



Department
of Energy &
Climate Change

Potential Cost Reductions for Ground Source Heat Pumps

The Scope for a Mass Market

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Contents

Executive summary	4
The Scope for Cost Reductions in a Mass Market for GSHP	6
Current Cost Structure of GSHP	8
Future Cost Structure of GSHP in a Mass Market Scenario	12
Scope for Reduction of Equipment Costs	13
Scope for Reduction of Non-Equipment Cost	16
Outlook by 2020	19

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Executive summary

In a UK “mass market” scenario for Ground Source Heat Pumps (GSHP), we would expect an overall cost reduction of ~18% compared to current costs. This would be comprised of ~30% cost reduction in non-equipment costs, and 5-10% in equipment costs. GSHP cost in 2014 is split roughly equally between non-equipment costs and equipment costs (excluding VAT).

Non-equipment costs are dominated by drilling and ground work costs in today’s market (~60% of the total non-equipment costs). In a mass market scenario, the greatest cost reduction would come from the following key areas:

- **The installer-base would shift from one dominated by mostly small specialist companies with high overheads**, to larger renewables installers with lower overheads (the effect of small companies growing rather than new entrants).
- **The supply chain would be consolidated** and provide UK-wide coverage more efficiently – particularly through expanding distribution networks and bringing installation and drilling / groundwork’s capabilities closer to customer demand.
- **Drilling companies can have a viable business focusing only on GSHP** and invest in equipment optimised for GSHP drilling, rather than doing GSHP as an add-on to water drilling, and using equipment optimised for water drilling, ultimately bringing drilling costs down.
- **Sales channels for the equipment would shift towards wholesaler routes** in the way boilers are sold today – reducing distribution/transport costs, tightening margins and increasing competition (though borehole/drilling activities would remain for specialists, who can now focus on GSHP as their main business rather than using GSHP as a side business as they do today).
- **Installer skill level and confidence in the technology would be higher**, bringing labour cost down as jobs can be done more quickly and efficiently, and there is less need for “insurance” in the margins that installers would add.

Equipment costs today are primarily made up of the heat pump unit and ground loop equipment (accounting for ~55% of total equipment costs). Auxiliary equipment e.g. new low temperature heat emitters, cylinders, pipes and valves, make up the remaining cost. Equipment costs are unlikely to come down significantly in a mass market scenario:

- **Many system components are already mass market products**, sold into global boiler and air conditioning industries at low price with competitive margins (including auxiliaries such as cylinders and HP parts such as pumps and fans). Though economies of scale, increasing market competition, and increased “volume buys” may still have price impacts.
- **Heat pump technology is essentially a mature technology**, despite low market penetration in the UK. 700,000 HPs per year are sold in Europe – of which almost 100,000 are GSHP. The impact of economies of scale on the HP unit part of the equipment cost is not linked only to UK HP market sales, but to the wider European and global industry. The components shared across all HP types (e.g. compressors) would feel the strongest effects of economies scale, while components specific to GSHP (e.g. ground loops, heat transfer fluids for ground loops) would feel less effect.
- **One factor which could drive some cost-reduction in the UK is HP manufacturers having the confidence to invest in R&D focused on UK applications.** There is high technical potential to increase efficiencies (e.g. finding the optimum ways to draw heat out of the ground at low cost with UK geology) – which would lead to lower lifetime costs, and to identify lower cost materials for heat pumps – but it has to make business sense for manufacturers to invest in the necessary R&D.
- **There are unanticipated factors which could result in greater equipment cost reduction** – if new competition emerges from outside the traditional GSHP player – for example, air conditioning market players - with new lower cost concepts for extracting heat from the ground. Such cost reduction may be possible if – as some of our research suggests – some current manufacturer margins are held quite high. It is difficult to quantify how high margins currently are, as manufacturers are not willing to share such insight, but we have collected indications through our primary research that some large manufacturers may have gross margins such that that there could be room for reduction under such an unanticipated scenario.

The data we gathered had a wide range of costs per kW (as much as +/- 10% in some cases). There was not enough data for full statistical analysis but we have chosen data which was most representative of a “normal” case, based on our existing knowledge and expert opinion informed by our primary research. This report focuses on how costs may change and what cost drivers are. It is not an attempt to improve evidence on current costs, which DECC is continually seeking to improve through scheme data. To avoid inconsistency, this report refers to relative costs (%), rather than absolute costs (£).

We do not expect to see a “mass market” by 2020, which would involve a step-change in GSHP uptake including significant penetration of the replacement gas boiler market. This is unlikely by 2020, given the market barriers to overcome.

The Scope for Cost Reductions in a Mass Market for GSHP

Introduction

GSHPs in the UK are a small part of the market today, which are typically bespoke in design and installation, and represent <1% of heating appliance sales in domestic and commercial buildings. The UK is at the lower end of GSHP market share compared to other European markets – in Sweden and Switzerland, Europe’s most successful GSHP markets, GSHP reach levels close to 20% of annual heating sales. Increase in market share is one important factor that could drive cost reductions - primarily in non-equipment costs as the supply chain is optimised – but there are many other factors influencing cost reduction potential (as seen in the “Scope for reduction in equipment / non-equipment costs” section).

Currently the GSHP market is dominated by large product manufacturers from a gas boiler background that have expanded their product portfolio to include GSHPs (but have to date not pushed sales strongly), and by small specialist GSHP manufacturers.

The traditional gas boiler routes to market are being utilised already for GSHP penetration, but are having limited effect. Small specialist installers are leading the way on GSHP installs, with a few large firms specialising in GSHPs. Drillers typically do not focus only on GSHP as there is insufficient work for them, costs are high and coverage is regional. Currently the supply chain is not well developed and installers generally have to travel significant distances to jobs. The following table gives an impression of what a mass market scenario could look like and how it would impact the current key stakeholders.

	2014	Mass market
Market	<p>Low awareness and lack of confidence in HP across value chain.</p> <p>Cost-intensive and sub-optimal supply chain – including drilling</p> <p>One-off installs: GSHP in small number of off-gas new builds, handful of applications in retrofit.</p> <p>RSLs, developers, large commercial enterprises: ‘Early adopter market’, mainly domestic but with emergence of small commercial GSHPs.</p>	<p>Awareness of and confidence in HP across value chain.</p> <p>Supply chain well-developed across the country.</p> <p>One-off installs: GSHP the product of choice in new build and high penetration of retrofit market – capturing most of the off-gas market and displacing some gas (widespread displacement still a challenge without energy price changes).</p> <p>RSLs, developers, large commercial enterprises: “Volume” purchases of large number of GSHP at once would be standard practice and enable lower prices to be secured.</p>
Manufacturers	<p>Specialist HP manufacturers - relatively high distribution costs, sales volumes in the order of 100s to low 1,000s of HPs per year. Typically sell direct to installers and support on e.g. commissioning.</p>	<p>Specialist HP manufacturers: Becoming competitive as major heating market players in Europe – not just HP market players. May benefit from greater economies of scale in ASHP. Sales channels moving towards wholesaler route</p>

	European boiler manufacturers also selling HP – well-established UK-wide distribution & sales channels for boilers, but generally not pushing HP very hard relative to core business, & offering high cost HP products. Prefer to sell through wholesalers.	and away from more labour-intensive channels. European boiler manufacturers push GSHP more strongly.
Installers	2-3 large specialist installers (10s – 100s of employees) and several small specialist installers (<10 employees) who are also importing and distributing European-manufactured GSHPs & ASHPs. Near UK-wide coverage and responsible for the majority of GSHP installations in the UK.	Small specialist installers would become larger scale companies with lower overheads.
Borehole specialists	Relatively wide geographic spread and expertise of borehole drilling, but GSHP is only a side business. The majority of drillers, across the UK have a core focus on ground stabilisation and water boreholes, and have rigs designed for this purpose (not optimised for GSHP borehole drilling).	Larger specialist renewable installers may branch out into drilling their own boreholes. Borehole specialists would have enough possible business in GSHP that they can invest in GSHP-specific borehole drilling rigs, which in the long-term leads to greater efficiency and lower drilling costs.
Renewables Specialist Distributors	Majority of GSHP sold via specialist distributors whose main business is in renewables / HP. Today a handful of specialist distributors design, specify and distribute HPs to installers. Typically buy direct from manufacturers and sell direct to the installer, supporting on commissioning. Often also have installation capabilities in-house, or work closely with installers.	Half of GSHP sold via specialists who would fulfil the current role of wholesalers – they would have (geographically) wider distribution capabilities than in 2014, acting like gas boiler wholesalers but with focus only on HP / renewables. May merge with or evolve into specialist installers above.
General Wholesalers	Minority of GSHP sold in UK via wholesalers whose main business is in boilers – mostly only stock the lowest capacity GSHP, with main focus on gas boilers. No after-sales support on e.g. HP commissioning.	Half of GSHP sold via general wholesalers , who would sell a higher proportion of HP alongside traditional boilers. They would grow their current portfolio of lower capacity GSHP today to include a wider size range.
Utilities	Utilities dipping their toes in the water with some partnerships with manufacturers and installers, and some with their own installation capabilities. But low sales volumes to date.	Greater engagement from all UK utilities across the value chain – potentially with in-house distribution and installation capabilities – GSHP become core part of energy services offering.

Table 1: Comparison of market characteristics of today's GSHP market compared to our assumption of what a mass market scenario would look like.

Current Cost Structure of GSHP

In this report we consider a 90kW GSHP retrofit as a base case for scoping the potential cost reductions. Lower and higher capacity systems of 12 kW and 600 kW respectively, as well as new build costs are compared to this base case. Figure 1 and 2 displays the current equipment and non- equipment cost breakdown of a 90 kW GSHP¹. The non-equipment costs for a 90 kW retrofit GSHP are slightly higher currently than the equipment cost, mainly due to the additional drilling, boreholes, and ground work (~60% of this cost) as well as the added complexity in the design and specification process. For comparison, an ASHP has a higher proportion of equipment cost because the installation process is much simpler than for a GSHP.

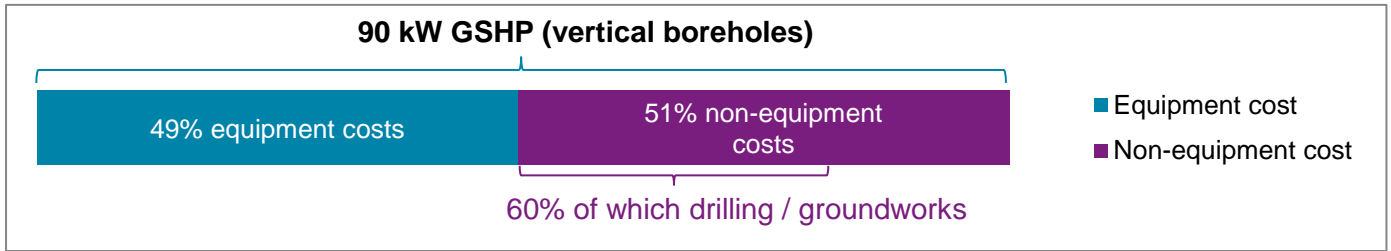


Figure 1: Current cost breakdown of a 90 kW GSHP (retrofit)

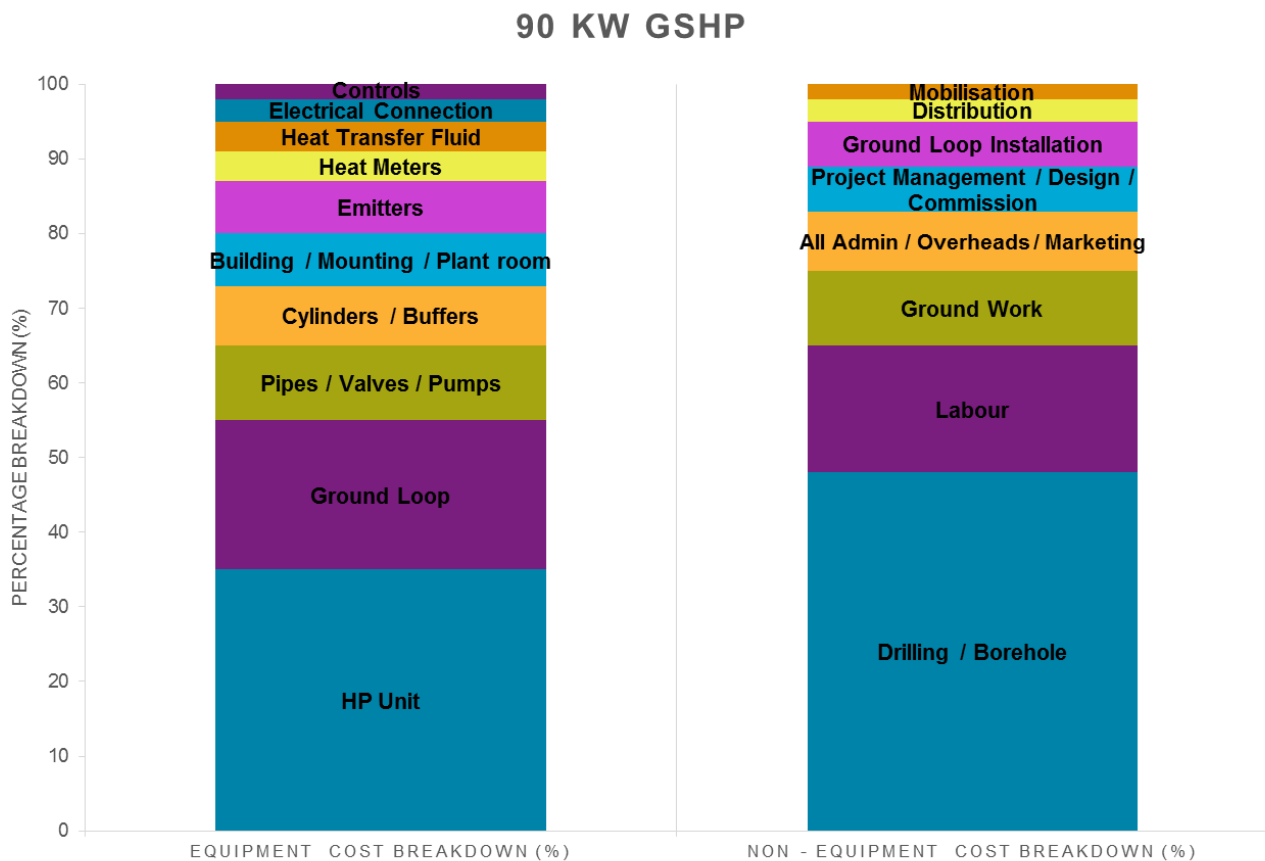


Figure 2: Detailed equipment and non-equipment cost breakdown of a 90 kW GSHP for retrofit. Comments outline the future potential for cost reduction.

¹ Current data and future scenarios are expert opinion from primary research (27 phone interviews with industry stakeholders, i.e. product manufacturers, installers, distributors, industry groups), our several years of heat pump market research through our Heat Pump Research Service and consultancy work into the heating market globally.

Notes for Figure 2

Central estimates for equipment and non-equipment cost: A 'typical' 90 kW GSHP does not exist in today's market because those which are installed are highly variable. This variability is greater for GSHP than ASHP because of the inherently bespoke nature of requirements for the groundwork's, which varies with geology and with physical space available at the site. From our primary research we have estimated these central costs, though the range in data collected was at least +/-10%. We have focused on a GSHP with vertical boreholes.

Cost sensitivities:

- Equipment & non-equipment costs for GSHP vary with heat source capture method and geology: The cost of ground loops are variable and depend on the length/number required, and whether horizontal or vertical. Horizontal ground works and laying lateral loops are significantly cheaper than boreholes (~30-40% cheaper). The ground work and drilling costs are very variable due to the inherently bespoke nature of drilling in different geologies. The cost of drilling depends on the depth of boreholes required, the availability of space to drill, the type / condition of ground as well as many other factors. For example, where the geology is soft sediment, boreholes need to be strengthened inside to prevent collapse (adding labour cost as well as equipment cost), compared with boring into granite, which requires no strengthening. The costs for boreholes per metre are approximately 10-15% lower in "easy" geology.
- It is possible that some of the smaller non-equipment cost components (e.g. admin, design) may be "hidden" in the labour costs, meaning that the actual time for admin and design is often higher than indicated in Figure 2. It is difficult to assign these percentages as, based on our research with stakeholders in the UK market, this sort of information is rarely recorded / aggregated on a project basis in this precise way.
- Project design and admin costs are dependent on the complexity of the project. Design time is quite variable and ranges from half a man hour for a simple domestic solution to a day or more for more complex projects and is not always relative to the kW thermal output. Design time depends on the requirement for and availability of the necessary prerequisite data required such as heat losses, heating and cooling loads, emitter types, cooling and DHW requirements, control strategies etc and whether this is supplied to the installer or if the installer has to gather the required data as part of the project.
- Heat pump system costs can vary depending on whether a "Rolls Royce" type product with maximum efficiency is chosen, or a more basic system, and whether additional optional add-ons are included such as buffers or sophisticated control systems and interfaces. For GSHP, more extensive ground-loops can be installed (at greater cost) to enable greater efficiency if required. These factors become particularly variable in the commercial sector due to the wider range of possible needs in commercial buildings compared to domestic. We have presented in Figure 2 the costs for a basic system (which we have asked for in our primary research), but we expect that this cost could increase in the order of 10-20% if a more complex / sophisticated system were chosen, and by more if, for example, extra boreholes are added to improve efficiency.
- There are regional differences in non-equipment costs: In more remote regions travel and logistic costs will be higher because installers have to travel further to the site, which could be 1-2 days additional 'cost of time' per installation. On a domestic heat pump, this could equate to doubling the cost of the time on the installation (which may take 1-2 days in itself). On a larger scale heat pump, the additional travel days may add an additional third to the cost of the time.

How do costs vary for larger and smaller installations?

	12 kW	600 kW
Overall Cost	<p>Overall cost is approximately 10-20% per kW higher than the 90 kW system (can be larger if boreholes are required). The split of equipment / non – equipment cost is comparable to a 90 kW system at 50:50</p>	<p>Overall cost is approximately ~15% per kW higher than the 90 kW system. The split between equipment / non – equipment cost is 45:55.</p>
Equipment costs	<p>Higher: Price / kW higher than for 90 kW because many of the same parts are used in a smaller system as in a larger – but are then proportionally a larger part of the total cost. E.g. sensors & transducers used in the 12 kW are similar in size & number to those used in a 90 kW. Further, the “full control package” is usually included with a domestic (12 kW) HP – even where the full functionality is not required, because it is generally a packaged system which is not customisable. Therefore there is an additional premium on smaller HPs for an “over-specified” control system. In a commercial-scale HP, the control capability is purchased based on what is needed in the application and can therefore be lower cost/kW.</p> <p>Biggest Cost Component: HP Unit and ground loops</p>	<p>Higher: Price / kW higher than 90 kW because of inherently bespoke nature of installation</p> <p>Biggest Cost Component: HP Unit and ground loops</p>
Non-equipment costs	<p>Higher: Total non-equipment costs / kW higher than for 90 kW, particularly because of ground works costs:</p> <p>Drilling costs per metre are higher than for a 90 kW system – the drillers’ start-up costs are the same whether for a small or large installation. <i>NB This is based on the costs only for vertical boreholes. If we consider horizontal trenches as an option, the overall cost/kW is lower than for boreholes. The likelihood of using trenches instead of boreholes is dependent on the physical land space available for trenches, which take up much more space. It could be argued that there is a greater chance of horizontal trenching in a 12 kW system than in a 90 kW system, simply because the chances of finding enough land to capture the heat needed for 90 kW could be more</i></p>	<p>Higher: Higher proportion of costs than for 90 kW:</p> <ul style="list-style-type: none"> • Typical larger-scale project (i.e. above ~250 kW) generally include not just a HP but a wider building solution including e.g. ventilation, cooling => need for more contractors with a wider range of skills (e.g. not just heating engineers) and significantly more complex project management.

	<p><i>challenging than for 12 kW. In this case, the groundwork's cost could be lower for a 12 kW using trenches than a 90 kW using boreholes).</i></p> <p>Project management costs are estimated to be lower than for the 90 kW because the project is simpler – but this saving is likely outweighed by the ground works costs.</p>	
	<p>Biggest Cost Component: Ground works, Commissioning and distribution</p>	<p>Biggest Cost Component: Ground works (including drilling), design, project management, commissioning and labour</p>

How do costs vary in new build?

The overall split between equipment and non-equipment cost is relatively similar in new build as in retrofit – although overall costs tend to be lower. In new build developments where there are multiple GSHPs installed at the same site, the cost split shifts more towards equipment, as non-equipment costs per HP drop. The total impact of drivers detailed below show that costs are ~10% lower in new build, and could potentially reduce by a further ~5-10% due to volume purchases, all costs impacts shown per kW.

Non-equipment costs are approximately 10% lower in new build today than in retrofit – and up to 20% lower where many installations are happening on the same site. The main reasons are the avoided additional labour cost to remove the current heating system, use of more standard repeatable system designs, and – crucially - reduced costs for ground works. In new build ground works can be completed during the construction phase of the whole building, reducing the time spent on e.g. preparing the ground and re-landscaping after the boreholes/trenches. Where the new buildings are at a new development where several GSHP are installed, the “start-up” drilling cost is much lower per HP than for a single installation because it is shared amongst the installations. This can significantly reduce costs.

Equipment costs for heat emitters in new build are higher (adding as much as 10% to the equipment costs) because they would have to be bought new in full, compared with retrofit where typically only a third to a half of radiators are replaced. Where underfloor heating is installed as a type of heat emitter in new build this is significantly more expensive than the standard radiators (or fan coils) – underfloor heating would not be installed in retrofit due to the disruption caused.

The Heat Pump unit part of the equipment cost could be 5-10% lower in new build because a more standardised system which can be easily repeated can be used in new builds, rather than more bespoke solutions. Further, volume purchase discounts are likely to be agreed in a new build where it is more likely that several HPs are installed at once (today the cost reduction for volume buying of ASHP is ~5-6% - we have not found examples of volume buying of GSHP but in a mass market we could imagine it).

Future Cost Structure of GSHP in a Mass Market Scenario

The majority of future cost reductions would come from the non-equipment costs – and in particular, drilling costs, which make up the majority of non-equipment costs. Figure 3 presents the future cost reduction potential under a mass market scenario². Under the mass market scenario equipment costs could reduce by ~5-10% and non-equipment costs could reduce by 30%.

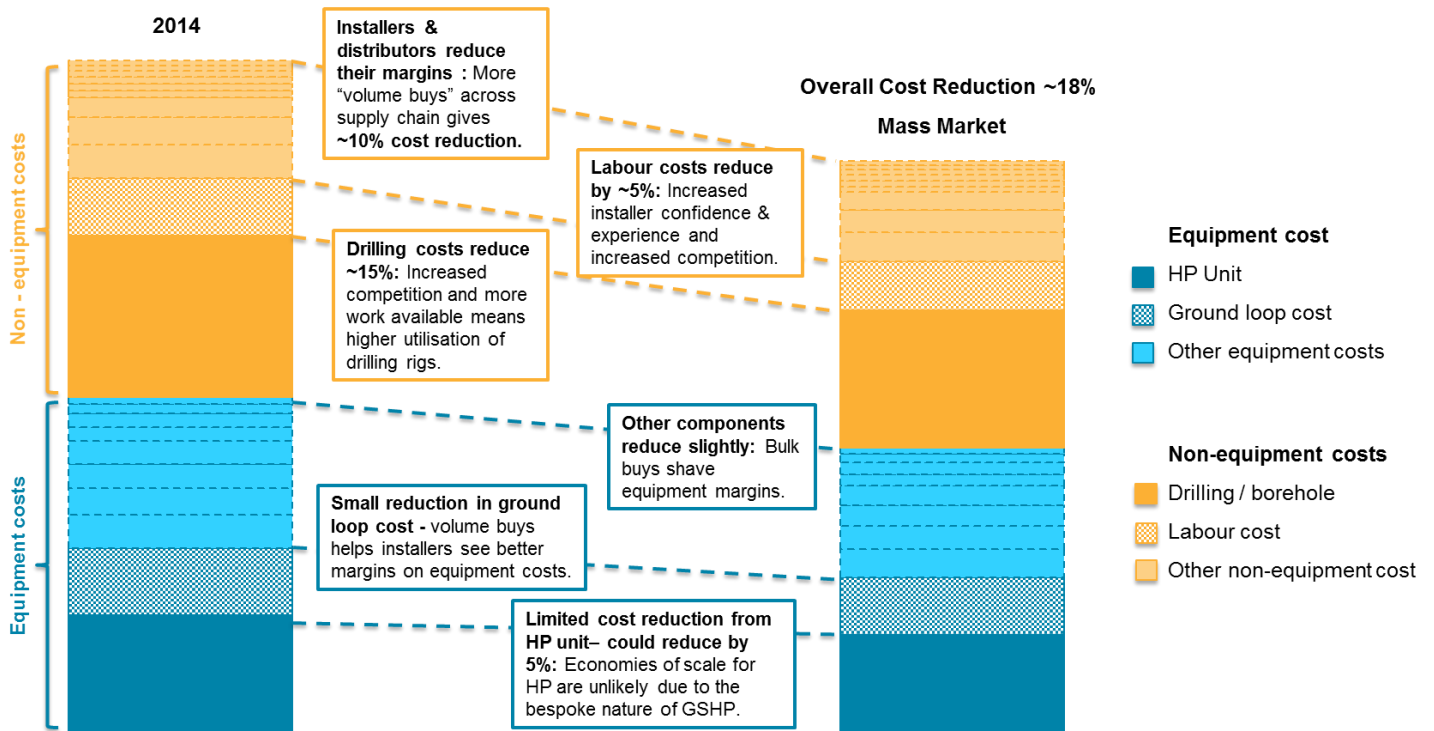


Figure 3: Margins across the supply chain and installation labour costs create the biggest cost-reduction potential in non-equipment costs*.

Notes on Figure 3:

Range of data and developing a central estimate: The percentage changes are based on a central cost breakdown which was developed through primary research – interviews with 27 stakeholders in the UK industry – combined with existing insight from the project team. We captured data showing a spread on total costs of at least +/- 10%. However, it is important to note that the focus of the report is on the cost reduction potential (percentage changes) and not the actual cost itself. Regarding future cost reduction potential, nearly all respondents in the interviews indicated very minimal future cost reductions were possible in equipment costs, but significant cost reduction could occur in non-equipment costs. This insight combined with our existing knowledge of equipment cost developments in other more developed heat pump markets, leads us to conclude that cost reduction of up to 10% is possible for the UK (though there are sensitivities as described below). In the future we expect that the normal distribution (range) of costs may narrow due to the market starting to use more standardised products (more like the gas boiler market today). However, compared to ASHP, this standardisation would not be possible to the same extent as GSHP are more bespoke by nature.

What could increase equipment cost reduction in a mass market? Delta-ee has defined in Table 1 what the characteristics of a mass market scenario would look like. Current GSHP equipment costs are

² Current data and future scenarios are expert opinion from primary research (27 phone interviews with industry stakeholders, i.e. product manufacturers, installers, distributors, industry groups), our several years of heat pump market research through our Heat Pump Research Service and consultancy work into the heating market globally.

unlikely to radically change. HP equipment costs in more developed HP markets in Europe, such as Sweden and Switzerland (where GSHPs have more than 20% share of the heating market), are not significantly lower than they are in the UK today.

What could drive larger cost reductions in a mass market? In order to drive an unanticipated scenario where a step change in equipment cost was possible, GSHP would need to have a much larger share (\Rightarrow 50%) of the boiler market – and the mass market would have to be felt not only in the UK but in the whole global market. The GSHP market outside the UK does not show signs of growing and has been stagnant for several years, which would be a challenge for UK prices to come down. An unanticipated scenario where equipment costs could drop more significantly would be if some of the air conditioning companies break successfully into the GSHP market with much lower price products (which is much less likely in the GSHP than ASHP market), and/or there is innovation in technology development for low cost capture of heat from the ground. The cost reductions would come from manufacturers being forced to reduce their margins to compete. Our primary research showed a very wide range for what manufacturer margins are today – from as high as ~40% for larger manufacturers, to some smaller companies saying they actually make a loss today. In a truly mass market scenario, the fact that margins at least for larger companies could be high, indicates that there could be room for further “squeezing” of margins than has been included in our analysis (potentially resulting in margins of 20% or less).

Regional differences in non-equipment costs: Currently rural areas are driving the HP market, hence when considering the mass market it is evident that the transport costs would reduce, as heat pumps more successfully penetrate increasingly urban areas. For GSHP the geology also significantly affects the drillings costs as described earlier.

Retrofit vs new build: Even under a mass market scenario GSHP retrofits would remain at least 10% more expensive than new build due to the need to remove old heating components and design in solutions to ‘fit’ to client and building requirements, and due to the additional ground works required in retrofit (preparation and landscaping as well as drilling). The use of large GSHP in district heating in new builds could also be considered under a mass market scenario, which would result in lower costs than for a GSHP district heating scheme as retrofit.

Margins included: “Equipment cost” includes manufacturer margins on the equipment. “Non-equipment cost” includes the margins from the distributor / wholesaler / installer.

Scope for Reduction of Equipment Costs

GSHP equipment costs are not likely to significantly reduce under the mass market scenario due to the maturity of the technology. The majority of auxiliary components used, i.e. cylinders, electronic controls, pipes and valves, are already at mass market and are dependent on world commodity prices and the manufacturing price of which are unlikely to decrease in the future. There may be some lower prices negotiated for auxiliary equipment through greater “volume” buys by installers – though these items are already bought relatively low cost by installers, with the heat pump part of the equipment being by far the most expensive part. The key drivers for cost reduction are outlined below, but are likely to only have a small impact on equipment costs. As described above, an unanticipated scenario is that we see the emergence of new competition in the GSHP market from companies coming from an air-conditioning background who are able to produce low costs systems. However there is a high barrier to entry for these companies who have little experience in capturing heat from the ground.

Key drivers for cost reduction of 90 kW GSHP equipment costs (retrofit focus)

Driver	Description	Cost component affected / Impact	Influenced by DECC / trade body?
Manufacturers having confidence to invest in R&D	To produce HPs better suited to UK retrofit, or in order to ultimately find lower cost production materials/methods.	Whole system	✓
Economies of scale	Enabling industrialisation of production, less labour intensive and more automated.	Whole system	✓
Increasing market competition	Increased number of GSHP players, and increasingly well-performing ASHP – driving GSHP manufacturers to find cheaper approaches. Lower cost new entrants may force existing manufacturers to squeeze their margins.	HP unit, fan coil emitters, UFH, manufacturer margins	✓
Increased “volume buys” leading to decreased manufacturer margins	Bulk buys today are not widespread throughout the supply chain - in a mass market, increased demand would mean ‘volume buys’ would be more commonplace across the supply chain. Typically a cost reduction of ~6-7% to the standard price is achievable for volume buying. Wholesalers, distributors, installers sourcing GSHP from manufacturers can secure better deals on the price per unit if they are buying a larger volume of heat pumps.	Whole system – especially HP unit, tanks and heat emitters, manufacturer margins	✓
Shift to wholesaler route to market rather than direct	Wholesalers reduce the ‘cost of sale’ for manufacturers, enabling heat pump units to be purchased at lower cost by the installer – this route only works as installer confidence & skill grows sufficiently, & depends on manufacturers reducing their margins when their costs come down.	Manufacturer margins, HP unit cost	✓
Increasing availability of lower cost OEM components	Meaning manufacturers can source components more cheaply and manufacture less themselves.	HP specific components	✗
Increasing availability of GSHP in the 90 kW range as a single unit	Many companies today can only offer e.g. 2 x 45 kW in cascade, which incurs the cost of setting up the cascade rig and can be more expensive in total.	HP unit	✓
Sourcing cheaper raw materials	Raw materials account for 90% of the HP production cost. A shift to e.g. use of more plastics would ultimately lead to lower prices (although may drive costs up initially to cover R&D costs). The extent of possible cost reduction is dependent on market prices for raw materials.	HP unit	✗

KEY: Impact of drivers – *high / medium / low* - ‘High’ meaning that the drivers are crucial for growth in the market and ‘low’ meaning that they would add value but not critical.

How would the influence of these drivers change with larger or smaller GSHP capacity?

<u>12 kW</u>	<u>90 kW</u>	<u>600 kW</u>
>10% reduction in equipment cost in a mass market scenario compared to 2014	5-10% reduction in equipment cost in a mass market scenario compared to 2014	>10% reduction in equipment cost in a mass market scenario compared to 2014

12 kW: In a mass market scenario, the drivers above would have a greater impact on a 12 kW system than on a 90 kW system, meaning the potential cost reduction from 2014 to a mass market scenario is greater for the 12 kW than the 90 kW. Equipment costs (primarily the HP unit) could lower faster in the period between now and a mass market for a 12 kW than for a 90 kW, because economies of scale, and the chance for “volume buys” may have a greater influence on the 12 kW than the 90 kW system. This is because domestic scale GSHP could be installed in greater numbers than commercial scale (compare ~1.5 million boilers replaced annually in the domestic sector and only ~50,000 in the commercial sector – so a 20% share of GSHP installed in domestic dwellings would equate to around 300,000 domestic installations, compared with a 20% share of non-domestic dwellings which would equate to 10,000 installations of 90 kW or above). However, there is less chance for the manufacturing cost of the HP unit to reduce for the 12 kW than the 90 kW (there is still on-going R&D to reduce the need for 2 compressors in a 90 kW GSHP – effectively halving the compressor cost. The 12 kW GSHP only uses one compressor so costs can only come down incrementally).

600 kW: In a mass market scenario, the drivers above would have a greater impact on a 600 kW system than on a 90 kW system, meaning the potential cost reduction from 2014 to a mass market scenario is greater for the 600 kW than the 90 kW. Equipment costs (particularly the HP unit but also more ‘standard’ products) could lower faster for a GSHP of this scale in the period between now and a mass market, because it is a much less mature product than a 90 kW. A mass market scenario would enable much more R&D focus on standardisation of larger scale products, which are currently very much bespoke products (the first steps are already being made, but sales volumes are too low to enable progress today). Even many basic components for a 600kW (e.g. pipes, valves, pumps, and plant room) are different from the basic components used in 12 or 90 kW systems so have to be made to order at high cost.

Forces which may drive cost up

Short Term

- Manufacturer focus on increases in efficiency to comply with e.g. Ecodesign Directive, is more likely to drive costs up to cover R&D costs. In the long-term, some such developments could of course reduce GSHP lifetime costs.
- A more efficient GSHP (i.e. COP 5) would require more extensive ground loops which may maintain or increase costs, but would decrease the running costs for the system.
- Shortage of refrigerants driven by F-Gas regulation may drive refrigerant prices up. New refrigerants tend to be more expensive initially due to covering the R&D cost.

- Demand for more sophisticated controls in heat pumps is another factor which could drive costs up to some extent in the short-term – particularly having connectivity to communicate with Building Energy Management Systems, which are increasingly used in the commercial sector. However, the costs associated with this are not that significant, and many companies already offer this.

Long Term

- Oil prices have a large effect on the cost of plastics and these are anticipated to increase in the long term. Similarly the price of metals may increase due to the commodity market. This could be off-set if HP companies sourced alternative lower cost materials (see above).
- The characteristics of UK buildings means there is a need to use larger capacity and high temperature HPs in retrofit - keeping costs high, until the retrofit housing stock thermal efficiency increases (converting the building stock thermal efficiency is a long-term challenge).
- In the wider energy environment, in the longer-term, the ability of heat pumps to be used in load management applications may require investment to optimise control systems to provide flexibility, while also maintaining comfort in the building. This could increase technology costs (though there is also a scenario where most of the “intelligence” to enable this is actually within a Building Energy Management System rather than within the heat pump, so would not impact so much on heat pump costs).






How would the driver change in new build?

The equipment cost reduction potential is higher in new build than in retrofit, assuming that new build regulations are much stricter in the future mass market scenario than they are today. Where 5-10% equipment costs are expected between now and a mass market in retrofit, this could be >30% in new build. The impact is that lower capacity systems can be used for new build, due to lower heat demand, which would lead to reduced equipment costs for new builds in comparison to retrofit (predominantly the heat pump part of the equipment costs, which is the largest part of the cost). Heat pump costs are linked to capacity more strongly than for example a boiler, so the costs differential between a 90 kW heat pump and a 450 kW heat pump is much larger than the cost differential between the equivalent boilers. This heat pump cost differential may narrow in a mass market scenario, but would still be expected to have a strong impact.

Scope for Reduction of Non-Equipment Cost

There is more scope for reduction of non-equipment costs compared to equipment costs. This is mainly from a reduction in margins across the supply chain because of increased expertise, experience and efficiency of GSHP. These could be achieved to a considerable extent with very high regional penetration.

Key drivers for cost reduction of a retrofit 90 kW GSHP non-equipment costs:

Driver	Description	Cost component affected / Impact	Influenced by DECC / trade body?
Decrease in installer margins	Decrease in installer costs and margins because of; <ol style="list-style-type: none"> 1. Increased confidence and expertise in GSHP (including HP and ground loops sizing) - ability to install it with no return visits required improved. 2. Increased installer skill level means more efficient and quicker installations 3. Stronger after-sales support available to installers 4. Increasing availability of remote fault diagnostics 5. Greater market pull 6. Ease of specifying GSHPs. 7. Increasing competition. 	Labour costs Time Costs Reduced installer margins Installer overheads	
Reduced drilling costs	<ol style="list-style-type: none"> 1. Drillers optimise their rigs for GSHP and run GSHP – only businesses (today GSHP boreholes are a bonus to their core business - ground stabilisation / water boreholes). 2. There are more drillers covering the country, and potential for more clustered working, so lower mobilisation costs. 3. More capacity utilisation of their rigs. 	Time cost Logistic / transport cost	
More developed and consolidated sales channels in the UK	Increasing availability of products in the UK (e.g. more UK-based “manufacturer depots” where HPs are stored, some companies even opening manufacturing in the UK) – reducing import & distribution costs and ‘internal transfer costs’ in large global companies. UK-wide geographical coverage – reduces travel costs (local jobs) and lowers overheads per installation.	Distribution margins Travel costs Overheads	
Competition from new market entrants (ground works / drilling)	The emergence of more installation companies, particularly those set up for GSHP-specific groundwork / drilling, as the GSHP market grows, would increase competition and force prices down.	Installation / drilling margins	
More efficient sales process	For example, increased use of wholesalers, and the increasing scale of distribution / installation businesses (e.g. from <10 to 100s) allows fixed overheads for office space, admin etc to reduce.	Admin and overheads	

KEY: Impact of drivers – *high / medium / low*

How would the influence of these drivers change with smaller or larger GSHP?

<u>12 kW</u>	<u>90 kW</u>	<u>600 kW</u>
35-40% reduction in non-equipment cost in a mass market scenario compared to 2014	30% reduction in non-equipment cost in a mass market scenario compared to 2014	20-25% reduction in non-equipment cost in a mass market scenario compared to 2014

12 kW: In a mass market scenario, the drivers above would have a greater impact on a 12 kW system than on a 90 kW system, meaning the potential cost reduction from 2014 to a mass market scenario is greater for the 12 kW than the 90 kW. This is primarily because reduced drilling costs could have a stronger impact on reducing costs for a 12 kW than a 90 kW GSHP. Today, drilling costs are higher per kW for a 12 kW than a 90 kW primarily because of the ‘start-up cost’ (the price is not increasing significantly to drill 2 or 3 holes rather than 1). Drillers can reduce their start-up costs if they do not have such distance to travel to installations, and/or they can drill at more than one installation in the same locality, and drillers may be forced to reduce these costs where there is more competition from other drillers. This is the main reason that drilling costs are lower in Sweden today than in the UK. (NB: in order to compare like for like, we focus only on boreholes – if we also included trenching, the picture could be different, as explained in Table 1).

600 kW: In a mass market scenario, the drivers above would have a lower impact on a 600 kW system than a 90 kW system, This is because it is more difficult to reduce installation margins for a 600 kW project – installation of systems greater than ~200 kW is likely to require more complex solutions e.g. incorporating ventilation systems, or other energy services – leading to higher project management costs and usually requiring external contractors (not only heating engineers). This situation is unlikely to be significantly different in a mass market scenario, because the more industrial sectors likely to need such a scale of heat pump call for inherently bespoke system designs.

Forces which may drive cost up

Short Term

- **Manufacturers cost of sales staying high** because of limited volume of sales - today manufacturers margins are already low, with most large manufacturers breaking even and in some cases making a loss due to lack of market pull.
- **The GSHP industry remains “bespoke”, without standardization:** GSHP sector is likely to continue to be a ‘specialist’ area, rather than attracting HVAC specialists to the industry – especially given the increasing competition from (and success of) lower cost and easier to install ASHP. As a result, margins may continue to stay high for the bespoke GSHP design and installation process.
- **Installers take larger margins in the shorter term** – Currently installers consider themselves ‘financially squeezed’ and would like to see higher margins for GSHP installations.

Long Term

- **GSHP specialists may invest in drilling rigs specifically designed for GSHP boreholes** rather than water boreholes, due to increase in demand for GSHP. In the

long-term it would lead to more efficient and cheaper drilling – but in the short term this would increase costs until the initial outlay has been recouped.

Cost of grid connection – not included in the costs presented here because they are very regionally specific, but can add in excess of £8,000 for domestic installs to more than £50,000 in commercial installations. This is already an issue today, but is unlikely to get smaller in the long-term. These costs are likely to increase in the future as distribution grid congestion and managing peaks becomes a greater issue.

How would the influence of these driver change in new build?

Cost reduction potential in a mass market compared to 2014 could be 35-40% for new build compared with 30% for retrofit. Reduction of labour costs and the increased efficiency of distribution channels could be a stronger cost reduction driver in new build than retrofit because of (1) more efficient ‘repeat’ installations, and no removal of old equipment, (2) lower transport costs (several installations at the same site), (3) lower margins due to competition with other installers bidding for the same job, and (4) lower design costs as the parameters do not have to be measured in situ.

Outlook by 2020

GSHP are expected to remain a relatively niche product and a specialist sector by 2020, with sales only modestly increasing, and the focus remaining on the new build market. Experience in GSHP industry is that manufacturing costs have been increasing in the last 5 years, and they are increasingly finding it difficult to meet their margins. Moreover borehole specialists have already been squeezed due to the recession, dropping what they can charge for borehole drilling by ~40% over the last 10 years, which leaves very little room for further decreases.

GSHP face increasing competition from significantly cheaper and more retrofitable ASHP - which are already essentially mass market products because the components are already sold in vast numbers in the air-conditioning market. The efficiencies of ASHP are also improving as more ASHP manufacturers are able to invest in R&D, so the efficiency benefits of additional investment in a GSHP are becoming smaller. An “unanticipated scenario” is that some of the Asian air-conditioning companies driving cost-reduction in ASHP are able to use their scale to launch efficient but lower cost GSHP products (we have already seen the first air-conditioning companies move into GSHP in the last 2 years).

For non-equipment costs, where the products are being sold through companies who are able to scale up business through selling ASHP and other renewables, some of the cost reduction may be achievable through reduced installer / distributor overheads and margins. This would not apply to drilling costs, however, which would be kept high as long as there are low numbers of GSHP installs. Since drilling costs and associated ground works typically make up 60-70% of the total non-equipment costs, only 30-40% of the non-equipment costs could come down.

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