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GEOTHERMAL UTILIZATION POTENTIAL IN POLAND – THE TOWN OF PODDĘBICE

Part 2. Selected energetic aspects of current and future geothermal district heating in Poddębice

ABSTRACT

The paper presents main energetic aspects of current geothermal district heating system in Poddębice, Poland, and its planned development in an optimal way from an energy and economic points of views (reservoir and production aspects are presented in Part 1). These topics, as part of pre-feasibility study, were elaborated in the framework of the EEA Project "Geothermal utilization potential in Poland – the town of Poddębice". That town has both prospective resources and ambitious plans of further geothermal uses' deployment for space heating and for wide range of other applications. They will contribute to low-emission heating, improvement the leaving conditions and modern local economy. Poddębice create a good study case for other localities in Poland which have geothermal resources. The paper gives in insight into the analyses, outcomes and recommendations that resulted from common works on Icelandic and Polish partners involved in the Project. Reservoir and production aspects are presented in Part 1 of this paper. The material presented in Part 2 is the result of the original work of the authors and includes only one citation of the literature. Most literary references were cited in part 1 accordingly.

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KEYWORDS

Geothermal energy, district heating, efficient energy uses, peak load, Poddębice, Poland, EEA, NFM funds

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INTRODUCTION

The paper presents selected issues elaborated in the framework of the “Geothermal utilization potential in Poland – the town of Poddębice” Project under the Fund for bilateral relations, Operational Programme PL04 “Energy savings and promoting RES” (European Economic Area and Norwegian Financial Mechanism 2009–2014 in Poland) (www.eeagrants.agh.edu.pl). It deals with energetic aspects of current geothermal district heating system and its planned extensions (along with several other uses), while Part 1 (this volume) addresses main reservoir and long-term stable geothermal water production aspects.

The paper gives in insight into the analyses, outcomes and recommendations that resulted from common works on Icelandic and Polish partners involved in the Project.

More information on the EEA Project itself is given in Part 1 of this paper.

1. GEOTHERMAL DISTRICT HEATING IN PODDĘBICE – GENERALS

The geothermal district heating in Poddębice has been in operation for close to 5 years, using geothermal water from production well Poddebice GT-2, which was drilled in 2010.

The current capacity of the heating system is around 4–5 MW_{th}, with an additional peak load boiler capacity of around 2 MW_{th}. The future plans of the Geotermia Poddębice Ltd. are to expand the system to all of Poddębice, with a total estimated peak load of 18 MW_{th}.

Below is a summary of the main findings regarding the surface installations of the Geotermia Poddębice Ltd. (geothermal well pump, heat exchanger station, distribution system, peak load installations and heat demand), both the current system and an outlook for future expansion. The information presented in this paper is partly from documented data and partly from verbal communication in work meetings. A data log, spanning around 4 years is used to evaluate the performance of the system. It contains the daily average values of flow, temperature and pressure in various points of the system, both on the geothermal and the distribution side. The paper concludes with a summary of best practices recommended for the implementation of the district heating system in Poddębice.

1.1. Geothermal production well Poddębice GT-2

The well has been in operation since 2013, when the Geothermal Heat Central was put into operation. The current production rate (2016–2017) is 190 m^3/h during winter peak load. Static well head pressure is around 2 bar (20 meters above ground level) while the water level is 36 m below the well head during the maximum flow. This gives a total dynamic drawdown of 56 meters during 190 m^3/h flow.

A 110 kW downhole pump is installed at a depth of 90 meters below the ground.

The pump has so far been operated at around 50% capacity at max. flow, so it can easily deliver a higher flow rate for the proposed increase from 190 to ca. 250–260 m^3/h, which is the planned increase in the near future. Also, no long term drawdown of water in the reservoir has so far been observed, so there appears to be no need for water re-injection to the reservoir for now. This may, however, become necessary if the flow rate is increased further to over 500 m^3/h in the future expansion of the system to 18 MW_{th}, if most of the energy comes from geothermal fluid.

From data logs at the heat central, the water level in the last 2 years (Sept. 2014–Sept. 2016) has been measured, either as water pressure when well is artesian (low flow rate) and as water depth over pump when water level is below ground surface.

2. HEATING CENTRAL AND PROPOSED PEAK LOAD INSTALLATION

The Geothermal Heat Central is equipped with 2 heat exchangers (2 x 5 MW_{th} capacity) and 3 circulation pumps. It has been in operation since 2012 and is shown in Fig. 1.

The supply temperature to the distribution system is approx. 60–65°C and the flow rate is 220 m^3/h during peak load. The Heat Central station is very neat and well built, with adequate thermal insulation on piping and heat exchangers. Return geothermal water from heat exchangers (approx. 47–52°C, see Fig. 4 in Part 1) is partly used in the nearby swimming pool but most of it is discharged to a large cooling pond beside the station, where it is cooled down to around 35°C, before it is released into the nearby river.

The expansion of the Geothermal Heat Central to approx. double the current size and to add a heat pump, which extracts heat from the 50°C return geothermal fluid and heats the supply water from 65°C to 75–80°C during coldest days is planned.

The cooling pond is located beside the Heat Central, into which the geothermal fluid from heat exchangers (47–52°C) is discharged. The area of the pond is approximately 2400 m^2, so it holds a large body of water.

The inlet/outlet temperature and the flow of geothermal fluid to the pond have been logged since 2012. The useful measurements spanning a full 2 year period (Sept. ’14–Sept. ’16) were used to show the effectiveness of the cooling pond. The flow to the pond ranges from 20–170 m^3/hour and it cools from 50–55°C down to 20–35°C, depending on the flow rate and the outdoor temperature.

Fig. 1. Poddębice Heat Central; circulation pumps (left) and heat exchangers (right)

Rys. 1. Ciepłownia w Poddębicach; pompy obiegowe (z lewej) i wymienniki ciepła (z prawej)

3. DISTRIBUTION SYSTEM AND CURRENT PEAK LOAD INSTALLATIONS

The distribution system is made entirely from pre-insulated steel pipes (polyurethane foam and plastic coating), a tried and tested method for transporting hot water. It branches to the north and south of Poddębice, each half is 2xDN 250 mm of the main pipeline, each transporting 100–120 m^3/h. The size of the piping can easily transport around 2–3 times higher flowrate. That's make extension of the system possible. Currently, around 12 km of piping have been installed, future expansion assumes another 33 km. There are currently 3 peak load boilers in the DH system – two oil fired and one fired with biomass. These heat the supply water up to 75–80°C during the coldest days. Each station has approx. 1–2 MW_{th} heating capacity.

The plan is to disconnect these installations from the system in the future, when the heat pump has been installed in the Heat Central.

Most of the users have heat exchangers in their house connections, which lowers the supply temperature by a couple of degrees. Radiators were earlier designed for higher supply temperatures (90°C supply, 70°C return) than nowadays. Radiators have since been retrofitted, so the design supply/return temperatures are currently 75/50°C, assuming 20°C indoor temperature and –20°C outdoors temperature during the peak heat load. This may not apply to all users in the system, though.

Installing floor heating in new apartments should also be considered. These systems can operate at lower supply temperature (around 35–50°C), so that should be suitable for the temperatures in the network. It is, however, foreseen that these users would require local mixing stations in the network (which has a common supply temperature from the Heat Central), where return water is mixed with supply water to cool it from 60–75°C down to required temperature. This kind of system has, for example, been implemented in Xianyang in China in the past.

There are currently 3 peak load stations operated in the district heating system, located in the northern part of town. Each station – oil or biomass fired – has a heating capacity of around 1 MW_{th}. They are used both for house heating and hot tap water heating. There used to be around 5–6 boiler stations in the system, connected to the current distribution network in the town but have been decommissioned, one by one. In the future, a single, central peak load heat pump is planned for the entire system and all the current peak load stations will be decommissioned.

4. HEAT DEMAND

The population of Poddębice is approximately 7900 people and has been fairly constant in the last years. The average number of people per household is estimated to be 2,7 prs/household. This corresponds to approx. 2930 households, each with average size estimated to be around 100 m^2. With –20°C design load outside temperature, the heating load is estimated to be 60 W/m^2 in each household, so the total peak load in all of Poddębice is estimated to be 2930 apt 100 m^2/apt 60 W/m^2 = 17.56 MW_{th}. This corresponds quite well to the estimated 18 MW_{th} total heat demand in the town. Other potential large users in the system are the Safari Park in Borysew and Sports' Centre in the outskirts of Poddębice.

Currently, the thermal power of the Geotermia Poddębice Heat Central is approximately 4 MW_{th}, including one large user (Poddębice Health Center). The current plan to increase flow from the production well Poddębice GT-2 from 190 to 260 m^3/h will increase the heating capacity to approx. 5.4 MW_{th}, or 30% of the total future heat load of Poddębice.

Fig. 2 shows the heating central in the Municipality Health Centre in Poddębice.

Several users, such as the Sports Centre, have local heat pumps installed, using the ground as a heat source. It will be fairly easy to modify these systems so that geothermal heat is used as an additional heat source.

Fig. 2. Heating central at Municipal Health Centre in Poddębice

Rys. 2. Instalacja geotermalna w Poddębickim Centrum Zdrowia

4.1. Measured heat load 2014–2016

The following is taken from a data log from Geotermia Poddębice, which consists of daily averages of flow, temperatures in the system, measured at the Heat Central. The data from September 2014 to September 2016 (a continuous 2 year period) is used.

One of the parameters – the return temperature of geothermal fluid from heat exchangers – is only taken once a week, so the estimated heat load is highly uncertain. The intermediate values used are averages between the weekly values. Other quantities, such as outdoor temperature, supply/return temperatures to/from district heating system, temperature from cooling pond etc. are taken daily.

Heat demand is calculated by multiplying daily average flow from well Poddębice GT-2 (30–190 m^3/h), heat capacity of water (4.18 kJ/(kg·K)) and temperature drop from supply temperature from well (around 65°C) down to return temperature from heat exchangers (50–55°C). The variation of these values over the 2 year period is shown in Fig. 3.

The outdoor temperature and estimated on real data heat demand duration curves over a 2 year period are shown in Fig. 4. The heat sold to the users might be estimated as 48 TJ/yr (assumed 10% of annual heat losses in the system).

The peak load installation is only used when the outdoor temperature drops below –10°C, so in this period this seems not to have occurred, except for extremely short periods. However, the system is designed for –20°C, so a peak load installation is definitely needed for this coldest period.

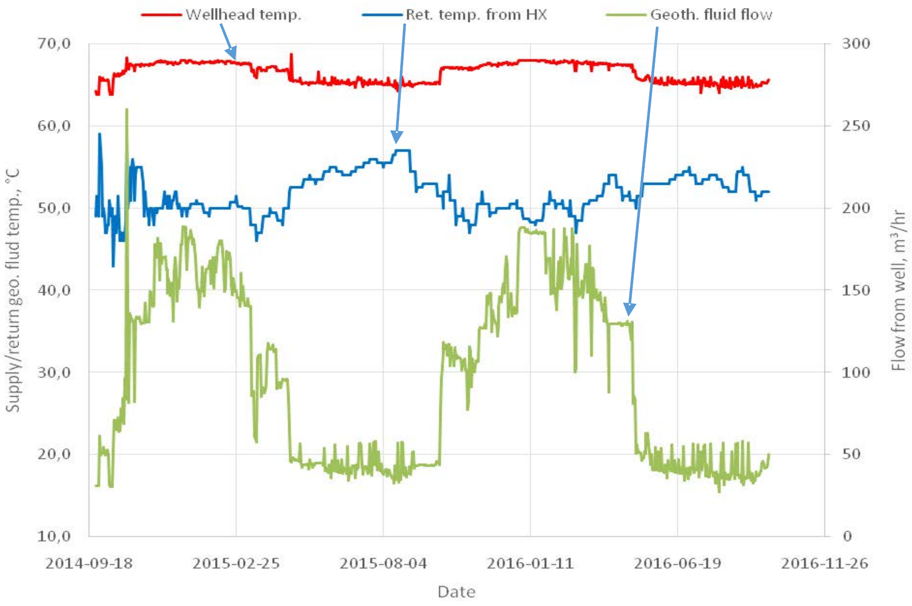

Fig. 3. Flow and temperature of water from Poddębice GT-2 and return temperature from Heat Central

Rys. 3. Przepływ i temperatura wody z otworu Poddębice GT-2 i temperatura powrotu z ciepłowni

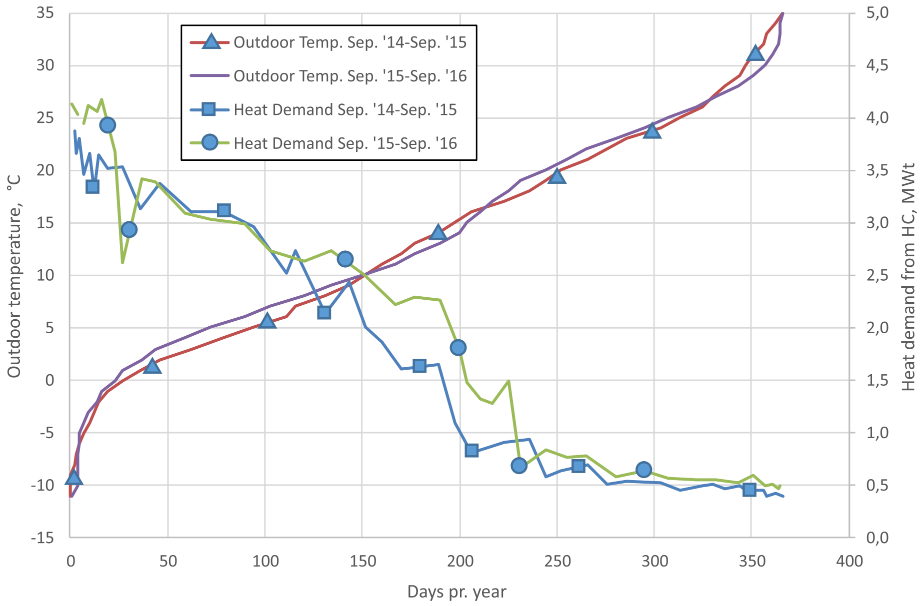

Fig. 4. Heat demand and outdoor temperature over a 2 year period

Rys. 4. Wykres zapotrzebowania na ciepło w funkcji temperatury zewnętrznej dla danych z ostatnich 2 lat

5. OVERVIEW OF THE VARIOUS DISTRICT HEATING SYSTEM CONFIGURATIONS

The following is an overview of the current configuration of the Poddębice district heating system and the planned expansion by approx. 1.4 MW$_{th}$. The proposed future peak load in all of Poddębice is expected to reach 18 MW$_{th}$. Two alternative configurations of the system are proposed, with regards to the ease of implementation of the 18 MW$_{th}$ heating of the entire town.

5.1. Current DH System, 2016

A schematic diagram showing the current geothermal DH system and peak load installations in Poddębice is shown in Fig. 5.

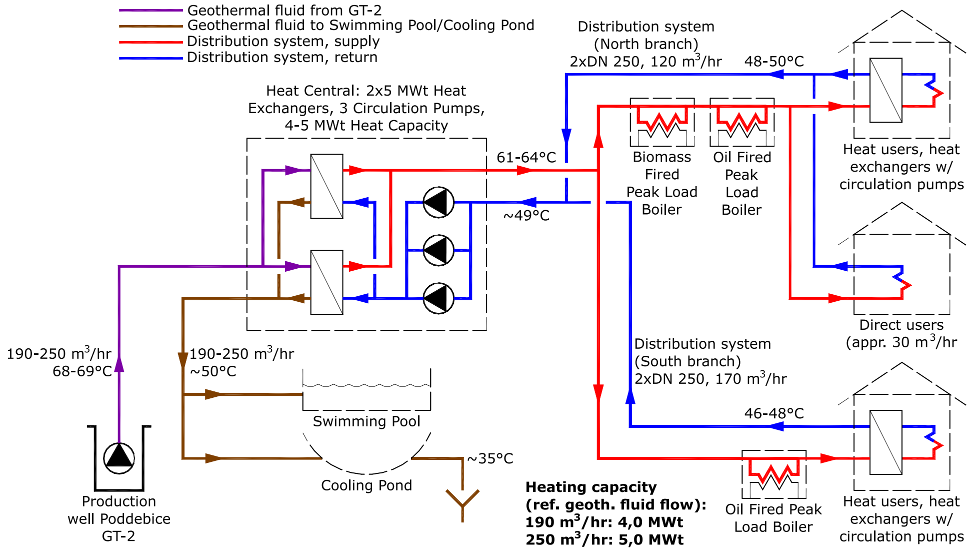

Fig. 5. Geothermal district heating system in Poddębice, current installation

Rys. 5. Aktualny geotermalny system ciepłowniczy w Poddębicach

The maximum power that may be obtained from the geothermal fluid, based on 70/50 supply/return temperatures, is 4.0 MW$_{th}$ – the current heating capacity of the Geotermia Poddębice Heat Central. There are 3 peak load installations in the distribution system (1 biomass fired, 2 oil fired). The flow in the distribution system heating circuit is 220 m^3/h, divided as shown in Fig. 5. The capacity of the peak load boilers for heating is approximately 1 MW$_{th}$ each. This means that the current peak load capacity is approximately 7 MW$_{th}$, of which a little less than half comes from the 3 peak load boiler plants.

Most heat users have a heat exchanger and circulation pump installed, which lowers the supply temperature to the house radiators by some 2°C.

5.2. Expanded District Heating System – Increased Flow and Heat Pump

The proposed expansion of the District Heating DH system in Poddębice is to increase the flow rate from the Poddębice GT-2 well from 190 to 252 m³/h. Current peak load installations in the distribution system are decommissioned and a heat pump is installed at the Heat Central instead.

The geothermal power increases from 4.0 to 5.5 MW_{th} from the increased flow. The heat pump ensures a 75°C supply temperature to the expanded DH system. With an approximately 4.3 MW_{th} heat pump, this amounts to roughly 10 MW_{th} peak load capacity of the system. With a COP (Coefficient of Performance, the ratio of heat produced vs. electricity used) of the heat pump around 3–4, so electrical connection should be 1.2–1.5 MW_{th}. Installing a different kind of heat source for peak load, such as gas or oil fired boilers, may also be possible.

5.3. Future District Heating System in All of Poddębice

The future 18 MW_{th} system in Poddębice might be as shown in Fig. 6. Four 5 MW_{th} heat exchangers are expected and 5–6 circulation pumps. A 4 MW_{th}/1 MW_{th} heat pump could be connected as shown, although the final configuration is not known at the moment.

At least 2 production wells are needed, if a significant portion of heat is to be extracted from geothermal fluid. This setup would mean a system, where 90–95% of the energy for heating comes from geothermal fluid but only 5–10% from peak load (electricity or gas) annually. Direct use of water in distribution system is recommended but depending on project implementation details, there may be a 2nd set of heat exchangers in each house connection.

Depending on the environmental regulations in the future, a cooling pond may or may not be used. The current 2,400 m² pond may have to be expanded, to ensure adequate water cooling, as the fluid temperature from the pond has proven to be higher when the heat demand (and flow of return geothermal fluid) is high. In any case, it may be expected that a re-injection may be needed in the unforeseeable future. For cost estimate purposes, a reinjection well is considered more likely than a 3rd production well and is therefore included in the future cost estimate.

Another possibility for the future system is not to drill any more wells and install a very large heat pump or gas boiler peak load installation. The energy from the geothermal fluid would thus be around 65–70% of the total energy produced for heating, the rest – around 30–35% – would come from electricity or gas. This is shown in Fig. 7: The uniform solid indicates the cumulative heat demand, varying from 1.8 to 18 MW_{th}. The line marked by circle shows the separation between geothermal heating (5.5 MW_{th}) and peak load. The area above the black line indicates the energy input from peak load installation, the area below the black line indicates energy input from geothermal energy. The former – heat from peak load – is around 33% of the total annual energy input, the latter – heat from geothermal energy – is around 66%.

The decision of not drilling a second production well will reduce the project CAPEX (capital expenditures) in the beginning as the cost of drilling a well is significantly high. Annual

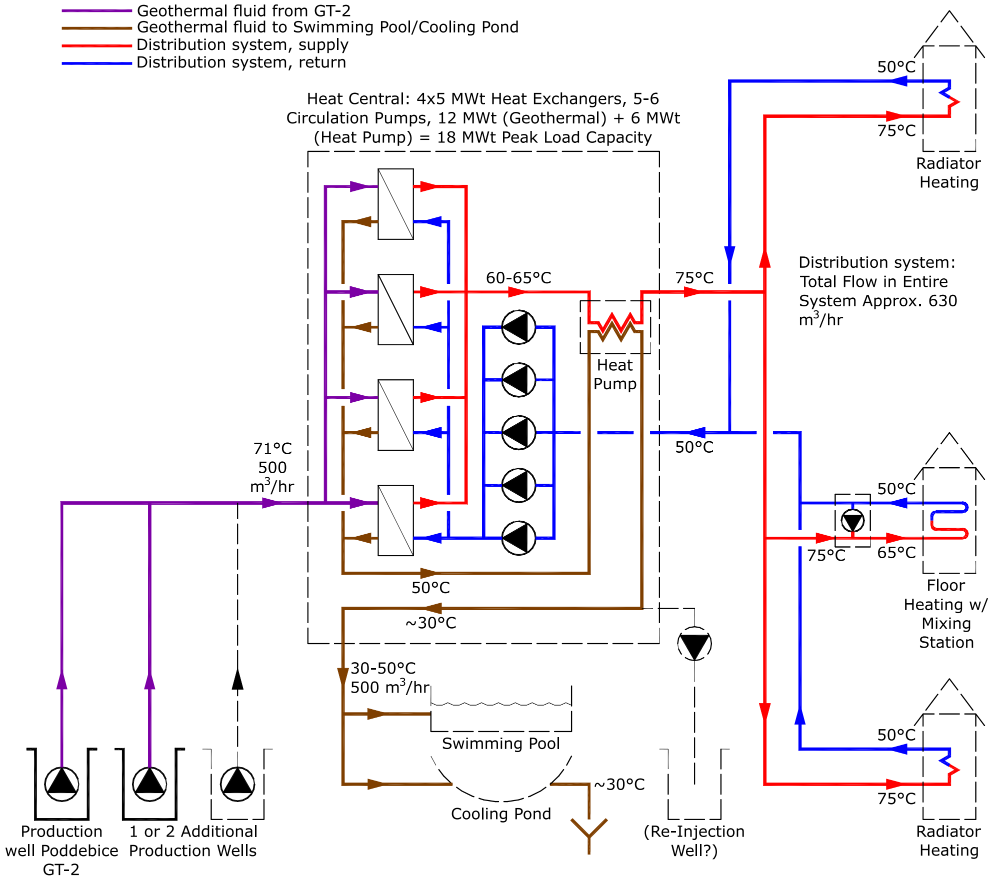

Fig. 6. Proposed configuration of entire geothermal District Heating system in Poddębice

Rys. 6. Proponowana konfiguracja geotermalnego systemu ciepłowniczego dla całych Poddębic

expenditure for peak load electricity or gas would be somewhere around 300.000–500.000 PLN/yr, depending on the peak load installation, heat pump or gas boiler. Installing a large heat pump, which would be approximately 12 MW_{th}, will require large space and will cost millions of PLN. Still, it appears to be a cheaper alternative to drilling a new production well. Installing a smaller heat pump, around 6 MW_{th}, would still cost a considerable amount in addition to a new production well for geothermal water. The energy savings, however – using 5–10% of annual energy as peak load instead of 30–35% – would not recoup these additional costs.

5.4. Distribution System Configuration

Due to rather high chlorine content in the geothermal water, it will not be possible to use it directly in the heating system. It is therefore recommended that the system be designed as proposed in Fig. 6 above, rather than having a second set of heat exchangers in every

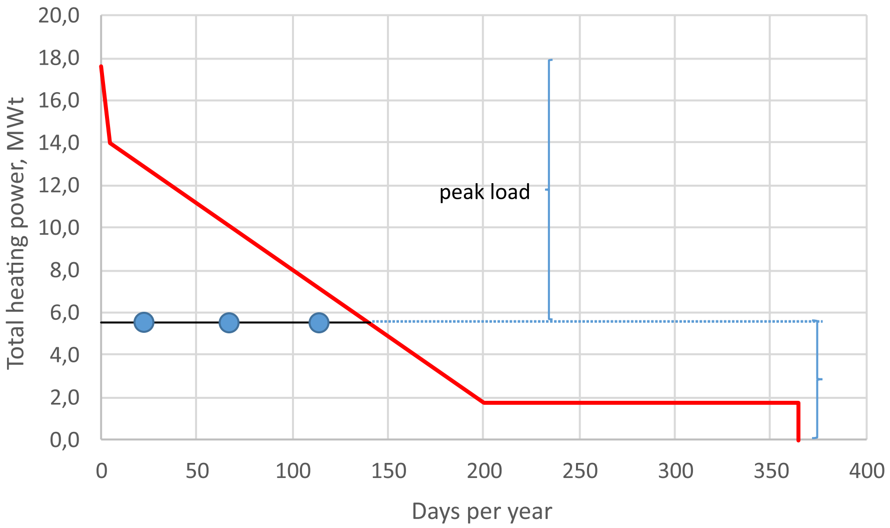

Fig. 7. Future heating power and annual energy input (explanations in the text)

Rys. 7. Przyszła moc grzewcza i produkcja energii w ciągu roku (objaśnienia w tekście)

house. If proper measures are taken for pressure control, this will reduce the fluid flow in the system, both on the geothermal and distribution side, extracting more energy from the geothermal fluid. Also, not installing complex house connections (not using heat exchanger, pump, etc. for secondary heating circuit) in every building may also reduce overall cost in the system expansion.

The case of the extension considered for the system be developed is shown in Fig. 6. At least 2 production wells will be needed and one reinjection well. It is not known at this stage if using a cooling pond will be permitted in the future, as a very large amount of geothermal fluid – at a considerable temperature – is being discharged into the environment.

The selection of the peak load installation is also not known at this point but as a central unit, a heat pump is being considered. In any case, an optimal combination of peak load installation CAPEX vs. annual energy consumption (OPEX – operational expenditures) will have to be selected, where a certain ratio of energy is from non-geothermal resources. A final recommendation of the future system of Poddębice geothermal heating system is therefore not available at this stage.

5.5. General SWOT analysis of applying gas boiler and absorption heat pump as peak load sources

Table 1 contains a general SWOT analysis of applying a gas boiler in a geothermal district heating system or compressor heat pump to cover peak load demand in Poddębice. The final decision which option to select belongs to the operator and / or owner of the heating system in Poddębice and depends on several factors.

Table 1

General SWOT analysis of applying gas boiler or compressor heat pump to cover peak load demand in Poddębice geothermal district heating system

Tabela 1

Ogólna analiza SWOT zastosowania kotła gazowego lub sprężarkowej pompy ciepła w celu zaspokojenia zapotrzebowania na szczytowe obciążenie w geotermalnym systemie ogrzewania w Poddębicach

Gas boiler		
Factors	Positive	Negative
Internal	Strengths 1. Low investment. 2. Stable and failure-free work.	Weaknesses 1. Relatively expensive fuel purchase price.
External	Opportunities 1. Public acceptance – users are used to that kind of equipment. 2. In present electricity production structure a heat pump might be the alternative for a gas boiler only in case of reduction of CO2 emission. Even in that case the mean annually value of COP should be at least 4.8 (Gonet et al. 2011).	Threats 1. Probable fuel price increase with time.

Compressor heat pump driven by electricity		
Factors	Positive	Negative
Internal	Strengths 1. Better (more complete) use of geothermal energy (RES).	Weaknesses 1. Very high purchasing price of the driving energy carrier. Electricity is the most expensive carrier of energy. 2. Very high investment expenditures. 3. Without a changes in the customer's heating installations, it will be necessary to have and use the peak source of energy. The peak source needs to have significant power. This results in increase of capital costs associated with depreciation.
External	Opportunities 1. Less sensitivity to the increase of the purchase price of the driven energy carrier (only about 1/4–1/3 of sold energy is drive energy originating as electricity, the rest of the energy input is from geothermal energy). 2. Positive marketing tone – using RES. 3. Possible improvement of ecological effects over the time due to increase the share of RES in the structure of electricity generation.	Threats 1. Probable increase of prices of electricity with time. 2. Problematic demonstration of a positive ecological effect on a global scale (the reference energy carrier that is natural gas is a pure source of energy). It may effect with difficulties in obtaining subsidies.

It appears that using a gas boiler as a peak load installation is favorable over using a heat pump. Overall, it then appears that installing a system with the one remaining geothermal production well, with max 252 m^3/h flow and installing a gas boiler instead of heat pump appears to be the more feasible option. Installing a second geothermal production well will be very costly and annual savings in energy cost for heat pump/gas do not appear to be able to recoup the high CAPEX of a geothermal well.

SUMMARY AND CONCLUSIONS

The district heating system in Poddębice has been analyzed, based on site visits, meetings and data acquisition from Geotermia Poddębice Ltd. and MEERI PAS in Poland. The current system of around 4–5 MW_{th} has been in operation for 4 years and overall, it appears to be well implemented and operated. Pending further studies and confirmation on the geothermal reservoir capacity, there still appears to be adequate water supply, that can sustain annual heat production of 163.9 TJ/yr for a 18 MW_{th} system with peak load installed, whether the peak load installed is from a heat pump or gas/oil boiler.

The need for heating in Poddębice is relatively high, as the heating season reaches approximately 200 days per year. The peak load installation is designed for relatively cold days, at –20°C. Although the peak load installation is approximately 2/3 of the total proposed future capacity (or heating power), the number of days where the temperature is below –10°C is not expected to be high. The peak load energy production, therefore, is only a relatively small fraction of the annual heat production, or 30–35%. Installing a second production well and using 1/3 of capacity from a peak load installation will mean that energy from peak load will be only 5–10%, instead of 30–35%. This reduction, however, will not result in significant savings in annual fuel/electricity cost, compared to the high cost of a production well.

All of the above findings have been compared to data logs from a continuous 2 year period and are found to correspond well with information presented at site visit meetings.

By reconsidering the type of peak load installation (gas boiler instead of heat pump) and re-thinking/simplifying the type of house connection (using fluid more directly and therefore lowering house connection costs and fluid flow), the CAPEX may be reduced by a few percent. It is still rather uncertain at this point and further investigation is needed in order to find the most optimal geothermal heating system.

The net price of gas heating to households is around 4.0 €cent/kWh. The goal, however, of using geothermal energy should be to reduce CO_2 emission, which may be of higher concern in the near future.

There are also two key project risks that need to be kept in mind when the project is developed:

Geothermal reservoir hydrogeology:

Although the reservoir appears to show no signs of long term drawdown (only dynamic drawdown that appears to fully recover), the reservoir will have to be fully analyzed for future exploitation of 45 GWh of heat annually, where water is used from 70 down to 50°C. This has to be ensured before drilling any additional production wells. This is a critical component of the geothermal district heating system. Without a secure water supply the pumping will become problematic and perhaps re-injection wells may be needed to recharge the system, resulting in additional project and exploratory costs.

Cooling ponds vs. re-injection wells:

Environmental regulations are constantly being reviewed and the current configuration of discharging 50–55°C geothermal fluid into a cooling pond and cooling it down to 30–35°C may not be permitted in the future. This may require a re-injection well, which will increase the project costs.

These project risks can be mitigated through proper monitoring and modelling of the geothermal reservoir and environmental impact assessment studies.

Additional geothermal energy use:

Additional geothermal energy recovery can be achieved by the use of heat pumps. It is possible to use both compressor and absorption pumps. The use of heat pumps allows connect additional energy customers. It is envisaged to expand the district heating network. To achieve this goal, it is necessary to bring natural gas and purchase peak boilers to the Geothermia Poddębice Ltd. system. It will also be necessary to extend the existing facility to a new building for boilers and/or heat pumps. The presented variant of the energy source development and heat distribution system will involve significant financial expenditures. It is anticipated that especially capital investments will be high for the installation of compressor heat pumps. Because of short operating time of the equipment long return time of investments is expected.

The alternative of the system expansion by connections of single family houses is use of existing gas-oil and biomass boilers as the peak sources. In this variant it is proposed to use heat pumps in existing heating stations, where gas connections were made earlier. This solution avoids interruptions in heat supply due to geothermal failure. Another element of this variant is the increase the surface or the numbers of radiators in heated objects. This element, however, can be difficult to fulfill due to social reasons (habits of consumers). Perhaps it may be a good idea to make the necessary changes to the selected pilot facility?

In conclusion it might be said that there is no simple solution and financially accessible to improve the energy efficiency of the geothermal system in Poddębice. The decision to adopt such a solution is also not easy.

As regards the visit to Iceland and the experiences that can be implanted in Poddębice, it might be said that there are favorable conditions both for terrain and temperature of geothermal water for the construction of greenhouses. Initially, this could be a cognitive and educational greenhouse, both in terms of installation, which would be based on geothermal water at a temperature of about 40–50°C (after the geothermal heat exchangers) and the selection of special untypical plants.

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Note: More references are given in Part 1 of this article (this volume).

Prezentowany w części 2 materiał jest efektem oryginalnych prac zespołu autorów i zawiera tylko jedno cytowanie literatury. Większość pozycji literaturowych została odpowiednio zacytowana w części 1.

POTENCJAŁ DLA ROZWOJU WYKORZYSTANIA ENERGII GEOTERMALNEJ W POLSCE – MIASTO PODDĘBICE

Część 2. Wybrane aspekty energetyczne obecnego i planowanego geotermalnego systemu ciepłowniczego w Poddębicach

STRESZCZENIE

Artykuł przedstawia zagadnienia energetyczne dotyczące pracującego obecnie geotermalnego systemu ciepłowniczego w Poddębicach, jak i jego planowanego rozwoju z uwzględnieniem optymalnych sposobów funkcjonowania pod względem energetycznym i ekonomicznym (aspekty złożowe i eksploatacyjne są natomiast podane w części 1 artykułu). Tematy zostały opracowane jako część wstępnego studium możliwości w ramach Projektu EOG „Potencjał dla rozwoju wykorzystania energii geotermalnej w Polsce – miasto Poddębice". Wymienione miasto posiada zarówno perspektywiczne zasoby, jak i znaczące plany rozwoju wykorzystania energii geotermalnej w ciepłownictwie i w szerokim zakresie innych zastosowań. Przyczynia się one do niskoemisyjnego ciepłownictwa, poprawy warunków życia oraz do nowoczesnej lokalnej działalności gospodarczej. Poddębice są dobrym przykładem dla innych miejscowości w Polsce, które posiadają zasoby geotermalne. Artykuł przedstawia wybrane analizy, ich wyniki oraz rekomendacje, które są rezultatem wspólnych prac zaangażowanych w Projekt partnerów z Islandii i Polski.

SŁOWA KLUCZOWE

Energia geotermalna, ciepłownictwo sieciowe, efektywne wykorzystanie energii, wspomaganie szczytowe, Poddębice, Polska, fundusze EOG i NMF

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