MARKET STATUS FOR GROUND SOURCE HEAT PUMPS IN EUROPE

Deliverable 2 Ground-Reach

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Market status for ground source heat pumps in Europe

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1 Impediments to renewables

The market for ground source heat pumps is, so far, only well established in a small number of the European countries (Sweden, Germany, France, Switzerland and Austria). Other countries like the UK, Ireland, Finland, Poland and the Netherlands show a great potential, but have not yet been able to gain a self-sustaining market. There are a number of countries, within the European Union, that face a real challenge in meeting their Kyoto targets. Ground source heat pumps present a technology that has proven to be very effective in reducing green house gas (GHG) emissions as well as being energy efficient and cost effective for the consumers. The need for exchange of technical know-how is however vast, which raises the need for international collaboration. The emerging markets in the EU may benefit from lessons learned on the more developed markets. Given the overall focus on energy efficiency and promotion of the use of renewable energy sources many markets are expected to grow rapidly in the years to come. Subsidy schemes and national information campaigns may help to overcome the initial barriers. The backside to subsidy schemes is of course the risk of major drawback when the schemes are withdrawn. The following section will discuss some of the barriers and risks that all renewable energy sources need to overcome in order to reach a self sustaining market

1.1 Barriers to overcome

Limited awareness

The limited awareness among decision makers, the public, authorities and politicians dealing with energy matters is due to a lack of professional information at all levels. It is worth mentioning that whereas such renewable energy sources as wind, solar, biomass and photo voltaic are well known alternatives, because of effective information campaigns and authority support, only modest emphasis has been placed on the energy saving and environmental benefits of systems for ground source heat pumps. The need for long term strategic collaboration among a broad field of stakeholders is necessary to overcome the initial needs for dissemination of information. Such collaboration will benefit from involvement by well established organisations like universities, electric utilities, banks and federal energy agencies.

High initial cost

High initial costs are in many cases a barrier, in spite of the fact that the overall lifecycle cost of the system is very satisfactory. Those promoting and marketing ground source heat pump systems may be facing a pedagogical or educational challenge. In addition to marketing arguments, environmental and comfort benefits of heat pumps should be stressed and valued. Emerging technologies, suffering from high development costs and small scale production series, will undoubtedly lead to costly products and services. Costs barriers may sometimes be hard to overcome without financial support or cost sharing in between manufacturers and suppliers during the development phase.

Poor perception and quality assurance

Poor perception has occasionally had a detrimental effect on the heat pump market. This has mainly been the result of a fast growing market, which has tempted inexperienced vendors and installers to enter. This has, in some instances and in combination with products not meeting a reasonable efficiency and quality standard, led to bad repute and a setback in sales. This situation has arisen in several European countries, often throughout periods when financial incentive schemes were at hand.

If initiatives aimed at increasing the future use of heat pumps in Europe are to be successful, steps must be taken to avoid that such situations are repeated. These steps include the training and certification of installers and marketing personnel. They should also include the establishment of a heat pump labelling programme, as a guarantee of energy efficiency performance and environmental benefits.

Low cost of energy

Energy prices, which do not fully reflect the external cost of the different energies, are a significant barrier in some European countries. This is often related to the fact that even if a ground source heat pump system is economically competitive, the energy cost difference may be too small to decide for the heat pump system. This is in spite of other benefits that a ground source heat pump system offers, such as reduced CO_2 emissions, more comfort etc. This barrier is becoming of less importance since the general public all over Europe has realised the future will inevitable lead to increased prices on energy.

2 Introduction to ground source heat pumps

Ground source heat pump is the collective term for a group of applications that one way or the other utilise the energy stored in the ground. The group primarily consists of horizontal ground soil systems, vertical ground source systems and groundwater systems. A detailed description of the different characteristics and required pre conditions is beyond the scope of this market study and will not be given. The following section will provide a basic introduction to the different types of ground source systems that are commonly used in Europe.

2.1 Ground soil systems

The use of ground soil as heat source for heat pumps enables the use of the solar energy stored in the ground. The ground serves as seasonal storage of solar energy. At a depth of 0.9-1.5 m the amplitude of temperature change due to changes of outdoor temperature is damped and delayed. This results in very favourable working conditions for a heat pump extracting energy from the ground. The ground may additionally serve as a heat sink for cooling applications. A heat pump utilising ground soil as heat source may either be designed for direct evaporation or as an indirect system where a secondary refrigerant is used as heat carrier between the heat source an the heat pump.

2.1.1 Direct evaporation system

A direct evaporation system, often referred to as direct expansion system, circulates the refrigerant in the ground coil. The advantages of direct evaporation systems are:

- Reduction of thermal losses, due to avoidance of an intermediate heat exchanger
- Avoidance of circulation pump

Owing to the advantages mentioned these systems will, if accurately designed, result in higher performance than the indirect systems.

Disadvantages:

- In comparison to indirect systems, the direct evaporation systems require higher refrigerant charge.
- May not be used for passive (free) cooling.
- Potential technical problems related to sufficient lubrication of the compressor exists.
- Damage to the coil may lead to severe leakage of refrigerant.

2.1.2 Indirect ground soil system

The indirect ground soil systems make use of a secondary refrigerant (anti freeze solution) as energy carrier in the ground coil. The advantages of indirect ground soil systems are:

- Minimize the refrigerant charge.
- May be used for passive cooling.
- Simplified installation

Disadvantages:

- Thermal losses are introduced, as the system requires an additional heat exchanger.
- Require a circulation pump.

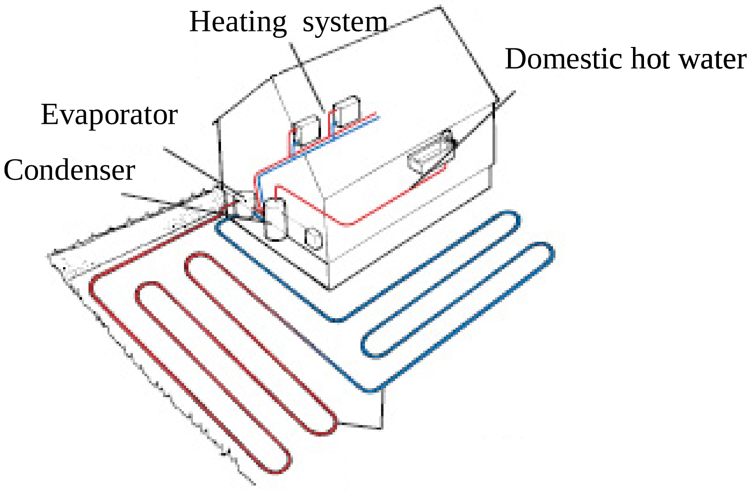


Figure 1 Indirect ground soil system

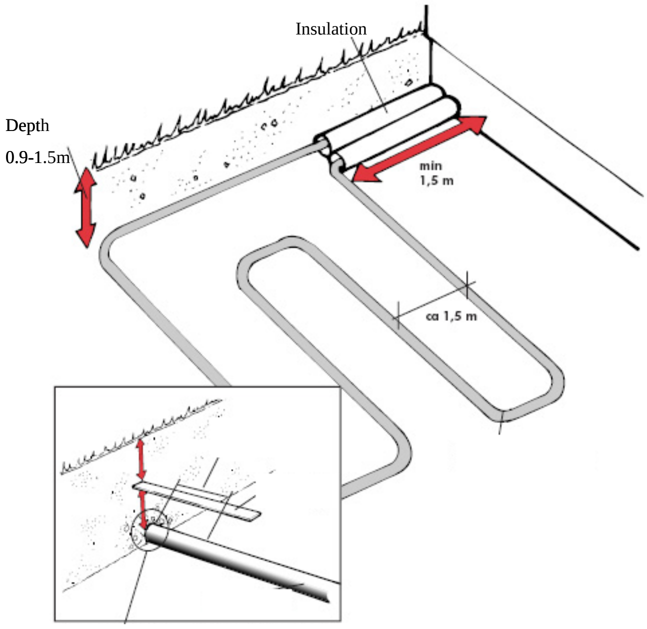


Figure 2 Example of ground coil configuration

At the beginning of the heating season the ground temperature adjacent to the coil, will be greater than the ambient air temperature. As heat is continuously extracted from the ground soil during the heating season, the temperature of the ground will decrease and in most cases the soil closest to the coil will freeze. The freezing process enables extensive heat extraction, as the soil undergo phase change. The frost formation around the coil enhances thermal conductivity of the soil. The thermal conductivity of the ground soil has significant impact on the design of the collector. The thermal conductivity of ground soil is mainly dependent on the water content of the soil, the higher water content, the higher thermal conductivity. The use of ground soil as heat source for heat pump applications has negligible influence on the vegetation above. Flowering might be delayed up to two weeks due to low ground temperatures. During summertime the temperature of the ground will be naturally recovered if the collector is properly designed. One of the drawbacks of horizontal ground coils are that a correct collector design in general requires a large surface area. This restricts the use in many areas around cities where available surface area is limited. The "slinky-coil" offers an alternative to the basic horizontal coil and reduce the required surface area to some extent.

Figure 3 Slinky-coil

2.2 Vertical ground soil or ground rock systems

For the last decade there has been a growing interest in using the ground rock as heat source for heat pumps. A lot of research and development have been performed in order to improve the knowledge base for the design of such systems. Most of the characteristics associated with ground soil systems are valid for the ground rock systems. Ground rock systems however require much less surface area and have consequently become the preferred choice in dense populated areas where space is limited. Ground rock systems may be designed for direct expansion or as an indirect system. A typical system for this type of application is shown in Figure 4.

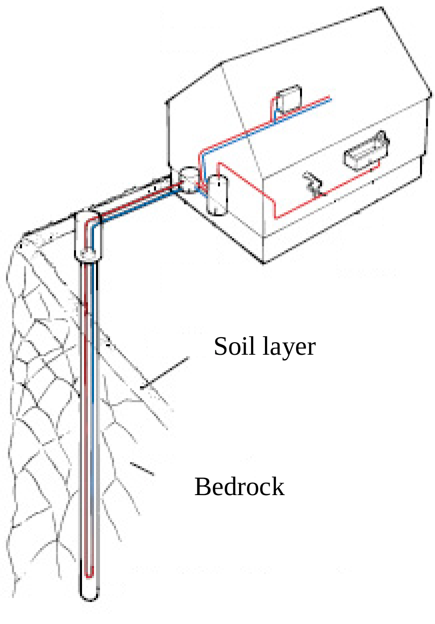


Figure 4 Vertical ground rock collector

In most cases the establishment of a borehole for a heat pump application requires permission from local authorities. General drilling restrictions might prevail in water protection areas and in the surroundings of tunnels. The most frequently used technique for drilling in rock is called down the hole hammer (DTH). Compressed air is fed through the drilling pipes down to a hammer at the bottom. The hammer is driven by the compressed air. The technique is suitable for drilling depths up to the range of 200 meters. The diameter of the borehole is usually 115 mm or 140 mm. The drilling equipment must be designed for drilling and mounting of lining and moreover, be able to move on different surfaces without damaging sensitive garden areas. The main aspects that influence the required borehole depth are thermal conductivity of the bedrock, undisturbed ground temperature, and annual heat extraction from the ground.

In order to obtain a high level of quality and lifetime of a ground rock system, and to protect the ground water many countries have developed standards or regulations for ground rock systems. Normbrunn 97 is a Swedish norm that has been developed by Geological Survey of Sweden (SGU) in collaboration with the Swedish Heat Pump Association and the two drilling organizations, Geotec and Avanti. Normbrunn 97 consists of requirements for the borehole itself and in addition requirements on the equipment and competence of the drillers. A collector is lowered into the borehole when the drilling is completed. Even though many different types of collectors exist, the single- and double U-pipes are predominant. The U-pipes are most commonly manufactured by high density polythene, PEM, Ø 40 mm, for 6 bars, and has a welded U bottom piece
General requirements for components used in bedrock systems are that all components need to be made of corrosion-proof material (e.g. copper-coated, synthetic material, stainless steel materials), which resist the hydro-chemical elements (e.g. heavily mineralised water). Where possible no joints should be used. In all cases a leak test should establish the tightness of the collector.

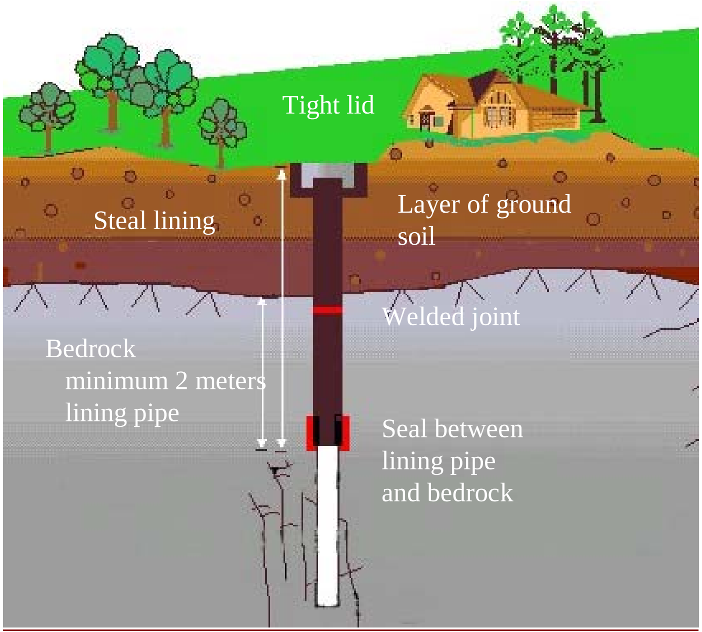


Figure 5 Configuration in compliance with Normbrunn 97

2.3 Ground water

In areas where ground water is abundant and uncomplicated to access this can be used as heat source as well. In these systems, ground water is extracted from a well and circulated through the cold side of the heat pump. The ground water can either be used directly by circulation through the evaporator, or indirectly by use of an intermediate heat exchanger. The use of an intermediate heat exchanger is preferred in most cases as ground water might cause corrosion or clogging of the evaporator. After leaving the heat exchanger the cold ground water is brought back to the ground by an injection well. It is important to separate the two wells properly in order to avoid thermal shortcutting. Due to risk of clogging and restricted authorization in many countries ground water is not widely used.

3 European market statistics

Sweden is still the most developed heat pump market in Europe. The market in Sweden has shown a tremendous growth over the last decade and seems to have reached a peak 2006. Other markets like Germany, France, Finland, Switzerland, Austria and Norway are however quickly increasing the number of sales and there are significant signs of a growing interest for the technology from large European companies. One of the largest Swedish manufacturers IVT, was purchased by BBT Thermotechnik GMBH (part of the BOSCH-group) in 2004. The large Danish company Danfoss acquired another of the leading Swedish manufacturers Thermia, as late as June 2005. In order to increase the understanding of the competitiveness for ground source heat pumps it is important to reveal the market situation for all of the different types of products within the heat pump family. Thereby the following section is dedicated to disclose the current statistics for the most common types of heat pumps that are used and designed for heating purposes.

There is an ever present debate whether the small reversible air-air heat pumps should be included in the statistics. These units are however installed in very large numbers all over Europe, but used in different ways depending on the climate. For heating purposes this product group offers one of the most cost efficient energy improvements that can be achieved for houses equipped with direct electricity heating and is for that reason sold in large quantities in Sweden, Norway and Finland where direct electricity is common. The cooling mode offered by these products are most commonly marketed as an added value on these markets, whereas the opposite applies to the southern market, where the need for cooling is more pronounced. As a result there is no consensus among the national heat pump associations whether these products should be included in the national heat pump statistics or not. The available statistics for this product group is not consistent and therefore not included below.

The official market statistics for countries in Europe that are revealed below have been compiled by the European Heat Pump Association (EHPA) and presented in the form of tables and diagrams. The statistics are based on an inquiry that was sent to 23 European countries. As the quality of the statistical data provided differ considerably, the EHPA has decided to only publish the statistics from 8 countries that are considered to be accurate.

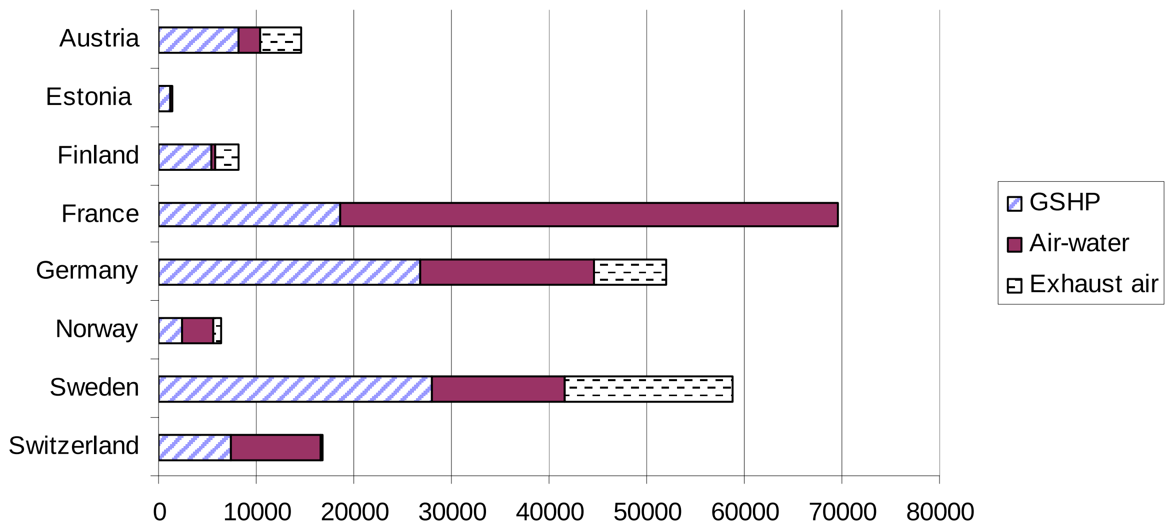


Figure 6 Heating only heat pumps sold in 8 European countries 2007

Type of heat pump	Switzerland	Sweden	Norway	Germany	France	Finland	Estonia	Austria
Air-Water	9181	13705	3200	17762	51000	450	209	2110
Exhaust air	100	17107	800.	7354	n.a.	2400	110	4264.
Ground source	7441	27956	2300	26887	18600	5300	1123	8288

Table 1 Heating only heat pumps sold in 8 European countries 2007

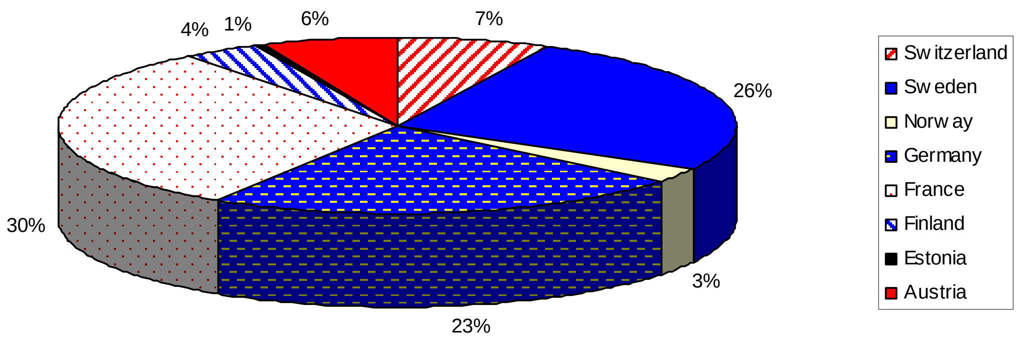


Figure 7 Country shares of all installed heating only heat pumps* in 8 European countries 2007
**France 51 000 air-water reversible heat pumps included in figures above*

3.1.1 European ground source heat pump market statistics

In recent years there has been a strong market development for ground source heat pumps. The benefits of the heat pump technology and the substantial market growth in Sweden has been recognised and highlighted as a tremendous example of successful development of a renewable energy source by the commission (Renewable Energy Road Map, COM(2006) 848 final) This type of application has the advantage of utilising a heat source that has the ability to store large quantities of solar energy until wintertime, thus enabling favourable working condition throughout the heating season, even in areas with cold winter climate. The use of ground source heat pumps was already foreseen by the early works of Ingerzoll et al 1954 (Ingerzoll et al, 1954), who in his work on adjusting the cylindrical heat source method stated that future use of heat pumps is highly dependent on the development of methods to utilise the energy stored in the ground. The work of Ingerzoll et al is still of great importance as it serves as a basis for several design software. The use of heat pumps and particularly ground source heat pumps have been hampered by the premium costs that embrace the installation. However, the overall increase on the price of energy has by now increased the acceptance for higher investment costs and ground source heat pumps are by now much more competitive than they used to be only 10 years ago.

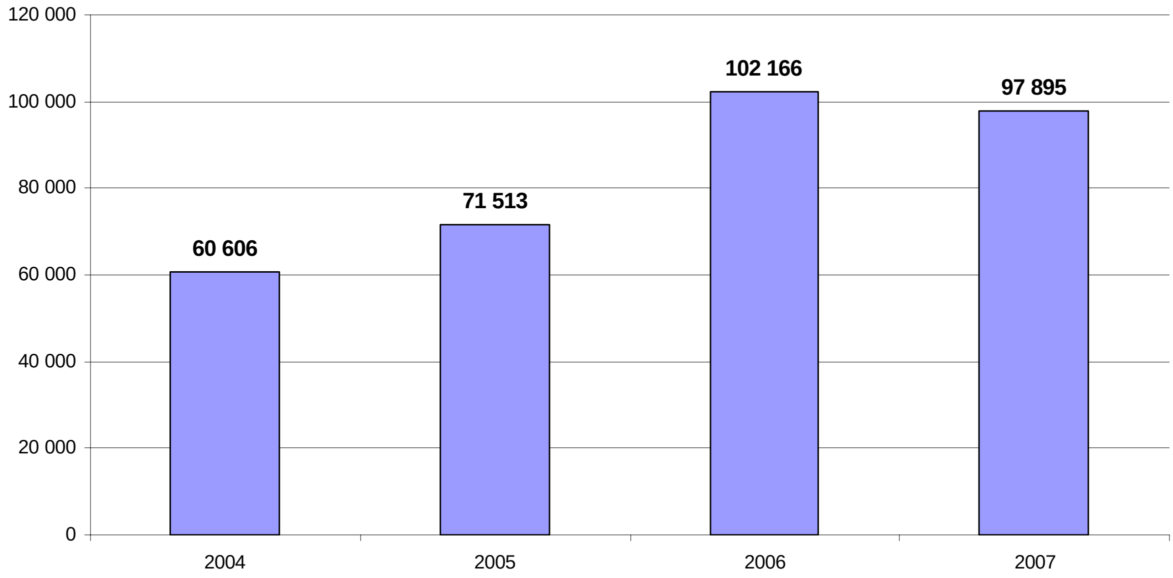


Figure 8 Total sales of ground source heat pumps in 8 European countries

The market development for ground source heat pumps in the eight most significant markets in Europe is depicted in Figure 8. Although the market for ground source heat pumps in the eight most significant markets indicate a small market decline there has been an increase in several other European countries which leads to the conclusion that the overall ground source heat pump market in Europe is still growing. Considering the large number of buildings in Europe the total sales of ground source heat pumps is still at a low level. There are however vast variations in terms of market penetration in the European countries.

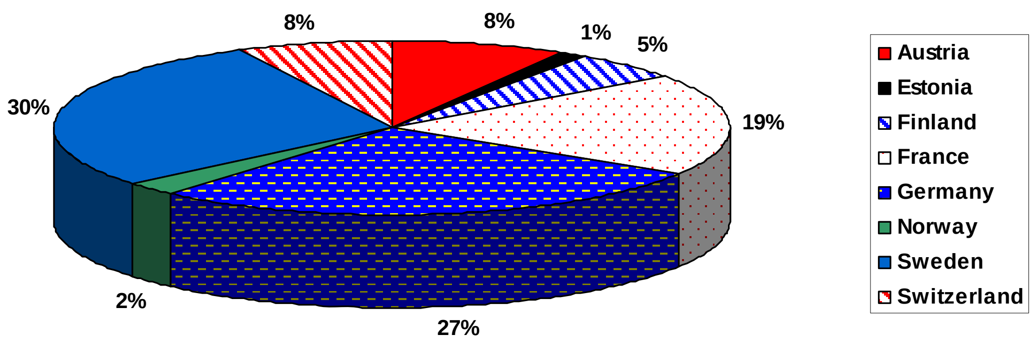


Figure 9 Country shares of all installed ground source heat pumps 2007

Sweden, that for many years have been leading market for installation of ground source heat pumps faced a 30% drop in sales during 2007. The market decline in Sweden is due to several reasons of which the most important one is the fact that the heat pump market for several years has been overheated. The intensive Swedish market has been caused by high energy prices and in 2006 pushed further by a subsidy scheme for phasing out of oil-boilers. The subsidy scheme was originally planned to be running for 5 years, but as all of the funds set off for the scheme was spent in less than 1,5 years the scheme was stopped 1 March 2007. The German market came to an unexpected halt in 2007. One of the explanations to this was that the German government raised the VAT 1 January 2007 leading to that a lot of sales were hastily done at the very end of 2006. Given the considerable magnitude of the German heating market, which is still dominated by oil and gas boilers, it is expected that the German market will become the most important market in the years to come. This belief is strengthened by the fact that the German market is growing on its own merits in contrast to e.g. the French market that is presently profiting from a generous subsidy scheme. The subsidy scheme in France has led to 13% market growth 2007. The lack of reliable market statistics for a majority of the member states yields in a somewhat blurred European market view. Much of the reason to the lack of statistics for the other countries is given by the fact that these markets are fairly small and scattered. There is however a number of countries with a small but notable and increasing market. Among these countries it is worth mentioning Ireland, United Kingdom, Poland and the Netherlands.

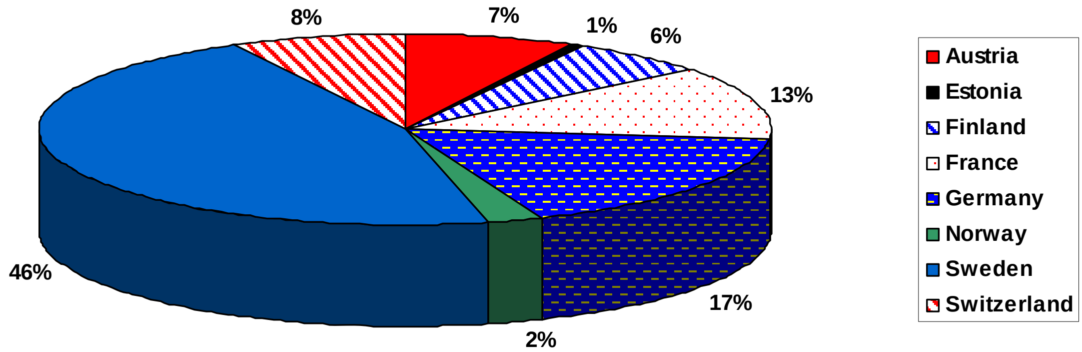


Figure 10 Country shares of installed stock of ground source heat pumps by the end of 2007

Stock of GSHP	2004	2005	2006	2007
Austria	30577	35810	43045	50 280
Estonia	1475	1985	2735	3 485
Finland	30000	33500	38000	42 500
France	49950	58330	71350	84 370
Germany	48662	60861	87875	114 889
Norway	9562	11562	14062	16 562
Sweden	195531	230094	270111	310 128
Switzerland	33000	38128	45258	52 388
Total	**398757**	**470270**	**572436**	**674 602**

Table 2 Installed stock of ground source heat pumps by the end of 2006

3.1.2 Market penetration for ground source heat pumps

The development of almost any market can be characterised by different phases of market penetration and acceptance by different groups of consumers. At present time most European markets for ground source heat pumps are focused on the new housing segment. The only exception to this is Sweden where exhaust air heat pumps have a market share exceeding 90% for new construction. The basic explanation to the focus on new construction is that most of the older buildings in Europe are equipped with hydronic heat distribution systems that require a relatively high supply water temperature. This technological pre condition impedes the efficiency of a heat pump system. For the new housing segment low temperature distribution systems such as under floor heating and convectors are gaining popularity all over Europe. These systems ensure excellent operating conditions for the heat pump and serves as a guarantee for high performance. The Scandinavian building stock is however generally of a higher standard of insulation and typical heat distribution system does not require such high temperature levels, thus do not jeopardise proper operation or significantly hamper the performance.

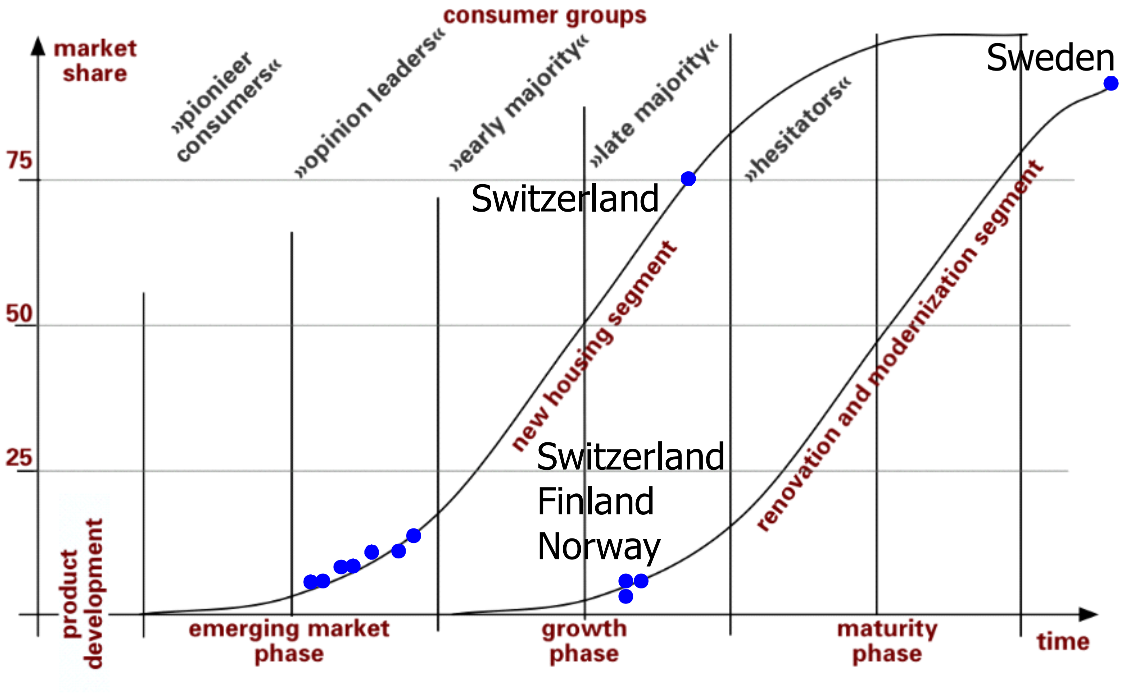


Figure 11 Market penetration for ground source heat pumps in 8 European countries 2006

4 Beneath the surface of national markets

Much depending on that different countries tackled the early oil crises differently, renewable energy technologies have developed differently in the European union. Research in the field of renewables has in most cases not been sufficient enough to push new technologies into the markets. The European markets for heat pumps have developed in a relatively short time period and still today many countries have not reached further than the early introduction phase. Recent decisions on EU-level will however stress an immediate need for an uptake in the use of all sorts of renewables and not least heat pumps. The fact that the need for comfort cooling is rapidly increasing all over Europe raises the interest for heat pumps. Heat pumps are unique in the sense that one and the same appliance are able to provide heating as well as cooling. Some systems that are designed for "free-cooling" provide comfort cooling at almost no electric input at all. Bearing in mind that more than 15 000 people died in Europe during the heat wave 2003 it is evident that the need for space cooling in many parts of Europe is not only a matter of comfort but a necessity for human well being. With the intention of gaining better understanding of the current European markets, the following section will scratch a little beneath the surface of basic sales statistics for some of the most important European markets.

4.1 The Swedish heat pump market

The market for domestic heat pumps in Sweden has for more than a decade shown strong growth and is by far the most developed market. Due to escalating price of oil and electricity in conjunction with an increase of energy related taxes the competitiveness for heat pumps have improved significantly. The technology is by now fully recognised both by consumers and decision makers. It is since many years the number one choice for retrofitting as well as for new construction of single family houses. The rapid market growth for heat pumps is the most important reason behind the fact that Sweden has reduced the use of heating oil by more than 50% during the last 15 years. Today nearly 700 000 heat pumps supply Swedish homes with 15 TWh of renewable energy per year. Substitute products such as district heating and wood pellet burners that often benefits from lower initial cost, challenge the heat pumps. The Swedish heat pump market is now self-sustaining and has reached maturity in the segment of single family houses. Commercial and multi-family buildings is still dominated by district heating, but offer a great opportunity for large ground source heat pump systems. These are the two housings segments that continuous to grow, even though the numbers are still low. By reason of the high rate of replacements during the last couple of years the sales of ground source heat pumps reached a peak 2006. The market dropped by approximately 30% 2007 and is expected to drop an additional 20% 2008. Exhaust air heat pumps still hold a strong position in new construction of single family houses. Their market share in this segment is exceeding 90%. Recent developments for air-water heat pumps have resulted in a number of new highly efficient models, which have led to an increased interest for this type of heat pump. Due to the high rate of direct electricity heating in Sweden and improved products, air-air heat pumps have become the most obvious choice to improve energy efficiency in these houses. The competition among the actors in this segment is fierce, which has led to considerable price reduction. The strong market growth for air-air heat pumps has attracted new actors on the market, among which some do not uphold required competence or high quality products.

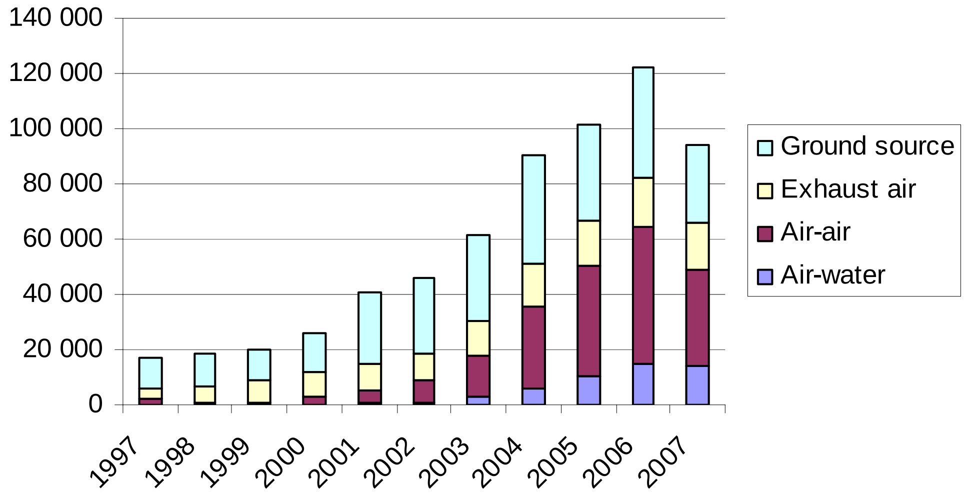


Figure 12 Swedish heat pump market development 1997-2007

The number of replacements on the Swedish heating market has been considerably above normal the last few years. The skyrocketing price of heating oil and increased environmental concern has led to a rapid replacement of existing oil boilers. Heat pumps are not the only technology that has benefited from this. Approximately 32 000 Wood pellet burners were installed 2006 and more than 10 000 single family houses were connected to district heating. Installations of the three leading technologies exceeded 175 000 units 2006. In comparison to the normal rate of heating installations that amounts to somewhere in the range of 75 000-80 000 units.

4.1.1 The Swedish Heat Pump Association

The Swedish heat pump association, SVEP, has a majority of the heat pump manufacturers present on the Swedish market enlisted. In addition to the manufacturers a majority of the dedicated heat pump installers are enlisted as well as the most important producers of ground collectors and the two drilling associations. The total number of members in the Swedish heat pump association amount to 745. The association embraces a technical committee, ethical committee and the consumer complaints board.

Among its activities, SVEP

- Administrate the nation heat pump statistics
- Stand host public information meetings
- Disseminate technical information sheets as well as guidelines for installers
- Organise training courses for installers and energy advisors
- Uphold telephone and mail support services for consumers and members
- Administrate collective marketing actions for its members
- Administrate the consumer complaints board
- Hold responsibility for response on all public consultation regarding regulation and legislation affecting the industry
- Regularly publish a national newsletter
- Coordinate collective research activities
- Represent the Swedish heat pump industry within the European Heat Pump Association

4.1.2 Swedish drilling associations

The Swedish drilling companies are organised in two associations, Geotec and Avanti. Geotec has 73 members enlisted. 13 of its members originate from neighbouring countries; hereby companies from Denmark, Norway, Finland, Iceland, Latvia and Lithuania are represented within the organisation. Avanti has 39 members enlisted of which all are located in Sweden. The drilling associations have taken an active part in the development of design guideline lines and standardisation of boreholes and collectors. Geotec organise vocational education as well as advanced training courses for drillers. Members of the drilling associations are active in the field of well-boring, construction foundations, geology surveys, road works and energy wells for ground source heat pumps. The strong growth of the market for ground source heat pumps has resulted in that many drilling companies have specialised in this field.

4.1.3 Training of installers

Training of installers is organised by manufacturers of heat pumps and by the Swedish heat pump association in collaboration with Mid Sweden University. The training scheme organised by the Swedish heat pump association has been adopted to the EU-Cert scheme and focus mainly on the basics of heat pump technology including heat load calculation as well as design of ground heat exchangers, temperature requirements for heat distribution systems and customer relations. The EU-Cert scheme is the result of the EIE project, European Certified Heat Pump Installer. The training offered by the manufacturers is more focused on design and installation of the specific systems that the company is marketing. More than 200 installers are trained per year under the different schemes available.

4.2 The German heat pump market

The German heat pump market first started to develop after the first oil crises in the nineteen seventies. The high price of heating oil and gas, which are dominating the heating sector, made it interesting to look for substitutes. The market reached an early peak 1981 before it started to drop and come to almost a complete stop 1987. The reasons behind the market decline were several. The two most import reasons were the sudden fall of oil price and poor perception. The poor perception was due to lack of competence among the installers and to some extent products of poor quality. At this early stage of the market development air-water and ground source heat pumps had roughly 50% each of the heat pump market. At the beginning of the 1990's electric utilities and the federal governments as well as the local governments initiated developments of ground source heat pump systems and support schemes. These actions in combination with the foundation of the German heat pump association, Initiativkreis Wärmepumpe 1983 and an overall energy price increase led to a slow but stable recovery of the market. The gentle market was fruitful in the sense that the industry had the time to build up knowledge and develop robust and reliable products. The significance of ground source systems has gradually grown since this period of the market development. Some barriers still exist in areas where the local authorities are reluctant to give permission for ground source collectors. This problem can be overcome by use of environmental benign secondary refrigerants and better understanding among the authorities. The strong product development in the field of air-water heat pumps in recent years have complemented the heat pump family with another competitive product that have added sales without loss for the ground source systems. The long winter 2006 in combination with further increases of energy prices and the considerable media attention to climate change resulted in 120% growth of sales on the heat pump market.

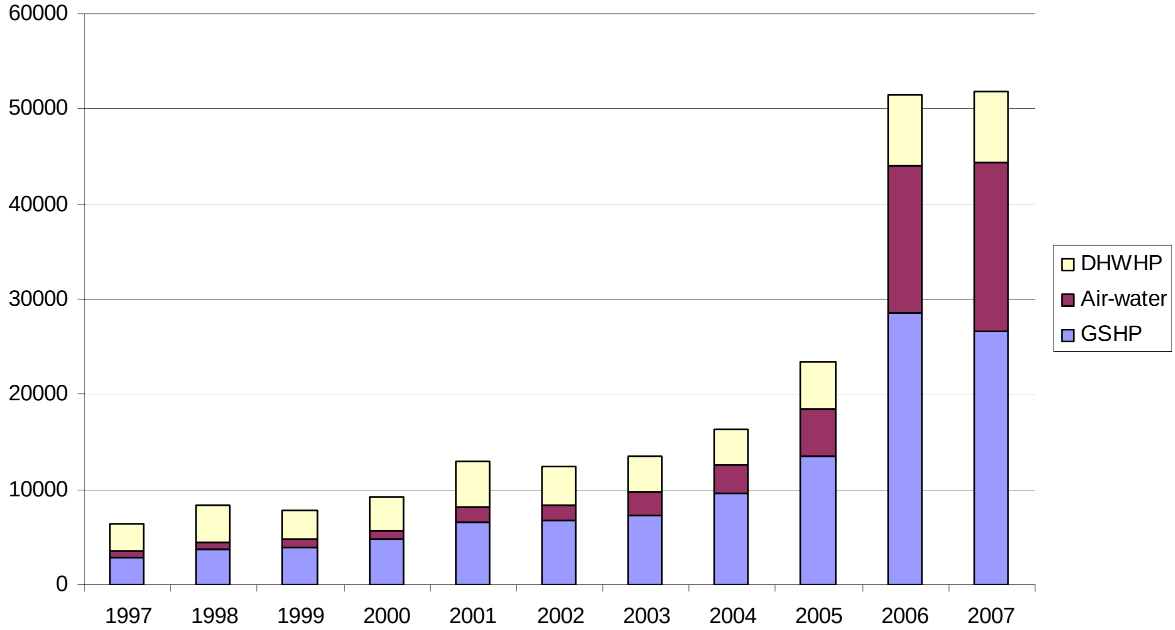


Figure 13 German heat pump market development 1997-2007 (source: BWP)

The dramatic increase of sales 2006 would have reach even higher if it wasn't for some bottlenecks in terms of lack of drilling capacity and at times the production facilities were not able 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 promotes the benefits of heat pumps. The electric utilities have identified a business opportunity in a sector that formerly was ruled by the oil and gas industry. Some of the electric utilities offer special heat pump tariffs that are favourable for the consumer.

4.2.1 The German heating market

The German heating market is still to a large extent dominated by oil and gas boilers. The urgent need to reduce the dependency of fossil fuel this will have to change quickly and the German authorities are set under strong pressure to come up with measures to large scale retrofit schemes. The sales of traditional boilers are currently dropping in the order of 20%.

	2004	2005	Change %
Condensing oil boiler	19.000	22.000	15.8
Low temp gas boiler	217.000	174.000	-19.8
Oil boiler	185.000	144.000	-22.2
Condensing gas boiler	347.000	320.000	-7.8
Total boilers	768.000	660.000	-14.1
Wood pellet boilers	8.000	16.000	100
Heat pumps	16.000	23.100	44.4

Table 3 Annual sales on the German heating market (source: BWP)

4.2.2 The German heat pump association, BWP

The first steps towards the foundation of a German heat pump association were taken 1992, when 7 electric utilities and several manufacturers united and initiated measures to reintroduce heat pumps on the market. The initial steps included a survey of installed stock as well as a questionnaire directed to HVAC installers. A majority (68%) of the installers was interested in the technology and would be in favour of marketing of heat pumps. The response of the initiative led to the foundation of "Initiativkreis Wärmepumpe" (IWP) 1993. 2001 the association reorganised and took its current name, "Bundesverband Wärmepumpe" (BWP). The association hosts 43 manufacturers, 26 energy supply utilities, 32 drilling companies, 54 planning companies and 326 installing companies. Much effort has been taken in order to improve quality assurance, marketing of the heat pump technology and customer relations. BWP has played an important role in the establishment of the quality labelling scheme D-A-CH Gütessigel.

Among its activities, BWP

- Administrate the national heat pump statistics
- Stand host for national conferences and seminars
- Disseminate technical information sheets as well as guidelines for installers
- Administrate collective marketing actions for its members
- Publication of regularly newletters
- Uphold customer service in the form of a telephone "hotline"

4.2.3 Training of installers

Training of installers is organised by manufacturers and lately by BWP. The courses organised by BWP follow the EU-Cert scheme.

4.3 The Austrian heat pump market

As most countries in Europe the introduction of heat pumps in Austria started in the beginning of the 1980's. Again it was the early oil crises that made policy makers and politicians aware that something had to be done in order to decrease the dependency of imported fossil fuels. One of those technologies that were easy to pick up was heat pumps. The lack of skilled installers led however quickly to bad repute due to poor performing installations. Owing to the bad reputation and declining oil prices the market dropped during the last years of the 1980's. The recovery of the market that could be seen in the beginning of the 1990's was related to growing interest from a small group of electric utilities. The utilities were at this time divided in two groups. The majority perceived heat pumps as a competitor to direct electricity heating, whereas some realised the market opportunities to compete with the oil and gas boilers. One of the smaller utilities located in Upper Austria, Energie AG formerly OKA, had been involved in an energy conservation campaign for school buildings. This programme covered improvements of insulation as well as refurbishment of heating systems. OKA took special interest in heat pumps and some of the top management group even installed heat pumps themselves. OKA started to promote heat pumps in Upper Aurstria and encouraged installers to take on the technology. As a consequence of the activities from OKA the Austrian market has for long time had it strongest position in Upper Austria. The market growth in recent years had not been possible without the strong emphasis on high quality products and ambitious training schemes for installers. The role of the electric utility companies has by now become of less importance and replaced by initiatives from the authorities.

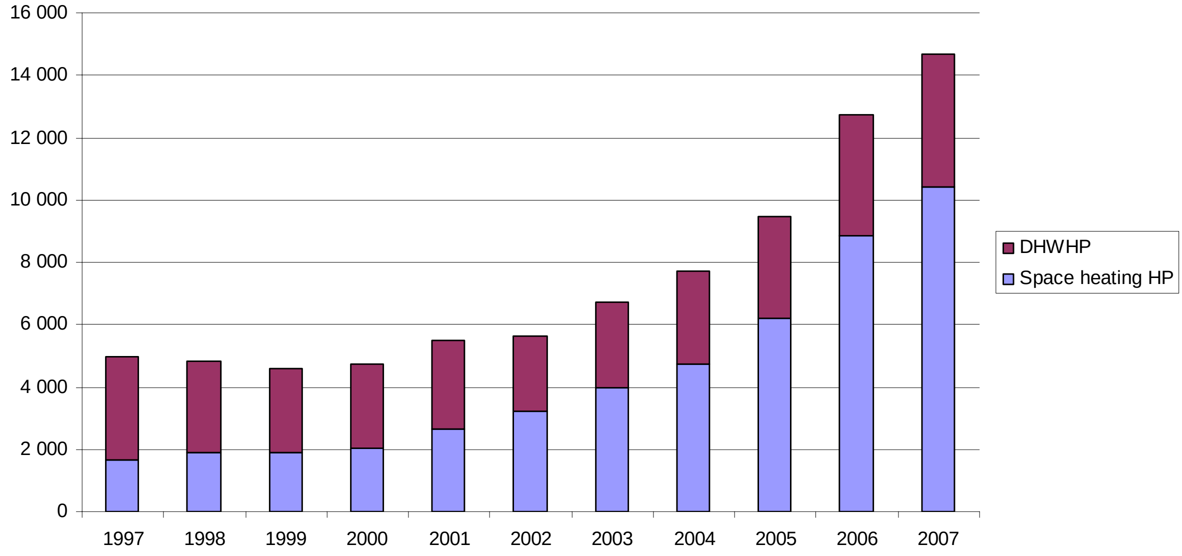


Figure 14 Austrian heat pump market development 1997-2007

The Austrian heat pump market is most successful in the new housing segment. Of all heat pump installations in Austria approximately 70% are performed in the new housing segment. New products enabling efficient operation at higher distribution temperatures are gradually being introduced and opening up the market for retrofit installations in the existing building stock. Ground source systems with horizontal flat collectors and vertical boreholes have for many years been dominating the Austrian heat pump market. The direct expansion systems have had a large market share for many years but are in recent years slowly decreasing in favour of the indirect systems (brine-water). The reason to this shift of dominance is due to the general trend towards reduced charges of refrigerants. Alike other European heat pump markets air-water heat pumps are rapidly gaining interest.

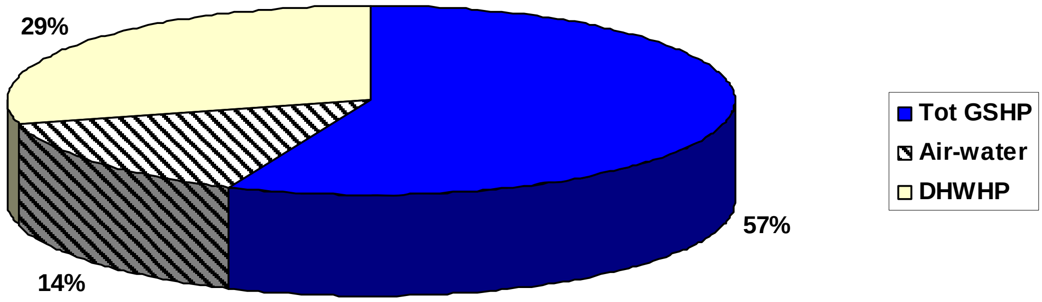


Figure 15 Heat pump market segmentation 2007

The Austrian heating market is still dominated by oil and gas. Renewable technologies such as wood pellet boilers, solar thermal and heat pumps are getting more interest from policy makers as well as consumers. The domestic hot water heat pumps have lost market shares in favour of solar thermal systems.

4.3.1 The Austrian heat pump associations

There are 2 heat pump associations in Austria. The largest in terms of number of members is the "Leistungsgemeinschaft Wärmepumpe Austria" LGWA, which organise manufacturers, electric utilities, heat pump installers and drilling companies. The other is the

"Bundesverband Wärmepumpe Austria", BWP. BWP is a hive off from the boiler association and thus only open for manufacturers. The Austrian associations have run a successful collaboration with each other and the German and Swiss associations. Their focus have been to establish a common quality labelling scheme under the D-A-CH Gütessiegel. As drilling companies are members of the LGWA there is no other drilling association dedicated to promote ground source heat pumps.

4.3.2 Training of installers

Training of installers is organised by manufacturers and Arsenal Research in Wienna. The ambitious training program for installers organised by Arsenal was developed in cooperation with the heat pump association started operating in the year 2001. In order to achieve the certificate the installers must be actively working in the field of heat pumps and take part regularly in further education in the field of heat pumps. Furthermore they have to document complaints and provide complete planning documentation for one installation every three years to the certification authority. In 2007 Austria adopted the EU-Cert scheme.

4.4 The Swiss heat pump market

The Swiss heat pump market has since the beginning of the 1990's grown constantly. Switzerland is by now the second most developed heat pump market in Europe. Heat pumps have for many years been recognized as an important technology to reduce the dependency of fossil fuel and green house gas emissions. The fact that the Federal Energy Office identified heat pumps as a renewable at an early stage, made the way for heat pumps to take part in the national energy programme "Energie 2000" that was launched in 1993. The succeeding programme "Energie Suisse" set an ambitious target aiming at a total stock of 100 000 heat pumps in operation by 2010. This target has already been surpassed. Heat pumps have reached a market share of 75% within the new housing segment and the annual sales of heat pumps are now at a comparable level to traditional oil and gas boilers. It is evident that the measures carried out by the Swiss federal government have played a vital role for the positive development of the national heat pump market. The activities stimulating the heat pump market within the energy program were focusing on 3 main tasks

- Assemble all major market players to concentrate marketing promotion and lobbying activities in a common association, - FWS
- Quality assurance
- Reduce economical barriers by financial incentives for consumers

A combination of the general price increase for fossil fuel and the successful execution of the tasks above made way for the progressive market development.

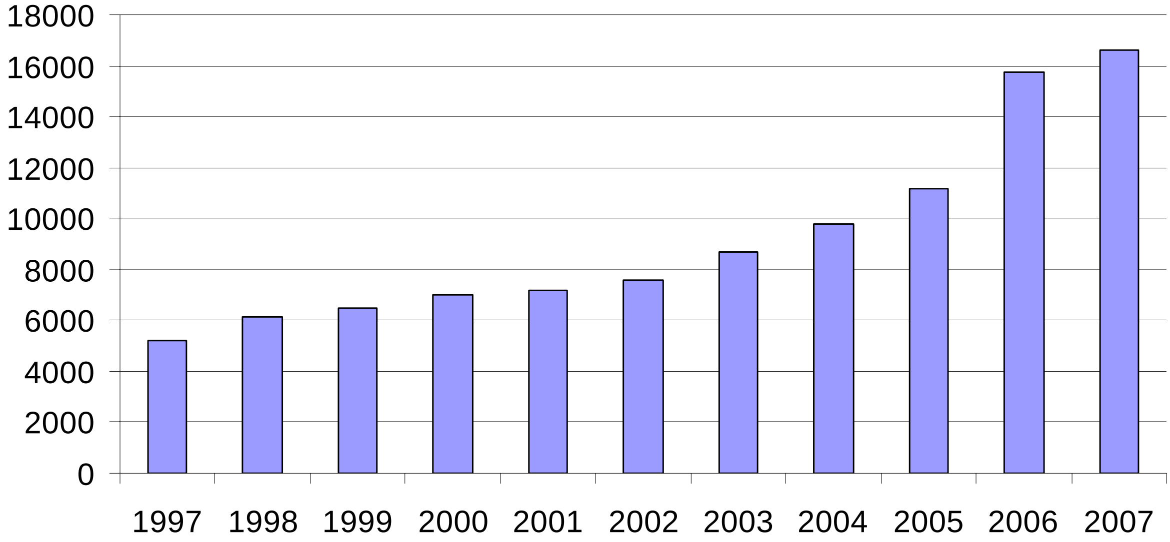


Figure 16 Swiss heat pump market development (source: FWS)

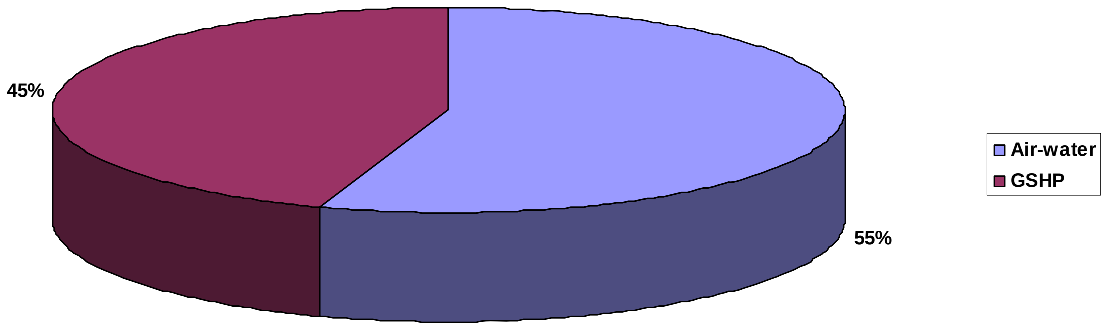


Figure 17 Swiss heat pump market segmentation 2007 (source: FWS)

4.4.1 The Swiss heating market

Although heat pump sales are concentrated in the new housing segment, the retrofit market has been growing for several years. In 2006 the retrofit market was equal to 20% of all heat pumps sold. One of the explanations to the Swiss success in the retrofit market is the existence of building regulations for renovation. The sales of heat pumps are now at the same level as oil boiler and just slightly below gas boilers.

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Share of HP in new built single family houses	30%	30%	32%	39%	40%	45%	53%	61%	72%	75%

Table 4 Share of heat pumps in new built single family houses (source: FWS)

4.4.2 The Swiss heat pump associations

There are 2 Swiss organisations with the aim to stimulate the heat pump market; Fördergemeinschaft Wärmepumpe Schweiz (FWS) and Arbeitsgemeinschaft Wärmepumpen (AWP).

AWP founded 1980 is organising manufacturers and importers of heat pumps. Its focus is set on technical issues such as testing. AWP has a strong collaboration with BWP.

BWP was founded within the framework of "Energy 2000" and was set up in order to fulfil the vast need for dissemination of information and promotion of the heat pump technology. The association includes members belonging to a broad group of market players counting; installers, designers, manufacturers, electric utility companies and federal and local public authorities.

The most important objectives of this association are:

- Dissemination of information and marketing activities,
- Coordinate the Swiss activities within D-A-CH Gütessiegel
- Coordinate training activities.
- Provide technical guidance to end consumers
- Administrate the national heat pump statistics
- Administrate collective marketing actions for its members

4.5 The French heat pump market

As for several other European countries, a first development of the market occurred in France between 1975 and 1985 in the frame of the oil crisis. After a promising start, this was finally a major failure. The main reasons were the lack of skilled installers and the poor quality of the machines that lead to poor performance systems and many breakdowns. This resulted in a durable lack of confidence for heat pump heating solutions among people, which, in combination with the oil counter-shock and the reduction of government encouragement to energy mitigation, lead to an almost complete extinction of the market during more than 10 years. The following graphic is showing the sales in France since 1976 for all type of heat pumps and this first attempt of development can clearly be seen.

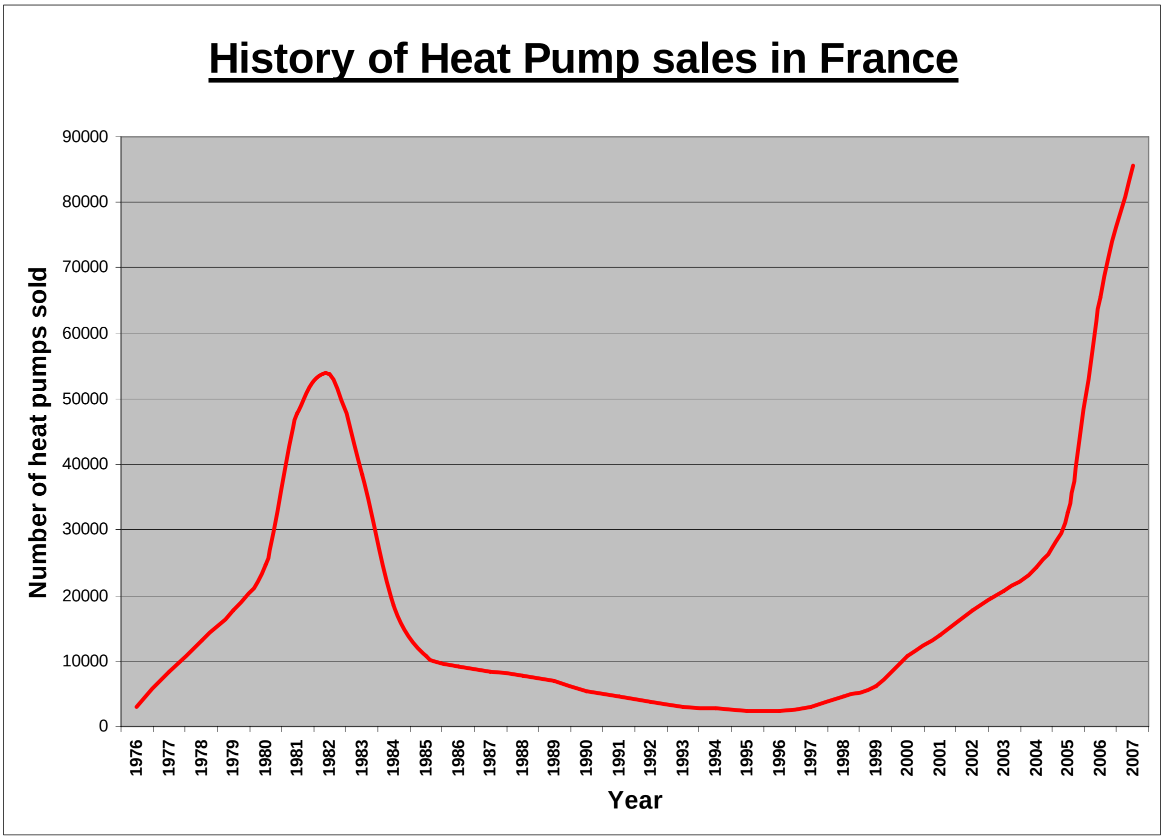


Figure 18 Market evolution for heat pumps in France

Since 1997, a new start of the market has been initiated by EDF (national French electricity company), in association with ADEME (French environment and energy management agency) and BRGM (French mining and geological research board). The focus has been set on a controlled development of the market based on quality, in order to avoid reproducing the mistakes of the past. In particular, the initial target was put on newly built single-family houses, where the thermal needs were well known and where there was the opportunity to implement heating floor with low input temperature to achieve maximal performance.
In 2005, the public authorities have implemented a strong subsidy scheme foreseen to last until the end of 2009. This subsidy is an income tax cut that takes the form of a reimbursement of 50% of the price of only the machine (meaning excluding the heat source collection system, the heating emission system and the labour costs for installation). The money is given as a reduction of the income tax of the family, or directly through a bank transfer in case the family is not submitted to an income tax.
This subsidy, in addition with a rise of environmental awareness among people and increasing prices of fossil energies, has resulted in a very strong acceleration of the heat pump market since 2005. Moreover, the market has been strongly modified. Prior the implementation of the income tax cut, about 98% of GSHP were intended for new dwellings. In 2007, about 13 % were installed in existing dwellings.
Air to water is the technology which benefits the more from the income tax as it is the easiest system to install in replacement of an old boiler (less impact on the garden and the house surroundings). In 2007, about 60% of the air/water sales have been installed in existing dwellings.
The following tables summarize the sales of heat pumps since 2002. The market is growing fast but is still small with regard to boilers with estimated sales of 700 000 units in 2007.
The growth of GHSP between 2006 and 2007 is practically zero. It is mainly due to the fact that this technology is strongly linked to the building of new houses and France has experienced a decrease in 2007. Moreover, the income tax cut is not correctly designed to

favour these solutions with regard to the less expensive aerothermic ones. Borehole heat exchangers and horizontal heat exchangers are indeed not considered in the calculation of the subsidy.

Heat Pumps sales **Source: AFPAC**	2002	2003	2004	2005	2006	2007	2007 vs 2006
Gnd direct evp / Gnd direct cond Gnd direct evp / Water	5100	5 400	6 800	7 800	9 600	9 600	+ 0 %
Brine / Water Water / Water	2900	3 600	4 900	5 400	8 850	9 000	+ 2 %
Air / Water	4 400	4 700	5 600	12 000	35 060	51000	+ 45 %
Air / Air (*): ADEME estimation	No data available			(7 500)*	(12 000)*	(16 000)*	
Total (excluding Air/Air)	**12 400**	**13 700**	**17 300**	**25 200**	**53 510**	**69 600**	**+ 30 %**

Table 5 Heat pump sales evolution in France by type

4.5.1 The French heat pump association

The French heat pump association, called AFPAC (Association Française pour les Pompes A Chaleur), has been created in 2002 with the help of EDF and ADEME. The aim was to create a dedicated place to discuss about HP in France and to organize the sector.
AFPAC is gathering all the actors of the heat pump sectors with industrials, professional unions of installers and drillers, engineering departments, energy companies and public actors like ADEME and BRGM.
The creation of AFPAC has been a very important move toward a better consideration of heat pumps by the French administration and the creation of subsidy schemes.
Since the beginning, the work of AFPAC has been focussed on quality. The target was to create quality tools promoted by the professional themselves. It resulted in the creation in 2007 of two main quality tools: NF PAC and QualiPAC.

4.5.2 Quality tools and training of installers

In April 2007, two quality tools have been officially launched by AFPAC, with the financial help of ADEME.
The first one, called NF PAC is a quality label for machine which is granted by an independent quality organism (CERTITA). Eligibility to NF PAC is conditioned to tests realised in independent laboratories to verify the conformity of the machine with regard to requirements consigned in the label rules. The requirements regard minimum COP, quality rules, and noise emission measurements. The French authorities are currently considering the possibility to use NF PAC as criteria for the income tax cut.
The second quality tool, called QualiPAC, is a quality charter for installers. QualiPAC is a complete quality approach with training sessions for installers, statistical controls of installations performed by each installer by an independent certified organism (APAVE), and clearly defined rules of admission and expulsion. ADEME is promoting QualiPAC and is using its diffusion network to advise people to do business with QualiPAC installers.

4.6 The Greek heat pump market

4.6.1 The Greek heat pump market development

The Greek heat pump market appeared for the first time in the beginning of 1992 (2 sales of GSHPs) but for the following years there was no further development. The growth of GSHP between 1992 and 1997 is practically zero. In 1998 the Greek heat pump market started its rise (4 sales of GSHPs). In 2000, 2001 and 2002 in the framework of demonstration projects that CRES had taken all responsibility, more heat pumps were installed. During the last 3 years and through the GROUND-REACH project there has been an increase in the heat pumps sales in Greece.

Figure 19 Greek heat pump market development

As far as it concerns the installed units in Greece, in 2006 129 units were installed and in 2007 the number increased to 194 units. In Greece there are approximately 10 installers, nine of which have personnel of 3-10 people and one has 40 people, forming a bottleneck to market growth. In figure 19, it is shown the GSHPs competition in Greece and how the Greek heat pump market is divided among different installers.

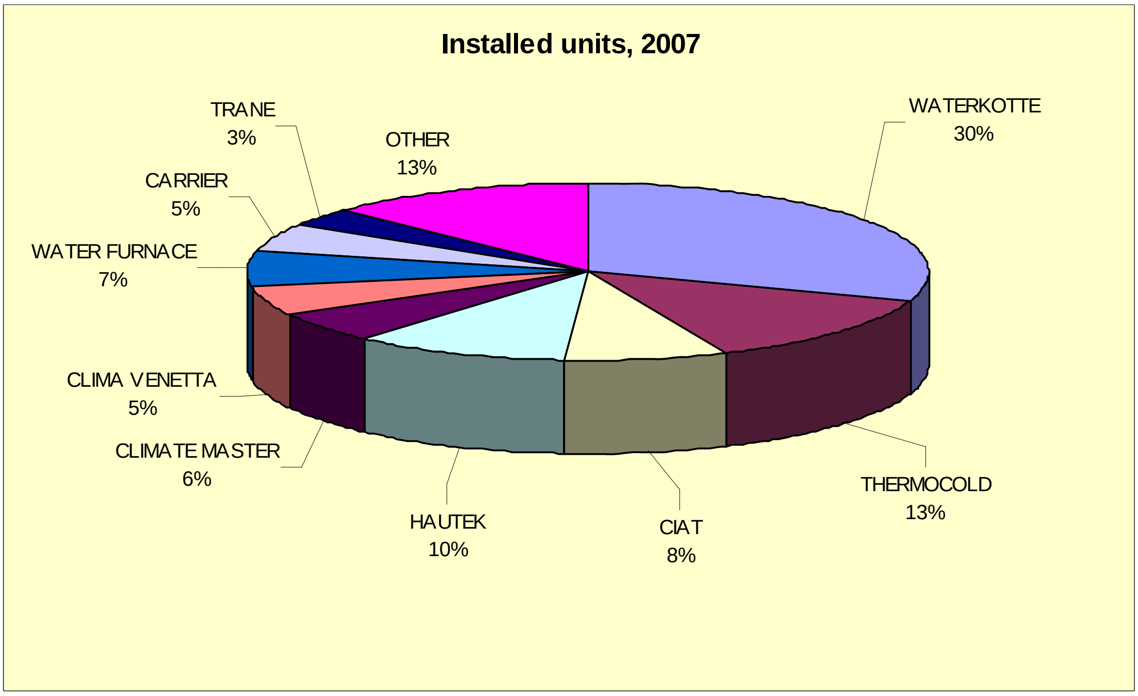


Figure 20 GSHPs competition in Greece

In table 5 typical prices for a complete system for a house of 200 m^2, that exist in the Greek heat pump market, are presented. In table 6 someone can see the prices for electricity, heating oil and natural gas.

System	Cost, €/kW
Direct expansion hp	not available
Horizontal brine-water hp	1000-1200
Vertical brine-water hp	1200-1400
Air-water hp	700-900
Air-air hp	200-300

Table 5 Typical prices for a complete system for a house of 200m^2

Energy prices	Cost, €/kWh
Electricity	12
Heating Oil	9
Natural Gas	7,5

Table 6 Typical prices for electricity, heating oil and natural gas

4.6.2 The Greek heat pump suppliers

In the next table 7 someone can see the companies that work on GSHPs in Greece.

Company	Activity	Internet
DELTA TECHNIKI	Representing Climate Master, and Climavenetta	http://www.deltatechniki.gr /geotherm_new.htm
SIELINE AE	Representing Dimplex	www.sieline.gr
KLT Energy	Representing Thermocold	http://www.klt.gr/
TSITSOS KLIMA	Representing central air conditioning equipment	nsit@tee.gr
G. RADOGLOU	Installer of GCHPs	http://www.globalsd.gr/
DIAMANTIDIS K.	Installer of GCHPs WaterKotte	diamantk@otenet.gr
AM KATASKEVASTIKI	Installer of GCHPs	http://www.geothermia.gr/ company.htm
BOUSGOLITIS CHRISTOS	Installer of GCHPs Water Furnace	http://www.geoexchange.gr/
GEOEREVNA OE	Drilling contractor, Installer of GCHPs	http://www.geoerevna.gr/
ERGON EQUIPMENT AETE	Installer of GCHPs, and floor heating systems	http://www.ergon.com.gr/
DIAMANTAKIS EDAFO MICHANIKI KRITIS	Installer of GCHPs	ddiama@tee.gr
EnergyHomes	Installer of GCHPs	http://www.energyhomes.gr/
TerraClima	Installer of GCHPs Rehau / Raugeo	http://www.terraclima.gr/
ict D.G.SPYROPOULOS	Installer of GCHPs Heliotherm	http://www.ict.gr/
MENTOR	Installer of GCHPs	mentorsa@otenet.gr mentorsa@hellasnet.gr
Exotherm HELLAS	Installer of GCHPs	http://www.exotherm.gr
KOLOMBAKIS AE	Energy, heating, cooling	info@kolomvakis.gr
Aid Engineering Ltd	Engineering design, construction	http://www.aidengineering.gr/indexgr.htm

Table 7 GSHPs suppliers

5 Economy of Geothermal Heat Pumps

Main factor determining the decision of any investor to choose an energy resource is the resulting economy: final price of used energy unit over the defined exploitation time.
For geothermal energy, the process is quite complicate and requires evaluation of a long list of influencing factors.

Final economy of geothermal project depends mainly on the investment, Operation and Maintenance, and development costs.

They can be grouped in:
- exploration costs
- drilling costs
- installation costs
- equipment costs
- assessment and costs of covering the project risks
- investment in project design and supervision of its completion
- investment in heat user's facilities construction
- investment in environmental protection
- annual heat loading factor
- operating and maintenance costs
- concession costs
- investment in further project development
- generating profit

Investment of the Geothermal HP technologies and estimated pay back time

The shallow geothermal systems cost is site dependent because of a changing geology, the presence or the absence of water in the rocks, the depth of the water table, the place at the surface to have a proper spacing between the wells or the verticals probes, the distance of the plant from the better adapted driller to perform a correct job etc…

1. Water wells

For this application, the parameters which influence mainly the investment costs of the doublet are:
- the depth of the well
- the water flow rate to be obtained which give the diameter of the casing pipes
- the nature of the aquifer (a well in a limestone formation is easier to complete and less expensive compared to the installation of special screens and gravel pack to produce from a sandstone reservoir)
- the physico-chemistry of the water which can oblige treatment to avoid corrosion or to facilitate the injection of the water after thermal use into the same aquifer
- the cost of the insurance coverage in case of insufficient productivity of the wells (5% of the investment- AQUAPAC guarantee system for example in France)
- the pumping system which is expensive for high flow rates

- the study to be performed to obtain the authorisation of the administration (when the flow rate is up to $8m^3/h$ for example in France)

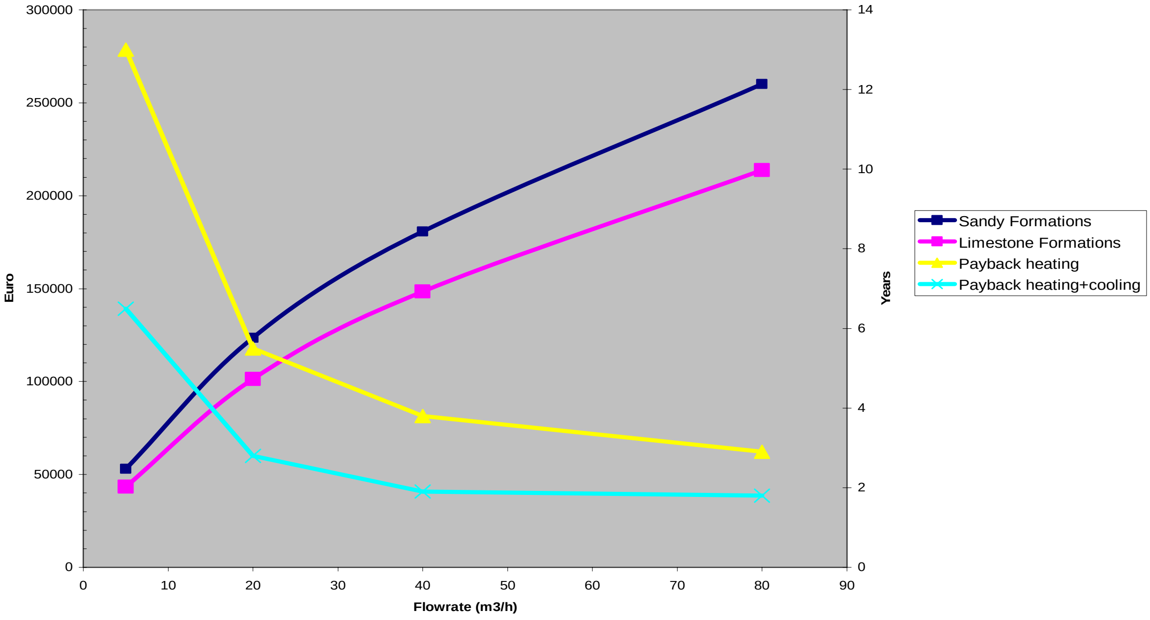


Figure 21 Evolution of doublet economics

The diagram shows the evolution of the doublet price depending mainly of the flow rate more than the geological cross section. The pay back time is calculated for 3500 h of working period for the heat pump during the cold season and 2000 during the cooling season.

2. Geothermal Ground Source Heat Pumps (GSHP)

For GSHP systems, the approach is quite different, the power of each well is also site dependent, but not in the same range. Everywhere it is possible to drill a GSHP and his cost is not so different for a location to another one. Nevertheless, the cost of a GSHP is influenced by the geological cross section (to drill in granite is easier and quicker because it is possible to drill with air and a down-hole hammer at the opposite to drill alternatively clays and sands necessitate to utilise a conventional rotary rig with mud) but also by the existence or not of the water in the ground.
The blue curve (normal case) corresponds to the average geological cross section in France.
The pink curve (simple case) corresponds to the geological zones with non consolidated formations from the surface to a maximum of 10m and after only one type of rocks such as granite, limestone, lava etc…

The following diagram shows the difference of price taking into account those parameters and also the number of GSHP to be drilled which is of paramount importance:

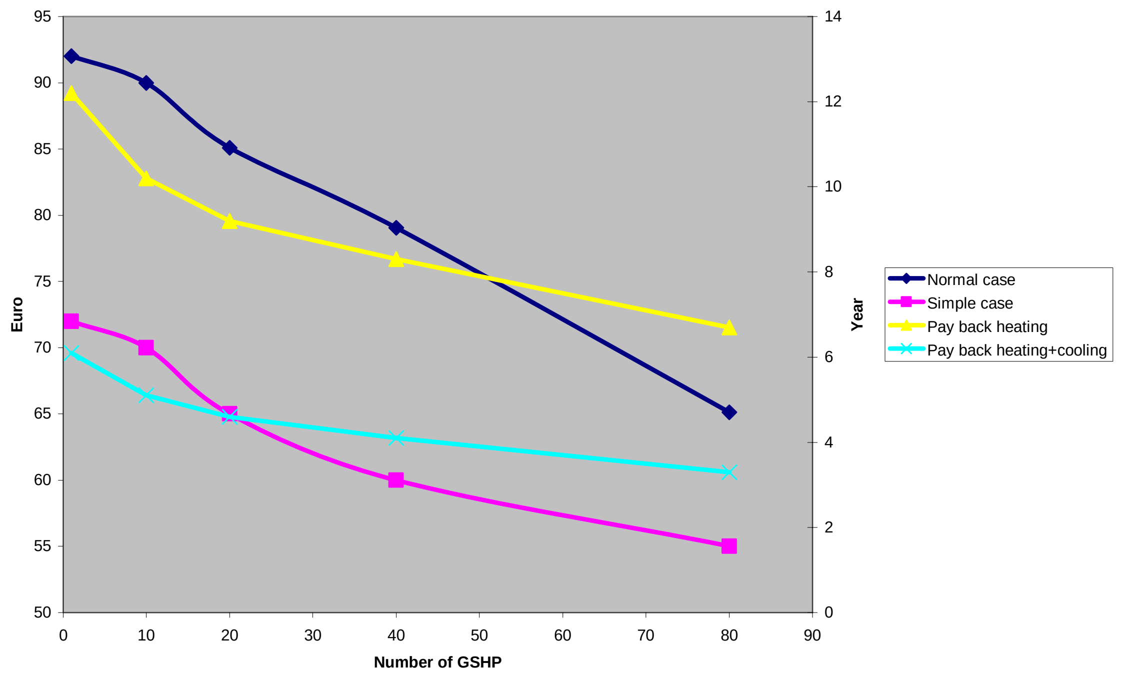


Figure 22 Evolution of GSHP economics

The pay back time has been calculated for two types of exploitation system. The yellow curve indicates the pay back for 3500h of working period for the heat pump which ensure only heating from October to April. The light blue has been calculated assuming heating for the same period and cooling in summer.

Exploitation costs and maintenance

1 Water wells

The doublet system is consuming electrical energy to pump the water in the production well, assuming that the pressure delivered at the surface will allow the water flowrate to go through the plate heat exchanger and go back to the injection well.

In shallow doublets it is considered that the injection will be done without injection pump. The consumption is depending of the drawdown of the water table while pumping at the exploitation rate + pressure losses in the piping network.

A submersible pump has a life time of 3 to 6 years, it is necessary to change it and during the operation to clean the well itself especially when exploiting sandy reservoirs.

Additionally a guarantee to ensure the productivity of the wells during 10 years can be subscribed with AQUAPAC (3% of the investment per year).

All those costs are not negligible and impossible to avoid in order exploiting the doublet for a minimum period of 25 years. It is strongly recommended to contract with a specialized company an annual maintenance package including the spare parts and the installation on site. As example those costs represent an annual average of 7000 € for a doublet producing around 1000 MWh in one year.

2 GSHP

The system doesn't require any maintenance.

The electrical consumption is for circulating the water in the closed loop in polyethylene tubes and the heat pump.

No heat exchanger is needed and the energy consumed just proportional to pressure losses in the 32mm diameter pipes. No insurance is needed and no replacement of equipment.

For a normal GSHP field of 30 BHEs, the average annual expenses can be estimated at 1000€ including an annual visit for control.

Cost and Competitiveness

An overview of the costs involved to provide Renewable Heating and Cooling services was undertaken in 2007 by the IEA - International Energy Agency (*Renewables for Heating and Cooling*). A similar methodology to estimate the costs of the energy delivered was applied for all technologies.
The results is that Biomass and deep geothermal technologies are the most cost competitive for heating applications.
Solar water heating costs can be competitive under certain conditions.
Shallow geothermal technologies applied for both heating in winter and cooling in summer can be cost competitive when evaluated on a life-cycle cost basis, whereas solar assisted cooling has the greatest cost gap.

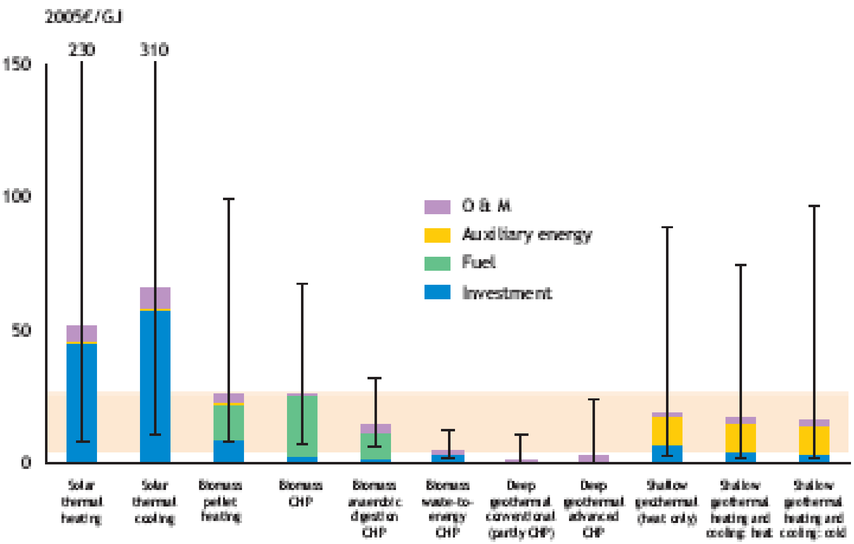
Typical fuel prices for delivered energy from fuel oil, gas and electricity used for heating:

	Conversion efficiencies of energy carrier to heat		Comparative prices for delivered heat energy €/GJ	
	industry	buildings	industry	buildings
Natural gas	90%	85%	3.4	7.9
Electricity	100%	100%	13.7	22.2
Fuel oil	85%	78%	6.3	10.4

Source: IEA – energy prices 2006.

Table 8 Fuel costs for heating

Figure 25 • *Cost breakdowns and ranges (excluding VAT) in 2005 for a selection of REHC systems compared with the reference energy price range (shaded bar) for gas, fuel oil and electricity heat energy carriers for the domestic (top of range bar) and industrial (bottom) sectors*



Notes: The conventional energy carrier costs are only based on fuel costs and conversion losses because investment and depreciation costs of appliances per GJ of heat are relatively small. Neither reference system nor avoided costs due to fuel savings are incorporated. Installation costs are included but heat distribution costs and costs allocated to electricity generation for CHP technologies are not. Details on cost assumptions are given in Annex A.

In Conclusion, Providing heating, and to a lesser degree cooling services, accounts for around 40-50% of global consumer energy demand each year, yet policies to encourage REHC technology development and deployment have often been neglected compared with those supporting energy efficiency, renewable electricity, or biofuels for transport.
There appears to be high potential for heating services to be provided from geothermal resources by displacing conventional fossil fuels and hence reducing greenhouse gas emissions as well as, under certain specific conditions, improving security of energy supply and reducing related risks to human health.
Deep geothermal heat is used mainly by industry and district heating schemes in regions where resources are available, whereas shallow geothermal heat is used more extensively, mainly for small-scale domestic applications. Projections out to 2030 show a significant increase in all of these commercially available technologies.

		Costs 2005		Costs reduction by 2030 (% 2005 costs)
		Range(€/GJ)	Average (€/GJ)	
Solar Thermal		8 to 307	52	-42
Bioenergy		2 to 99	26	-5
Deep geothermal		0,5 to 11	2	+11*
Shallow	Heat only	3 to 89	19	-9
	H&C: heating	2 to 75	17	-8
	H&C: cooling	2 to 97	16	-8
*: Increase costs due to the scarcity of sites and many of the good sites are already developed				

Source: IEA. 2007

Table 9 Summary of estimated installed global capacities, energy outputs 2005 and projected costs 2030

Parameter		Value
Interest rate		5% to 15% (average 10%)
Auxiliary energy costs (electricity)		5€ to 20 € /MWth (average 25€/MWth)
Plan Lifetime	Solar	15 to 25 years (average 20)
	Biomass	10 to 20 years (average 15)
	Deep geothermal	25 to 55 years (average 35)
	Shallow geothermal	20 to 30 years (average 25)

Table10 Overview of parameters to calculate the costs of providing heat energy

All data in the overview are based on estimates by GIA (Mongillo, 2007). Costs by 2030 might have come down to €15.4 /GJ (range €2.2 to 69 /GJ) for heating and €15 /GJ (range €1.8 to 89 /GJ) for cooling, mainly due to expected lower investments and increased coefficient of performances (COP).

Based on the assumptions used, average costs appear reasonable, but the maximum costs seem high.

Table A10 • *Cost parameters for shallow* geothermal heating and cooling in 2005 (excluding VAT) with projections to 2030***

		Data for base year 2005				Extrapolation to 2030
		Minimum	Average	Maximum	Unit	
Input data	Investment cost	200	500	1 150	2005€/kW_{th}	-15%
	Share investment cost for					
	- heating	67	67	67	%	0%
	- cooling	33	33	33	%	0%
	Coefficient of performance***	3	4	5		+33%
	Auxiliary energy needed for					
	- heating	240	500	930	kWh_e/kW/yr	0%
	- cooling	120	325	670	kWh_e/kW/yr	0%
	Cost of auxiliary energy	0.05	0.15	0.2	2005€/kWh_e	+25%
	O&M	4	9	15	2005€/kW_{th}/yr	-15%
	Full load hours				hrs/yr	0%
	- heating****	1 200	2 000	2 800		
	- cooling****	600	1 300	2 000	hrs/yr	0%
	Life of plant	20	25	30	yr	+20%
	Interest rate	5	10	15	%/yr	+10%
Intermediate results	Investment				2005€/kW_{th}	
	- heating-related	133	333	767		
	- cooling-related	67	167	383	2005€/kW_{th}	
	Annuity	6.5	11.0	16.0	%/yr	
	Annual investment payment					
	- heating-related	9	37	122	2005€/kW_{th}/yr	
	- cooling	4	18	61	2005€/kW_{th}/yr	
	Annual auxiliary energy cost					
	- heating	12	75	187	2005€/kW_{th}/yr	
	- cooling	6	49	133	2005€/kW_{th}/yr	
	Annual O&M cost	4	9	15	2005€/kW_{th}/yr	
	Energy produced per year					
	- heating	1 200	2 000	2 800	kWh_{th}/kW/yr	
	- cooling	600	1 300	2 000	kWh_{th}/kW/yr	
Output data	Total energy cost heating					
	- investment	0.9	5	28	2005€/GJ	-16% to -10%
	- fuel	0.0	0	0	2005€/GJ	0%
	- auxiliary energy	1.2	10	43	2005€/GJ	-25%
	- O&M	0.4	1	3	2005€/GJ	-15%
	Total - heating	**2.4**	**17**	**75**	**2005€/GJ**	**-20% to -19%**
	Total energy cost cooling					
	- investment	0.6	4	28	2005€/GJ	-16% to -10%
	- fuel	0.0	0	0	2005€/GJ	0%
	- auxiliary energy	0.8	10	62	2005€/GJ	-25%
	- O&M	0.6	2	7	2005€/GJ	-15%
	-Total - cooling	**2.0**	**16**	**97**	**2005€/GJ**	**-21% to -19%**

**The other major shallow direct uses not included here are bathing/swimming pools (30.4% of total direct use) and non-district space heating (3.4%).*

***Covers worldwide systems for the base year 2005, and projected relative differences by 2030. Neither a reference system nor avoided costs due to fuel savings are incorporated. Installation costs are included but heat distribution costs are not.*

**** Assumed geothermal heat pumps only and higher COPs for future technologies.*

***** Assumed 1200 hrs/yr for USA; 2000 hr for Europe; 2 800 hr for northern Europe and Canada.*

Shallow geothermal heat only

All data in the overview are based on estimates by GIA (Mongillo, 2007). Costs in 2030 might have come down to €18 /GJ (range €2.5 to 82 /GJ) mainly due to expected lower investments and an increased coefficient of performance (COP).

Table A11 • *Cost parameters for shallow* geothermal heat only in 2005 (excluding VAT) and projections to 2030***

	Shallow geothermal heat only	Data for base year 2005				Extrapolation
		Minimum	Average	Maximum	Unit	to 2030
Input data	Investment cost	200	500	1150	2005€/kW$_{th}$	-15%
	COP***	3.0	4.0	5.0	-	+33%
	Auxiliary energy needed	240	500	933	kWh$_e$/kW/yr	n/a
	- cost	0.05	0.15	0.2	2005€/kWh$_e$	+25%
	O&M	4	9	15	2005€/kW$_{th}$/yr	-15%
	Full load hours heating****	1 200	2 000	2 800	hrs/yr	0%
	Lifetime	20	25	30	yr	+20%
	Interest rate	5	10	15	%/yr	+10%
Intermediate results	Investment heat-related	200	500	1 150	2005€/kW$_{th}$	
	Annuity	6.5	11.0	16.0	%/yr	
	Annual investment payment	13	55	184	2005€/kW$_{th}$/yr	
	Annual auxiliary energy cost	12	75	187	2005€/kW$_{th}$/yr	
	Annual O&M cost	4	9	15	2005€/kW$_{th}$/yr	
	Energy produced per year	1 200	2 000	2 800	kWh$_{th}$/kW/yr	
Output data	Total energy cost - investment	1.3	8	43	2005€/GJ	-16% to -10%
	- fuel	0.0	0	0	2005€/GJ	0%
	- auxiliary energy	1.2	10	43	2005€/GJ	-6%
	- O&M	0.4	1	3	2005€/GJ	-15%
	Total	2.9	19	89	2005€/GJ	-12% to -8%

**The other major shallow direct uses not included here are bathing/swimming pools (30.4% of total direct use) and non-district space heating (3.4%).*

***Covers worldwide systems for the base year 2005, and projected relative differences by 2030. Neither a reference system nor avoided costs due to fuel savings are incorporated. Installation costs are included but heat distribution costs are not.*

**** Assumes geothermal heat pumps only which make up 32% of total direct heat use (current technology provides the higher COPs listed here)*

***** 1200 hours operation assumed for USA; 2 000 hrs for Europe; 2 800 hrs for northern Europe and Canada.*

Appendix 1: European building stock

	Dwelling stock	Stock of one/two family houses	% of dwellings in one/two family houses	Annual replacement (units)
Austria	3.863.262	1.557.420	46,84%	77.871
Belgium	4.083.991	2.516.309	63,71%	125.815
Czech Republic	3.827.678	1.379.430	41,89%	68.971
Cyprus	292.934	157.921	62,06%	7.896
Denmark	2.509.000	1.479.000	58,95%	73.950
Estonia	617.399	169.750	29,02%	8.488
Finnland	2.512.442	1.013.560	40,34%	50.678
France	28.699.868	16.635.423	59,18%	831.771
Germany	38.690.000	13.977.000	45,02%	698.850
Greece	5.476.162	2.731.905	58,89%	136.595
Hungary	4.064.653	2.434.438	61,50%	121.722
Ireland	1.279.617	1.157.170	91,57%	57.859
Italy	27.320.022	8.782.749	40,49%	439.137
Lithuania	795.700	193.568	26,14%	9.678
Latvia	1.292.336	452.806	37,40%	22.640
Luxemburg	171.953	108.453	66,11%	5.423
Netherlands	6.456.036	5.409.322	100,00%	270.466
Poland	12.523.583	4.923.430	42,45%	246.172
Portugal	3.551.229	2.026.753	61,05%	101.338
Slowenia	777.772	431.884	64,69%	21.594
Slowakia	1.896.554	957.283	52,15%	47.864
Spain	14.184.026	4.812.801	36,92%	240.640
Sweden	4.294.000	1.963.000	45,71%	98.150
United Kingdom	25.283.000	20.226.400	80,00%	1.011.320
EU-25		95.497.773		4.774.889
Liechtenstein	14.263	6.797	53,52%	340
Norway	1.961.548	1.206.337	65,91%	60.317
Switzerland	3.581.001	951.479	30,19%	47.574
Subtotal		2.164.613		108.231
Total		97.662.386		4.883.119

Table 5 Existing building stock and annual refurbishment rate for heating systems in Europe (source: Eurostat 2001)

Project Description

The GROUND-REACH project is expected to effectively assist EU policy towards both short and long term market penetration of ground coupled heat pumps, through analysing the market for ground coupled heat pumps and providing best practices, guidelines for local/regional authorities and key professional groups, conferences, meetings, website, brochure and other promotional tools. It will facilitate: A better understanding of ground coupled heat pumps merits and benefits and their importance towards Community policy objectives in relation to Kyoto targets and the buildings performance directive. An increased awareness and improved knowledge and perception of the ground coupled heat pumps technology among key European professional groups for short term market penetration.

The work is grouped in the following work packages:

WP#1 – Project management

WP#2 - Estimating the potential of ground coupled heat pumps for reducing CO_2 emissions and primary energy demand for heating and cooling purposes in the built environment: evaluation of available statistical information, definition of competing heating/cooling technologies, analysis of existing calculation tools, CO_2 emissions calculation.

WP#3 - Compiling and evaluating existing ground coupled heat pumps best practice information in Europe: identifying and updating information from all European member states, including case studies, and technical guidelines.

WP#4 - Analysing the contribution of ground coupled heat pump technologies to reach the objectives of the Buildings Performance Directive: Analysis of the technical, environmental and economic feasibility of ground coupled heat pump technologies; Guideline for supporting planners and architects in detailed technical aspects and in general questions; Standards review, evaluation and proposals.

WP#5 - Defining measures to overcome barriers for broader market penetration and setting up a long term dissemination plan: identification of market barriers including legal/ regulatory, economical and technical, proposals for long term EU level interventions to overcome them, including a new directive on RES-Heat.

WP#6 - Launching a large scale promotional campaign at European level: brochure, poster, promotional text, presentations, interactive Internet site, setting-up the European Geothermal Heat Pump Committee, publications, international conference and exhibition, a series of regional meetings targeting key professional groups.

WP#7 - Common dissemination activities

Project partners

Project Coordinator: Centre for Renewable Energy Sources (CRES)

SVEP Information & Service AB (SVEP)

Ecofys Netherlands b.v. (ECOFYS)

Cestec SpA

European Geothermal Energy Council (EGEC)

University of Oradea (UOR)

The Energy Efficiency Agency (EEA)

Agence de l'environnement et de la Maîtrise de l'energie (ADEME)

European Heat Pump Association (EHPA)

BESEL S.A. (BESEL)

Escola Superior De Tecnologia De Setubal (ESTSetubal)

Narodowa Agencja Poszanowania Energii S.A. (NAPE)

COWI A/S (COWI)

Fachinformationszent rum Karlsruhe G mbH

Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H (ARSENAL)

Ellehauge & Kildemoes (E & K)

EnPro Engineers Bureau Ltd (ENPRO)

Bureau de Recherches Géologiques et Minières (BRGM)

Flemish Institute for Technological Research (VITO)

Geoteam Technisches Büro für Hydrogeologie, Geothermie und Umwelt Ges.m.b.H (GEOTEAM)

TERA Energy S.r.l. (TERA)