GROUND SOURCE HEAT PUMPS IN THE UK – MARKET STATUS AND EVALUATION

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Abstract: This paper reviews the status of the ground-source heat pump (GSHP) market in the UK and contrasts this with the more mature European markets (Austria, Germany, Sweden and Switzerland). The reasons for such a strong difference in GSHP installed capacity and the barriers that the UK market is facing are investigated. The paper presents a comparison of key facts and statistics from the UK and four nations with a strong GSHP market. A questionnaire was also designed and circulated in order to gain a greater insight into market inhibitors from those working in the UK GSHP industry. From the market assessment it is shown that GSHP development in the UK is some twenty years behind the other nations and received lower levels of support from government and utilities. A significant inhibitor appears to be the legacy of previous fossil fuel security in the UK. Feedback from the questionnaire suggests high capital costs are also a key factor.

Key Words: ***ground-source heat pumps, UK, market, barriers***

1 INTRODUCTION

Ground Source Heat Pump (GSHP) technology has the potential to assist the UK government reduce CO_2 emissions associated with domestic space and water heating requirements, in a market currently dominated by natural gas boilers and direct electric heating. They could also play a role in ensuring “every home is adequately and affordably heated” and in reducing reliance on energy imports.

However, the number of installed units in the UK is very small, and much lower than in some other European nations. This paper aims to assess the current status of the UK GSHP industry. This will be conducted by assessing the GSHP markets of Austria, Germany, Sweden and Switzerland and then comparing these with the current situation in the UK. Various barriers are investigated further to determine their relative significance. In order to gain the opinion of those working in the UK GSHP industry, a questionnaire was designed and sent to key organisations active in the field and the responses are analysed. Through this investigation into GSHP markets this paper aims to establish how best to maximise the potential of the technology. This paper is a condensed overview of the main findings in the first author’s MSc thesis (Le Feuvre, 2007).

2 MARKET OUTLINE

2.1 Global Picture

In general the implementation of GSHP technology is fast growing with annual global increases in excess of 10% over the last ten years. Furthermore over 30 different countries

are experiencing similar impressive growth rates. In May 2005 it was gauged that world installed capacity amounted to 15,380 MW_{th}. However despite this positive trend "at a country level, there are great differences. In addition to some pioneering countries, there are several countries and regions in which there are only a few or even no GHP's in operation" (Rybach, 2005). There are many underlying factors that explain this and these will be made clear during the barriers evaluation in section four. The four European nations selected were done so on the basis of their strong GSHP industries. Sweden has the second highest installed GSHP capacity and highest capacity per capita of systems worldwide. In terms of GSHP capacity per land area Switzerland is ranked highest with Austria fifth (Rybach, 2005). Germany was selected on the basis of its strong GSHP market and the fact it has a more comparable population and fossil fuel resources with the UK.

2.2 Ground Source Heat Pumps in Austria

There are approximately 23,000 heat pumps in Austria with a total capacity of 275 MW_{th} and a thermal energy use of 370 GWh/yr (Curtis et al., 2004). Approximately 95% of heat pumps used in the housing market are ground sourced. The growth of heat pumps and renewable technologies in general can be traced back to the second oil crisis of 1978 when the Austrian government commissioned an energy review with a lasting legacy. This resulted in a boom in heat pumps sales from 1980, which was based upon government tax reductions for this technology and higher oil prices. However the market could not cope with this rapid rate of growth and many systems were unreliable since the large demand opened the door to less established companies with plumbing or air-conditioning backgrounds to step in. This resulted in poor system performance, mainly due to poor integration with the existing heat distribution system or from over sizing, and caused the market to decline during the 1980's before an upturn in 1990 when it has been increasing since. Austria has a high proportion of district heating systems, either fossil fuel or biomass fired, and in many cases heat pumps are seen as 'the' alternative for residences too remote to be connected. The LGW (Leistungsgemeinschaft Wärmepumpe) trade association was formed in 1990 to promote heat pumps and their environmental benefits, influence regulations and develop education and training and research and development (Halozan, 2003). This has clearly corresponded with an upturn in the market. The main Austrian manufacturers of heat pump systems are Junkers, Buderus, Elco, Aglitter, Ochsner, Vaillant and Veismann.

2.3 Ground source Heat Pumps in Germany

There are approximately 46,000 heat pumps in Germany with a total capacity of 640 MW_{th} and a thermal energy use of 930 GWh/yr. Approximately two thirds of heat pumps sold in Germany utilise the ground as a heat source (Curtis et al., 2005). The development of the heat pump market in Germany bears many similarities to Austria. There is a sales explosion in 1980 and then a gradual reduction to 1990. After this there is a slow but gradual recovery. Again the same explanation is hypothesised. After the second oil crisis heat pumps were pushed onto the market without the widespread industrial or professional competence for manufacture and installation at level to meet demand. Fluctuating oil prices were also influential. The federal heat pump association was formed in 1993 and has over 300 members, including 95% of manufacturers and approximately half of suppliers. The main goal is to increase the use of heat pumps in the new build sector from 2% to 20%. Selected German manufacturers are ERW Wärmepumpen, Dimplex, Steibel Eltron and Veissmann.

2.4 Ground Source Heat Pumps in Switzerland

There are approximately 30,000 heat pumps in Switzerland with a total capacity of 525 MW_{th} and a thermal energy use of 780 GWh/yr (Curtis et al., 2005). Forty percent of all heat pump systems utilise the ground as a heat source; of these 5% use horizontal loops, 65% boreholes (100-400m depth) and 30% use groundwater as a heat source.

A strong emphasis on heat pump use from Government and Utilities alike has resulted in a "steadily growing residential market" (Van de Ven, 1998). In some regions one third of all new houses utilise a heat pump system and there are set targets for numbers of installations. Growth rates are annually increasing at a rate of more than 10% (Curtis et al., 2005), with the biggest increases for systems under 20 kW. The Swiss market does not show the 'boom and bust' characteristics of Austria and Germany but demonstrates steady growth. The Swiss Heat Pump Association (FWS) provides information, produces publications and runs events. In addition there is the national heat pump test and training centre WPZ, and AWP the heat pump manufacturers association, members include Steinmann, Novalen and Hoval among others. The Austrian, Swiss and German heat pump associations have worked together to form the D-A-CH heat pump quality label, this specifies achievable coefficient of performances, set servicing standards (24hr call out service), spare part availability for ten years and gives a three year system guarantee. To ensure quality in the whole heat pump system, a certification programme for installers has also been initiated.

2.5 Ground Source Heat Pumps in Sweden

There are approximately 230,000 heat pumps in Sweden with a total capacity of 2,300 MW_{th} and thermal energy use of 9,200 GWh/yr (Curtis et al., 2005). Sixty five percent of all domestic heat pump sales in Sweden are brine/water ground systems, it should also be noted that GSHPs in Sweden are able to offer particularly competitive emissions reduction due to the high contribution of hydropower and nuclear in the nation's electricity generation portfolio. Heat pump systems first became popular in the early 1980's, and by 1985 over 50,000 units had been sold. From the middle of the decade onwards sales were stunted slightly due to lower energy prices and some quality issues, however development of the heat pump market in Sweden has demonstrated stable and sustainable growth. Sweden is undoubtedly the European leader in GSHP technology. One of the main reasons behind this can be attributed to unlocking the potential within the existing housing stock "more than 75% of all heat pumps sold are retrofitted into buildings" (Böswarth, 2004). This has proven a considerable stumbling block in other European nations. To reflect the high number of installations Sweden has two national heat pump associations, SVEP and SEV.

2.6 The UK Market

Lund et al. (2005) estimate that there are approximately 550 heat pumps in the United Kingdom, with a total capacity of 10.2 MW_{th} and a thermal energy use of 12.6 GWh/yr. These figures, dwarfed by other European nations, suggest, "the adoption of heat pumps for heating buildings has been inexorably slow" (Curtis et al., 2005) in the UK when compared with the other countries outlined above. Between 1970 and 1994 it is estimated that just twelve GSHP systems were installed in the UK. This is significantly different from the gradually developing markets of Sweden/Switzerland and erratic but prominent development in Germany and Austria during this time. However, there has been rapid growth since the turn of the century, which is depicted in Figure 1. This is encouraging but the numbers are still far lower than the European markets already presented; however it does appear that "markets are developing and at a pace that should allow the industry's capabilities and structures to grow in step with demand" (Hitchin, 2004).

As regards public awareness of the technology it is a safe assumption that "heating optimised dedicated heat pumps for domestic space heating and domestic water heating are almost unknown in the UK" (Freeborn, 2003). And since 20% of total energy consumption for space and water heating is in the domestic sector, bridging the domestic market is key to successful widespread implementation of GSHP technology. The UK Heat Pump Network was formed in 1999 to offer support, provide a platform for networking and bring together expertise within UK manufacturers and installers. It has been stated however that, "there is considerable scope for developing a more competitive network of developers and installers"

(DEFRA, 2004). A sub-committee has also been established to investigate domestic ground source heat pumps. In 1999 the UK joined the International Energy Agency (IEA) Heat Pump programme. The national Ground Source Heat Pump Association (GSHPA) was formed in 2006 with the aims of raising standards, promoting the industry and market and developing technology (Ellis, 2006). Its presence will support the development required to meet the growing demand shown in Figure 1.

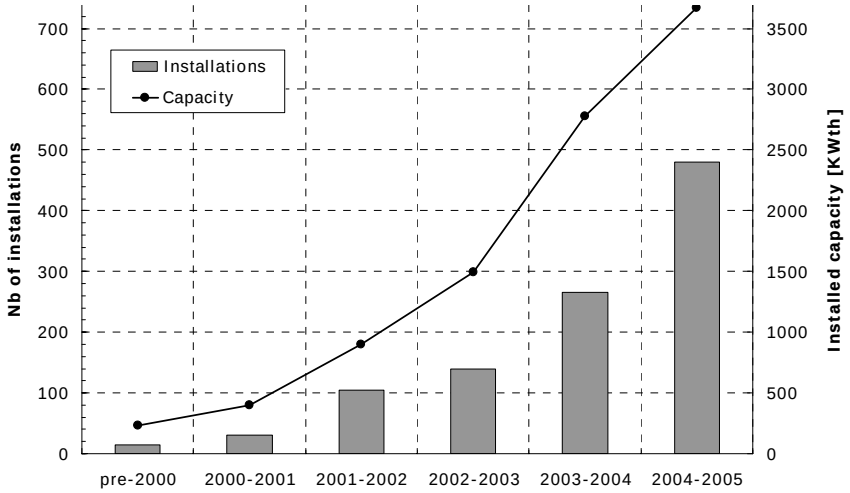

Figure 1: Estimated GSHP Market Growth in the UK 2000- 2005, adapted from (Ellis, 2006)

3 UK MARKET BARRIERS

"Success in the market is not an accident – it is a result of research, excellent products, skilled installers, the support of utilities and a political goal" (Halozan, 2003). There have been many reasons postulated to explain the lower levels of GSHP utilisation in the UK compared to the market development shown in other European nations. The next sections review these barriers and attempt to evaluate their impact. How influential is each specific circumstance? Can some be ruled out altogether as inhibitors to the GSHP market?

3.1 Single Phase Electricity

Heat pumps are driven by an electric motor, which will draw an inductive load and therefore require high electric currents on start up. This can cause disturbance to the electricity distribution network, which will result in lights flickering, premature main fuse failure and voltage surges which can damage electronic equipment (EST, 2004). This is especially true where the electric grid is weak, such as in off-gas remote locations thought to be ideal for GSHP systems. The vast majority of all UK domestic properties are supplied with a single phase 230V 50Hz electricity supply. With a single phase supply the size of load that can be connected is limited and high start-up currents can cause disruptive loads across the network, which will therefore limit compressor size to 2-3 kW without soft-start technologies. The four other European nations discussed all have a widespread 230V 50Hz three phase electricity distribution network. Since "almost all EU homes have a three phase power supply" (Freeborn, 2003) it can also be difficult to obtain European closed loop water-water heat pumps which are manufactured to offer >4 kW capacity and operate on single phase power (Curtis, 2001).

3.2 Poor Efficiency of Housing Stock

The large majority of housing in the UK is / was built with what would be considered, by the standards of other European nations, a very low level of insulation and air tightness.

"Comparisons with other European countries confirm the view that British homes are the least efficient with comfort levels the lowest in Northern Europe" (Schipper 1987, cited in Guy and Shove, 2000). The 2006 building regulations in the UK stipulate that energy demand should not be higher than 146 kWh/m²/yr. In Austria, new buildings are required to use less than 100 kWh/m²/yr. Swiss regulations from 2001 and German regulations have approximately the same requirements. Standards from 1990 in Sweden were tighter than the UK's current levels at 108 kWh/m²/yr. Austria, Germany and Switzerland are also part of the 'Passivhaus' building network of nations – buildings that comply with that standard have an energy demand that is 85% lower than UK 2002 regulations.

This has resulted in a higher and more variable heat demand, less suitable for GSHP systems. In addition, high heat demand compounds the limitations on heat pump capacity imposed by a weak electricity distribution network. This is particularly detrimental to heat pump development since rural areas are typically off the gas grid and have large areas of available space to install a ground loop. This is not a problem that can be quickly solved, in fact "86% of the 1996 housing stock will still be standing in 2050" (ECI, 2006).

3.3 Limited Support from Utilities

It has been clearly demonstrated in the case studies of Austria, Germany and Switzerland that utilities have played key role in developing the heat pump market through promotion, active marketing, forming networks with installers and offering financial incentives. Although there has been some involvement from utilities with Heat Pumps in the UK it has been on a far smaller scale with very little publicity and active marketing to end users.

In the early 1990's 40 domestic 1.4 & 2.5kW DX systems were installed in Scotland by Scottish Hydro-Electric, this pioneering development however was not built upon. More recently, Powergen has launched the 'Heat Plant' scheme which aims to install 1,000 'Calorex' GSHP systems into the social housing sector to satisfy its Energy Efficiency Commitment (EEC) targets. However, it is clear that Heat Pumps are not being seen as a core element of the business, such as is the case with OKA in Austria and SAK in Switzerland. British activity seems more aimed at generating positive publicity and satisfying legislative requirements than at developing new markets, as a genuine business activity.

In Austria, Germany and Switzerland utilities, as well known organisations, have played a key role in providing credibility to GSHPs and by backing the technology have helped to erase customer scepticism. The successful example of Austrian utilities seems to be based on the concept of creating "a climate of confidence for the customers, and to support them by supplying reliable systems" (Van de Ven, 1998), many also offer special heat pump tariffs. Several Swiss utilities have played a key role in developing the heat pump market. For example the approach of the utility SAK has proved to be successful is that the market share of heat pumps in the target group is almost 50% in certain SAK regions; "The comprehensive service package, from the consultancy phase to monitoring efficiency, was a determining factor in the success of this direct marketing campaign" (Bürkler and Gasser, 1998).

3.4 Prevalence of Fossil Fuels

The UK has a long history of being self sufficient in fossil fuels, being described as "an island of coal, sitting on a bubble of gas, surrounded by a sea of oil" (Hitchin, 2004). It could be that these once vast reserves have cultivated a rather blinkered attitude, both from government and the general public, towards alternative energy sources and means of generation.

The United Kingdom has a widespread mains gas distribution grid that serves approximately 75% of UK housing and most urban areas. Natural gas is typically cheaper per kWh than alternatives such as oil, LPG, coal or electric heating which are mainly utilised in areas off

the gas grid. The presence of gas utilised in conjunction with a high efficiency (condensing) boiler can provide a cost-effective and controllable heating option; which is therefore appealing to the general public. Table 1 compares the gas distribution networks in the UK with the 4 countries selected in this paper.

Table 1: Gas Distribution Network Comparison

Country	Gas network status
UK	The domestic gas supply network is available to approximately 75% of households
Austria	27.4% of households utilised gas as a heating fuel in 1999.
Germany	48% of households have a gas fired heating system.
Sweden	Gas only accounts for 1.5% of primary energy use and the majority of this is for industry. There is only one supply pipeline in Sweden (from Denmark).
Switzerland	40% of households have a domestic gas supply.

The popularity of the natural gas domestic boiler, based on historical cheap gas prices and high efficiency condensing units, also limits the use of GSHPs indirectly as it is relatively small and easy to install. Furthermore condensing boilers utilise high temperature 'wet' distribution systems (i.e. 80 ºC & 70 ºC flow and return temperatures) with heat exchange areas not suitable for utilisation of a heat pump system. Therefore to retro-fit a system to fit oversized radiators will cause significant disturbance and add to the project costs. If heat pumps are to compete with fossil fuel systems and penetrate the retrofit market in gas network areas payback periods will need to improve.

3.5 Costs

The relatively high installation costs, compared to other more conventional heating systems and therefore long pay back period on running costs savings are "at present a major barrier to the widespread adoption of this technology" (DEFRA, 2004). Running cost savings will be aided by an increase in fossil fuel prices however. As previously mentioned the main competitor to widespread use of the electric vapour compression heat pump is the gas fired domestic boiler and the relative prices between gas and electricity are fundamental in determining comparative running costs. Figure 2 shows the evolution of electricity and natural gas prices and their ratio in the UK (EIA, 2007). It is clear that the ratio is decreasing and is now well within the range of COP's achievable by GSHPs.

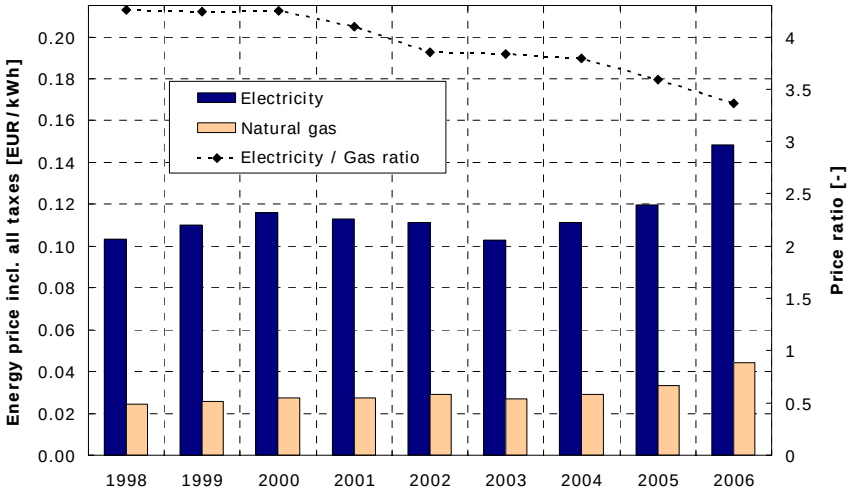

Figure 2: Historic electricity and natural gas prices in the UK and their ratio

Table 2 shows the electricity and gas prices in the UK, Austria, Germany and Sweden in July 2006 (Goerten and Clement, 2006a and 2006b) and for Switzerland in 2006 (EIA, 2007). It

shows that the ratio between gas and electricity costs was almost the same between the UK and Germany, although gas is almost twice the cost of in the UK. In Austria and Sweden, however, gas and electricity are closer in terms of cost.

Table 2: Comparative Gas and Electricity Price Ratios [2006 prices incl. all taxes]

	UK	Austria	Germany	Sweden	Switzerland
Gas [EUR/kWh]	0.036	0.056	0.062	0.097	0.052
Electricity [EUR/kWh]	0.12	0.14	0.19	0.16	0.11
Electricity / Gas ratio	3.2	2.6	3.0	1.6	2.1

3.6 Awareness & Acceptance

It is clear that as regards GSHP systems in the UK there is a “lack of understanding and confidence around their use amongst both potential users and investors” (DEFRA, 2004). If the general public as a whole is not aware of the environmental and cost reduction benefits of installing such a system they will not view them as an attractive proposition.

When considering the European nations reviewed it is not just the GSHP market that is less well developed in the UK, utilisation of most renewable technologies is higher in these countries. This more significant variability brings greater acceptance of non fossil fuel technologies and can therefore be seen as a stimulant to the use and acceptance of heat pumps. During the 2005 UK general election the green party did not win a single parliamentary seat and polled just 1.07% of the vote. This is in stark contrast to Germany for example where the green party has had a strong influence on politics and was in fact part of a coalition government between 1998 and 2005. Using utilisation of other renewable technologies as a proxy for general public awareness and flexibility as regards non fossil fuels, it can be seen that the UK should have far lower levels of awareness, see Table 3 (percentage of renewable energy in total primary energy supply and in domestic production).

Table 3: Comparative Utilisation of renewable energy (Le Feuvre, 2007)

	UK	Austria	Germany	Sweden	Switzerland
Primary energy supply [%]	2	21	4	26	15
Domestic production [%]	2	71	10	41	34

3.7 Role of Government

It can be alleged that the UK government has not done enough to facilitate growth in the UK GSHP market. The initial developments within the heat pump markets of Austria, Germany, Sweden and Switzerland occurred as a result of the second oil crisis in the late 1970’s. Prompted to reduce the reliance on important fuels the governments of these nations sought alternative energy sources and as such stimulated heat pump demand through generous subsidies. Perhaps due to the relative security of domestic fossil fuel reserves at the time the UK did not follow this path. In addition the earliest response to climate change concerns also did not include energy efficiency and alternative energy sources but instead pursuing the ‘dash for gas’ (and its associated lower CO_2 emissions, when compared with coal fired generation, in combined cycle electricity generation) of the 1990’s. Although there are numerous targets for renewable electricity generation in the UK, such as 10% by 2010 for the UK and Scotland’s ambitious target of 40% by 2020, there has as yet been no development of a renewable heat target. This is despite the fact the domestic sector accounts for approximately a third of all primary energy use and CO_2 emissions.

As highlighted by the European nations reviewed, subsidies have played a vital role in market development. Heat pumps are eligible for funding under several schemes but none of these are dedicated heat pump programmes, instead they support a wide range of technologies such as the Energy Efficiency Commitment (now CERT), Low Carbon Buildings Programme (Phase 2), and Scottish Community and Householder Renewables Initiative (SCHRI) funding schemes. It is also clear that the level of support offered to heat pumps, whether in the form of regional grants such as found in Austria or assistance with borehole geology information in Germany, is not present from Local Authorities in the UK. Specific examples of government actions to stimulate the heat pump market can be cited from the European nations reviewed. The introduction of a carbon tax in Switzerland in 2008 will further raise the appeal of heat pumps; this option however is not on the political agenda of the UK according to the 2007 'Energy White Paper'.

In Germany government support has been specifically offered for GSHPs since 1997 and is available for heat pump projects at a varying rate per kW of heating capacity which reduces for larger systems i.e. if above 15kW. There are no direct subsidies to install heat pumps in Sweden, although R&D is still supported. Therefore it can be assumed that the market has reached a stage of maturity where installation/running costs are deemed competitive with other fossil fuel technologies. Financial incentives were on offer however from the mid eighties to nineties. Swedish building regulations state that the maximum distribution temperature of hydronic (wet) systems is 55ºC; this of course greatly advances the use of GSHP technology with low distribution temperatures. In Austria each of the nine federal areas offers different support. A typical level of support for a ground source space heating heat pump would be in the region of 2000€. These examples show the strong role government needs to play for renewable technologies to become more established.

3.8 Other barriers

Le Feuvre (2007) also investigated potential barriers relating to UK geology and climate, quality of systems and installation and the 'state of the art' of the technology. These are not deemed as influential as the barriers described in 3.1 – 3.8.

3.9 No Barrier Argument

It could be suggested that there is no overwhelming barrier, or combinations of circumstances, which explains the reasons for lower utilisation rates of GSHPs in the UK and that the market will eventually grow and establish itself as accepted technology like in Austria, Germany etc. For this to be true the explanation is simply that the UK started involvement in the heat pump market later. While other nations were experiencing high sales numbers in the early 1980's the UK market only exhibited clear growth since 2000. And while manufacturers and installers were forming trade associations in the early 1990s the UK GSHP Association only started in 2006. The same can be said for the provision of subsidies etc Assuming this argument is to believe that the current impressive growth stats in the UK will continue; matching global trends, negating the various barriers highlighted until a natural market level is reached.

4 BARRIERS EVALUATION

Of the various base conditions which were suggested to be impeding GSHP market development in the UK there is no doubt that some appear more influential than others.

The historical high abundance and utilisation of fossil fuels in the UK has created a legacy of inefficient housing stock and preconceived conceptions as regards what is a conventional or acceptable means of domestic heating i.e. fossil fuel based. In addition the UK has more

widespread gas distribution network than the other countries mentioned; this, in tandem with cheap gas prices, has made it hard for alternative heating technologies to become established in these areas. Since the vapour compression cycle needs a work input in the form of electricity the greater inequality of gas and electricity prices highlighted in the UK does not aid GSHP cost effectiveness either.

Other barriers may well be removed in time but will present a massive undertaking. Due to national government and European legislation initiating programmes to raise levels of insulation in the housing stock, complemented by higher quality new build, energy efficiency in housing is increasing. However since there is a relatively small stock turnover and large number of properties unsuitable for improvement measures or with 'unaware' residents it will take a long time to reach parity with the four other countries discussed. Switching to three phase domestic power supplies would require large scale investment and reconfiguration of the electricity distribution network; easier adoption of heat pump technology is not reason enough to undertake this.

The fact that the UK heat pump market has developed far later (in the region of 15-20 years) that the other nations mentioned cannot be ignored when considering the lower number of installations present. Estimates show the UK market is currently growing rapidly and with the correct support this should continue. With this in mind it may well be that the relative impact of these potential inhibitors will not be discovered until the market reaches a level of stability. If this is at a far lower level than the other nations it may be that these base conditions are constraining the market.

5 MARKET ASSESSMENT QUESTIONNAIRE

As part of this research it was thought beneficial to obtain the viewpoint of those involved in the British ground source heat pump industry as regards the various barriers discussed and also gauge opinion on possible solutions. Therefore a questionnaire was drafted and sent to 123 members of the UK Ground Source Heat Pump Association, members of the Heat Pump Association, and system installers registered under the Low Carbon Building Programme. The response rate was 16%. A blank copy of the questionnaire and tables of respondent's answers can be found in (Le Feuvre, 2007). It is acknowledged that due to the relatively small number of responses no wide ranging conclusions can be made of the opinions of the UK ground source heat pump industry as a whole. But it is hoped that the responses will give a useful insight into what the main issues are perceived to be and how they could be tackled.

5.1 Response to Question One – Market Barriers

In question one the respondents were asked to select up to three of nine possible explanations of what they perceived to be key factors in the relatively immature UK ground source heat pump market. The response is shown in Figure 3.

Perceived UK GSHP market barriers	Number of answers															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Single Phase Elecricity	■	■	■	■	■	■	■	■								
Varied UK Geology	■	■														
UK Climate	■															
Poor Insulation of Housing Stock	■	■	■	■												
Limited Installer Capacity	■	■	■	■	■	■	■	■								
Capital Costs	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Poor Government Support	■	■	■	■	■	■	■	■								
Limited Public Awareness	■	■	■	■	■	■	■									
Extensive Gas Supply Network	■	■	■	■	■											

Figure 3: Responses to Questionnaire Question One

The clearest message from this feedback is that the high capital cost of systems, especially compared with fossil fuel heating, are considered to be inhibiting market growth. Issues of single phase electricity, limited installer capacity and low public awareness are also acknowledged to be influential. It is perhaps surprising that the UK's legacy of energy inefficient housing and high fossil fuel availability do not appear high on the agenda. Perhaps this can be explained since these factors cannot be overcome, at least not in the short term, and therefore the focus falls on the issues that are inhibiting growth within the defined niche of what is thought to be the potential GSHP market i.e. new build houses off the gas grid. UK climate and geology (the latter only being chosen by drilling / trenching contractors) were not in the main seen to be major constraining influences. The questionnaire also solicited information on any barriers not put forward, question two, the response to this is included in the first author's thesis (Le Feuvre, 2007).

5.2 Response to Question Three – Removing Barriers

Question three posed the question of which three of the nine solutions suggested would be most effective in stimulating the UK GSHP industry. The results are shown in Figure 4.

Removing UK GSHP market barriers	Number of answers															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Greater Utility Involvement																
Larger Financial Subsidies																
Renewable Heat Targets																
Installer Training Programme																
Greater R&D Funding																
Awareness Raising Measures																
Quality Label/Accreditation																
Carbon Tax																
Local Authority Support																

Figure 4: Responses to Questionnaire Question Three

Unlike the responses to question one there is not one answer which received a significantly higher backing than others. Not surprisingly due to the high number of respondents who considered high capital costs a primary inhibitor methods to make GSHP's more financially attractive scored highly. Renewable heat targets were supported as a means by which government could strengthen its support for the technology. In order to tackle the issues regarding installer capacity and quality of work training programmes and quality label / accreditation schemes were endorsed. It is interesting however that these ideas were not widely supported by the respondents who actually install systems. Other solutions not put forward in the questionnaire were also solicited, question four, the suggestions given can be found in the first author's thesis (Le Feuvre, 2007).

6 RECOMMENDATIONS

It is clear from reviewing barriers present that more could be done to harness the potential of GSHP's; and there a numerous positive examples that can be found from the European nations evaluated. It should be mentioned that many of these issues, such as higher installed cost, poor market networks and guidance for installers can be remedied.

Although not the case in Sweden, where utilities are not actively involved in the market, the examples from Austria, Germany and Switzerland show there is clear benefit to the industry through forging alliances with utility companies. Within these countries where utility companies offer heat pump services and technology a marked increase in installations are present in their region. Demonstrating the financial potential of the technology will be fundamental to convincing utility companies to become more involved.

To ensure a quality service to customers a support and training network for suppliers/installers to develop “a skilled design and installation workforce” (Hitchin, 2004) would be beneficial; this has proved successful in the European markets already discussed. An accreditation system similar to those found in Europe (i.e. the D-A-CH label) would give customers added reassurance and help to allay fears as regards investing in a ‘new’ technology. Market expansion however will “require considerable investment by the industry to expand its capacity” (Curtis, 2001). This will be required to ensure the same problems of poor quality installation which occurred in Germany and Austria, when supply could not match demand, do not occur in the UK; encouragingly, “the UK is beginning to see developments in terms of the supporting infrastructure that will be required before these systems can be widely applied” (Curtis, 2001). At present there is no independent test centre in the UK for heat pumps, developing such a facility would allow optimisation of GSHP technology for the UK market.

Leading the market to a point where a significant number of systems are installed UK wide however will require an increase in support from government. Specific grant schemes for GSHP units, as available in Austria, Germany and Switzerland, would also act as more of a stimuli than the generic renewable energy funding schemes that cover heat pumps. A renewable heat target, in the same vein as the 10% renewable electricity by 2010 goal, could go a long way to furthering the case of heat pumps. Until the market has reached a point where installation costs are competitive with fossil fuel heating systems it is unlikely the general public will be sufficiently convinced in order to install in such numbers to meet technical potential.

At present GSHP technology, and its environmental/cost saving potential, is not widely recognised by the general public and as such there is a real need for demonstration and promotional efforts from central government and also local authorities who have the ability to support GSHP installations and utilise systems within social housing. In addition “there is little, if any, direct marketing effort from manufacturers or installers to end users” (Böswarth, 2004). This is a marked distinction with, for example, Austria where close relationships and familiarity have been built up with the general public.

7 CONCLUSIONS

The aim of this paper was to evaluate the ground source heat pump market in the UK and understand any inhibitors which are constraining its development. Furthermore lessons which can be learnt from abroad so the technology can play a significant role in meeting government energy policy to reduce the carbon footprint of the United Kingdom’s space and water heating requirements, meet fuel poverty targets and increase security of supply have been noted. If designed and operated correctly a ground source heat pump should be able to offer reduced running costs and save on CO_2 emissions when compared to other domestic fossil fuel systems. It seems clear that ground source heat pumps have the potential to make a more significant contribution in assisting the government meet these goals and with the right support encouraging recent growth trends should continue.

This paper should have demonstrated that there is a wide range of reasons postulated for the relatively low levels of ground source heat pump utilisation found in the United Kingdom. While all of these may play a role to a certain degree it appears that they vary in overall influence, with the UK’s history of large fossil fuel reserves particularly pertinent. It should not be ignored however that the UK ventured into the heat pump market far later than the other countries mentioned and this will to an extent explain the discrepancy in numbers installed.

Whether the level of installations found in Sweden for example will be met remains to be seen, with the large scale gas distribution grid a significant constraining factor on installation

numbers. Considering this it is clear that the technology should be utilised alongside other low carbon heating methods such as combined heat and power and biomass, aided by greater utilisation of energy efficiency measures, to reduce the carbon footprint of space and water heating in the UK.

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