EXPLORING THE POTENTIAL FOR GSHP UPTAKE – AN INTEGRATED APPROACH TO GSHP DEPLOYMENT TO ADDRESS FUEL POVERTY IN THE UK

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Abstract: Ground source heat pumps represent the single best renewable technology for space heating applications. The ratio between electrical energy input and heating energy output allows for few comparisons – they are, in short, the best at what they do. Yet the GSHP market in the UK has not been fully developed, even in tandem with Government support mechanisms such as the Green Deal or the Renewable Heat Incentive. High initial and residual costs often eclipses actual long-term benefits, meaning GSHPs are not seen as a valid option for many projects within the built environment. This paper takes a holistic approach to GSHP deployment, and explores novel ways in which the full benefits of GSHPs can be realised. Critically, this integrated approach places the real and increasing problem of fuel poverty at the heart of the solution.

Key Words: market opportunities, heat pump deployment, fuel poverty, integrated approach

1 INTRODUCTION

The seasonal climate in the UK means that space heating makes up a large proportion of the final energy demand across all sectors, with about 9 out of 12 months requiring heating rather than cooling. This is especially important within the domestic sector, where space heating accounts for more than 50% of total energy consumption (DECC, 2012). Cooling does not play a significant role other than through natural ventilation. With the addition of heat pumps, it is anticipated that more efficient heating, and less wasteful cooling practices, can be achieved.

With such a large space heating demand, appropriate options that consider this portion of the UK energy consumption should achieve large gains in carbon reduction, as well as assisting this future renewables mix. Heat pumps, with efficiencies in excess of 300%, represent a suitable option for this, especially when complemented by increased energy efficiency and lower energy demand (Ochsner, 2007) – in short, they are the best at what they do. However, it is common that heat pumps are often eclipsed in favour of other technologies, especially where there is access to mains gas (Fawcett, 2011). How therefore can we fit heat pumps within this developing energy landscape, and how best can we target and support their deployment? This research paper serves to show that innovation, integration, and targeting beyond, and in tandem with, climate change targets are critical for the heat pump market in the UK to develop.

2. POLICY SUPPORT FOR RENEWABLE HEATING

The UK has gone a long way in setting strict emissions targets, as well as offering support mechanisms for renewables, and renewable heating. The drivers for this can be found across a number of policy areas – no one policy exists in isolation that can transform the heating market towards specific uptake of GSHPs.

2.1 The Renewable Heat Incentive, Green Deal, the ECO, and Smart Meters

UK policy and incentive schemes are contributing to a growing increase in more efficient and renewable heating installations (Abu-Bakar, et al., 2013). Underpinning this is the UK Government's Renewable Heat Incentive (RHI) scheme (Donaldson & Lord, in press). A world first for renewable heating, the scheme pays cash payments to producers of accredited renewable heating installations. Payments are made quarterly over 20 years for the non-domestic sector, and 7 years for the domestic sector (launching in 2014), aiming to cover the capital costs of the installation as well as having the potential for a residual amount of money to be left over to cover running costs (DECC, 2011). Tariffs are technology specific (for GSHPs this is payable at 8.7p/kW·h for non-domestic, 18.8p/kW·h for domestic), tailored to incentivise an appropriate mix of renewable technologies towards meeting climate change targets, and provide market confidence for investment (ICAX, 2014).

Functioning independently of the RHI is the Green Deal, a mechanism that serves to transform the energy efficiency of the UK building stock through lending for energy efficiency measures that is taken out against a property (Rosenow & Eyre, 2013). The lending is paid back via savings on energy bills up to a period of 25 years, underpinned by the rule that the cost of improvements be covered by the savings they produce.

The Energy Companies Obligation (ECO) is a mandated effort by the UK Government to have utilities invest a minimum level of efficiency measures back in the building stock for which they supply energy (Rosenow & Eyre, 2013). This is targeted at hard to treat properties, for which cavity wall insulation is often appropriate.

Whilst not compulsory, the rollout of smart meters across the UK building stock is a moderately supportive energy efficiency measure. A predicted eventual two way flow of information will assist in demand side management and even demand side response for utilities (ENA, 2012). This also means that property owners will have greater transparency over their interaction with energy and energy companies, which aims to assist more appropriate day-to-day end uses.

2.2 Targets, UK Legislation, and Localised Support

Climate change targets, set at the EU Level and drafted into UK Legislation under the Climate Change Act (2008), provide a benchmark on which UK climate change incentive schemes are built on. This states a required level of GHG emissions reduction of 80% by 2050, and provision for an interim reduction of 34% by 2020 (Bassi et. al, 2013). The EU Renewable Energy Directive (2009) also mandates specifics on the levels of renewables penetration, which is set at 15% of total energy to come from renewables for the UK 2020, within which 12% of heat is to come from renewable sources (UK Government, 2010).

These two legislative paths have seen the creation of the Committee on Climate Change publications, including the UK Renewable Energy Roadmap, as well as creating incentive schemes such as the RHI. More localised approaches include local authority plans such as sustainability appraisals for cities and towns to incentivise new business and investment.

2.3 Policy Effect on Heat Pump Infiltration

If packaged together, policy support offered for renewable heating installations and climate change targets should provide a significant boost to the potential for increasing ground source heat pump market penetration. However, figures for GSHPs in the UK remain low – total domestic installations to date are between 13,000 and 15,000 – with the domestic sector accounting for 75-90% of the total GSHP market (Environment Agency, 2009). Notably, support for the domestic sector is currently only available under the voucher based Renewable Heat Premium Payment (RHPP) scheme, a one-off grant, valued at up to £2300 for GSHPs, which must be paid back if owners seek to claim the RHI instead when it is launched in spring 2014 (YouGen, 2014). The current policy structure supports both the domestic & non-domestic heating sectors, all be it functioning independently.

Comparing figures for uptake across both the RHI (currently 'non-domestic') and the RHPP ('domestic') shows that the rate of GSHP installations is declining, not increasing as anticipated, especially in the domestic sector (figure 1).

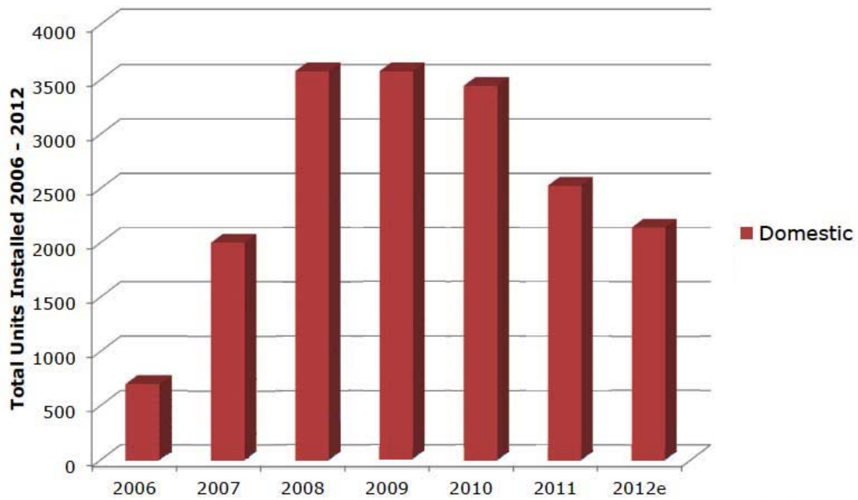

Figure 1: Total Domestic GSHP Units Installed UK

Source: http://www.gshp.org.uk

The reasons for this decline are two-fold. The economic recession, beginning in 2008, had drastic effects on the housing market, including public & private spending, a crucial component in making GSHPs viable due to the high initial capital cost. The RHI scheme itself may have had an adverse effect on the GSHP market, even although it aims to revolutionise the affordability of renewable heating methods. It is possible that the introduction of the RHI in 2011, exclusively for the non-domestic sector, may have had a negative effect in the domestic sector. Installers may also be waiting for the domestic RHI launch in 2014 before committing to developing a GSHP system. Whilst domestic support remains in place under the RHPP, funding for GSHPs is low relative to capital costs making many GSHP installations not viable or financially attractive.

Any examination of GSHP impact using installation figures is also compounded by the difficulty of there being no one organisation that records GSHP installations, meaning cumulative figures can vary by as much as 2000 installs year on year (Environment Agency, 2009). It is feasible to use recorded application figures for the RHI and recorded voucher redemptions for the RHPP (both being a basis for installed systems) centrally from the UK Department of Energy and Climate Change (DECC), in effect using the current support structure as proxies for the non-domestic and domestic sectors respectively (table 1). There is no mandate that installations are registered, however it is a fair assumption that if GSHPs are being installed, it will be to receive the RHI or RHPP payments for which they have to be statistically recorded.

Table 1: Domestic & Non-Domestic RHI/RHPP Installations

Date	RHI GSHP Applications ('non-domestic')	RHPP GSHP Voucher Redemptions ('domestic')
2011	9	1000
2012	70	704
2013	102	245

Source: http://www.gov.uk

In tandem with the RHI, the Green Deal serves to strengthen the potential for rollout of renewable heating technologies. However, figures for this loan based scheme also show declining installations (DECC, 2014). Installations undertaken as part of the ECO are increasing, aimed at providing a basic level of efficiency through mechanisms such as insulation (DECC, 2014). However, the structure of the ECO means that costs are paid for by the customer through a levy on energy bills, regardless of whether ECO measures have been carried out at the property or not. The ECO therefore has the potential to adversely increase energy bills for customers.

2.4 The Potential for Heat Pump Deployment

However the figures are looked at – whether through total installations, total applications, or accredited applications – the falling deployment rate of GSHPs is less than encouraging. The assumption is that it is a failure of the RHI and RHPP schemes – however, figures for other technologies such as that for solid biomass boilers, where the application totals amount to the 1000s (DECC, 2013), show that the Government renewable heating schemes are working to an extent – just not so well for GSHPs.

It is also too early to comment on the effect or success of the RHI under what is a 20-year scheme. What is clear however is that Government support alone, even if tailored for renewable heating, is not working for GSHPs. The relatively small number of GSHP installations – specifically 89 fully operating, accredited systems under the RHI alone (DECC, 2013) – may well have happened anyway irrespective of RHI support.

How can we explore avenues for GSHPs through policy options that are tailored more appropriately to enable GSHP deployment? UK GSHP installation figures do not allow a full examination of the barriers to deployment – these are simply indicators – however, the same generalised barriers are consistently associated with GSHPs. These include physical space constraints (Navigant Consulting, 2009) as well as high capital costs, and limited public awareness (Hughes, 2008). Other barriers include the skills base to support the GSHP market, however this will develop as universal uptake increases.

Land availability, cost management through innovative funding routes, as well as a crucial awareness of the end user (for example, the ECO could be seen as operating regressively through increasing energy bills) are important enablers to rapidly develop the fledging GSHP market. Taking each one of these in turn and analysing where failures exist, or more appropriately how these can be adopted into GSHP design and development, builds the potential and opportunities for a much stronger GSHP market.

3. MAXIMISING GSHP OPPORTUNITIES: A TARGETED APPROACH

The 4th UK Government carbon budget, designed to have the UK on track for decarbonisation of the energy system well into the 2020s, anticipated 6.8 million heat pumps by 2030 (Equity Consulting, 2012). Backed by eight leading heat pump manufacturers and installers, the GSHP industry in the UK believes that this is realistic and feasible. How is it possible to make this a reality?

3.1 Competing Factors

The 6.8 million heat pumps envisaged will largely be displacing systems that are currently on mains gas (Equity Consulting, 2012). However, it is anticipated that a large displacement such as this will not begin to occur until the mid 2020s, as the continued reliance on natural gas fed boilers within households will aid the transition to a low carbon economy.

The projected transition to heat pumps is backed by EU climate change targets, as well as the significance of heating demand in the UK where more than 50% of the domestic energy use is for space heating (Kane et al, 2011). The roll out of smart meters also further supports the transition, where for the first time energy suppliers create an open dialogue with end users. The benefits of using heat pumps can also drive forward the industry – for example, RHI eligibility as well as relatively low-cost heat.

However, in the UK the market for GSHP is very much ‘niche’, broadly limited by public awareness and a skills base that is just beginning to develop. Barriers, including physical space constraints as well as high initial costs, are consistent across many projects (Environment Agency, 2009). The increasing cost of subsidised renewable electricity, when GSHPs require a small electrical input, compounds this issue further.

3.2 Targeting the Benefits of Low-cost Heating

If the temperature of a building or room fluctuates by 1 or 2 degrees celsius, it is noticeable whether that be subconsciously or not. In short, heating is almost as comparable to water – a necessity. Is the need for heating therefore equal across all levels of society, or are there sub sections that may benefit from low-cost heating more than others?

3.2.1 Fuel Poverty

In order to identify if there are individuals that may benefit from low-cost heating, we have to create an understanding of the end user. Factors such as age, disability, health, behaviour and access to heating technologies could all be used to narrow down the focus of a low-cost heating deployment strategy such as community GSHPs. Energy bills and energy costs per household represent a window into how the end user interacts with the provision of energy. Focusing on these costs therefore relates the energy need to the implications of meeting that energy need.

Describing how households are affected by energy costs (a part function of housing quality), can be summed up in one term – fuel poverty (Boardman, 2010). This occurs where the cost of all energy bills exceeds a threshold relative to household income. For Scotland this is where energy bills exceed 10% of total household income (Scottish Executive, 2002), and for England this is where energy bills are above the average leaving a residual income below the poverty line (DECC, 2013). Ultimately, if a household is spending a disproportionate amount of their available income on energy bills, they are in fuel poverty.

In energy terms, fuel poverty creates a base point upon which we can begin to target low-cost heating deployment. Disproportionately high energy bills have the potential to affect health through living in cold conditions, as well as having developmental effects in children through over-crowding, for example where only one room in a household is kept warm (Boardman, 2010). This has the potential for long-term effects on quality of life overall, as well as contributing to excess winter deaths primarily in the elderly – however, little data exists for pre-existing ill health as a factor (Boardman, 2010). High energy bills also result in a lower net available income remaining once bills have been paid, meaning this can seriously affect other aspects of living.

The World Health Organisation (WHO) recognises the importance of household warmth, and that a property be maintained to a certain temperature for a certain period each day (WHO, 2007), based on the demographic of the occupant. This recommendation laterally informs housing standards in the UK. This is also echoed by the Scottish Government who have set the ambitious target to eradicate fuel poverty in Scotland as far as is reasonably practical by November 2016 (Scottish Executive, 2002), recognising that it is a serious issue.

Choosing to target the fuel poor therefore draws in elements of equality and social justice, through specifically relating approaches to the needs of the end user.

3.2.2 Characteristics of the Fuel Poor

It is estimated that 1 in 5 households in the UK are fuel poor (Energy Action Scotland, 2013). For Scotland alone this 1 in 4. For every 5% increase in energy bills it is estimated that 46,000 properties are pushed into fuel poverty (Scottish Government, 2010). The figure for Scotland therefore could become as high as 1 in 3. It could be assumed that fuel poverty is prevalent, and that relating energy bills to household income will identify the fuel poor.

Energy bills are a dynamic and changing aspect of the fuel poverty debate. This means that households drop in and out of fuel poverty throughout the year. Also, as households approach the fuel poverty line, they can self regulate energy use to mitigate fuel poverty, which means they are not officially classed as being fuel poor – but, they are still using an insufficient amount of energy to meet their needs.

Individual household energy bills, as well as individual household income, are also not recorded which adds to the difficulty in identifying the fuel poor. What can be said is that the fuel poor are likely to be single people, single parents, the unemployed, the elderly, those on Government means-tested benefits, and those that live in energy inefficient properties – in short, often those that are income deprived, and those that are living in sub standard conditions.

3.3 Spatially Identifying Options for Deployment

Many of the factors that influence fuel poverty (including but not limited to health, relative income, employment, and housing) are recorded through incidences of deprivation. This is an area-based survey approach that spatially details deprivation, scored according to pre-defined indicators (Scottish Government, 2012) (figure 2).

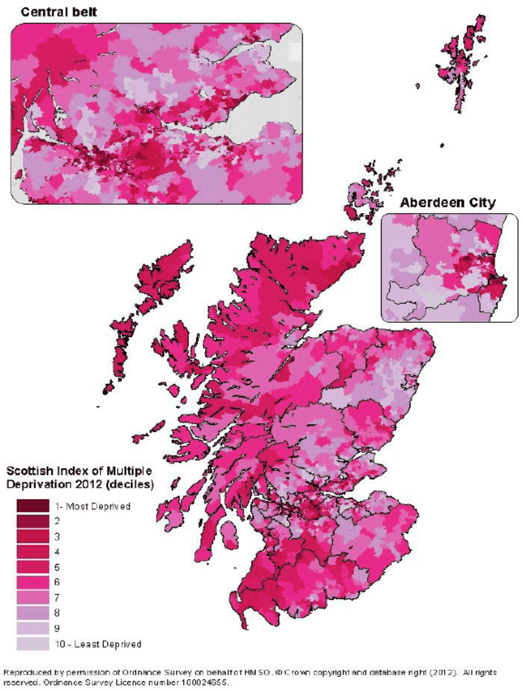

Figure 2: Deprivation Levels in Scotland, 2012

Source: http://simd.scotland.gov.uk

In the absence of having complete data for determining exactly who and where the fuel poor are, what can be used is a generalised approach – that is, we can say who the fuel poor are likely to be, and where the fuel poor are likely to be. Developing this spatial link therefore forms the second stage in trying to target low-cost heating correctly.

3.3.1 Vacant & Derelict Land

Considering fuel poverty as a spatial issue places greater reliance on one of the main barriers associated with GSHP deployment – land availability. Space allowances for any heat pump system design are often a limiting constraint in the project development (Navigant Consulting, 2009). Equipment mobilisation, equipment operation, and borefield development require significant space that often cannot be met within the urban environment. For substantial GSHP deployment, we require vacant land as a factor within the opportunity equation.

The UK has a long industrial history with previously developed land, often termed as 'brownfield' (Barton, 2000). This is land that is vacant and in some cases may have a level of contamination from previous industrial uses. Vacant and derelict land is unused, has little to no economic value, yet is distributed across many towns and cities, impacting on neighbourhoods and affecting planning and regeneration. Within Scotland, Glasgow City Council has 3 out of the top 5 areas that are ranked as being the most deprived (Scottish Government, 2012), which represents a significant opportunity to target fuel poverty if the land requirement for GSHPs and deprivation levels match. Figure 3 details land use and deprivation within Glasgow, Scotland for 2012.

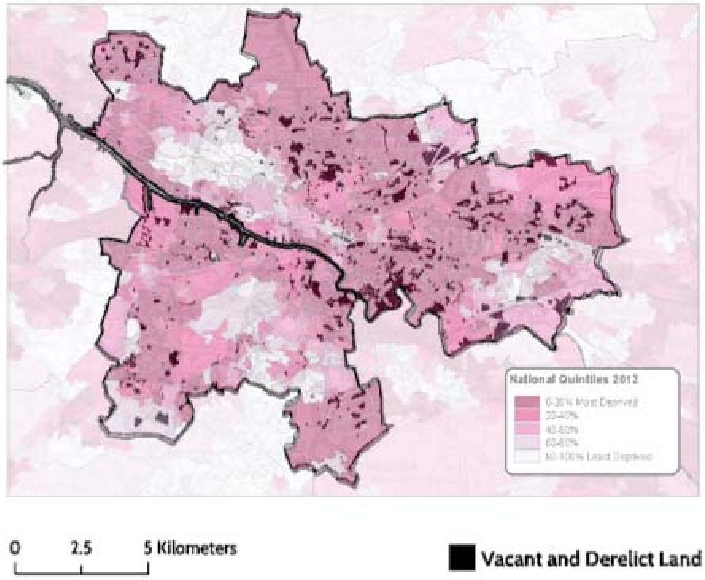

Figure 3: Deprivation Levels & Vacant/Derelict Land in Glasgow, 2012

Source: http://simd.scotland.gov.uk & http://www.glasgow.gov.uk

Comparing vacant and derelict land with relative deprivation levels in Glasgow reveals an obvious association that has not yet been explored for GSHPs and the provision of low-cost ‘renewable’, heating. However, although this land is identified as being vacant, it is important to quantify the potential value of this land for GSHPs, drawing on statistics of fuel poverty estimates, based on anticipated energy use (table 2).

Table 2: Projected Vacant & Derelict Land Heat Energy Yield using GSHPs

Vacant and Derelict Land Area, Glasgow:	12,350,000 m^2
Households in Fuel Poverty, Estimate:	~62,000 (~*13,000 high risk*)
Peak heat demand, household of size 200m^2:	~9kw
Applying horizontal array GSHPs:	
Heat pump capacity:	9kw
COP:	3.3
Energy provided by ground source:	6.3kW (6,300W)
Energy yield per metre of horizontal collector:	15W (conservative estimate)
Collector size per household (peak demand):	420m^2 (*factor in 20% buffer = 504m^2*)
Meeting peak demand via GSHPs:	Potential to heat 24,504 properties
Meeting 80% of peak demand via GSHPs:	Potential to heat 31,505 properties

There are variances in the figures – for example, fuel poverty levels could be as high as 90,000 within Glasgow (Scottish Parliament , 2012) – however this has the potential to fully heat 24,504 properties in this worked example. The GSHP technology option of a horizontal array is also representative of a worst-case scenario for energy extracted. A proportional increase in vertical boreholes with a smaller footprint will also increase the energy yield substantially, softening other limiting factors associated with vacant and derelict land, such as fragmented distribution and availability of some land parcels. Correct sizing also influences the potential to heat a greater number of properties, where options include meeting 80% of the household heating demand (Lund, 2011) where the rest is met by electricity or gas. In all cases, consideration should be given to the sub-surface, where temperature degradation may occur in the long-term due to the quantity of heat extracted; this however is mitigated at the design stage.

3.4 Defining a Suitable Access Point

Exploring the potential for GSHPs on vacant and derelict land is a significant step forward in the provision of low cost heating. A method such as this creates value where there was none previously. Basing any GSHP design criteria on the availability of vacant and derelict land alone however does not include a consideration for one of the most important factors – the end user. If there is no market for the heat harnessed through GSHPs on vacant and derelict land, then an approach such as this becomes significantly unattractive.

3.4.1 Social Housing

A viable option as an access point is social housing. Social housing has a long history associated with low-income households, traditionally housing vulnerable persons and those that are disadvantaged within society (Carley, 1990). Prerequisites found here such as income deprivation can compound incidences of fuel poverty. Although fuel poverty is also found in the privately rented/owned sector, this is increasingly difficult to target with a fixed heating installation due to the nature of mixed ownership in many housing estates and apartment buildings.

Social housing assists this dilemma by providing access to one landlord who can speak on behalf of, in some cases, thousands of tenants, all whom have a demand for space heating. Examining social housing as access opens up a powerful avenue where GSHP deployment can be maximized on a large scale, equivalent in some instances to industrial applications. Relating social housing spatially across Glasgow, using the largest social housing provider Glasgow Housing Association (GHA) with around 43,000 properties (GHA, 2013), demonstrates a striking relationship with both vacant land and also relative deprivation (figure 4). This shows that if the market for heat from GSHPs on vacant and derelict land is social housing, then it is exactly where we need it to be.

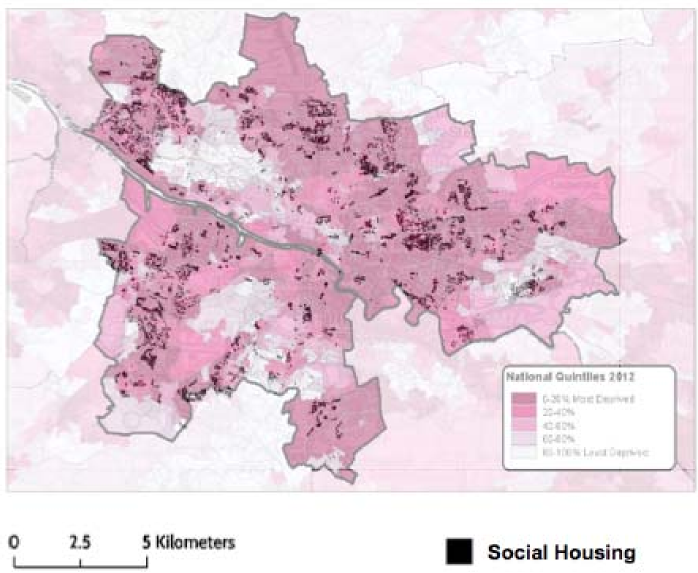

Figure 4: Deprivation Levels & Social Housing in Glasgow, 2012

Source: http://simd.scotland.gov.uk & http://www.gha.org.uk

4. CONCLUSIONS AND FUTURE CONSIDERATIONS

Through examining previously developed land availability, relative deprivation as a proxy for fuel poverty, and an end use towards social housing, a distinct case can be made for the use of GSHPs. Technical considerations, environmental considerations through regeneration, and social considerations all spatially fall exactly where they need to be in order to complement the deployment potential for GSHPs towards the provision of low-cost heating.

Whilst this develops a targeted approach towards enhancing options for GSHPs, it is important that an approach such as this be integrated correctly with key enablers such as financing, project viability, and long-term project management. This includes innovative financing routes, such as targeting funding set aside for vacant and derelict land remediation, as well as fully integrating GSHPs within planning frameworks. Viewed in this way, GSHPs have the potential to be a significant remediation and planning support option towards a low carbon economy. Long-term project management options involve the use of Energy Service Companies (ESCOs) where costly financing and risk management can mitigated as barriers to deployment.

With heat pump installations shown as declining, making the correct case for GSHP deployment can only serve to strengthen the GSHP market. Presenting a targeted, integrated approach such as this enhances both drivers and opportunities. Relating the need for low-cost heating to the end user, as is provided by GSHPs, creates a new dialogue - gone is the simple provision of renewable energy, replaced instead by provision targeting, where the end user is at the core of its design.

Integration across planning, innovative funding options, and ultimately the removal of cost barriers strengthen the possibilities for GSHPs towards a much stronger role in the provision of low-cost heating. The opportunities are there, providing they are harnessed correctly.

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