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UTILIZATION POSSIBILITIES OF GEOTHERMAL ENERGY IN LITHUANIA

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ABSTRACT

The results of the study on the possibilities of geothermal power in West Lithuania are presented.Three approaches to supplying thermal power to a settlement were studied a) no heat pump, extended heating surfaces in individual houses, b) a heat pump in each individual house, c) a central heat pump power plant for the settlement.

It was concluded that heat carriers of low potential heat can be applied in standard houses of the Construction Plant in Alytus (panel walls and floors) only after improving the thermal insulation of the houses.

The project of a central heat pump power plant requires minor reconstruction of the houses.It is more expensive than approuch a), but cheaper than approach b).

The settlement Venckai can consume just 1/10 of the power of such thermal plant.Consequently, a project for the township Priekulė should be considered.

1. INTRODUCTION

Lithuania has also a considerable resource of geothermal energy (Suveizdis and Rastenienė, 1993) Fig. 1. The most promising region is in West Lithuania, the heat flux reaches there 90 mW/m^2, compare to 46 mW/m^2 in the surrounding areas of European Russia, Scandinavia, Poland.Lithuania has also some advantages for its exploitation.

The distribution of geothermal energy in West Lithuania and to some extent in Central Lithuania is related to four horizons: Upper/Middle Devonian

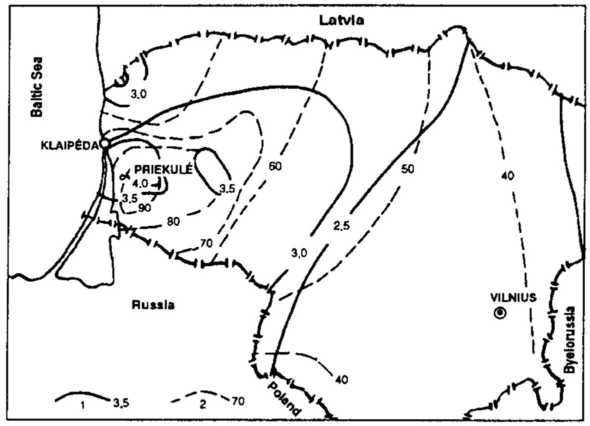

Fig.1. Change of geothermal gradient and density of heat flux in Lithuania: 1 - geothrmal gradient isolines (°C/100 m), 2 - heat flux density isolines (mW/m^2).

(Šventoji-Upninkai layer), Middle/Lower Devonian (Parnu-Kemeri layer in the Gargždai series), Cambrian and crystalline basement rocks.The three former are hydrogeothermal complexes, the last is petrogeothermal.

In the optimal area of the West Lithuanian Geothermal Field (anomaly), several cities and towns (Klaipėda, Palanga, Kretinga, Plungė, Gargždai, Nida, Šilutė and Šilalė) and numerous settlements are situated. They are potential consumers of the Earth's thermal energy.

All projects of geothermal circulation systems in West Lithuania are adapted to the Devonian and Cambrian hydrogeothermal complexes at 2 to 4 km depths, where temperature reaches 120 to 140 °C.

Lower flowrates are expected in the Cambrian layers, up to 100 m³/h of highly mineral water of 150 to 200 g/l, with insignificant effects on corrosion.

2. EXPLORATION

Geothermal power sites may be indentified through the exsisting wells of mineral oil exploration. We consider as an example a prospective site in Venckai near Priekulė.

See in Fig.2. that the Venckai settlement is only 200 m away from the "Vilkyčiai 3" well. The initial parameters of the geothermal water are: flowrate 100 m³/h, temperature 43 °C, salt contents 60 g/l.

The "Vilkyčiai 5" well could be used as a return duct for the cool water. "Vilkyčiai 3" and "Vilkyčiai 5" are 2.5 km spaced.

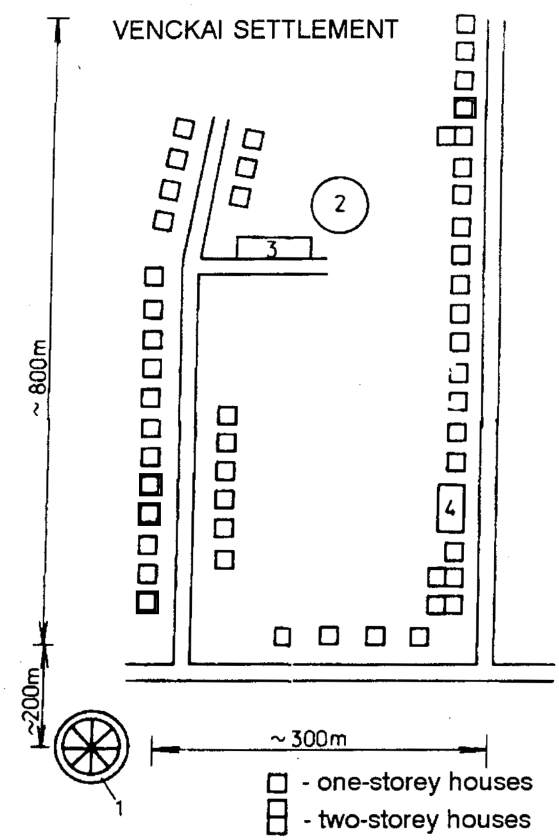

Fig.2. A schematic representation of the Venskai township.

We consider three possible variations of the overground technology:

1) no heat pumps, extended surfaces of the domestic heating appliences, Fig.3.,

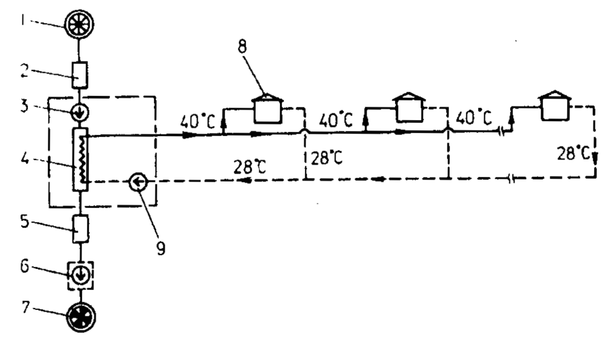

Fig.3. 1 - supply well with a submerged pump and a motor, 2 - accumulation tank, 3 - circulation pump, 4 - heat exchanger, 5 - accumulation tank, 6 - return pump, 7 - return well, 8 - dwelling house, 9 - circulation pump.

2) heat pumps in eatch individual house, Fig.4.,

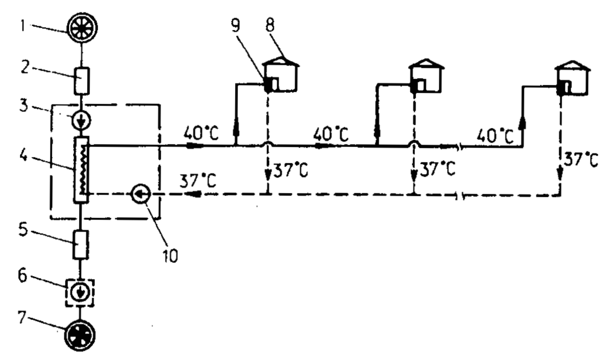

Fig.4. 1-8 - as in Fig.3., 9 - heat pump, 10 - circulation pump.

3) a plant of heat pumps serving the whole settlement, Fig.5.

The three technologies were compared and optimal solution was found for three integral parts of the technology:
1) domestic appliences,
2) distribution pipelines and central power plant,
3) geothermal water loop, see Fig.3-5 items 1-7.
The reference for the solutions was the heat demand of the living settlement.

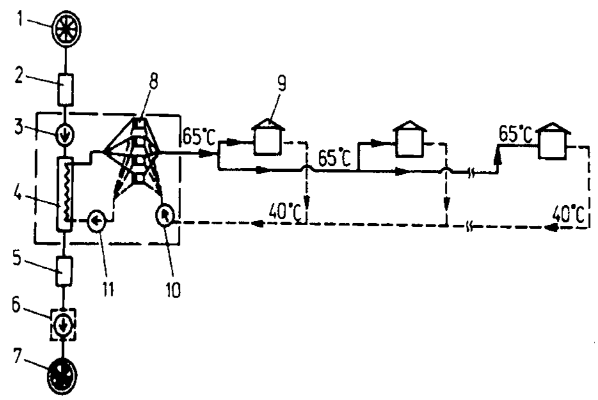

Fig.5. 1-7 - as in Fig.3., 8 - heat pump, 9 - dwelling house, 10 and 11 circulation pumps.

3. RESULTS AND DISCUSSION

DOMESTIC APPLIENCES.The demand of heat in standard houses of the Alytus Construction Plant ranges from 20 to 25 kW including hot water and depends on the size.Hot water excluded, the demand becomes 12.5 to 17.7 kW.Distribution of the heat loss in such houses and the project power saving rates are shown in Fig. 6., where dark areas and white areas stand for heat loss and heat saving, respectively.

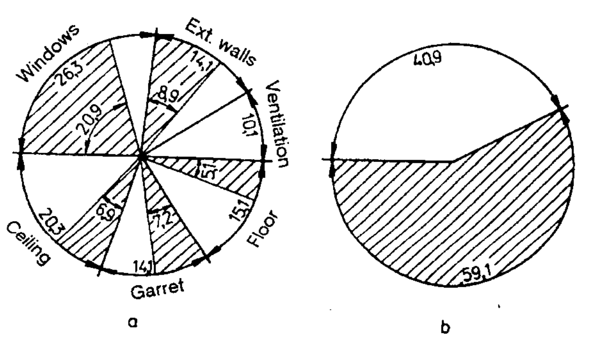

Fig.6. Annual energy balance: a) the present heat loss of 214 kWh/m² or 12.6 kW, for the standard of 121 kWh/m² or 7.1 kW, b) overall potential saving of heat.

We use the further values of 15 kW for the present conditions and of 7.5 kW for renovated houses with improved thermal insulation.

HEATING APPLIENCES.The choice of heating appliences is based on the following parameters of the heat carrier in the existing central heating system (CIBSE, 1986):

- supply temperature 95 °C, return temperature 70 °C $\Delta t = 25$ °C
- average potential of 65 °C and 50 °C $\Delta t = 15$ °C
- low potential of 45 °C and 35 °C $\Delta t = 10$ °C
- very low potential of 35 °C and 30 °C $\Delta t = 5$ °C
- of 30 °C and 26.5 °C $\Delta t = 3.5$ °C

Heating applainces to be considered: radiators, two-side heating panels in internal walls, one-side heating panels in external walls, two-side heating panels in the ceiling and intermediate floor.

Heat transfer was calculated from 100 mm thick two-side heating panels in internal walls Fig. 7a, from one-side heating panels in external walls Fig. 7b, from both one-side and two-side heating panels in the horizontal coverings by an analogy to the upright panels with proper corrections, here - the panels are of concrete, the tubes are 200 mm spaced, panel thickness 100 mm, external diameters of the tubes 15.7 and 21.2 mm , Fig. 7c.

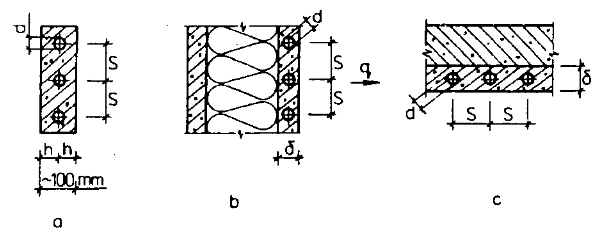

Fig.7. Panels.

Table 1 presents predicted heat transfer per 1 m² of the heating surface for 18 °C inside temperature. Note, the higher efficiencies of the two-side heating panels in walls and of the radiators.The one-side panels in walls are less efficient.The lowest efficiency was of the horizontal panels in ceilings and floors.

Different diameters of the tubes in the panels, 15 mm and 20 mm, have little effects.They extend the heated area by 3 to 7%. A similar extension by 3 to 5 % may be achieved by polyethylene tubes.

The following heating areas can be mounted in the standard houses of the Alytus Construction Plant:

- two-side panels in the walls -15 m²,
- one-side panels in external walls of lager houses - 20 to 30 m²,
- two-side panels in horizontal coverings of lager

Table 1. Heat flux density (W/m^2) of the heating surface

Applience	Temperature of heat carrier (°C) 95/70	65/50	45/35	35/30	30/26.5
Two-side panels in external walls					
ϕ15	864.5	490	230.5	147.5	90.25
ϕ20	906.0	510	239.0	151.0	93.0
One-side panel					
ϕ15	312.8	181.4	89.4	50.0	27.6
ϕ20	337.3	195.6	96.4	53.8	29.8
Two-side panel in horizontal parts					
ϕ15	131.4	76.2	37.6	21.0	11.6
ϕ20	136.2	78.8	38.9	21.7	12.0
One-side panel in the floor					
ϕ15	52.0	30.2	15.0	8.4	4.6
ϕ20	54.6	31.8	15.8	8.8	4.8
Radiator	728.4	385	189.2	117.1	79.6

Note: 1. Heat flux from radiator panels is given for 15 mm and 20 mm diameter tubes.
2. The tubes are 200 mm spaced in the panels.

houses - 20 to 30 m^2,
- one-side panels of the ground floor - 30 to 45 m^2.

Meeting the demand of heat by such heating panels is shown in Table 2.

Consequently all possible innovations with low potential heat carriers meet only 30% of the maximum demand for heat.This corresponds to plus 5.7 °C outside temperature, which is just a bit lower than in the early heating season, or 58% of the demand for a house with auxilliary insulation up to the outside temperature of minus 5.6 °C.

With a 35/30 °C heat carrier at most 47.4% of the present demand for heat can be met, up till minus 1.4 °C outside temperature, or 95% of the demand for a house with auxilliary insulation up till minus 21 °C outside temperature.

The 45/35 °C heat carrier can meet all the demand for heat of an insulated house, but only 79% of the non-renovated house, up till minus 14.3 °C outside temperature.

A free choice of heating appliences can be made with a 65/50 °C heat carrier.

MEETING THE DEMAND AND VARIABLE OUTSIDE CONDITIONS.A 45/35 °C heat carrier can meet the heat demand over the whole heating season, Fig. 8., but with just 8.4 °C inside temperature for minus 24 °C outside temperature.The period with inside temperature below 18 °C include 100 h per heating season.35/30 °C heat carrier can maintain inside temperature at 18 °C for 3200 h, about 70% of the heating season.A heat carrier of the lowest potential covers only 730 h, which is by no means sufficient.With a new insulation, Fig. 9., a 30/26.5 °C heat carrier can maintain 18 °C inside temperature for 3800 h, or for 82% of the heating season.A 35/30 °C heat carrier can maintain 18 °C inside for 4600 h.This means about 50 h of a lower inside temperature during heating the season, and just plus 15 °C in the coldest days.

THE HEAT PIPELINE.For Technology 1, the supply water arrives from the heat exchanger at 40 °C and returns at 28 °C.The water is heated by geothermal source at a fast heat exchanger of the circulation loop that supplies heat for the whole settlement

Table 2. Heat flux density from heating appliences (kW)

Applience	Temperature of heat carrier (°C) 95/70	65/50	45/35	35/30	30/26.5
Two-side panel in the wall	13.0	7.35	3.46	2.21	1.35
One-side panel in the wall	6.3-9.4	3.6-5.4	1.8-2.7	1.0-1.5	0.55-0.83
Two-side panel in the covering	2.6-3.9	1.5-2.3	0.75-1.13	0.42-0.63	0.23-0.35
One-side panel in the floor	1.5-2.3	0.91-1.36	0.45-0.68	0.25-0.38	0.14-0.21
Radiators for the given area	15.0	7.93	3.90	2.41	1.64
		21.3-24.4	10.35-11.9	6.3-7.1	3.9-4.4

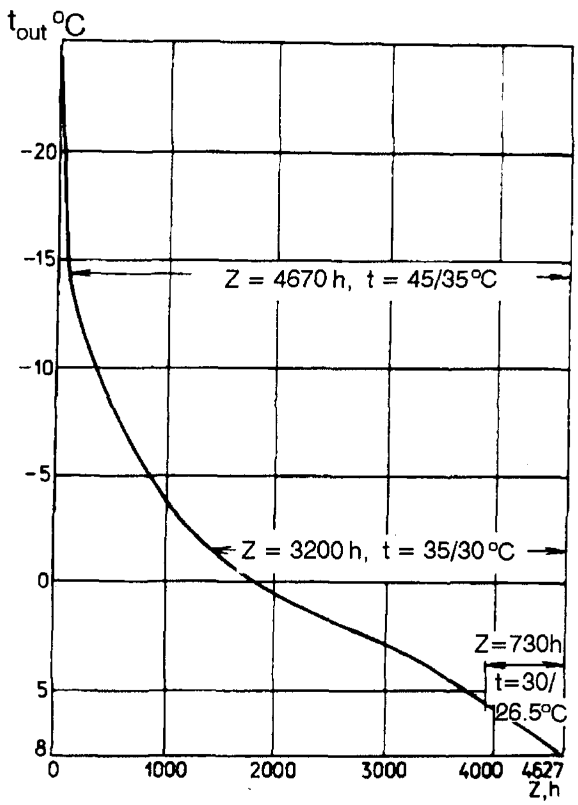

Fig. 8. Meeting the heat demand over the heating period by a low-potential heat carrier in a non-renovated house.

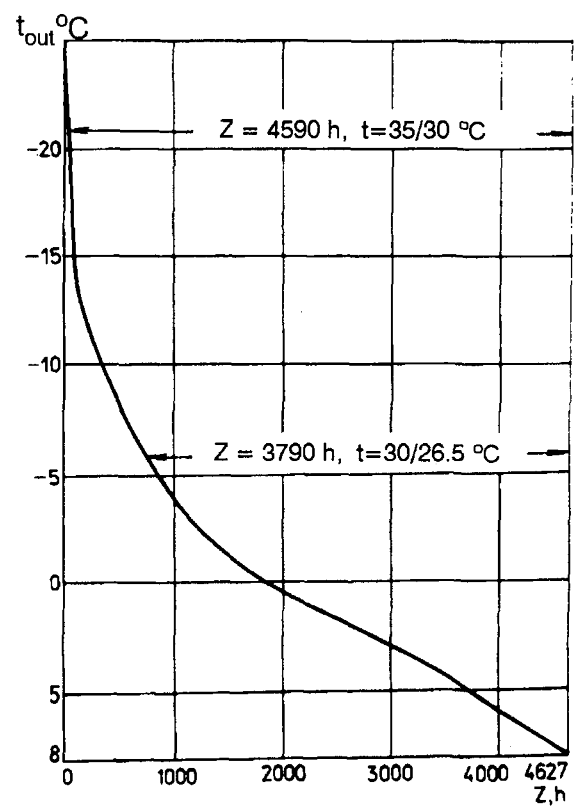

Fig. 9. Meeting the heat demand over the heating period by a low-potential heat carrier in house with a new insulation.

by circulation pumps.The loop is refilled by pumps of lower power (Gedgaudas et al., 1992).

For Technology 2 past the heat exchanger the circulation water is supplied at 40 °C and returns at 37 °C.Heat pumps are mounted in the individual houses and maintain the supply water for the domestic appliences at 65 °C.

For Technology 3 hot water past the central power plant is of 65 °C and returns at 40 °C.Heat pumps at the central power plant serves the whole settlement.For details of the three technologies see Table 3.

Table 4 presents the units of the central power plant where T_s and T_r are supply and return temperatures, respectively, W - flow rate in the pipeline, Q - amount of heat supplied.

CHOICE OF CIRCULATION PUMPS.For Technology 1 K-65-50-160 circulation pump applies.Its nominal power is 25 m^3/h, pressure - 3.2 Bar, power of motor 5.5 kW.For Technology 2 use the K-100-

Table 3. Variation of pipelines

Technology	Pipelines (m)									
	D_s150	D_s125	D_s100	D_s80	D_s65	D_s50	D_s40	D_s32	D_s25	Σ
1	-	20	320	1180	1040	530	160	310	1130	4690
2	20	1130	1060	430	610	250	140	1050	-	4690
3	-	-	-	20	2110	590	450	80	1440	4690

Table 4. Parameters of central power plant

Technology	Flow parameters			
	T_s/T_r	Δt, °C	W, m³/h	Q, kW
1	40/28	12	28.5	397.5
2	40/37	3	76.0	265.1
3	65/40	25	13.67	397.5

80-160 circulation pump.Its nominal power is 100 m³/h, pressure - 3.2 Bar, power of the motor 15 kW.For Technology 3 apply the K-50-32-12 circulation pump.Its nominal power is 12.5 m³/h, pressure - 20 Bar, power of the motor 2.2 kW.This technology of heat exchanger - heat pump includes circulation pump K-100-80-160.Its nominal power 100 m³/h, pressure - 3.2 Bar, power of the motor 15 kW.

CHOISE OF HEAT PUMPS.For Technology 2, heat pumps of 7.5 to 15 kW are installed in each house.They must heat the water to 65 °C by their 5 kW power.

For Technology 3 four heat pumps are installed in the central power plant, one of them HT-80-1-1 stands by.The pumps operate on 30 m³/h flowrates of low temperature heat carriers.One heat pump produces 130 kW of heat and consumes 40 kW of power.

GEOTHERMAL WATER LOOP.Geothermal water is exhausted by a 300 m deep submerged pump.Its paramerters power 100 m³/h, pressure - 40 Bar, motor power 200 kW.The water is accumulated in tank of 2000 m³ and deaerated. The water is supplied from the tank by a stainless-steel pump into a heat exchanger. The cool water is again accumulated in a 2000 m³ tank and pumped along the return well into the Devonian layer. The loop is a standard component of arbitrary technologies, and is therefore eliminated from all comparisons of technologies.

The price of 1993 of a heat pump for an individual house was 20000 Lt, that of HT-80-1-1 pump - 30000 Lt. In the reference technology without the geothermal water loop relative investments are 1, 9.94, 3.05. This makes Technologies 1 and 3 optimal ones, Fig.10.

The present study was an integral part of a complex program of research. Town Venckai is able of consuming just 1/10 of the flow of the "Vilkyčiai 3" well, evaluated by an earlier technique (Shulz et al., 1992), with the return temperature of 10 °C. The larger part of the heat is to be supplied to Priekulė 5 km away, a township of 2000 inhibitants.Here the demand of heat for flats and other houses is about 3.8 MW and the "Vilkyčiai 3" well could contribute significant to the energy balance of Priekulė.

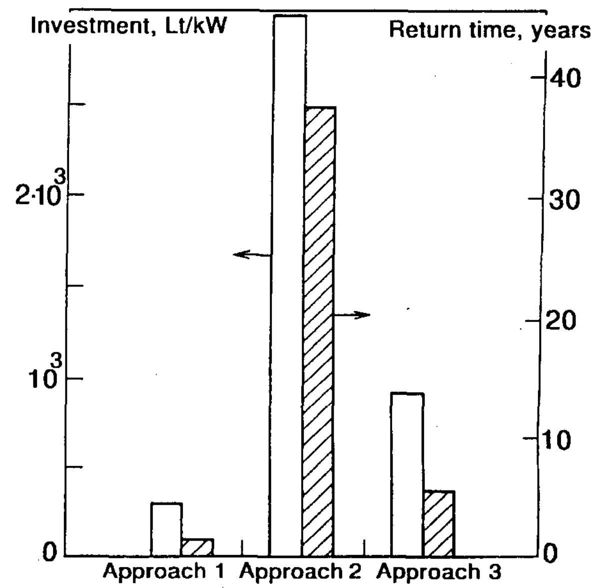

Fig. 10. Three approaches of supplying thermal power to a settlement Venckai

CONCLUSIONS

1. Low potential geothermal water can be reasonably applied in low temperature heating systems of heating panels in walls, ceilings and floors, as well as to heat the ground in green-houses.

2. The potential of the geothermal source can only be used in winter after improving thermal insulation of the houses.

3. The project of a central heat-pump power plant requires minor reconstructions of the houses, channels and pipes of the distribution network are cheapest.

4. The settlement Venskai can consume just 1/10 of the power of such thermal plant, the largest part of this power must be used to heat in Priekulė.

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