

EUROPE “HEAT PUMPS - STATUS AND TRENDS”

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Abstract: Heat pumping technology finds wide applications in industry, commercial buildings and residential property. The climate in Europe varies considerably from north to south, as do infrastructures and the age and conditions of building stock. Everything from mature to new markets can be found in Europe. This paper discusses the market and trends for heat pumps in Europe. Although statistics show that the conditions vary widely from one country to another, the overall trend of market growth of heat pumps in Europe is favourable.

Key Words: *Europe, heat pumps, market*

1 INTRODUCTION

Energy prices and each country's energy mix affect the conditions for heat pumps to be competitive with other alternatives, taking into account both economy and environmental impact. Other important factors influencing how and if heat pumps are used are first cost, tradition, knowledge and the condition of existing and new buildings. Research and development, various types of political incentives, requirements for specific minimum levels of energy efficiency and the dissemination of knowledge are all important instruments for encouraging growth of the heat pump market. The fact that climate, the condition of building stock, experience of the use of heat pumps and energy mix all vary widely from one country to another means that Europe is not a homogenous market. This has meant that everything from mature markets, through developing markets to markets with little experience of heat pumping technology, can all be encountered within the borders of Europe. The purpose of this paper is to describe the situation on the European heat pump market.

2 ENERGY IN EUROPE

Europe is dependent on primary energy imports from other regions. (Ramsay 2008) reported that, from 1990 to 2005, the import of gas increased from 150 MToe to over 250 MToe for EU27, and that of coal from 80 MToe to over 120 MToe for EU27. Security of supply and climate change are important questions for Europe. Figure 1 shows energy consumptions in buildings, industry and transport.

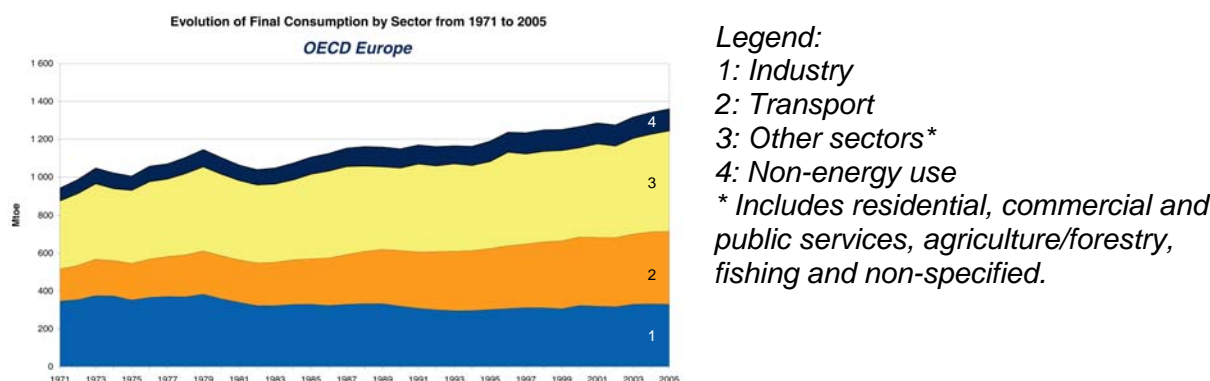


Figure 1: Energy consumption by sector Europe 27, (IEA 2008).

Electricity consumption is increasing in Europe and increased by over 27 % between 1994 and 2005, (Eurostat 2008). Buildings are the largest energy user, with electricity supplying over 50 % of the total energy used in buildings. 63 % of all electricity production in the EU is based on combustible fuel, 22 % on nuclear power and about 13.3 % on hydro power: see Figure 2. Geothermal, wind solar and other energy sources contribute only 1.5 % to electricity production. From 2006 to 2007 total electricity production grew by 3 %. Combustible fuel use grew by 6.9 %, driven mainly by a sharp 11.3 % growth in OECD Europe. Geoth./Wind/Solar/Other grew by 9.0 %, with the largest growth of 11 % occurring in OECD Europe, (IEA Monthly Electricity Statistics, December 2007).

The energy mix for electricity production in Europe varies. Within the EU, Luxemburg and Austria have the highest proportion of hydro power: in the wider OECD, Norway and Iceland occupy top places with almost 100 % hydro power. Nuclear power production dominates in some countries, such as France, although Sweden and Switzerland also have relatively high proportions of nuclear power. Waste incineration provides a relatively high proportion of electricity production in (particularly) Belgium and The Netherlands, although it is also commonly used in Denmark and Germany. Natural gas supplied 24.2 % of total energy use in the EU states in 2005: see Figure 3. Its proportions vary from about 1 % in Portugal and Ireland, to almost 40 % in the UK. District heating and district cooling are further alternatives for heating and cooling. Heat pumps may be used in both types of systems on the supply side: those supplying cooling often, in fact, use the district heating system as their heat sink. The following European countries have substantial district heating systems: Austria, Denmark, Sweden, Finland, Germany, Poland and France.

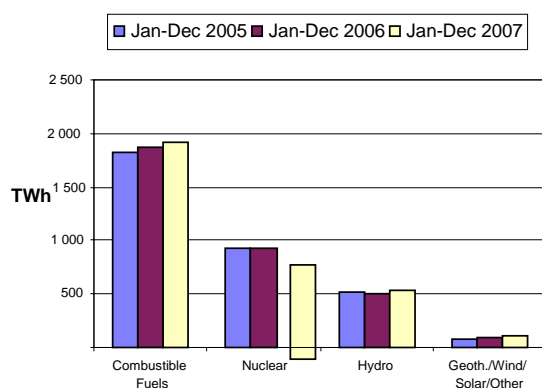
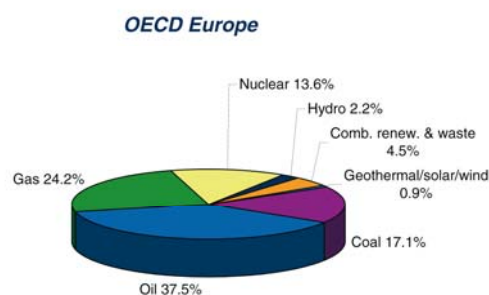


Figure 2: OECD Europe electricity production, (IEA 2008).

Share of Total Primary Energy Supply* in 2005



*Share of TPES excludes electricity trade

1 876 Mtoe

Figure 3: Share of total primary energy supply in 2005 for OECD Europe, (IEA 2008).

Shares of under 0.1% are not included and consequently the total may not add up to 100%.

The competitiveness of electrically driven heat pumps depends on the electricity price in comparison with other energy sources such as natural gas, oil or biofuels. The price of electricity in comparison with other energy sources varies, as do the electricity prices from one country to another and from one customer category to another. Despite the ongoing harmonisation of the electricity and gas markets, there are substantial differences between European countries today in these respects. Historically, energy prices have been low, which has not encouraged improvements in the efficiency of energy use to the extent that would have been desirable. However, trends over the last five years show that prices have risen. Energy prices have in general increased by more than 50 % from 2007 to 2008 in Europe. For example, the price of oil for both industry and the building sector has increased from 40 % to over 60 %, with variations from one country to another, (IEA Statistics, 2008).

3 ENERGY AND CLIMATE POLICY FOR EUROPE

In January 2007 the European Commission put forward an integrated energy/climate change proposal that addressed the issues of energy supply, climate change and industrial development. Two months later, the European Heads of State endorsed the plan and agreed to an Energy Policy for Europe. The action plan runs for a six-year period from 1 January 2007 to 31 December 2012. The objective is to control and reduce energy demand and take targeted action on consumption and supply in order to save 20 % of primary energy by 2020 (compared to the energy consumption forecasts for 2020).

The plan calls for a:

- 20% increase in energy efficiency by 2020
- 20% reduction in greenhouse gas emissions by 2020
- 20% share of renewables in overall EU energy consumption by 2020
- 10% biofuel component in vehicle fuel by 2020

These targets are very ambitious: today 8.5 % of energy is from renewable sources. Three sectors are affected by renewable energy: electricity, heating and cooling, and transport. It is up to the member states to decide on the mix of contributions from these sectors to reach their national targets, choosing the means that best suit their national circumstances. They will also be given the option of achieving their targets by supporting the development of renewable energy in other member states and third countries. The biggest potential energy savings can be found in the following sectors: residential and commercial buildings, with savings potential estimated at 27 % and 30 % respectively; manufacturing industry, with the potential for a 25 % reduction; and transport, with a potential for a 26 % reduction in energy consumption. Heat pumping technology has a high potential for contributing to energy savings both in the building sector and in the industrial sector.

4 DIRECTIVES AND LEGISLATION INFLUENCING MARKET AND DEVELOPMENT

A number of European directives are expected to influence the market and development of heat pumping technology in Europe.

4.1 Refrigerants

The most common refrigerants used in heat pumps produced in Europe today are R407C and R410A, although R717, R404A, R507, R134a and R290 (propane) are commonly used for refrigeration and air-conditioning. R22 is still commonly used, but the use of "virgin" R22 for refilling is banned. All R22 systems should be converted before 2010. R744 has attracted growing interest in the automotive industry. A smaller number of transcritical systems are installed in supermarkets in the Nordic countries, and the Eco Cute concept for domestic hot water production has been introduced on the European market. The F-gas regulations came into force in August 2006. For the European refrigeration and heat pump industry, it applies to the use of all HFC refrigerants. The directive includes mandatory requirements for leakage checking of all installations containing more than 3 kg of refrigerant, and for all personnel performing leakage checking to be individually certified, as must also be companies performing installation, maintenance or servicing. The F-gas regulations have a time schedule for implementation and will be completed in July 2009.

4.2 Energy conservation

In order to improve energy performance, a number of directives are under implementation or have already been taken into force on a European level. The Directive on the Eco-design of Energy-using Products (EuP), 2005/32/EC, such as electrical and electronic devices or heating equipment, provides coherent EU-wide rules for eco-design. Products that fulfil the requirements will benefit both businesses and consumers, by facilitating free movement of

goods across the EU and by enhancing product quality and environmental protection. The Directive constitutes a breakthrough in EU product policy and introduces many innovative elements together with concrete application of the principles of the "better regulation" package. The first step includes 14 groups of products, among which are two directly related to heat pumping technology: air conditioners and food display cabinets.

The Directive on the Promotion of End Use Efficiency and Energy Services, 2006/32/EC, is intended to enhance the cost-effective and efficient end use of energy. Member states must adopt them and aim to achieve an overall national indicative energy savings target of 9 % by the end of 2016, to be reached by means of energy services and other energy efficiency improvement measures. Member states must take cost-effective, practicable and reasonable measures designed to contribute towards achieving this target. Implementation at national level can influence the competitiveness of heat pumping technology in comparison with other competing technologies. The overall objective of the Energy Performance of Building Directives, EPBD (2002/91/EC), is to promote improvements in the energy performance of buildings. Each EU state is required to convert the directive into national law by mid-2006, and to achieve 9 % savings in energy consumption over the nine years beginning in 2008. This will increase the need for energy conservation improvements in buildings, which will most likely favour heat pumping technology, while national implementation can also raise need for further development of the efficiency of future heat pumps.

The European Eco-label, (Directive 2007/742/EC), is a voluntary tool. The criteria for electrically driven, gas driven or gas absorption heat pumps were adopted in November 2007. They include following minimum efficiency for heat pumps up to 100 kW. If refrigerants with a GWP less than 150 are used, the required minimum energy efficiency (COP and EER) will be reduced by 15 %. This decision recognizes that GWP alone does not satisfactorily describe the climate impact of a greenhouse gas. A proposal for the promotion of the use of energy from renewable sources for heating and cooling was published on 23rd January 2008. In this proposal ground- source heat pumps are defined as renewable. Heat pumps using ambient air must meet the minimum requirements for coefficient of performance, COP, established in EU Directive 2007/742/EC (Eco label). This means a COP of 3.1 at an outdoor condition of +2 °C for a low-temperature system having an outlet temperature of +35 °C. Since 2002, there has been an EU-wide ban on the disposal of sorted combustible waste material in landfill, described in the EU's Waste Incineration Directive (2000/76/EC). with increased waste incineration Thermally-driven heat pumps, in combination with district heating, or in combination with flue gas condensation will have a large potential.

5 BUILDINGS IN EUROPE

Energy use in buildings accounts for 40 % of energy use in Europe, with about 70 % of this relating to the residential sector.

5.1 Residential buildings

The greatest challenges, and also the greatest potentials, are presented by the retrofit market: for example, France there is 28 million homes, of which 14 million are single-family houses, (Barbouchi, 2006). The new building construction rate is only 1-2 % of new single-family houses, while 300 000 owners per year renovate their heating systems in existing single-family houses. 60 % of single-family houses in France have hydronic heating systems. The situation is more or less the same in Germany, according to IEA HPP Annex 30, the challenge is that most of the older buildings have high-temperature hydronic systems (Laue 2006). Another challenge is the relatively large number of houses in Europe without central heating systems.

The annual refurbishment rate for heating systems is relatively high, according to (Eurostat 2001). Eurostat reports a total annual refurbishment rate of almost 4,9 million units in the

EU 25, Norway, Switzerland and Liechtenstein. The UK is top of the list, with an annual replacement 1.0 million units, followed by France with 0,88 million units; Germany 0,7 million and Italy 0,4 million units. The total stock of one/two family houses in the EU 25, Norway, Switzerland and Liechtenstein is almost 98 million. The end use of energy in existing residential buildings varies from over 300 kWh/m²a down to 30 kWh/m²a, with a weighted average of around 180 kWh/m²a. Today, there are several different definitions for low-energy buildings, and different actions have started at national levels to encourage further construction of low-energy buildings, both for the new and for the retrofit market. In Germany, Austria, Norway, Sweden and Denmark, low energy building been more or less synonymous with 'passive houses'. 'Passive House' is a trade mark of the Passive House Institute, and passive buildings aiming to comply must have a heating energy consumption that should not exceed 15 kWh/m²a. Preheating of ventilation air and heat recovery are necessary, but final heating can be provided by any desired system. In Switzerland, the MINERGIE definition is used both for retrofitting and for new buildings. For retrofits, energy consumption should not exceed 80 kWh/m²a, while for new buildings it should be 40 kWh/m²a or lower.

5.2 Commercial buildings

Commercial buildings generally have high internal heat sources due to daylighting and lighting, occupants and equipment used. Supermarkets are among the most energy-intensive buildings in the commercial sector. It has been estimated that 3-5 % of the total use of electricity stems from supermarkets in industrialised countries. There is a need further to improve energy efficiency in this sector. Other commercial buildings, such as shops and offices, have a cooling demand more or less year round caused by internal loads. Improved building envelopes and increasing internal heat releases move the border for cooling to lower outdoor temperatures, so the buildings have to be heated and cooled in winter time – heat has to be shifted from one part of building to another, which is possible only with heat pumps, and cooled during the summer time - again, a task for heat pumps.

6 HEAT PUMPS FOR BUILDINGS

6.1 Ground-source heat pumps

The use of the ground as a heat source has attracted growing interest. One reason is the more uniform temperature throughout the year. In addition, it is possible to use the ground for “free cooling” and for thermal storage. Ground-coupled systems are therefore competitive for large buildings having both heating and cooling demands. Systems with ground heat sources/sinks, in combination with other heat sources such as solar heating, have become more popular in Europe in order to improve the overall system efficiency by recharging the energy wells. There are various types of national obstacles throughout the EU, and IEA HPP Annex 29 has investigated barriers for further deployment of ground source-heat pump systems. The main outcome is that it is still a lack of trained well drillers and installers in emerging markets and in rapidly growing markets such as Germany and France. There is also a lack in drilling capacity. Other difficulties may be physical, such as unsuitability of the rock for drilling, or legal, such as ownership of the bedrock. Most countries in Europe require some form of application for a licence before an individual property-owner can install a ground-source heat pump. Further difficulties that may be encountered include a recommendation for a certain minimum distance between boreholes in order to prevent energy wells from affecting each other thermally, which can be a practical limitation in urban areas. For natural recharging of boreholes; if the area is not sufficient, the temperature of the borehole drops or artificial recharging is required, either with the surplus heat from cooling operations or from other sources such as ventilation or solar heat. In some areas, horizontal earth collectors can be an alternative to vertical boreholes. Work is in progress on

the development of collectors for improving the efficiency of such systems in small plots, and to reduce the cost of installation.

6.2 Air source heat pumps and air conditioning

Generally, air as the heat source is particularly common in central and southern Europe, but has shown itself as an attractive alternative in northern Europe as well. However, it is important that such systems have effective control strategies for defrosting. Heat pumps of this type can be divided into two categories: air/air and air/water. The advantage of an air/air heat pump is that it is independent of the existing heating system in the house, and that it can be used for both heating and cooling. Its drawback, on the other hand, is that it cannot be used for domestic hot water production, and the thermal comfort that it delivers is not as good as that of an air/water unit connected to a central heating system. Air-to-air systems are widely installed in southern Europe because of their ability to supply air conditioning in the summer. Interest in systems of this type has increased dramatically in the Nordic countries over the last few years as a response to rising electricity prices. They offer an interesting alternative for houses with direct electric heating, as their investment cost is relatively low in comparison with other heating alternatives. Interest in air/water heat pumps has been greatest in central Europe, and the market has expanded significantly over the last three years. One explanation for this is a lower cost for installation.

Table 1: All air conditioners expressed in thousands of units (source: JRAIA)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Actual	Actual	Actual	Actual	Projected	Forecast	Forecast	Forecast	Forecast
World total	41,874	44,834	*46,840	54,379	58,147	60,422	62,97	65,663	68,654
Japan	7,791	8,367	7,546	7,307	7,679	7,5	7,5	7,5	7,5
Asia (excl. Japan)	13,897	16,637	*17,761	23,65	26,43	28,312	30,34	32,524	34,881
Middle East	1,673	1,73	*1,804	2,218	2,366	2,515	2,604	2,66	2,717
Europe	2,907	2,918	*3,412	4,359	4,799	5,087	5,382	5,694	6,118
North America	12,322	11,894	12,91	13,075	12,876	12,881	12,889	12,897	12,905
Central & South Ame	2,109	1,939	*2,036	2,243	2,331	2,418	2,473	2,53	2,592
Africa	664	758	700	814	850	885	915	944	978
Oceania	512	593	671	712	815	825	868	913	963

Table 2: Room air conditioners expressed in thousands of units (source: JRAIA)

	2000	2001	2002	2003	2004	2005	2006	2007	2008
	Actual	Actual	Actual	Actual	Projected	Forecast	Forecast	Forecast	Forecast
World total	31,538	34,695	*36,212	43,352	46,559	48,655	50,967	53,409	56,126
Japan	7,084	7,638	6,898	6,633	6,931	6,8	6,8	6,8	6,8
Asia (excl. Japan)	12,034	14,593	*15,558	21,187	23,733	25,448	27,295	29,284	31,429
Middle East	1,339	1,394	*1,475	1,878	2,001	2,13	2,212	2,259	2,308
Europe	2,48	2,477	*2,958	3,93	4,324	4,592	4,861	5,149	5,543
North America	5,586	5,581	6,235	6,3	5,945	5,945	5,947	5,949	5,951
Central & South Ame	1,959	1,793	*1,864	2,054	2,135	2,218	2,269	2,323	2,381
Africa	623	714	651	763	795	827	854	881	912
Oceania	433	506	572	607	696	696	730	765	802

The market for air conditioners is growing all over the world, and also in Europe. Tables 1 and 2 above show an increased market for air conditioners in Europe, and particularly for room air conditioners. The figures apply to air conditioners for residential and commercial use, and each product, which may be provided in more than one assembly, is designed to be used as a unit. (It is direct-expansion air conditioners that are the object of these figures. They include heating and cooling equipment which employs heat pumps.) Room fan-coil units and central air-handling units, both of which are used for water chillers, are excluded.

6.3 Heat pumps for heat recovery

Waste heat from various types of industrial processes can provide a heat input to absorption heat pumps or compressor heat pumps. Sewage water is used both untreated and cleaned

as a heat source for heating and cooling of buildings. Another application is to recover heat from the exhaust air from mechanically-ventilated residential buildings. Exhaust air heat pumps are very common in newly built houses in Sweden, with over 90 % of all new builds having such a heat pump installed. With European actions towards low-energy houses and passive houses, it is necessary to have a heat recovery system in the house. Compact units for low-energy houses are increasingly being introduced on the market in Austria, Germany and Switzerland. Such systems commonly provide preheating/precooling of supply air, further heating in a heat recovery system and finally end heating of the air, perhaps with a heat pump: see Figure 4.

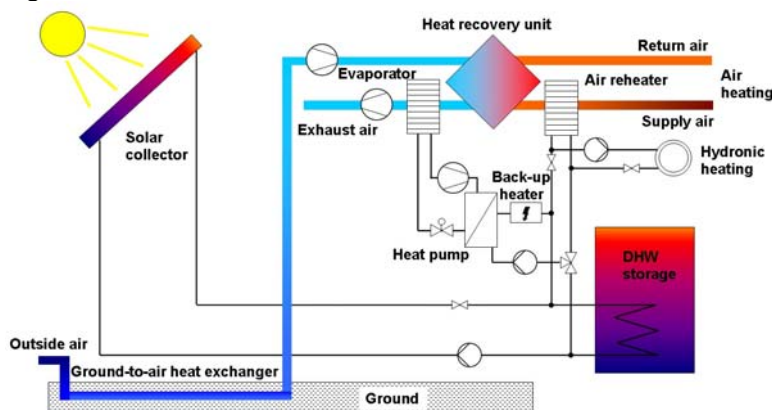


Figure 4: Compact units for low energy buildings, (Source IEA HPP Annex 32)

7 HEAT PUMPS FOR INDUSTRIAL APPLICATIONS

Industrial heat pumps include heat pumps for air conditioning, industrial processes and high-temperature heat pumps for process integration. They can provide a number of process-related benefits, including reduced energy consumption for process heating, increased capacity of existing process heating systems, improved plant-wide environmental performance, expanded production capacity through de-bottlenecking, and improved product quality. Despite these potential benefits, the number of industrial heat pumps installed to date is relatively low in comparison with the number of existing technically and economically viable opportunities. The greatest barrier to further installations, and also to the operation time for existing plants, is the relationship between fuel prices and electricity prices. In Sweden, large industrial heat pumps, recovering waste heat from industrial processes, are also widely used for district heating, supplying around 40 TWh in the residential sector and about 6 TWh in the industrial sector, (Energy in Sweden 2007). There is still a large potential for recovering waste heat from industrial processes. However, one barrier is the distance between the source (location of industry) and the load in the residential area, while another is long-term availability. New large heat pumps for district heating have been installed in Norway. An 18 MW heat pump system in Norway, utilising untreated sewage as its heat source, was installed in Oslo by Viken Fjernvarme, (Pedersen, 2006). In the agricultural sector, Greenhouse" is cooled ("free cooling") in the summer and the heat is stored in a thermal storage. The heat is upgraded with heat pumps and utilised by surrounding buildings during heating season. (Kleefkens, 2008).

8 R&D DEVELOPMENTS

Research in advanced heat pumping technology is ongoing all over Europe. The main drivers are reduced environmental impact, improved energy efficiency and increasing market growth. Leakage-free systems and systems with lower charge contents are of interest as is, for example, further development of compact heat exchangers. This topic is covered by IEA HPP Annex 33. Efficient heat pumping technology using refrigerants with low GWP, such as

natural refrigerants, is attracting growing interest. Heat pump systems with capacity control by means of variable-speed drive for single family houses are now available on the European market, and ongoing R&D activities aim at improving the efficiency even further. The trend show an increased use of air as the heat source, and R&D is concentrating on improving the system efficiency. There is still room for further improvement of ground-coupled systems, both in terms of reducing the first cost and of further improvement of system efficiency. Other ongoing activities are improved variable-speed heat pump systems, economisers, two-stage systems including desiccants, hybrid air-conditioners/dehumidification with DEC, cooling with compression and regeneration with excess heat. Less traditional heat pump cycles are also being investigated, such as thermo-acoustic cycles, magneto-caloric cycles etc.

9 MARKET DEVELOPMENT FOR HEAT PUMPS

Market growth has been high, but Europe is still a diversified market, ranging from emerging to mature markets. Subsidies have played an important role for market growth in many countries, and will be important in the future, especially for emerging markets. In some countries, energy utility companies have played a key role in developing the heat pump market through promotion, active marketing, and offering financial incentives. Different labelling schemes for products and installers have been developed at both national and European levels, such as DACH. Increased knowledge of the technology, and training of installers, are important for future market growth.



Figure 5: Market development in Europe, (Groundreach 2008).

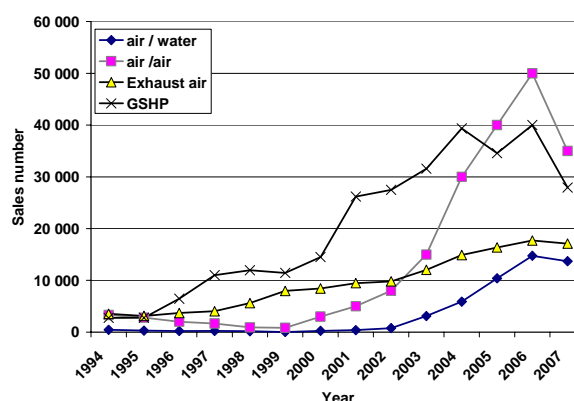


Figure 6: Market development in Sweden, (SVEP 2008)

Sweden is by far the largest heat pump market in Europe, with sales having grown strongly every year during the last decade. However, sales in other markets such as Germany, France, Finland, Switzerland, Austria and Norway are starting to increase, accompanied by significant signs of a growing interest in the technology from large European companies: see Figure 5. The development of almost any market can be characterised by different phases of market penetration and acceptance by different groups of consumers. At present, most European markets for heat pumps are focused on the new housing segment. The only exception to this is Sweden. Today more than 690 000 heat pumps for heating applications are installed in Sweden. The market is mainly retrofit, with most sales being for replacement of oil firing (Forsén, 2008). This is the explanation for the decreasing sales figures for 2007, as shown in Figure 6. The expected growth for heat pumps in Sweden is in larger buildings, such as offices and multi-family houses. The Norwegian market for heat pumps has experienced a tremendous growth during the last seven years, (Baardsen, 2006). The most popular type of heat pump is the air-to-air type, mainly because there are a lot of older single-family houses without central heating systems. The growing interest is driven by higher electricity prices, the availability of subsidies since 2003, and a long-term effort from market actors over several years to establish a favourable image for heat pumps.

The Austrian heat pump market for heating increased by 45 % in 2006, mainly because of the increased interest for environmentally friendly technology, (Höller, 2007). The market is concentrated on new buildings, because they offer ideal conditions for heat pumps, due to high building standards and low-temperature hydronic systems. The most popular (71 %) are ground-coupled heat pump systems, followed by air/water (18,3 %), and with the most important application being for heating. See Figure 7.

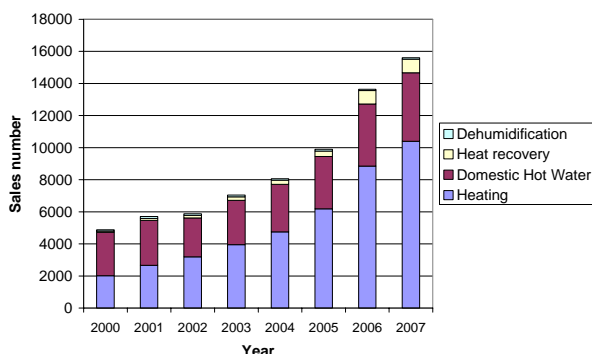


Figure 7: Market in Austria, (Fanningner 2008).

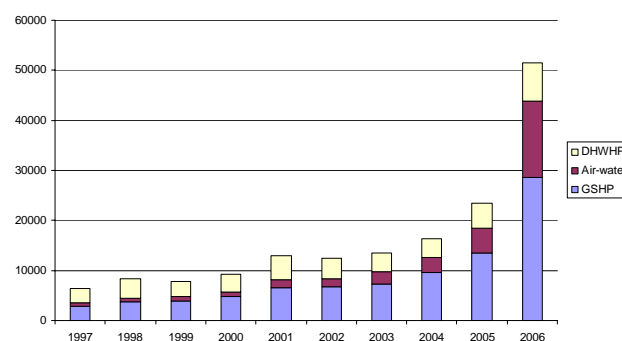


Figure 8: Market in Germany, (IZW 2008).

The long winter of 2006, in combination with further increases in energy prices and the considerable media attention given to climate change, resulted in a 120 % growth in heat pump sales in Germany. See figure 8. This dramatic increase would have been even higher if it had not been held back by bottlenecks in terms of lack of drilling capacity and, at times, of production facilities to keep up with the demand. The German market has grown on its own merit without financial support from the authorities. The heat pump industry has a strong ally in many of the electric utilities that promote the benefits of heat pumps. The utilities have identified a business opportunity in a sector that was formerly ruled by the oil and gas Industry. Some of the utilities offer special heat pump tariffs that are favourable to the consumer.

Table 3: Heat pump sales in France, (Source AFPAC)

Heat Pump sales	2002	2003	2004	2005	2006	2007	2006 vs 2007
GSHP DX / Gnd DX	5100	5400	6800	7800	9600	9600	0 %
GSHP DX / Water							
Brine / Water	2900	3600	4900	5400	8850	9000	2 %
Water / Water							
Air / Water	4400	4700	5600	12000	35060	51000	45 %
Air / Air (*) ADEME estimation	No data available			7500*	12000*	16000*	
Total (excl. Air / Air)	12400	13700	17300	25200	53510	69600	30 %

The French market grew by 112 % in 2006, to a total number of 53 510 heat pump installations: see Table 3. Air/water heat pumps show the largest growth, at 139 %, and it is expected that this segment will overtake ground-source heat pumps quite soon (IEA Heat Pump Newsletter, 2007). Since 1997, a new market impetus has been initiated by EDF (Electricité de France), in association with ADEME (French Environment and Energy Management Agency) and BRGM (French Mining and Geological Research Board). The emphasis has been on a controlled development of the market, based on quality, in order to avoid repeating the mistakes of the past. In 2005, public authorities introduced a strong subsidy scheme, expected to run until the end of 2009.

The Dutch market is growing very rapidly. New manufacturers are coming on to the market concentrating on existing buildings. A financial support scheme will be launched by the second half of 2008 (Kleefkens 2008). Heat pumping technology can offer high system

efficiencies and relatively short payback times for commercial buildings having both heating and cooling demands. Almost 60 % of new large buildings in The Netherlands are equipped with heat pumps and aquifer cooling: coefficients of performance, COP, above 5.5 have been reported (Kleefkens 2008). Also in Italy a financial support scheme is launched by the Ministry for Economic Development for replacement of old boilers with high efficiency geothermal heat pumps. The support can arrive up to 55% of the investment costs. The average annual market growth in Switzerland has been 12 % since 2000 (Rognon 2008). Today, heat pump systems are the commonest heating system for new installations, as shown in Figure 9. Most of the installations are still performed in new buildings: see Figure 10. The potential is still large, with more than a million oil-fired boilers for sooner or later requiring retrofit replacement. The greatest potential for new buildings is in larger buildings with a heating demand above 50 kW, and in commercial buildings with both heating and cooling loads.

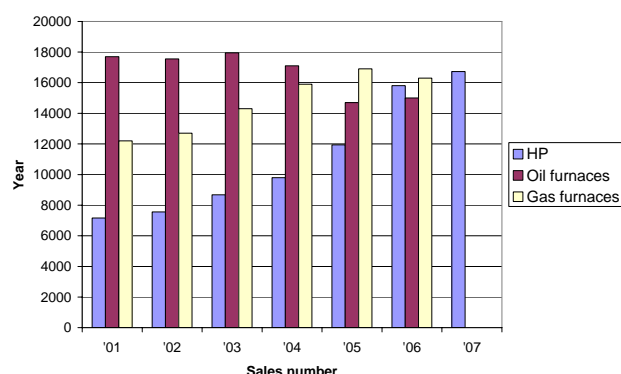


Figure 9: Switzerland new installations, (Rognon 2008).

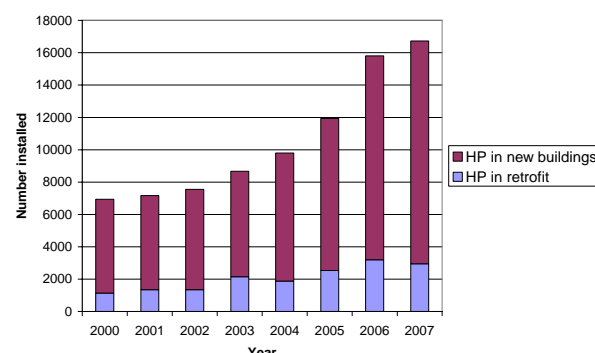


Figure 10: Market in Switzerland, (Rognon 2008).

10 DISCUSSION

Interest in energy conservation has increased, and Europe has an action plan for energy and climate which is expected to favour the market growth of heat pumps in Europe. Although heat pumps are not a renewable technology, they are an efficient technology for upgrading renewable heat sources. However, there is still room for further research and development to improve system efficiencies.

Reversible air-to-air heat pumps, bought mainly for heating, have shown remarkably successful market growth in Norway and Sweden. One of the main reasons for this market growth is the large number of single-family houses without central heating systems. (Karlsson et al., 2006) report that the air-to-air heat pumps have become more efficient. Prices have also fallen, so that the expected payback time has been reduced by about 30 %. Although heat pumps have become more efficient on average, the spread is wider, i.e. the difference between the best and worse was greater in 2005 than it was in 1991. The results show that the performance of defrost systems seems to have been improved, but there is still room for improvement. The study also shows the importance of using SPF, Seasonal Performance Factor, for evaluation of the best products on the market. A heat pump with peak performance at +7 °C does not necessarily have the best performance on an annual basis. Performance should be measured under a range of conditions, and a theoretical SPF calculated from the results.

The greatest potential for heat pumps is the retrofit market. In nearly all European countries, most installations are in new buildings with low-temperature hydronic systems, which are favourable for heat pump system efficiencies. Interest in retrofitting has, for example, resulted in the ongoing IEA HPP Annex 30, aiming at investigating the availability,

technology, economy, ecology and possible R&D trends of heat pump systems for retrofit applications to provide energy-efficient space heating and tap water heating systems in existing residential buildings. In addition, of course, they will provide the further benefit of drastically reducing fossil energy consumption and the related greenhouse gas emissions. The project is operated by Germany, with participants from France and The Netherlands. (Laue 2006) reports that there is a need for a new generation of heat pumps with improved efficiency at delivery temperatures up to 65 °C, or development of cost-efficient hydronic systems, so that hydronic systems can be retrofitted in combination with installation of a heat pump for improved system efficiency.

New European directives will encourage the market to move towards new buildings in the form of low-energy buildings and passive houses. This is definitely the correct way forward for energy conservation, starting with decreasing energy demands in buildings. But there is also a risk that internal loads from more domestic electronic equipment and solar radiation will increase the need for cooling, especially in southern Europe. Heat pumps can provide heating, cooling and domestic hot water production from the same system. There is a need for further research and development to design heat pump systems for low-energy buildings. The objective of the ongoing IEA HPP Annex 32, operated by Switzerland with participation from Austria, Canada, Germany, Japan, The Netherlands, Norway, Sweden and the USA, is to focus on cost-efficient heat pumps for low-energy buildings.

Thermally driven heat pumps for heating and cooling applications have attracted growing interest. The objective of the new IEA HPP Annex 34 is to reduce the environmental impact of heating and cooling through the use of thermally driven heat pumps. This is an area of significant interest for European countries such as The Netherlands, with an infrastructure with gas grids, and also for countries with district heating systems in combination with waste incineration. The economic, environmental and energy performance of integrated thermally driven heat pumps in cooling and heating systems in a range of climates, countries and applications will be quantified, and the greatest market potential will be identified. The project is operated by Germany with participation of the USA, The Netherlands and Austria.

The air conditioning market has doubled between 2000 and 2008, with no sign of any fall-off in market growth. In order to achieve the European energy and environmental targets, it will be important to install the best available technology. The air conditioning market has been identified as important by a number of European directives, such as the EPBD, with its demand for inspection of air conditioning systems, and the eco-labelling scheme.

11 CONCLUSION

The situation has probably never been better than now, with a European focus on energy conservation and renewable energy. Energy prices are expected to increase even more. Possible threats are;

- Changes in the price relationship between gas, electricity, oil and other fuels.
- Too much protection against drilling can be a barrier for ground-coupled heat pump systems.
- The market growing too rapidly, with a risk that poor-performance heat pump systems are installed by less serious players on the market

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