Geothermal Energy Use, Country Update for Lithuania

Saulius Šliaupa[1], Feliksas Zinevičius[2], Arūnas Mazintas[3], Sigitas Petrauskas[4], Vytautas Dagilis[5]

[1] Nature Research Center, Akademijos 2, LT 08412 Vilnius, Lithuania

[2] Kaunas Regional Energy Agency, Breslaujos 3B-202, LT 44403 Kaunas, Lithuania

[3] Steltronika UAB, Uzupio street 25, LT 01202 Vilnius, Lithuania

[4] Geoterma UAB, Lipkiu street 17, LT-94100 Klaipėda, Lithuania

[5] Kaunas University of Technology, Donelaicio 73, LT 44029, Kaunas, Lithuania

saulius.sliaupa@gamtc.lt

Keywords: Lithuania,

ABSTRACT

So far, there is the only district heating geothermal plant installed in Klaipėda City in westernmost Lithuania within the West Lithuanian geothermal anomaly. Due to problems with injection of the used geothermal water the plant is not operating since two years ago. The reconstruction of the geothermal plant is seen as the only way to solve the injection problems and restart the plant operation. Due to unfavourable economical environment and problems with injection of used geothermal water - the operation of Klaipėda geothermal plant was stopped in year 2017. We hope, that problems faced by this plant will be solved and this pioneering installation also will serve for research and education purposes, essential for further activities aimed at geothermal energy development in Lithuania. As regards the shallow geothermal installations a part of this kind of energy is systematically increasing. The total installed capacity is assessed as large as 102 MW. Geothermal balneology is also gaining a speed. There is one centre that uses Lower Devonian hot water for SPA treatments in west Lithuania (Žybininkai). Drilling of deep wells was started in Palanga Resort Town in 2018. The hot water will be used for SPA treatments and heating. The new alternative prospects of utilisation of geothermal water is related to geothermal agriculturing. The new alternative prospects of utilisation of geothermal water is related to geothermal agriculturing. The geothermal fish (shrimp) farm (pilot project) was installed in west Lithuania in 2018.

1. INTRODUCTION

Lithuania contains large hydrogeothermal resources confined mainly to the largest Cambrian, Lower Devonian and Upper-Middle 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. The thickness of the sedimentary cover is increasing from 200 m in southeast Lithuania to 2.3 km in westernmost Lithuania (Figure 1). Accordingly, the highest temperatures are reached in the west. Furthermore, high temperatures are also accounted to the additional heat flow anomaly effect (up to 95 mW/m^2), which is the highest in the East European Craton (Kepežinskas, Rastenienė, Suveizdis, 1996). The Lower Devonian aquifer is considered as the most prospective deep reservoir for district heating in west Lithuania owing to large thickness and high reservoir properties (porosity about 26%, permeability 2-4 Darcy). The Cambrian reservoir of 40-60 m thick has the highest prospects in Middle Lithuania that is accounted to good reservoir properties (porosity 15-22%), the temperature ranges from 35ºC to 65ºC. The western part of Lithuania is less prospective despite of higher temperatures (up to 95ºC). It is related to sever quartz cementation above temperatures of 65ºC. As regards the Upper-Middle Devonian (Šventoji-Upninkai) geothermal aquifer its prospects are seen as combined use for balneological purposes and heating in west Lithuania (temperatures 30-45ºC). The exceptional geothermal conditions resulted in establishing the Klaipėda geothermal heating plant (Lower Devonian), which is the only district heating installation in the Baltic region.

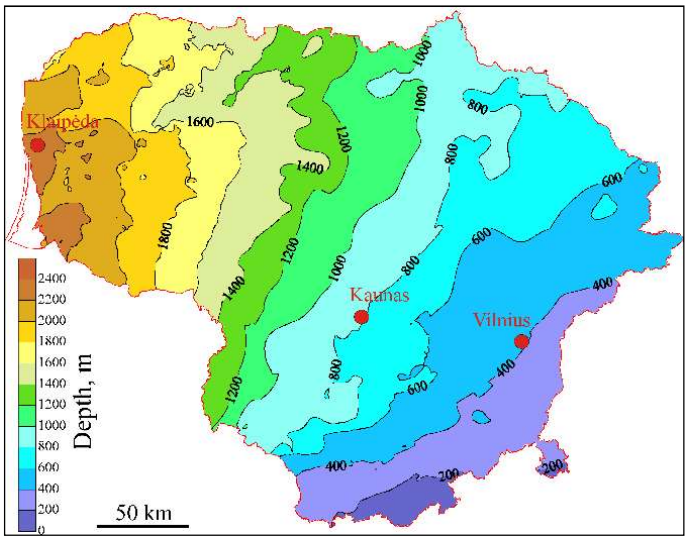

Figure 1: Depths of top of the crystalline basement

Lithuania has unique hydrogeological conditions. All potable water is exploited from the geological aquifers of the Quaternary (Figure 2), Paleogene, Cretaceous, Upper Permian, and Upper-Middle Devonian ages. It provides good favourable conditions for developing shallow geothermal installations. The horizontal loops are mostly used for heating of the private houses. For large buildings are mainly heated by vertical loops (borehole heat exchangers), while the open loop systems are rarely used.

2. DISTRICT HEATING

Despite of very good geothermal conditions there is the only Klaipėda geothermal district heating plant in Lithuania. It started operating in 2001. A part of the geothermal energy was planned initially 13.6 MW and the total power generation 35 MW (two production wells and two injection wells, bottom depth about 1100 m, temperature of the produced water 38°C) (Zinevicius *et al*. 2003; Zinevicius and Sliaupa 2010) The power production was systematically decreasing, however, since the beginning of the plant operation (Figure 3).

It is related to decreasing injectivity. There are different explanations of this phenomenon, *e.g.* fines migration under high rate water flow (pollution by drilling mud, mobilization of the original clay minerals presents in sandstones, erosion of the walls of shaly layers and injection of fines into sandy layers during exploitation), precipitation of new minerals (gypsum, pyrite), bubble clogging due to high gas (nitrogen) content in the formation water (may be important during sudden stops in pumps operation), large sized bacteria growth (fostered by application of the phosphate inhibitor). A peculiar feature of the Lower Devonian sandstones is fine-grained composition. The average grain size is only 0.10 mm. Therefore, these sandstones are very sensitive to any clogging of pores as described above (Figure 4). This process is also fostered by euhedral shape of quartz grains due to authigenic quartz overgrows.

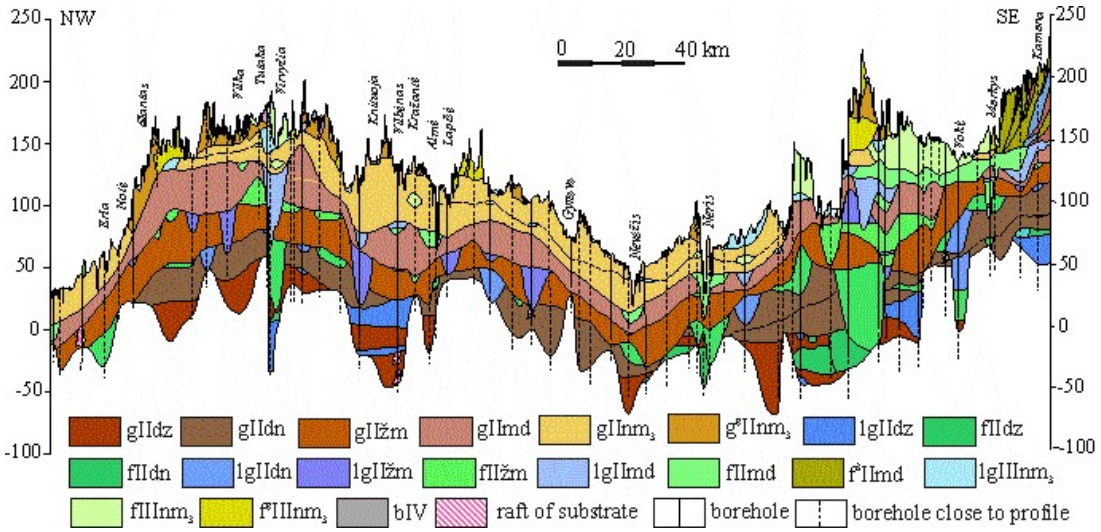

Figure 2: Geological cross section of the Quaternary deposits across Lithuania NW-SE. Brown layers indicate morain deposits (indexed g) of different age, blue layers are glaciolimnic (indexed l) deposits, green layers show glaciofluvial sediments (indexed fl)

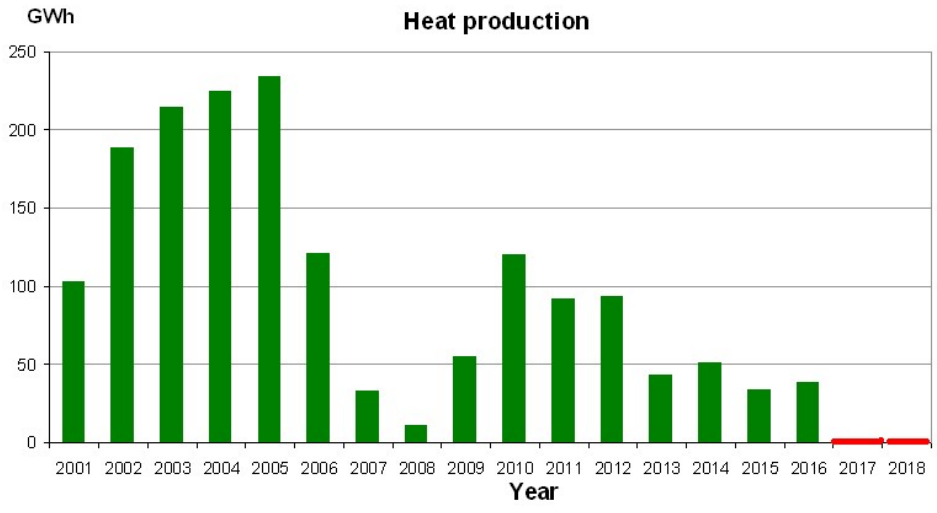

Figure 3: Heat production of the Klaipėda geothermal plant from 2001 to 2018

It is related to decreasing injectivity. There are different explanations of this phenomenon, *e.g.* fines migration under high rate water flow (pollution by drilling mud, mobilization of the original clay minerals presents in sandstones, erosion of the walls of shaly layers and injection of fines into sandy layers during exploitation), precipitation of new minerals (gypsum, pyrite), bubble clogging due to high gas (nitrogen) content in the formation water (may be important during sudden stops in pumps operation), large sized bacteria growth (fostered by application of the phosphate inhibitor). A peculiar feature of the Lower Devonian sandstones is fine-grained composition. The average grain size is only 0.10 mm. Therefore, these sandstones are very sensitive to any clogging of pores as described above (Figure 4). This process is also fostered by euhedral shape of quartz grains due to authigenic quartz overgrows.

Seeking to increase the injectivity the radial drilling was performed in the lowest quality Klaipėda 1I injection well in November 2014. Twelfth laterals mainly 40 m long were jetted in three sandstone layers separated by shale and siltstone layers. To increase effectiveness of jetting two soft acidization campaigns (HCl and HF-HCl) were performed in the well Klaipėda 1I seventeen and 29 days after the jetting (January 2015). The jetting had little effect on enhancement of the reservoir performance, but combined with acidization had discernible effect on increasing injectivity (Figure 5).

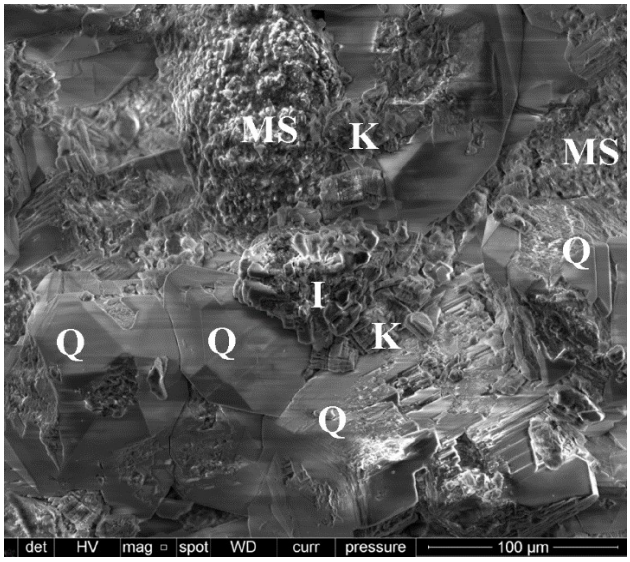

Figure 4: Drilling mud (MS) displacing original illite (I) and kaolinite (K). Please note authigenic quartz overgrows, well Klaipėda 1I. Lower Devonian, depth 1112 m (bottom part of the reservoir)

Despite of these efforts to increase the infectivity, the operation of the plant was stopped in 2017. The general reconstruction of the deep and surface installations is planned to reopen the plant.

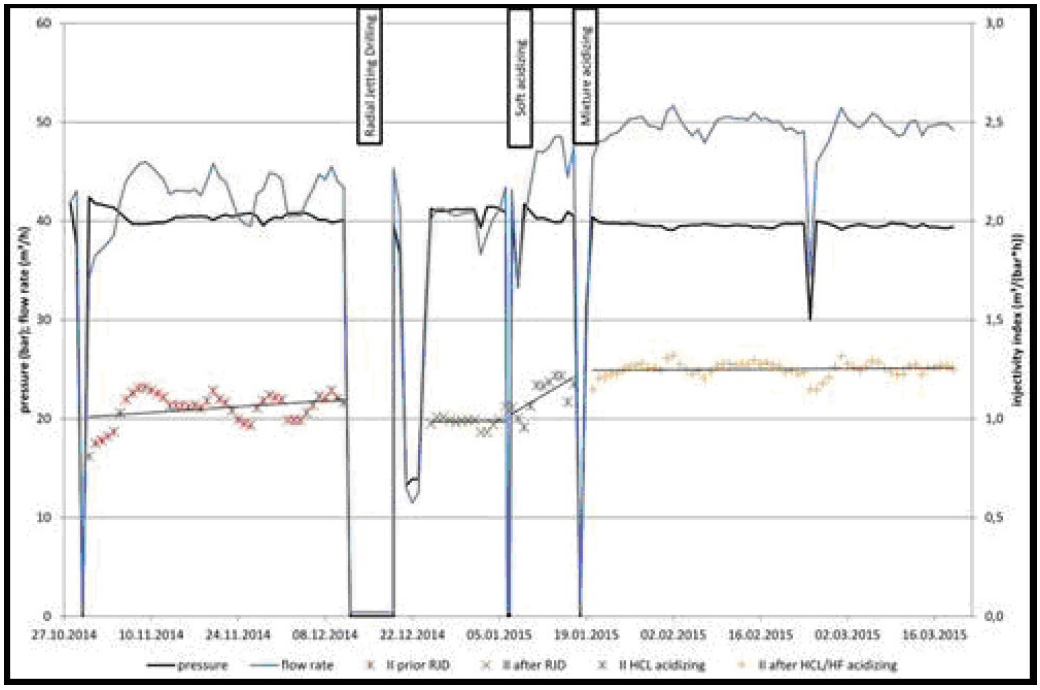

Figure 5: Production history (pressure (bar)-black, flow rate (m^3/h)-blue, and injectivity index (m3/bar*h)-dots) after jetting and two soft accidisation campaigns, well Klaipėda 1I

3. SHALLOW GEOTERMICS

The number of small-scale ground source heat pump systems in Lithuania is growing. There is a number of installations thanks to private enterprises as JSC Ekoklima, JSC "Naujos idejos", JSC "Tenko Baltic", JSC "EES", JSC "Vilpra", JSC "Ekokodas", JSC "Steltronika", JSC "Geoterminis sildymas", JSC "Ardega", JSC "Kauno hidrogeologija", JSC "Donasta", JSC "Airr", "VVS Montavimo grupe", *etc*. The total installed capacity is more than 100 MWt (Figure 6).

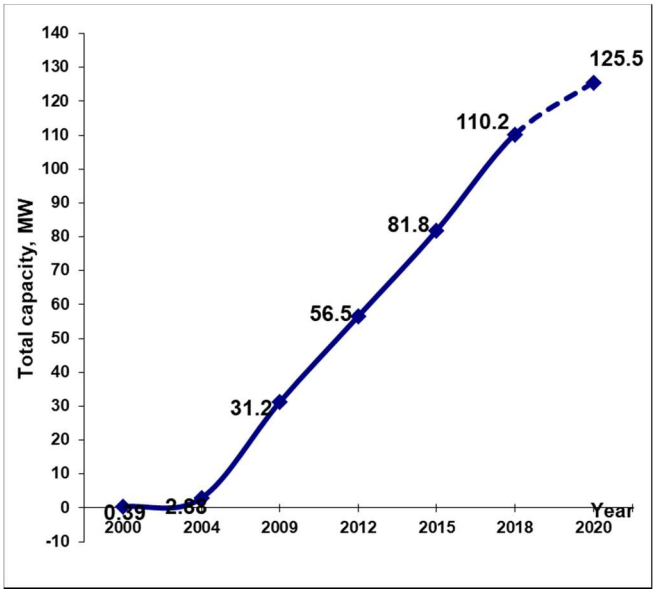

Figure 6: Total capacity of installed small-scale GSHP systems, years 2000-2018, and prognoses up to 2020

4. ALTERNATIVE APPLICATIONS OF THE GEOTHERMAL WATER

4.1 Geothermal balneology

There is a number of mineral water SPA centres in Lithuania exploiting 10-15°C mineral water. There is one Žybininakai SPA centre established in west Lithuania in 2015. It uses geothermal mineral water produced from reopened old oil exploration wells. It uses the Lower Devonian mineral water of 60 g/l salinity from as deep as 1 km.

The new imitative was taken in Palanga Town (Baltic Sea resort) in 2018. The establishment of the geothermal mineral water pool is planned. The mineral water of 33 g/l salinity will be exploited from the Šventoji-Upninkai (D_3-D_2) aquifer of the depth of 480-680 m. The water temperature is 20°C. The aquifer water will be used for only the pool system.

4.2 Geothermal fish farming

In Lithuania salt water recirculating aquaculture is still in its infancy, while it develops intensively in the world. As part of the EU South Baltic projects InnoAquaTech and Alliance, the first recirculating marine aquaculture system was established in 2018 in Klaipeda for shrimp cultivation. The eight tank, 40 m^3 system is designed to grow up to 400 kg of whiteleg shrimp. The task of this pilot RAS is to carry out shrimp growing tests and experiments, to aquire shrimp aquaculture knowledge and competences, to get expertise in marine recirculating aquacultre technology, and to transfer these competences to the aquaculture business.

5. LEGAL BASIS

The main new legal act is:
National Energy Independence Strategy of the Republic of Lithuania (approved by the Seimas of the Republic of Lithuania on 21 June 2018)

Executive summary - Energy for competitive Lithuania

Item 1.4.4.2. Lithuania is a centre of information technology and cyber security solutions for energy, biomass and biofuel technology, solar and wind energy technology, geothermal technology, energy market development, improvement of electricity system operation, development of new electricity system management methods and implementation of energy projects

Chapter VI. Research and development demand and development of country's business

Item 69. As a result of completed significant strategic energy projects, the successful design and development of individual energy branches, Lithuanian energy companies, business enterprises and science and study institutions have accumulated exclusive competences in the field of solar energy, biomass, geothermal energy, LNG and other areas, which need to be maintained, further developed and strengthened. It is necessary to achieve that research and development in Lithuania and the resulting products acquire industrial production and become part of Lithuanian exports, thus contributing to the country's economic growth. This requires focusing on priority research directions and, at the same time, ensuring the practical use of the results of these studies and of existing and advanced competences.

Item 71.1. Increasing synergies among science and study institutions, energy companies and engineering companies by promoting various forms of cooperation through the use of investments from the EU research and innovation program Horizon 2020, national and other programs, developing digital energy innovations and improving technologies in Lithuanian energy sector, thus strengthening the ecosystem of scientific research and innovation in Lithuania. The first geothermal fish farming experiment was performed in west Lithuania that shows high potential for development of the alternative application of the geothermal energy.

6. CONCLUSIONS

The only available district heating geothermal plant in Klaipėda was stopped in 2017. A change of the owner (possibly municipality) is expected. It is realized that serious modifications of the plant system is required to increase effectiveness (e.g. changing the natural gas to biofuel). By contrast to deep geothermal the number of the shallow geothermal installations I increasing. It shows very similar growth trend since 2004. There is a growing realization in the society that shallow geothermal energy is competitive and even have advantages compared to other energy sources.

REFERENCES

Kepezinskas, K., Rasteniene, V., Suveizdis, P.: The West Lithuanian Geothermal Anomaly, Monograpfy, Vilnius, Institute of Geology, 1996, 68 p.

Zinevicius, F., Rasteniene, V., and Bickus, A.: Geothermal Development in Lithuania, Proceedings of the European Geothermal Conference 2003, Szeged, Hungary, (2003), 1-9.

Zinevicius, F., and Sliaupa, S.: Lithuania - Geothermal Energy Country Update, Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, (2010), paper # 0153,1-8.

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

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2018	-	-	3404	4693	-	-
Under construction end of 2018	-	-	-	-	-	-
Total projected by 2020	-	-	-	-	-	-
Total expected by 2025	-	-	-	-	-	-
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2018 (indicate exploration/exploitation if applicable):					Under development:	
					Under investigation:	

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

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for buildings		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)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018	18.0	34.1	18	0	-	-	-	-
Under construction end 2018	-	-	-	-	-	-	7	10
Total projected by 2020	18.0	34.1	18	0	-	-	10	13
Total expected by 2025	18.0	34.1	18	18	-	-	13	16

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GW_{th}/y)	Geoth. share in total prod. (%)
Klaipėda	Klaipėda geothermal plant	2000	0.06	-	18.0	34.1	0	100
total								

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018	8729	110.2	255			
Projected total by 2020	9964	125.5	290			

Table F: Investment and Employment in geothermal energy

No information available

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	-	-	-
Financial Incentives – Investment	-	-	-
Financial Incentives – Operation/Production	-	-	-
Information activities – promotion for the public	Yes	Yes	Yes
Information activities – geological information	Yes	Yes	Yes
Education/Training – Academic	No	No	Yes
Education/Training – Vocational	No	No	Ph.D. programs

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)