FINLAND, A RAPIDLY GROWING HEAT PUMP MARKET

Jussi Hirvonen, M.Sc., the Finnish Heat Pump Association SULPU ry, Lansankallio 16 B, FIN02630 Espoo, Finland, tel. +358-9-4520750, e-mail: jussi.hirvonen@ivtlampopumput.fi

ABSTRACT

The heat pump market has risen tenfold in Finland during the last five years. The outside temperature in Finland, in the extreme North East Country of the European Union, varies from 20-35ºC in the summer to subzero temperatures of -40ºC in the winter. The hard requirements for inside temperature, hot water and ventilation combined with the Scandinavian climate, causes a lot of energy consumption even though the Finnish houses are well insulated.

Energy prices have risen and environmental thinking has gained ground. The heat pump technology and commercial products are very highly developed in Scandinavian countries. The rapid market growth is thus very natural and understandable and no doubt it is supposed to be continued and even quickening.

In Finland heat pumps are mostly used to keep dwelling warm and to heat tap water. Nowadays also air conditioning is wished. As an energy source there is used surrounding ground, rock, water (sea, lake, river) or outside air. Also the exhaust air of the ventilation system is a very good energy source for a heat pump.

Information and education are most important, the technology exists. To produce and disseminate information, to educate installers, sales personnel, consultants, etc, and to keep the quality of deliveries high are the biggest challenges for the heat pump sector.

INTRODUCTION

Heat pump sales have increased by 50 to 100 per cent per year during the last 5 years in Finland. An outlook that this phenomenon were only occasional has not been expressed. This paper explains the backgrounds and requirements for the heating ways and systems of the Finnish houses. The article both deals with development of the heating system market, potential sectors of the heat pumps and reasons for the rapid market growth. The most popular and commercial heat pump types and energy sources are also showed with pictures. And finally to measures to promote heat pumps there is paid attention.

1. THE AVERAGE FINNISH FAMILY USES 20,000 KWH PER YEAR

Five million Finnish people are accustomed to an indoor temperature of 21ºC, regardless of the outside conditions. They also expect hot water on tap, especially for the traditional Finnish Saturday sauna. After sitting in the sauna the whole family and sometimes wife's relatives as well like to take a long hot shower. Finnish people also want to breath fresh air inside their homes so Finnish standards require an air change rate of 0.5 h^{-1}.

The outside temperature in Finland, in the extreme North East of the European Union, varies from 20-35ºC in the summer to subzero temperatures of -40ºC in the winter. The

requirements for temperature, hot water and ventilation combined with the Scandinavian climate means that Finnish families must ensure their houses have a good heating, plumbing and air conditioning. This technology requires 20,000 kWh of energy every year.

Picture 1. A typical Finnish house of 150 m2 uses 20,000 kWh energy to keep dwelling warm and to heat tap water. The outside temperature in Finland, in the extreme North East Country of the European Union, varies from 20-35ºC in the summer to subzero temperatures of -40ºC in the winter.

2. HEAT PUMP MARKET

The energy consumtion for heating houses is high in the Finnish hard climate. Energy prices have risen and environmental thinking has gained ground. The heat pump technology and commercial products are very highly developed in Scandinavian countries. The rapid market growth is thus very natural and understandable and is supposed to be continuing and even quickening.

2.1. HEAT PUMP SALES HAVE INCREASED BY 50 TO 100 % PER YEAR DURING THE LAST 5 YEARS

Huge energy requirements, rising energy prices, environmental considerations and existing reliable technology explain why Finnish families are now choosing heat pumps to heat their new houses. Five years ago only 1% of the new houses used a heat pump. This year over 15% of the Finnish builders are supplying free and non-polluting energy to homes by means of the heat pump. Most of these are brine/water heat pumps, which use as a heat source a vertical or horizontal ground heat exchanger or one of the 200,000 lakes in Finland. The exhaust-air heat

pumps are now entering the market. They are a very attractive alternative because of their low investment and operational cost and small space requirements. On the basis are the high air change requirements of the Finnish houses.

Table 1 shows a cost comparison of various heating systems for new houses in Finland, and their rough market shares in the years 1995 and 2001 and prognoses for the year 2005.

Table 1: Comparison of heating systems for new houses in Finland. Energy consumption, costs for heating and hot water in a typical 150 m^2 house, investment, market shares in the year 2001 and prognosis for the year 2005.

Heating system	Purchased energy (/year)	Operation cost (Euros/year)*	Investment (Euros)**	Market share (%) 1995	2001	2005
Direct electric heating	20,000 kWh	1,300	7,500	60	45	10-30
Electric heating with hydronic distribution	20,000 kWh	1,000	9,500	10	25	10-30
Oil-fired boiler	2,500 litres	1,200	12,000	20	8	0-5
Exhaust-air source heat pump	11,000 kWh	750	9,000	0	2	10-30
Ground source heat pump	6,500 kWh	437	16,000	<1	13	20-40

*) Energy prices: electricity 0.065 Euro/kWh, (0.05 Euro/kWh for electric heating with hydronic system); oil 0.5 Euro/litre.
**) 'turn key' delivery including heating, hot water production and heat distribution system.

2.2. HALF A MILLION HOUSES HEATED DIRECTLY BY ELECTRICITY, GREAT POTENTIAL FOR AIR-SOURCE HEAT PUMPS

Finland has been and still is the promised land for direct electric heating systems. Most of the houses built in the 1970s to1990s have electric radiators or electric floor heating, owing to cheap electricity and the aggressive marketing policy of an electricity supply company. Electricity is the only form of distribution in almost 500,000 houses.

Air-to-air heat pumps are attractive complementary systems for saving energy in these houses. The heat pump can take free energy from outside air at temperatures up to -15ºC and produce directly warmed air for the heating of the house. Indeed half of the heating energy required can be taken from the outside air in Finland. Also air conditioning, which is another feature of air heat pumps, is useful on the hot summer days. The total number of the heat pumps in Finland is 30,000 and 5000 of them are air-to-air heat pumps. Pure air conditioners are not included in the figures.

2.3. RENOVATION MARKET OPENS UP

In the year 2000 oil price in Finland was under 0.2 Euros per litre whereas after that it has been over 0.5 Euros. At least 25,000 water distributed heating systems are in the need of renovation annually. This potential has given rise to considerable optimism in the heat pump field. In future years thousands of oil and electric boilers will be annually replaced by ground or rock heat pumps.

3. HEAT PUMP TYPES AND ENERGY SOURCES

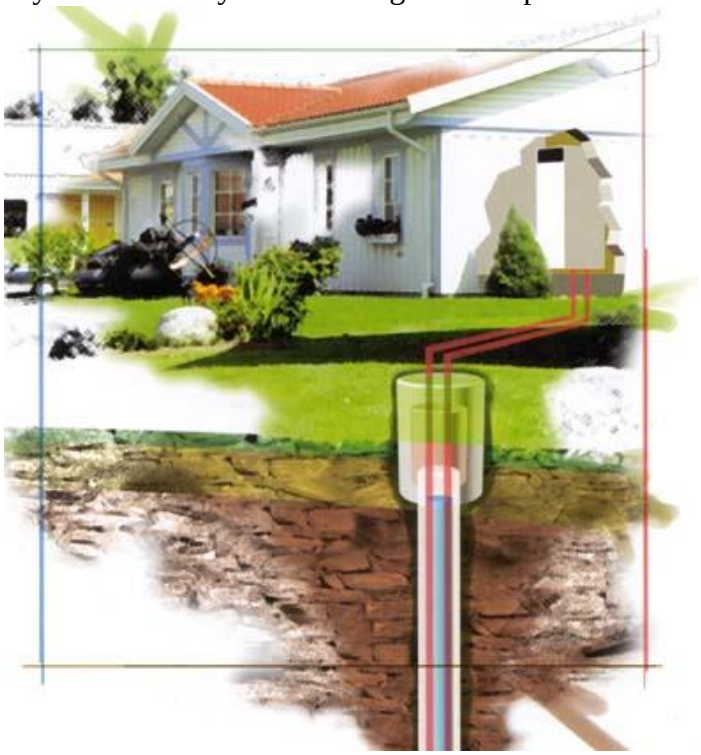
Heat pumps are mostly used to keep dwelling warm and to heat tap water. As an energy source there are used surrounding ground, rock, water (sea, lake, river or ground water) or outside air. Also the exhaust air of the ventilation system is a very good energy source for a heat pump. The heating of the house is usually based on either direct electricity, water or air based delivery system. The heat energy produced by heat pumps is delivered either to water/air based heating of dwelling and/or to heating of tap water.

3.1. WATER/WATER HEAT PUMPS

The ground, rock, lake or see surrounding the house are very good storages of solar or earth energy and so good energy source for heat pump. The energy is collected from the source by a collector pipe (usually plastic) to the heat pump, which produces hot water to distribution system and to heat tap water. As liquid in the collector is usually used water-alcohol mixtures. For the heat pump itself it does not matter where the collector is placed. The heat pump is only interested in the temperature of the collecting liquid.

Picture 2. <u>The ground</u> energy collector pipe has been dug in the depth of 0,8 – 1,2 meter. The depth is depending on the climate circumstances. A typical 150-m2 house has a ground heat pump with the heating capacity of 5-8 kW and 300-400 meters ground collector is in the depth of 1 meter. The minimum distance between pipes is the same as the depth. Associated with the

bigger buildings several collector loops are possible. In new houses the produced heat is generally distributed by floor heating and to tap water tank.



Picture 3. <u>The rock</u> under the house is a good energy tank. The energy collector pipe is put in one or several parallel drill holes with the depth of 100-200 meters (vertical heat exchanger). The collector length is depending among the other things on the energy consumption of the warmed house and the temperature of the rock. The drill hole is a little more expensive, but a very safe, everlasting energy tank and it is not limiting the later use of the grounds. In many cases the drill hole with summertime temperature 8 C is used as a cold source for passive cooling of the house. In some big objects there has been used several parallel drill holes or even fields of tens of drill holes.

Picture 4. <u>The water</u> in the lake, sea or river is also a good solar energy storage and a good energy source for a heat pump. The installed weights are keeping the energy collector pipe in the bottom of the water. The collector in the water can be dimensioned 20-30 % shorter than the ground collector.

In some areas **<u>the ground water</u>** can be lead to heat pumps heat exchanger and used directly or indirectly as heat source.

Typical heat pump capacity for a single house heat pump is 5-10 kW. In blockhouses, district heating and other big buildings water/water heat pump capacities can be hundreds of kilowatts, even megawatts. As an example from Finland's neighbourg country Sweden, The Castle of the King has a heat pump of capacity 260 kW and 6000 m collector in the lake.

3.2. AIR /WATER HEAT PUMPS

Picture 5. <u>Outside air</u> can be use used directly as a heat source of a heat pump down to temperatures –10- -15 C. Air/water heat pumps can be used either for heating the water based heat distribution system or tap water. Mostly these applications are used in the warmer European countries, but some special market has been found for them also in the hard northern climate conditions. Typical capacity is 3-15 kW.

3.3. AIR/AIR HEAT PUMPS

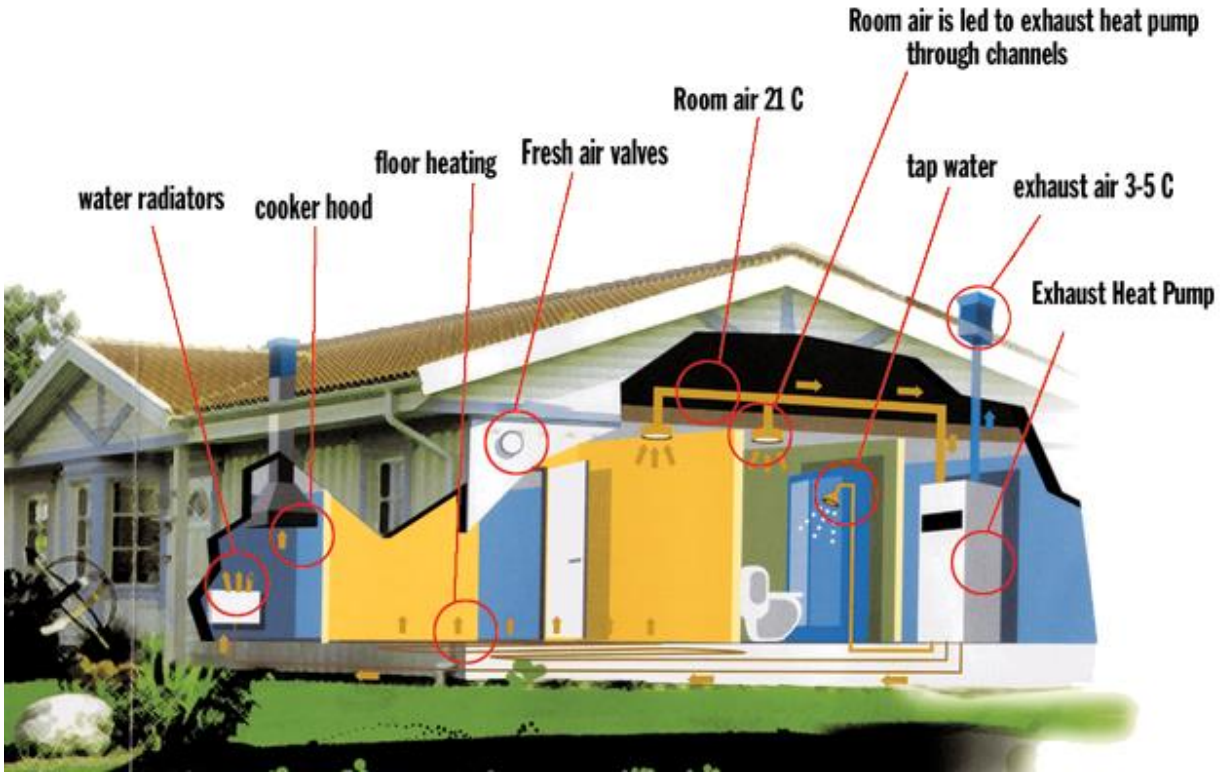
Picture 6. Air/air heat pumps take also their free energy from the **<u>outside air</u>**. They make directly hot air inside the house for heating the house. They manage to take free energy still from

the outside air of temperature -15 C. In northern countries they are often installed parallel to the old direct electric heating system to save energy. Air heat pumps have also reverse function to cool the house. That's why air heat pumps in southern countries are very often air conditioners with heating possibility. Typical capacity for an single room air heat pump is 3-5 kW by outside air temperature of + 7 C. Multisplit units can have heat effect of 6-15 kW.

3.4. EXHAUST HEAT PUMPS

The ventilation requirements demand that the inside air volume must changed even once in two hours. The exhaust air is a very good, warm energy source for a heat pump. The exhaust heat pump lowers the temperature of the exhaust air near to 0 C and produces hot water to heat the tap water and/or to the distribution system. Some pump models remove recovered energy to the incoming air. Exhaust heat pumps are used both in small houses and in big buildings.

Typical capacity for a small house application is 2-3 kW. Big exhaust heat pumps can have a heat capacity of hundreds kilowatts. Almost a half of Sweden's 360.000 heat pumps are exhaust heat pumps and Finnish market is opening up for them.



Picture 7. **Exhaust heat pump** is changing the air volume of the house once in two hours and recovering the heat from the outlet air. Recovered energy is used for warming up water for distribution and for tap water system.

4. INFORMATION AND EDUCATION ARE VERY IMPORTANT, THE TECHNOLOGY EXISTS

To produce and disseminate information, to educate installers as well as sales personnel and consultants, etc. and to keep the quality of deliveries high are the biggest challenges for the heat pump sector. These were the reasons why the 'Finnish Heat Pump Association, SULPU' was set up in 1999. Currently SULPU has 30 members. The author of this article (Jussi Hirvonen, e-mail: jussi.hirvonen@ivtlampopumput.fi) was the first chairman of the board and is also a member of the European Heat Pump Association's (EHPA) Strategic and Planning Committee.

CONCLUSION

The heat pump market has risen tenfold in Finland during the last five years. The outside temperature in Finland, in the extreme North East Country of the European Union, varies from 20-35ºC in the summer to subzero temperatures of -40ºC in the winter. The hard requirements for inside temperature, hot water and ventilation combined with the Scandinavian climate, causes a lot of energy consumption even though the Finnish houses are well insulated.

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In Finland heat pumps are mostly used to keep dwelling warm and to heat tap water. As an energy source is used surrounding ground, rock, water (sea, lake, river) or outside air. Nowadays also air conditioning is already wished during a short, but sometimes a very hot Finnish summer. The reverse function air conditioners start to be a very temting possibilty to supplement the existing heating system. Also the exhaust air of the ventilation system is a very good energy source for a heat pump because of the high air change requirements.

Information and education are most important, the technology exists. To produce and disseminate information, to educate installers, sales personnel, consultants, etc, and to keep the quality of deliveries high are the biggest challenges for the heat pump sector. To reach economical and ecofriendly energy maintainance for houses in future is not only the challenge for the heat pump market actors but also for the EU, state, polticians, European and national heat pump associations etc. The author of this paper (Jussi Hirvonen, e-mail: jussi.hirvonen@ivtlampopumput.fi) was the first chairman of the board of the Finnish Heat Pump Association SULPU ry and is a member of the European Heat Pump Association's (EHPA) Strategic and Planning Committee.

Picture 8. M. Sc. Jussi Hirvonen, The author of this paper, and an exhaust heat pump. Jussi Hirvonen in addition to representing the Finnish Heat Pump Association SULPU is also a member of the European Heat Pump Association's (EHPA) Strategic and Planning Committee.