Use of Geothermal Heat of Mine Waters in Upper Silesian Coal Basin, Southern Poland – Possibilities and Impediments

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Abstract In Upper Silesian Coal Basin, Poland where mining activity and energy production is based on hard coal, alternative sources of energy are largely underdeveloped. Complicated geological structure of USCB as well as interconnections of active and abandoned mines are the main reason that mine closure is associated with continuous dewatering. The process results in discharge of c.a. 80 million m3/year of mine water from pumping systems in abandoned mines. Mine waters are very limitedly used for geothermal purposes, although there is huge potential for that. Paper presents possibilities and problems of implementation nonconventional mine water heat extraction in polish conditions.

Key words Geothermal heat, mine water, mine closure

Introduction

The investigations described in current paper are being carried out in the frame of an international project under the EU Research Fund For Coal and Steel, named: "Low Carbon Afterlife: Sustainable Use of Flooded Coal Mine Voids as a Thermal Energy Source – a Baseline Activity for Minimising Post-Closure Environmental Risks" (Acronym: LoCAL). The LoCAL Project aimed at providing bespoke tools for investigating flow and heat transfer in flooded mine workings. New tools for quantifying and modelling heat transfer in networks of flooded mine workings have been under development in frame of the project as well as overcoming the hydrochemical barriers to effective heat transfer from raw and treated mine waters (ochre clogging phenomenon which affects a lot of mine water heating and cooling systems). The LoCAL project not only have covered technical and engineering issues, but also provided economic and management models for efficient energy extraction and distribution. Technical, legal, managerial and cost-benefit analyses of various types of heat pump systems have been carried out. Project activities have been simultaneously undertaken in mining areas by research organizations in partnership with industrial enterprises in the UK (by University of Glasgow in partnership with Alkane Energy Ltd.), in Spain (by University of Oviedo, with HUNOSA as the industrial partner) as well as in Poland (Central Mining Institute, in partnership with Armada Development).

This paper presents general overview of limitations and the potential in use of mine waters for geothermal heat extraction in USCB, Poland. International cooperation within the project LoCAL gave the opportunity to provide wider technical, technological and engineering overview for geothermal use of mine waters in USCB. Research investigations, pilot and monitoring activities in Polish site – abandoned coal mine Szombierki in Bytom (Northern part of USCB) are now completed.

LoCAL project outcomes revealed very stable temperatures of mine waters pumped in Szombierki system ranging from 23.2 to 28.0°C, and remarkable stability in the characteristics of the main hydrothermal reservoirs. Monitoring campaign was conducted to assess chemical and isotopic composition of mine water in Szombierki mine and results revealed promising technological capacity for geothermal purpose.

Experience gained during the project in relation to pilot action pointed out the obstacles and capabilities of its implementation in polish conditions, especially for future operators and end – users of still nonconventional source of geothermal energy – water from abandoned coal mines.

Use of mine waters for geothermal purpose

The potential of the use of water from underground mines for geothermal purpose was first investigated back in the 1970s. Water in the Springhill coal mines with a temperature of 18°C was used for geothermal energy production in Nova Scotia, Canada (Jessop 1995) and numerous sites all over the world: Park Hills, USA; Follda, Norway; Shettleston, UK; and Ochil View, UK (Wolkersdorfer 2008). In USCB, Poland pumped mine water temperatures range from 11.3 to 29.2°C, generally increasing with depth. Given that many of these waters are pumped in urban areas (where there is a demand for space-heating and cooling) and given that several of the former colliery sites are ripe for redevelopment, the mine waters have a high potential for ground source heating and cooling via the use of heat pumps (Banks et al. 2004; Gudek 2006; Karwasiecka 2001; Małolepszy et al. 2005; Solik-Heliasz and Małolepszy 2001;). The viability of this has been demonstrated at a small scale with coal mine water in Scotland (Burnside et al. 2016) and at a large (district heating) scale at Heerlen, Netherlands (Demollin-Schneiders 2008).

The usual method to exploit geothermal energy contained within mine water is heat pumps in conjunction with either open or closed loops (Hall et al. 2011). Heat pumps can be used to provide both space heating and cooling. In the winter, energy is taken from the water and in the summer, energy transferred into the water (Małolepszy, 2003). If the mine water is used only for heating, it may cause the temperature of the water to slowly decrease, resulting in a diminished heating capacity. The amount of energy recovered will depend primarily on the size and number of heat pumps that are installed. These in turn will be based on the temperature and flow of water from or back into the mine (Hall, et al. 2011) of abandoned coal mine workings with recent practical advances in overcoming the perceived environmental risk obstacles to heat-pump exploitation of mine water, to interrogate and document full-scale working examples of newly-developed mine water heat pump pilot systems in three European countries.

The concept of mine water use as a heat source is fully in line with the EU's environmental policy objectives. Such activity refer to the EU climate and energy package (especially in context of CO_2 reduction), in polish energy package 3x20% means 20% reduction of CO_2, 20% lower energy consumption and 20% increase of the use of renewable sources of energy (Ryżyński and Majer 2015). These legal requirements should be taken as priority in planning and implementation of geothermal installation with use of mine waters. As experiences gained during the LoCAL project revealed – many obstacles occurred in this process.

Project area in USCB, Poland

In USCB Poland since 1989, 34 of the65 hard coal mines in Upper Silesia have been abandoned and the remaining collieries have been forced to adopt a free-market approach. In 2014 restructuring process of polish mining industry has been reached second phase and 5 hard coal mines are going to be closed down due to economic and technical problems (depletion of coal deposits etc). In the Bytom Syncline (northern part of USCB) intensive underground exploitation of coal and Zn-Pb ore since the 19th century has changed the local groundwater flow and chemistry regime. After mine abandonment, dewatering is continued to protect hydrologically connected low-lying coal deposits and active mines from water inundation.

The study area is located in the Bytom Syncline(Figure 1), in the northern part of the Upper Silesian Coal Basin in Poland. Records of coal mining in Bytom Syncline date back to the 16th Century, with initial shallow workings of coal mines and Zn-Pb ore mines. The area of mining exploitation (active and abandoned) and dewatering fields covers c.60 km^2 and has an average altitude of 270 – 295 m asl., with a maximum depth of mining exploitation of c. 900 m bgl (-630 m asl.). Active exploitation of coal is conducted in three mining fields (Bobrek, Centrum and Piekary), and dewatering of abandoned mines is continued in Powstańców Śl – Bytom I, Szombierki (coal mines) and Bolko – (Zn-Pb mine) (Janson et al. 2016)

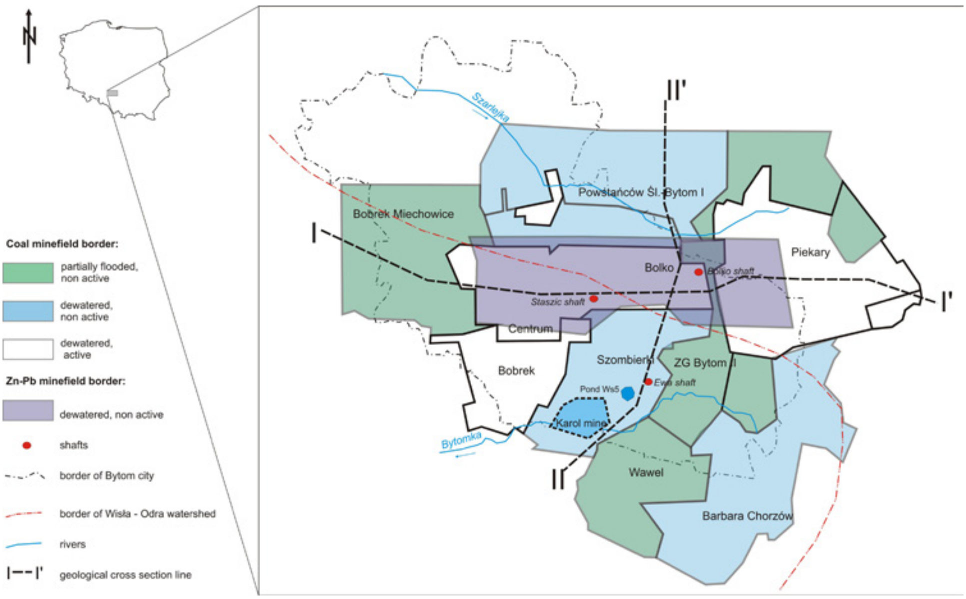

Figure 1 *Location of Szombierki mine field in Bytom Syncline (Janson et al. 2016).*

During LoCAL activities monitoring campaign was conducted and first results were published (Janson et al. 2016). Its outcomes revealed very stable temperatures of mine waters pumped in Szombierki system ranging from 23.2 to 28.0°C, and remarkable stability in the characteristics of the main hydrothermal reservoirs. It seems to be huge potential for heat exchange, taking into consideration chemistry of pumped water (very low concentration of total iron and probable less problems with ochre precipitation observed in other project's sites described by Athresh et al. 2016) as well as very stable temperature on the discharge point at the surface – 24.2 to 25.0°C.

Pilot site is located in Bytom on post mining area where polish project partner – Armada Development, continues its activity after land reclamation as golf course club and housing development (figure 2). The proximity of mine water discharge from abandoned but still dewatered Szombierki mine (to protect interconnected active mines, like Bobrek coal mine in Bytom city centre against water hazard) was an argument for using renewable energy as the main source for heating and cooling at the planned residential area. Szombierki mine is now included in Polish Mine Restructuring Company, with one of department (CZOK) which is responsible for dewatering abandoned hard coal mines in Upper Silesia. Szombierki is one of CZOK's 15 pumping stations with continuous dewatering. Polish Mine Restructuring Company is the owner of technical infrastructure and shaft "Ewa" (source of water for future installation).

Figure 2 *Location of golf course of Armada Development and surface reservoir of mine water (fot. E. Janson).*

During the project activities in relation to pilot installation in Armada the main problem occurred when the permission for use of water generally resulted in delay of construction works. In June 2015 it was possible to obtain the preliminary permission from Central Mine Dewatering Department (CZOK – owner of mine water) for uptake of heat from mine waters with the note that final legal and financial terms for future water use will be designed. Armada Development got also an acceptation from CZOK of construction project for pilot site. After a lengthy period of seeking to resolve minewater ownership and access the matter was resolved in February 2016, when finally Armada received permission for use the water for free. Collection and transfer pipeline was installed and the 9KW compacted heat pump system was constructed during the second half of 2016. Final installation of the heating systems in the buildings utilising fan coil units was carried out in early 2017 with the system now being operational (figure 3).

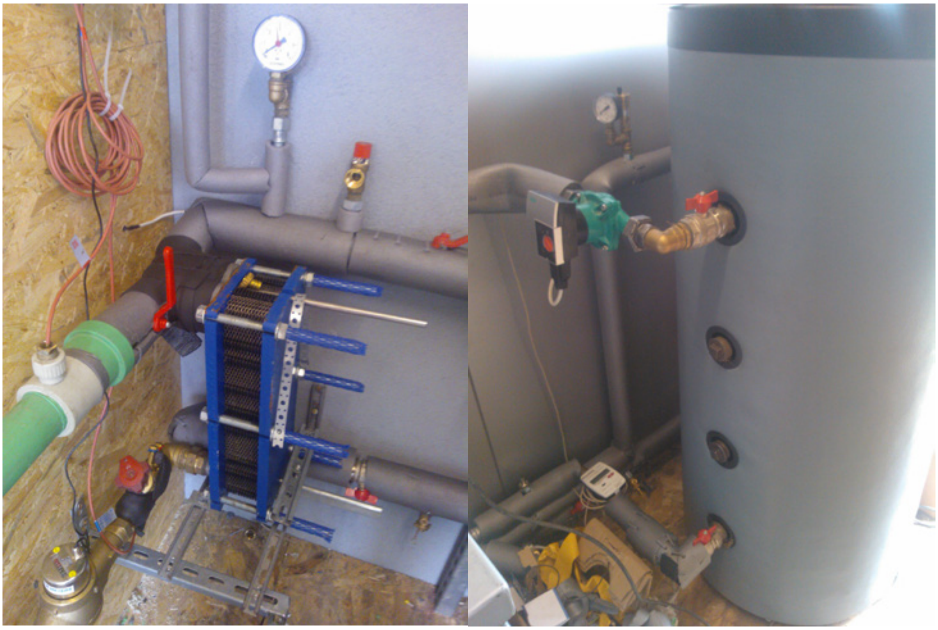

Figure 3 *Pilot installation of heat pump in Armada Development (fot. M. Głodniok).*

Unfortunately, the pumping of mine water at the Szombierki site by the mine operators (CZOK) may be terminated in the next few years. The pumping is currently carried out to protect working mines and the pumping regime may be rationalised at other sites leading to non-availability of the pumped mine water in future. While the main activity of CZOK is to protect active coal mines against water hazard, this point emphasises the need to establish the long-term certainty of continued pumping in evaluating project development. After closure all coal mines in Bytom basin probably the necessity of dewatering abandoned mines would determine possibility of mine water use for heat exchange. Understanding the ownership and rights to utilise the mine water is shown to be a key aspect to be established prior to proceeding in developing a mine water heating and cooling project.

Impacts from social acceptance for geothermal energy projects may occur on the local, regional or national level. There are two main ways of understanding of social impact of geothermal heat of mine waters. First: impact of the geothermal project on the society – it can have both positive and negative impact leading to changes to people's way of life, culture, community structure, stability, services and facilities. Second way of understanding it the impact of society, especially of social awareness and people's level of participation in decision-making processes on realization of any geothermal project.

Conclusions

Positive reception of planned use of geothermal heat of mine water is based on mostly on people's awareness of possible improved standard of living while maintaining relatively low heating costs and of positive impact on environment. In order to ensure this, it is necessary to perform earlier research on lack of possible negative impact on landscape and recreational areas and lack of negative impact on water quality (especially on water for such uses as drinking or irrigation) and widely spread their results among potentially interested people, and above all among decision-makers. LoCAL project revealed that different interests of stakeholders, local community and end-users in general result that the probability of project development is dubious. When developing projects, there are social – connected crucial aspects, such as involvement of stakeholders into economic and environmental benefits from first moment, including information and general understanding of potential in geothermal heat form mine water discharged into tributaries as waste water.

Taking into consideration research tools and experiences gained during the project, it seems like the important issue here is the availability of geothermal heat from mine waters that can be used for beneficial use as well as good planning and understanding of all stakeholders (industrial and otherwise). This is a good post-closure opportunity to mitigate impacts on environment.

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