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Ecological School Building Heating Using a Hybrid Heating System: Heat Pump and Gas Boiler. The Concept, Implementation, Operation

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Abstract

The article presents the concept, construction and analysis of the hybrid operation of the heating system of the school building in Wielka Wies, near Wojnicz, district of Tarnow.

Due to the technical use of the existing heating system and increasing energy costs it was decided to complete its modernization. In consultation with the department's ENION in Tarnow, a complex analysis of the possibility and advisability of the use of heat pumps for heating purposes. Favourable environmental conditions in the vicinity of the premises, such as available land and shallow ground water reservoir is located, were decisive factors in the fundamental way of the economic support of the proposed project. After the wells drilled, revealed the presence of ground water resources of the relevant parameters for energy and performance, in the amount of the protection needs of the planned site, allowing for its rapid deployment. As a source of peak left an existing gas boiler water [1].

The heat pump works in the building of schools since the winter of 2004. In the design of technical – economic project adopted the production of heat from the heat pump at the level of 255 GJ/year and the unit price 37 zl/GJ gross. The average working time over the heating season was 10 hrs/day. Return on investment costs such assumptions followed by nine years of operation. The current heat production promises to be even more preferably, for receiving the heat occurs in a continuous 24 hrs/day during the heating season. For example, energy production from January 2005 to January 2006 amounted to 458 GJ. Based on these data we can say that in the heat production of 460 GJ/year, the time invested in investment return is less than 8 years. However, taking into account the possible funding sources (grants, loans, ecological, depreciation) payback period does not exceed 3 to 4 years [2].

The analysis is based on real data confirmed the return on investment for customers by reducing costs and the optimal selection system, which after the first year of operation produced 87% of the heat required to heat the building. It should be stressed that the current demand for heating power is 105 kW, while the heat pump heating output only 32 kW, provides 30.5% of demand. This choice of heating system and pump power has proved to be optimal both in terms of technical and economic feasibility, and investment for the recipient, the Office for the District, which finances energy management utilities.

Keywords: heat pump, hybrid heating system, renewable energy

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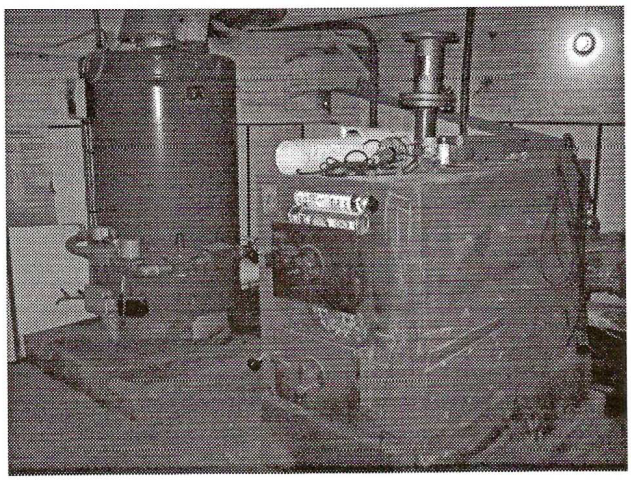

Fig. 1. Boiler room school - Jubam Gas boiler with a capacity of 145 kW and thermal coal boiler [2].

Description of the Object before making the Investment

The Primary School and Middle School in Wielka Wies is located in the valley of Dunajec on clay soils, the area has several acres next to the building as possible to install a gas manifold, in addition, these sites are rich deposits located in shallow ground water.

Building primary schools in Wielka Wies, was built according to traditional technology before the year 1987. The object's surface is approximately 1107 m^2 and capacity of 3538 m^3. In order to reduce heat loss in the building, began the work of counterpart, consisting of the replacement windows. The next stage of the project is the modernization of the heat source and central heating [1, 3].

The building is located in climate zone III. The demand for thermal power is 105,4 kW (heat loss calculation for the north and the rooms are 70.4 kW peak, while for the south – 35 kW). Boiler room was equipped with a gas boiler with a capacity of 145 kW (for lack of efficiency was assumed 80%) and in an unused old coal boiler.

Central heating, is made in an open system of steel pipes, corroded, requiring replacement. Part of the pipeline has already been mentioned in the premises during the renovation of toilets. Heat transfer is done using cast iron radiators equipped with a faulty valve at the radiator. Internal installation which was designed to power about 105 kW and water parameters 90/70°C installation. It provided for replacing old cast iron radiators, steel plate.

Assumptions for the Analysis of Technical – Economic

The basis of the analysis were obtained from an invoice for the gas received from the Office for the District. On the basis of estimated annual demand of your building about 500 GJ/year. Due to the nature of the project, it was assumed that the heat pump will not be matched to the source of peak power demand, but the base of the object about 30 kW and annual production of approximately 255 GJ/year. This is to ensure continuous operation of the device by the heating season and at the same time maximize the power of the device. For the municipal office is expected to deliver a cheaper supply of heat energy, and for ENION SA – Tarnow Power Plant became warm reception [3].

It was assumed that the lower heat source will be placed on a flat plate collector in the field and the square adjacent to the school. After resigning from the collector of a concept of a flat construction of deep wells, and draw heat from the deeper layers of groundwater (May 2004). The premise compels us to this solution was an old unused wells deep in the school board, and data on water (10-15 m below the surface) in the Dunajec Valley. The collector of this type results in an improved heat pump efficiency, investment cost is lower than the gas exchanger [1, 2].

Geological Analysis

The next stage of action was to order the execution of the project NOT Tarnow geological wells and aquifers to determine the resources (June 2003), to obtain necessary permits and performing well. "Design work on the implementation of hydrogeological wells drilled in the Quaternary to the collection for heating purposes in Great Village on the plot No. 683," is made by geologist Mr Andrew Bezkorowajnego (June 2004). The deposits were estimated groundwater in the project with a capacity of more than 10 m^3/h, while the performance needed for the PC is about 6 m^3/h. For the safety of investments foreseen in the project execution of 4 deep wells (2 production wells and 2 injection wells) [2, 4].

Implementation and Testing of Production Wells

Promising assessment of the draft was the basis production well drilled (June 2004). A well was performed by "Szymar" specializing in this type of work. Well drilling technology used by the aforementioned. company is called – "the washer". Drill spoil is rinsed with pressurized water from the hole causing a diversion of material to the surface.

When carrying out drilling has confirmed the geological strata laid down in the draft that is impermeable layer rich in clay reaches a depth of about 8 m below the surface, followed by 3.5 m in the aquifer containing coarse gravel with a high performance filtration of about 25 m/day and a layer impermeable clay beginning at 12 m below the surface.

Then the pumping test was performed – for 24 hours, pumping water with a yield of 10 m^3/h, caused a decrease in water level from 0.6 m below the surface by about 2.5 m. The study confirmed the efficiency of the actual deposit of the design data.

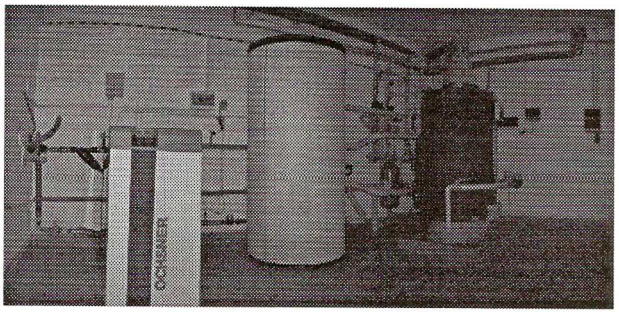

Fig. 2. Assembled heating system - heat pump, buffer tank, electricity distribution, water installation [1, 2, 5].

Was the need to examine the composition of the water in terms of mineral content. Retrieved from the reservoir water sample, was commissioned to study 29 June 2004. The County Sanitary – Epidemiological Station in Tarnow. Tests were conducted in the period from 29 June – 08 July 2004., Numbered PSE-LB/3/50/1231/455/04 No attempt 1310/500/S. The study showed a high content of iron, but did not exclude the application of heat pumps [2].

Implementation and Testing of Injection Wells

Well damping was performed on 22 XII 2004 by "HYDRODOL". It specializes in sealing wells between aquifers. The technology used by this company is drilling the well's dry. This ensures that there is in this case, the leaching of ore under pressure, which can cause additional erosion of the walls of the hole and the porous soil adhesion to the pipe above the filter. Profile made drilling has been very beneficial, because the level of about 8.3 m below the surface is impermeable layer of dust and clay, followed by about 3.5 m are gravels and sands, and from 12.8 m below the impermeable layer begins clay. Aquifer starts at 9.25 m below the surface and remains stable at this level. The resulting profile of the layers turned out to be very promising for use as a discharge of water from the heat pump. In order to confirm the assumptions made were 24-hour pumping test (by using fire hoses), which confirmed the absorption bed and tightness done well. The study was conducted at constant inspection of the drilling company representative [1].

Selection of Heat Pump Suppliers

Which required the announcement and completion of the tender procedures. The tender was won by Ochsner Heat Pump, the value of the works and equipment amounted to 48838 zl. Assembly work included involvement in the heating system, installation of a buffer with a capacity of 1 m^3, heat pumps, heat meter on the output of the PC, submersible pump, the main electricity distribution and the relevant RCD and overcurrent protection, and making connections with the water pipes stacked wells. Mounted heat pump is a device OCHSNER Golf Maxi GMWW 38 [5].

Start-up Period and the Initial Results of the Technical

Conducted launch showed the system for leaks.

The final stage was the final acceptance of work connected with the training of people who will deal with the continuing operation of the heat pump (05 I 2005).

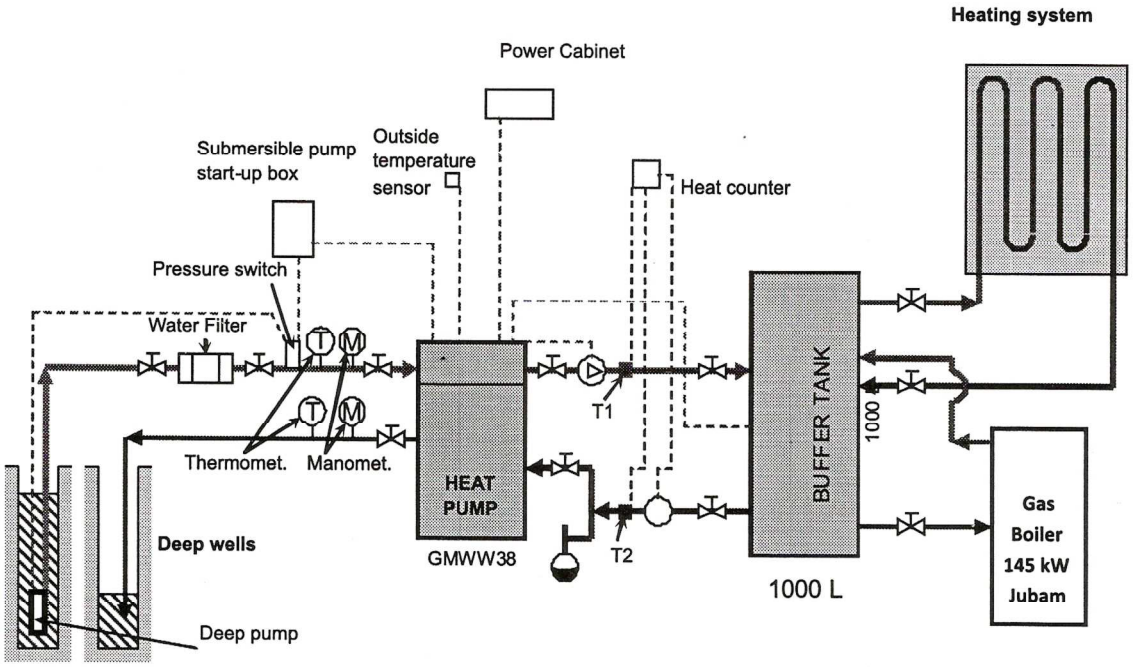

Fig. 3. Schematic of the heating system [1, 2, 5].

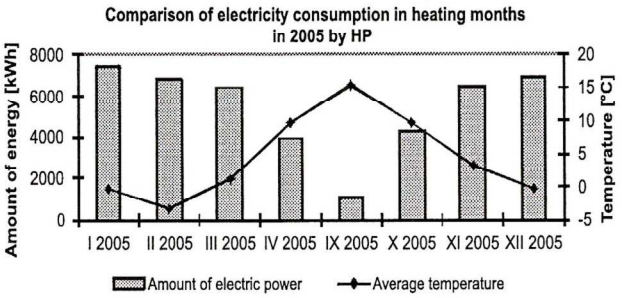

Fig. 4. Comparison of expenditure of electric power in heating months in 2005 by HP [2].

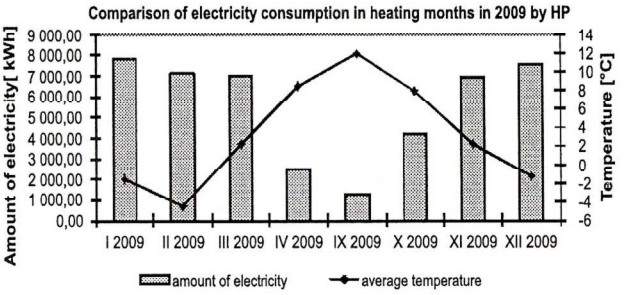

Fig. 6. Comparison of electricity consumption in heating months in 2009 by HP [2].

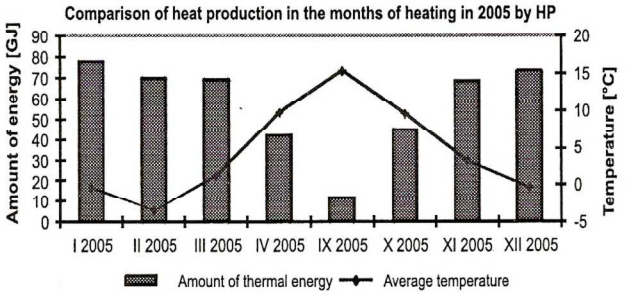

Fig. 5. Comparison of production of thermal energy in heating months in 2005 by HP [2].

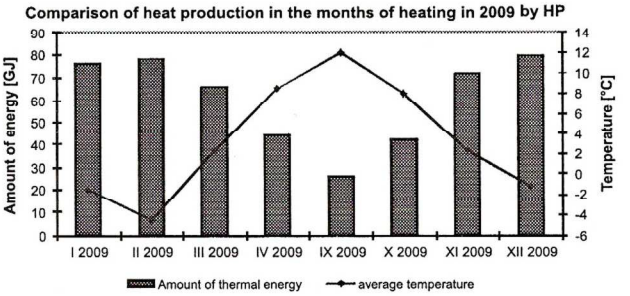

Fig. 7. Comparison of heat production in the months of heating in 2009 by HP [2].

Preliminary measurements of the parameters of the device:

- water temperature in the flow of production well, +11°C
- water temperature drop the flow through a heat exchanger in the PC, +3.5°C
- temperature at the exit from the PC and power supply to the buffer, +51.5°C
- temperature at the entrance to the PC and the return of the buffer, +42°C
- efficiency of the whole heating system with heat pump (with a circulating pump and submersible) – about 3.0.

Preliminary analysis indicated that the technical parameters of the heat pump system. Intermittent increased heat demand is covered by switching on the gas boiler, working in parallel with the heat pump.

Installation Operation

In the design of technical – economic project production assumed heat from the heat pump at the level of 255 GJ/year and the unit price 37 zł/GJ Gross. The average working time during the heating season was approximately 10 h/day. Return on investment costs such assumptions followed by nine years of operation [6].

Currently, heat production is going to be preferably, for the supply of heat is carried out continuously for 24 hours a day (in the winter months, typically). Energy production from 3 January 2005 to 2 January 2006, amounted to 458 GJ. Based on these data can be expected that in the heat production of 460 GJ/year, the payback period will reduce the effort invested less than 7 years.

The main objective of installing a heat pump, was to reduce heating costs Elementary School and Middle School in Wielka Wies. The following are results of calculations which show the extent to which this has been achieved in 2005 and 2009.

In the year preceding the installation of heat pumps, gas consumption by the school was at the level of 20893 m^3/year, of which about 1440 m^3/year were used for the preparation of meals, while the remainder 19453 m^3/year has served to produce heat. Amount of heat produced was 500 GJ/year. Due to such a high consumption, it has been accounted for in the tariff W4. For the calculation could be compared by simulating the costs to the rates in 2005, taking into account changes of gas tariffs. For such assumptions, the cost of gas for heating purposes would be 17 990 zl/year.

As a result of the heat pump, gas consumption has dropped to around 4200 m^3/year, with a gas furnace for about 2320 m^3 per year. However, total heat production for the facility amounts to approximately 522 GJ/year. Due to the significant fall in consumption, the object should be accounted for in the tariff W3. The cost of gas for heating will be in this case approximately 2541 zl/year. After adding up the cost of gas for the manufacture of heat in a gas furnace and heat cost of the heat pump, the total cost is 16340 zl/year. The result is a decrease in costs for the purposes of central heating, which is approximately 9.2%.

Increasing economic effect, is caused mainly by an increase in gas prices (reference costs). In addition, the tariff change favorably with the W3 for W4, where the

share of fixed costs is much smaller. Was obtained from the cost reduction of 4.2% increase in profit for the municipal office, despite a high heat production of 22 GJ [1, 2].

The analysis is based on real data confirmed the return on investment for customers by reducing costs and optimal selection of the device that after the first year of work produced as many as 87% of the heat needed to heat the building.

It should be noted that the demand for power facility is calculated to 105 kW, while the pump has a heat output of only 32 kW, which represents only 30.5% of demand. It turns out that such selection proved to be optimal in terms of investment for the owner of a heat pump – ENION Tarnow SA Power Plant, as well as economical for the customer – the Office for the District.

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