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HEATING FOR INTELLIGENT BUILDING – CASE STUDY

Доведено, що теплові помпи як джерело відновлювальної енергії є дуже ефективні та безпечні для довкілля. За достатніх умов енергія від низькопотенціального тепла, що переважно не придатне, використовується як джерело енергії для теплових помп. Застосування цих систем супроводжується використанням електроенергії за низького тарифу, що підходить для роботи інших електроприладів. У цій роботі встановлено величину затрат на обігрівання та функціонування електроприладів будівель і показано нові шляхи використання комбінованої системи з низькотемпературними обігрівальними системами.

Abstract. It is argued that heat pumps as one of renewable energy source are very energy efficient, and therefore environmentally-friendly. With good conditions the energy from low-potential heat, in other way unusable, is used as a source of energy for heat pump performance. The applicability of this system supports utilization of electric energy at low tariff rate, which is also valid for operation of other electrical appliances. This article determines operative production costs for heating and operation of other electrical appliances and indicates new ways in using it in combination with low-temperatures heating systems.

1. Introduction. The EU and the world are at a cross-roads concerning the future of energy. Climate change, increasing dependence on oil and other fossil fuels, growing imports, and rising energy costs are making our societies and economies vulnerable. These challenges call for a comprehensive and ambitious response. The heating and cooling sector accounts for approximately 50% of overall EU final energy consumption and offers a largely cost-effective potential for using renewable energies, notably biomass, solar and geothermal energy. However, with renewables today accounting for less than 10% of the energy consumed for heating and cooling purposes, this potential is far from being exploited [1].

It is argued that heat pumps are very energy efficient, and therefore environmentally-friendly. With good conditions the energy from low-potential heat, in other way unusable, is used as a source of energy for heat pump performance. The applicability of this system supports utilization of electric energy at low tariff rate, which is also valid for operation of other electrical appliances. This article determines operative production costs for heating and operation of other electrical appliances.

1.1. Heat pump general description. The principle of the heat pump (HP) is known for more than 100 years. The usefulness of heat pump is clearly demonstrated by relatively low cost of the system and the competitive prices of other energy sources. Heat pumps can be thought of as a heat engine which is operating in reverse. For examples are food refrigerators and freezers and air conditioners and reversible-cycle heat pumps for providing thermal comfort. The sources of energy are in our surroundings (water, air, ground), which are huge natural resources at low temperature level. Their utilization is efficient when the energy at low temperature level is overdrawn by HP to higher temperature level. The useful heat consists of the energy extracted from the source (in this case the groundwater at 10 °C is cooled down) and the heat, which is equal to with delivered electrical energy. From these energies it is possible to define the coefficient of performance (E_1+E_2). The term coefficient of performance (COP) is used to describe the ratio of the output heat of the supplied work.

$$COP = \frac{E_1 + E_2}{E_2} \quad (1)$$

where

E_1 - energy extracted from the source (water temperature from 10 °C to 6 °C)

E_2 - delivered electrical energy for HP

This number is spaceless and it is the main indicator of quality, or particularly appropriate of the source. The COP depends on work conditions. On the input side there is the temperature of the cooled down water, HP quality and working order and on the output side temperature of heated medium (water for heating or heated water). When the temperature difference between heated and cooled medium is smaller, the COP is higher. On the contrary, with the higher temperature difference COP goes down. For example: with COP = 5 the output energy is 5 kWh and electrical energy input is 1 kWh. Therefore we want to use the low temperature heating systems.

2. Description of studied system. The system is designed for Administrative building with heat loss 140 kW without water heating. Hot water is heated by electrical flow water heater. The source of heat is the ground water at temperature 11-13 °C. The heating system is hot water conventional radiators with temperature drop 60/50°, and outdoor temperature -15°C. The whole building is electrified.

- Heating with the HP
- Water heating by electrical flow water heater
- Lights and other appliances

During the operation we used the tariff BENEFIT- EKO- MAXI**.** Following outputs are from the operating costs.

2.1. Calculation methodology. The calculations are taken from the real- measured, average day temperatures and their frequency in the heating season 2006/2007. Every outdoor temperature is related to heating water temperature (heated medium temperature), which has influence on the COP. HP must heat water for heating to required temperature.

Graph 1shows the performance of HP relative to outdoor temperature. Covering the building heat loss by HP is possible up to the exterior temperature -11 °C. Below this temperature an external heat source is needed. The engine room is connected to the heat exchanger plant where it is possible to raise the temperature of heating water in case of need. The value of COP for central heating is 2.4 – 5.3 that is an average 3.5. COP also covers the other electrical appliances (pumps, regulation, etc.).

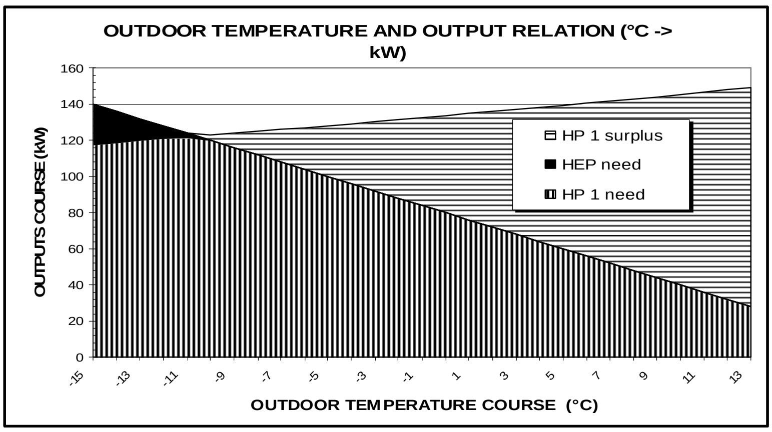

Figure 1. HP performance relative to exterior temperature
(Heat loss =140 kW, HP performance =118 kW, outdoor temperature -15°C)

Figure 2 shows an overview of heating needs in heating season consumption. Supply of derived energy used for heating relative to outdoor temperature from -15 °C to +13 °C. The heat pump performance is only 85% of maximal heat loss. HP can cover up to 99% of required energy for central heating depending on frequency and average temperature of heating days. The external heater is needed only for 1% of energy consumption. Pie slice 2 in graph 2 shows the quantity of heat available to supply to another customer. When the outdoor temperature rises above -11 °C the system generates a surplus, which can be used to supply energy to another customer. In that case 53% of heat is used for own building and 47% of heat is given to the distribution network.

On the Figure 3 you can see a shape of the temperatures, charging the energy to the tank and time of running HP. To achieve efficiency of HP is off during periods of high tariff of electrical energy. It is between 8^{30}-9^{30} and 18^{30}-19^{30}. This one hour pause in heating is compensated by accumulation of building heat and has no influence on thermal balance.

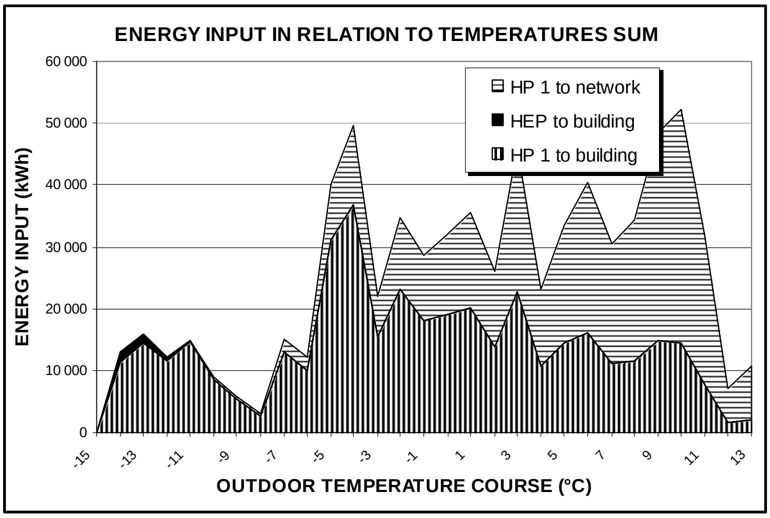

Figure 2. The period of delivered energy for heating according to frequency of heating season with related exterior temperature

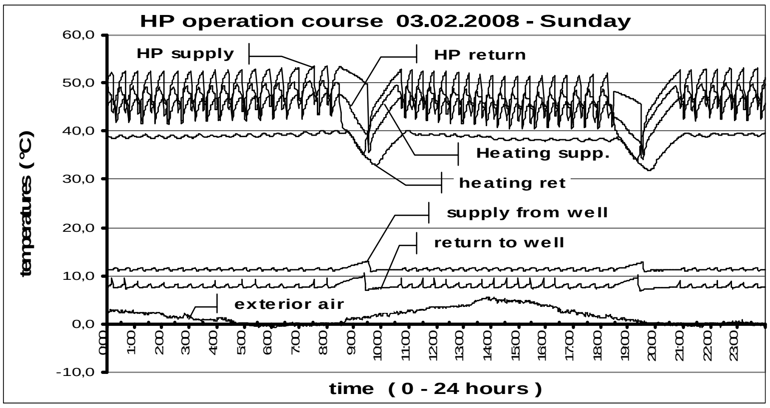

Figure 3. The period of measured temperatures during the heating in one typical day

Conclusions. The low tariff rate for HP is used for the whole building. COP = 3.5 was used for operation of HP. That determines demand of electrical energy for HP = 100 000 kWh in comparison with delivered heat for central heating 350 000 kWh. The operation of HP is preferable. The evaluation of any other cases depends on the prices of wells (injection and extraction well). The balance involves only the heat for the building that is why it is necessary to re-evaluate all factors which have influence on the realization.

Heat from the fossil fuel combustion (gas, coal) substitution by using a heat pump aimed at emission decreasing per 6000 GJ heat production yearly assumes decreasing for reference building:

SO2 = 413,846 kg/year
NOx = 34,26 kg/year
TZL = 19,67 kg
CO = 10,00 kg
CO2 = 151,15 t/year

In the next period of our research we want to study an applicability capillar mats technology for a heating/cooling, using of a radiant heat part at decreasion of operational water temperature to 40 °C – possible increasing of a heat pump efficiency to the ratio 1 : 5,5 up to 1 : 6 for a suction water well at 12-14 °C as well as utilization of accumulated energy as a heat/cool in the building construction interaction and finding a smart regulation of dynamical parameters. We expect the only technology for simultaneuosly solution a heat supply during a heating season as well as cool supply in a summer season (see Figure 4).

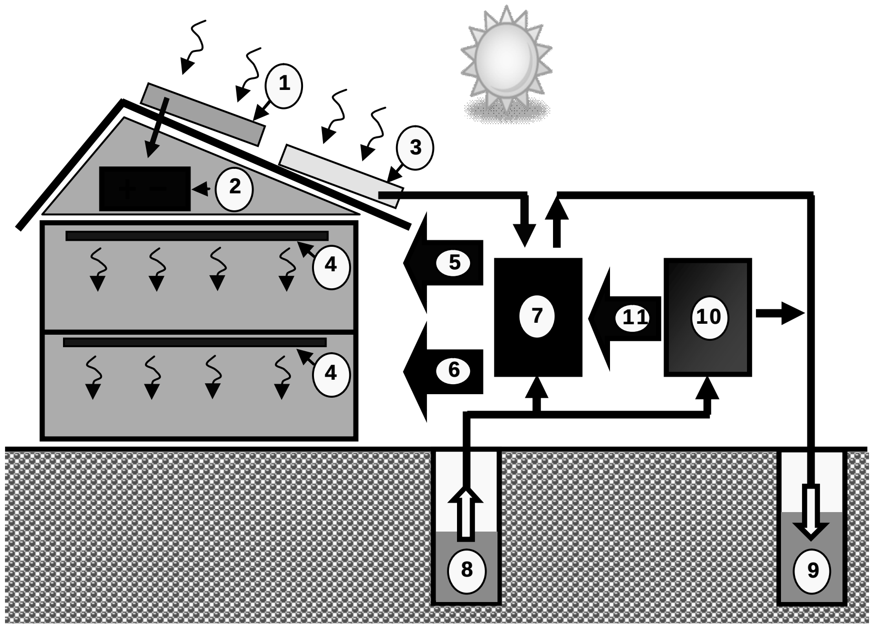

Figure 4. Scheme of a future heating system

Legend: 1. photovoltaic cells, 2. accumulator of produced electric energy, 3. solar collectors, 4. capillar ceiling heating – cooling, 5. heat supply for a heating, 6. cold supply, 7. heat-cold accumulator, 8. suction well (heat and cold source), 9. seepage well, 10. heat pump (water-water heat source), 11. heat produced in a heat pump.

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1. Renewable Energy Road Map, Renewable energies in the 21st century: building a more sustainable future, COM Brusel, 2007. 2. Sedláková, A., Rusnák, A.: Thermotechnical problems of substructure in industrial buildings. In: Selected Scientific Papers / Journal of Civil Engineering. roč. 2 (2007), s. 49-67. ISSN 1336-9024.