

Heat Pumps in Europe – an Overview

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Abstract:

Heat pumps can contribute considerably to the reduction of CO₂ emission and of the use of primary energy in the residential, tertiary and industry sectors.

According to data collected by the IEA Heat Pump Centre and EHPA, The European Heat Pump Association there are at present in Europe some 4,5 million heat pumps in the residential sector, 1,5 million or more in the tertiary sector and 25-30 000 in industry.

The heat pump potential in the residential sector is considerable, also taking into account that space and water heating consumes 225 Mto in residential sector, compared to 125 Mto in the tertiary sector. It is believed that 75% of the dwellings in the EU area can be considered as a potential, technical heat pump market.

The target of EHPA is at least 15 million residential units in operation by 2010. This number could save 100 TWh of primary energy per year and reduce the annual CO₂ emissions by 40 million tons.

To achieve this target, a common EU heat pump strategy and national policy plans will be needed in an effort to diminish heat pump barriers and encourage potential buyers.

A consequent energy policy related to the residential sector would of course also encourage potential users in the other sectors, although the use of heat pumps in the industry sector is limited since fast return on investment is a decisive factor.

Introduction

Heat pumps can contribute considerably to reduction of CO₂ emissions and of the use of primary energy in the residential, tertiary and industry sectors. Furthermore heat pumps are a well proven technology using renewable, free energy from the environment to provide space and/or water heating.

Heat pumps are therefore included as one of the measures that should be taken advantage of in the EU directive on energy performance in buildings.

The importance and potential of heat pump in the European context can be illustrated by the fact that space and water heating alone is consuming more than 80% (some 225Mtoe or 2700 TWh) of the energy used in the residential sector and more than 60% (some 125 Mtoe or 1500 TWh) energy used in the tertiary sector within the EU-15 area.

In the residential sector alone 75% of the 150 million dwellings in that area can be considered as a potential, technical heat pump market.

The tertiary sector includes offices, trade, restaurant and hotel buildings, schools, hospitals, sport halls etc. Limited data on heat pumps are available from this sector.

Available data may also be misleading, due to the fact that real heat pumping devices, such as for instance roof top units in offices are often neglected in European heat pump statistics.

In the industry sector return on investment will always be the decisive factor when heat pumps any or any other new installations are considered. For this reason the use of heat pumps in this sector is limited, despite the technical potential for heat pumps in a wide variety of processes. Industrial companies are at large aware of the benefits heat pumps can provide as regards process and environment improvement, but very often energy prices do not justify the installation of a heat pump system. Exceptions are, however, found in the timber and food industries where mechanical recompression systems used for drying have a certain spread.

According to data collected by IEA Heat Pump Center and EHPA, The European Heat Pump Association, there are at present some 4,5 million residential heat pumps in Europe (Southern, Central Western and Northern), 1,5 million or more heat pumps in the tertiary sector and some 25-30 000 in industry.

Residential Heat Pumps

Market development and barriers.

The introduction of residential heat pumps in Europe in the early 80'ies was not much of a success when compared to the development in the US and Japan. Because of increasing oil price in this period, the heat pump market more or less took off in many European countries. In this context should be mentioned the IEA "strategy study" following the oil crisis in 1978 that mentioned heat pumps as one of the measures in an attempt to reduce the oil dependence.

However, a drop in oil prices in the mid 80'ies and last but not least bad perception had a detrimental effect on the heat pump market. The bad perception was largely a result of a fast growing market which tempted incompetent sellers and installers to enter. In many instances the result was low quality installations that did not meet the promised savings. The obvious consequence was frustrated buyers and set-back in sales.

The European heat pump market has also been influenced by other barriers such as limited awareness by decision makers, authorities and politicians, high initial systems costs and low energy prices. Often heat pump systems with reasonably short pay-back periods have not been installed because of the relatively high procurement costs.

A growing market.

The development of the European market during the last years has been illustrated in Fig. 1 with examples from Austria, France, Norway, Sweden and Switzerland. The very positive trend seen in this picture is partly due to the fact that barriers have diminished and that environmental considerations have entered the picture. The trend has been continued in 2001.

Heat pumps and environment.

The environmental aspect stems from the fact that heat pumps are in support of energy policy goals and thus contributes to a sustainable energy supply. This is demonstrated in Table 1 comparing CO₂ emissions from various space heating systems. The ground

source heat pump with a COP =3 is superior to any other system in the table both regarding efficiency and CO₂ emission. The data are based on the latest revision UK SAP (Government's Standard Assessment Procedure).

It should in this context be mentioned that the positive environmental effect of a heat pump can be considerable even if the electricity fed to the system is coming from a fossil fuel power plant. The CO₂-reducing effect is of course dependent on the heat pump COP and the emission of CO₂ from electricity production, i.e. the factor kgCO₂/kWh electricity produced, which is different from country to country.

What is a heat pump.

Different definitions as to what a heat pump really is, are used in different parts of the world. According to EHPA a heat pump (in the residential and tertiary sectors) is a heat pumping device that can be used for space heating and cooling, for space heating alone and/or for tap water heating.

This means that reversible air to air units as well as for example ground source heat pump dumping heat into the bore hole for cooling purposes in warm periods both are defined as heat pumps in spite of their alternative role as air conditioners.

Furthermore, when the impact of such systems on energy use and environment is considered, only the space heating periods are taken into account.

Different European markets

There are at least two different heat pump market zones in Europe. In the South i.e. in Greece, Italy, Spain and Southern France there is a considerable need of air conditioning whereas the need of space heating can be moderate. As a result a large number of reversible air to air units have been installed.

In Central, Western and Northern Europe there is a lesser demand for air conditioning and a pronounced demand for space heating in many areas. This opens the market for a wide variety of very different heat pump system solutions.

Development of COP.

The efficiency of a heat pump is usually expressed by the term COP (Coefficient of Performance, describing the relationship between the energy supplied by a heat pump and energy needed for operating the unit).

Fig. 2 shows the COP-development of heat pumps tested by the heat pump test and training centre Winterthur-Töss (Switzerland) in the period 1993-2000.

It is quite obvious that the COP has increased with the number of units that have been tested, and is highest for the water-source heat pumps and lowest for the air-source units, which should be expected.

The seasonal COP for a heat pump system will in many cases be lower than the COP's in this figure, due to low winter temperatures and other energy consuming units (pumps, etc) in the system.

Statistical overview 1999 and expected market growth.

The EHPA has produced a residential heat pump statistical overview covering units installed in the EU area, Norway and Switzerland by the end of 1999.

The overview is shown in Table 2. The data are largely based on information from the countries in question, with three exceptions, Italy, Spain and Greece. For the three latter countries data are extrapolated from previous (1996) reports from the IEA Heat Pump Centre. Later data (2000) received from Spain indicates a total number of 1,5 million residential heat pumps in that country (i.e. 0,4 million more than in the table)

And that the number of heat pumps sold in Spain in 1999 was 360 000.

The average heat capacity for heat pumps in Southern Europe is around 3kW, whereas the average capacities in the other countries are between 5 and 12 kW. The European average is around 4kW.

In most countries the expected annual market growth is between 10 and 25% with a smaller growth in a few countries.

It can be concluded that at present more than 4 million residential heat pump systems have been installed. These systems represent a total heat production of more than 40TWh per year, primary energy savings of more than 28TWh, and reduced CO₂ emissions close to 10 million tons per year.

In Northern, Western and Central Europe a majority of the heat pumps are installed in new buildings, in spite of the fact the potential retrofit market is much larger. This latter finding (IEA Heat Pump Centre) is based on the fact that the building stock is increased by 2% annually in most countries, whereas 5-6% of the existing building stock is confronted with heating system retrofit every 15-20 years. Switzerland offers an interesting example in this context. Here heat pumps are used for space heating in 40% of all new dwellings and in 4% of the refurbished units. This means that some 80% of the residential heat pumps sold in 1999 were installed in new houses. Table 3 indicates that the number of installed residential heat pumps per capita is by far highest in Sweden and relatively high also in Switzerland, Austria, Norway and Denmark.

Forecast 2010

Based on the same sources as Table 2, the residential heat pump stock in 2010 has been projected at 7,3 million units as shown in Table 4. This stock is expected to save more than 50TWh per year of primary energy and reduce the annual CO₂ emission by almost 20 million tons.

Later information received from Spain indicates that the total European stock in 2010 will be greater than 9 million units, i.e. some 2 million more than indicated in Table 4.

A future heat pump market target

As mentioned earlier, more than 100 million dwellings can be seen as the potential technical market for heat pumps in the EU area. In this context the 9 million installations projected in 2000 represent a modest effort.

From the viewpoint of energy savings emission reductions it is therefore worth while to plan for a considerable greater number of heat pumps to be installed by 2010.

EHPA has to this effect suggested a target of at least 15 million installations. This number could save 100 TWh of primary energy each year and reduce the annual CO₂ emissions by 40 million tons. Such a target would be well in line with the policy behind the EU Green Paper. "Towards a European strategy for the security of energy supply" and the EU directive on energy performance in buildings.

How to reach the market target.

To achieve the EHPA target, a common EU heat pump strategy and national policy plans adapted to the countries in question will be required in an effort to further diminish heat pump barriers and encourage potential heat pump buyers and users. It is in this context essential that heat pumps are accepted as a complement to other renewable energy sources, and that the EU commission promotes and supports heat pump technologies through funding such activities as information and quality assurance.

As to heat pumps vs. other renewable technologies it is worth mentioning that recent data countries like Austria and Sweden demonstrate that heat pumps account for 75 to 80% of the reduction of fossil fuel consumption whereas renewables account for the rest.

Another important task for the Commission would be to integrate heat pumps in European and member state energy policies, and to encourage heat pump deployment through a specific incentive policy. The EHPA is in this context prepared to maintain statistics and conduct market surveys, initiate a programme to increase heat pump awareness and knowledge and encourage education, training and certification.

National attitudes to heat pumps

The extent to which residential heat pumps have been included in national energy and environmental planning differs considerably from country to country. Heat pumps are for instance accepted as one of the renewable energy options in Denmark, Finland, Germany (if electricity is renewable), the Netherlands (except industrial applications), Norway and Switzerland. Also the stage of market development differs considerably. Whereas Sweden and Switzerland have mature markets due to a determined energy policy over years, the heat pump markets in countries like Austria, Finland, France, Germany and Norway are still developing.

In Sweden the policy has been supported by heat pump installation subsidies. In addition particular emphasis has been on information, not only through technical publications, but also in newspapers and on television. Heat pumps are now looked upon as a “natural heating solution”.

From 1993 to 2000 the federal Swiss government developed an intensive program for the promotion of heat pumps for space heating. Incentives were an important part of the program where the target was to replace up to 3,5% of the fossil fuel based energy for space heating by renewable energy. The promotion was a part of the “Energy 2000” programme. In 1999 a program for the promotion of heat pumps in renovated buildings was launched. The “Energy 2000” program has now a successor, “Energie Suisse”. The ambition of this program is to have at least 1000 000 heat pumps in operation by 2010. This would mean that heat pumps are to be installed in 50% of all new houses, in 10% of all renovated houses and replace 10% of all boilers ready for replacement.

Certification systems are needed

An important basis for the success of the heat pump promotion efforts in Sweden, Switzerland and other European countries has been the establishment of certification systems for heat pump sellers and installers. The aim of this system, which differs from country to country is to contribute to:

- Satisfactory agreement between calculated (by the seller) and real energy savings and operating cost.
- Good system design and proper installation work.
- High quality and efficiency of all system parts and components.

In most countries having established such systems the idea is that all personnel responsible for marketing/sales, system design and installation should be certified. As certificate is usually obtained after a course of several days duration and a written examination.

Cost and potential of heat pump heating

Low energy prices which do not fully reflect the external cost of various energies, are a significant barrier against residential heat pump installations in several European countries. This is often related to the fact that even if a heat pump is economically competitive, the energy cost difference is too small to decide for a heat pump system. A relevant question in this context is therefore; what are the real cost of heat pump heating and how do they compare with other systems? The answer to this question will of course differ from country to country.

National, systematic information on cost and potential of heat pump heating are scarce. In many cases the reason for this is that few countries have included heat pumps in their energy planning.

In an attempt to produce a reliable overview the EHPA has suggested to the SAVE Programme to undertake an evaluation where heat pumps will be compared with conventional heating systems. The comparison will take into account economy, energy use and environmental impact. Important elements in the evaluation will be mapping of the heating market in Europe, assessment of the present and potential heat pump markets in Europe, comparison of heat pumps with conventional heating systems where also total systems are considered. Total systems could comprise electricity production + heat pumps as a whole, and for instance use of gas for heating applications with respect to total efficiency as regards energy and environmental impact. Comparisons of this type have been carried out in some countries. Different calculation methods and disparity in presentation of results makes it impossible to compare countries. It is therefore suggested to draw up a European calculation framework which can be used for national assessments.

Heat pumps in the Tertiary Sector

In view of the more than 4,5 million heat pump installations in the residential sector, 1,5 million units in the tertiary sector may look low at first sight. This is not necessarily a valid impression if we take into account total installed heat pump capacities. (Fig. 5 shows stock in various countries in 1966).

The total installed capacity in the residential sector (Table 2) is 14-15000 MW, and the average heat pump capacity 4kW.

The average heat pump capacity in the tertiary sector is higher, and an estimate of 100 kW is hardly on the high side. 100 kW would correspond to some 150 000 MW of total installed capacity, i.e. ten times the capacity in the residential sector.

One of the explanations for the difference between the two sectors may be that larger heat pumps reduce specific investment and hence, heating costs.

Most arguments in favour of heat pumps in the residential sector are also valid for the tertiary sector. Similarly, action in support of increasing the sales in the residential sector will also effect the sales of heat pumps in the tertiary sector. Furthermore, an increasing demand for air conditioning in offices, schools etc. can be met with moderate investments through the installation of "dual purpose" heat pump systems. To some extent the same barriers are found in the two sectors. There are, however, reasons to believe that bad perception hardly has had the same impact in the tertiary as in the primary sector. The reason is that bigger systems often are designed and built/installed by experienced professionals.

It is believed that an improved awareness by decision-makers, architects and entrepreneurs would anyhow lead to an increased number of heat pump installations also in the tertiary sector.

Industrial Heat Pumps

It has earlier been mentioned that low energy prices and hence, low return on investment are the main reasons for the moderate number of industrial heat pump installations in Europe.

Few countries can provide reliable data on the number of heat pumps used in industrial processes today. A survey conducted by IEA Heat Pump Centre (Table 6) indicated that the total number of industrial heat pumps in Europe was almost 19000 in 1996.

This survey did not include Austria, Greece, Italy and Switzerland.

Based on historical market data and information from several other market related sources the annual sales after 1996 has been estimated at 1000. As a result it has been concluded that these European industrial heat pump stock today is in the range 25-30 000.

An industrial heat pump installation can both be process-integrated or added on to a process installation. The largest number of installations is traditionally in the timber and wood industry for drying purposes. The other major applications are in food, chemical, petrochemical, pulp and paper, textile industries and in fish farming (Norway).

The mostly used types of industrial pumps are closed-cycle compression and mechanical vapour recompression machines. COP's for close-compression machines are found in the range 3-6 and for the mechanical vapour compression machines in the range 14-50. These numbers indicate the unique potential heat pumps represent with respect to fuel conservation in industry and agriculture and hence, reduced CO₂ emissions.

At present process heat supply by heat pump is 0,1 to 0,3% in most of the countries in Table 3. Norway stands out with 15%. It is believed that industrial heat pumps world wide can reduce energy consumption for process heating by 2 to 5%.

Conclusion

Heat pumps are contributing considerably to reduction of CO₂ emissions and saving of primary energy. The sales of residential heat pumps in most European countries are expected to increase by 10-25% in the years to come, thus increasing the number of more than 4 million heat pumps today to 8-9 million in 2010.

The aim of the EHPA is that the number in 2010 should be increased to at least 15 million in 2010. This number would save 100TWh of primary energy each year and reduce the annual CO₂ emission by 40 million tons. It is believed that more than 100 million dwellings can be seen as a potential, technical market for heat pumps in the EU area.

To achieve the EHPA target for 2010 a common EU heat pump strategy and national policy plans adapted to the different countries will be required to diminish heat pump barriers and improve heat pump awareness.

It is believed that such initiatives also would encourage potential heat pump users in the tertiary sector.

The use of heat pumps in the industrial sector depends on the extent to which a process heat pump installation gives a satisfactory return on investment.