x 1.1 kW x 2 heat pumps =2.56 MWh). So seasonal COP (or SPF) =5.57 is excellent result. Then the customer’s expenses for the heating season were (29.5+2.56) MWh x 0.13 EUR/kWh x 1,000 = 4,170 EUR.

6. CONCLUSIONS

1. There is a large geothermal potential for district heating in the country. Three major reservoirs are defined, referred to as Cambrian, Lower Devonian and Middle-Upper Devonian geothermal aquifers in Lithuania. Aquifers with water temperature ≥ 35^{o}C are considered as potential formations for district heating applications in western Lithuania. The heat extracted from the Cambrian aquifer from well doublet is estimated to vary from 0.5 to 6.5 MWt, while it is in the range of 4-9 MWt in Lower Devonian. Only local sites show temperatures over 35^{o}C in the Middle-Upper Devonian aquifer.

2. There is growing interest in geothermal balneology in Lithuania. A large variations in water salinity and temperature provides a wide spectra of utilization of different aquifers for balneological purposes. The Baltic seaside zone is considered the most prospective area.

3. Klaipeda Geothermal Plant is struggling not only with technical problems (injecting), but also for its place in the market.

4. Total capacity of installed ground source heat pump reached over 70 MWt.

5. In the period from 2010 to 2015 two important legal acts passed the Seimas (Parliament): Law on Energy from Renewable Sources (in 2011) and National Energy Independence Strategy (in 2012).

6. The pilot project of heat accumulation into the soil using a novel effective heat exchange system was implemented at a countryside house.
7. The right choice of heating system solution (low temperature Uponor PePEX 20*20 floor heating system), efficient STIEBEL ELTRON heat pump option (Coefficient of Performance at BO/W35 (EN 14511) 4.56), the right investigation and exploitation of local geological conditions choosing 150 drilling depth (aquifers are below 100 m, as a standard Lithuanian drilling depth at the project site), energy efficient building envelope is enabling cheap, efficient environment friendly heating mode.

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STANDARD TABLES

Table 1. Present and planned production of electricity

	Geothermal		Fossil Fuels		Hydro*		Bio		Wind		Solar		Waste		Total	
	Capacity, MW_e	Gros prod. GWh/y	Capacity, MW_e	Gros prod, GWh/y	Capacity, MW_e	Gros prod. GWh/y	Capacity, MW_e	Gros prod, GWh/y	Capacity, MW_e	Gros prod, GWh/y	Capacity, MW_e	Gros prod, GWh/y	Capacity, MW_e	Gros prod, GWh/y	Capacity, MW_e	Gros prod, GWh/y
In operation in January 2014	-	-	2846	3269	128	516	61	263	282	600	68	45	20		3404	4693
Under construction in December 2014	-	-														
Funds committed, but not yet under construction in December 2014	-	-														
Estimated total projected use by 2020	-	-	2846	2175	141	470	355	1940	500	1250	68	45	20		3910	5880

* - excluding Kruonis Hydro Pumping Power Plant

Table 5. Summary table of geothermal direct heat uses as of 31 December 2014

Use	Installed capacity1), (MWt)	Annual Energy Use2)	Capacity Factor3)
Subtotal			
Geothermal Heat Pumps: - Small scale (total) - Big (in Klaipeda Geothermal Demonstration Plant)	 76.6 18	 678.8 34.1	 0.281 0.06
TOTAL	94.6	712.9	

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.004184

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171

Table 7. Allocation of Professional personnel to Geothermal

Year	Professional Person-years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2010	3	15	6	8		34
2011	3	18	6	4		34
2012	3	18	6	3		34
2013	3	18	6	6		34
2014	(3)	(18)	(6)	(6)		(34)
Total	15	87	30	27		170

(1) – Government; (2) – Public utilities; (3) – Universities; (4) – Paid Foreign consultants; (5) – Contributed Through Foreign Aid Program; (6) – Private Industry.

Table 8. Total investments in Geothermal in (2014), US$

Period	Research & Development incl. Surface Explor. & Exploration Drilling, mln. USD	Field Development incl. Productipon Drilling & Surface Equipment, mln. USD	Utilization		Funding Type	
			Direct, mln. USD	Electrical, mln. USD	Private, %	Public, %
1995-1999	0.035	8.51	15.4	-	0.4	99.6
2000-2004		1.03	2.97	-	45.6	54.4
2005-2009	0.144	35.22	5.27	-	86.67	13.33
2010-2014	0.08	0.3	42.2	-	98.6	1.42