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4.4. PROFITABILITY OF GEOTHERMAL ENERGY USE IN LOCALITIES OF VARIOUS POPULATION

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Abstract

Costs and basic economic results that can be achieved by a geothermal station supplying heat to localities of various population in average hydrogeological conditions, are presented in the paper. It was concluded that geothermal investments are profitable for towns from 20,000 of population, when a 4-year income is at a disposal. Under certain conditions such investments may be profitable for 15,000-population towns.

1. ENERGY COSTS DEPENDING ON THE QUANTITY OF HEAT RECEPTION

Non-emission geothermal energy is a very interesting source of heat for those who are care about environmental protection. Those, for whom the profitability of heat stations is the main criterion, take the exploitation costs of heating utilities. Experience gathered during many years at the geothermal station in Pyrzyce enables one to objectively judge whether or not it is possible for the heat of the earth to be attractive to both the above-mentioned groups. The cost analysis was made under the following assumptions, and the results are presented below:

- geothermal deposit provides 150 m^3/h water at temperature 60ºC at the inlet to the heat exchangers;
- Nº of the citizens that are supplied with heat and warm useful water from a geothermal station;
- supply capacity for warm useful water constitutes 20% of peak capacity; the highest capacity for a temperature of –16ºC constitutes 250% of average annual capacity of the heat station;
- heat losses in the pipeline 9%;
- boilers average capacity 82% annually;
- market heat net price 50 PLN/GJ
- amortization and capital costs are proportionate
- to the Pyrzyce ones;
- operating costs are stable; they are element of peak power in places of assumed population to the highest assumed power in Pyrzyce ratio, 20 MW;
- temperature of supplied and received network water are like in Pyrzyce (Fig. 1);
- investments for four-year amortization of assets and four year profits (minus 19% tax).

The temperature of injected groundwater is very important. The geothermal heat capacity is conditioned by the flow rate and the temperature gradient of produced and injected thermal waters. Prior to injection, water is cooled in the heat exchanger, where geothermal energy is passed to the network water, returning from the customer. Thus, chilled thermal water may reach temperature of the returning network water and cannot be cooler. Thus, the thermal water gradient (_T) is conditioned by wellhead temperature and also temperature to which network water can be cooled by the customer.

Additionally, water temperature is decreased by a heating pump, operational only in the heating period (provided the heating station has been appropriately configured) (Fig. 5.).

Network water is cooled by customers by an approximately constant value (heating pump too), therefore _T of thermal water changes. At low temperatures, when citizens need warmer water supplies, the value is lower, at higher – it is bigger, to additionally lower in summer when the pumps are off. This situation has been presented in Fig. 1.

These costs are high, because of the corrosion fighting costs. If the pipelines were free of corrosion, the costs of the heating station would be even a dozen percent lower. The obtained results have been presented in Fig. 2.

Hence a conclusion that in the assumed conditions, the heat station can profit in a 20,000 citizen-city. 8.3 mln PLN for investments covers a four-year cash flow. This money has to be used for covering the cost of a geothermal station equipped with a doublet, heat pump and a heat exchanger. Such an undertaking is unrealistic, because a pair of wells drilled to a depth of about 1600 m (60oC) on the surface would cost about 5 mln PLN, a heat

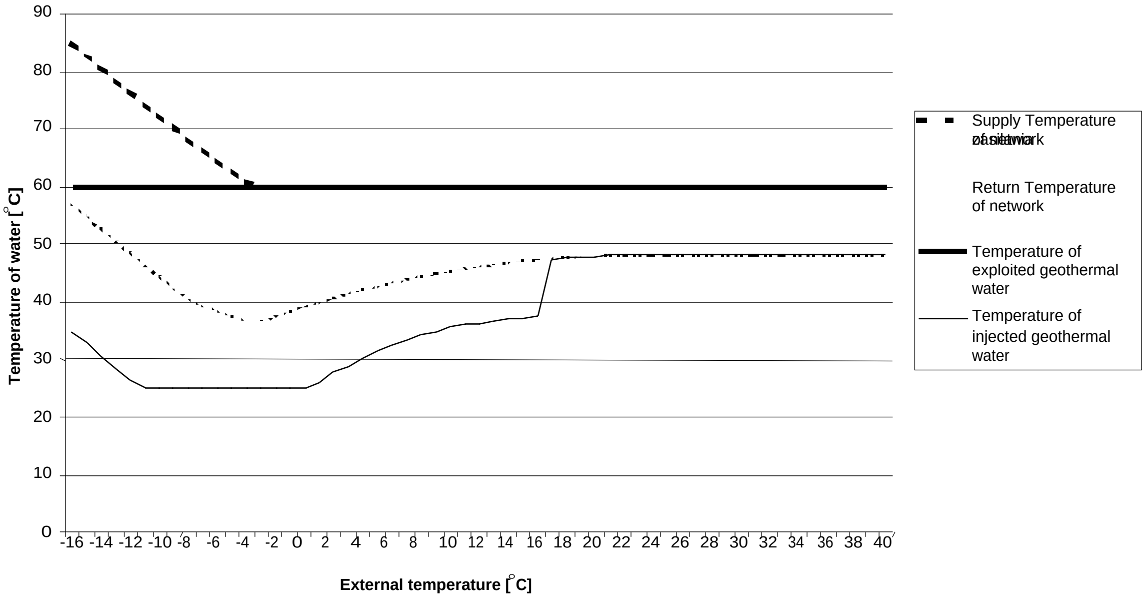
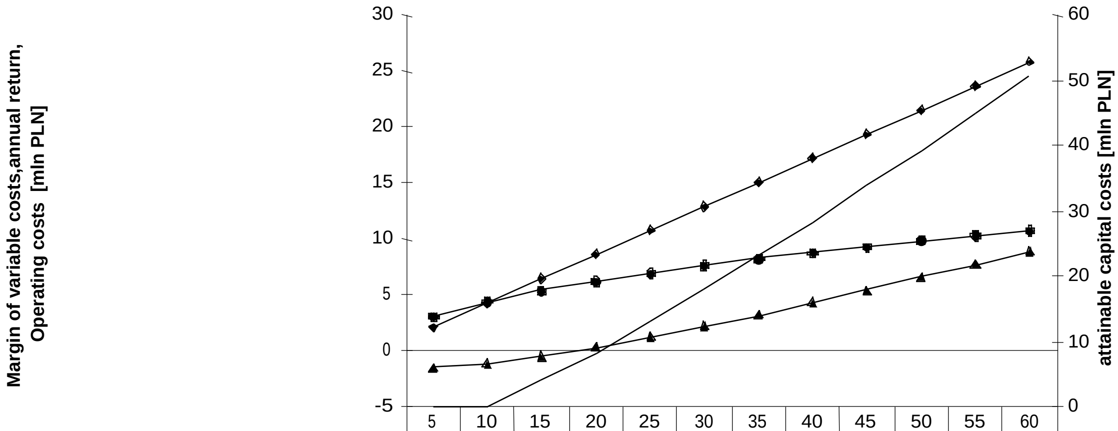


Fig. 1. Temperature of network and thermal waters, for various external temperatures.



	5	10	15	20	25	30	35	40	45	50	55	60
Margin of variable costs [mln PLN]	2,2	4,3	6,5	8,6	10,8	12,9	15,1	17,2	19,4	21,5	23,7	25,8
Annual return [mln PLN]	-1,5	-1,1	-0,5	0,3	1,2	2,2	3,3	4,3	5,4	6,6	7,7	8,9
Operating costs [mln PLN]	3,1	4,4	5,4	6,2	7,0	7,6	8,2	8,8	9,3	9,9	10,3	10,8
Attainable capital costs [mln PLN] for geothermal heat plant supplied by aquifer of 60°C and 150 m3/h of flow rate	0,0	0,0	3,9	8,3	13,0	18,0	23,2	28,4	33,8	39,3	44,9	50,5

Number of inhabitants in localities supplied with heat in thousands

Fig. 2 Expected economic results for geothermal heat stations supplying places of various population

2. ENERGY COSTS DEPENDING ON HEAT STATION CONFIGURATION

Limiting sources of geothermal heat would result in only partial use of its advantages. This has been illustrated in Fig. 3.

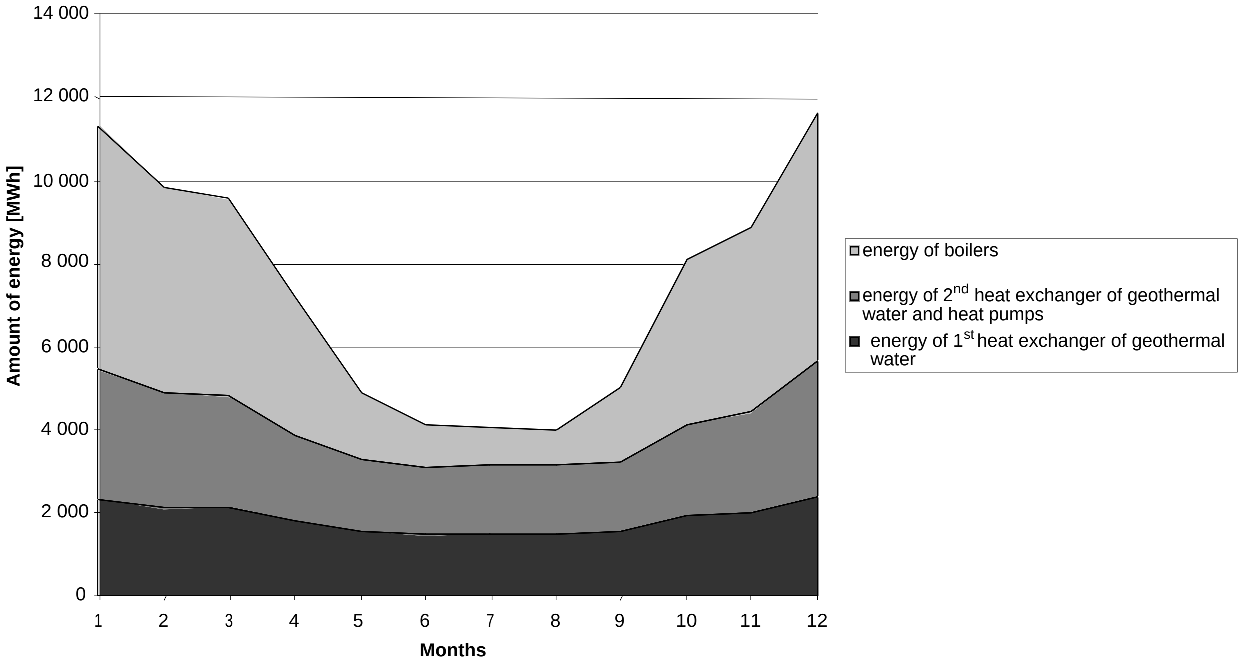


Fig. 3 Use of specific energy sources in a city of 20,000 population with a doublet (150 m^3/h) producing thermal water at 60ºC on surface.

The situation changes radically if it were possible to obtain a yield of 350 m^3/h of thermal intake in the same conditions. This case has been illustrated in Fig. 4.

Then the four-year cash flow of a heat station in a 20,000-population city would increase by 10 mln PLN. Owing to this, the investment costs of the geothermal station could be covered mainly from the increased income and profits.

In such conditions (yield on intake 350 m^3/h), a town of only 15,000-population can have a geothermal heat station. Only one doublet would suffice. It should be slightly improved (non-filter wells or a directional absorptive well with a longer working section of skew or horizontal non-filter working section injecting to, e.g. a higher aquifer). The investment costs would pay back in five years.

Adjustments should be made to enable the citizens receive network water at 85ºC in winter, at –16ºC outside. Building should be covered with warming layers and equipped with larger heaters, which is not a problem nowadays.

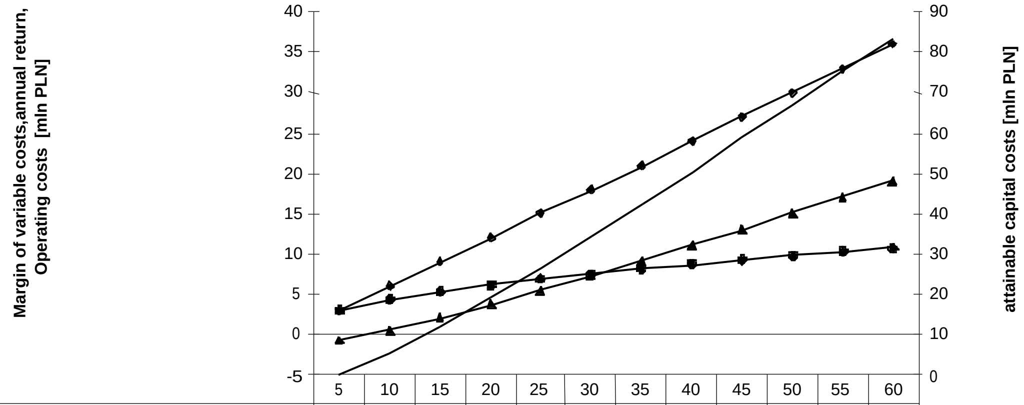
The use of energy sources in the above-described situation in a 20,000-population town has been presented in Fig. 4.

Geothermal could be used and enjoyed to the full then. It would not be necessary to use peak boilers almost at all, and geothermal could find new applications. The increased yield of the intake would improve the conditions of geothermal heat reception by bigger towns. Unit investments are in this way reduced, and the dividend can be given to the proprietors of the station when the credits are being paid back.

Geothermal heat stations use much less gas and electrical energy than classical boiler rooms, especially when the yield of the intake is adjusted to the demand for heat energy. This situation has been presented in Fig. 5. The yield of the intake in a 15,000-population town will be 350 m3/h, whereas in a 60 000-population city up to 1250 m3/h. This means that some intakes have to be made in various spots of the city. The expected profits would cover the costs (Fig. 6). Therefore, the higher the yield of the intake and the greater the customer, the bigger funds can be engaged.

Technical advancement thermal intake construction, aiming at increasing the yield, will enable such enterprises in smaller towns. Owing to this, gas and coal consumption will be reduced and emissions minimized. Electrical energy consumption will increase. It will be used for the transportation of thermal water, generally doubling the electrical energy consumption for heat production. In this way a lot of Polish coal electrical power plants would still be operational, especially in the times when they are inevitably going to lose their significance. This is caused by decentralization of electrical energy supplies – presently heat and electrical energy tend to be produced in joined electrical power-and-heat plants.

Thus, the use of thermal waters belongs to the investors and society. Being a potential source of great income, geothermal should attract investors to risk their money on it. Social benefit in mind, the State should promote such enterprises and help implement them.

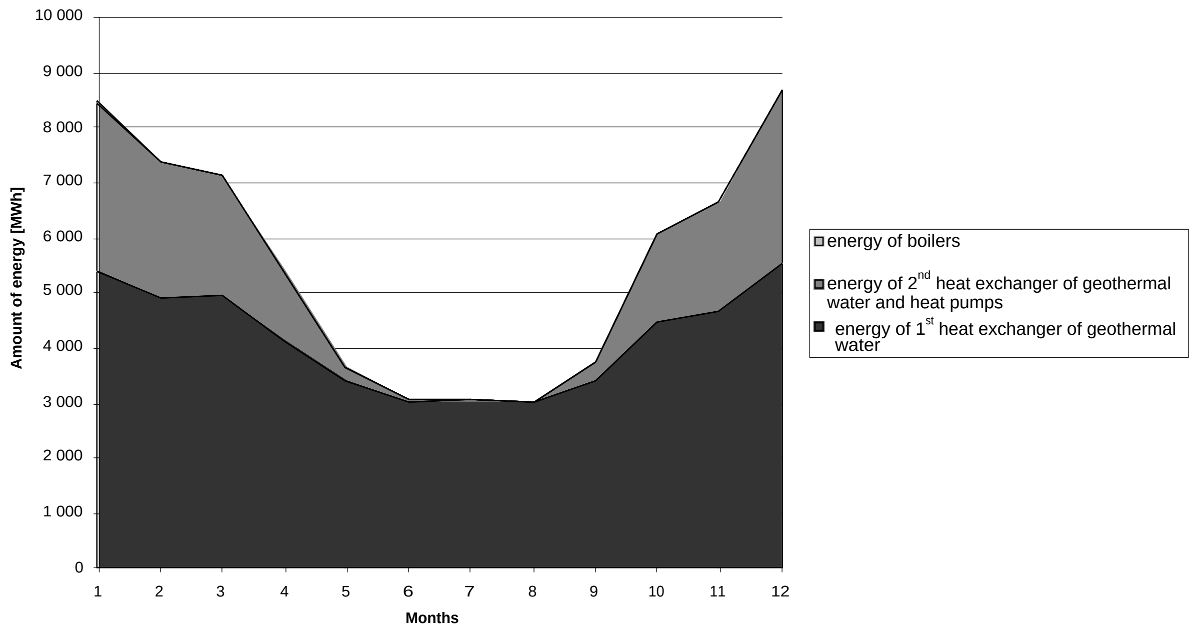


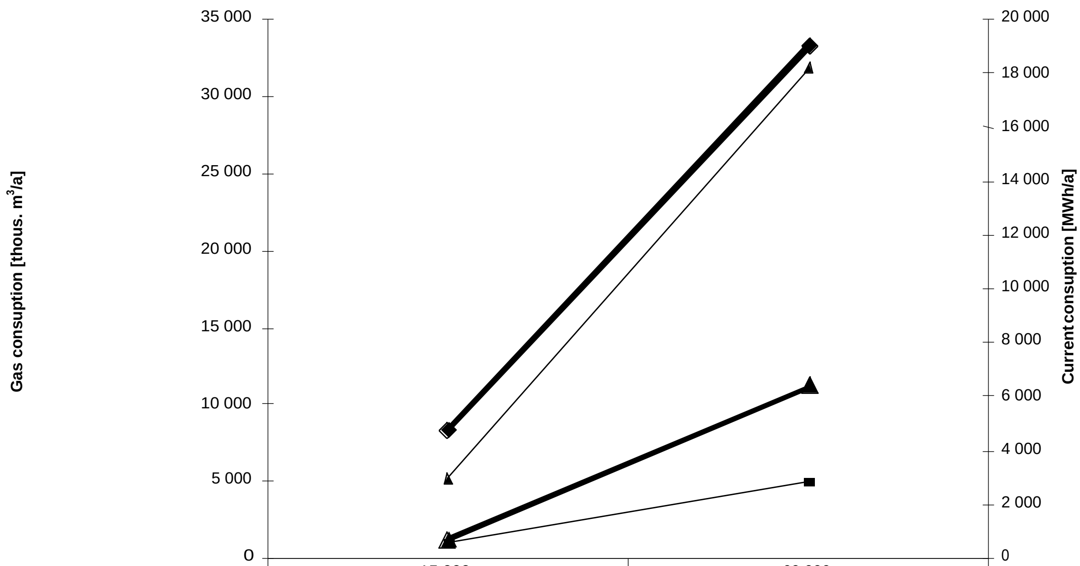
	5	10	15	20	25	30	35	40	45	50	55	60
Margin of variable costs [mln PLN]	3,0	6,0	9,0	12,0	15,0	18,0	21,0	24,0	27,0	30,0	33,0	36,0
Annual return [mln PLN]	-0,6	0,6	2,1	3,7	5,5	7,3	9,2	11,1	13,1	15,1	17,1	19,1
Operating costs [mln PLN]	3,1	4,4	5,4	6,2	7,0	7,6	8,2	8,8	9,3	9,9	10,3	10,8
Attainable capital costs [mln PLN] for geothermal heat plant supplied by aquifer of 60°C and 350 m3/h of flow rate	0,0	5,5	12,2	19,4	26,9	34,6	42,5	50,5	58,7	66,9	75,3	83,7

Number of inhabitants in localities supplied with heat in thousands

Fig. 4. Expected economic results of a heat station supplying energy to various size towns, at a higher yield of thermal water intakes

Fig. 5. Use of individual energy sources in a 20,000-population town with a thermal intake (350 m^3/h) receiving network water at 85ºC at –16ºC outside.





	15 000	60 000
Gas consuption in geothermal heat plants in thousands of m^3/a	1 002	4 934
Gas consuption in conventional heat plants in thousands of m^3/a	8 333	33 332
Current consuption in geothermal heat plants in MWh/a	2 946	18 197
Current consuption in conventional heat plants in MWh/a	683	6 385

Number of inhabitants

Fig. 6. Gas and electrical energy consumption in heat stations supplying towns of various size