POSSIBILITIES OF APPLYING HEAT PUMPS IN SLOVAKIA

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ABSTRACT

Today's trend for keeping acceptable conditions of living on Earth is closely related to cease the generation of Greenhouse effect. One of the advisable technologies today so popular used in East Asia and USA is a heat pump. Heat pumps at the same time enable to save primary energy and also to reach desired thermal comfort by lower energy consumption. But the essential problem not only in Slovakia but also all over the World is the relatively high price of heat pumps.

In this paper are described the possibilities of applying heat pumps in Slovakia. The main important of low energy potential sources are described. Further it is focused also on the environmental quality of electricity and from a questionnaire held in 2003 it is tried to calculate possible arise of heat pump installations in Slovakia and their impact of emissions reduction.

Key words: ***heat pumps, Slovakia, quality of electricity***

1 INTRODUCTION

The greatest heat pump nowadays successfully and reliable operating in Slovakia is a heat pump in spa called Vysne Ruzbachy with thermal output of 800 kW. So far up to 100 heat pumps are used all over Slovakia excluding air-conditioning units. The essential problem of installing heat pumps in Slovakia it their relatively high price (5 000 – 7 500 EURO). In Slovakia there are two associations trying to achieve different forms of financial support for heat pumps either from government or from electricity generating companies. Those two are "Slovak Heat Pump Association" and "Slovak Association for Cooling and Air-Conditioning Technology".

2 ABOUT SLOVAKIA

Slovakia, landlocked republic in Central Europe, bounded on the northwest by the Czech Republic, on the north by Poland, on the east by Ukraine, on the south by Hungary, and on the southwest by Austria. Bratislava is its capital and largest city. Slovakia was considered part of Greater Hungary until 1918, when it united with the Czech lands of Bohemia and Moravia, in addition to a small part of Silesia, to form Czechoslovakia. In 1939, shortly before the start of World War II, Slovakia declared its independence under pressure from German dictator Adolf Hitler, but in 1945 it was reunited with the rest of Czechoslovakia. From 1948 until 1989 Czechoslovakia was ruled by a Soviet-style Communist regime. In 1993 the country broke apart, and Slovakia and the Czech Republic became independent. On 1th May 2004 Slovakia became a member of European Union.

Fig. 1. Slovakia on World and Europe map

2.1 Land

Slovakia's total area is about 49,012 sq km (about 18,923 sq mi). The country's maximum length from east to west is about 416 km (about 258 mi), and its maximum width from north to south is about 208 km (about 129 mi). The Danube River, located in the southwest, forms part of Slovakia's border with Hungary.

2.2 Environmental Issues

Citizen concerns about the environment - particularly air and water pollution - have increased in the 1990s. However, efforts to shut down pollution-producing industrial plants have been hampered by economic considerations, including concern about the high rate of unemployment.

2.3 Population and Settlement

The Slovaks are descendants of Slavic people who settled near the Danube between 400 and 500 AD. Slovaks comprise about 86 percent of the country's inhabitants; Hungarians, who constitute the largest minority group, comprise close to 11 percent; and Roma (Gypsies) represent less than 2 percent. Small numbers of Czechs, Moravians, Silesians, Ruthenians, Ukrainians, Poles, and Germans also live in Slovakia.
Slovakia's total population is about 5,347,000. The population density is about 110 persons per sq km (about 285 per sq mi). Nearly 57 percent of the population lives in urban areas.

3 LOW-TEMPERATURE ENERGY SOURCES

The most interesting low-potential energy sources in Slovakia are air, underground water and geothermal energy. Especially in the southern part of Slovakia there are ideal condition for installing a heat pump system especially for heating in winter and also cooling in summer. Moreover in Slovakia there are about 52 Spas utilizing the geothermal energy with output water temperature between 20 to 30 °C (68° to 86° F), which is sluiced to the sewage without taking any advantage of it.

3.1 Air

Slovakia has a continental climate, with four distinct seasons. Winters are typically cold and dry, while summers tend to be hot and humid. The average daily temperature range in Bratislava is -3° to 2° C (27° to 36° F) in January and 16° to 26° C (61° to 79° F) in July; temperatures tend to be cooler in the mountains.

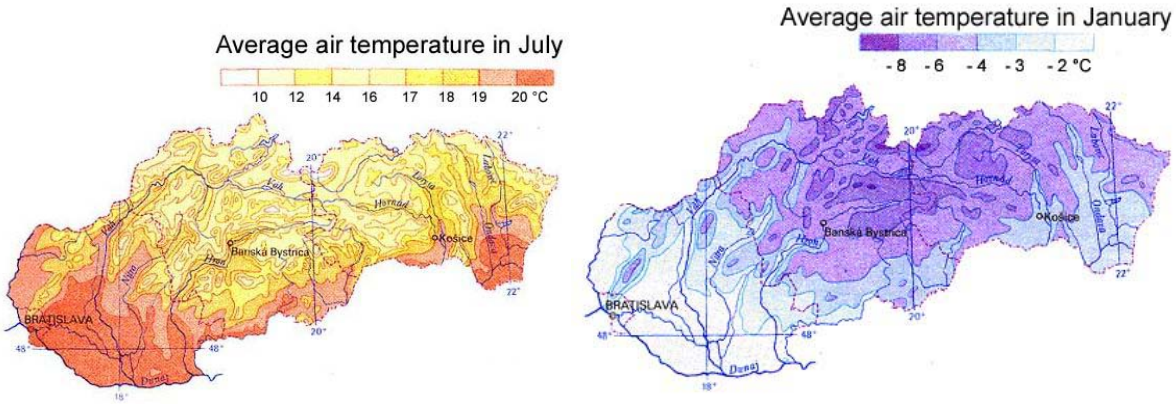

Fig. 2. Average air temperatures in the hottest (July) and coldest (January) months

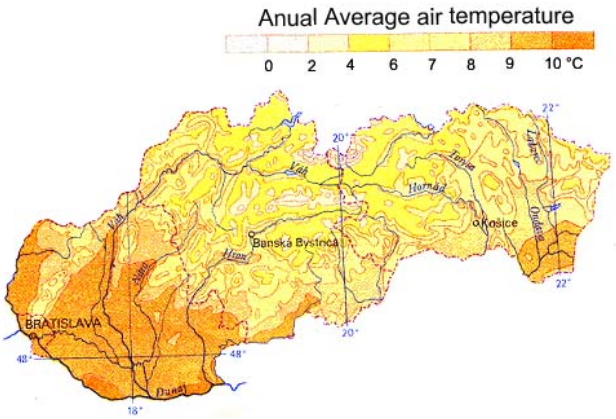

Fig. 3. Annual average air temperatures

3.2 Underground Water

The most considerable documented utilizable underground water quantities and underground water resources are in west-south part of Slovakia (56 %), where these are bound to the quaternary sediments of Podunajska lowland and fluvial deposits of river Vah and its inflow rivers. On the east part of Slovakia there are documented substantially lower utilizable underground water quantities (17 %). The rest (27 %) is situated in the middle part of Slovakia.

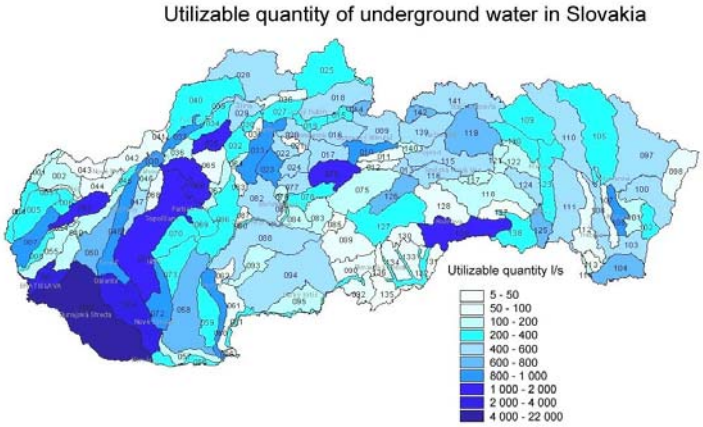

Fig. 4. Utilizable underground water quantities in Slovakia

During the last ten years the underground water consumption has decreased from 22 200 l/s in 1990, to 14 200 l/s in 2000 (i.e. annual underground water quantity consumption decrease of 35,95%).

The decreasing tendency of underground water consumption has been reflected to the relation between potential possibilities of exploitation of underground water resources and their real utilizations. In 1990 in Slovakia was utilized approximately one-third of the utilizable underground water resources. During the following ten years annual consumptions had been decreasing and in 2000, only about one-fifth of the whole utilizable underground water quantities were used commercially. Today it is even less.

3.3 Geothermal Energy

"Geothermal" comes from the Greek words geo (earth) and therme (heat). Our earth's interior - like the sun - provides heat energy from nature. This heat - geothermal energy - yields warmth and power that we can use without polluting the environment. Geothermal heat originates from Earth's fiery consolidation of dust and gas over 4 billion years ago. At earth's core – 6 400 km (4 000 miles) deep - temperatures may reach over 5 000 °C (9 000 °F). The heat from the earth's core continuously flows outward. It transfers (conducts) to the surrounding layer of rock, the mantle. When temperatures and pressures become high enough, some mantle rock melts, becoming magma. Then, because it is lighter (less dense) than the surrounding rock, the magma rises (convects), moving slowly up toward the earth's crust, carrying the heat from below.

Substantial thermo-energetic potential of Slovakia is covered under the ground known as geothermal energy. Today in Slovakia there are qualified 26 hydro geothermal regions, which cover 27 % of the whole area of Slovakia. So far many boreholes in 15 selected regions have verified the presence of geothermal waters in Slovakia. Between 1971 and 2000 had been realized 66 geothermal boreholes, which confirmed geothermal water quantity of more than 1000 l/s with the temperature from 20 to129 °C (68° to 264° F) at the borehole exhaust. Their thermal output is about 220 MW_t (when utilizing up to the reference temperature of 15 °C (59 °F)). Information about geothermal waters was obtained from boreholes 210 to 3 616 m deep; the water quantity in a borehole by free overflow was mostly between 5 and 40 l/s. From the composition point of view there were in water determined following substances: Na-HCO_3-Cl, Ca-Mg-HCO_3-SO_4 and Na-Cl with the mineralization from 0,7 to 20,0 g/l. Gross thermal-energy potential in Slovakia in whole perspective regions is 5 538 MW_t. Today the geothermal energy is utilized in 35 regions of Slovakia with the utilizable thermal output of approximately 83 MW_t. But the efficiency is relatively low, about 30 %, which means approximately 25 MW_t.

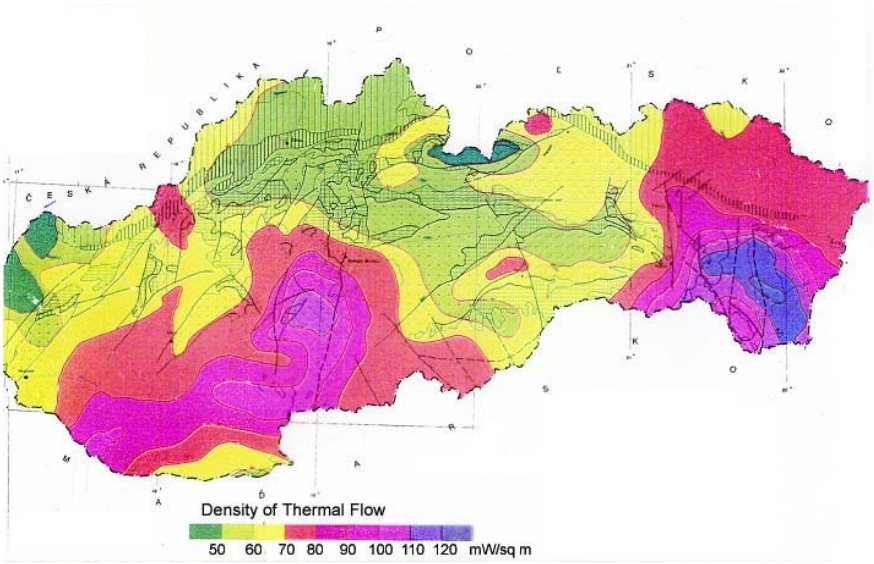

Fig. 5. Regions of Slovakia with potential geothermal energy utilization

4 ENVIRONMENTAL QUALITY OF ELECTRICITY

The positive environmental effect of a heat pump depends on refrigerant type, heat pump efficiency and the environmental quality of electricity, i.e. the factor $kg_{emission}/kWh_{produced}$.. The quality is different from country to country and depends on what kinds of fuels are used for electricity generation in power plants.

In Slovakia approximately 85 % of all electricity is generated by SE a.s. company and the rest is generated in different ways (own factory generating plants, cogeneration, etc.).

Table 1. Electricity generation and its pollutants production – in Slovakia

		1995	1996	1997	1998	1999	2000	2001	2002	2003
Electricity	(GWh)	22 861	22 007	21 171	22 025	23 425	26 258	27 215	25 639	26 048
SO_2	(tons)	69 389	74 503	69 118	68 197	67 930	40 069	52 702	41 285	46 039
NO_x	(tons)	25 159	24 606	23 428	24 351	23 086	21361	18 687	12 283	11 636
Dust	(tons)	10 532	11 022	11 632	11260	10 013	8 529	7 959	6 680	6 802
CO	(tons)	1 166	1 629	1 566	1 507	1 503	1 278	1 870	2 298	1 236
CO_2	(10^3 tons)	6 811	7 023	6 777	6 846	6 252	5 310	5 434	4 723	5 277

Table 2. Specific pollutants production – in Slovakia

		1995	1996	1997	1998	1999	2000	2001	2002	2003
SO_2	(kg/MWh)	3,04	3,39	3,26	3,10	2,90	1,53	1,94	1,61	1,77
NO_x	(kg/MWh)	0,36	0,33	0,34	0,36	0,34	0,53	0,35	0,30	0,25
Dust	(kg/MWh)	0,42	0,45	0,50	0,46	0,43	0,40	0,43	0,54	0,58
CO	(kg/MWh)	0,11	0,15	0,13	0,13	0,15	0,15	0,23	0,34	0,18
CO_2	(kg.100/MWh)	2,98	3,19	3,20	3,11	2,67	2,02	2,00	1,84	2,03

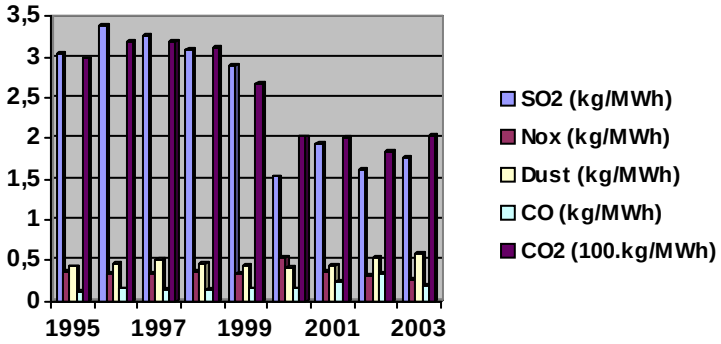

Fig. 6. Development of pollutants production by electricity generation in past few years in Slovakia

In figure 7 we can see comparison of the main resources for electricity generation between Slovakia and other countries. In figure 8 we can see comparison of pollutants production from electricity generation between Slovakia and other countries.

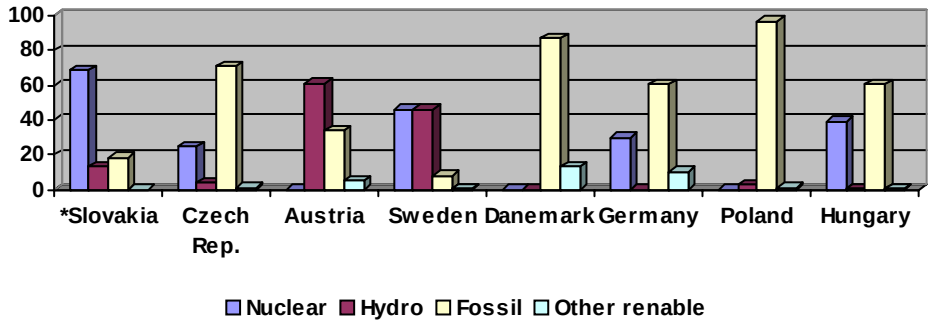

Fig. 7. Electricity production resources for different countries
*** For Slovakia from 2003, for the rest from 2002**

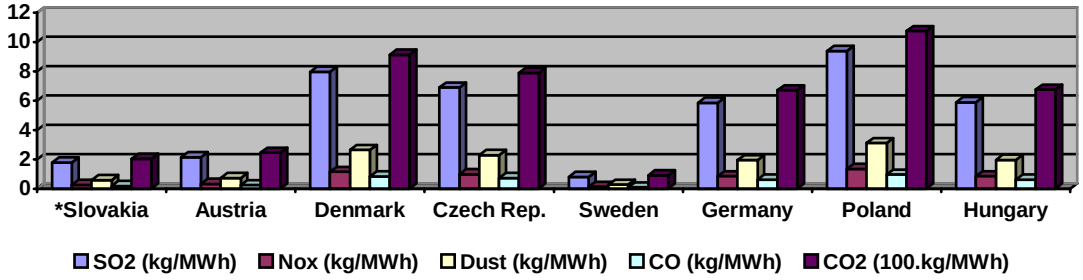

Fig. 8. Pollutants production of electricity generation for different countries
(estimated only on ratio of fossil fuel combusted for electricity generation in Slovakia)
*** For Slovakia from 2003, for the rest from 2002**

5 QUESTIONNAIRE

This questionnaire was realized by SE a.s. in cooperation with Slovak Heat Pump Association and Ing. Marian Rutschek – R.F.C. company in 2003. Its major aims were to investigate people's attitude towards question about heat pump installation and economical background of possible heat pump purchase. This opinion research was realized within the DSM (Demand Site Management) program, which had been processing between 1993 and 1995 by Canadian company BCHydro (British Columbia Hydro), in cooperation with American specialists. Before the questionnaire was handed to the respondents, they had been familiarized with heat pump basics by means of a prospect, because the majority of them didn't even know what a heat pump is and what for it is used. In the questionnaire there were involved 632 respondents from 8 different Slovak regions and also from Internet. 602 of them were laymen and 30 specialists. The questions were as follows:

1. Do you find heat pump applications prospective for heating and hot water heating?
   Yes No I don't know
2.* If he government decreased the tax from 23% to 10% would you install a heat pump?
   Yes No I don't know
3. How much would you invest to buying a heat pump?
   Up to (EURO): 3 750 6 250 8750 11 250
4. What is in your eyes the most important criterion for choosing a heat pump?
   Reliability Price Investment repayment Annual operating costs

* By now there is in Slovakia 19% same tax for all products.

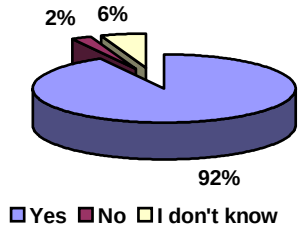

Figure 9a. Answers to question 1

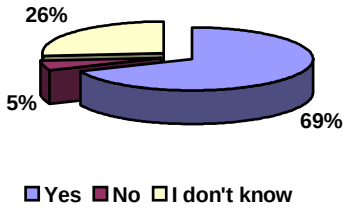

Figure 9b. Answers to question 2

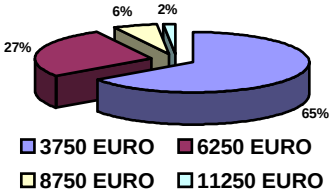

Figure 9c. Answers to question 3

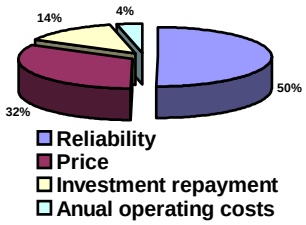

Figure 9d. Answers to question 4

From the questionnaire the results are clear that Slovakians consider heat pumps as a prospective system for heating and hot water heating. Moreover, if there were any support (from government, any funds or electricity generating companies) to decrease the heat pump price to about 4 000 EURO, more than 50 % of Slovakians would buy a heat pump (at present the price of a heat pump in Slovakia is between 5 000 and 7 500 EURO). The most important issue in getting a heat pump is its investment repayment (half of respondents state that), the second important considered is the price (32%) and the third one are annual operation costs (14%).

6 DISCUSSION

What results from the questionnaire?

In Slovakia about 73 500 residences are using electricity for heating and hot water preparation. According to the questionnaire if 50 % of them replaced electric boiler for a heat pump working with efficiency of COP = 3,0, 982 GWh.year of electricity would be saved. And further 2,8 % of all emissions produced by electricity generation would be reduced or 0,6 % of all emissions produced by conversing primary energy resources would be reduced.

Heat pumps in Slovakia and Europe

In Slovakia there are two associations trying to achieve better conditions for heat pump installations: “Slovak Heat Pump Association” and “Slovak Association for Cooling and Air-Conditioning Technology”.

The greatest heat pump nowadays successfully and reliable operating in Slovakia is a heat pump in spa called Vysne Ruzbachy with thermal output of 800 kW. So far up to **100 heat pumps** are used all over Slovakia excluding air-conditioning units. This number sounds ridiculous comparing to the number of heat pump installations in other countries. By year 2000 in Europe about 600 000 heat pumps had been installed. The largest number of heat pumps for space heating were in Sweden with 370 000 units, far ahead from Switzerland (67 000 units), Germany (63 000 units), Austria (33 000 units) and France (30 000 units). But again as results from the questionnaire there is a good potential for heat pump installations also in Slovakia. If there are better understandings from Slovak government and its funds the number of heat pump installations could rise up to 20 thousand in next few years. And this raise can considerably decrease both energy consumption and emissions production.

7 CONCLUSION

In Slovakia there is a great potential of heat pump installations. The average air temperature between 9 and 11 °C (48° to 52° F) in the west-southern part of Slovakia makes this area considerably suitable for installing air source heat pumps. This part of Slovakia with utilizable water quantity of 4 000 to 22 000 l/s also perfectly suits for installations of water source heat pumps. At last all over Slovak country there are many geothermal sources with utilizable geothermal water quantity of 1 000 l/s and the temperature between 20 and 129 °C (68° to 264° F) (direct or indirect utilization of heat pumps).
The environmental quality of electricity comparing with other countries makes Slovakia another advantage in using heat pump for heating and hot water heating and also cooling in summer season.
Finally it is believed that in short time heat pumps will became a trend that would definitely leads to improving the environment and quality of life also in Slovakia.

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NOMENCLATURE

l/s	liters per second
g/l	grams per liter
MW_t	thermal megawatt
°C	degree of Celsius
°F	degree of Fahrenheit
sq km	square kilometer
sq mi	square mile
sq m	square meter
m	meter
mW/sq m	miliwatts per square meter
kg	kilogram
kWh	kilowatt-hour
GWh	gigawatt-hour
kg/MWh	kilograms per gigawatt-hour